CE2004: Circuits & Signal Analysis Part 1

Lu Shengliang

SLU001

School of Computer Engineering

Nanyang Technological University

SLU001@e.ntu.edu.sg

October 15, 2013

Abstract

lab 1: verify the circuit analysis techniques – Ohm Law, KCL, KVL experimentally. *lab 2*: verify the circuit analysis techniques - Superposition and Thévenin's Theorems, experimentally.

1 lab 1

1.1 Introduction

KVL states that the sum of the voltages in a closed loop in a circuit is zero when voltage polarities are properly taken into consideration.
KCL states that the sum of the currents entering a point in a circuit at any instant equals the sum of the currents leaving that point.
The measurement method is shown in Figure 1.

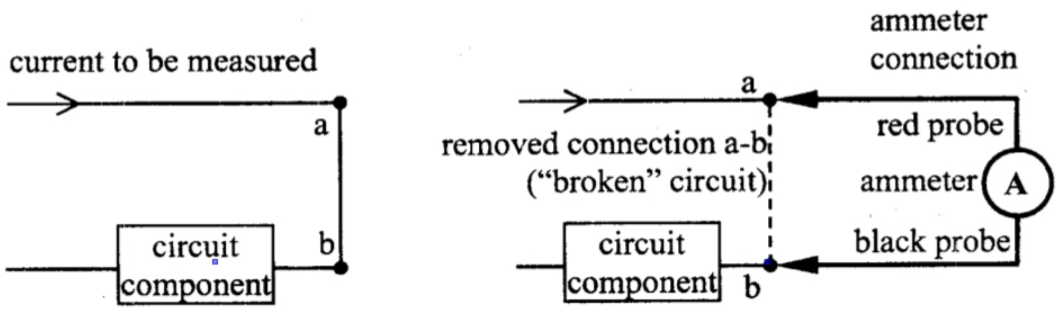


Figure 1: Voltage and Current measurement

1.2 Experiments and Results

5.2.1 Series Circuit

Connect the series circuit of figure 2.

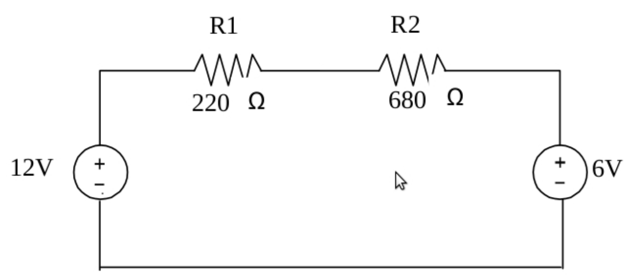


Figure 2

Measure the current and voltage for all circuit elements in the circuit. Indicate the readings on a circuit diagram.

Figure 2: lab1-5.2.1

Circuit Elements	Current	Voltage	Power
12V Voltage Source	6.579mA	-11.936V	78.290mW
6V Voltage Source	6.583mA	6.117V	40.156mW
R1	6.574mA	1.446V	9.506mW
R2	6.615mA	4.519V	29.893mW

Table 1: lab1-5.2.1

Since 12V voltage source is greater than 6V voltage source, with opposite voltage polarities. The real voltage polarity in the circuit should be the same as the 12V one. It results that the current direction is clockwise. **Lab 1 Question 1:** The resistors used in the lab are typically rated at 0.25 W. What is the maximum current that can be allowed in (a) R1, (b) R2 and (c) the given circuit?
Lab 1 Answer 1:

$$P = \frac{I^2}{R} \tag{1}$$

$$P \leq 0.25W \tag{2}$$

$$I \leq \sqrt{P * R} \tag{3}$$

$$R1(a) : I \leq 0.25W * 220\Omega = 33.710mA \tag{4}$$

$$R2(b) : I \leq 0.25W * 680\Omega = 19.174mA \tag{5}$$

$$Circuit(c) : Min\{R1(a), R2(b)\} = 19.174mA \tag{6}$$

Connect the series-parallel circuit of figure 3.

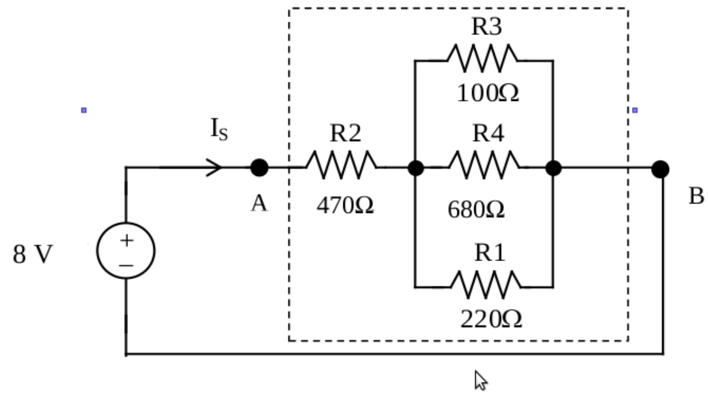


Figure 3

Measure the current and voltage for each resistor in the circuit. Indicate the readings on a circuit diagram.

