# Monitoring, Measurement and Control

## How Can Computers Measure Things?

A **sensor**, such as a temperature sensor, can be connected to a computer. The computer can then **monitor** the signal from the sensor, reacting to **changes**, or it can **record the data** from the sensor at predefined **time intervals**.

*Note: If the sensor is an analogue one then an **analogue-to-digital convertor** (ADC) will be required.*

## Where is Computer Measurement Used?

Anywhere that data needs to be gathered **regularly**, a computerized **data-logging** system can be used. Some examples are shown below…

### Scientific experiments

Many experiments can be set-up and left to run with a data-logging system measuring things like the **temperature** of a liquid, etc.

### Weather stations

Often these are placed in very **remote** areas to collect data about **rainfall**, **temperature**, **wind-speed**, **wind-direction**, etc. Data needs to be gathered all day, every day. This data can then be used by weather forecasters to help predict the weather over the coming days.

### Environmental monitoring

Scientists are very concerned about the effect that humans are having on the environment. Computer-based data-logging is often used to help gather evidence of these effects: the **level of water** in a dam, the **speed of water** flowing down a river, the **amount of pollution** in the air, etc.

## Why Use Computers to Measure Things?

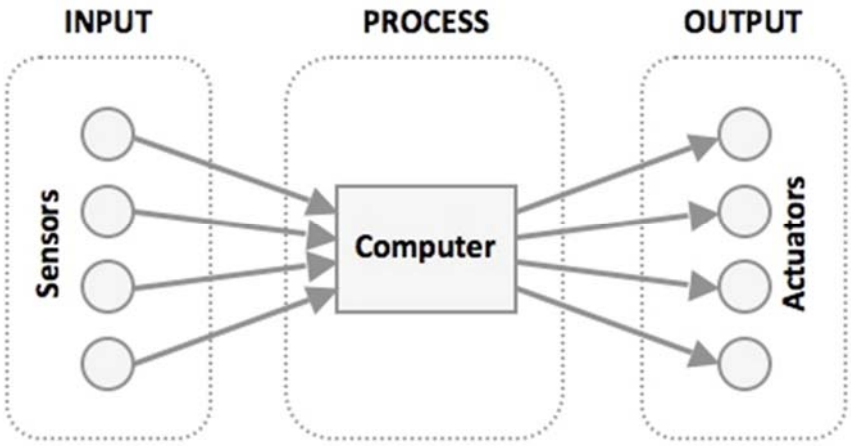
The main reasons that you would want to use a computer-based data-logging system, instead of a person taking measurements are...

- Computers **do not need to take breaks** - they can log data all day, every day, without stopping
- Computers take much **more accurate** readings than humans can
- Computers can take data readings **more frequently** (1000s of times a second if necessary)

- Since the logged data is already in a computer, the **data can be analyzed more quickly and easily** (graphs drawn instantly, etc.)
- Data logging systems can operate in **difficult environments** (e.g. in the Arctic, or on top of a mountain)
- People are **free to do other more useful tasks** (rather than watching a thermometer)

## How Can Computers Control Things?

A computer control system, like any system, is made up of three parts...




1. **Input** devices called sensors feed **data into** the computer
2. The computer then **processes** the input data (by following a set of **instructions**)
3. As a result of the processing, the computer can **turn on or off output** devices called actuators.

## Sensors

A normal PC has no way of knowing what is happening in the real world around it. It doesn't know if it is light or dark, hot or cold, quiet or noisy. How do we know what is happening around us? We use our eyes, our ears, our mouth, our nose and our skin - our **senses**.

A normal PC has no senses, but we can give it some: We can connect **sensors** to it...

A **sensor** is a device that **converts** a **real-world property** (e.g. temperature) into **data** that a computer can **process**.

Examples of sensors and the properties they detect are...

| Sensor | What it Detects |
|---|---|
| **Temperature** | Temperature |
| **Light** | Light / dark |
| **Pressure** | Pressure (e.g. someone standing on it) |
| **Moisture** | Dampness / dryness |
| **Water-level** | How full / empty a container is |
| **Movement** | Movement nearby |
| **Proximity** | How close / far something is |
| **Switch** or **button** | If something is touching / pressing it |

*Note: many sensors are **analogue** devices and so need to be connected to the computer using an analogue-to-digital convertor.*

## Actuators

A normal PC has no way of **affecting** what is happening around it. It can't turn on the lights, or make the room hotter. How do we change what is happening around us? We use our **muscles** to move things, press things, lift things, etc. (and we can also make **sound** using our voice).

