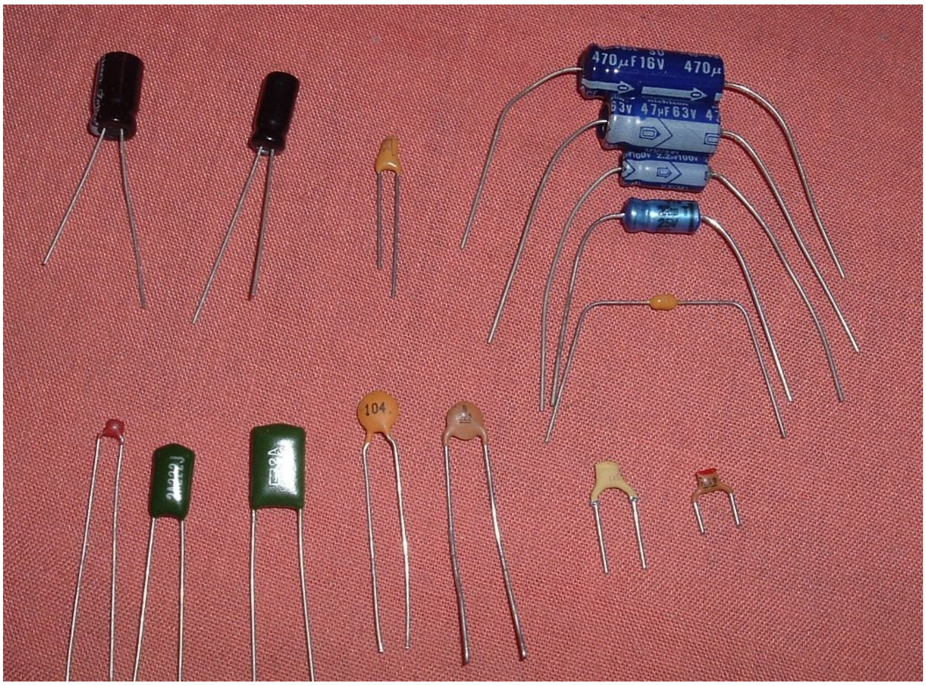
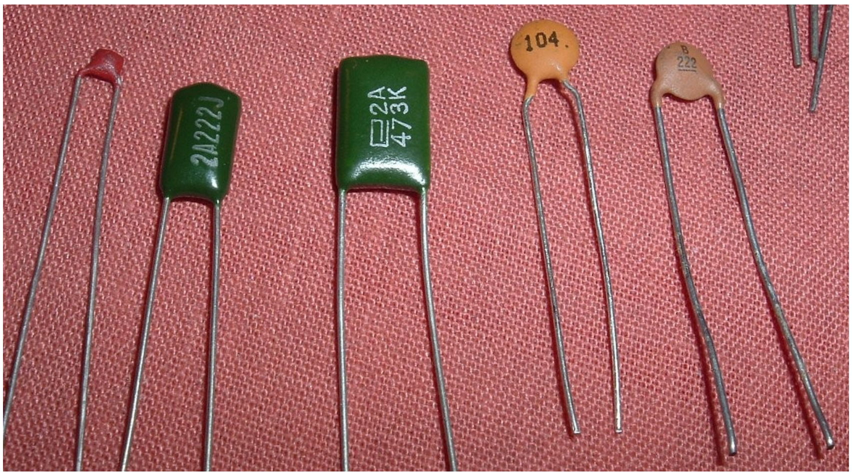
<u>Capacitors</u>

