EXPERIMENT E12: KIRCHHOFF'S CIRCUIT LAWS

Related course: KIE1005 (Circuit Analysis I)

OBJECTIVES:
1. To verify Kirchhoff's current law (KCL) and Kirchhoff's voltage law (KVL)
2. To observe the effect of some modifications in a special circuit

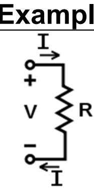
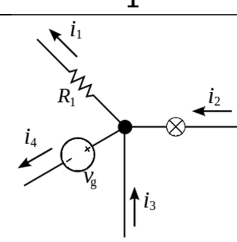
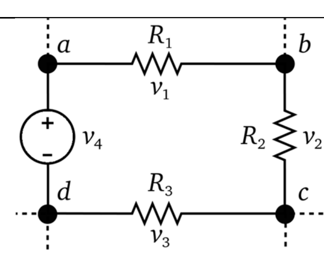
EQUIPMENT:
DC power supply; breadboard; multimeter; wires/jumpers; resistors: 100Ω (2 units), 220Ω (2), 150Ω (1), 50Ω (1), 470Ω (1), 120Ω (5)

INSTRUCTIONS:
1. Make sure that you have done **Experiment X2** (in previous semester) before performing this experiment in the lab. Bring the simulation result along during the lab session.
2. Record all your results and observations in a log book or on a piece of paper
3. Follow the demonstrator's instructions throughout the experiment

REFERENCE(S):
Refer to the main references of KIE1005

TESTS:
TEST 1: Kirchhoff's current and voltage law (KCL, KVL)
TEST 2: Special circuit

INTRODUCTION:
Simple resistive circuit can be solved by determining the voltage across and the current in every element. Three laws can provide a solution for determining the voltage and the current; Ohm's law, Kirchhoff's current law (KCL) and the Kirchhoff's voltage law (KVL). Circuit analysis can be done using the following techniques; Node Voltage, Mesh Current, Thevenin and Norton, Source transformation and Superposition Theorem.

Circuit law	Definition	Example
Ohm's law	• Voltage across a resistor is directly proportional to the current flowing through the resistor. $V = IR$	
Kirchhoff's current law (KCL)	• At any node (junction) in a circuit, the sum of currents flowing into that node equals to the sum of currents flowing out of that node. $\sum_{k=1}^{n} I_k = 0$ where n = total number of branches • Algebraic sum of all the currents at any node in a circuit equals zero	 $i_2 + i_3 = i_1 + i_4$
Kirchhoff's voltage law (KVL)	• The sum of electromotive force (emf) in any closed loop is equivalent to the sum of the potential drops in that loop. $\sum_{k=1}^{n} V_k = 0$ • Algebraic sum of all the voltages around any closed path in a circuit equals zero.	 $v_4 - v_1 - v_2 - v_3 = 0$

To measure a current, connect a multimeter / ammeter (A) in series in a circuit branch.

Red probe

Ammeter

Black probe

To measure a voltage, connect a multimeter / voltmeter (V) in parallel with a resistor.

Red probe

Voltmeter

Black probe

PROCEDURE:

TEST 1: Kirchhoff's current and voltage law (KCL, KVL)

1. Make sure that you already have your simulation results and calculated values obtained from EXPERIMENT X2. Otherwise, referring to the circuit in Figure 1, calculate I_1 to I_5 and V_{R1} to V_{R6} using any circuit analysis technique that you have learned.
2. Construct the circuit as shown in Figure 1 on a breadboard. Connect point G to 0V of the DC power supply. Before turning ON the DC power supply, measure the actual resistance values (in Ω) for R_1, R_2, R_3, R_4, R_5 and R_6 using a multimeter by taking out each of them from the circuit one by one. Do not touch the multimeter probe tip with your finger while measuring the resistance.
3. Turn ON the DC power supply and apply +5V DC to the circuit. Measure current I_1 to I_5 using a multimeter or ammeter. Do not touch the multimeter probe tip with your finger while measuring the current. Then, verify KCL (Does $I_1 = I_2 + I_3$ and $I_3 = I_4 + I_5$?).
4. Compare the measured currents in step 3 with the calculated values in step 1. Are they almost the same with each other?
5. Measure the voltage across R_1, R_2, R_3, R_4, R_5 and R_6 using a multimeter.
6. Compare the measured voltages in step 5 with the calculated values in step 1. Are they almost the same with each other?
7. Verify KVL for SAGS, ABGA and SABGS loops. E.g. for SAGS, does $V_{in}+V_{R1}+V_{R2}=0$?
8. Connect a 470Ω resistance between S and G. Does I_5 change? Explain why.

