Name of Examination	Continuous Assessment Test -2 (CAT-2), Fall 2021-2022 Semester, (December **2021)**	
Slot: **A1**	Course Mode: **CBL**	Class Number (s): **VL2021220105914**

Course Code:	**EEE101L**	Course Title:		
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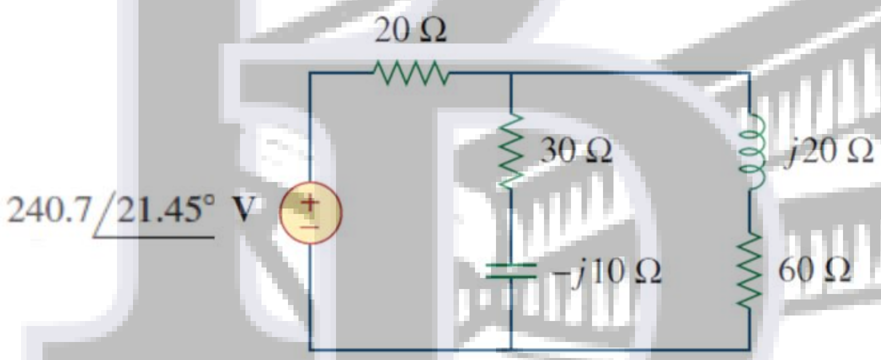
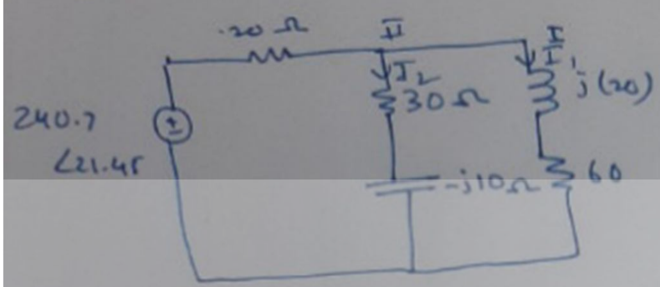
General Instructions (if any):

