57307, B.E/B.Tech. DEGREE EXAMINATION, MAY/JUNE 2016

Second Semester, Electronics and Communication Engineering

EE 6201 – CIRCUIT THEORY

(Common to EEE, E & IE, I & CE, BME & MEE) (Reg 2013)

CT 001

Time: Three Hours | Maximum: 100 Marks

Answer ALL questions.

PART – A (10 × 2 = 20 Marks)

1. The resistance of two wires is 25Ω when connected in series and 6 Ω when connected in parallel. Calculate the resistance of each wire.

Ans. 1. For answer refer: **page 1.60, Q9.**

2. Distinguish between mesh and loop of a circuit.

Ans. 2. For answer refer: **page 1.27, Topic 1.4.1 grey box**. Take definition of loop and mesh.

3. State reciprocity theorem.

Ans. 3. For answer refer: **page 2.39, Topic 2.7 Grey box**.

4. What is the condition for maximum power transfer in DC and AC circuits?

Ans. 4. For answer refer: **page 2.34, Topic 2.6 Grey Box**.

$$R_L = R_{TH}$$
$$Z_L = Z_{TH}^*$$

5. Define co-efficient of coupling.

Ans. 5. For answer refer: **page 3.24, Topic 3.6 fully**.

6. In a series RLC circuit, if the value of L and C are 100 mH and 0.1 μF, Find the resonance frequency in Hz.

Ans. 6. For answer refer: Similar problem solved in **page 3.12, Q5**

7. In a series RLC circuit, L = 2 H and C = 5 μF. Determine the value of R to give critical damping.

Ans. 7. For answer refer: **page 3.43, Q9.**

8. Define time constant of RL circuit.

Ans. 8. For answer refer: **page 4.15, 2nd, 3rd and 4th line**.

9. A 3 phase 400 V is given to balanced star connected load of impedance 8 + 6j Ω. Calculate line current.

Ans. 9. For answer refer: **page 5.41, Q6.**

10. List out the advantages of three phase system over single phase system.

Ans. 10. For answer refer: **page 5.1, Topic 5.1 1st paragraph**

PART – B (5 × 16 = 80 Marks)

11. **(a) (i)** Determine the current I_L in the circuit shown in Fig. 11 (a) (i) (8)

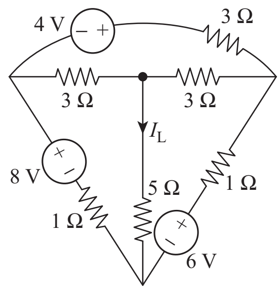


Fig. 11 (a) (i)

Ans. 11. (a) (i) For answer refer: **page 1.76, Q 10**.

11. **(a) (ii)** Calculate the voltage across A and B in the circuit shown in Fig. 11 (a) (ii) (8)

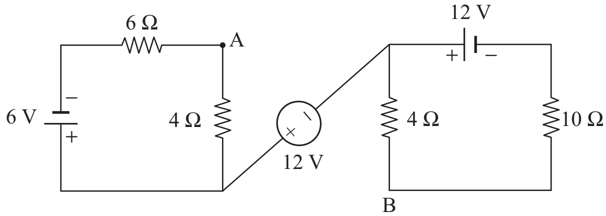
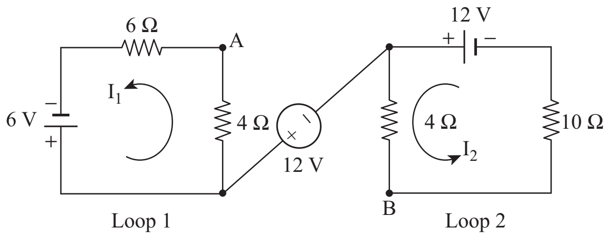


Fig. 11 (a) (ii)

Ans. 11. (a) (ii)



The two closed loops are independent of each other. No current flows through the connecting 12V voltage source as it has no closed path.
Applying Ohm's law in loop 1 and 2, we have,

$$I_1 = \frac{V_1}{R_1} = \frac{6}{10} = 0.6A$$

$$I_2 = \frac{V_2}{R_2} = \frac{12}{14} = 0.86A$$

Voltage drop across 4 Ω in loop 1 $V_{4\Omega} = I_1(4) = 0.6 \times 4 = 2.4$ V

So at Pt. A, $V_A = 6 - 2.4 = 3.6$ V

Voltage drop across 4Ω in loop 2 $V_{4\Omega} = I_2\,(4) = 0.86 \times 4 = 3.44$ V

