Lec-25

$\frac{dy}{dt} + ay = x(t)$ → if $x(t)$ can be expressed in exponential form

$(D+a)y = Ae^{st}$ — s could be imaginary or complex.

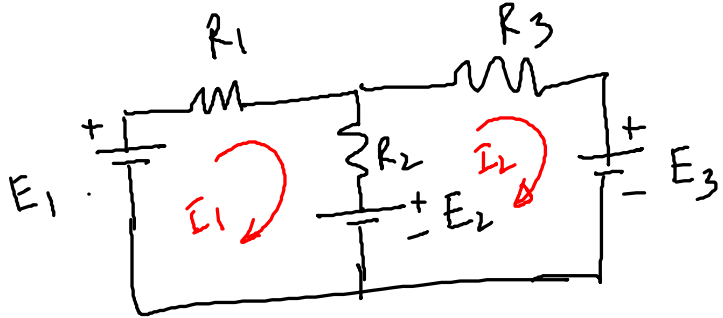
$$y_f(t) = \frac{Ae^{st}}{(D+a)}\Big|_{D=s}$$

If $x(t)$ = constant $= A = Ae^{0xt}$ $s=0$

$$\frac{d^2y}{dt^2} + a\frac{dy}{dt} + by = Ae^{st}$$

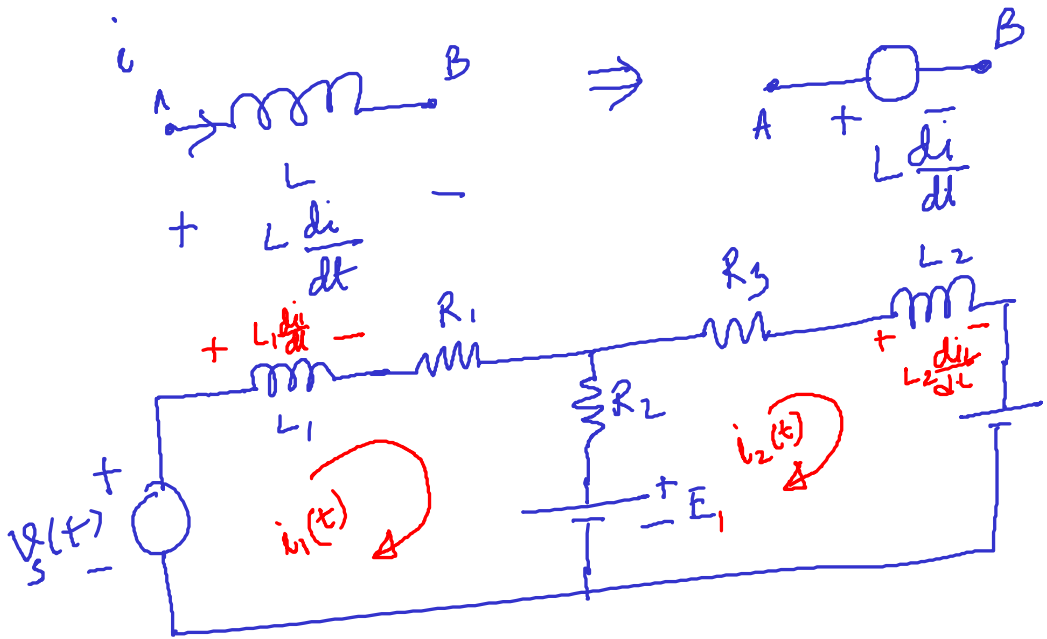
$$y_f(t) = \frac{Ae^{st}}{(D^2+aD+b)}\Big|_{D=s}$$

$$y(t) = \underline{A_1 e^{m_1 t} + A_2 e^{m_2 t}} + y_f(t)$$



$$(R_1+R_2)\,I_1 - R_2\,I_2 = E_1 - E_2$$

$$-R_2\,I_1 + (R_2+R_3)\,I_2 = E_2 - E_3$$



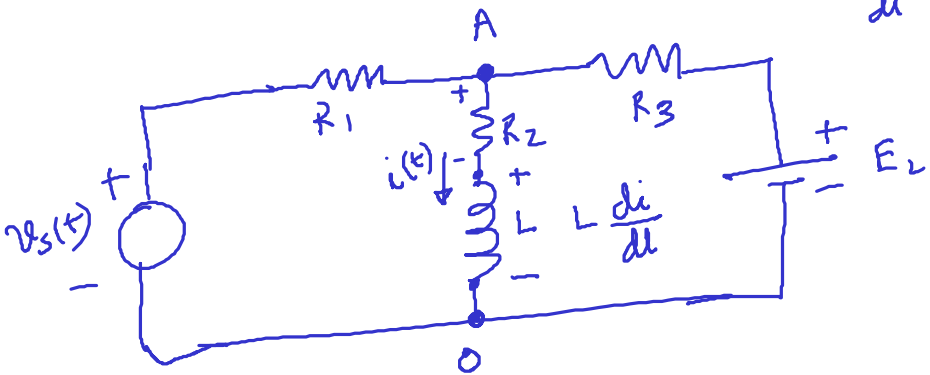
g_n mesh-1 : KVL

$$(R_1+R_2)\,i_1 - R_2\,i_2 = v_s(t) - E_1 - L_1\frac{di_1}{dt}$$

g_n mesh-2 KVA

$$-R_2\,i_1 + (R_2+R_3)\,i_2 = E_1 - E_2 - L_2\frac{di_2}{dt}$$

i ⇒ $L\frac{di}{dt}$ ⇒ Nodal method

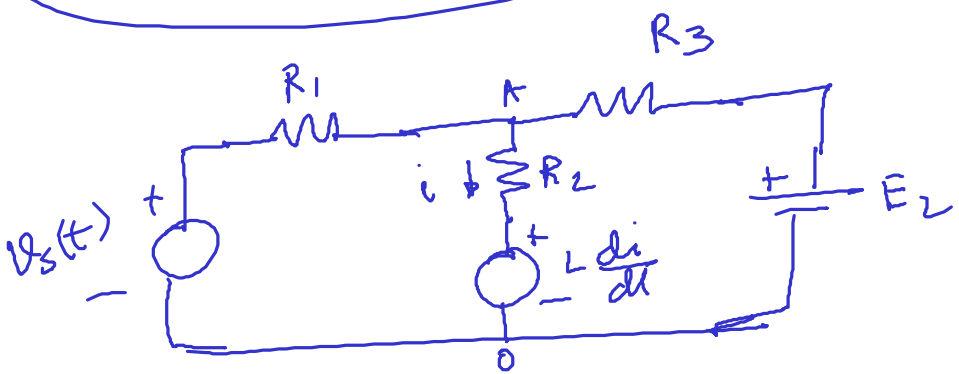


To write the KCL at node A:

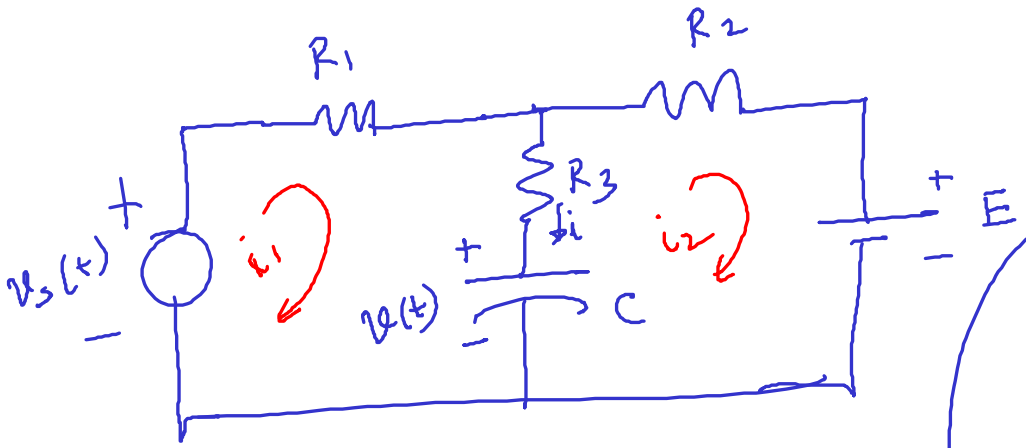
$$\frac{v_{A0} - v_s(t)}{R_1} + i(t) + \frac{v_{A0} - E_2}{R_3} = 0$$

or $$\left(\frac{1}{R_1} + \frac{1}{R_3}\right) v_{A0} + i(t) = \frac{v_s(t)}{R_1} + \frac{E_2}{R_3}$$

$$v_{A0} = L\frac{di}{dt} + R_2 i$$



$$v_{A0}\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) = \frac{v_s}{R_1} + \frac{L\frac{di}{dt}}{R_2} + \frac{E_2}{R_3}$$



$i = i_1 - i_2$

mesh analysis.

$i = C\frac{dv}{dt}$

KVL in mesh 1

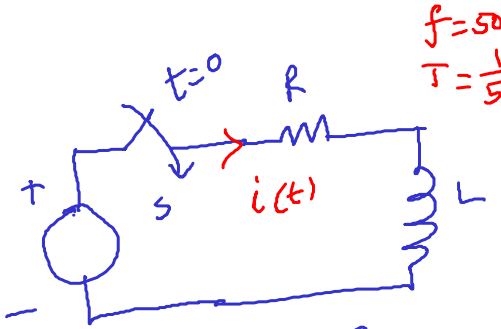
$(R_1 + R_3)\, i_1 - R_3 i_2 = v_s(t) - v(t)$

$-R_3\, i_1 + (R_2 + R_3) i_2 = v(t) - E$

$i_1 - i_2 = C\frac{dv}{dt}$

$\therefore i_1, i_2$ & v can be solved.

