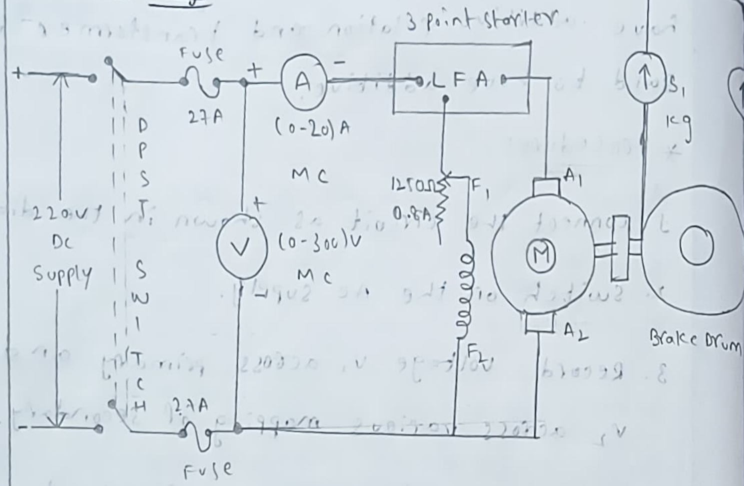
the EMF induced in primary and secondary have additive relation and transformer is said to have additive.

* Procedure:

1. connect the circuit as shown in the diagram
2. switch on the AC supply.
3. Record voltage V_1 across primary and V_2 across various mapping of secondary.
4. If $V_1 > V_2$ then transformer is step down.
5. if $V_2 > V_1$ then transformer is step up.
6. Switch off AC supply.

*Result:- The transformation ratio and the secondary current and measured for a given single phase transformer.

* circuit Diagram:-



* Tabular column:

circumference of Brake Drum = 60 cm

S.No	voltage	current	speed in rpm	spring Balance		$F=(S_1-S_2)\times 9.81$	Torque (NM)	output power (W)	input power (W)	Efficiency η in (%)
				S_1	S_2					
1.	210	1.2	1532	0	0	0	-	-	-	-
2.	210	2.2	1500	4	1	29.43	3.4	441.436	462	95.54
3.	208	7.1	1480	8	2	58.86	6.7	871.04	1476	59.01
4.	200	9	1450	10	3	68.67	7.8	995.74	1800	55.32
5.	200	10.6	1400	12	3	88.29	10.1	1236	2120	59.24

Experiment - 13

DC shunt Motor

* **Aim:-** To conduct the brake Load test on DC shunt motor and determin its performance characteristics

* **Apparatus Required:**

Sl.No	Name of the Apparatus	Range	Type	Quantity
1.	Ammeter	(0-20) A	Digital	1
2.	voltmeter	(0-300) v	Digital	1
3.	Rheostat	370 / 1.7 A	wire wound	1
4.	RPM meter	(0-9999) rpm	Digital	1
5.	connecting wires	-	-	As Required

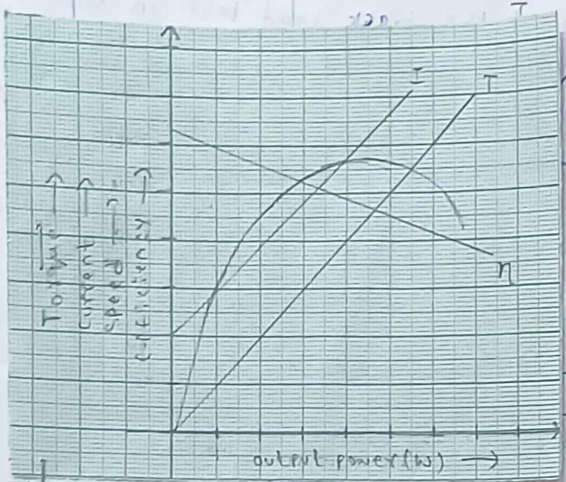
* **Theory:-**

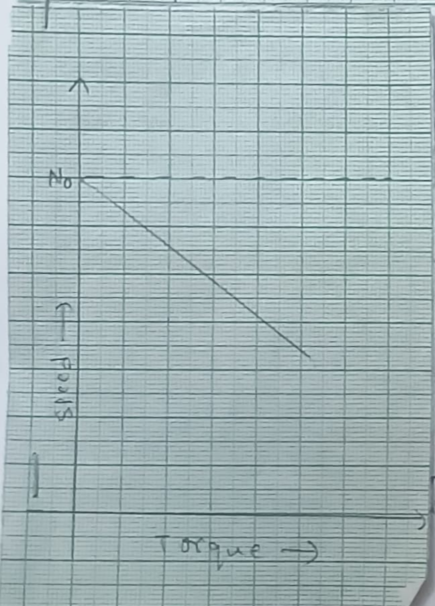
It is a direct method in which a braking force is applied to a pulley mounted on the motor shaft. A belt is wound round the pulley and its two ends are attached to the frame through two spring balance S1 and S2. The tension of the belt can be adjusted with the help of tightening wheels. The tangential force acting on the pulley is equal to the difference between the readings of the two spring balances.

