AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH

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Assignment Title:	Study of Combination of Series-Parallel Circuits and Verification of Δ–Y or Y– Δ Conversion Introduction

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Abstract :-

This experiment aims at testing the relation alongside calculating the similar resistance. This includes comparing two networks to find out the - transformation and ensuring that a particular pair of nodes provide the same - resistance in different networks. Taking a single, - configurations through - noting the currents and voltage - from a closed circuit. For a clearer outlook, this process can also be used in circuit analysis.

Theory:-

i) Series Circuit :- A circuit consist of any number of elements joined at terminal points, providing at least one closed path through which charge can - flow.

Two elements are in series if,

a) They have only one terminal in common (ie, one lead of one is connected to only one lead of the other).

5) The common Point between the two elements is not connected to another current-carrying element.

The current is the same through series elements.

The total resistance of a series circuit is the sum of the resistance levels. In general, to find the total resistance of 'N' resistors in series, the following equation is applied:-

$$R_T = R_1 + R_2 + R_3 + \dots R_N \text{(Ohms)} \qquad I = \frac{E}{R_T} \text{(Ampere)}$$

The voltage accross each resistor (fig. 1) using Ohm's law, that is,

$$V_1 = IR_1;\ V_2 = IR_2,\ V_3 = IR_3, \dots, V_n = IR_N \text{ (volts)}$$

using KVL,

The voltage divider rule states that the voltage accross a resistor in a series circuit is equal to the value of that resistor times the total impressed voltage accross the series elements - divided by the total resistance of the series elements.

The following VDR equation is applied:-

$$V_x = \frac{R_x E}{R_T} \text{ ; Similarly, } V_1 = \frac{R_1}{R_T} \times E \text{ , } V_2 = \frac{R_2}{R_T} \times E$$

Where, V_x is the voltage accross R_x, E is the - impressed voltage accross the series elements, and R_T - is the total resistance of the series circuit.

ii) <u>Parallel Circuit</u>:- Two elements, branches, or networks are in parallel if they have two points in - common. In general, to find the total resistance of 'N' resistors in parallel, the following equation is - applied:-

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots + \frac{1}{R_N} \text{ (ohms)}$$

The voltage accross parallel elements is the same (Figure 2) $(V_1 = V_2 = E)$

$$I_1 = \frac{E}{R_1} \text{ , } I_2 = \frac{E}{R_2} \text{ (Amperes)}$$

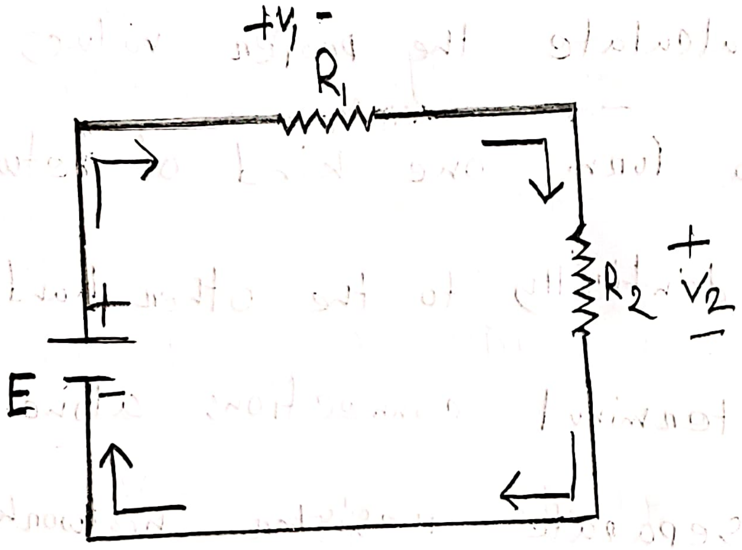
Using KCL,

$$I_S = I_1 + I_2 \quad (\text{Amperes})$$

The current divider rule states that the current through any parallel branch is equal to the product of the total resistance of the parallel branches of resistance and the input current divided by the resistance of the branch through which the current is to be determined. The following CDR equation is applied:-

$$I_x = \frac{R_T I}{R_x} \; ; \; \text{Similarly, } I_1 = \frac{R_T}{R_1} \times I, \; I_2 = \frac{R_T}{R_2} \times I$$

Where, the input current I equal $\frac{V}{R_T}$, R_T is the total resis-tance of the parallel branes. Substituting $V = I_x R_x$ into the above equation, I_x refers to the current through a parallel branch of resistance R_x.