A normal PC has no muscles, but we can give it some. In fact we can give it the ability to do lots of things by connecting a range of **actuators** to it…

An **actuator** is a device, controlled by a computer that can **affect the real-world**.

Examples of actuators, and what they can do are...

| Actuator | What it Can Do |
|---|---|
| **Light bulb** or **LED** | Creates light |
| **Heater** | Increases temperature |
| **Cooling Unit** | Decreases temperature |
| **Motor** | Spins things around |
| **Pump** | Pushes water / air through pipes |
| **Buzzer** / **Bell** / **Siren** | Creates noise |

*Note: some of these devices require an **analogue** signal to operate them. This means that they need to be connected to the computer using a digital-to-analogue convertor.*

## Where is Computer Control Used?

Many of the devices that we use in our everyday lives are controlled by small computers...

- **Washing machines**
- **Air-conditioning** systems
- Programmable **microwave ovens**

If we look beyond our homes, we come across even more systems that operate automatically under the control of a computer...

- Modern **cars** have engines, brakes, etc. that are managed and controlled by a computer
- Most **factory production lines** are computer-controlled, manufacturing products with little or no human input
- **Traffic lights** are switched on and off according to programs running on computers which manage traffic flow through cities

Of course, car engines, factories and traffic lights were not always computer-controlled. Before microprocessors even existed, car engines ran, factories produced goods and traffic lights changed.

However, using computers to manage these systems has brought many benefits...

# Why Use Computers to Control Things?

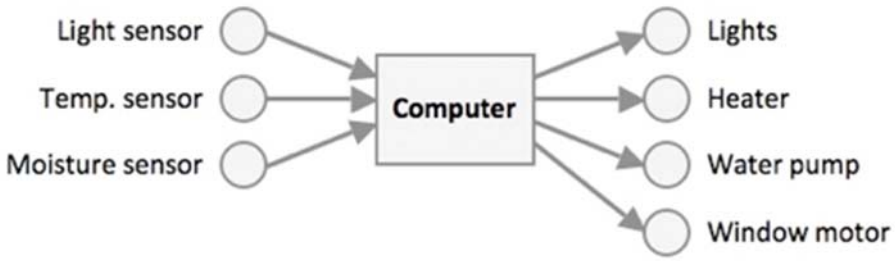
It is often far better to have a system that is managed and controlled by a computer rather a human because...

- Computers **never need breaks** - they can control a system without stopping, all day, every day
- Computers **don't need to be paid**. To buy and install a computerized control system can be very expensive, but, in the long-term, money is saved by not having to employee staff to do the work
- Computers can operate in conditions that would be very **hazardous to human health**, e.g. nuclear power stations, chemical factories, paint-spraying areas
- Computers can control systems far more **accurately**, and respond to changes far more **quickly** than a human could

# An Example Control System - An Automated Greenhouse

A computer-controlled greenhouse might have a number of sensors and actuators:

- A **light sensor** to detect how much light the plants are getting
- A **temperature sensor** to see how cold/hot the greenhouse is
- A **moisture sensor** to see how wet/dry the soil is
- **Lights** to illuminate the plants if it gets too dark
- A **heater** to warm up the greenhouse if it gets too cold
- A **water pump** for the watering system
- A **motor** to open the window if it gets too warm inside




The process for this system would be...

1. Check **light sensor**
    - If it is dark, **turn on the lights**
    - If it is not dark, **turn off the lights**
2. Check **temperature sensor**
    - If it is too cold, **turn on heater** and use motor to **close window**
    - If it is too warm, **turn off heater** and use motor to **open window**

3. Check the **moisture sensor**
    - If soil is too dry, **turn on the water pump**
    - If soil is too wet, **turn off the water pump**
4. Go back to step 1 and **repeat**