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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Course Title: Introduction to Electrical Circuits Laboratory

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Abstract:

The main objective of this experiment was to analysis of simple DC series-parallel circuit. In doing so, we had to design an electrical circuit with relevant parameters and sources and set up the circuit with appropriate connections, sources, and instruments. Then compared the measured value with the theoretical and simulation estimated value. For that, the series circuit can be solved using the Kirchoff's voltage Law (KVL) and voltage divider rule (VDR). The parallel circuit can be solved using Kirchoff's current law (KCL) and current divider rule (CDR).

Theory:

i) Series circuit: A circuit consist of any number of elements joined at terminal point, providing at least one classed path through which charge can flow. Two elements are in series if.

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

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

The current is the same through series elements.
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:

$RT = R_1 + R_2 + R_3 + \cdots + R_N$ (ohms) $I = \frac{E}{R_T}$ (Amperes)

The voltage across each resistor (Figure 1) using ohm's law; that is,

$V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3 \cdots$, $V_N = IR_N$ (volts) using

KVL, $E = V1 + V2$

The voltage divider rule states that the voltage across a resistor in a series elements, and RT is the total resistance of series circuit is equal to the value of that resistor times the total impressed voltage across the series elements divided by the total resistance of the series elements.
the following VDR equation is applied:

$V_x = \frac{R_x E}{R_T}$ similarly, $V_1 = \frac{R_1 E}{R_T}$, $V_2 = \frac{R_2 E}{R_T}$

where, V_x is the voltage across R_x, E is the impressed voltage across the series elements, and RT is the total resistance of the series circuit

ii) parallel circuit:

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:

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

The voltage across parallel elements is the same (Figure 2). $(V1 = V2 = E)$

$$I1 = \frac{E}{R_1}, I_2 = \frac{E}{R_2} \text{ (Amperes)}$$

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 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

$$I_x = \frac{R_T I}{R_x} \text{ similarly } I_1 = \frac{R_T I}{R_1}, \quad I_2 = \frac{R_T I}{R_2}$$

where, the input current I equal $\frac{V}{R_T}$, RT is the total resistance of the parallel branches. substituting $V = I_x R_x$ into the above equation, I_x refers to the current through a parallel branch of resistance R_x.

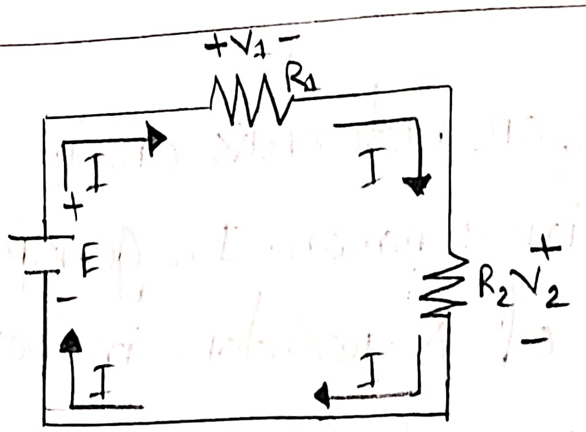


Figure1: series circuit

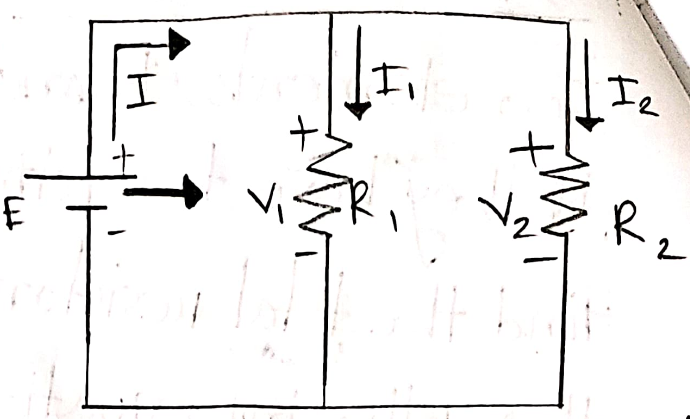
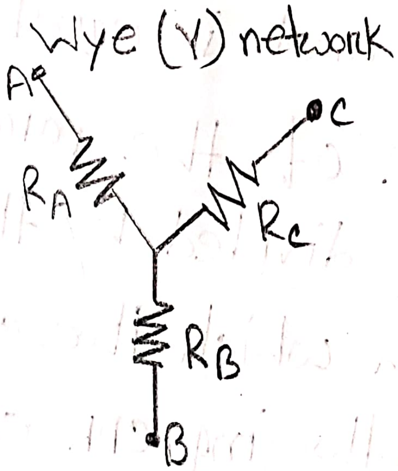
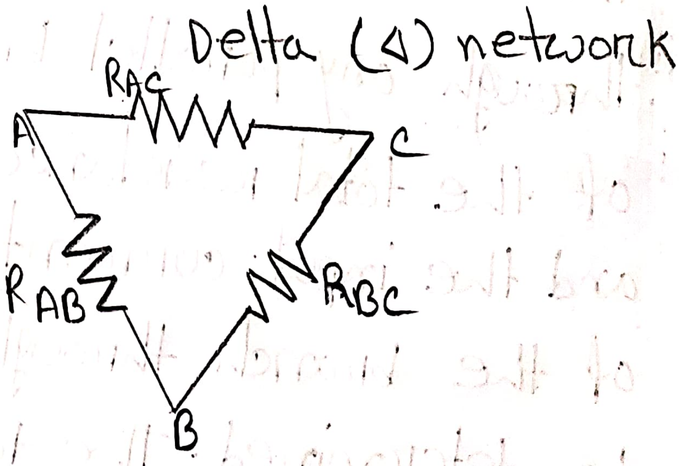


