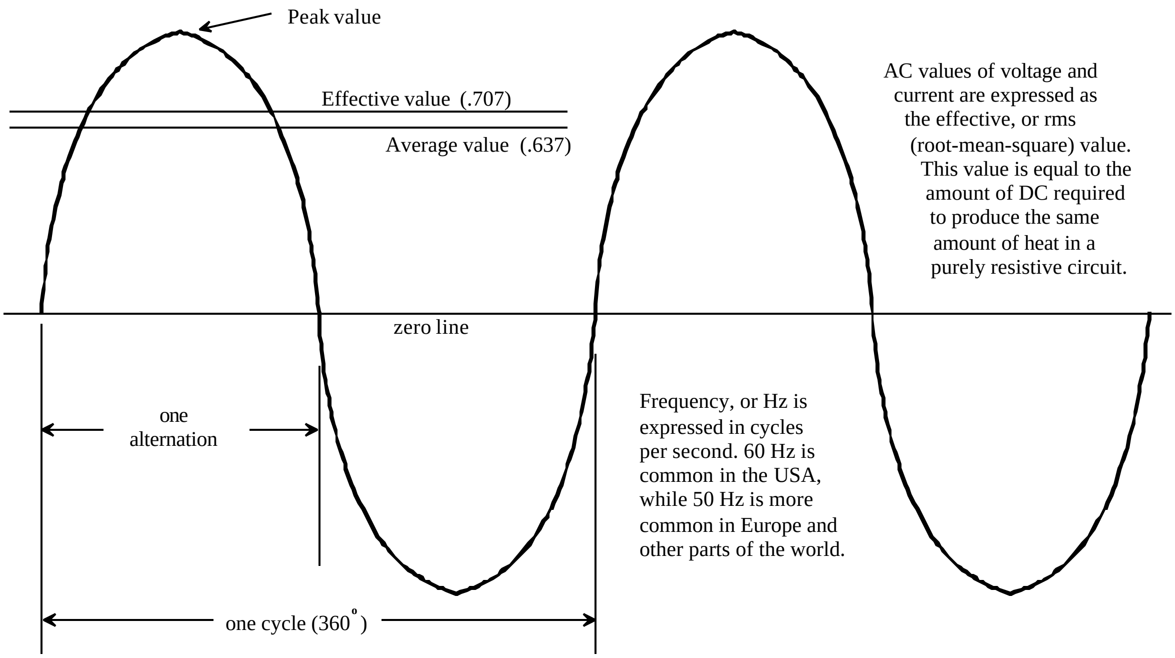
AC Theory

Alternating Current is common because of it's ability to change voltage through the use of transformers. However, AC is not as efficient as DC for power transmission lines, due to the many AC characteristics that consume power.

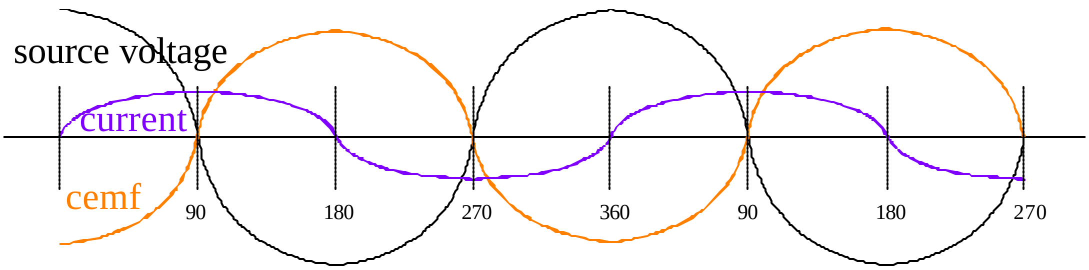


Components and Characteristics of Alternating Current

Hysteresis loss is the power consumed in an AC circuit by the rapid and constant realignment of magnetic polarity within a conductive material. One alternation of an AC sine wave occurs in the time it takes for voltage, (or current), to increase from zero to peak value and back again. There are 120 alternations per second in 60-cycle power. This constant realignment of magnetic properties in the conductive material of an AC circuit, causes eddy currents and skin effect. Random movement of electrons, (eddy currents), cause current flow to be concentrated near the surface of a conductor, (skin effect).

When a magnetic field increases as current increases, the flux lines expand from the center of the conductor, effectively cutting the conductor as they expand. This movement of flux lines induces a voltage in the conductor whose direction is such that it opposes the change in current. The direction of self-induced electromotive force, (emf), was first explained by Lenz, and it helps us understand why induction causes current to lag voltage. The magnitude of the induced emf is directly proportional to the rate of change of the magnetic field; the faster current changes, the higher the induced voltage. This induced voltage is referred to as counter emf, because it opposes the applied voltage. Inductance tends to oppose any change of current in a circuit. When a conductor is wound into a coil, the inductance value increases due to the interaction between adjacent coils, or turns of the wire.

In an AC circuit that contains only inductance, the primary characteristics are the applied voltage, induced cemf, and current. In a purely resistive circuit, source voltage and current rise and fall together, in phase. In an inductive circuit the cemf, and the time delay generated by the inductance, alters the in-phase relationship between voltage and current, causing the current to lag the voltage by 90 electrical degrees. Notice that the induced cemf is highest when the current's rate of change is greatest, (0,180,360), and zero when the current is not changing, (90 and 270).

