Eample 11.1

Date:
Day:

Given that

$v(t) = 120\cos(377t + 45°)$ V
$i(t) = 10\cos(377t - 10°)$ A.

Find instantaneous power and average power by the passive linear network.

Solution:

Instantaneous power $= P = vi$

$P = vi = 120\cos(377t+45)\, 10\cos(377t-10)$

$P = 1200(\cos(377t+45))(\cos(377t-10))$

$P = \frac{1200}{2}\left[2\cos(377t+45)\cos(377t-10)\right]$

$P = 600\left[\cos(377t+45+377t-10) + \cos(\cancel{377t}+45-\cancel{377t}+10)\right]$

$P = 600\left[\cos(754t+35°) + \cos 55°\right]$

$\boxed{P = 344.2 + 600\cos(754t+35)\,W}$

Average power $= P = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$

$P = \frac{1}{2}(120)(10)\cos(45+10)$.

$\boxed{P = 344.2\,W}$

Practice 11.1

Date:
Day:

Calculate the instantaneous power and average power absorbed by the passive linear network

$v(t) = 330\cos(10t+20)$ V
$i(t) = 33\sin(10t+60°)$ A $= 33\cos(10t+60-90°)$
$= 33\cos(10t-30°)$

Solution:

Instantaneous power $= P = vi$

$P = vi = 330\cos(10t+20)\, 33\sin(10t+60°)$

$P = 10890\cos(10t+20)\sin(10t+60)$

$P = \frac{10890}{2}\left[2\cos(10t+20)\sin(10t+60°)\right]$.

$P = 5445\left[\sin(10t+20+10t+60°) - \sin(10t+20-10t+60°)\right]$

$P = 5445\left[\sin(20t+80°) - \sin(-40°)\right]$.

$P = 5445\left[\sin(20t+80) + \sin 40°\right]$.

$P = 3499.97 + 5445\sin(20t+80°)$

OR

$\boxed{P = 3499.97 + 5445\cos(20t-10)\,W}$

Average power $= P = \frac{1}{2}(330)(33)\cos(20+30°)$

$\boxed{P = 3499.97\,W}$

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Date:

Day: M T W T F S S

Example 11.2

Calculate the averge power absorbed by an impedence $Z = 30 - 70j\,\Omega$. when voltage $V = 120\angle 0^\circ$ is applied across it.

Solution:

$$I = \frac{V}{Z} = \frac{120\angle 0^\circ}{30-70j}$$

$$\boxed{I = 1.57\angle 66.80}$$

$$\text{Average power} = P = \frac{1}{2} I_m V_m \cos(\theta_v - \theta_i)$$

$$P = \frac{1}{2}(120)(1.57)\cos(0 - 66.80^\circ)$$

$$P = 94.2\cos(-66.80^\circ)$$

$$\boxed{P = 37.10\,W}$$

Date:

Day: M T W T F S S

Practice 11.2

A current $I = 33\angle 30^\circ$ A flows through an impedence $Z = 40\angle -22\,\Omega$. Find the average power delievered to the impedence.

Solution:

$$V = IZ = (33\angle 30^\circ)(40\angle -22).$$

$$\boxed{V = 1320\angle 8}$$

$$\text{Average power} = P = \frac{1}{2} V_m I_m(\cos(\theta_v - \theta_i)$$

$$P = \frac{1}{2}(1320)(33)\cos(8 - 30^\circ)$$

$$P = 21780\cos(-22^\circ)$$

$$P = 20194.06\,W$$

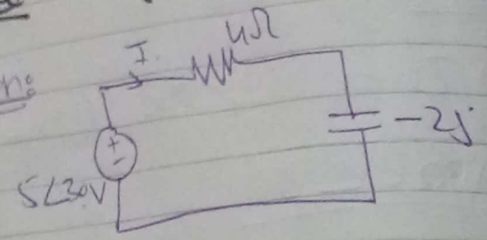
OR

$$\boxed{P = 20.194\,kW}$$

Example 11.3

For the circuit given. Find the average power supplied by the source and the average power absorbed by the resistor.