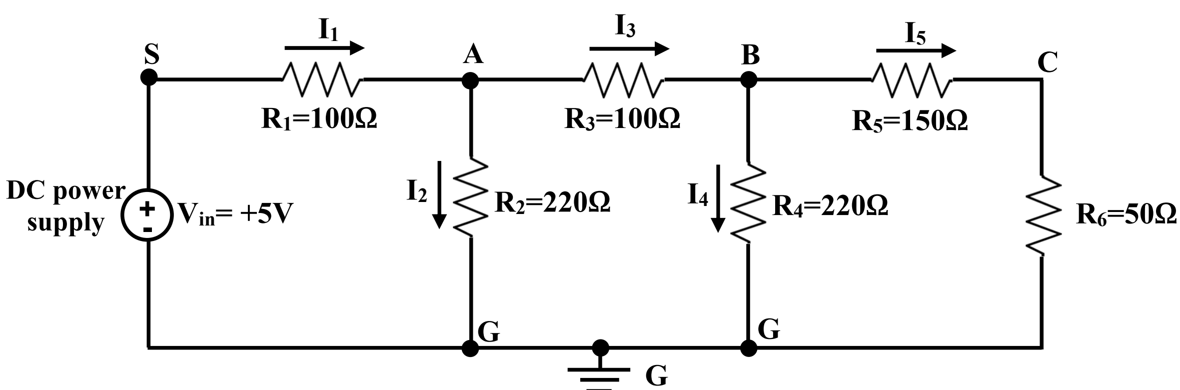


Figure 1

TEST 2: Special circuit

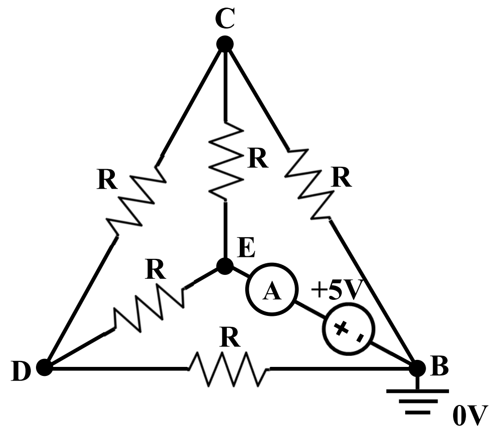


Figure 2

1. Connect the circuit as shown in Figure 2 with each R = 120Ω and A is a multimeter or ammeter. Connect point B to 0V of the DC power supply. Before connecting the resistors in your circuit, measure the resistance values (Ω) of each R using a multimeter.
2. Turn ON the DC power supply and apply +5V DC to the circuit. Record this DC value as V_{EB} in your result.
3. Measure the current in branch EB using a multimeter or ammater. This current is named as I_{EB}.
4. Calculate the input resistance (V_{EB} in step 2 divided by I_{EB} in step 3).
5. Compare the calculated input resistance value in step 4 with your calculated input resistance from EXPERIMENT X2. Are they almost the same with each other?
6. Measure the voltage between (i) B and C, (ii) B and D, (iii) C and D. Give comments.
7. Remove R between C and D and then, insert a wire or jumper between C and D. Measure the current in branch EB using a multimeter or ammeter. Compare this current value with the value obtained in step 3. Give comment.
8. Continued from step 6, remove the wire or jumper between C and D (Do not insert R between C and D). Measure the current in branch EB using a multimeter or ammeter. Compare this current value with the value obtained in step 3. Give comment.

DISCUSSION:

Your discussion should include answers for all questions asked in the PROCEDURE section for TEST 1 and TEST 2.

OTHER TASKS (do after the lab session and include the results in your lab report):

Using your PSpice simulation results and calculation from EXPERIMENT X2, compare between your measurement, simulation and calculation results for TEST 1 and TEST 2 of EXPERIMENT E12. Do they almost equal to each other? If they are not, identify what factors which may cause the difference between them.

END OF EXPERIMENT