* **Procedure:-**

1. Make the connection as shown in the circuit diagram.

*Model Graph:





2. Keeping the field rheostat (Rf) at the minimum position, switch on the supply and start the motor.

3. Adjust the speed of the motor on no load to its rated value by means of the field rheo-stat. Do not distrub the position of the rheostat throughout the test.

4. Put on the load by tightening the screws of the spring balances. Note down the spring tensions, the speed, the voltage and the currents at different loads until full load current obtained.

*Result:- Thus the performance characteristics of DC shunt motor was obtained by conducting brake test

Model calculation:

Formula:

$$\boxed{\text{Slip} = \frac{\text{Calculated RPM} - \text{running RPM}}{\text{Calculated RPM}}}$$

$P = 4$

$$\text{calculated RPM} = \frac{120F}{P}$$

1) calculated RPM for $f = 6.42$

$$RPM = \frac{120 \times 6.42}{4}$$

$$\boxed{RPM = 192.6}$$

$$\text{Slip} = \frac{192.6 - 192}{192.6}$$

$$\boxed{\text{Slip} = 0.003}$$

Experiment - 14

Three phase Induction motor drive systems in electrical vehicle applications:

* Aim:- To study the function of three phase induction motor drive systems in E-mobility.

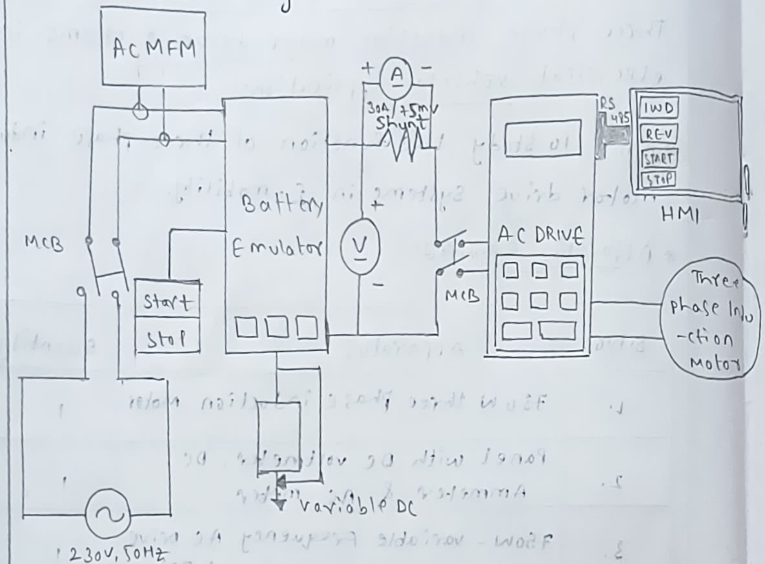
* Apparatus Required:-

S.No	Apparatus	Quantity
1.	750 W three phase induction Motor	1
2.	Panel with DC voltmeter, DC, Ammeter & AC meter.	1
3.	750W - variable Frequency AC Drive (VFD)	1
4.	Human Machine Interface (HMI)	1
5.	12V Alternator with 12V Batteries for Electrical Loading	1

* Procedure:

1. Give AC supply to meter(s), Battery Emulator/ DC Drive & HMI etc..
2. Fully Rotate Potentiometer of DC control connected with Battery Emulator.
3. Select Forward / Reverse Mode using HMI.
4. vary the Frequency using VFD.
5. connect 12V Battery in excitation Panel of Alternator according to connection Diagram & Make sure to switch on the Toggle switch.

* Three phase AC Induction motor Based Model connection Diagram.



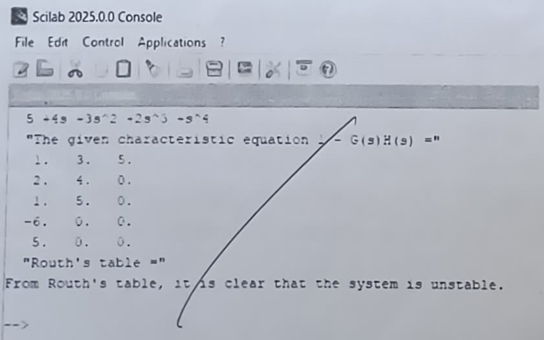
calculations:

S.No	Frequency (f)	Output voltage (V)	Ratio V/f	RPM calculated (NS=120F/P)	Tacho-meter RPM	slip
1.	6.42	31	4.82	192.6	192	0.003
2.	12.80	58	4.53	384	384	0
3.	17.63	79	4.48	528.9	528	0.0017
4.	21.37	95	4.44	641.1	641	0.0001
5.	30.82	136	4.412	924.6	924	0.0006
6.	37.41	165	4.410	1122.3	1122	0.0002

6. Calculate different values given on the below Table to understand the working characteristics of VFD & Three phase Induction Motor Drive System.

