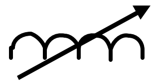
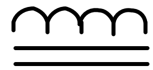
Inductors

Schematic Symbols

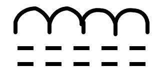
Inductor



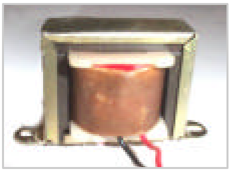
Adjustable Inductor



Iron Core Inductor



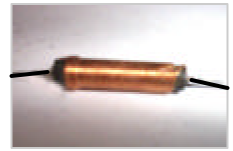
Powdered Iron Core



17 mh power supply smoothing reactor. One-half actual size.

Left: Reactor used in conjunction with capacitors for harmonic filtering.

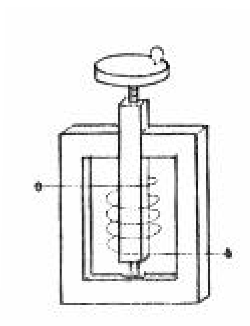
Above: Large DC link reactors used in 4160 volt 5000 hp VFD.



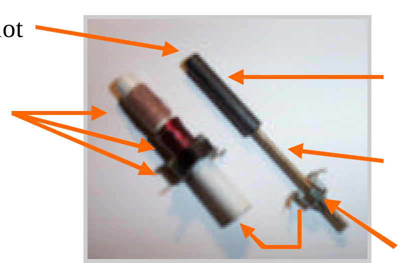
Radio frequency "choke" coil wound on ceramic powdered iron core. Shown actual size.

Inductor Characteristics

- An inductor is created when a conductor is wound into a coil.
- The unit of inductance is the Henry - named after the American inventor Joseph Henry. By definition: an inductor has an inductance of one (1) henry if an electromotive force of one (1) volt is induced in the inductor when the current through the inductor changes at the rate of one (1) ampere per second. The abbreviation for the Henry is h and mh stands for millihenry.
- The inductance of a coil is affected by a number of factors including: the type and size of the core material, the size of the conductor, and the way in which the coil is wound.
- In an electrical circuit, an *inductor opposes* a change in *current*. This characteristic has resulted in the term "choke coil", particularly in radio work.
- Adjustable inductors are made by changing the amount of core material within the coil. The drawing below left illustrates a common method of achieving "slope control" in a welder by raising or lowering the iron core within the coil. The the AM broadcast band antenna coil pictured below right is tuned by moving the position of the powdered iron core within the coil form; a non-magnetic "tuning wand" is required for this adjustment.



Arc Welder Slope Control



Loopstick Antenna Coil
Shown with core slug removed from coil form.
Shown one-half actual size.

AC Theory
Inductive Reactance - Page 1

- Inductive Reactance is the opposition to the flow of current in an electrical circuit due to inductance and is measured in ohms.
- The symbol for reactance is X; inductive reactance is represented by the symbol $\mathbf{X_L}$.
- The formula for inductive reactance is: $\mathbf{X_L = 2 \pi f L}$

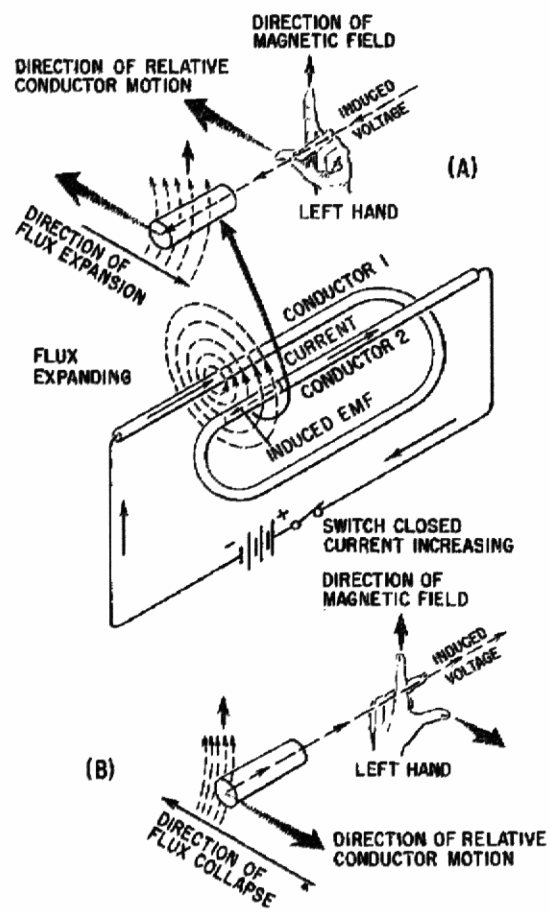
  Where: XL = Inductive Reactance in ohms, f = Frequency in hertz, L = Inductance in henrys, $2\pi = 6.28$.
- As illustrated by the formula above, inductive reactance is *directly* proportional to frequency. When an alternating current is applied to an inductor, the inductive reactance will increase as the frequency increases.
- The opposition offered to the flow of steady-state Direct Current (DC) by an inductor is equal to the resistance of the inductor only (the ohmic value of the conductor with which the coil is wound). During the application of DC to an inductor, during any fluctuations or ripple, or during de-energization of the coil, inductive reactance becomes a factor.
- An inductor opposes a change in current. The mechanical analogy of inductance is inertia.