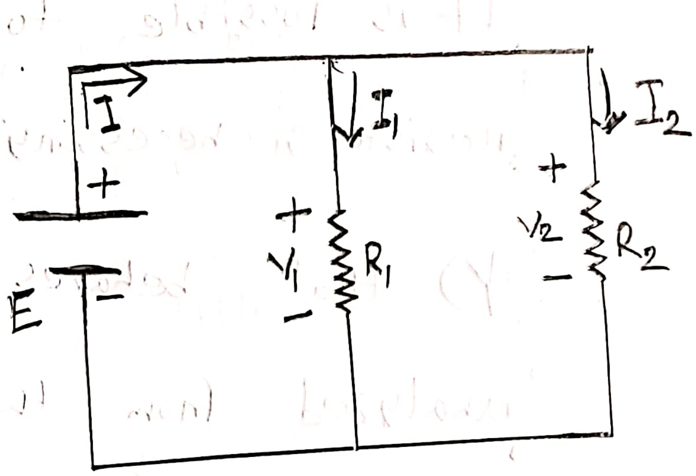
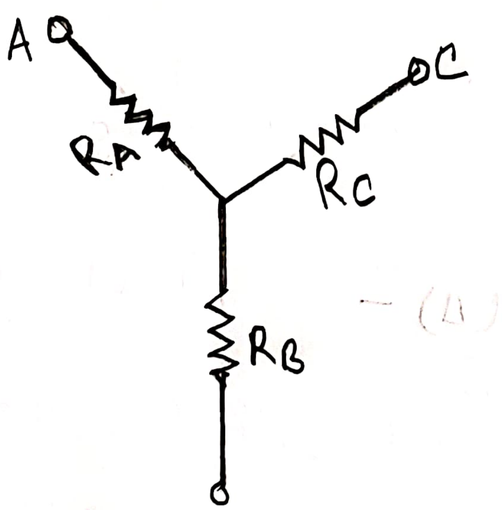
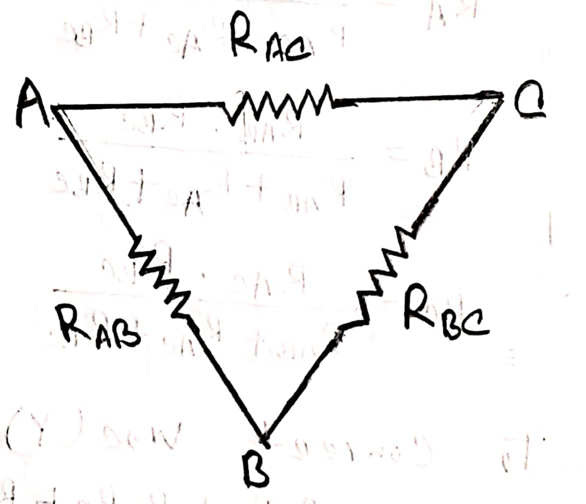


Figure 1 :- Series Circuit.

Figure 2 :- Parallel Circuit.

<u>Delta (Δ) and Wye (Y) network</u> :- In many circuit applications we encounter components connected together in one of two ways to form a three-terminal network: the "Delta," or Δ (also known as "Pi," or π) configuration, and the "Y" (also known as the "T") configuration.





Wye (Y) Network.

Delta (Δ) Network.

It is possible to calculate the proper values of resistors necessary to form one kind of network (Δ or Y) that behaves indentically to the other hand, as - analyzed from the terminal connections alone. That is, if we had two separate resistor networks one Δ and one Y, each with its resistor could be sized for the two networks so there would be no-way to electrically determine one network apart-from the other. In other words, equivalent Δ and Y networks behave identically.

To convert Delta (Δ) to wye (Y) -

$$R_A = \frac{R_{AB} \cdot R_{AC}}{R_{AB} + R_{AC} + R_{BC}}$$

$$R_B = \frac{R_{AB} \cdot R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

$$R_C = \frac{R_{AC} \cdot R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

To Convert wye (Y) to Delta (Δ) -

$$R_{AB} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}$$

$$R_{BC} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A}$$

$$R_{AC} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_B}$$

Apparatus:-

1. Trainer Board
2. AVO meter or Multimeter.
3. DC Source.
4. Resistors.
5. Connecting wires.

Precaution:- We've checked all the appatus were working properly or not. We've implemented the circuit carefully where it's necessary. The voltmeter was connected in the parallel through the resistor and the Ammeter was connected in the series through the resistor. We didn't switch on the DC source while implementing the circuit in the trainer board.