*Result: The test on three phase induction motor drive system in E-Mobility is performed successfully.

```
clear;
clc;
mode(0);
s = %s;
H = s^4 + 2*s^3 + 3*s^2 + 4*s + 5;
disp(H, 'The given characteristic equation 1 - G(s)H(s) =');
c = coeff(H);
len = length(c);
r = routh_t(H);
disp(r, 'Routh''s table =');
x = 0;
for i = 1:size(r, 1)
    if r(i, 1) < 0 then
        x = x + 1;
    end
end
if x >= 1 then
    printf('From Routh''s table, it is clear that the system is unstable.\n');
else
    printf('From Routh''s table, it is clear that the system is stable.\n');
end
```



```
Scilab 2025.0.0 Console
File  Edit  Control  Applications  ?

  5 +4s -3s^2 -2s^3 -s^4
  "The given characteristic equation 1 - G(s)H(s) ="
   1.   3.   5.
   2.   4.   0.
   1.   5.   0.
  -6.   0.   0.
   5.   0.   0.
  "Routh's table ="
From Routh's table, it is clear that the system is unstable.

-->
```

Experiment - 15

Stability of a system using Routh Hurwitz criterion

*** Aim:-** To determine the stability of the closed-loop system using Routh Hurwitz criterion for the given polynomial characteristics equations.

$\Rightarrow (S) = S^4 + 2S^3 + 3S^2 + 4S + 5$

*** Software Required:**

$\Rightarrow$ scilab.

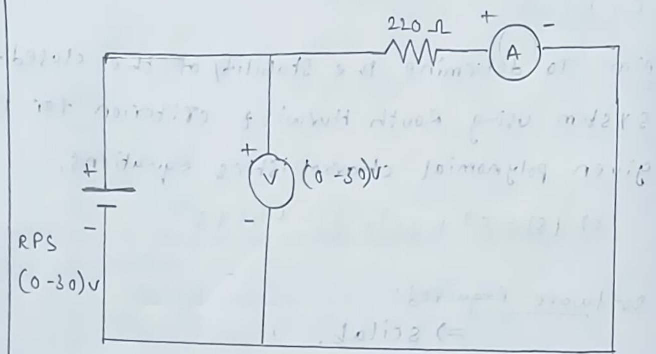
*** Procedure:**

1. Start the scilab program.
2. Open the scinotes & type the program in current directory compile & run the program.
3. If any error occur in the program correct the error & run the program.
4. For the output, see the console window.

*** Result:-** Scilab program is generated successfully.

Thus the stability of a system using routh hurwitz criterion is verified.

* Circuit Diagram:



*Observations:

S.No	Voltage (V)	Current (mA)	Experimental value R=V/I in Ω	Theoretical value R=V/I in Ω
1.	1	5	200	220
2.	2	10	200	220
3.	3	16	187.5	220
4.	4	20	200	220
5.	5	24	208.3	220

Experiment -16 (a)

verification of ohm's and kirchhoff's laws

(a) verification of ohm's law:

* Aim:- To verify ohm's law for a given resistive network.

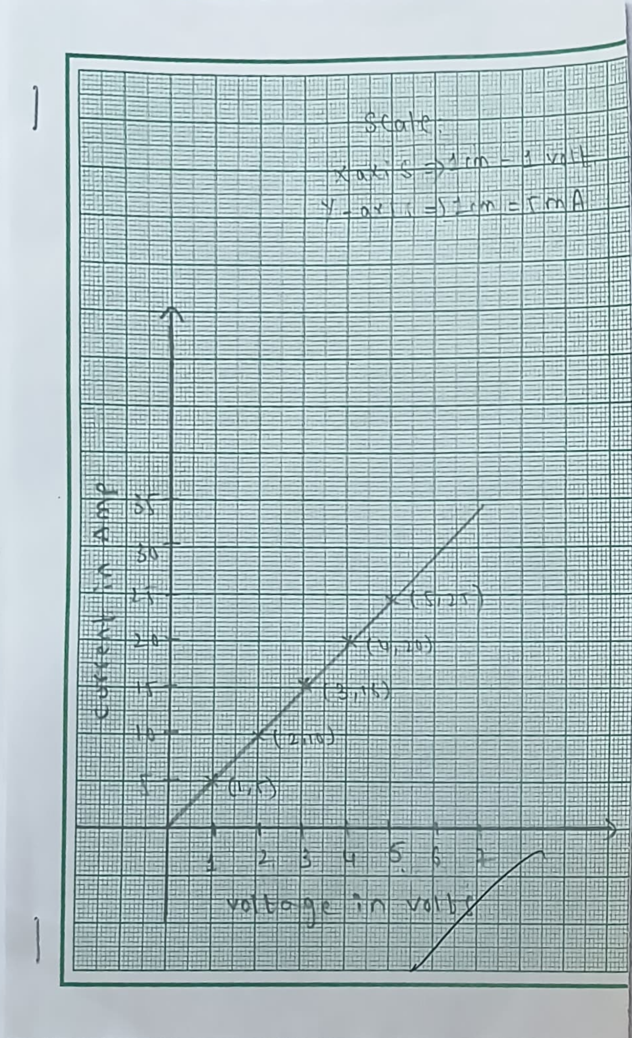
* Apparatus Required:

S.No	Apparatus	Range	Quantity
1	RPS	(0-30) V	1
2	Ammeter	(0-200) mA	1
3	voltmeter	(0-30) V	1
4	Resistor	1 KΩ	1
5	Rheostat	300 Ω/2A	1
6	Bread board & connecting wires	-	Required

