BME 211 Circuit Analysis Laboratory

Experiment #2: Kirchhoff's Voltage and Current Laws,

Equivalent Resistance, Resistive Voltage and Current Dividers

Objective

The objective of this experiment is to examine Kirchoff's Voltage Law and Kirchoff's Current Law using simple resistive circuits. Voltage, current and equivalent resistance for different combinations of resistors and voltage and current divider rules are investigated.

Background

1. Kirchhoff's Voltage Law

Kirchhoff's voltage law (KVL) states that the algebraic sum of the potential rises and drops around a closed loop (or path) is zero. A continuous path that leaves point *a* through R_1 and returns through V_S without leaving the circuit can be traced by following the current which is given in Figure 2.1. Therefore, *abcda* is a closed loop. To be able to apply Kirchhoff's voltage law, the summation of potential rises and drops must be made in one direction around the closed loop.

Kirchhoff's voltage law is applied to the circuit shown in Figure 2.1. The closed path is traced clockwise, assigning a positive algebraic sign to voltage drops. Starting at point d leads to the expression given below [1].

$$-V_S + V_1 + V_2 = 0$$

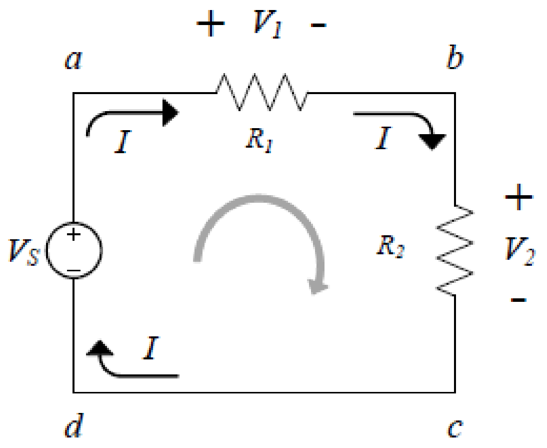

Figure 2.1 Applying Kirchhoff's voltage law to a series dc circuit.

2. Kirchhoff's Current Law

Kirchhoff's current law (KCL) states that the algebraic sum of the currents entering and leaving an hypothetical closed surface or junction is zero.

Applying KCL to four of the nodes in the circuit shown in Figure 2.2 using the convention that currents leaving a node are considered positive, yields four equations:

Node A	$-i_1 - i_2 + i_3 = 0$
Node B	$i_1 + i_4 - i_6 = 0$
Node C	$i_2 - i_4 - i_5 = 0$
Node D	$-i_3 + i_5 + i_7 = 0$

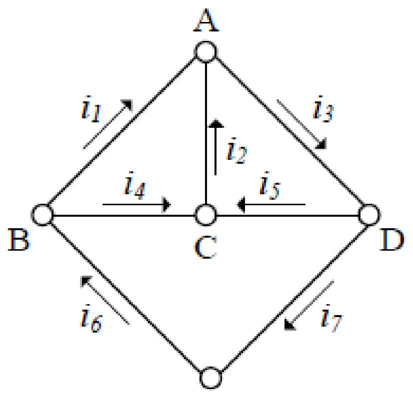

Figure 2.2 Applying Kirchhoff's current law

3. Series and Parallel Resistors

If two resistors have only one terminal in common, they are called series resistors (Figure 2.3) and if two resistors have two terminals in common, they are called parallel resistors (Figure 2.4).

Equivalent Resistance of *N* Series Resistors:

$R_{eq} = R_1 + R_2 + ... + R_N$

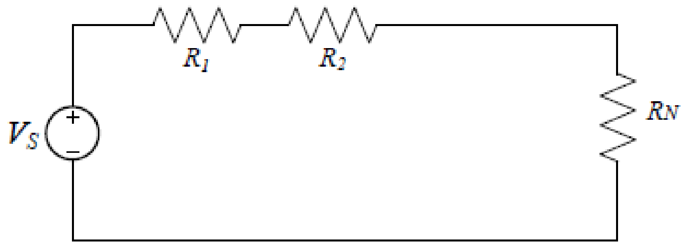

Figure 2.3 Series resistors

Equivalent Resistance of *N* Parallel Resistors :

$1/R_{eq} = 1/R_1 + 1/R_2 + ... + 1/R_N$

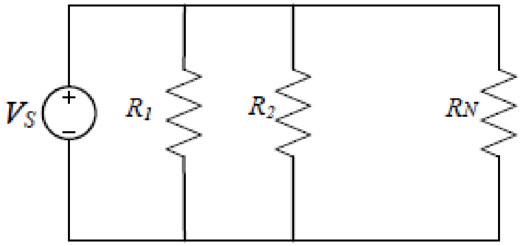

Figure 2.4 Parallel resistors

4. Resistive Voltage and Current Dividers

A resistive voltage divider that is formed by the resistances R_1 and R_2 is given in Figure 2.5. For this circuit, it can be observed that the current flowing through R_1 and R_2 is the same.

