TCET/FRM/IP-02/12 **Term Work Index Sheet** Revision: A

(To be filled up on regular basis)

Sr. No.	Name	DOP	DOC	Marks Obtained (100)	Signature of Faculty
	Basic Experiments				
1	Mesh and Nodal Analysis	18-2	25-2	92	
2	Superposition Theorem	25-2	4-3	87	
3	Thevenin's and Maximum Transfer Theorem	4-3	9-3	[illegible]	
4	Series Resonance	9-3	16-3	93	
5	Circuits for SC and OC Test	16-3	18-3	[illegible]	
6	Slip Ring Induction Motor	18-3	25-3	96	
7					
8					
	Design Experiments / Project / Case Study				
9					
10					
11					
12					
13					
14					
	Formative Assessment / Seminar / Remedial work / Assignments				
15	7 Tutorials	18-2	25-3	93	
16					
17					
18					

DOP – Date of Performance. DOC – Date of Completion

Certificate

This is to Certify that Ms. **ISHIKA NEERAJ SHARMA** Class **AI&DS** Roll no. **45** Course **B.Tech** has successfully completed the term work requirements in the Subject **Basic Electrical Engineering** during the academic Year **2020-2021.**

Signature of faculty	Signature of HOD	Signature of Dean (Academic)
Date:	Date:	Date:

LAB EVALUATION SHEET

Cycle-1 Roll No.:**45**
Experiment/Tutorial No.: **1-3**

Parameters	Weightage	Category	Performance					
			Excel-lent (5)	Very Good (4)	Good (3)	Average (2)	Below Average (1)	Score
Technical Knowledge (Preparedness and Execution)	30	Prerequisites (2)	✓					
		Skills in performing experiment (2)						
		Learning (1)						
Technical Documentation (Developing skills for Journal Writing and Maintenance of Lab Notebook)	30	Format (1)		✓				
		Contents as per Format (2)						
		Quality (2)						
Level of Interaction (Developing Expression Power)	10	Level of Understanding (2)		✓				
		Questions & Answers (2)						
		Application (1)						
Behavioral (Attitude Towards Learning)	10	Attitude (1)	✓					
		Regularity (2)						
		Team Work / Group Activity(2)						
Compliance (Attainment of Objectives / Outcomes)	20	Course Objective Attainment (3)	✓					
		Learning Objective Attainment (2)						
Total	**100**							

Signature of Subject Teacher

LAB EVALUATION SHEET

Cycle-2 Roll No.: **45**
Experiment/Tutorial No.: **4-6**

Parameters	Weightage	Category	Performance					
			Excel-lent (5)	Very Good (4)	Good (3)	Average (2)	Below Average (1)	Score
Technical Knowledge (TK) (Preparedness and Execution)	30	Prerequisites (2)	✓					
		Skills in performing experiment (2)						
		Learning (1)						
Technical Documentation (TD) (Developing skills for Journal Writing and Maintenance of Lab Notebook)	30	Format (1)		✓				
		Contents as per Format (2)						
		Quality (2)						
Level of Interaction (LI) (Developing Expression Power)	10	Level of Understanding (2)	✓					
		Questions & Answers (2)						
		Application (1)						
Behavioral (B) (Attitude Towards Learning)	10	Attitude (1)	✓					
		Regularity (2)						
		Team Work / Group Activity(2)						
Compliance (C) (Attainment of Objectives / Outcomes)	20	Course Objective Attainment (3)	✓					
		Learning Objective Attainment (2)						
Total	**100**							

Signature of Subject Teacher

Evaluation Index Sheet

Sr. No	Cycle	Expt. No.	TK	TD	LI	B	C	Total
1	Cycle-1	1-3	30	24	8	10	20	92
2	Cycle-2	4-6	30	24	10	10	20	94
	Total		60	48	18	20	40	186
	Average		30	24	9	10	20	93

Signature of Subject Teacher

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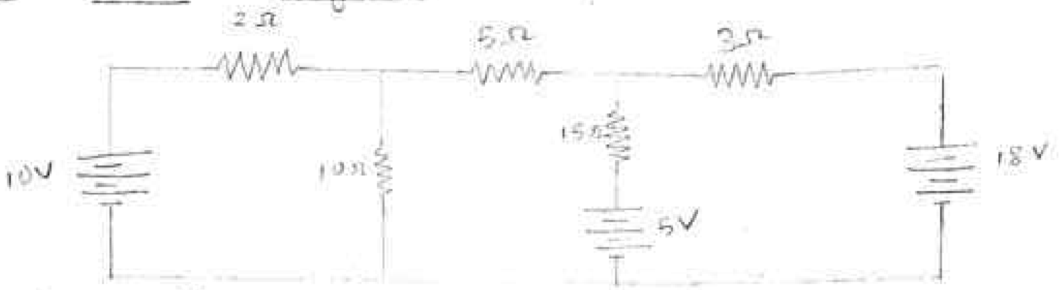
Subject :- BEE Experiment / Tutorial / Assignment No. :- 1 Page :- 1 Date :- 18 / 2 / 2021

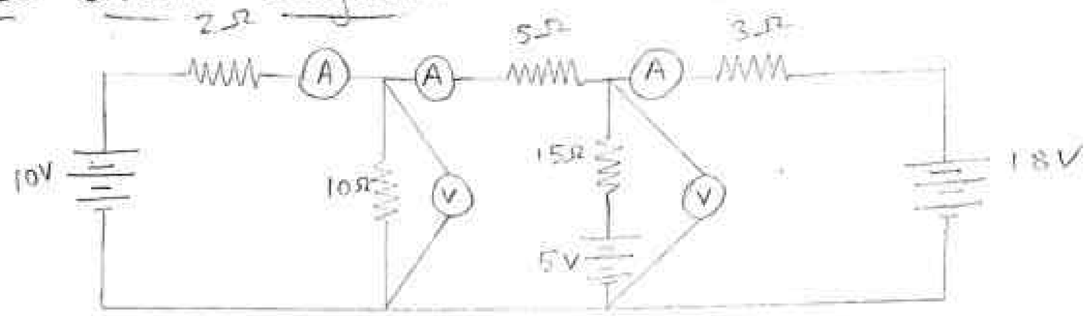
EXPERIMENT NO. 1

MESH AND NODAL ANALYSIS

Electrical Circuit Diagram :



Practical Circuit Diagram



Nodal Analysis :

V_1		V_2	
Calculated	Observed	Calculated	Observed
9.69 V	9.70 V	13.78 V	13.8 V

Calculations: Applying KCL to V_A,

$$I_1 + I_2 + I_3 = 0$$

$$\frac{V_A - 10}{2} + \frac{V_A - V_B}{5} + \frac{V_A - 0}{10} = 0$$

$$\therefore 8V_A - 2V_B = 50 \quad \text{--- (1)}$$

Applying KCL to V_B,

$$I_4 + I_5 + I_6 = 0$$

$$\frac{V_B - V_A}{5} + \frac{V_B - 5}{15} + \frac{V_B - 18}{3} = 0$$

$$\therefore 9V_B - 3V_A = 95 \quad \text{--- (2)}$$

$\therefore$ one solving eq^n 1 & 2

$V_A = 9.69$ V , $V_B = 13.78$ V

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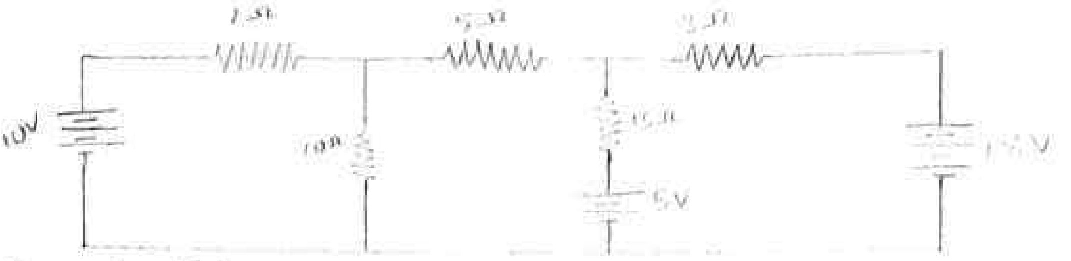
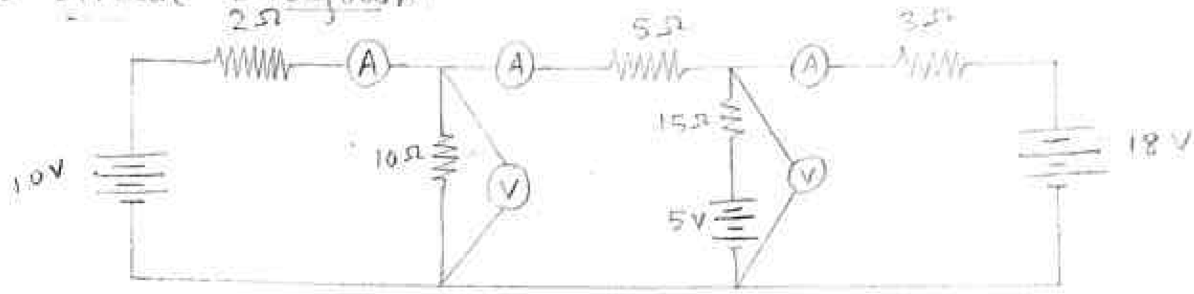
AIM : To perform Mesh and Nodal Analysis for the given circuits.

APPARATUS : Digital multimeter, power supply, resistors, bread board, wires

Electrical Circuit Diagram:



Practical Circuit Diagram:



Mesh Analysis:

I_1		I_2		I_3	
Calculated	Observed	Calculated	Observed	Calculated	Observed
0.151 A	152 mA	-0.818 A	-818 mA	-1.404 A	-1.40 A

Calculations: In Mesh 1, Applying KVL,

$$-2I_1 - 10(I_1 - I_2) + 10 = 0$$

$$-12I_1 + 10I_2 = -10 \quad — ①$$

Applying KVL in mesh 2,

$$-5I_2 - 15(I_2 - I_3) - 5 - 10(I_2 - I_1) = 0$$

$$10I_1 - 30I_2 + 15I_3 = 5 \quad — ②$$

Applying KVL in mesh 3,

$$-3I_3 - 18 + 5 - 15(I_3 - I_2) = 0$$

$$15I_2 - 18I_3 = 13 \quad — ③$$

$\therefore$ On solving eq^n 1, 2 & 3

$I_1 = 0.151$ A , $I_2 = -0.818$ A , $I_3 = -1.404$ A

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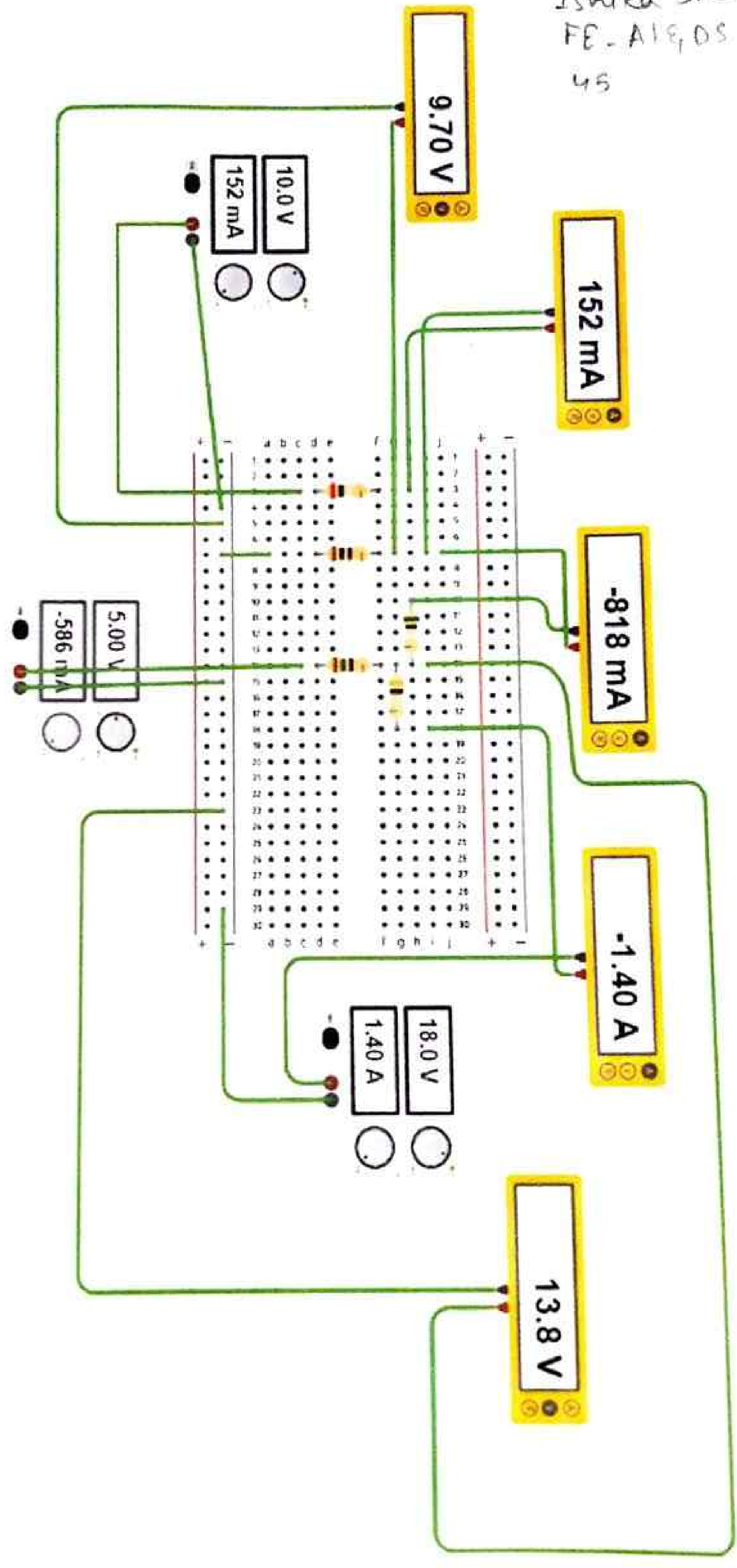

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Subject :- BEE Experiment / Tutorial / Assignment No. :- 1 Page :- 3 Date :- 18/2/2021

CONCLUSION : Hence by applying Mesh and Nodal analysis current and voltage across any resistance can be calculated.

QUIZ :

1] What is the use of breadboard and multimeter?
→ The purpose of breadboard is to make quick electrical connections between components like - resistors, LEDS, etc. Multimeter is a device used to measure voltage, current & resistance.

2] What do you require mesh & nodal analysis?
→ In analysing a circuit using KCL, one can either do nodal analysis or Mesh analysis using KVL.

3] Define voltage & current.
→ Voltage is the difference in change between 2 points. current is the rate at which charge is flowing.

Objective	PRO 1	PRO 2	PRO3		TOTAL	ES&H DEPARTMENT TCET
Weight	20	30	30		SCORE	Date of Performance : 18/2/21
Points						Date of Correction :
Score						Roll No : 45
Earned Points (EP) = Total Score/100				Marks in 100 = EP * 20		Marks : ____ /100
						Signature of Faculty :

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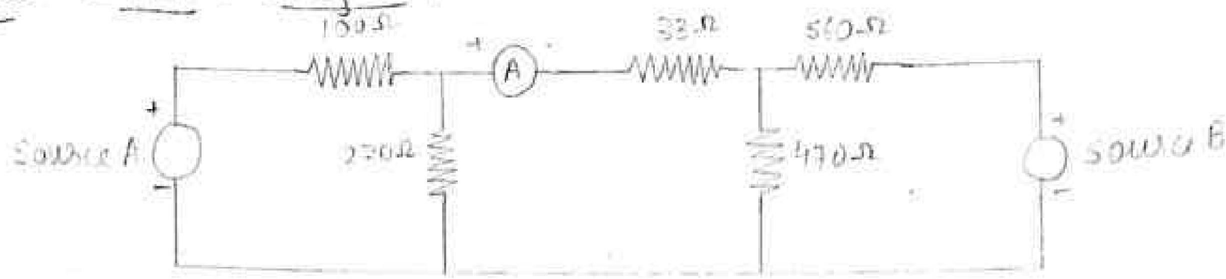
EXPERIMENT NO. 2

VERIFICATION OF SUPERPOSITION THEOREM

Electrical Circuit Diagram:



Source A : 12 V
Source B : 5 V
Resistor under observation : 33Ω

Observation Table :

	PRO 2				PRO 3	
A = 12V B = 5V	I_A (mA)		I_B (mA)		I_{actual} (mA)	
	Cal.	Obs.	Cal.	Obs.	Cal.	Obs.
	23	23.1	6.4	6.39	16.6	16.7

Calculations : At Node 1,

$$\frac{V_1}{100} + \frac{V_1}{220} + \frac{V_1 - V_2}{33} = 0 \quad \text{—①}$$

~~0.01 V1 +~~

At Node 2,

$$\frac{V_2}{470} + \frac{V_2 - 5}{560} + \frac{V_2 - V_1}{33} = 0 \quad \text{—②}$$

$$I'_{33\Omega} = \frac{V_1 - V_2}{33} \qquad I''_{33} = \frac{V_2 - V_1}{33}$$

$$I'_{33\Omega} = 0.023\ A\ (\rightarrow)$$

$$I''_{33\Omega} = -0.0064 A\ (\leftarrow)$$

$$I_{33\Omega} = I'_{33\Omega} + I''_{33\Omega}$$
$$= 0.023 + (-0.0064)$$
$$= 0.023 - 0.0064$$
$$I_{33\Omega} = 0.0166\ \Omega\ (\rightarrow)$$

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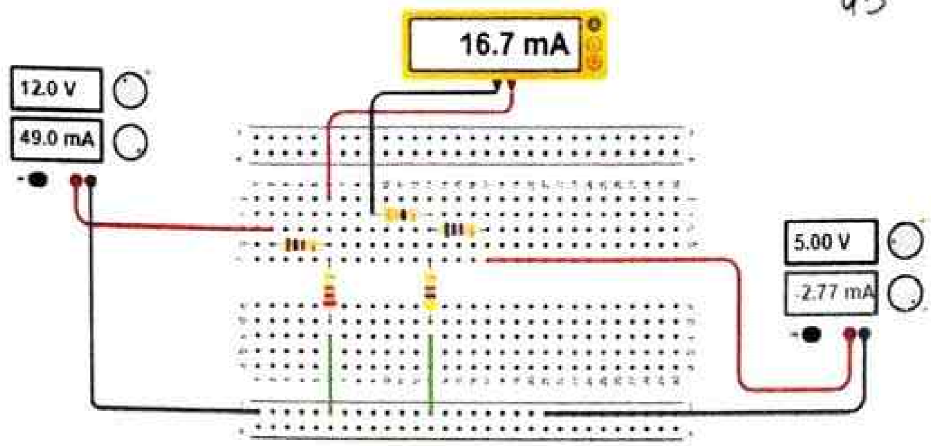

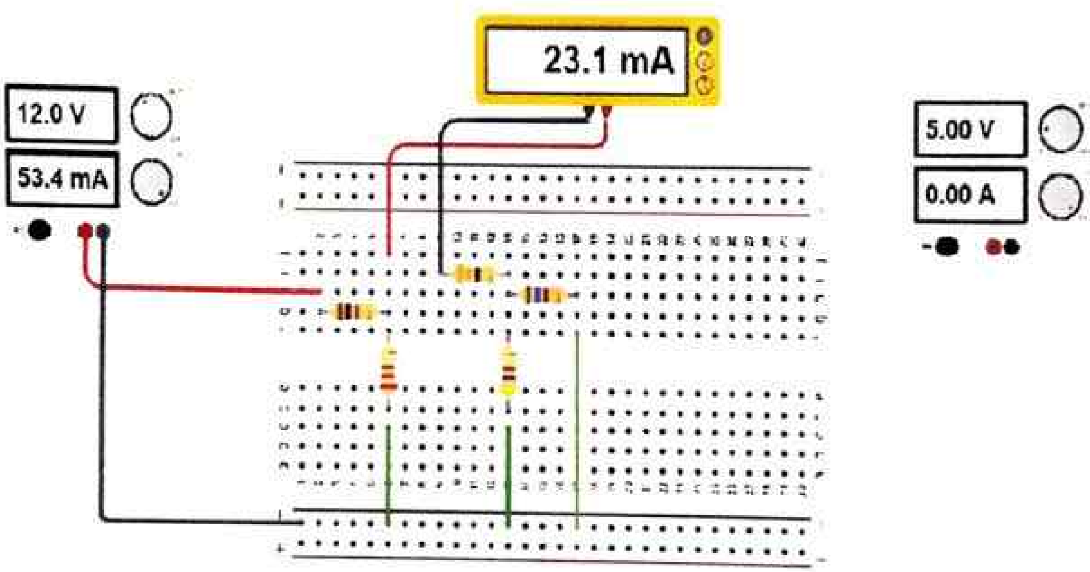

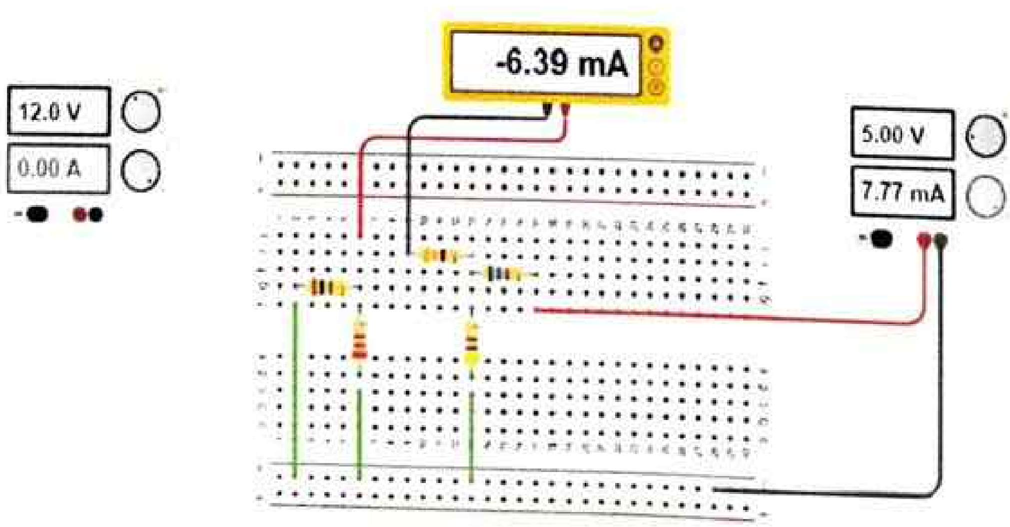

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Subject :- BEE Experiment / Tutorial / Assignment No. :- 2 Page :- 2 Date :- 25/2/2021

AIM : To verify Superposition Theorem

APPARATUS : Digital Multimeter, Power supply, Resistors, Bread board, and connecting wires.

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Subject :- BEE Experiment / Tutorial / Assignment No. :- 2 Page :- 3 Date :- 25/2/2021.

CONCLUSION: In any bilateral network having more than one source current in any resistance can be found out by algebraic sum of currents that would flow when each source is acting independently and other is replaced by its internal resistance. This was verified through our experiment wherein we took 12V and 5V individually and calculated the current through 33Ω. On algebraically adding the two currents, we get the value of the current when both 12V and 5V are acting together. This verifies the superposition theorem.