Q. No.	SET	Question
1.	A	Determine the Total current, and branch currents for the given circuit shown Fig.1. 

1a



for Branch I,

$$Z_1 = 60 + j20$$

$$Y_1 = \frac{1}{60 + j20} = \cancel{0.016}\ 0.0146 - (0.0047)j$$

$$= 0.0153 \angle -17.844 \text{ mho}$$

for branch II,

$$Z_2 = 30 - j10$$

$$Y_2 = \frac{1}{30 - j10} = 0.03 + (0.01)j$$

$$= 0.0317 \angle 18.434$$

Total Admittance,

$$Y_{T} = Y_1 + Y_2 = 0.0446 + (0.0053)j$$

$$= 0.0449 \angle 6.777$$

$$Z_{12} = \frac{1}{0.0446 + (0.0053j)}$$

$$= 22.109 - (2.627)j$$

Total Z ⟹

$$Z_T = 20 + 22.109 - (2.627)j$$

$$= (42.109 - 2.627)j$$

$$Z_T = 42.19 \angle -3.5698$$

~~Total~~

$$\boxed{\text{Total current } (I_T) = \frac{V}{Z_T} = 5.71 \angle 25.019}$$

$$V_1 = 5.03 \times 20$$

$$\Rightarrow 100.6 \; \cancel{\angle 18.19} \; \angle 18.19$$

V is ... H is const. $240.7 - 100.6$

$140.1\,V \angle 18.19$

$$i_1 = \frac{V}{Z_1} = \frac{140.1 \angle 18.19}{Z_1}$$

$Z_1 = 60 + j20$

$= (3600 + 400)^{1/2} \tan^{-1} \frac{20}{60}$

$\Rightarrow 63.24 \angle 18.26$

$i_1 = \frac{140.1 \angle 18.19}{63.24 \angle 18.26}$

$\Rightarrow 2.21 \angle 0.07$ A

$Z_2 = 30 - j10$

$\Rightarrow (900 + 100)^{1/2} \tan^{-1} -\frac{1}{3}$

$\Rightarrow 31.6 \angle -18.26$

$i_2 = \frac{140.1 \angle 18.19}{31.6 \angle -18.26}$

$\Rightarrow 4.43 \angle 36.45$ A

B A coil of resistance 20 ohm and inductance 100 mH is connected in parallel with a 50 μF capacitor across a 30 V variable-frequency supply. Determine (a) the resonant frequency of the circuit, (b) the dynamic resistance, (c) the current at resonance, and (d) the circuit Q-factor at resonance.

[(a) 63.66 Hz (b) 100 Ω (c) 0.30 A (d) 2]

C Determine for the parallel network shown in **Fig.1** the values of inductance L for which the network is resonant at a frequency of 1 kHz

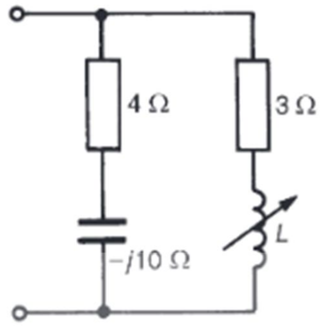


Fig.1

The total network admittance, Y, is given by

$$Y = \frac{1}{3 + jX_L} + \frac{1}{4 - j10} = \frac{3 - jX_L}{3^2 + X_L^2} + \frac{4 + j10}{4^2 + 10^2}$$

$$= \frac{3}{3^2 + X_L^2} - \frac{jX_L}{3^2 + X_L^2} + \frac{4}{116} + \frac{j10}{116}$$

$$= \left(\frac{3}{3^2 + X_L^2} + \frac{4}{116}\right) + j\left(\frac{10}{116} - \frac{X_L}{3^2 + X_L^2}\right)$$

Resonance occurs when the admittance is a minimum, i.e., when the imaginary part of Y is zero. Hence, at resonance,

$$\frac{10}{116} - \frac{X_L}{3^2 + X_L^2} = 0 \text{ i.e., } \frac{10}{116} = \frac{X_L}{3^2 + X_L^2}$$

Therefore $10(9 + X_L^2) = 116\,X_L$ i.e., $10\,X_L^2 - 116\,X_L + 90 = 0$

from which, $X_L^2 - 11.6\,X_L + 9 = 0$

Solving the quadratic equation gives:

$$X_L = \frac{11.6 \pm \sqrt{[(-11.6)^2 - 4(9)]}}{2} = \frac{11.6 \pm 9.93}{2}$$

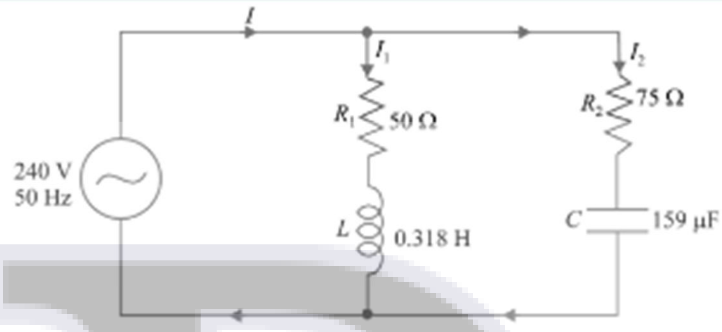
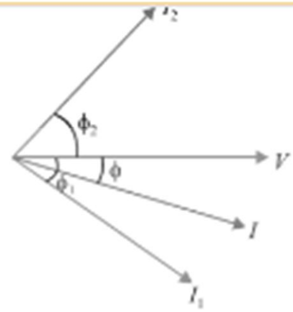
i.e., $X_L = 10.765\ \Omega$ or $0.835\ \Omega$. Hence $10.765 = 2\pi f_r L_1$, from which,

$$\text{inductance } L_1 = \frac{10.765}{2\pi(1000)} = 1.71\text{ mH}$$

and $0.835 = 2\pi f_r L_2$ from which,

$$\text{inductance, } L_2 = \frac{0.835}{2\pi(1000)} = 0.13\text{ mH}$$

	D	A coil of resistance 50 ohm and 0.318H is connected in parallel with a circuit comprising a 75 ohm resistor in series with a 159 microfarad capacitor. The resulting circuit is connected to a 230V, 50Hz ac supply. Determine the supply current, and branch currents.