Figure2: parallel circuit

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





It is possible to calculate the proper values of resistors necessary to form one kind of network (Δ or Y) that behaves identically to the other kind, as analyzed from the terminal connections alone. That is, if we had two separate resistor networks, one Δ and one Y, each with its resistors hidden

from view, with nothing but the three terminals. (A, B, and C) exposed for testing, the resistor could be sized for other. In other words, equivalent Δ and Y networks behave indentically.
There are several equations used to convert one network to the other.

To convert a Delta (Δ) to wye (Y)

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

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

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

To convert a 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.

Precautions: we've checked all the appatus were working properly or not. we' implemented the circuit carefully where necessary. It was made sure that the voltmeter was connected in series through the resistor. we did not switch on the DC source while implementing the circuit in the trainer board.

Circuit Diagram:

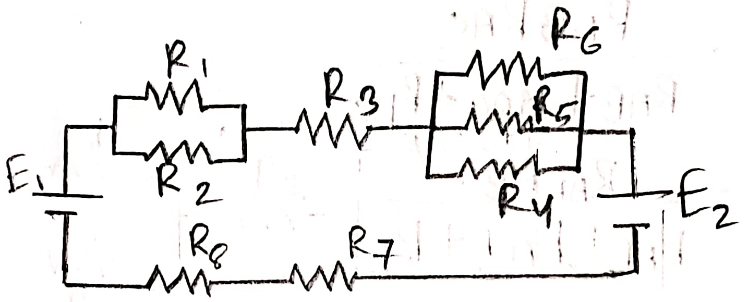
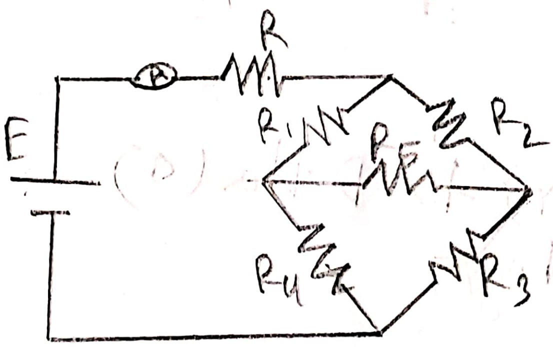


Figure 4



(a)

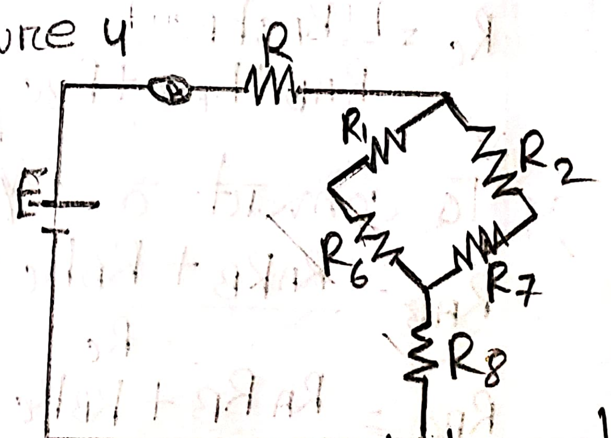


Figure 5

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)
8.64×10^{-4}	44	·28	·11	·48	87.2	8.59×10^{-4}	43	·29	·11	·49	87.33

Table-2: Data table for delta connection

VR	VR1	VR2	VR3	VR4	VR5	IR	IR1	IR2	IR3	IR4	IR5
6.801	0.58	1.72	2.521	1.43	1.211	2.03	1.2	0.756	0.53	1.47	0.66

Table-3: Data table for wye connection

V_R	V_{R1}	V_{R2}	V_{R6}	V_{R7}	V_{R8}	I_R	I_{R1}	I_{R2}	I_{R6}	I_{R7}	I_{R8}
6.821	0.59	1.78	0.188	1.387	1.211	2.032	1.23	0.8	0.8	1.24	1.8