So at pt B, $V_B = 12 - 3.44 = 8.56$

Voltage across A and B, $V_{AB} = V_A - V_B$

$$V_{AB} = 3.6 - 8.56 = -4.96 \simeq -5$$

Or

11. **(b) (i)** Three loads A, B, C are connected in parallel to a 240 V source. Load A takes 9.6 kW. Load B takes 60 A. and local C has a resistance of 4.8 Ω. Calculate R_A and R_B, the total current, Total power and equivalent resistance. (8)

21390, May/June 2013. CT Reg 2008/2010

Ans. 11. (b) (i) For answer refer: **Question paper 21390, Circuit Theory Reg 2008/2010 May/June 2013**.

11. **(b) (ii)** For the circuit shown in Fig. 11 (b) (ii), determine the total current and power factor. (8)

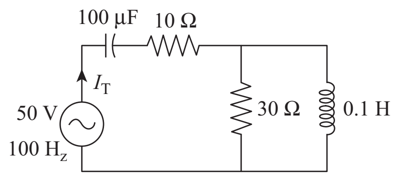


Fig. 11 (b) (ii)

Ans. 11 (b) (ii) For answer refer: **page 2.87 / Q 14**.

12. **(a)** Find the voltage across 5 Ω resistor for the circuit shown in Fig. 12 (a) using source transformation technique and verify the results using mesh analysis. (16)

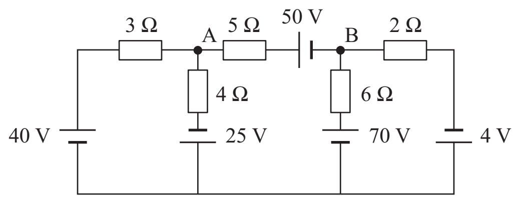
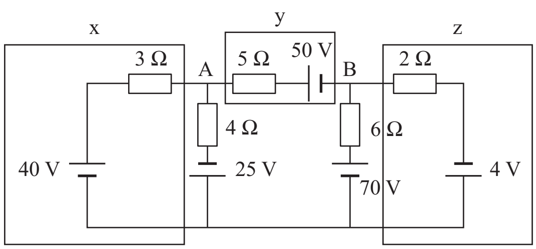
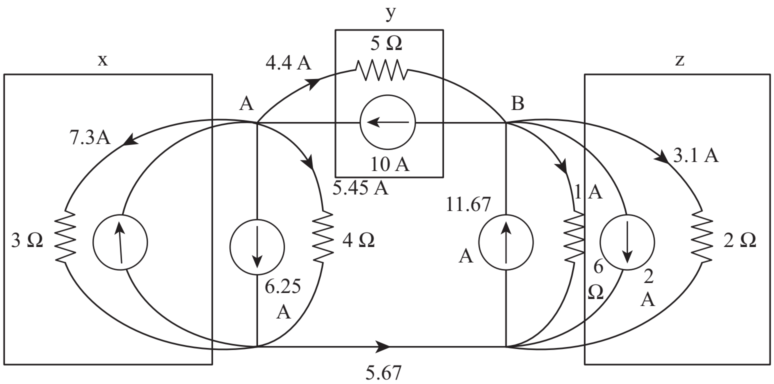


Fig. 12 (a)

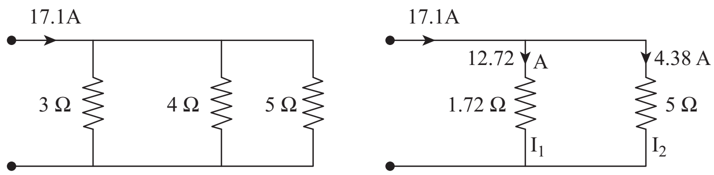
Ans. 12. (a)



Converting the above circuit from voltage source to current source, we have,



At node A,
We have,
(Incoming – Outgoing) current = 13.33 + 10 – 6.25
  Net current = 17.08 A
This current has to flow through 3Ω, 4Ω and 5Ω.