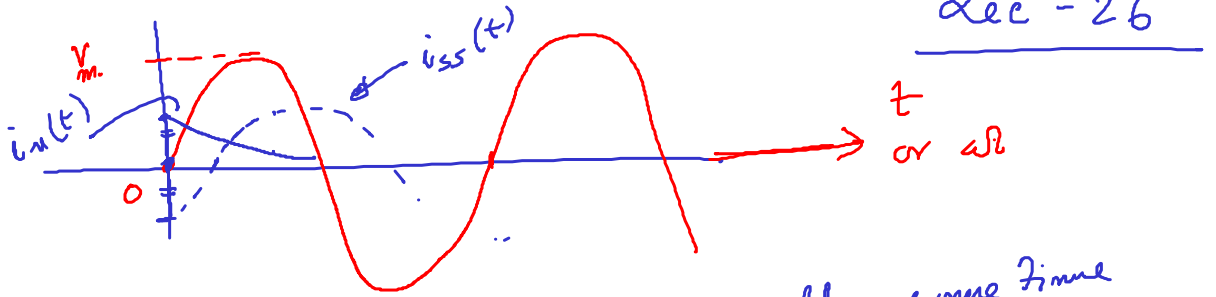
Lec - 26



$f = 50\,Hz$

$T = \frac{1}{50} = 20\,ms.$

$i(0^-) = 0$



$$v_s(t) = V_m \sin \omega t$$

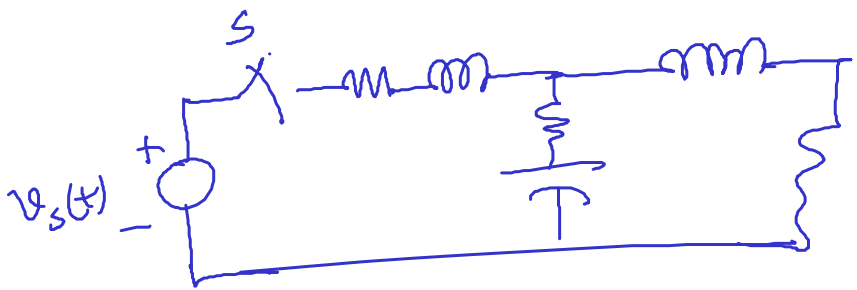
$$i(t) = -\frac{V_m}{\sqrt{R^2+\omega^2L^2}} \sin(-\theta)\, e^{-\frac{R}{L}t} + \frac{V_m}{\sqrt{R^2+\omega^2L^2}} \sin(\omega t - \theta)$$

$i_{ss}(t)$

where $\tan\theta = \frac{\omega L}{R}$

So $i_n(t) \to 0$ after some time

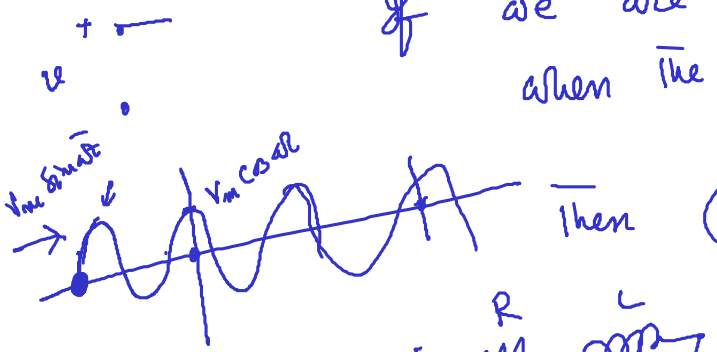
If we are interested in steady state current only Then is there a simpler technique to do that.



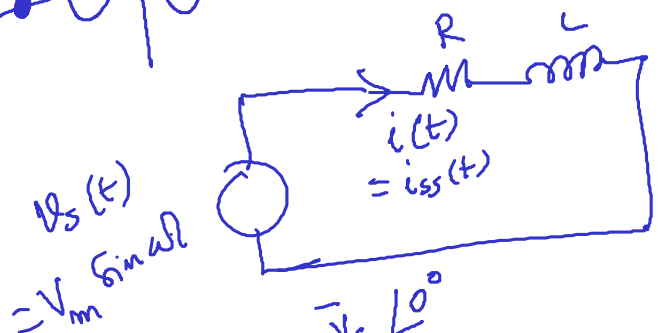
If we are interested in steady state solution alone $i_{ss}(t) = [\ i_f(t)$ when the supply sinusoidally time varying

$v_s(t) = V_{max} \sin(\omega t)$. $\omega = 2\pi f$

f = supply freq.



Then Phasor approach is adopted



$v_s(t) = V_m \sin\omega t$

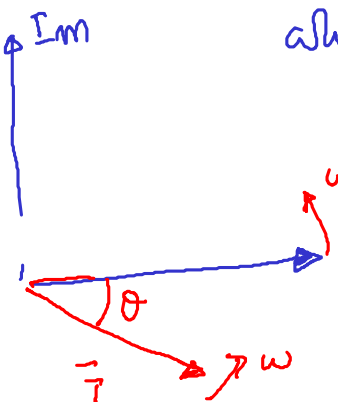
$i_{ss}(t) = i(t) = \frac{V_m}{Z} \sin(\omega t - \theta)$

where $Z = \sqrt{R^2 + \omega^2 L^2}$ $\quad \theta = \tan^{-1}\frac{\omega L}{R}$

$v_s(t) = V_m \sin\omega t \Rightarrow$

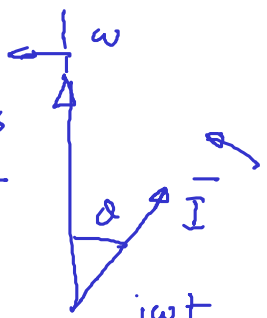
$i_s(t) = \frac{V_m}{Z} \sin(\omega t - \theta)$

$= \bar{I}_m$



$\bar{V}_s \angle 0^\circ$

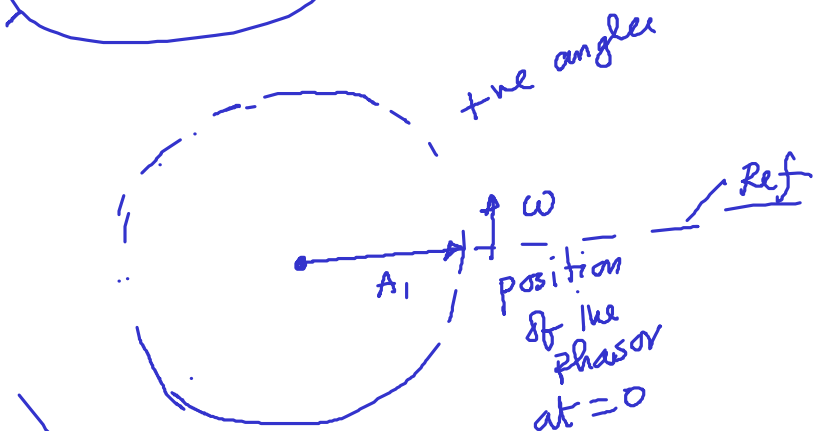
$\bar{V}_s$ - - - Ref - - - Re

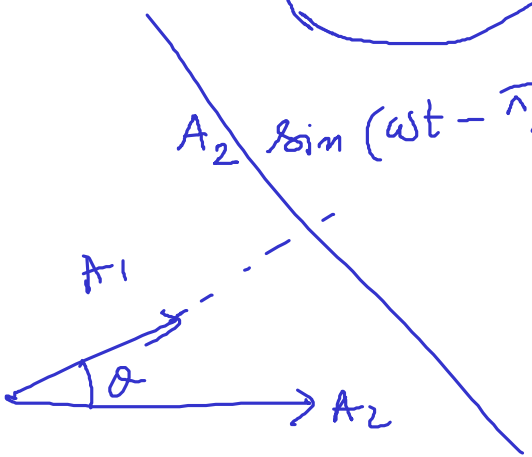


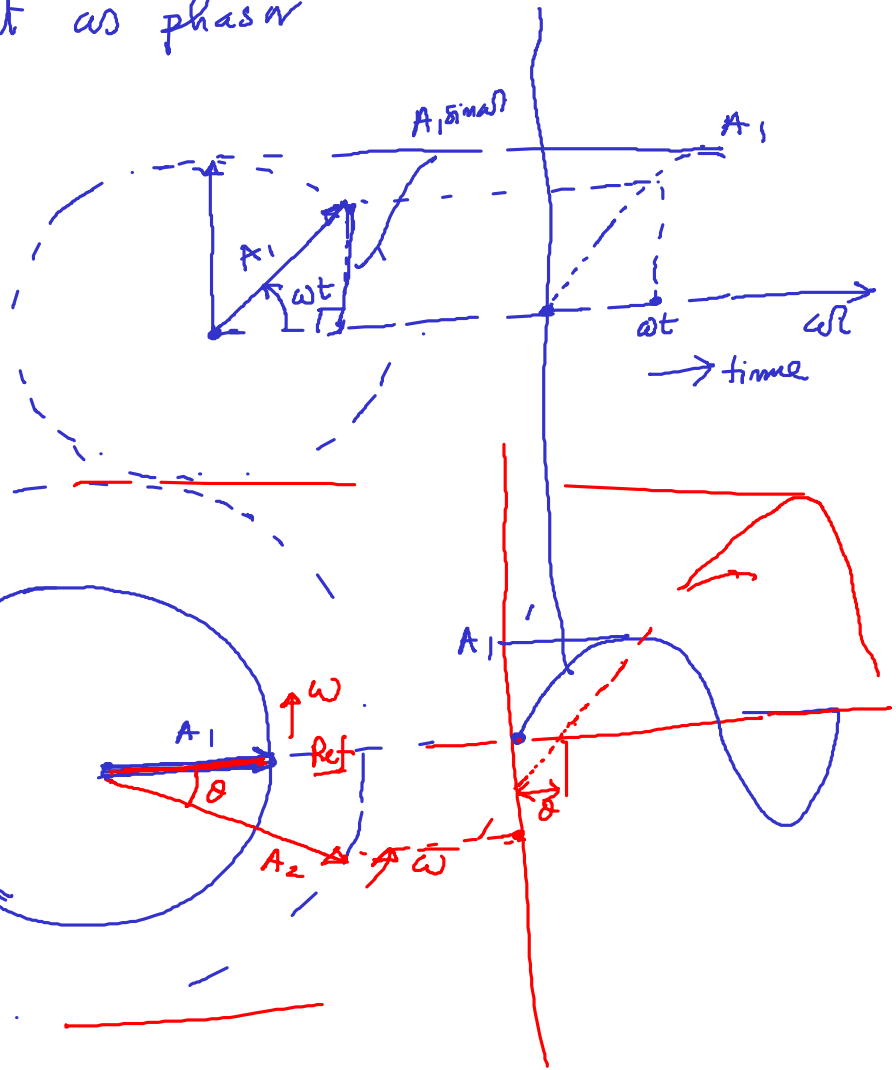
$V_s \angle 0^\circ = V_s e^{j\omega t}$

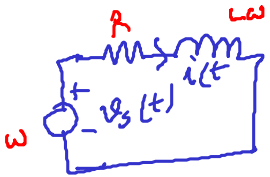
$\bar{I} \angle -\theta = \bar{I}_m e^{j(\omega t - \theta)}$

$A_1 \sin \omega t$ how to represent it as phasor









Phasor Analysis of Electrical Circuit when excitation or forcing f.n is sinusoidal.

