Abu Dhabi University

EEN 340 - Energy Conversion

Lab Report 1
Single Phase Transformer

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Section 1

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Contents

Abstract

In this lab experiment, we are going to examine two important tests on a transformer model (approximate equivalent circuit of a transformer); so that, we can calculate the values of components of the of that model like (Rc, Xc, R1, X1, V1, Io, P1, V2, I1, I2) . The two tests are the Open Circuit Test which is related to Core Losses and the Short Circuit Test which is related to Copper Losses. After getting the values, we can refer the equivalent circuit of the transformer either to the primary side or to the secondary side (to the primary side in our experiment).

1 Introduction

In this lab experiment which is about the Transformer Model, we were introduced to the equivalent circuit model of the transformer which is affected by two major losses (Core losses and Copper losses) and it is as shown below :-

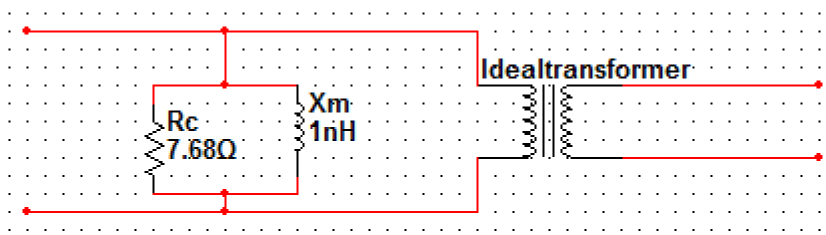
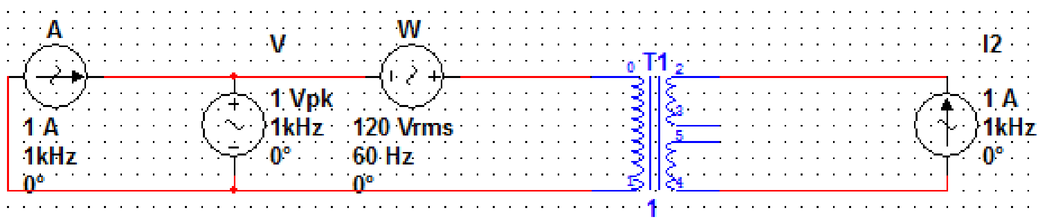
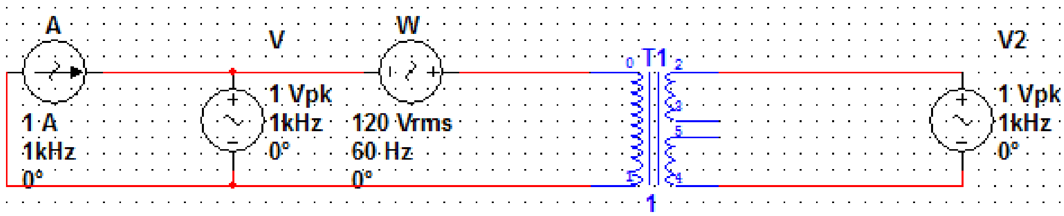


Figure 1: The equivalent circuit of an ideal transformer.[1]

We performed two tests (Open Circuit Test and Short Circuit Test) in order to construct the equivalent circuit for transformer referred to the primary side including all of the values of the components included in that circuit . First, for the Open Circuit Test, we applied full line voltage to the secondary side (V2) of the transformer as shown in the below circuit; so that, we can calculate the primary volts V1, primary current Io, input power P1, secondary volts V2, and the excitation branch (Rc and Xm).[3]



For the second test, the Short Circuit test, we applied short circuit (current source(I2)) to the secondary side and fairly low input voltage to the primary side of the transformer as shown in the circuit below. Since the input primary voltage is low, the current flowing through the excitation branch is negligible; so that, all the voltage drop in the transformer is due to the series elements in the circuit (R1 and X1), and we calculated primary voltage V1, primary current I1, input power P1, secondary current I2, R1, and X1. [2]