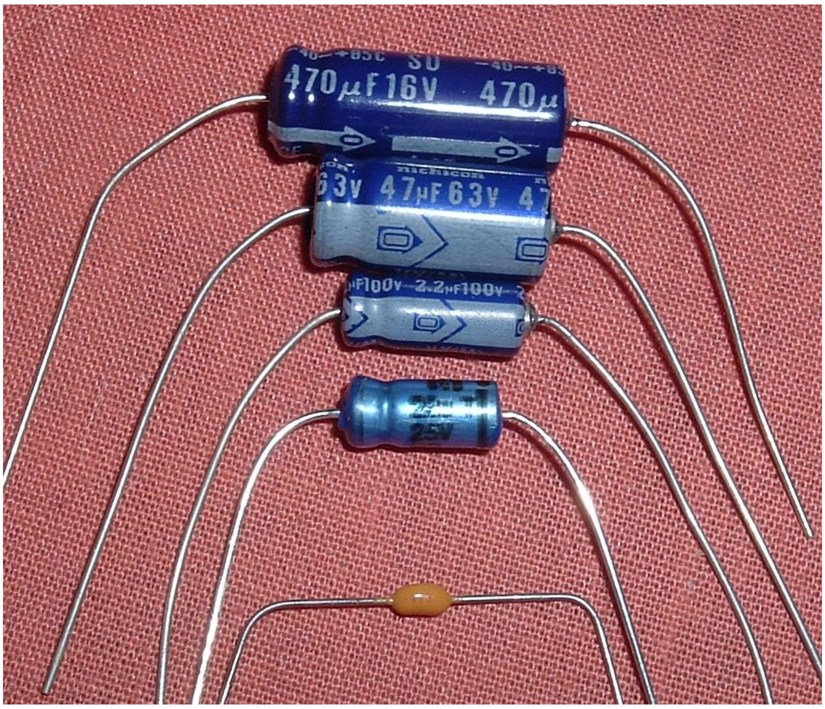


Capacitors, or to use their old name "condensers" have to be the most widely used components next to resistors. Pictured left is a selection of common types.

A capacitor is two conductive plates separated by a layer of insulating material (called a "dielectric"). This insulating material can be glass, paper, oil or wax impregnated paper, mica, a ceramic material, plastic film, air or even a vacuum. In the case of plastic films used, there is amongst others, mylar, polycarbonate, polystyrene, polyester and polyethylene.



Example of Radial capacitors



Example of Axial capacitors

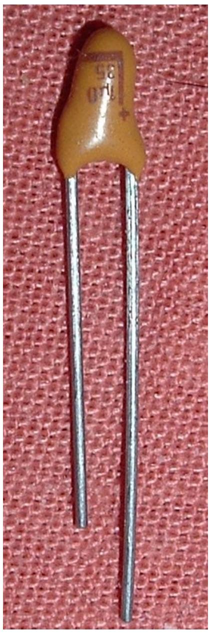
Capacitors come in a variety of shapes and sizes and are made from a wide variety of materials. Some look like resistors, and use the same colour code (The value being given in picoFarads) There are Axial types – a component with a lead out wire at each end, and Radial – where the lead out wires both come from the same end. Radial components are usually designed for direct mounting on a PCB.

	µF	nF	pF
µF	1	1,000	1,000,000
nF	0.001	1	1,000
pF	0.000001	0.001	1

The SI unit of capacitance is the Farad, which is a huge unit. Practical capacitors are measured in micro Farads (µF), nano Farads (nF) and pico Farads (pF). A micro Farad is a millionth of a Farad, and a pico Farad is one millionth of a micro Farad – so a pico Farad is one million millionth of a Farad. We use the Greek letter mu (µ) to denote micro. See table opposite.

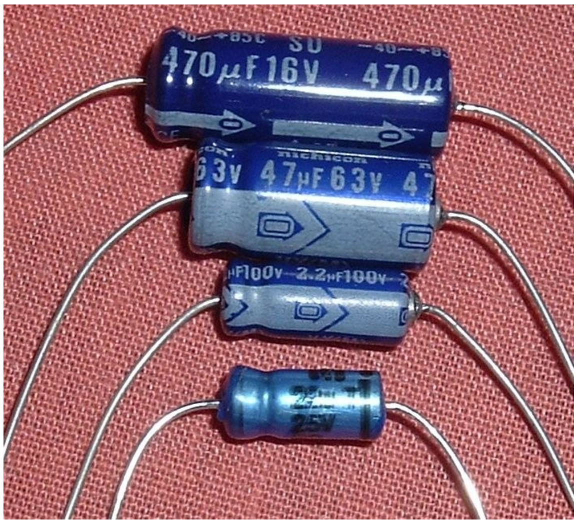
A capacitor stores an electric charge and blocks the flow of a direct electrical current (DC) but allows an alternating current (AC) to pass. Depending on the frequency and voltage of the AC waveform though, characteristics change. Higher frequencies tend to be conducted better.

As the value and/or the working voltage of a capacitor increases, so the physical size of the component grows. It soon gets to a point where the physical size of a large value capacitor is just too large and bulky to be convenient, and so conventional capacitors of larger values - 2.2µF and above, are hard to obtain and extremely expensive.



For higher values, we use what are termed "Electrolytic" capacitors and they have special conditions for their use. Electrolytics are usually made from aluminium but some are made from Tantalum.