* Procedure:

1. Make the connections as per circuit diagram.
2. Switch ON the power supply to RPS and apply a voltage (say 10V) and take the reading of voltmeter and ammeter.
3. Adjust the rheostat in steps and take down the readings of ammeter and voltmeter.
4. Plot a graph with V along x-axis and I along y-axis.
5. The graph will be a straight line which

* Model Graph:



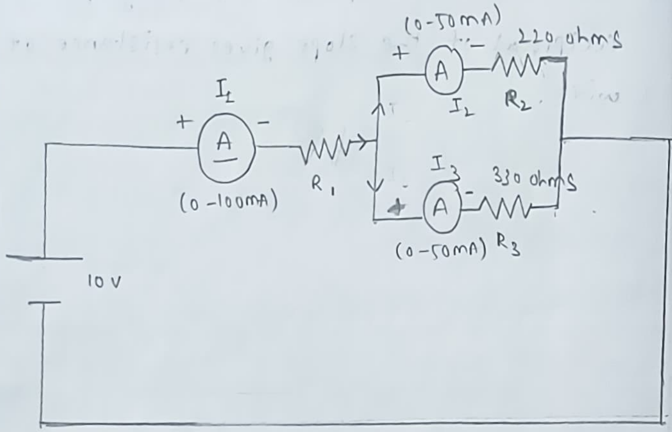
verifies ohm's law.

6. Determine the slope of the V-I graph. The reciprocal of the slope gives resistance of the wire.

* Result:-

Thus the ohm's law is verified for the given circuit.

* kirchhoff's current law circuit diagram:



* Tabulation for KCL

Parameter	Theoretical value			
supply voltage	current I_1 (mA)	current I_2 (mA)	current I_3 (mA)	I_2+I_3
10V	21.64	12.98	8.6575	21.64

Experiment-16(b)

verification of kirchhoff's law

*Aim:-

1. To verify kirchhoff's voltage law
2. To verify kirchhoff's current law

*Apparatus Required:

S.No	Name of the Equi-pment	Type	Range	Qty
1.	RPS	-	(0-15) v	1
2.	Bread board	-		1
3.	Ammeter	MC MC	(0-10) mA (0-5) mA	1 2
4.	voltmeter	MC MC	(0-10) v (0-15) v	1 1
5.	Resistor	-	470Ω, 330Ω, 4kΩ, 4.7kΩ	Each 1
6.	connecting wires	-	-	As Required

* Procedure:

1. connections are given as per the circuit diagram.
2. Apply d.c voltage to the circuit from the given RPS.
3. Tabulate the voltmeters and Ammeters readings for the corresponding experiment.
4. Increase the voltage step by step to get

* Theoretical calculation:

To find R_{eq}:

$R_{eq} = R_1 + R_2 \| R_3$

$R_{eq} = 330 + 220 \| 330$

$R_{eq} = 330 + \left(\frac{220 \times 330}{220+330} \right) = 462\,\Omega$

$V = 10V$

$I = V/R = 10/462 = 0.02164\,A = 21.64\,mA$

$V_1 = I_1 R_1 = 0.02164 \times 330 = 7.14V$

$V = V_1 + V_2$

$10 = 7.14 + V_2$

$V_2 = 2.857\,V$

$I_2 = \frac{V_2}{R_2} = \frac{2.857}{220} = 0.01298 = 12.98\,mA$

$I_3 = \frac{V_3}{R_3} = \frac{2.857}{330} = 8.6575\,mA$

Sum of incoming current = Sum of outgoing current

$I_1 = I_2 + I_3$

$I_1 = 12.98 + 8.657$

$\boxed{I_1 = 21.64\,mA}$

different readings till the voltage reached up to 15V.

5. Repeat step 3 for different values.

6. switch OFF the power supply after bringing RPS to the minimum voltage position.

Result: Thus the kirchhoff's current law is verified for a given circuit.

Theoretical calculation:

$V = 20\,V$

$R = R_1 + R_2 + R_3$

$R = 330 + 330 + 220 = 880\,\Omega$

$I = V/R = 20/880 = 0.02273\,A$

$= 22.73\,mA$

$V_1 = IR_1 = 0.02273 \times 330 = 7.5\,V$

$V_2 = IR_2 = 0.02273 \times 330 = 7.5\,V$

$V_3 = IR_3 = 0.02273 \times 220 = 5\,V$

$V = V_1 + V_2 + V_3$

$V = 7.5 + 7.5 + 5$

$\boxed{V = 20\,V}$

* Kirchhoff's voltage law

* Aim:- To verify kirchhoffs voltage law.

* Apparatus Required.

