EXPERIMENT NO 4

TO VERIFY THE MAXIMUM POWER TRANSFER THEOREM

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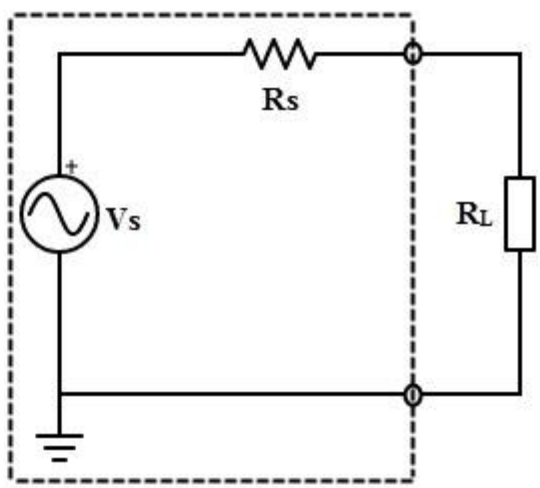
AIM :- ***<u>TO VERIFY THE MAXIMUM POWER TRANSFER THEOREM</u>***

THEORY

The amount of power received by a load is an important parameter in electrical and electronic applications. In **DC** circuits, we can represent the load with a resistor having resistance of R_L ohms. Similarly, in **AC** circuits, we can represent it with a complex load having an *impedance of* Z_L **ohms**.

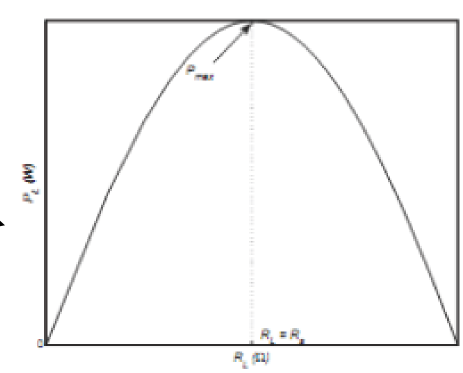
Maximum power transfer theorem states that the **DC voltage** source will deliver **maximum** power to the *variable* load resistor only when the load resistance is equal to the source resistance.

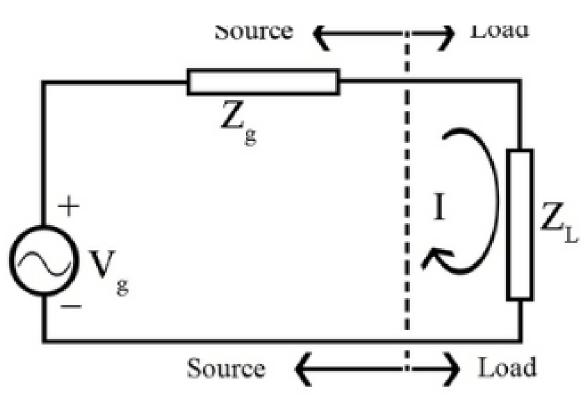
Similarly, **Maximum power transfer theorem** states that the **AC voltage** source will deliver **maximum** power to the *variable* complex load only when the load impedance is equal to the complex conjugate of source impedance.