PRECAUTIONS: A learner has to:
1] Mount & unmount the resistors carefully.
2] Be careful while checking the values of voltages before switching on the circuit.

objective	PRO1	PRO2	PRO3			Total Score	ES&H DEPARTMENT-TCET
weight	20	30	30				Date of Performance: 25/2/21
Points							Date of Correction:
Score							Roll NO: 45
Earned Points (EP) = Total Score / 60							Marks: ___/100
							Signature of Faculty:

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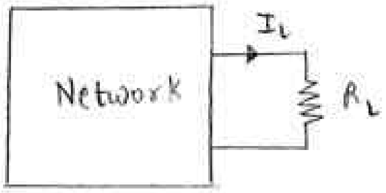
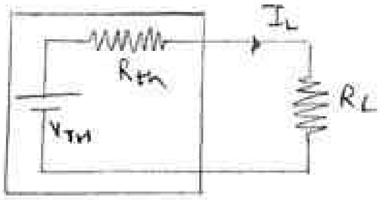
Subject :- BEE   Experiment / Tutorial / Assignment No. :- 3   Page :- 1   Date :- 4/3/2021

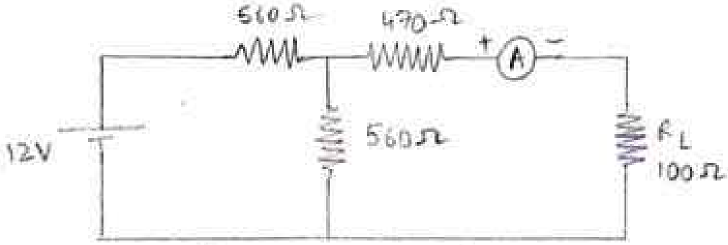
EXPERIMENT NO. 3

MAXIMUM POWER TRANSFER & THEVENIN'S THEOREM

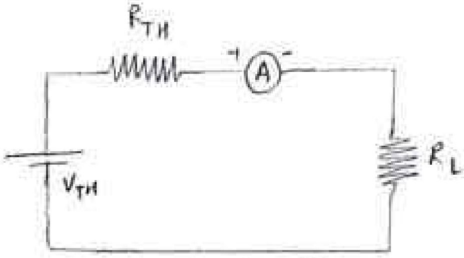
Circuit Diagram







Any Complex Network



Thevenin's Equivalent Circuit

OBSERVATION :

Thevenin's Theorem : PRO 1

	observed	Calculated
V_{TH} (V)	6V	6V
R_{TH} (Ω)	750Ω	750Ω
I_L (mA)	7.06mA	7.06mA

CALCULATION :

Calculating V_{TH} :

Applying KVL in mesh 1,

$-560 I_1 - 560(I_1 - I_2) + 12 = 0$

$-560 I_1 - 560 I_1 + 560 I_2 = -12$

$-1120 I_1 + 560 I_2 = -12$ — (1)

$\therefore -1120 I_1 = -12$ $(\because I_2 = 0)$

$\boxed{I_1 = 0.0107\ A}$

Applying KVL in mesh 2,

$-470 - V_{TH} - 560(I_2 - I_1) = 0$

$-470 + 560 I_1 = V_{TH}$

$-470 + 560(0.0107) = V_{TH}$

$\boxed{V_{TH} = 6V}$

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AIM : To verify Maximum Power transfer & Thevenin's theorem

APPARATUS: Digital Multimeter, Power supply, Resistors, Bread Board and connecting wires.

RESULT AND DISCUSSION : PRO1: Verification of values theoretically and practically verifies Thevenin's Theorem.
PRO 2: Verification of values theoretically and practically verifies Maximum Power Transfer Theorem.

CONCLUSION : Hence when load resistance is equal to internal resistance of the network (R_{TH}) maximum power is transferred to the load. This was verified by taking a constant value of R_{TH} and five differents values of R_L. When $R_{TH} = R_L$, the value of power dissipated across R_L is maximum and decreases otherwise. This verifies maximum power transfer theorem.

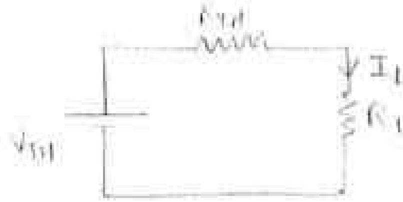
QUIZ :

1] State Thevenin's Theorem.
→ "Any two terminals of a network can be replaced by an equivalent voltage source and an equivalent series resistance"

calculating R_{TH}

$\therefore \boxed{R_{TH} = 750\,\Omega}$

calculating I_L , $R_L = 100\,\Omega$



$$I_L = \frac{V_{TH}}{R_{TH}+R_L} = \frac{6}{750+100} = 7.06\,mA$$

$\therefore \boxed{I_L = 7.06\,mA}$

PRO 2: <u>OBSERVATION</u> :

R_{TH}	R_L	I_L (cal)	I_L (obs.)	$P_{RL}(mW) = I^2 R_L$	
				Calcul	Observ.
750Ω	100Ω	7.06mA	7.06mA	4984	4984.3
750Ω	470Ω	4.9 mA	5 mA	11284	11750
750Ω	750Ω	4 mA	4mA	12000	12000
750Ω	1 kΩ	3.4mA	3.42mA	11560	11696.4
750Ω	1.47 kΩ	2.7mA	2.7mA	10716.5	10716.5

<u>CALCULATIONS</u> :

1) $I_L = \frac{V_{TH}}{R_{TH}+R_L} = \frac{6}{750+100} = \underline{7.06\,mA}$ $\quad P_{RL} = I^2 R_L = (7.06)^2 \times 100 = \underline{4984\,mW}$

2) $I_L = \frac{6}{750+470} = \underline{4.9\,mA}$ $\quad P_{RL} = (4.9)^2 \times 470 = \underline{11284\,mW}$

3) $I_L = \frac{6}{750+750} = \underline{4\,mA}$ $\quad P_{RL} = (4)^2 \times 750 = \underline{12000\,mW}$

4) $I_L = \frac{6}{750+1000} = \underline{3.4\,mA}$ $\quad P_{RL} = (3.4)^2 \times 1000 = \underline{11560\,mW}$

5) $I_L = \frac{6}{750+1470} = \underline{2.7\,mA}$ $\quad P_{RL} = (2.7)^2 \times 1470 = \underline{10716\,mW}$

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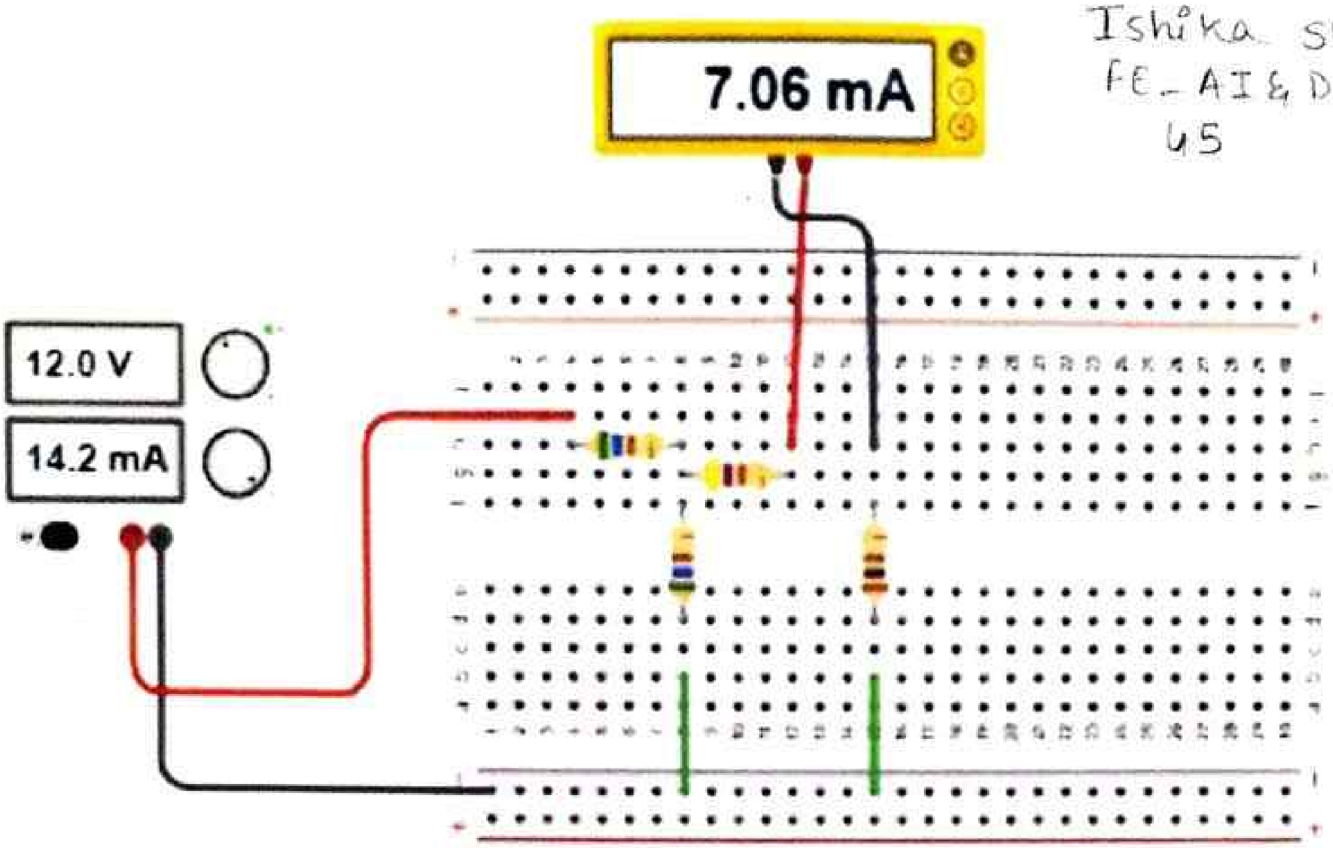

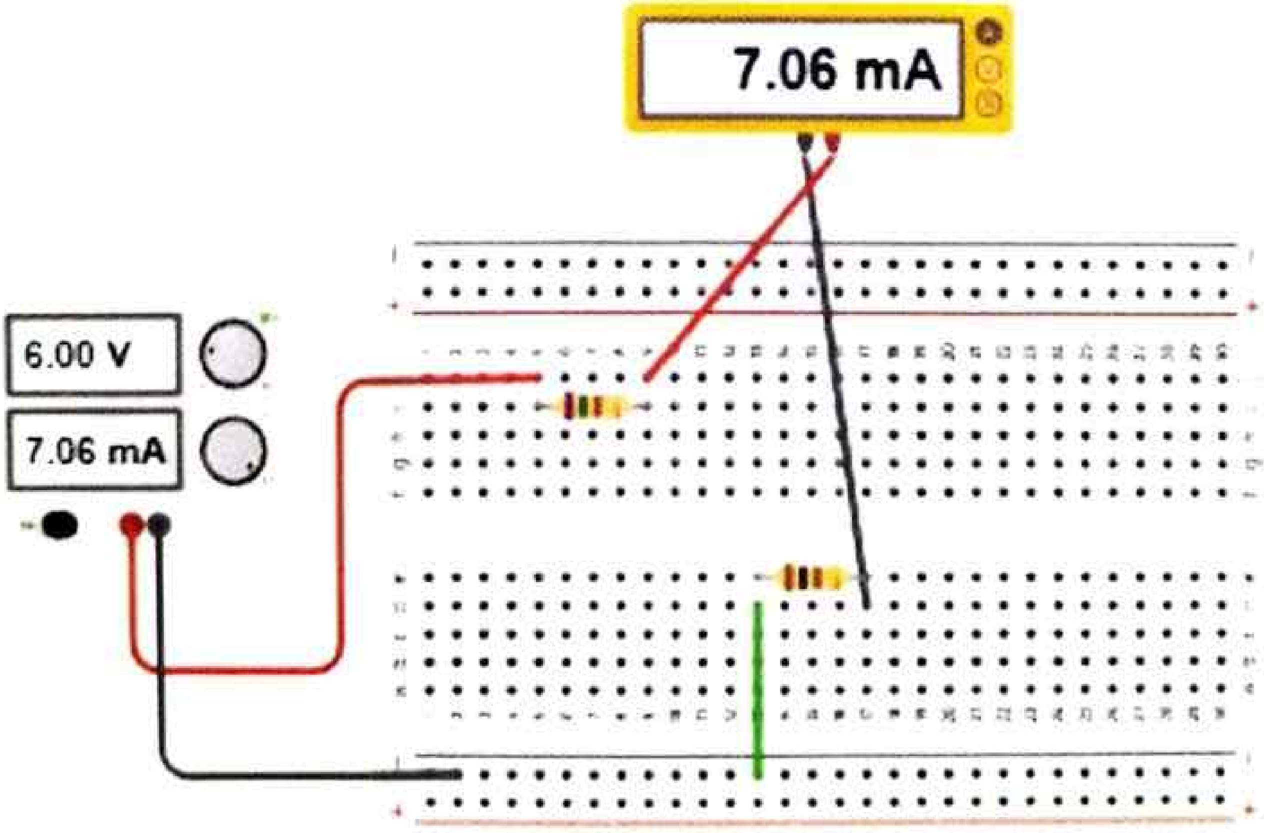

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Subject :- BEE   Experiment / Tutorial / Assignment No. :- 3   Page :- 3

2] State Maximum Power Transfer Theorem
→ "The maximum power is delivered from a source to a load when the load resistance is equal to the source resistance"

Objective	PRO 1	PRO 2	PRO3			Total score	H&S DEPARTMENT- TCET
Weight	20	30	30				Date of Performance: 4/3/21
Points							Date of Correction:
Score							Roll No: 45
Earned Points (EP) = Total Score/100 =					Marks in 100 = EP * 20		Marks : ___ / 100
							Signature of Faculty:

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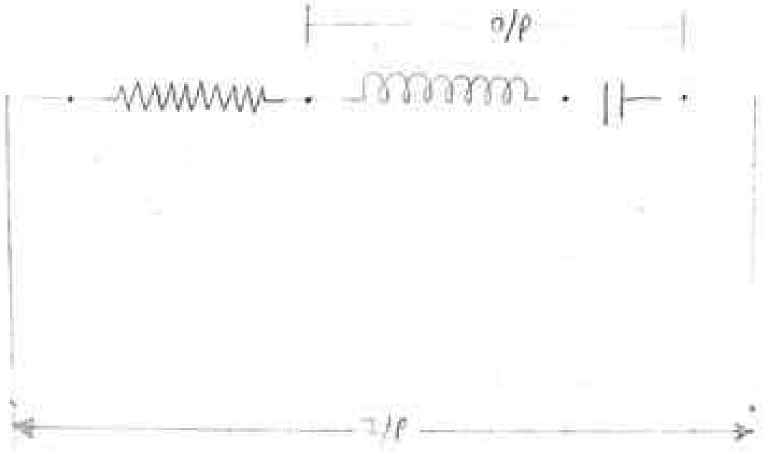
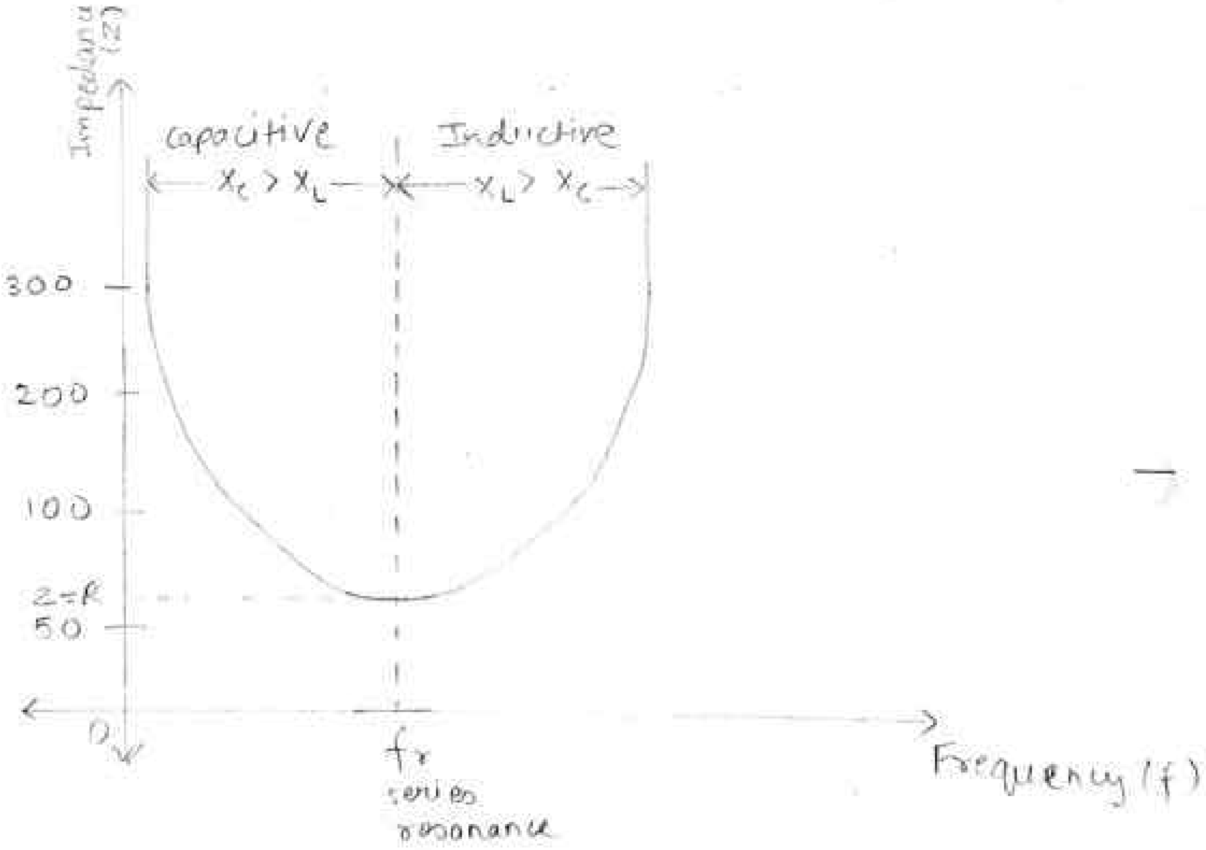
EXPERIMENT NO. 4

SERIES RESONANCE

CIRCUIT DIAGRAM:





Impedance Curve
for Series Resonance

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Subject :- BEE Experiment / Tutorial / Assignment No. :- 4

AIM : To study series resonance circuits

APPARATUS : Function generator, CRO, series resonance kit

$R = 1\,k\Omega$, $L = 39\,mH$, $C = 0.1\,\mu F$

SrNo	PRO 2	
1.	Series Resonant Frequency (KHz)	
	Observed	Calculated
	2.5485 Hz	2.5485 Hz

SrNo	PRO 3	
	Frequency (Hz)	Vpp
1	100	2.55 V
2	500	2.42 mV
3	1000	9.00 mV
4	1200	2.49 V
5	1500	5.16 mV
6	2000	1.56 mV
7	2300	1.13 mV
8	2500	5.95 mV
9	3000	-2.59 mV
10	4000	-1.56 mV

CALCULATION:

$$X_L = X_C$$

$$2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{4\pi^2 LC}$$

$$f = \frac{1}{2\pi\sqrt{LC}} = 2548.5$$

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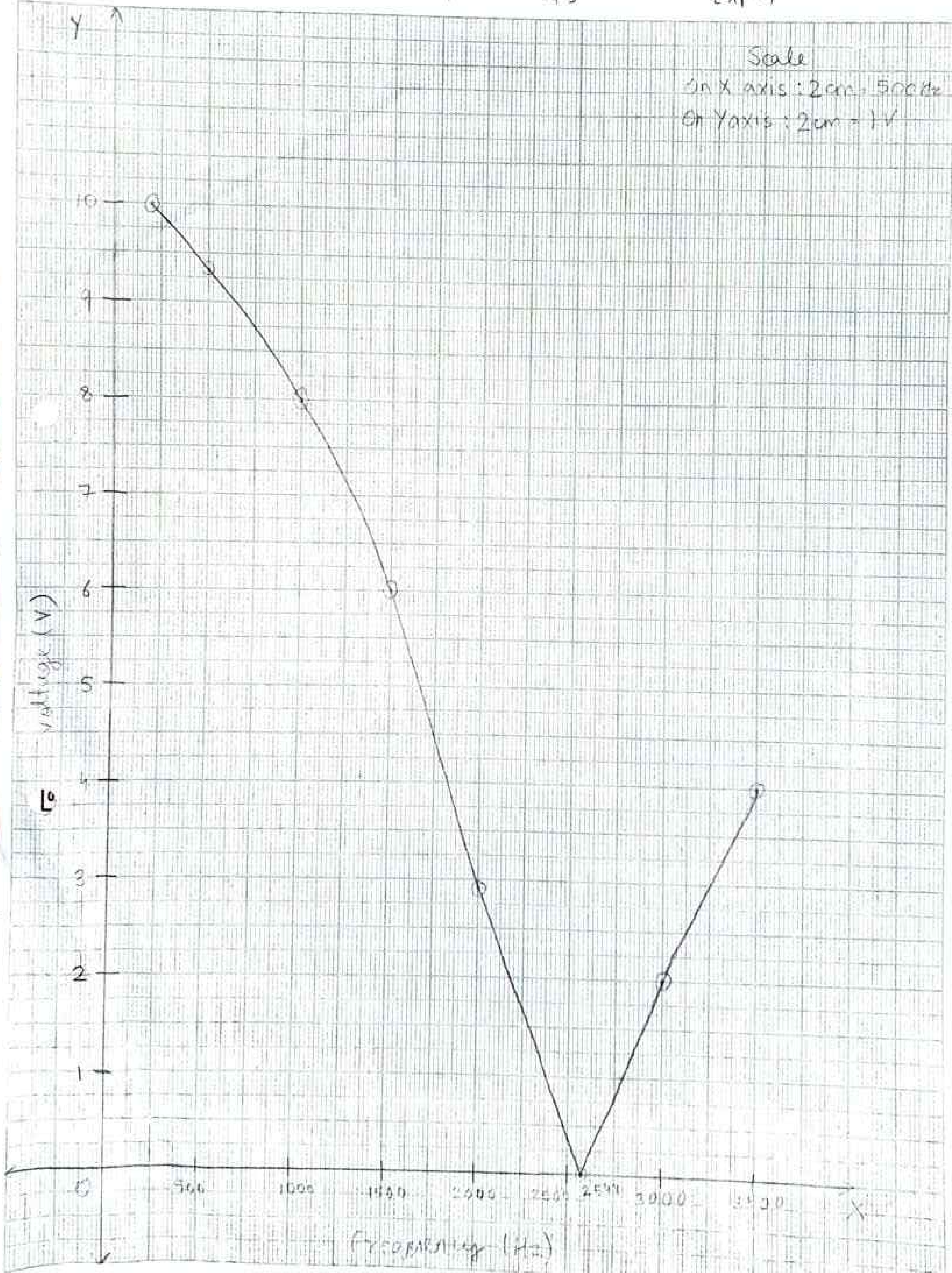