S.NO	Apparatus	Range	Quantity
1	DC regulator Power supply	(0-30) v	2
2	voltmeter	(0-30) v	3
3	Resistor	1kΩ, 220Ω, 330Ω	each one
4	Bread board and connecting wires	-	Required

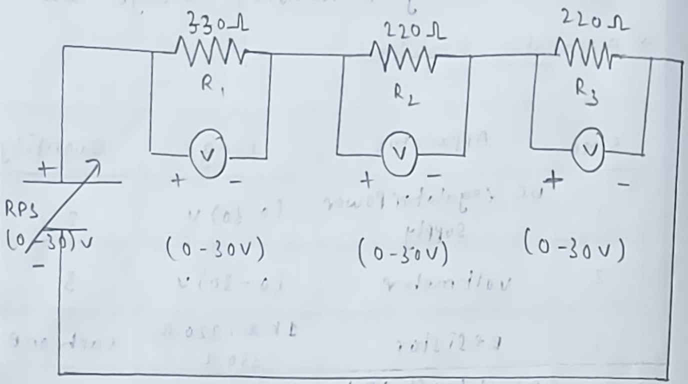
* Statement:

KVL: In any closed path/mesh, the algebraic sum of all voltage is zero.

* Procedure:

1. Give the connections as per the circuit diagram.
2. Set a particular value in RPS.
3. Note all the voltage reading.
4. Repeat the same for different voltege.

* Circuit diagram for KVL:



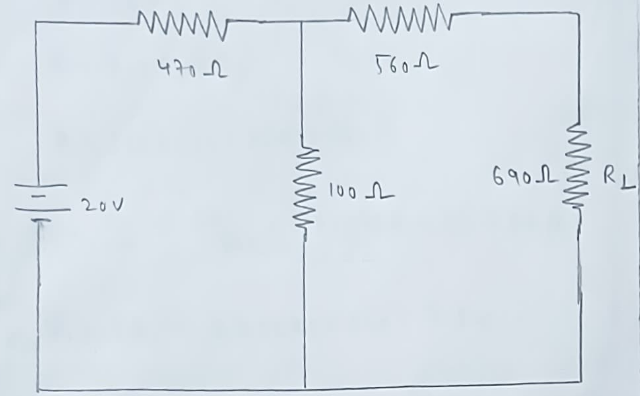
* Tabulation for KVL:

Parameter	Theoretical value			
Supply voltage	voltage Across R_1	voltage Across R_2	voltage Across R_3	Loop current (mA)
20V	7.5V	7.5V	5V	22.73

* Result:-

Thus the kirchhoff's voltage law is verified for the given circuit.

* circuit Diagram:



observation:

S.No	Supply voltage (V)	Theoretical values			Measured values		
		Rth (Ω)	Vth (V)	IL (mA)	Rth (Ω)	Vth (V)	IL (mA)
1.	20	642.5	3.5	4.06	640	3.5	4

Experiment - 17

verification of Thevenin's and Norton's Theorem

* Aim:- To verify the equivalent circuit param-eters to Thevenin's and Norton's Theorem theoritically and Practically.

* Apparatus Required:

S.No	Apparatus Name	Range	Quantity
1.	DC Regulator Power supply	(0-30) V	1
2.	voltmeter	(0-30) V	1
3.	Ammeter	(0-200) mA	1
4.	Resistor	330 Ω, 220 Ω, 470 Ω, 560 Ω, 110 Ω	As Required
5.	Multimeter	-	1
6.	Bread board and connec-ting wires.	-	As Reqired

* Procedure for Thevenin's Theorem:

1. Give the connection as per the circuit diagram.
2. Measure Rth using a multimeter by killing Source (oc the current source and s.c the voltage) and open circuit RL.
3. Measure Vth across A & B (open circuit RL)
4. Measure load current IL through RL.

$$\boxed{I_L = \frac{V_{th}}{R_{th} + R_L}}$$

Model calculation for Thevenin's Theorem.

To find R_{th} $\Rightarrow$ $\frac{470 \times 100}{570}$

$= 82.5\,\Omega$

$R_{th} = 82.5 + 560$

$= 642.5\,\Omega$

To find V_{th} $\Rightarrow$

$I = \frac{20}{470+100} = 0.035\,A$

$V_{th} = V_{100\,\Omega} = 100 \times 0.035$

$V_{th} = 3.5\,V$

To find I_L from Thevenin's equation

$I_L = \frac{V_{th}}{R_{th}+R_L} = \frac{3.5}{642.5+220}$

$I_L = 4.06\,mA$

5. Draw the Thevenin's Equivalent circuit.

* Procedure for Norton's Theorem:

1. Give the connection as per the circuit diagram.
2. Measure R_{th} using a multimeter by killing source (o.c the current source and sc the voltage source) and open circuit. R_L
3. Measure I_n through A & B (short circuit R_L).
4. Measure load current I_L through R_L.
5. Draw the Norton's Equivalent circuit.