Solution:



$Z = 4-2j \ \Omega$
$V = 5\angle 30^\circ \ V$

$I = \frac{V}{Z} = \frac{5\angle 30^\circ}{4-2j}$

$\boxed{I = 1.11\angle 56.56}$ A

i) Average power $= P = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$

$P = \frac{1}{2}(5)(1.11)\cos(30 - 56.56)$

$\boxed{P = 2.482 \ W}$

*) Average power $= P = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$

$P = \frac{1}{2}(2.22)(1.11)\cos(-33.44 - 56.56)$

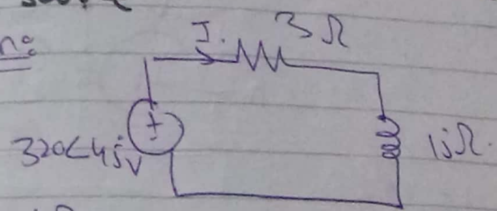
$\boxed{P = 0}$

ii) $P = \frac{1}{2}(4.44)(1.11)\cos(56.56 - 56.56)$

Practice 11.3

In the given circuit, calculate the average power absorbed by the resistor and inductor. Find the average power supplied by the voltage source

Solution:



$Z = 3 + j\Omega$
$V = 320\angle 45^\circ$

$I = \frac{V}{Z} = \frac{320\angle 45^\circ}{3+j}$

$\boxed{I = 101.192\angle 26.56 \ A}$

$V_R = IR = 303.57\angle 26.56$ $V_Z = 101.192\angle 116.56$

i) $P = \frac{1}{2}(303.57)(101.192)\cos(26.56 - 26.56)$

$\boxed{P = 15359.4 \ W}$

$P = \frac{1}{2}(101.19)(101.192)\cos(116.56 - 26.56)$

$\boxed{P = 0 \ W}$

ii) $P = \frac{1}{2}(320)(101.192)(\cos(45 - 26.56))$

$\boxed{P = 15359.4 \ W}$

$-V + 20I_1 + (I_1 - I_2)10j \Rightarrow V = \ldots$

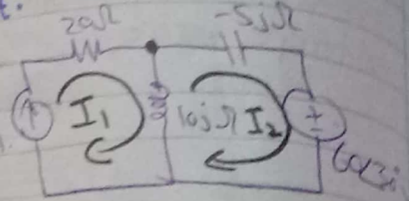
$P_{2\Omega} = \frac{1}{2}(184.87)(4)\cos(6.20 - 0°)$

$\boxed{P = 367.57W}$

Example 11.4

Determine the average power generated by each source and average power absorbed by each passive element in the circuit.

Solution:



$\boxed{I_1 = 4\angle 0°}$ A

$-5jI_2 + 60\angle 30° + 10j(I_2 - 4\angle 0°) = 0$

$-5jI_2 + 60\angle 30° + 10jI_2 - 40j = 0$

$5jI_2 = -[52.91\angle -10.89)]$

$\boxed{I_2 = 10.58\angle 79.10 \text{ A}}$

$\boxed{I_1 - I_2 = 10.58\angle -79.10}$

$P_V = \frac{1}{2}(60)(10.58)\cos(30 - 79.10)$

$\boxed{P_V = 207.81W}$

$P_{5j} = \frac{1}{2}(52.9)(10.58)\cos(-10.9 - 79.10)$

$\boxed{P_{-5j} = 0W}$

$P_{10j} = \frac{1}{2}((105.7)(10.57)\cos(10.9 + 79.10)$

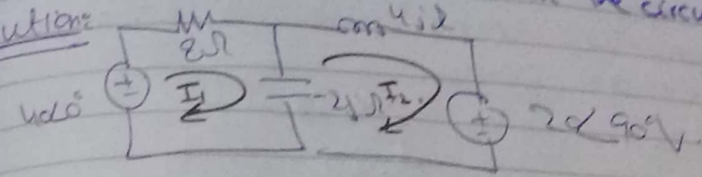
$\boxed{P_{10j} = 0W}$

$P_C = \frac{1}{2}(\ldots)(4)\ldots$

Practice 11.4

Calculate the average power absorbed by each of the five element in the circuit.