Resistive Voltage Divider Equation:

$$V_o = V_s \frac{R_2}{R_1+R_2}$$

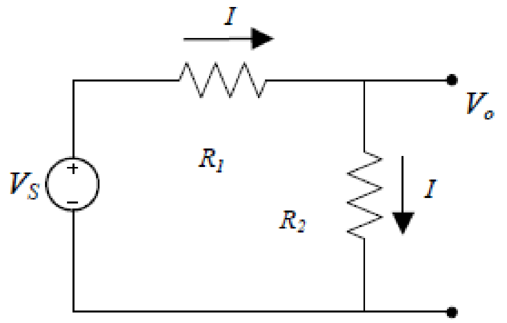

Figure 2.5 Resistive Voltage Divider

A resistive current divider that is formed by the resistances R_1 and R_2 is given in Figure 2.6. For this circuit it can be observed that the voltage across each resistor is the same.

Resistive Current Divider Equation:

$$I_o = I_s \frac{R_1}{R_1+R_2}$$

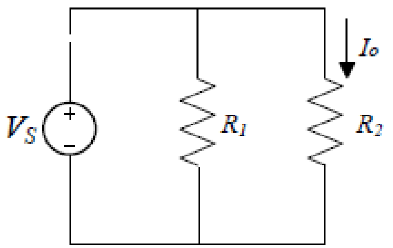

Figure 2.6 Resistive Current Divider

Preliminary Work

1. Using KVL and/or KCL, determine the unknown current and voltage for each resistor for the circuit given in Figure 2.7. Verify that the total voltage is equal to the supply voltage.

$V_S = 12$ V
$R_1 = 120\ \Omega$
$R_2 = 4.7$ kΩ
$R_3 = 1.5$ kΩ

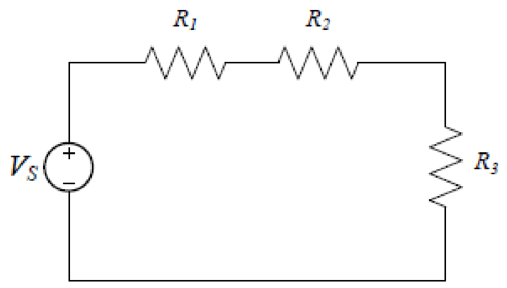

Figure 2.7

2. Using KVL and/or KCL, determine the unknown current and voltage for each resistor for the circuit given in Figure 2.8.

$V_S = 10$ V
$R_1 = 3.3$ kΩ
$R_2 = 22$ kΩ
$R_3 = 1.5$ kΩ

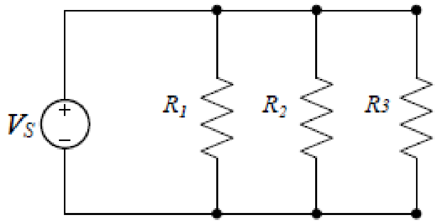

Figure 2.8

3. Using KVL and/or KCL, determine the unknown current and voltage for each resistor for the circuit given in Figure 2.9 [2].

