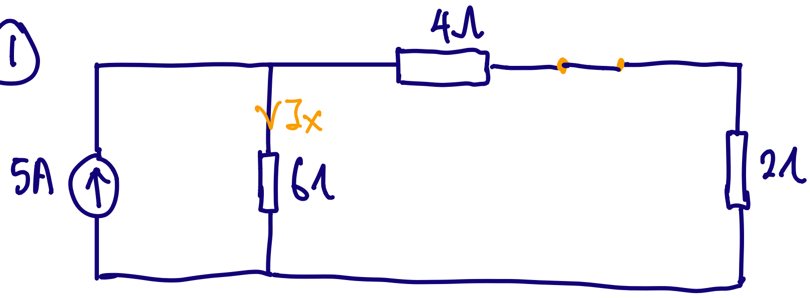
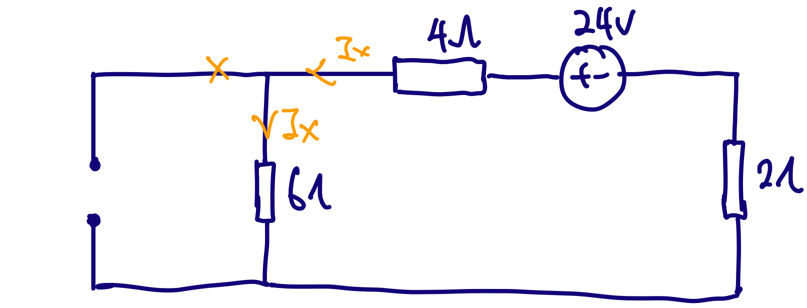
DEREK CHEEN XIN HEE 20317350

1



omit 24V supply

$$I_x' = \frac{4+2}{6+4+2}(5)$$
$$= 2.5A \ (\downarrow)$$



omit 5A source

$$I_x'' = \frac{24}{6+4+2} = 2A \ (\downarrow)$$

$$\therefore I_x = I_x' + I_x''$$
$$= 2.5 + 2$$
$$= 4.5A$$

Power dissipate $= I_x^2(R)$

$$= (4.5)^2(6)$$
$$= 121.5 \text{ W} \quad \text{(absorb)}$$

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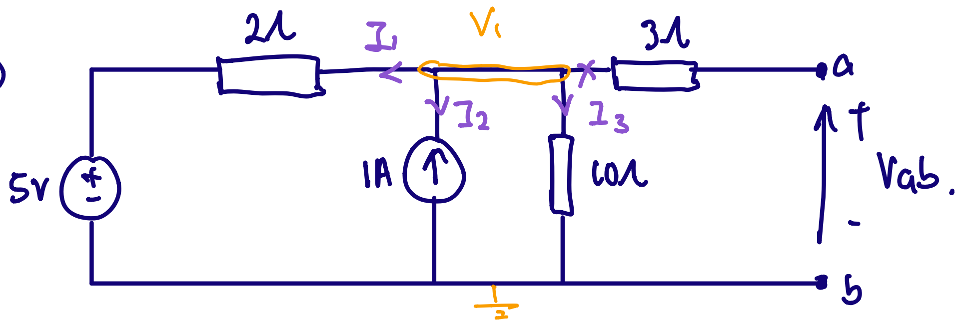
(2)



By KCL:

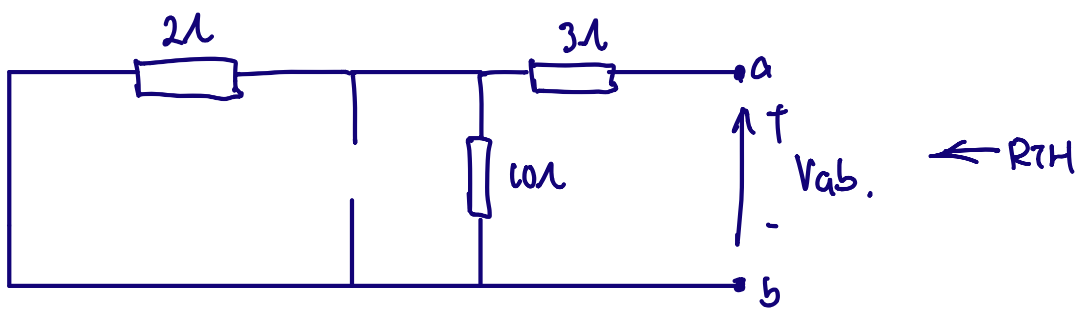
$$\frac{V_1 - 5}{2} - 1 + \frac{V_1}{10} = 0$$