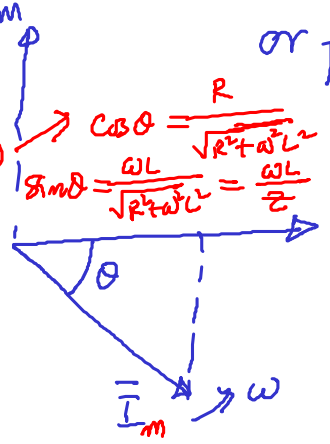
Lec-27

$$v_s(t) = V_m \sin \omega t$$

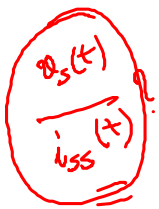
$$i_{ss}(t) = \frac{V_m}{Z} \sin(\omega t - \theta) \qquad I_m$$

$$Z = \sqrt{R^2 + \omega^2 L^2}$$

$$\tan\theta = \frac{\omega L}{R}$$

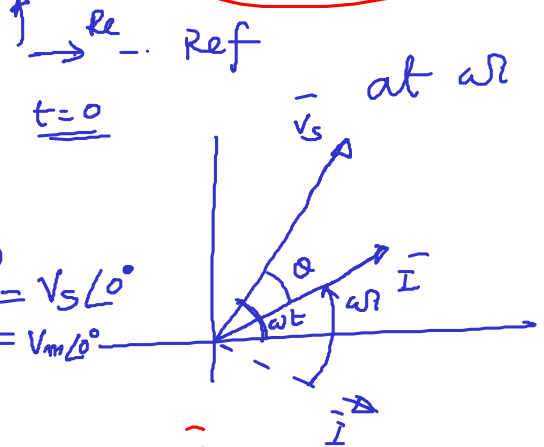


$$R = Z\cos\theta$$
$$\omega L = Z\sin\theta$$



out of curiosity

$$I_m = \frac{V_m}{Z} \quad \therefore \frac{V_m}{I_m} = Z$$



at ωt

Phasor

$$v_s(t) \longrightarrow \bar{V}_s = V_s + j0 = V_s e^{j0} = V_s \angle 0^\circ = V_m \angle 0^\circ$$

$$\bar{I}_m = I_m \cos\theta - j I_m \sin\theta$$

$$i(t) \longrightarrow \bar{I} = \underline{I}_m e^{-j\theta} = I_m \angle -\theta \qquad \bar{I}_s = \frac{\bar{V}_s}{\bar{Z}}$$

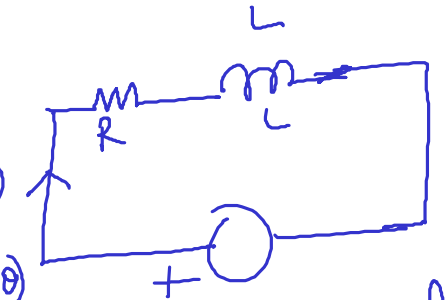
voltage ph − Current ph

$$\frac{\bar{V}_s}{\bar{I}_s} = \frac{V_m \angle 0^\circ}{I_m \angle -\theta} = \frac{V_m e^{j0}}{I_m e^{-j\theta}}$$

$$= \left(\frac{V_m}{I_m}\right) e^{j(+\theta)}$$

$$= Z e^{j\theta} = Z\cos\theta + jZ\sin\theta = (R + j\omega L) = \frac{\bar{V}_s}{\bar{I}_s} = \text{constant}$$

$$= \bar{Z}$$

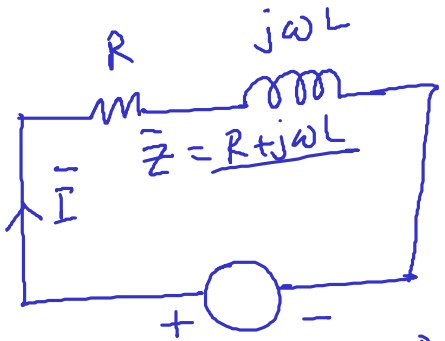


$i(t)$

$= I_m \sin(\omega t - \theta)$

$= \frac{V_m}{Z} \sin(\omega t - \theta)$

$v_s(t) = V_m \sin \omega t$



$\bar{Z} = R + j\omega L$

$\bar{I}$

$\bar{V}_s = V_m \angle 0^\circ$

$\bar{V}_s = \bar{I}\,\bar{Z}$ $\quad V = IR$

$\bar{Z} = R + j\omega L$

$\bar{I} = \frac{\bar{V}_s}{\bar{Z}}$

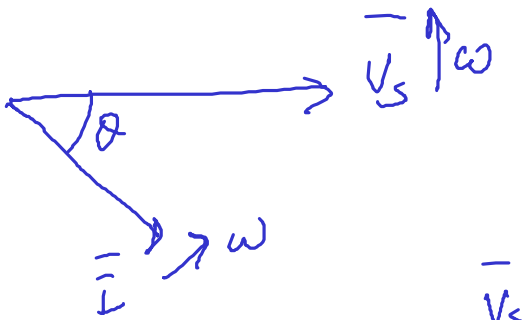
$= \frac{V_m \angle 0^\circ}{Z \angle \theta}$

$\bar{Z} = Z \angle \theta$

$= Z\cos\theta + jZ\sin\theta$

$= R + j\omega L$

$= R + jX_L$



phasor current

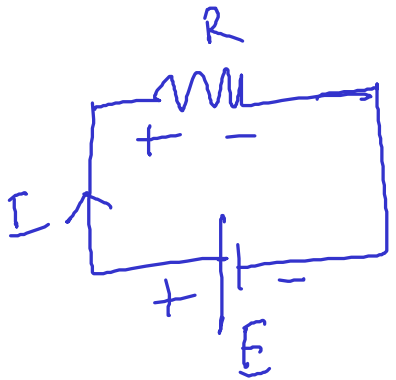
$\bar{I} = \frac{V_m}{Z} \angle -\theta$

$i(t) = \frac{V_m}{Z} \sin(\omega t - \theta)$

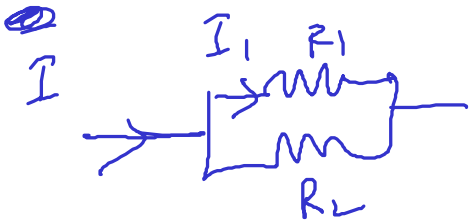
$\bar{V}_s$ write $\bar{Z}$

Then get $\bar{I}$

Then $i(t)$

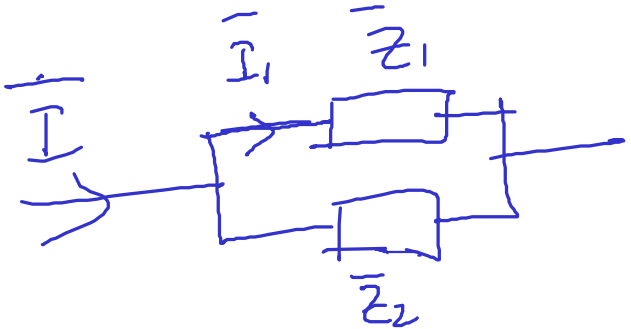


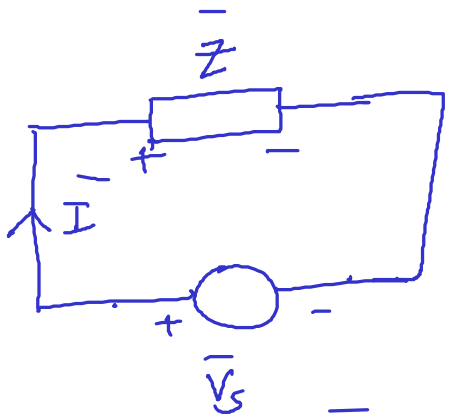
$$E = IR$$



$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

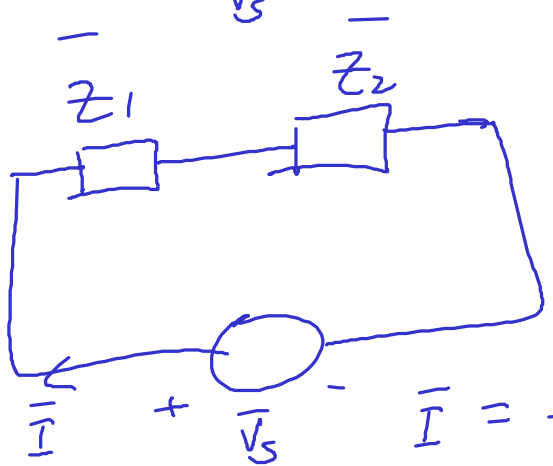
$$I_1 = \frac{I R_2}{R_1 + R_2}$$





$$\bar{V}_s = \bar{Z}\bar{I}$$

$$\bar{V}_s - \bar{Z}\bar{I} = 0$$



$$\bar{I} = \frac{\bar{V}_s}{\bar{Z}_1 + \bar{Z}_2}$$

$$\bar{Z}_{eq} = \frac{\bar{Z}_1 \bar{Z}_2}{\bar{Z}_1 + \bar{Z}_2}$$

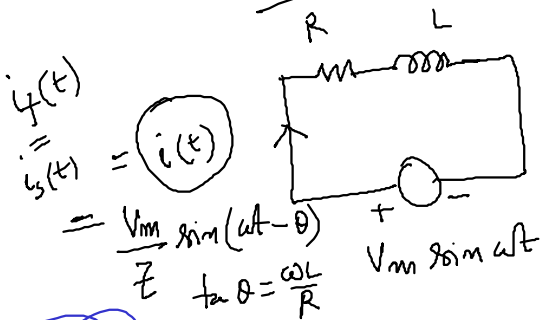
$$\bar{I}_2 = \bar{I}\frac{\bar{Z}_1}{\bar{Z}_1 + \bar{Z}_2}$$

Phasor Analysis of electrical circuit:

Lec - 28

(Applicable only to sinusoidal excitation of single frequency - ω)

