

Data Acquisition and Control Tutorial

PC-based Data Acquisition System Overview

In the last few years, industrial PC I/O interface products have become increasingly reliable, accurate and affordable. Because of this, PC-based data acquisition and control systems are widely used in industrial and laboratory applications like monitoring, control, data acquisition and automated testing.

Selecting and building a DA&C (Data Acquisition and Control) system that actually does what you want it to do requires some knowledge of electrical and computer engineering. This tutorial gives a brief introduction to what DA&C systems do and how to configure them. It covers:

- Transducers and actuators
- Signal conditioning
- Data acquisition and control hardware
- Computer systems software

Transducers and Actuators

A transducer converts temperature, pressure, level, length, position, etc. into voltage, current, frequency, pulses or other signals.

Thermocouples, thermistors and resistance temperature detectors (RTDs) are common transducers for temperature measurement. Other types of transducers include flow sensors, pressure sensors, strain gauges, load cells and LVDTs which measure flow rate, pressure variances, force or displacement.

An actuator is a device that activates process control equipment by using pneumatic, hydraulic or electrical power. For example, a valve actuator opens and closes a valve to control fluid rate.

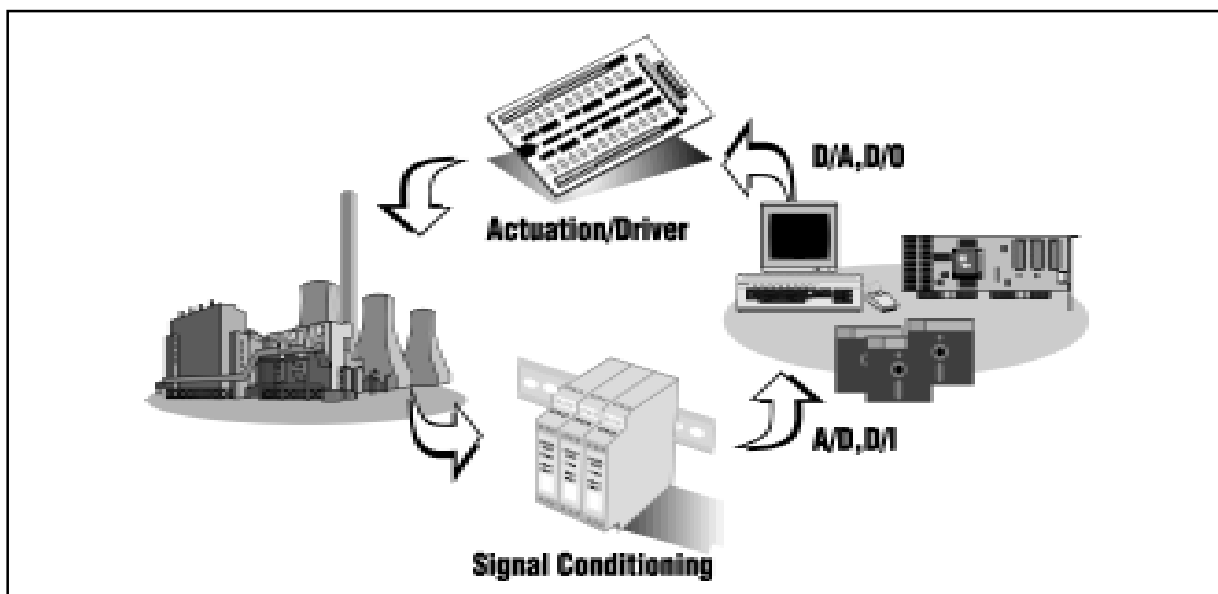
Signal Conditioning

Signal conditioning circuits improve the quality of signals generated by transducers before they are converted into digital signals by the PC's data-acquisition hardware. Examples of signal conditioning are signal scaling, amplification, linearization, cold-junction compensation, filtering, attenuation, excitation, common-mode rejection, and so on.

One of the most common signal conditioning functions is amplification. For maximum resolution, the voltage range of the input signals should be approximately equal to the maximum input range of the A/D converter. Amplification expands the range of the transducer signals so that they match the input range of the A/D converter. For example, a x10 amplifier maps transducer signals which range from 0 to 1 V onto the range 0 to 10 V before they go into the A/D converter.

