EEE108 Electromagnetism and Electromechanics

Lab 2 Single-phase Transformers

General Information

Operating instructions

(1) Be familiar with equipment used and understand the functions;

(2) Work in groups of 3 people;

(3) Make wiring according to the connection diagrams;

(4) Observe the instruments after switching on the equipment, if there is any abnormal operation or smell, switch off the power immediately and identify the fault;

(5) Measure parameters according to the operating instructions;

(6) Turn off the power supply system when finished a set of measurements, then continue to the next step.

Safety Instructions

(1) Never touch a live circuit.

(2) Only connect or disconnect wires with the power switched off.

(3) Turn on the power supply with instructor's permission, and switch off the power immediately if a fault occurs.

(4) Check the power meter and ammeter before switching on the power, a short-circuit fault must be avoided.

(5) The main power switch should be operated with instructor's permission.

1. Objectives

To measure the transformation ratio and parameters of a single-phase transformer.

2. Pre-lab

(1) What are the features of no load and short circuit tests of a transformer, respectively? To which side should the power supply be connected during each test and why?

(2) How should the instruments be connected to avoid measurement errors during no load and short circuit tests? How should the wattmeter **W** be connected to a circuit?

3. Laboratory exercises

(1) No load test

Measure the no load characteristics $U_0 = f(I_0)$, $P_0 = f(U_0)$, and $\cos\varphi_0 = f(U_0)$ as the instructions in section 5.1.

(2) Short circuit test

Measure the short-circuit characteristics $U_K = f(I_K)$, $P_K = f(I_K)$, and $\cos\varphi_K = f(I_K)$ as the instructions in section 5.2.

4. Equipment List

The modules should be placed in the order of D33, DJ11, D32, D34-3, D51, and D42 from left to right.

No.	Module	Name
1	D33	AC digital/analog Voltmeter
2	D32	AC digital/analog Ammeter
3	D34-3	Intelligent P/cos ϕ meter
4	DJ11	Shell-type transformer

5. Operating instructions

5.1 No load test instructions

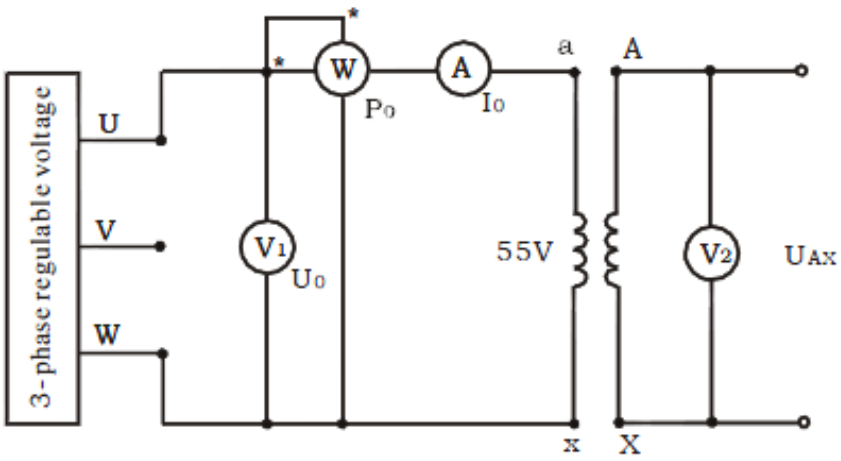

Figure 1: No load test circuit

The connection diagram is shown in Figure 1. The transformer is the single-phase transformer of module DJ11 with Low Voltage (LV) winding terminals ***a*** and ***x*** connected to the power supply, while High Voltage (HV) winding terminals ***A*** and ***X*** are open circuit. Use module D33 for voltmeters $\mathbf{V_1}$ and $\mathbf{V_2}$. Use module D32 for ammeter **A**, and module D34-3 for wattmeter **W**. The wattmeter **W** consists of an ammeter and a voltmeter; be sure to connect those appropriately.

The specifications of the DJ11 transformer are:

$P_N = 77\ V{\cdot}A$

$U_{1N}/U_{2N} = 220/55\ V$

$I_{1N}/I_{2N} = 0.35/1.4\ A$

1) Select appropriate ranges for all meters, and turn the control knob of autotransformer counter clockwise (CCW) to the end, setting the output voltage to zero (0 volts).

2) Switch on the main power with the key, press the **Start** button, then turn the autotransformer knob for $U_0 = 1.2\ U_N$. Measure several sets of U_0, I_0, P_0, U_{AX} while decreasing the regulated voltage from $1.2\ U_N$ to $0.3\ U_N$, recording your results in Table 1. Be sure to measure $U = U_N$.

3) When finished measurements, press the **Stop** button, and switch off the main power with the key. Disassemble your circuit, removing all cables.

include this page in your report

U_N = _____ volts 0.3 U_N = _____ volts 1.2 U_N = _____ volts

***Table* 1:** *Open circuit test results*

No.	Measured data				Calculated data
	U_0 (V)	**I_0 (A)**	**P_0 (W)**	**U_{AX} (V)**	**cos ϕ_0**

include this page in your report

I_N = _____ amps 0.2 I_N = _____ amps 1.1 I_N = _____ amps

Table 2: *Short circuit test results*

No.	Measured data				Calculated data
	U_K (V)	**I_K (A)**	**P_K (W)**	**I_{short} (A)**	**cos ϕ_K**

