NATIONAL UNIVERSITY OF SINGAPORE

Faculty of Engineering
Electrical and Computer Engineering
Energy Management and Microgrid Laboratory

EE2022 Electrical Energy Systems

Laboratory Manual
Experiment 2

Electrical Energy Delivery Systems

Academic Year 2012/2013

1. Objectives

This experiment familiarizes students with application of transformers in an electrical energy delivery system. The aim of this experiment is to develop broad perspective and understand basic operation of transmission and distribution systems. You will conduct the experiment in two parts. The first part requires you to build a laboratory scale electrical energy system comprising of generation, transmission, and distribution systems with transformers. The experiment simulates how energy is delivered where transformers are used to step up the voltage from a generation source to a transmission line and to step down the voltage from the transmission line to a load. The second part requires you to repeat the experiment without transformers. You will perform tests on the two circuits and analyze energy loss and voltage drop in energy transmission and distribution with and without transformers.

2. Equipments

(a) 2.1-2.2 Variac & transformers

(b) 2.3-2.4 Transmission line model & resistive load

(C) 2.5 CW240 clamp on power meter

(d) 2.6 Multimeter

Figure 1: Equipments

2.1. A variac used as a generation source.

2.2. Two transformers with the same rating and turn ratio.

2.3. A transmission line model comprises of a resistor ($LR_{2\text{-}1.5\Omega}$) and an inductor ($L_{1\text{-}10mH}$).

2.4. Resistive load ($R_{1\text{-}3.1\Omega}$).

2.5. CW240 clamp on power meter.

2.6. One portable digital multimeter.

3. Safety

(a) You will be working with electric power. To avoid electric shock, connecting circuits is permitted only after power has been disconnected. **Circuits must be inspected by the lab demonstrator before they are powered on.**

(b) Always choose sufficiently long leads, do not connect two or more short leads to make one long lead. Remove disconnected leads from the bench.

(c) Transformers, inductors, resistors and power supplies are quite heavy. The laboratory does not require that this equipment is moved.

4. Log book report

Each student must submit an individual report after the completion of this experiment.

A good laboratory report is concise while providing enough details about the experiment. Use the following guide for your report presentation.

Title: Provide the title of the lab exercise along with your name, and date the experiment was performed.

Objective: Briefly state the objective of the experiment.

Measurements/results: You will be required to make various measurements and observations. In certain cases you will be comparing theoretical values with those measured, or two different measurements of the same quantity. Most measurements will contain some error (difference between theoretical and measured values). Record these readings and the percent error in the form of a table. Show all calculations.

Discussion and Conclusion: In this section you are to state whether the objectives of the experiment were met. Were there any errors in measurements that you could not account for?

A good lab report should provide comments and observations to indicate your understanding. Your lab reports should not contain the degree of detail as present in the lab manual, nor should you simply rephrase what is in the lab manual. Try to keep you reports as concise as possible without deleting essential information.

IMPORTANT!

Students are warned that copying of lab report is a serious offence which may lead to expulsion from the University. The lab officers have been instructed to confiscate all copies of lab reports not belonging to the students concerned during the lab sessions.

5. Ratings

Power equipment is designed by the manufacturer to operate in a certain range of voltages and currents. The parameters quoted by the manufacturer are known as the rating of the equipment. Operating the equipment at voltage or current higher than the rated voltage and current is unsafe and may damage the equipment. These ratings must not be exceeded at any time during the laboratory exercises.

6. Experimental Procedure

Warning: Do not make any connections with the power on! Have your circuits checked by the laboratory demonstrator before turning on the supply.

6.1. Part 1: A laboratory scale electrical energy system

6.1.1. The equipment in Figure 1(a) includes two identical transformers. One to step up the voltage and the other to step down the voltage. The ratings of the <u>**step up**</u> transformer are given in Table 1

