CE2004: Circuits & Signal Analysis
Electronics Lab (N4 B1C-17)

No. 2: Circuit Analysis Techniques

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1. **OBJECTIVES**

1.1 To verify the circuit analysis techniques - Superposition and Thévenin's Theorems, experimentally.

2. **LABORATORY**

Electronics Laboratory

3. **EQUIPMENT**

Components

100 Ω	1.2 kΩ	All resistors are about $0.01 each.
220 Ω	3.3 kΩ	
470 Ω	4.7 kΩ	
680 Ω	5.6 kΩ	
1 kΩ	10 kΩ	

(total no. of resistors : 10)

4. **INTRODUCTION**

4.1 **Superposition Theorem**

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.

In other words, if two or more independent sources are connected to a network of linear circuit elements, the actual voltage and current in any part of the circuit can be found by having one source at a time in the circuit, and then add up the separate responses of the element concerned. For example, consider a circuit with passive components and independent voltage sources only. When we evaluate the voltage or current components due to one voltage source, the remaining independent voltage sources are disabled by being replaced with short circuits.

4.2 Thevenin's Theorem

In the analysis of linear electric networks, cases occur in which one portion of a network remains fixed while the other portion is variable, and we need to determine the currents and voltages in the variable portion of the circuit. We may refer to the variable part of the circuit as the load circuit. A simple example is a circuit in which only the load resistance is varied. 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:

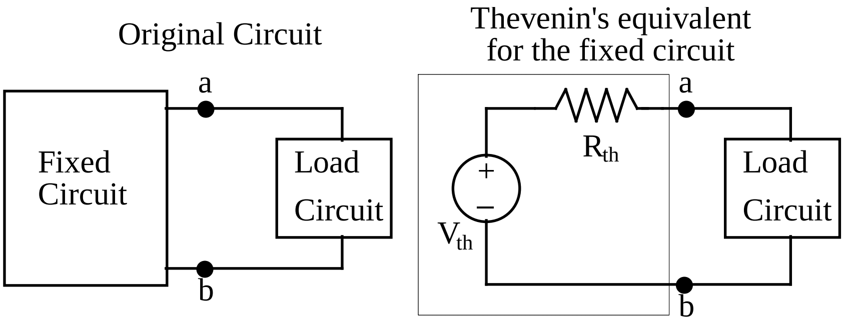


Figure 1

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}.

5. EXPERIMENT

5.1 Superposition

Connect the circuit shown in figure 2.

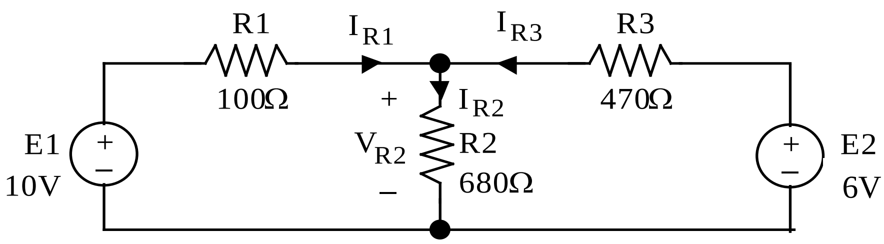


Figure 2

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.

IMPORTANT :
To disable a voltage source, remove it from the network before adding a short circuit to the network. Do not put a short circuit across the terminals of the power supply unit or the function generator as this will damage the equipment.

Table 1

	V_{R2}	I_{R1}	I_{R2}	I_{R3}
E1 & E2 together	8.29v	16.78mA	12.10mA	-4.83mA
E1 alone	7.37v	25.62mA	10.72mA	-15.23mA
E2 alone	0.63v	-6.14mA	0.92mA	7.13mA

Indicate the measurements obtained in steps 1, 2 and 3 in three separate diagrams of the circuit. Verify that your results recorded in table 1 satisfy the superposition theorem.

Q Did you encounter any negative current or voltage in your measurement? If yes, what do these results mean?

