

## Electronic Basics Part VI

### Inductors

**Inductors are used in almost all electronic equipment. They are used in power supplies, transformers and are used to produce motion. Inductors are coils of wire formed on some type of center core. Some are as small as a pencil eraser and the largest are several feet in diameter.**

**Fundamental to all action by coils is a magnetic field in and around the coil. A single wire with electricity flowing thru it has a small magnetic field around it. When the wire is coiled or looped with one or more turns the magnetic field adds together and reinforces the magnetic effect. The magnetic field is referred to as magnetic flux.**

**Coils can have one of two types of cores. A core is simply the material inside the wire coil. Cores are either air or metal. Metal cores tend to concentrate the magnetic flux more than air cores. There are several types of metal cores. Some cores are laminated metal and are frequently found in power transformers. Others are made of iron filings held together with a binder. These are used in small transformers used in radio's. Air cores are simply made by winding a coil or wire on a cardboard form or coiling the wire upon itself with the center open. Air cores are used when for small and large coils.**

**Magnetomotive force sends the magnetic flux around and thru the core. Reluctance is the opposition of the core to the flow of magnetic flux. The opposite of reluctance is permeability. This is the measure of how easily the magnetic flux flows thru the core. Metal cores have a lower reluctance and greater permeability than air cores.**

**The amount of voltage applied to a coil in conjunction with the core's permeability determines the amount of magnetic flux in and around the coil.**

**As we said in an earlier tech talk the voltage must vary to cause a change in the magnetic flux. To provide useful work such as in relays or transformers the voltage must change. Of course, this would be thru the use of an AC voltage or pulses of voltage.**

**When a voltage is initially applied to a relay or solenoid the core or moveable part has a magnetic flux induced in it thereby causing it to move to the desired position and opens and/or closes contacts or causes a valve or some other part to move.**

**When two coils are in close proximity to each other and a voltage is applied to one the magnetic flux causes a voltage to be induced into the second coil. Unless the voltage continues to change no further voltage is induced in the second coil. Thus an AC voltage or pulses must be applied to cause a voltage to continue to be**

induced. Only the initial application of DC voltage will induce a voltage causing a relay or solenoid to move or cause an initial voltage to be induced in a second coil. The voltage must continue to change to cause a voltage to be induced in the second coil. Incidentally, two coils grouped as just described is called a transformer.

The property of a coil that governs or determines the voltage induced in the coil is called inductance. Voltage applied to a coil will induce a voltage in the coil similar to the way it would be induced into a second coil. This voltage, however, is in opposite phase to the voltage that produced the magnetic flux. Thus we have what might be considered a forward and reverse voltage. These two voltages combine and the overall voltage is less than that initially applied.

The reverse voltage opposes the flow of current in the coil caused by the initial or first voltage. Thus, we say that current lags behind the initially applied voltage. Or, we can say that the voltage leads the current. The current may lag as much as 90 degrees. However, it is usually less as wire resistance and other factors influence the amount of actual lag.

Inductance of a coil is measured in henry's. This name comes from an outstanding scientist by the name of Joseph Henry who studied coils and their properties in the early days of electronics. Typically, millihenry's or even microhenry's are used to measure inductance. Large power transformers that you see in power substation may have 1000 henry's or more of inductance.

The opposition to current flow we just described is known as inductive reactance and is measured in ohms. Individual coils have inductive reactance. Two coils in close proximity have mutual inductance. That is the magnetic flux in one coil influences the inductance in the other coil.

Inductive reactance may be determined by the formula:  $X_L = 6.28 \times f \times L$ . That is the inductive reactance in ohms is determined by multiplying 6.28 times the frequency times the inductance in henry's.

The inductive reactance of coils in series is determined by simply adding their respective inductance's together. Inductive reactance of parallel coils is found by the same formula as for resistors in parallel. That is the two values are added and then divided by the product of them multiplied together.

Simple ohms law will not determine unknown values in an AC circuit. Remember we said that current lags voltage in an inductive circuit and in an earlier tech talk that voltage lags current in a capacitive circuit. However, in a purely resistive circuit with AC voltage applied both voltage and current is in phase. Simply measuring the resistance in a circuit with inductance, capacitance and resistance and dividing that resistance into the voltage will not provide the correct current level in the circuit. In the next tech talk we will discuss this further and include how to determine these values.

**Earlier we mentioned that coils have some DC resistance in their wire. We also said that coils have inductance reactance. The ratio of two is known as the “Q” of a coil. The ratio is determined by dividing the inductive reactance by the coils DC resistance. The higher the Q the better the coil. This means that the coil has little DC resistance to the flow of current. This makes the coil more efficient. Coils with a Q of 100 or more are quite common.**

**This conclude or discussion of coils. In the next tech talk we will discuss how coils, capacitors and resistors are used together.**