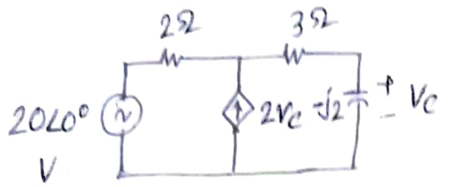
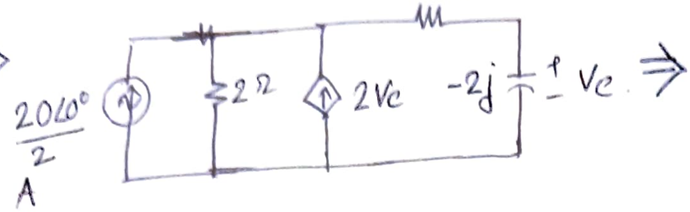
Prob - 17 Chapter 11



Avg power supplied by the dependent source?

⇒



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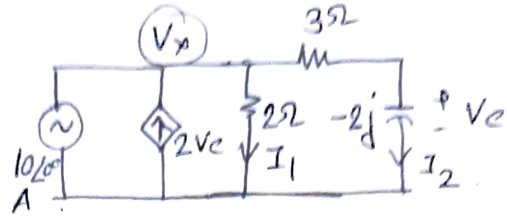


$$I_2 = \frac{(10\angle 0^\circ + 2V_c) * 2}{(2 + 3 - 2j)}$$

$$V_c = -2j I_2 = -2j \frac{2(10\angle 0^\circ + 2V_c)}{5-2j}$$

$$5V_c - 2V_c j = -40j - 8j V_c$$

$$V_c(5 - 2j + 8j) = -40j$$

$$V_c = \frac{-40j}{5+6j} = -3.93 - 3.28j = 5.12\angle -140.15^\circ \text{ V}$$

Volt across ct source 2Vc

$$V_x = V_c + 3I_2$$

$$= V_c + 3\frac{2(10+2V_c)}{5-2j}$$

$$= \frac{60}{5-2j} + V_c + \frac{12V_c}{5-2j} = \frac{60}{5-2j} + V_c\left(\frac{17-2j}{5-2j}\right) = 9.23\angle -83.79^\circ \text{ V}$$

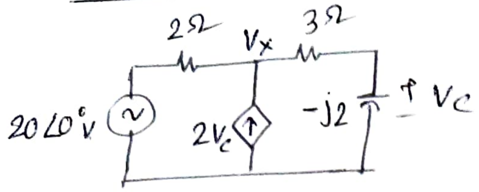
$$S = V_x (2V_c)^* = 9.23\angle -83.79^\circ \,(2 * 5.12\angle -140.15^\circ)^*$$

$$= 94.5\angle 56.36^\circ$$

Avg power $P = \frac{1}{2}\text{Re}(S) = \frac{1}{2} * 94.5 \cos 56.36^\circ$

$= 26.175$ Watt

Method -2



KCL :- $\dfrac{20\angle 0^\circ - V_x}{2} + 2V_c = \dfrac{V_x}{3-2j} \rightarrow (1)$

$$V_c = \frac{V_x}{3-2j}(-2j) \rightarrow (2).$$

Substitute (2) in (1).

$$\frac{20\angle 0^\circ - V_x}{2} + 2\frac{V_x}{3-2j}(-2j) = \frac{V_x}{3-2j}$$

$$10\angle 0^\circ - \frac{V_x}{2} - \frac{4j\,V_x}{3-2j} = \frac{V_x}{3-2j}$$

$$V_x\left(\frac{1}{3-2j} + \frac{4j}{3-2j} + \frac{1}{2}\right) = 10.$$

$$V_x = 9.23\angle -83.9^\circ \text{ V}$$

From (2), $V_c = \dfrac{-2j}{3-2j} V_x = 5.119\angle -140.2^\circ$ V.

Power supplied ?

$$S = \bar{V}_x (2\bar{V}_c)^*$$

$$= 9.23\angle -83.9^\circ\,(2\times 5.119\angle -140.2^\circ)^*$$

$$= 94.5\angle 56.36^\circ.$$

Avg power $= \frac{1}{2}Re(S) = \frac{1}{2}\times 94.5\cos 56.36^\circ$

$= 26.175$ watt

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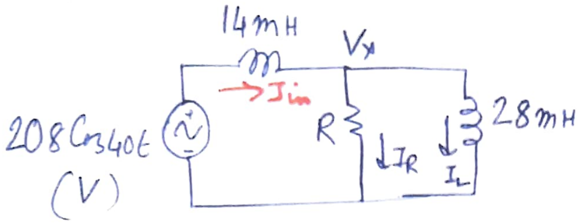


a) What is the value of R for which Voltage across 14mH and R will have same RMS value ?

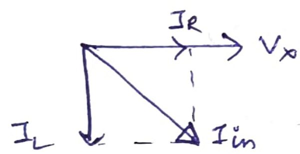
b) Find the RMS voltage across R.