5.2 Short circuit test

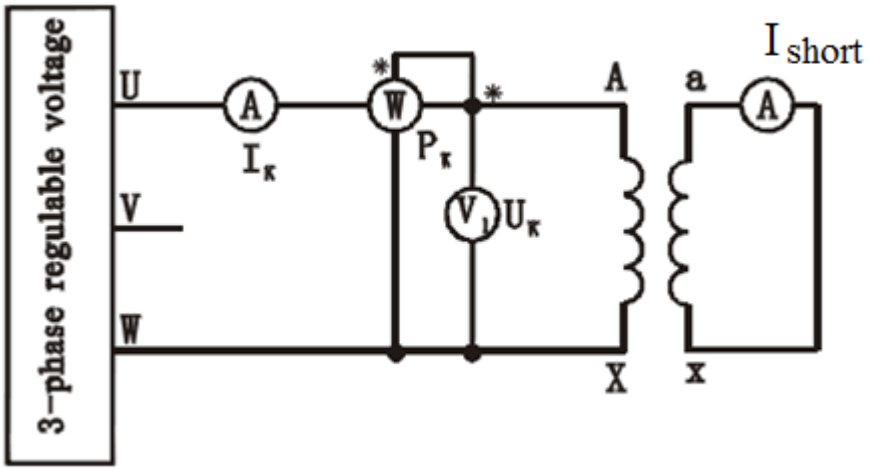

Figure 2: Short circuit test

1) Connect the circuit as per Figure 2. The HV winding is connected to the power supply, while the LV winding has the short circuit.

2) Select appropriate ranges for all meters, and turn the control knob of autotransformer counter clockwise (CCW) to the end, setting the output voltage to zero (0 volts).

3) Switch on the main power with the key, press the **Start** button, and measure several sets of U_K, I_K, P_K and I_{short} while increasing the regulated voltage from the value for 0.2 I_N to 1.1 I_N, recording your results in Table 2. Be sure to measure $I_K = I_N$.

4) When finished measurements, press the **Stop** button, and switch off the main power with the key. Disassemble your circuit, removing all cables. Return the cables to the drawer.

Note: *Due to the high currents during the short circuit test, the equipment can suffer heating effects which biases results. It is advisable to make measurements as quickly as possible, and it is acceptable to only switch on the power during measurements using the* **Start – Stop** *buttons.*

6. Laboratory report

Your report must have the following:

Cover page

Include title, name, student ID number, and names of your 2 group members.

1. **Abstract (10%)**

   Write a 3 or 4 sentence summary of the experiment, any problems, and summarize the results.

2. **Introduction (10%)**

This section describes, in general terms, the scope of the experiment and its relevance to the field of study you are engaged in. A statement of objectives should be given along with general comments about how the experiment will be carried out.

You may describe the equipment used in the experiment in this section.

3. **Experimental results (45%)**

3.1 Table of data

Include Tables 1 and 2 (Original form with your recorded data), and a brief description of how you undertook the experiment.

3.2 Graphs of date (No load test)

No Load Test: Including the equivalent circuit accordingly

1) Plot the no-load characteristics on graph paper by hand:

Original graph should be drawn by hand and scan it to your softcopy.

$U_0 = f(I_0)$

$P_0 = f(U_0)$

$\cos \varphi_0 = f(U_0)$, where $\cos \varphi_0 = \dfrac{P_0}{U_0 I_0}$

3.3 Graphs of date (Short circuit test)

Short Circuit Test: Including the equivalent circuit accordingly

1) Plot the short-circuit characteristics on graph paper by hand:

Original graph should be drawn by hand and scan it to your softcopy.

$U_K = f(I_K)$

$P_K = f(I_K)$

$\cos \varphi_K = f(I_K)$

3.4 Comments on graphs and results

4. Discussion Errors analysis (20%)

The followings should be included:

(1) *Transformation ratio calculation*

Calculate the ratios from the experimental data and take the average value as the ratio:

$K = U_{AX}/U_{ax}$

(2) *Calculate the relevant parameters of no load circuit*

Look up values of I_0 and P_0 at $U_0 = U_N$ in the no load characteristic curve, then calculate the excitation parameters according to:

$$r_m = \frac{P_0}{I_0^2}, \quad Z_m = \frac{U_0}{I_0}, \text{ and } \quad X_m = \sqrt{Z_m^2 - r_m^2}$$

(3) *Calculate the short-circuit parameters*

Look up values of U_K and P_K at $I_K = I_N$ in the short circuit characteristics curve, and then calculate the short-circuit parameters at θ (℃):

$$r_K^{'} = \frac{P_K}{I_K^2}, \quad Z_K^{'} = \frac{U_K}{I_K}, \quad \text{and} \quad X_K^{'} = \sqrt{\left(Z_K^{'}\right)^2 - \left(r_K^{'}\right)^2}$$

Equivalent parameters at the LV side:

$$r_K = \frac{r_K^{'}}{K^2}, \quad Z_K = \frac{Z_K^{'}}{K^2}, \quad \text{and} \quad X_K = \frac{X_K^{'}}{K^2}$$

Short-circuit loss P_{KN} equals to $I_N^2 r_{K,75^0C}$ when $I_K = I_N$.

where $r_{K,75^0C} = r_{K,\theta}\frac{234.5+75}{234.5+\theta}$, 234.5 is the coefficient of copper conductor.

(4) *Errors analysis.*

Including: individual equipment and process/method used in the experiment.

5. Conclusion(10%)

This is a concise statement of what has been learnt from or confirmed by the experiment. This section must be consistent with earlier sections. Usually, a short paragraph is used here to summarize the most important findings

6. References(5%)

List any textbooks or other reference material you referred to in your write-up.

Your individual formal report for this experiment should be submitted approximately 2 weeks after you did the experiment, as per the deadline given on ICE/lectures. This assessment is worth 10% of module EEE108.