$\sqrt{3} - \frac{3}{2}$

$\frac{\sqrt{3}}{2}$ $\quad -\frac{1}{2}$

1. CBM 17.18.

(a) $A = \dfrac{5e^{-j30^\circ}}{2+j3} - j4 = \dfrac{5(\cos(-30^\circ) + j\sin(-30^\circ))}{2+j3} - j4$

$= \dfrac{5(\frac{\sqrt{3}}{2} - j\frac{1}{2})}{2+j3} - j4 = \dfrac{5(\frac{\sqrt{3}}{2} - j\frac{1}{2})(2-j3)}{(2+j3)(2-j3)} - j4$

$= \dfrac{5(\sqrt{3} - \frac{3}{2}) + j5\cdot(-1 - \frac{3}{2}\sqrt{3})}{13} - j4$

$= \dfrac{5(\sqrt{3} - \frac{3}{2}) + j(-57 - \frac{15}{2}\sqrt{3})}{13} = 0.0893 - j5.0062$

$|A| = \sqrt{0.0893^2 + 5.0062^2} = 5.0770$

$\theta = \tan^{-1}\left(\dfrac{-5.0062}{0.0893}\right) = -89^\circ$

Polar form $= 5.0770 \angle -89^\circ = 5.0770\, e^{j(-89^\circ)}$

(b) $-20\angle 45^\circ = -20[\cos 45^\circ + j\sin 45^\circ] = -20[\frac{\sqrt{2}}{2} + j\frac{\sqrt{2}}{2})$

$= -10\sqrt{2} - 10j\sqrt{2}$

$B = \dfrac{(-20\angle 45^\circ)(3-j4)}{2-j} + (2+j)$

$= \dfrac{(-10\sqrt{2} - 10j\sqrt{2})(3-j4)}{2-j} + (2+j) = -40.4264 - j13.1421$

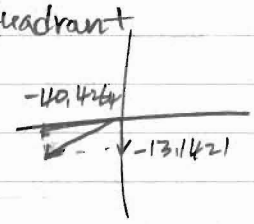
$|B| = 42.5089$

$\tan^{-1}\left(\dfrac{13.1421}{40.4264}\right) = 18^\circ$. But, $-40.4264 - j13.1421$ is on third quadrant

So, $\theta = -180 + \tan^{-1}(\quad)$

$= -180 + 18$

$= \boxed{-162^\circ}$



Polar form $\quad B = 42.5089 \angle -162^\circ$

(c) $C = \dfrac{j4}{(3+j2)-2(1-j)} + \dfrac{1}{1+j4} = 1$

$|C| = 1. \qquad \theta = 0.$

$C = 1.\angle 0^\circ.$

(d). $\begin{vmatrix} (2-j) & -(3+j4) \\ -(3+j4) & (2+j) \end{vmatrix} = (2-j).(2+j) - [(-1)(3+j4) \times (-1)(3+j4)]$

$= (2-j)(2+j) - (3+j4)(3+j4)$

$= 5 - [9-16+24j] = 5-[-7+24j]$

$= 12 - j24$

$|D| = 26.8328$

$\theta = \tan^{-1}\left(\frac{-24}{12}\right) = -63.4349^\circ$

$D = 26.8328 \angle -63.4349^\circ.$

(e) $E = \begin{vmatrix} 5\angle 30^\circ & -2\angle 45^\circ \\ -2\angle 45^\circ & 4\angle 60^\circ \end{vmatrix} = 5\angle 30^\circ \times 4\angle 60^\circ - (-2\angle 45^\circ)(-2\angle 45^\circ)$

$= 5\angle 30^\circ \times 4\angle 60^\circ - (2\angle 45^\circ)^2$

$= 20\angle 90^\circ - 4\angle 90^\circ = 16\angle 90^\circ = 16i$

$|E| = 16 \qquad \theta = 90^\circ \qquad \rightarrow \qquad E = 16\angle 90^\circ.$

2. <u>U&M 7.20</u>

(a) $I_1 = 6e^{j60^\circ}$ A at $f = 60$ Hz.

$I_1(t) = 6\cos(2\pi f t + \theta)$

$= 6\cos(2\pi \times 60t + \frac{\pi}{3}) = 6\cos(120\pi t + \frac{\pi}{3})$

(b) $I_2 = -2e^{-j30}$ A $\quad f = 1\text{kHz} = 1000$ Hz

$= 2 \cdot (-1) \cdot e^{-j30}$ A

$= 2 \cdot (-1) \cdot e^{j(-\frac{\pi}{6})}$ A.