2 Experiment Set-up

We connect the circuit as shown in the figures:-

2.1 Open Circuit Test

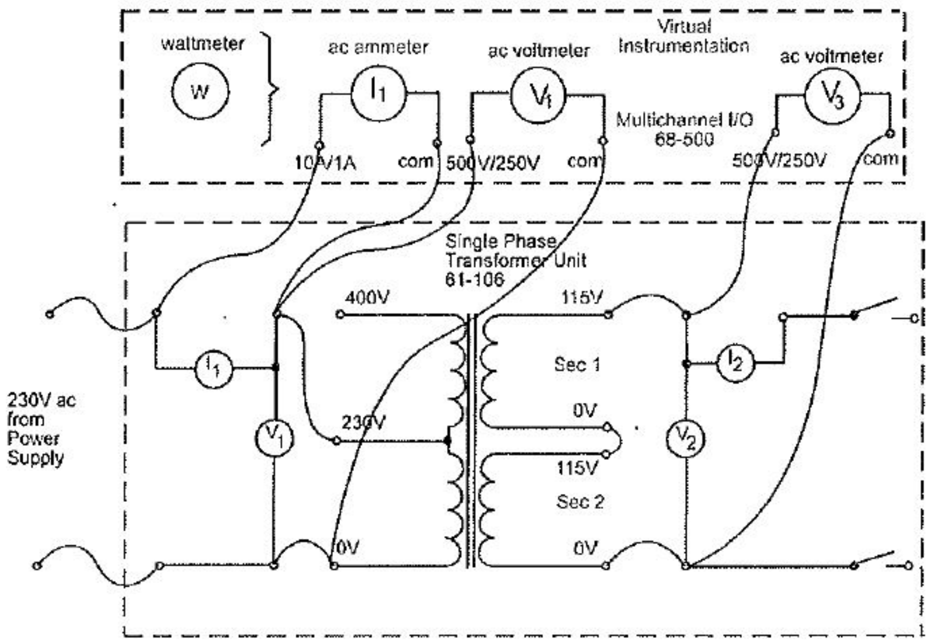


Figure 2: This is how we setup the circuit for open circuit test

2.2 Short Circuit Test

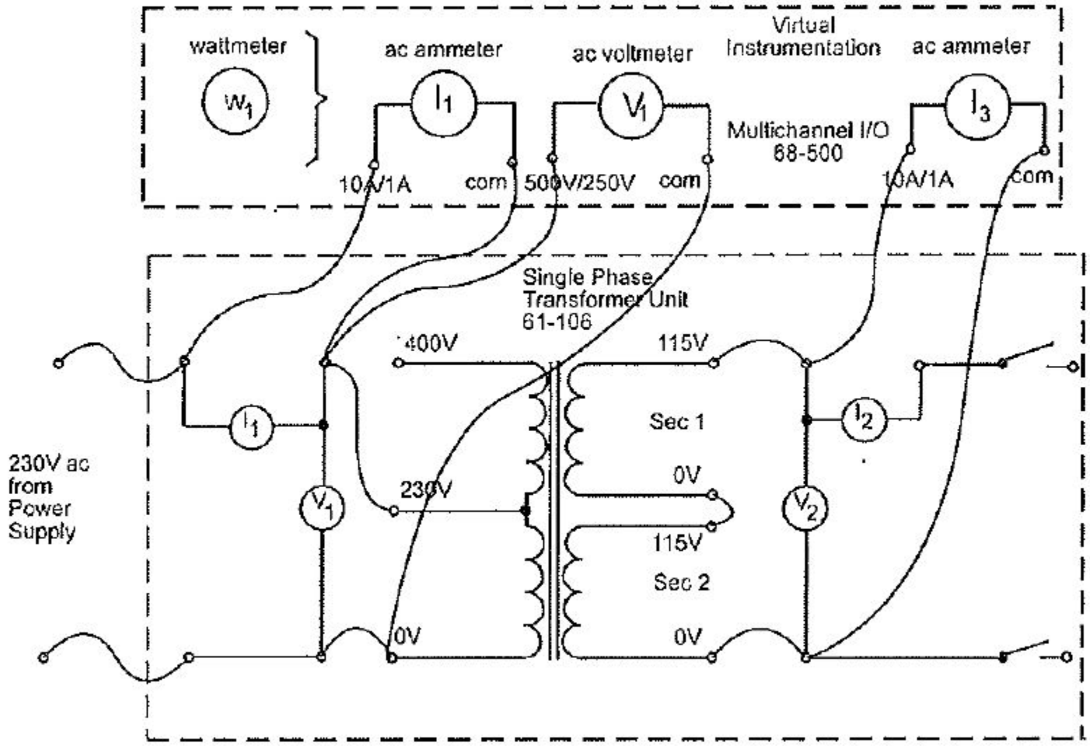


Figure 3: This is how we setup the circuit for short circuit test

3 List of Equipment used

- Power Training Module.
- Wires.
- Wattmeter.
- Voltmeter.
- Ammeter.
- High power supply.

