AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)

FACULTY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

ELECTRICAL CIRCUIT LAB - 1

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Section: W, Group: 2

LAB REPORT ON

Study of Combination of Series-Parallel Circuits and Verification of Δ−Y or Y− Δ Conversion Introduction

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1. Introduction:

The series-parallel networks are networks that contain both series and parallel circuit configurations. The series circuit can be solved using Kirchoff's voltage law (KVL) and Voltage divider rule (VDR). The parallel circuit can be solved using Kirchoff's current law (KCL) and the Current divider rule (CDR). The combination of the series-parallel network can be solved using KVL, KCL, VDR, and CDR. In solving networks (having a considerable number of branches) by the application of Kirchhoff's Laws, one sometimes experiences great difficulty due to many simultaneous equations that have to be solved. However, such complicated networks can simplify by successively replacing delta meshes with equivalent Y systems and vice versa.

2. Theory and Methodology:

i) Series Circuit:

A circuit consists 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 (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. 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:

$RT = R1+R2+R3+..........+RN$ (Ohms) $I=E/RT$ (Amperes)

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

$V1= IR1, V2= IR2, V3= IR3, \ldots, VN= IRN$ (Volts)

Using KVL,

$E = V1 + V2$

The voltage divider rule states that the voltage across a resistor in a series circuit is equal to the valueof 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:

$V_x = R_x E / R_T$

Similarly,

$V_1 = R_1 E / R_T$, $V_2 = R_2 E / R_T$

Where Vx is the voltage across Rx, E is the impressed voltage across the series elements, and RT is thetotal 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, tofind the total resistance of *N* resistors in parallel, the following equation is applied:

$1/R_T = (1/R_1) + (1/R_2) + (1/R_3) + \ldots\ldots + (1/R_N)$ (Ohms)
The voltage across parallel elements is the same
(Figure2).
($V_1 = V_2 = E$)$I_1 = E/R_1$, $I_2 = E/R_2$ (Amperes)
Using KCL,
$I_s = I_1 + I_2$ (Amperes)

The current divider rule states that the current through any parallel branch is equal to the product ofthe 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:

$I_x = R_T I / R_x$

Similarly,

$I_1 = R_T I / R_1$,

$I_2 = R_T I / R_2$

Where the input current I equal V/RT, RT is the total resistance of the parallel branches. SubstitutingV=Ix Rx into the above equation, Ix refers to the current through a parallel branch of resistance Rx.

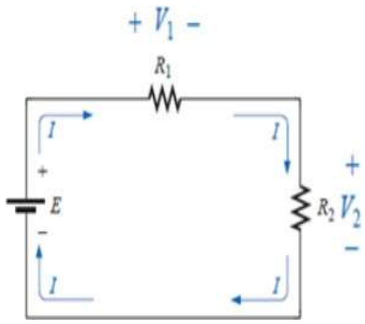


Figure 1: Series Circuit

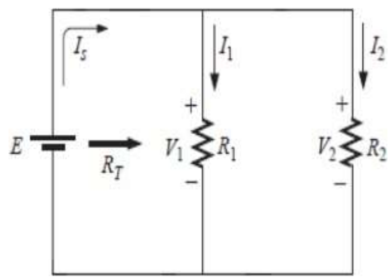


Figure 2: Parallel Circuit

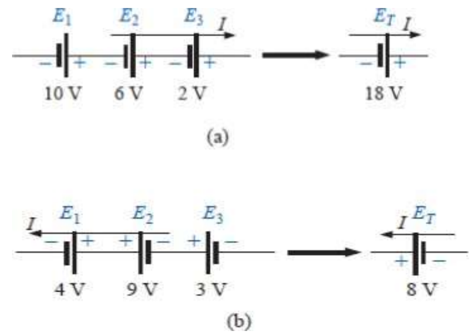


Figure 3: Voltage Sources in series

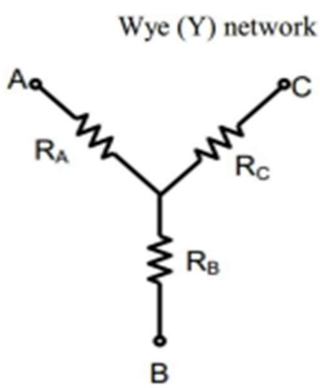
iii)Voltage Sources in Series:

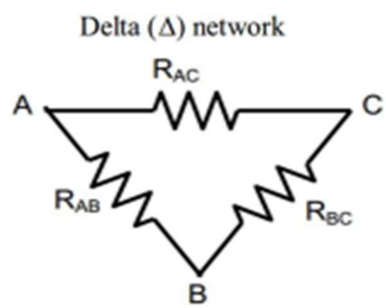
Voltage sources can be connected in series, as shown in (Figure 3), to increase or decrease the total voltage applied to a system. The net voltage is determined simply by summing the sources with the same polarity and subtracting the total of the sources with the opposite "pressure." The net polarity isthe polarity of the larger sum.

In Figure 3(a), for example, the sources are all "pressuring" current to the right, so the net voltage is$E_T = E_1 + E_2 + E_3 = 10V + 2V + 6V = 18V$ as shown in the figure.

