American International University- Bangladesh

Department of Electrical and Electronic Engineering

EEE 2109: Introduction to Electrical Circuits Lab

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

Objective:

- Analysis of simple DC series-parallel circuit
- Verify the conversion of equivalent resistances in Δ (delta) to Y (wye) connection and vice versa.

Introduction:

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

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:
$R_T = R_1+R_2+R_3+...........+R_N$ (Ohms) $I=E/R_T$ (Amperes)
The voltage across each resistor (Figure 1) using Ohm's law; that is,

$V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$,........., $V_N = IR_N$ (Volts)
Using KVL, $E = V_1 + V_2$

The voltage divider rule states that the voltage across a resistor in a 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:

$V_x = R_x E/R_T$ Similarly, $V_1 = R_1 E/R_T$, $V_2 = R_2 E/R_T$

Where, V_x is the voltage across R_x, E is the impressed voltage across the series elements, and R_T 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:

$1/R_T = (1/R_1) + (1/R_2) + (1/R_3) + \ldots\ldots + (1/R_N)$ (Ohms)
The voltage across parallel elements is the same (Figure 2). ($V_1 = V_2 = E$)
$I_1 = E/R_1$, $I_2 = E/R_2$ (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 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:

$I_x = R_T I/R_x$ Similarly, $I_1 = R_T I/R_1$, $I_2 = R_T I/R_2$
Where, the input current I equal V/R_T, R_T 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.

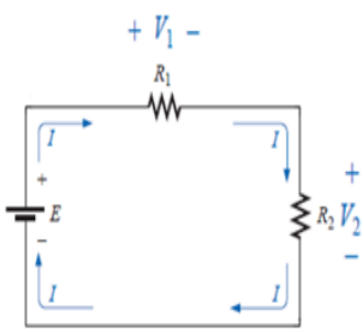


Figure 1: Series Circuit

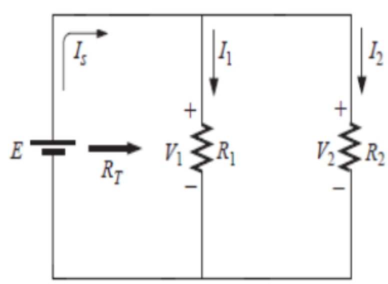


Figure 2: Parallel Circuit

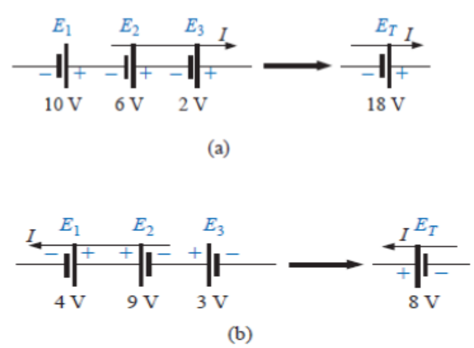


Figure 3: Voltage Sources in series

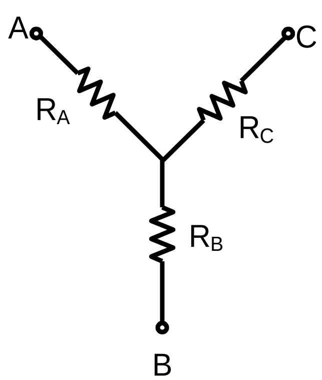
iii) Voltage Sources in Series:
Voltage sources can be connected in series, as shown in (Figure 3), to increase or decrease the total voltage applied to a system. The net voltage is determined simply by summing the sources with the same polarity and subtracting the total of the sources with the opposite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

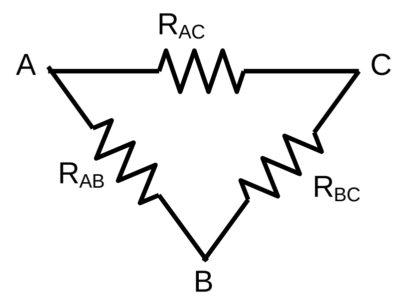
In Figure 3(b), however, the greater "pressure" is to the left, with a net voltage of $E_T = E_2 + E_3 - E_1 = 9V + 3V - 4V = 8V$ and the polarity shown in the figure.

