1155116317 Ng Chi Hon

ELEG 2202A Homework 4

Due: 11:59 pm, Dec. 7, 2020 (**Monday**) (HKT)

Submission: Please submit your answer (**PDF ONLY**) through the **Blackboard** system.

You are required to show the steps of your calculations, otherwise, marks will be deducted.

If you have questions about this homework, please send an email to minglei@link.cuhk.edu.hk.

Q1. Obtain the power factor of the circuit in Fig. 1 (seen from points a and b), please also specify the factor as leading or lagging. **(20)**

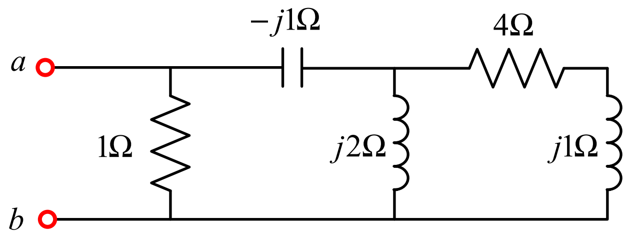


Fig. 1

Q2. For the circuit shown in Fig. 2, $V_s = 200\sqrt{2}\cos(\omega t)$, $\omega = 100$ rad/s, $L = 10$ mH, R = 10 Ω, C = 5 mF, Solving: **(30)**

1) Active and reactive power drawn from source;

2) Apparent power from the source;

3) Power factor seen from the source;

4) If the value of C (capacitor) is unknown, and other parameters keep unchanged, please find the proper value of C to make the power factor equals to 1.

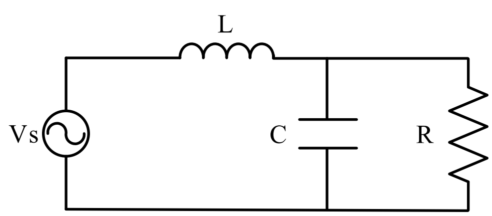


Fig. 2

Q3. In Fig.3, $V_p = 100\sqrt{2}$ V, R = 1 Ω, L = 10 mH, $\omega = 100$ rad/s. Solving: **(25)**

1) I_{aA}, I_{bB}, I_{cC}, and V_{Nn};

2) Make Y-Δ transformation on both the source side and load side, draw the circuit and compute the value of each load and source (please mark on the circuit as well).

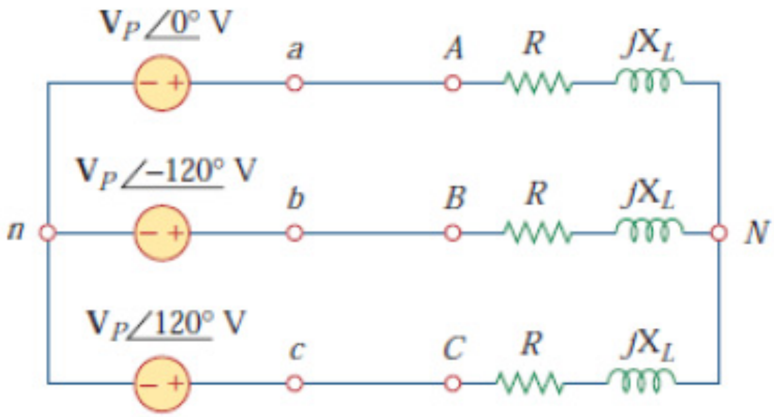


Fig. 3

Q4. In Fig. 4, $v_{s1} = 5$ V; $v_{s2} = 3$ V, please determine the value of v_o. **(25)**

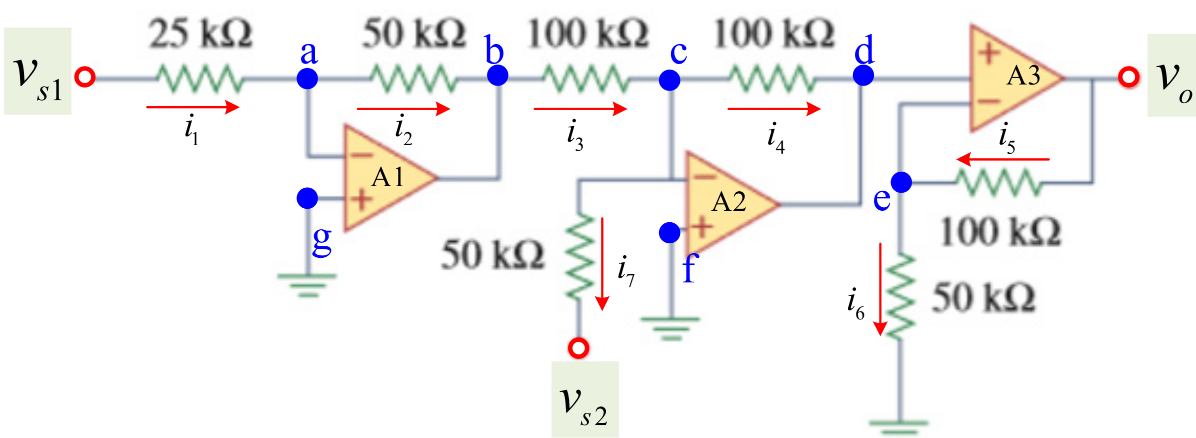
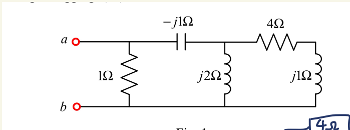