Figure 3: lab1-5.2.2

Resistor	**Current**	**Voltage**
R1 220Ω	4.583mA	1.051V
R2 470Ω	14.745mA	7.049V
R3 100Ω	9.970mA	1.051V
R4 680Ω	1.513mA	1.050V

Table 2: lab1-5.2.2

Lab 1 Question 2:

1) From the measurements made, determine the resistance between terminals A-B of the given circuit. Verify your answer through calculation using the known circuit configuration and resistor values.

2) If all resistors between terminals A-B are allowed to be connected in any configuration except for four resistors in parallel, re-arrange the resistors so that the current I_S is maximum. What is this maximum value of I_S?

lab 1 Answer 2:

$$1)R_{AB} = 540.781\Omega \tag{7}$$

$$2)\frac{1}{\frac{1}{100\Omega} + \frac{1}{470\Omega+680\Omega} + \frac{1}{220\Omega}} = 64.872\Omega \tag{8}$$

$$3)I_S = \frac{8V}{64.872\Omega} = 0.123A \tag{9}$$

The method is arranging 470Ω, 680Ω in series, and then connect it with 220Ω and 100Ω in parallel. The maximum value of I_S is 0.123A.

1.3 Conclusion

Part 1: a series circuit is under measurement, in order to observe KVL. **Part 2**: a series-parallel circuit is seted up and under Measurement, in order to observe KCL and Ohm's law.

2 lab 2

2.1 Introduction

The Superposition Theorem states that the current or voltage associated with a branch in a linear network equals to the sum of the current or voltage components set up in that branch due to each of the independent sources acting one at a time on the circuit.
Thevenin's theorem enables us to replace the fixed portion of the circuit by a greatly simplified equivalent circuit. This reduces the complexity of computations required to determine the response in the load circuit when the load changes. The Thevenin's equivalent circuit consists of a voltage source V_{TH} in series with a resistor R_{TH} as shown:

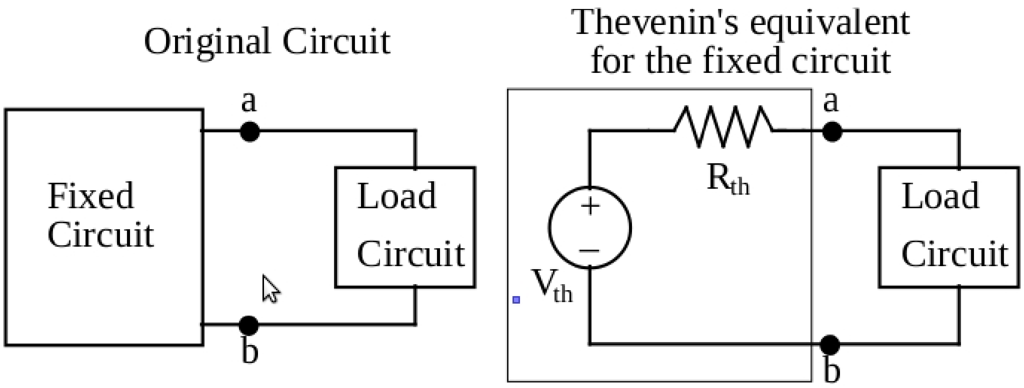
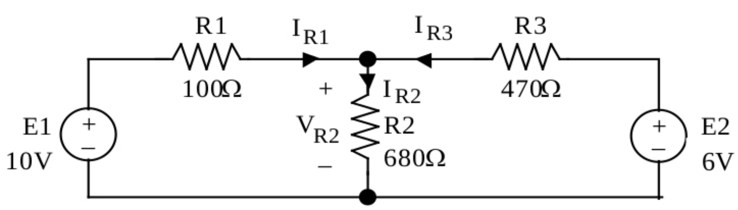


Figure 4: lab2-4.2

2.2 Experiments and Results



Step1: Measure the voltage V_{R2} and currents I_{R1}, I_{R2} and I_{R3} as indicated in figure 5. Use Table 1 for recording and indicate clearly the units chosen for voltage and current. Please use the same current directions and voltage polarity as indicated in figure 2 throughout this section of the experiment.

Step 2: To verify the superposition theorem, we need to measure separately the voltage and current components due to the source E1 alone, and then due to E2 alone. We start by disabling the source E2 and repeat the measurements in step 1. This gives the voltage and current components caused by E1 alone.

Step 3: Disable source E1 and repeat the measurements in step 1. This gives the voltage and current components caused by E2 alone.

Figure 5: lab2-5.1

Source	V_{R2}	I_{R1}	I_{R2}	I_{R3}
E1 & E2	8.36V	17.03mA	12.14mA	-5.01mA
E1	7.31V	25.74mA	10.74mA	-15.58mA
E2	0.92V	-9.05mA	1.33mA	10.49mA

Table 3: lab2-5.1

Lab 2 Question 1:
Did you encounter any negative current or voltage in your measurement? If yes, what do these results mean?
Lab 2 Answer 1:
Yes.
The negative sign means the direction of a certain current is opposite from the current meter measurement.