In many circuit applications, we encounter components connected 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 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 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.
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)

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

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

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

Pre-Lab Homework:

Read about the basic laws of series and parallel circuits and theories related to Delta to Wye conversion and perform the simulation using PSpice 9.1. and MUST present the simulation results to the instructor before the start of the experiment.

Apparatus:

1. Trainer Board
2. AVO meter or Multimeter
3. DC source
4. Resistors
5. Connecting Wires

Precautions:

1. Check all the apparatus are working fine or not.
2. Implement the circuit carefully where necessary.
3. Voltmeter should be connected in parallel through the resistor. Ammeter should be connected in series through the resistor.
4. Do not switch on the DC source while implementing the circuit in the trainer board.

Circuit Diagram:

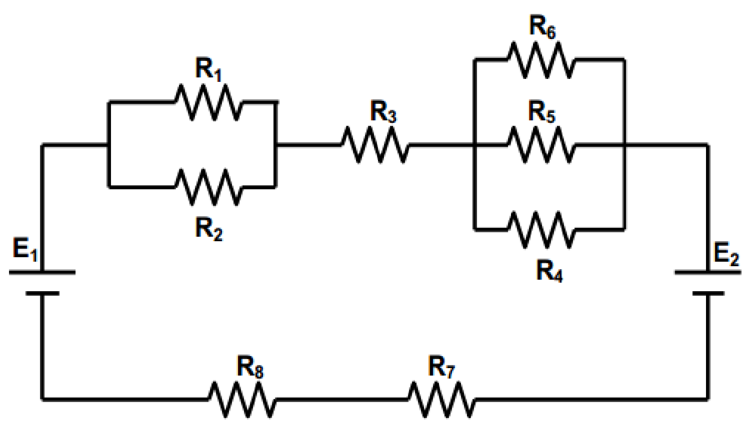
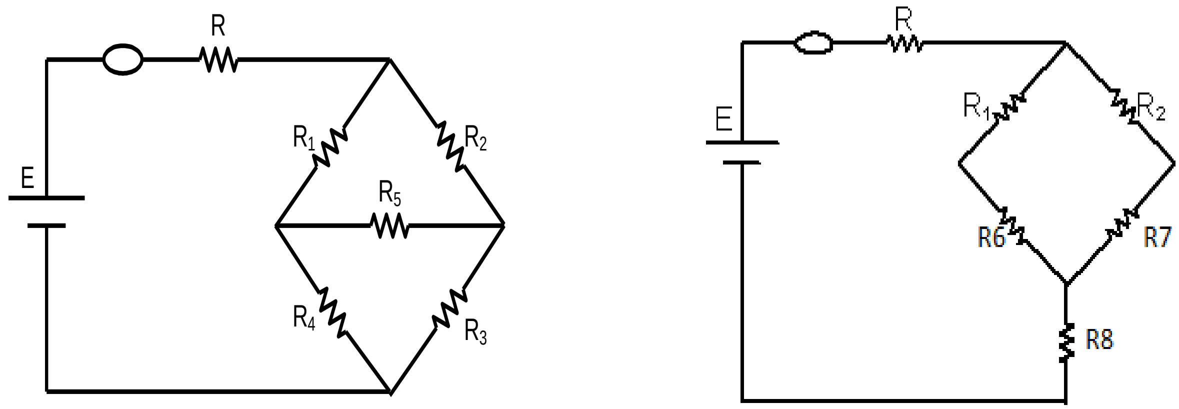


Figure 4



(a) **(b)**

Figure 5

Data Table:

Table-1 (For Figure-4)

Value of Resistors: R_1=1kΩ, R_2=1kΩ, R_3=3.25kΩ, R_4=2kΩ, R_5=10kΩ, R_6=5kΩ, R_7=5.57kΩ, R_8=1kΩ.

Value of Voltage Sources: E_1=20V, E_2=10V.

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)

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

V_R	V_{R1}	V_{R2}	V_{R3}	V_{R4}	V_{R5}	I_R	I_{R1}	I_{R2}	I_{R3}	I_{R4}	I_{R5}

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}

Reports:

1. Verify Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) by analyzing practical data and support them by comparing the results with the theoretical values by proper circuit solution.
2. Verify ∆- Y conversion formula from the experiment.
3. Verify the measured value of total circuit current with theoretical value. Show necessary calculation.
4. Comment on the result as a whole.
5. Write the lab report following the template as given before.

References

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