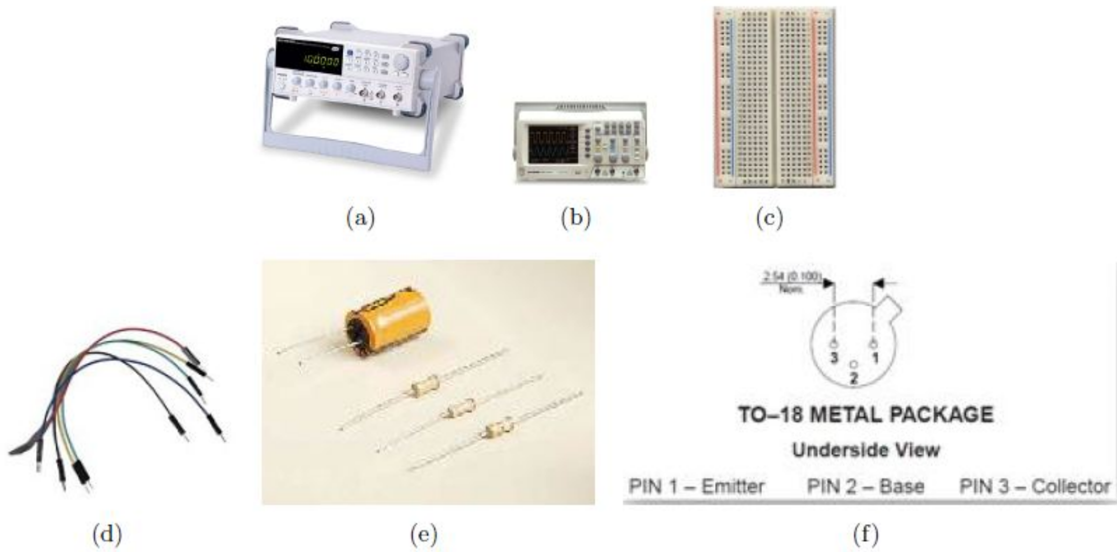


Figure 1: List of equipment

4 Procedure

4.1 Open Circuit Test

- Connect the circuit as shown in the figure below.

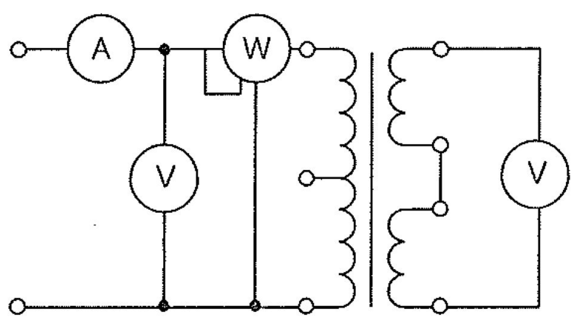


Figure 4: Since the Voltmeter has approximately infinite resistance (High Resistance), Its presence at the secondary coil can be assumed as open circuit.

- Calculate cosθ, the angle θ, Ic and Im using equations given below.
- Now that Ic and Im have been calculated, we can find the value for Core loss Resistance and Magnetizing reactance Xm.
- Now we can draw a equivalent circuit for the transformer.

The volt-amperes taken by the primary on no-load is:

$$VA_1 = V_1 I_0$$

And the power input is:

$$P_1 = V_1 \times I_0 \cos\phi$$

Hence:

$$\cos\phi = \frac{P_1}{V_1 I_0}$$

and:

$Ic = I_0 \cos\phi$ (Core loss component in phase with the applied voltage)

$I_m = I_0 \sin\phi$ (Magnetising component in quadrature with applied voltage)

4.2 Short Circuit Test

- Connect the circuit as shown in the figure below.

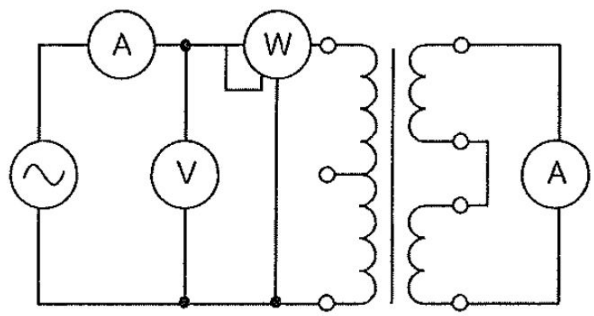


Figure 5: Since the Ammeter has approximately zero resistance, Its presence at the secondary coil can be assumed as short circuit.