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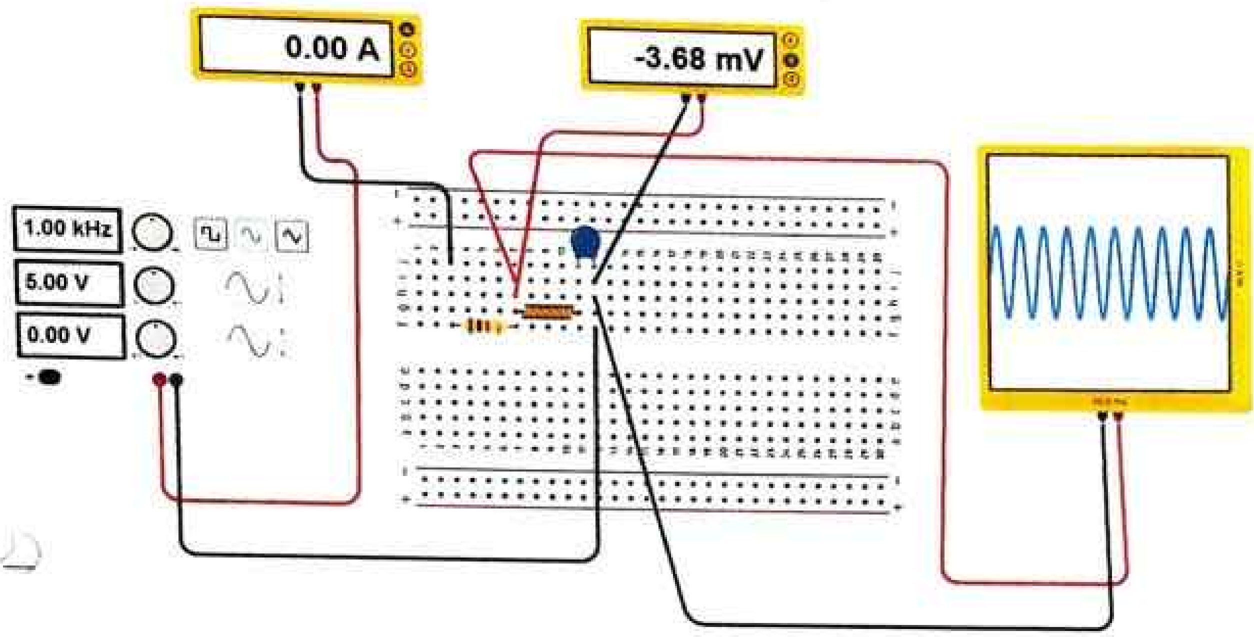

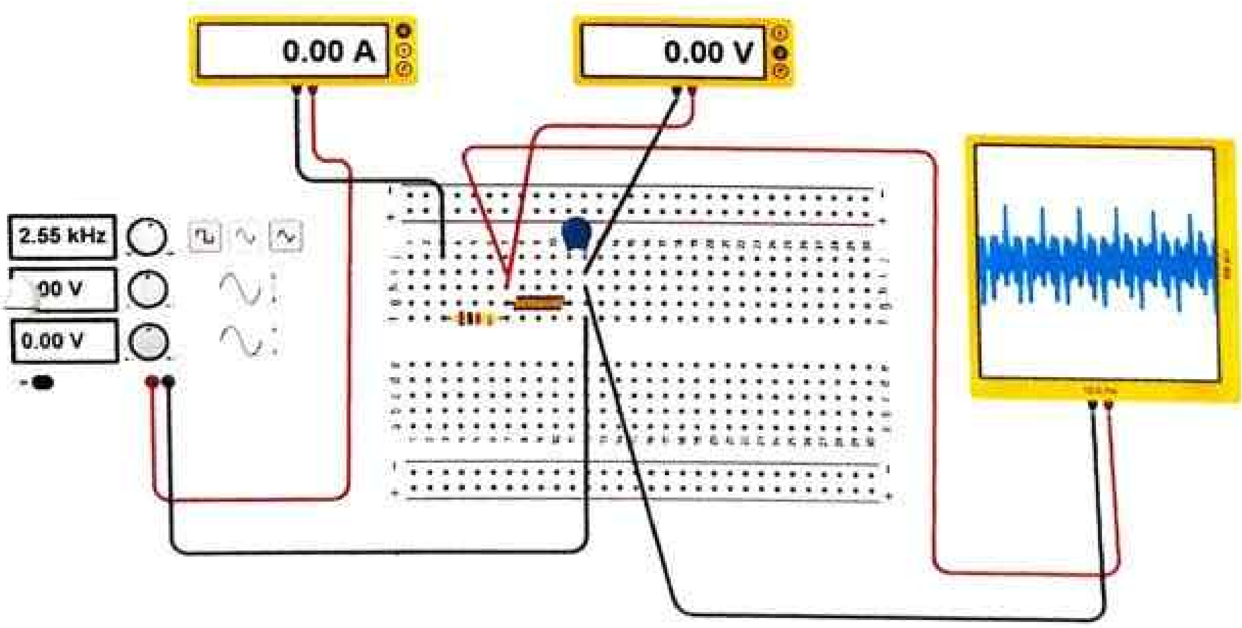

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RESULT AND DISCUSSION :

PRO2 : At series resonance frequency, the peak-to-peak voltage almost tends to zero to make the input AC signal appear a straight line.

PRO3 : The voltage across the inductor and capacitor is very high as compared to the input voltage, however the voltages are 180° out of phase with each other resulting in a total voltage drop of 0V at series resonant frequency.

CONCLUSION : Hence in series RLC circuit when AC signal of variable frequency is applied at low frequency ($f < f_0$) circuit is capacitive in nature, at very high frequency ($f > f_0$) circuit is inductive in nature. When $X_L = X_C$, resonance occurs and current in the circuit is maximum.

QUIZ :

1] Derive the expression at series resonant frequency

→ Imaginary term of impedance Z is zero i.e. the value of $X_L - X_C$ should be equal to zero

$\Rightarrow X_L = X_C$

Substitute $X_L = 2\pi f L$ & $X_C = 1/2\pi f C$

$\therefore 2\pi f L = \dfrac{1}{2\pi f C} \Rightarrow f^2 = \dfrac{1}{4\pi^2 LC} \Rightarrow f = \dfrac{1}{2\pi\sqrt{LC}}$

2] Draw the impedance curve for series resonance

→ Refer Blank page.

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Subject :- BEE   Experiment / Tutorial / Assignment No. :- 4   Page :- 4

Objective	PRO1	PRO2	PRO3			TOTAL	ES&H DEPARTMENT TCET
weight	20	30	30			SCORE	Date of Performance: 9/3/21
Points							Date of correction:
SCORE							Roll No: 45
							Marks : ______ /100
Earned Points (EP) = Total score /60 =						Marks in 100 = EP * 20	Signature of Faculty: ______

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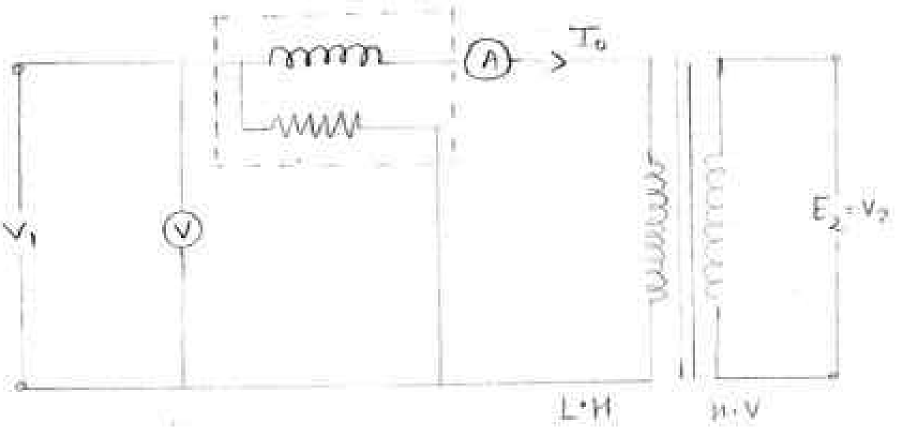
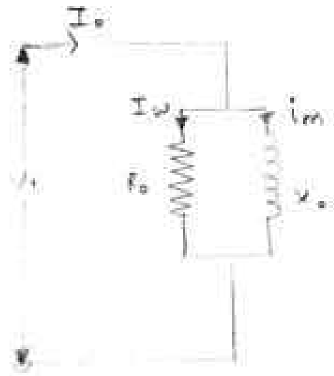
Subject :- BEE   Experiment / Tutorial / Assignment No. :- 5   Page :- 1   Date :- 16 / 3 / 2021

EXPERIMENT NO. 5

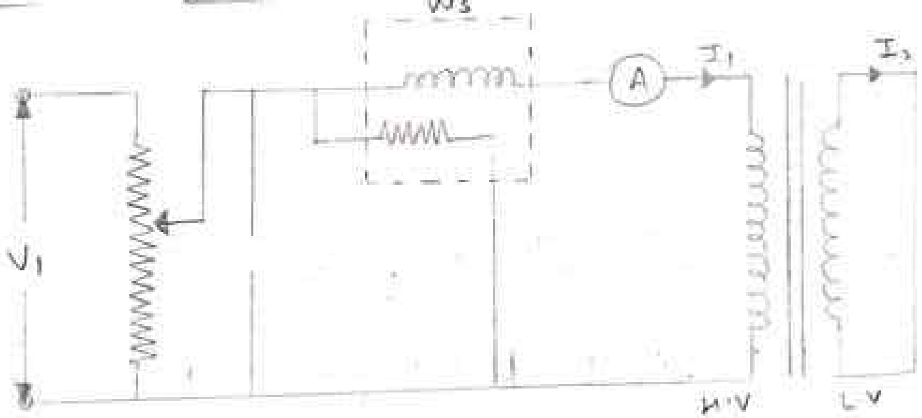
TRANSFORMER EQUIVALENT CIRCUIT FROM OC & SC TEST

* CIRCUIT DIAGRAM FOR O.C TEST





* CIRCUIT DIAGRAM FOR SC TEST



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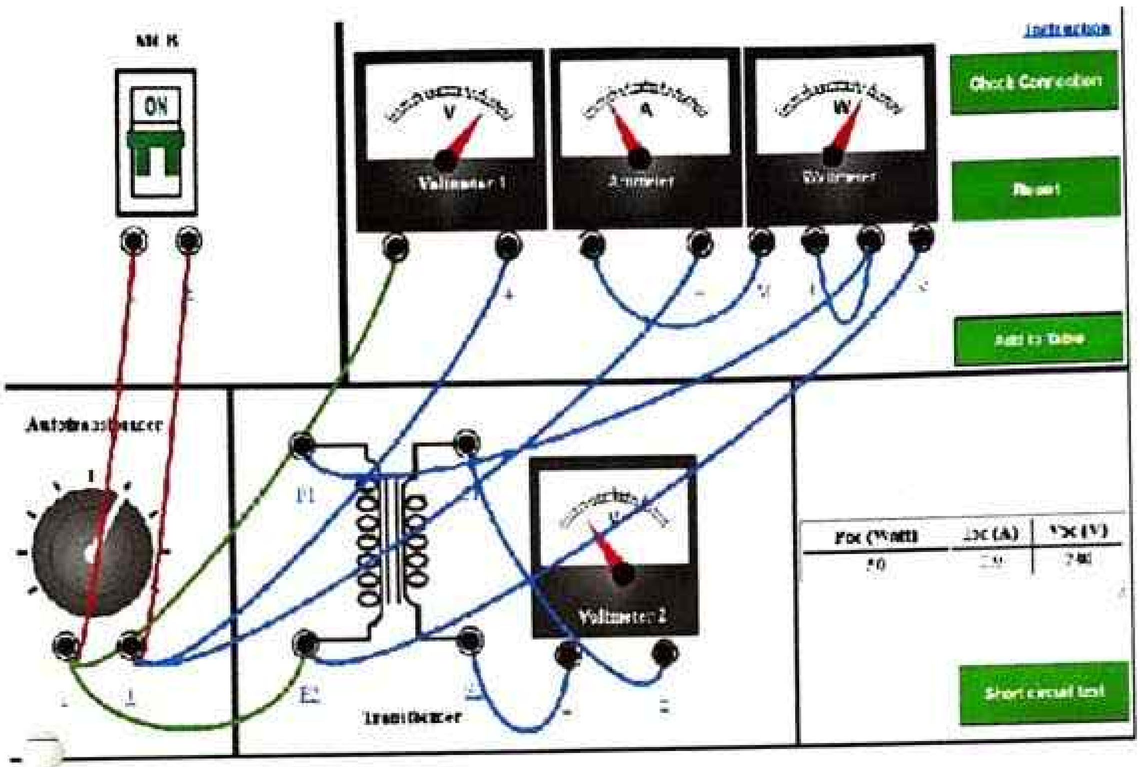

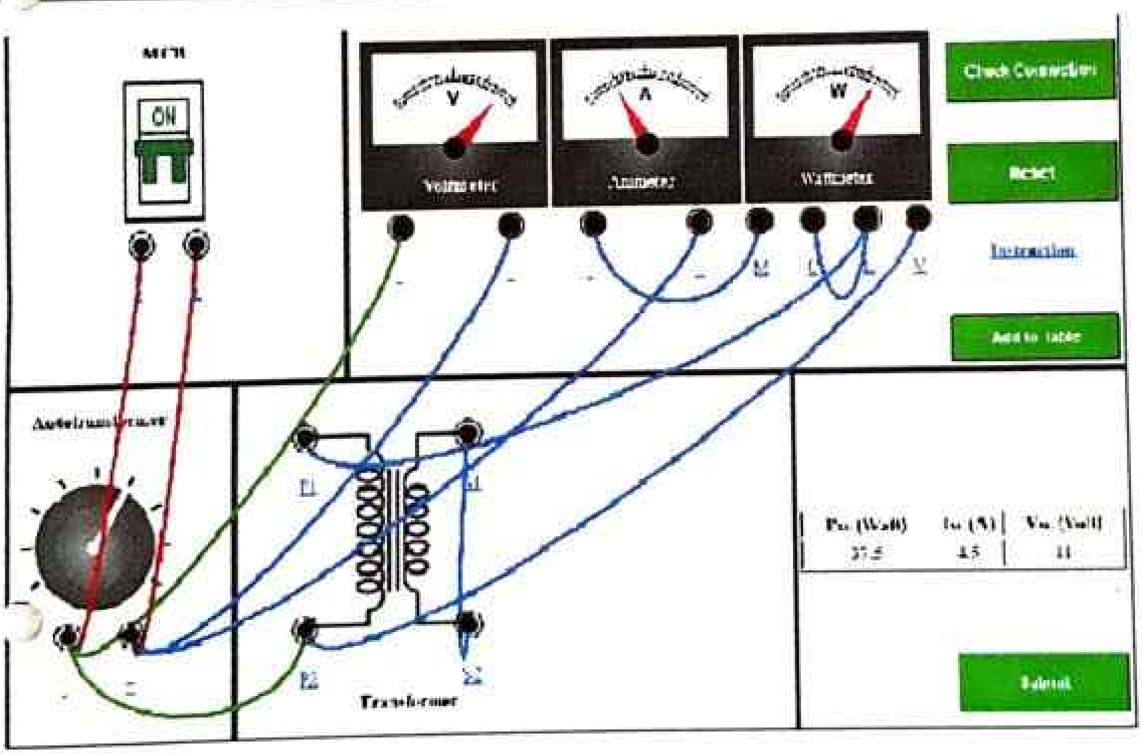

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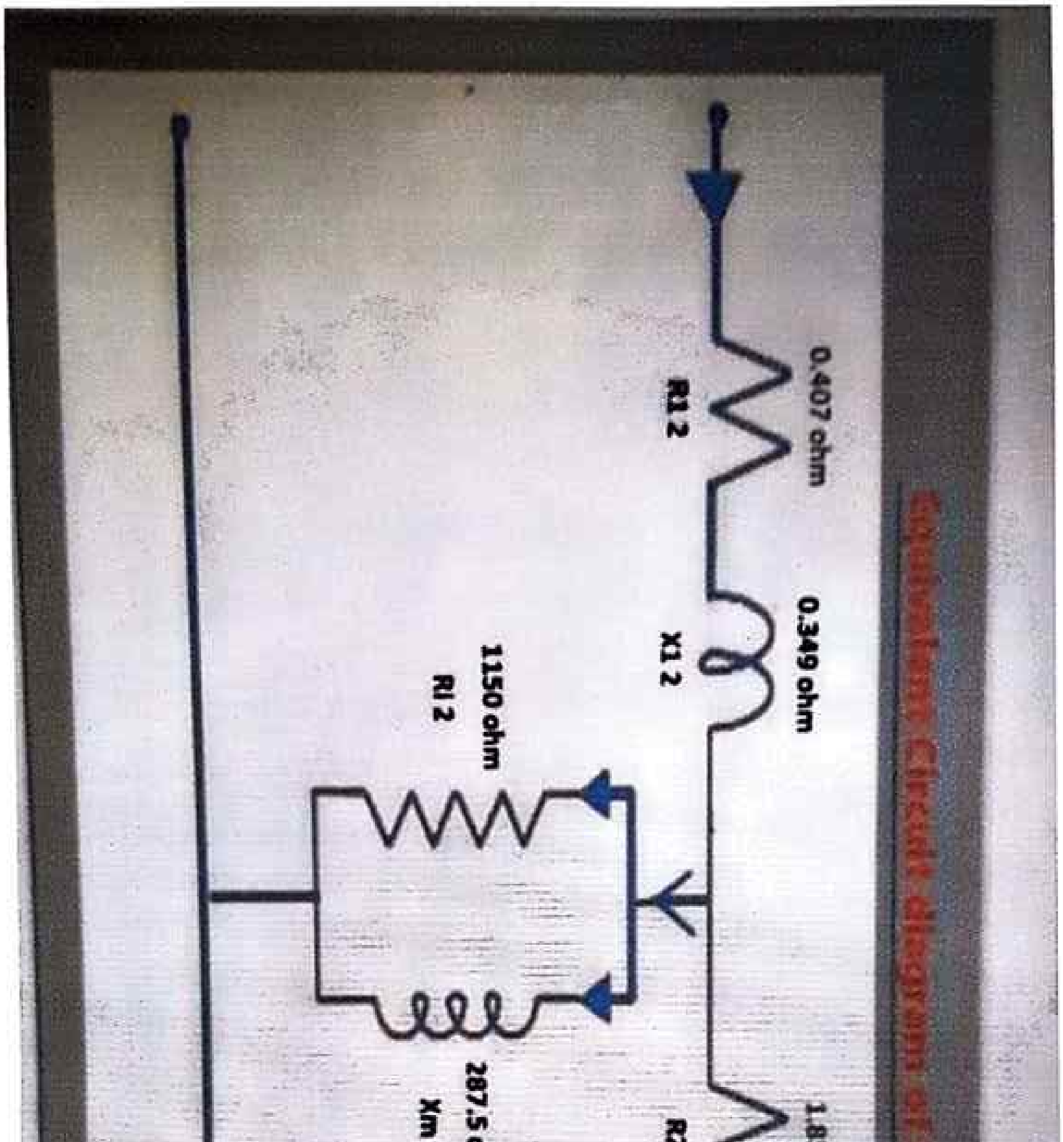

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Subject :- BEE   Experiment / Tutorial / Assignment No. :- 5   Page :- 2

AIM: Determination of Transformer equivalent circuit from Open Circuit and Short Circuit Test

CONCLUSION: We have successfully determined transformer equivalent circuit from open circuit & close circuit. we performed the OC test to find the transformer equivalent.

Objective	PR01	PR02	PR03	TOTAL	ES&H DEPARTMEN TCET
weight	20	20	20	SCORE	Date of Performance:
Points					Date of Correction:
SCORE					Roll No : 45
					Marks : ____ /100
Earned Points (EP) = Total Score / 60				Marks in 100 = EP * 20	Signature of Faculty:

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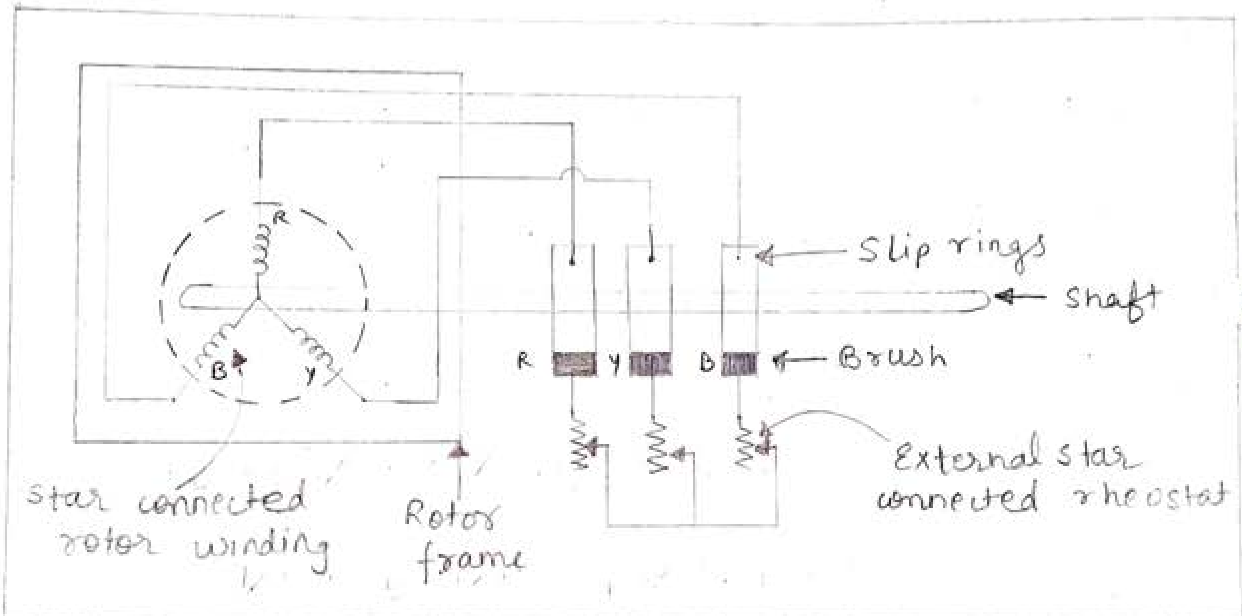
EXPERIMENT NO. 6

SLIPRING INDUCTION MOTOR



R
B
Y
R
Y
B
Slip rings
Shaft
Brush
External star connected rheostat
star connected rotor winding
Rotor frame