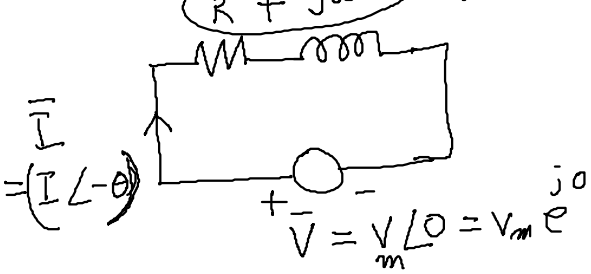
time domain



$i_s(t) = i(t) = \frac{V_m}{Z} \sin(\omega t - \theta)$

$\tan\theta = \frac{\omega L}{R}$

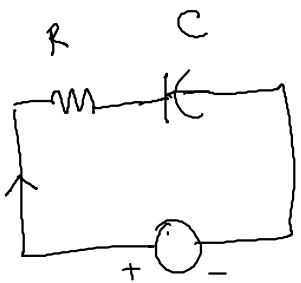
$R + j\omega L = \bar{Z} = Z\angle\theta$



$\bar{I} = \frac{\bar{V}}{\bar{Z}} = \frac{V_m\angle 0}{Z\angle\theta} = \frac{V_m}{Z}\angle -\theta$

ωL = in ohm = inductive reactance

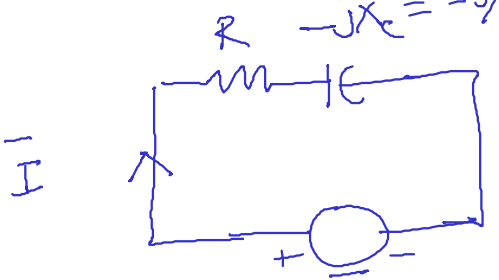
$\frac{v(t)}{i(t)} = ?$



$Z = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}$

$i(t) = \frac{V_m}{Z} \sin(\omega t + \theta)$

$\tan\theta = \frac{1/\omega C}{R} = \frac{1}{\omega CR}$



$\bar{V} = \bar{I}\bar{Z}$ →

$\frac{1}{\omega C}$ = in ohm → capacitive reactance

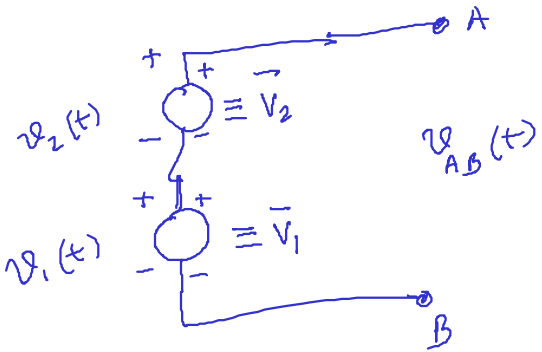
$\bar{Z} = R - \frac{j}{\omega C} = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}\angle -\theta$

$= Z\angle -\theta$

$\bar{I} = \frac{V_m\angle 0^\circ}{Z\angle -\theta}$

$= I_m\angle\theta$

$V = IR$



Let $v_1(t) = V_{m1} \sin\left(\omega t + \frac{\pi}{6}\right)$

$\sin(-\alpha) = -\sin\alpha$

and $v_2(t) = V_{m2} \cos\omega t$

$= V_{m2} \sin\left(\frac{\pi}{2} - \omega t\right)$

$v_2(t) = -V_{m2} \sin\left(\omega t - \frac{\pi}{2}\right)$

$v_1(t) = V_{m1} \sin\left(\omega t + \frac{\pi}{6}\right) \equiv V_{m1} \angle +\frac{\pi}{6} = \bar{V}_1$

$v_2(t) = -V_{m2} \angle -\pi/2 = -V_{m2} \angle -\frac{\pi}{2} = \bar{V}_2$

$v_{AB}(t) = V_{m1} \sin\left(\omega t + \frac{\pi}{6}\right) + V_{m2} \cos\omega t$

$=$

$\bar{V}_{AB} = \bar{V}_1 + \bar{V}_2 = \left(V_{m1} \angle +\frac{\pi}{6}\right) - V_{m2} \angle -\frac{\pi}{2} = V_m \angle \theta'$

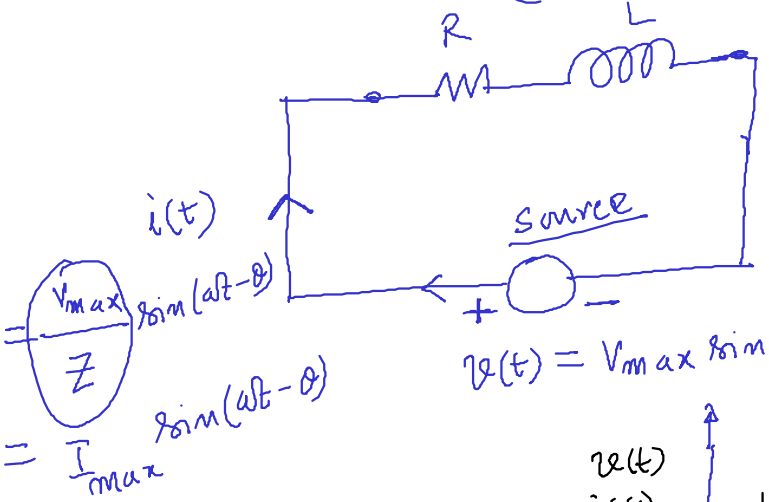
$\downarrow$

$v_{AB}(t) = V_m \sin(\omega t + \theta')$

Power in A.C circuit (sinusoidal)

$\bar{Z} = R + j\omega L$

$|\bar{Z}| = Z = \sqrt{R^2 + \omega^2 L^2}$

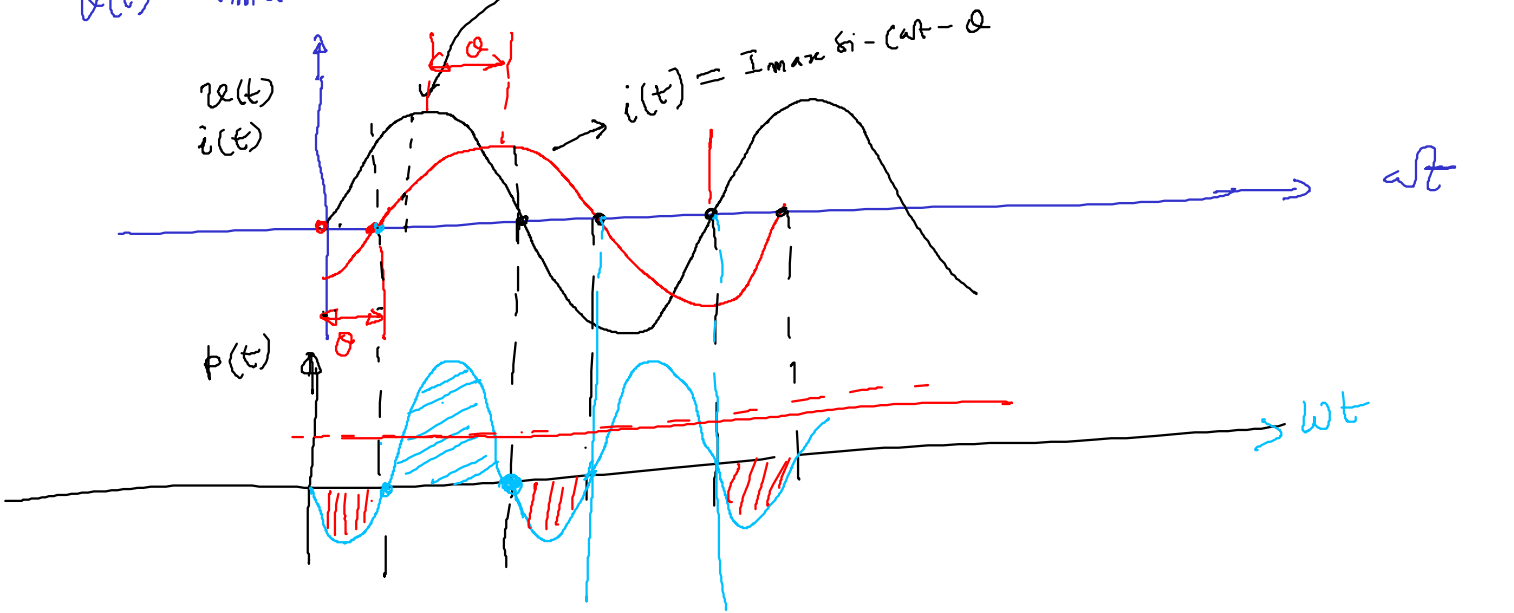


Instantaneous Power delivered by the source to the load

$p(t) = v(t)\, i(t)$

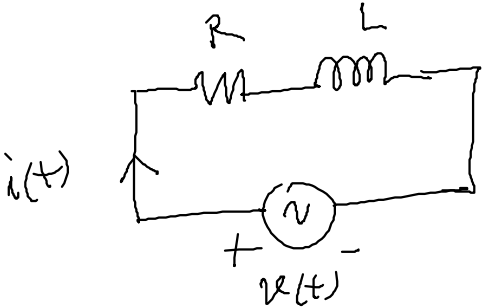
$= V_{max} \sin \omega t \; I_{max} \sin(\omega t - \theta)$

$= V_{max} I_{max} \sin \omega t \sin(\omega t - \theta)$



Instantaneous Power in A.C circuit

Lec 29



Let $v(t) = V_{max} \sin \omega t$

$i(t) = I_{max} \sin(\omega t - \theta)$

$$I_{max} = \frac{V_{max}}{Z}$$

$$\tan\theta = \frac{\omega L}{R}$$

$$p(t) = V_{max} I_{max} \sin \omega t \sin(\omega t - \theta)$$

$$p(t) = V_{max} I_{max} \sin \omega t (\sin \omega t \cos\theta - \cos \omega t \sin\theta)$$

$$= V_{max} I_{max} \cos\theta \sin^2 \omega t - V_{max} I_{max} \sin\theta \sin \omega t \cos \omega t$$

$$p(t) = \frac{V_{max} I_{max}}{2} \cos\theta (1 - \cos 2\omega t) - \frac{V_{max} I_{max}}{2} \sin\theta \sin 2\omega t$$