In figure 3,

Given, $R_1 = 1K\Omega = 1000\Omega$

$R_2 = 1K\Omega = 1000\Omega$

$R_3 = 3.25K\Omega = 3250\Omega$

$R_4 = 2K\Omega = 2000\Omega$

$R_5 = 10K\Omega = 10000\Omega$

$R_6 = 5K\Omega = 5000\Omega$

$R_7 = 5.57K\Omega = 5570\Omega$

$R_8 = 1K\Omega = 1000\Omega$

Now, $R_{12} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \left(\frac{1}{1000} + \frac{1}{1000}\right)^{-1} = 500\Omega$

$R_{456} = \left(\frac{1}{R_4} + \frac{1}{R_5} + \frac{1}{R_6}\right) = \left(\frac{1}{2000} + \frac{1}{10000} + \frac{1}{5000}\right)^{-1} = 1250\Omega$

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

$= 500 + 3250 + 1250 + 5570 + 1000 = 11570\Omega$

Then,

$$V_{R12} = \left(\frac{E + R_{12}}{R_T}\right) = \frac{10 + 500}{11570} = .0440V = 44mV$$

$$V_{R3} = \frac{E + R_3}{R_T} = \frac{10 + 3250}{11570} = .2817V$$

$$V_{R456} = \frac{E + R_{456}}{R_T} = \frac{10 + 1250}{11570} = .1089V$$

$$V_{R7} = \frac{E + R_7}{R_T} = \frac{10 + 5570}{11570} = .4822V$$

$$V_{R8} = \frac{E + R_8}{R_T} = \frac{10 + 1000}{11570} = .0872V = 87.2mV$$

And,

$$I = \frac{E}{R_T} = \frac{10}{11570} = 8.64 \times 10^{-4} A$$

In figure 4,

Given, $R = 3.357K$

$R_1 = 0.48K$

$R_2 = 2.221K$

$R_3 = 4.751K$

$R_4 = 0.973K$

$R_5 = 1.828K$

And,

$VR = 6.8V$

$VR_1 = 0.58V$

$VR_2 = 1.7V$

$VR_3 = 2.5V$

$VR_4 = 1.43V$

$VR_5 = 1.2V$

So, $IR = \frac{VR}{R} = \frac{6.8}{3.35} = 2.03\ mA$

$IR_1 = \frac{VR_1}{R_1} = \frac{0.58}{0.48} = 1.2\ mA$

$IR_2 = \frac{VR_2}{R_2} = \frac{1.7}{2.221} = 0.765\ mA$

$IR_3 = \frac{VR_3}{R_3} = \frac{2.5}{4.75} = 0.53\ mA$

$IR_4 = \frac{VR_4}{R_4} = \frac{1.43}{0.973} = 1.47\ mA$

$IR_5 = \frac{VR_5}{R_5} = \frac{1.2}{1.828} = 0.66\ mA$

Δ-Y conversion:

$R_6 = (R_5 \times R_4)/R_3 + R_4 + R_5 = 0.973 \times 1.828/(4.75 + 0.973 + 1.828) = 0.235\ K$

$R_7 = (R_5 \times R_3)/R_3 + R_4 + R_5 = 4.75 \times 1.828/(4.75 + 0.973 + 1.828) = 1.12K$

$R_8 = (R_4 \times R_3)/R_3 + R_4 + R_5 = 4.75 \times 0.973/(4.75 + 0.973 + 1.828) = 0.596K$

Now,

$VR = 6.821V$

$VR_1 = 0.59V$

$VR_2 = 1.78V$

$VR_6 = 0.188V$

$VR_7 = 1.387V$

$VR_8 = 1.211V$

And,

$IR = 2.032\ mA$

$IR_1 = 1.23\ mA$

$IR_2 = 0.8\ mA$

$IR_6 = 0.8\ mA$

$IR_7 = 1.24\ mA$

$IR_8 = 1.8\ mA$

Result:

For Delta,

$VR = 6.801V$ and $IR = 2.03\ mA$

for wye,

$VR = 6.821V$ and $IR = 2.032\ mA$

Discussion: In this experiment we observed calculated series - parallel circuit. In the first circuit resistors were organised in series and parallel connection and current and voltages of different component were calculated. In the 2nd circuit the complicated network branchers were solved by converting the delta to Y connections. We solved the matter by following bread board connection rules. for measuring the current. Ammeter should be connected in series and voltmeter in parallel for voltage.

Conclusion: The whole experiment was about studing the series parallel circuit and veryfing the Δ-Y conversion. Our experiment results fully support or verifies the Δ-Y conversion. In delta and Y connection we found the same amount of current which is enough to state experiment is accurate.

Reference:

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