Embedded Systems

1. Embedded systems

The computers we are most familiar with are those that are in plain view. For example laptops, desktops, tablets and so on. They have an input device such as a keyboard or touch screen and one or more outputs such as screen and speaker.

But there is another class of computer, called the **embedded computer**. These are often overlooked, as they are part of larger pieces of equipment or systems.

The section describes the embedded computer.

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2. What is an embedded system?

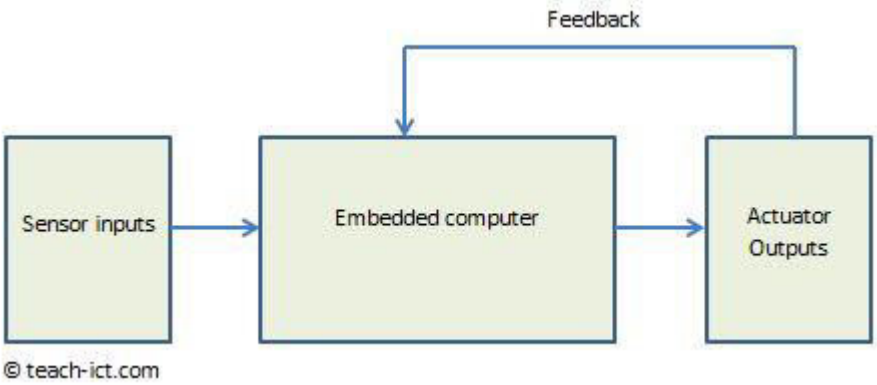
An **embedded system** is a dedicated computer system that performs one or more specific functions within a larger piece of equipment.

For example a DVD player will have an embedded computer to handle all of the hardware and input/output. You don't need to install an entire operating system to get your DVDs to play.

Embedded computers control a system, but often require additional hardware.

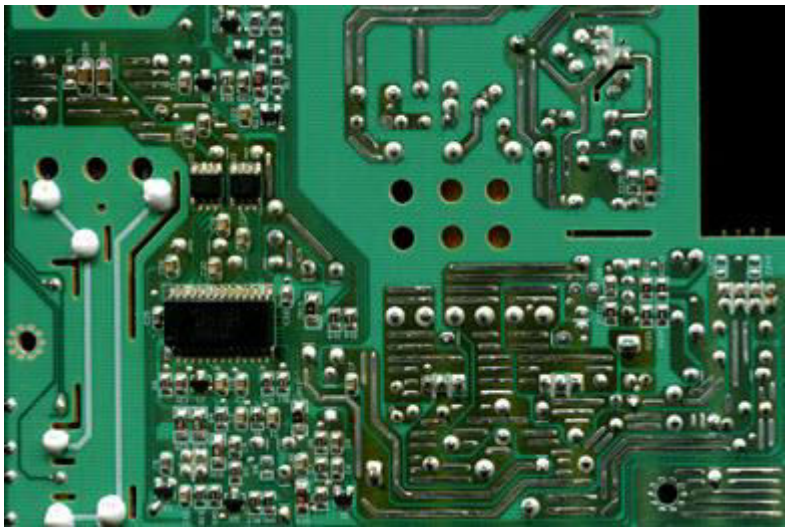
For example, it may take in inputs from specialised **sensors**. The computer processes those inputs, and then produces an output that requires some physical action, such as spinning up or ejecting a DVD.

These physical actions are carried out by **actuators**.



Once the actuators have carried out their task, they send data back to the embedded computer, which decides what to do next. This is called 'negative feedback'.

Embedded computers are often built as a single unit, with everything mounted on a printed circuit board. RAM, ROM, CPU, Clock and connectors are all pre-installed.



