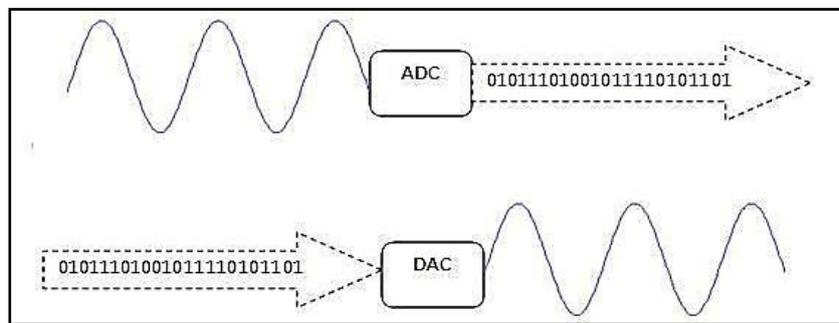


Objective:

- Show an understanding of monitoring and control systems Including:
 - Difference between monitoring and control
 - Use of sensors (including temperature, pressure, infra-red, sound) and actuators
 - Importance of feedback

SENSORS are **input devices** which read or measure **physical properties** such as temperature, pressure, acidity and so on.

SENSORS measure physical properties and read data is **ANALOGUE** in nature which means it is **constantly changing** and doesn't have a **discrete** value. Computers cannot make any sense of this analogue data and data needs to be converted into a **digital format** by using **ANALOGUE TO DIGITAL CONVERTER (ADC)**. This device converts physical values into discrete digital values.



When computer is used to **control devices**, such as a motor or a valve, it is necessary to use a **DIGITAL TO ANALOGUE CONVERTER (DAC)** since these devices need analogue data to operate. An **ACTUATOR** is used in these control applications.

Actuator is device that accept a **signal** from computer and turn it into a **physical movement**. It is also known as **output transducer**. **Transducer** is a device which converts one form of energy to another e.g. light bulb, electric motor, microphone, loudspeaker etc.

- Examples of Actuator :**
- 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.

Types of Sensors and their application

Sensors	Applications
Magnetic Field	Used in anti-lock braking systems in motor vehicles
pH	Monitor/control acidity/alkalinity levels in the soil in a greenhouse. Pollution/environmental monitoring in rivers

Gas	Monitor pollution levels in a river or in the air. Measure O ₂ and CO ₂ levels in a greenhouse. Check for CO ₂ leaks in a power station.
Acoustic/sound	Pick up noise levels (e.g. footsteps) in a burglar alarm system. Detect the noise of liquids dripping in a pipe
Pressure	Detect intruders in a burglar alarm system Monitor/control a process where gas pressure is important
infra-red / Motion	Turn on the windscreen wipers on a car automatically. Detect intruders in a burglar alarm system. Count people entering/leaving a building.
Light	Switch street lighting on at night and off during the day. Monitor/control light levels in a greenhouse. Automatically switch on a car's headlights when it gets dark.
Thermocouple	Control a central heating system. Control/monitor a chemical process. Control/monitor the temperature in a greenhouse.
Moisture/humidity	Control/monitor the moisture levels in soil in a greenhouse.

Sensor for measuring temperature is a **thermocouple** which outputs an **electrical voltage** that changes with **temperature**.

Advantage and Disadvantage of using Sensor:

Advantage	Disadvantage
Readings taken using sensors are generally more accurate than those taken by human operators .	Faulty sensors can give bogus results . Example: if sensors on rear bumper of a car which monitor for obstacles become dirty, they may either not identify an obstacle or give a continuous alarm.

Monitoring Applications

Monitoring System can be used to create **record** of **condition** of a system over a **period of time**.

Computerised monitoring system is a system designed to watch or monitor some state external to a computer system.

Monitoring process is **automatic** and there is **no human interaction**.

A monitoring system is used to detect when a particular physical property of a system goes outside a desired range; for example, if CPU is too hot.