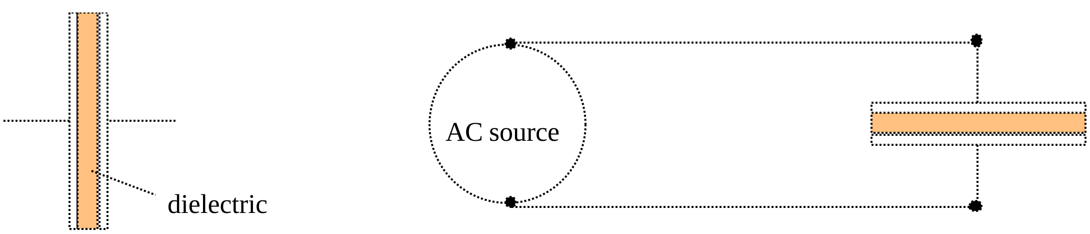


Author's note; In a purely inductive circuit, maximum current occurs when the voltages are at their maximum rate of change.

The symbol for inductance is L, and the symbol for capacitance is C.

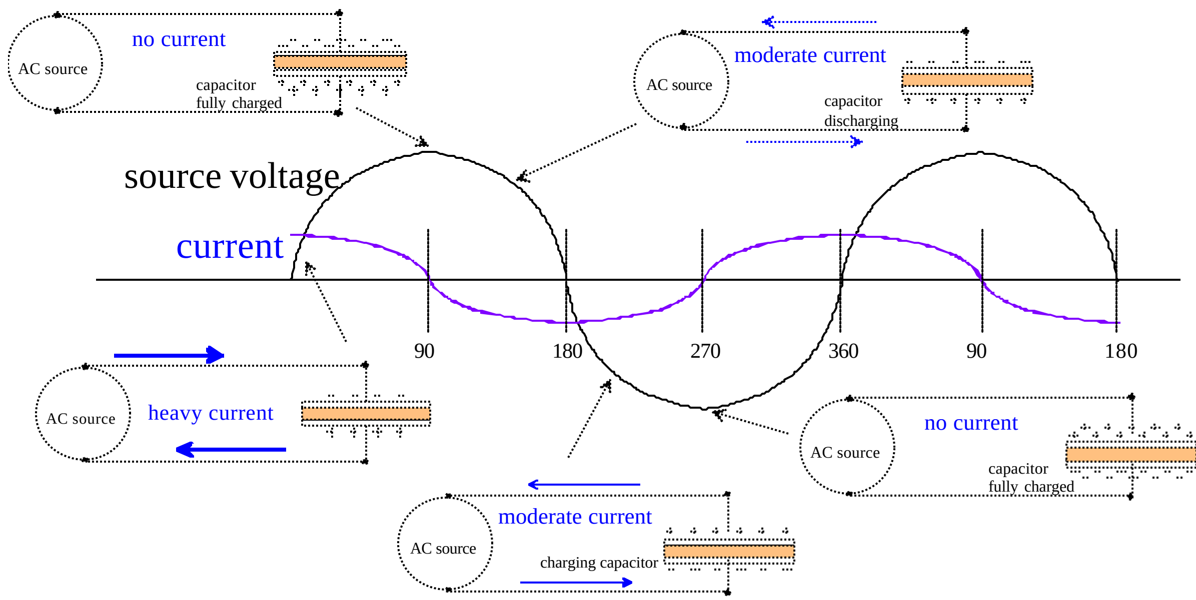
In an inductive circuit, voltage leads current, and in a circuit with capacitance, voltage lags current. An easy way to remember this relationship is; **ELI the ICE man**.

A capacitor is an electrical device that is capable of storing an electrical charge. It is made up of two plates separated by an insulating material called a dielectric. This device cannot pass electron flow unless the dielectric breaks down. However, when placed in series in an AC circuit, it seems like the capacitor conducts electricity because the plates alternately charge and discharge as the voltage changes direction.



The instant voltage rises from the zero line, electrons race to the capacitor plate and are held there by an electrostatic field that exists in the dielectric. Current flow is greatest when the rate of change in voltage is greatest, and decreases to zero when the voltage is at it's peak, (the capacitor is fully charged). When the voltage starts dropping, the capacitor starts discharging, and current flow changes direction as electrons leave the plate and return to the source. The voltage changes direction, and again the current flow is at maximum, charging the other capacitor plate.

In a purely capacitive AC circuit, voltage lags current by 90 electrical degrees. Maximum current occurs when the voltage is at it's greatest rate of change, and decreases as the capacitor becomes fully charged at the peak voltage. Current then changes direction when the voltage decreases and the capacitor discharges. It reaches maximum again when the voltage is at the greatest rate of change, and once again, current decreases as the voltage reaches it's peak, (because the capacitor is fully charged again). Notice that the capacitor does not have a static polarity . . . it will charge and discharge equally from either plate.



In an inductive AC circuit such as a motor winding, current lags voltage, somewhere between 0 and 90 electrical degrees. The more inductance in the circuit, the greater the lag. This out-of-phase characteristic contributes to poor power factor, and results in an inefficient consumption of electricity. A capacitor can be connected in the inductive circuit to counteract the effect of the inductance, and return the current and voltage to an 'in-phase' relationship. The capacitor must be carefully chosen for the characteristics needed to produce the desired effect in a given circuit.

Remember that frequency and voltage have dramatic effects on these devices, and the components must be carefully chosen for compatibility.

Got Questions?

e-mail your questions to a.step@comcast.net