*Model calculations for Norton's Theorem

$R_{th} = 642.5$

To find I_{sc} or I_N:

$$R_{eq} = 470 + \frac{560 \times 100}{560+100}$$

$$= 470 + 84.85$$

$$R_{eq} = 554.85\,\Omega$$

$$I_t = V/R_{eq} = \frac{20}{554.85} = 0.0364$$

By current division rule

$$I_{sc} = I_{560} = \frac{I_t}{R_t} \times R_{eq} = \frac{0.036}{100+560} \times 100 = 5.455\,mA$$

$$I_L = \frac{I_{sc}}{R_{th}+R_L} \times R_{th}$$

$$= \frac{5.455 \times 10^{-3} \times 642.5}{642.5+220}$$

$$I_L = 4.063\ mA$$

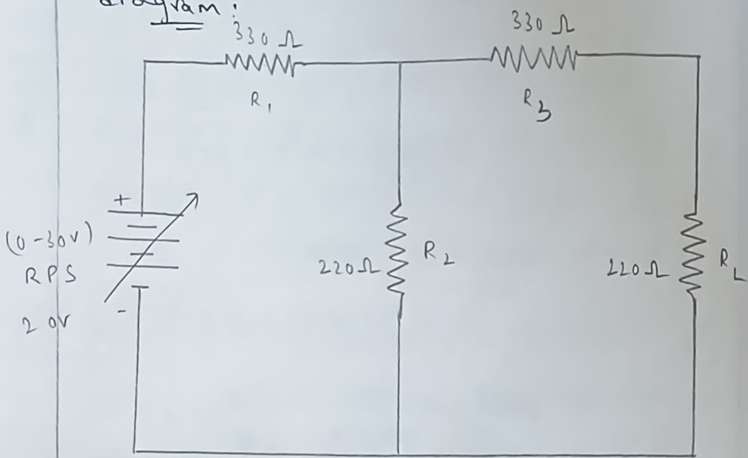
* observation:

S.no	supply voltage (V)	Theoretical values			Measured values		
		R_{th} (Ω)	I_{sc} (mA)	I_L (mA)	R_{th} (Ω)	I_{sc} (mA)	I_L (mA)
1.	20	642.5	5.455	4.063	640	5.5	4.0

***Result**:- Thus the equivalent circuit parameters are obtained using Thevenin's and Norton's Theorem.

verification of max power transfer circuit

diagram:



observation:

S.No	Supply voltage (v)	Theoretical values Rth (Ω)	Vth (v)	I_L (mA)	Measured values Rth (Ω)	Vth (v)	I_L (mA)	Maximum Power $P_{max} = I_L \cdot R_L$ (watt)
1.	20	47	13.38	91.38	47	13	88	0.363
2.	25	75	13	76.57	75	13	74.2	0.414
3.	30	100	13	67.2	100	13	65.5	0.422
4.	35	120	13	60.4	120	13	59	0.417
5.	40	150	13	53.3	150	13	52	0.4056

Experiment - 18

verification of maximum Power transfer theorem and superposition theorem.

(a) verification of maximum Power transfer theorem

* Aim:- To verify maximum Power transfer theorem.

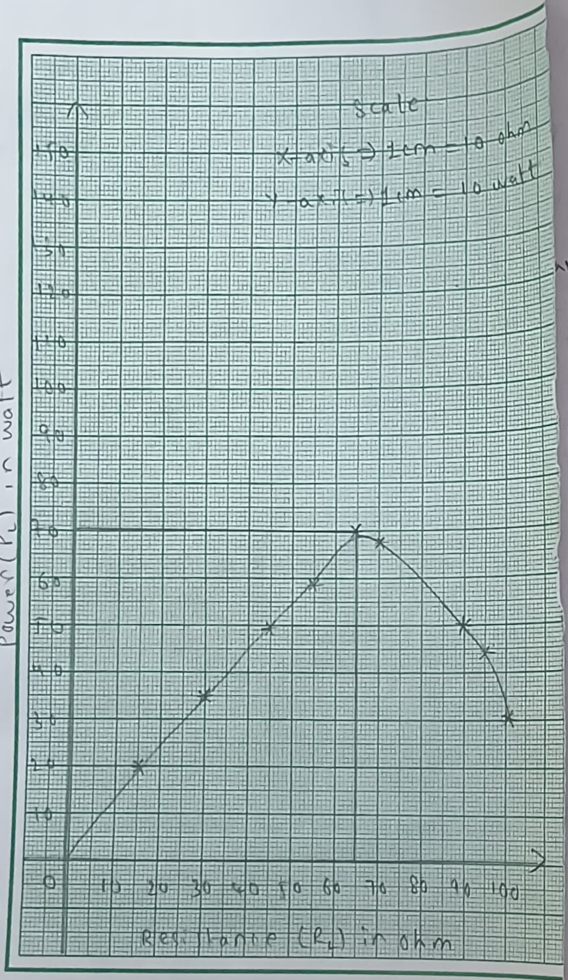
* Apparatus Required:

S.No	Apparatus Name	Range	Quantity
1.	DC regulater, Power supply.	(0-30) v	1
2.	voltmeter	(0-30) v	1
3.	Ammeter	(0-200) mA	1
4.	Resistor	330 Ω, 220 Ω	each two
5.	Multimeter	-	1
6.	Bread board & connecting wires.	-	Required

* Procedure:-

1. Give the connection as per the circuit diagram.
2. Measure Rth using a multimeter.
3. Measure Vth across 220 Ω (R_2)
4. measure load current I_L through R_L.
5. calculate maximum power transferred to the load.

