Unit - II
2.15 Problems in Series RLC Circuits

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Syllabus

UNIT – II **14 Periods**

DC Circuit Analysis: Voltage source and current sources, ideal and practical, Kirchhoff's laws and applications to network solutions using mesh analysis, - Simplifications of networks using series- parallel, Star/Delta transformation, DC circuits-Current-voltage relations of electric network by mathematical equations to analyse the network (Superposition theorem, Thevenin's theorem, Maximum Power Transfer theorem), Transient analysis of R-L, R-C and R-L-C Circuits.

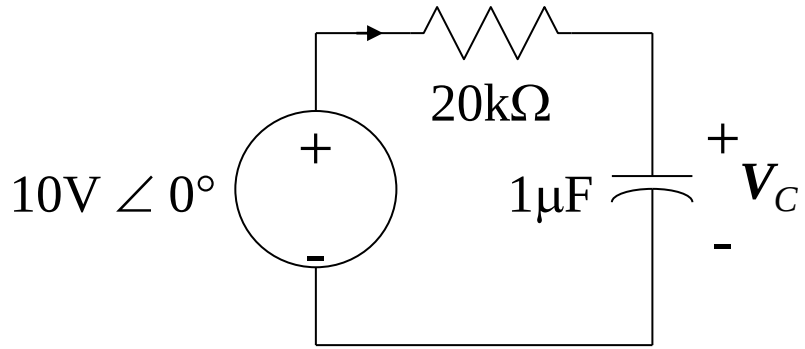
AC Steady-state Analysis: AC waveform definitions - Form factor - Peak factor - study of R-L - R-C -RLC series circuit - R-L-C parallel circuit - phasor representation in polar and rectangular form - concept of impedance - admittance - active - reactive - apparent and complex power - power factor, Resonance in R-L-C circuits - 3 phase balanced AC Circuits

Sinusoidal Steady State Analysis

Impedance

Complex Impedance

Phasors and complex impedance allow us to use Ohm's law with complex numbers to compute current from voltage and voltage from current



ω = 377

Find V_C

- How do we find V_C?
- First compute impedances for resistor and capacitor:

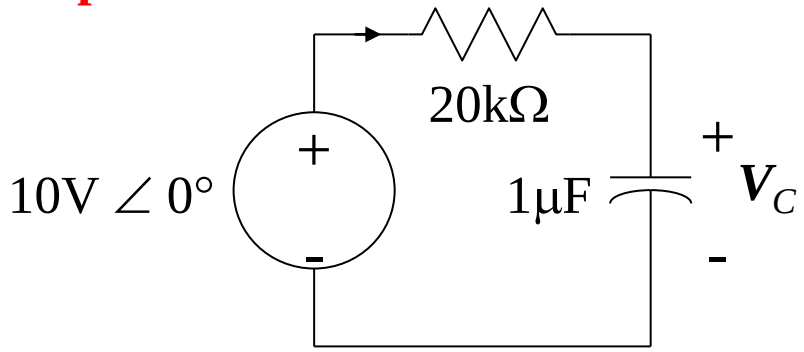
$$\mathbf{Z}_R = 20\text{k}\Omega = 20\text{k}\Omega \angle 0°$$

$$\mathbf{Z}_C = 1/j\,(377 * 1\mu\text{F}) = 2.65\text{k}\Omega \angle -90°$$

Sinusoidal Steady State Analysis

Impedance

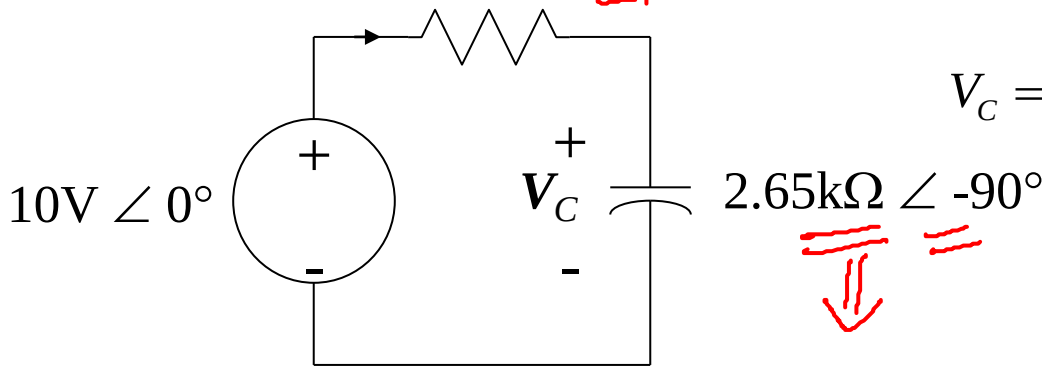
Complex Impedance



$\omega = 377$

Find V_C

Now use the voltage divider to find V_C:



