Maximum Power Transfer Theorem

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Objective: Verification of Maximum Power Transfer theorem.

1 Theory

Maximum power is transferred from a source of given voltage and an initial impedance to the load impedance $Z_L = R_L + jX_L$ in a circuit (Figure 1) under three different conditions.

1.1 When only X_L is adjustable

Under this condition the power consumed by the load (I^2R_L) is maximum, when I the RMS current is maximum, since R_L is constant.

$$I = \frac{V_s}{(R_i + jX_i) + (R_L + jX_L)} \tag{1}$$

$$\Rightarrow |I|_{max} = \frac{V_S}{R_i + R_L} \text{ when } X_L = -X_i. \tag{2}$$

This means that if the load reactance X_L is made equal in magnitude and opposite in sign to the internal reactance X_i, the power transferred is maximum.

1.2 When only R_L is adjustable:

From Equation 1 in Section 1.1, one may write,

$$\begin{aligned} P &= |I|^2 R_L \\ &= \frac{V_s^2 R_L}{(R_i + R_L)^2 + (X_i + X_L)^2}. \end{aligned} \tag{3}$$

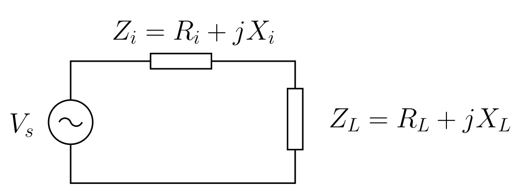

Figure 1: Circuit 1.

Differentiating Equation 3 *w.r.t.* R_L and equating to zero, one obtains,

$$R_L = \sqrt{R_i^2 + (X_i + X_L)^2}. \tag{4}$$

1.3 When both R_L and X_L are adjustable:

Under this condition, both Equations 2 and 4 are valid simultaneously and one obtains,

$$R_L = R_i,\ X_L = -X_i. \tag{5}$$

2 Procedure

2.1 First Part

1. Take a suitable set of values of V_s, R_i and X_i as shown in Figure 2. You can choose X_i to be inductive (assume the resistive loss of the coil to be negligible).

2. Next choose a suitable load resistance R_L and a variable capacitance C_L such that the critical value C_0 of C_L, ($C_0 = \dfrac{1}{4\pi^2 f^2 L_i}$) falls within the range of the values of C_L, ~~available (decade box) in steps~~.
This is to ensure that for a particular frequency, we can obtain the condition:

$$|X_C| = |X_L|\,,\ \text{or}\ ,\ \frac{1}{\omega C_L} = \omega L_i, \tag{6}$$

for some value of C_L within the range provided.
Now for different value of C_L note down V_3 and V_1,

$$P_L = I^2 R_L = I \cdot I R_L = \frac{V_1}{100} \cdot V_3 = K \cdot V_1 V_3,\ \text{where}\ K = \frac{1}{100} = \frac{1}{R_i}. \tag{7}$$

Enter the values of the voltage for different 8 values of C_L and obtain the set corresponding to the maximum value of $(V_1 V_3)$. Verify that for this set $V_2 = V_4$.

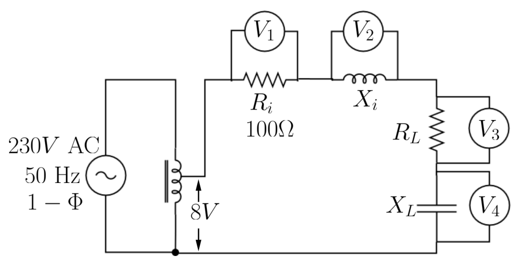

Figure 2: Circuit 2.

Enter the data in the following table:

Sl. No.	C_L	V_1	V_3	$(V_1 \cdot V_3)$	Maximum $(V_1 \cdot V_3)$
1					
2					
3					
4					
5					
6					
7					
8					

Table 1: Experiment observation table.

2.2 Second Part

Repeat the procedure of Section 2.1, with C_L fixed and R_L varied. At the point of maximum power, check

$$R_L = \sqrt{R_i^2 + (X_i + X_L)^2}. \tag{8}$$

2.3 Third Part

Repeat the procedure of Section 2.2, varying both R_L & C_L and obtain the maximum power condition. Check under this condition:

$$V_{RL} = V_{Ri} \quad i.e. \quad V_1 = V_3 \tag{9}$$

$$\text{and, } V_{XL} = V_{Xi} \quad i.e. \quad V_2 = V_4. \tag{10}$$
