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Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

Vellore – 632014, Tamil Nadu, India
SCHOOL OF ELECTRICAL ENGINEERING
FALL SEMESTER 2023-2024

CAT-II

SLOT: E1+TE1

Programme Name & Branch: **Fall Semester** Course Code: **BEEE102L**
 Course Name : **Basic Electrical and Electronics Engineering**
 Faculty Members: **Dr. M V Chilukuri, Dr. Mukul Chankaya, Dr. Thirumurugan C**
 Class Number(s): 7876, 7752, 7788
 Date of the Examination : 19-10-2023, 2:00-3.30 PM
Duration: 90 minutes

Max. Marks : 50

| Q. No | Question | Marks |
|-------|--|-------|
| 1. | <p>A balanced 3-phase Y-Y connected circuit shown in Figure 1 is having phase-a voltage $V_{an} = 100\angle 0^\circ$. If each line and load impedances per phase are $Z_{Line} = 5 - 2j \Omega$, and $Z_{Load} = 10 + 8j \Omega$ respectively. Calculate line voltages, phase currents, line currents and power factor on assuming 'ABC' phase sequence. Draw the phasor diagram from the computed values per scale on the graph sheet.</p> <p>Answer:</p> <p>The handwritten solution shows the following steps:</p> <ul style="list-style-type: none"> Circuit Diagram: A Y-Y connected circuit with phase-a voltage $V_{an} = 100\angle 0^\circ$. Line impedance $Z_{Line} = 5 - 2j \Omega$ and load impedance $Z_{Load} = 10 + 8j \Omega$ are shown per phase. Line Impedance: $Z_L = 5 - 2j = 6.155 \angle -21.8^\circ$ Phase Current: $I_a = \frac{100\angle 0^\circ}{16.155 \angle 21.8^\circ} = 6.1896 \angle -21.8^\circ$ Line Voltage: $V_{LL} = \sqrt{3} \times 100 \angle -120^\circ + 30^\circ = 173.2 \angle 30^\circ$ Power Factor: $\cos \theta = \frac{15}{16.16} = 0.928$ Phasor Diagram: Shows $V_{LA} = 173.2 \angle 30^\circ$, $V_{LB} = 173.2 \angle -90^\circ$, $V_{LC} = 173.2 \angle -210^\circ$ and $I_a = 6.1896 \angle -91.8^\circ$. | 10 |

| | | |
|----|--|----|
| 2. | <p>A closed magnetic circuit of cast iron contains a 5cm long path of cross sectional area 2cm^2 and a 4cm path of cross sectional area 0.5cm^2. A coil of 200 turns is wound around the 5cm length of the circuit and current of 0.4 A flows. (a) Draw the magnetic circuit with dimensions (b) Determine the reluctance of each section (c) Determine the flux density in the 4cm path. If the μ_r of cast iron is 750.</p> <p>Answer</p> | 10 |
|----|--|----|

Q2 ÷ $l_1 = 5 \text{ cm}$ Area 1 = 2 cm^2
 $l_2 = 4 \text{ cm}$ Area 2 = 0.5 cm^2

Turns $\rightarrow N = 200$ around 5 cm length
 $I = 0.4 \text{ A}$

Solution
 Section B
 $R_{\text{total}} = R_1 + R_2$

$$R_1 = \frac{l_1}{\mu_0 \mu_r \text{ Area}_1}$$

$$R_1 = \frac{5 \times 10^{-2}}{4\pi \times 10^{-7} \times 750 \times 2 \times 10^{-4}} = 265258.24$$

$$R_1 = 265258.24$$

Like wire

$$R_2 = \frac{l_2}{\mu_0 \mu_r \text{ Area}_2} = \frac{4 \times 10^{-2}}{4\pi \times 10^{-7} \times 750 \times 0.5 \times 10^{-4}} = 848826.36$$

$$R_2 = 848826.36$$

$$R_{\text{total}} = R_1 + R_2 = 1114084.6$$

Section C. Elct Density $B = ?$

$$NI = n \cdot l = 200 \times 0.4 = n \cdot 4 \times 10^{-2}$$

$$n = \frac{200 \times 0.4}{4 \times 10^{-2}} = \frac{80}{0.04} = 2000 \text{ A/m}$$