$\omega = 2\pi f = 2000\pi$.

$-1 = -1 + j0 = e^{j\pi}$

$\Rightarrow I_2 = 2 \cdot e^{j(\pi - \frac{\pi}{6})} = 2e^{j(\frac{5}{6}\pi)} = 2 \cdot \cos(2000\pi t + \frac{5}{6}\pi)$

(c) $I_3 = j3$A at $f = 1\text{kHz} = 1000$ Hz $\quad \omega = 2\pi f = 2000\pi$

$= 3 \cdot j \cdot e^{j0}$

$= 3 \cdot e^{j\frac{\pi}{2}} \cdot e^{j0} = 3 \cdot e^{j \cdot \frac{\pi}{2}}$

$\Rightarrow I_3 = 3 \cdot \cos(2000\pi t + \frac{\pi}{2})$

(d) $I_4 = -(3 + j4) = 5e^{j(-\pi + \tan^{-1}(\frac{4}{3}))} = 5e^{j(-\pi + 0.9273)}$

$= 5e^{j(-2.2143)}$

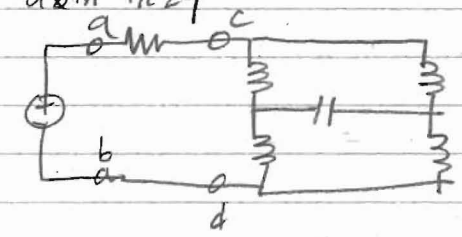
$= 5\cos(2\pi f t - 2.2143) = 5\cos(20000\pi t - 2.2143)$

(e) $I_5 = -4\angle -120^\circ = 4 \cdot e^{j\pi} \cdot e^{j(-\frac{2}{3}\pi)} = 4e^{j(\frac{1}{3}\pi)}$

$= 4\cos(2\pi f t + \frac{1}{3}\pi) = 4\cos(6 \times 10^6 \pi t + \frac{1}{3}\pi)$.

3. U&M 7.29

(a)



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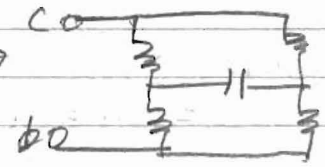

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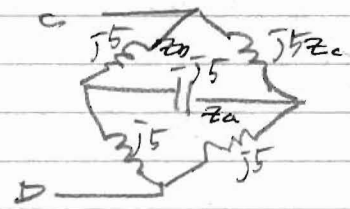

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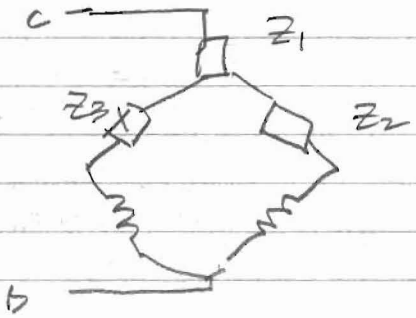


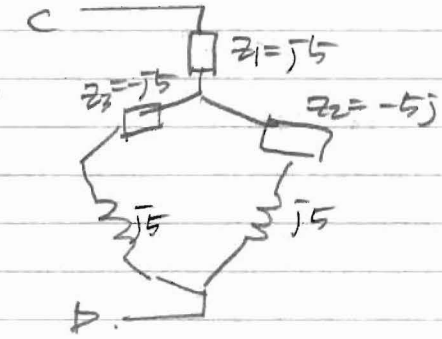
$$Z_1 = \frac{Z_b Z_c}{Z_a + Z_b + Z_c} = \frac{(j5)(j5)}{-j5 + j5 + j5}$$

$$= \frac{-25}{j5} = \frac{-25j}{-5} = \boxed{j5}$$

$$Z_2 = \frac{Z_a Z_c}{Z_a + Z_b + Z_c} = \frac{(-j5)(j5)}{j5} = \frac{25}{j5} = \frac{25j}{-5} = \boxed{-5j}$$

$$Z_3 = \frac{Z_a Z_b}{Z_a + Z_b + Z_c} = \frac{(-j5)(j5)}{j5} = \frac{25}{j5} = \boxed{-5j}$$

⇒



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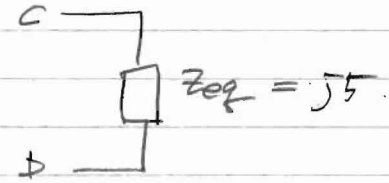

