PAPER 4

1. (a) Explain about dot convention.

Solution Refer Section 9.4.

(b) An iron ring of mean length 50 cm has an air gap of 1 mm and a winding of 200 turns. If the permeability of iron is 400 when a current of 1.25 A flows through the coil. Find the flux density.

Solution AT_1 required for iron path in the ring = $H_i \times l_i = \dfrac{B}{\mu_o \mu_r} \times l_i$

$$= \frac{B}{4\pi \times 10^{-7} \times 400} \times 0.5$$

AT_2 required for air gap of 1 mm = $H_g l_g = \dfrac{B}{\mu_o} \times l_g$

$$= \frac{B}{4\pi \times 10^{-7}} \times 1 \times 10^{-3}$$

Total ampere turns = $AT_1 + AT_2$

$$200 \times 1.25 = \left[\frac{B \times 0.5}{4\pi \times 10^{-7} \times 400} + \frac{B}{4\pi \times 10^{-7}} \times 10^{-3}\right]$$

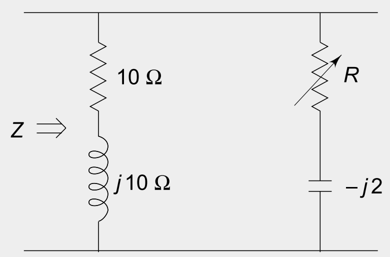
$$250 = \frac{B}{4\pi \times 10^{-7}}\left[1.25 \times 10^{-3} + 10^{-3}\right]$$

$B = 0.314$ web/m^2.

2. Derive the expressions for half power frequencies, Q factor ϕ Bandwidth of a series resonant circuit.

Solution Refer Sections 8.4. and 8.5.

3. (a) For the parallel network shown below, determine the value of R at 10 Ω resonance.



Solution $Z = (10 + j10) \,||\, (R - j2)$

$$= \frac{(10+j10)(R-j2)}{10+j10+R-j2}$$

$$= \frac{10R-j20+j10R+4}{10+R+8j}$$

$$= \frac{10R+4+j(10R-20)}{10+R+8j}$$

$$= \frac{[(10R+4)+j(10R-20)][10+R-j8]}{(10+R)^2+64}$$

$$= [(10R + 4)(10 + R) + 8\,(10R - 20) - j8(10R + 4) + j\,(10 + R)$$

$$(10R - 20)]\ \frac{1}{(10+R)^2+64}$$

At resonance imaginary part = 0

$\Rightarrow$ $8\,(10R + 4) - (10 + R)\,(10R - 20)$

$\Rightarrow$ $100R - 200 + 10R^2 - 20R = 80R + 32$

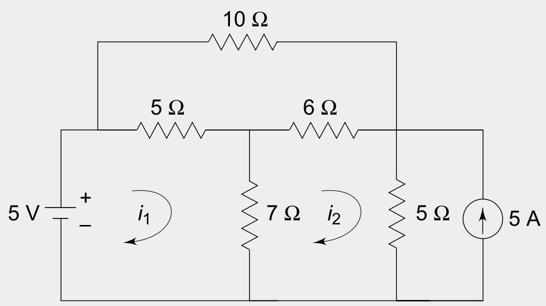
$$10R^2 = 232$$

$$R = 4.8166\ \Omega$$

(b) Define average value, rms value and form factor in a circuit.

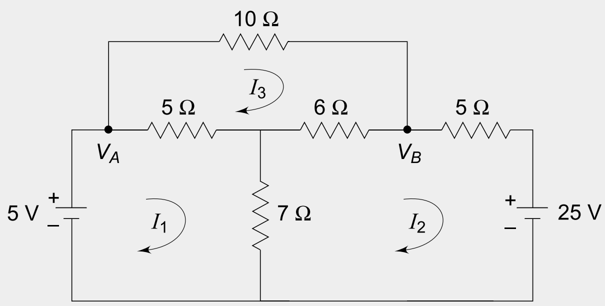
Solution Refer Section 4.4.

4. Determine the current in all branches of the following network and the voltage across for resistor using loop method.



Solution Applying mesh equation to the loops (1), (2) and (3)

We get



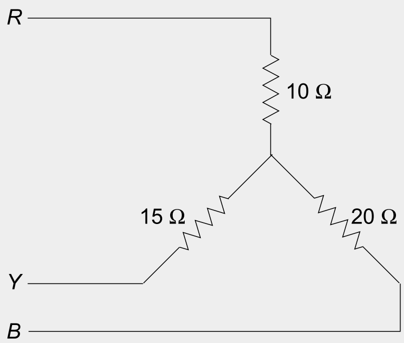
$$5(I_1 - I_3) + 7(I_1 - I_2) = 5$$
$$12I_1 - 7I_2 - 5I_3 = 5 \quad (1)$$
$$7(I_2 - I_1) + 6\,(I_2 - I_3) + 5I_2 = -25$$
$$-7I_1 + 18I_2 - 6I_3 = -25 \quad (2)$$
$$10I_3 + 5(I_3 - I_1) + 6(I_3 - I_2) = 0$$
$$-5I_1 - 6I_2 + 21I_3 = 0 \quad (3)$$

By solving above 3 equations, we get

$$I_1 = -1.231 \text{ A}$$
$$I_2 = -2.172 \text{ A}$$
$$I_3 = -0.9138 \text{ A}$$

