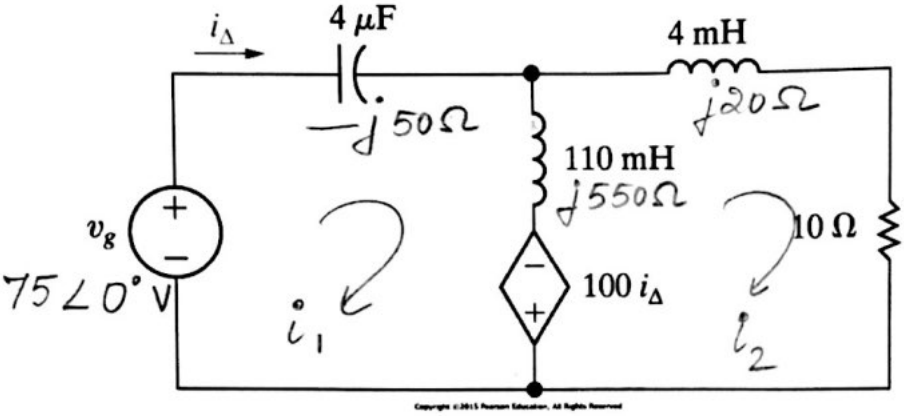
A P#9.64

Please provide your ans in sinusoidal form

1. If $v_g = 75\cos 5000t$ V in the following circuit, find i_Δ using Mesh Analysis Method.

[20 points]

(10pts for anything reasonable)



5pts for conversion into freq domain

5pts (3 for any final ans).

i_Δ = $2.55\angle 78.7°$ A

mesh 1:

$$-75 - j50 \cdot i_1 + j550(i_1 - i_2) - 100 i_1 = 0$$

$$\Rightarrow i_1(-100 + j500) + i_2(-j550) = 75 \quad —— ①$$

mesh 2:

$$j20\, i_2 + 10 i_2 + 100 i_1 + j550(i_2 - i_1) = 0$$

$$\Rightarrow i_1(100 - j550) + i_2(10 + j570) = 0 \quad —— ②$$

10 pts.

$$\Rightarrow i_2 = \frac{i_1(-100 + j550)}{10 + j570}$$

substituting in ① ⟶

$$i_1(-100 + j500) + i_1 \frac{(-100 + j550)}{10 + j570}(j550) = 75$$

Page intentionally left blank. You may use this page for your work.

$$\Rightarrow i_1(-100+j500)(10+j570) + i_1(-100+j550)(-j550) = 75(10+j570)$$

$$\Rightarrow i_1(-1000+j5000-j57000-285000+j55000+302500) = 750+j42750$$

$$\Rightarrow i_1(16500+j3000) = 750+j42750$$

$$\Rightarrow i_1 = \frac{42756.6\angle 88.99^\circ}{16770.5\angle 10.3^\circ}$$

$$= \underline{\underline{2.55\angle 78.7^\circ}} \text{ A} \quad = 0.5+j2.5$$

$$i_2 = i_1\left(\frac{-100+j550}{10+j570}\right) = \frac{(2.55\angle 78.7^\circ)(559\angle 100.3^\circ)}{570.09\angle 88.99^\circ}$$

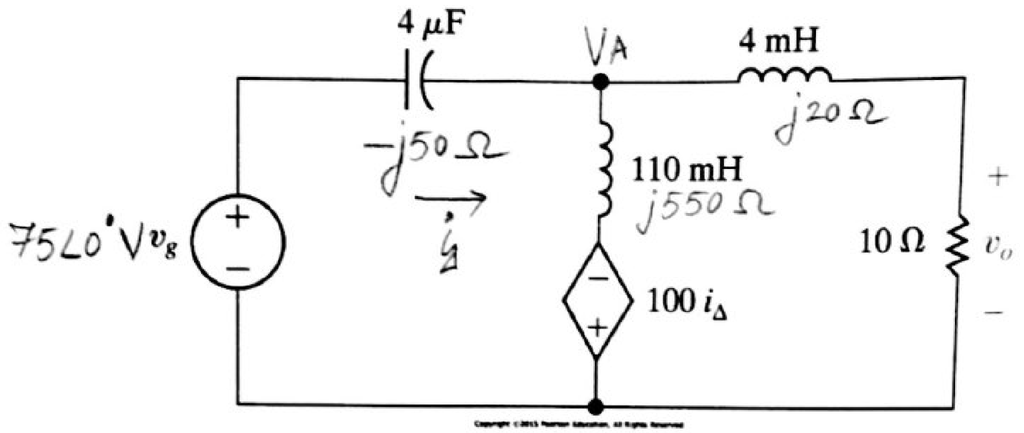
$$= \underline{\underline{2.5\angle 90^\circ \text{ A}}}$$

$$\Rightarrow V_o = 10 i_2 = \underline{\underline{25\angle 90^\circ}} \text{ V}$$