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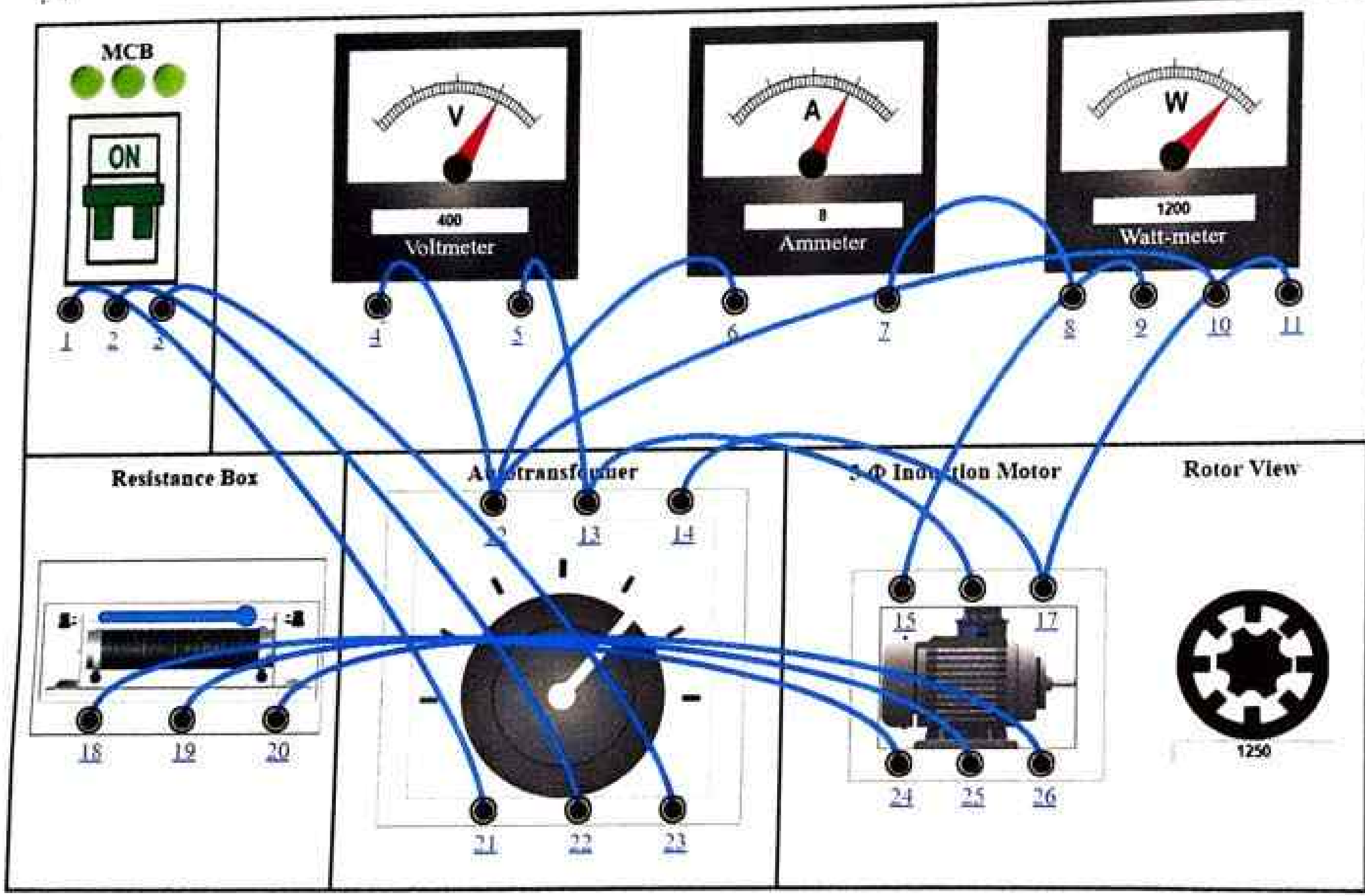


Instruction

SN	Ammeter	WattMeter	Speed
1	2.6	40	1474
2	2.9	140	1454
3	4.8	680	1388
4	5.5	820	1363
5	6.1	940	1352
6	6.4	1040	1334
7	6.9	1100	1300
8	7.5	1160	1278
9	8	1200	1250

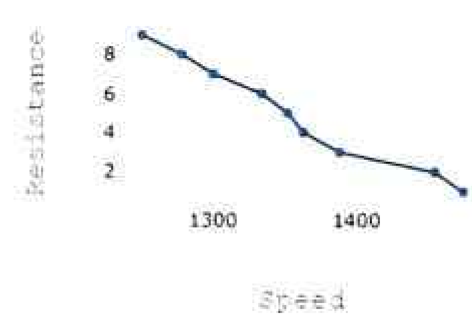
Print this page

Reset

Check

Graph

Add to table



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Subject :- BEE   Experiment / Tutorial / Assignment No. :- 6   Page :- 2

AIM: Speed control of slipring Induction Motor

CONCLUSION: We got to learn about the slipring Induction motor and its speed control. We were also able to make proper connection and get the readings.

objective	PRO1	PRO2	PRO3		TOTAL	ES&H DEPARTMENT - TCET
weight	20	20	20		SCORE	Date of Performance: 18/3/21
Points						Date of Correction:
SCORE						Roll No: 45
						Marks : ______ /100
Earned Points (EP) = Total Score / 60					Marks in 100 = EP * 20	Signature of Faculty:

TUTORIAL 1

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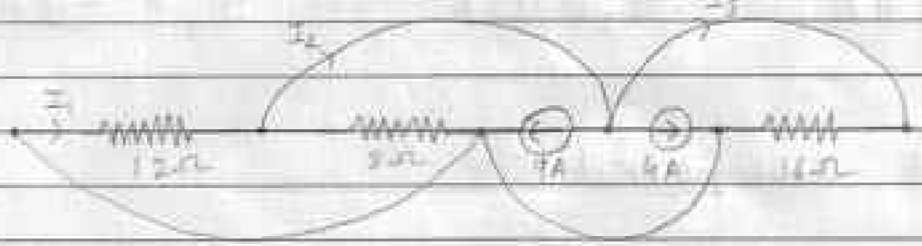
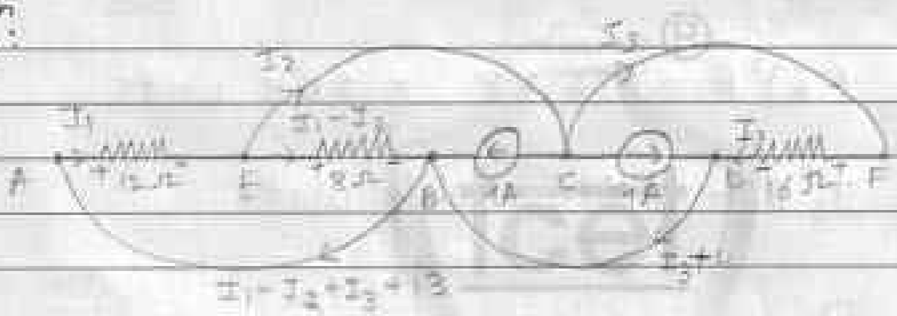
Subject :- BEE   Experiment / Tutorial / Assignment No. :- 1   Page :- 1

Q1] Determine currents I_1, I_2 and I_3 in Fig. given below. Also find power dissipated in each resistor.



soln:



From fig.

$$I_1 = I_1 - I_2 + I_3 + 13$$
$$I_2 - I_3 = 13 \quad \text{—(1)}$$

Apply KVL in ABEA

$$-12I_1 - 8(I_1 - I_2) = 0$$
$$-12I_1 - 8I_1 + 8I_2 = 0$$
$$-20I_1 + 8I_2 = 0 \quad \text{—(2)}$$

Apply KVL in AECFDBA

$$-12I_1 - 16I_3 = 0 \quad \text{—(3)}$$

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By solving 1, 2 & 3

$I_1 = 4A$, $I_2 = 10\,A$, $I_3 = -3A$

Power dissipated

$P_{12\Omega} = I_1^2 R = 16 \times 12 = 192$ watt

$P_{8\Omega} = (-6)^2 R = 36 \times 8 = 288$ watt

$P_{16\Omega} = I_3^2 R = 9 \times 16 = 144$ watt

∴ Power dissipated through 12Ω, 8Ω & 16Ω resistors are 192 watt, 288 watt & 144 watt respectively.

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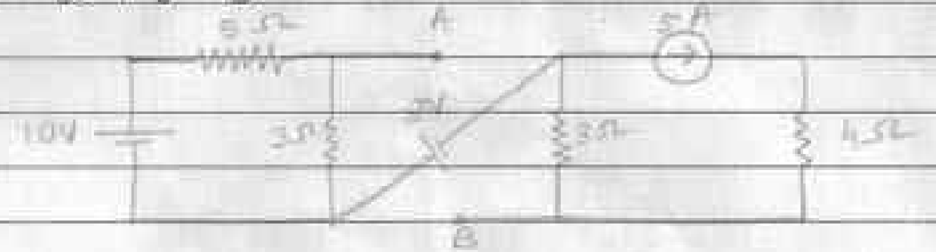
Subject :- BEE   Experiment / Tutorial / Assignment No. :- 1   Page :- 3

Q2] Find the voltage of point A w.r.t. B, A is +ve w.r.t B



Sol^n:

In loop 1,

$\therefore I_1 = \frac{10}{5+3} = \frac{10}{8} = 1.25\,A$

In second loop,

$I_2 = 5A$

Apply KVL from A to B

$\therefore V_A - 3 \times I_1 - 8 - 3(-I_2) - V_B = 0$

$V_{AB} - 3I_1 - 8 + 3I_2 = 0$

$V_{AB} - 3(1.25) - 8 + 3(5) = 0$

$V_{AB} + 3.25 = 0$

$\therefore V_{AB} = -3.25\,V$

$\therefore$ voltage of point A w.r.t. B is $-3.25V$

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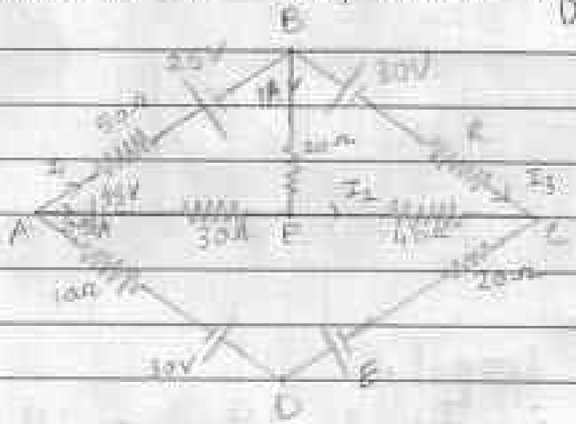
Subject :- BEE   Experiment / Tutorial / Assignment No. :- 1   Page :- 4

Q.3] For the network shown below determine i) I_1, I_2 & I_3 ii) Resistance R iii) Value of EMF E.



Sol^n: Apply KVL in loop ABEA,

$$-50I_1 - 25 - 20\times1 - 30(-0.5) + 45 = 0$$
$$-50I_1 - 25 - 20 + 15 + 45 = 0$$
$$-50I_1 + 15 = 0$$
$$I_1 = \frac{15}{50}$$
$$I_1 = 0.3\,A$$

Now,

$$I_2 = 1 + 0.5$$
$$I_2 = 1.5\,A$$

$$I_1 = 1 + I_3$$
$$0.3 = 1 + I_3$$
$$I_3 = -0.7\,A$$

Apply KVL in loop EBCE

$$-20(-1) - 30 - R(I_3) - 40(-I_2) = 0$$
$$20 - 30 - R(-0.7) - 40(-1.5) = 0$$
$$0.7R + 50 = 0$$
$$R = \frac{-50}{0.7} = -71.43$$

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Subject :- BEE   Experiment / Tutorial / Assignment No. :- 1   Page :- 5

But, Resistance cannot be negative

$\therefore R = 71.43\,\Omega$

Apply KVL in loop AECDA,

$-45 - 30(0.5) + 40(1.5) - 20(I_3 + I_2) + E - 30 - 10(I_3 + I_2) = 0$

$-45 - 15 - 60 - 20(-0.7 + 1.5) + E - 30 - 10(-0.7 + 1.5) = 0$

$E = 174$

$\therefore E = 174\,V$

$\therefore I_1 = 0.3A, \; I_2 = 1.5A, \; I_3 = -0.7A$

$R = 71.43\,\Omega$

$E = 174\,V$

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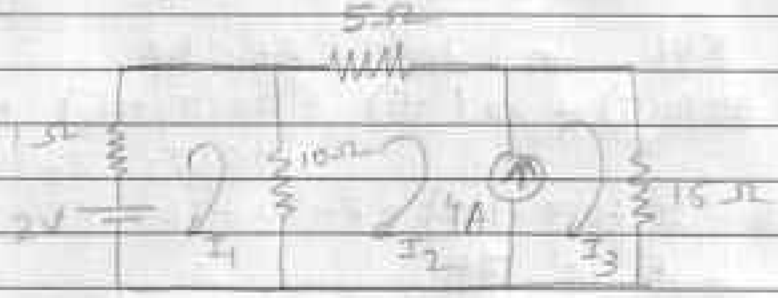
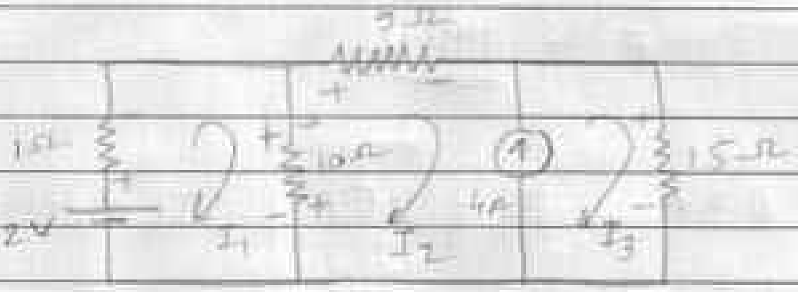
Subject :- BEE   Experiment / Tutorial / Assignment No. :- 1   Page :- 6

Q4] Find current through $10\,\Omega$ resistor using mesh ~~ang~~ analysis.



Sol^n:



Writing current eq^n for supermesh

$$I_3 - I_2 = 4 \qquad \{\because \text{Direction of } I_3 \text{ is same}\}$$

$$0I_1 - I_2 + I_3 = 4 \quad -(1)$$

Writing KVL eq^n for outerloop of supermesh

$$-5I_2 - 15I_3 - 10(I_2 - I_1) = 0$$

$$-5I_2 - 15I_3 - 10I_2 + 10I_1 = 0$$

$$10I_1 - 15I_2 - 15I_3 = 0 \quad -(2)$$

Apply KVL in mesh 1,

$$-10(I_1 - I_2) + 2 - I_1 = 0$$

$$-10I_1 + 10I_2 + 2 - I_1 = 0$$

$$-11I_1 + 10I_2 + 0I_3 = -2 \quad -(3)$$

solving eq^n 1, 2 & 3

$I_1 = -2.35\,A$, $I_2 = -2.78\,A$, $I_3 = 1.22\,A$

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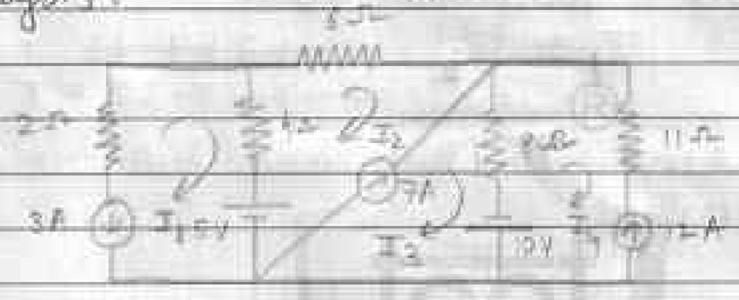
Subject :- BEE Experiment / Tutorial / Assignment No. :- 1 Page :- 7

$\therefore$ current through 10Ω is

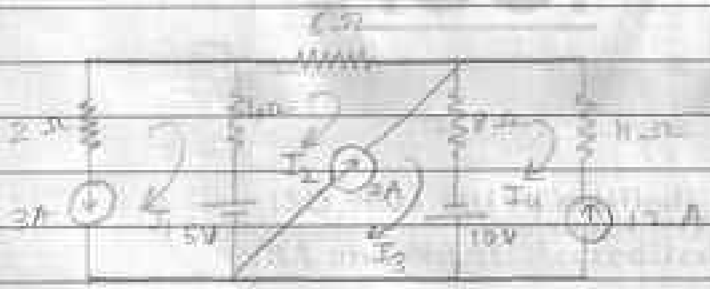
$$I_{10\Omega} = I_1 - I_2 = -2.35 + 2.78 = \underline{0.43\,A}$$

$\therefore$ current through 10Ω is $\underline{0.43\,A}$.

Q5] Find current through 4Ω resistor using mesh analysis.



Sol^n:



Here, mesh 2 & 3 form supermesh,

$\therefore$ Current eq^n for supermesh,

$$I_3 - I_2 = 7$$

$$0I_1 - I_2 + I_3 = 7 \qquad —(1)$$

$\because$ Mesh 1 & mesh 4 contains current source

$\therefore$ $I_1 = -3A$, $I_4 = -12\,A$

Apply KVL in the outerloop of the supermesh,

$$-6I_2 - 8(I_3 - I_4) + 10 + 5 - 4(I_2 - I_1) = 0$$

$$-6I_2 - 8I_3 + 8I_4 + 15 - 4I_2 + 4I_1 = 0$$

$$-12 - 10I_2 - 8I_3 - 96 = -15$$

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$-10I_2 - 8I_3 = 93$ —— ②

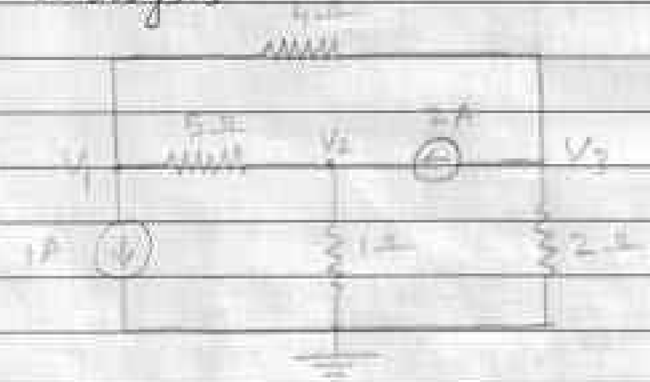
solving eq^n ① & ②

$I_2 = -8.28\ A$, $I_3 = -1.28\ A$

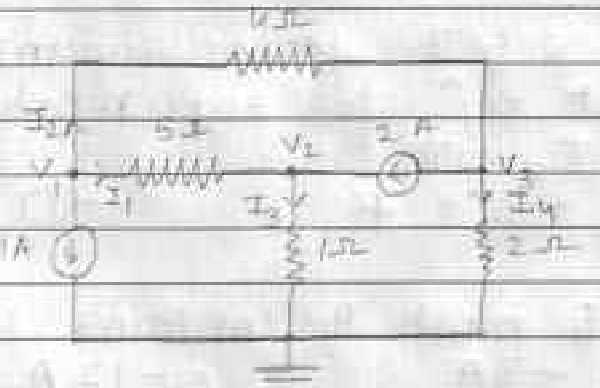
∴ current through 4Ω

∴ $I_{4\Omega} = I_1 - I_2 = \cancel{-1.28+12} = \cancel{10.72\ A}$
$= -3 + 8.28 = 5.28\ A$

Q6] Find current in 1Ω and 4Ω resistor using nodal analysis



sol^n:



Apply KCL at node 1

$1 + I_1 + I_2 = 0$

$\frac{V_1 - V_2}{5} + \frac{V_1 - V_3}{4} = -1$

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$0.2V_1 - 0.2V_2 + 0.25V_1 - 0.25V_3 = -1$

$0.45V_1 - 0.2V_2 - 0.25V_3 = -1$ — (1)

Apply KCL at node 2,

$I_1 + 2 = I_3$

$\frac{V_1 - V_2}{5} - \frac{V_2 - 0}{1} = -2$

$0.2V_1 - 0.2V_2 - V_2 = -2$

$0.2V_1 - 1.2V_2 = -2$ — (2)

Apply KCL at node 3,

$I_2 = 2 + I_4$

$\frac{V_1 - V_3}{4} = 2 + \frac{V_3 - 0}{2}$

$0.25V_1 - 0.25V_3 = 2 + 0.5V_3$

$0.25V_1 - 0.75V_3 = 2$ — (3)

On solving 1, 2, 3

$V_1 = -4V$, $V_2 = 1V$, $V_3 = -4V$

Current through $1\Omega\ (I_{1\Omega}) = I_3 = \frac{V_2}{1} = 1A$

Current through $4\Omega\ (I_{4\Omega}) = \frac{V_1 - V_3}{4} = \frac{-4+4}{4} = 0A$

TUTORIAL 2

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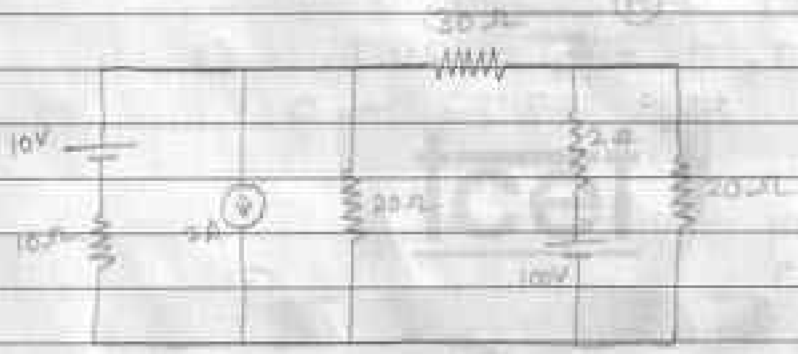
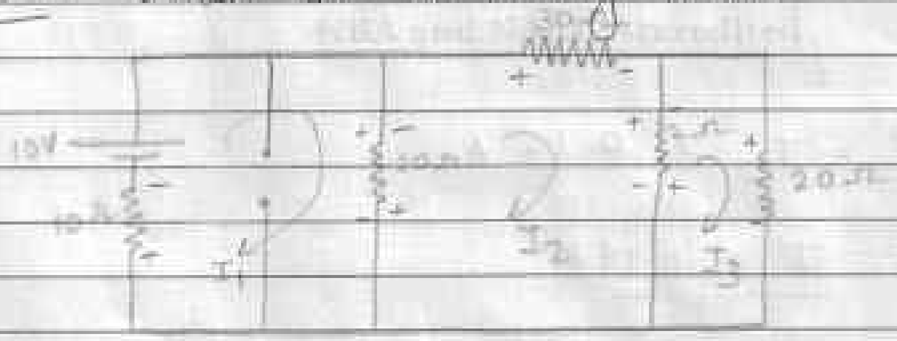
Subject :- BEE   Experiment / Tutorial / Assignment No. :- 2   Page :- 1

Q1] For given circuit find current through $30\,\Omega$ resistor using superposition theorem

Sol^n:



Case 1: when 10V is acting alone



Apply KVL in mesh 1,

$10 - 20(I_1 - I_2) - 10I_1 = 0$

$10 - 20I_1 + 20I_2 - 10I_1 = 0$

$-30I_1 + 20I_2 = -10$ — (1)

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Subject :- BEE Experiment / Tutorial / Assignment No. :- 2 Page :- 2

Apply KVL in mesh 2,

$$-20(I_2 - I_1) - 30I_2 - 2(I_2 - I_3) = 0$$
$$-20I_2 + 20I_1 - 30I_2 - 2I_2 + 2I_3 = 0$$
$$\therefore 20I_1 - 52I_2 + 2I_3 = 0 \quad -(2)$$

Apply KVL in mesh 3,

$$-2(I_3 - I_2) - 20I_3 = 0$$
$$-2I_3 + 2I_2 - 20I_3 = 0$$
$$2I_2 - 23I_3 = 0 \quad -(3)$$

solving eq^n 1, 2, 3

$I_1 = 0.45$ A
$I_2 = 0.17$ A
$I_3 = 0.015$ A

$\therefore I' = I_2 = 0.17$ A

$\therefore I' = 0.17$ A

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Case 2 : when 2A is acting alone.