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3. Microcontroller

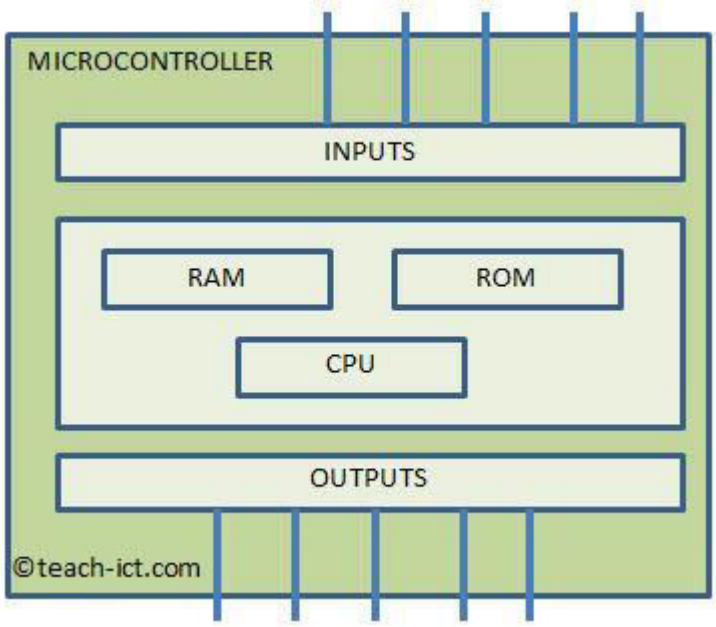
We have mentioned that a standard CPU chip can be used in an embedded system - that is true. But that chip will definitely need some input-output interfaces to be able to deal with the real world.

And so the idea of a microcontroller with an in-built input-output interface came about.

An embedded system needs to have the following features

- Handle a set of inputs
- Provide a set of outputs
- Be programmable
- Low power consumption
- Be cheap
- Be reliable
- Be compact

All of these requirement point to one thing - it would be best if all of these features were available as a single chip.
This single chip is called a **microcontroller.**



As you can see, a microcontroller is different to a standard microprocessor in that it has built-in input\outputs along with ROM to store permanent code.

The chip usually comes with its own 'design kit' that provides the means to program it. This often includes support of a high level language such as 'C'.

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4. Examples of embedded systems

Embedded computer systems are everywhere in our daily lives as they are built into very familiar equipment and systems.

Examples of embedded systems include

At home

- Microwave Oven
- Washing machine
- Satellite set-top box
- Television
- Central heating
- Electronic toys and action figures

At work

- Air conditioning system
- Lifts
- Automatic doors
- Automated factory machinery
- Robots

Outdoors

- Traffic light systems
- On-board computers in cars
- Speed cameras
- Active roadside displays
- Advertising systems

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5. Input - Sensors

A sensor is a device designed to measure some physical quantity in its environment. An example might be a heat sensor that measures the temperature in a room or a pressure sensitive mat that detects someone walking over it.

A temperature sensor is inside every fridge as it has to be controlled. The temperature reading may also be output via a digital display (like the one in the photo) but sometimes it may just feed the control system without a display.

Once a reading or measurement has been recorded, the sensor sends the result to a computer. It might do this immediately, or it might store up readings for a while and send them in a batch.

This data is an 'input' for the embedded computer. To the sensor, it is an 'output'.

There are many different types of sensors. Below is a table showing you a few of the most common ones:

Sensors

Heat	Temperature	Living room for central heating system
Humidity	Water vapour in the air	Swimming pool, greenhouse

Sensors

Infra-red	Infra-red radiation e.g. body heat	Security alarm systems
Light	Light levels	External security lights
PH	Acid/alkali levels e.g. pH of soil	Environmental experiments, river pollution
Pressure	Pressure	Burglar alarm systems, automatic doors
Smoke	Smoke in the atmosphere	Offices
Sound	Levels of sound	Security alarm systems
Tilt	Angle of tilt	Windows in security alarm system
Touch	Detects if one object bumps into another	Computer controlled robots

