FREE NOTES · NCERT + JEE/NEET LEVEL

Alternating Current

AC voltage, rms value, R, L aur C ke saath AC, phasors, LCR circuit, impedance, resonance, power factor, LC oscillations aur transformer. Phasor diagrams aur solved numericals ke saath.

01 AC kya hai
02 RMS & average value
03 AC across resistor
04 Series LCR circuit
05 Resonance
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01 AC kya hai

Jo voltage/current time ke saath **sine wave ki tarah** direction badalta rahe.

$$v = V_m \sin \omega t,\ i = I_m \sin(\omega t + \varphi)$$

V_m = peak value, $\omega = 2\pi f$. Ghar ki supply India me 220 V (rms), 50 Hz.

AC kyun? Transformer se voltage aasaani se upar-neeche ho jaata, isliye door tak high voltage pe kam loss se bheja ja sakta.

02 RMS & average value

$I_{rms} = I_m/\sqrt{2} \approx 0.707\ I_m$

$V_{rms} = V_m/\sqrt{2}$

Poore cycle ka average $= 0$; aadhe cycle ka average $= 2I_m/\pi \approx 0.637\ I_m$

RMS KA MATLAB

Wo DC value jo resistor me **utni hi garmi** paida kare. Voltmeter, ammeter aur ghar ka "220 V" sab rms value hain. Peak = 220√2 ≈ 311 V.

03 AC across resistor

v aur i **same phase** me (φ = 0). $I_m = V_m/R$. Power $P = I^2_{rms}R$.

04 AC across inductor

Inductive reactance $X_L = \omega L = 2\pi fL$

Current voltage se **π/2 peeche** (lag). f badhe ⇒ X_L badhe. DC (f = 0) pe X_L = 0. Average power = 0.

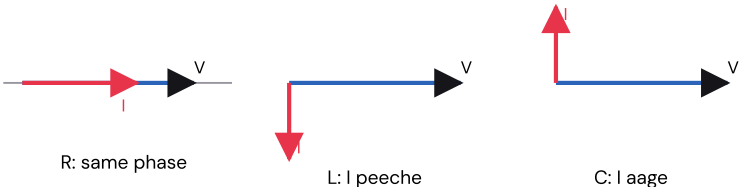
05 AC across capacitor

Capacitive reactance $X_C = 1/(\omega C) = 1/(2\pi fC)$

Current voltage se **π/2 aage** (lead). f badhe ⇒ X_C ghate. DC pe X_C = ∞ (capacitor DC rok deta). Average power = 0.

YAAD KARNE KI TRICK: "CIVIL"

C me **I** pehle **V** (current leads); **V** pehle **I** in **L** (voltage leads, current lags).



Phasors anticlockwise ghoomte hain; aage = upar

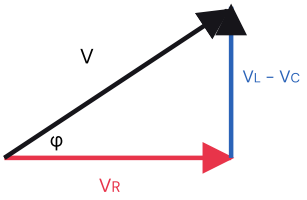
04 Series LCR circuit

$$Z = \sqrt{(R^2 + (X_L - X_C)^2)}$$

$$I = V/Z$$

$$\tan \varphi = (X_L - X_C)/R$$

Z = impedance (Ω). $X_L > X_C$: inductive (I lag). $X_C > X_L$: capacitive (I lead).



Voltage triangle (impedance triangle jaisa)

Voltages: $V = \sqrt{(V_R^2 + (V_L - V_C)^2)}$. V_L aur V_C akele supply se zyada ho sakte hain!

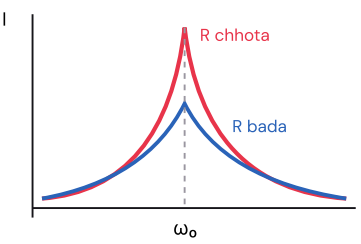
05 Resonance

Jab $X_L = X_C$, tab Z = R (minimum), current **maximum**, φ = 0.

$$\omega_0 = 1/\sqrt{(LC)},\ f_0 = 1/(2\pi\sqrt{(LC)})$$

Quality factor $Q = \omega_0 L/R = (1/R)\sqrt{(L/C)}$

Q zyada ⇒ peak nukeela ⇒ tuning sharp. Bandwidth = $R/L = \omega_0/Q$.



Kam R ⇒ tez aur patla peak

Radio/TV tuning: capacitor badal ke circuit ko station ki frequency pe resonance me laate hain. Resonance sirf **L aur C dono** ho tab.

06 Power & power factor

$$P_{avg} = V_{rms}\, I_{rms} \cos\varphi$$

Power factor $\cos\varphi = R/Z$

Circuit	φ	cos φ	Power
Sirf R / resonance	0	1	Max ($V_{rms}I_{rms}$)
Sirf L ya sirf C	π/2	0	0 (**wattless current**)

WATTLESS CURRENT

Pure L ya C me current behta hai par average power 0: energy ek half-cycle me store, agle me wapas. Isliye **choke coil** (bada L, chhota R) se current kam karna resistor se behtar (energy waste nahi). Factories me low power factor improve karne ke liye capacitor lagaate hain.

07 LC oscillations

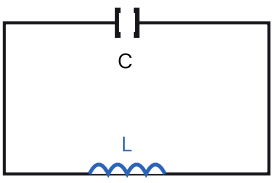
Charged capacitor ko inductor se jodo: energy capacitor ke electric field se inductor ke magnetic field me aur wapas, baar-baar.

$$\omega = 1/\sqrt{(LC)}$$

$q = q_0 \cos \omega t$

Total energy $= q_0^2/(2C) = \frac{1}{2}LI_0^2$

Spring-mass SHM jaisa: L ↔ m, 1/C ↔ k, q ↔ x. R ho toh oscillations damp ho jaate.