Sol^n

~~RMS~~ volt across R = volt across 28 mH .

$$|I_{in}| \times 40 \times (14m) = |I_L| \times 40 \times 28m$$

$$|I_{in}| = 2|I_L|$$



$$\Rightarrow |I_{in}| = \sqrt{I_R^2 + I_L^2}$$

$$(2 I_L) = \sqrt{I_R^2 + I_L^2}$$

$$|I_R| = \sqrt{3}\,|I_L|$$

$$|I_R| = \frac{V_x}{R} \quad \& \quad |I_L| = \left|\frac{V_x}{j\,40 \times 28m}\right| = \frac{V_x}{40 \times 28m}$$

$$\frac{V_x}{R} = \sqrt{3}\,\frac{V_x}{40 \times 28m}$$

$$R = \frac{40 \times 28m}{\sqrt{3}} = 0.6466\,\Omega$$

~~$|V_x| = \frac{208}{\sqrt{2}}$ $\frac{1}{\sqrt{2}}(208$ $V_x = 208\angle 0^\circ$~~

Verify

$$R = 0.6466\,\Omega .$$

$$I_{in} = \frac{208\angle 0^\circ}{j14m \times 40 + \frac{R\,j\,28m \times 40}{R + j\,28 \times 40}} = 214.45\angle -60^\circ\,A$$

volt across 14mH

$$= \overline{V_L} = j\,I_{in}(14m \times 40) = 120\angle 30^\circ\ V$$

$$\overline{V_x} = 208\angle 0^\circ - 120\angle 30^\circ = 120\angle -30^\circ\ V \Rightarrow RMS = \frac{V_L}{\sqrt{2}} = 84.85\,V$$

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Method - II

$$Z = R \| (j\omega\, 28m) = R \| 1.12j = \frac{j1.12R}{R + j1.12}$$

$$V_R = \frac{Z}{j\omega 14m + Z} \cdot V_S = \frac{Z}{j0.56 + Z} \; 208\angle 0^\circ$$

$$= \frac{j1.12}{-0.6272 + 1.68Rj} \cdot (208\angle 0^\circ)\ V \rightarrow (1)$$

V_L : Volt across 14mH

$$= \frac{j0.56}{j0.56 + Z} \, (208\angle 0^\circ)\ V.$$

$$= \frac{-0.6272 + j0.56R}{-0.6272 + j1.68R} \; 208\angle 0^\circ\ V. \rightarrow (2)$$

$$V_{R,RMS} = V_{L,RMS}$$

$$|V_R| = |V_L| \quad (\text{from } (1) \& (2))$$

$$\Rightarrow \frac{1.12R}{\sqrt{0.6272^2 + (1.68R)^2}} = \frac{\sqrt{0.6272^2 + (0.56R)^2}}{\sqrt{0.6272^2 + (1.68R)^2}}$$

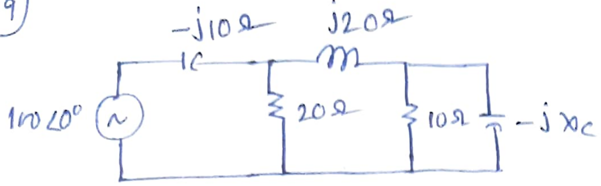
$$1.12R = \sqrt{0.6272^2 + (1.68R)^2}$$

$$R = \frac{0.6272}{\sqrt{0.9408}} = 0.6466\,\Omega$$

Put R in (1) or (2)

$$V_{R\,rms} = V_{L,rms} = \frac{120}{\sqrt{2}} = 84.92\ V$$

(49)



Find X_C that improves pf to 0.95.

Solution

Method 1

Without X_C, find the pf.

$$Z_{eq} = -j10 + 20 \parallel (10 + j20)$$
$$= 11.435\angle -19.65° \ \Omega$$

$\cos(19.65°) = 0.94$ leading

↳ as $\angle Z_{eq} = -19.65°$ indicates predominantly capacitive loading

With X_C pf improves to 0.95 leading.

$$Z_1 = 10 \parallel -jX_C = \frac{-j10X_C}{10 - jX_C}.$$

$$Z_2 = j20 - \frac{j10X_C}{10 - jX_C} = \frac{20X_C + j(200 - 10X_C)}{10 - jX_C}.$$

$$Z_3 = 20 \parallel Z_2 = \frac{2(20X_C + j(200 - 10X_C))}{(20 + 2X_C) + j(20 - 3X_C)}$$

$$Z_{eq}^{new} = Z_3 - 10j = -10j + \frac{2(20X_C + j(200 - 10X_C))}{(20 + 2X_C) + j(20 - 3X_C)}$$

Simplify through a number of steps!

$$= \frac{8000 - 800X_C + 140X_C^2}{(20 + 2X_C)^2 + (20 - 3X_C)^2} + j\frac{(-50X_C^2)}{(20 + 2X_C)^2 + (20 - 3X_C)^2}$$

