

Basic Electronics Part 25

by

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Now we consider a series circuit with an inductor, a capacitor, and an alternating voltage source, Fig. 1.

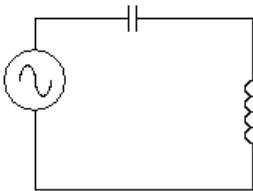


Fig. 1

This is a series circuit so the alternating voltage causes the same current to flow through each component. That is, the current through the capacitor is in phase with the current through the inductor. Because of this we consider the current to be at 0 degrees. The voltage across each of these components is not in phase, however. Remember that the alternating voltage in a capacitor lags the current by 90 degrees and the alternating voltage in an inductor leads the current by 90 degrees. Taking these two together we see that the voltage across the capacitor is 180 degrees out of phase with the voltage across the inductor. Since the current was at 0 degrees, then the voltage across the inductor is at 90 degrees and the voltage in the capacitor is at -90 degrees, Fig. 2.

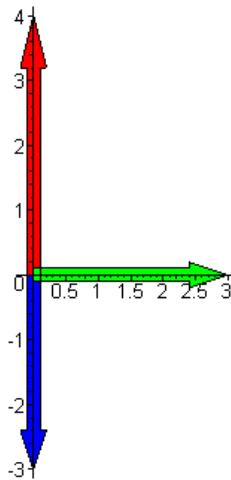


Fig. 2

Here the red arrow represents voltage across the inductor, the blue arrow represents the voltage across the capacitor, and the green arrow represents current.

If we know the current in the circuit we can calculate the voltages using Ohm's law. Let's assume that the current is 1 amp in this circuit. Suppose that the capacitor has a capacitive reactance of 3000 ohms and the inductance has an inductive reactance of 5000 ohms. To calculate the voltage across the capacitor, we use Ohm's law in the form

$$E = I X_C$$

where E is the voltage, X_C is the capacitive reactance, and I is the current.

Then $E = (1 \text{ A})(3000 \Omega) = 3000 \text{ volts}$. We take this voltage in the direction of -90 degrees as described above.

For the voltage across the inductor we use Ohm's law in the form

$$E = I X_L$$

where E is the voltage, X_L is the inductive reactance, and I is the current.

Then $E = (1 \text{ A})(5000 \Omega) = 5000 \text{ volts}$. We take this voltage in the direction of 90 degrees as described above.

Because of the phase relationship, we note that when the voltage across the inductor is at its positive peak, the voltage across the capacitor is at its negative peak. This 180 degree phase difference continues at each point of every cycle. To determine the total voltage we must combine these two voltages. To do this we consider the voltage across the capacitor as a -3000 volts since it is represented by the downward pointing arrow and the voltage across the inductor as $+5000$ volts since it is represented by the upward pointing arrow. The resulting voltage is the sum of these voltages or $+2000$ volts. The plus sign means that the resulting voltage is due to more inductive reactance than capacitive reactance.

We could have considered the total reactance in the circuit to be X . Then $X = X_L - X_C$. This means that $X = 5000\Omega - 3000\Omega = 2000\Omega$. Therefore, the voltage is

$$E = I X = (1 \text{ A})(2000\Omega) = 2000 \text{ volts.}$$

We subtract the capacitive reactance from the inductive reactance because we take the inductive voltage at 90 degrees and the capacitive voltage at -90 degrees.

Consider what would happen in this circuit if $X_C = 1000\Omega$ and $X_L = 800\Omega$. Calculate the voltage in the series circuit and interpret the result.