Vellore – 632014, Tamil Nadu, India

SCHOOL OF ELECTRICAL ENGINEERING

FALL SEMESTER 2023-2024

CAT-I

SLOT: E1+TE1

Programme Name & Branch: **Fall Semester** Course Code: **BEEE102L**

Course Name : **Basic Electrical and Electronics Engineering**

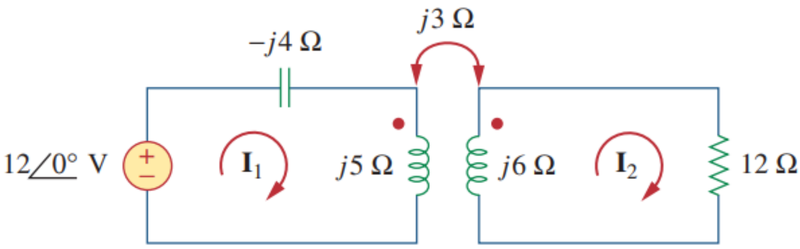
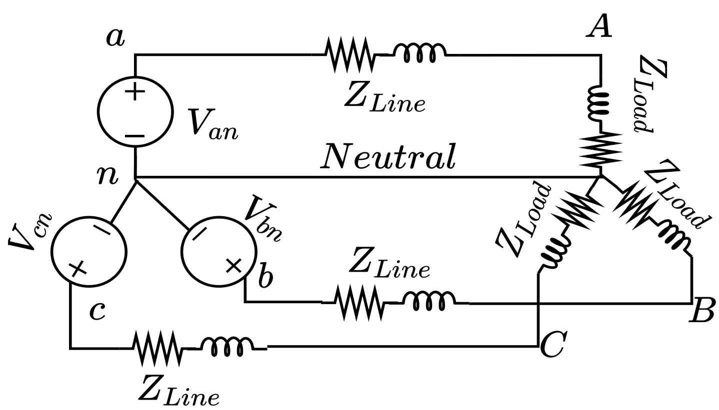
Faculty Members: **Dr. M.Chilukuri, Dr. Mukul Chankaya, Dr. Thirumurugan C**

Class Number(s):

Date of the Examination:

Duration: 90 minutes **Max. Marks : 50**

General instruction(s):

Q. No	Question	Marks	CO	BL
1.	Calculate the phasors currents I_1 and I_2 in circuit below. Also draw the electrical equivalent circuit for the same,  Fig. 1.	10	3	5
2.	In a balanced 3-phase Star-Star connection having phase ‘a’ voltage $V_{an} = 100\angle 0^{\circ}$, each phase line and load impedances is $Z_{Line} = 5 - 2j$, and $Z_{Load} = 10 + 8j$ respectively. Consider the ‘acb’ phase sequence and calculate phase voltages, line voltages, and phase currents on both the generator and load sides.  Fig. 2.	10	2	5

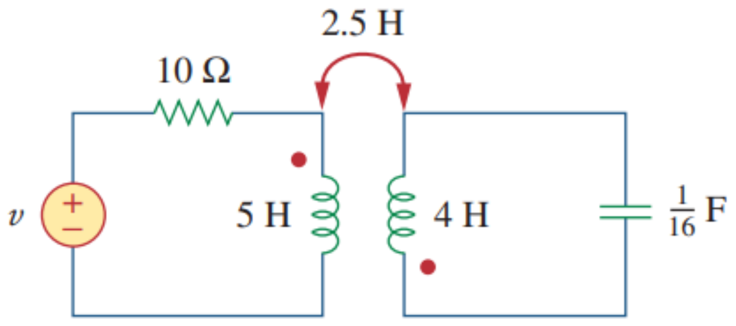
<table>
<tr><td>3.</td><td>

Fig 3.

