

Basic Electronics Part 15
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As we observed in Basic Electronics Part 14, in a series circuit with resistance, inductance and a battery (Fig. 2 of Part 14), changes in resistance cause changes in the current of the circuit. The resistance and inductance determine how quickly the current reaches a new value when the resistance changes. The inductor works against any current change. Inductors store energy in a magnetic field. Any change in current produces a change in the magnetic field. This produces a voltage that tries to prevent current change.

We use the term reactance to describe the opposition of an inductor to changes in current. We use the same term to describe the opposition of a capacitor to changes in voltage as we discussed earlier. We call the former inductive reactance and the latter capacitive reactance. The symbol, X_C , denotes capacitive reactance, and the symbol, X_L , denotes inductive reactance.

Since an inductor consists of a piece of wire wound to form a cylinder, the wire itself has a low resistance. If we connect the inductor to a dc voltage, the current won't change instantly because of the inductance, however, it will build to a high value because of the low resistance. That is, inductors act like a short circuit to direct current. In many circuits, we place a resistor in series with the inductor to limit the current. Inductive reactance is the opposition inductors have to current changes. Since inductors act like a short circuit at dc, we say they have zero reactance at dc.

Now suppose we apply a 100 Hz sine-wave voltage to a 10 mH inductor as in Fig. 1.

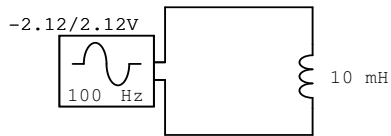


Fig. 1

In this case the ac source is 100 Hz with a peak value of 2.12 volts. This means the RMS value of the voltage is $E_{RMS} = (2.12)(0.707) = 1.5$ volts. If the inductor is 10mH and we measure the current as 0.239 amperes, then we can use Ohm's law to calculate the inductive reactance, as follows:

$$X_L = \frac{E_{RMS}}{I}$$

In this case the inductive reactance, X_L , replaces resistance on Ohm's law.

Therefore,

$$X_L = \frac{1.5}{0.239} = 6.28 \text{ ohms.}$$

Now let's replace the 10 mH inductor with a 20 mH inductor. When we read the ammeter in the circuit it reads 0.1194 A. If we calculate the inductive reactance again we get

$$X_L = \frac{1.5}{0.1194} = 12.56 \text{ ohms.}$$

Notice that this inductive reactance is exactly twice that of the previous example.

If we change the applied sine-wave voltage to a 1000 Hz source and change the inductor back to the original 10 mH inductor, the voltage supply still produces 1.5 volts RMS, but the current now reads 23.9 mA. If we calculate the inductive reactance with the new voltage source we get

$$X_L = \frac{1.5 \text{ volts}}{0.0239 \text{ A}} = 62.8 \text{ ohms.}$$

Notice that the new signal frequency is ten times larger than the original frequency and the current is ten times smaller than the first example. Also, the reactance is ten times larger! We see that a higher frequency signal produces a larger inductive reactance, for a given inductor.

We find that when either inductance or signal frequency increases, the inductive reactance increases. A relationship that expresses inductive reactance in terms of inductance and signal frequency is as follows:

$$X_L = 2\pi fL$$

where f is the frequency in hertz and

L is the inductance in henrys.

Use this formula in the above examples to see how they work. For example, if $f = 100$ Hz and $L = 10$ mH, then

$$X_L = 2\pi(100)(0.010) = 6.28 \text{ ohms.}$$

You calculate the other examples.