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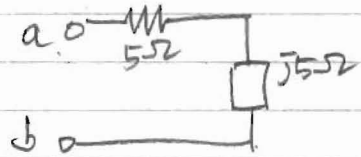

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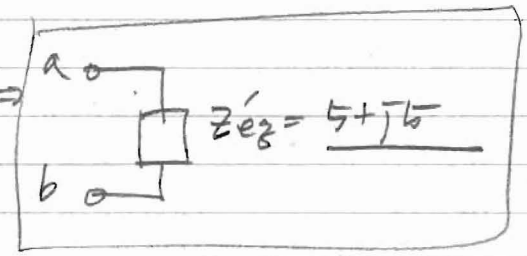
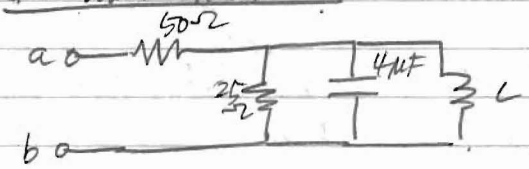


(b) $I = \frac{V_s}{Z'_{eq}} = \frac{25\angle 45^\circ}{5+j5} = \frac{25\angle 45^\circ}{5\sqrt{2}\angle 45^\circ} = \frac{5}{\sqrt{2}} = \frac{5}{2}\sqrt{2}$

$= \frac{5}{2}\sqrt{2}\angle 0^\circ$

4. UAM 1733

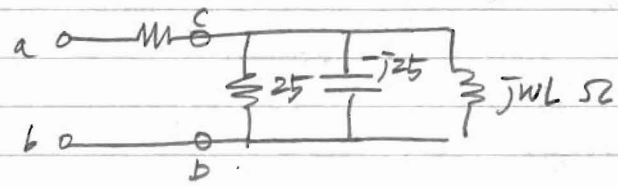


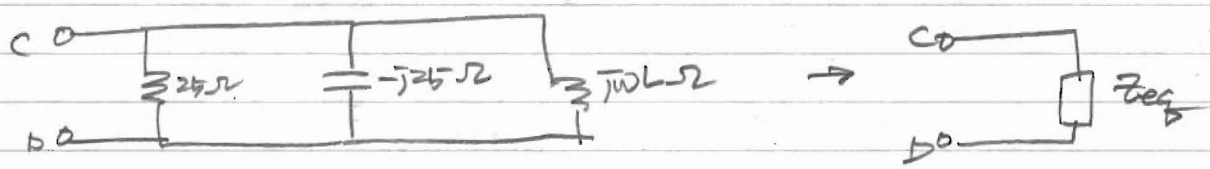
$\omega = 10^4$ rad/s

$\frac{1}{j\omega C} = \frac{1}{j\times 10^4 \times 4\times 10^{-6}}$

$= \frac{1}{j\times 4\times 10^{-2}}$

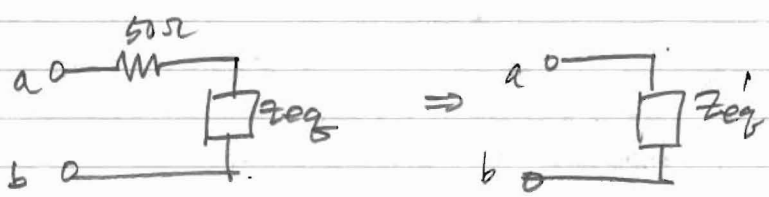
$= \frac{j\times 10^2}{-4} = \boxed{-j25}$





$\frac{1}{Z_{eq}} = \frac{1}{25} + \frac{1}{j(-25)} + \frac{1}{j\omega L}$

then



$Z'_{eq} = Z_{eq} + 50\Omega$

To have TH phase circuit, Z'_{eq} should be only real part.

i.e. $Z'_{eq} = |Z'_{eq}|\angle 0^\circ$

So, Z_{eq} also should be real part only

Then $\frac{1}{Z_{eq}}$ should be real part only, too.

then $\frac{1}{j(-25)} + \frac{1}{j\omega L}$ should be real part only

So, $\frac{1}{j(-25)} + \frac{1}{j\omega L} = \frac{j\omega L + j(-25)}{j(-25)\cdot j\omega L} = \frac{j(\omega L - 25)}{(-1)(-25)\omega L}$

$= \frac{j(\omega L - 25)}{25\omega L}$

denominator is real. So, $j(\omega L - 25)$ should be real.