2. If $v_g = 75\cos 5000t$ V in the following circuit, find v_0 using Node Analysis Method.

[20 points]

all eq correct = 15 pts
+ final wrong ans = 2pts



v_0= 25 ∠ 90° V

KCL @ node A ⟶

$$\frac{V_A - 75}{-j50} + \frac{V_A + 100 i_\Delta}{j550} + \frac{V_A}{10+j20} = 0 \quad \text{—— 10 pts}$$

$$\Rightarrow \frac{V_A j - j75}{+\cancel{50}\ 1} + \frac{jV_A + j100 i_\Delta}{-\cancel{550}\ 11} + \frac{V_A 10 - j20 V_A}{\cancel{100+400}\ 10} = 0$$

$$\Rightarrow \frac{j11 V_A - j825 - jV_A - j100 i_\Delta}{11} + \frac{10V_A - j20V_A}{10} = 0$$

$$\Rightarrow j11 V_A - j825 - jV_A - j100 i_\Delta + 11V_A - j22V_A = 0$$

$$\Rightarrow V_A(11 - j12) - j825 + \cancel{j}\,\overset{2}{\cancel{100}}\left(\frac{75 - V_A}{-\cancel{j}\cancel{50}}\right) = 0$$

→ i_Δ (5pts)

$$\Rightarrow V_A(11 - j12) - j825 + 150 - 2V_A = 0$$

Page intentionally left blank. You may use this page for your work.

$\Rightarrow V_A(9-j12) = -150+j825$

$$\Rightarrow V_A = \frac{-150+j825}{9-j12}$$

$$= \frac{838.5\angle 100.3^\circ}{15\angle -53.13^\circ}$$

$$= \underline{\underline{55.9\angle 153.4^\circ}}\ V \quad \text{— 5 pts.}$$

$$V_0 = \frac{V_A}{10+j20} \times 10$$

$$= \frac{10V_A(10-j20)}{10^2+20^2}$$

$$= V_A\frac{(1-j2)}{5}$$

$$= \frac{(55.9\angle 153.4^\circ)(2.24\angle -63.4^\circ)}{5}$$

$$= \underline{\underline{25\angle 90^\circ}}\ V \quad \text{— 5 pts.}$$

(total 10 for even attempting anything reasonable)

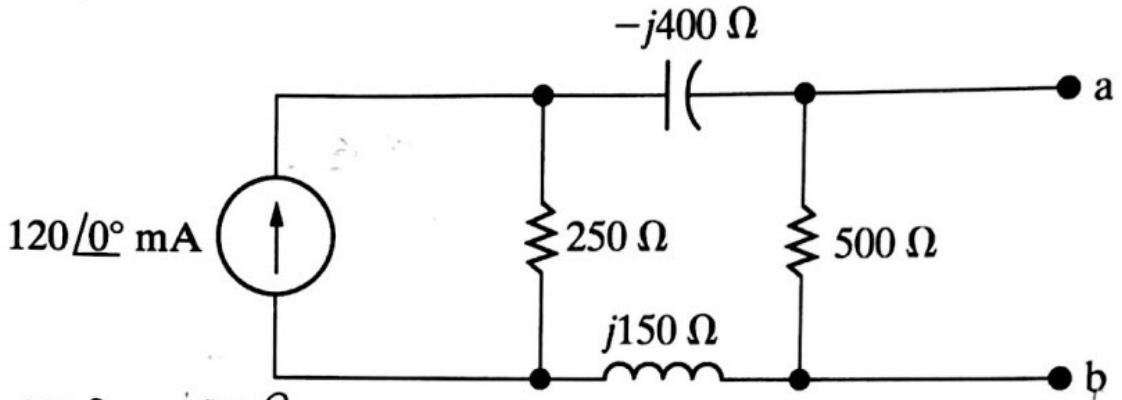
P# 9.45

3. *For the circuit shown below:* (10 pts for attempt)

✓ *A.* Draw the Thevenin equivalent circuit, with respect to terminals a &b. *[20 points]*
Note: Leave the voltage in polar form & impedance in rectangular form.