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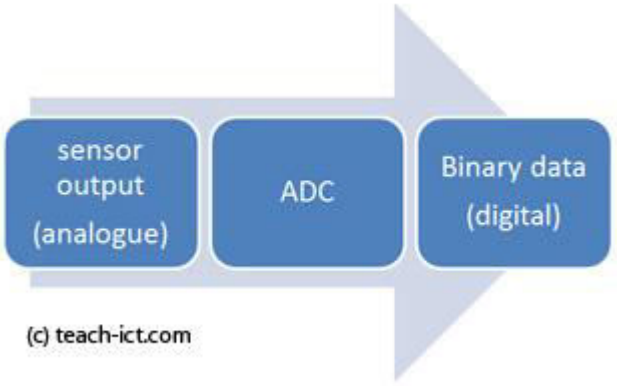
6. ADC

The measurements taken by most sensors are analogue. They can take any value within its limits. But computers only understand digital data, which has discrete values. So a converter is needed between the sensor and the computer. Since it converts analogue to digital, this is called an **analogue-to-digital converter**, or **ADC.**



The ADC produces digital translations of the sensor's analogue data. This digital data can then be read and used by the embedded computer.

The ADC chip is often built into the single-board embedded computer.

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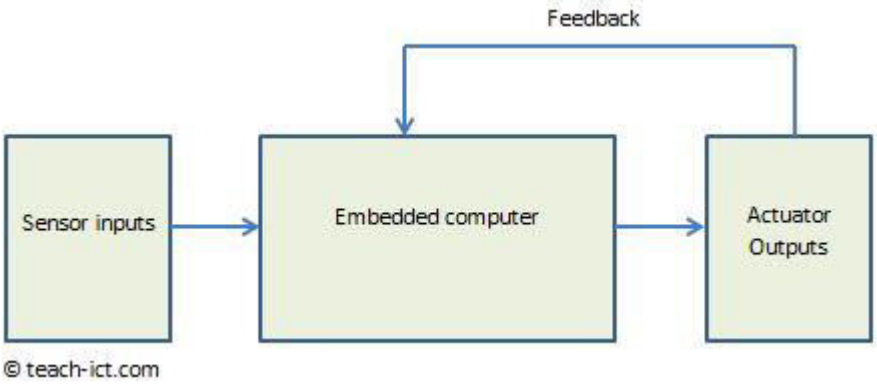
7. Output - Actuator

A typical control system with an output actuator is shown below



An actuator is often part of a computer control system.

The actuator is a mechanical device or motor which carries out the action or decision made by the embedded computer.

For example the lens of this digital camera moves in and out according to how much zoom is wanted.

This movement is controlled by an 'actuator'. In this case it is a tiny electric motor that is controlled by a computer control system within the camera.

Once the actuators have carried out their task, they send data back to the embedded computer, which decides what to do next. This is called 'negative feedback'.

An example of negative feedback is when the actuators of a DVD player may recognise that something is blocking the ejection tray, and feed that information back to the computer. The computer halts or reverses the ejection.

Another example is when the actuators of a printer may recognise that there is no paper in the feeder tray, and it feeds that information back to the embedded computer so that the computer stops the printer from continuing to print

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8. Advantages and disadvantages

There are both pros and cons to using an embedded system for a task, rather than a general-purpose computer such as a PC.

Advantages:

- Embedded computers are small. This means less space is needed inside the equipment. This in turn means that a washing machine or microwave can be made smaller.
- An embedded computer is built on a single printed circuit board. It is much easier to replace it if it breaks down.

- They use less power than a general purpose computer. The running costs of the machine or device is reduced. Less power also means they run cooler so no need for cooling fans.

- More reliable and robust than a general purpose computer as they have no moving parts and are located on a single circuit board. This means they are less likely to stop working.

- They are cheaper to produce than a general purpose computer. So the overall cost of the equipment in which it is embedded is reduced.

- An embedded computer is usually designed with one task in mind - washing machine control for example. This means its software can be made to be very efficient and runs as soon as the equipment is switched on.

Disadvantages

- If the embedded computer goes wrong then the equipment itself will very likely stop working.

- They need specialist skills to design them as they are so specific to their task.

- If the embedded computer fails you might have to go to a specialist supplier to purchase a replacement or organise a repair.

- General purpose computers such as a laptop can handle a wide range of tasks by simply changing the program currently running - an embedded systems is usually dedicated to doing one thing.