3.6 MONITORING AND CONTROL SYSTEMS

3.6.1 OVERVIEW OF MONITORING AND CONTROL SYSTEMS

REAL-TIME APPLICATIONS

A real-time system is one that can react quickly enough to data input to affect the real world. If this is true, it implies that the output from the system must be produced quickly enough to produce the effect on the outside world before that world has enough time to change. Consider the case of the airline booking system. The "world" that we are talking about is the world of the database that contains all the booking details. The use of a real-time system here refers to the concept that if a ticket is bought by a member of the public, the database must be updated before the next person has a chance to book a ticket. Notice that the idea of working **"incredibly fast"** or **"in a billionth of a second**" does not apply here. In some real-time applications these comments may be reasonable, but it depends on the 'world' that the application is concerned with.

When asked to describe a real-time application, the first thing that needs to be described is the world of the application. Everything else falls into place. Students should then describe the hardware necessary to allow input and output from that world and the decisions that the software must take.

A nuclear reactor may start to react too violently and sensors inform the computer controlling the reaction that this is happening. The computer takes the decision to insert the graphite rods to slow the reaction down. This is a real-time application. The world of the application has been identified, the input devices are the sensors that inform the computer of the state of the reaction, the computer makes an immediate decision and the graphite rods are now moved into place. Notice that the rods moving is not immediate but will take place over a period of time, however the **decision** was taken immediately. Note also that the sensors simple report on the state of the world, there is no hint at decision making on the part of the sensors. Many students would phrase their answer in the form of "The sensors spot that the reaction is too violent and the processor makes a, b, c, d changes". Here, the sensors are being credited with having processing power in that they can interpret the readings that are produced.

Students should also be able to identify when a real-time system is appropriate as opposed to a system where the decision making is in some way delayed.

CONTROL SYSTEMS

A control system typically comprises of a computer or a **microprocessor,** a control program which handles data from sensors and sends signals to output devices and **an interface box** to convert signals between the sensors and the processor.

- Computers can respond very rapidly to change.
- Systems can run 24 hours a day, 365 days a year.
- Control systems can operate in places that humans would find dangerous or awkward.
- Outputs are consistent and error free.
- Computers can process data quickly and machines can operate faster than humans.

Computers are now used to control many types of devices such as:

- Air conditioning and central heating systems in large buildings.
- Security systems and burglar alarms.
- Manufacturing process.
- Traffic lights and pedestrian crossings.

SENSORS

A sensor is an input device that captures physical data. It converts physical quantities into electrical voltages. It is also known as "input transducer".

Examples:

- LDR converts brightness (of light) to resistance.
- Thermistor converts temperature to resistance.
- Microphone converts sound to voltage.
- Variable resistor converts position (angle) to resistance.

Tactile Sensors are employed wherever interactions between a contact surface and the environment are to be measured and registered. Tactile sensors are useful in a wide variety of applications for robotics and computer hardware. In robotics, tactile sensors provide useful information about the state of contact between a robot hand and an object in pretension.

Use of sensors:

- **Light sensors** can be used to detect low light levels so that street lighting is turned on. It could also be used to detect the light reflected from a barcode.
- **Temperature sensors** are used for example, in central heating systems to keep the temperature of a house constant. Or in air conditioners to keep the room at a constant temperature.
- **Sound sensors** are used by environmental health officers to record the level of sound coming from shops, houses, etc. where loud music is being played.
- **pH sensors** are used to find out how basic or acidic a solution is.
- **Humidity sensors** are used to determine the amount of moisture present in the air or in the soil.

Using sensors in hospitals:

- Respiration
- Blood pressure
- Temperature
- Electrical activity of the heart and pulse

All the above can be measured by the sensors. A computer is used to continually monitor the results from the sensors and if the patient's condition changes suddenly, then an alarm sounded to alert the medical staff.

