

# UNDERSTANDING ELECTRONICS

## Capacitors

### Objectives

1. Know what a capacitor is.
2. Know the symbol used and the units of capacitance.
3. Understand what is meant by the term polarised and non-polarised.
4. Know what capacitors are used for.
5. Be able to calculate the time constant of a simple circuit.

### What is a Capacitor?

A capacitor consists of two conducting surfaces (plates) separated by a thin layer of insulation called a **dielectric**. This layer of insulation can be ceramic, polystyrene, polyester, polycarbonate, mica, air, paper or electrolyte.

### How does it work?

When a battery is connected to a capacitor the voltage does not reach the plates straight away. To achieve this difference in potential between the plates of the capacitor, electrons have to be supplied to the more negative plate and removed from the more positive one. This takes time, the time is dependent on the size of the current carrying the electrons. A capacitor stores an electrical charge.

### Symbols



Fig 3.1  
Capacitor symbol



Fig 3.2  
Electrolytic

The circuit symbol for a capacitor is shown above.

The symbol in fig 3.1 is used to indicate a **non-polarised** capacitor. This means that it can be connected either way round. The symbol in fig 3.2 is used to indicate a **polarised** capacitor. This means that the + lead has to be connected to the + side of the circuit. This type of capacitor is normally an electrolytic type and is very common in electronic circuits.

The scientist who discovered what we call capacitors was Michael Faraday. The unit of capacitance is named after him and is called the **Farrad**. The symbol is **F**.

The Farrad is a very large unit so we tend to use the sub divisions  $\mu\text{F}$ ,  $\text{nF}$  and  $\text{pF}$ .

The smallest capacitors are usually ceramic plate or disc types with their value measured in  $\text{pF}$ . Electrolytic capacitors are the largest in terms of their value which is measured in  $\mu\text{F}$ . Polyester capacitors can be in  $\text{nf}$  or  $\mu\text{F}$  and fall between ceramic types and electrolytic types.

### What are capacitors used for?

As you have already discovered a capacitor takes time to achieve a difference in potential between the plates. So a capacitor can be used to create a **time delay**. But capacitors can be used for other applications.

Another feature of a capacitor is that it allows AC voltage to pass through it but stops DC voltage from doing so. You will find capacitors used extensively in circuits because of this especially in audio equipment and in power supplies.

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Capacitors are also used in filters to get rid of unwanted signals or frequencies. An example of this is in tone controls or graphic equalisers.

## Time Delay

A circuit showing a resistor and capacitor connected together to create a time delay is shown below.

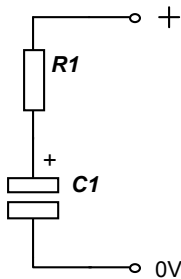


Fig 3.3

$$TC = C \times R \times 1.1$$

As the last part of the formula 1.1 makes very little difference we tend to ignore it so the formula becomes

$$TC = C \times R$$

The units are seconds for time, Farrads for capacitance and Ohms for resistance.

## Example

If R1 is 100K and C1 is 100 $\mu$ F what is the time constant of the circuit?

$$T = C \times R$$

$$T = 100\mu\text{F} \times 100\text{K}$$

$$T = 0.000100 \times 100\,000$$

$$T = 10 \text{ seconds}$$

What this actually means is that the capacitor will take 10 seconds to become charged.

## Exercise 3.1

1. If R1 is 47K and C1 is 470 $\mu$ F what is the time constant?
2. If R1 is 1M and C1 is 10 $\mu$ F what is the time constant?
3. If the time constant is 20 seconds and C1 is 100 $\mu$ F what value of resistor is required?

You will find out more about time constants in the chapter on timers.

## Capacitors in series and Parallel

Capacitors can be connected in series and parallel just like resistors. However connecting two capacitors in series is like connecting resistors in parallel.

For capacitors in series

$$C = C1 \times C2 / (C1 + C2)$$

For capacitors in parallel

$$C = C1 + C2$$

We rarely need to use these formulas.