Data Acquisition & Control Hardware

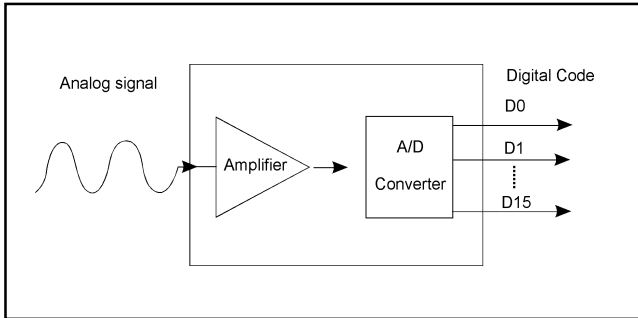
Data acquisition and control hardware generally performs one or more of the following functions: analog input, analog output, digital input, digital output and counter/timer functions. This section will discuss each function and list some considerations that are important when you select a data acquisition and control system.



The layout of a typical PC-based data acquisition system

Analog Inputs (A/D)

Analog to digital (A/D) conversion changes analog voltage or current levels into digital information. The conversion is necessary to enable the computer to process or store the signals.



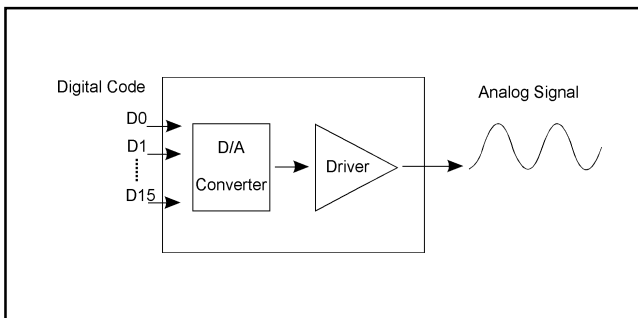
The most significant criteria when selecting A/D hardware are:

1. Number of input channels
2. Single-ended or differential input signals
3. Sampling rate (in samples per second)
4. Resolution (usually measured in bits of resolution)
5. Input range (specified in full-scale volts)
6. Noise and nonlinearity

Analog Outputs (D/A)

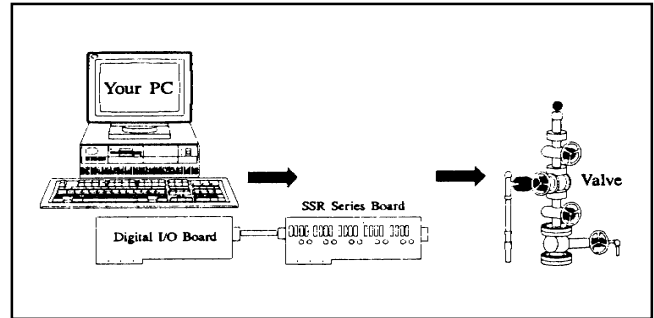
The opposite of analog to digital conversion is digital to analog (D/A) conversion. This operation converts digital information into analog voltage or current. D/A devices allow the computer to control real-world events.

Analog output signals may directly control process equipment. The process can give feedback in the form of analog input signals. This is referred to as a closed loop control system with PID control. Analog outputs can also be used to generate waveforms. In this case, the device behaves as a function generator.



Digital Inputs and Outputs

Digital input/output functions are useful in applications such as contact closure and switch status monitoring, industrial On/Off control and digital communications.



Using digital I/O and SSRs to open and close a valve

Counter/timer

A counter/timer can be used for event counting, flowmeter monitoring, frequency counting, pulse width measurement, time period measurement, and so on.

Software

The driving force behind any data acquisition and control system is software control. Programming your data acquisition and control system can be accomplished in the following three ways: hardware-level programming, driver-level programming and package-level programming.

In hardware-level programming, you program your data acquisition hardware's registers directly. To do this, you must determine the control code values that will be written to the hardware's registers. You must program in a language that offers low-level bit-control functions, such as C or assembly language. This is complex and takes a lot of time; time that you may not want to spend. That is why most manufacturers of data acquisition hardware supply their customers with either driver-level or package-level programs.

In driver-level programming, you simply call high-level functions from libraries provided by the card manufacturer. These functions encapsulate complete tasks such as A/D conversion into a single call. You can use high-level programming languages like Microsoft Visual C++, Visual Basic, Borland C++ and Delphi.

In package-level programming, the application program does the work for you. You simply tell it what to do. Software packages integrate data analysis, presentation and instrument control capabilities into a single interface. These programs offer a multitude of features, such as pull down menus and icons, data logging and analysis and real-time graphic displays.