EXPERIMENT # 7

MAXIMUM POWER TRANSFER

OBJECTIVE:

1. To obtain maximum output power from a sinusoidal source with an internal impedance
2. To experimentally verify the theory of maximum power transfer.

Pre- Lab Assignment:

For the circuit shown Figure 1:

1. Assume that the inductor has an internal resistance of 51 ohms accounts for this resistance in this calculation
2. Find the value of R_L and C_L for maximum power transfer, and
3. Calculate the maximum power transferred to this load
4. Summarize your results in Table 4.

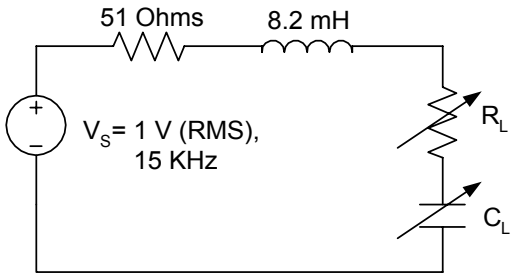

Figure 1

APPARATUS:

- Signal Generator
- Digital Multimeter
- Cornell Dubillier Decade Resistance Boxes RDB and RDA
- Cornell Dubillier Decade Capacitance Box CDA (Two boxes)
- Inductor (8.2 mH)
- Resistance (51 ohms)

THEORY:

Consider Figure 1. If the source impedance has a resistive and reactive parts, the maximum power is transferred to the load (actually to the resistive part of the load) when the load resistance equal the source resistance and the load reactance is opposite to the source reactance. Namely

$$Z_L = Z_S^* \qquad (1)$$

Equation (1) implies that if the source impedance is inductive the load impedance must be capacitive and vice versa. In order to compute the value of a capacitance, one can use the following relation

$$C = \frac{1}{\omega x_c} = \frac{1}{2\Pi f x_c} \qquad (2)$$

where x_c is a capacitive reactance.

Note that since $Z_L=Z_S$, V_S sees a combined load with impedance $Z_L+Z_S=Z_S+Z_S=2R_S$ which is purely resistive. This means, under this condition (the condition of maximum power transfer), V_S becomes in phase with the current through the load and thus V_S becomes <u>in phase</u> with the voltage across the load resistance.

The maximum power transferred to the load in this is

$$P_{\max} = \frac{V_s^2}{4R_s} \qquad (3)$$

PROCEDURE:

1. Consider the 8.2 mH inductor in the circuit of Fig. 1. as part of the source impedance. Measure its internal resistance R_i. Add 51 Ohm in addition to this resistance. This means $R_S= R_i+51$. Set the source voltage to a sinusoid of 1 V r.m.s and frequency of 15 KHz.

2. With R_L set the value of R_S, vary C from 0.01 F to 0.02 F in steps of 0.001 F (use two decade capacitors in parallel). Measure the voltage across R_L in each case, <u>maintaining an input voltage of 1 V r.m.s.</u> Record the values in table 2.

3. Display the source voltage and the voltage across R_L simultaneously on the oscilloscope. Vary C and notice the phase shift between the two signals. Record the value of C that makes the two signals in phase.
4. With C set at the value found in step 3, vary R_L from 10-200 and measure the voltage across R_L in each case, again maintaining an input voltage of 1 V r.m.s. Record the values in Table 4.

IMPORTANT NOTES:

1. Your results are based on having an ideal voltage source (one whose terminal voltage is independent of the current and frequency). You convert your physical signal generator in to an ideal voltage source by changing the gain setting for each measurement so that the terminal voltage remains constant.
2. Whenever two signals are to be displayed simultaneously on the oscilloscope, they should have one common node as a reference. Therefore, you may have to change the position of some elements to be able to measure two signals simultaneously.

REPORT:

1. Complete the tables in your report sheets
2. Plot the load power vs. C and the load power vs. R_L. Determine from the graphs the value of Z_L for maximum power transfer, and compare it with the theoretical value.
3. Compare the theoretical and experimental values of the maximum power transferred to the laod.
4. Comment on the causes of errors between the measure and calculated values.

TABLE 1

Resistive value

Resistor	R1
Nominal Value (Ohm)	51
Ohmmeter Reading	

Internal Resistance of the inductance R_i =

TABLE 2

Results for C

C (nF)	10	11	12	13	14	15	16	17	18	19	20
V_L (V)											
P_L (W)											

TABLE 3

Results for R_L

R_L (Ohm)	10	50	90	100	102	103	104	105	110	150	200
V_L (V)											
P_L (W)											

TABLE 4

Comparison at Maximum Power Transfer

	R_L	C	P_{max}
Theory			
Experiment			
% Error			

QUESTIONS:

1. Comment on the sharpness of the maximum of the power curves. Is it necessary to match with great care to achieve maximum power transfer?
2. What is the phase difference between the current and the voltage source when maximum power transfer is achieved?
3. If the frequency of the source is doubled, what change should be done to maintain maximum power transfer to the load? How does this change affect the value of the maximum power? Explain.
4. The term available power is used to describe a source in many communication applications. It is the maximum possible power which the source can deliver to an external load. What is the available power of a source of voltage V and internal resistance R?