

Electronic Fundamentals – Part VIII

Combining Capacitors, Coils and Resistors

As we discussed earlier capacitors and coils resist the flow of current through them. As has been noted their resistance to current flow is called reactance. When these two reactance's are combined the combined reactance is referred to as impedance. Notice we said combined rather than added. We will go into more detail about this shortly.

The reactance of a coil, that is an inductor, is found using the formula of:

$$X_L = 6.28 \times F \times L$$

This is read as the inductive reactance of a coil is equal to 6.28 times the applied frequency times the inductance. The inductive reactance is expressed in ohms and the unit of inductance is the henry. So a coil with one henry of inductance at one megahertz has an inductive reactance of 6.28 megohms.

The reactance of a capacitor is found with a similar formula of:

$$X_C = \frac{1}{6.28 \times F \times C}$$

This is read as the capacitive reactance of a capacitor is equal to one divided by 6.28 times the applied frequency times the capacitance. The capacitive reactance is expressed as ohms and the unit of capacitance is the farad. So a capacitor with one farad of capacitance at one megahertz has a capacitive reactance of 0.000001 or one microhm.

Typically, resistors and or capacitors and inductors are combined in a circuit so the collective impedance expressed in ohms is in the range of several thousand ohms to several megohms. The capacitance of capacitors is usually measured in micro or pico farads. The inductance of coils is usually measured in henrys or milihenrys.

The impedance of a circuit as we said is the combined resistance, capacitance reactance and inductive reactance. First we need to know how to designate capacitance reactance and inductive reactance. Capacitance reactance is designated with the notation of “-j” and inductive reactance is designated as “+j”. By using these designation we can know instantly whether a reactance is capacitive or inductive. It is very important to know this as in many circuits including antennas we want to have an equal amount of each inductance to form a resonance circuit. By knowing the values of each we can readily know how much of each we may need to add or subtract to obtain resonance.

There is a formula we must use to combine them. The formula is:

$$Z = \sqrt{R^2 + X^2}$$

This is read as impedance equal to the square root of “R” squared times “X” squared. “X” is found by combining XC with XL. Lets say we have an capacitive reactance of -j300 and an inductive reactance of +j400. When combined they would equal +j100. Lets say our circuit has 150 ohms of resistance. Placing these values in the formula we would have an impedance of 180.28 ohms.

Lets presume our voltage source is 180 volts. We can easily see that the current through this series circuit will be one ampere. With one ampere flowing in the series circuit the voltage across the capacitive reactance is 300 volts and the voltage across the inductive reactance is 400 volts. Remember ohms law where $E = I \times R$. This situation is referred to as series resonance step-up voltage. So we have a total combined voltage in the circuit of over 800 volts.

Remember we have said that the voltage and current will be opposite in capacitors and inductors. If you viewed the AC wave form of each of the components in the above circuit you would see that the voltage across the inductor would be leading the voltage across the capacitor by approximately 180 degrees. But, it would be at 400 volts as compared to 300 volts across the capacitor. Thus the voltages don't in fact add they simply combine in the circuit leaving only 100 volts across the two.

You should notice the above is not a totally resonant circuit. In a totally resonant circuit the capacitive reactance and inductive reactance will be equal. We chose these value to help clarify the mathematics and circuit characteristics.

That concludes this series of tech talks on electronic fundamentals. Hopefully you have gained a bit of knowledge, understanding and appreciation of this very fascinating subject.