EE283 Lab 4
Superposition
And
Thevenin, Norton Analysis

Objective: The object of this exercise is to

- Verify the superposition principle.
- Use Thevenin and Norton equivalent circuits to simplify circuits.

Equipment Required:

- Digital Multimeter (DMM)
- Resistor Decade Box
- Resistor Color Codes (see attachment A)
- Power Supply (see attachment B)
- Breadboard (see attachment C)

Superposition Theory:

The total current in any part of a linear circuit equals the algebraic sum of the currents produced by each source separately. To evaluate the separate currents to be combined, replace all other voltage sources by short circuits and all other current sources by open circuits.

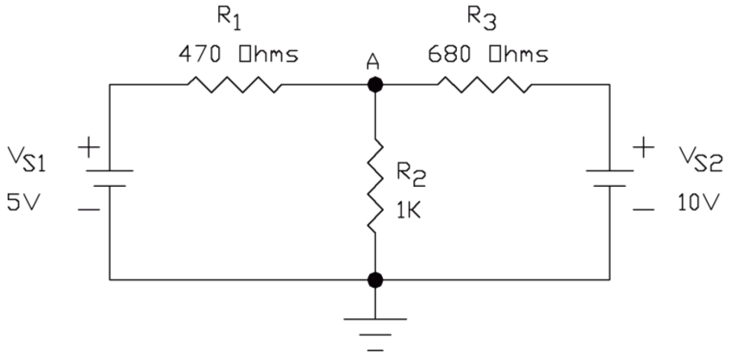
Procedure:

- Use the DMM to measure the voltage at node A with both voltage sources turned on. Then measure the voltage at node A with V_{S1} removed and replaced with a short circuit. Then measure the voltage at node A with V_{S2} removed and replaced with a short circuit and V_{S1} reinstalled and set to the original voltage.

1. Using the resistors supplied, measure the resistance values using the DMM and record the values and tolerances in the table below and in your report. Then construct the circuit below on your breadboard.

Reference Designation	Nominal Resistance value – Ohms	Actual Resistance Value – Ohms	Resistor Tolerance %
R_1	470		
R_2	1K		
R_3	680		

Table 1



2. Set the voltage of V_{S1} to +5 V_{DC} and set the voltage of V_{S2} to +10 V_{DC}. Using the DMM set to measure V_{DC} measure the voltage at node A. Record this voltage in the table below. Repeat this measurement with V_{S1} = +5 V_{DC}, V_{S2} = 0 V_{DC} (i.e. replace V_{S2} with a short circuit) and again with V_{S1} = 0 V_{DC} (i.e. replace V_{S1} with a short circuit), V_{S2} = +10 V_{DC}. Record these values in your report.

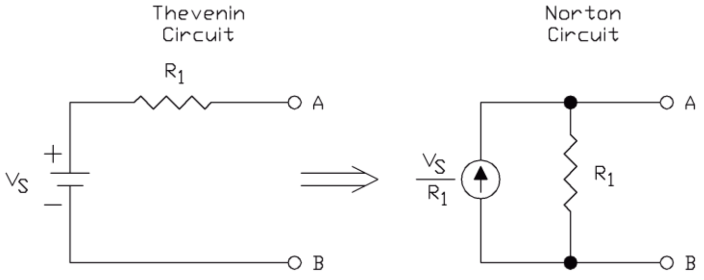
Column 1	Column 2	Column 3
V_{S1}=5 V_{DC} V_{S2}=10 V_{DC}	V_{S1}=5 V_{DC} V_{S2}=0 V_{DC}	V_{S1}=0 V_{DC} V_{S2}=10 V_{DC}

Table 2

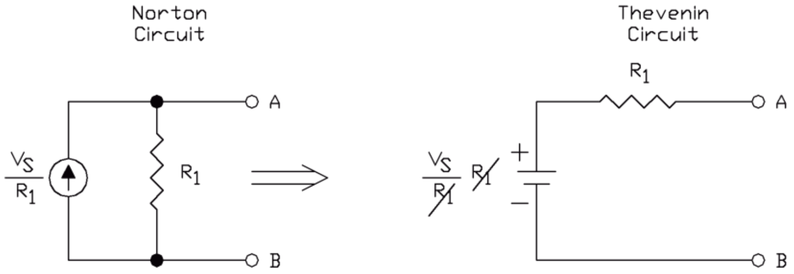
Add the voltages in columns 2 and 3. Does the sum of these voltages equal the voltage in column 1? Show this summation in your report.

Thevenin and Norton Equivalent Circuit Theory:

A Thevenin circuit is a voltage source connected in series with a resistor. This Thevenin circuit can be converted to a Norton equivalent circuit which is a current source in parallel with a resistor. The current source will have the value of the Thevenin voltage source divided by the Thevenin resistance. The Norton equivalent resistance will have the same value as the Thevenin resistance. This is shown in the figure below. An external linear component (i.e. a resistor, inductor or capacitor) connected between terminals A and B will have the same voltage and current no matter which circuit it is connected to. The Norton circuit is equivalent to the Thevenin circuit.