Control Applications

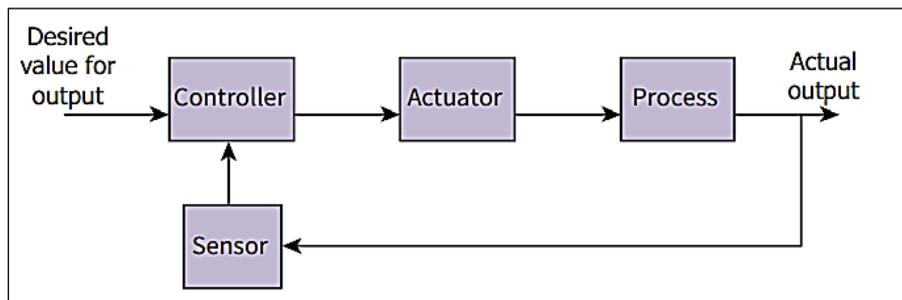
A control system has **monitoring activity** plus capability to **control** a system. **Control element** of a monitoring and control system needs a device called an **actuator**. **Feedback** is essential in a **Control system**.

Advantage of using Control System:

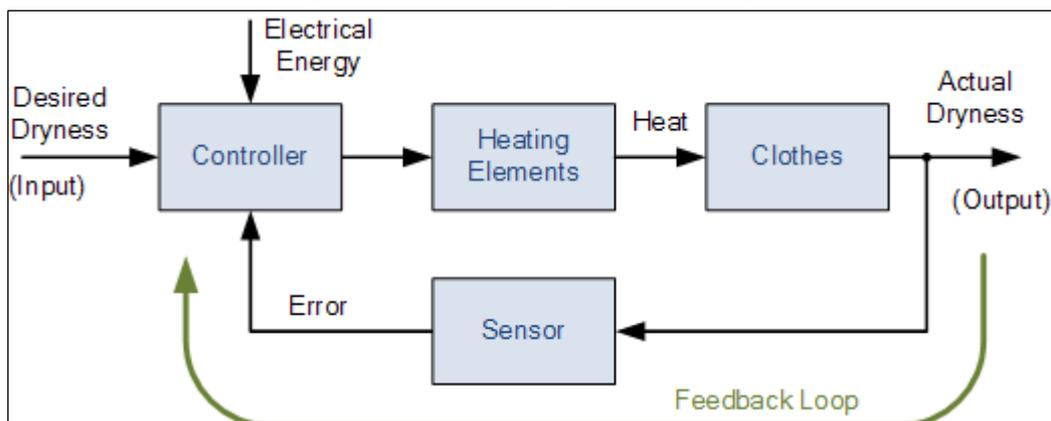
- ☒ Computers can respond very **rapidly** to change.
- ☒ Systems can run 24 hours a day, 365 days a year
- ☒ Control systems can operate in places that humans would find **dangerous** or awkward.
- ☒ Outputs are **Consistent** and **Error free**.
- ☒ Computers can process **data quickly** and machines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

Closed Loop Feedback:

A **closed-loop feedback** control system is a special type of monitoring and control system where feedback directly controls operation. A **microprocessor** functions as **controller**. This compares value for **actual output**, as read by sensor, with **desired output**. It then transmits a value to **actuator** which depends on difference calculated.



Example of Closed Loop Feedback System



☒ Importance of feedback in a control system.

To ensure system operates with the given criteria by enabling system output to affect subsequent system input thus allowing conditions to be automatically adjusted.

Example of use of Sensors in both Monitoring and Control applications.

Monitoring Applications	Control Application
Monitoring a patient in hospital for vital signs such as heart rate, temperature, and so on. Checking for intruders in a burglar alarm system. Checking temperature levels in a car engine. Monitoring pollution levels in a river.	Turning street lights on at night and turning them off again during daylight. Controlling the temperature in a central heating/air conditioning system. Controlling the traffic lights at a road junction. Operating anti-lock brakes on a car when necessary. Controlling the environment in a greenhouse.

How a monitoring and control system works?

Step # 1: Sensors continuously take readings and sent to processor.

Step # 2 Analog sensors reading are converted to digital using ADC so that computer can **process** them.