(×10) $5V_1 - 25 - 10 + V_1 = 0$

$$6V_1 = 35$$

$$V_1 = 5.83V$$

$V_1 = V_{ab} = 5.83V$

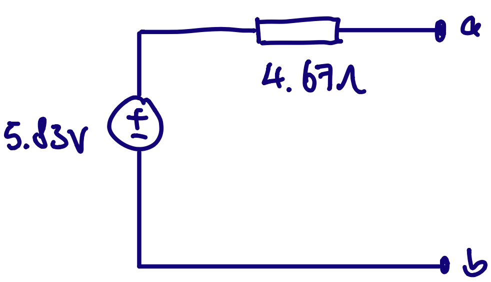


$R_{TH} = 2\Omega // 10\Omega + 3\Omega$

$= \left(\frac{1}{2} + \frac{1}{10}\right)^{-1} + 3$

$= 4.67\Omega$

Thevenin circuit:



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3

$Z_L = j\omega L$

$= j2\pi(50)(6.5\times10^{-3})$

$= j2.042$

$Z_1 = 2 + j2.042$

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

$= \frac{1}{j(2\pi)(50)\,1.06\times10^{-3}} \frac{(\times j)}{(\times j)}$

$= \frac{-j}{2\pi(50)1.06\times10^{-3}}$

$\approx -j3$

$Z_2 = 1 - j3$

$Z_{total} = Z_1 // Z_2$

$= \left(\frac{1}{2+j2.042} + \frac{1}{1-j3}\right)^{-1}$

$\approx 2.84 - j0.412$

$= 2.87\angle{-8.26^\circ}\ \Omega$

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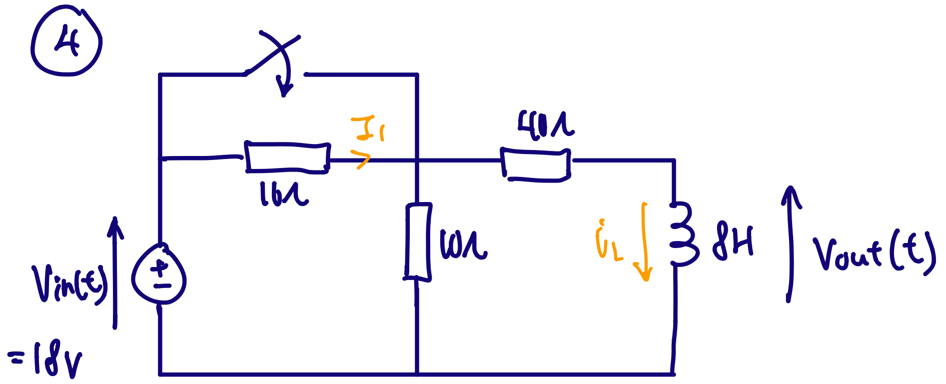
4



a) at $t=0$, current in inductor cannot change instantaneously.