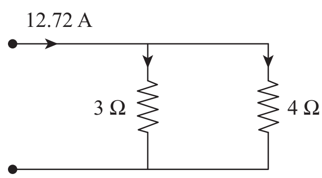


As 3Ω parallel 4Ω, $R_{eq} = 3 \parallel 4 = \dfrac{3\times 4}{3+4} = 1.72\,\Omega$
By current division principle, we have,

$$I_1 = \left(\frac{5}{5+1.72}\right)17.1 = 12.72A$$

$$I_2 = \left(\frac{1.72}{5+1.72}\right)17.1 = 4.37A = I_{5\Omega}$$

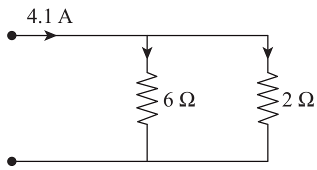
Current through 3Ω and 4Ω is given by



$$I_{3\Omega} = \left(\frac{4}{4+3}\right)\times 12.72 \; = 7.3A$$

$$I_{4\Omega} = \left(\frac{3}{3+4}\right)\times 12.72 = 5.45A$$

Let's mark all the currents in the circuit diagram.
At node B, Net current = 11.67 + 4.4 – 10 – 2 = 4.07



$$I_{6\Omega} = \left(\frac{2}{6+2}\right)4.1 = 1A$$

$$I_{2\Omega} = \left(\frac{6}{6+2}\right)4.1 = 3.1A$$

Let's check if KCL is satisfied at Node A.
Incoming current = Outgoing current.

13.33 + 10 = 6.25 + 7.3 + 4.4 + 5.45
23.33 = 23.4
At node B, we have,
11.67 + 4.4 = 10 + 1 + 2 + 3.1
16.07 = 16.1
Thus KCL is verified at node A and B.
Now, the voltage drop at 5Ω resistor

$$V_{5\Omega} = 5\times 4.4 = 22\text{ volts.}$$

Or

12. **(b)** Obtain the Norton's model and find the maximum power that can be transferred to the 100 Ω load resistance, in the circuit shown in Fig. 12 (b) (16)

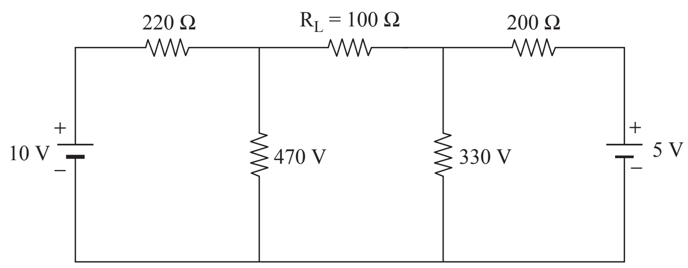
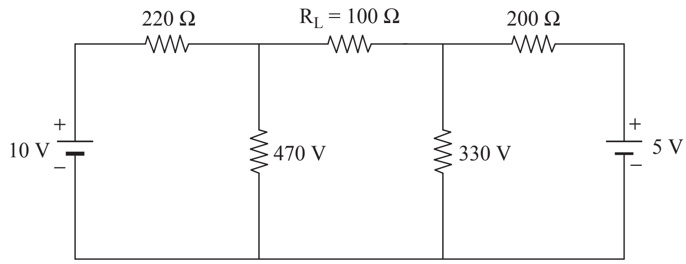
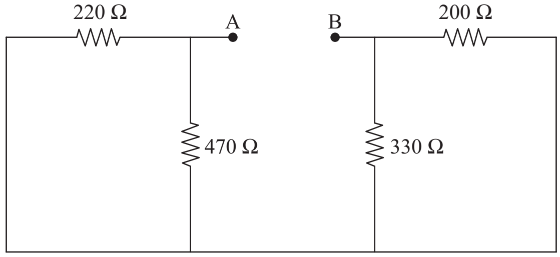


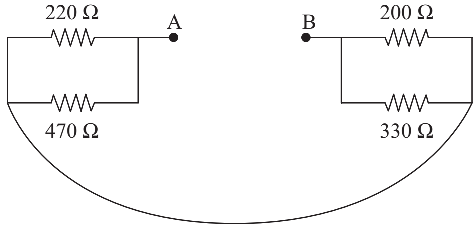
Fig. 12 (b)

Ans. 12. (b)



To obtain Norton's model, we have to find the R_{TH} and I_{sc}.
Let's find the Thevenin's resistance R_{TH}, by opening the load resistor and short circuiting the voltage sources.