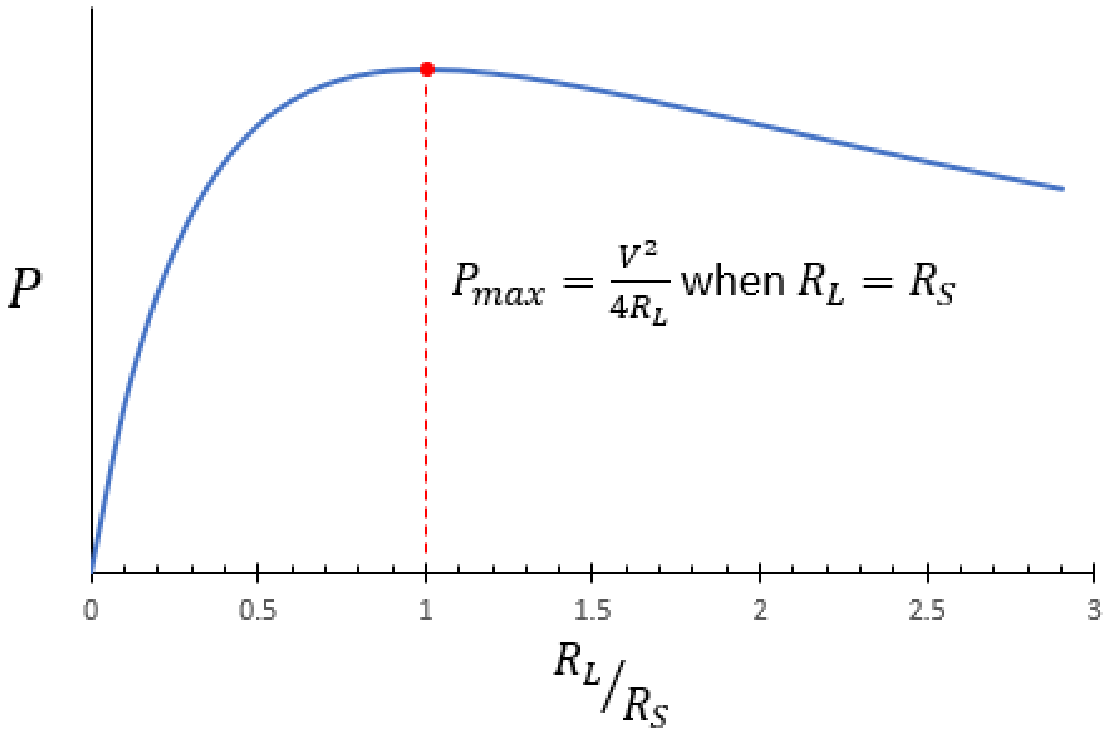


$$P_{max} = \frac{V_s^2}{4R_s}$$

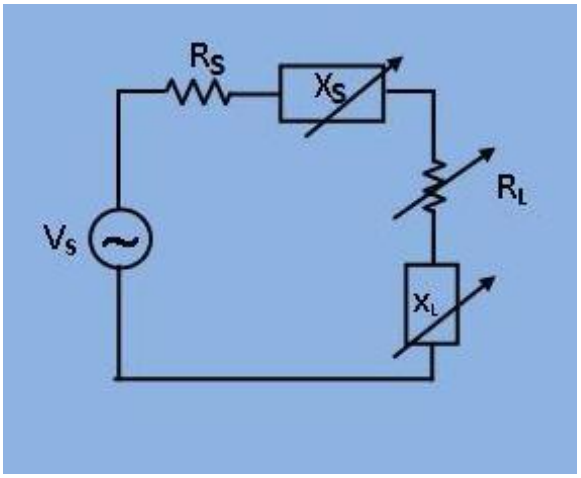
MAX. POWER TRANSFER GRAPH







Maximum power is transferred from a source of given voltage and an **internal impedance** to the **load impedance Z_L** in the following circuit, under **three conditions.**



Circuit diagram with source and load impedance

(i.e. $\mathbf{Z_S}$ and $\mathbf{Z_L}$)

1. *When only X_L is adjustable*:

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

I=VsRs+jXs+R_L+jX_L

|I|**max**=VsRs+R_L

X_L=−XsX_L=-Xs

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

2. *When only **R_L** is **adjustable***

P=||I2||·RL=V2s·RL(Rs+RL)2+(Xs+XL)2...(3)P=|I2|·RL=Vs2·RL (Rs+RL)2+(Xs+XL)2...(3)

Differentiating the equation (3) w.r.t **R_L** and equating to **zero**, one obtains.

$$R_L=\sqrt{(R_2s+(Xs+X_L)2)}$$

3. *When both* R_L *and* X_L *are adjustable*

$$R_L=Rs, X_L=-XsR_L=Rs,$$

$$X_L= -Xs$$

We must remember that this theorem results maximum power transfer but not a maximum efficiency. If the load resistance is smaller than source resistance, power dissipated at the load is reduced while most of the power is dissipated at the source then the efficiency becomes lower.

Consider the total power delivered from source equation (equation 2), in which the power is dissipated in the equivalent Thevenin's resistance R_{TH} by the voltage source V_{TH}.