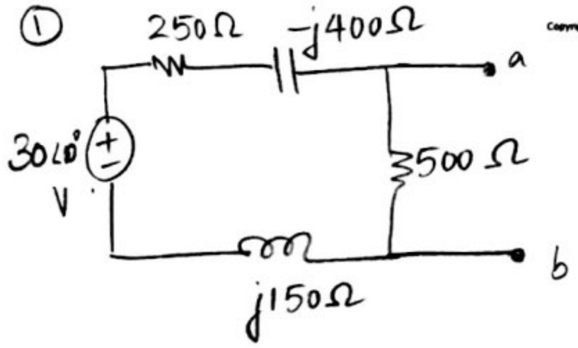
✓ *B.* Find the load impedance required for maximum power transfer. *[5 points]*

C. Find the maximum average power delivered to the load. *[5 points]*

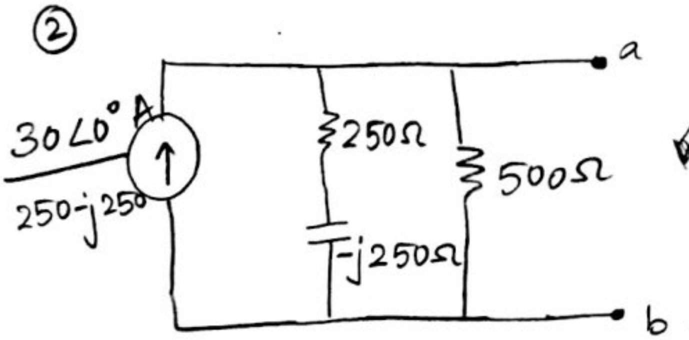


5pts for sub circuits

①



②



Thevenin Equivalent Circuit:

5pts

Z_{Th}^{*} = 5pts

Z_{Load} = $200 + j100\ \Omega$

P_{max} = $0.225\ W$

Z_{Th}

$$\Rightarrow (250 - j250) \parallel 500$$

$$= \frac{(250 - j250)(500)}{250 - j250 + 500} = \frac{500(353.5\angle -45^\circ)}{790.6\angle -18.4^\circ}$$

$$= 223.56\angle -26.6^\circ$$

$$= 200 - j100\ \Omega$$

$$= \frac{125000(1-j)}{250(3-j)}$$

$$= 500\,\frac{(1-j)(3+j)}{9+1}$$

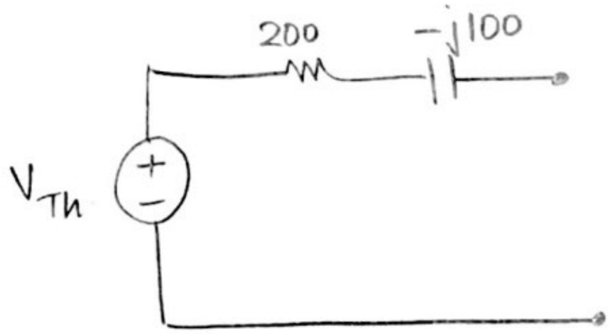
$$= 50(3 - j3 + j + 1)$$

$$= 50(4 - j2)$$

Page intentionally left blank. You may use this page for your work.

$\Rightarrow Z_{Th} = 200 - j100\ \Omega$

(3)



$$V_{Th} = \frac{30\angle 0^\circ}{250 - j250} \times (200 - j100)$$

$$= \frac{30\angle 0^\circ}{353.5\angle 45^\circ} \;(223.6\angle -26.6^\circ)$$

$$= 18.97\angle +18.4^\circ\ \text{V}$$

$$Z_{load} = Z_{Th}^{*} = 200 + j100\ \Omega$$

$$P_{max} = \frac{V_{Th_{rms}}^2}{4R_{Th}} = \frac{(18.97/\sqrt{2})^2}{4 \times 200}$$

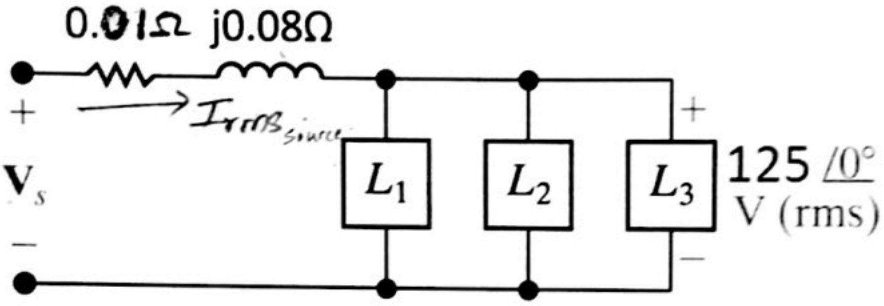
$$= 0.225\ \text{W}$$

− 5 pts if they used RMS & correct equation & unit.

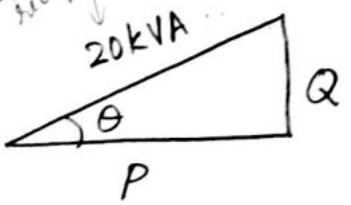
P#10.33

→ Please include the correct units.

