Questions to Ask Before Choosing a DAQ Board

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Overview

Today's data acquisition (DAQ) products should use modern technologies and proper designs to deliver measurements—accurate readings. Modern technologies and design offer specific advantages, yet many vendors still use the technologies of the 1980s. This design limits the results to approximations or estimates of the event monitored. If old technologies produce estimates, then why do some vendors still use them? Reasons include reluctance to invest in DAQ products, noninnovative development, and direct cloning of old technologies. Whatever the reasons, the result is a compromised reading. At National Instruments, we do not compromise the reading. The term *Measurement-Ready* identifies our products, which use a collection of technology and design that delivers measurements. Even our low-cost DAQ products are *Measurement-Ready*. Before purchasing a DAQ board, you should be aware of these technologies, how they contribute to measurements, and how to determine whether a DAQ product has them.

Measurement-Ready Technologies	**1980s Technologies**
Autocalibration	Manual Calibration
No Potentiometers	Potentiometers
Multilayer Design	Single, Nonisolated Planes
Surface-Mount Design	Through-Hole Design
ASICs	Many Components
High-Grade Components	Low-Grade Components
Complete Software Driver	Token I/O Calls

Technology Questions

Does the board require calibration?

Some DAQ boards are designed with intrinsic calibration, which means that the board has no components, such as potentiometers or amplifiers, that significantly contribute to gain or offset errors. The product is intrinsically calibrated because of its design.

Does the board perform autocalibration?

Measurement-Ready DAQ boards have the capability to perform automatic calibration, which means they automatically subtract any errors that occur due to offsets and gains. Offsets occur because of environmental changes, including electronic emissions and temperature drift. Gain errors occur because of manufacturing tolerances of various components. With proper board design, these errors can be automatically removed without the need for physical access. Automatic calibration can be performed whenever the driver is launched and by software command. There are two ways to perform autocalibration—using onboard coefficients, and using onboard precision voltage and temperature references with onboard coefficients.

Onboard coefficients are used for automatic calibration of boards with gains. In this case, the board is calibrated at the factory and coefficients are stored in an onboard EEPROM that characterizes the gain and offset errors associated with the board. Each time the driver is launched, by software command, the coefficients are read and used by the driver to correct the reading. Here, the user has the option to redetermine the onboard calibration coefficients by supplying a known voltage.

Onboard precision voltage and temperature references with onboard coefficients provide advanced automatic calibration. The onboard precision voltage source is switched into a selected channel and digitized. The measured value is compared against the known value to determine the offset coefficient. The precision reference is changed to new levels and measured, which provides slope to determine gain errors. These coefficients are modified further by accounting for temperature effects. An onboard temperature sensor reads board temperature and adjusts the offset and gain coefficients accordingly. These coefficients are stored in an onboard EEPROM and used to remove errors on the reported readings.

Does the board use potentiometers?

Potentiometers often are used to calibrate old-technology DAQ boards. Calibration is performed by turning the potentiometer until the resistance nulls out errors. Problems with using potentiometer-based calibration include the difficulty of access, temperature drift, mechanical failure, and inadvertent alteration. Tuning a potentiometer is a manual process and requires physical access to the board, which is difficult because DAQ boards are inside the computer and often hard to reach. Changing temperatures alter the resistance values of potentiometers and can cause the DAQ board to drift out of calibration. Potentiometers wear out over time and through repeated use. Contact points between the resistor element and wiper can wear away and create an open or very high resistance value. This too can cause the DAQ board to become uncalibrated. Inadvertently altering potentiometers by bumping them also can cause a DAQ board to become uncalibrated. Recognizing this hazard, vendors guard against it by applying a locking paint on the screw head. Upon manual recalibration, more paint should be applied to prevent the screw head from turning. In practice, however, this is often not done, and the problem remains. DAQ boards with potentiometers are easy to spot because the potentiometers are large components and are typically brightly colored blue, red, or white.

Does the board use multilayer design?

Multilayer or multiple-ground-plane design is used to separate sensitive analog circuitry from digital signals to improve accuracy. Lines carrying analog signals to the amplifier and digitizer can pick up noise from digital lines changing states. A digital line changing from low to high has a very fast rise time and looks like a square wave on an oscilloscope. This sharp edge actually is made up of very high frequency components. To these high frequencies, the copper traces on a DAQ board, separated by an insulator, act as a capacitor that couples energy to neighboring traces. If these neighboring traces are carrying analog signals, this digital noise is added, amplified, and digitized to give inaccurate readings (estimates). Proper design prevents this inaccuracy. Separating the analog and digital circuits into layers with whole copper ground planes between them prevents the digital noise from corrupting the analog signals. The ground planes also provide a very low impedance path to computer ground, and therefore, a less noisy reference for the analog circuitry.

How can you tell if a board uses multilayer design?

One clue that a board uses multilayer design is opacity—the inability to see light through it. Boards with multiple ground planes appear opaque because light does not shine through the copper. On some boards there are copper tags or numbers on the edge; you can count the layers. Some boards have multiple layers but not multiple ground planes. These boards transmit light so you can see the traces. Where you see the traces overlap, the traces can "talk" to one another and are potential sources of noise.

Does the board use surface-mount technology?

