Electronic Basics #13: Coils / Inductors (Part 2) || Reactance

Inductive Reactance and Its Effect on Current Flow

Inductive reactance (XLX_L) is the opposition that an inductor presents to an **alternating current (AC)** due to its ability to generate a self-induced voltage. It is given by the formula:

X_L=2πfL

where X_L is inductive reactance (in ohms), **f** is the frequency of the AC signal (in hertz), and **L** is the inductance (in henries). From this equation, we can observe that:

- **At higher frequencies, X_L increases**, meaning the inductor blocks more current.ϕϕ

- **At lower frequencies, X_L decreases**, allowing more current to pass.

This behavior makes inductors useful for filtering signals in AC circuits, as they block high-frequency noise while allowing lower-frequency signals to pass.

Power in an Inductive Circuit

In an AC circuit containing an inductor, power is not purely consumed like in resistive loads but is instead alternately **stored and released** due to the magnetic field. The instantaneous power (PP) in an inductor is given by:

P=V×IP

However, because inductors cause a **phase shift** (explained below), the actual power delivered is influenced by the **power factor (cosϕ)**. The average or real power (Pavg) consumed by an ideal inductor over a full cycle is:

Pavg=VrmsIrmscosϕ_P

For an ideal inductor, the phase angle (ϕ) is **90°**, making cos90°=0, meaning the real power consumed is zero. Instead, inductors temporarily store energy in their magnetic field and return it to the circuit. However, in practical cases, small losses occur due to resistance in the coil.

Relation Between Reactance, Current Flow, and Phase Shift

Inductive reactance directly affects **current flow and phase shift** in AC circuits. According to **Ohm's Law for AC circuits**:

I=VXLI

Since X_L increases with frequency, the current decreases as frequency increases. This property is used in frequency-dependent applications like **filters, tuning circuits, and chokes**.

One of the most significant effects of an inductor is the **phase shift** between voltage and current. In a purely inductive circuit:

- **Voltage leads current by 90°**, meaning the voltage reaches its peak before the current does.

- This phase shift is essential in **AC power systems, transformers, and reactive power management**.
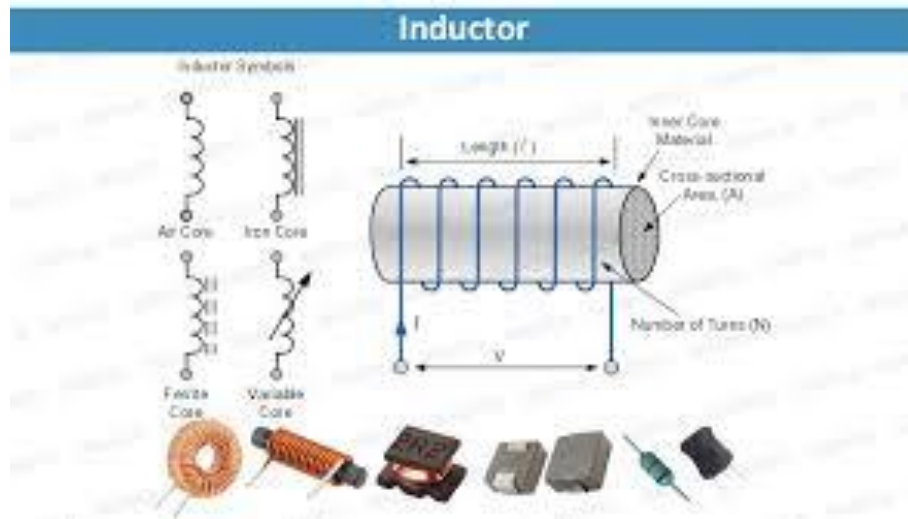
Fig13.2: Various Inductors

Conclusion

Inductors play a crucial role in controlling current flow, storing energy, and shaping electrical signals. Their opposition to AC current, measured by inductive reactance, increases with frequency, making them useful in applications like filtering and impedance matching. The phase shift between voltage and current in inductors is fundamental to AC circuit design, impacting power calculations and system efficiency.