PNS School of Engineering & Technology

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Internal Assessment Examination-2022(3rd Semester)

Subject : Th-2 -Circuit & Network Theory

Branch : Electrical Engineering

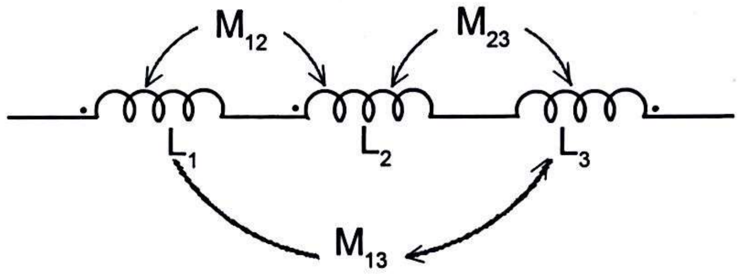
Time : $1\frac{1}{2}$ Hours F.M. : 20

1. Answer the following questions (any Five). [2 x 5]

(a) Define permeability. What is the value of μo ?

(b) What is B - H Curve ? What do you mean by hysteresis ?

(c) Find equivalent inductance.



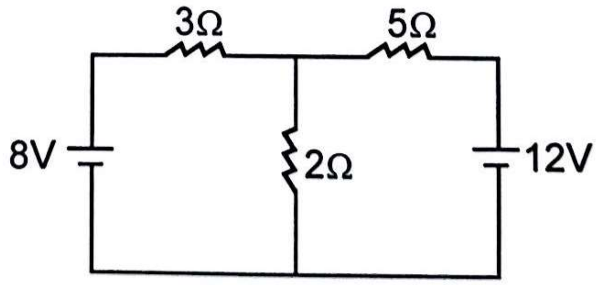
L_1 =10mH, L_2=5mH, L_3=6mH, M_{12}= 2mH, M_{23}=M13 = 1mH.

(d) State super position theorem.

(e) Draw impedance triangle of RLC series circuit and write the formula of power factor.

(f) Define active elements and passive elements.

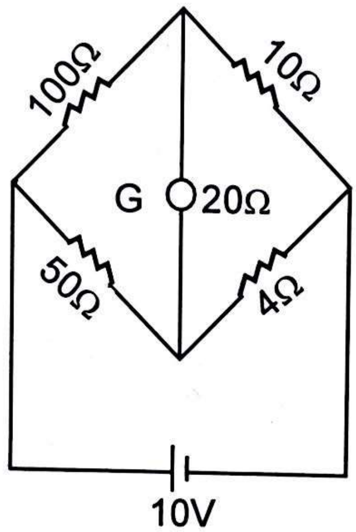
(g) Write the nodal equation of the below circuit.



P.T.O

2. Answer the following questions (any Two) [5 x 2]

(a) In the below circuit, compute the current flowing through the galvamometer.



(b) State and explain maximum power transfer theorem.

(c) Two impledanes Z_1 and Z_2 when connected separately across a 230V, 50Hz supply consumed 100w and 60w at power factors of 0.5 lagging and 0.6 leading respectively. If these impedances are now connected in series across the same supply, find (i) total power consumed and over all power factor. (ii) the value of the impedance to be added in series so as to raise the over all power factor to unity.

❖❖❖

ANSWER

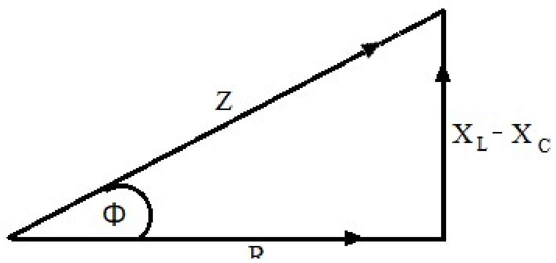
1(a) Permeability of a material describes its ability to support or concentrate magnetic flux. It means, it is a measure of the ease with which the material can be magnetized. It is denoted by μ. Its unit is Henry/meter (H/m). $\mu_0 = 4 \pi * 10^{-7}$ Henry/meter (H/m).

1(b) The curve showing the relation between magnetic flux density 'B' and magnetic field strength 'H' is known as B-H curve. The phenomenon of lagging of magnetic flux density 'B behind the magnetic field strength 'H' in a magnetic material subjected to the cycle of magnetization called as magnetic hysteresis.

