Experiment 4
Impedance Matching

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No data page. You will need to bring a diskette to save your data.

OBJECT:

To study impedance matching and the method of measuring the output impedance.

APPARATUS:

DC power supply box with a battery (4.5 V) and an internal resistance of a few hundred ohms, resistor box, computer and interface, voltage and current sensors.

THEORY:

Often times we need to connect two electronic networks (such as a battery to a resistor, a sampling circuit to an amplifier, a power amplifier to a speaker and so on). The best connection is achieved if the output impedance, including both the resistance and the reactance, of the source is equal to the input impedance of the load. This is known as impedance matching. There are two important advantages for impedance matching: When the impedance is matched, the power output is the greatest, and there is no reflection of the traveling waves. This principle is applied the electronics as well as in the cable telecommunication, microwave communication and optical fiber communication.

In this experiment, we will only look at the power aspect of impedance matching, and we will use the DC voltage only. Namely, we are going to study a special case of impedance matching -- resistance matching. As shown in Figure 1, the load resistor R is connected to a source with an internal resistance r. Do not expect the internal resistance to be small, because most electronic devices have significant output impedance and our experiment is a simulation of the electronic impedance matching.

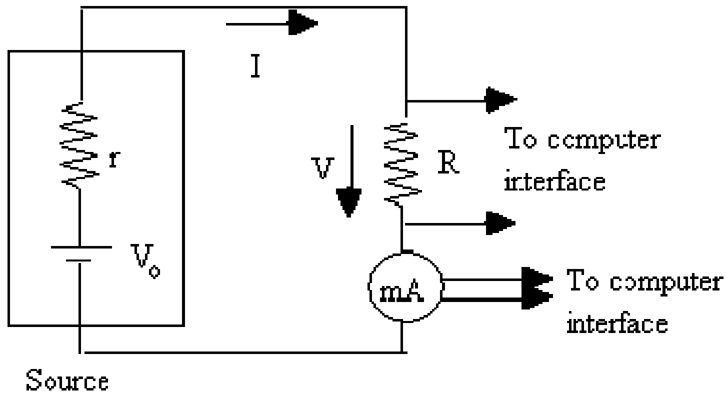

Figure 1

The current is given by

$$I = V_o / (r+R) \qquad (1)$$

The voltage across the load resistor is

$$V = I R = R V_o / (r+R) \qquad (2)$$

And the power delivered to the load resistor is

$$P = V I = R [V_o / (r+R)]^2 \qquad (3)$$

Figure 2 is a plot of the power delivered to the load versus the ratio of the load resistance over the internal resistance of the source. The power is small when R is small because of the small voltage drop. In this case, most of the power is consumed by the internal resistance of the source. On the other hand, if the load resistance is too large, the power delivered is also small simply because the current gets smaller. When the ratio of R/r is equal to unity (R=r), the power delivered is the maximum. This is the condition of impedance matching.

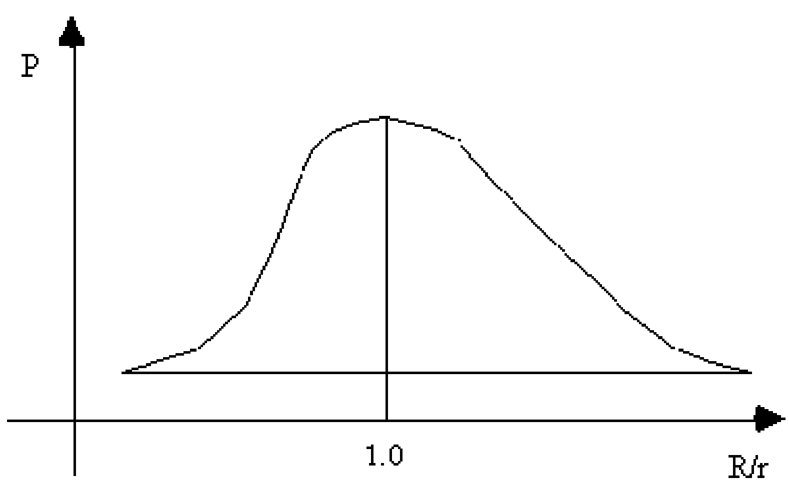

Figure 2.

PROCEDURE:

1. Construct a circuit as shown in Figure 1.

2. Start with a small load resistance R = 100 ohms. Measure and record the voltage across the load and the current passing through it, together with the corresponding resistance.

3. Increase the resistance by 100 ohms and repeat the measurement again until the maximum resistance of the box is reached. Cut and paste your data into an Excel file, save the file on a diskette.

DATA ANALYSIS:

1. Calculate the power delivered, P, which is equal to the product of the voltage across the resistor box and the current. Plot the power versus the load resistance.

2. Find the load resistance corresponding to the maximum delivered power P_{max}. This is the experimental value of the internal resistance of the source. Compare this value with the nominal value of the internal resistance obtained from your instructor. Find the percentage error of your measurement.

3. Derive a mathematical proof (using calculus) that the maximum power delivered to the load is arrived at when the load resistance is equal to the output resistance of the source.

4. Describe a method to measure the output impedance of a source.

Reminder: Check you math, check the units, check your graph, do not forget to follow the format for your lab report (see syllabus).