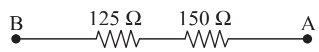




$$R_{eq(1)} = 220 \text{ parallel } 470 = \frac{220 \times 470}{220 + 470} = 150\Omega$$

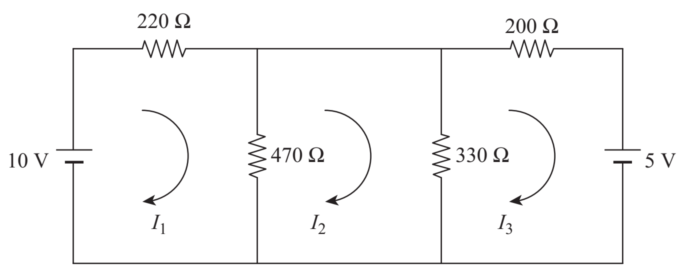
$$R_{eq(2)} = 200 \text{ parallel } 330 = \frac{200 \times 330}{200 + 330} = 125\Omega$$

$$R_{eq} = R_{eq(1)} + R_{eq(2)}$$



$$R_{TH} = R_{eq} = 150 + 125 = 275\ \Omega$$

To find the short circuit current, let's short the load R_L and find I_{SC}.



By Maxwell's mesh method, we have,

$$\begin{bmatrix} 690 & -470 & 0 \\ -470 & 800 & -330 \\ 0 & -330 & 530 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} +10 \\ 0 \\ -5 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 690 & -470 & 0 \\ -470 & 800 & -330 \\ 0 & -330 & 530 \end{vmatrix}$$

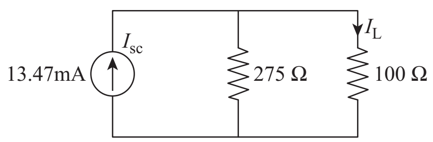
$$\Delta = 690\left[800(530) - (330)^2\right] + 470[530(-470) - 0]$$

$$\Delta = 100.3 \times 10^6$$

$$\Delta I_2 = \begin{vmatrix} 690 & 10 & 0 \\ -470 & 0 & -330 \\ 0 & -5 & 530 \end{vmatrix}$$

$$\Delta I_2 = 690\left[-(330)(5)\right] - 10\left[(-470)(530)\right]$$
$$\Delta I_2 = 1.352 \times 10^6$$

$$I_2 = \frac{\Delta I_2}{\Delta} = \frac{1.352 \times 10^6}{100.3 \times 10^6} = 13.47 \times 10^{-3}\ A$$
$$I_{SC} = I_2 = 13.47 \times 10^{-3}\ A$$

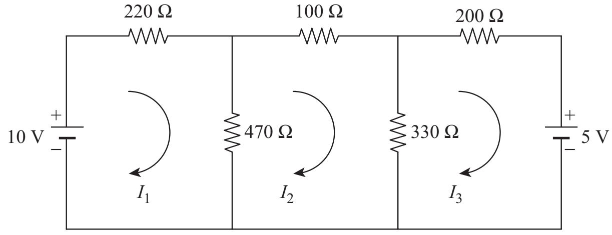


$$I_L = \left(\frac{275}{275 + 100}\right) 13.47 \times 10^{-3}\ A.$$
$$I_L = 9.88 \times 10^{-3}\ A \simeq 10\ mA.$$

The maximum power that can be transferred to the load is,

$$P_L = I_L^2 R_L = (10 \times 10^{-3})^2 \times 100 = 10 \times 10^{-3}\ \text{Watts}$$

Let's check the result using Maxwell's mesh method.



Let's form the Maxwell's mesh matrix,

$$\begin{bmatrix} 690 & -470 & 0 \\ -470 & 900 & -330 \\ 0 & -330 & 530 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \\ -5 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 690 & -470 & 0 \\ -470 & 900 & -330 \\ 0 & -330 & 530 \end{vmatrix} = 690[900(530) - (330)^2] + 470[(-470)(530)] = 136.9 \times 10^6$$

$$\Delta I_2 = \begin{vmatrix} 690 & 10 & 0 \\ -470 & 0 & -330 \\ 0 & -5 & 530 \end{vmatrix} = 690\left[-(330)(5)\right] - 10\left[-470 \times 530\right] = 1.35 \times 10^6$$

$$I_2 = \frac{\Delta I_2}{\Delta} = \frac{1.35 \times 10^6}{136.9 \times 10^6} = 9.86 \times 10^{-3} A$$

$$I_L = I_2 = 9.86 \times 10^{-3} \text{ A.} \simeq 10 \text{ mA.}$$

Answer by both Norton's method and Mesh method is some and hence the result tallies.