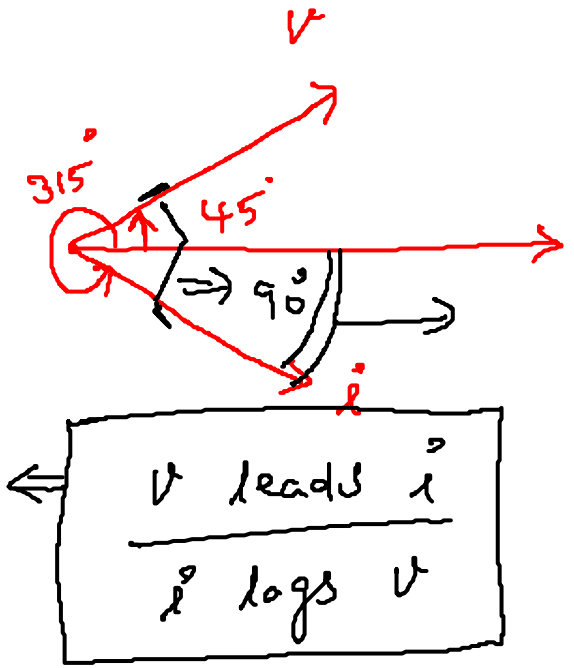
$$V_C = 10V\angle 0^\circ\left(\frac{2.65k\Omega\angle -90^\circ}{2.65k\Omega\angle -90^\circ + 20k\Omega\angle 0^\circ}\right)$$

$$\mathbf{V_C} = 10\text{V}\angle 0^\circ \frac{2.65\angle -90^\circ}{20.17\angle -7.54^\circ}$$

$$= 1.31\text{V}\angle -82.46^\circ$$

Question 3

Example 11.52. *The voltage across and current through a circuit element are :*
$v = 100 \sin (314t + 45°)$ *volts ; *$i = 10 \sin (314t + 315°)$ *amperes*
(i) Identify the circuit element. (ii) Find the value. (iii) Obtain expression for power.



i) Inductor

ii) $L = ?$

$V = IX$

$X_L = \frac{V_M}{I_M} = \frac{100}{10} = 10\,\Omega$

$X_L = \omega L = 10 \Rightarrow L = \frac{10}{\omega} = \frac{10}{314} \Rightarrow \boxed{L = 0.031\ H}$

iii) $p = \frac{-V_m I_m}{2} \sin 2\omega t = \frac{-100 \times 10}{2} \sin (2 \times 314 \times t)$

$\boxed{p = -500 \sin 628t}$

Ques 4

$v = 240 \sin(1.25\times10^4 t - 30^\circ)$ | $i = C\cdot\frac{dv}{dt}$

Example 11.55. *The voltage across a 0.01 μ F capacitor is 240 sin (1·25 × 10^4 t − 30°) V. Write the mathematical expression for the current through it.*

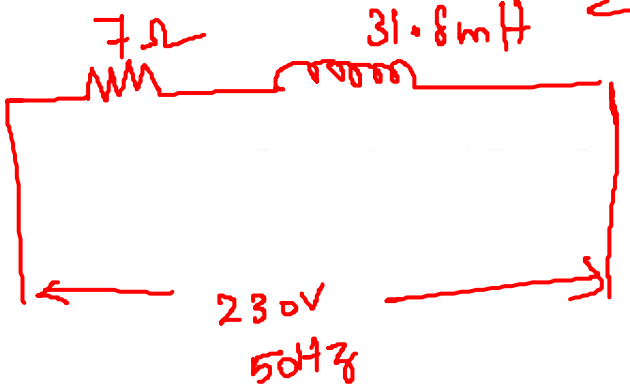
$$i = I_m \sin(1.25\times10^4 t - 30 + 90^\circ)$$