Fig. 4

1)



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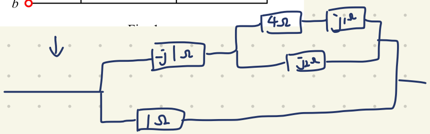

∴ for above side,

let Z_{j1} be in above side,

$$Z_{j1} = \frac{(4\Omega + j1)j2}{4\Omega + j1 + j2} + -j1 = \frac{(4+j)(j2)}{4+j3} + -j1$$

$$= \frac{(4+j)(j2) + (-j)(4+j3)}{4+j3}$$

$$= \frac{j2 \cdot 4 + j2 \cdot j - j4 - j \cdot j3}{4+j3}$$

$$= \frac{j8 - 2 - j4 + 3}{4+j3}$$

$$= \frac{1+j4}{4+j3}$$

Z_{j1} is parallel with 1Ω

$$\therefore Z_F = \frac{1 \cdot \left(\frac{1+j4}{4+j3}\right)}{1 + \frac{1+j4}{4+j3}} = \frac{1+j4}{4+j3+1+j4} = \frac{1+j4}{5+j7}\left(\frac{5+j7}{5+j7}\right) = \frac{33+j13}{74}$$

For impedance,

$$Z = R + jX$$

$$= \frac{33}{74} + \frac{j13}{74}$$

$$\therefore |Z| = \sqrt{\left(\frac{33}{74}\right)^2 + \left(\frac{13}{74}\right)^2}$$

$$= 0.4793$$

$$\therefore \cos\theta = \frac{33}{74} / 0.4793$$

$$= 0.9304$$

∴ Power factor = 0.9304
> 0

∴ It is lagging Power factor

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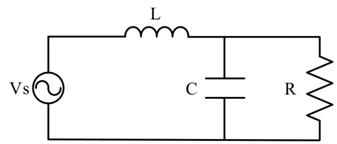

Fig. 2

$V_s = 200\sqrt{2}\cos(wt)$, $w = 100$ rad/s , $L = 10$mH $R = 10\,\Omega$ $C = 5$mF

$V_{rms} = 200$

$$jX_C = \frac{1}{jwC} = \frac{1}{j100 \cdot 5 \cdot 10^{-3}} = -j2\,\Omega$$

$$jX_L = jwL = j \cdot 100 \cdot 10 \cdot 10^{-3} = j\,\Omega$$

$$Z_{Total} = \frac{-j2(10)}{-j2+10} + j = \frac{-j20}{10-j2}\frac{(10+j2)}{(10+j2)} + j$$

$$= \frac{-j200+40}{104} + j$$

$$= \frac{5-j25}{13} + j$$

$$= \frac{5}{13} - \frac{j25}{13} + j$$

$$\therefore I = \frac{200}{\frac{5}{13} - \frac{j25}{13} + j} = 200 \quad \angle 67.38°\text{A}$$

Active Power, $P = V_s I_s \cos\theta$

$= 200 \cdot 200 \cos(67.38)$

$= 15.385$ KW

Reactive Power, $Q = V_s I_s \sin\theta$

$= 200 \cdot 200 \sin(67.38)$

$= 36.92$ KW

Apparent Power, $|S| = |V||I|$

$= 200 \cdot 200$

$= 40$KVA

Power factor $= \cos(67.38°)$

$= 0.385$

For C unkwon, and power factor equal zero,
The θ should be zero so the imaging part is zero.

We set c as $\frac{-j}{100}c$

$$Z_{Total} = j + \frac{10\left(-\frac{j}{100c}\right)}{10 - \frac{j}{100c}}$$

$$= j - \frac{j10}{1000c-j}\frac{1000c+j}{1000c+j}$$

$$= j - \frac{j10(1000c+j)}{(1000c)^2+1}$$

$$= j - \frac{j10000c}{(1000c)^2+1} + \frac{10}{(1000c)^2+1}$$

For Img Part = 0

$$j - \frac{j10000c}{(1000c)^2+1} = 0$$

$\therefore 10^6c^2 - 10^4c + 1 = 0$

$\therefore C = 9.899 \cdot 10^{-3}$ or $1.01 \cdot 10^{-4}$F

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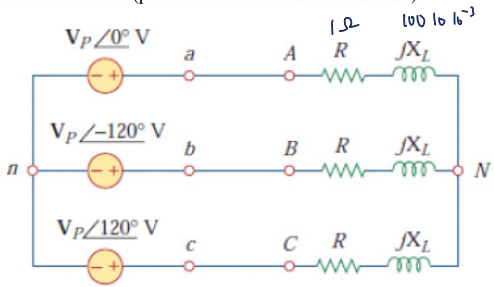


