Lab Exercise No. 8
Maximum Power Transfer

Paul Andrew F. Parras , Vaun Michael C. Pace
Department of Computer Engineering
School of Engineering, University of San Carlos
Nasipit, Talamban Cebu City, Philippines
parraspaul13874@gmail.com pacevaun@gmail.com

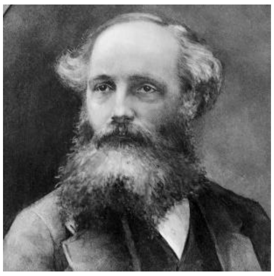
Abstract—**This laboratory exercise will demonstrate the Maximum Power Transfer theorem. The theorem asserts that when a load's resistance equals the source resistance, the maximum amount of power is transferred to it, is examined in this lab. The Experiment serves as an example of how the Maximum Power Transfer concept is used in circuit design.**

Keywords- Source Resistance, Power Transfer, Load Resistance , Efficiency, Electrical Circuit, Impedance

I. Introduction

The **Maximum Power Transfer Theorem** states that to generate maximum external power through a finite internal resistance, the resistance of the given load must be equal to the resistance of the available source. The theorem is widely used in Electrical and electronics engineering, where matching impedances optimizes power delivery to devices.

The concept was initially brought upon us by **Moritz von Jacobi**, a German physicist and engineer during the 1840's. He discovered the principle while working on DC systems specifically those of telegraphy and electric motors. After this, another key figure by the name of **James Clerk Maxwell,** a Scottish physicist further developed and formalized circuit theory. Maxwell's equations were formulated in the 1860's and unified the understanding of electromagnetism and influenced many aspects of electrical engineering, including **power transfer**.

Moritz von Jacobi & James Clerk Maxwell

To put it simply, the **Maximum Power Theorem** helps us in maximizing power delivery efficiency, especially in systems that require the most efficient transfer of energy or signals from a source load.

II. Procedure

A. Calculating for Theoretical Valuess

To start the experiment, we first must look at the given circuit and analyze it.

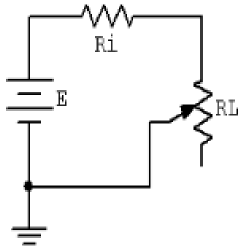


Figure 2.1 The Circuit

In the experiment, the resistance and Voltage values are already given, so all we should do now is calculate the Values needed in table 12.1

R_L	V_L	P_L	P_T	η
30				
150				
500				
1 k				
2.5 k				
Actual=				
4 k				
10 k				
25 k				
70 k				
300 k				

Table 12.1

To find these values, we use the following formulas:

Voltage across the Load(V_L):

$$= \frac{RL}{Ri + RL} * E$$

Power in Load (P_L):

$$= \frac{VL^2}{RL}$$

Total Power (P_T):

$$= \frac{E^2}{RL+Ri}$$

Efficiency(Ƞ):

$$= \frac{PL}{PT} * 100\%$$

After we calculate for these values, we then insert them into the table above (Table 12.1).

B. *Building and Measuring the Circuit*

To build the circuit, we follow the layout of the illustration illustrated above earlier (**Figure 2.1**). Determine the following values and insert them to table:

R_L	V_L	P_L	P_T	η
30				
150				
500				
1 k				
2.5 k				
Actual=				
4 k				
10 k				
25 k				
70 k				
300 k				

Table 12.2

III. Results and Analysis

After performing the experiment and doing the necessary calculations, we have come up with the following data:

A. *Answers for Table 12.1*

R_L	V_L	P_L	P_T	η
30	0.09V	0.27mW	30.03mW	0.90%
150	0.43V	1.23 mW	28.99mW	4.25%
500	1.34V	3.59mW	26.32 mW	13.65%
1 k	2.34V	5.48 mW	23.26mW	23.55%
2.5 k	4.33V	7.50 mW	17.24mW	43.50%
Actual= 3.3K	5.02V	7.64mW	15.15 mW	50.40%
4 k	5.51V	7.59mW	13.70mW	55.41%
10 k	7.53V	5.67mW	7.52mW	75.41%
25 k	8.84 V	3.13 mW	3.53mW	88.46%
70 k	9.56V	1.30mW	1.36mW	95.70%
300 k	9.70V	0.94mW	0.97mW	97.19%

Table 12.1

This table of data represents the relationship between the voltage and power of the load resistors, as well as the total power of the circuit. We can see from the data that as the RL increases, the voltage and efficiency rise.