$V_m = X_C I_m$

$$I_m = \frac{V_m}{X_C} = \frac{240}{\frac{1}{(1.25\times10^4)\times(0.01\times10^{-6})}} = 0.03\,A$$

$$i = 0.03 \sin(1.25\times10^4 t + 60^\circ)\ A$$

Q5: *A coil having a resistance of 7 ohm and an inductance of 31·8 mH is connected to 230 V, 50 Hz supply. Calculate (i) the circuit current (ii) phase angle (iii) power factor (iv) power consumed and (v) voltage drop across resistor and inductor.*



(iv) Active Power

i) $V = IZ$

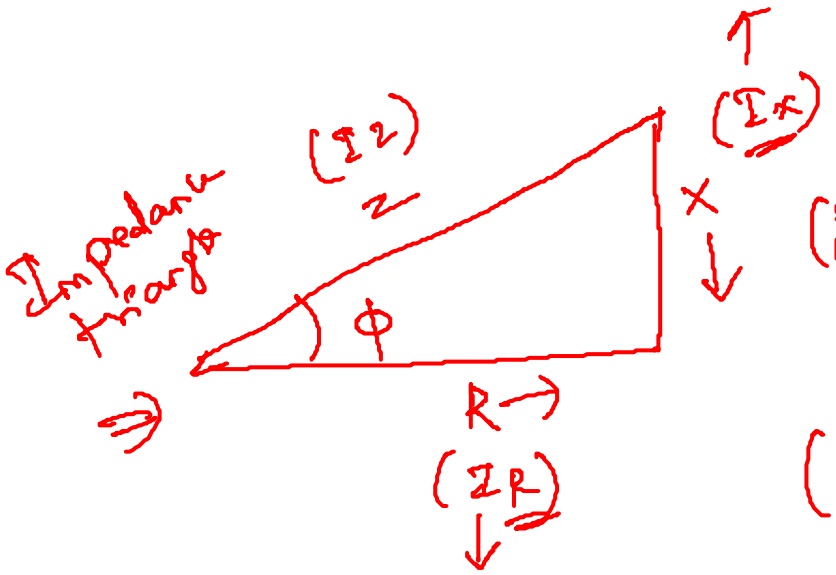
$Z = \frac{V}{I} \Rightarrow I = \frac{V}{Z} = \frac{230}{12.2} = 18.85A$

$Z = \sqrt{R^2 + X_L^2} = \sqrt{7^2 + (2\pi \times 50 \times 31.8 \times 10^{-3})^2}$

$X_L = 2\pi \times 50 \times 31.8 \times 10^{-3}$

$X_L = 9.985 \simeq 10$

$\boxed{Z = 12.2\ \Omega}$



(ii) $\tan\phi = \frac{X}{R} = \frac{10}{7} =$

$\boxed{\phi = 54.96^\circ \text{ (lag)}}$

(iii) $pf = \cos\phi = \cos(54.96^\circ) = 0.57 \text{ (lag)}$

(iv) $P_a = VI\cos\phi$

$= 230 \times 18.85 \times 0.573$

$P_a = 2484.24$ (W)

(v) $V_L = IX_L$

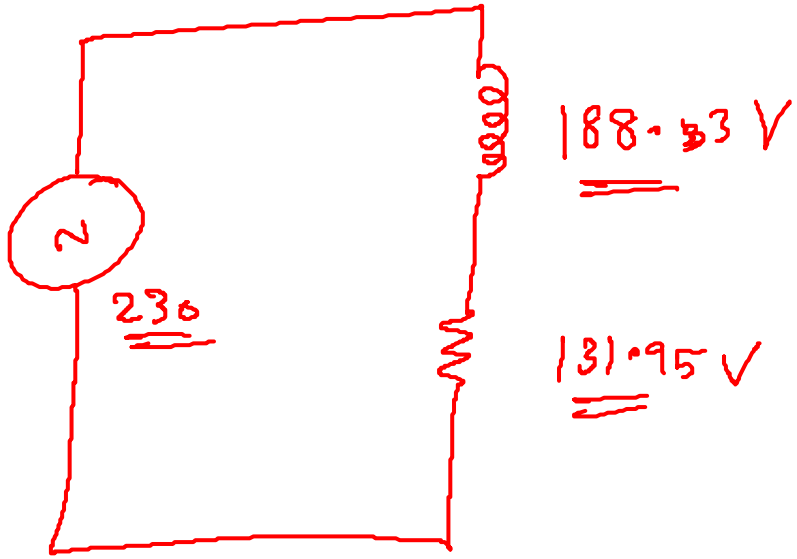
$V_L = 188.3$ (V)