		 Fig. 16.9  Fig. 16.10 *Second branch.* $X_C = \frac{1}{2\pi fC} = \frac{10^6}{2\pi\times 50\times 159} = 20\ \Omega$ $Z_2 = \sqrt{R_2^2 + X_C^2} = \sqrt{75^2 + 20^2} = 77.7\Omega$ $\phi_2 = \cos^{-1} R_2/Z_2 = \cos^{-1} 75/77.7 = 15°$ *lead* $I_2 = V/Z_2 = 240/77.7 = 3.09$ A ... *leads* V *by* 15° $X_L = 2\pi fL = 2\pi \times 50 \times 0.318 = 100\ \Omega$ $Z_1 = \sqrt{R_1^2 + X_L^2} = \sqrt{50^2 + 100^2} = 112\ \Omega$ $\phi_1 = \cos^{-1} R_1/Z_1 = \cos^{-1} 50/112 = 63.5°$ *lag* $I_1 = V/Z_1 = 240/112 = 2.15$ A ...*lags* V *by* 63.5°
2.	A	Three phase circuit – STAR –STAR **A Y-connected balanced three-phase generator with an impedance of 0.4 +j3 ohm per phase is connected to a Y-connected balanced load with an impedance of 24 +j19 ohm per phase. The line joining the Generator and the load has an impedance of 0.6 +j 0.7 ohm per phase. Assuming a positive sequence for the source voltages and that** $\mathbf{V}_{an} = 120\angle 30°$ V,

Determine

(a) all the line voltages,

(b) all the line currents.

(a) determine the line voltage V_{ab}

$$V_{ab} = \sqrt{3}\, V_{an} \angle 30°$$

Substitute $120 \angle 30°$ for V_{an} in the equation

$$V_{ab} = \sqrt{3}\,(120 \angle 30°) \angle 30°$$
$$= \sqrt{3}\,(120 \angle 60°)$$
$$= 207.8 \angle 60° \, V$$

There for line voltage is $\boxed{207.8 \angle 60° \, V}$

⇒ As the given system is a balanced 3 phase system, the other line voltages differ by 120° phase shift with same magnitude.

• Determine line voltage V_{bc}

$$V_{bc} = V_{ab} \angle -120°$$
$$V_{bc} = (207.8 \angle 60°) \angle -120°$$
$$= 207.8 \angle -60$$
$$\boxed{V_{bc} = 207.8 \angle 60 \, V}$$

$$V_{ca} = V_{ab} \angle -240°$$
$$V_{ca} = (207.8 \angle 60°) \angle -240°$$
$$\boxed{V_{ca} = 207.8 \angle -180°}$$

In a star connection, the line current is equal to phase current.

→ Determine line current I_a

$$\boxed{I_a = \frac{V_{an}}{Z_y}}$$

where Z_y is total impedance seen from source to load

$$\therefore Z_y = (0.4 + j0.3) + (24 + j19) + (0.6 + j0.7)$$

$$= 25 + j20$$

$$Z_y = 32.016 \angle 38.66° \ \Omega$$

$$\Rightarrow I_a = \frac{V_{an}}{Z_y} = \frac{120 \angle 30°}{32.016 \angle 38.66°}$$

$$\boxed{I_a = 3.75 \angle -8.66° \ A}$$

As the given system is a balanced 3 phase system, line currents differ by 120° phase shift with same magnitude