∵ Resistors 2Ω & 20Ω are parallel

∴ $\frac{1}{2} + \frac{1}{20} = \underline{\underline{1.82\,\Omega}}$

Apply KVL over mesh 1 & 2

$\therefore -10I_1 - 20(I_2 - I_3) = 0$

$-10I_1 - 20I_2 + 20I_3 = 0 \quad - (4)$

Apply KVL in mesh 3,

$-20(I_3 - I_2) - 30I_3 - 1.82I_3 = 0$

$-20I_3 + 20I_2 - 30I_3 - 1.82I_3 = 0$

$\therefore 20I_2 - 51.82I_3 = 0 \quad - (5)$

Apply supermesh condition in mesh 1 & 2

$I_1 - I_2 = 2 \quad - (6)$

By solving 4, 5, 6

$I_1 = 1.1\text{ A}, \quad I_2 = -0.89\text{ A}, \quad I_3 = -0.346\text{ A}$

$\therefore I'' = I_3 = \underline{-0.346\text{ A}}$

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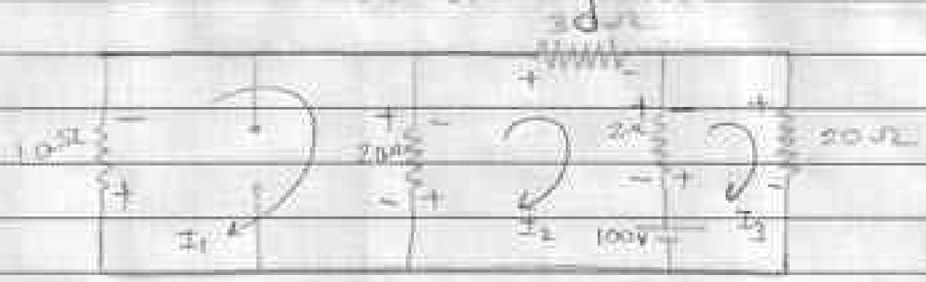
Case 3 : when 100 V is acting alone.



Apply KVL in mesh 1,

$$-20(I_1 - I_2) - 10I_1 = 0$$
$$-20I_1 + 20I_2 - 10I_1 = 0$$
$$-30I_1 + 20I_2 = 0 \quad — (7)$$

Apply KVL in mesh 2,

$$-30I_2 - 2(I_2 - I_3) - 100 - 20(I_2 - I_1) = 0$$
$$20I_1 - 52I_2 + 2I_3 = 100 \quad — (8)$$

Apply KVL in mesh 3,

$$100 - 2(I_3 - I_2) - 20I_3 = 0$$
$$\therefore 2I_2 - 22I_3 = -100 \quad — (9)$$

$\therefore$ On solving 7, 8, 9

$I_1 = -1.57\,A$, $I_2 = -2.36\,A$, $I_3 = 4.33\,A$

$\therefore I''' = I_2 = -2.36\,A$

$\therefore$ current through 30 Ω ,

$$I_{30\Omega} = I' + I'' + I'''$$
$$= 0.17 + 0.346 - 2.36$$
$$= -2.54\,A$$

$\therefore$ current through 30 is $-2.54A$

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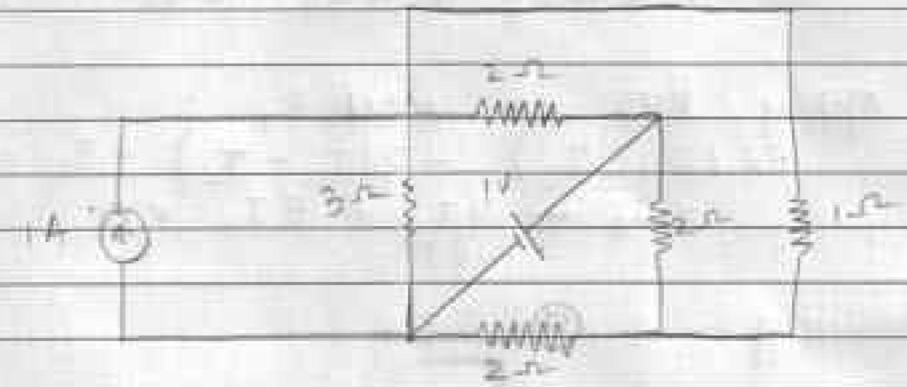
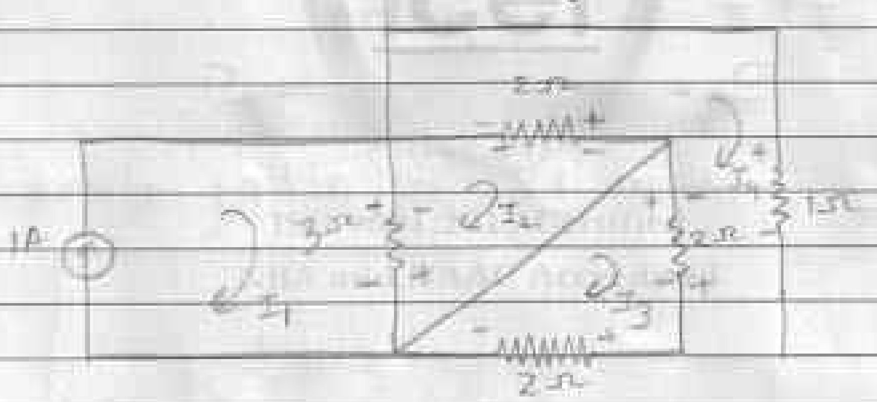
Subject :- BEE   Experiment / Tutorial / Assignment No. :- 2   Page :- 5

Q2] Find the current through 1Ω resistor using superposition theorem.



Soln: When 1A is acting alone,



∵ Mesh 1 contains a current source
∴ $I_1 = 1A$ {∵ Direction is same}

Apply KVL in mesh 2,

$$-2(I_2 - I_4) - 3(I_2 - I_1) = 0$$

$$-2I_2 + 2I_4 - 3I_2 + 3I_1 = 0$$

$$-5I_2 + 2I_4 = -3 \quad — (1)$$

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Apply KVL in mesh 3,

$$-2(I_3 - I_4) - 2I_3 = 0$$
$$-4I_3 + 2I_4 = 0 \quad -(2)$$

Apply KVL in mesh 4,

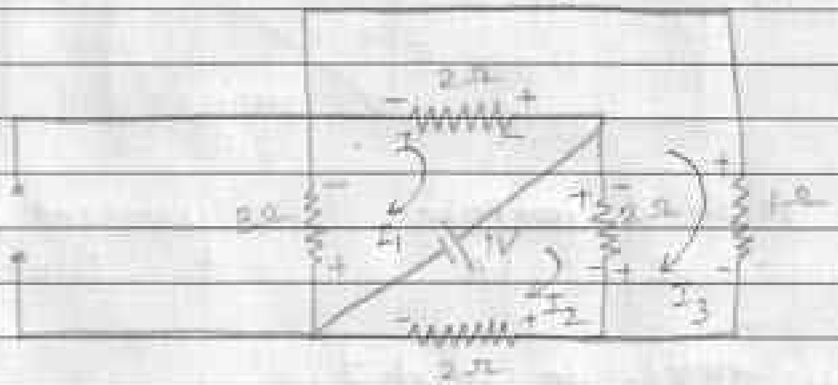
$$-2(I_4 - I_3) - 2(I_4 - I_2) - I_4 = 0$$
$$2I_2 + 2I_3 - 5I_4 = 0 \quad -(3)$$

solving 1, 2, 3

$I_2 = 0.75A$, $I_3 = 0.18A$, $I_4 = 0.375A$

$\therefore I' = I_1 = 0.375A$

Case 2: when 1V is acting alone.



Apply KVL in mesh 2,

$$-3I_1 - 2(I_1 - I_3) - 1 = 0$$
$$-3I_1 - 2I_1 + 2I_3 - 1 = 0$$
$$-5I_1 + 2I_3 = 1 \quad -(4)$$

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Apply KVL in mesh 2,

$$1 - 2(I_2 - I_3) - 2I_2 = 0$$

$$-4I_2 + 2I_3 = -1 \quad — (5)$$

Apply KVL in mesh 3,

$$-2(I_3 - I_2) - 2(I_3 - I_1) - I_3 = 0$$

$$-2I_3 + 2I_2 - 2I_3 + 2I_1 - I_3 = 0$$

$$2I_1 + 2I_2 - 5I_3 = 0 \quad — (6)$$

∴ On solving 4, 5, 6

$$I_1 = 0.18A, \quad I_2 = 0.26A, \quad I_3 = 0.031A$$

$$\Rightarrow \quad \therefore I'' = I_3 = \underline{0.031\,A}$$

Current flowing through 1Ω is

$$I_{1\Omega} = I' + I''$$

$$= 0.375 + 0.031$$

$$= 0.406\,A$$

∴ current through 1Ω is $\underline{0.406A}$

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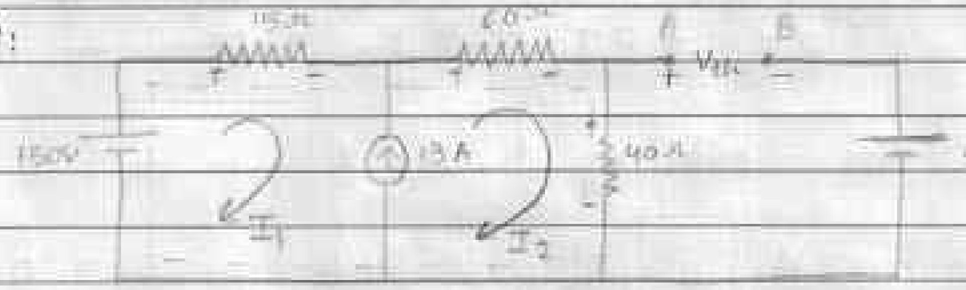
Subject :- BEE   Experiment / ~~Tutorial~~ / Assignment No. :- 2   Page :- 9

Q3] Find the current through 30Ω resistor using Thevenin's theorem

sol^n:



$R_L = 30\Omega$

~~Apply KVL in mesh 1~~

writing current eq^n for supermesh

~~$-15I_1$~~ $I_2 - I_1 = 13$ {∵ the direction of I_2 and source is same}

$I_1 - I_2 \cancel{+ 0I_3} = -13$ — ①

Writing KVL eq^n for outer loop of supermesh

$-15I_1 - 60I_2 - 40I_2 + 150 = 0$

$-15I_1 - 100I_2 = -150$

$15I_1 + 100I_2 \cancel{+ 0I_3} = 150$ — ②

solving eq^n 1 & 2

$I_1 = -10\text{ A}$, $I_2 = 3\text{ A}$

Writing V_{th} eq^n

$-50 + 40I_2 - V_{th} = 0$

$-50 + 120 - V_{th} = 0$

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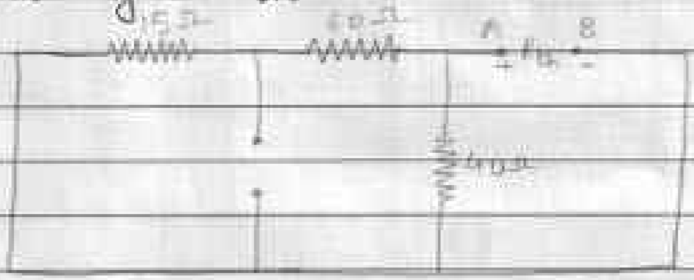
$V_{th} = \underline{70\,V}$

Calculating R_{th} :-



$\because$ Resistors 15Ω & 60Ω are in series

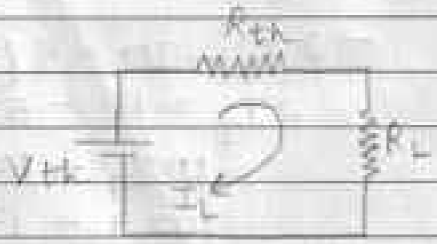
$\therefore$ $15 + 60 = 75\Omega$

$\because$ Resistors 75Ω & 40Ω are in parallel

$\therefore \dfrac{1}{75} + \dfrac{1}{40} = 26.08\,\Omega$

$\therefore R_{th} = 26.08\,\Omega$

Calculating I_L :-



$$I_L = \frac{V_{th}}{R_{th} + R_L} = \frac{70}{26.08 + 30}$$

$$= \underline{1.25\,A}$$

$\therefore$ current through 30Ω is $\underline{1.25\,A}$

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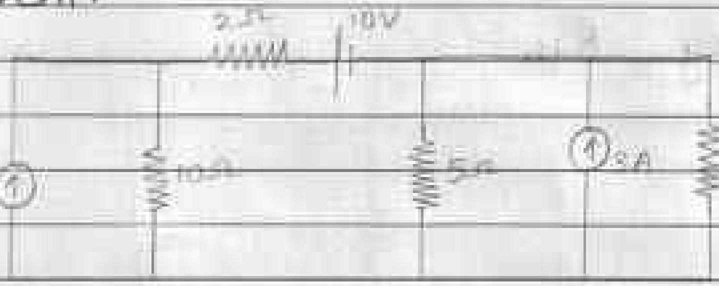
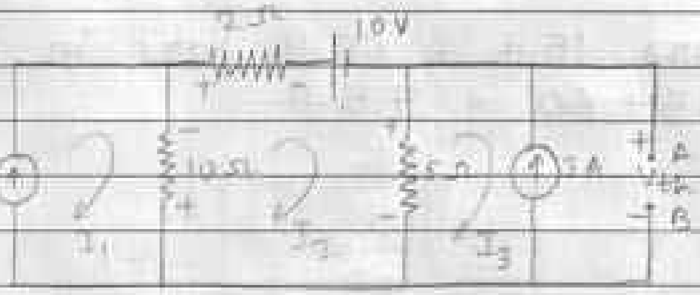
Q4] Find current through 6Ω resistor using Thevenins Theorem.



Soln:



$R_L = 6\Omega$

∵ mesh 1 & mesh 3 are containing current source

∴ $I_1 = 4A$ {∵ Direction is same}

∴ $I_3 = -3A$ {∵ Direction is opposite}

Apply KVL in mesh 2,

$$-2I_2 - 10 - 5(I_2 - I_3) - 10(I_2 - I_1) = 0$$
$$-2I_2 - 10 - 5I_2 + 5I_3 - 10I_2 + 10I_1 = 0$$
$$10I_1 - 17I_2 + 5I_3 - 10 = 0$$
$$10\times4 - 17I_2 + 5(-3) - 10 = 0$$
$$40 - 17I_2 - 15 - 10 = 0$$
$$-17I_2 = -15$$
$$I_2 = \frac{15}{17}$$
$$I_2 = \underline{0.88}\ A$$

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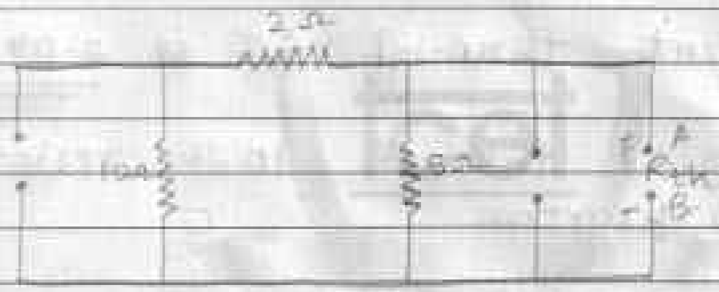
Writing V_{th} eq^n

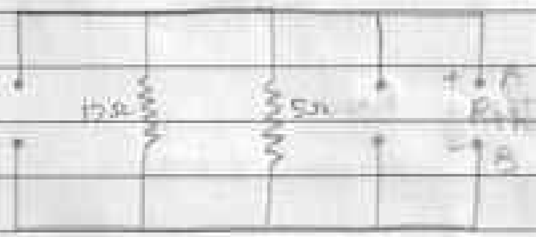
$$-V_{th} + 5(I_3 - I_2) = 0$$
$$-V_{th} + 5I_3 - 5I_2 = 0$$
$$-V_{th} - 15 - 4.4 = 0$$
$$-V_{th} - 19.4 = 0$$
$$V_{th} = -19.4\,V$$
$$V_{th} = 19.4\,V$$ (B is positive w.r.t. A)

Calculating R_{th}:



∵ Resistors 2Ω & 10Ω are in series

$\therefore 10 + 2 = 12\,\Omega$



∵ Resistors 12Ω & 5Ω are parallel

$\therefore \frac{1}{12} + \frac{1}{5} = 3.53\,\Omega$

$\therefore R_{th} = 3.53\,\Omega$

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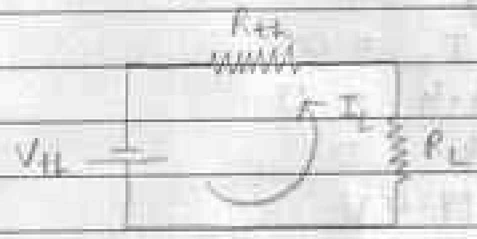
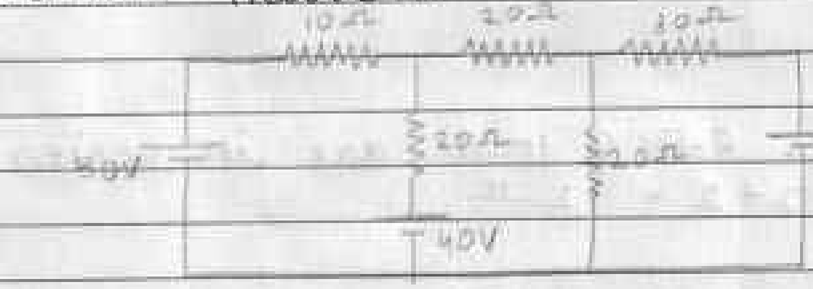
Calculating I_L



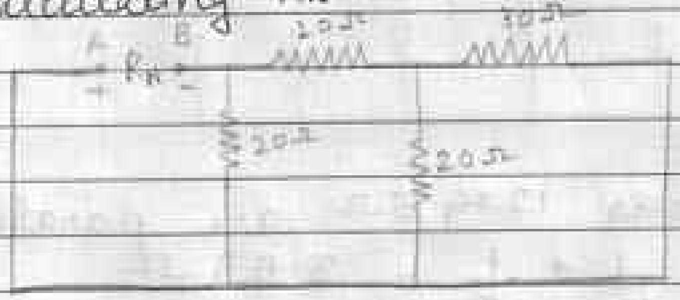
$$I_L = \frac{V_{th}}{R_{th} + R_L} = \frac{19.4}{3.53+6} = \underline{2.04\ A}$$

$\therefore$ current through 6Ω is $\underline{2.04\ A}$

Q5] Find current through 10Ω resistors using Nortons Theorem.



Sol^n: Calculating R_N



R_N $R_L = 10\Omega$

$\because$ Resistors 30Ω & 20Ω are parallel

$$\frac{1}{30} + \frac{1}{20} = 12\Omega$$

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∵ Resistors 20Ω & 12Ω are in series

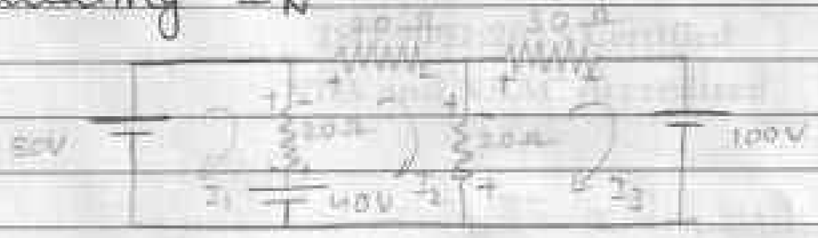
$\therefore 20 + 12 = 32\,\Omega$

∵ Resistors 20Ω & 32Ω are parallel

$\therefore \frac{1}{20} + \frac{1}{32} = 12.30\,\Omega$

$\therefore R_N = \underline{12.3\,\Omega}$

Calculating I_N



Apply KVL in mesh 1,

$50 - 20(I_1 - I_2) - 40 = 0$

$50 - 20I_1 + 20I_2 - 40 = 0$

$-20I_1 + 20I_2 = -10 \quad —(1)$

Apply KVL in mesh 2,

$-20I_2 - 20(I_2 - I_3) + 40 - 20(I_2 - I_1) = 0$

$-20I_2 - 20I_2 + 20I_3 + 40 - 20I_2 + 20I_1 = 0$

$20I_1 - 60I_2 + 20I_3 = -40 \quad —(2)$

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Apply KVL in mesh 3,

$$-30I_3 - 100 - 20(I_3 - I_2) = 0$$

$$-30I_3 - 100 - 20I_3 + 20I_2 = 0$$

$$20I_2 - 50I_3 = 100 \quad — (3)$$

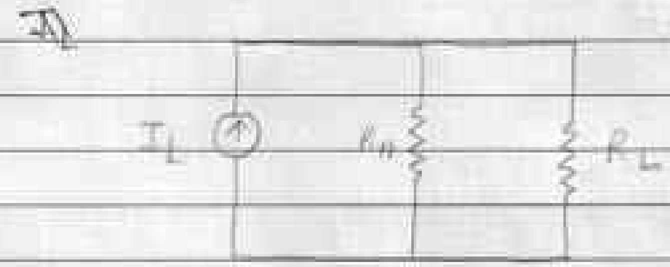
On solving eq^n 1, 2 & 3

$I_1 = 0.8125A$

$I_2 = 0.3125A$

$I_3 = -1.875A$

$I_N = I_1 = \underline{0.812A}$



$$I_L = \frac{R_N}{R_N + R_L} \times I_N$$

$$= \frac{12.3}{12.3 + 10} \times 0.812$$

$I_L = 0.448\ A$

∴ current through 10Ω is $\underline{0.448A}$

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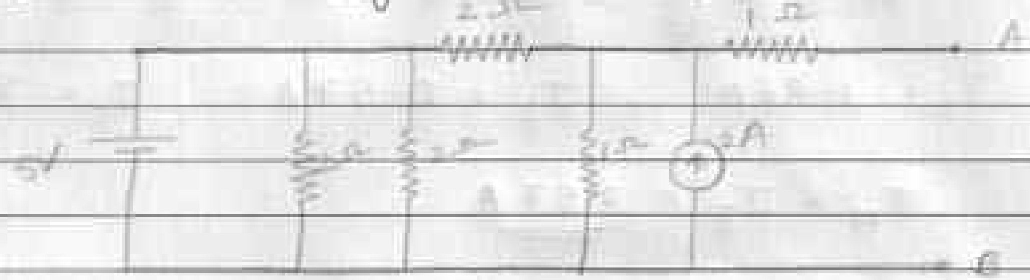
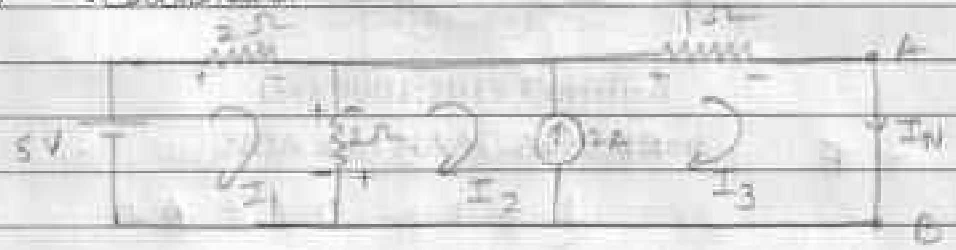
Q6] Find Norton's Equivalent network