$$n = 2000 \text{ A/m}$$

$$B = \mu H = \mu_0 \mu_r n$$

$$B = 4\pi \times 10^{-7} \times 750 \times 2000$$

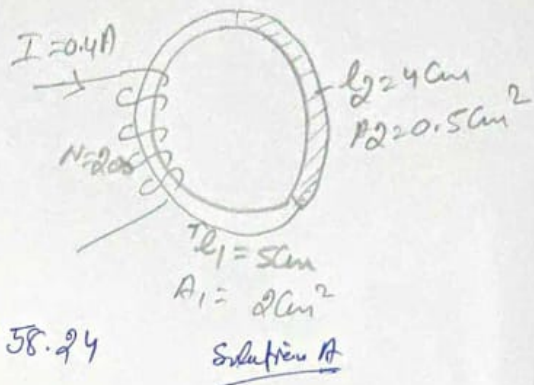
$$B = 1.885 \text{ T}$$

$$R_1 = 265258.24$$

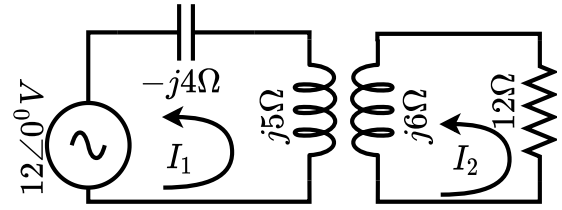
$$R_2 = 848826.36$$

$$R_{\text{total}} = 1114084.6$$

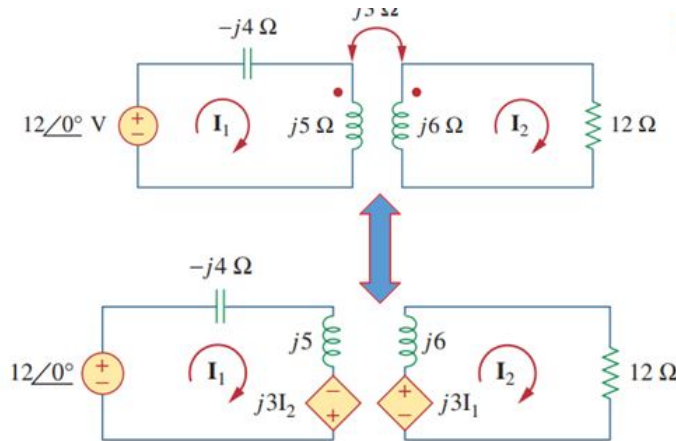
$$B = 1.885 \text{ T}$$



3. Draw the electrical equivalent circuit for the magnetic circuit shown in Figure 2. Calculate the currents I_1 and I_2 using mesh analysis.



10



Solution: For loop 1, KVL gives

$$-12 + (-j4 + j5)I_1 - j3I_2 = 0$$

$$\text{or } jI_1 - j3I_2 = 12$$

For loop 2, KVL gives

$$-j3I_1 + (12 + j6)I_2 = 0$$

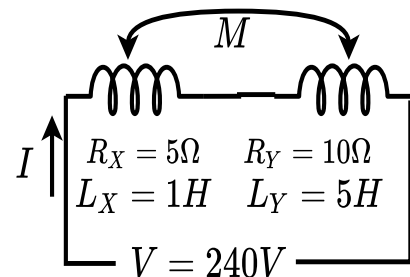
$$I_1 = \frac{(12 + j6)I_2}{j3} = (2 - j4)I_2$$

$$I_2 = \frac{12}{4 - j} = 2.91 \angle 14.04^\circ \text{ A}$$

$$I_1 = (2 - j4)I_2 = (4.472 \angle -63.43^\circ)(2.91 \angle 14.04^\circ)$$

$$I_1 = 13.01 \angle -49.39^\circ \text{ A}$$

4. Two mutually coupled coils X and Y are connected in series to a 240 V d.c. supply as shown in Figure 3. Coil X has a resistance of 5 Ω and an inductance of 1 H. Coil Y has a resistance of 10 Ω and an inductance of 5 H. At a certain instant after the circuit is connected, the current is 5 A and increasing at a rate of 10 A/s. Determine (a) the mutual inductance between the coils and (b) the coefficient of coupling.



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Figure 3

Solution: Given that $V = 240 \text{ V}$, $R = R_X + R_Y = 15 \Omega$, $L_X = 1 \text{ H}$, $L_Y = 5 \text{ H}$, $i = 5 \text{ A}$ and $di/dt = 10 \text{ A/s}$

$$V = iR + L \frac{di}{dt}$$

$$240 = 5(5 + 10) + L(10) = (240 - 75)/10 = 16.5 \text{ H}$$

$$L = L_X + L_Y + 2M$$

$$16.5 \text{ H} = 1 \text{ H} + 5 \text{ H} + 2M; \quad M = 5.25 \text{ H}$$

$$\text{coefficient of coupling, } k = \frac{M}{\sqrt{L_X L_Y}}$$

$$k = 5.25 / \sqrt{1 \times 5} = 2.34$$

5. A single-phase, 50 Hz transformer has 25 primary turns and 300 secondary turns. The cross-sectional area of the core is 300 cm^2 . When the primary winding is connected to a 250 V supply, determine (a) the maximum value of the flux density in the core, and (b) the voltage induced in the secondary winding (c) compute the same when area of cross section is reduced to half.

10

Solution:

Given data $V = 250 \text{ V}$, $f = 50 \text{ Hz}$, $N_1 = 25$ and $N_2 = 300$, $A = 300 \text{ cm}^2$

$$E_1 = 4.44f\Phi_m N_1 = 250 \text{ V} = 4.44 \times 50 \times \Phi_m \times 25$$

$$(a) \Phi_m = 45.04 \text{ mWb} \text{ and } B_m = 45.04 / (300 \times 10^{-4}) = 1.50 \text{ Wb/m}^2 = 1.5 \text{ T}$$

$$(b) E_2 = 4.44 \times 50 \times 45.04 \times 10^{-3} \times 300 = 3 \text{ kV}$$

$$(c) \text{ New area of cross-section, } A = 150 \text{ cm}^2$$

$$250 = 4.44 \times 50 \times B_m \times 150 \times 10^{-4} \times 25$$

$$B_m = 3 \text{ Wb/m}^2 = 3.0 \text{ T (flux density doubles)}$$

$$E_2 = 3.0 \text{ kV (remains same)}$$