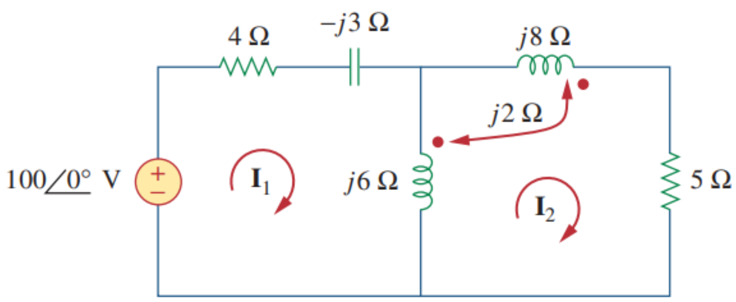
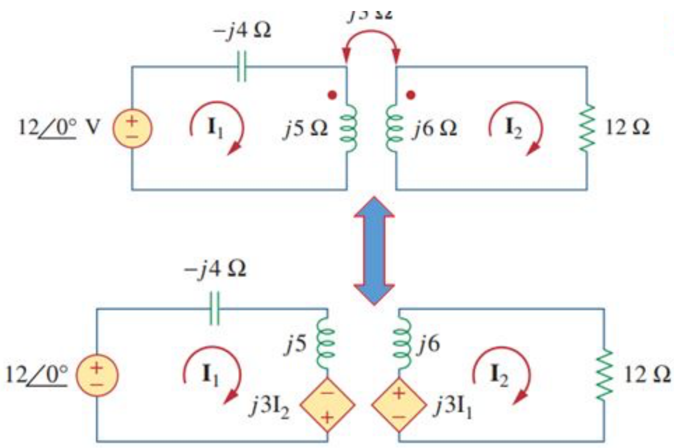
Calculate energy stored in the coupled inductors at a time t=1s, if v = 60cos (4t+30°) V. Also find the coupling coefficient.</td><td>10</td><td>3</td><td>5</td></tr>
<tr><td>4.</td><td>A transformer with 1000 primary turns and 400 secondary turns is supplied from a 220 V AC supply. Calculate the secondary side voltage and volts per turn ?</td><td>10</td><td>4</td><td>3</td></tr>
<tr><td>5.</td><td>

Fig 4.

Calculate the mesh currents in circuit shown (Fig 4.) above.</td><td>10</td><td>3</td><td>5</td></tr>
</table>

Solution

Answer1:



Solution: For loop 1, KVL gives

$$-12 + (-j4 + j5)\mathbf{I}_1 - j3\mathbf{I}_2 = 0$$

or $\quad j\mathbf{I}_1 - j3\mathbf{I}_2 = 12$

For loop 2, KVL gives

$$-j3\mathbf{I}_1 + (12 + j6)\mathbf{I}_2 = 0$$

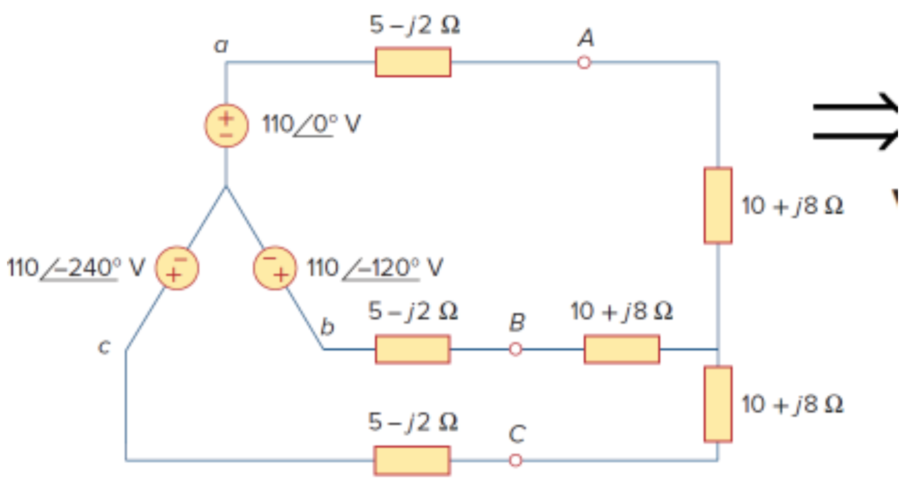
$$\mathbf{I}_1 = \frac{(12 + j6)\mathbf{I}_2}{j3} = (2 - j4)\mathbf{I}_2$$