5.2 Thevenin's Theorem

Connect the circuit of figure 3 without the load resistor R_L(open **a-b**). Measure the input voltage, E, at the terminals **c-d** with the multimeter. 7.00v

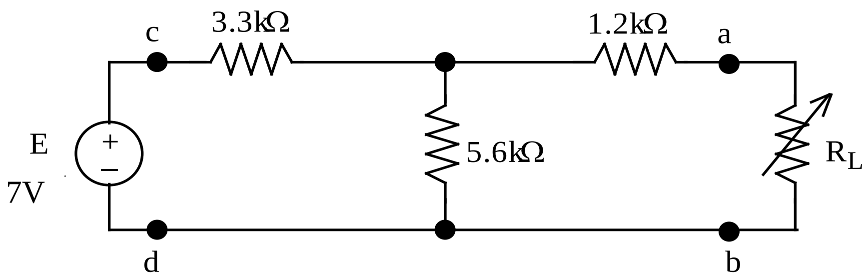


Figure 3

4.42v
(i) Measure the voltage at the terminals **a-b**. This open-circuit voltage $V_{o/c}$ is the Thevenin's equivalent voltage of the circuit as seen by the load resistor at the terminals.
(ii) Short circuit the terminals **a-b** and measure the current flowing from terminal **a** to terminal **b**. This short-circuit current $I_{s/c}$ is the Norton's equivalent current. 1.35mA

(iii) Calculate the value of the Thevenin's (or Norton's) equivalent resistance using the formula:
$R_{th} = V_{o/c} / I_{s/c}$. 3.27k = 4.42v / 1.35mA

(iv) Remove the short circuit across a-b, the voltage source E and short circuit **c-d**. Measure the resistance at the terminals **a-b**. 3.25k This is the measured Thevenin's equivalent resistance at the terminals. Compare this value of Thevenin's equivalent resistance with that calculated earlier.

(v) Connect a load resistor R_L at the terminals **a-b**. Measure the voltage across R_L and calculate the current through it. Make measurements for these values of R_L (ohms): 1 k, 4.7 k, 10k and put your results in a table.

1.03v 2.62v 3.32v

1.03mA 0.56mA 0.332mA

(vi) Using the circuit of figure 4, repeat the measurements as before with the same values of R_L and again put your results in a table. Compare and comment on the results in these two tables. Are they as expected?

1k: 1.02v 4.7k: 2.61v 10k: 3.33v

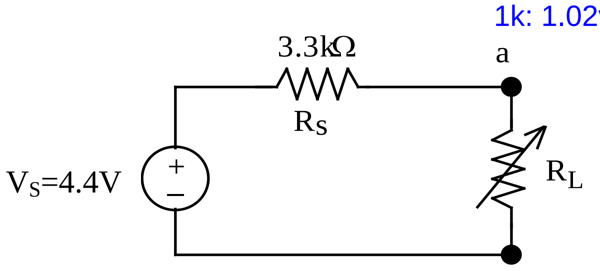
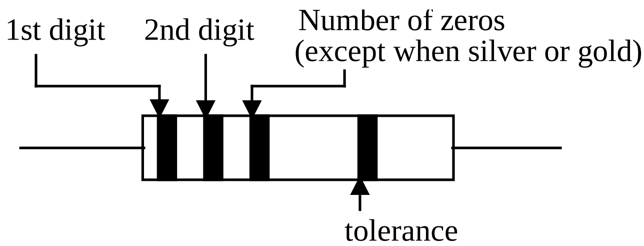


Figure 4

6. APPENDIX

Resistor colour code

The value of a resistor is colour-coded as shown below:



First three bands			Fourth band	
Black	0		Gold	± 5%
Brown	1		Silver	± 10%
Red	2		None	± 20%
Orange	3			
Yellow	4			
Green	5			
Blue	6			
Violet	7			
Grey	8			
White	9			
Silver	0.01			
Gold	0.1			

For example: A resistor coded as orange, blue, red, gold has a resistance of $36 \times 10^2\ \Omega \pm 5\%$, i.e. $3.6k\Omega \pm 5\%$.