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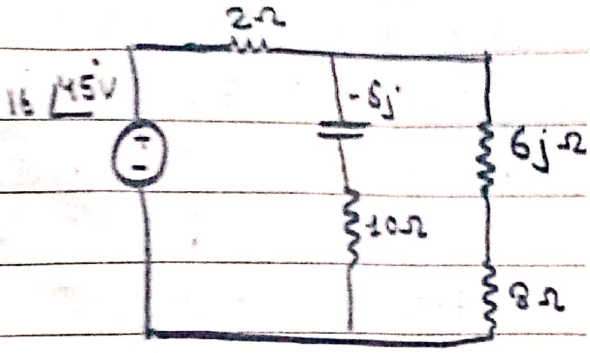
Day / Date

ENA Assignment 3

Amina Qadeer

359607

CE-42-A



(a) Power factor:

Q1 Find impedence Total (Z_T):

- $Z_1 = (8+j6) \parallel (10-5j)$

$$Z_1 = \frac{(8+j6)(10-5j)}{(8+6j+10-5j)} = \frac{110+20j}{18-j} = \frac{\sqrt{110^2+20^2}\ \angle 10.30}{\sqrt{18^2+(-1)^2}\ \angle -3.17}$$

$$Z_1 = \frac{111.8\ \angle 10.30}{18\ \angle -3.17} = \boxed{6.22+0.77j}$$

- $Z_T = Z_1 + 2\Omega = 6.15 + 2 + 0.77j = \boxed{8.15+0.77j}$
- Rewrite in phasor form: $Z = 8.18\ \angle 5.39°$
- Since Power factor angle is same as angle of (Z)

$$\therefore P_f = \cos(\theta_v - \theta_i)$$
$$= \cos(5.39)°$$
$$\boxed{P_f = +0.995}$$

(b) Power delievered by the source / Complex Power:

- Using ohm's law, Find I, in circuit;

$$I = \frac{V}{Z_T} = \frac{16\ \angle 45° V}{8.18\ \angle 5.39°} = \frac{16}{8.18}\ \angle 45-5.39° = \boxed{1.96\ \angle 39.61°\ A}$$

- Taking complex conjugate of I,

$$I^* = 1.96\ \angle -39.61°$$

We know that,

- $$S = \frac{1}{2} V I^*$$

$$S = 0.5 \times (16\ \angle 45°)(1.96\ \angle -39.61)$$
$$S = 15.68\ \angle 45-39.61$$
$$\boxed{S = 15.7\ \angle 5.39\ (VA)}$$

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Day / Date (c) Average Power delievered by the Source:

we already have

$V_m = 16V$ $I_m = 1.96A$ $\theta v - \theta i = 5.39^\circ$

According to the formula,

$$P = \frac{1}{2} V_m I_m \cos(\theta v - \theta_i)$$

Putting values,

$$P = 0.5 \times 16V \times 1.96A \times \cos(5.39^\circ)$$

$$\boxed{P = 15.62 \text{ Watt}}$$

(d) Reactive Power delievered by the Source (s).

we have already know complex power (s)

$$S = 15.7 \angle 5.39^\circ \text{ (VA)}$$

Write in vector form :

$$\cancel{S = \sqrt{(15.6)^2 + (5.39)^2} \tan^{-1}\left(\frac{5.39^\circ}{15.7}\right)}$$

$$\cancel{S = 15.5 \cos(5.39) + j \sin(15.51)}$$

$$S = A\cos\theta + jA\sin\theta$$

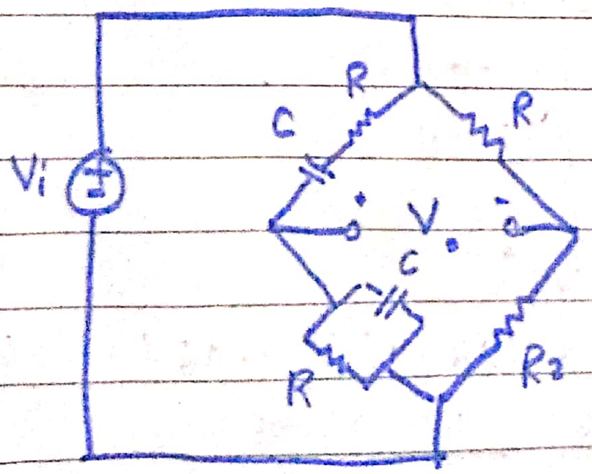
$$S = 15.7\cos(5.39) + j(15.7)\sin(5.39^\circ)$$

$$\boxed{S = 15.53 + 1.47j \text{ VA}}$$

we know Imaginary Part of Complex Power S is Q the Reactive Power. $\boxed{I_m(S) = Q}$