Solution:



$-40\angle 0° + 8I_1 - 2j(I_1 - I_2) = 0$

$8I_1 - 2jI_1 + 2jI_2 = 40\angle 0°$

$(8 - 2j)I_1 + 2jI_2 = 40\angle 0°$ (1)

$4jI_2 + 20\angle 90° - 2j(I_2 - I_1) = 0$

$4jI_2 + 20\angle 90° - 2jI_2 + 2jI_1 = 0$

$2jI_1 + 2jI_2 = -20\angle 90°$ (2)

$\boxed{I_2 = \cancel{-360 - 80j}\ -13 - 4j} = 13.60\angle -162.89$

$\boxed{I_1 = \cancel{7.10 + 160j}\ 3 + 4j} = 5\angle 53.130$

$\boxed{I_1 - I_2 = 16 + 8j} = 17.88\angle 26.56$

$P_{V_1} = \frac{1}{2}(40)(5)\cos(0 - 53.130°)$

$\boxed{P_{V_1} = -60W}$

$P_{V_2} = \frac{1}{2}(20)(13.60)\cos(90° + 162.89)$

$\boxed{P_{V_2} = +40W}$

$P_R = \frac{1}{2}(40)(5)\cos(53.13 - 53.13)$

$\boxed{P_R = 100W}$

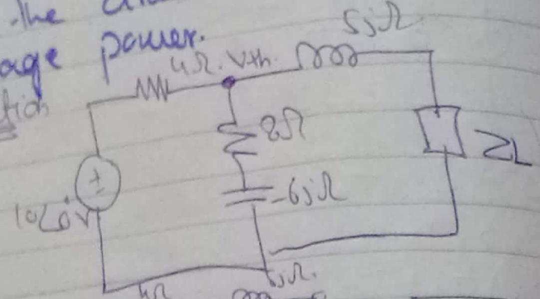
$P_C = \frac{1}{2}(35.77)(17.88)\cos(-63.43 - 26.56)$

$Z_L = \overline{Z}_{th}$

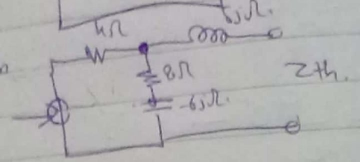
Example 11.5

Determine the load impedence Z_L that maximize the average power draw from the circuit. what is the maximum average power.

solution



For Z_{th}



$\boxed{Z_{th} = 2.93 + 4.466j}$

$$V_{th} = \frac{8-6j}{(8-6j)+(4+5j)} \times 10\angle 0°$$

$\boxed{V_{th} = 7.45\angle -10.30}$

$\boxed{Z_L = Z_{th}^{*} = 2.93 - 4.466j}$

$$\boxed{P_{max} = \frac{|V_{th}|^2}{8R_{th}}}$$

$$P_{max} = \frac{|7.45 \cancel{\angle -10.30}|^2}{8(2.93)}$$

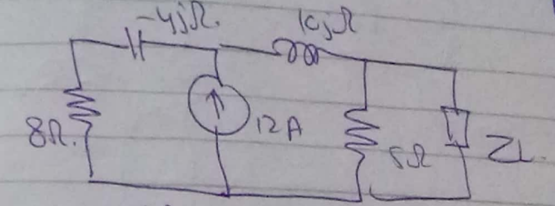
$\boxed{P_{max} = 2.367W}$

$P = \frac{|V_{th}|^2}{8R_{th}}$

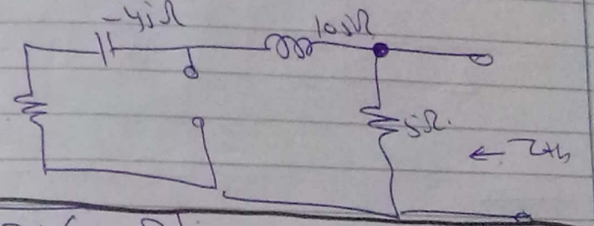
Practice 11.5

For the circuit. Find load impedance Z_L that absorbs maximum average power. Calculate that maximum average power.

solution:



Z_{th}:



~~$Z_{th} = 13+6j\ \Omega$~~

~~$Z_L = 13-6j\ \Omega$~~

~~V_{th} =~~

wrong track

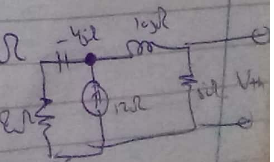
$8jI - 4jI + 10I + 5I \neq 0$

$\cancel{I(8-4j+10+5)=0}$

$Z_{th} = 5 \| (10j - 4j + 8)$

$Z_{th} = 3.444 + 0.7837\Omega$

$\boxed{Z_L = 3.444 - 0.7837}\ \Omega$



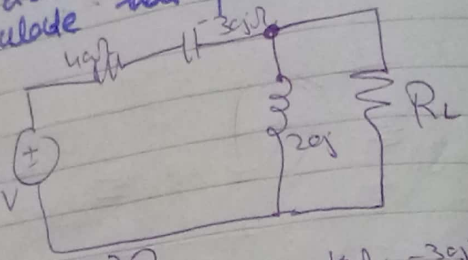
$V = IZ = (12)(8-4j)$

$\boxed{V = 96-48j} = 107.33\angle -26.56$

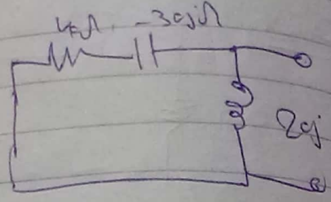
$R_L = |Z_{th}|$ $P_{max} = \frac{1}{2} I R_L$

Example 11.6

In the circuit. Find the value of R_L that will absorb the maximum average power calculate that power.



$P_{max} = \frac{1}{2} I^2 R_L$.



$\underline{\underline{Z_{th}:}}$

$Z_{th} = 9.411 + 22.352j$

$Z_L = 9.411 - 22.352j$

$R_L = \cancel{9.411} |Z_{th}| = 24.25$

$I = \frac{V_{th}}{Z_{th} + R_L} = \frac{72.76\angle 134°}{40.40\angle 33.58}$

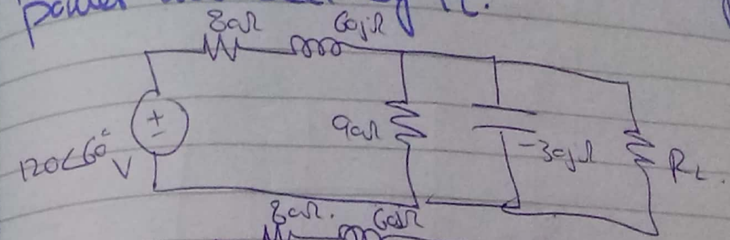
$\boxed{I = 1.800\angle 100.414}$

$P_{max} = \frac{1}{2} (I)^2 (R_L)$

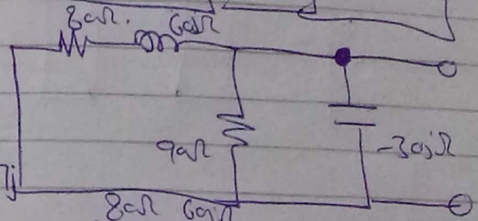
$\boxed{P_{max} = 39.29}$

Practice 11.6

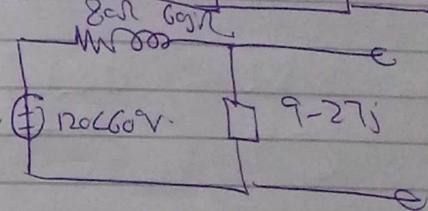
In figure, the resistor R_L is adjusted until it absorbs the maximum average power. Calculate R_L and maximum average power absorbed by it.



$\underline{\underline{Z_{th}}}$



$Z_{th} = 17.18 - 24.57j$



$R_L = 29.98$

$\boxed{R_L = 30\Omega}$

$V_{th} = \frac{9-27j}{80+60j+9-27j} \times 120\angle 60°$

$\boxed{V_{th} = 35.98\angle -31.90.}$

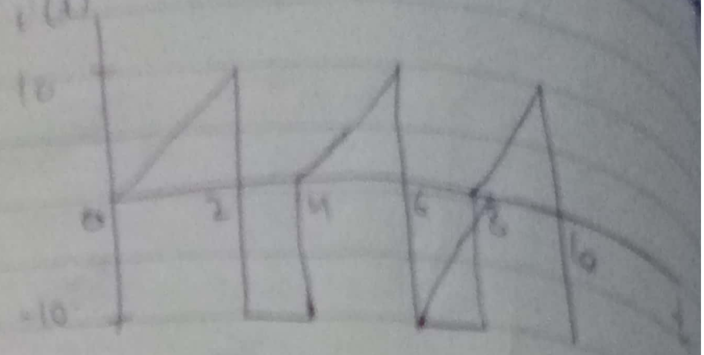
$I = \frac{V_{th}}{Z_{th} + R_L} = 0.6763\angle -4.399$