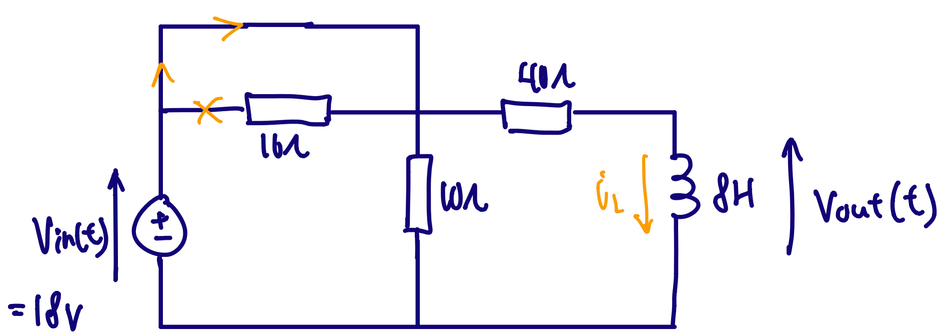
$i_L(0^-) = i_L(0^+)$

$10\Omega // 40\Omega = \left(\frac{1}{10} + \frac{1}{40}\right)^{-1}$
$= 8\Omega$

$V = \frac{8}{16+8}(18)$
$= 6V$

$i_L(0^+) = \frac{6}{40}$
$= 0.15A$

at $t = \infty$



$i_L = \frac{18}{40} = 0.45A$

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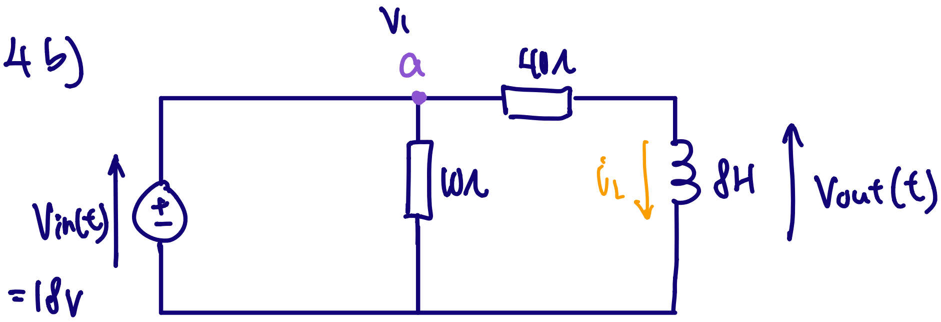
4 b)



$$V_{in}(t) = 40 I_L(t) + V_{out}(t)$$

using $V_{out}(t) = L \frac{dI_L}{dt}$,

$$V_{in}(t) = 40 I_L(t) + L \frac{dI_L}{dt}$$

$$V_{in}(t) = 40 I_L(t) + 8 \frac{dI_L}{dt}$$

$(\div 8)$ $$\frac{V_{in}(t)}{8} = 5 I_L(t) + \frac{dI_L}{dt}$$

$$5 I_L(t) + \frac{dI_L}{dt} = \frac{V_{in}(t)}{8}$$ (shown)

c) By using general approach :

