Control Technology
Data Logging & Control Systems

Data logging systems

Meteorological data logging.

Meteorological data logging involves taking measurements of such weather conditions as air pressure, temperature, humidity, wind speed and wind direction. These measurements are used in many different areas. For example, weather stations use these reading to provide sailors with vital weather forecasting information. TV and radio weather forecasters use them to keep us informed about what weather conditions we can expect in the near future. Military forces need wind speed and direction information for their weapon systems.

Meteorological measurements are taken using a variety of instruments. Some are simple mechanical devices such as the rotating vane anemometer (described later). Others include computer-controlled electronic sensors with no moving parts. All of them, however, convert a climatic condition such as temperature into an electrical signal which can be displayed or recorded. This recording can be a graph produced on paper, a value displayed on a meter or a digital recording stored on magnetic disk. If the data is later to be analysed by computer then it needs to be a digital recording.

Logging wind speed

Wind speed can be measured using an instrument called an anemometer.

- This is the system sensor

  As the picture shows, the instrument consists of a vertical shaft, with three or four cups projecting at right angles from the top of the shaft.

- The wind is caught by the cups and the pressure turns the vertical shaft.
- The rate of rotation of the shaft is used to calculate the wind speed.

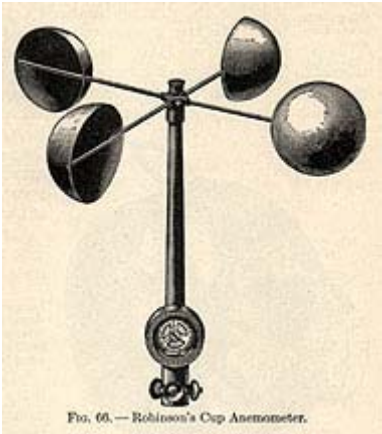


Fig. 66.—Robinson's Cup Anemometer.

A data logging system would measure the wind speed at regular intervals (this is called sampling). These sampled values could be recorded on a storage device, such as magnetic disk, for later analysis or reporting.

- The analysis may produce, for example, a graph showing the variation in wind speed over a period of time.
- The values may also be used for immediate reporting as part of a maritime weather report.
- Combined with wind direction, the data may be required for athletics meetings at which records may be broken.

Medical data logging

Hospital patients who have had operations, or for some other reason need to be closely monitored, require a great deal of attention from hospital staff such as nurses. When someone is in a critical condition and is put into intensive care, his or her heart rate, breathing rate and blood pressure must be measured at frequent intervals. Computer-based patient monitors are now commonly used to collect the required information and present it visually on a digital display or produce it as paper output.

In addition, these devices can be set to sound an alarm if there is any significant change in a measurement such as heartbeat. Microprocessors are commonly built into patient monitoring devices as integral parts of the machines and as such are examples of embedded systems.

People with high blood pressure sometimes wear a device that measures their blood pressure every hour over a 24-hour period. The monitor is designed to operate automatically as patients go about their daily lives. It consists of an arm band containing a sensor connected to a control box which is worn around the waist. The control box contains a microprocessor which periodically measures the blood pressure detected by a sensor in the arm band and records it digitally. The log of blood pressure readings is later downloaded to a PC where special software analyses it and produces graphs showing how the blood pressure has varied over the 24-hour period.

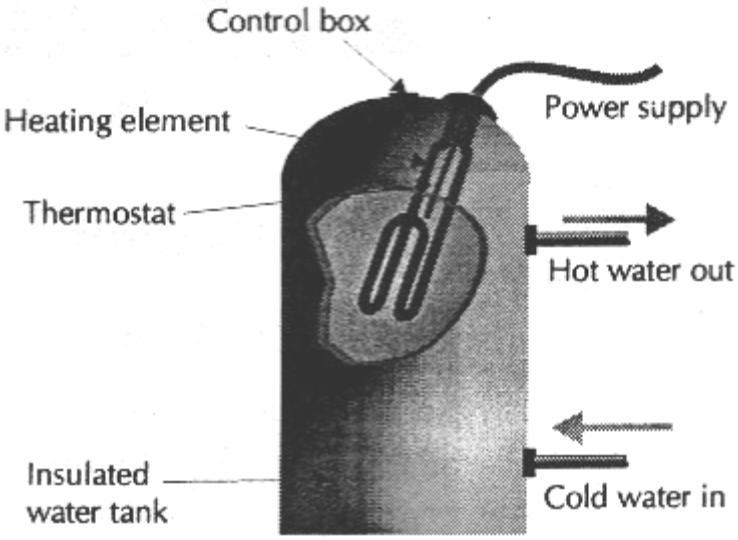
Control Systems

Computers, and in particular microprocessors, are frequently used in situations where the output from a device must be maintained at a desired value by adjusting its inputs automatically. The input to be measured, such as temperature, speed or fluid depth, is compared with a desired value. Using feedback, any difference between the measured value and the desired value will result in the difference being reduced.