1(c) $L_T = L_1 + L_2 + L_3 + 2M_{12} – 2M_{23} – 2M_{13} = 10 + 5 + 6 + 4 - 2 - 2 = 21$ mH

1(d) Superposition theorem states that in a linear, bilateral network containing more than one energy source, the current which flows at any point is the sum of all the currents which would flow at that point if each source where considered separately and all the other sources replaced for the time being by resistances equal to their internal resistances.

1(e)



Power factor = R / Z

Impedance Triangle for RLC series circuit

1(f) Active Elements: The elements which are capable of providing or delivering energy to the circuit are known as active element. Example – Voltage source, Current source.

Passive Elements: A passive element is one which receives electrical energy and then either converts it into heat (resistance) or stores in an electric field (capacitance) or magnetic field (inductance). Examples – Resistor, Inductor and Capacitor.

1(g) Nodal equation is $V_A\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{5}\right) - 8 - 12 = 0$ Or $V_A\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{5}\right) - 20 = 0$

2(a) Finding V_{Th}: To find V_{Th} at terminals BD, remove the load (i.e. 20 Ω galvanometer) as shown in Fig.2). The voltage between terminals B and D is equal to V_{Th}.

Current in branch ABC = $\frac{10}{100+10}$ = 0.0909 A

P.D. between A and B, V_{AB} = 100 × 0.0909 = 9.09 V

Current in branch ADC = $\frac{10}{50+4}$ = 0.1852 A

P.D. between A and D, V_{AD} = 50 × 0.1852 = 9.26 V

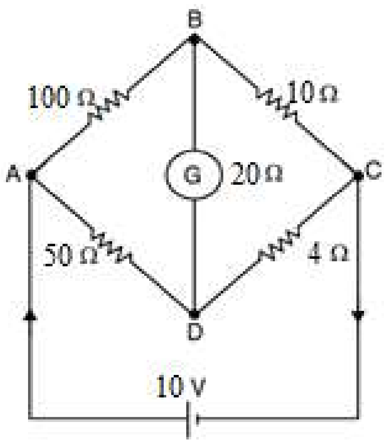


Fig.1

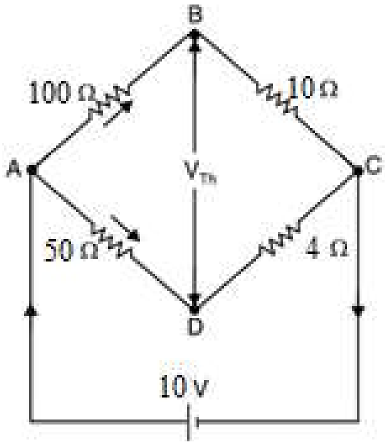


Fig.2

P.D. between B and D, $V_{Th} = V_{AD} - V_{AB} = 9.26 - 9.09 = 0.17$ V

Obviously, point B is positive w.r.t. point D i.e. current in the galvanometer, when connected between B and D, will flow from B to D.

Finding R_{Th}: In order to find R_{Th}, remove the load (i.e. 20 Ω galvanometer) and replace the battery by a short (as its internal resistance is assumed zero) as shown in Fig.1. Then resistance measured between terminals B and D is equal to R_{Th}.

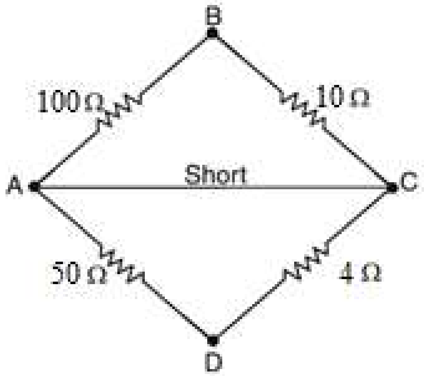


Fig.3

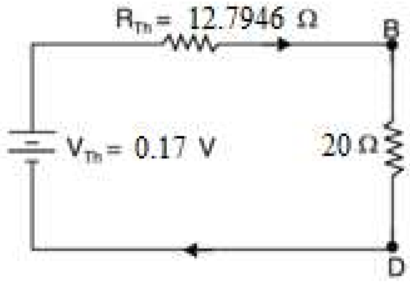


Fig.4

R_{Th} = Resistance at terminals BD in Fig.3

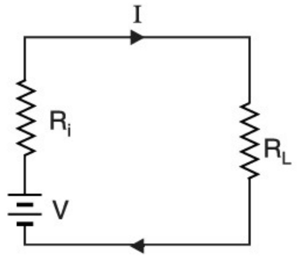
$$R_{Th} = \frac{100*10}{100+10} + \frac{50*4}{50+4} = 9.0909 + 3.7037 = 12.7946\ \Omega$$