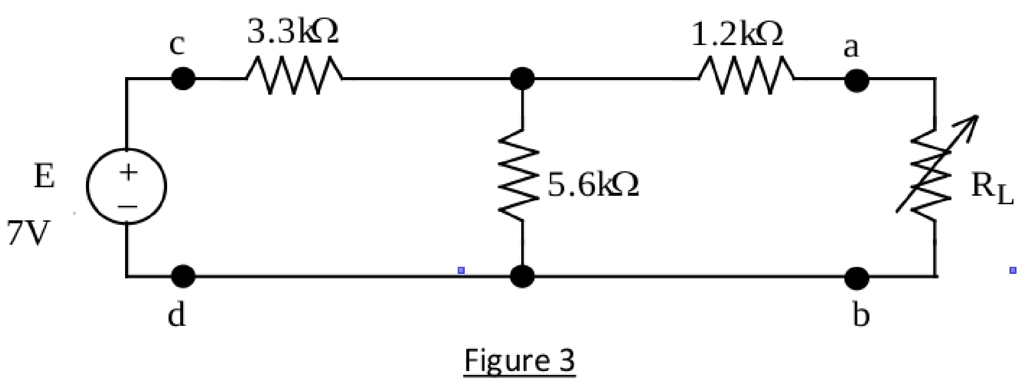


Figure 6: lab2-5.2.1

i) Connect the circuit without the load resistor R_L(o/s **a-b**). Measure the input Voltage, E, at the terminals **c-d**. Make sure the voltage is *7.00V*.
ii) Measure the voltage at the terminals **a-b**, which is V_{TH} = *4.42V*.
iii) Short circuit the terminals **a-b** and measure the current flowing from terminal **a** to terminal **b**, which is I_{TH} = *1.34mA*.
iv)

$$R_{TH} = \frac{V_{TH}}{I_{TH}} = \frac{4.42V}{1.34mA} = 3.30K\Omega \tag{10}$$

v) Remove short circuit across **a-b** and voltage source, and then short circuit **c-d**. Measure the resistance at the terminals **a-b**.

$$R'_{TH} = 3.28K\Omega \approx R_{TH} \tag{11}$$

vi) Connect different load resistors R_L at the terminals **a-b**. Measure the voltage across R_L and calculate the current through it.

Resistor	**Voltage**	**Current**
1 kΩ	1.04V	1.04mA
4.7 KΩ	2.60V	0.55mA
10 KΩ	3.35V	0.34mA

Table 4: lab2-5.2.1

vii) Using the circuit below and repeat the measurements.

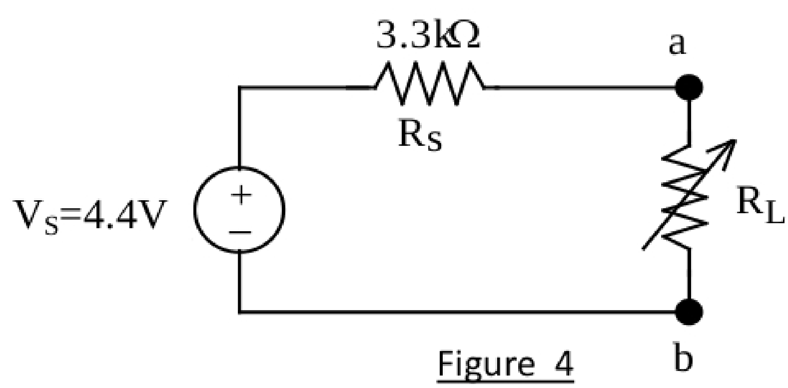


Figure 7: lab2-5.2

Resistor	Voltage	Current
1 kΩ	1.02V	1.03mA
4.7 KΩ	2.58V	0.54mA
10 KΩ	3.30V	0.33mA

Table 5: lab2-5.2.2

Table 4 and Table 5 shows that the second circuit is the expected circuit for the original circuit. To find the Thevenin's equivalent circuit, first disconnect the load circuit from the terminals **a-b** and then follow by measuring the voltage in the fixed circuit at the terminals **a-b**. This gives the Thevenin's equivalent voltage V_{TH}. The next step is to disable all the independent sources in the fixed circuit and measure the resistance at the terminals **a-b**. This gives the Thevenin's equivalent resistance R_{TH}. Then if a V_{TH} voltage source and a R_{TH} resistor is connected with R_L. It will behave then same as the original circuit.

2.3 Discussions

Part 1: Open circuit two voltage sources one by one, and then compare the data with originally measured data. **Part 2**: Thevenin's theorem is enables us to replace the fixed portion of the circuit by a greatly simplified equivalent circuit, which is obsered buy using R_{TH} and V_{TH} to reset up Thevenin's equivalent circuit.

3 Discussions

One common mistake is using wrong resistors during circuit set-up section. Choosing correct resistors is required for a correct result. A simple and clear circuit is helpful for mistake detection.