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| Formula | Explanation |
| Inductor | Inductor can also be called as **choke coil** |
| Inductance | L =  = induced volt in coil  = rate of change in current  Ex. L = 1 Henry = |
| Energy stored inform of magnetic field | L = inductance  I = current |
| Inductance (L) | Two types of inductances   1. Self-Inductance 2. Mutual Inductance   L =  N = number of turns in the coil  = Magnetic Flux through one turn of coil  I = current in the coil |
| Lenz’s law | If current is induced in a conductor loop and is flowing anti-clock wise it acts as **S** pole of magnet  If current is induced in a conductor loop and is flowing clock wise it acts as **N** pole of magnet |
| Self-Inductance | **Definition:**  Self-inductance is the property of a coil (or any conductor) to oppose the change in current flowing through it by inducing a voltage (emf) in itself.  **How?**  When current in a coil changes, it creates a changing magnetic field. This changing magnetic field **cuts through the same coil** and induces a voltage **that opposes the current change** (as per Lenz’s Law).  **Formula:**  Induced emf (e) =  Where:   * L = self-inductance (in henrys, H) * ​ = rate of change of current   **Think of it like:**  A coil "resisting" change in its own current, like inertia for electricity.  **Ex. :** **Self-inductance**: You turn off a fan, and it slows down gradually — the motor’s coil tries to keep current flowing (inductance). |
| Mutual Induction | **Definition:**  Mutual inductance is the ability of one coil to induce a voltage in **another nearby coil** when current in the first one changes.  **How?**  If two coils are near each other, a changing current in coil 1 creates a changing magnetic field → this magnetic field **passes through coil 2** → induces voltage in coil 2.  **Formula:**  Induced emf in coil 2 (e₂)= ​​  Where:   * M = mutual inductance between coil 1 and coil 2 * ​​ = rate of change of current in coil 1   **Ex. : Mutual inductance**: You place your phone on a wireless charger — the changing magnetic field from the charger induces current in your phone’s coil. |
| Time for inductor charging and discharging | Time taken for an inductor to charge fully /discharge fully is 5  Here by charging discharging means when the magnetic field is generated fully/collapsed fully as per the change in current  This τ tells you **how quickly current changes in an RL circuit**. |
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| Inductor in series and parallel |  |
| Inductor power in AC circuits | * In DC voltage and current has no phase angle between them * In AC voltage and current are sinusoidal * Power here in terms of AC has two components (Active power (that is been consumed or used) + reactive power (that is been consumed but released also (so net power is 0)) (ex. inductor saves energy in form of magnetic field and then releases it when needed –thus net power is 0) * S = P(active power) + Q(reactive power) = S=P+jQ (jQ is imaginary 🡪 as it gets consumed and released so net power is 0)   **Real (Active) Power, P**   * Power that actually does useful work * Converts into heat, light, motion, etc. * Unit: **Watt (W)** * Formula:   P = VI cos Ø  **Reactive Power, Q**   * Power that is stored and returned to the source * No actual energy is consumed permanently * Unit: **VAR (Volt-Amp Reactive)** * Formula:   Q = VI sin Ø   * For **resistor** S = P + Q = VI cos(0) + VI sin(0) = VI (1) + VI (0) = VI [only real part exists for resistor] * For **Capacitor** S = P + Q = VI cos(-90) + VI sin(-90) = VI (0) + VI (-1) = -VI [only imag part exists for capacitor as it consumes and releases power so net power is 0] * For **inductor** S = P + Q = VI cos(90) + VI sin(90) = VI (0) + VI (1) = VI [only imag part exists for inductor as it consumes and releases power so net power is 0]   So, for Inductor S = P + Q = VI cos(90) + VI sin(90) = VI (0) + VI (1) = VI |
| Inductor behaviour in AC and DC | | **Behaviour** | **DC (constant current)** | **AC (changing current)** | | --- | --- | --- | | 🔋 **Steady DC** | Acts like a **short circuit** after initial magnetic buildup | --- | | ⚡ **AC** | Reacts to changing current → constantly **creates opposition (reactance)** | Voltage and current can be **out of phase** | | ⏱️ **At switch ON** | Initially resists sudden current rise | Keeps opposing every change — always working |   **In DC:**   * When you first apply voltage → inductor resists current rise (acts like open). * After a while → current stabilizes → inductor acts like a **wire** (short).   **In AC:**   * Since current is **always changing**, inductor **keeps resisting**. * Opposition to AC is called **inductive reactance**:      * + F = frequency   + Higher the frequency → greater the opposition. |