$\rightarrow \therefore I_b = I_a \angle -120°$

$I_b = (3.75 \angle -8.66°) \angle -120°$

$\boxed{I_b = 3.75 \angle -128.66° \text{ A}}$

$\rightarrow I_c = I_a \angle -240°$

$I_c = (3.75 \angle -8.66°) \angle -240°$

$I_c = 3.75 \angle -248.66°$

$I_c = 3.75 \angle -248.66 + 360$

$\boxed{I_c = 3.75 \angle 111.34° \text{ A}}$

Answer: (a) $207.85\angle 60°$ V, $207.85\angle -60°$ V, $207.85\angle -180°$ V.
(b) $3.75\angle -8.66°$ A, $3.75\angle -128.66°$ A, $3.75\angle -111.34°$ A.

B Three phase circuit -STAR DELTA

The line voltage of a balanced star connected source is

$\mathbf{V}_{AB} = 240\angle -20°$ V.

If the source is connected to a delta connected load of

$20\angle 40°\ \Omega$,

Determine the phase and line currents. Assume the ABC sequence

2) Given:- Line voltage $V_{AB} = 240\angle -20^\circ V$ → Balanced star connected source.

Balanced Δ-load with $Z_\Delta = 20\angle 40^\circ \Omega$.

Phase current, $I_{AB} = \dfrac{V_{AB}}{Z_\Delta}$

$$I_{AB} = \frac{240\angle -20^\circ}{20\angle 40^\circ} = 12\angle -60^\circ A$$

Phase currents, $I_{AB} = 12\angle -60^\circ A$

$I_{BC} = I_{AB}\angle -120^\circ = 12\angle -180^\circ A$ — By considering positive sequence.

$I_{CA} = I_{AB}\angle +120^\circ = 12\angle 60^\circ A$

Line currents, $I_a = \sqrt{3}\, I_{AB}\angle -30^\circ$

$I_a = \sqrt{3}(12)\angle(-60^\circ - 30^\circ) A$

$I_a = 20.784\angle -90^\circ A$

$I_b = I_a\angle -120^\circ = 20.784\angle(-90-120) A$ — By considering positive sequence.

$I_b = 20.784\angle -210^\circ A$

$I_c = I_a\angle 120^\circ = 20.784\angle(-90+120) A$

$I_c = 20.784\angle 30^\circ A$

Answer: $12\angle -60^\circ$ A, $12\angle -180^\circ$ A, $12\angle 60^\circ$ A, $20.79\angle -90^\circ$ A, $20.79\angle -150^\circ$ A, $20.79\angle 30^\circ$ A.

C Three phase circuit -DELTA –STAR

In a balanced delta – star circuit,

$\mathbf{V}_{ab} = 240\angle 15^\circ$

and Z_y = 12+j15 ohm ,

Determine the line currents. Assume the abc sequence .

For conversion to pure Delta – Delta circuit,
we will have to first
undergo star to delta transformation

$\therefore R_{ab} = R_a + R_b + \frac{R_a R_b}{R_c}$

$= 12 + j(15) + 12 + j(15) + \frac{(12+j(15))^2}{(12+j(15))}$

$R_a = 36 + j(45)\,\Omega$

$R_a = R_b = R_c = 36 + j(45)\,\Omega$

For pure Delta circuit,

$$V_{phase} = V_{Line} = 240\angle 15^\circ$$

$$\Rightarrow I_{phase} = \frac{240\angle 15^\circ}{36 + j(45)} = \frac{240\angle 15^\circ}{\left(\sqrt{36^2+45^2}\right)\left(\tan^{-1}\left(\frac{45}{36}\right)\right)}$$

$$\Rightarrow I_{phase} = \frac{240\angle 15}{57.628\angle 51.340} = 4.164\angle -36.34$$