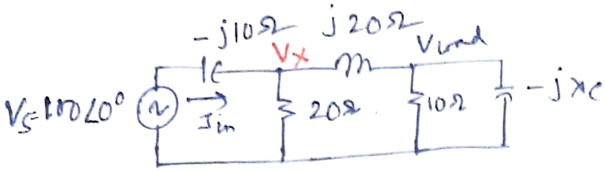
$\angle Z_{eq}^{new}$

$$= \tan^{-1}\frac{-50X_C^2}{8000 - 800X_C + 140X_C^2} = \cos^{-1}(-0.95)$$

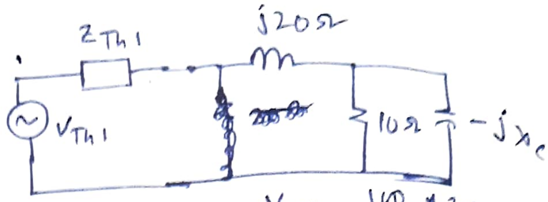
$$X_C = 8.82\Omega$$

For 50 Hz supply, $C = 360.89\mu F$

Method 2



$\Rightarrow$

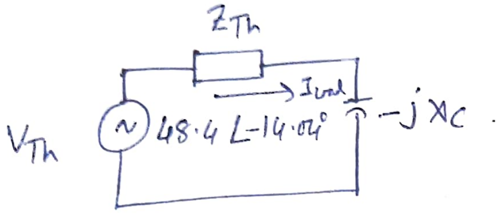


$$V_{Th1} = \frac{100 \times 20}{20 - j10}$$

$$Z_{Th1} = \frac{20(-j10)}{20-10j}$$

$$V_{Th2} = V_{Th1}\frac{10}{10+j20}$$

$$Z_{Th} = \frac{10 \parallel (Z_{Th1}+20j)}{10+Z_{Th1}+20j}$$



$$Z_{Th} = \frac{10(4+12j)}{14+12j} = 5.88 + j3.53\,\Omega$$

$$\bar{I}_{load} = \frac{V_{Th}}{Z_{Th} - jX_C} = \frac{48.4\angle -14.04°}{5.88 + j(3.53 - X_C)}\ A$$

Need to find I/P pf i.e. the angle between V_s and I_{in} ~~which~~ is of interest.

* Note that, what we have found above is $\bar{I}_{load}$, not $\bar{I}_{in}$.

From $\bar{I}_{load}$, $\bar{V}_{load} = -jX_C\,\bar{I}_{load}$

$$\bar{V}_x = \bar{V}_{load} + \underbrace{\left(\frac{\bar{V}_{load}}{10} + \bar{I}_{load}\right)}_{\text{ct in } j20\Omega} j20$$

$$\bar{I}_{in} = \frac{\bar{V}_s - \bar{V}_x}{-j10}$$

$$\angle I_{in} = \cos^{-1} 0.95 = 18.19°$$

~~Equating~~ From this X_C can be found. However, this method is not less computationally intensive than the previous method.

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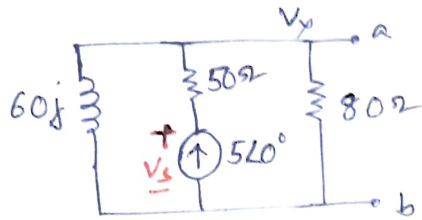


a) $\frac{\bar{V}_x}{80} + \frac{\bar{V}_x}{j60} = 5$

$\bar{V}_x = 144 + 192j$

$\bar{V}_s - 50 * 5\angle 0° = \bar{V}_x$

$\bar{V}_s = 250 + \frac{80(j60)}{80 + j60} = 394 + 192j$

b) i) $S_{80} = VI^* = \left[\frac{5(80 * j60)}{80 + j60}\right]\left[\frac{1}{80}\ \frac{5(80 * j60)}{80 + j60}\right]^*$

$= (144 + 192j)\ \frac{(144 - 192j)}{80} = 720 + j0$ VA

ii) $S_{j60} = (144 + 192j)\left(\frac{144 + 192j}{j60}\right)^*$

$= 0 + 960j$ VA.

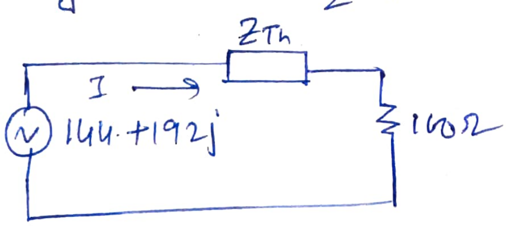
(iii) $S_{50} = \frac{1}{2}(V_s - V) * 5 = \frac{1}{2}(394 + 192j - 144 - 192j) * 5$

$= (1250\ \cancel{\text{watt}} + 0.j)$ VA

c) $S_{source} = V_s * 5 = 1970 + 960j$

Avg. Power $= \frac{1}{2} \times 1970 = 985$ watt

d)



$Z_{Th} = 80 \| 60j$

$= 48\angle 53.13°\ \Omega$

$V_{Th} = 5(80 \| 60j)$

$= 144 + 192j$ V

$I = \frac{144 + 192j}{48\angle 53.13° + 160} = 1.7856\angle 36.53°$ A

Avg power $= \frac{1}{2} I^2 R \simeq 160$ watt