∴ Reactive Power by source $= \boxed{Q = 14.7}$ (VAR)

Q2)



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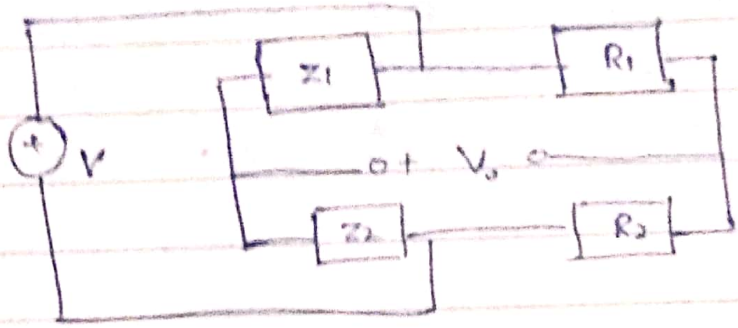
$Z_C = \frac{1}{C\omega j}$, so,

$Z_1 = R + \frac{1}{C\omega j} \Rightarrow \boxed{Z_1 = \frac{RC\omega j + 1}{R\omega j}}$

$Z_2 = R \,||\, \frac{1}{C\omega j} \Rightarrow \boxed{Z_2 = \frac{R}{1 + C\omega j}}$

The circuit becomes,



$\Rightarrow$ Applying VDR across Z_2 and R_2

$V_1 = \frac{Z_1}{Z_1 + Z_2} V_i$

$= \frac{R/1+C\omega j}{\frac{R}{1+C\omega j} + \frac{1+C\omega RC}{C\omega j}} = \frac{R}{1+C\omega j} \div \frac{RC\omega j + (1+RC\omega j)^2}{(1+C\omega j)(C\omega j)}$

$V_1 = \frac{RC\omega j}{RC\omega j + (1+RC\omega j)^2}$.

$\boxed{V_2 = \frac{R_2}{R_1+R_2} V_i}$

Since $V_o - V_1$

$V_o = \frac{R\omega Cj}{RC\omega j + (1+RCj\omega)^2} V_i = \frac{R_1}{R_1+R_2} V_i$

$\boxed{V_o = \left[\frac{RC\omega j}{1 - \omega^2R^2C^2 + 3R\omega}\right] V_i - \frac{R_1}{R_1+R_2}}$

For V_o and V_i to be in phase, $\frac{V_o}{V_i}$, must be purely real i.e, no complex part) To ensure the condition

$1 - \omega^2R^2C^2 = 0$

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

$$\boxed{\omega = \frac{1}{RC}}$$

- We know that, $\omega = 2\pi f$, so,

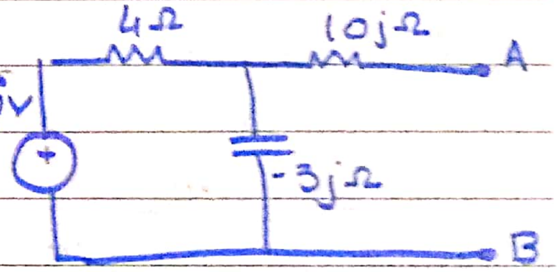
$$2\pi f = \frac{1}{RC}$$

$$\boxed{f = \frac{1}{2\pi RC}}$$

Q4 Find the lead Impedence that will receive the maximum power when connected across terminal A & B. Compute the value of max Power.