In a similar manner a Norton circuit can be converted into a Thevenin equivalent circuit as shown in the figure below.



The Thevenin equivalent voltage source will have the value of the Norton current source multiplied by the Norton resistance. The Thevenin equivalent resistance will have the same value as the Norton resistance. The Thevenin circuit is equivalent to the Norton circuit.

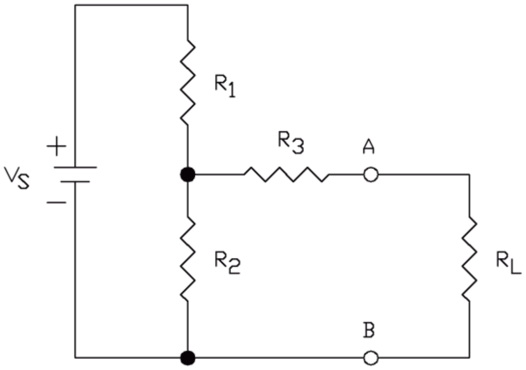
Procedure:

1. Using the resistors supplied, measure the resistance values using the DMM and record the values and tolerances in the table below and in your report. Then construct the circuit below on your breadboard.

Reference Designation	Nominal Resistance value – Ohms	Actual Resistance Value – Ohms	Resistor Tolerance %
R_1	2.2K		
R_2	2.7K		
R_3	470		
R_L	1K		

Table 3

2. Construct the circuit shown below on your breadboard. Set the power supply voltage, V_S to +10 V_{DC}.

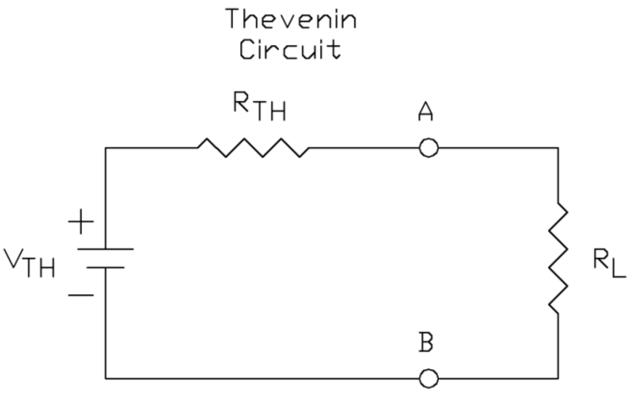


3. With the DMM set to measure V_{DC} measure the voltage from A to B (V_{A-B}) for the following three conditions and record these voltages in the table below and in your report.
    - With R_L removed
    - With R_L shorted
    - With R_L installed

	R_L removed	R_L shorted	R_L installed
V_{A-B}			

Table 4

4. Using the measured values of V_S, R_1, R_2 and R_3 determine the values for Thevenin equivalent circuit shown below. Mark these values on the circuit below and in your report.



5. Construct the Thevenin circuit using a resistance decade box set for the valuc of the Thevenin resistance, R_{TH}. Set the power supply voltage to the Thevenin voltage, V_{TH}.

6. With the DMM set to measure V_{DC} measure the voltage in the Thevenin circuit from A to B (V_{A-B}) for the following three conditions and record these voltages in the table below and in your report.
    - With R_L removed
    - With R_L shorted
    - With R_L installed

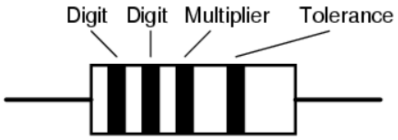
	R_L removed	R_L shorted	R_L installed
V_{A-B}			

Table 5

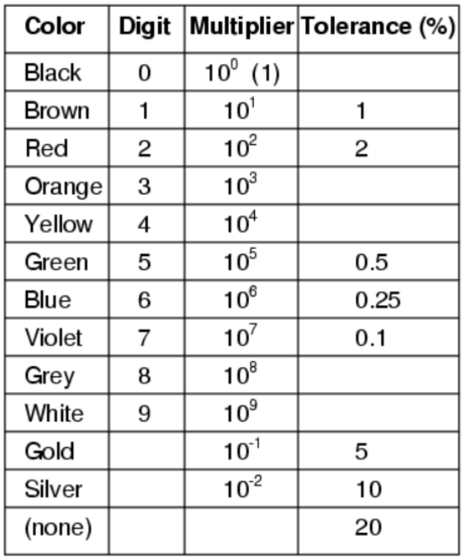
7. In your report compare the voltages in tables 4 and 5. Do they agree? If not why not?

Remember that your report must be legible. If I can’t read it you won’t get credit for it!

