Power Engineering 3

Tutorial 1 Solution

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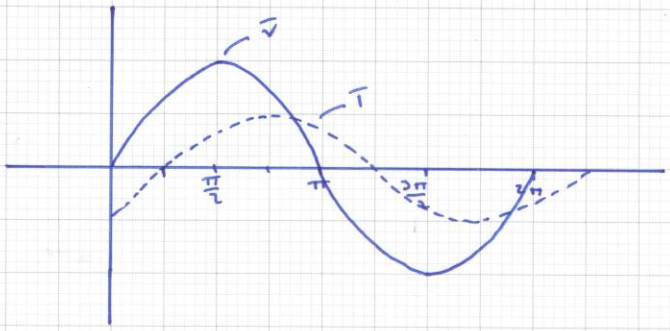
Subject: POWER ENG 2: TUTORIAL 1 Date:

Q1. a) $V_{rms} = \frac{V_{pk}}{\sqrt{2}} = \frac{141}{\sqrt{2}} = 99.7\,V$

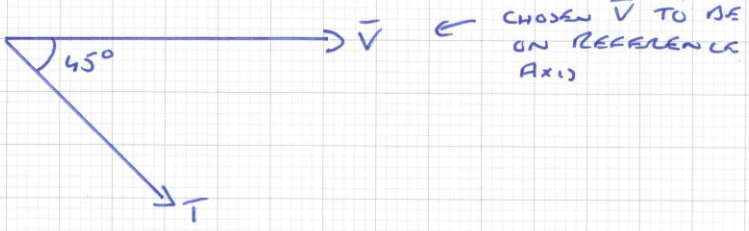
b) $I_{rms} = \frac{I_{pk}}{\sqrt{2}} = \frac{20}{\sqrt{2}} = 14.1\,A$

Q2.



THE CURRENT LAGS THE VOLTAGE BY 45°

Q3.



← CHOSEN $\bar{V}$ TO BE ON REFERENCE AXIS

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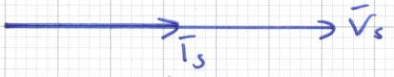
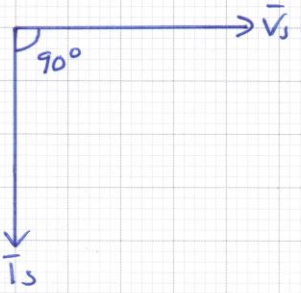
Q4 a)



$$I_{rms} = \frac{V_{rms}}{R} = \frac{100}{5} = \underline{\underline{20A}}$$

b)

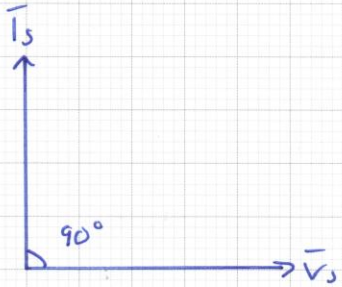


$$X_L = \omega L = 2\pi \times 50 \times 15 \times 10^{-3}$$

$$\Rightarrow X_L = 4.71\,\Omega$$

$$I_{rms} = \frac{V_{rms}}{X_L} = \frac{240}{4.71} = \underline{\underline{50.9A}}$$

c)



$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi \times 60 \times 3300 \times 10^{-6}}$$

$$\Rightarrow X_C = 0.8\,\Omega$$

$$I_{rms} = \frac{V_{rms}}{X_C} = \frac{240}{0.8} = \underline{\underline{300A}}$$

Note: In each case we are computing MAGNITUDE only of I_{rms}!

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Q5 $f = 60\,Hz$

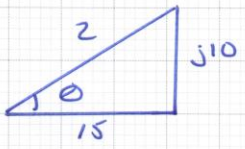
a) $X_L = 2\pi f \times L = 6.28 \times 60 \times 220 \times 10^{-3}$

$\Rightarrow X_L = \underline{\underline{82.9\,\Omega}}$

b) $X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 60 \times 220 \times 10^{-6}} = \underline{\underline{12.0\,\Omega}}$

Q6 a) $15 + j10$

Draw the Impedance Triangle.



Note this has an Inductive Element a +j Component

$Z^2 = (R^2 + X_L^2) = (15^2 + 10^2) = 325$

$\Rightarrow Z = 18\,\Omega$

$\theta = \cos^{-1}\frac{15}{18} = 33.5^\circ$ (BETTER TO USE $\tan^{-1}\frac{10}{15}$!)

$\Rightarrow \underline{\underline{18 \angle 33.5^\circ}}$

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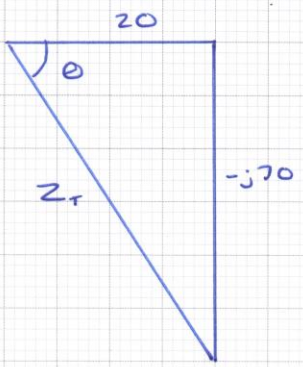
Q6 b) $20 - j30$

Draw the Impedance Triangle:



$Z_T^2 = (R^2 + X_c^2)$

$= 20^2 + 30^2$

$= 1300$

$\Rightarrow Z_T = 36$

$\theta = \tan^{-1}\frac{-30}{20} = -56.3°$

(Note θ is -ve)

That's why drawing the Impedance Triangle is worthwhile as we can clearly see θ is NEGATIVE

$Z_c = \underline{\underline{36 \angle -56.2°}}$

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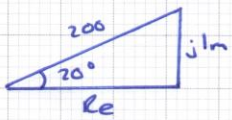
Q7 a) $\bar{V} = 200 \angle 20°$