$j(\omega L - 25)$ to be real

$\omega L = 25$ then $L = \frac{25}{\omega} = \frac{25}{10^4} = 2.5\times10^{-3}\,H = \boxed{2.5\,mH}$

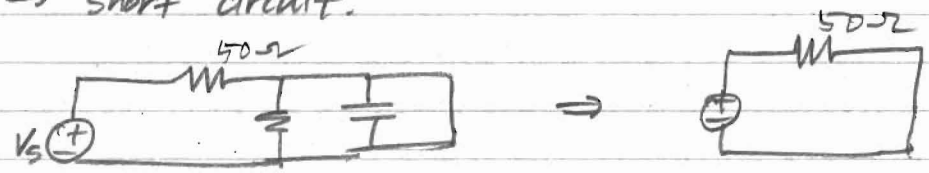
At the same time, when we use $\frac{1}{j\omega L}$, we assume that $L \neq 0$.

Let's check what happens if $L=0$

when $L=0 \rightarrow j\omega L = 0 \rightarrow$ no impedence

$\rightarrow$ short circuit.

then



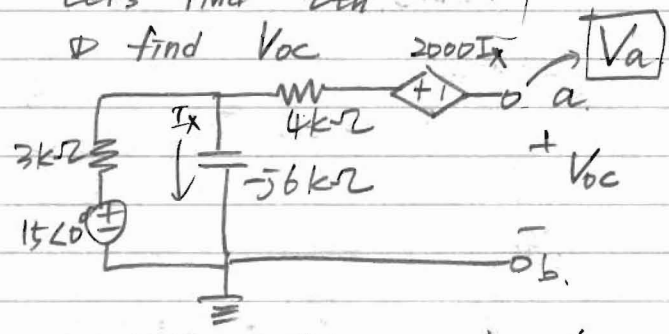
It becomes in-phase circuit when $L=0$, too.

So, $L = 0$ or $2.5\,mH$

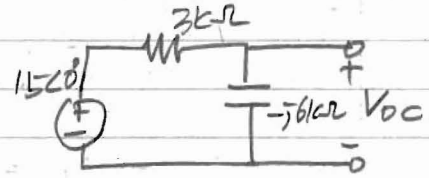
5. U&M 17.39

Let's find Z_{th}

① find V_{oc}



⇒



$$I_x = \frac{15}{(3-j6)\times 10^3} = (1+j2)\times 10^{-3}\ A$$

then Voltage across capacitor $V_c = I_x \times (-j6)\times 10^3 = 12-6j$

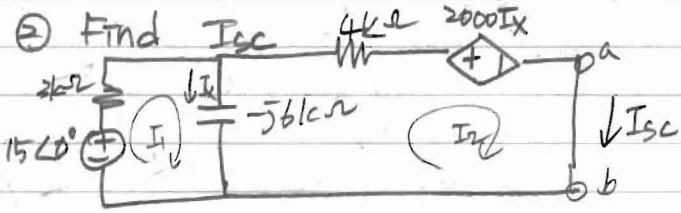
then $V_a = V_c - 2000 I_x = (12-6j) - 2\times \cancel{10^3} \times (1+j2)\times \cancel{10^{-3}}$

$= 12-6j-(2+j4)$

$= 12-6j-2-4j = \boxed{10-10j}$

So, $V_{oc} = V_a = 10-10j$

② Find I_{sc}



mesh analysis

$-15 + 3\times 10^3 \times I_1 + (-j6\times 10^3)(I_1 - I_2) = 0$

$(-j6\times 10^3)(I_2 - I_1) + 4\times 10^3 \times I_2 + 2000 I_x = 0$

$I_x = I_1 - I_2$

$(-j6\times 10^3)(I_2 - I_1) + 4\times 10^3 \times I_2 + 2000(I_1 - I_2) = 0$

$(2000 + j6000) I_1 + (-2000 + 4000 - j6000) I_2 = 0$

$(2000 + j6000) I_1 + (2000 - j6000) I_2 = 0$

$(2+j6) I_1 + (2-j6) I_2 = 0$

$(3000 - j6000) I_1 + (j6000) I_2 = 15$

$(3-j6) I_1 + (j6) I_2 = 0.015$

$$\begin{pmatrix} 2+j6 & 2-j6 \\ 3-j6 & j6 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} 0 \\ 0.015 \end{pmatrix}$$

$$\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} 2+j6 & 2-j6 \\ 3-j6 & j6 \end{pmatrix}^{-1} \begin{pmatrix} 0 \\ 0.015 \end{pmatrix} = \begin{pmatrix} 0.0022 + j0.0004 \\ 0.002 - j0.001 \end{pmatrix}$$