A control system for heating water

An example of a control system, which illustrates the concepts discussed above, is the domestic water heater.

The insulated water tank contains a combined heating element and thermostat. The thermostat is simplv a heat-activated switch which is off when the temperature of the water reaches a certain level, and is on when the water temperature is below that level.

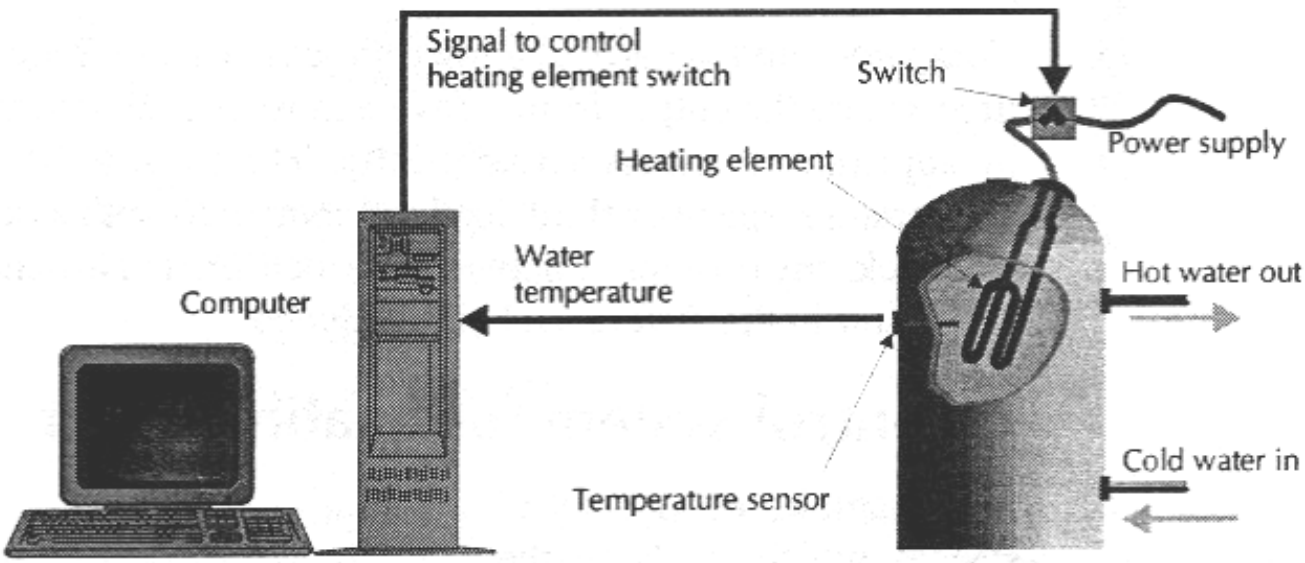


Domestic water heater

The heating element is connected to the electricity supply via the thermostat. While the temperature of the water is below a certain level, the heating element is on, otherwise it is off. The control box contains the connections between the heater, the thermostat and the power supply.

In this simple control system for regulating the temperature of the water in the tank, the input is the temperature of the water, the thermostat is the sensor and heat generated by the heating element is the output. The thermostat switches the heater off when the water reaches the required temperature. When hot water is drawn from the tank, cold water enters and reduces the temperature of the water. This reduction in temperature is detected by the thermostat which activates the heater, thus heating the water until it again reaches the required temperature. Thus the output (heat) provides feedback to the sensor so that the water temperature can be regulated.

In a computer-controlled system, such as that illustrated below, the mechanical thermostat could be replaced by a different sensor. This transducer would need to provide a voltage proportional to the temperature of the water. This signal would be monitored by a computer and compared with the required temperature of the water. The computer could control a relay to switch the heater on when the temperature falls below a minimum value, and switch it off when the temperature exceeds a maximum value.