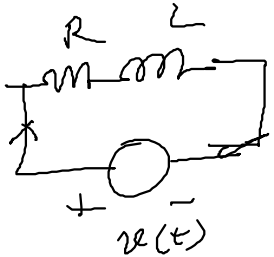
→ It will be equal having both +ve & -ve excursion about ωt axis

* This term will never become -ve

$\frac{V_{max} I_{max}}{2}\cos\theta - \frac{V_{max} I_{max}}{2}\cos\theta\cos 2\omega t$

$V_{max} I_{max}\cos\theta$

$p(t) = \frac{V_{max} I_{max}}{2}\cos\theta\,(1 - \cos 2\omega t) - \frac{V_{max} I_{max}}{2}\sin\theta\,\sin 2\omega t$



1st term $p(t)$

$\frac{V_{max} I_{max}\cos\theta}{2}$

Active power

↓

Average power absorbed by load $= P_{av} = \frac{V_{max} I_{max}}{2}\cos\theta$

ωt

$\frac{\pi}{4}$ $\frac{\pi}{2}$ $\frac{3\pi}{4}$

$= VI\sin\theta$

$\left(\frac{V_{max} I_{max}}{2}\sin\theta\right)\sin 2\omega t$

$\frac{V_{max} I_{max}\sin\theta}{2}$

2nd term of $p(t)$

double frequency oscillating power

ωt

$\pi/4$ $\pi/2$ $\frac{3\pi}{4}$

origin of reactive power

In A.C circuit :- $\bar{I} = \frac{\bar{V}}{\bar{Z}}$

$$\bar{Z} = \frac{\bar{V}}{\bar{I}} = \frac{V_{max}\angle 0^\circ}{I_{max}\angle -\theta}$$

for R-L circuit

$$= \frac{\frac{V_{max}}{\sqrt{2}}\angle 0^\circ}{\frac{I_{max}}{\sqrt{2}}\angle -\theta} = \frac{V_{RMS}\angle 0^\circ}{I_{RMS}\angle -\theta}$$

Suppose $v(t) = 245 \sin \omega t$ $\longrightarrow$ $\bar{V} = \frac{245}{\sqrt{2}}\angle 0^\circ$

$$\bar{I} = \frac{\bar{V}}{\bar{Z}} = I_{RMS}\angle -\theta$$

average power

$$P_{av} = \frac{V_{max} I_{max}}{2}\cos\theta$$

(Real power)

$$= \frac{V_{max}}{\sqrt{2}} \frac{I_{max}}{\sqrt{2}} \cos\theta$$

$$P_{av} = V_{RMS} I_{RMS} \cos\theta$$

Power factor of the circuit

In d.c

$I = \frac{V}{R}$

$P = VI$

$\bar{Z} = R + j\omega L$

Active & Reactive Power in A.C Circuit :-

Lec-30

average power absorbed by load

$$P = V_{RMS} I \cos\theta = \frac{1}{2\pi}\int_0^{2\pi} v(t)\, i(t)\, d(\omega t) = \frac{1}{2\pi}\int_0^{2\pi} V_{max} I_{max} \sin(\omega t) \sin(\omega t - \theta)\, d(\omega t)$$

$$= \frac{V_{max} I_{max}}{2\pi \times 2}\int_0^{2\pi} 2 \sin\omega t \sin(\omega t - \theta)\, d(\omega t)$$

$$= \frac{V_{max} I_{max}}{4\pi}\int_0^{2\pi} [\cos\theta - \cos(2\omega t - \theta)\, d(\omega t)$$

$$= \frac{V_{max} I_{max}}{4\pi}\int_0^{2\pi} \cos\theta\, d(\omega t) - 0$$

$$= \frac{V_{max} I_{max}}{4\pi} \cos\theta \times 2\pi$$

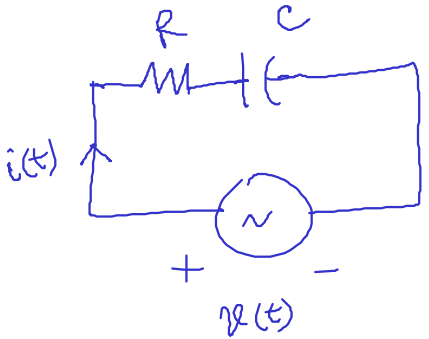
$$= \frac{V_{max} I_{max}}{2} \cos\theta = V I \cos\theta$$

Reactive power

$Q_{inductive} = \frac{V_{max} I_{max}}{2} \sin\theta$

$= V I \sin\theta$

= It is peak value of the oscillating power between the source and the load.



$v(t) = V_{max} \sin \omega t$

$i(t) = I_{max} \sin(\omega t - \theta)$

$Z = \frac{V_{max}}{I_{max}} = \frac{V}{I}$

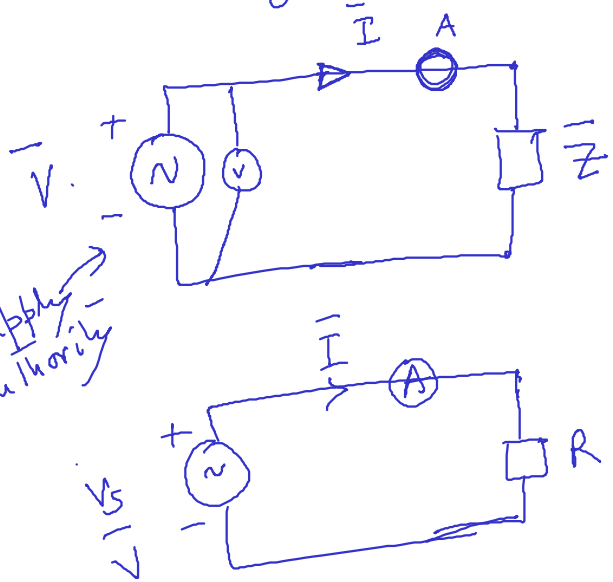
$\tan\theta = \frac{1/\omega C}{R} = \frac{1}{\omega CR}$

$P = VI\cos\theta$

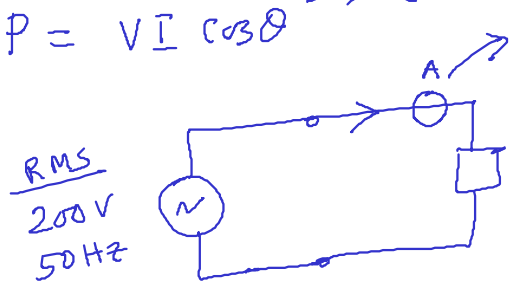
$Q = VI\sin\theta$ → Reactive Power capacitive.

Significance of power factor $\cos\theta$

$\cos\theta$ → $(0 < \cos\theta < 1)$



$P = VI\cos\theta$



$\bar{V} = 200\angle 0^\circ$

$P = 200 \times 20 \cos 53^\circ$

$= 2400$ W consumer

$\bar{Z} = 6 + j8\ \Omega = 10\angle 53^\circ\ \Omega$

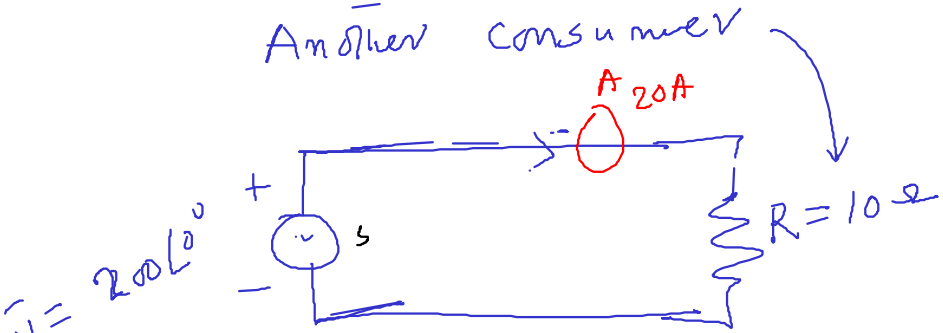
$\bar{I} = \frac{200\angle 0^\circ}{10\angle 53^\circ}$

$= 20\angle -53^\circ$

$Q = 200 \times 20 \sin 53^\circ$

$= 3200$ VAR

Volt ampere reactive



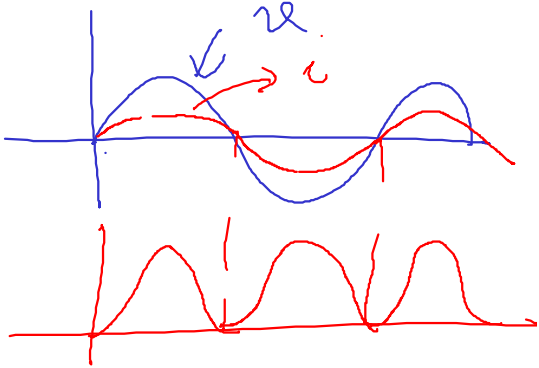
$\bar{V} = 200\angle 0^\circ$

$\bar{V} = 200\angle 0^\circ V$

$$\bar{I} = \frac{200\angle 0^\circ}{10\angle 0^\circ} = 20\angle 0^\circ \, A$$

$\bar{Z} = 10 + j0$

$= 10\angle 0^\circ \, \Omega$ $\quad \theta = 0$



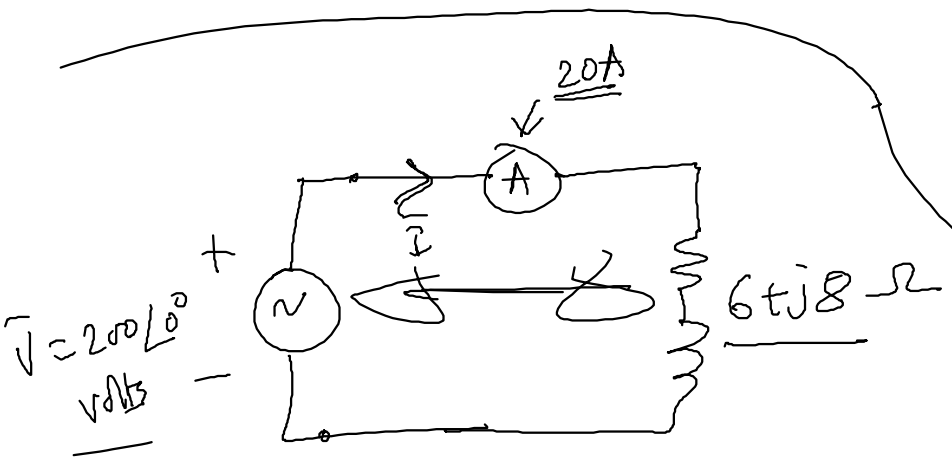
$P_{av} = 200 \times 20 \cos 0^\circ$

$= 4000$ W

$Q_{Reactive} = 200 \times 20 \sin 0^\circ$

$= 0$

P.f ⟩ .8 P.f (lagg)