$\tau = \frac{L}{R}$, $R = 40\Omega$, $L = 8$

i_L initial $= 0.15A$

i_L final $= 0.45A$

$\tau = \frac{8}{40} = \frac{1}{5}$

$$I_L = I_f - (I_i - I_f) e^{-t/\tau}$$

$$= 0.45 - (0.15 - 0.45) e^{-5t}$$

$$= 0.45 + 0.3 e^{-5t}$$ # for $t \geq 0$

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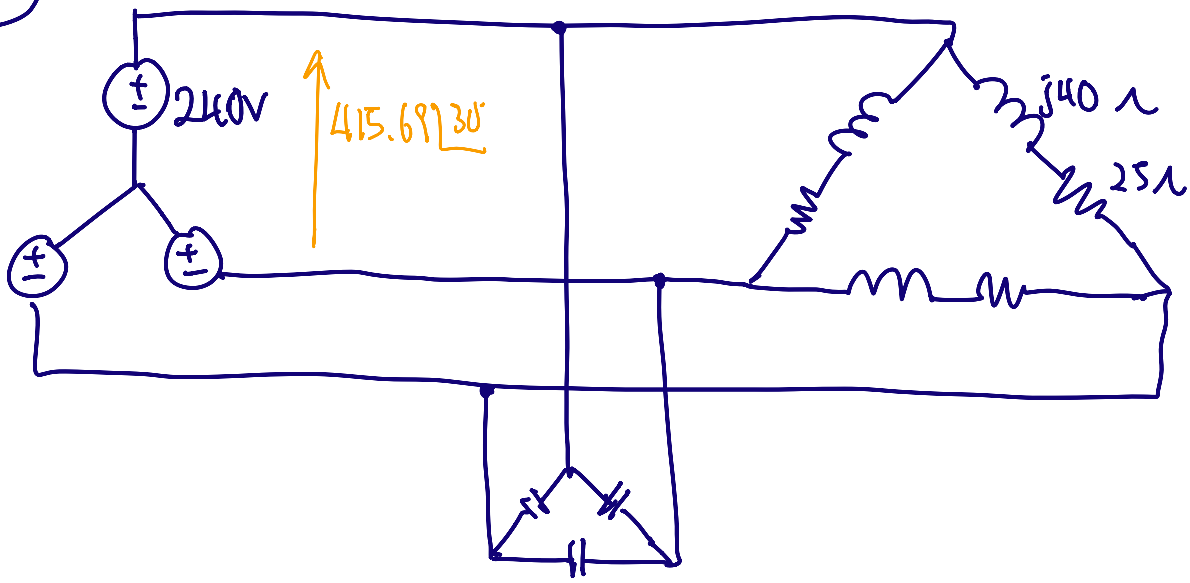
5



a) $V_L = \sqrt{3}\, V_{ph} \angle 30^\circ$

$= \sqrt{3}(240) \angle 30^\circ$

$= 415.69 \angle 30\ V$

For delta $V_L = V_{ph} = 415.69 \angle 30^\circ\ V$

b) $I_{ph} = \dfrac{415.69 \angle 30^\circ}{25 + j40}$

$= 7.781 - j4.1365$

$= 8.813 \angle -28\ A$

c) $I_L = \sqrt{3}\, I_{ph} \angle -30^\circ$

$= \sqrt{3}(8.813) \angle -28 - 30^\circ$

$= 15.26 \angle -58^\circ\ A$

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d) $S^* = \sqrt{3}\, V_L I_L^*$

