EE 448 Laboratory Experiment 3
Transformer Experiment

EE 448
Fall 2008

Lab Experiment No. 3
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Transformer Experiment
I. INTRODUCTION

OBJECTIVES:

1. To learn how real world transformers operate under ideal conditions.
2. To learn what happens to the output voltage when the transformer is loaded.

INSTRUMENTS AND COMPONENTS

Power Supply Module  
AC Metering Module (V)  
AC Metering Module (I)  
Transformer Module  
Ammeter (8A)  
1.25 Ohm Load Resistor

II. PRELAB EXERCISES

All voltages given in Figures 1 – 3 have phase angles of 0 degrees.

1) Consider the following ideal transformer circuit in Figure 1.

\[
\begin{align*}
\text{V1} & \quad \text{I1} \rightarrow \text{11:1} \rightarrow \text{I2} \\
\text{PRI} & \quad \text{SEC} \\
\text{V2} & \quad R_{\text{load}}\quad \text{600}
\end{align*}
\]

Figure 1: Ideal Transformer Circuit

a. Compute the voltage across V_2, I_1, and I_2.
b. Compute the power input and power output.
c. Compute the reflected impedance seen on the primary side (Hint, you know V_1 and I_1).
2) Consider the following circuit (Figure 2) that models a real transformer.

![Real Transformer Circuit](image)

**Figure 2: Real Transformer Circuit**

a. Explain how the following equivalent circuit (Figure 3) was obtained. This circuit is functionally identical to the circuit above it (Figure 2).

![Real Transformer Equivalent Circuit](image)

**Figure 3: Real Transformer Equivalent Circuit**

b. What is the output voltage $V_2$?

c. Calculate the voltage $V_2'$ for the following loads. (Remember, you are reflecting these resistances to the primary side of the transformer.)

i. 300 Ohms
ii. 1200 Ohms
iii. 1.25 Ohms
d. Calculate the real power on the input side of the circuit $V_1$ and the real power on the output side with each of the three load resistances.

e. How do these powers compare to those that you calculated in problem 1?

f. Calculate the efficiencies of both the real and ideal transformer.

$$\text{efficiency} = \frac{\text{Power}_{\text{output}}}{\text{Total } \text{input power}} (100\%)$$

(Remember, these quantities are in terms of real power.)

Figure 4: Lab Volt Transformer
III. LABORATORY EXPERIMENTS

**CAUTION:** HIGH VOLTAGES ARE PRESENT IN THIS LABORATORY EXPERIMENT! DO NOT MAKE ANY CONNECTIONS WITH THE POWER ON! THE POWER SHOULD BE TURNED OFF BEFORE THE CIRCUIT IS MODIFIED!

1. To perform an open circuit test, the high voltage (primary) side of the transformer is energized by connecting it to the variable voltage supply terminals as shown in the circuit of Figure 5. In order to obtain open circuit test data, adjust the variable AC voltage supply to its zero voltage position before turning on the AC power switch. Next turn on the AC power switch and adjust the variable AC voltage supply until the voltmeter $V_1$ reads 100 volts. Record the measurements of $I_1$, $V_2$, $W_1$, and $V_1$ in Table 1.

<table>
<thead>
<tr>
<th>Load</th>
<th>$V_1$</th>
<th>$V_2$</th>
<th>$I_1$</th>
<th>$W_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Circuit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5: Open Circuit Test Setup

How do your calculated voltage ratios compare to the real ratios of $N_1 = 344$ turns and $N_2 = 32$ turns?

The wattmeter reading is actually the power lost due to the core resistances and primary winding resistance.
2. A short circuit test can be performed by connecting a voltage source to the primary (high voltage) side of the transformer with the secondary (low voltage) side shorted. In this situation it is **VERY IMPORTANT TO ADJUST THE VARIABLE AC VOLTAGE SUPPLY TO ZERO BEFORE TURNING ON THE AC POWER SWITCH**. Use the 8 amp range on the ammeter to short the secondary winding as shown in Figure 6. Then increase the supply voltage slowly until the $I_2$ ammeter reads 4.0 amps. A typical value is for $I_1$ is about 0.40 amps. Record the measurements for $V_1$, $I_1$, and $I_2$.

![Figure 6: Short Circuit Test Setup](image)

Theoretically what would happen to the output current $I_2$ if the input voltage was increased to 100V? (Do not actually increase the voltage to 100V, just predict what will happen.)

3. Set up the circuit shown in Fig. 7 with the 1.25 ohm resistor. This circuit can be used to measure voltage regulation and power efficiency. Make sure the variable AC voltage supply is in the lowest position and turn the power on. Slowly increase the voltage until $V_1$ equals 100 volts and wait for the resistor to stabilize thermally (about 2 minutes). Record $V_1$, $I_1$, $V_2$, $W_1$, and $I_2$ in Table 3.

<table>
<thead>
<tr>
<th>Load</th>
<th>$V_1$</th>
<th>$V_2$</th>
<th>$I_1$</th>
<th>$I_2$</th>
<th>$W_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25 ohms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Use the voltages from Part 3 to calculate the voltage ratio and compare with the winding ratio.

How do the ratios in Part 3 compare to the ratios from Part 1?

Fill in Table 4 with the following calculations:

Calculate percent regulation. (Hint: Vnoload comes from Part 1 of the Procedure.)

\[
\text{regulation} = \frac{V_{noload} - V_{load}}{V_{load}} \times 100\%
\]

Calculate the output power \( W_2 \) in the load resistor. Why is \( W_2 \) different from the input power \( W_1 \)?

What is the efficiency of the transformer?

\[
\text{efficiency} = \frac{\text{Power}_{\text{output}}}{\text{Total}_{\text{input}} \text{ Power}} \times 100\%
\]

<table>
<thead>
<tr>
<th>Load</th>
<th>Percent Regulation</th>
<th>( W_1 )</th>
<th>( W_2 )</th>
<th>Power Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25 ohms</td>
<td></td>
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IV. PRESENTATION OF LABORATORY RESULTS WITH SPREADSHEET COMPUTER PROGRAM

V. OBSERVATIONS AND COMMENTS