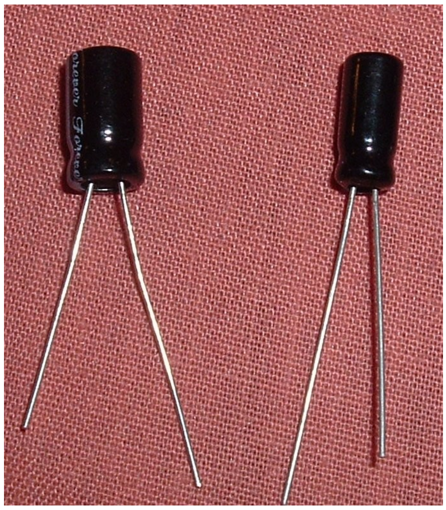
Tantalum electrolytics (pictured left) are generally limited to relatively small values and have comparatively lower working voltages but have superior characteristics to the usual Aluminium types



Axial electrolytics

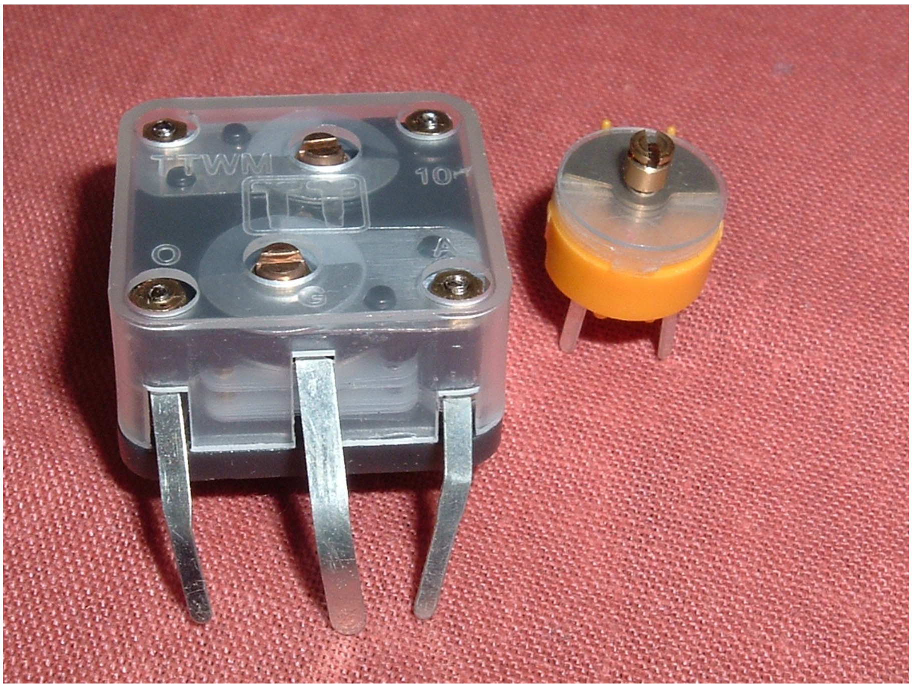
Normal capacitors are not polarised – you can use them like resistors, either way around. Electrolytic capacitors are polarised though, they have to be connected into circuit with the correct polarity, else they can explode. Luckily, the case is marked very clearly which lead out wire is negative, and so when you use these capacitors, you must make sure you fit them into circuit correctly.

Electrolytic capacitors also have a maximum working voltage printed on the case – it's not safe to use them in circuits where the voltage applied is too high for them – again, they may explode. When a 16V (say) component is specified in the parts list, then it's safe to use a higher rated component (say 25V) but definitely not less.


Radial electrolytics

.It's a well documented, but often overlooked fact that aluminium electrolytic capacitors dry out with age, causing all kinds of problems. It's a wise precaution to change all the electrolytic capacitors in equipment older than ten years or so. That old ZX Spectrum you've had in the loft for the past twenty odd years is full of electrolytics well past their best before date. It's also wise to occasionally power up equipment just so the electrolytics get charged. This prevents them from ageing too quickly since the insulating layer is electrically deposited by the electrolyte present inside the component. This insulating layer dissolves slowly into the electrolyte over time, but passing a current through the capacitor helps to prevent this insulating layer breaking down too quickly. Applying a voltage of the incorrect polarity will make this layer dissolve very much quicker, with potentially explosive results!

Variable Capacitors



Like Resistors, variable capacitors are available. They are often used in circuits that generate and use RF energy, such as radio receivers or other applications where a tuned circuit is required.

The component to the right in the photograph is a "trimmer" capacitor.