In delta,

$$I_{line} = \sqrt{3}\, I_{phase}$$

$$\Rightarrow I_{line} = \sqrt{3}\,(4.164)\angle -36.34$$

$$\Rightarrow I_{line} = 7.212\angle -36.34$$

$$\Rightarrow \boxed{I_a = 7.212\angle -66.34 \text{ A}}$$

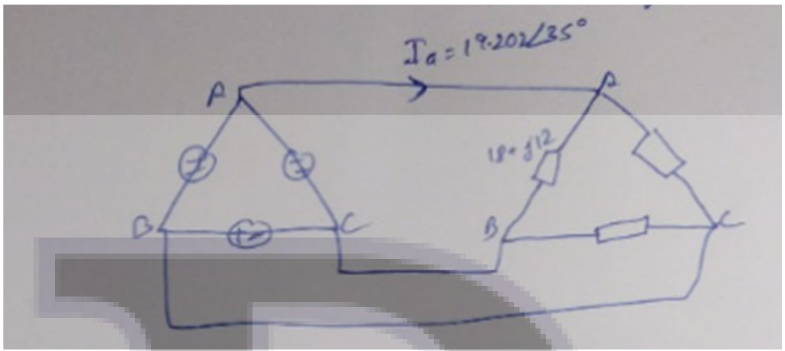
$$\boxed{I_b = 7.212\angle -156.34 \text{ A}}$$

$$\boxed{I_c = 7.212\angle 83.66 \text{ A}}$$

D **A positive-sequence, balanced delta connected source supplies a balanced Delta connected load. If the impedance per phase of the load is 18 +j 12 ohm and** $\mathbf{I}_a = 19.202\angle 35^\circ$ **A,**

Determine all the phase currents and phase voltages.

Answer: $11.094\angle 65^\circ$ A, $240\angle 98.69^\circ$ V.



$$Z_a = 18 + j12 = 21.63\angle 33.69$$

$$I_a = 19.202\angle 35^\circ$$

$$\boxed{I_a = \sqrt{3}\, I_{AB}\angle -30^\circ} \longrightarrow \text{formula}$$

(2) $$I_{ab} = \frac{I_A \angle 30^\circ}{\sqrt{3}}$$

$$= \frac{19.202}{\sqrt{3}}(\angle 35 + 30)$$

$$I_{ab} = 11.0867(\angle 65)$$

$$\boxed{\frac{V_{ab}}{Z_L} = I_{AB}}$$

$$\boxed{I_{AB} = 11.0867\angle 65}$$

$$I_{BC} = I_{AB}\angle -120$$

$$\boxed{I_{BC} = 11.0867\angle -55}$$

$$I_{CA} = I_{AB}\angle -240$$

$$I_{CA} = 11.0867\angle 65-240$$

$$\boxed{I_{CA} = 11.0867\angle -175}$$

		$V_{AB} = Z_\Delta I_{ab}$ $V_{AB} = (21.63\angle 33.69)(11.0867\angle 65)$ $\boxed{V_{AB} = 239.805\angle 98.69}$ $V_{BC} = (V_{AB})\angle -120$ $\boxed{V_{BC} = 239.805\angle -21.31}$ $V_{AC} = (V_{AB})\angle -240$ $\boxed{V_{AC} = 239.805\angle -141.31}$
3	A	MAGNETIC CIRCUIT – Two coils are connected in series and their effective inductance is found to be 15 mH. When the connection to one coil is reversed, the effective inductance is found to be 10 mH. If the coefficient of coupling is 0.7, Determine (a) the self-inductance of each coil, and (b) the mutual inductance

i.e., $\boldsymbol{L_B = L_1 + L_2 - 2M}$ (43.12)

Thus the total inductance L of inductively coupled circuits is given by:

$$\boxed{\boldsymbol{L = L_1 + L_2 \pm 2M}} \quad (43.13)$$

Equation (43.11) - equation (43.12) gives:

$$L_A - L_B = (L_1 + L_2 + 2M) - (L_1 + L_2 - 2M)$$

i.e., $L_A - L_B = 2M - (-2M) = 4M$

from which, $\boxed{\textbf{mutual inductance, } \boldsymbol{M = \frac{L_A - L_B}{4}}}$ (43.14)