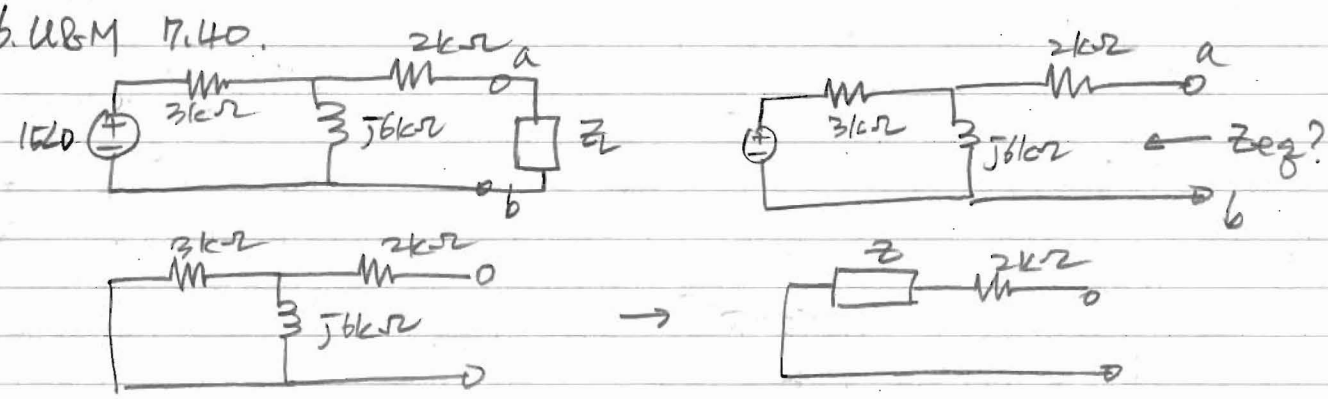
$$I_{sc} = I_2 = 0.002 - j0.001$$

③ $$Z_{th} = \frac{V_{oc}}{I_{sc}} = \frac{10 - j10}{0.002 - j0.001} = (6 - j2) \times 10^3 \Omega = (6 - j2)\, k\Omega$$

then

$$Z_L = Z_{TH}^* = (6 - j2)^* k\Omega = \boxed{(6 + j2)\, k\Omega}$$

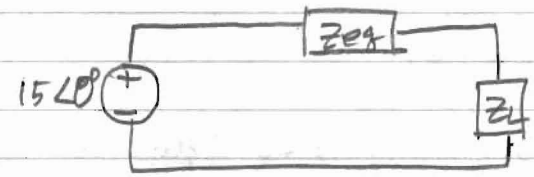
6. U&M 7.40.



$$Z = \frac{1}{\left(\frac{1}{3000} + \frac{1}{j6000}\right)} = (2.4 + j1.2) \times 10^3$$

then $Z_{eq} = Z + 2000 = (4.4 + j1.2) \times 10^3$

then



$$I_L = \frac{15\angle 0^\circ}{Z_{eq} + Z_L} = \frac{15}{(4.4 + j(1.2)) \times 10^3 + Z_L} = \left(\frac{78}{41} - j\frac{36}{41}\right) \times 10^{-3}$$

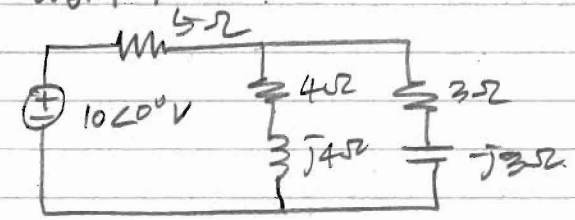
$$\Rightarrow \frac{(4.4 + j(1.2)) \times 10^3 + Z_L}{15} = \frac{1}{\left(\frac{78}{41} - j\frac{36}{41}\right) \times 10^{-3}}$$

$$\Rightarrow (4.4 + j(1.2)) \times 10^3 + Z_L = \frac{15 \times 10^3}{\left(\frac{78}{41} - j\frac{36}{41}\right)}$$