Surface-mount technology, a system for connecting components to a printed circuit board, actually can affect the accuracy of the DAQ board. Surface-mount design shortens trace length, which reduces the amount of noise they pick up. Surface mounting places component contacts on the surface of the printed circuit board and solders them in place. This technology is in contrast to through-hole technology, which drills holes through the board, inserts component contacts through the holes, and solders them in place. Surface-mount components are smaller because they do not require large physical contacts. The traces between surface-mount components can be shorter because of this smaller component size and because holes are not required. Shorter traces not only pick up less noise but also create tighter clusters of components. Because of the increased component density, the designer can place circuits strategically to further isolate sensitive elements. For example, the analog components can be clustered and positioned far away from noisy digital circuits. Another strong feature of surface-mounting is that components can be placed on both sides of the board, which adds more functionality on smaller printed circuit boards. The combined effect of surface mounting and positioning reduces noise on the analog signals for more accurate readings.

How do you identify surface-mount technology?

Surface-mount components do not have "pins" that go through the DAQ board. The component contacts or leads are usually smaller than those of through-hole components. Through-hole boards usually have components on only one side with sharp pins protruding on the other side of the board.

Does the board use ASICs?

ASIC components on DAQ boards increase functionality, but they also can reduce noise and power consumption. ASICs are used to consolidate functionality and improve performance. Consolidating components reduces component count and eliminates the traces that run between them. Removing traces reduces the opportunity for digital noise to affect analog signals. Consolidation also frees up space for strategic placement and isolation of separate functionality. Finally, reducing components can reduce the overall power consumption of the board.

How do you identify ASICs?

ASICs are usually large chips designed by the vendor. Often boards that use them have important features such as Plug and Play and sometimes have additional unused space.

Does the board use adequate grade A/D components?

Analog-to-digital converters (ADCs) come in different grades, and the grade used can affect the accuracy of the reading. Not all ADCs are created equal. Manufacturers offer a spectrum of converters that have the same general characteristics, such as resolution and conversion speed, but actually vary in the output quality. Some ADCs offer better accuracy. They guarantee a given accuracy within a given number of least significant bits. Another way ADCs vary is by montonicity. Montonicity refers to the ability of the ADC to deliver linearly increasing codes with increasing voltage values. Not all ADCs actually can do this. They miss codes altogether and do not ever report that code. High-grade ADCs guarantee no missing codes. The cost of a high-grade ADC can be as much as 20% more than a low-grade component. DAQ board performance claims stem from the ADC classification, such as 100 kHz and 16-bit, but give little insight on the actual capability of the part. National Instruments uses the highest-grade components to deliver the stated accuracy with no missing codes.

Is the DAQ driver software fully functional?

Drivers exist at many different levels; those with low functionality can jeopardize the ability to get the job done. Unlike DAQ boards, which have categories such as low-cost and high-performance that convey functionality, driver software is simply called driver software. On one end of the spectrum, a driver could be a piece of code with four peeks and pokes into a register. On the other end, it could be a complete library of functions that covers all board capabilities, runs functions simultaneously, runs multiple boards simultaneously, offers event messaging and buffer and resource management, and preserves its API across multiple platforms. All of these features are important, but some crucial ones are full functionality, simultaneous functionality, and multiple board operation. Full functionality means that all of the capabilities advertised in the product data sheet can be exercised. Generally, if you cannot access the function with the driver, the function may as well not exist. Secondly, the ability to perform functions simultaneously is a must. A multifunction board that cannot perform its functions at the same time might jeopardize the solution. Many drivers do not permit simultaneous functions. For example, you might have to wait for the acquisition to be completed before running the next function. This condition precludes simultaneous output. One last important point is the ability to perform simultaneous I/O across multiple boards. Most people put together systems by selecting several boards. The ability to perform good buffer and resource management as well as synchronization is critical in making these systems work. Much development and testing must go into a driver that delivers these capabilities.

Cost Questions

There are other questions that relate to the *real* cost of a board, which can greatly exceed the price.

Is the board Plug and Play?

Plug and Play gets you up and running quickly. It does not contribute directly to accuracy but it does significantly reduce the amount of work required to begin delivering measurements. Non-Plug-and-Play DAQ boards can take hours of trial and error to get up and running. Setting switches, jumpers, and turning potentiometers requires powering the computer up and down, board removal and insertion, and lots of patience. Adding further peripherals to your system starts the trial-and-error process all over again. Plug and Play dynamically allocates and reallocates resources and provides hands-free configuration.

Is the board truly low-cost?

Plug and Play is especially important in low-cost data acquisition where the intent is to reduce cost, yet deliver measurements. Spending hours to get a board configured can cost hundreds of dollars beyond the initial price of the board. And if you are dealing with old technologies that give you only estimates, are the measurements even worth making?

National Instruments Delivers!

National Instruments DAQ products, from low-cost boards to high-performance E Series boards, deliver measurements. The technologies and designs discussed in this paper are used to give you measurements, not estimates.

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Corporate Headquarters • 6504 Bridge Point Parkway • Austin, TX 78730-5039 USA
Tel: (512) 794-0100 • Fax: (512) 794-8411 • E-mail: info@natinst.com
Branch Offices: Australia 02 9874 4100 • **Austria** 0662 45 79 90 0 • **Belgium** 02 757 00 20 • **Canada (Ontario)** 905 785 0085
Canada (Québec) 514 694 8521 • **Denmark** 45 76 26 00 • **Finland** 90 527 2321 • **France** 01 48 14 24 24 • **Germany** 089 741 31 30
Hong Kong 2645 3186 • **Israel** 03 5734815 • **Italy** 02 413091 • **Japan** 03 5472 2970 • **Korea** 02 596 7456
Mexico 5 520 2635 • **Netherlands** 0348 433466 • **Norway** 32 84 84 00 • **Singapore** 2265886 • **Spain** 91 640 0085
Sweden 08 730 49 70 • **Switzerland** 056 200 51 51 • **Taiwan** 02 377 1200 • **U.K.** 01635 523545