(a) From equation (43.13), total inductance, $L = L_1 + L_2 \pm 2M$
and from equation (43.9), $M = k\sqrt{(L_1L_2)}$
hence $L = L_1 + L_2 \pm 2k\sqrt{(L_1L_2)}$
Since in equation (43.11),

$$L_A = 15 \text{ mH}, \quad 15 = L_1 + L_2 + 2k\sqrt{(L_1L_2)} \quad (43.15)$$

and since in equation (43.12),

$$L_B = 10 \text{ mH}, \quad 10 = L_1 + L_2 - 2k\sqrt{(L_1L_2)} \quad (43.16)$$

Equation (43.15) + equation (43.16) gives:

$$25 = 2L_1 + 2L_2 \text{ and } 12.5 = L_1 + L_2 \quad (43.17)$$

From equation (43.17), $L_2 = 12.5 - L_1$
Substituting in equation (43.15), gives:

$$15 = L_1 + (12.5 - L_1) + 2(0.7)\sqrt{[L_1(12.5 - L_1)]}$$

i.e., $15 = 12.5 + 1.4\sqrt{(12.5L_1 - L_1^2)}$

$$\frac{15 - 12.5}{1.4} = \sqrt{(12.5L_1 - L_1^2)}$$

$$\frac{15 - 12.5}{1.4} = \sqrt{(12.5L_1 - L_1^2)}$$

and $$\left(\frac{15 - 12.5}{1.4}\right)^2 = 12.5L_1 - L_1^2$$

i.e., $3.189 = 12.5L_1 - L_1^2$

from which, $L_1^2 - 12.5L_1 + 3.189 = 0$

Using the quadratic formula:

$$L_1 = \frac{-(-12.5) \pm \sqrt{[(-12.5)^2 - 4(1)(3.189)]}}{2(1)}$$

i.e., $$\boldsymbol{L_1} = \frac{12.5 \pm (11.98)}{2} = \mathbf{12.24\ mH} \text{ or } \mathbf{0.26\ H}$$

From equation (43.17):

$$\boldsymbol{L_2} = 12.5 - L_1 = (12.5 - 12.24) = \mathbf{0.26\ mH}$$

$$\text{or } (12.5 - 0.26) = \mathbf{12.24\ mH}$$

(b) From equation (43.14),

$$\textbf{mutual inductance, } \boldsymbol{M} = \frac{L_A - L_B}{4} = \frac{15 - 10}{4} = \mathbf{1.25\ mH}$$

B

MAGNETIC CIRCUIT -SERIES OPPOSING

Determine the Vo voltage in the circuit of Fig. 3

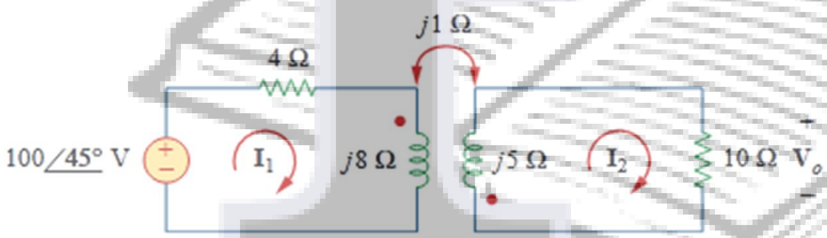


Fig. 3

3) Clearly from fig, both currents I_1, I_2 entering at dotted terminal

Applying KVL to Loop1

$$-100\angle 45^\circ V + (4+j8)I_1 + jI_2 = 0$$

$$\Rightarrow (4+j8)I_1 + jI_2 = 100\angle 45^\circ \longrightarrow (1)$$

KVL to second Loop 2,

$$(10+j5)I_2 + jI_1 = 0$$

$$\Rightarrow I_1 = -\frac{(10+j5)}{j} I_2$$

$$\Rightarrow I_1 = (-5+10j) I_2$$

Subst. I_1 in (1),

$$(4+j8)(-5+j10)I_2 + jI_2 = 100\angle 45^\circ$$

$$\Rightarrow I_2 = \frac{100\angle 45^\circ}{100\angle 179.42^\circ}$$

$$= 1\angle -134.42^\circ \text{ A}$$

$$\therefore V_0 = 10(1\angle -134.42^\circ) = 10\angle -134.42^\circ \text{ V}$$ Ans

Answer: $10\angle -135^\circ$ V.