Ans)

For Z (Total impedence) of given circuit.



$$Z_T = \frac{(-3j)(4)}{4-3j} + 10j = \frac{-12}{4-3j} + 10j$$

$$= \frac{-12j}{4-3j} \times \frac{4+3j}{4+3j} + 10j$$

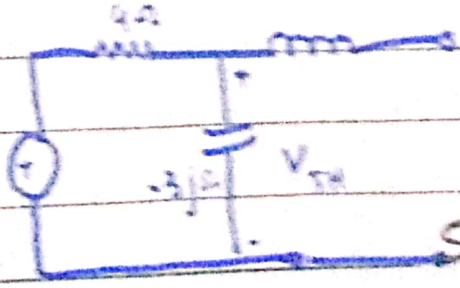
$$= \frac{-48j}{25} + \frac{36}{25} + 10j$$

$$\boxed{\begin{aligned} Z_T &= 1.44 + 8.08j \quad \text{or} \\ Z_T &= 8.21 \angle 79.89 \end{aligned}}$$ (phasor form)

→ For V_{TH}

Applying voltage divider Rule.

$$V_{TH} = \frac{-3j}{-3j+4} \times 30\angle 0^\circ$$



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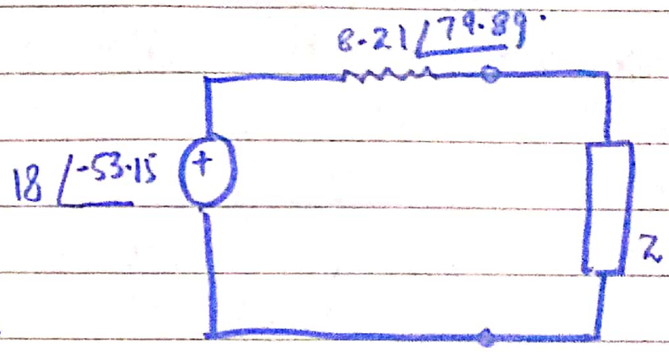
$$= \left[\frac{-3j}{-3j+4} \times \frac{3j+4}{3j+4}\right] 30\angle 0^\circ$$

$$= \left[\frac{-12j}{25} + \frac{9}{25}\right] 30\angle 0^\circ$$

$$= 0.6\angle -53.13^\circ \times 30\angle 0^\circ$$

$$\boxed{V_{TH} = 18\angle -53.13^\circ \, V}$$

The return equivalent.



For maximum Power,

$Z_L = Z_{TH}^*$

$$\boxed{Z_L = 8.21\angle -79.89 \, \Omega}$$

⇒ For max Power,

$$\text{Average Power} = P = \frac{1}{2} \frac{|V_{TH}|^2 R_L}{(R_{TH}+R_L)^2 + (X_{TH}+X_L)^2}$$

from Previous Part of questions

$Z_L = 1.44 - 8.08j$ so, $R_L = 1.44$, $X_L = +8.08j$

$Z_{TH} = 1.44 + 8.08j$ so, $R_{TH} = 1.44$, $X_{TH} = -8.08j$

Substituting in eq of average Power,

$$P = \frac{1}{2} \frac{18^2 \times 1.44}{(1.44+1.44)^2 + (8.08j - 808j)}$$

$$P_{max} = \frac{466.56}{2(2.88)^2}$$

$$\boxed{P_{max} = 28.125 \text{ Watt}}$$

Q5) Load 2 draws 20KVA at pf of 0.85 lagging from 220V 50Hz rms, sinusoidal

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(a) Average and relative Power delievered by the Source:

we know that,

Average Power = $P = pf \times S$

So,

$P = 0.85 \times 20 \times 10^3$

$\boxed{P = 17 kW}$

⇒ For Reactive Power Q,

$Pf = \cos(\theta v - \theta i)$

$0.85 = \cos(\theta v - \theta i)$

$\boxed{\theta v - \theta i = 31.79}$

$Q = S \sin(\theta v - \theta i)$

$= (2 \times 10^3)(\sin(31.799))$

$\boxed{Q = 10.54 \ kVAR}$

b) PEAK CURRENT:

We know that,

$I_{rms} = \frac{S}{V_{rms}} = \frac{20 \times 10^3}{220}$

$\boxed{I_{rms} = 90.91 A}$

Since,

$I_{rms} = I_{rms} / \sqrt{2}$

$= 90.91 \times \sqrt{2}$

$\boxed{I_{rms} = 128.56 A}$

c) LOAD IMPEDENCE:

From Previous Parts of the question.