Fig. 3

$jX_L = j\omega L$

$= j(100)(10\cdot 10^{-3}) = j$

$R = 1\Omega$

∴ Each Impedance is $(1+j)\Omega$

$I_{aA} = \dfrac{100\sqrt{2}\angle 0}{(1+j)} = 100\angle -45°\ A$

$I_{bB} = 100\angle -165°\ A$

$I_{cC} = 100\angle 75°\ A$

∴ $I_{nN} = I_{aA} + I_{bB} + I_{cC}$

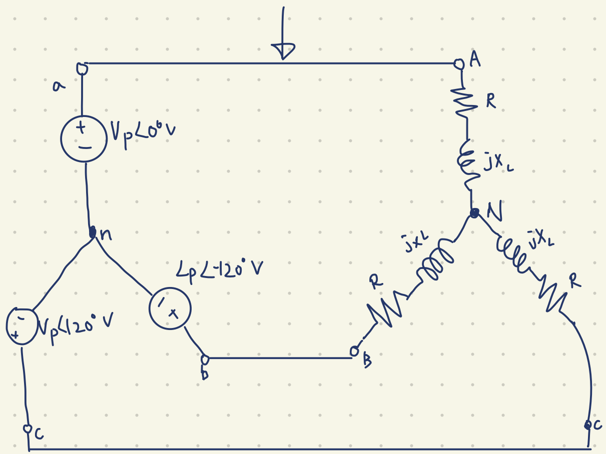
$= 0\ A$

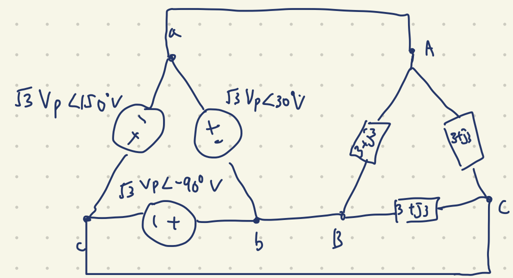
∴ $V_{nN} = 0\ V$

For Z_Δ in N,

$Z_\Delta = 3(1+j)$

$= 3 + j3$





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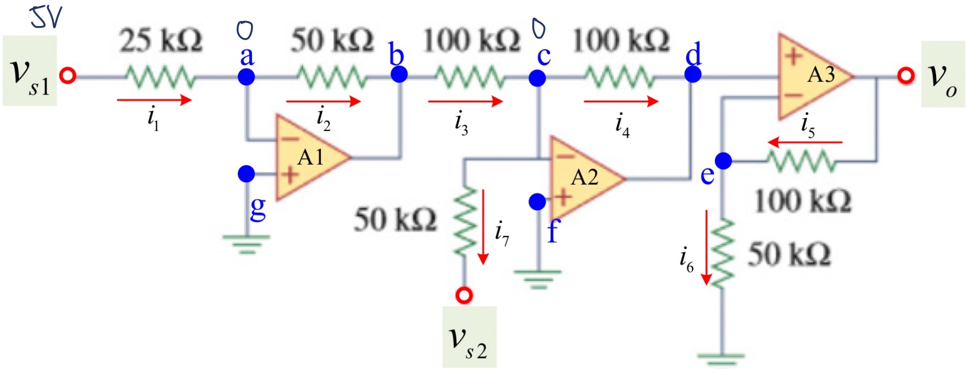

Fig. 4

For ideal Op.Amp,
voltage of two input is the same
Since node g & node f connect to grd,
∴ V at node a (V_a) = 0V
V at node c (V_c) = 0V
Let V_b & V_d be the voltage at node b & d

$$\frac{0-V_{s1}}{25k} + \frac{0-V_b}{50k} = 0$$

$$\frac{-V_{s1}}{25k} = \frac{V_b}{50k}$$

$$V_b = -2V_{s1}$$
$$= -10$$

$$\frac{0-V_b}{100k} + \frac{0-V_{s2}}{50k} + \frac{0-V_d}{100k} = 0$$

$$\therefore V_d = -V_b - 2V_{s2}$$
$$= -(-10) - 2(3)$$
$$= 4V$$

$$V_d = \frac{V_o \cdot 50k}{100k+50k}$$

$$V_o = 3V_d$$

$$\therefore V_o = 3 \cdot 4V$$
$$= 12V$$