C

MAGNETIC CIRCUIT - SERIES Aiding

For the coupled circuit shown **Fig.3.**

determine the values of currents I_1 and I_2

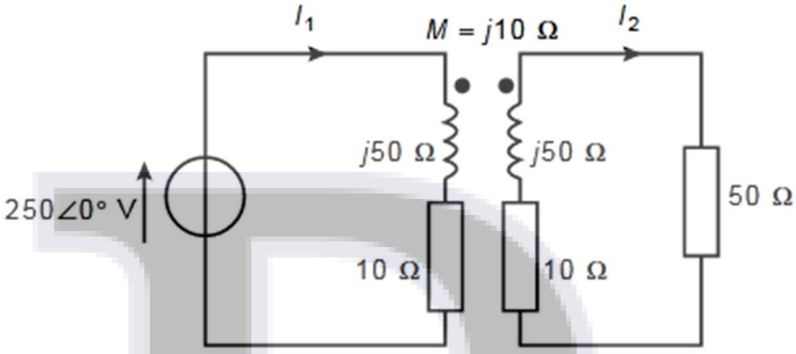


Fig.3.

The position of the dots and the current directions correspond to Figure 43.15(a), and hence the signs of the M and L terms are opposite. Applying Kirchhoff's voltage law to the primary circuit gives:

$$250\angle 0° = (10 + j50)\boldsymbol{I}_1 - j10\boldsymbol{I}_2 \qquad (1)$$

and applying Kirchhoff's voltage law to the secondary circuit gives:

$$0 = (10 + 50 + j50)\boldsymbol{I}_2 - j10\boldsymbol{I}_1 \qquad (2)$$

From equation (2), $\quad j10\boldsymbol{I}_1 = (60 + j50)\boldsymbol{I}_2$

and $\quad \boldsymbol{I}_1 = \dfrac{(60 + j50)\boldsymbol{I}_2}{j10} = \left(\dfrac{60}{j10} + \dfrac{j50}{j10}\right)\boldsymbol{I}_2 = (-j6 + 5)\boldsymbol{I}_2$

i.e., $\quad \boldsymbol{I}_1 = (5 - j6)\boldsymbol{I}_2 \qquad (3)$

Substituting for I_1 in equation (1) gives:

$$250\angle 0^\circ = (10 + j50)(5 - j6)I_2 - j10I_2$$
$$= (50 - j60 + j250 + 300 - j10)I_2$$
$$= (350 + j180)I_2$$

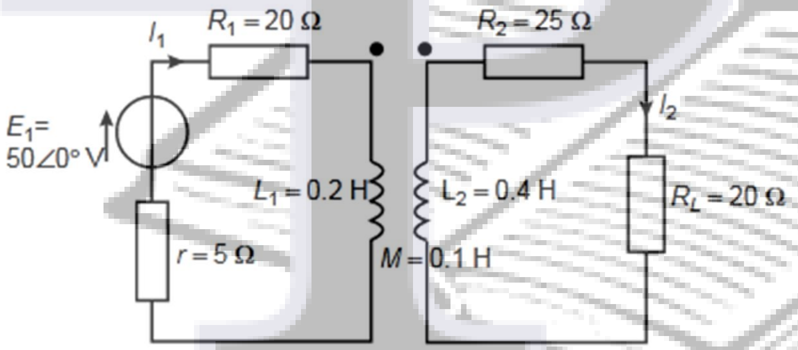
from which, $$I_2 = \frac{250\angle 0^\circ}{(350 + j180)} = \frac{250\angle 0^\circ}{393.57\angle 27.22^\circ}$$
$$= \mathbf{0.635\angle -27.22^\circ\ A}$$

