INDUSTRIAL DESIGN - DESIGN ACTIVITIES

The development of a product starts with a design brief used to create a specification. Circuits are developed using computer-aided design (CAD) and various modelling techniques. Evaluation and testing are carried out throughout the process to make sure that quality standards are being achieved and to identify improvements.

DESIGNING ELECTRONIC PRODUCTS

DESIGN BRIEF AND SPECIFICATION

Products are developed to **meet a need**. The designer is given a design brief which outlines the need as a **problem to be solved**.

The designer investigates the need in detail to produce a design specification. This is a list of all the requirements of the product. It should contain details of the functional and design features of the finished product, as well as information on weight and size, maintenance, cost and safety. The specification for an electronic product should include electronic factors such as component details, maximum working voltages, maximum currents, and temperature or frequency ranges.

The design brief and specification are used to continually test and evaluate the product. This ensures that the product meets the needs of the customer.

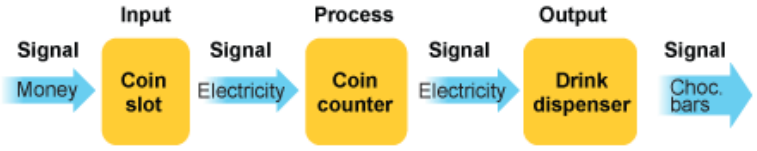
SYSTEMS DIAGRAMS

A system is a collection of parts that performs a function. A systems diagram is a representation of how a system will work. These are often used during the design process to generate ideas for electronic systems.

A simple systems diagram contains three boxes:

- **Input**: the input starts the system, such as a switch or sensor.
- **Process**: the mind of the system, which considers the inputs and decides what to do. Common process blocks include comparators, latches, logic gates, counters, timers and pulse generators.
- **Output**: the system's response to being activated - eg a flashing light or a buzzer.

Systems diagram



Vending machine systems diagram

Each box in the system diagram has a specific function, and they are **joined by a signal**. Each box is normally a physical item: this could be a single component or a collection of components.

SUB-SYSTEMS

A complex system contains many inputs, processes and outputs. Some of these might form smaller systems - called 'sub-systems' - that work within the system. For example, the systems diagram for a car can have over 400 boxes and more than 10 sub-systems (including steering, braking, lighting etc).

Systems diagrams can be used to show how these different sub-systems relate to each other.

OPEN- AND CLOSED-LOOP SYSTEMS

OPEN-LOOP SYSTEMS

Open-loop systems are set up to achieve desired results, but there's no way of checking if the results have been achieved. For example, an old-fashioned heating system might include:

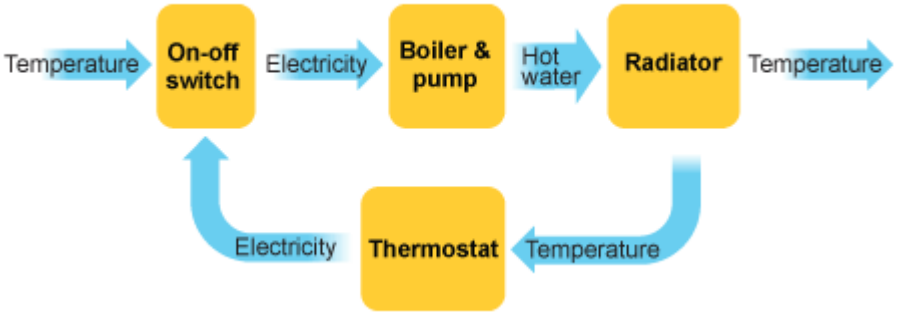
- input: an on-off switch
- process: boiler (water heater) and pump
- output: radiator

The aim of the system would be to heat a house. When turned on, the heating would stay on until it was turned off, regardless of whether the house remained cold or became too hot.

CLOSED-LOOP SYSTEMS

Closed-loop systems are able to correct in order to meet target results. Normally a sensor is used to look at the output and adjust the process accordingly. This is called **feedback**.

