



MEC102 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

2.1 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?

2.2 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

3.1 No load test

Measure the no load characteristics $U_0 = f(I_0)$, $P_0 = f(U_0)$, and $\cos\phi_0 = f(U_0)$ as the instructions in section 5.1.

3.2 Short circuit test

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

4. Equipment List

The modules in the table below are used in the experiment.

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	D42	Adjustable resistor

5. Operating instructions

5.1 No load test instructions

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 **V**₁ and **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.

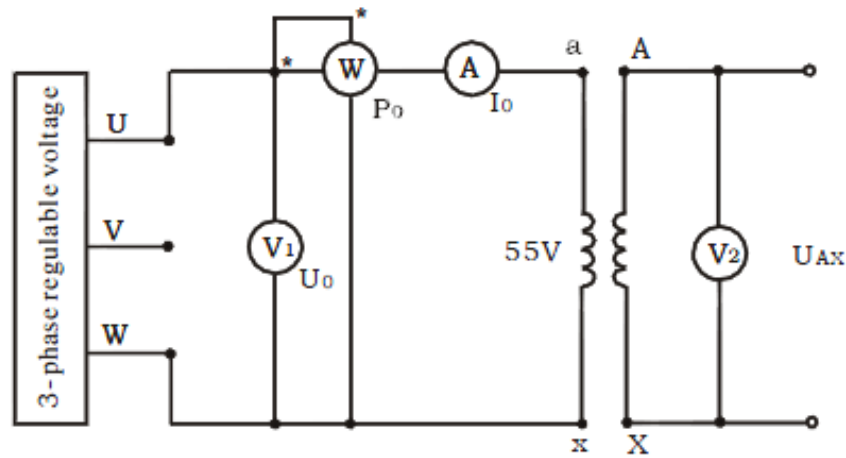


Figure 1: No load test circuit

The specifications of the DJ11 transformer are:

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

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

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

- 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 $U_0 = 1.2U_N$. Measure several sets of U_0 , I_0 , P_0 , U_{AX} while decreasing the regulated voltage from $1.2U_N$ to $0.3U_N$, 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)	$\cos \phi_0$

5.2 Short circuit test

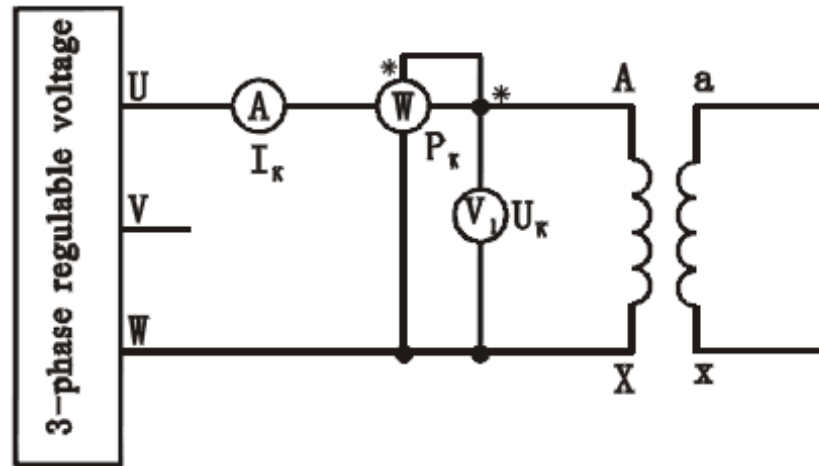


Figure 2: Short circuit test

- 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. An additional ammeter can be inserted in the path of the short circuit as optional/advanced work.
- 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, then turn the autotransformer knob to get $I_K = 0.2 I_N$ on ammeter **A**. Measure several sets of U_K , I_K , P_K 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 $I_K = I_N$. Measure I_{short} as optional/advanced work with each set, if of interest.
- 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.*

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)	$\cos \phi_K$

6. Laboratory report

Your report must have the following:

6.1 Cover page

Include title, name, and student ID number.

6.2 Abstract

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

6.3 Experimental results

Include Tables 1 and 2.

6.4 Discussion

Include the following:

(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) *Plot the no load characteristics and calculate the relevant parameters*

Including the equivalent circuit accordingly

1) Plot the no-load characteristics:

$$U_0 = f(I_0)$$

$$P_0 = f(U_0)$$

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

2) Excitation parameters

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:

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

(3) *Plot the short-circuit characteristics and calculate the short-circuit parameters*

Including the equivalent circuit accordingly

1) Plot the short-circuit characteristics:

$$U_K = f(I_K)$$

$$P_K = f(I_K)$$

$$\cos \phi_K = f(I_K)$$

2) Parameters calculation

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 ($^{\circ}\text{C}$):

$$r'_K = \frac{P_K}{I_K^2}, \quad Z'_K = \frac{U_K}{I_K}, \quad \text{and} \quad X'_K = \sqrt{(Z'_K)^2 - (r'_K)^2}$$

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 $I_N^2 r_{K,75^{\circ}\text{C}}$ when $I_K = I_N$.

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

Comment on your graphs and results!!!

6.5 Conclusion

Briefly describe the experiment as you undertook it, the major findings, any errors or difficulties that you found, and comment on the relevance to your study.

6.6 References

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

7. Assessment

Your individual formal report for this experiment should be submitted before the deadline. This report is worth 10% of module MEC102.