Types of Data Acquisition Systems

Two Types of DAQ Systems

The core of every DAQ system is the computer. A standard PC is commonly used but other options include laptop computers or hardened PCs that are designed for severe industrial environments.

In some special systems, even a personal data appliance (PDA) such as a Palm Pilot can be used as the computer and display. The computer runs the software that essentially implements the data capture process, its analysis, and display.

This leaves the remainder of the system including the sensors, signal conditioning, multiplexer, ADC, output interfaces, and data communications circuits.

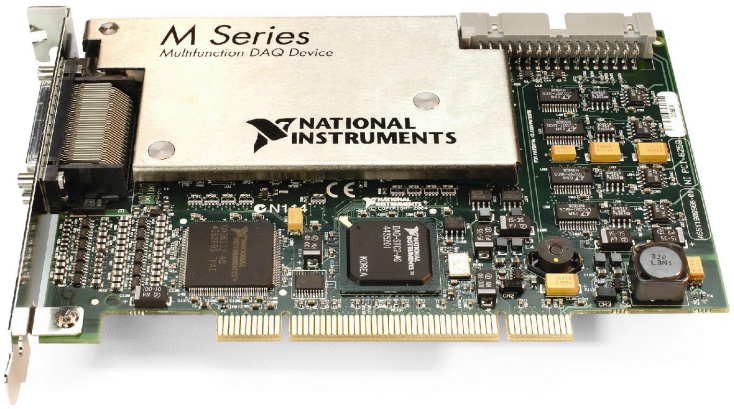
Packaging

The sensors, signal conditioning, multiplexer, ADC, output interfaces, and data communications circuits are packaged two ways:

- On a printed circuit card that plugs into the standard PCI bus in most personal computers or into a PCMCIA/Card bus on a laptop
- In a separate enclosure with its own power supply that connects to the computer via some data communications link

There are also several other formats for specialized applications.

DAQ Plug-In Boards



One of the most common forms of DAQ systems is a single printed circuit board that plugs into the PCI bus on any personal computer. Most of the newer PCs have this fast parallel bus. Some DAQ boards are also available for the ISA bus used in older PCs. The metal shield at the top covers the sensitive analog input section to help prevent interference from nearby high speed digital circuits on this board and in the host PC.

Photo courtesy of National Instruments Inc.

Plug-In Boards

These boards contain the analog input connections at the connector shown on the left in the figure, some signal conditioning such as amplification, multiplexer, ADC, as well as one or more DACs to generate analog outputs. Some boards contain digital counters that can be configured for frequency measurement, timing, or other operations. Other connections are for digital inputs and outputs.

A variation of this format is a plug-in card compatible with the PCMCIA slot on most laptop computers.

Photo courtesy of National Instruments Inc.

Analog and Digital Inputs

Most DAQ boards feature 16 single-ended inputs and 8 differential inputs. These are terminated on a connector at the back of the board that exits out the back of the PC. Other configurations are available with as few as 8 single-ended inputs and 4 differential to as many as 64 to 80 single-ended inputs and 32 differential inputs.

Different input voltage ranges are also provided to ensure a good match up with the type of sensor. Some common input ranges are ±10, ±5, ±2.5, ±1.25, ±1 volts, ± 500 mV, ±200 mV, ±100 mV, and ±50 mV. Most boards provide selectable gain amplifiers to boost the input signal amplitude into the range of the ADC. Common selectable gains are 1, 2, 5, 10, 20, 50, 100, and 200.

The analog input impedance may be as low as 10k ohms to as high as 1G ohms.

Digital inputs are CMOS or TTL compatible with a typical range of 0 to +5 volts. The inputs are single-ended.

Sampling Rate

A key specification of a DAQ board is the sampling rate of each input channel. With a 16 input multiplexer, each input is sampled at a rate that is one sixteenth of the fastest sampling rate of the ADC. A common sampling rate per channel is 200 kilosamples per second (kS/s). For sixteen channels, this represents a total ADC sampling rate of 16 x 200 kS/s = 3200 kS/s or 3.2 MS/s (megasamples per second).

A key factor to remember is that the sampling rate must be at least twice the highest frequency variation in the input signal. The sampling rate depends upon the type of sensor, application, and other factors. In most cases, the 200 kS/s rate is fast enough for most applications.

Sampling Rate Example

Other sampling rates are also available from as low as 0.5, 1, 2, or 10 S/s up to 20 MS/s.

To compute the sampling rate of a given input, divide the conversion rate in samples per second by the number of multiplexer inputs used. For example, if the sampling rate is 2 Ms/s with a 16 input MUX, the sampling rate per channel is 2,000,000/16 = 125 kS/s.

Resolution

Another key factor is resolution of data conversion. Resolution is the smallest increment of input voltage to be digitized. This is determined by the number of data bits used in the ADC. The two most commonly used resolutions are 12 and 16-bits. With 12 bits, the input voltage range is divided up into 2^{12} = 4096 increments. For an input range of ± 1 volt, the total voltage range is 2 volts. The resolution then is 2/4096 = .000488 volts or 488 µV. Voltages or voltage increments less than this are not recognized.

If greater resolution is required, a 16-bit ADC can be obtained. This divides the input resolution into 2^{16} = 65,536 increments.

The resolution is determined by the input signal size, its range of change, the desired precision of measurement, and the noise level. For non-critical applications, resolutions of 8 and 10-bits are available. For high precision, 24-bit boards are available.

Analog and Digital Outputs

Most DAQ boards also include two or more analog outputs. These come from digital-to-analog converters (DACs). These outputs are derived from binary words produced by the PC during some processing of the input data. These outputs may be DC levels or AC signals that are used to control some aspect of the system such as motor speed or proportional valve opening.

Typical DAC resolutions available are 12 and 16-bits.

Digital outputs are CMOS and TTL compatible in the 0 to +5 volt range. Some boards have no digital outputs others may have 8, 16, or 32.

Other features of most DAQ boards are built in counters and timers. These are 16 or 32-bit counters that can count fixed clock pulses to provide a way to time I/O operations, specify sampling rate, or keep track of time for some applications. The 16 or 32-bit words are read by the PC and used in the processing calculations.

External DAQ Configurations

While the majority of DAQ applications can be met with a DAQ plug in card in a PC, other applications may require a special or more flexible arrangement. In such cases, an external piece of equipment is used. It is an enclosure or chassis with plug in slots for signal conditioning cards, DAQ cards, and I/O interfaces.

One example is shown here. It is a box containing four inputs from standard BNC connectors and special signal conditioning circuits. The signals are digitized at 100 kS/s with 16-bit precision. The outputs of the circuits are then fed to a USB port interface which is connected to the computer by a short cable.

Photo Courtesy of National Instruments Inc.

Other External DAQ Configurations

Another example is a chassis that contains not only the signal conditioning plug in boards but also one or more DAQ boards. The ADC outputs (or DAC inputs) connect to an interface such as the GPIB, RS-232, or USB that is then connected to the computer.

In some applications, a special measuring instrument may be used to actually connect to the application for signal measurement. The instrument output then connects via a standard interface to the computer.

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