

ECE 281

Electrical Circuits and Instrumentation + Laboratory

Fall 2016/2017

LAB # 8

28.11.2016

**Thevenin and Norton Equivalent circuits:** Thevenin and Norton Equivalent Circuits are simplified circuit diagrams of a more complex circuit. When some basic operations are performed (like open circuit and short circuit), the complex circuit turns into simplified one with same characteristics between the selected terminal nodes. The complex circuit and the simplified circuit are equivalent to each other.

**Objective:**

1. To find  $V_{th}$  and  $R_{th}$  between two points in a circuit by measurement.
2. To find  $I_N$  and  $R_N$  between two points in a circuit by measurement.
3. Maximum power transfer

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**1. To find  $V_{th}$  and  $R_{th}$  between two points in a circuit by measurement (30 Points)**

For a Thevenin Equivalent circuit we can refer to Figure 1 where  $R_{TH}$  is the Thevenin equivalent resistance between points A and B and  $V_{TH}$  is the Thevenin equivalent voltage between points A and B (open circuit voltage between points A and B).

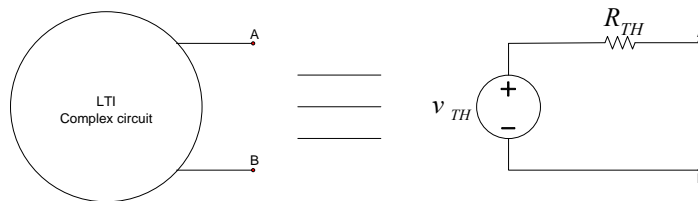


Figure 1: Thevenin Equivalent Circuit.

**Procedure:**

1. Construct the circuit in Figure 2 ( $R_1= 1k\Omega$ ,  $R_2= 5k\Omega$ ,  $R_3= 5k\Omega$ ,  $V_S= 10$  Volt).

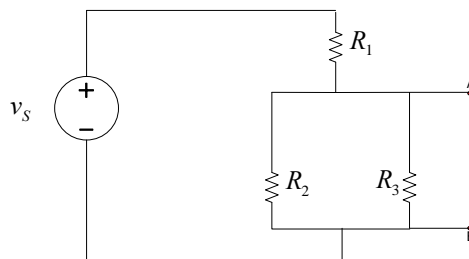
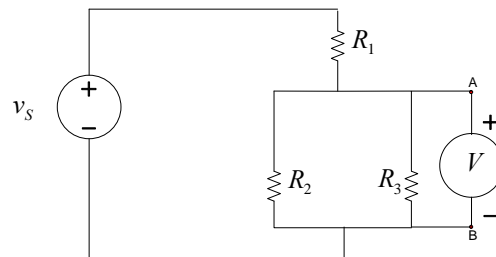


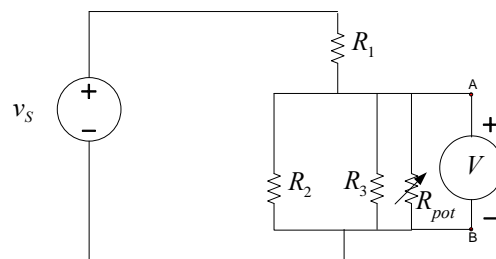
Figure 2

2. Firstly, in order to find  $V_{TH}$  connect a Voltmeter between points A and B as in Figure 3. The voltmeter will measure the **open circuit voltage between points A and B ( $V_{TH}$ )**.



**Figure 3**

3. Now, put a potentiometer (nominal value  $10\text{ k}\Omega$ ) between points A and B as in Figure 4 and adjust the potentiometer such that potential difference between the nodes A and B is equal to  $\frac{V_{TH}}{2}$ . After this point, disconnect the potentiometer from the circuit and find potentiometers' adjusted resistance value which will give us  $R_{TH}$ .



**Figure 4**

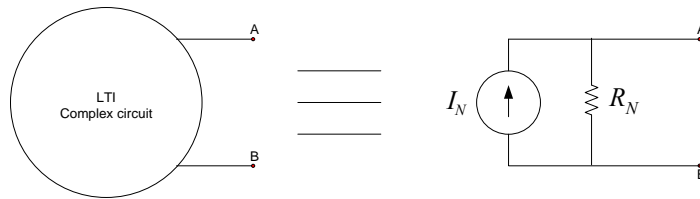
4. Now compare your theoretical results (by deriving the Thevenin Equivalent Circuit theoretically) with the experimental results. Write your results on Table 1.

	Theoretical Results	Experimental Results
$V_{TH}$		
$R_{TH}$		

**Table 1:** Table for comparing the theoretical and experimental results

## 2. To find $I_N$ and $R_N$ between two points in a circuit by measurement (20 Points)

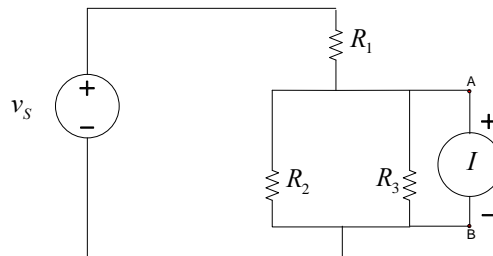
Similar to Thevenin equivalent circuit, we can use Figure 5 for Norton equivalent circuit. In Figure 5,  $R_N$  is the Norton equivalent resistance between points A and B and  $I_N$  is the Norton equivalent current between points A and B (short circuit current from A to B).  $R_N$  and  $R_{TH}$  are equal to each other and  $R_{TH} = R_N = \frac{V_{TH}}{I_N}$  always hold.