$$Z_L = \frac{15 \times 10^3}{\left(\frac{78}{41} - j\frac{36}{41}\right)} - (4.4 + j(1.2)) \times 10^3$$

$$= [2.1 + j(1.8)] \times 10^3 = \underline{(2.1 + j(1.8))\ k\Omega}$$

7. UBM 7.42



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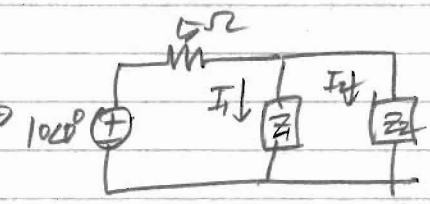


$Z_1 = 4 + j4\ \Omega$

$Z_2 = 3 - j3\ \Omega$

(a) current division

$Y_1 = \frac{1}{Z_1} = \frac{1}{4+j4}$ $\qquad I_1 = \frac{Y_1}{Y_1+Y_2} I_s = (0.36 - j0.48) I_s$

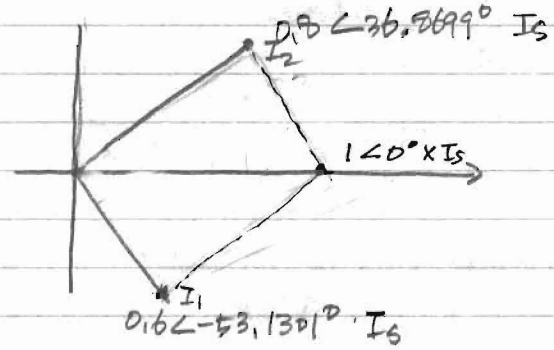
$Y_2 = \frac{1}{Z_2} = \frac{1}{3-j3}$ $\qquad I_2 = \frac{Y_2}{Y_1+Y_2} I_s = (0.64 + j0.48) I_s$

check $\underline{I_1 + I_2 = I_s}$

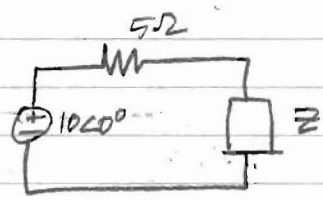
(b) Relative phasor diagram to I_s

$I_1 = (0.36 - j0.48) I_s = 0.6\angle -53.1301^\circ\ I_s$

$I_2 = (0.64 + j0.48) I_s = 0.8\angle 36.8699^\circ\ I_s$

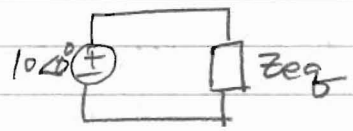


(c)



$$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

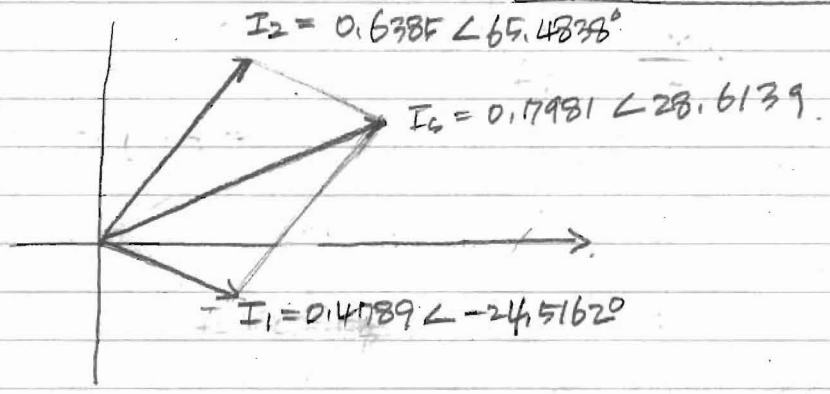
$$Z = \frac{Z_1 Z_2}{Z_1 + Z_2} = \underline{6 - j6}$$



$$Z_{eq} = 5 + Z = \boxed{11 - j6}$$

$$I_s = \frac{10}{11 - j6} = 0.7006 + j0.3822$$

$$\boxed{= 0.7981 \angle 28.6139^\circ}$$



$$I_1 = 0.6\angle -53.1301^\circ I_s = 0.4789 \angle -24.5162^\circ$$

$$I_2 = 0.8\angle 36.8699^\circ I_s = 0.6385 \angle 65.4838^\circ$$