$$\mathbf{I}_2 = \frac{12}{4 - j} = 2.91\underline{/14.04^\circ} \text{ A}$$

$$\mathbf{I}_1 = (2 - j4)\mathbf{I}_2 = (4.472\underline{/-63.43^\circ})(2.91\underline{/14.04^\circ})$$

$$\mathbf{I}_1 = 13.01\underline{/-49.39^\circ} \text{ A}$$

Answer2:



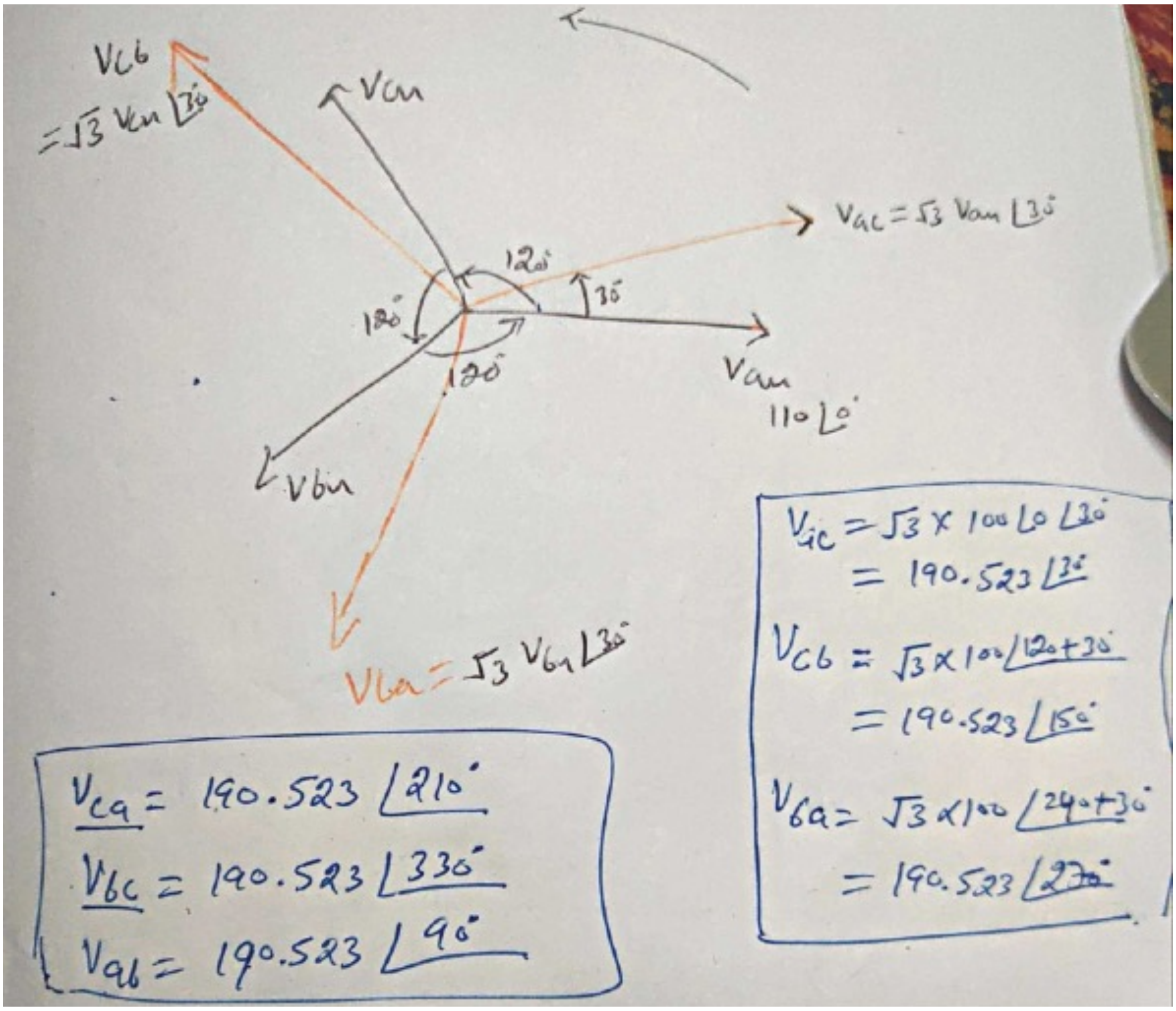
$$Z_Y = (5 - j2) + (10 + j8) = (15 + j6)$$
$$= 16.155\angle 21.8^0$$