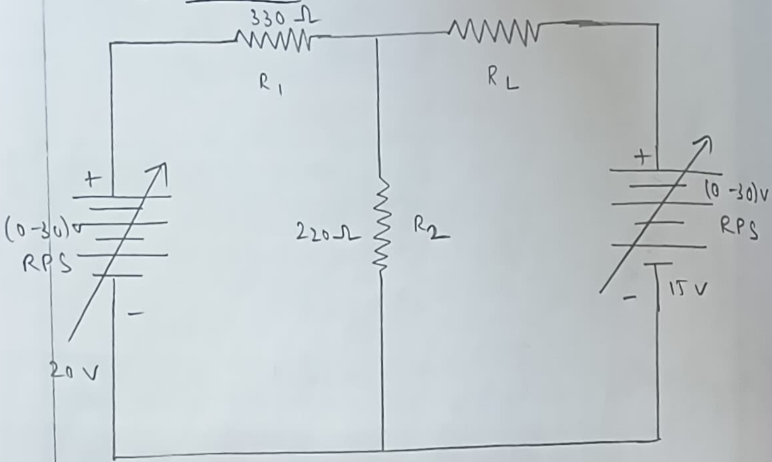
Model Graph



...nsfer $\boxed{R_L = R_i}$

* **Result:-** Thus the maximum power transfer theorem is verified.

*circuit Diagram:



* observations:

S.No	Measured current (mA) through 1KΩ when both supplies are connected	calculated current (mA) through 1KΩ		Measured current (mA) through 1KΩ		net current (mA)
		V=20Ω	V=15Ω	V=20Ω	V=15Ω	
1.	6mA	6mA	-12mA	6mA	-12.1mA	6mA

(b) verification of Superposition Theorem:-

* Aim:- To determine the current flow through the load resistor using superposition Theorem.

* Apparatus Required:

S.No	Apparatus Name	Range	Quatity
1.	Dc Regulater Power Supply	(0-30)v	2
2.	voltmeter	(0-30) v	1
3.	Ammeter	(0-200) mA	1
4.	Resistor	1KΩ, 200Ω, 330 Ω	Each one
5.	Multimeter	-	1
6.	Bread board & connecting wires.	-	Required

* Procedure:-

1. Give the connections as per the circuit diagram
2. Measure current flow through 1KΩ by conneting both the supplies.
3. short circuit 15 v source.
4. Measure current flow through 1KΩ by connecting 20 v supply.
5. short circuit 20v source.
6. Measure current flow through 1KΩ by connecting 15v supply.

* calculation!

$I_1 = 6mA$

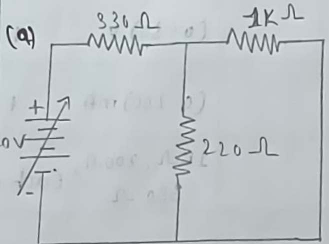
$I_2 = -12mA$

$\boxed{I_L = I_1 + I_2}$

$= -(6+12) mA$

$I_L = 6mA$

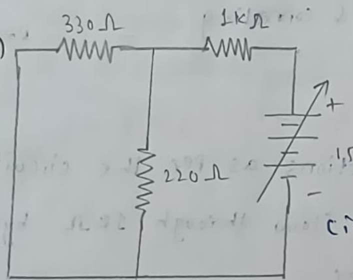
(a)



$I_1 = 6mA$

15v is short circuited and 20v is active.

(b)



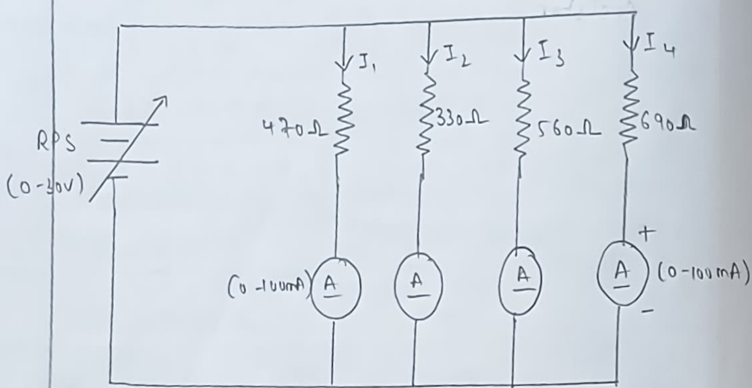
$I_2 = -12mA$

20v is short circuited and 15v is active.

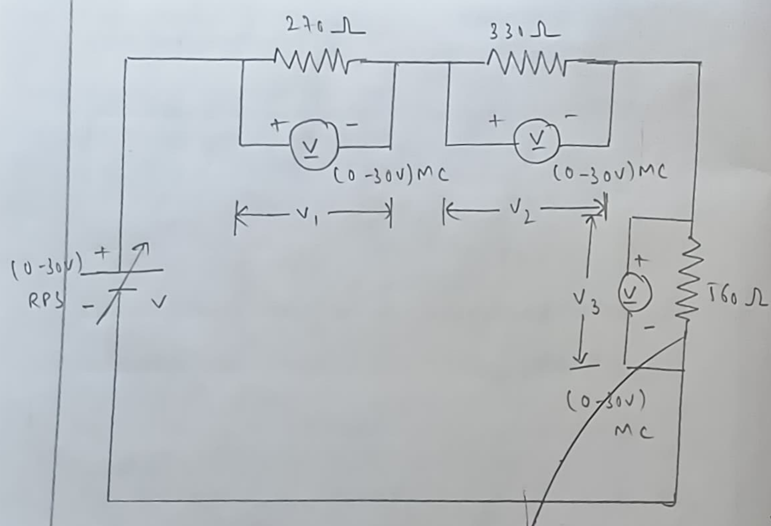
7. verify the net current through 1kΩ resistor.

