Appendix E

Model Question Papers

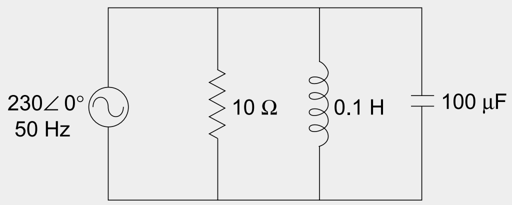
PAPER 1

1. (a) Obtain the response of R-L-C series circuit for impulse excitations.
   (b) Define reluctance of a magnetic circuit and derive an expression for reluctance.

Solution Refer section 9.11 and Chapter 13 in the textbook.

2. In an electrical circuit R, L and C are connected in parallel. $R = 10\ \Omega$, $L = 0.1\text{H}$, $C = 100\ \mu\text{F}$. The circuit is energized with a supply at 230 V, 50 Hz. Calculate
   (a) Impedance
   (b) Current taken from supply
   (c) p.f. of the circuit
   (d) Power consumed by the circuit

Solution The circuit is as shown in figure.



The impedance of 3 branches are

$Z_1 = 10\ \Omega$

$Z_2 = j2\ \pi f L = 2 \times 50 \times 0.1 = j31.41\ \Omega$

$$Z_3 = \frac{-j}{2\pi fc} = \frac{-j}{2\times 50\times 100\mu} = -j31.84\,\Omega$$

(a) Impedance of circuit $Z = \left[\frac{1}{Z_1}+\frac{1}{Z_2}+\frac{1}{Z_3}\right]^{-1}$

$$= \left[\frac{1}{10}+\frac{1}{j31.41}+\frac{1}{-j31.84}\right]^{-1}$$

$$\approx 10\Omega$$

(b) Current taken from supply $I = \frac{V}{Z} = \frac{230\angle 0^\circ}{10} = 23A$. i.e. $23\angle 0^\circ$ A

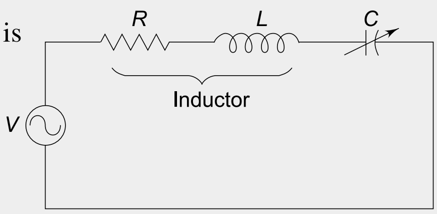
(c) p.f. of the circuit = $\cos\theta = 1$

(d) Power consumed by the circuit
Real power consumed = $I^2R = 23^2\times 10 = 5.3$ kW
Reactive power consumed = 0 KVAR

3. A constant voltage at a frequency of 1 MHz is applied to an inductor in series with a variable capacitor when the capacitor is set to 500 PF, the current has the max. value, while it is reduced to one half when capacitance (i) 600 PF, find (i) resistance (ii) inductance (iii) Q factor of inductor.

Solution Given f = 1 MHz
Let the max. current be $I_{max.}$
Given at 1 MHz, for C = 500 Pf

$$I = I_{max}$$



$\therefore$ Imaginary part of impedance is zero, i.e. $X_L = X_C$

$$2\pi fL = \frac{1}{2\pi fc}$$

$$6.283\times 10^6\times L = 318.31$$

$$L = 50.66\ \mu\text{H}$$

Now also given $I = \frac{I_{max}}{2}$ at C = 600 PF

$$I = \frac{I_{max}}{2} = \frac{V}{R + j\left(6.283\times 10^6 L - 265.25\right)} \quad (1)$$

$$\left(\because X_C = \frac{1}{2\pi fc} = \frac{1}{2\pi\times 10^6\times 600\times 10^{-12}} = 265.25\right)$$

and $I_{max} = \frac{V}{R}$ (2)