4. A group of appliances require a total of 20kVA at 0.85 pf lagging, when operated at 125Vrms and 60Hz. The impedance of the line supplying the appliances is 0.01 + j0.08 Ω.
   - A. Draw the power triangle showing the apparent, average and reactive power required by the group of appliances. *[10 points]*
   - B. Find the capacitor (in mF) that needs to be connected across the load to improve the load power factor to unity. *[10 points]*
   - C. Find the average power loss in the line **before *and* after** the capacitor is added. *[10 points]*



5pts for recognizing the C



C = 1.79mF

(before adding C) P_{loss} = 256 W

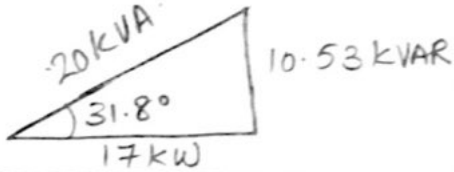
(after adding C) P_{loss} = 185 W

$\cos\theta = 0.85 \Rightarrow \theta = 31.78°$

$P = S\cos\theta = (20k) \times 0.85 = 17\,kW$

$Q = S\sin\theta = 10.53\,kVAR$

Load Power Triangle:



---

capacitor needs to provide −10.53 kVAR. 5pts

$\Rightarrow Q = -10.53\,kVAR$

$Q = \dfrac{V_{rms}^2}{X} = -10.53\,kVAR$ 3pts

$\Rightarrow X_c = \dfrac{125^2}{-10.53k} = -1.48$

Page intentionally left blank. You may use this page for your work.

$\Rightarrow Z_C = -j1.48\ \Omega$

$= \frac{-j}{\omega C}$

$\Rightarrow C = \frac{1}{2\pi \times 60 \times 1.48} = 0.001792\ F$

$= \underline{\underline{1.79\ mF}}$ — 2pts

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

Before: $S_1 = 20\angle 31.78^\circ\ kVA = (125\angle 0^\circ)(I_{rms}\angle -\theta_i)$

$\Rightarrow I_{rms}\angle -\theta_i = 160\angle 31.78^\circ$ — 3pts

$\Rightarrow I_{rms}\angle \theta_i = 160\angle -31.78^\circ\ A$

$P_{loss} = I_{rms}^2 \times R = 160^2 \times 0.01 = \underline{\underline{256\ W}}$ — 2pts

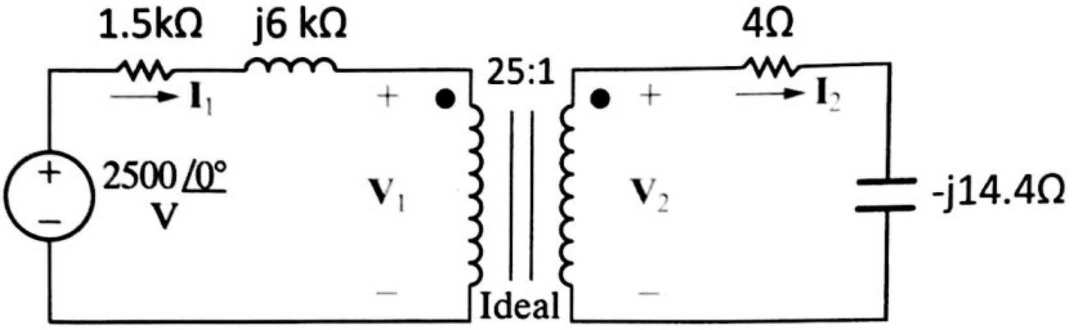
After: $S_2 = 17\angle 0^\circ\ kVA = (125\angle 0^\circ)(I_{rms}\angle -\theta_i)$

$\Rightarrow I_{rms}\angle \theta_i = 136\angle 0^\circ\ A$ — 3pts

$P_{loss} = I_{rms}^2 R = 136^2 \times 0.01 = \underline{\underline{185\ W}}$ — 2pts

AP # 9.15 w/ modified dot convention.

5. For the following circuit containing ideal transformer, find ~~V_2 and~~ I_2. *[Bonus 10 points]*



~~V_2~~ =

I_2 = $12.5 \angle \pm 36.8°$ A

① $-2500 + (1.5k + j6k) I_1 + V_1 = 0$

② $-V_2 + (4 - j14.4) I_2 = 0$ — 5pts.

$$\frac{V_1}{V_2} = \frac{I_2}{I_1} = \frac{25}{1}$$

$\Rightarrow V_1 = 25V_2 \quad I_1 = I_2/25$ — 4pts.

$\Rightarrow$ ① $\longrightarrow -2500 + (\overset{60}{\cancel{1500}} + j\overset{240}{\cancel{6000}}) \frac{I_2}{\cancel{25}} + 25V_2 = 0$.

$\Rightarrow -2500 + (60 + j240) I_2 + 25(4 - j14.4) I_2 = 0$.

$\Rightarrow I_2 (60 + j240 + 100 - j360) = 2500$

$\Rightarrow I_2 = \frac{2500}{160 - j120} = \frac{2500 \angle 0°}{200 \angle -36.8°} = 12.5 \angle +36.8° \text{ A}$.