$\bar{V} = 200\angle 0^\circ$ volts

200×20

4000 VA

$$\bar{I} = \frac{200\angle 0^\circ}{6 + j8\,\Omega} = \frac{200\angle 0^\circ}{10\angle 53^\circ} = 20\angle -53^\circ$$

$P = 2400$ W → active

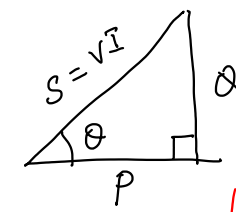
$Q = 3200$ VAR → Reactive

Lec 31

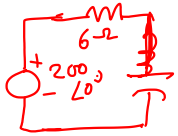
Apparent Power, Active Power (or Real) and Reactive Power

Apparent Power (S)	Active Power (P)	Reactive Power (Q)
VI	$VI\cos\theta$ ← p.f	$VI\sin\theta$

total complex power → $\bar{S} = P + jQ$

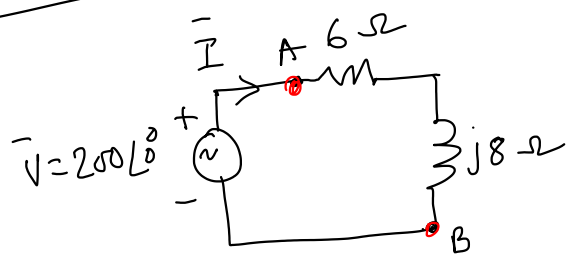


$\bar{V} = \bar{I}\bar{Z}$



$\bar{I} = 20\angle 53^\circ$ Power absorbed

$200\angle 0^\circ \times 20\angle -53^\circ = 4000 - j3200$ KW VAR



$\bar{Z} = 6 + j8\ \Omega$

$\bar{V} = 200\angle 0^\circ$ volts

$\bar{I} = \dfrac{200\angle 0^\circ}{6+j8} = 20\angle -53^\circ$ A

$\therefore \bar{I}^* = 20\angle +53^\circ$ $(10_{W} - j50_{VAR})$

$P = 200 \times 20 \cos(-53^\circ)$

$Q =$

Complex Power supplied by the source : $\bar{S} = \bar{V}\bar{I}^* = 200\angle 0^\circ \times 20\angle 53^\circ$

$= 4000\angle 53^\circ = (\underset{P}{2400} + j\underset{Q}{3200})$ VA

" " absorbed by the load

$\bar{V}_{AB}\,\bar{I}^* = 200\angle 0^\circ \times 20\angle 53^\circ$ $P = 2400$ W & $Q = 3200$ VAR

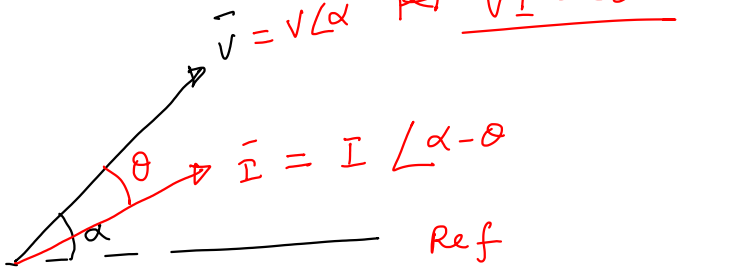
$= 2400\ W + j3200\ VAR$

In general

Let $\bar{V} = V\angle\alpha$

Then if $\bar{Z} = Z\angle\theta$ (if $\theta > 0$)

$$\therefore \bar{I} = \frac{\bar{V}}{\bar{Z}} = \frac{V}{Z}\angle\alpha-\theta$$



VI cos α

$$\bar{S} = \bar{V}\,\bar{I}^{*}$$

$$= V\angle\alpha \left(I\angle\alpha-\theta\right)^{*}$$

$$= \left(V\angle\alpha \times I\angle\theta-\alpha\right) = VI\angle\theta = VI\cos\theta + jVI\sin\theta$$

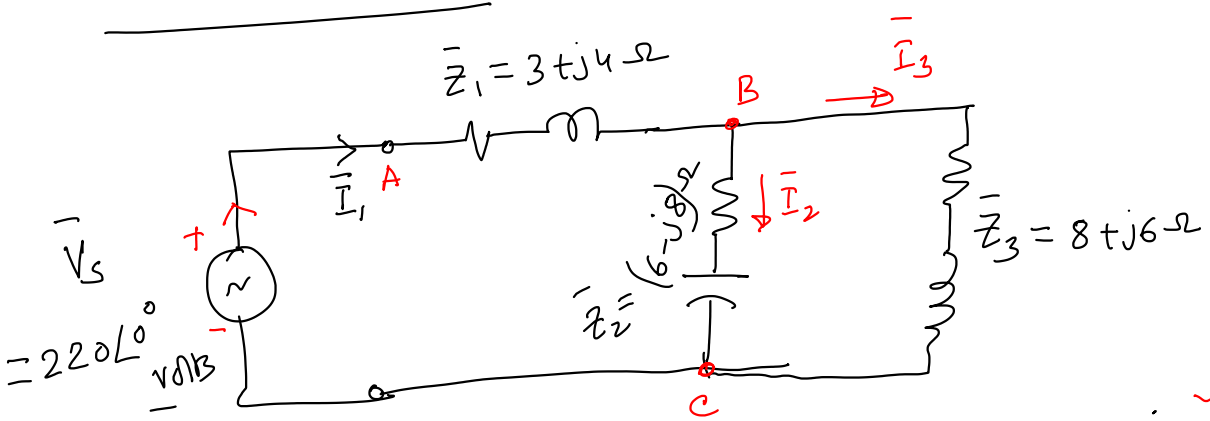
$$\bar{S} \neq \bar{V}\bar{I} = V\angle\alpha \times I\angle\alpha-\theta)$$

$$= VI\angle(2\alpha-\theta) \quad \not= P$$

$$= VI\cos(2\alpha-\theta) + jVI\sin(2\alpha-\theta)$$

$\neq \alpha$

Numerical Problem :



$$\bar{I}_1 = \frac{220\angle 0^\circ}{\left(\bar{Z}_1 + \frac{\bar{Z}_2\bar{Z}_3}{\bar{Z}_2+\bar{Z}_3}\right)} = \frac{220\angle 0^\circ}{\bar{Z}_{eq}}$$

$$\bar{Z}_{eq} = (3+j4) + \frac{(6-j8)(8+j6)}{14-j2}$$

$$= 10+j3\ \Omega$$

$$\therefore \bar{I}_1 = \frac{220\angle 0^\circ}{10+j3} = 21.07\angle -16.69^\circ\ \text{A} = \bar{I}_1$$

$$\bar{I}_2 = \bar{I}_1 \times \frac{\bar{Z}_3}{\bar{Z}_2+\bar{Z}_3} = \frac{21.07\angle -16.69^\circ \times (8+j6)}{14-j2}$$

$$= 13.116+j7.06 = 14.89\angle 28.31^\circ\ \text{A} = \bar{I}_2$$

$$\bar{I}_3 = \bar{I}_1 - \bar{I}_2 = 21.07\angle -16.69^\circ - 14.89\angle 28.31^\circ = 14.89\angle -61.65^\circ = \bar{I}_3$$

Complex Power supplied by source $= \bar{V}_s \times \bar{I}_1^* = 220\angle 0^\circ \times 21.07\angle 16.69^\circ$

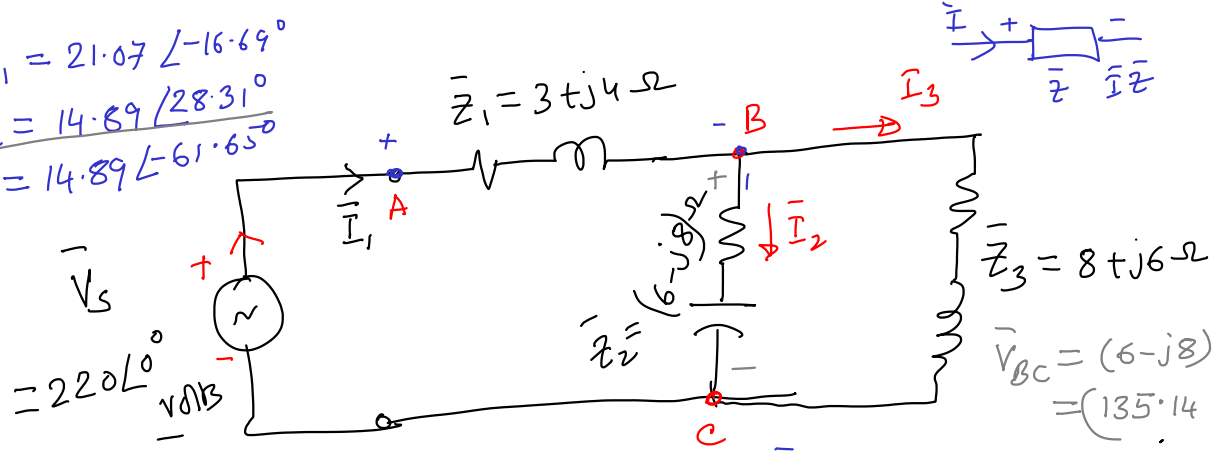
$= 4393.76\ \text{W} + j1331.25\ \text{VAR}$

Lec-32

$\bar{I}_1 = 21.07\angle -16.69^\circ$

$\bar{I}_2 = 14.89\angle 28.31^\circ$

$\bar{I}_3 = 14.89\angle -61.65^\circ$



$\bar{V}_{BC} = (6-j8)\times 14.89\angle 28.31^\circ$

$= (135.14 - j62.5)$ V

Total (complex) Power supplied by the source =

$= 4393.76\ W + j1331.25\ VAR$

Total power absorbed by all loads (i.e., $\bar{Z}_1, \bar{Z}_2$ & $\bar{Z}_3$)