Dividing Equation (2) by Equation (1)

$$Z = \frac{R + j\left(6.283 \times 10^6 L - 265.25\right)}{R}$$

$\Rightarrow$ $2R = R + j\,(6.283 \times 10^6\, L - 265.25)$

$R = j(318.31 - 265.25)$

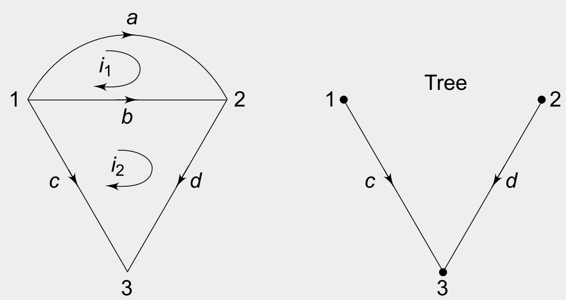
$R = 53.06\ \Omega$

$\therefore$ (i) $R = 53.06\ \Omega$

(ii) $L = 50.66\ \mu\text{H}$

(iii) $G = \dfrac{\omega L}{R} = 5.999 \approx 6$

4. For the given graph and tree shown in the figure, write the tie-set matrix and obtain the relation between branch currents and link currents.



Solution Number of link branches = $b - (n - 1)$

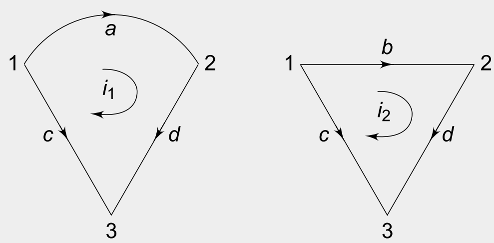
Where b is number of branches and n is number of nodes

$\therefore$ Link branches = 4 – (3 – 1) = 2

The link branches are a and b.

Let the branch currents are i_a, i_b, i_c and i_d

The two link currents are i_1 and i_2 as shown in the figure.



There are two fundamental loops corresponding to the link branches a and b. If V_a and V_b are branch voltages, the KVL equations for the two f-loops can be written as

$$V_a + V_d - V_c = 0$$
$$V_b + V_d - V_c = 0$$

The above equation can be written in matrix form as

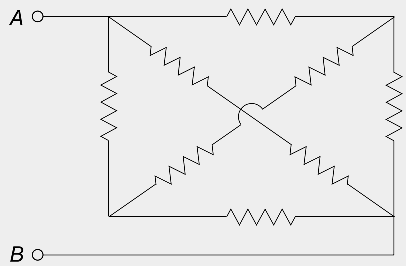
Loop Currents $\downarrow$ branches $\rightarrow$

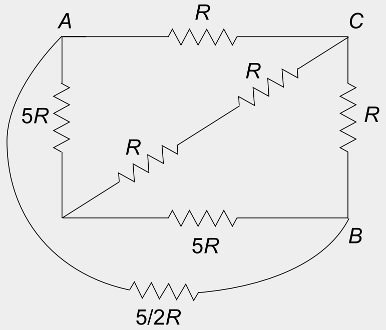
$$\begin{array}{c} \\ i_1 \\ i_2 \end{array} \quad \begin{array}{cccc} a & b & c & d \end{array}$$

$$\begin{bmatrix} 1 & 0 & -1 & 1 \\ 0 & 1 & -1 & +1 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \end{bmatrix} = 0$$

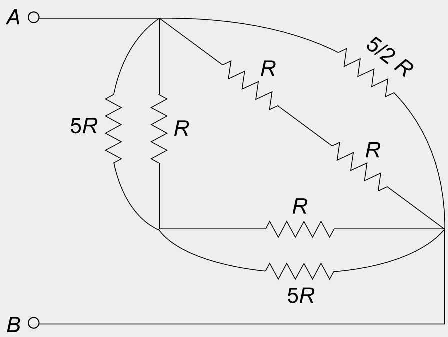
5. Find the equivalent resistance between AB in the circuit shown in the figure. All resistances are equal to R.