- Calculate X1 and R1 using equations given below.
- Now we can draw a more accurate equivalent circuit for the transformer.

Then since there is no power dissipated in the reactance:

$$W_1 = I_1^2 R_1'$$

so that:

$$R_1' = \frac{W_1}{I_1^2}$$

Also the total impedance is:

$$\frac{V_1}{I_1} = \sqrt{R_1'^2 + X_1'^2}$$

So that X_1' can be calculated as:

$$X_1' = \sqrt{\left(\frac{V_1}{I_1}\right)^2 - R_1'^2}$$

5 Results and Discussions

At the end of the lab we got the following results:-

5.1 Open Circuit Test Results

Primary Volts V_1	Primary Current I_0	Input Power P_1	Secondary Volts V_2
230V	0.03A	2.5 W	250V

Table 4-7-1

Figure 6: As we can see, the voltage in primary side of the transformer is 230 V and current is 0.03A. which is what we supplied through the High power supply. The power produced at the output secondary coil is about 2.5W and the voltage is 250V.

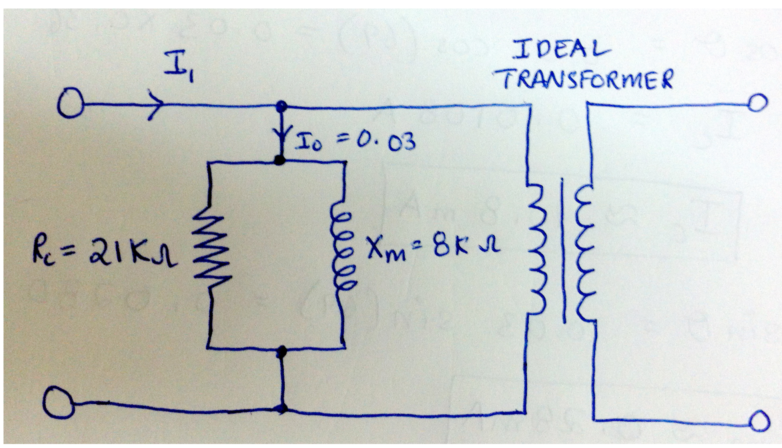


Figure 7: This is the equivalent circuit we get after doing calculations given below

$$\cos\theta = \frac{P_1}{V_1 I_0} = \frac{2.5\,W}{230V \times 0.03} = 0.36$$

$\therefore$ power factor $= 0.36 = \cos\theta$

$\theta = \cos^{-1}(0.36) = 69^\circ$

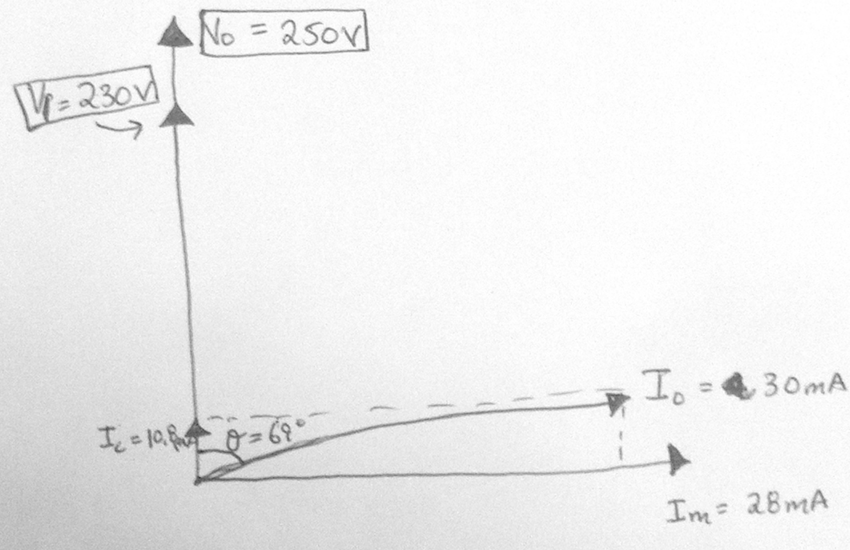
$$I_c = I_0 \cos\theta = 0.03\cos(69) = 0.03 \times 0.36$$

$$I_c = 0.0108\ A$$

$I_c \approx 10.8\ mA$

$$I_m = I_0 \sin\theta = 0.03\sin(69) = 0.0280$$

$I_m \approx 28\ mA$



$$R_c = \frac{230}{0.0108} = \frac{V_1}{I_c} = 21296\ \Omega$$

$$X_m = \frac{V_1}{I_m} = \frac{230}{0.0280} = 8214\ \Omega$$

5.2 Short Circuit Test Results

Practical 8.1

Primary Voltage (V_1)	Primary Current (I_1)	Input Power (P_1)	Secondary Current (I_2)
20V	0.48A	3.75W	0.43A