In Figure 3(b), however, the greater "pressure" is to the left, with a net voltage of$E_T = E_2 + E_3 – E_1 = 9V + 3V – 4V = 8V$ and the polarity shown in the figure.

In many circuit applications, we encounter components connected 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





It is possible to calculate the proper values of resistors necessary to form one kind of network (□ 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 □ and one Y, each with its resistors hidden from view, withnothing but the three terminals (A, B, and C) exposed for testing, the 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 □ and Y networks behave identically.
There are several equations used to convert one network to the other.

To convert a Delta (□) to Wye (Y)

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

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

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

To convert a Wye (Y) to Delta (□)

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

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

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

3. Apparatus

- Trainer Board
- AVO meter or Multimeter
- DC source
- Resistors
- Connecting Wires

4. Precautions:

- We need to check whether all the apparatus are working fine or not.
- Then we implemented the circuit carefully where necessary.
- Connected the voltmeter in parallel through the resistor and the Ammeter should be in series through the resistor.
- We should not switch on the DC source while implementing the circuit in the trainer board.

5. Circuit Diagram:

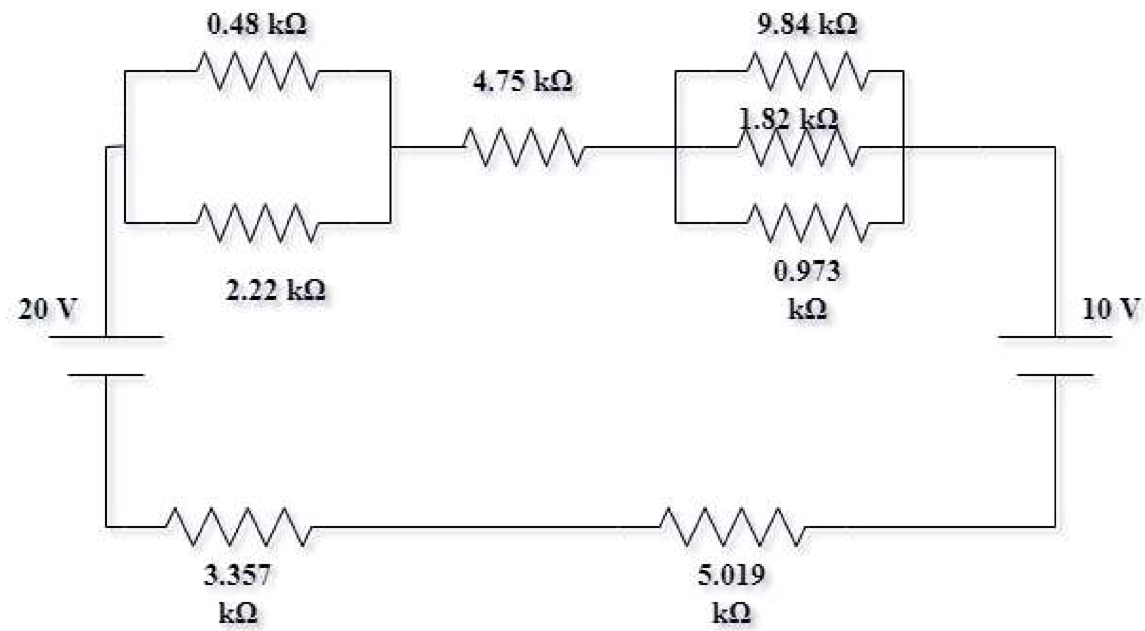


Figure 4

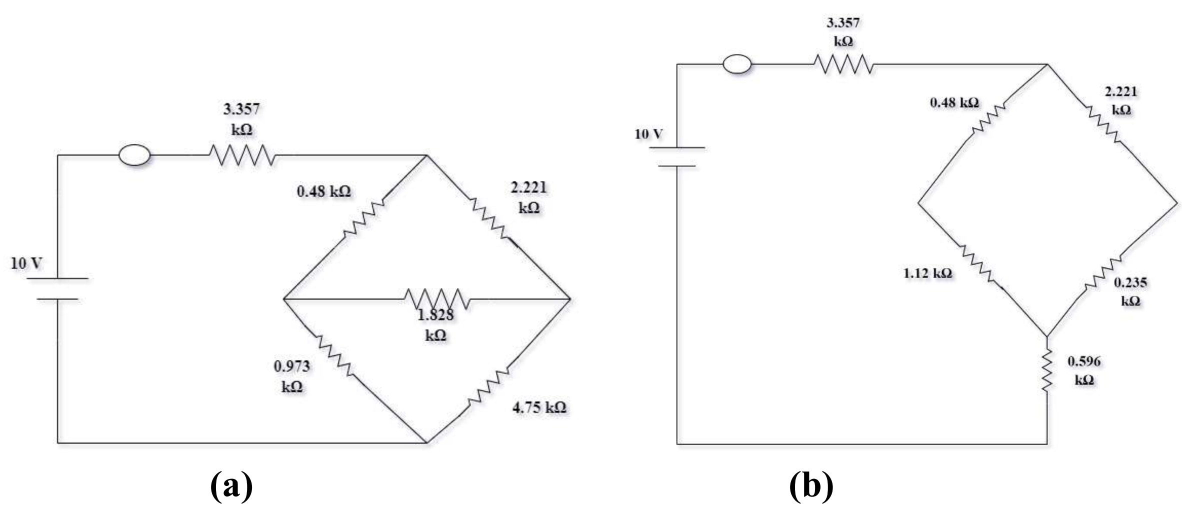


Figure 5

6. Data Table:

Table-1 (For Figure-4)

