EXPERIMENT 4:

Thévenin Equivalent Circuit and Maximum Power Transfer

Objective:

Verify Thévenin's theorem by obtaining the Thévenin equivalent voltage (V_{TH}) and Thévenin equivalent resistance (R_{TH}) for the given circuit. Verify the Maximum Power Transfer Theorem.

Equipment:

- Circuit Board
- Assorted Resistors(300 Ω (2), 560 Ω (2), 820 Ω and 1.2 KΩ)
- Decade Resistance Box.

Theory:

Thévenin's Theorem: It is a process by which a complex circuit is reduced to an equivalent series circuit consisting of a single voltage source (V_{TH}), a series resistance (R_{TH}) and a load resistance (R_L). After creating the Thévenin Equivalent Circuit, the load voltage V_L or the load current I_L may be easily determined.

One of the main uses of Thévenin's theorem is the replacement of a large part of a circuit, often a complicated and uninteresting part, by a very simple equivalent. The new simpler circuit enables us to make rapid calculations of the voltage, current, and power which the original circuit is able to deliver to a load. It also helps us to choose the best value of this load resistance for *maximum* power transfer.

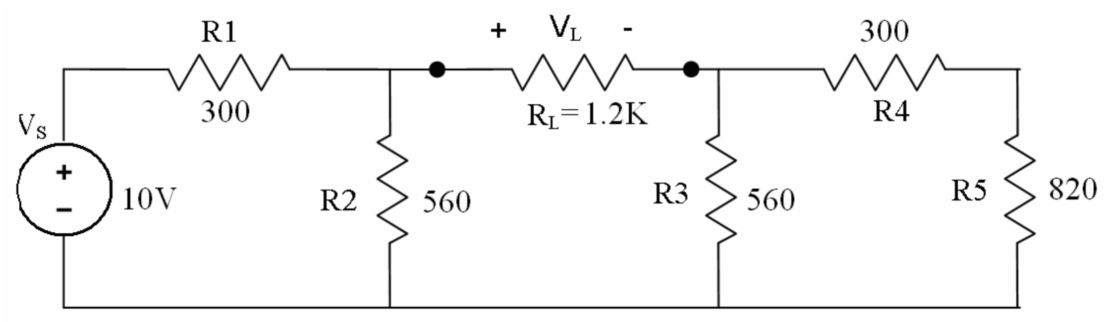

Figure 1.

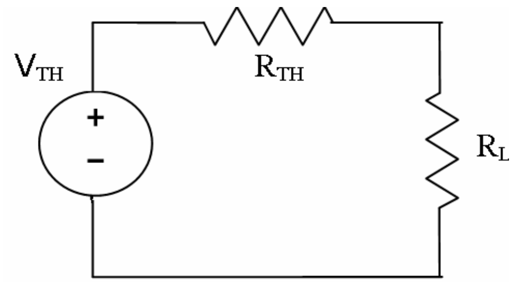

Figure 2: Thévenin Equivalent Circuit of Figure 1

2. ***Maximum Power Transfer Theorem*** states that an independent voltage source in series with a resistance R_S or an independent current source in parallel with a resistance R_S, delivers a maximum power to that load resistance R_L for which $R_L = R_S$.

   In terms of a Thévenin Equivalent Circuit, maximum power is delivered to the load resistance R_L when R_L is equal to the Thévenin equivalent resistance R_{TH} of the circuit.