Circuit Diagram:-

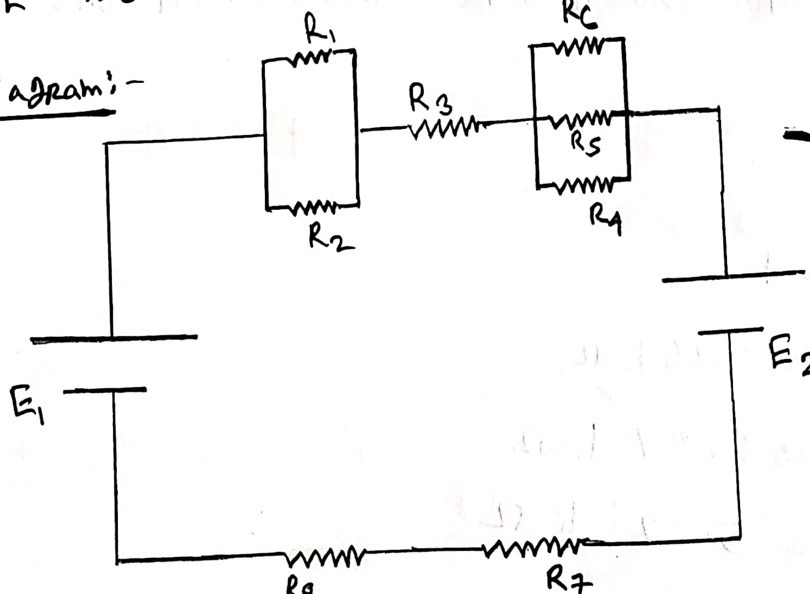


Figure :- 1

Data Table:-

Table:- 1: Data Table For Series-Parallel Connection

Calculated Value						Measured Value					
I (μA)	V_{R12} (mV)	V_{R3} (V)	V_{R456} (V)	V_{R7} (V)	V_{R8} (mV)	I (μA)	V_{R12} (mV)	V_{R3} (V)	V_{R456} (V)	V_{R7} (V)	V_{R8} (mV)
407	1070	2.202	0.521	1.55	1570	970	1.08	2.293	0.519	1.531	1553

Table-2: Data Table For delta connection.

V_R (V)	V_{R1} (V)	V_{R2} (V)	V_{R3} (V)	V_{R4} (V)	V_{R5} (V)	I_R (mA)	I_{R1} (mA)	I_{R2} (mA)	I_{R3} (mA)	I_{R4} (mA)	I_{R5} (mA)
1.33	0.911	0.960	0.960	0.745	0.491	0.35	0.23	0.11	0.12	0.22	0.10

Table-3: Data Table For Wye Connection.

V_R (V)	V_{R1} (V)	V_{R2} (V)	V_{R6} (V)	V_{R7} (V)	V_{R8} (V)	I_R (mA)	I_{R1} (mA)	I_{R2} (mA)	I_{R6} (mA)	I_{R7} (mA)	I_{R8} (mA)
1.35	0.981	0.963	0.651	0.429	0.195	0.35	0.25	0.11	0.15	0.22	0.10