| **Applications of Inductors — and How They Work** | **Power Supplies (DC-DC Converters, SMPS)**  🔋 Role of the Inductor:   * In buck, boost, or buck-boost converters, inductors store energy when the switch is ON and release energy when the switch is OFF. * This controls how much voltage reaches the output.   🧠 How it works:   * When the switch is ON → current builds up in the inductor → energy is stored in the magnetic field. * When the switch is OFF → inductor keeps current flowing to the output → smoothens the voltage.   👉 Why used?   * To regulate voltage efficiently * To avoid sudden current drops * Acts like a "magnetic battery"   **Filters (Signal Filtering – Low Pass, High Pass)**  🎚️ Role of Inductor:   * In low pass filters, inductors block high-frequency signals but allow low frequencies. * In high pass filters, capacitors are used instead.   🧠 How it works:   * Since inductor’s reactance XL=2πfL , it increases with frequency. * So, high-frequency signals are blocked or redirected. * Low-frequency (or DC) signals pass freely.   👉 Used in:   * Audio electronics * Analog circuits * EMI suppression   **Transformers (Mutual Inductance)**  🔄 Role:   * Two inductors (coils) placed close together can transfer energy via magnetic field. * Used to step up/down voltage or isolate circuits.   🧠 How it works:   * Primary coil → AC current → changing magnetic field * Secondary coil → experiences that field → induces voltage   👉 Based on mutual inductance, and key to:   * Power transmission * Charging adapters * Isolation transformers   **Motors and Relays (Inductive Loads)**  🔄 In Motors:   * Windings act as inductors. * Magnetic fields create torque on the rotor.   🔌 In Relays:   * Relay coil is an inductor — energized by current to pull contact switch. * When turned OFF suddenly → needs a flyback diode to protect from voltage spike (you already nailed this one! 😉)   **Energy Storage (Magnetic Field)**  🧠 How:  Inductors store energy as   * This stored energy is used to keep current flowing when supply drops momentarily.   👉 Used in:   * Battery backup systems * Buck/boost regulators   **EMI Filters / Chokes**  📡 Problem:   * Fast-switching circuits generate electromagnetic interference (EMI).   🛡️ Solution:   * Inductors (ferrite beads, common-mode chokes) resist rapid current changes → filter out noise.   👉 Found in:   * Laptop chargers * TVs, radios * VLSI board power lines |
| Inductor in RL circuit | **1. What is an RL Circuit?**  It’s a circuit that contains:   * **Resistor (R)** * **Inductor (L)** * **Voltage source (V)**   **2. Time Constant (τ) for Inductor Circuits**   * τ = time constant (in seconds) * L = inductance (henrys) * R = resistance (ohms)   🧠 **What does it mean?**  τ is the time it takes for the current to reach about **63.2% of its final value** during growth or drop to **36.8%** during decay.  Inductors **resist sudden current change**, so current grows or falls **exponentially**, not instantly.  **3. Current Growth in RL Circuit (Switch ON)**  ⚡ When you turn ON the switch:   * (final steady state current) * t = time after switch is closed * **=** exponential decay   **⚠️ Behaviour:**   | **Time** | **Current I(t)** | | --- | --- | | t=0 | 0 A (initial) | | t=τ | ~63.2% of final current | | t=5τ | >99% (considered "fully charged") |   **4. Current Decay in RL Circuit (Switch OFF)**   * ​ = initial current at the moment switch is opened * Current decreases **exponentially** as the magnetic field collapses   **⚠️ Behaviour:**   | **Time** | **Current I(t)** | | --- | --- | | t=0 | I₀ A (initial) | | t=τ | ~36.8% of I₀ | | t=5τ | ~0 A (almost fully decayed) | |
| LC circuit | LC Circuit is also known as a "tank circuit" or "inductor-capacitor circuit".  LC Circuit is a simple electrical circuit that consists of two main components: an inductor and a capacitor.  These components can further be added together in **series or parallel** configurations based on the required task at hand.  An LC circuit is used to store electrical energy in the circuit with the help of magnetic resonance.  The **energy** or **current** in an LC circuit **oscillates** between the **inductor and capacitor** just like a pendulum swing back and forth.  An LC circuit is used to store electrical energy in the circuit with the help of magnetic resonance. Resonance in an LC circuit occurs when the magnitude of inductive reactance and capacitive reactance in the LC circuit becomes equal. The frequency at which this occurs is known as resonant frequency. ( )   * If f < f0 then XC >> XL. Thus, the circuit is capacitive in nature. * If f < f0 then XC << XL. Thus, the circuit is inductive in nature.   **Series LC Circuit (impedance Z in series ckt = 0)**  In a series LC circuit, capacitor C and inductance L are connected in series with each other. A series LC circuit is shown below:  Series-LC-Circuit  **Parallel LC Circuit (impedance Z in parallel ckt = Z = ) (as in parallel impedance is 1/z = 1/xc + 1/xl = 1/0 = )**  In a series LC circuit, capacitor C and inductance L are connected in parallel with each other. A parallel LC circuit is shown below:  Parallel-LC-Circuit |
| DCR (DC resistance) | Even a coil of copper wire has some resistance. DCR = DC resistance of inductor winding.   * Lower DCR → better efficiency * Higher DCR → more heat, more voltage drops |
| Q factor (quality factor) | L = Inductance  R = resistance(DCR)  High Q = low energy loss → useful in **filters**, **RF circuits** |
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