Step # 3: Microprocessor process sensors readings by comparing sensor reading to a stored **pre-set value**.

Monitoring System:

Step 4: If data is outside **acceptable range**, a warning message is sent to a screen or an alarm is activated.

Step # 5: Microprocessor has no effect on what is being monitored – it is simply ‘watching’ process.

Control Systems:

Step # 4: If data is outside **acceptable range**, microprocessor sends signals to control valves, motors and so on.

Step # 5: Output from system affects next inputs from sensors.

Step # 6. Computer takes action by sending a digital signal to specific **actuator**.

Step# 7: Processor produce digital signal but actuator may require analog signal therefore Digital to Analog Converter (ADC) is required.

Step # 8: Actuator will turn off / on device like heater, door etc.

Monitoring Applications:

a) Monitoring of patients in a hospital:

- ☒ Sensors are attached to patient to measure temperature, heart rate, breathing rate.
- ☒ Sensors are attached to computer system and sensors constantly send data back to the computer system. Computer **samples the data** at frequent intervals.

- ☒ Range of acceptable values for each parameter is **preset** in to the computer. Computer **microprocessor** compares values from the sensors with **preset value**.
- ☒ If anything is out of **acceptable range**, signal is sent by computer to sound alarm. If data from sensors is within range, values are shown in graphical form on screen.
- ☒ Monitoring continues until sensors are disconnected from patient.

b) Burglar Alarm System:

Burglar alarm monitoring system will carry out following actions:

- ☒ System is activated by keying in a password on a keypad.
- ☒ **Infra-red sensor** picks up movement of person in building, **Acoustic sensor** picks up sounds such as footsteps and **Pressure sensor** picks up weight of person coming through window.
- ☒ Sensor data is passed through **ADC** to convert **analogue data** into **digital data**.
- ☒ **Microprocessor** will sample digital data coming from these sensors at a given time and data is compared with **preset values** by microprocessor.
- ☒ If any of incoming data values are outside acceptable range, then microprocessor sends a signal to:
 - A siren to sound the alarm, or
 - A light to start flashing.
- ☒ Alarm continues to sound/lights continue to flash until system is reset with a password.

Control Applications:

a) Control of Street lighting:

Microprocessor is used to control operation of street lamp.

- ☒ Lamp is fitted with **light sensor** which constantly sends data to microprocessor. Data value from sensor changes according to weather (sunny, cloudy, raining or night time).
- ☒ **Light Sensor** sends data to **ADC** which will convert Analogue Signal to Digital Signal and sends it to the microprocessor. Microprocessor samples the data every minute.
- ☒ If data from sensor is less than **Preset value** stored in memory then signal is sent from microprocessor to street lamp and lamp is switched on.
- ☒ If data from sensor is greater than **preset value** stored in memory then signal is sent from microprocessor to street lamp and lamp is switched off.

b) Anti-Lock Braking Systems:

- ☒ ANTI-LOCK BRAKING SYSTEMS (ABS) on cars use **Magnetic Field Sensors** to stop wheels **locking up** on car if brakes have been applied **too sharply**.
- ☒ When one of car wheels rotates too slowly (i.e. it is locking up).
- ☒ **Magnetic field** sensor sends data to **microprocessor**.
- ☒ Microprocessor checks **rotation speed** of other three wheels.
- ☒ If they are different (i.e. rotating faster), microprocessor sends a signal to **braking system** and **braking pressure** to affected wheel is **reduced**, wheel's rotational speed is then increased to match other wheels.

- ☞ Checking **rotational speed** using these **magnetic field sensors** is done several times a second and braking pressure to all wheels can be constantly changing to prevent any of wheels locking up under heavy braking; this is felt as a '**judder**' on brake pedal as braking system is constantly switched **off and on** to equalize rotational speed of all **four wheels**.
- ☞ If one of wheels is rotating **too quickly**, braking pressure is increased to that wheel until it matches other three.

List Down Difference between Monitoring and Control System:

- Monitoring system does not **control** any process means there are not **actuators** involved while **control systems** control some process.
- Control system output effects input, there is **continues feedback**.

EMIK