Table 4-8-1

Practical 8.2

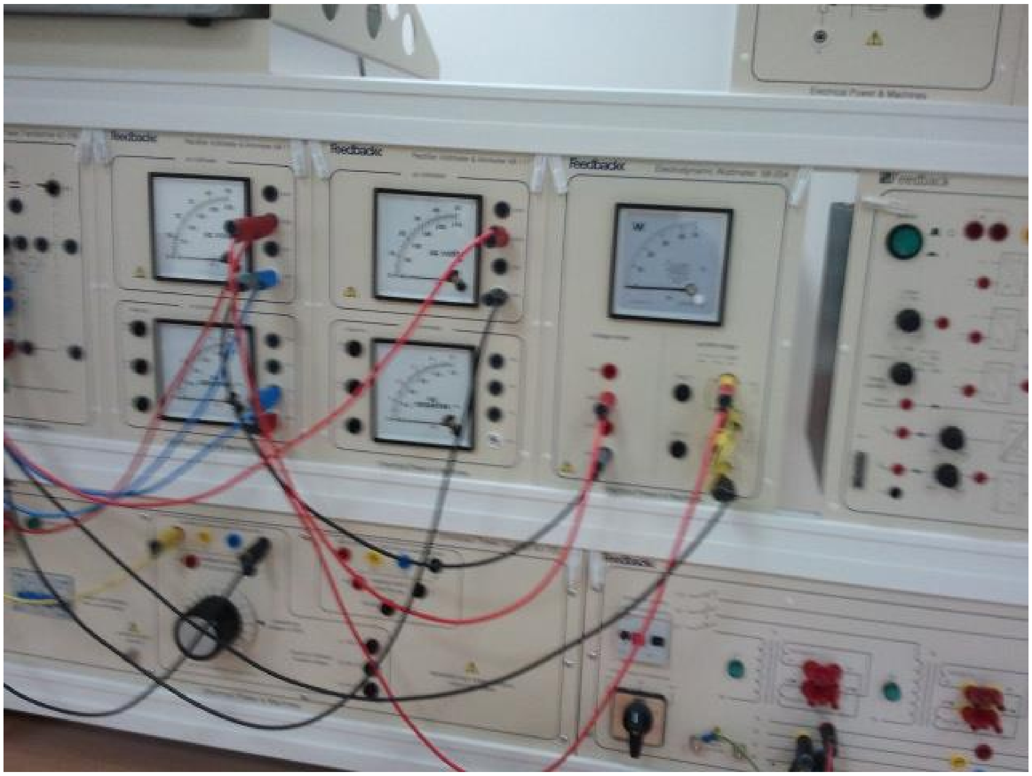
Core loss with short circuit removed	0.2

