UCD School of Electrical, Electronic and Communications Engineering

EEEN20090 Electrical Energy Systems II

**Transformer Parameter and Loss Measurement**

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### Declaration

I declare that the work described in this report was done by the people named above, and that the description and comments in this report are my own work, except where otherwise acknowledged. I have read and understand the consequences of plagiarism as discussed in the EECE School Policy on Plagiarism, the UCD Plagiarism Policy and the UCD Briefing Document on Academic Integrity and Plagiarism. I also understand the definition of plagiarism.

Signed: Fergal Lonergan Date: 25/3/25

## Summary

In this report I will explain the reason for which this lab was undertaken, explain the method used, present and interpret the results and findings and finally provide recommendations which I have drawn from undertaking the lab.

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## Introduction

In this lab we were tasked with measuring particular properties of a transformer in order to build a more accurate model of a real transformer which could then be used for more detailed analysis. The lab was divided into three sections, each testing a different aspect of the transformer under certain conditions in order to obtain the properties we needed to build our transformer model. An ideal transformer contains none of these “non-ideal” properties and even though it is ok to use it for simple circuit analysis it is not an accurate model for a real transformer.   
The three sections, or tests, where divided as such :

* DC Winding resistance
* Open Circuit test
* Short circuit test

## Theory

For circuit analysis there are two different types of transformer, the ideal and the real transformer. The ideal transformer consists of two separate coils of wire each wrapped around a single iron core. It is so-called “ideal” because it assumes that there are no losses in power from the transformer as well as there being no leakage flux. This however is not the case. We apply an AC voltage to one side of the transformer, this is known as the primary side, and on the other side, the secondary side, we can get a stepped up or down voltage depending on the turns ratio between the twoAs a result the current in the secondary side must reflect the step up or step down ratio as the supplied power must be kept constant, no loss as stated above.   
Of course if an ideal transformer is able to step up or step down voltage, it is just as capable at stepping up or down the currents in either side of the transformer should that be required. This is summarised in the figure below, the ideal transformer, in which V1 and I1 refer to the voltage and current on the primary side of the transformer, and similarly V2 and I2 refer to the voltage and current on the secondary side of the transformer. N1 refers to the number of turns in the primary coil whereas N2 refers to the number of coils in the secondary coil.

image

The relationship between the primary voltage and secondary voltage in relation to the turns ration is:

Whereas the relationship between the primary and secondary currents in relation to the turns ratio is:

Real transformers however have many non-ideal properties that the ideal transformer simply fails to take into account. These non-ideal properties must then be taken into account when modelling a real transformer in order to get accurate results. In our model of our ideal transformer we assumed that the transformer had zero impedance, perfect magnetic coupling between the primary and secondary coils as well as a core reluctance of zero. This is not the case in an ideal transformer and as a result these properties must be taken into account in our transformer model. For the purpose of this lab we will consider these properties even though there are more non-ideal properties of transformers that have been factored out in our calculations.   
Our new model of a real transformer can be seen in the equivalent circuit below. This new model takes into account the non-ideal characteristics of a transformer detailed above and should enable us to make much better estimations for how our transformer will act under the conditions tested in the lab.

Image

R1 : Primary winding resistance  
R2 : Secondary winding resistance  
X1: leakage reactance in the primary coil of our transformer  
Xm: Magnetising reactance in the primary coil of our transformer  
Rc: Resistance for total core loss due to Eddy currents and hysteresis in transformer

In order to adapt the transformer circuit shown below it is necessary to find values for each of the variables labelled above. In order to do this we must put our circuit through three separate tests, the tests we undertook in the lab.

#### Dc Winding Resistance

This test allows us to measure the primary and secondary winding resistance, R1 and R2 respectively, using the four terminal test. We use the four terminal test in order to get an accurate reading for our resistance as our normal Ohmmeter is not reliable at measuring resistances this ……….. . The test involves us passing a substantially large DC current to our primary and secondary sides and measuring the voltage drop which will be due to the winding resistance. Seeing as we are using a DC current we eliminate the inductive and coupling effects of the transformer.

#### Open Circuit Test

Using this test we are able to find values for Rc and Xm. In order to do this we must open circuit the secondary side of our transformer, hence the name open circuit test. The equivalent circuit can then be modelled in Figure 3 below. Looking at the circuit we note that the primary current will be very low in comparison to its rated current, and so we discount the voltage drop across the primary winding resistance, R1, assuming that it is negligible. Furthermore we can assume that the current flowing through X1, leakage reactance in the primary coil of our transformer, and R2, the secondary winding resistance, is approximately 0A and so we can further reduce the circuit to the parallel combination of Rc, resistance for total core loss due to Eddy currents and hysteresis in transformer, and Xm, magnetising reactance in the primary coil of our transformer.   
Using the following equations we can now determine these values.

P = Power  
V = Voltage across the parallel combination or V1  
I = Current through the elements or I1

Short Circuit Test

Using this test we can measure X1. To do this we must now short circuit the secondary side of the transformer. By doing this we can simplify the circuit to the equivalent circuit shown below in Figure 4.

Image

We consider loss due to R1 and R2: 𝑃 = 𝐼1 2𝑅1 + 𝐼2 2𝑅2 Bringing R2 over to the primary side we find: 𝑃 = (𝑅1 + ( 𝑁1 𝑁2 ) 2 𝑅2) 𝐼1 2 Let: 𝑅𝑤 = 𝑅1 + ( 𝑁1 𝑁2 ) 2 𝑅2 We can then say the following: 𝑃 = 𝑅𝑤 𝐼1 2 This allows us to calculate Rw for finding X1. If we consider the voltage dropped across the primary side we find: 𝑉 = 𝑅𝑤𝐼1 + 𝑗𝑋1𝐼1 Solving for I1 and taking the absolute value we find the following equation: |𝐼1 | = 𝑉 √𝑅𝑤 2 + 𝑋1 2 This allows us to calculate a value for X1 now which we require to build up our power transformer model

### DC Winding Resistance

Open Circuit Test

Short Circuit Test

## Procedure

### DC Winding Resistance

This lab was divided into three parts, the first of which involved obtaining the DC winding resistance of our transformer. For

### Open Circuit Test

### Short Circuit Test

For more on procedure see EEEN 20090 Transformers Parameter Loss and Measurement Lab link in references section.

## Findings (evidence)

### DC Winding Resistance

### Open Circuit Test

### Short Circuit test

## Conclusions

From the results we have obtained above we can see that:

## References/bibliography/sources

EEEN 20090 course notes  
EEEN 20090 Electrical Energy Systems II Transformer Parameter and Loss Measurement Lab