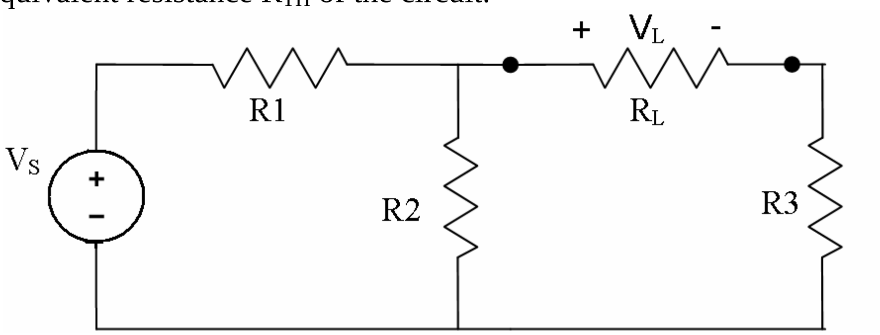

Figure 3: Maximum Power Transfer

Procedure:

1. Verifying the Thévenin's theorem:
   a) Construct the circuit of Figure 1 using the following component values:
      R1 = 300 Ω
      R2 = 560 Ω
      R3 = 560 Ω
      R4 = 300 Ω
      R5 = 820 Ω
      R_L = 1.2 KΩ
      V_S = 10 V

   b) Accurately measure the voltage V_L across the load resistance using NI Elvis voltmeter or an external DMM. This value will later be compared to the one you will find using Thevenin Equivalent.

c) Find V_{TH}: Remove the load resistance R_L and measure the open circuit voltage V_{OC} across the terminals. This is equal to V_{TH}. See Figure 4. below

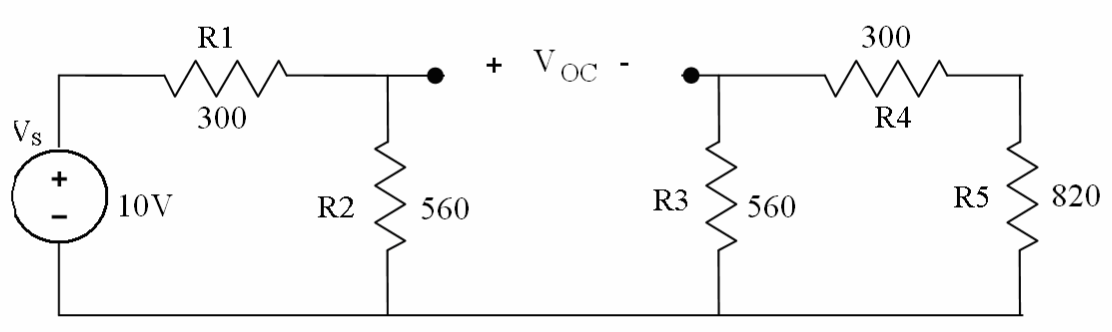

Figure 4: Measuring the Thevenin Voltage

d) Find R_{TH}: Remove the source voltage V_S and construct the circuit as in Fig.5.. below. Measure the resistance looking into the opening where R_L was with an ohmmeter (DMM). This gives R_{TH}. Make sure there is no power in the circuit before measuring with an Ohm-meter.

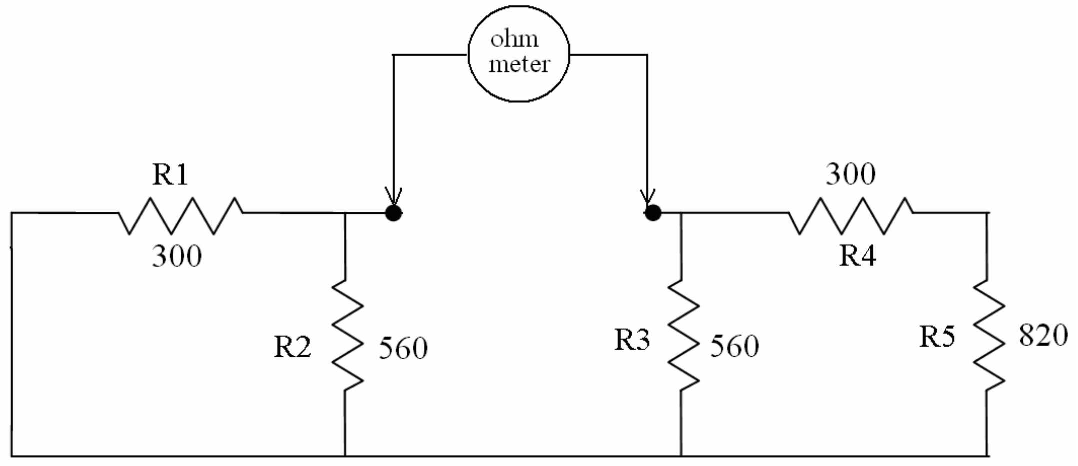

Figure 5: Measuring the Thevenin Resistance RTH.

