



***THE HASHMITE UNIVERSITY***  
***ELECTRICAL ENGINEERING DEPARTMENT***  
***ELECTRICAL MACHINES LAP***

***LAP REPORT # 4***

***Transformer I***

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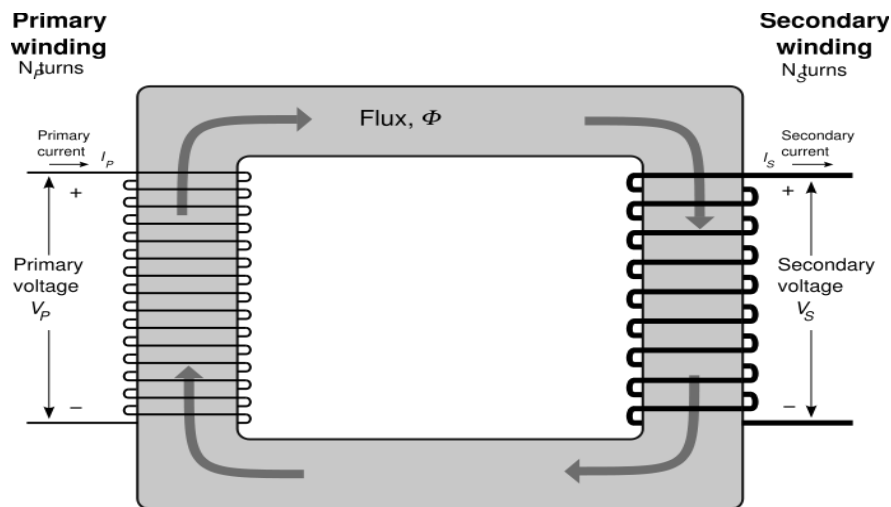
## **Objectives:**

We will use the open circuit test to determine the excitation branch parameters alongside with the no load current , and we will determine the iron losses four various voltages .

## **Theoretical Background:**

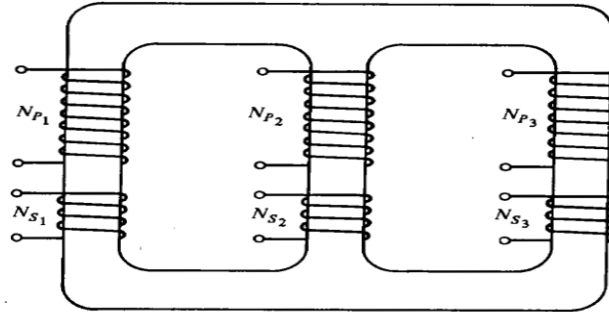
The transformer is an electrical device used to change electrical power form one ac voltage level to electrical power at another voltage level , there are two types of transformers depending on the core shape and how the windings are wrapped :

1.Core form : used only as a single phase transformer , consists of a simple rectangular laminated piece of steel with the transformer windings wrapped around two sides of the rectangle , this transformer is shown next :



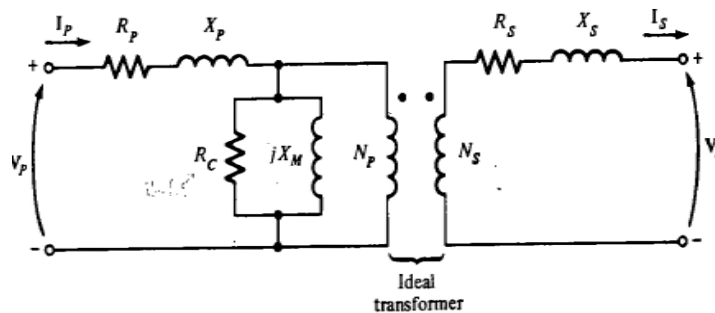
*Single Phase Core form Transformer*

2.Shell form : This type consists of a three legged laminated core with windings wrapped at either the center leg if it is 1 phase or at each of the legs if it's three phase , this transformer can be one of three phase transformer , this type of transformer is shown in the figure next :



*Three Phase Shell form Transformer*

*The equivalent circuit of the single phase transformer is shown in the figure next :*



*Equivalent circuit for single phase transformer*

*In this circuit :*

*Rp : primary winding resistance .*

*Rs : Secondary winding resistance .*

*Xp : Primary winding inductance (to represent leakage flux in the first winding) .*