One last point about sensors, there are many different sensors as there are physical quantities that need measuring, but their reports need to be kept as simple as possible to allow the processor to make decisions quickly. The idea of a sensor being a TV camera because it can show the processor what is going on in a large area is unrealistic because it would be providing too much information. What would be possible would be a TV picture which could be scanned by a processor for any kind of movement in order to indicate the presence of a burglar. Never forget that the processor is limited in the amount of data that can be interpreted just like the software that the processor is running.

ACTUATORS

An **actuator** is a device used to carry out the physical requirements of a computer. Alternatively, an actuator is the device that can accept a signal from the computer and turn it into a physical movement. It is also known as output transducer.

Examples include:

- **A lamp** which converts electricity to light.
- **A loudspeaker** which converts electricity to sound.
- **A heater** which converts electricity to heat.
- **A motor** which converts electricity into movement.

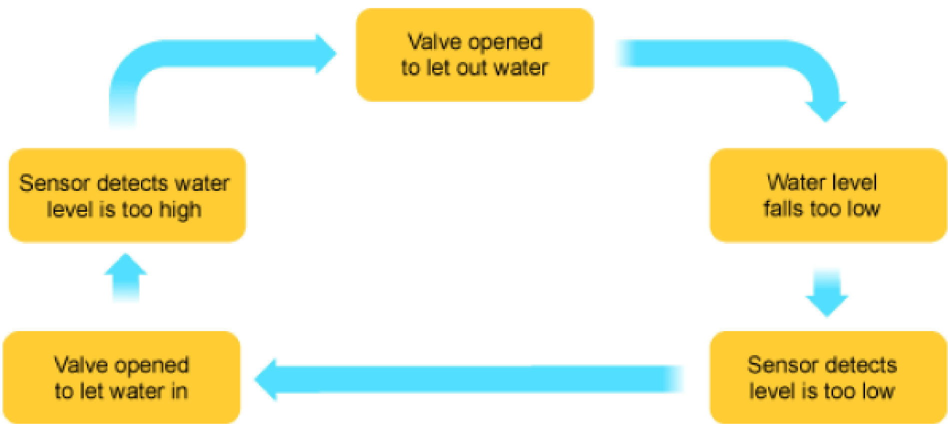
An actuator motor would, for example, be used to open a window in a greenhouse when it gets too hot inside.

ANALOGUE TO DIGITAL CONVERSION

Data such as pressure, light and temperature is **analogue data**. Computers only work with **digital data**. An **interface box** or an analogue to digital converter (ADC) is needed to convert the analogue data from sensors into digital data for the computer to process.

FEEDBACK CYCLE

The diagram below shows a control program for maintaining the water level in a fish tank.



Feedback cycle for a fish tank

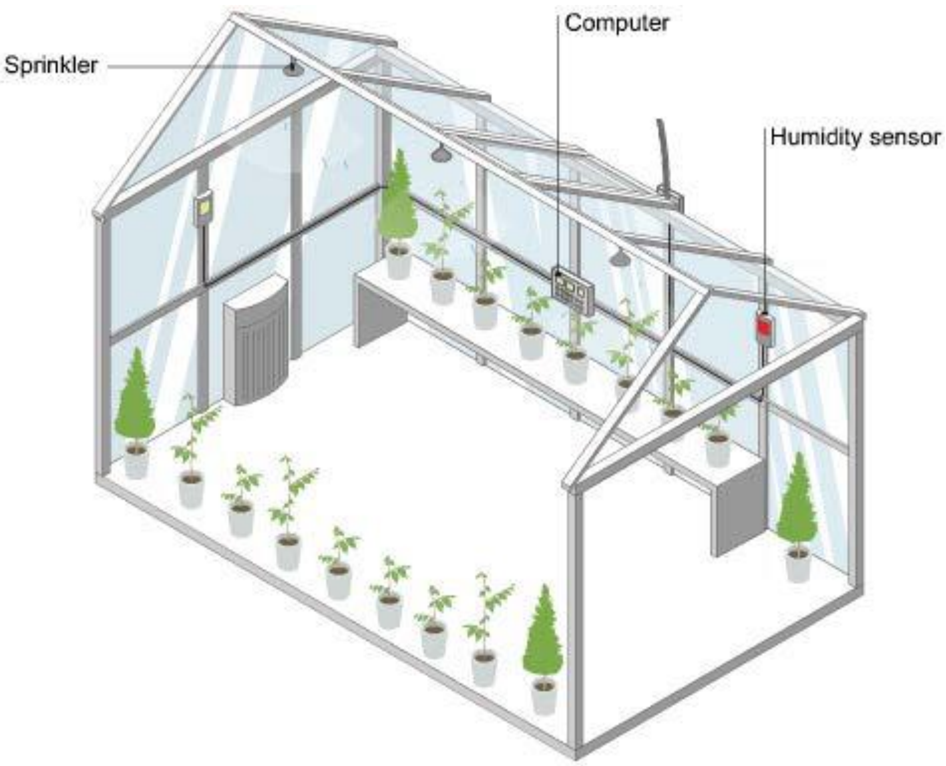
The **control program** stores the highest and the lowest acceptable water levels and what action to take if they are exceeded. This process is continuous and is referred to as a **feedback cycle.**