$V_R = IR$

$V_R = 131.95$ (V)

Power

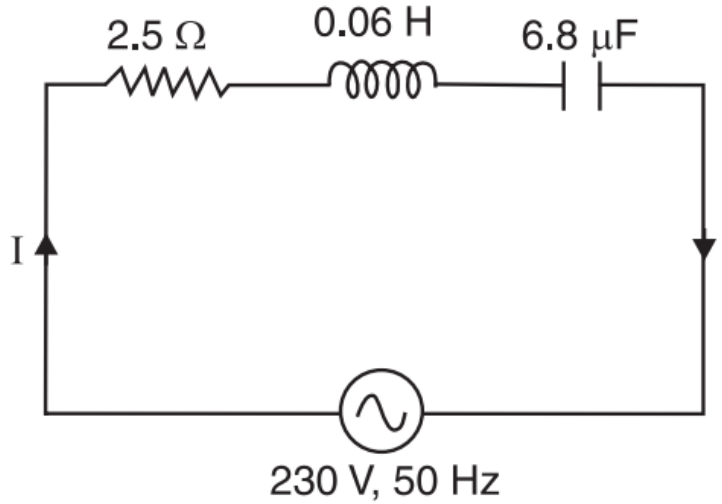
- Real → $VI\cos\phi$
- Reactive → $VI\sin\phi$
- Apparent → VI

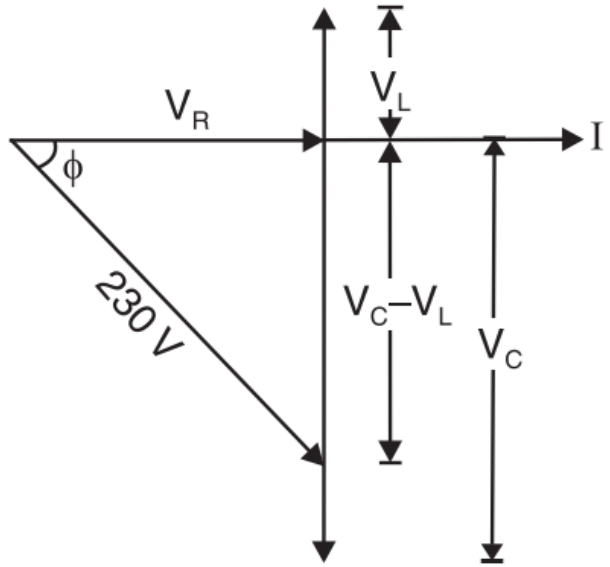


$\Rightarrow 230 \neq 188.3 + 131.95$

$v = v_L + v_R$ ✓

Q7:*A 230 V, 50 Hz a.c. supply is applied to a coil of 0.06 H inductance and 2.5 Ω resistance connected in series with a 6·8 μF capacitor. Calculate (i) impedance (ii) current (iii) phase angle between current and voltage (iv) power factor and (v) power consumed.*