Voltage of Self Inductance

When a changing current is applied to an inductor, a counter electromotive force (cemf) is generated. This generated voltage is termed a “counter” or “back” emf because it is in a direction which opposes the applied voltage.

Figure A of the drawing at the right illustrates how this counter emf is generated. As current is applied to a coil and flows through the conductors of that coil, an expanding magnetic field will be established that surrounds each of the conductors. This expanding flux cuts through the adjacent conductors and induces a voltage in these adjacent conductors. Using the Left Hand Rule, it can be seen that the direction of this induced voltage is in a direction that opposes the applied DC voltage.

When the switch is opened (or the level of the applied voltage is reduced), the reverse effect takes place. The magnetic field will collapse and effectively cut through the adjacent conductors in the opposite direction than was previously described. The counter emf will reverse and will oppose the reduction on the applied voltage. This directional change is illustrated in Figure B, on the right.



Lenz’s Law

The induced EMF in any circuit is always in a direction to oppose the effect that produced it.

Remember - To Generate a Voltage:

A conductor can be moved so as to cut the lines of force of a magnetic field .

Or

An expanding or collapsing magnetic field can cut through a stationary conductor.

AC Theory
Inductive Reactance - Page 2

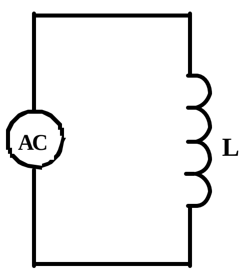
Continued from Page 1

In a purely inductive circuit, the circuit current will lag the applied voltage by 90°. This is a theoretical condition, since any circuit will have some value of resistance or capacitive reactance in addition to the inductance.

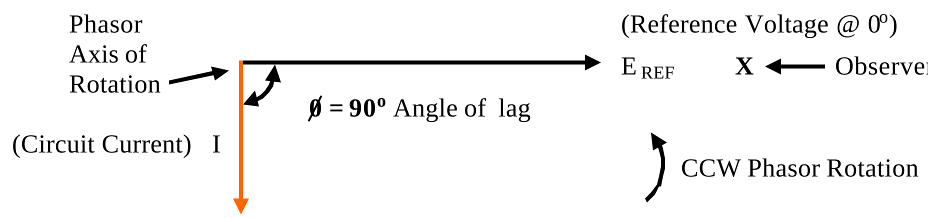
In this circuit the current is all reactive and no work will be done. Single-phase power in watts in an AC circuit is: **$P = E \times I \times \cos Ø$**. The phase angle in this case is 90°. Since $\cos 90° = 0$, the circuit power therefore equals zero.

Remember:

- There are 360 degrees in a sine wave.
- Electrical Phasors rotate counter-clockwise (CCW).
- Phasors (electrical vectors) show two things: (1) magnitude, and (2) direction.

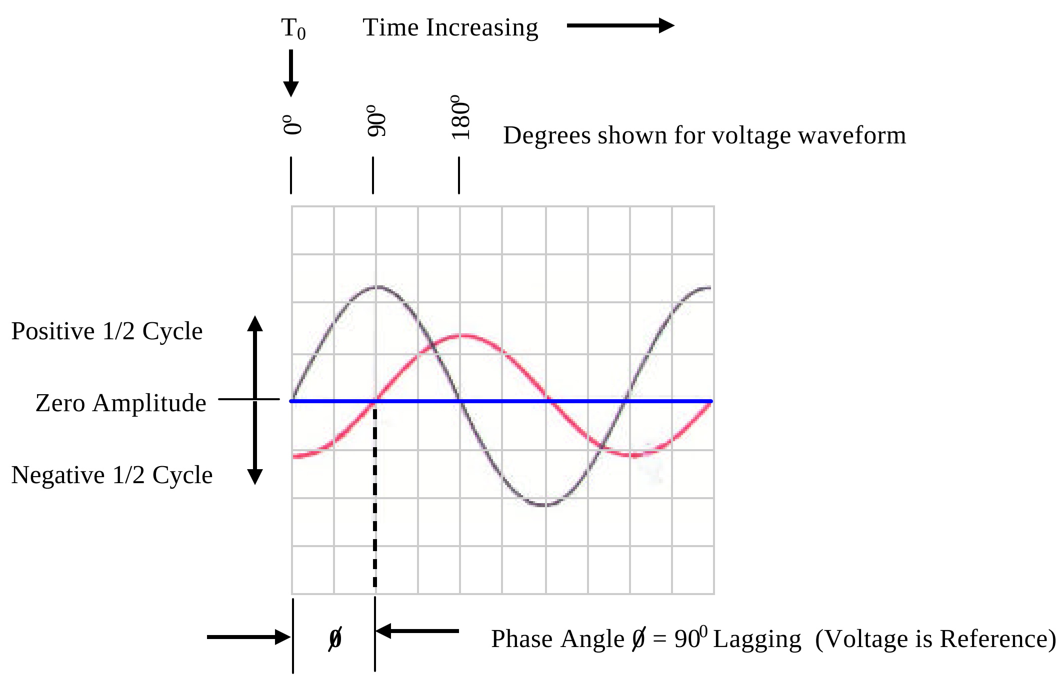


Circuit Diagram



Phasor Diagram

If the observer stands a point X above and watches the phasors rotate CCW, the voltage phasor will appear first, followed 90° later by the current phasor.



Sine Wave Relationship
Red - Current
Black - Voltage

In the above drawing, the voltage crosses zero and goes positive 90° before the current crosses zero and goes positive.