Draw the Phasor on the Complex Plane to Determine Real and Imaginary Parts:



$Re = H\cos\theta$

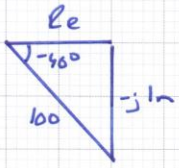
$= 200 \cos 20° = 188$

$Im = H\sin\theta$

$= 200 \sin 20° = 68.4$

$\Rightarrow \bar{V} = \underline{188 + j68.4}$

b) $\bar{V} = 100 \angle -40°$



$Re = H\cos\theta$

$= 100 \cos -40° = 76.6$

$Im = H\sin\theta$

$= 100 \sin -40° = -64.2$

$\Rightarrow \bar{V} = \underline{76.6 - j64.2}$

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Q8 a) $X_L = \omega L$

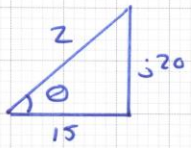
$\Rightarrow L = \frac{X_L}{\omega} = \frac{20}{2\pi \times 50} = \underline{\underline{63.7\ mH}}$

b) $\bar{V}_S = Z_T . \bar{I}_S$

$\Rightarrow \bar{I}_S = \frac{\bar{V}_S}{Z_T}$

Need to determine Polar value for Z_T:

$Z_T = 15 + j20$



$Z^2 = (15^2 + 20^2) = 625$

$\Rightarrow Z = \underline{\underline{25}}$

$\cos\theta = \frac{A}{H} = \frac{15}{25} = 0.6$ (Better to use $\tan^{-1}\frac{20}{15}$!)

$\Rightarrow \theta = 53.1°$ $\Rightarrow Z_T = \underline{\underline{25 \angle 53.1°}}$

$\Rightarrow \bar{I}_S = \frac{\bar{V}_S}{Z_T} = \frac{110 \angle 0°}{25 \angle 53.1} = \underline{\underline{4.4 \angle -53.1°}}$

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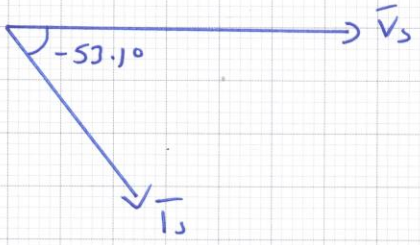

a) $P_{out} = I_s^2 R = 4.4^2 . 15 = \underline{290\,W}$

e) Input Power = Total output Power

$\Rightarrow P_{in} = \underline{290\,W}$

f) $\bar{V}_R = R . \bar{I}_s = 15 . 4.4 \angle -53.1°$

$\Rightarrow \bar{V}_R = \underline{66 \angle -53.1°}$

$\bar{V}_L = Z_L \bar{I}_s = j20 . 4.4 \angle -53.1°$

$= 20 \angle 90° . 4.4 \angle -53.1°$

$= \underline{88 \angle 36.9°}$

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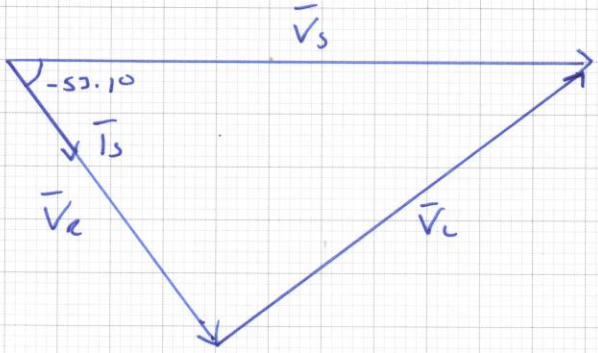


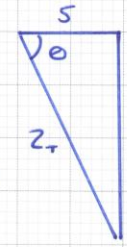
Q9

a) $Z_T = j10 + 5 - j20 = \underline{\underline{5 - j10}}$

b) $\bar{I}_s = \dfrac{\bar{V}_s}{Z_T}$

$\Rightarrow \bar{I}_s = \dfrac{11000\angle 0°}{11.18\angle -63.4°}$

$\Rightarrow \bar{I}_s = \underline{\underline{983.4\angle 63.4°}}$



$Z_T^2 = 5^2 + 10^2$

$= 125$

$\Rightarrow Z_T = 11.18$

$\theta = \tan^{-1}\dfrac{-10}{5}$

$\Rightarrow \theta = -63.4°$

$\Rightarrow Z_T = 11.18\angle -63.4°$

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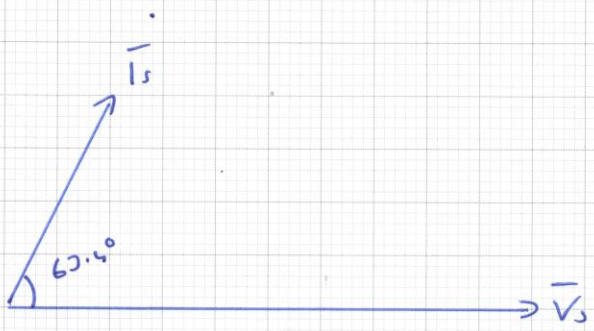

d) For the current to be in phase with the voltage then the j term must equal zero so- Z_T

$\Rightarrow Z_T = R + j0$

$\Rightarrow Z_T = R + j10 - j10$ ($j10 \uparrow Z_L$, $-j10 \downarrow Z_C$)

$\Rightarrow Z_C = -j10$

$\Rightarrow X_C = 10 = \frac{1}{\omega C}$

$\Rightarrow C = \frac{1}{10\omega} = \frac{1}{10.2\pi \times 50} = \underline{\underline{318\mu F}}$

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