$=$

Total Power absorbed by $\bar{Z}_1$

$\bar{V}_{AB}\ \bar{I}_1^*$

now $\bar{V}_{AB} = \bar{I}_1 \bar{Z}_1 = 21.07\angle -16.69^\circ \times (3+j4)$ volts

$= 84.8 + j62.6$ volts

$\bar{S}_1 = (84.8 + j62.6) \times 21.07\angle 16.69^\circ = 1332 + j1777$

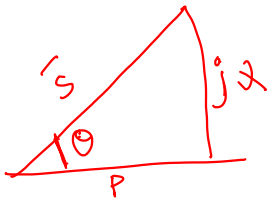
Power absorbed by $\bar{Z}_2$: $\bar{S}_2 = \bar{V}_{BC}\ \bar{I}_2^* = (135.14 - j62.5) \times 14.89\angle 28.31^\circ$

$= 1330.21 - j1773.60$

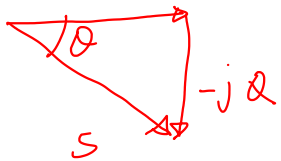
Power " by $\bar{Z}_3$: $\bar{S}_3 = \bar{V}_{BC}\ \bar{I}_3^* = (135.14 - j62.5) \times 14.89\angle 61.65^\circ$

$= 1774.53 + j1328.98$

Σ $\quad 4438 + j1332$



for inductive CKT



$\bar{V}$ known

Get $\bar{I}$ $(= \bar{V}/\bar{Z})$

Get Power supplied by source

Power absorbed by load

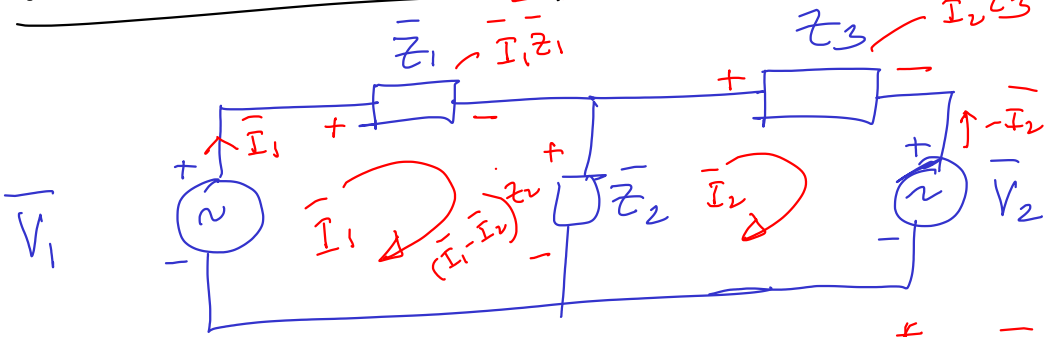
$$P = V I \cos\theta$$

$$= IZ\, I \cos\theta$$

$$= I^2 (Z \cos\theta)$$

$$= R I^2$$

Nodal & Mesh analysis can be adopted to solve network problems in the same way as in D.C ckt. $\left[V = IR \equiv \bar{V} = \bar{I}\bar{Z} \right]$



KVL in mesh 1 & 2

$$(\bar{Z}_1 + \bar{Z}_2)\bar{I}_1 - \bar{Z}_2\bar{I}_2 = \bar{V}_1$$

$$-\bar{Z}_2\bar{I}_1 + (\bar{Z}_2 + \bar{Z}_3)\bar{I}_2 = -\bar{V}_2$$

* Solve for $\bar{I}_1$ & $\bar{I}_2$

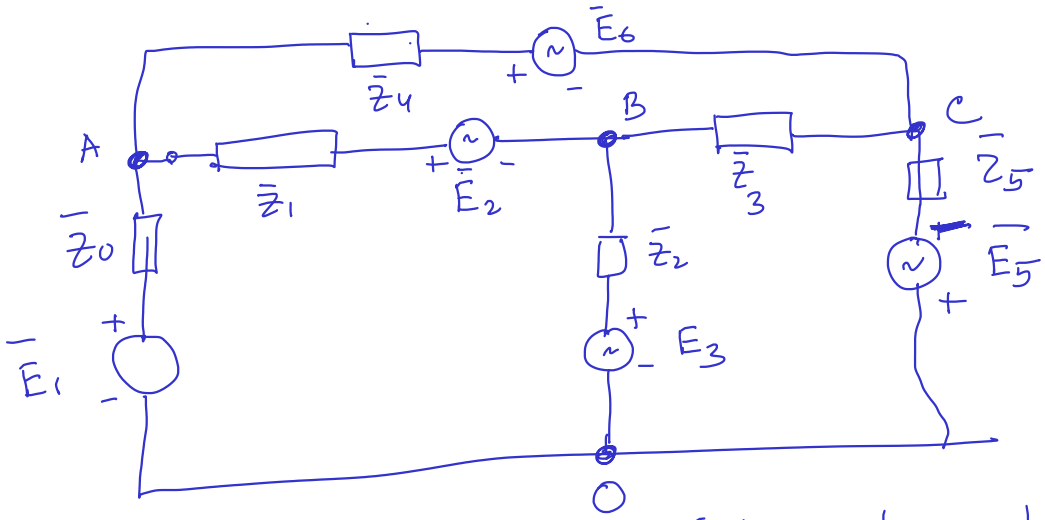
Power delivered by sources : $\bar{V}_1 \bar{I}_1^* + \bar{V}_2 (-\bar{I}_2)^*$

$$= \bar{V}_1 \bar{I}_1^* - \bar{V}_2 \bar{I}_2^*$$

Power Absorbed by loads

$$\bar{V}_{Z_1} \bar{I}_1^* + \bar{V}_{Z_2} (\bar{I}_1 - \bar{I}_2)^* + \bar{V}_{Z_3} \bar{I}_2^* = \bar{V}_1 \bar{I}_1^* - \bar{V}_2 \bar{I}_2^*$$

Lec -33



KCL at node A :-

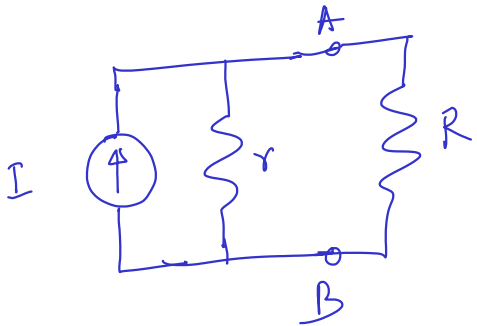
$$\left(\frac{1}{\bar{Z}_0}+\frac{1}{\bar{Z}_1}+\frac{1}{\bar{Z}_4}\right)\bar{V}_{AO}-\frac{1}{\bar{Z}_1}\bar{V}_{BO}-\frac{1}{\bar{Z}_4}V_{CO}=\frac{\bar{E}_1}{\bar{Z}_0}+\frac{\bar{E}_6}{\bar{Z}_4}+\frac{\bar{E}_2}{\bar{Z}_1} \quad \cdots (1)$$

at node B :-

$$-\frac{1}{\bar{Z}_1}V_{AO}+\left(\frac{1}{\bar{Z}_1}+\frac{1}{\bar{Z}_2}+\frac{1}{\bar{Z}_3}\right)V_{BO}-\frac{1}{\bar{Z}_3}\bar{V}_{CO}=\frac{E_3}{\bar{Z}_2}-\frac{\bar{E}_2}{\bar{Z}_1} \quad \cdots (2)$$

at node C :-

$$-\frac{1}{\bar{Z}_4}V_{AO}-\frac{1}{\bar{Z}_3}\bar{V}_{BO}+\left(\frac{1}{\bar{Z}_3}+\frac{1}{\bar{Z}_5}+\frac{1}{\bar{Z}_4}\right)\bar{V}_{CO}=-\frac{E_5}{\bar{Z}_5}-\frac{\bar{E}_6}{\bar{Z}_4} \quad \cdots (3)$$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r
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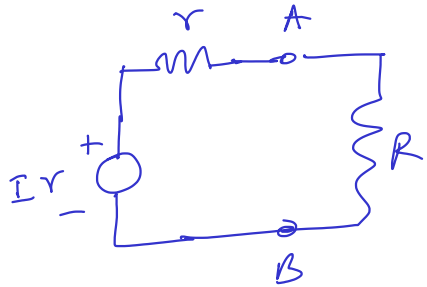
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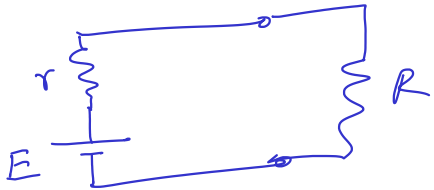
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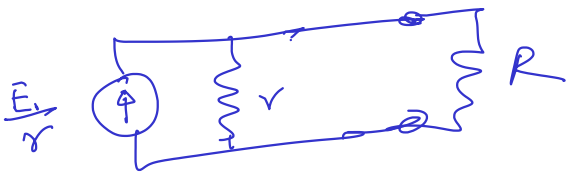
E/r
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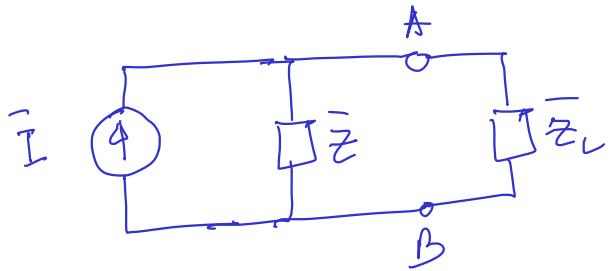
A
Ī
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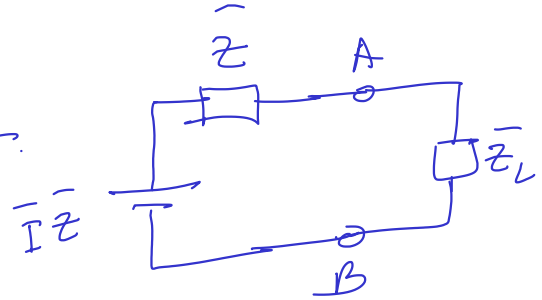
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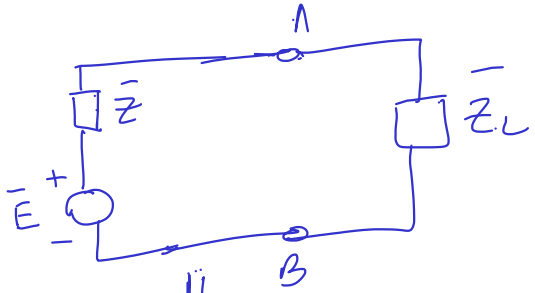
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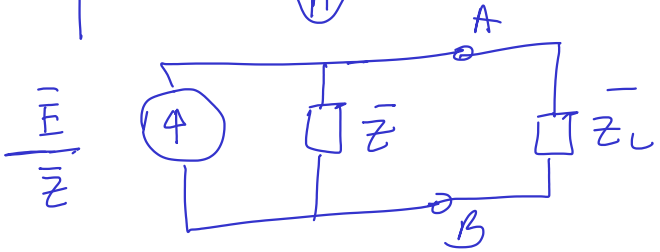
Ē/Z̄
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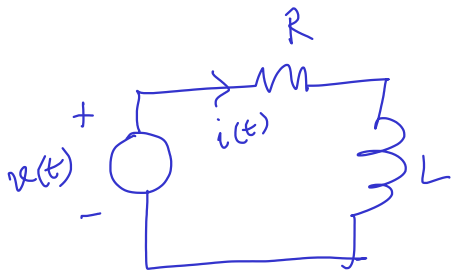
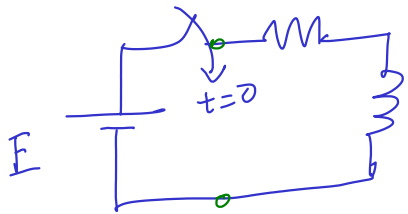