From equation (3), $$I_1 = (5 - j6)I_2$$
$$= (5 - j6)(0.635\angle -27.22^\circ)$$
$$= (7.810\angle -50.19^\circ)(0.635\angle -27.22^\circ)$$

i.e., $$I_1 = \mathbf{4.959\angle -77.41^\circ\ A}$$

D MAGNETIC CIRCUIT - SERIES OPPOSING

A mutual inductor is used to couple a 20 ohm resistive load to a $50\angle 0^\circ$ V generator as shown in Fig. 3 . The generator has an internal resistance of 5 ohm and the mutual inductor parameters are $R_1 = 20$ ohm, $L_1 = 0.2$ H, $R_2 = 25$ ohm, $L_2 = 0.4$ H and M = 0.1 H. The supply frequency is 25 Hz. Determine (a) the generator current I_1 and (b) the load current I_2.



(a) Applying Kirchhoff's voltage law to the primary winding gives:

$$I_1(r + R_1 + j\omega L_1) - j\omega M I_2 = 50\angle 0^\circ$$

i.e., $\quad I_1\left[5+20+j2\pi\left(\frac{75}{\pi}\right)(0.2)\right]-j2\pi\left(\frac{75}{\pi}\right)(0.1)I_2=50\angle 0^\circ$

i.e., $\quad I_1(25+j30)-j15I_2=50\angle 0^\circ \qquad (1)$

Applying Kirchhoff's voltage law to the secondary winding gives:

$$-j\omega MI_1+I_2(R_2+R_L+j\omega L_2)=0$$

i.e., $\quad -j2\pi\left(\frac{75}{\pi}\right)(0.1)I_1+I_2\left[25+20+j2\pi\left(\frac{75}{\pi}\right)(0.4)\right]$

i.e., $\quad -j15I_1+I_2(45+j60)=0 \qquad (2)$

Hence the equations to solve are:

$$(25+j30)I_1-j15I_2-50\angle 0^\circ=0 \qquad (1)'$$

and $\quad -j15I_1+(45+j60)I_2=0 \qquad (2)'$

Using determinants:

$$\frac{I_1}{\begin{vmatrix}-j15 & -50\angle 0^\circ\\ (45+j60) & 0\end{vmatrix}}=\frac{-I_2}{\begin{vmatrix}(25+j30) & -50\angle 0^\circ\\ -j15 & 0\end{vmatrix}}=\frac{1}{\begin{vmatrix}(25+j30) & -j15\\ -j15 & (45+j60)\end{vmatrix}}$$

i.e., $$\frac{I_1}{50(45+j60)}=\frac{-I_2}{-50(j15)}=\frac{1}{(25+j30)(45+j60)-(j15)^2}$$

$$\frac{I_1}{50(75\angle 53.13^\circ)}=\frac{I_2}{750\angle 90^\circ}=\frac{1}{(39.05\angle 50.19^\circ)(75\angle 53.13^\circ)+225}$$

$$\frac{I_1}{3750\angle 53.13^\circ}=\frac{I_2}{750\angle 90^\circ}=\frac{1}{2928.75\angle 103.32^\circ+225}$$

$$\frac{I_1}{3750\angle 53.13^\circ}=\frac{I_2}{750\angle 90^\circ}=\frac{1}{(-449.753+j2849.962)}$$

$$\frac{I_1}{3750\angle 53.13^\circ}=\frac{I_2}{750\angle 90^\circ}=\frac{1}{2885.23\angle 98.97^\circ}$$

(a) **Generator current,** $I_1=\frac{3750\angle 53.13^\circ}{2885.23\angle 98.97^\circ}=\mathbf{1.30\angle -45.84^\circ\ A}$

(b) **Load current,** $I_2=\frac{750\angle 90^\circ}{2885.23\angle 98.97^\circ}=\mathbf{0.26\angle -8.97^\circ\ A}$