For example, considering the heating system above, a thermostat could be added to measure the temperature of a room and compare it to a set target. If the room became too cold, the thermostat would turn the heating on and if the temperature became too hot the system would be turned off. The effectiveness of the system could be analysed by monitoring how good it is at keeping the room at the target temperature.

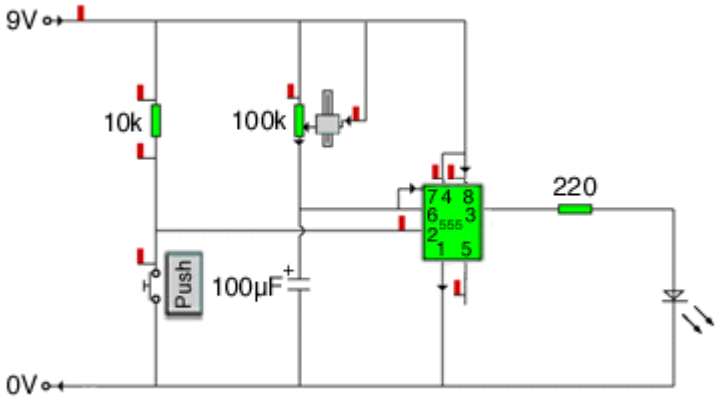


COMPUTER-AIDED DESIGN

A common mistake is to believe that computer-aided design (CAD) refers only to drawings of a product when in reality CAD refers to any use of computer software that supports the design process.

CAD software is commonly used for circuit design. The software might use system blocks to identify which components are needed, or it might help to generate the design by calculating which components are required and laying out the circuit diagram.

One advantage of CAD software is that different design ideas can be changed quickly and easily. The circuit can be built and tested virtually to make sure that it will work. This helps to reduce the cost of buying parts and modifying prototypes.



Once the circuit diagram has been created, CAD software can use this to create the design for the printed circuit board, which is much quicker than doing it manually.

Several different CAD packages are used in this way in schools to build up and virtually test circuits. Some of the most common include **Crocodile Clips**, **Livewire**, and **PCB Wizard**.

OTHER USES OF CAD SOFTWARE

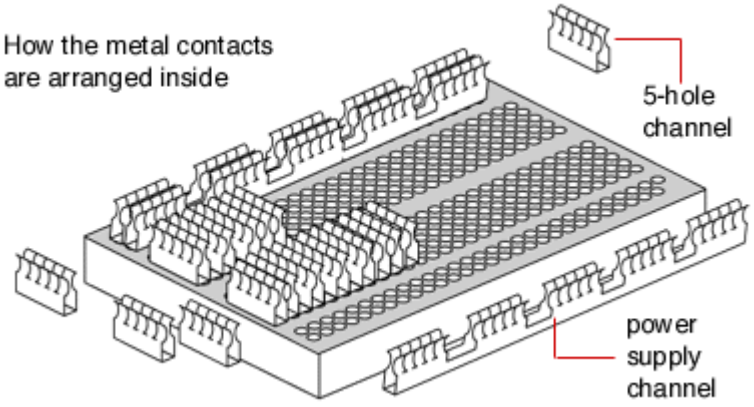
Designers use CAD to make accurate 2D and 3D drawings of circuits and enclosures. In particular, solid modelling is used to show how finished products will look. Different colours and textures can be added to the model and the product can be rotated to show different views.
CAD software is also used to create flowcharts and programs for microcontrollers.