**Figure 5:** Norton Equivalent Circuit

### Procedure:

1. Again use the circuit shown in Figure 2.
2. This time instead of the voltmeter connect an ampere meter as in Figure 6. The ampere meter will measure the **short circuit current from node A to node B ( $I_N$ )**.



**Figure 6**

3. Now compare your theoretical results (by deriving the Norton Equivalent Circuit theoretically) with the experimental results. Write your results on Table 2.

	Theoretical Results	Experimental Results
$I_N$		
$R_N$		

**Table 2:** Table for comparing the theoretical and experimental results

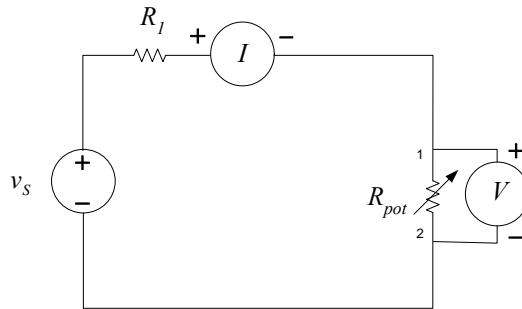
### Questions:

- Draw equivalent Thevenin and Norton circuits.
- Why the value shown by the potentiometer equal to  $R_{th}$  when the voltage is equal to  $\frac{V_{TH}}{2}$  ?

### 3. Maximum Power Transfer (50 Points)

#### Procedure:

1. Construct the circuit shown in Figure 7 ( $V_s=10$  Volt,  $R_1=5$  k $\Omega$ ,  $R_{pot}=10$  k $\Omega$  (nominal value)).

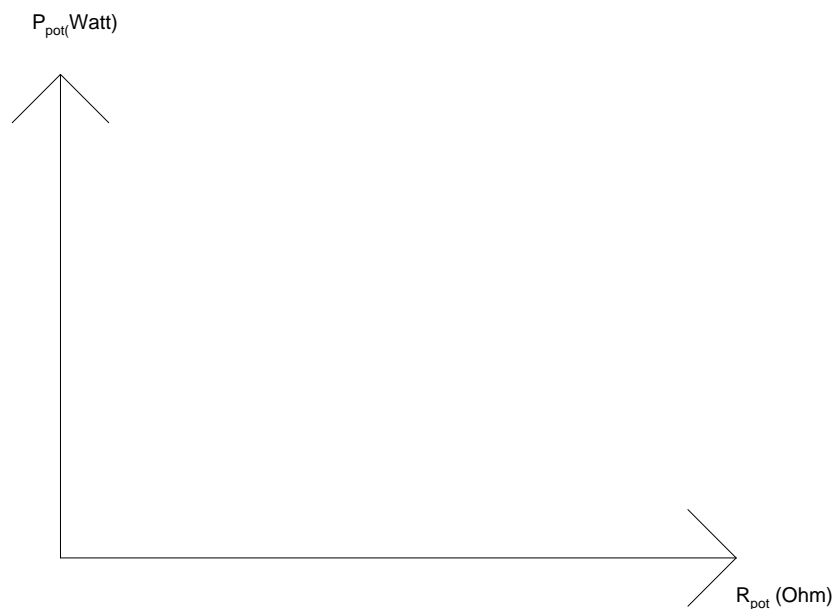


**Figure 7:** Circuit for current and voltage measurement over a potentiometer.

2. Use **digital multimeter as ampermeter** your measurements.
3. In the set up, the potentiometer will be externally adjusted to 0, 1000, 2000, ..., 10000  $\Omega$  values respectively in order as shown in Table 3 (disconnect the potentiometer from the circuit, adjust it to the required value than connect the potentiometer to the circuit once again for voltage and current measurements at each step).
4. According to these adjusted resistance values, you are supposed to measure the voltage and current values and calculate the power values associated with each measurement for the potentiometer.
5. Finally Draw  $P_{pot}$  (power produced over the potentiometer) as a function of  $R_{pot}$  (resistance of the potentiometer) over Figure 8 using the data you have obtained from Table 3.

	$R_{pot} (\Omega)$	I (measured) (mA)	V (measured) (Volt)	$P_{pot}$ (Watt)
1.	0			
2.	1000			
3.	2000			
4.	3000			
5.	4000			
6.	5000			
7.	6000			
8.	7000			
9.	8000			
10.	9000			
11.	10000			

**Table 3:** Voltage and current measurements and power calculation over  $R_{pot}$



**Figure 8:** Plot of power versus the resistance over the potentiometer

**Questions:**

- When (at which resistance values) does maximum power is delivered to the potentiometer? Why?