Overview of Signal Conditioning and Data Acquisition
(934 words)

PC-based data acquisition (DAQ) systems and plug-in boards are used in a wide range of applications in the laboratory, in the field, and on the manufacturing plant floor. A DAQ system includes signal conditioning hardware, acquisition and digitizing hardware, and software that is used to acquire raw data from sensors. The user determines the shape and functionality of the system. Users mix and match hardware and software to acquire, analyze, and display data.

A DAQ system is made up of:

- **Sensors** – sensors, also called transducers, are attached to or submerged in the phenomenon (physical property, such as temperature) being measured. Sensors produce an output signal voltage proportional to a change in the phenomenon (for example, when the temperature changes).
- **Signal Conditioning** – some of the signals from the sensors are in the millivolt (mV) range. These low-level signals need to be boosted to a level that the plug-in hardware can read. Most real-world sensors and transducers generate signals that need to be conditioned before a DAQ device can reliably and accurately acquire the signal.
- **Plug-in hardware devices** – plug-in boards, PCMCIA interfaces, and external boxes digitize signals that are stored by the computer for users to analyze with software.
- **Driver software** – takes information from the hardware device and puts it into the computer's memory.
- **Application software** – communicates through the driver software; analyzes and presents the data as programmed by the user.
- **Computing platform** – desktop or laptop PC that receives and uses the data (Wintel PCs, Macintosh computers, and NEC workstations).

A Simple Sensor Example
A microphone is a good example of a DAQ system. The microphone, which is the sensor, turns the phenomena, in this case soundwaves, into electrical analog signals. The signals are amplified or made bigger through signal conditioning hardware. The DAQ hardware then turns the signals from analog to digital so that the computer can read the signals. The driver software then puts the signals from the DAQ board into the computer's memory, and the application software analyzes and presents the signals.

Analog and Digital Devices
The world is an analog place. But computers use information in digital format, which means that DAQ equipment needs to digitize the information it collects.

An analog device has an infinite number of values within the range the device can handle. For example, an adjustable dimmer light control, or rheostat, provides varying levels of light. The dimmer control provides all levels of light between dark and bright.

A digital device moves values that fall between two numbers to either the higher or lower number. If the light control were a preset knob with only four levels, the control would provide only four discrete levels of light. This is an example of a digital device.

Signal Conditioning
Some signals are not ready to be digitized by a DAQ board when they come out of a sensor. Signal conditioning prepares signals to be used by the digitizer. A signal can be corrupted by a noisy environment – not in terms of audible sound but in terms of electronic noise. Signal conditioning helps shield signals from electrical noise. In the microphone example, the signal was amplified to make the signal bigger. Another type of signal conditioning is attenuation, which makes the signal smaller. Signal conditioning also can act as a circuit breaker, isolating the computer from dangerous signals. Filtering is a type of signal conditioning that removes the parts of the signal that the user does not want to read.

An example is National Instruments SCXI, a modular signal conditioning system. Each module supports specific sensors or signal types, or provides specialized signal conditioning. With this flexible design, users

choose modules needed for their application, slide them into an SCXI chassis, and connect the system to a data acquisition (DAQ) board. To interface to more sensors, SCXI lets users dramatically expand the total number of channels in a DAQ system.

DAQ Hardware
PC-based data acquisition gives users the flexibility to develop measurement solutions for virtually any application. Products are available in the following hardware classifications:

- Analog I/O – for static single-point updates and reading high-speed waveform generation and acquisition
- Digital I/O – for static on/off sensing and control as well as high-speed pattern or handshaked I/O rates
- Timing I/O – for event counting, pulse and frequency measurements, pulse and pulse-train generation, buffered measurements, and quadrature encoder measurements

When selecting a DAQ device, users should consider vendors that offer similar functionality across different bus platforms. This way, they easily can move applications from one computer system to another.

DAQ Software
Users need complete driver software to take advantage of all of the features of a DAQ board. The software should come with examples to demonstrate the use of hardware. Even if the hardware device has all of the features needed for an application, without complete driver software, users cannot take advantage of the features, and cannot solve their application.

For a higher level development environment, many users choose National Instruments LabVIEW application software for their DAQ solutions. LabVIEW is a revolutionary graphical programming development environment based on the G programming language for data acquisition and control, data analysis, and data presentation. LabVIEW gives users the flexibility of a powerful programming language without the difficulty and complexity of text-based languages. Its block diagram methodology is inherently intuitive to scientists and engineers. LabVIEW features a Solution Wizard for users to quickly develop simple DAQ applications and hundreds of example programs, called virtual instruments, that users can include in their own programs and adapt as needed for their specific applications.