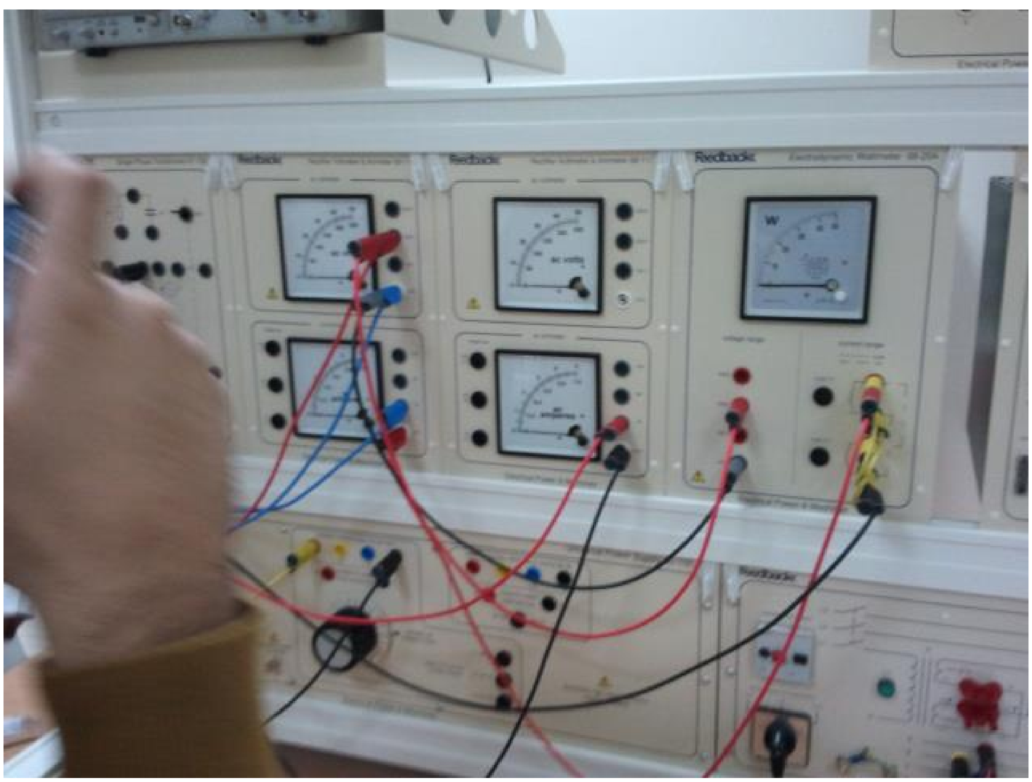
Table 4-8-2

Figure 8: After Short circuiting the secondary side of the transformer, we provided 20V, 0.48A current, 3.75W power to the primary side of the transformer we got 0.43A of current going in the secondary side of the transformer. The core losses were calculated to be 0.2

$$R_1 = \frac{W_1}{(I_1)^2} = \frac{\text{Input Power}}{(\text{Primary Current})^2} = \frac{3.75}{(0.48)^2} = 16.3\,\Omega$$

$$X_1 = \sqrt{\left[\frac{V_1}{I_1}\right]^2 - R_1^2} = \sqrt{\left(\frac{20}{0.48}\right)^2 - (16.3)^2} = 38.3\,\Omega$$





6 Conclusion

- Short circuit test is used for finding out Core losses and open circuit test is used for finding out reactance Xm and Resistance Rc.
- Both, short circuit test and open circuit test should be performed in order to get the accurate equivalent circuit for the transformer.
- Core losses include Hysteresis losses and Eddy current losses.
- Hysteresis Loses are those loses, which are due to the energy lost in continuously change the direction of rotation of electrons in the core. In other words, continuously aligning and re-aligning atoms of core to make them in sync with changing magnetic field causes loss in energy.
- Eddy Current losses are losses due to presence of unwanted current in the core. The core is made up of metal, usually iron. When a changing magnetic field is applied in the primary side, a current is induced in metallic core. This Current in turn then produces another magnetic field which interacts with the present flux.

7 Team Dynamics

Part and Member	**Weight Grade**	**Muhammad Obaidullah**	**Ali Raza**	**Abdulla Hamoud**
Abstract	10%	33.3%	33.3%	33.3%
Introduction	15%	33.3%	33.3%	33.3%
Procedure Part 1	15%	33.3%	33.3%	33.3%
Procedure Part 2	15%	33.3%	33.3%	33.3%
Results Part 1	15%	33.3%	33.3%	33.3%
Results Part 2	15%	33.3%	33.3%	33.3%
Conclusion	15%	33.3%	33.3%	33.3%
Total	100%	33.3%	33.3%	33.3%

References

[1] The online electrical engineering study site. *Equivalent Circuit of Transformer referred to Primary and Secondary* [Electronic] Available: `http://www.electrical4u.com/equivalent-circuit-of-transformer-referred-to-primary-and-secondary/` [5 June 2013].

[2] Bulletin B900-92005 *Transformer Insulation Options* Page 1 of 6 [Electronic]. Available: `http://www.spxtransformersolutions.com/assets/documents/B900-92005TransformerOptionsforFireSensitiveLocations.pdf` September 2006 [4 June 2013].

[3] Fundamentals of Power Engineering *Lab 6: Transformers in parallel and 3-phase transformers* Page 1 of 8 [Electronic]. Available: `http://www.ee.lamar.edu/gleb/power/labs/lab%2006%20-%20transformers%20in%20parallel%20and%203-phase%20transformers.pdf` Spring 2008 [5 June 2013].