$$I_a = \frac{110\angle 0^0}{16.155\angle 21.8^0} = 6.81\angle -21.8^0\,\text{A}$$

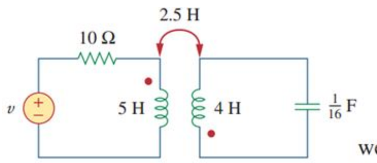
ch as the source voltages in Fig. 1 a
are also in positive sequence:

$$I_b = I_a\angle -120^0 = 6.81\angle -141.8^0\,\text{A}$$
$$I_c = I_a\angle -240^0 = 6.81\angle 98.2^0\,\text{A}$$

110∠



Answer 3:

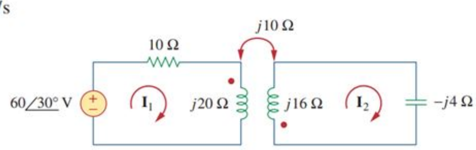


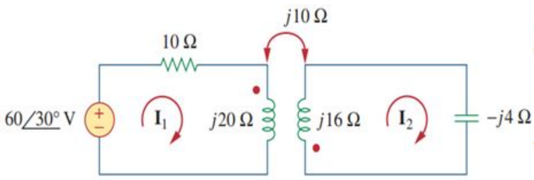
Solution: The coupling coefficient is

$$k = \frac{M}{\sqrt{L_1 L_2}} = \frac{2.5}{\sqrt{20}} = 0.56$$

we need to obtain the frequency-domain equivalent of the circuit.

$$60\cos(4t + 30^\circ) \Rightarrow 60\angle 30^\circ, \quad \omega = 4 \text{ rad/s}$$
$$5\text{ H} \Rightarrow j\omega L_1 = j20\ \Omega$$
$$2.5\text{ H} \Rightarrow j\omega M = j10\ \Omega$$
$$4\text{ H} \Rightarrow j\omega L_2 = j16\ \Omega$$
$$\frac{1}{16}\text{ F} \Rightarrow \frac{1}{j\omega C} = -j4\ \Omega$$





For mesh 1,

$$(10 + j20)\mathbf{I}_1 + j10\mathbf{I}_2 = 60\angle 30^\circ$$

For mesh 2,

$$j10\mathbf{I}_1 + (j16 - j4)\mathbf{I}_2 = 0$$

or $\mathbf{I}_1 = -1.2\mathbf{I}_2$

Substituting this into above equation

$$\mathbf{I}_2(-12 - j14) = 60\angle 30^\circ \Rightarrow \mathbf{I}_2 = 3.254\angle 160.6^\circ \text{ A}$$ and $$\mathbf{I}_1 = -1.2\mathbf{I}_2 = 3.905\angle -19.4^\circ \text{ A}$$

In the time-domain, $i_2 = 3.254\cos(4t + 160.6^\circ)$ and $i_1 = 3.905\cos(4t - 19.4^\circ)$

At time $t = 1$ s, $4t = 4$ rad $= 229.2^\circ$ $\quad i_2 = 3.254\cos(229.2^\circ + 160.6^\circ) = 2.824$ A

$$i_1 = 3.905\cos(229.2^\circ - 19.4^\circ) = -3.389 \text{ A}$$

$$w = \frac{1}{2}L_1 i_1^2 + \frac{1}{2}L_2 i_2^2 + M i_1 i_2$$

$$w = \frac{1}{2}(5)(-3.389)^2 + \frac{1}{2}(4)(2.824)^2 + 2.5(-3.389)(2.824) = 20.73 \text{ J}$$

Answer 4;

A transformer with 1000 primary turns and 400 secondary turns is supplied from a 220 V AC supply. Calculate the secondary voltage and the volts per turn.