$I_{rms} = 90.91 A$

$V_{rms} = 220V$

$\theta v - \theta i = 31.79°$

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$$\rightarrow \text{Power} = \frac{V_{rms}}{2} I_{rms} \cos(\theta v - \theta i)$$

$$100 = 220 \times 1.67 \times \cos(\theta v - \theta i)$$

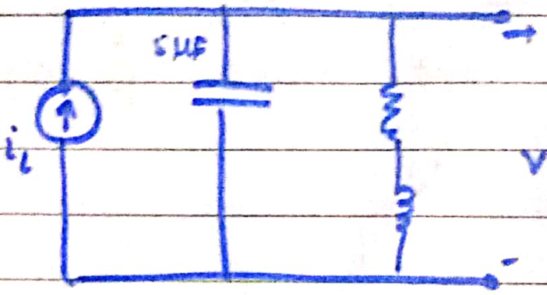
$$\cos(\theta v - \theta i) = 0.27$$

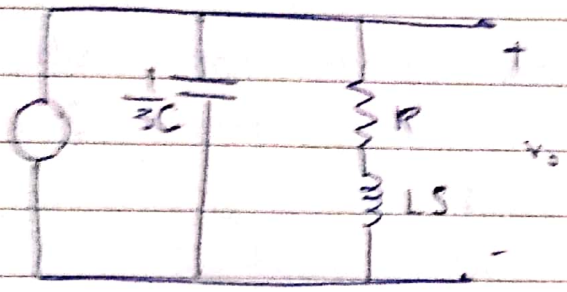
Since,

$$\cos(\theta v - \theta i) = Pf$$

$$\boxed{Pf = 0.27}$$

Q3 Re drawing circuit.





$$Z_T = \frac{(R+LS)\left(\frac{1}{SC}\right)}{(R+LS)+\left(\frac{1}{SC}\right)} = \frac{(R+LS)(1/SC)}{\frac{RSC+LSC+1}{SC}}$$

$$\boxed{Z_T = \frac{R+LS}{(RCS+LS^2C+1)}}$$

Using ohm's law,

$$\boxed{Z = \frac{V_o}{I_i}}$$

$$\frac{V_o}{I_i} = \frac{R+LS}{RSC+LS^2C+1}$$

Thus,

Tranfer function $H(s) = \frac{V_o}{I_i}$

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Day / Date

$$H(s) = \frac{R + LS}{RSC + LS^2C + 1}$$

*** DIMENSIONAL CHECK:**

Each of numerater term has same dimensions as that of resistance. Each of denominator term ~~has same~~ is dimensionless. Ratio of 2 sets is Ω, the same dimensions ratio as $\frac{V_o}{I_i}$

Our function thus passes the dimension test

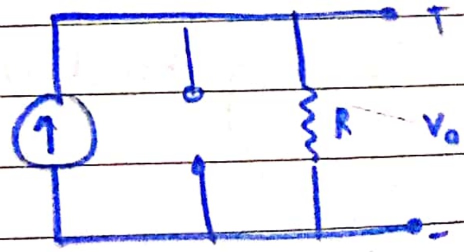
*** ASYMPTOTIC CHECKING**

letting $s \to 0$, our transfer function, H(s)

$$H(s) = R = 120\Omega$$

To verify it physically, At S = 0 our capacitance acts as an open circuit.

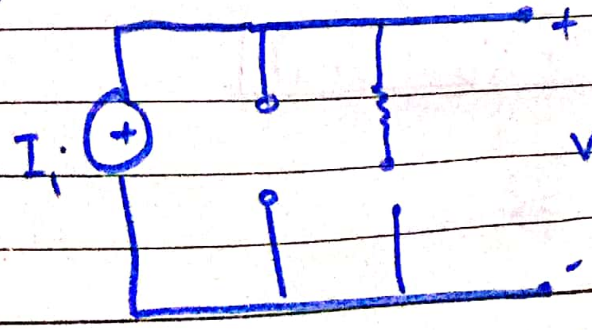
$$\boxed{\lim_{s \to \infty} Z_L = 0}$$



- Transfer function = $R = 120\Omega$
- $H(\infty) = 0$

$$\lim_{s \to \infty} Z_C = 0 \text{ — short circuit}$$

$$\lim_{s \to \infty} Z_L = \infty \text{ - Open circuit.}$$



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Any voltage through short circuit is zero, Thus the transfer function is 0.