V_S = 15 V
R_1 = 120 Ω
R_2 = 4.7 kΩ
R_3 = 1.5 kΩ
R_4 = 4.7 kΩ

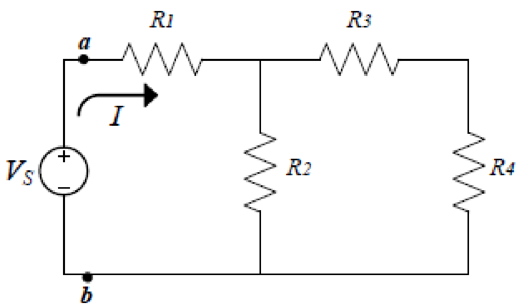

Figure 2.9

4. Determine the equivalent resistance seen from the voltage supply for the circuits given in Step 1, Step 2 and Step 3.

5. Using the voltage divider rule, determine the voltages V1, V2 and V3 for the series circuit of Figure 2.10.

V_S = 12 V
R_1 = 120 Ω
R_2 = 4.7 kΩ
R_3 = 1.5 kΩ

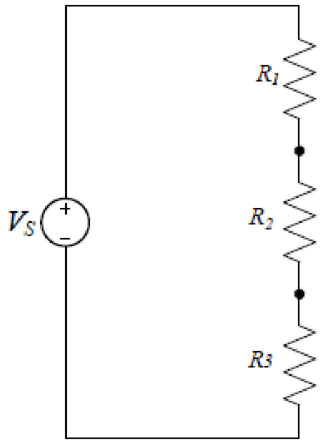

Figure 2.10

6. Using the current divider rule, determine the current I_o for the circuit given Figure 2.11.

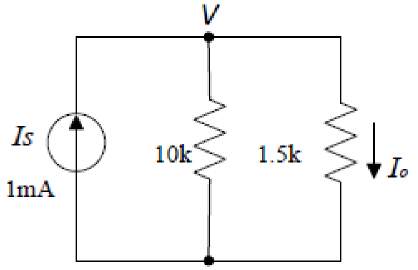

Figure 2.11

7. Calculate the terminal current of the device shown in Figure 2.12, if the terminal voltage is measured to be 12 V.

$R_1 = 6.8\ k\Omega$
$R_2 = 100\ k\Omega$
$R_3 = 1.5\ k\Omega$
$R_4 = 22\ k\Omega$

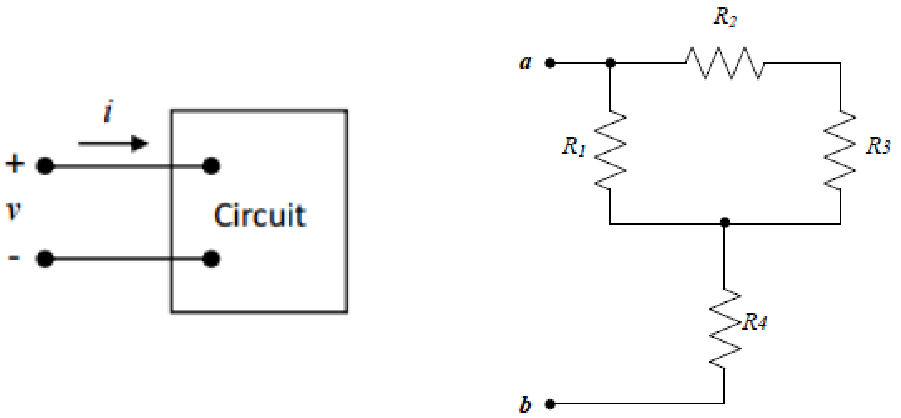

Figure 2.12

Procedure

Before starting, read the laboratory safety instructions on Page 4.

1. Set up the circuit given in Figure 2.7,

   a) Measure the current and voltage for each resistor and tabulate the results. Compare your measurements with your calculations and comment on the differences.
   DO NOT FORGET TO CHANGE PROBE CONNECTIONS ON THE MULTIMETER AND SELECT APPROPRIATE MODES WHEN SWITCHING BETWEEN VOLTAGE AND CURRENT MEASUREMENTS.

   b) Measure the resistance seen by the voltage source and compare the results with your calculations.

   c) Repeat the step (a) and (b) for the circuits given in Figure 2.8 and Figure 2.9.

2. Set up the circuit in Figure 2.12 and measure the terminal current. Compare your measurement with your calculation.

List of Components

Equipments: DC Voltage Supply, Digital Multimeter

Resistors: 120 Ω, 1.5 kΩ, 22 kΩ, 3.3 kΩ, 4.7 kΩ, 6.8 kΩ, 22 kΩ, 100 kΩ

References

[1] James W. Nilsson, Susan A. Riedel, Electric Circuits (Ninth Edition)

[2] Boylestad, Introductory Circuit Analysis (Tenth Edition)

BME 211 Report #2
Kirchhoff's Voltage and Current Laws, Equivalent Resistance Calculations, Resistive Voltage and Current Dividers

Objective

Results

1. Comparison of calculated and measured current values: (Circuit 2.7)

R	$V_{calculated}$	$V_{measured}$
120Ω		
4.7kΩ		
1.5kΩ		

I_{source} (calculated) = ... I_{source} (measured) = ...

V_{Total} = ...

R_{eq} (calculated) = ... R_{eq} (measured) = ...

Comments:

2. Comparison of calculated and measured current values: (Circuit 2.12)

R	**$V_{calculated}$**	**$V_{measured}$**	**$I_{calculated}$**	**$I_{measured}$**
6.8kΩ				
100kΩ				
1.5kΩ				
22kΩ				

R_{eq} (calculated) = ... R_{eq} (measured) = ...

Comments: