Basic Electronics Part 11

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As we mentioned last month, if you connect a capacitor to a battery, the battery moves extra electrons onto one surface or plate and reduces the number of electrons on an opposite surface or plate. The electric charge on these plates produces an electric field. The charge will increase until it is equal to the supply voltage. We can increase the charge by connecting a larger voltage or by making the plates larger.

Let's discuss the size of the plates. If we have a small plate surface area then we have a small electric charge and there is a weak electric field between the capacitor plates. When we have a larger surface area in the plates, the capacitor can hold a larger charge therefore, the electric field between these plates will be stronger. The electric field between the capacitor plates represents stored electrical energy. As we increase the surface area of the opposing plates, we realize there is a practical limit. We can increase the surface area of opposing plates by interleaving smaller plates and connecting alternate edges. Many capacitors use this stacked-plate construction, but it is sometimes difficult to see because the capacitor is encased in a protective coating.

Some electronic circuits require adjustable capacitors. This can be accomplished by using one set of plates that rotate and another set that is fixed. The rotating plates interleave with the fixed plates and changing the overlapping area varies the capacitance. When the plates completely mesh, we have maximum capacitance and when they have no overlapping area, the capacitance is minimum. A layer of air separates the rows of plates, preventing electrons from flowing between them. These are called "air variable capacitors".

Another way to reduce a capacitor's size is to make the plates from a metal foil. You can use two pieces of foil separated by a solid insulating material. This package can be rolled up and sealed with wax. Of course you would need a lead from each foil plate to extend outside the wax to connect the capacitor to a circuit. The insulating material between the plates is called a dielectric because the capacitor does not conduct direct electric current. An air dielectric capacitor uses air to insulate the capacitor plates. Others use mica, polystyrene plastic, paper, ceramic and aluminum oxide.

Another method of construction uses two plates separated by a thin ceramic insulation layer and encased in a ceramic or plastic coating. These are called ceramic disk capacitors. Again, a small wire is connected to each plate so the capacitor can be connected to a circuit.

The three main factors that determine a capacitor's ability to store charge are plate surface area, distance between plates, and the dielectric constant of the insulating material. Increasing surface area increases the ability to store charge and decreasing spacing between plates increases the ability to store charge. The capacitance also depends on the kind of insulating material between the plates. It is smallest with air insulation. Substituting other insulating materials for air may greatly increase the capacitance. The ratio of the capacitance with a material other than air between the plates to the capacitance of the same capacitor with air insulation is called the dielectric constant (K). For example, the relative dielectric constant of mica is listed as 5.4. This means that if we construct a capacitor using mica as an insulating material and another using air, assuming the same plate spacing and surface area, the mica capacitor will have about 5.4 times more ability to store charge than the air capacitor. There are other factors that need to be considered here, however, this should be enough for our purposes at this time.

A measure of this ability to hold charge is called the capacitance of the capacitor. The basic unit of capacitance is the farad (F). This unit is generally too large for practical radio work, however. Capacitance is usually measured in microfarads (μF), nanofarads (nF), or picofarads (pF). The microfarad is one millionth of a farad ($10^{-6}\,F$), the nanofarad is one thousandth of a microfarad ($10^{-9}\,F$), and the picofarad is one millionth of a microfarad ($10^{-12}\,F$).

When high voltage is applied to the plates of a capacitor, considerable force is exerted on the electrons in the dielectric. If the force is great enough, the dielectric will breakdown. Failed dielectrics usually puncture and offer a low-resistance current path between the plates. If the dielectric is air, break down is evidenced by a spark or arc between the plates. Manufacturers specify a dc working voltage (dcwv) to express the maximum safe limits of dc voltage across a capacitor to prevent dielectric breakdown.

In the next few installments of Basic Electronics we will discuss capacitors and their use in electronic circuits.