Value of Resistors:
R1= 0.48kΩ
R2= 2.221kΩ
R3= 4.75 kΩ
R4= 0.973kΩ
R5= 1.828kΩ
R6= 9.84kΩ
R7= 5.019kΩ
R = R8 = 3.357kΩ

Value of Voltage Sources:
E1=20V
E2=10V

Calculated Value						Measured Value					
I (mA)	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)
7.08×10^{-4}	28.687	0.337	0.043	0.356	238.49	7.08×10^{-4}	28.568	0.331	0.046	0.338	237.96

Table-2 (For Figure-5-a):

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
6.801	0.58	1.72	2.521	1.43	1.211	2.03	1.2	0.765	0.53	1.47	0.66

Table-2 (For Figure-5-b):

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	1.26	1.8

7. Calculation:

(For Figure 4)

Value of Resistors:
R1= 0.48kΩ
R2= 2.221kΩ
R3= 4.75 kΩ
R4= 0.973kΩ
R5= 1.828kΩ
R6= 9.84kΩ
R7= 5.019kΩ
R = R8 = 3.357kΩ

Now,
$R_{12} = (1/R_1 + 1/R_2)^{-1} = (1/0.48 + 1/0.221)^{-1} = 0.395$ kΩ= 395Ω
$R_3 = 4.75$ KΩ =4750Ω
$R_{456} = (1/R4 + 1/R5 + 1/R6)^{-1} = (1/0.973 +1/1.828 +1/9.84)^{-1} = 0.597$ kΩ= 597Ω
$R_7 = 5.019$ KΩ = 5019Ω
$R_8 = 3.357$ KΩ= 3357 Ω
$R_T = R_{12} + R_3 + R_{456} + R_7 + R_8 =$ 14.118 kΩ= 14118 Ω

Then,
$VR_{12} = (E+R_{12})/R_T = (10+395)/14118 = 0.0286$ V = 28.687 mV
$VR_3 = (E+R_3)/R_T = (10+4750)/ 14118 = 0.337$ V
$VR_{456} = (E+R_{456})/R_T = (10+597)/ 14118= 0.043$ V
$VR_7 = (E+R_7)/R_T = (10+5019)/ 14118= 0.356$ V
$VR_8 = (E+R_8)/R_T = (10+3357)/ 14118= 0.238$ V = 238.49 mV

And,
$I = E/R_T =10/14118 = 7.08\times 10^{-4}$ A

(For Figure 5)

Given,
R=3.357K
R1=0.48K
R2=2.221K
R3=4.75K
R4=0.973K

R5=1.828K

And,
VR=6.8V
VR1=0.58V
VR2=1.7V
VR3=2.5V
VR4=1.43V
VR5=1.2V

So,
IR=VR/R=6.8/3.35=2.03mA
IR1=VR1/R1=0.58/0.48=1.2mA
IR2=VR2/R2=1.7/2.221=0.765mA
IR3=VR3/R3=2.5/4.75=0.53mA
IR4=VR4/R4=1.43/0.973=1.47mA
IR5=VR5/R5=1.2/1.828=0.66mA

<u>Δ - Y conversion:</u>

R6= (R5×R4)/R3+R4+R5 = 0.973×1.828/ (4.75+0.973+1.828) = 0.235K
R7= (R5×R3)/R3+R4+R5 = 4.75×1.828/ (4.75+0.973+1.828) = 1.12K
R8= (R4×R3)/R3+R4+R5 = 4.75×0.973/ (4.75+0.973+1.828) = 0.596K

Now,
VR=6.821V
VR1=0.59V
VR2=1.78V
VR6=0.188V
VR7=1.387V
VR8=1.211V

And,
IR=2.032mA
IR1=1.23mA
IR2=0.8mA
IR6=0.8mA
IR7=1.24mA
IR8=1.8mA

8. Result:

(For Figure 4)

I=7.08$\times 10^{-4}$ A
VR_{12} = 28.687 mV
VR_3=0.337 V
VR_{456}=0.043 V
VR_7=0.356 V
VR_8=238.49 mV

(For Figure 5)

For Delta Connection:

VR=6.801V and IR=2.03mA

For Wye Connection:

VR=6.821 and IR=2.032mA

9. Discussion and Conclusion:

- The data/findings were interpreted and determined to the extent to which the experiment was successful in complying.
- The goal was initially set.
- The ways of the study could have been improved, investigated, and described.

In this experiment, the Study of the Combination of Series-Parallel Circuits and Δ−Y or Y−ΔConversion was Verified.

10. References

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