26: Capacitors and Dielectrics

Capacitors are simple circuit devices that have immense practical utility.

e.g., for tuning radio receivers, as power supplies, etc.

They're everywhere.

1: Definition of Capacitor and Capacitance

A capacitor is a device consisting of two conductors called **PLATES** (which sometimes are plates or rolled up plates).

FIGURE: Generic Capacitor and Capacitor Symbol

In their conventional operation the plates carry equal and opposite charges: Q and $-Q$: the charge of a capacitor is just called Q.

In electrostatic equilibrium, the plates are equipotentials.

The potential differece V between the plates is the capacitor potential: it's always given as positive and so it positive plate potential minus negative plate potential.

CAPACITANCE is defined to be

$$C = \frac{Q}{V}$$

which leads to

$$Q = CV \qquad \text{and} \qquad V = \frac{Q}{C} \ .$$

The unit of capaciticance is the farad (F) named for Michael Faraday:

$$1\,\mathrm{F} = 1\,\mathrm{C/V} \ .$$

It turns out that 1 farad is a bloody big capacitance.

So typical small device capacitors are often in microfarads (μF or, confusingly, mF which are not millifarads) or picofarads (pF which are sometimes called puffs [WP-621]).

Ideally, **CAPACITANCE** is actually independent of Q and V—which seems odd given its official definition.

Ideally, **CAPACITANCE** should depend on the geometry of the plates and the **DIELECTRIC** (insulating material) in which the plates are embedded.

To understand, imagine a capacitor with charge Q and potential V.

FIGURE: Generic Capacitor with forces on a single charge indicated

Any bit of charge on the capacitor is held in static equilibrium by the forces of all the other charge and the force of the conductor wall.

The conductor wall force is actually an electrostatic force to caused by the nature of the conductor. But structural force of the conductor is idealized as an impenetrable wall.