A COMPUTER-CONTROLLED GREENHOUSE

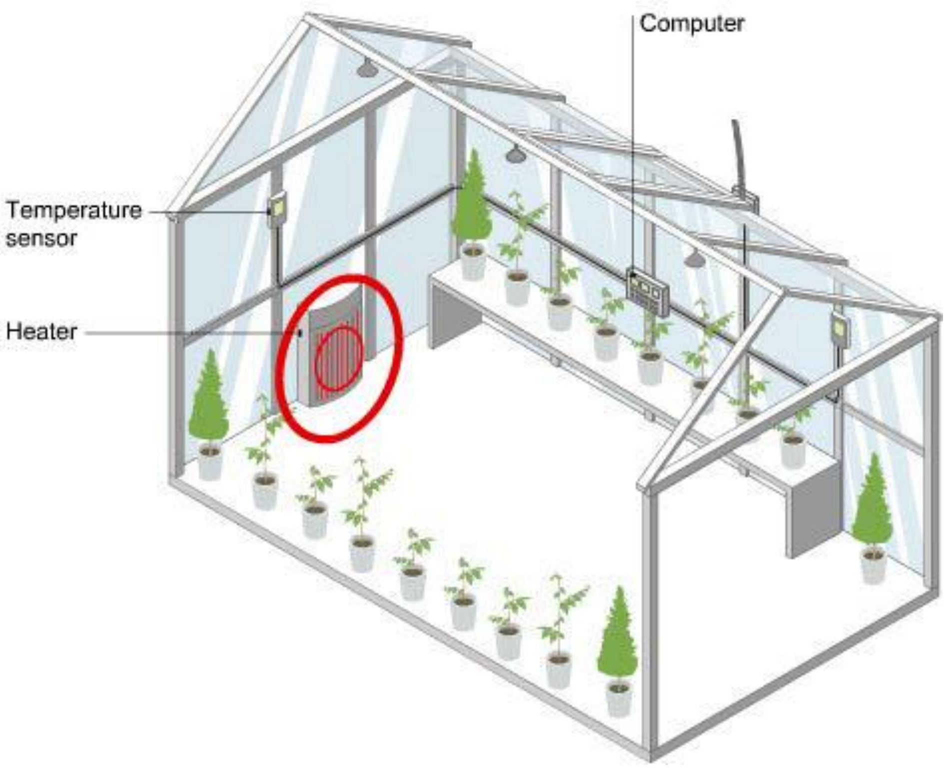
To get the best plant growing conditions, temperature and humidity (moisture in the air) have to be controlled.

The greenhouse therefore has temperature and humidity sensors linked to a computer, and the computer has a control program storing the details of the correct temperature and humidity settings. The greenhouse is fitted with a heater, sprinkler and window monitor is also linked to the computer.

- If the humidity falls below the values stored in the program, the computer activates the sprinklers and closes the windows.



- If the temperature falls outside the values stored in the program, the heater is activated by the computer.



The system monitors the conditions day and night with immediate response to any changes. To alter the growing conditions, the values in the computer program can of course be changed.