Thevenin's equivalent circuit at terminals BD is V_{Th} (= 0.17 V) in series with R_{Th} (= 12·7946 Ω). When galvanometer is connected between B and D, the circuit becomes as shown in Fig.4

$$\text{Galvanometer current} = \frac{V_{Th}}{R_{Th}+R_L} = \frac{0.17}{12.7946+20} = 0.00518\ \text{A} = 5.18\ \text{mA from B to D.}$$

2(b) Maximum power transfer theorem states that in d.c. circuits, maximum power is transferred from a source to load when the load resistance is made equal to the internal resistance of the source as viewed from the load terminals with load removed and all e.m.f. sources replaced by their internal resistances.

Proof of Maximum Power Transfer Theorem:



Consider a voltage source V of internal resistance Ri delivering power to a load R_L. We shall prove that when $R_L = R_i$, the power delivered to R_L is maximum. Referring to Fig. T18, we have,

Circuit current,

$$I = \frac{V}{R_i + R_l}$$

Power delivered to load,

$$P = I^2 R_L = [V/(R_i + R_L)]^2 R_L$$

For a given source, generated voltage V and internal resistance R_i are constant. Therefore, power delivered to the load depends upon R_L. In order to find the value of R_L for which the value of P is maximum, differentiate P w.r.t. R_L and set the result equal to zero.

$$\text{Thus,} \quad \frac{dP}{dR_L} = V^2 \left[\frac{(R_i + R_L)^2 - 2R_L(R_i + R_L)}{(R_i + R_L)^4} \right] = 0$$

Or $\quad (R_L + R_i)^2 - 2 R_L (R_L + R_i) = 0$

Or $\quad (R_L + R_i)(R_L + R_i - 2R_L) = 0$

Or $\quad (R_L + R_i)(R_i - R_L) = 0$

Since $R_L + R_i$ cannot be zero,

$$R_i - R_L = 0$$

Or $\quad R_L = R_i$

Or $\quad$ Load resistance = Internal resistance of the source

Thus, for maximum power transfer, load resistance R_L must be equal to the internal resistance R_i of the source.

2(c) Inductive Impedance

$V_1 I_1 \cos \varphi 1$ = power;

$230 \times I_1 \times 0.5 = 100$

$I_1 = 0.87$ A

Now, $\quad I_1^2 R_1$ = power

or $\quad 0.872\ R_1 = 100$

$R_1 = 132\ \Omega$

$Z_1 = 230/0.87 = 264\ \Omega$

$$X_L = \sqrt{Z_1^2 - R_1^2} = \sqrt{264^2 - 132^2} = 229\ \Omega$$

Capacitance Impedance

$I_2 = 60/230 \times 0.6 = 0.434$ A

$R_2 = 60/0.4342 = 318\ \Omega$

$Z_2 = 230/0.434 = 530\ \Omega$

$X_C = \sqrt{Z_2^2 - R_2^2} = \sqrt{264^2 - 132^2} = 424\ \Omega$

When Z_1 and Z_2 are connected in series

$R = R_1 + R_2 = 132 + 318 = 450\ \Omega$

$X = 229 - 424 = -195\ \Omega$ (capacitive)

$Z = \sqrt{R^2 - X^2} = \sqrt{450^2 + (-195)^2} = 490\ \Omega$

$I = 230 / 490 = 0.47$ A

(i) Total power absorbed = $I^2R = 0.47^2 \times 450 = 99$ W, $\cos\varphi = R/Z = 450/490 = 0.92$ (lead)

(ii) Power factor will become unity when the net capacitive reactance is neutralised by an equal inductive reactance. The reactance of the required series pure inductive coil is 195 Ω.