$P_{max} = \frac{1}{2} I^2 R_L$

$\boxed{P_{max} = 6.86W}$

Example 11.7

Determine the rms value of current waveform. If the current is passed through a 2Ω resistor. Find the average power absorbed by the resistor.



$\boxed{T=4}$

$$i(t) = \begin{cases} 5t, & 0<t<2 \\ -10, & 2<t<4 \end{cases}$$

$$I_{rms} = \sqrt{\frac{1}{T}\int_0^T i^2\,dt}$$

$$I_{rms} = \sqrt{\frac{1}{4}\left[\int_0^2 (5t)^2\,dt + \int_2^4 (-10)^2\,dt\right.}$$

$$I_{rms} = \sqrt{\frac{1}{4}\left[\frac{25t^3}{3}\Big|_0^2 + (+100)t\Big|_2^4\right.}$$

$$I_{rms} = \sqrt{\frac{1}{4}\left[\left(\frac{25(2)^3}{3} - \frac{5(0)}{3}\right) + 200\right]}$$

$\boxed{I_{rms} = 8.16\,A}$

$P = I^2R = 8.16 \times 2 = 133.17\,W$

Example 11.9

A series connected load draws a current $i(t) = 4\cos(100\pi t + 10°)$ A. When the applied voltage is $v(t) = 120\cos(100\pi t - 20°)$ V. Find the apparent power and the power factor of the load. Determine the element values from the series connected load.

Solution:

The apparent power is

$S = V_{rms} I_{rms}$

$S = \frac{4}{\sqrt{2}} \cdot \frac{120}{\sqrt{2}}$

$\boxed{S = 240\,VA}$

Power factor is

$pf = \cos(\theta_v - \theta_i) = \cos(-20° - 10°)$

$\boxed{pf = 0.866°}$ leading

$Z = \frac{V}{I} = \frac{120\angle -20°}{4\angle 10} = 30\angle -30°$

$Z = 25.98 - 15j\,\Omega$

$X_c = \frac{-1}{wC}$

$-15 = -\frac{1}{wC}$

$C = \frac{1}{15w}$

$C = \frac{1}{15 \times 2450\pi}$

Practice 11.9

Obtain the power factor and apparent power of load whose impedance is $Z = 60 + 40j\,\Omega$. When the applied voltage is $v(t) = 320\cos(377t + 10°)$ V.

Solution

Apparent power $= S = V_m I_m$.

$S = V_m I_m$.

$I = \frac{V}{Z} = \frac{320\angle 10}{72.11\angle 33.69} = 4.43\angle -23.69$

$S = \frac{320}{\sqrt{2}} \cdot \frac{4.43}{\sqrt{2}}$

$\boxed{S = 708.8}$ VA.

$pf = \cos(\theta_v - \theta_i)$

$pf = \cos(10 + 23.69)$

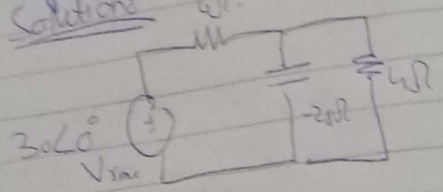
$\boxed{pf = 0.8321}$ lagging.

$-ve \longrightarrow$ leading.
$+ve \longrightarrow$ lagging.

Example 11.10

Determine the power factor of the entire circuit as seen by the source. Calculate the average power delievered by the source.