* Result:- Thus the current flow through the load resistor is determined using superposition theorem.

* circuit diagram for current Division:



* circuit diagram for voltage Division:



Experiment-19

verification of current and voltage division rule:

* Aim:- To calculate the individual branch current and total current drawn from the power supply using current and voltege division rule.

* Apparatus Required:

S.No	Apparatus Name	Range	Quantity.
1.	DC Regulated Power Supply	(0-30) V	1
2.	Ammeter	(0-200)mA	4
3.	Resistor	1KΩ, 200Ω	Each two
4.	Bread board & connecting wires	-	Required

* Procedure:

1. Give the connection as per the circuit diagram.
2. Set a particular value in RPS.
3. Note down the corresponding ammeter reading.
4. Repeat the same for different voltages.

observations:

current Division Rule:

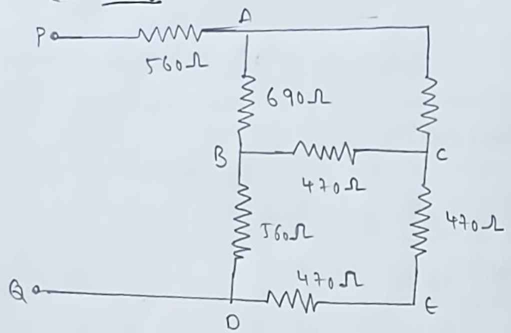
S.NO	voltage(v)	current(mA)			
		I_1	I_2	I_3	I_4
1.	1	5	10.64	15.15	8.93
2.	2	10	21.28	30.3	17.86
3.	3	15	31.91	45.45	26.79
4.	4	20	42.55	60.61	35.71
5.	5	25	53.19	75.76	44.64

voltage Division Rule:

S.NO	RPS voltage (v)	(v) voltage across Resistors			$V_1+V_2+V_3$ (v)
		V_1	V_2	V_3	
1	5	1.16	1.42	2.41	5
2	10	2.32	2.84	4.83	10
3	15	3.49	4.26	7.24	15
4	20	4.65	5.68	9.66	20
5	25	5.81	7.1	12.07	25

* Result:- Thus individual branch currents and total current drawn from the power supply are calculated using current and voltage division rules.

* circuit Diagram:

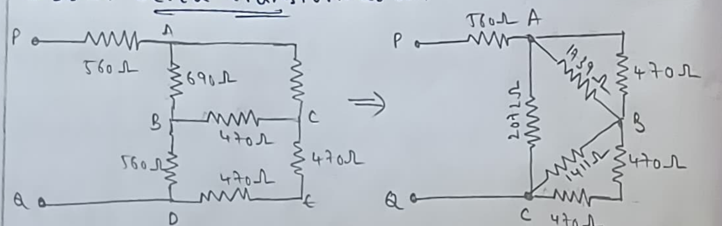


* observation:

S.No.	Theoretical value (R_{PQ}) in ohm	Measured value (R_{PQ}) in ohm
1.	1204	1200

* Theoretical calculations:

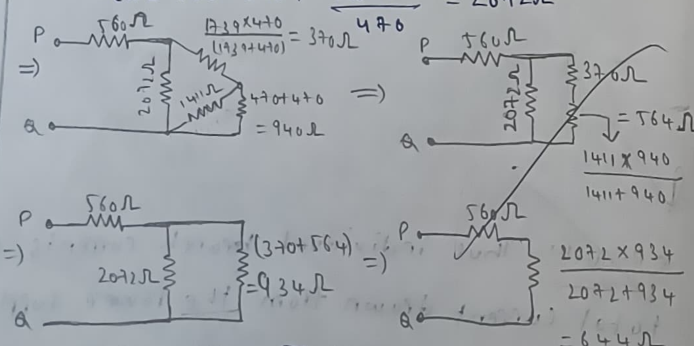
* Star Delta Transformation:



$$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_L} = 690+470+\frac{690\times470}{560} = 1.739\Omega$$

$$R_{BC} = 470+560+\frac{470\times560}{690} = 1411\Omega$$

$$R_{CA} = 560+690+\frac{560+690}{470} = 2072\Omega$$



$\therefore R_{PQ} = 560+644$

$\boxed{R_{PQ} = 1204\Omega}$

Experiment-20

verification of star delta transformation using Resistance Reduction Technique.

* Aim:- To calculate the equivalent circuit resistance using star delta transformation technique.

* Apparatus required:

S.NO	Apparatus Name	Range	Quantity
1.	Resistor	Any	7
2.	Bread board & connecting wires	-	Required.

* Procedure:

1. Give the connections as per the circuit diagram
2. Determine the equivalent resistance of the circuit between P and Q using star - delta transformation technique.
3. verify the same by connecting Multimeter across PQ.

* Result:- The equivalent circuit resistance is obtained using star delta transformation technique.