Put $R = 120\,\Omega$ $L = 20\,mH$

$C = 5\,\mu F$

$$\boxed{H(s) = \frac{120 + 20m(s)}{(600\mu s) + (100n)s^2 + 1}}$$

→ Zero:

$$N(s) = 120 + 20ms = 0$$

$$S = -\frac{120}{20m}$$

$$\boxed{z = -6k\ NP/s}$$

→ Poles: $P_1 = -3k + 1kj$

$P_2 = -3k - 1kj$

→ Scaling factor:

$$k = \frac{a_m}{b_n} = \frac{20m}{100n}$$

$$\boxed{k = 200k}$$

$$\boxed{H(s) = \frac{200k\ (s + 6k)}{(100ns^2 + 600\mu s + 1)}}$$

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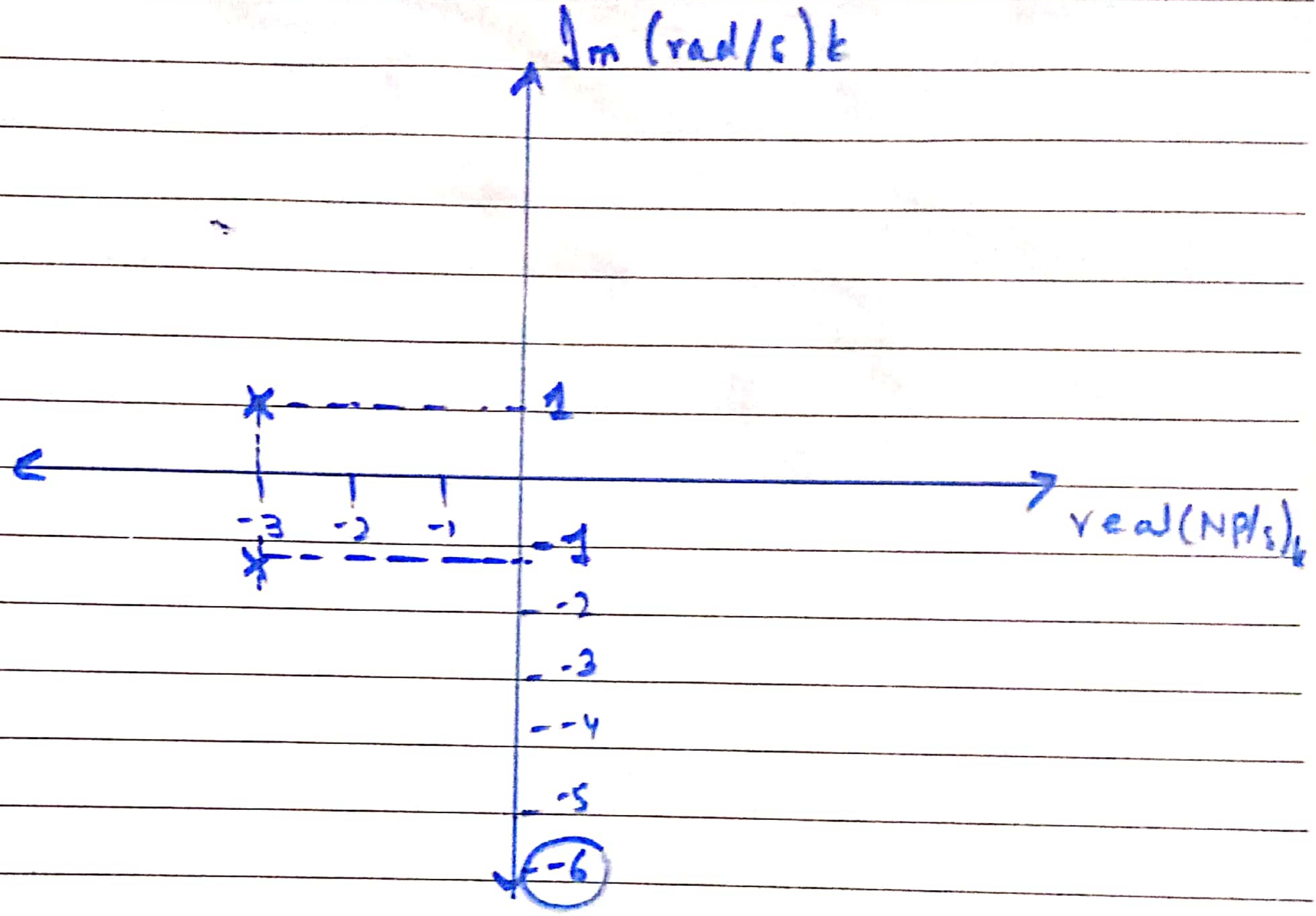

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