Solution Converting the Y point C into Δ

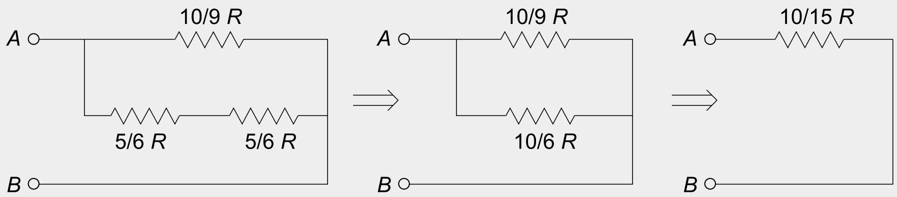




$\rightarrow$ The equivalent circuit now is

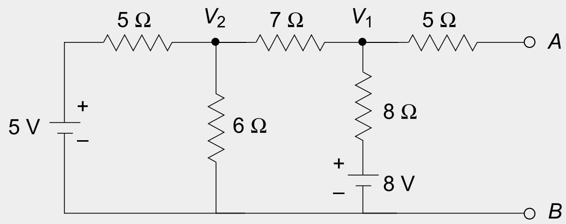


The equivalent circuit for this is as shown below.

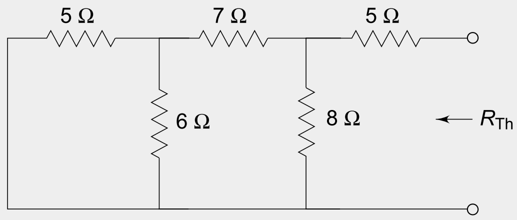


$\therefore$ Resistance between AB is $R = \dfrac{10}{15} R = 0.666\, R$

6. Find the Thevenins equivalent for the circuit in figure



Solution The Thevenins equivalent resistance is calculated assuming all voltage sources shorted and as seen from *AB*, the circuit will be as shown below:



$$R_{Th} = [\{(5//6) - 7\}//8] + 5$$

$$\left[\left\{\frac{30}{11} + 7\right\}//8\right] + 5 = \left[\frac{\frac{107}{11} \times 8}{\frac{107}{11} + 8}\right] + 5 = 4.389 + 5 = 9.389\ \Omega$$

Let us assure voltages at nodes (1) and (2) be V_1 and V_2.
Now writing node equations.

$$\frac{V_1 - 8}{8} + \frac{V_1 - V_2}{7} = 0$$

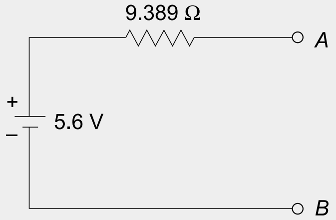
$$7V_1 - 56 + 8V_1 - 8V_2 = 0 \Rightarrow 15\ V_1 - 8V_2 = 56 \qquad (1)$$

$$\frac{V_2}{6} + \frac{V_2 - V_1}{7} + \frac{V_2 - 5}{5} = 0 \quad \Rightarrow -30V_1 + 107V_2 = 210 \qquad (2)$$

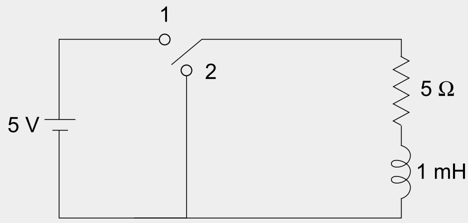
on solving equations (1) and (2) we get

$V_1 = 5.6$ V $\quad \Rightarrow \quad V_{OC} = 5.6$

$\therefore$ Thevenins equivalent circuit is



7. The switch in the circuit shown in figure is in position (1) for two time constants and then charged to position (2) find transient response.



Solution When the switch is in position (1)
Convert equation in laplace transform is given as

$$I(S) = \frac{V(S)}{R + LS} = \frac{5/S}{5 + 0.001S} = \frac{5000}{S(5000 + 3)}$$

Assuming initial conditions be zero.

$$I(S) = \frac{1}{S} - \frac{1}{S + 5000}$$

Taking inverse Laplace transform

$$i(t) = 1 - e^{-5000t}$$

the switch is cosed for two time constants

$\therefore$ $i(t)$ after two time constants i

$$i = 1 - e^{-2} = 0.864 \text{ A}$$

Now when switch is moved to position (2) the mesh equation is given by

$$L\frac{di}{dt} + Ri(t) = 0$$

$$\Rightarrow i(t) = C_1\, e^{-5000t}$$

initially $i(o) = 0.864$ A

$$C_1 = 0.864 \text{ A}$$

$$\therefore \quad i(t) = 0.864\, e^{-5000t}$$

The response can be plotted as