Capacitor markings

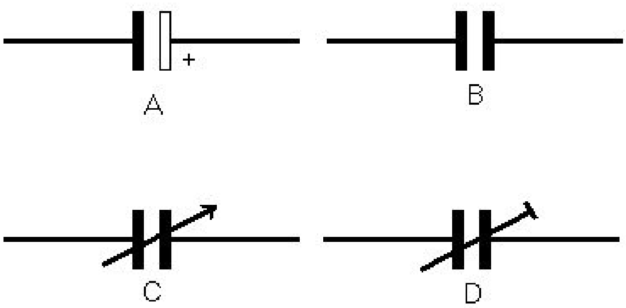
It isn't always easy to identify the value of a capacitor. There are several different ways in which they are marked, and so we'll have a look at some of the more common methods used.

Electrolytics are marked in µF along with their voltage ratings. Also the polarity of the component is identified. In the case of smaller value components though, it's a different matter. Most use written markings on their case, which identify the value, sometimes the working voltage and tolerance. Sometimes, it's just a matter of reading the value directly, but sometimes you will see a code instead of a literal value.

This code is usually three digits, the first two digits represent the value, the third number is the number of zero's you add. The result being in picofarads. For example, a marking of 473 would indicate 47 with three zero's – or 47,000 pF. 47,000 pF is the same as 47 nanofarads (nF) so a capacitor marked 47n would be the same. A capacitor marked 104 would be 10 with 4 zero's, or 100,000 pF – or 100 nF – or 0.1µF Sometimes you may see a letter after the value – 104K for example. The K means that the tolerance of the component is within 10% of the marked value. See table opposite.

Letter	Tolerance
F	1%
G	2%
H	2.5%
J	5%
K	10%
M	20%

Symbols



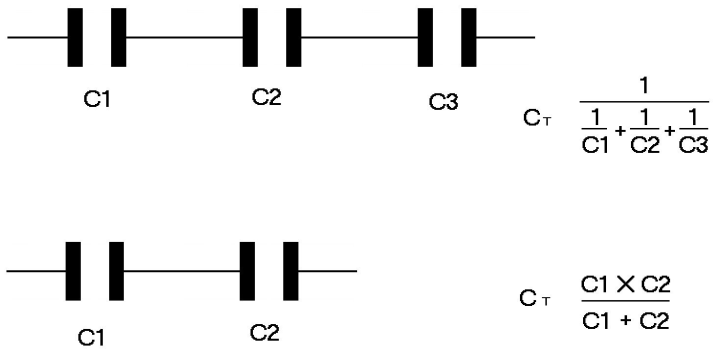
A – Electrolytic capacitor – note the hollow plate and the + symbol to denote polarity

B – Fixed capacitor

C – Variable Capacitor

D – Preset or trimmer capacitor

Capacitors in series

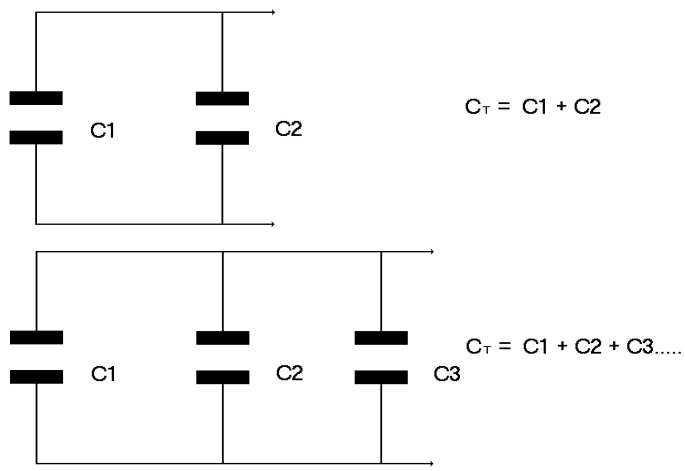


Capacitors in series do not simply add up in value as resistors do.

The formula for calculating two capacitors in series is: Total capacitance (C_T) = (C1 x C2) / (C1 + C2)

For three or more, the formula is C_T = 1 / (1 / C1 + 1 / C2 + 1 / C3)

Capacitors in Parallel



Again, capacitors in parallel do not react the same way resistors do: The formula for calculating the total value of two or more capacitors in parallel is: C_T = C1 + C2 + C3......

Warning

Capacitors can store a charge for a length of time after the charge current has been removed. A large value electrolytic capacitor in a photographer's flashgun can store a dangerously high – even potentially fatal - charge for days, weeks or even months. Be careful when you work with mains powered equipment. Even a capacitor charged with a low voltage can melt a screwdriver blade in a brilliant blue flash if the value of it is high enough.