ET 304a Laboratory 7 The Maximum Power Transfer Theorem

- **Purpose:** Experimentally prove the maximum power transfer theorem for dc circuits. Observe the effects that source resistance has of the power transfer from the source.
- **Objectives:** Experimentally determine the Thevenin's equivalent circuit of a network. Find how the voltage across a load varies with the value of load resistance. Determine the load resistance that produces the maximum power transfer from a network to a load resistance. Observe the changes in load current as load resistance and power change. Compare the results of the laboratory measurement to the theoretical calculations to prove that the maximum power transfer to a load resistance occurs when the load and source resistances are equal.

Procedure

1.) Construct the circuit shown in Figure 1. Measure the voltage Va-Vb with no load resistor connected.



Figure 1. Circuit for maximum power test.

- 2.) Select the values of load resistance listed in Table 1 from the lab resistor stock and measure the actual values with a multimeter. Record the values in the table for later use. Connect the values of load resistors RL listed in Table 1 across the points Va, Vb and measure the voltage drop across the values of the load resistor.
- 3.) Compute the power dissipated for each load resistor using the formula:

$$P_{\rm L} = \frac{V_{ab}^2}{RL}$$

record this value in the table for later reference.

- 4.) Compute the load current for each load resistor using Ohm's law and enter it into the table for later use.
- 5.) Connect a 5,000 Ohm potentiometer across the network output terminals as shown in Figure 2. Measure the voltage, V_{ab} across the potentiometer with a voltmeter. Adjust the potentiometer until the voltage across it reads 1/2 of the open circuit voltage. Remove the potentiometer from the circuit and measure the resistance across the potentiometer with a multimeter.



Figure 2. Experimental Setup to Measure Thevenin's Resistance.

6.) Record the value of this resistance in the table below for later use. Compute the values of resistor power, and current for this reading.

R1=1000 ohms			
Measured R _{th}	Load Voltage	Calculated Load	Calculated Load
(ohms)	V _{ab} (Volts)	Power (P _L)	Current (I _L)

7.) Repeat steps 1-6 for the circuit in Figure 1 with the value of R1 changed to 470 ohms from 1000 ohms. Record this data in Table 2. Record the experimental results from the Thevenin's resistance test in the table below for later reference.

R1=470 ohms			
Measured R _{th}	Load Voltage	Calculated Load	Calculated Load
(ohms)	V _{ab} (Volts)	Power (P _L)	Current (I _L)

Theoretical Calculations

Compute the theoretical Thevenin's equivalent values for The circuit is Figure 1 with R1=1000 ohms and R1=470 ohms. Include these values in the lab report. Using the Thevenin's equivalents compute the theoretical values of load resistor voltage, power, and current for both circuits using all the resistor values listed in column 1 of Tables 1 and 2. Show sample calculations for this procedure in the report. Compute the percentage error between the power values found in lab and the theoretical calculations using the formula:

$$\% error = \frac{P_{Ltheo} - P_{Llab}}{P_{Ltheo}} \cdot 100\%$$

Where: P_{Ltheo} = theoretical value of power P_{Llab} = power value from lab measurements

Calculate these values for the R1=1000 ohm case only.

Graphs and Plots

Construct the following plots for the lab report.

 $P_L(y)$ vs RL (x), R1=1000 ohms

Plot the lab measurements and theoretical values on the same axis for the circuit. Make this a semilog plot with the RL axis having the Log scaling.

 $\underline{P_L(y) \text{ vs } RL(x)}$ R1=470 ohms

Plot the lab measurements and theoretical values on the same axis for the circuit. Make this a semilog plot with the RL axis having the Log scaling.

 V_{ab} (y) vs RL (x)

Plot the voltage drop across the load resistors for both the R1=1000 and R1=470 case on the same axis. Only plot the experimental results.

 $I_L(y)$ vs RL (x)

Plot the current though the load resistors for both the R1=1000 and R1=470 case on the same axis. Only plot the experimental results.

<u>% error $P_{L}(y)$ vs RL (x)</u>

Plot the power error for the R1=1000 ohm case only.

Discussion Points

Was the theory from the class confirmed by these tests within the experimental error? What effect did changing R1 have on the power transfer, load voltage and current? What values of load resistance give the maximum current and voltage across the load? Does maximum power occur when maximum voltage or maximum current occur?

RL	Measured RL	Load Voltage	Calculated Load	Calculated Load
(ohms)	(ohms)	V _{ab} (Volts)	Power (P _L)	Current (I _L)
220				
470				
1,000				
1,200				
1,500				
1,800				
2,200				
2,700				
4,700				
8,200				
12,000				
18,000				

 Table 1.
 Power Transfer data (R1=1000 ohms)

Table 2.Power Transfer data (R1=470 ohms)

RL	Measured RL	Load Voltage	Calculated Load	Calculated Load
(ohms)	(ohms)	V _{ab} (Volts)	Power (P _L)	Current (I _L)
220				
470				
1,000				
1,200				
1,500				
1,800				
2,200				
2,700				
4,700				
8,200				
12,000				
18,000				