PHYSICAL METHODS OF CIRCUIT MODELLING

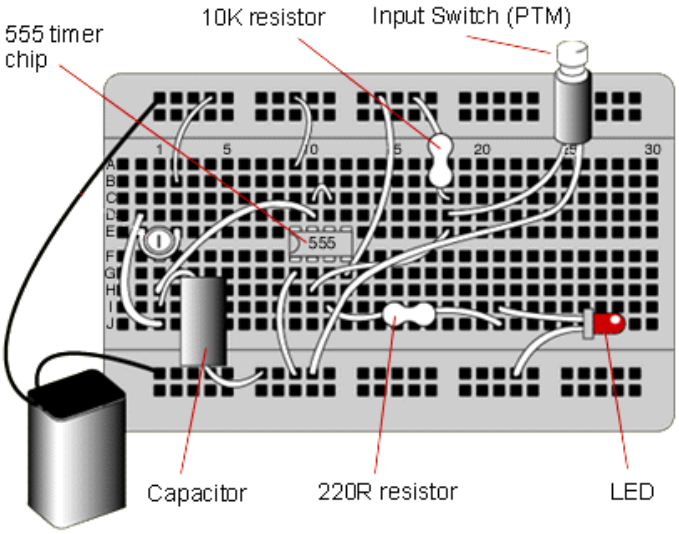
CIRCUIT MODELLING
Once there is a potential design, the electronic circuit is **modelled to make sure that it meets the requirements of the brief and the specification**. Often this is tested using CAD software and then a physical model is made. This allows you to test that the circuit works with similar components to those intended for the final product.

BREADBOARD MODELLING
A common form of modelling uses a prototype board, also known as a **breadboard**. This is a board covered with small sockets into which components can be plugged.

The graphic shows a breadboard with holes connected in two long rows at the top and bottom, and columns of five linked holes elsewhere. Components and wires are plugged into the board in order to make circuit connections. The top and bottom rows act as power supply channels for the circuit.



A breadboard prototype for a 555 monostable timer circuit might look like this:



Breadboards are a **temporary construction** method, meaning components are not permanently attached so it is still easy to move them around or to replace them in order to evaluate possible improvements to the circuit.

STRIPBOARD

Stripboard (sometimes referred to as **veroboard**) is used as an alternative to a breadboard. The stripboard is a board coated with straight copper tracks and pre-drilled holes at regular intervals. Components are soldered to the board.

Advantage of a stripboard

- it is a permanent construction

Disadvantages of a stripboard

- it's more difficult to modify the design
- the layout can be very different from the final design of the printed circuit board

Once a design has been tested and evaluated, this can be used to create the final product.

TESTING, EVALUATION AND QUALITY

At all stages in the development it is important to make sure that the product is doing what it was intended to do.

This is done by **testing the product against the specification** and **evaluating** how well the needs of the specification are being met. For example, testing virtual models using CAD software, or testing different functional blocks or components within the circuit using a multimeter or **logic probe** to ensure that they are providing the expected outputs.

Activities that help to ensure that the final product will fully meet the needs of the specification are called '**quality assurance**'. Activities that check a product after it has been made to see if it is right are called '**quality control**'.

INDUSTRIAL DESIGN – TEST

INSTRUCTIONS – Copy the question into your jotter then choose the correct answer and write that underneath the question.

1. What does CAD stand for?

- Computer-assisted design
- Computer-assisted development
- Computer-aided design

2. What are the three types of box in a systems diagram called?

- Input, process and output
- Input, process and feedback
- Process, output and feedback

3. Which of the following is an advantage of modelling using stripboard rather than CAD?

- It is quicker and easier to make changes to the design.
- Fewer parts need to be bought.
- You can test the circuit works with components similar to those intended for the final product.

4. Which of the following is a permanent construction method?

- Breadboard
- Prototype board
- Stripboard

5. What is the purpose of a design brief?

- To show you ideas of what could be designed.
- To state the problem to be solved.
- To list all the design criteria and needs that the product must meet.

6. What is meant by quality assurance

- Checking that the product is correct after it has been made.
- Making sure that a product will meet the needs of a specification when it is made.
- Testing and evaluating products using a multimeter.

7. What is a design specification?

- A short statement of the problem to be solved.
- A list of needs that the product must meet.
- A list of the components to be used in the product.

8. Which of the following can be used to make a virtual model of an electronic circuit?

- CAD software
- Breadboard modelling
- Stripboard

9. What is meant by 'feedback' in a systems diagram?

- Modifying the performance of the system by using information from the output.
- Setting up a system to achieve the result wanted.
- Electrical interference from the output.

10. Which of these might be an input block in a systems diagram?

- A buzzer
- A logic gate
- An on/off switch