Solution:



$Z = (4 || -2j) + 6 = 7\angle -13.24$

$\boxed{Z = 6.8 - 1.6j}$

$\boxed{R = 6.8\Omega}$

$I = \frac{V}{Z} = \frac{30\angle 0}{7\angle -13.24}$

$\boxed{I = 4.286\angle 13.24\ A}$

$Pf = \cos(\theta_v - \theta_i) = \cos(0 - 13.24)$

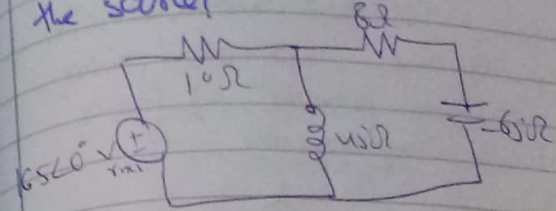
$\boxed{Pf = 0.9734 \text{ leading}}$

$P = I_{rm}^2 R$

$P = (4.286)^2 (6.8)$

Practice 11.10.

Calculate the power factor of the entire circuit as seen by the source. what is the average power applied by the source?



$Z = 10 || 4j || (8 - 6j)$

$Z = \ldots\angle 20.65\ \Omega$

$\boxed{Z = 12.882 + 9.470j}$

$I = \frac{V}{Z} = 43.18\angle -46.55$

$\boxed{I = 12.99\angle -20.61 A}$

$Pf = \cos(0 + 46.55)$

$Pf = 0.9359$

$\boxed{Pf = 0.9359}$ lagging.

$P = I_{rms}^2 R.$

$\boxed{P = 2004.96\ W}$

Example 11.11

The voltage across the load is $v(t) = 60\cos(\omega t - 10)$ V and the current through the element in the direction of the voltage drop is $i(t) = 1.5\cos(\omega t + 50)$ A.
Find a) complex and apparent power, b) real and reactive power c) power factor and load impedence.

Complex power $S = V_{rms} I_{rms}^*$

$$S = \left(\frac{60\angle -10}{\sqrt{2}}\right)\left(\frac{1.5\angle -50}{\sqrt{2}}\right)$$

$$S = 22.5 - 38.97j$$

$$\boxed{S = 45\angle -60^\circ}$$

$$\boxed{S = |S| = 45} \text{ VA}$$

$$\boxed{P = 22.5 W}$$

$$\boxed{Q = -38.97 VAR}$$

$$pf = \cos(-10 - 50^\circ)$$

$$\boxed{pf = 0.5 \text{ leading}}$$

$$\boxed{Z = \frac{V}{I} = 40\angle -60^\circ \Omega}$$

Practice 11.11

For a load $V_{rms} = 110\angle 85^\circ$ V, $I_{rms} = 0.4\angle 15^\circ$ A determine a) the complex and apparent power b) real and reactive power and c) power factor and load impedance.

Solution:

$$S = V_{rms} I_{rms}^*$$

$$S = 110\angle 85 \times 0.4\angle -15^\circ$$

$$S = 15.04 + 41.34j \text{ VA}$$

$$\boxed{S = 44\angle 70} \text{ VA.}$$

$$\boxed{|S| = 45 \text{ VA}}$$

$$\boxed{P = 15.04 W}$$

$$\boxed{Q = 41.34 VAR}$$

$$pf = \cos(85 - 15)$$

$$\boxed{pf = 0.34 \text{ lagging}}$$

$$\boxed{Z = \frac{V}{I} = 275\angle 70 \Omega}$$

Example 11.12

A load Z draws 12kVA at a power factor 0.856 lagging from a 120V rms sinusoidal source. Calculate a) average and reactive power delivered to load b) peak current c) load impedance.

Solutions

$S = 12000\,VA$
$pf = 0.856$
$V_{rms} = 120V_{rms}$

$\frac{P}{S} = \cos\phi$
$P = S\cos\phi$
$P = (12000)(0.856)$

$\boxed{P = 10272W}$

$\frac{Q}{S} = \sin\phi$
$Q = S\sin\phi$
$Q = (12000)\sin(\cos^{-1}(0.856))$

$Q = 12\times10^3 \times 0.516$

$\boxed{Q = 6.204\,kVA}$

$S = P + Q$
$S = 10.272 + 6.204\ kVA$

$S = VI^*_{rms}$

~~$I = 85.6\angle-$~~

$\boxed{I_{rms} = 100\angle-31.13}$

$I_{rms} = \frac{I_p}{\sqrt{2}}$

$\boxed{I_p = 141.04}$

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

$\boxed{Z = 1.2\angle 31.13\Omega}$

Practice 11.12

A sinusoidal source supplies 100kVAR reactive power to load $Z = 250\angle-75\,\Omega$. Determine a) power factor b) apparent power delivered to load c) rms voltage.