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Exercise

i) $X_L =$

$X_C =$

$Z = R + j(X_L - X_C)$

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

Deetchitha

$|Z| =$

(ii) $I = \frac{V}{Z}$

$I =$

Ruhi Raju

(iii) $\tan\phi = \frac{X_L - X_C}{R}$

Vrinda

$\phi =$

(iv) $Pf = \cos\phi$

$Pf =$

Shrishketh

(v) $P = VI\cos\phi$

$P =$

Malvika

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Malvika

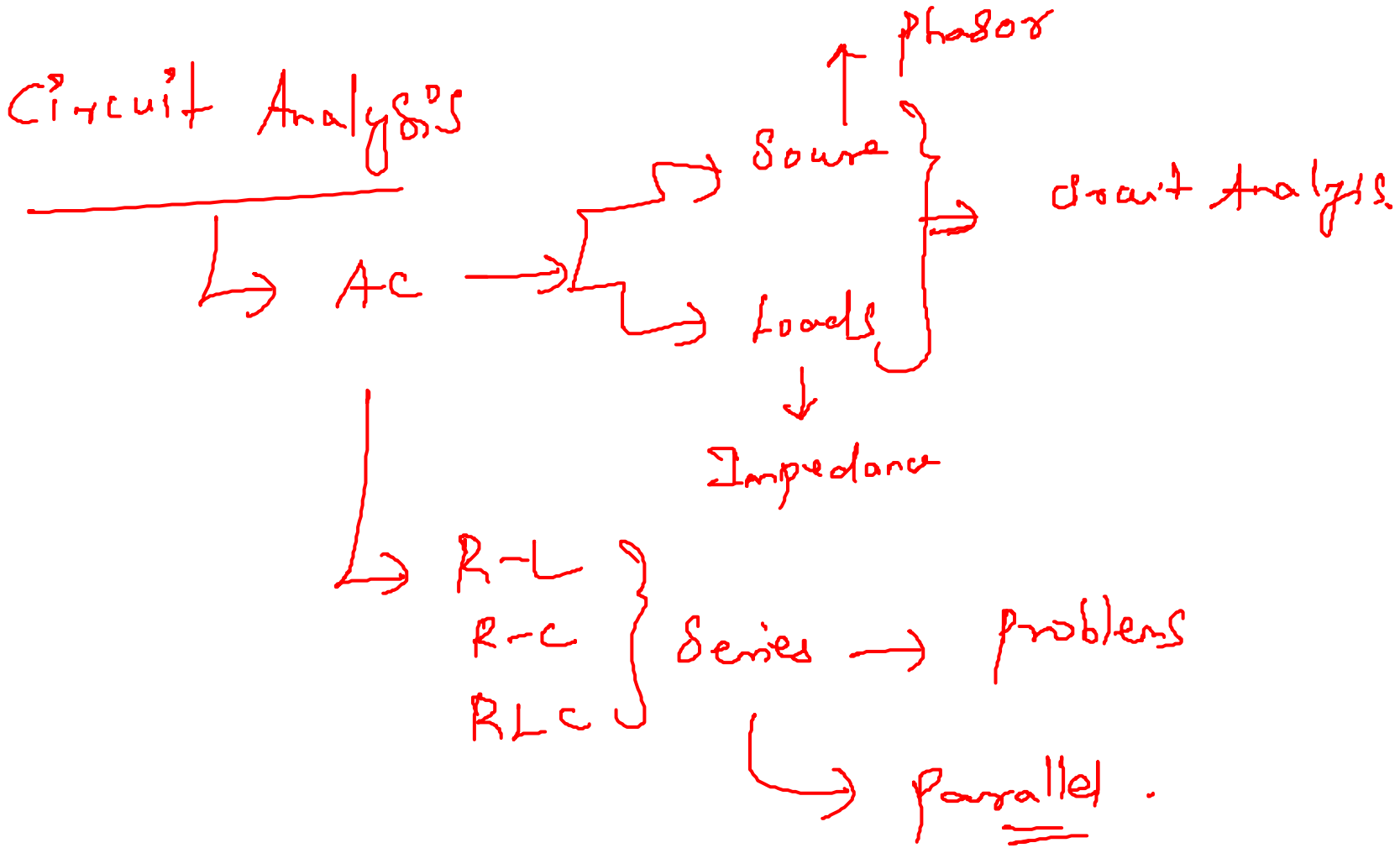
Q8. In a series circuit containing pure resistance and a pure inductance, the current and the voltage are expressed as :

$$i(t) = 5\sin(314\,t + 2\pi/3)\; and\; v(t) = 15\sin(314\,t + 5\,\pi/6)$$

Find (i) impedance of the circuit (ii) resistance value (iii) inductance value (iv) average power drawn by the circuit (v) circuit power factor.

Exercise

Summary


Circuit Analysis
AC
Source
Loads
phasor
circuit analysis
Impedance
R-L
R-C
RLC
Series → problems
Parallel.