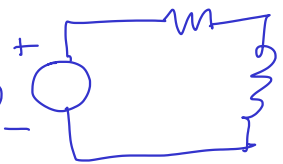
$$i(t) = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right)$$

if $v(t) = E$

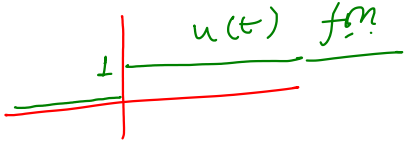
with $i(0^-) = 0$

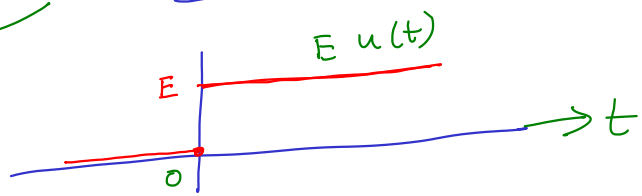


$\Rightarrow v(t) = E\,u(t)$



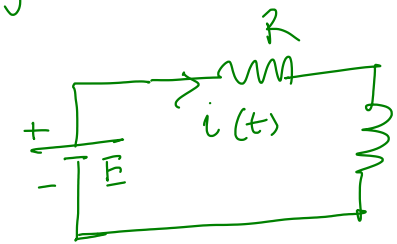
unit step fn $u(t)$





for $t < 0$

for $t > 0$



$$Ri + L\frac{di}{dt} = E\,u(t)$$

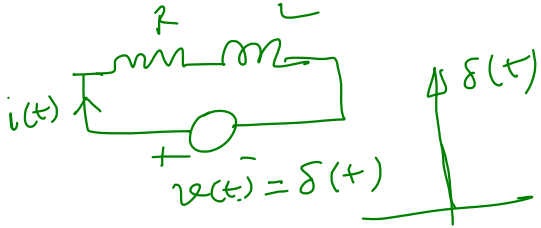
$$= E \quad \text{for } t > 0$$

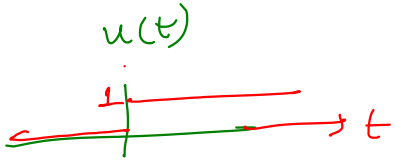
$$Ri + L\frac{di}{dt} = v(t)$$

$v(t)$ ↑ excitation or input voltage

$v(t)$ is not an impulse voltage

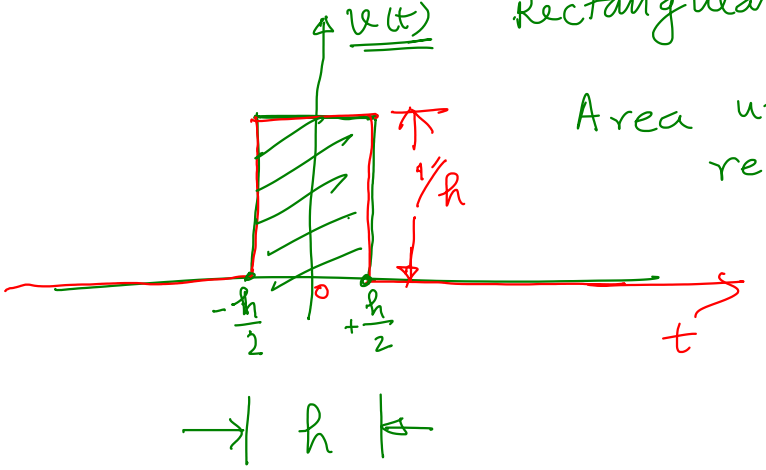
$$i(0^-) = i(0^+)$$





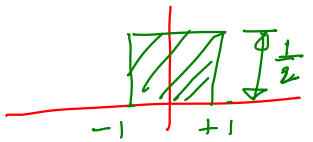
What happens if an impulse voltage $\delta(t)$ is applied to R-L circuit

Rectangular Pulse



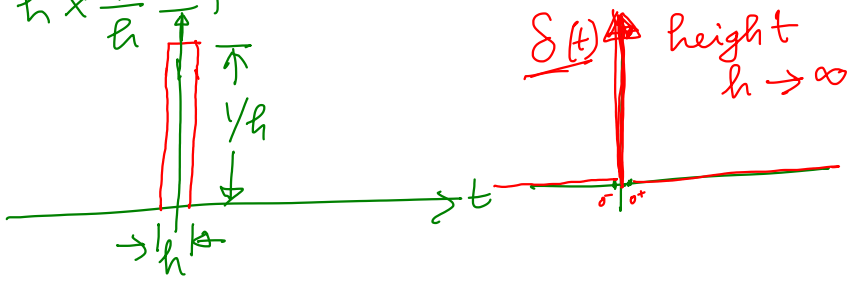
Area under this rectangular pulse

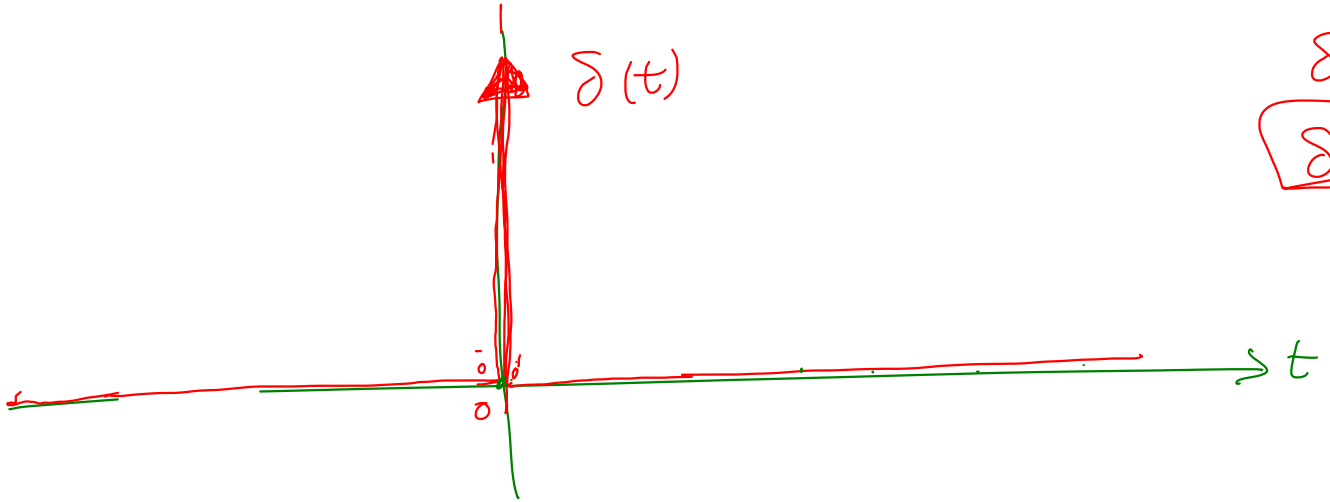
$$= h \times \frac{1}{h} = 1$$



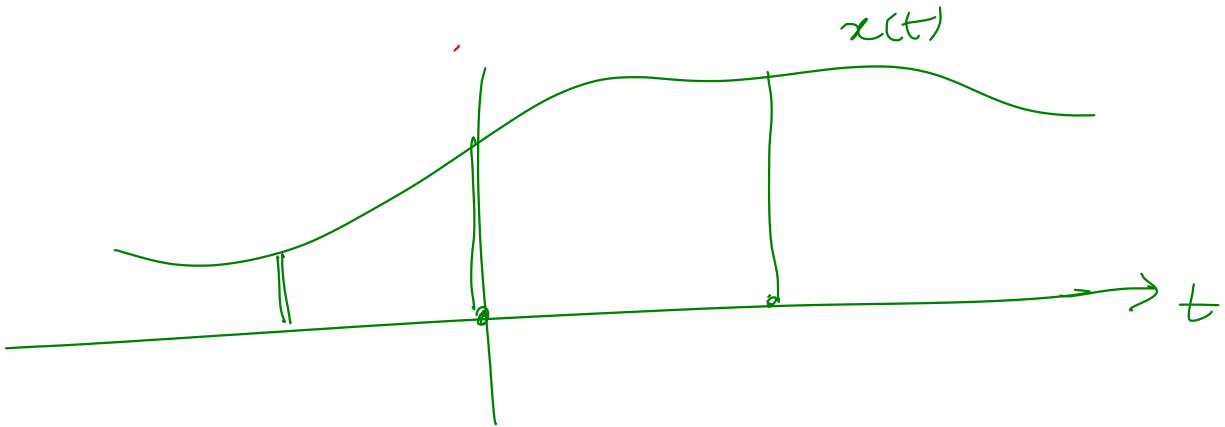
Area under the pulse $= \frac{1}{2} \times 2 = 1$

Let $h \to 0$





$\delta(t)$ = going ∞ (cannot be defined)

$\delta(t) = 0$ if $t \neq 0$

$$\int_{t=0^-}^{0^+} \delta(t)\,dt = 1$$