Sol^n: calculating I_N by joining A & B points

Here, 2Ω resistore are in parallel with 5V, so it is reductant



Apply KVL in mesh 1,

$$5 - 2I_1 - 2(I_1 - I_2) = 0$$
$$-3I_1 + I_2 = -5 \quad — (1)$$

Apply KVL in mesh 2 & 3,

$$-1I_3 - 2(I_2 - I_1) = 0$$
$$2I_1 - 2I_2 - I_3 = 0 \quad — (2)$$

writing current eq^n of supermesh,

$$I_3 - I_2 = 2 \quad — (3)$$

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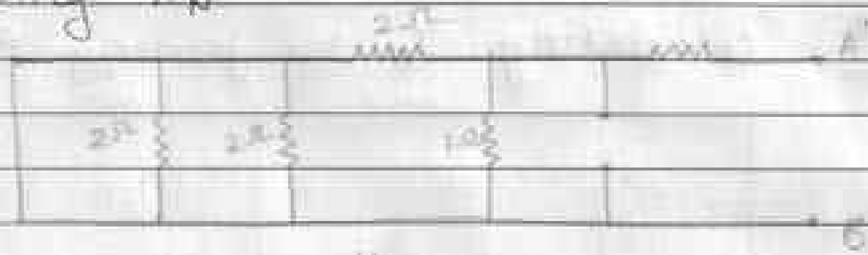
∴ On solving 1, 2, 3

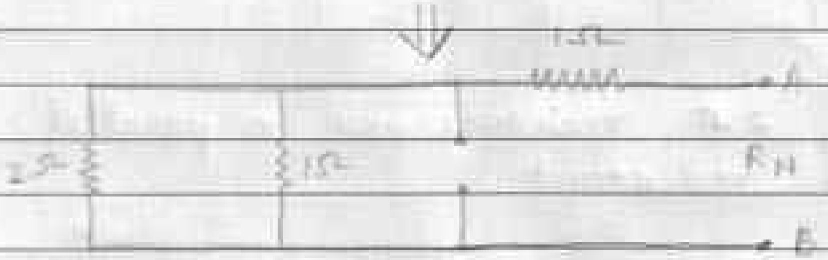
$I_1 = 1.86A$, $I_2 = 0.57A$, $I_3 = 2.57A$

∴ $I_N = I_3 = \underline{\underline{2.57A}}$

Calculating R_N



⇓

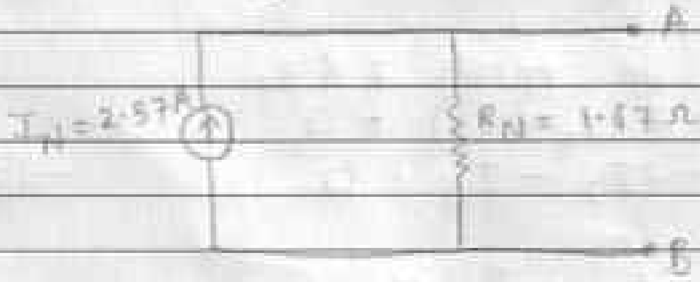


∴ Resistors 2Ω & 1Ω are parellel

∴ $\frac{1}{2} + 1 = 0.67\ \Omega$

∴ $R_N = 1 + 0.67 = \underline{\underline{1.67\ \Omega}}$

Norton's Equivalent network,



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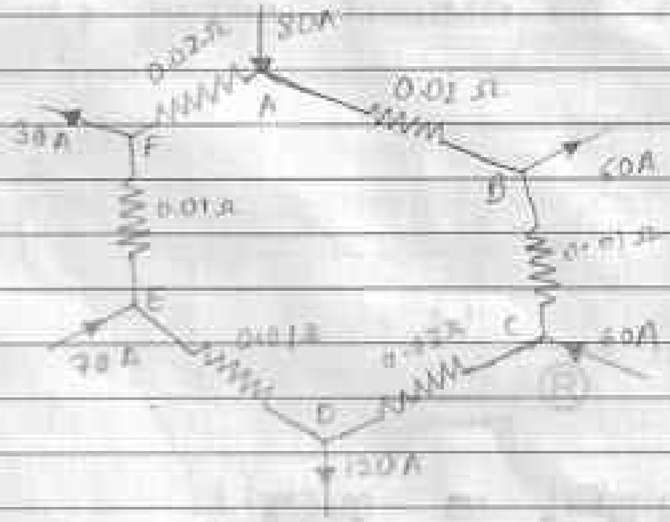
TUTORIAL 3

Subject :- BEE   Experiment / Tutorial / Assignment No. :- 3   Page :- 1

Q1] Find currents in all the branches of the network shown



Sol^n: let current in branch FA be I (→)
∴ current in AB is $(I+80)$ (→)

∴ Applying KVL,

$0.02I + 0.02(I+80) + 0.01(I+20) + 0.03(I+80)$
$0.01(I-40) + 0.01(I+30) = 0$
$0.01I - 0.4 + 0.01I + 0.3 = 0$
$0.1I + 4.1 = 0$
$I_{FA} = I = -41\,A$
$I_{AB} = I+80 = 39\,A$
$I_{BC} = I+20 = -21\,A$
$I_{CD} = I+80 = 39\,A$
$I_{DE} = I-40 = -81\,A$
$I_{EF} = I+30 = -11\,A$

∴ $I_{AB} = 39A$, $I_{BC} = -21A$, $I_{CD} = 39A$, $I_{DE} = -81A$,
$I_{EF} = -11A$, $I_{FA} = 41A$

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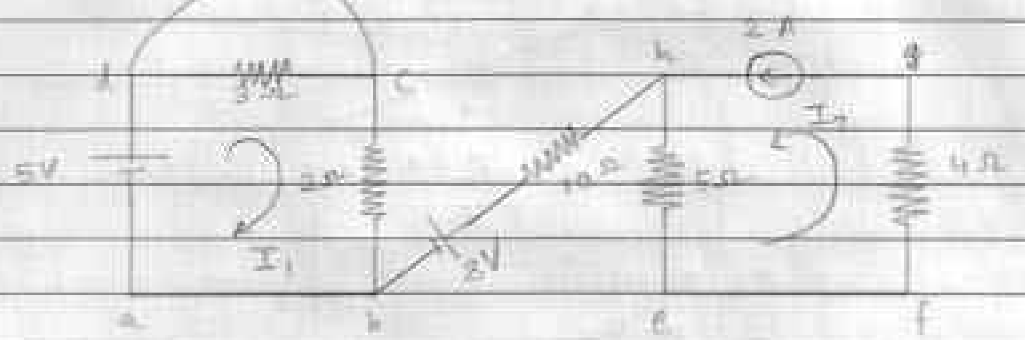
Q2] Find the potential at point e with respect to c (V_{ce}) in the network shown below.



Sol^n:

Apply KVL in mesh 1,

$-2I_1 + 5 = 0$

$I_1 = \underline{2.5\,A}$

Also current in mesh 2 is $I_2 = \underline{2\,A}$

∴ Now Applying KVL from node c to e

$V_c - 2I_1 + 8 - 10(0) - 5I_2 - V_e = 0$

$V_{ce} - 2(2.5) - 5(2) + 8 = 0$

$V_{ce} = \underline{7V}$

∴ The potential at point e w.r.t. c (V_{ce}) is $\underline{7V}$

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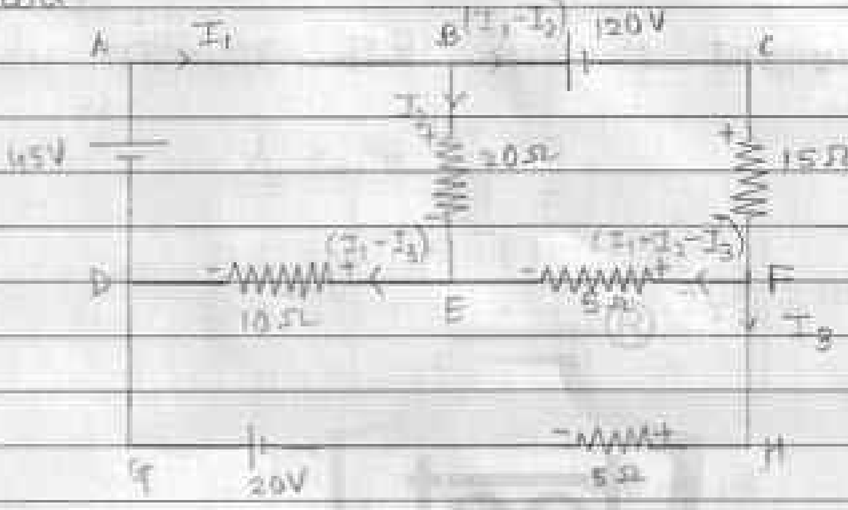
Q3] Determine the current through 20Ω resistor in the circuit shown below using KVL, KCL method



Sol^n:

Applying KVL in loop ABEDA,

$$-20I_2 - 10(I_1 - I_3) + 45 = 0$$
$$-20I_2 - 10I_1 + 10I_3 + 45 = 0$$
$$10I_1 + 20I_2 - 10I_3 = 45 \quad -(1)$$

Applying KVL in loop BCFEB,

$$-120 - 15(I_1 - I_2) - 5(I_1 - I_2 - I_3) + 20(I_2) = 0$$
$$-120 - 15I_1 + 15I_2 - 5I_1 + 5I_2 + 5I_3 + 20I_2 = 0$$
$$20I_1 - 40I_2 - 5I_3 = -120 \quad -(2)$$

Applying KVL in loop DEFHGD,

$$10(I_1 - I_3) + 5(I_1 - I_2 - I_3) - 5I_3 + 20 = 0$$
$$10I_1 - 10I_3 + 5I_1 - 5I_2 - 5I_3 - 5I_3 + 20 = 0$$
$$15I_1 - 5I_2 - 20I_3 = -20 \quad -(3)$$

Solving eq^n 1, 2 & 3

$I_1 = -0.98A$, $I_2 = 0.55A$, $I_3 = -0.378A$

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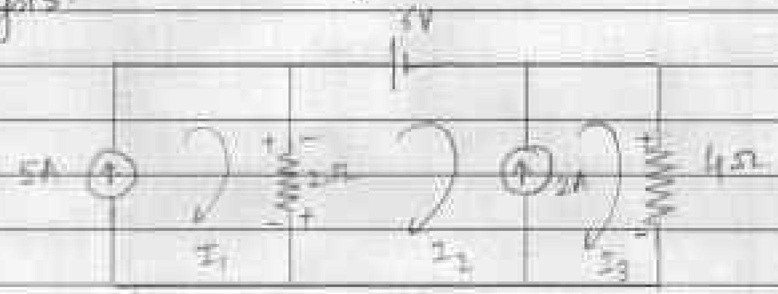
$\therefore$ current through 20Ω is
$I_{20\Omega} = I_2 = 2.55A$

Q4] Find current through 4Ω resistor using mesh analysis.



Sol^n: $I_1 = 5A$

Writing equation for supermesh

$\therefore I_3 - I_2 = 2A$

$\therefore 0I_1 - I_2 + I_3 = 2$ — ①

Applying KVL eq^n in the outerloop of supermesh.

$-6 - 4I_3 - 2(I_2 - I_1) = 0$

$-6 - 4I_3 - 2I_2 + 2I_1 = 0$

$2I_1 - 2I_2 - 4I_3 = 6$

$-2I_2 - 4I_3 = -4$ — ②

Applying KVL in mesh 1,

$\therefore$ On solving eq^n 1 & 2

$\therefore I_2 = -0.67A \quad I_3 = 1.33A$

$\therefore$ current through 4Ω is

$I_{4\Omega} = I_3 = 1.33A$

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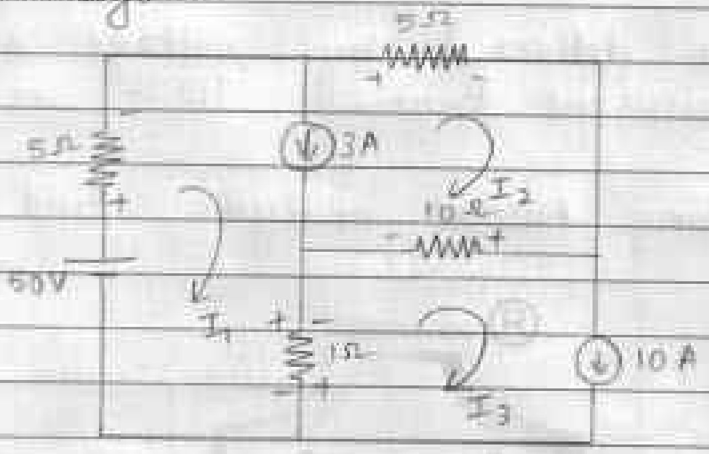
Q5] Determine the power delivered by the voltage source and the current in 10Ω resistor using mesh analysis.



Sol^n:

Mesh 3 contains current source.

$\therefore \quad I_3 = \underline{10\ A}$

Writing current eq^n for supermesh,

$I_1 - I_2 = 3 \quad \text{--- (1)}$

Applying KVL in outerloop of supermesh.

$-5I_2 - 10(I_2 - I_3) - 1(I_1 - I_3) + 50 - 5I_1 = 0$

$-5I_2 - 10I_2 + 10I_3 - I_1 + I_3 + 50 - 5I_1 = 0$

$-6I_1 - 15I_2 + 11I_3 = -50$

$-6I_1 - 15I_2 + 11(10) = -50$

$-6I_1 - 15I_2 = -160 \quad \text{--- (2)}$

$\therefore$ On solving eq^n 1 & 2

$I_1 = \underline{9.76\ A} \quad I_2 = \underline{6.76\ A}$

$\therefore$ current through ~~↑~~ 10Ω is

$I_{10\Omega} = \cancel{I_2 - I_3} = I_3 - I_2 = 10 - 6.76 = \underline{3.24\ A}$

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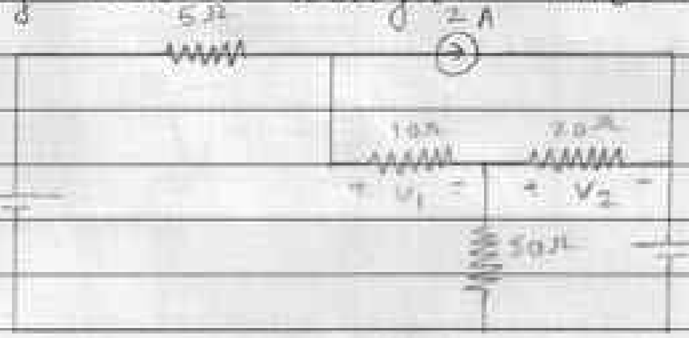
Subject :- BEE   Experiment / Tutorial / Assignment No. :- 3   Page :- 6

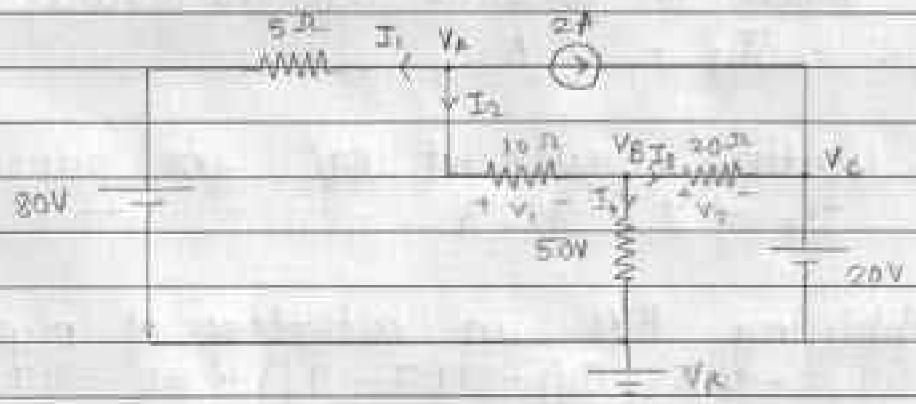
Power ~~diss~~ delivered by 50 V is
$P = I_1 V = 9.76 \times 50 = \underline{\underline{488 W}}$

$\therefore$ Power delivered by voltage source is $\underline{\underline{488 W}}$ and current through 10Ω is $\underline{8.24 A}$

6] By using Nodal analysis find V_1 & V_2



Sol^n.



Assuming all currents are moving away from nodes.

Applying KCL at node A.

$$I_1 + I_2 + 2 = 0$$

$$\frac{V_A - V_R - 80}{5} + \frac{V_A - V_B}{10} + 2 = 0$$

$$0.2V_A - 1.6 + 0.1V_A - 0.1V_B + 2 = 0$$

$$\therefore 0.3V_A - 0.1V_B = 1.4 \quad \text{--- (1)}$$

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Applying KCL at node B,

$$I_2 = I_4 + I_3$$

$$\frac{V_A - V_B}{10} = \frac{V_B - V_R}{50} + \frac{V_B - V_C}{20}$$

$$0.1V_A - 0.1V_B = 0.02V_B + 0.05V_B - 0.05V_C$$

$$\therefore \quad 0.1V_A - 0.17V_B + 0.05V_C = 0 \quad -(2)$$

Applying KCL at node C,

$$V_C - 20 = 0$$

$$V_C = 20\,V \quad -(3)$$

$\therefore$ eqⁿ 2 becomes

$$0.1V_A - 0.17V_B = -1 \quad -(4)$$

$\therefore$ On solving eqⁿ 1 & 4

$V_A = 60.4\,V$, $V_B = 41.46\,V$

$$\therefore \quad V_1 = V_A - V_B = 18.94\,V$$

$$V_2 = V_B - V_C = 21.46\,V$$

$\therefore$ V_1 & V_2 are 18.94 V and 21.46 V respectively.

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TUTORIAL 4

Subject :- BEE   Experiment / Tutorial / Assignment No. :- 4   Page :- 1

Q1] An alternating current varying sinusoidally with 50Hz has an rms value of 20A. write down the equation for the instantaneous value and find this value 0.0025 sec. After passing through a positive maximum value. At what time measured from a positive maximum value will the instantaneous current be 14.14 A?

Sol^n:

Given,

$f = 50\,Hz$

$I_{rms} = 20A$

$t_1 = 0.0025\,s$

$I_{inst} = 14.14A$

* To find,

$t = ?$

* Solution,

$\because f = 50$

$\therefore \omega = 2\pi f = 314.15$ rad $= 100\pi$

$I_{rms} = \frac{I_o}{\sqrt{2}}$ $\therefore I_o = \underline{28.28A}$

$\therefore I = I_o \sin(\omega t)$ ... eq^n for instantaneous value

$\therefore \underline{I = 28.28 \sin(314.15\,t)}$

at $t = 0.0025$ sec.

$\therefore$ ~~I = 28.28 sin (314.15 × 0.0025)~~

$I = 28.28 \sin(45)$

$\boxed{I = 20A}$

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Now, for positive maximum,

$I = I_0 \cos\omega t$

$\frac{14.14}{28.28} = \cos 100\pi t$

$\therefore t = \frac{60}{100\pi} = \frac{1}{300}$

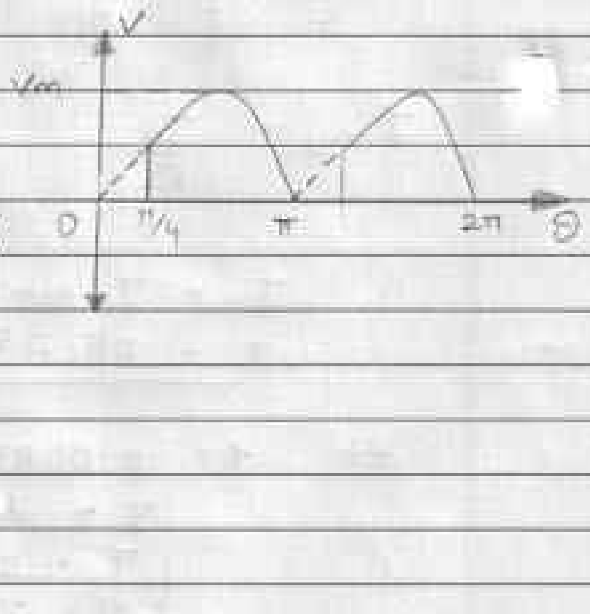
$\therefore \boxed{t = \frac{1}{300} \text{ sec}}$

$\therefore$ Eq^n for Instantaneous value : $I = 28.28 \sin(100\pi t)$

Instantaneous current : 20 A

Time measured from positive maximum is 1/300 sec

Q2] Find average value and rms value of the following waveform.



a) Sol^n :

Here, $V = V_m \sin\theta$

$\therefore$ ~~.....~~

Average value (half period)

$V_{avg} = \frac{1}{\pi}\int_{\pi/4}^{\pi} V_m \sin\theta \, d\theta$

$= -\frac{1}{\pi}\left[V_m \cos\theta\right]_{\pi/4}^{\pi}$

$V_{avg} = -\frac{V_m}{\pi}(-1.707)$

$\therefore \boxed{V_{avg} = 0.543 V_m}$

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RMS value,

$$\therefore V_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi}(V_m \sin\theta)^2\,d\theta}$$

$$= \sqrt{\frac{1}{2\pi} V_m^2 \int_0^{2\pi} \sin^2\theta\,d\theta}$$

$$= \sqrt{\frac{V_m^2}{2\pi}\left[\frac{\theta}{2} - \frac{\sin 2\theta}{4}\right]_0^{2\pi}}$$

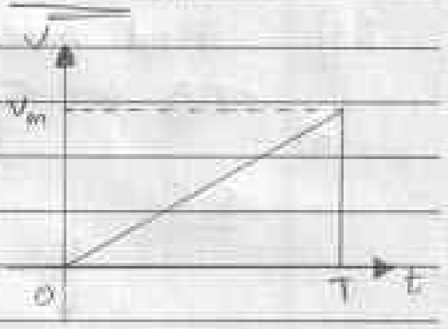
$$= V_m\sqrt{\frac{1}{2} - \frac{1}{8\pi}}$$

$$\boxed{V_{RMS} = 0.674\,V_m}$$

$$\therefore V_{avg} = \underline{0.543\,V_m} \quad \& \quad V_{rms} = \underline{0.674\,V_m}$$

b) Here,

$$V = \frac{V_m t}{T}$$



Average value,

$$V_{avg} = \frac{1}{T}\int_0^T V_m \frac{t}{T}\,dt$$

$$= \frac{V_m}{T^2}\int_0^T t\,dt$$

$$= \frac{V_m}{T^2}\left[\frac{t^2}{2}\right]_0^T$$

$$= \frac{V_m}{T^2} \times \frac{T^2}{2} = \frac{V_m}{2}$$

$$\therefore \boxed{V_{avg} = 0.5\,V_m}$$

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RMS value,

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T \left(V_m \frac{t}{T}\right)^2 dt}$$

$$= \sqrt{\frac{V_m^2}{T^3}\left[\frac{t^3}{3}\right]_0^T}$$

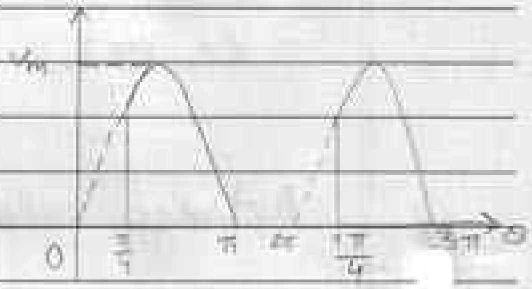
$$= \frac{V_m}{\sqrt{3}}$$

$\therefore$ $V_{rms} = \underline{0.577\,V_m}$

$\therefore$ $V_{avg} = \underline{0.543\,V_m}$ & $V_{rms} = \underline{0.577\,V_m}$

Q3] Find average value and rms value of the following wave forms.

a)



Soln.