Solution:

$\frac{P}{S} = \cos\phi \quad \frac{Q}{S} = \sin\phi$

$\boxed{Q = 100k\,VAR}$

$\boxed{Z = 250\angle-75\,\Omega}$

$pf = \cos\phi$
$pf = \cos(-75)$

$\boxed{pf = 0.25 \text{ leading}}$

$\cos\phi = 0.25$

$\boxed{\cancel{\phi} = 75}$

$\boxed{S = \frac{Q}{\sin\phi} = 103.52\,kVA}$

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

$V_{rms} = Z I_{rms}$

$Z_{rms} = \sqrt{|S| Z^*} = \sqrt{885148130972431924.083}$

?

Date:

Day: M T W T F S S

Example 11.13

A load being fed by a voltage source through a transmission line. The impedance of the line is represented by the $(4+2j)\Omega$ impedance and a return path. Find the real power and reactive power absorbed by

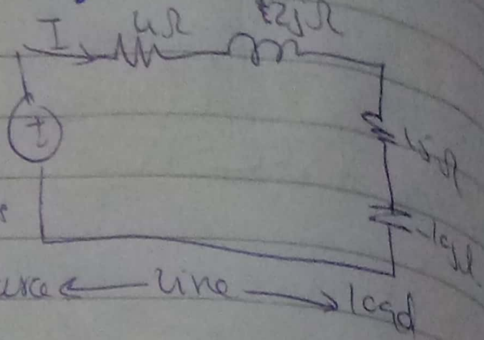
a) Source b) Line c) load.

$Z = 20.62\angle -22.83$

$\boxed{Z = 19-8j}$

$\boxed{I = 10.67\angle 22.83\ A}$

$220\angle 0°\ V_{rms}$



a) $S = V_s I^* = (220\angle 0°)(10.67\angle -22.83)$

$$\boxed{S = 2163.5 - 910.8j\ VA}$$

$$\boxed{P = 2163.5\ W}$$

$$\boxed{Q = 910.8\ VAR}$$ leading.

b) $V = (2j+4)\, I$

$$\boxed{V = 47.72\angle 49.4}$$

$S = VI^*$

$$\boxed{S = \underbrace{455.4}_{P} + \underbrace{227.7j}_{Q}\ VA}$$

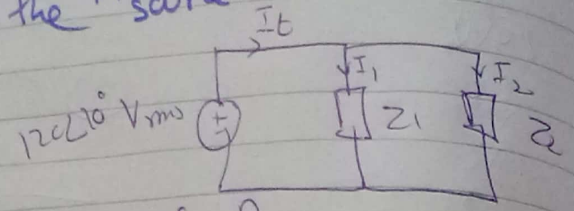
c) $V = (15-10j)\, I$

$V = 192.38\angle -10.87$

$$\boxed{S = VI^* = 1708 - 1139j\ VA}$$

Example 11.14

$Z_1 = 60\angle{-30}\,\Omega$ $Z_2 = 40\angle{45^\circ}\,\Omega$. Calculate the total a) apparent power b) real power c) reactive power, d) pf, supplied by the source and seen by the source.



$I_1 = \frac{V}{Z_1} = 2\angle{40^\circ}$ A

$I_2 = \frac{V}{Z_2} = 3\angle{-35^\circ}$ A

$S_1 = \frac{V_{rm}^2}{Z_1}$ $S_2 = \frac{V_{rm}^2}{Z_2}$

$\boxed{S_1 = 207.85 - 120j\,VA}$ $\boxed{S_2 = 254.6 + 254.6j\,VA}$

$S_t = S_1 + S_2$.

$\boxed{S_t = \underbrace{462.4}_{P_t} + \underbrace{134.6}_{Q_t}j\ VA}$

$\boxed{St = 481.6\,VA}$

$pf = \frac{P}{S} = 0.96$ lagging.

