

# 132: Data Acquisition Systems (DAS) in General

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## 1 INTRODUCTION

Data acquisition systems (DAS) interface between the real world of physical parameters, which are analog, and the artificial world of digital computation and control. With current emphasis on digital systems, the interfacing function has become an important one; digital systems are used widely because complex circuits are low cost, accurate, and relatively simple to implement. In addition, there is rapid growth in the use of microcomputers to perform difficult digital control and measurement functions.

Computerized feedback control systems are used in many different industries today in order to achieve greater productivity in our modern industrial societies. Industries that presently employ such automatic systems include steel making, food processing, paper production, oil refining, chemical manufacturing, textile production, cement manufacturing, and others.

The devices that perform the interfacing function between analog and digital worlds are analog-to-digital (A/D) and digital-to-analog (D/A) converters, which together are known as *data converters*. Some of the specific applications in which data converters are used include data telemetry systems, pulse code modulated communications, automatic test systems, computer display systems, video signal processing systems, data logging systems, and

sampled data control systems. In addition, every laboratory digital multimeter or digital panel meter contains an A/D converter.

## 2 BASIC DATA ACQUISITION SYSTEM

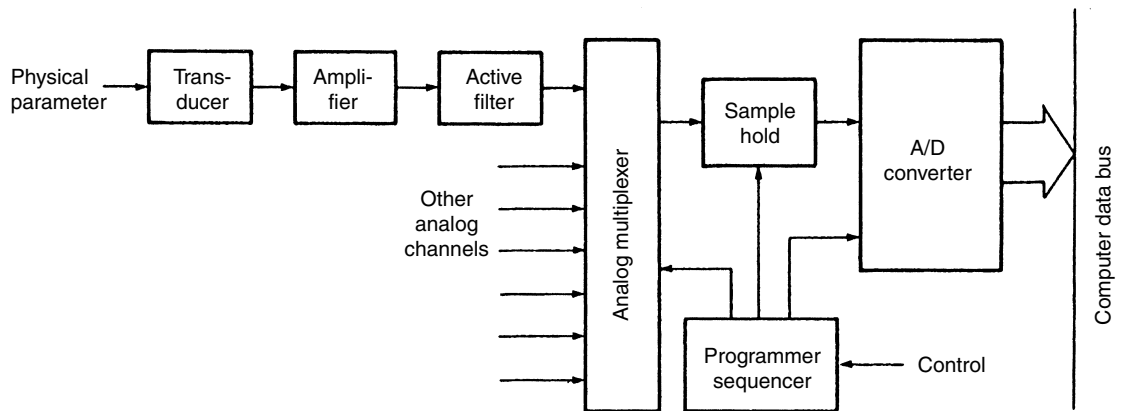
Besides A/D and D/A converters, data acquisition and distribution systems may employ one or more of the following circuit functions:

- transducers,
- amplifiers,
- filters,
- nonlinear analog functions,
- analog multiplexers,
- sample-holds.

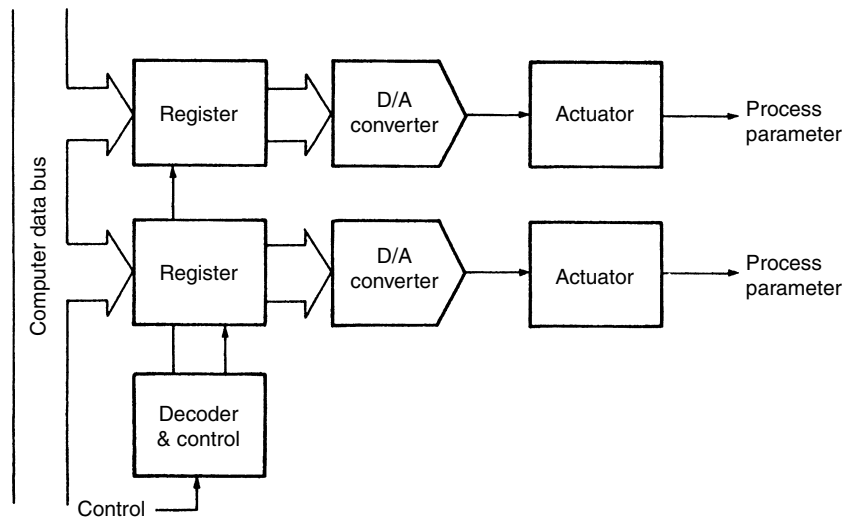
The interconnection of these components is shown in the diagram of the data acquisition portion of a computerized feedback control system in Figure 1.