Solution

Given data,

$$N_1 = 1000 \text{ and } N_2 = 400$$

$$V_1 = 220 \text{ V}$$

The turns ratio of transformer is,

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\Rightarrow V_2 = V_1 \times \frac{N_2}{N_1} = 220 \times \frac{400}{1000}$$

$$\therefore V_2 = 88 \text{ Volts}$$

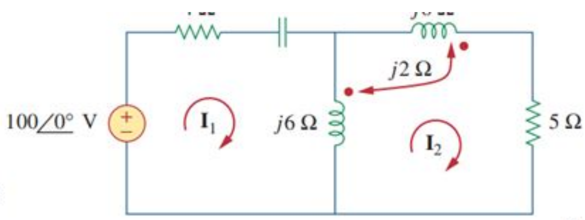
The volts per turn is given by,

$$\text{For primary winding} = \frac{V_1}{N_1} = \frac{200}{1000} = 0.22 \text{ Volts}$$

$$\text{For Secondary winding} = \frac{V_2}{N_2} = \frac{88}{400} = 0.22 \text{ Volts}$$

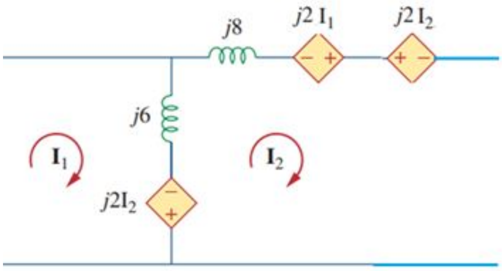
Hence, from this example, it is clear that the volts per turn for a transformer remain the same on both primary and secondary windings.

Answer 5.



olution:

Model showing the polarity of the induced voltages.



for mesh 1 KVL gives

$$-100 + \mathbf{I}_1(4 - j3 + j6) - j6\mathbf{I}_2 - j2\mathbf{I}_2 = 0$$

$$\text{or} \quad 100 = (4 + j3)\mathbf{I}_1 - j8\mathbf{I}_2$$

for mesh 2 , KVL gives

$$0 = -2j\mathbf{I}_1 - j6\mathbf{I}_1 + (j6 + j8 + j2 \times 2 + 5)\mathbf{I}_2$$

$$\text{or} \quad 0 = -j8\mathbf{I}_1 + (5 + j18)\mathbf{I}_2$$

Putting **equations** in matrix form, we get

$$\begin{bmatrix} 100 \\ 0 \end{bmatrix} = \begin{bmatrix} 4 + j3 & -j8 \\ -j8 & 5 + j18 \end{bmatrix} \begin{bmatrix} \mathbf{I}_1 \\ \mathbf{I}_2 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 4 + j3 & -j8 \\ -j8 & 5 + j18 \end{vmatrix} = 30 + j87$$

$$\Delta_1 = \begin{vmatrix} 100 & -j8 \\ 0 & 5 + j18 \end{vmatrix} = 100(5 + j18) \qquad \mathbf{I}_1 = \frac{\Delta_1}{\Delta} = \frac{100(5 + j18)}{30 + j87} = \frac{1{,}868.2\angle 74.5^\circ}{92.03\angle 71^\circ} = 20.3\angle 3.5^\circ \text{ A}$$

$$\Delta_2 = \begin{vmatrix} 4 + j3 & 100 \\ -j8 & 0 \end{vmatrix} = j800 \qquad \mathbf{I}_2 = \frac{\Delta_2}{\Delta} = \frac{j800}{30 + j87} = \frac{800\angle 90^\circ}{92.03\angle 71^\circ} = 8.693\angle 19^\circ \text{ A}$$