*Xs : Secondary winding inductance (to represent leakage flux in the second winding) .*

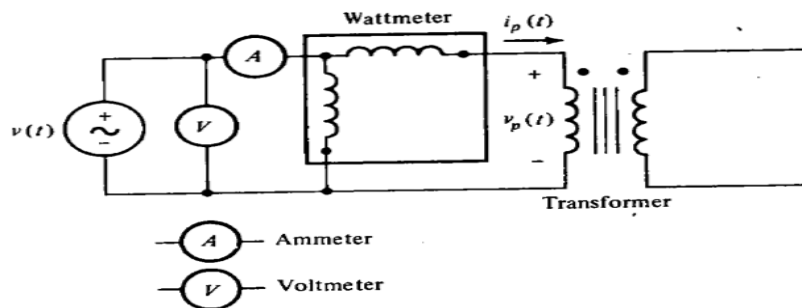
*Rc: Core resistance (represents core losses) .*

*Xm : Core inductance (to represent the inductance of the core) .*

*Np, Ns: primary and secondary windings number .*

We will perform 4 tests :

1. *Open circuit test* : in this test the secondary winding is open circuited , so almost all current will pass through the excitation branch of the transformer , the primary resistance and inductance causes negligible voltage drop because they are much smaller than  $R_C$  and  $X_m$  , the connection for this circuit is shown in the figure next :



We will use this circuit to measure apparent power , voltage ,and current and from these parameters we will be able to calculate  $X_m$  &  $R_c$  as will be shown in the procedure .

2. *Turns Ratio test* : we will simply calculate the ratio between the voltage of primary winding and the voltage of secondary winding, this ratio will also represent the ratio between the turns of the primary winding and the turns of the secondary winding.

$$\left| \frac{v_p(t)}{v_s(t)} = \frac{N_p}{N_s} = a \right|$$

3. *Polarity test* :

*Polarity*: refers to the relative direction of the induced voltages between the high voltage terminals and the low voltage terminals.

This test is used to determine the polarity of the transformer windings , this is done by connecting the windings together and set a certain input voltage and measure the output voltage , if the output voltage is larger than the input voltage the polarity is additive otherwise it's subtractive .

4. Measuring the resistance of the transformer windings : this is a simple test in which we use an ohmmeter to measure the resistance of the windings of the transformer .

**Equipments :**

We used a set of millimeters to measure currents and voltages , and an ohmmeter to measure the resistance of the transformer , and of course the transformer it self .

**Procedure :**

1. Open Circuit test :

We open circuited the the secondary winding then we applied a avoltage to the primary winding and took measurements of voltage, current , and power as follows :

Applied voltage V1	No load current I1	Open side voltage V2	No load input power W	Calculated Cos $\theta$	Calculated I <sub>m</sub>	Calculated I <sub>xm</sub>
110V	.14	220	10	.65	.04536	.125
90V	.1	180	8	.888	.0444	.080
70V	.07	140	4	.81	.0357	.0518
50	.06	100	2	.667	.0297	.0453

We used the following relations to calculate Cos  $\theta$  , I<sub>rm</sub> , and I<sub>xm</sub> :

$$\text{Cos } \theta = \frac{W}{I \cdot V} \quad I_{rm} = I_1 \cdot \text{cos } \theta \quad I_{xm} = I_1 \cdot \text{sin } \theta$$

results :

1. Find the no load currents I<sub>rm</sub>, I<sub>xm</sub>, Cos  $\theta$  , R<sub>m</sub> , and X<sub>m</sub> at the rated voltage .