The input to the system is a physical parameter such as temperature, pressure, flow, acceleration, and position, which are analog quantities. The parameter is first converted into an electrical signal by means of a transducer; once in electrical form, all further processing is done by electronic circuits.

Next, an amplifier boosts the amplitude of the transducer output signal to a useful level for further processing (*see also Article 133, Amplifiers and Filters for DAS, Volume 1*). Transducer outputs may be microvolt or millivolt level signals, which are then amplified to 1 to 10 V levels. Furthermore, the transducer output may be a high-impedance signal, a differential signal with common-mode noise, a current output, a signal superimposed on a high



**Figure 1.** Data acquisition system. (Source: reproduced by permission of Sydenham, P.H. (1983) *Handbook of Measurement Science*, Volume 1, Theoretical Fundamentals. John Wiley & Sons Ltd., Chichester.)



**Figure 2.** Data distribution system. (Source: reproduced by permission of Sydenham, P.H. (1983) *Handbook of Measurement Science*, Volume 1, Theoretical Fundamentals. John Wiley & Sons Ltd., Chichester.)

voltage, or a combination of these. The amplifier, in order to convert such signals into a high-level voltage, may be one of several specialized types.

The amplifier is frequently followed by a low-pass active filter that reduces high-frequency signal components, unwanted electrical interference noise, or electronic noise from the signal (*see also Article 133, Amplifiers and Filters for DAS, Volume 1*). The amplifier is sometimes also followed by a special nonlinear analog function circuit that performs a nonlinear operation on the high-level signal. Such operations include squaring, multiplication, division, rms conversion, log conversion, or linearization.

The processed analog signal next goes to an analog multiplexer, which switches sequentially between a number of different analog input channels (*see also Article 134, Analog Multiplexers, Volume 1*). Each input is in turn connected to the output of the multiplexer for a specified

period of time by the multiplexer switch. During this connection time, a sample-and-hold circuit acquires the signal voltage and then holds its value while an A/D converter converts the value into digital form. The resultant digital word goes to a computer data bus or to the input of a digital circuit.

Thus the analog multiplexer, together with the sample-and-hold, time shares the A/D converter with a number of analog input channels (*see also Article 135, Sample-and-hold Circuits, Volume 1*). The timing and control of the complete DAS is done by a digital circuit called a *programmer-sequencer*, which in turn is under the control of the computer. In some cases, the computer itself may control the entire DAS.

While this is perhaps the most commonly used DAS configuration, there are alternative ones. Instead of multiplexing high-level signals, low-level multiplexing

is sometimes used with the amplifier following the multiplexer. In such cases, just one amplifier is required, but its gain may have to be changed from one channel to the next during multiplexing. Another method is to amplify and convert the signal into digital form at the transducer location and send the digital information in serial form to the computer. Here, the digital data must be converted to parallel form and then multiplexed onto the computer data bus.

### 3 BASIC DATA DISTRIBUTION SYSTEM

The data distribution portion of a feedback control system, illustrated in Figure 2, is the reverse of the data acquisition system. The computer, based on the inputs of the data acquisition system, must close the loop on a process and control it by means of output control functions. These control outputs are in digital form and must, therefore, be converted into analog form in order to drive the process. The conversion is accomplished by a series of D/A converters as shown (also often called DAC's). Each D/A converter is coupled to the computer data bus by means of a register, which stores the digital word until the next update. The registers

are activated sequentially by a decoder and control circuit, which is under computer control.

The D/A converter outputs then drive actuators that directly control the various process parameters such as temperature, pressure, and flow. Thus, the loop is closed on the process and the result is a complete automatic process control system under computer control.

### FURTHER READING

The general principles of DAS are found explained in various titles.

- Austerlitz, H. (2003) *Data Acquisition Techniques Using PCs*, Academic Press, San Diego.
- Mihura, B. (2001) *LabVIEW for Data Acquisition*, Prentice Hall PTR, Upper Saddle River NJ.
- James, K. (2000) *PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control*, Newnes, Oxford.
- Park, J. and MacKay, S. (2003) *Practical Data Acquisition for Instrumentation and Control Systems*, Newnes, Oxford.
- Taylor, H.R. and Taylor, J.R. (1997) *Data Acquisition for Sensor Systems*, Chapman & Hall, London.