$V = V_m \sin\theta \qquad \frac{\pi}{4} < \theta < \pi$

Average value

$$V_{avg} = \frac{1}{2\pi}\int_{\pi/4}^{\pi} V_m \sin\theta \, d\theta$$

$$= \frac{-1}{2\pi} V_m \left[\cos\theta\right]_{\pi/4}^{\pi}$$

$$= \frac{-V_m}{2\pi}(-1.707)$$

$V_{avg} = \underline{0.272\ V_m}$

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RMS value,

$$V_{rms} = \sqrt{\frac{1}{2\pi}\int_{\pi/4}^{\pi}(V_m \sin\theta)^2 \, d\theta}$$

$$= V_m \sqrt{\frac{1}{2\pi}\int_{\pi/4}^{\pi} \frac{1-\cos 2\theta}{2} \, d\theta}$$

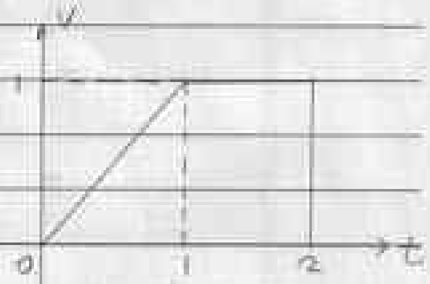
$$= V_m \sqrt{\frac{1}{2\pi}\left(\frac{\theta}{2} - \frac{\sin 2\theta}{4}\right)_{\pi/4}^{\pi}}$$

$$= V_m \sqrt{\frac{3}{16} - \frac{1}{8\pi}}$$

$$V_{RMS} = \underline{0.476 \, V_m}$$

$\therefore \quad V_{avg} = \underline{0.272 \, V_m}, \quad V_{rms} = \underline{0.476 \, V_m}$

b) $\underline{Sol^n}$:



$V = \frac{V_m t}{T}$

$V = t \qquad 0 < t < 1$

$\;\; = 0.5t \qquad 0 < t < 2$

Average value,

$$V_{avg} = \frac{1}{2}\left[\int_0^1 t \, dt + \int_0^2 0.5t \, dt\right]$$

$$= \frac{1}{2}\left[\frac{t^2}{2}\right]_0^1 + \frac{1}{4}\left[\frac{t^2}{2}\right]_0^2$$

$$= 0.25 + 0.5$$

$V_{avg} = 0.75 \, V$

RMS value,

$$\therefore \quad V_{rms} = \sqrt{\int_0^2 (0.5\,t)^2 \, dt}$$

$$= \sqrt{\frac{1}{4}\left[\frac{t^3}{3}\right]_0^2}$$

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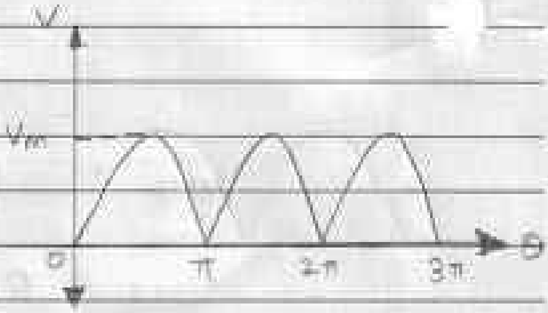
$V_{rms} = \sqrt{\frac{2}{3}} = 0.816\,V$

$\therefore V_{avg} = \underline{0.75\,V}$ $V_{rms} = \underline{0.816\,V}$

Q4] Find average value and rms value of the following waveforms.

a) Sol^n:

$V = V_m \sin\theta$



Average value,

$$V_{avg} = \frac{1}{\pi}\int_0^{\pi} V_m \sin\theta \, d\theta$$

$$= \frac{V_m}{\pi}\left[\cos\theta\right]_0^{\pi}$$

$$= \frac{2\,V_m}{\pi}$$

$\therefore V_{avg} = \underline{0.637\,V_m}$

RMS value,

$$V_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (V_m \sin\theta)^2 \, d\theta}$$

$$= V_m \sqrt{\frac{1}{2\pi}\int_0^{2\pi} \frac{1-\cos 2\theta}{2} \, d\theta}$$

$$= V_m \sqrt{\frac{1}{2\pi}\left[\frac{\theta}{2} - \frac{\sin 2\theta}{\pi}\right]_0^{2\pi}}$$

$$= V_m \sqrt{\frac{1}{2}}$$

$V_{rms} = 0.707\,V_m$

$\therefore V_{avg} = \underline{0.637\,V_m}$, $V_{rms} = \underline{0.707\,V_m}$

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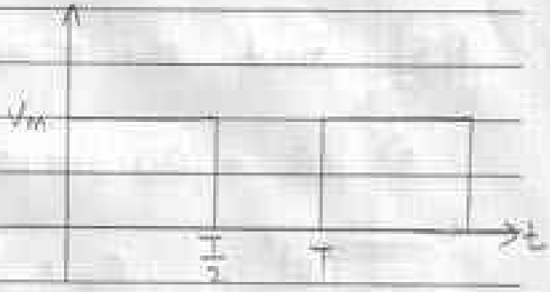
b) Sol^n:



$$V = \frac{V_m t}{T}$$

$$V = \frac{2V_m t}{T} \qquad 0 < t < \frac{T}{2}$$

$$= 0 \qquad \frac{T}{2} < t < \pi$$

Average value

$$V_{avg} = \frac{1}{T/2} \int_0^{T/2} \frac{2V_m t}{T} \, dt$$

$$= \frac{2^2}{T^2} V_m \left[\frac{t^2}{2}\right]_0^{T/2}$$

$$= \frac{V_m}{2}$$

$$V_{avg} = \underline{0.5 \, V_m}$$

RMS value,

$$V_{rms} = \sqrt{\frac{1}{T} \int_0^{T/2} (V_m)^2 \, dt}$$

$$= \sqrt{\frac{1}{T} \int_0^{T/2} V_m^2 \, dt} = \sqrt{\frac{1}{T} V_m^2 [t]_0^{T/2}}$$

$$= \sqrt{\frac{V_m^2}{T} \times \frac{T}{2}}$$

$$V_{rms} = \underline{0.707 \, V_m}$$

$$\therefore V_{avg} = \underline{0.5V_m}, \quad V_{rms} = \underline{0.707 V_m}$$

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5] Find the resultant of following voltages

a) $e_1 = 20 \sin \omega t$, $e_2 = 30 \sin(\omega t - \pi/4)$, $e_3 = 40 \cos(\omega t + \pi/6)$

Sol^n : $e_3 = 40 \cos(\omega t + \pi/6)$
$= -40 \sin(\omega t + \pi/6 - \pi/2)$
$e_3 = -40 \sin(\omega t - 2\pi/6)$

$e_r = e_1 + e_2 + e_3$
$= 20\angle 0^\circ + 30\angle 45^\circ - 45\angle -60^\circ$
$= 25.1 \angle 32.33^\circ$

$\therefore e = 25.1 \sin(\omega t + 32.33)$

b) $v_1 = 147.3 \cos(\omega t + 98.1^\circ)$, $v_2 = 294.6 \cos(\omega t + 45^\circ)$,
$v_3 = 88.4 \sin(\omega t + 135^\circ)$

Sol^n : $v_1 = 147.3 \sin(\omega t + 188.1)$
$v_2 = 294.6 \sin(\omega t + 45^\circ)$
$v_3 = 88.4 \sin(\omega t + 135)$

$v_r = v_1 + v_2 + v_3$
$= 147.3\angle 188.1 + 294.6\angle 45 + 88.4\angle 135$
$= 25.1 \angle 90$

$v = 25.1 \sin(\omega t + 90)$

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c) $e_1 = 25\sin \omega t$, $e_2 = 30 \sin(\omega t + \pi/6)$, $e_3 = 30 \cos \omega t$
$e_4 = 20 \sin(\omega t - \pi/6)$

Sol^n:

$e_3 = 30 \cos \omega t$
$e_3 = -30 \sin(\omega t - 90)$

$e = e_1 + e_2 + e_3 + e_4$
$= 25\angle 0 + 30\angle 30 + -30\angle -90 + 20\angle -30$
$e = 76.75 \angle 27.13$

$\therefore \quad e = 76.75 \sin(\omega t + 27.13)$

d) $v_1 = 60 \cos \omega t$, $v_2 = 40 \sin(\omega t - \pi/3)$, $v_3 = 15$

Sol^n:

$v_1 = 60 \cos \omega t$
$v_1 = -60 \sin(\omega t - 90)$

$V = v_1 + v_2 + v_3$
$= -60\angle -90 + 40\angle -60 + 15\angle 0$
$= 43.22 \angle 35.92°$

$v = 43.22 \sin(\omega t + 35.92)$

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TUTORIAL 5

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1] An alternating voltage $80 + j60$ V is applied to a circuit and the current flowing is $4 - j2$ A. Find a) impedance b) power consumed c) phase angle d) power factor.

Sol^n:

Given,

$V = 80 + j60 V = 100 \angle 37$ V

$i = 4 - j2$ A $= 2\sqrt{5} \angle -26.56$ A

To find,

Z, Power, ϕ, $Pf = ?$

Formula,

i) $Z = \frac{V}{I}$, ii) $P = VI \cos\phi$, iii) $Pf = \cos\phi$

Solution,

i) $Z = \frac{V}{I} = \frac{80 + j60}{4 - j2} = 22.36 \angle 63.43 \Omega$

ii) Power $= VI \cos\phi = 200W$

iii) Phase angle $(\phi) = 63.43°$

iv) $Pf = \cos\phi = 0.447$ (lagging)

$\therefore$ a) Impedance $= 22.36\ \Omega$

b) Power consumed $= 200$ W

c) Phase angle $= 63.43°$

d) Power factor $= 0.447$ (lagging)

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Q2] An AC circuit has following voltage and current $v = 325 \sin 314t$, $i = 65 \sin(314t + 1.57)$. Find (i) frequency (ii) RMS value of voltage and current (iii) impedance (iv) power factor

Sol^n: given,

$v = 325 \sin 314t$

$i = 65 \sin(314t - 1.57)$

To find

f, V_{rms}, I_{rms}, Z, $Pf = ?$

Formula,

i) $\omega = 2\pi f$, ii) $V_{rms} = V_0/\sqrt{2}$, iii) $I_{rms} = I_0/\sqrt{2}$

iv) $Z = \frac{V_0}{I_0}$, v) Pf :

Solution,

$\omega = 2\pi f$

$f = \frac{2\pi}{\omega} = \frac{2\pi}{314} = 50\ Hz$

$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{325}{\sqrt{2}} = 229.81\ V$

$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{65}{\sqrt{2}} = 45.96\ A$

$Z = \frac{V_0}{I_0} = \frac{325}{65} = 5\ \Omega$

$Pf = \cos\phi = \cos(1.57) = 0.99$ (lagging)

$\therefore$ a) frequency = 50 Hz, b) $V_{rms} = 229.81V$ c) $I_{rms} = 4596A$

d) $Z = 5\Omega$ e) power factor = 0.99 (lagging)

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Q3] In a series circuit containing resistance and inductance, the current and voltage are expressed as $i(t) = 5\sin(314t + 2\pi/3)$ and $v(t) = 20\sin(314t + \frac{5\pi}{6})$ a) what is the impedance of the circuit? b) what are the values of resistance, inductance and power factor c) what is the average power drawn by circuit?

Solⁿ:

Given,

$V = 20\sin(314t + 5\pi/6) = 20\angle 150^\circ$ V

$I = 5\sin(314t + 2\pi/3) = 5\angle 120^\circ$ A

To find,

Z, R, L, Pf, P_{avg}.

Formula,

i) $Z = \frac{V}{I}$; ii) $X_L = \omega L$, iii) $Pf = \cos\phi$,

iv) $P = VI\cos\phi$

Solution,

$Z = \frac{V}{I} = \frac{20\angle 150}{5\angle 120} = 4\angle 30\ \Omega$

$\therefore Z = 3.46 + 2j$

$\therefore R = 3.46\ \Omega$

$X_L = \omega L$

$L = \frac{X_L}{\omega} = \frac{2}{314} = 0.0063\ H$

$Pf = \cos\phi = \cos(30) = 0.866$ (lagging)

$P = VI\cos\phi = 43.3\ W$

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∴ i) Impedance = 4Ω
ii) Resistance = $3.46\ \Omega$
iii) Inductance = 0.0063 H
iv) Power factor = 0.866 (lagging)
v) Power drawn = 43.3 W

Q4] The voltage applied to a circuit is $e = 100\sin(\omega t + 30°)$ and current flowing in the circuit is $i = 15\sin(\omega t + 60°)$. Determine impedance, resistance, reactance, power and power factor.

Sol^n:

Given,

$e = 100\sin(\omega t + 30°) = 100\angle 30$

$i = 15\sin(\omega t + 60°) = 15\angle 60$

To find,

i) Impedance (z), ii) R, X_c, iii) P & pf.

Formula,

i) $z = \frac{V}{I}$ ii) $P = VI\cos\phi$ iii) $pf = \cos\phi$

Solution,

$z = \frac{V}{I} = 6.67\angle -30\ \Omega$

$z = 5.77 - 3.33j$

∴ $R = 5.77\ \Omega$

$X_c = 3.33\ \Omega$

$P = VI\cos\phi = 649.5$ W

$pf = \cos\phi = \cos(30) = 0.866$ (leading)

∴ i) Impedance = $6.67\ \Omega$

ii) Resistor = $5.77\ \Omega$ iii) reactance = $3.33\ \Omega$

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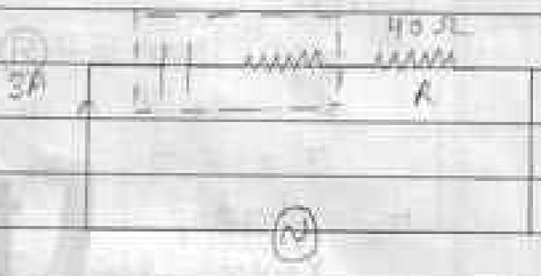
iv) Power = 649.5W v) Power factor = 0.866 (leading)

Q5] A load consisting of a capacitor in series with a resistor has an impedance of 50Ω and pf 0.707 leading. The load is connected in series with 40Ω resistor across AC supply and resulting current is 3A. Determine the supply voltage and overall phase angle.

Sol^n:

Given:



$Z = 50\Omega$

$pf = 0.707$ (leading)

$R = 40\Omega$

$I = 3A$

To find,

V, phase angle = ?

Formula,

i) $pf = \cos\phi$ ii) $V = IR$

Solution,

$pf = \cos\phi \Rightarrow \phi = 45°$

$\therefore Z = 50 \angle -45°$

$= 35.35 - 35.35j$

$Z = 75.35 - 35.35j$

$Z = 83.23 \angle -25.13\ \Omega$

$V = IZ = 3 \times 83.23 = 249.69V$

$\phi = -25.13°$

$\therefore$ Voltage = 249.69V & phase angle = $-25.13°$

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Q5] A leaky capacitor $Z_c = 74.5\Omega$ is in series with a coil $Z_L = 40\Omega$ & a resistor $R = 56\Omega$. when voltage $V = 200V$ is applied, $I = 2.5A$ & the p.d across R & Z_L combined is 194V. Find the loss in the capacitor.

Sol^n:

given,

$Z_c = 74.5\Omega$, $Z_L = 40\Omega$

$R = 56\Omega$, $V = 200V$

$I = 2.5$, $V_{Rcoil} = 194V$

To find,

Power loss = ?

Formula

$P = I^2 R$

solution,

$$Z_{Rcoil} = \frac{194}{2.5} = 77.6\Omega$$

$$\sqrt{(R+r_1)^2 + X_L^2} = 77.6$$

$$(56+r_1)^2 + X_L^2 = 77.6^2 \quad -(1)$$

Also $\sqrt{r_1^2 + X_L^2} = 40$

$$r_1^2 + X_L^2 = 40^2 \quad -(2)$$

on solving 1 & 2

$r_1 = 11.48\Omega$ $X_L = 38.32\Omega$

$$\sqrt{r_2^2 + X_c^2} = 74.5 \quad -(3)$$

$$Z_T = \frac{200}{2.5} = 80$$

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$$\sqrt{(R+r_1+r_2)^2+(X_1-X_c)^2} = 80$$
$$\sqrt{(56+11.48+r_2)^2+(38.32-X_c)^2} = 80$$

$$(56+11.48+r_2)^2+(38.32-X_c)^2 = 80^2$$
$$4553.55+134.96r_2+r_2^2+1468.42-76.64X_c+X_c^2 = 80^2$$

$\therefore$ Now eq^n 3 becomes,
$$134.96r_2 - 76.64X_c = -9172.22$$
$$X_c = 1.76r_2 + 67.49$$

$$\therefore r_2^2 = 5550.25 - X_c^2$$
$$= 5550.25 - (1.76r_2+67.49)^2$$
$$r_2 = 3.92$$

$\therefore$ Power ~~consumed~~ loss in capacitor is $= I^2 r_2 = (2.5)^2 \times (3.92) = 24.5\,W$

$\therefore$ Power loss in capacitor is $24.5W$

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TUTORIAL 6

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RLC

Q1] A RLC series circuit has a current which lags the applied voltage by 45°. The voltage across the inductance has maximum value equal to twice the maximum value of voltage across the capacitor. Voltage across the inductance is 300 sin (1000t) and R = 20Ω. Find the value of inductance and capacitance.

Sol^n:

Given,

$\phi = 45$

$v = 300 \sin(1000t)$

$R = 20\Omega$, $V_L = 2V_C$

To find,

$L, C = ?$

Formula,

$X_L = 2\pi f L = \omega L$

$X_C = \frac{1}{2\pi f C} = \frac{1}{\omega C}$

solution,

$V_L = 2V_C$

$\cancel{I} X_L = 2 \cancel{I} X_C$

$X_L = 2X_C$

$\cos\phi = \frac{R}{Z} \Rightarrow Z = \frac{20}{\cos 45} = 28.28\,\Omega$

$\therefore Z^2 = R^2 + (X_L - X_C)^2$

$28.28^2 = 20^2 + (X_C)^2$

$\therefore X_C = 20\Omega$

$\therefore X_C = \frac{1}{\omega C} \Rightarrow C = 50\mu F$

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$X_L = 2X_C = 40\,\Omega$

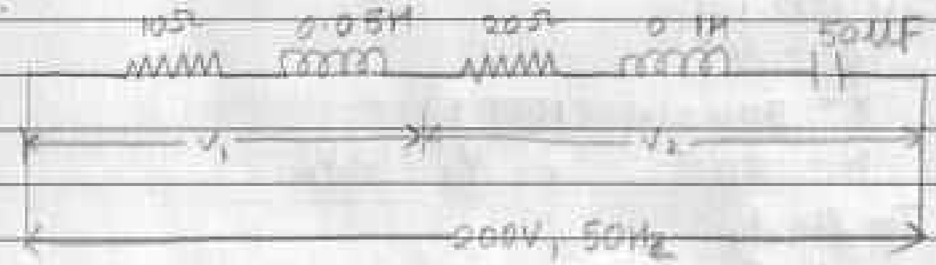
$\therefore X_L = \omega L$

$L = 0.04\,H$

$\therefore$ Inductance $= 0.04\,H$ & capacitance $= 50\,\mu F$

Q.2] Draw a vector diagram for circuit shown. Find the value of current, V_1 & V_2 & power factor.

Soln :



Soln:

Given,

$L_1 = 0.05\,H$, $R_2 = 20\,\Omega$

$L_2 = 0.1\,H$, $C = 50\,\mu F$

$R_1 = 10\,\Omega$

To find,

$I, V_1, V_2, P.f = ?$

Formula,

i) $I = \frac{V}{R}$, ii) $P.f = \cos\phi$

Solution,

$X_{L_1} = 2\pi f L_1 = 15.7\,\Omega$

$X_{L_2} = 2\pi f L_2 = 31.4\,\Omega$

$X_C = \frac{1}{2\pi f C} = 63.67\,\Omega$

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$Z = 30 - 16.57j = 34.27 \angle -28.9° \ \Omega$

$\therefore I = \frac{200 \angle 0}{34.27 \angle -28.9} = 5.83 \angle 28.9 \ A$

$Z_1 = R_1 + jX_{L_1} = 10 + 1.57j \ \Omega = 18.6 \angle 57.3° \ \Omega$

$Z_2 = R_2 + j(X_{L_2} - X_c) = 20 + j(31.4 - 63.67)$
$= 37.95 \angle -58.21° \ \Omega$

$Z_T = (R_1 + R_2) + j(X_{L_1} + X_{L_2} - X_c) = 30 + j(-16.57)$
$Z_T = 34.27 \angle -28.9° \ \Omega$

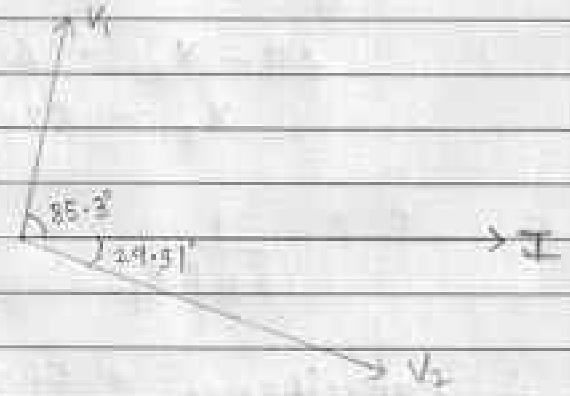
$\bar{V}_1 = \bar{I}\bar{Z}_1 = 5.83 \angle 28.9 \times 18.6 \angle 57.3$
$\bar{V}_1 = 108.56 \angle 85.3° \ V$

$\bar{V}_2 = \bar{I}\bar{Z}_2 = 5.83 \angle 28.9 \times 37.75 \angle -58.21$
$= 220.34 \angle -29.31° \ V$

~~cos ϕ~~ = Pf = $\cos\phi = 0.875$

$\therefore I = 5.83 \ A$,
$V_1 = 108.56 \ V$
$V_2 = 220.34 \ V$
$Pf = 0.875$

Phasor diagram:



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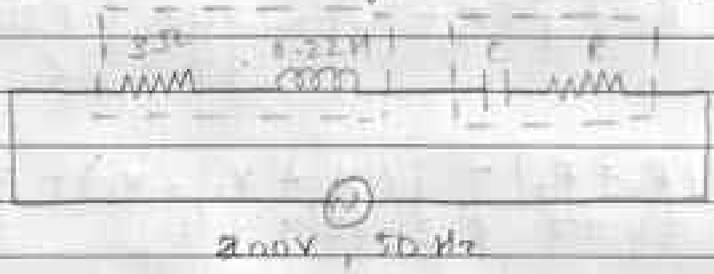
Q3] A coil of resistance 3Ω and inductance 0.22H is connected in series with imperfect capacitor when such a series circuit is connected across a supply of 200V, 50Hz, it has been observed that their combined impedance is (3.8+j6.4)Ω calculate the capacitance and its equivalent capacitor's resistance

Solⁿ:



Given,

$R = 3\Omega$, $L = 0.22H$, $V = 200V$, $f = 50Hz$,

$Z = (3.8 + j6.4)\Omega$

To find,

$C = ?$, $X_c = ?$

Formula,

$$C = \frac{1}{2\pi f X_c}$$

Solution

$$X_L = 2\pi f L = 69\Omega$$

$$\therefore Z = 3.8 + j6.4 \quad -①$$

$$Z = (3+R) + j(69 - X_c) \quad -②$$

$$\therefore 69 - X_c = 6.4 \quad \& \quad 3.8 = 3 + R$$

$$X_c = 62.6\Omega \qquad R = 0.8\Omega$$

$$C = \frac{1}{2\pi f X_c} = 50.87\,\mu F$$

$\therefore$ Capacitance $= 50.87\,\mu F$, Resistance $= 0.8\Omega$

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Resonance

Q1] A voltage $V(t) = 10 \sin \omega t$ is applied to a series RLC circuit. At resonant frequency voltage across capacitor is found to be 500V. The bandwidth of the circuit it known to 400 rad/sec and impedance at resonance is 1Ω. Determine resonant frequency, upper & lower cut off frequencies, L & C.