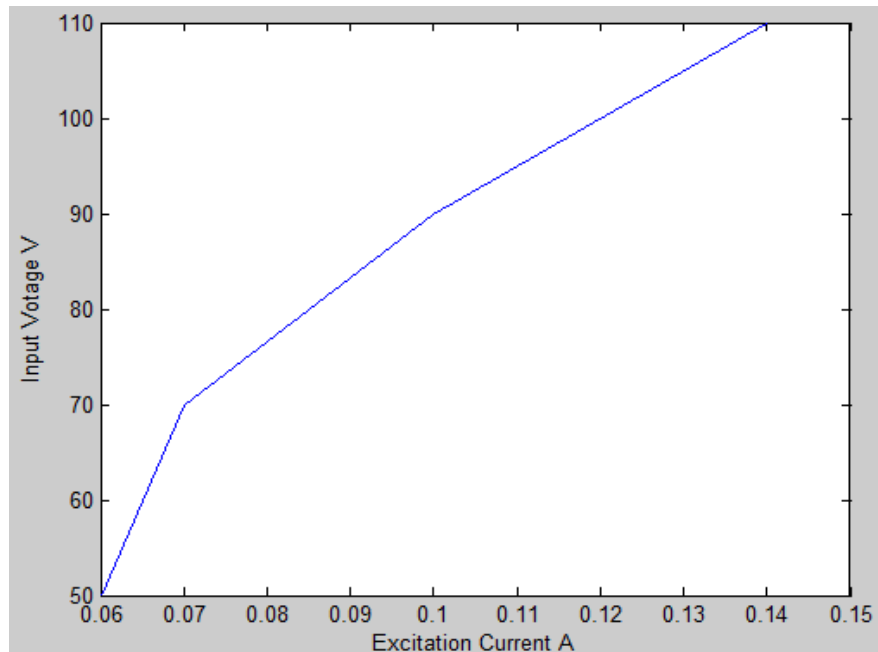
The rated voltage is 115 V (from the secondry side) so :

$$I_m = .091 , I_{xm} = .08085A , \text{Cos } \theta = .65$$

$$Y_m = I_1/V = 1.27 \cdot 10^3 \angle -49.46 = 8.25 \cdot 10^{-4} - j \cdot 9.65 \cdot 10^{-4}$$

$$R_m = 1/8.25 \cdot 10^{-4} = 1212.1 \Omega \quad X_m = 1/9.65 \cdot 10^{-4} = 1036.2 \Omega$$

*2. Plot the applied voltage  $V_1$  against  $I_m$  .*



*Questions :*

*1. Why does the wattmeter in no load test read the iron losses only ?*

*Because when the second winding is open all current will pass through the excitation branch , so all power is considered loss power is the core .*

*2. Why the no load test is usually done with supply given to low voltage side?*

*We will obtain the same results for the excitation branch if we perform the test on either side , but it will be much easier to provide a lower voltage (for the low voltage side ) than providing a high voltage (for the high voltage side) .*

*Turns ratio :*

*Questions :*

*1. How does the transformer change the voltage from one value to another?*

*The ratio between the primary winding and the secondary winding will be the same ratio between the primary voltage and the secondary voltage , this is a step up transformer , so by means of magnetic flux voltage will be induced in the secondary winding if current passes through the primary winding .*

*2. What is the voltage ratio ? is it same for all conditions ?*

*Voltage ratio =  $\frac{1}{2}$  , yes it is the same for all conditions .*

*3. Polarity test :*

*We used the practical diagram to connect the transformer , then we set the power supply to the rated voltage and measured the voltage between the open terminals of the winding .*

*The results were :  $V = 230$  and  $V_1 = 88$*

*Because  $V > V_2$  the polarity of the tested transformer is subtractive .*

*Questions :*

*1. What is meant by the additive polarity of the transformer ?*

*It means that the primary and the secondary windings have the same direction of dot convention (same direction of relative voltage) . .*

*2. Explain the importance of the polarity test on a transformer ?*

*An understanding of polarity is essential to correctly construct three-phase transformer banks and to properly parallel single or three-phase transformers with existing electrical systems ..*

*D. Measuring the resistance of the transformer windings:*

*We simply used an Ohmmeter to measure the resistance of each winding, the results is show in the table .:*

<i>Winding</i>	<i>R<sub>x</sub></i>
<i>High voltage side 0V-220V</i>	<i>5.5</i>
<i>High voltage side 0V-160V</i>	<i>4</i>
<i>Low voltage side 110V</i>	<i>2.3</i>

***Conclusions:***

- 1. We have learned to connect the transformer to obtain a certain output voltage and how take measurements of current , voltage , and power .*
- 2. We used the open circuit test to determine the parameters of the excitation branch , also we measured the resistance of each winding .*
- 3. We performed the polarity test to determine the polarity of out transformer , the result was a subtractive polarity transformer .*