LC circuit: energy aage-peeche

08 Transformer

Mutual induction pe: primary coil me AC ⇒ core me badalta flux ⇒ secondary me EMF. **Sirf AC** pe chalta.

$$V_s/V_p = N_s/N_p = I_p/I_s$$

Ideal: $V_pI_p = V_sI_s$. Step-up: $N_s > N_p$ (voltage upar, current neeche). Step-down: ulta. Efficiency = output/input.

Energy loss	Kam kaise
Copper loss (I^2R)	Mote taar
Eddy current	Laminated core
Hysteresis	Soft iron core
Flux leakage	Coils ek ke upar ek lapetna

09 JEE Extra + Tricks

JEE LEVEL

- Phase trick "**ELI the ICE man**": L me voltage (E) current (I) se 90° aage; C me current voltage se 90° aage.
- Impedance $Z = \sqrt{(R^2 + (X_L - X_C)^2)}$; $\tan\varphi = (X_L - X_C)/R$; resonance $\omega_o = 1/\sqrt{(LC)}$, Z = R, current max.
- Quality factor $Q = \omega_o L/R = (1/R)\sqrt{(L/C)}$; bandwidth = R/L (ω me).
- Average power $P = V_{rms} I_{rms} \cos\varphi$; sirf L ya C $\Rightarrow \cos\varphi = 0$ (wattless current).
- Sine wave ke liye $I_{rms} = I_o/\sqrt{2}$; poore cycle ka average 0, aadhe cycle ka $2I_o/\pi$.
- Ideal transformer: $V_s/V_p = N_s/N_p = I_p/I_s$.

10 Solved numericals

Q1. 220 V rms supply ka peak voltage?
$V_m = 220\sqrt{2} \approx 311$ V. **Ans: ≈ 311 V**

Q2. 0.5 H inductor 50 Hz pe. X_L? (π = 3.14)
$X_L = 2\pi \times 50 \times 0.5 = 157\ \Omega$. **Ans: 157 Ω**

Q3. LCR: R = 30 Ω, X_L = 80 Ω, X_C = 40 Ω, V = 200 V. Z, I, power factor, power?
$Z = \sqrt{(900 + 1600)} = 50\ \Omega$. $I = 4$ A. $\cos\varphi = 30/50 = 0.6$. $P = 200 \times 4 \times 0.6 = 480$ W. **Ans: 50 Ω, 4 A, 0.6, 480 W**

Q4. L = 1 mH, C = 10 µF. Resonant frequency?
$\omega_o = 1/\sqrt{(10^{-3} \times 10^{-5})} = 1/\sqrt{(10^{-8})} = 10^4$ rad/s ⇒ $f_o \approx 1592$ Hz. **Ans: ≈ 1.6 kHz**

Q5. Transformer: 220 V se 11 V, primary me 1000 turns. Secondary turns? Secondary me 2 A ho toh primary current (ideal)?
$N_s = 1000 \times 11/220 = 50$. $I_p = 2 \times 11/220 = 0.1$ A. **Ans: 50, 0.1 A**

11 Common mistakes

- AC ka average poore cycle pe $2I_m/\pi$ maan lena (poore cycle pe 0).
- L aur C me lead/lag ulta yaad karna (CIVIL).
- $Z = R + X_L + X_C$ seedha jodna (vector way se jodo).
- Wattless current ko "current nahi" samajhna (current hai, power 0).
- Transformer ko DC pe chalana ya energy badhane wala samajhna.

12 Formula sheet

RMS	$V_{rms} = V_m/\sqrt{2}$
Reactances	$X_L = \omega L,\ X_C = 1/\omega C$
Impedance	$Z = \sqrt{(R^2 + (X_L - X_C)^2)}$
Phase	$\tan\varphi = (X_L - X_C)/R$
Resonance	$\omega_0 = 1/\sqrt{(LC)}$
Q factor	$\omega_0 L/R$
Power	$P = V_{rms} I_{rms} \cos\varphi,\ \cos\varphi = R/Z$
LC oscillation	$\omega = 1/\sqrt{(LC)}$
Transformer	$V_s/V_p = N_s/N_p = I_p/I_s$

13 Practice questions

1. Frequency 2 guna. X_L aur X_C?
2. Resonance pe LCR circuit ka power factor?
3. L aur C dono 4 guna. Resonant frequency?
4. Capacitor DC pe kya karta hai?

ANSWERS

1) X_L 2 guna, X_C aadha · 2) 1 · 3) 1/4 · 4) Charge hone ke baad current rok deta ($X_C = \infty$)

14 Quick revision: exam se pehle 5 minute

BASICS

- $V_{rms} = V_m/\sqrt{2}$.
- R: same phase; L: I lag; C: I lead.
- $X_L = \omega L$; $X_C = 1/\omega C$.

LCR

- $Z = \sqrt{(R^2 + (X_L - X_C)^2)}$.
- Resonance: $X_L = X_C$, Z = R, I max.
- $\omega_o = 1/\sqrt{(LC)}$.

POWER

- $P = VI \cos \varphi$; $\cos \varphi = R/Z$.
- Pure L/C: wattless.
- Choke coil: loss nahi.

TRANSFORMER

- $V \propto N$, $I \propto 1/N$.
- Laminated soft iron core.
- Sirf AC.

Doubt hai? padhaiadda.netlify.app pe AI Doubt Solver se poocho, ya is chapter ka mock test do.