$= \sqrt{3}\left(415.69\angle 30^\circ \times 15.26\angle 58\right)$

$= 10987.142\angle 88^\circ$

$= 383.45 + j10980.45$

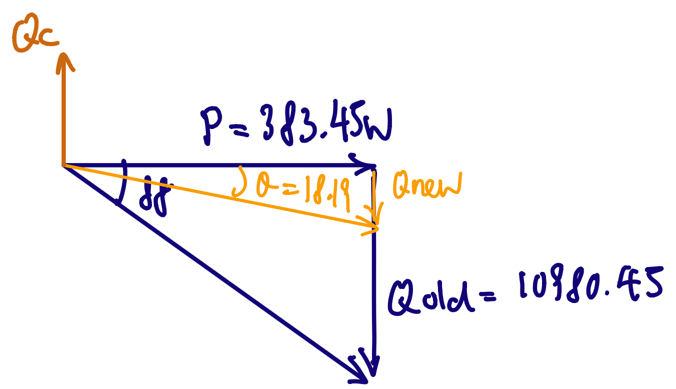
$P = 383.45\,W$

e) new pf = 0.95

old $\theta = 88^\circ$

$\cos\theta = 0.95$

$\theta = 18.19^\circ$



$\tan(18.19) = \frac{Q_{new}}{383.45}$

$Q_{new} = 126\ VAr$

$Q_c = Q_{old} - Q_{new}$

$= 10980.45 - 126$

$= 10854.45\ VAr$

$Q_c \text{ per phase} = \frac{10854.45}{3}$

$= 3618.15\,VAr$

$Q_c = \frac{(415.69)^2}{X_c}$

$3618.15 = \frac{172798.176}{\frac{1}{\omega C}}$

$3618.15 = \frac{172798.176}{\frac{1}{2\pi(50)(C)}}$

$C = 66.6\,\mu F$ #

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6

a) 4kVA, $\frac{V_1}{V_2} = \frac{200}{400} = \frac{1}{2} = a$

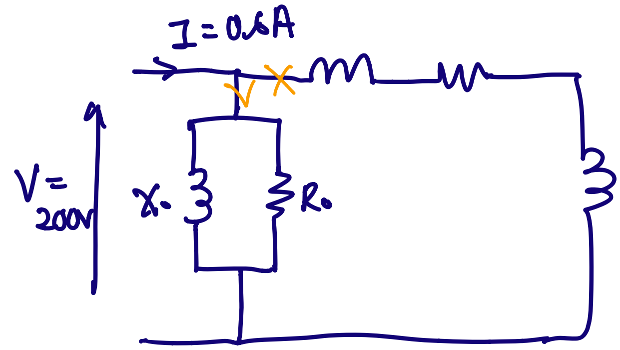
Open circuit test

$P = VI\cos\theta$

$65 = 200(0.6)\cos\theta$

$\cos\theta = 0.5417$

$\theta = 57.2^\circ$



$R_0 = \frac{200}{0.6\cos\theta}$

$= \frac{200}{0.6(0.5417)}$

$= 615.35\Omega$

$X_0 = \frac{200}{0.6\sin\theta}$

$= \frac{200}{0.6\sin(57.2)}$

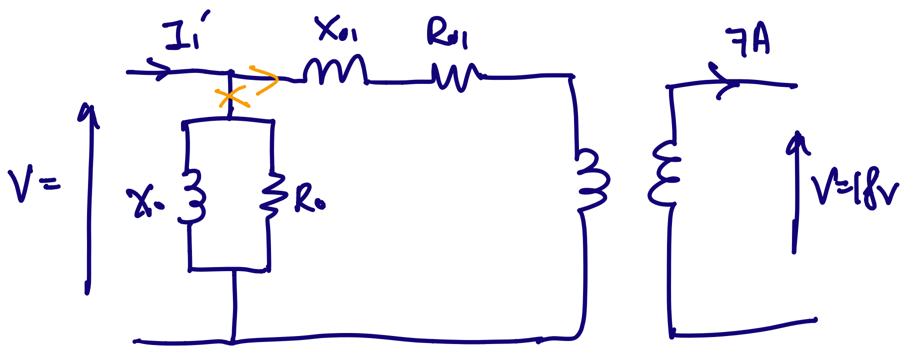
$= 396.56\Omega$

Short circuit test

$80 = 18(7)\cos\theta$

$\cos\theta = 0.6349$

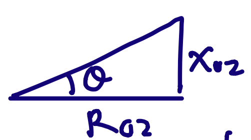
$\theta = 50.586^\circ$



$P = I_2^2 R_{02}$

$80 = 7^2(R_{02})$

$R_{02} = 1.632\Omega$



$\tan\theta = \frac{X_{02}}{R_{02}}$

$\tan(50.586) = \frac{X_{02}}{1.632}$

$X_{02} = 1.9858\Omega$

[continue...]

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6 a)

$R_{01} = a^2 R_{02}$

$= \left(\frac{1}{2}\right)^2 1.632$

$= 0.408 \, \Omega$

$X_{01} = a^2 X_{02}$

$= \left(\frac{1}{2}\right)^2 (1.9858)$

$= 0.496 \, \Omega$

b) $\eta = \frac{P_{out}}{P_{in}} \times 100\%$ given 4kVA, $\frac{V_1}{V_2} = \frac{200}{400}$, pf = 0.8