Sol^n:

Given,

$BW = 400$ rad/s

$V_c = 500V$, $V = 10 \sin \omega t$

$R = 1\Omega$

To find,

f_r, f_1, f_2, L & C = ?

Formula,

i) Bandwidth = $\frac{R}{L}$, ii) $f_r = \frac{1}{2\pi\sqrt{LC}}$, iii) Lower = $f_r - \frac{R}{4\pi L}$

iv) upper = $f_r + \frac{R}{4\pi L}$

Solution,

$V = \frac{V_m}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 7.07$ V

$BW = \frac{R}{L} = \frac{1}{400}$

$L = 0.0025$ H

$Q = \frac{V_c}{V} = \frac{500}{7.07} = 70.72$

$Q = \frac{1}{R}\sqrt{\frac{L}{C}} \Rightarrow C = 0.5\mu F$

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Resonant frequency : $f_r = \frac{1}{2\pi\sqrt{LC}} = 4503.86\ Hz$

lower cut frequency(f_1) : $f_r - \frac{R}{4\pi L} = 4475\ Hz$

upper cut frequency (f_2) = $f_r + \frac{R}{4\pi L} = 4538\ Hz$

∴ Resonant frequency = 4503.86 Hz
lower cut frequency = 4475 Hz
Upper cut frequency = 4538 Hz
Inductance = 0.0025 H
capacitance = 0.5 μF

Q2] Impedance of a circuit is observed to be capacitance and decreasing from 1Hz to 100Hz beyond 100Hz, impedance start increasing. Find the value of circuit elements if the power drawn by the circuit is 100W at 100Hz, when the current is 1A. Power factor of the ~~[illegible]~~ circuit at 70Hz is 0.707.

Soln:

Given,
$f_0 = 100Hz$, $P = 100W$,
when $I = 1A$, $f_1 = 1Hz$

To find
R, L, C = ?

Soln Formula,
i) $P = I^2 R$, ii) $f_0 = \frac{1}{2\pi\sqrt{LC}}$

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Solution,

lower cut off frequency $(f_1) = f_r - \frac{R}{4\pi L}$

$1 = 100 - \frac{R}{4\pi L}$

$\frac{R}{4\pi L} = 99$

$\frac{R}{L} = 396\pi$ — ①

$\because P = 100W$ when $I = 1A$

$\therefore P = I^2 R$

$100 = (1)^2 R$

$\therefore R = 100\,\Omega$

$\therefore$ from ①

$\frac{100}{L} = 396\pi$

$L = 0.08\,H$

At resonance, $f_r = \frac{1}{2\pi\sqrt{LC}}$

$\therefore C = 31.66\,\mu F$

$\therefore$ Resistor $= 100\,\Omega$
Inductance $= 0.08\,H$
capacitance $= 31.66\,\mu F$

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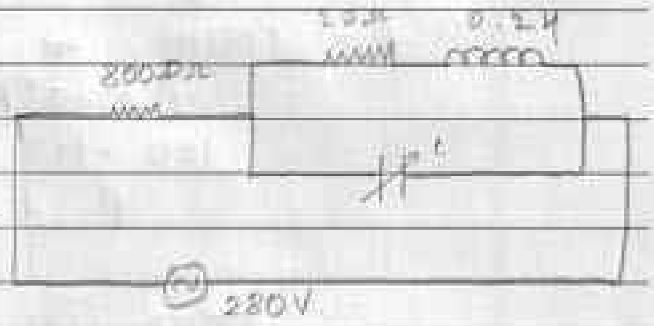
Q3] An inductance coil having a resistance of 20Ω and an inductance of 200 mH is connected in parallel with a variable capacitor. This parallel combination is connected in series with a resistance of 8000 Ω. A voltage of 230 V at frequency of 10^6 Hz is applied across the circuit. Calculate i) capacitance at resonance ii) Q factor of the circuit iii) dynamic impedance of circuit iv) total circuit current.

Sol^n:



given,

$R_s = 8000\,\Omega$

$R = 20\,\Omega$

$L = 0.2$ H

$V = 280$ V $\quad f_r = 10^6$

To find,

$C_r,\ Q,\ Z_0,\ I_T = ?$

Formula,

i) $f_r = \dfrac{1}{2\pi\sqrt{LC}}$ ii) $Q = \dfrac{2\pi f_r L}{R}$ iii) $Z_0 = \dfrac{L}{CR}$

Solution.

$f_r = \dfrac{1}{2\pi\sqrt{LC}} \Rightarrow 1/\sqrt{C} = 2\pi f_r \sqrt{L}$

$\therefore C = 1.269 \times 10^{-13}$ F

$Q = \dfrac{2\pi f_r L}{R} = 62800$

$Z_0 = \dfrac{L}{CR} = 7.88 \times 10^{10}\ \Omega$

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$Z_T = Z_1 + Z_3 = 7.883 \times 10^{10} \Omega$

$I = \frac{230}{7.883 \times 10^{10}} = 2.99 \times 10^{-9} A$

∴ Capacitance $= 1.269 \times 10^{-15}$ F
Q factor $= 62800$
Dynamic Impedance $= 7.88 \times 10^{10} \Omega$
Total circuit current $= 2.99 \times 10^{-7}$ A

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TUTORIAL 7

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Q1] A 30 kVA, 24500/120V, 50Hz transformer has a high-voltage, winding resistance of 0.1 ohm and leakage reactance of 0.22 ohm. The low voltage winding resistance is 0.035 Ω and the leakage reactance is 0.012 Ω, calculate for transformer:

a) Equivalent resistance as referred to both primary and secondary side.

b) Equivalent reactance as referred to both primary and secondary side.

c) Equivalent impedance as referred to both primary and secondary side.

d) copper loss at full load.

Sol^n:

a) Primary resistance = R_{01}
Secondary resistance = R_{02}

$$\therefore K = \frac{120}{24500} = 4.9 \times 10^{-3}$$

$$\therefore R_{01} = R_1 + \frac{R_2}{K^2} = 0.1 + \frac{0.035}{2.4 \times 10^{-5}}$$

$$R_{01} = 1458.44\ \Omega$$

$$R_{02} = R_2 + R_1(K^2) = 35\ m\Omega$$

b) Primary reactance = X_{01}
secondary reactance = X_{02}

$$X_{01} = X_1 + \frac{X_2}{K^2} = 500.22\ \Omega$$

$$X_{02} = X_2 + X_1(K^2) = 12\ m\Omega$$

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c) Primary impedance = Z_{01}
Secondary impedance = Z_{02}

$\therefore Z_{01} = \sqrt{R_{01}^2 + X_{01}^2}$
$Z_{01} = 1541.8\ \Omega$

$\therefore Z_{02} = \sqrt{R_{02}^2 + X_{02}^2}$
$Z_{02} = 0.037\ \Omega$ //

d) $I_{01} = \frac{30 \times 1000}{24500} = 1.22\ A$

Copper loss = $I_{01}^2 R_{01}$ = 2170.74 W.

$\therefore$ a) $R_{01} = 1458.44\ \Omega$
$R_{02} = 35\ m\Omega$
b) $X_{01} = 500.22\ \Omega$
$X_{02} = 12\ m\Omega$
c) $Z_{01} = 1541.8\ \Omega$
$Z_{02} = 0.037\ \Omega$
d) Copper loss = 2170.74 W //

Q2] A 5 KVA, 1000/200V, 50 Hz, single-phase transformer gives the following test results

No Load Test / O.C. Test (H.V side)	1000V	0.24A	90W
S.C. Test (L.V. Side)	50V	5A.	110W

Calculate :
a) The equivalent circuit constants refer to low voltage side and draw equivalent circuit diagram.

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sol^n:

1] for O.C. Test

$$\cos\phi = \frac{W_i}{I_0 V_1} = \frac{90}{0.24 \times 1000} = 0.375$$

$$\therefore \phi = 68^\circ$$

$$I_w = I_0 \cos\phi = 0.09\ A$$

$$I_\mu = I_0 \sin\phi = 0.22\ A$$

$$R_0 = \frac{V_1}{I_w} = 11.111\ K\Omega$$

$$X_0 = \frac{V_1}{I_\mu} = \frac{1000}{0.22} = 4545.45\ \Omega$$

2] for S.C. Test

$$Z_{02} = \frac{V_{sc}}{I_{sc}} = 10\ \Omega$$

$$R_{02} = \frac{W_{sc}}{I_{sc}^2} = \frac{110}{8^2} = 4.4\ \Omega$$

$$X_{02} = \sqrt{Z_{02}^2 - R_{02}^2}$$

$$X_{02} = 8.98\ \Omega$$

$\therefore$ So the equivalent circuit referred to L.V. side can Now, be drawn showing all the parameter values as Turn ratio, $K = \frac{200}{1000} = 0.2$

$$\therefore R_{01} = R_{02} / K^2 = 110\ \Omega$$

$$X_{01} = X_{02} / K^2 = 8.98 / 0.2^2$$

$$X_{01} = 224.5\ \Omega$$

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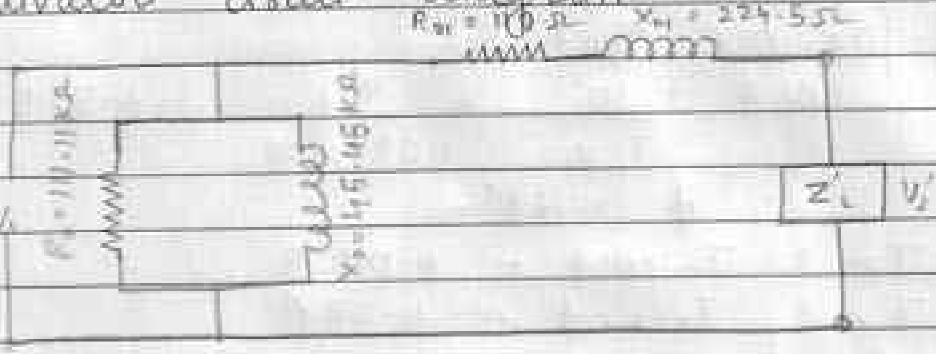
3] Equivalent circuit diagram



Q3] A 5kVA, 200/400 V, 50Hz, single-phase transformer gives the following test results:

O.C Test (L.V. side)	200 V	0.7 A	60 W
S.C. Test (H.V. side)	22 V	16 A	120 W

calculate :

a) The equivalent circuit constants refer to primary side and draw equivalent circuit diagram
b) Find efficiency and regulation at 0.9 p.f (lead) if operating at rated load
c) Find current at which efficiency is maximum

Sol^n: a) i) for OC test

$$K = \frac{400}{200} = 2$$

$$\cos\phi = \frac{W_i}{V_1 I_0} = \frac{60}{0.7 \times 200} = 0.428$$

$$\therefore \phi = 64.62^\circ$$

$\therefore I_w = I_0 \cos\phi$, $I_\mu = I_0 \sin\phi$

$I_w = 0.3\ A$ $I_\mu = 0.632\ A$

$\therefore R_0 = \dfrac{V_1}{I_w} = 666.67\ \Omega$, $X_0 = \dfrac{V_1}{I_\mu} = 316.45\ \Omega$

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ii) For S.C. test

$\therefore Z_{o2} = \frac{V_{sc}}{I_{sc}} = \frac{22}{16} = \underline{1.375\Omega}$, $R_{o2} = \frac{W_{sc}}{I_{sc}^2} = \underline{0.47\Omega}$

$\therefore X_{o2} = \sqrt{Z_{o2}^2 - R_{o2}^2} = \underline{1.29\Omega}$

$R_{o1} = \frac{R_{o2}}{K^2} = \frac{0.47}{2^2} = \underline{0.117\Omega}$, $X_{o1} = \frac{X_{o2}}{K^2} = \underline{0.322\Omega}$

iii) The equivalent circuit is

b) $W_i = 60W$

$\therefore I_{o2} = \frac{5000}{400} = 12.5A$

$\therefore W_{cu} = I_{o2}^2 R_{o2} = 12.5^2 \times 0.47$

$W_{cu} = 73.43 W$

$x = 1$, $pf = 0.9$

$\eta = \frac{x S \times pf}{pf \times S \times x + W_i + x^2 W_{cu}} = \frac{1 \times 5000 \times 0.9}{0.9 \times 5000 \times 1 \times 60 + 1^2(73.43)}$

$\eta = 0.9712 \times 100$

$\eta = \underline{97.12\%}$

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$\therefore$ Regulation at rated load and 0.9 pf.

$\cos\phi = 0.9$ $\quad$ $\sin\phi = 0.43$

$\therefore$ regulation $= \frac{I_2 (R_{02}\cos\phi - X_{02}\sin\phi)}{V_2} \times 100$

regulation $= \underline{-0.41\%}$

c) current at which efficiency is maximum

$W_i = I_{02}^2 R_{02}$

$I_{02} = \sqrt{\frac{60}{0.42}}$

$\therefore$ $\underline{I_{02} = 12 A}$

Q4] A 5KVA, 250/500 V, 50 Hz, single-phase transformer gives the following test results.

No Load test / O.C Test (L.V. side)	250 V	0.75 A	60 W
S.C. Test (H.V.) side	9 V	6 A	21.6 W

Calculate:

a) The equivalent circuit constants refer to primary side and draw equivalent circuit diagram

b) Efficiency at 60% of full load unity pf

c) Maximum efficiency and the load at which it occurs

d) The secondary terminal voltage on full load at pf of 0.8 lagging, unity and 0.8 leading

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Sol^n:

a) i) for O.C Test

$\therefore \cos\phi = \frac{W_i}{I_o V_1} = \frac{60}{250\times0.75} = 0.32$

$\phi = 71.33^\circ$

$\therefore I_w = I_o \cos\phi = 0.75\cos(71.33)$

$I_w = \underline{0.24\ A}$

$\therefore I_\mu = I_o \sin\theta = 0.75\sin(71.33)$

$I_\mu = 0.71\ A$

$\therefore R_o = \frac{V_1}{I_w} = 1041.67\ \Omega$

$X_o = \frac{V_1}{I_\mu} = 352.11\ \Omega$

ii) for S.C. Test

$\therefore K = \frac{500}{250} = 2$

$\therefore Z_{o2} = \frac{V_{sc}}{I_{sc}} = \frac{9}{6} = \underline{1.5\ \Omega}$

$R_{o2} = \frac{W_{sc}}{I_{sc}^2} = \frac{21.6}{6^2} = \underline{0.6\ \Omega}$

$\therefore X_{o2} = \sqrt{Z_{o2}^2 - R_{o2}^2} = \underline{1.374\ \Omega}$

$R_{o1} = \frac{R_{o2}}{K^2} = \frac{0.6}{2^2}$ $X_{o1} = \frac{X_{o2}}{K^2} = \frac{1.374}{2^2}$

$\underline{R_{o1} = 0.15\ \Omega}$ $X_{o1} = \underline{0.3435\ \Omega}$

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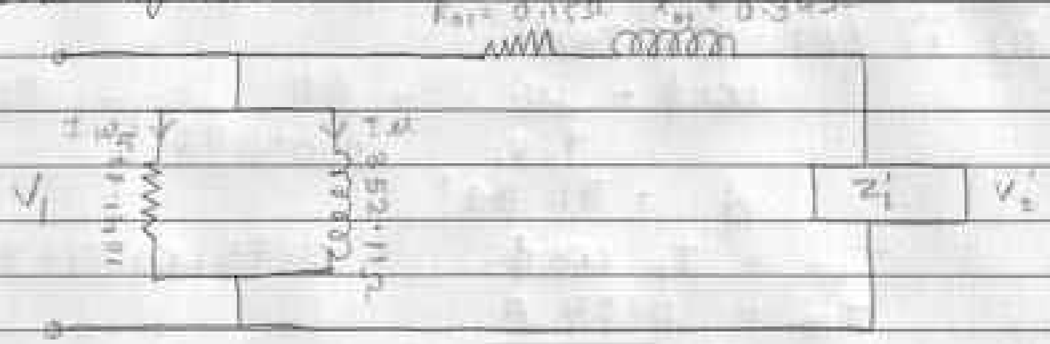
iii] The equivalent circuit is



b) $W_i = 60W$

$\therefore I_{02} = \frac{5000}{500} = 10 A$

$W_{cu} = I_{02}^2 R_{02} = 60 W$

$x = 0.6$, $Pf = 1$

$\eta = \frac{x_s \cos\theta}{\cos\phi \times S \times x + W_i + x^2 W_{cu}} = \frac{0.6 \times 5000 \times 1}{1 \times 5000 \times 0.6 + 60 + (0.6)^2 60}$

$\eta = 0.9735 \times 100$

$\therefore \eta = 97.35 \%$

c) $KVA_{(max)} = KVA_{FL} \sqrt{\frac{W_i}{W_{cu}}} = 5000 \times \sqrt{\frac{60}{60}}$

$= 5000 VA$

For maximum efficiency

$W_i = W_{cu} = 60W$, $Pf = 1$

$\eta = \frac{\text{load KVA} \times Pf}{\text{load KVA} \times Pf + W_i + W_{cu}} \times 100 = \frac{5000 \times 1}{5000 \times 1 + 60 + 60} \times 100$

$\eta = 97.65 \%$

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d) $\% \text{ regulation} = \frac{E_2 - V_2}{V_2}$

$\therefore \frac{I_2 R_{02} \cos\phi \pm I_2 X_{02} \sin\phi}{V_2} = \frac{E_2 - V_2}{V_2}$

$\therefore E_2 - V_2 = I_2 (R_{02} \cos\phi \pm X_{02} \sin\phi)$

$V_2 = E_2 - I_2 (R_{02} \cos\phi \pm X_{02} \sin\phi)$

For pf = 0.8 lagging

$\cos\phi = 0.8$

$\sin\phi = 0.6$

$\therefore E_2 = 500 \text{ V}$

$V_2 = 500 - 10 (0.6(0.8) + 1.37(0.6))$

$\therefore V_2 = \underline{486.98 \text{ V}}$

For pf = 0.8 leading

$V_2 = 500 - 10(0.6(0.8) - 137(0.6))$

$\therefore V_2 = \underline{503.42 \text{ V}}$

For unity pf

$V_2 = 500 - 10(0.6(1) + 0)$

$V_2 = \underline{494 \text{ V}}$

REPORT ON BULLET TRAIN

On the 5th of April 2021, the Innovative Exam of BEE was conducted where everyone was supposed to give a presentation on the topic assigned by the teachers in a group of four. Group no. 12 got the topic **BULLET TRAINS.** This group consisted of roll no. 45,46,47 and 48 namely Ishika Sharma, Sarvesh Sharma, Aditi Shetty and Aditya Shukla respectively.

The presentation was started by Ishika Sharma (roll no. 45). She gave the introduction to the topic and her above-mentioned group members along with the points that will be covered in the presentation. She told about bullet trains in short and the brief was covered by rest of the members. Bullet trains are named so because of their appearance and speeds. Many countries have also introduced Bullet trains which will also include India soon.

Ishika also told about the history of bullet trains, Hideo Shima was the one who invented bullet trains, the first bullet train was '**Tōkaidō Shinkansen**' from 1st October 1964 also the booming sound that train made while moving through a tunnel was then corrected by taking inspiration from the bird **KINGFISHER** and many more. Ishika then handed the presentation to Sarvesh Sharma (roll no. 46) to continue the presentation.

Sarvesh started his presentation with Existing High-Speed Rail Systems by Different Countries, with the help of tables he showed Countries of different regions like Asia, Europe, Africa, United States and Australia with their top speed of Bullet Trains.

In the Asia region, China was at the topmost position with speed of 320km/hr followed by Japan, South Korea, Turkey and many more with a speed of 320,305,300 km/hr respectively. In the Europe region, France is at the top with a speed of 320km /hr followed by Spain, Germany, the UK, Italy with speeds of 310,300,300,300 km/hr respectively. In Africa, US, Australia region, Morocco, USA & Oceania got trains with a top speed of 320,240,200 km/hr respectively.

Then he explained the Advantages and Disadvantages of Bullet Train whereas in the Advantages he included some of the major points like Speed, Comfort, Safety, No Overcrowding, Toughness and Bullet Trains are Eco-Friendly. In Disadvantages, he covered some important points like Cost of Construction, High Fares, Time Consuming Project, Land Acquisition and Other Issues as well. He Covered all the positive and negative points wisely. Sarvesh then requested Aditi Shetty (roll no. 47) to continue the presentation.

Bullet Trains seems to be one of the most magnificent creations of the human era. There is no comparison to this mode of transport. But, still just to make the critics clear about the significance of this transport, Aditi Shetty Roll no.47 elaborated how bullet trains are better than any other transport mode. Some of the many factors in which bullet trains are reliable are speed, safety, energy efficiency and market shares as well.
Also, Aditi Shetty further explained the deadly accidents in which unfortunately many people lost their lives. A few of them were Eschede, Wenzhou, Ankara and Lodi derailment in Italy. Unfortunately, It caused an ample amount of loss to mankind and financially to the government as well. But as of now, safety measures have been increased and they are much more reliable than before. From here Aditya Shukla (roll no. 48) continued the presentation.

Aditya started by saying that Prime minister Narendra Modi proposed the first bullet train in India for the Ahmedabad-Mumbai link covering 534 km at about 300km/h speed. Aditya highlighted bullet train in India there is many bullet train project in India but the one which would be completed early is Mumbai to Ahmedabad. japan gave Rs.79000

Crores to India. India will have to pay back till 2050 with a nominal interest of 0.1 percent. then it was followed by the ridership of bullet train Japan`s Shinkansen network had the highest annual passenger ridership of any high-speed rail network until 2011, when the Chinese high-speed railway network surpassed it at 370 million passengers annually, reaching over2.3billon passengers in 2019. Intercity effects of the bullet train are with high-speed rail there has been an increases inaccessibility within cities.it allows for urban regeneration, accessibility in cities near and far, and efficient inter-city relationships lead to high-level services to companies, advanced technology, and marketing. He onclude by saying that Bullet Train is a very good option to replace normal train as it is more efficient and does not make pollution.

Some of the most interesting actuality was shared by Aditi Shetty

So, at the end Sarvesh Ended the Presentation by saying that Bullet Trains are one of the best Magnificent Man-Made Creation.

- ISHIKA SHARMA-45
- SARVESH SHARMA-46
- ADITI SHETTY-47
- ADITYA SHUKLA-48