Capacitors

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This article explains what capacitors are, what they do and where they are used.

If you have any suggestions for improving this application note, please drop us a line at:
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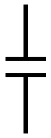
The most basic capacitor is made of 2 parallel plates with a gap between them. Electric charge builds up on one plate creating an electric field between the plates, thus energy is stored

It has the following electrical symbol:



It can be used in two different ways: to store a dc voltage or to pass an ac voltage.

Storing a dc voltage
It is best to visualise a capacitor in this application as being similar to a bucket storing water. Current is fed into the capacitor in the same way a hosepipe fills a bucket. The more current that flows into the capacitor, the higher the voltage gets. With this in mind, it is easy to understand why capacitors can occasionally be used as a replacement for rechargeable batteries.

Passing an ac signal
If the surface of a filled bucket of water is hit, ripples travel through the water and eventually appear at the bottom of the bucket. Similarly, if a changing voltage is applied to one plate of a capacitor, this voltage will appear on the other plate. The voltage has to be alternating, so dc voltages are blocked. In fact a capacitor conducts higher frequencies better than lower frequencies and it is this property that makes them very useful when designing filters. A treble/bass control in any piece of audio equipment makes use of this exact characteristic of a capacitor.

The main characteristics of a capacitor are:

Value - Just as a large bucket can hold a large amount of water, a large capacitor can store a big charge. The larger the value of the capacitor the longer it will take to charge for a given flow of current. Likewise, a bigger bucket takes longer to fill with a given flow of water.

Capacitors values are expressed in submultiples of Farads (F). They can range from picoFarads (pF) to microfarads (μF). These multiples are explained below:

1,000,000,000,000pF	=	1F
1,000,000,000nF	=	1F
1,000,000uF	=	1F

It is not necessarily so that a larger value of capacitor can store a larger voltage. If you picture the voltage on the capacitor as being similar to the depth of water in a bucket, you can have a bucket that is the size of a swimming pool and 2 feet deep. You can also have a normal sized bucket that stores water to a depth of 2 feet.

Working Voltage –The voltage you can charge the capacitor to without degrading its life.

Type – A capacitor stores charge between 2 plates. An insulating material (or dielectric) is placed between the plates to hold them apart. Dielectrics are made of different materials and have different properties. Some are cheap and can provide large capacitances in small spaces. Some have good audio properties (low distortion etc)

Uses of a capacitor

We have discussed that the rate a capacitor charges is determined by the size of the current flowing into it. A large current charges a capacitor very quickly. Likewise a small current flowing out of the capacitor will discharge it very slowly. Many circuits today run on extremely low currents so can, indeed be powered temporarily from capacitors instead of batteries. The rate of discharge of a capacitor is proportional to the current and the size of the capacitor. If a capacitor has a large value and the current drain from it is small, it is possible to use a capacitor as a backup power system for devices such as memory and time keeping chips inside electronic equipment.

We can also use a capacitor to change ac to dc. The circuit in FIG 1 is used in most mains powered electronics. It may be worth reading our article on diodes before considering the following circuit.

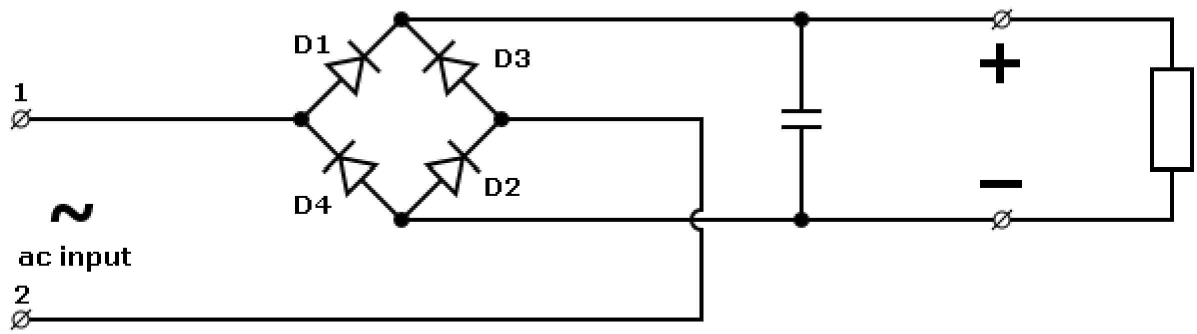


FIG 1

The mains voltage is applied to a transformer to convert the ac signal from 240V to something more sensible (12V or 5V). This 5V ac waveform is then applied to the input of the circuit in FIG 1. As the voltage is ac, FIG 1 will spend half a cycle with input 1 being more positive than input 2 and the other half of the cycle with input 2 more positive than input 1.

With input 1 more positive, diode D1 conducts, passes current (and a positive voltage) to the + side of the capacitor, charging it. The current flows through the capacitor and back to the negative input (2) through diode D2.

When input 2 is more positive, current passes through D3, charges the capacitor and this current continues to flow to the negative input (1) via diode D4. Thus the capacitor gets 2 pulses of energy per cycle.

When the voltage at the input starts to fall, the capacitor stores charge to keep the voltage across the output at a steady level.

For the truly insane, see our guide to 'Designing a Linear Power Supply' for a more in depth of how this works…

We can also use a capacitor's frequency dependent nature to design filters. A capacitor will only pass ac signals and the higher the frequency the better they pass these signals. This characteristic is used in virtually every aspect of audio equipment.

In the circuit in FIG 2 our 'signal in' is being fed through a resistor to a capacitor. We know that capacitors pass higher frequencies better than lower frequencies, so as the frequency of the input signal increases, more of the input signal gets shorted to ground and less of the input appears at the output. Thus we have created a filter that passes lower frequencies to the output better than higher frequencies. This is known as a Low Pass Filter

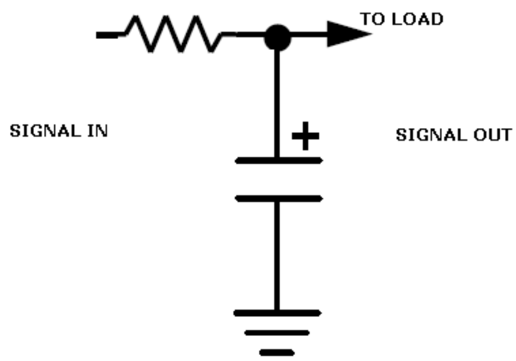


FIG 2

Likewise in FIG 3, using the same components we have created a circuit that passes higher frequencies from the input to the output better than it passes lower frequencies. This is called a High Pass Filter.

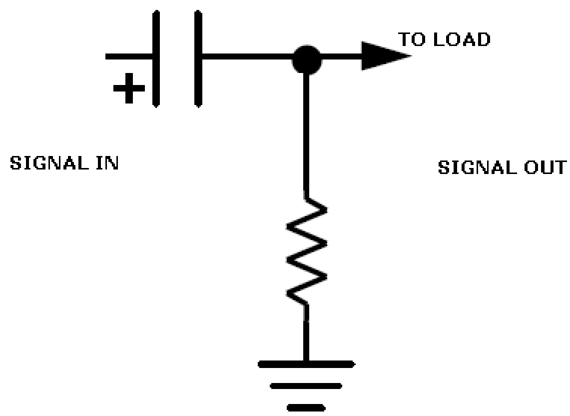


FIG 3

In conclusion, capacitors can be used to store dc voltage to act as a very low capacity battery or to pass an ac signal that can be used in filtering circuits.