

TYPES OF CAPACITORS

There are all sorts of capacitor types out there, each with certain features and drawbacks which make it better for some applications than others.

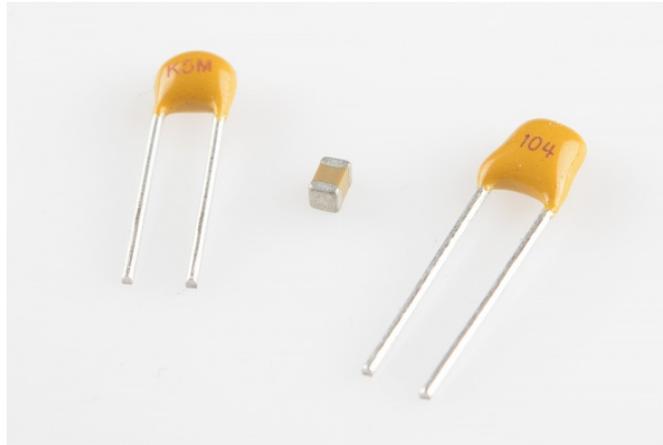
When deciding on capacitor types there are a handful of factors to consider:

- **Size** - Size both in terms of physical volume and capacitance. It's not uncommon for a capacitor to be the largest component in a circuit. They can also be very tiny. More capacitance typically requires a larger capacitor.
- **Maximum voltage** - Each capacitor is rated for a maximum voltage that can be dropped across it. Some capacitors might be rated for 1.5V, others might be rated for 100V. Exceeding the maximum voltage will usually result in destroying the capacitor.
- **Leakage current** - Capacitors aren't perfect. Every cap is prone to leaking some tiny amount of current through the dielectric, from one terminal to the other. This tiny current loss (usually nanoamps or less) is called leakage. Leakage causes energy stored in the capacitor to slowly, but surely drain away.
- **Equivalent series resistance (ESR)** - The terminals of a capacitor aren't 100% conductive, they'll always have a tiny amount of resistance (usually less than 0.01Ω) to them. This resistance becomes a problem when a lot of current runs through the cap, producing heat and power loss.
- **Tolerance** - Capacitors also can't be made to have an exact, precise capacitance. Each cap will be rated for their nominal capacitance, but, depending on the type, the exact value might vary anywhere from $\pm 1\%$ to $\pm 20\%$ of the desired value.

Ceramic Capacitors

The most commonly used and produced capacitor out there is the ceramic capacitor. The name comes from the material from which their dielectric is made.

Ceramic capacitors are usually both physically and capacitance-wise **small**. It's hard to find a ceramic capacitor much larger than $10\mu\text{F}$. A surface-mount ceramic cap is commonly found in a tiny 0402 (0.4mm x 0.2mm), 0603 (0.6mm x 0.3mm) or 0805 package. Through-hole ceramic caps usually look like small (commonly yellow or red) bulbs, with two protruding terminals.



Two caps in a through-hole, radial package; a 22pF cap on the left, and a 0.1μF on the right. In the middle, a tiny 0.1μF 0603 surface-mount cap.

Compared to the equally popular electrolytic caps, ceramics are a more near-ideal capacitor (much lower ESR and leakage currents), but their small capacitance can be limiting. They are usually the least expensive option too. These caps are well-suited for high-frequency coupling and **decoupling** applications.

Aluminum and Tantalum Electrolytic

Electrolytics are great because they can pack *a lot* of capacitance into a relatively small volume. If you need a capacitor in the range of 1μF-1mF, you're most likely to find it in an electrolytic form. They're especially well suited to high-voltage applications because of their relatively high maximum voltage ratings.

Aluminum electrolytic capacitors, the most popular of the electrolytic family, usually look like little tin cans, with both leads extending from the bottom.