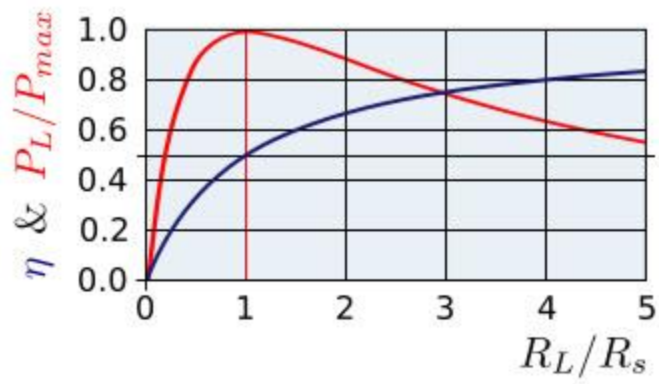
Therefore, the efficiency under the condition of maximum power transfer is

$$\text{Efficiency} = \text{Output} / \text{Input} \times 100$$

$$= I_L^2 R_L / 2 I_L^2 R_L \times 100$$

$$= 50\ \%$$

Hence, at the condition of maximum power transfer, the efficiency is 50%, that means a half percentage of generated power is delivered to the load and at other conditions small percentage of power is delivered to the load , as indicated in efficiency verses maximum power transfer the curves below.



For some applications, it is desirable to transfer maximum power to the load than achieving high efficiency such as in amplifiers and communication circuits.

On the other hand, it is desirable to achieve higher efficiency than maximised power transfer in case of power transmission systems where a large load resistance (much larger value than internal source resistance) is placed across the load. Even though the efficiency is high the power delivered will be less in those cases.

PROCEDURE

1. Apply Supply voltage (***Vin = 230v, f = 50Hz***) and Choose whether to connect or bypass L_S and C_S by clicking on the corresponding white check box. **(By default they are all connected. 'Tick sign' indicates, the component is bypassed.)**

2. Now set the values of different elements of **source impedance(**Z_S**)** then switch on circuit board to get the voltmeter readings.

3. **Case-1 (Only** X_L **is adjustable)** Choose whether to connect or bypass L_L and C_L. Adjust them and click on simulate to set $\mathbf{X_S=-X_L}$. Check if the power transferred to Load (P_LPL) is maximum and check the corresponding efficiency.

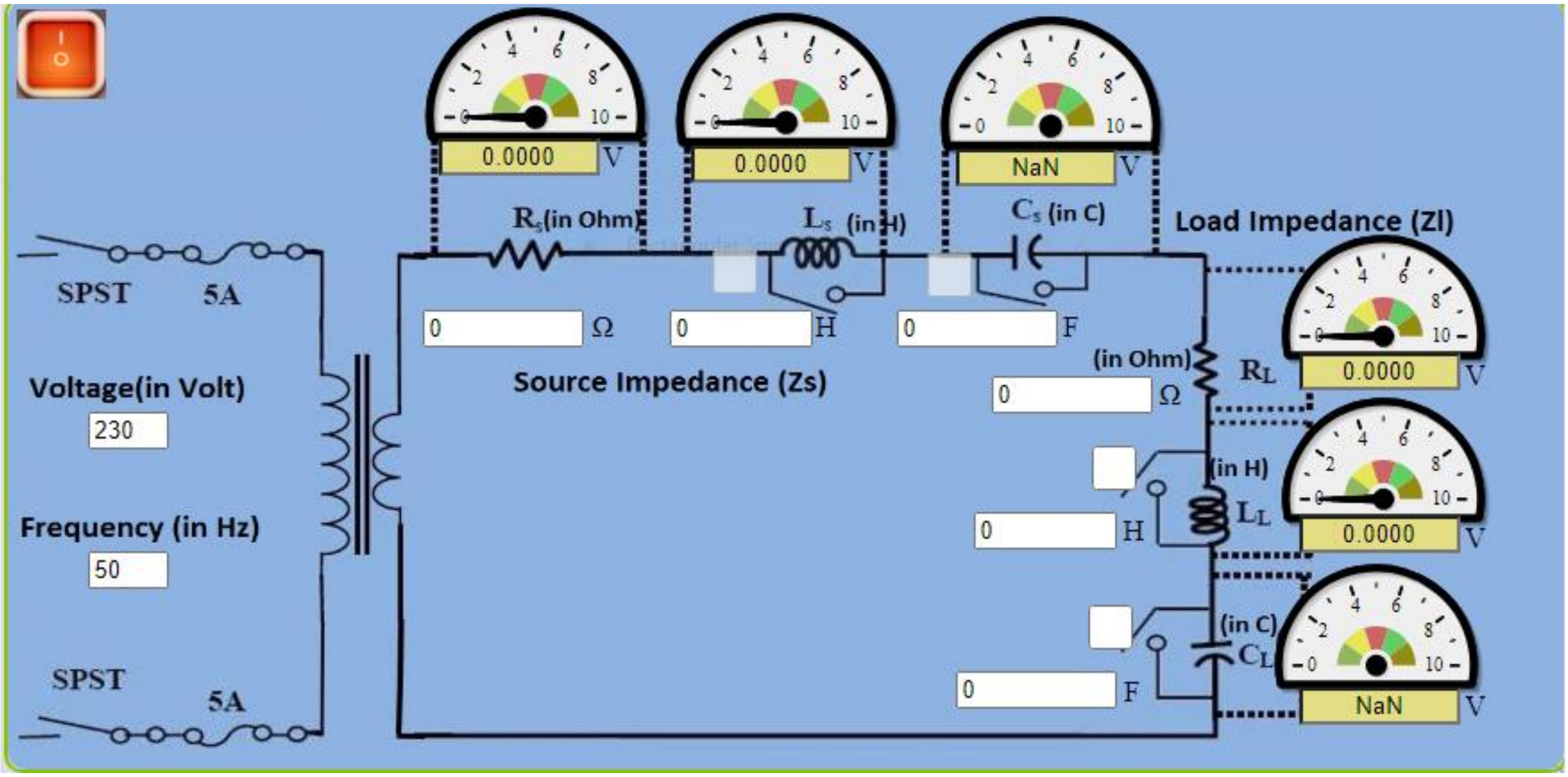
4. **Case-2 (Only** R_L **is adjustable)** Adjust R_L and click on simulate to set $R_a=R_L$Ra=RL. Where; $R_a=\sqrt{R_s^2+(X_s+X_l)^2}$Ra=Rs2+(Xs+Xl)2. Check if the power transferred to **Load**($\mathbf{P_L}$) is **maximum** and check the corresponding **efficiency**.