Appendix A



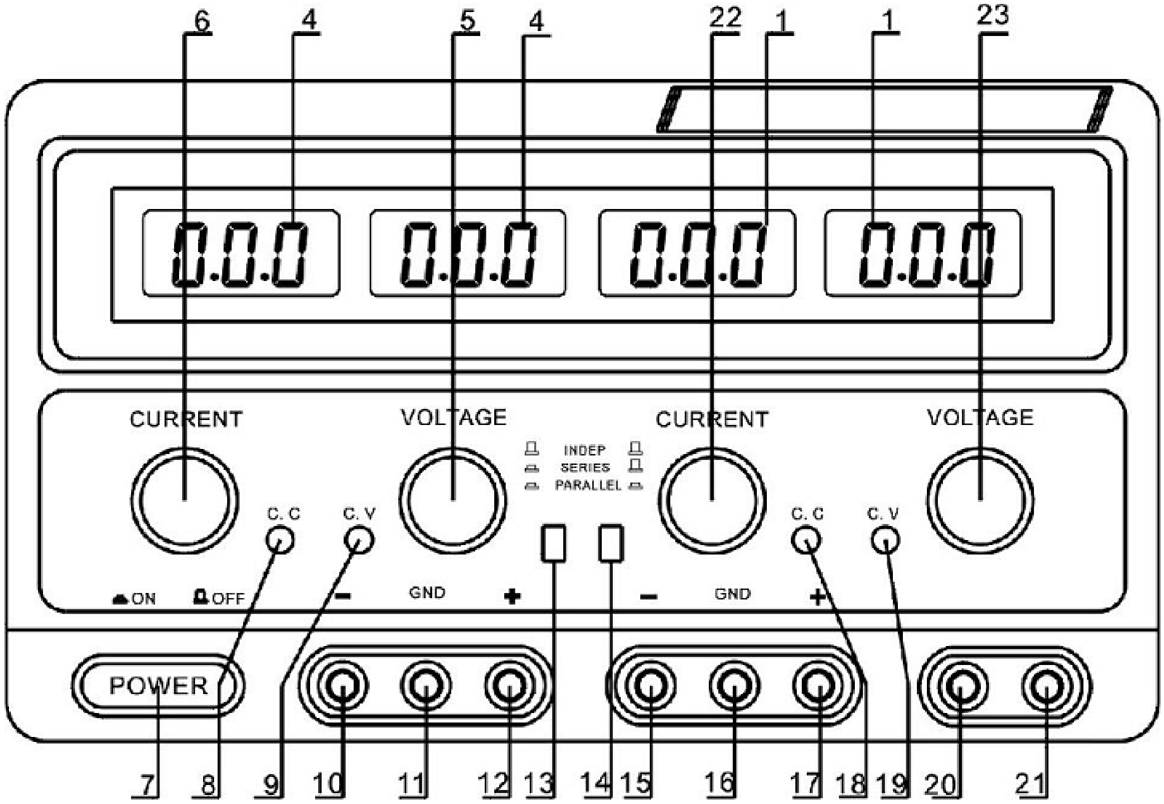
4-band code



Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

Appendix B

TekPower TP3005D-3 Power Supply



To turn this power supply on push in the power switch 7. This unit has three independent and isolated power supplies.

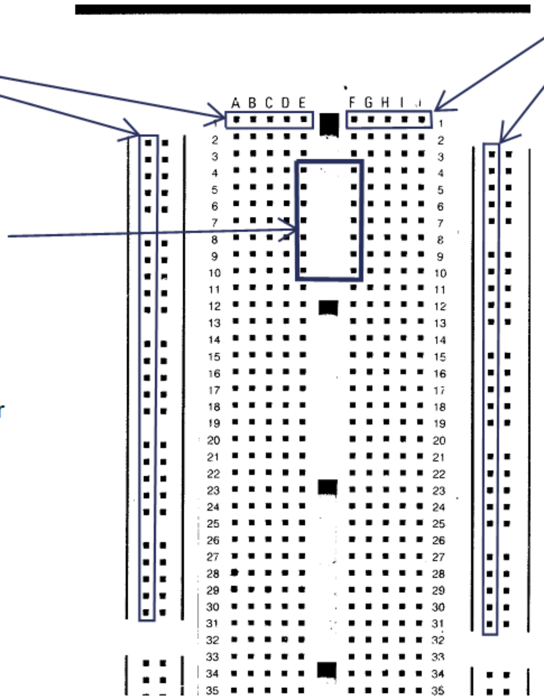
The first supply has an adjustable voltage range of 0 to 30 volts and can supply up to 5 amperes of current. The controls and terminals for this supply are located on the left side of the unit. Knob 5 controls the voltage, knob 6 sets the maximum current limit and the output voltage is obtained from terminals 12(+) and 10(-). Terminal 11 is connected to the chassis (we won’t use this terminal). The digital readout directly above the current limit knob displays the power supply current and the digital readout directly above the voltage adjustment knob displays the power supply output voltage. If the power supply is in voltage control mode the indicator light 9 will be illuminated. If the power supply is in current limiting mode the indicator light 8 will be illuminated. We will always operate the power supply in voltage control mode.

The second power supply is identical to the first power supply except that all of the controls and terminals are located on the right hand side of the unit.

The third power supply has a fixed voltage of 5 V_{DC} which is obtained from terminals 21(+) and 20(-). We will use this voltage for our digital lab exercises.

Appendix C

Breadboard Connections



These holes are all connected together but they are not connected to anything else.

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Integrated circuit 14 pin dip package is inserted here so the package pins are inserted into the column E and F holes. Connection to the package pins is then made by connecting wires to the A,B,C and D holes or the G, H, I and J holes