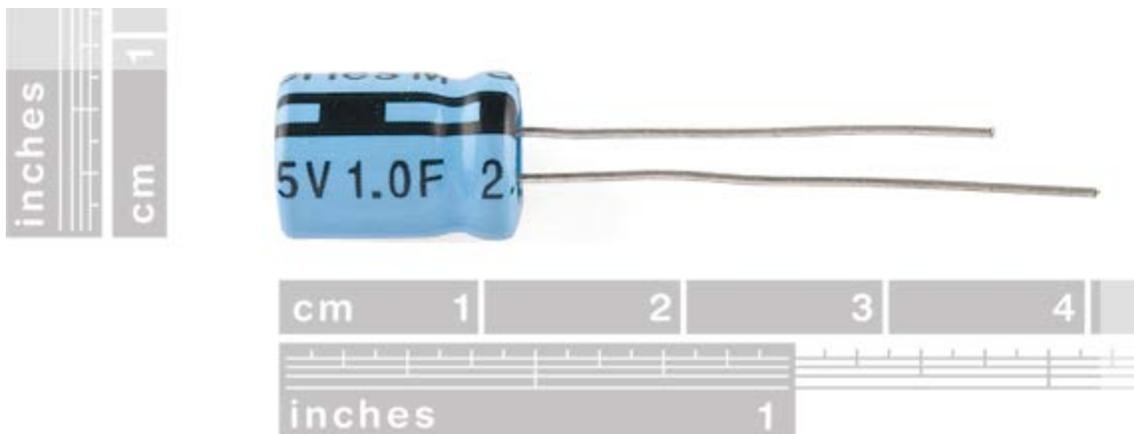
An assortment of through-hole and surface-mount electrolytic capacitors. Notice each has some method for marking the cathode (negative lead).

Unfortunately, electrolytic caps are usually **polarized**. They have a positive pin – the anode – and a negative pin called the cathode. When voltage is applied to an electrolytic cap, the anode must be at a higher voltage than the cathode. The cathode of an electrolytic capacitor is usually identified with a '-' marking, and a colored strip on the case. The leg of the anode might also be slightly longer as another indication. If voltage is applied in reverse on an electrolytic cap, they'll fail spectacularly (making a *pop* and bursting open), and permanently. After popping an electrolytic will behave like a short circuit.

These caps also notorious for **leakage** – allowing small amounts of current (on the order of nA) to run through the dielectric from one terminal to the other. This makes electrolytic caps less-than-ideal for energy storage, which is unfortunate given their high capacity and voltage rating.

Supercapacitors

If you're looking for a capacitor made to store energy, look no further than supercapacitors. These caps are uniquely designed to have *very* high capacitances, in the range of farads.



A 1F (!) supercapacitor. High capacitance, but only rated for 2.5V. Notice these are also polarized.

While they can store a huge amount of charge, supercaps can't deal with very high voltages. **This 10F** supercap is only rated for 2.5V max. Any more than that will destroy it. Super caps are commonly placed **in series** to achieve a higher voltage rating (while reducing total capacitance).

The main application for supercapacitors is in **storing and releasing energy**, like batteries, which are their main competition. While supercaps can't hold as much energy as an equally sized battery, they can release it much faster, and they usually have a much longer lifespan.

Others

Electrolytic and ceramic caps cover about 80% of the capacitor types out there (and supercaps only about 2%, but they're super!). Another common capacitor type is the **film capacitor**, which features very low parasitic losses (ESR), making them great for dealing with very high currents.

There's plenty of other less common capacitors. **Variable capacitors** can produce a range of capacitances, which makes them a good alternative to variable resistors in tuning circuits. Twisted wires or PCBs can create capacitance (sometimes undesired) because each consists of two conductors separated by an insulator. **Leyden Jars** – a glass jar filled with and surrounded by conductors – are the O.G. of the capacitor family. Finally, of course, **flux capacitors** (a strange combination of inductor and capacitor) are critical if you ever plan on traveling back to the glory days.

Source : <https://learn.sparkfun.com/tutorials/capacitors#types-of-capacitors>