5. **Case-3 (Both** X_L**and** R_L **are adjustable)** Choose whether to connect or bypass L_L and C_L. Adjust R_L and X_L and click on simulate to set $\mathbf{R_s=R_L}$**Rs=RL** and $\mathbf{X_s=-X_L}$.

6. Check if the power transferred to **Load** (P_L) is **maximum** and check the corresponding **efficiency**.

OBSERVATIONS

ALL READINGS ARE TAKEN FROM VLABS



OBSERVATION TABLE

Case 1: Only X_L is adjustable

S.no.	Source Reactance(X_S)	Load Reactance(X_L)	Load Power(P_L)	Efficiency (%)
1.	0.31416	-0.31831	5.0009	83.333
2.	0.62832	-0.31831	4.9876	83.333
3.	0.94248	-0.31831	3.6451	71.429
4.	1.2566	-0.31831	2.7748	62.5

Table 1

Case 2: Only R_L is adjustable

S.no.	Source Reactance(X_S)	Load Reactance(X_L)	R_a	Load Resistance (R_L)	Load Power(P_L)	Efficiency
1.	3.1098	25.097	103.9	15.000	1.3502	75.000
2.	3.1098	25.097	103.9	17.5	0.088	50
3.	3.1098	25.097	103.9	20	0.04797	16.677

4.	3.1098	25.097	103.9	90	0.089	47.3

Table 2

Case 3: Both R_L and X_L is adjustable

S.no.	Source Reactance(X_S)	Load Reactance(X_L)	Source Resistance	Load Resistance (R_L)	Load Power(P_L)	Efficiency
1.	3.1098	-0.6490	100	30	0.049988	16.669
2.	3.1098	-1.8492	100	30	0.063824	25.077
3.	3.1098	-1.5708	100	60	0.042146	37.5
4.	3.1098	-3.1098	100	100	0.090016	50

Table 3

CONCLUSION/RESULT :

IT IS **OBSERVED** THAT THE **IMPEDANCE OF LOAD** IS A **COMPLEX CONJUGATE** OF THE **IMPEDANCE OF SOURCE**

THE FOLLOWING VERIFIES THE MAXIMUM POWER TRANSFER THEOREM