e) Obtaining V_{TH} and R_{TH}, construct the circuit of figure 2. Set the value of R_{TH} using a Decade Resistance Box, and set V_{TH} using variable power supply.

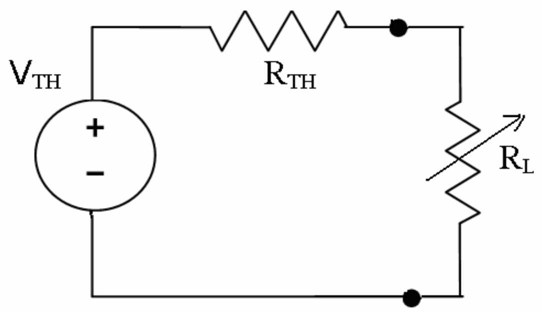

Figure 6: Thevenin Equivalent Construction

f) Measure the V_L for this circuit and compare it to the V_L obtained in Procedure 1-b. This verifies the Thévenin theorem.

g) Optional: Repeat steps 1(b) to 1(f) for R_L = 3.3 KΩ

2. Verifying the Maximum Power Transfer theorem:

a) Construct the circuit as in Figure 7 using the following values:
V_S = 10 V
R1 = R2 = 560 Ω
R3 = 820 Ω
R_L = Decade Resistance Box (DRB)

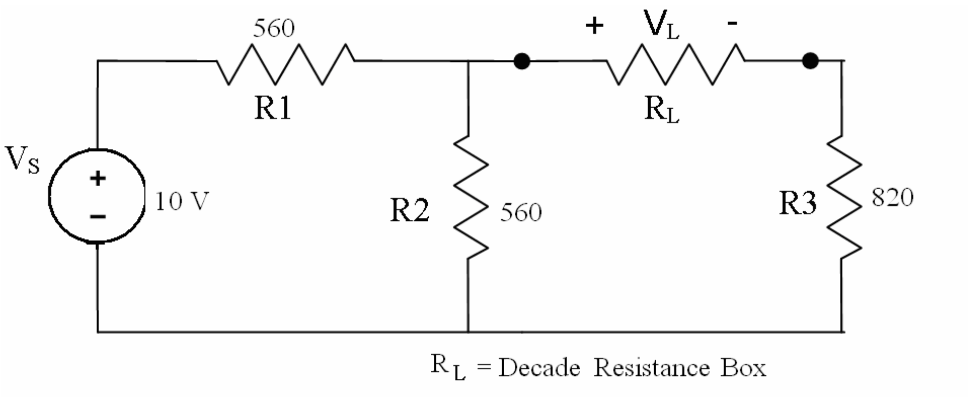

Figure 7: Circuit for Max. Pow. Theorem

b) Connect the DMM across R_L for measuring the load voltage.
c) To find the value of R_L for which maximum power is transferred, vary the resistances on the DRB between 800 Ω to 1400 Ω in 100 Ω steps and note down V_L for each case.
d) Calculate the power for each load resistor value (DRB) using $P_L = V_L^2 / R_L$. Then, find the resistor value corresponding to the maximum power (P_{L-max}). This value should be equal to R_{TH} of circuit in fig.7 with respect to load terminals.

Questions for Lab Report:

1. Calculate the percentage error difference between the load voltages obtained for circuits of figure 1 and figure 2.
2. Using Voltage Division for circuit of figure 2, calculate V_L. Compare it to the measured values. Explain any differences.
3. Calculate the maximum power transmitted to the load R_L obtained for the circuit of figure 3.

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