Capacitance

Opposition to Change in Voltage

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Derivation: From Latin capere, to hold, contain.

Alternating current (AC) electricity can be pictured as a wave, rising and falling many times a second. We even call its form a "waveform." Perhaps you've seen diagrams of a sine wave, a modified square wave, or a square wave. These diagrams represent the fluctuations of the basic parts of what we call electricity—voltage and amperage.

Voltage is the electrical "pressure"—the push that makes electrons move. Amperage is the rate of electron flow—we call this flow rate "current." If these two values fluctuate in step with each other, we can graph their waveforms as parallel, undulating lines. When a circuit has only resistance in it, voltage and amperage peak at the same time and go to zero at the same time. They are said to be "in phase." But two other electrical effects can shove the voltage and the charge flow rate out of sync.

In my last column, I talked about inductance, an electrical effect that opposes a change in electron flow (current). Inductors are simply coils of wire, and the way their magnetic fields affect the charge flow is called inductance. It's like a flywheel in an electrical circuit, grabbing some of the energy and tossing it back toward the source in a delayed reaction. In this case, the voltage "leads" or peaks before the amperage—the charge flow rate is reduced by the inductor.

Capacitance has a similar effect on a circuit, but the timing and focus are different. The voltage "lags," peaking after the amperage. This can effectively cancel out inductance in a circuit, so capacitance and inductance are considered opposites. Inductors store energy in a magnetic field. Capacitors store energy in an electric field.

A capacitor is two metal plates that are separated by an air space or another insulating material. When the circuit is energized, electrons are pushed into one plate, and the voltage there increases. The fields from these extra electrons reach across the gap between the plates, forcing an equal number of electrons to flow out of the other plate and back toward the source.

It's as if you have a loop of hose with a pump (analogous to a generator, PV, or battery) circulating water through the loop. But the loop is cut at one point, and a balloon is put on each of the cut hose ends, with the balloons forced next to each other inside a rigid housing. Water flows into one balloon, pressurizing it, but at the same time pushing on the other balloon. There's no direct transfer of water, but some of the energy is transferred.

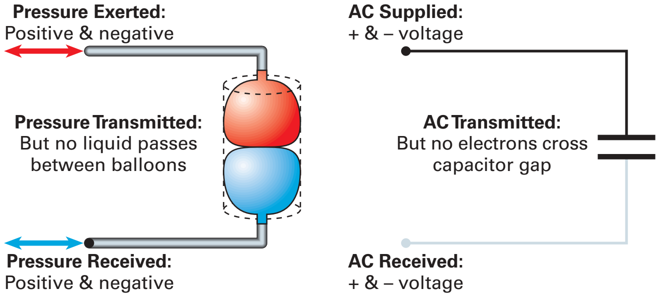
In a DC circuit, with the charges flowing all one way, a capacitor will be "charged" very quickly and that's the end of it. The balloon gets pressurized with water and the flow stops. If you connect (short) both sides of the capacitor, it will discharge its energy, just as when you release the pressure in the balloon, it will empty itself.

But in AC circuits, the charge flow direction changes constantly, so the two sides of the capacitor are alternately being charged and discharged. The net effect is that the capacitor, like an inductor, stores a bit of energy in each cycle and bounces it back toward the source. But the voltage (pressure, in the balloon analogy) builds up first on one side and then the other, "lagging" the charge flow (current). When the potential of one side changes, strong electric fields affect the other side. A dose of charge is needed to force the change in voltage between the two plates, and the net effect is that capacitors resist a change in voltage.

Capacitors are used widely in electronic circuits, acting as filters, timers, frequency tuners, and for other functions. They are often used to smooth a waveform and absorb spikes or "noise" in a circuit. They can filter out high or low frequencies. Timing applications rely on the finite time interval required to charge and discharge a capacitor. Capacitors and inductors have opposite effects on electrical circuits, so capacitors are used to offset inductance in industrial machinery to help AC motors start more easily.

In my next column, I'll look at how inductance and capacitance relate to "power factor."

Balloon Model & Circuit



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