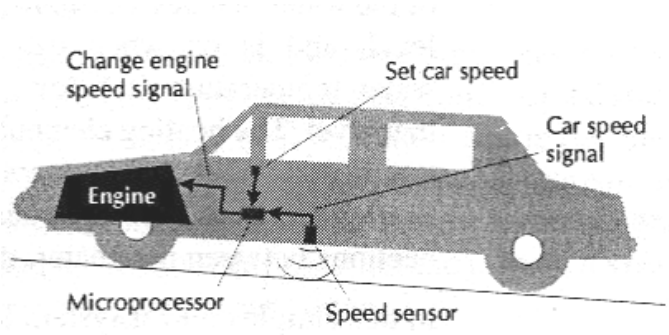


Computer controlled water heating system

Control systems used in cars

Cruise control

Some modem cars, particularly in the USA, have a "cruise control" that allows a driver to set the speed of the car to be maintained automatically by pressing a button. A microprocessor is used to monitor the speed of the car, from data provided by a sensor, and continuously compare it with the required speed.



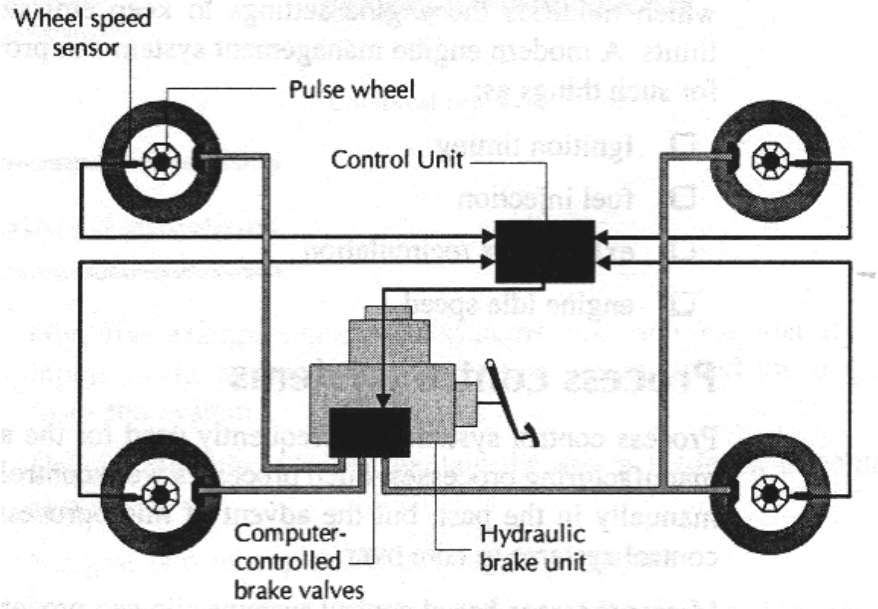
Cruise control system

If the car starts to slow down while going up a hill or speeds up going down a hill, the microprocessor activates a control that changes the car's speed. The control system is illustrated alongside.

The microprocessor uses feedback provided by the speed sensor to determine whether the car is travelling at the required speed. If the microprocessor detects that the car is travelling slower than the required speed, it increases the delivery of fuel to the engine. This speeds the car up so that the difference between the actual speed and the required speed is reduced. The microprocessor continuously reacts to speed changes as they occur and adjusts the fuel delivery to keep the car travelling at a nearly constant speed.

Anti-locking brake system

Another application of control systems in cars is the anti-locking brake system, usually known as ABS. This is illustrated below.



Anti-locking brake system (ABS)

The rotational speed of the wheels are continuously measured by wheel speed sensors. This data is transmitted to the ABS control unit. The control unit processes the rotation data for each wheel separately and if a wheel is in danger of locking, it sends a signal to brake valves to reduce the braking effect for that wheel. If the braking effect on a wheel is too weak, the control unit increases the braking effect, still ensuring that the wheel does not lock. ABS has several advantages over other types of braking systems:

- The vehicle does not tend to swerve during braking;
- The vehicle can still be steered during braking;
- Stopping distances are reduced;
- Tyre damage during emergency braking is eliminated;
- Less physical effort is required of the driver in emergency situations.