13. **(a)** Determine the resonant frequency, bandwidth and quality factor of the coil for the series resonant circuit considering R = 10 Ω, L = 0.1 H and C = 10 μF. Derive the formula used for bandwidth. (16)

Ans. 13. (a) Similar problem solved in page 3.36, Q 13. Only value of L and C is changed.

For derivation of formula used refer page 3.15, Topic 3.3.1 to page 3.17 till $BW = \left(\frac{R}{2\pi L}\right)$

Or

13. **(b) (i)** Derive the expression for equivalent inductance of the parallel resonant circuit as shown in Fig. 13 (b) (i). (8)

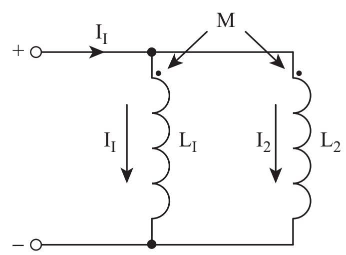


Fig. 13 (b) (i)

Ans. 13. (b) (i) For answer refer: **page 3.31, Topic 3.9 till page 3.33, fig 3.35**

13. (b) (ii) Write the mesh equations and obtain the conductively coupled equivalent circuit for the magnetically coupled circuit shown in Fig. 13 (b) (ii) (8)

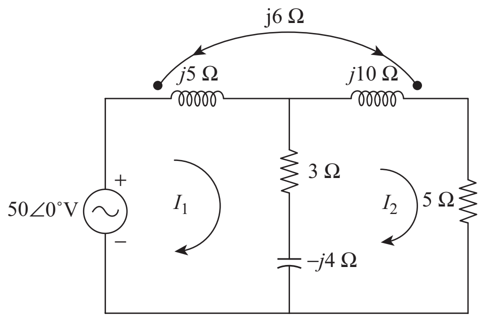


Fig. 13 (b) (ii)

Ans. 13. (b) (ii) For answer refer: **page 3.27, Q9**.

14. (a) A sinusoidal voltage of 10 sin 100 is connected in series with a switch and R = 10 Ω & L = 0.1 H. If the switch is closed at t = 0, determine the transient current i(t) (16)

Ans. 14. (a) For answer refer: **page 4.39, Q6.**

Or

14. (b) In the circuit shown in Fig. 14 (b). Determine the transient current after switch is closed at time t = 0, given that an initial charge of 100µC is stored in the capacitor. Derive the necessary equations.

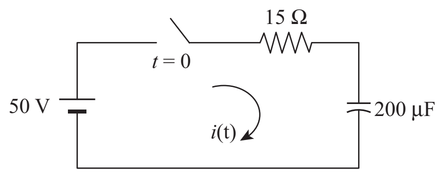


Fig. 14 (b)

Ans. 14. (b) For answer refer: **page 4.38, Q6.**

15. (a) Obtain the readings of two wattmeters connected to a three phase, 3 wire, 120 V system feeding a balanced Δ connected load with a load impedance of 12∠30° Ω. Assume RYB phase sequence. Determine the phase power and compare the total power to the sum of wattmeter readings. (16)

Ans. 15. (a) For answer refer: **page 5.45, Q9.**

Or

15. (b) (i) If W_1 and W_2 are the reading of two wattmeters which measures power in the three phase balanced system and if $W_1 / W_2 = a$, show that the power factor of the circuit is given by (8)

$$\cos\phi = \frac{a+1}{\sqrt[2]{a^2 - a + 1}}$$

Ans. 15. (b) (i) For answer refer: **page 5.37, Q2**

15. (b) (ii) A symmetrical, three phase, three wire 440 V ABC system feeds a balanced Y-connected load with $Z_A = Z_B = Z_C = 10\angle 30°$ Ω. Obtain the line currents. (8)

Ans. 15. (b) (ii) For answer refer: **similar solved** problems at **page 5.41, Q6 and page 5.9, Q1**.