$= \frac{P_{out}}{P_{out} + P_{loss}} \times 100\%$

$P_{loss} = 65 + 80$

$= 145$

$= \frac{4000(0.8)}{4000(0.8) + 145} \times 100\%$

$= 95.7\%$

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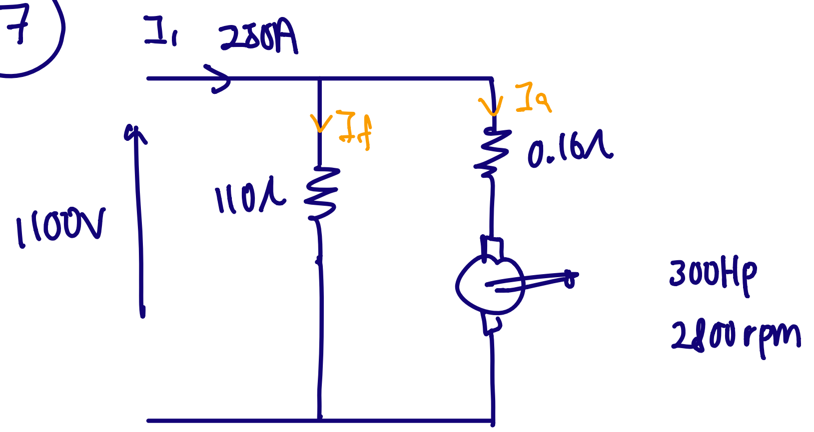
7



a) $P = T\omega$

$$300(745.7) = T\left(2800 \times \frac{2\pi}{60}\right)$$

$$T = 762.95\ \text{Nm}$$

$$I_1 = I_f + I_a$$

$$250 = \frac{1100}{110} + I_a$$

$$I_a = 240\text{A}$$

$$E_a = 1100 - I_a(R_a)$$

$$= 1100 - 240(0.16)$$

$$= 1061.6\text{V}$$

$$E_a I_a = T\omega$$

$$1061.6(240) = T\left(2800 \times \frac{2\pi}{60}\right)$$

$$T = 868.931\ \text{Nm}$$

$$\eta = \frac{P_{out}}{P_{in}} \times 100\%$$

$$= \frac{300(745.7)}{1100(250)} \times 100\%$$

$$= 81.35\%$$

#

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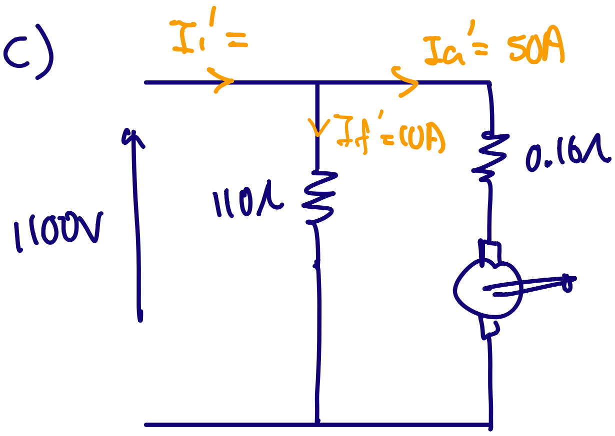
7 b) $P_{loss} = P_{dev} - P_{out}$

$= 1061.6(240) - 300(745.7)$

$= 31074\,W$

c)



$I_f' = \frac{1100}{110} = 10A$

$I_a' = 50$

$I_f \propto \phi$

I_f constant so ϕ constant

$E_a = K_a \phi \omega$

$\frac{E_a}{W} = k_a \phi$

$E_a' = 1100 - 50(0.16)$

$= 1092\,V$

$\frac{E_a}{W} = \frac{E_a'}{W'}$

$\frac{1061.6}{2800} = \frac{1092}{W'}$

$W' = 2880.18\text{ rpm}$

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(8) 15GWh per year

a) $\eta = \frac{P_{out}}{P_{in}} \times 100\%$

$21 = \frac{12.25 \times 10^6}{1100(A)} \times 100\%$

$A = 53030.3 \text{ m}^2$

b) capacitor factor

$= \frac{(15 \times 10^9)}{(12.25 \times 10^6)(365)(24)} \times 100\%$

$= 14\%$