Cars with an ABS fitted are therefore considerably safer in hazardous conditions than those having ordinary braking systems.

Engine management systems

Engine management systems use a microprocessor to monitor and control the operation of a car's engine. Though devices to control such things as exhaust emissions, fuel supply and ignition timing have been available for years, recent regulations regarding pollution control have resulted in new computer-controlled systems which integrate a number of functions and use feedback to continuously regulate the operation of the engine. The systems sample exhaust gases to provide feedback to the computer system which modifies the engine settings to keep emissions within required limits. A modern engine management system can provide system support for such things as:

- ignition timing
- fuel injection
- exhaust gas recirculation
- engine idle speed

Process control systems

Process control systems are frequently used for the automatic control of manufacturing processes. Such processes were controlled mechanically or manually in the past, but the advent of microprocessors allowed digital control systems to take over.

Microprocessor-based control systems allowed process control to become more efficient and profitable by providing a means of responding to changes much more rapidly than was previously possible.

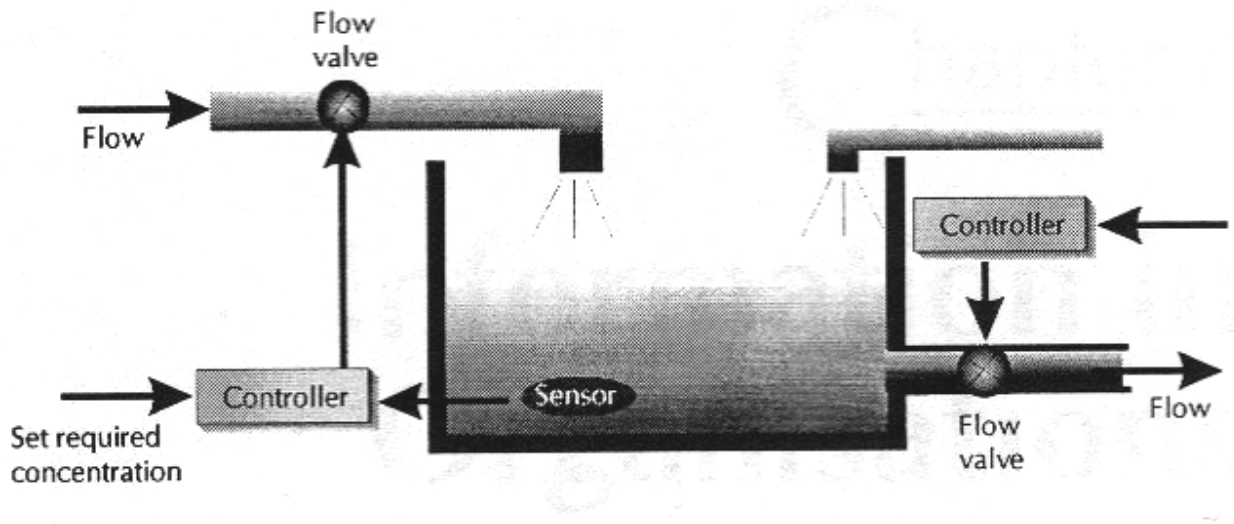
Process control systems are typically found in industries that produced chemicals, steel, aluninium, food, beverages, petroleum products etc.

For example, suppose that a certain chemical process requires that a concentration of a particular chemical is maintained in a tank. Fluid is being drained from the tank at the same time as other chemicals are being added. A sensor in the tank provides continuous information to a

microprocessor regarding the concentration of the chemical concerned. The system is illustrated below.

The figure shows that the output to be controlled is the concentration of the chemical in the tank. The difference between the required concentration and the concentration measured by the sensor is compared by the controller. If the difference between the two becomes too large, the controller opens the flow valve until the difference is reduced to an acceptable level.

The process has been controlled when the concentration of the chemical is maintained at the required level. Note that there may be several processes interacting with each other, with each separate controller keeping its particular process under control.



Chemical process control

Exercises

1. Give five examples of control systems. For each one, identify the inputs to the system, the sensors that are used and the outputs from the system.

2. Using a suitable example, explain the use of feedback in control systems.

3. Suggest two examples of data logging systems.

4. Why are analogue to digital converters (ADCs) needed in control and data logging systems?

5. Sketch a computer-controlled system for regulating the temperature of a room.