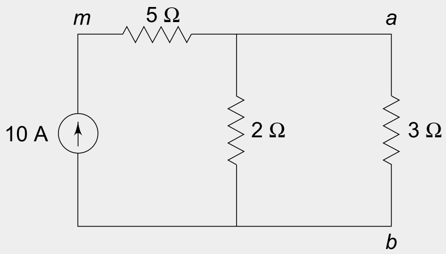
Current in 5 Ω resistor is –0.3172 A
7 Ω resistor is –1.231 A
6 Ω resistor is –1.2882 A
10 Ω resistor is –0.9138 A
5 Ω resistor is –2.172 A

5. A 440V, 3ϕ, 3-wire system is connected to an unbalanced star connected load shown in the figure. Determine the line currents and power *I*/*P* to the network.



$$V_{RY} = 440$$
$$I_R = \frac{440}{\sqrt{3} \times 10} = 25.4 \text{ A}$$
$$I_Y = \frac{440 \angle{-120^\circ}}{\sqrt{3} \times 15}$$
$$= 16.93 \angle{-120^\circ} \text{ A}$$
$$I_B = \frac{440 \angle{-240^\circ}}{\sqrt{3} \times 20}$$
$$= 12.7 \angle{-240^\circ} \text{ A}$$
$$P = I_R^2 R_R + I_Y^2 R_Y + I_B^2 R_B$$
$$= 13.976 \text{ kW}$$

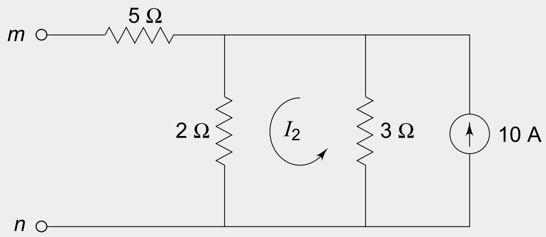
6. (a) Verify reciprocity theorem in circuit shown in the following figure.



Solution Let us find current in 3 Ω resistor.

$$I_3 = 10 \times \frac{2}{2+3}$$
$$= 4 \text{ A}$$
$$V_{ab} = 3 \times 4 = 12$$

According to reciprocity theorem the voltage across ab $V_{ab} = 12$
Now connect the current source across *ab* and find the voltage across *m* and *n*.



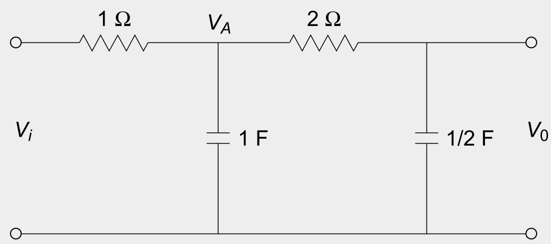
$$I_2 = 10 \times \frac{3}{5} = 6 \text{ A}$$

The voltage across $mn = 2 \times 6 = 12$ volts, same as V_{ab}. Hence, the reciprocity theorem is proved.

(b) State and explain compensation theorem.

Solution Refer Section 3.6.

7. Find transfer function $\frac{V_o(S)}{V_i(S)}$ for the circuit shown in the following figure.



Also $$\frac{V_A - V_i}{1} + V_A\, S + \frac{V_A - V_O}{2} = 0$$

$$V_A(1.5 + S) = V_i + \frac{V_o}{2}$$

$$V_A = \frac{V_i + \frac{V_o}{2}}{S + 1.5}$$

Also $$V_o = \frac{V_A \times \frac{2}{5}}{2 + \frac{2}{5}}$$

$$= \frac{V_A}{S+1}$$

$$V_o = \frac{2V_i + V_o}{(2S+3)(S+1)}$$

$$V_o\left[1 - \frac{1}{(2S+3)(S+1)}\right] = \frac{2V_i}{(2S+3)(S+1)}$$

$$V_o[(2S+3)(S+1) - 1] = 2V_i$$

$$\frac{V_o}{V_i} = \frac{2}{2S^2 + 5S + 2}$$

8. (a) In the circuit shown find the expression for transient current.

Solution $5i(t) + 3\dfrac{di(t)}{dt} = 100$

$$5I(S) + 3[SI(S) - i(0)] = \frac{100}{S}$$

$i(0) = -6$

$$100 = 5I + 3\frac{di}{dt} + 1°(0)$$

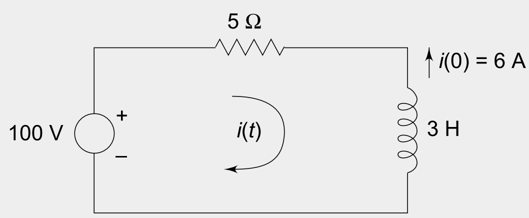
$$\frac{100}{S} = (5+3S)\,I(S) + 18$$

$$I(S) = \frac{100 - 18S}{S(3S+5)}$$

$$= \frac{20}{S} - \frac{78}{3S+5}$$

$$= \frac{20}{S} - \frac{26}{S + 5/3}$$

$i(t) = 20 - 26\,e^{5/3t}$



8. (b) Obtain the lattice equivalent of a symmetrical T-network.

Solution Refer Example 15.13.