Calculation:-

In figure-4,

$R_1 = 3.86\ k\Omega$

$R_2 = 8.27\ k\Omega$

$R_3 = 5.57\ k\Omega$

$R_4 = 3.34\ k\Omega$

$R_5 = 4.62\ k\Omega$

$R_6 = 3.89\ k\Omega$

$R_7 = 3.82\ k\Omega$

$R_8 = 3.87\ k\Omega$

$E_1 = 10V$

$E_2 = 3V$

here,

$$R_{12} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

$$= \left(\frac{1}{3.86} + \frac{1}{8.27}\right)^{-1}$$

$$= \cancel{2.28}.$$

$$= 2.63\ k\Omega$$

$$R_{456} = \left(\frac{1}{R_4} + \frac{1}{R_5} + \frac{1}{R_6}\right)^{-1}$$

$$= \left(\frac{1}{3.39} + \frac{1}{4.62} + \frac{1}{3.89}\right)^{-1}$$

$$= 1.28\ k\Omega$$

$$R_T = R_{12} + R_3 + R_{456} + R_7 + R_8$$

$$= 2.63 + 5.57 + 1.28 + 3.82 + 3.87$$

$$= 17.17\ k\Omega$$

$$I = \frac{E}{R_T}$$

$$= \frac{7}{17.17 \times 1000} = 407 \times 10^{-9} A = 407 \mu A$$

$$V_{R12} = \frac{R_{12}}{R_T} \times E = \frac{2.63}{17.17} \times 7 = 1.07V = 1070mV$$

$$V_{R3} = \frac{R3}{RT} \cancel{E} = \frac{5.57}{17.17} \times 7 = 2.202\,V$$

$$V_{R456} = \frac{R456}{R_T} \times E = \frac{1.28}{17.17} \times 7 = 0.521\,V$$

$$V_{R7} = \frac{R7}{R_T} \times E = \frac{3.82}{17.17} \times 7 = 1.55\,V$$

$$V_{R8} = \frac{R8}{R_T} \times E = \frac{3.87}{17.17} \times 7 = 1.57\,V = 1570\,mV$$

In figure 5,

$R = R_7 = 3.82\,k\Omega$

$R_1 = 3.86\,k\Omega$

$R_2 = 8.27\,k\Omega$

$R_3 = 5.57\,k\Omega$

$R_4 = 3.34\,k\Omega$

$R_5 = 4.62\,k\Omega$

And,

$VR = 1.33\,V$

$VR1 = 0.911\,V$

$VR2 = 0.960\,V$

$VR3 = 0.696\,V$

$VR4 = 0.745\,V$

$VR5 = 0.491\,V$

So,

$$IR = \frac{1.33}{3.82} = 0.35\ mA$$

$$IR1 = \frac{0.911}{3.86} = 0.23\ mA$$

$$IR2 = \frac{0.960}{8.27} = 0.11\ mA$$

$$IR3 = \frac{0.696}{5.57} = 0.12\ mA$$

$$IR4 = \frac{0.745}{3.39} = 0.22\ mA$$

$$IR5 = \frac{0.491}{4.62} = 0.10\ mA$$

$\Delta - Y$ Conversion:-

$$R_6 = \frac{R_3 R_5}{R_3 + R_4 + R_5} = \frac{5.57 \times 4.62}{5.57 + 3.39 + 4.62} = 1.901\ k\Omega$$

$$R_7 = \frac{R_4 R_5}{R_3 + R_4 + R_5} = \frac{3.39 \times 4.62}{5.57 + 3.39 + 4.62} = 1.14\ k\Omega$$

$$R_8 = \frac{R_3 R_4}{R_3 + R_4 + R_5} = \frac{5.57 \times 3.39}{5.57 + 3.39 + 4.62} = 1.37\ k\Omega$$

here,

$V_R = 1.35V$

$V_{R_1} = 0.981V$

$V_{R2} = 0.963V$

$V_{R6} = 0.651V$

$V_{R7} = 0.424V$

$V_{R8} = 0.145V$

$$IR = \frac{1.35}{3.82} = 0.35\ mA$$

$$IR_1 = \frac{0.981}{3.86} = 0.25\ mA$$

$$IR_2 = \frac{0.963}{8.27} = 0.11\ mA$$

$$I_{R6} = \frac{0.651}{1.90} = 0.15 \text{ mA}$$

$$I_{R7} = \frac{0.424}{1.14} = 0.22 \text{ mA}$$

$$I_{R8} = \frac{0.145}{1.37} = 0.10 \text{ mA}$$

Result:-

For Delta,

$V_R = 1.33\text{V}$ and $I_R = 0.35\text{mA}$

For wye,

$V_R = 1.35\text{V}$ and $I_R = 0.35\text{ mA}$

Conclusion:-

In this experiment, we've successfully learned,- how to measure values from a 'Series-Parallel' circuit and also get the knowledge that how to convert a Delta (Δ) to Wye (Y) and Wye (Y) to Delta (Δ) connection effectively.

References:-

1. Robert L. Boylestad, "Introductory Circuit Analysis". Prentice Hall, 12th Edition, New York, 2010, ISBN 9780137146666.