Practice 11.14

Two loads connected in parallel are respectively 2kW at a pf of 0.75 leading and 4kW at a pf of 0.95 lagging. calculate the pf of the two loads. Find complex power supplied by the source

Solution:

$P_1 = 2kW$ $P_2 = 4kW$
$pf = 0.75$ $pf = 0.95$.

$\theta_1 = \cos^{-1}(0.75)$ $\theta_2 = \cos^{-1}(0.95)$

$\boxed{\theta_1 = 41.41}$ $\boxed{\theta_2 = 18.19^\circ}$

$S = S_1 + S_2 = (P_1 + Q_1 j) + (P_2 + Q_2 j)$

$S_1 = \frac{P_1}{\cos\theta_1}$, $S_2 = \frac{P_2}{\cos\theta_2}$

$\boxed{S_1 = 2.667\,kVA}$ $\boxed{S_2 = 4.2105\,kVA}$

$Q_1 = -S_1 \sin\theta_1$ $Q_2 = S_2 \sin\theta_2$

$\boxed{Q_1 = -1.764\,kVAR}$ $\boxed{Q_2 = 1.3145\,kVAR}$

$S = S_1 + S_2$.

$\boxed{S = 6 - 0.4495j\ kVA}$

$pf = \frac{(P_1+P_2)}{|S|}$ $\because \frac{P}{|S|} = \frac{P_1+P_2}{|S|}$

$\boxed{pf = 0.9972 \text{ leading}}$

Example 11.15

When connected to a 120V (rms), 60Hz power line, a load absorbs 4kW at a lagging power factor of 0.8. Find the value of capacitance necessary to raise the pf to 0.95

$P = 4kW$

$pf = 0.8 = \cos\theta_1$

$\boxed{\theta_1 = 36.86}$

$pf = 0.95 = \cos\theta_2$

$\boxed{\theta_2 = 18.19}$

$\frac{P}{S_1} = \cos\theta_1 \Rightarrow S_1 = \frac{P}{\cos\theta_1} = \frac{4000}{0.8}$

$\boxed{S_1 = 5000\ VA}$

$\frac{P}{S_2} = \cos\theta_2 \Rightarrow S_2 = \frac{P}{\cos\theta_2} = \frac{4000}{0.95}$

$\boxed{S_2 = 4210.53}$ VA

$\frac{Q_1}{S_1} = \sin\theta_1$ $\qquad$ $\frac{Q_2}{S_2} = \sin\theta_2$

$Q_1 = S_1 \sin\theta_1$ $\qquad$ $Q_2 = S_2 \sin\theta_2$

$Q_1 = 5000 \sin(36.86)$

$\boxed{Q_2 = 1314.39\ VAR}$

$\boxed{Q_1 = 2999.3\ VAR}$

$Q_c = Q_1 - Q_2$

$Q_c = 1684.91$

Practice 11.15

Find the value of parallel capacitance needed to correct a load of 140 kVAR at 0.85 lagging pf to unity pf. Assume that the load is supplied by a 110kV (rms), 60Hz line.

$pf = \cos\theta_1 = 0.85$

$\boxed{\theta_1 = 31.78}$

$pf = \cos\theta_2 = 1$

$\boxed{\theta_2 = 0}$

~~$\frac{Q_1}{S_1} = \sin\theta_1 \Rightarrow S_1 = \frac{Q_1}{\sin\theta_1} = \frac{140k}{0.85}$~~

~~$S_1 = 164.7\ kVA$~~

$\frac{Q_2}{S_2} = 2\theta$

$\frac{Q_1}{S_1} = \sin\theta_1$ $\qquad$ $\frac{Q_2}{S_2} = \sin\theta_2$

$\boxed{S_1 = 265.82\ kVA}$ $\qquad$ $\boxed{Q_2 = 0}$

$\frac{P}{S_1} = \cos\theta_1$ $\qquad$ $\frac{Q_2}{S_2} = \sin\theta_2$

$\boxed{P = 225.9\ kW}$ $\qquad$ $S_2 = \dots$

$\frac{P}{S_2} = \cos\theta_2$ $\qquad$ $\frac{Q_2}{S_2} = \sin\theta_2$

$S_2 = 225.9$ $\qquad$ $\boxed{Q_2 = 0}$