B. *Answers for Table 12.2*

R_L	V_L	P_L	P_T	η
30	0.09V	0.27mW	30.03mW	0.90%
150	0.43V	1.23 mW	28.99mW	4.25%
500	1.34V	3.59mW	26.32 mW	13.65%
1 k	2.34V	5.48 mW	23.26mW	23.55%
2.5 k	4.33V	7.50 mW	17.24mW	43.50%
Actual= 3.3K	5.02V	7.64mW	15.15 mW	50.40%
4 k	5.51V	7.59mW	13.70mW	55.41%
10 k	7.53V	5.67mW	7.52mW	75.41%
25 k	8.84 V	3.13 mW	3.53mW	88.46%
70 k	9.56V	1.30mW	1.36mW	95.70%
300 k	9.70V	0.94mW	0.97mW	97.19%

Table 12.1

This table shows the values for the experimental data. As we can see, it is very similar to the previous table(Table 12.1) whereas the RL increases, the efficiency also increases.

C. *Questions*

1. **At what point does maximum load power occur?**
   - Maximum load power occurs when the load resistance R_L is equal to the source's internal resistance R_i. Since R_i is given as 3.3KΩ, then Maximum load power occurs when R_L is 3.3 KΩ.
2. **At what point does maximum total power occur?**
   - In the given circuit, maximum total power occurs when the load resistance approaches Zero.
3. **At what point does maximum efficiency occur?**
   - Maximum efficiency occurs when the load resistance (R_L) becomes much larger than the internal resistance (R_i).
4. **Is it safe to assume that generation of maximum load power is always a desired goal? Why/why not?**
   - Maximum load power can be beneficial in certain applications where high power output is essential, it is not universally desirable due to efficiency losses, potential overheating, and safety concerns. Often, a balance between power transfer and efficiency is sought depending on the system's requirements.

IV. Conclusion

In conclusion, a useful concept for comprehending how to maximize power delivery in electrical circuits is the Maximum Power Transfer Theorem. Studies of circuit behavior and power optimization have shown that the maximum power is delivered to the load when the load resistance is equal to the source resistance. Applications where maximal power output is essential, such audio systems or specific kinds of communication equipment, benefit greatly from this theory. But because half of the power is lost to the source's internal resistance, this condition only offers 50% efficiency, which makes it inappropriate for situations where energy efficiency is a top concern.

TNG

Although optimizing power transfer could be advantageous in certain situations, it is not necessarily the ideal objective. Excessive heat, safety hazards, and accelerated battery depletion are all consequences of high current and low efficiency. Prioritizing efficiency by selecting a higher load resistance is more sensible in many real-world situations since it reduces power loss and prolongs component life. Therefore, developing circuits that balance performance, safety, and energy conservation requires an understanding of the trade-off between maximum power and efficiency.

REFERENCES

[1] J. D. Irwin and R. M. Nelms, *Basic Engineering Circuit Analysis*, 11th ed. Hoboken, NJ, USA: Wiley, 2015.

[2] R. C. Dorf and J. A. Svoboda, *Introduction to Electric Circuits*, 9th ed. Hoboken, NJ, USA: Wiley, 2013.

[3] A. S. Sedra and K. C. Smith, *Microelectronic Circuits*, 7th ed. New York, NY, USA: Oxford Univ. Press, 2015.

[4] R. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory*, 11th ed. Upper Saddle River, NJ, USA: Pearson, 2015.