Table 1: Specifications of the step up transformer

Primary voltage V_1(V)	Secondary voltage V_2(V)	VA rating (VA)
230	20	60

6.1.2. Connect the circuit as shown in Figure 2. <u>**Have your circuit checked by the laboratory demonstrator.**</u>

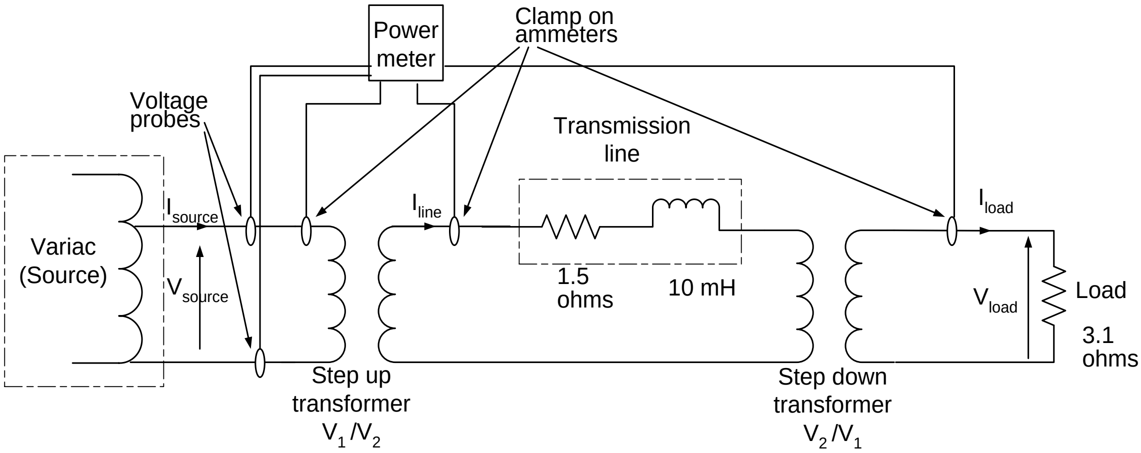

Figure 2: A laboratory scale power system model

6.1.3. Set the variac to zero output and then switch on the supply.

6.1.4. Switch on the power meter. Observe the voltage display in the power meter, adjust the variac and set the source voltage (V_{source}) to a value given in Table 2.

Table 2: Source voltage

Voltage rating of the transformer	V_{source}(V)
20/230 V	8

6.1.5. Use the portable digital multimeter to measure the voltage across the resistance and the reactance of the model transmission line. Record the values.

6.1.6. Use the power meter to measure the source current (I_{source}), source voltage (V_{source}) and power supplied by the source (P_{source}). In addition, use the same meter to measure the line current (I_{line}) and load current (I_{load}). Use the portable digital multimeter to measure the voltage across the load (V_{load}).

6.1.7. Take the measurements mentioned in step 6.1.6 in three trials and record the measured values in Table 3. Switch off the power supply without changing the voltage knob of the variac.

6.1.8. Find the average of the measured values and fill in Table 3.

Table 3: Measurements in part 1

Trial	V_{source}(V)	I_{source}(A)	P_{source}(W)	I_{line}(A)	I_{load}(A)	V_{load}(V)
1						
2						
3						
Average						

6.2. Part 2: A laboratory scale electrical energy system without transformers

6.2.1. Connect the circuit as shown in Figure 3. **Have your circuit checked by the laboratory demonstrator.**

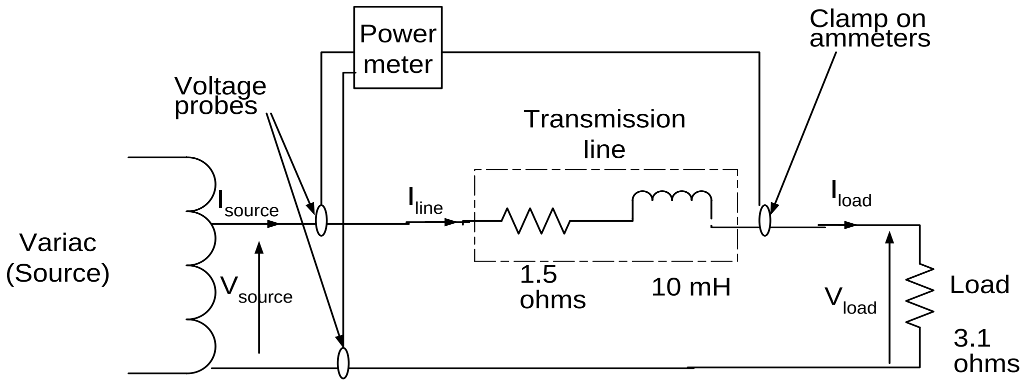

Figure 3: A laboratory scale power system model with no transformers

6.2.2. Switch on the power supply to the variac.

6.2.3. Use the power meter to measure the source voltage (V_{source}), source current (I_{source}) and power supplied by the source (P_{source}). Use the same meter to measure the load current (I_{load}). Use the portable digital multimeter to measure the voltage across the load (V_{load}).

6.2.4. Read the measurements mentioned in step 6.2.3 in three trials and tabulate all readings in Table 4.

6.2.5. Find the average of the measured values and fill in Table 4.

6.2.6. After all values have been noted down, **restore the variac to zero output**, and switch off the supply.

Table 4: Measurements in part 2

Trial	V_{source}(V)	I_{source}(A)	P_{source}(W)	I_{load}(A)	V_{load}(V)
1					
2					
3					
Average					

7. Report

7.1. Using the measurements taken in 6.1.5 and the line current measured in 6.1.6, calculate the resistance and inductance of the model transmission line. Use the load current and load voltage measured in 6.1.6 to calculate the value of the resistive load.

7.2. Consider the measurements taken in section 6.1, calculate the followings.

(a) Real power consumed by the load resistor (W)

(b) Real power loss in the transmission line (W)

(c) Total power loss (W)

(d) Efficiency $(\eta) = \frac{P_{load}}{P_{source}} \times 100\%$.

(e) Percentage voltage drop $(\%) = \frac{V_{load}}{V_{source}} \times 100\%$.

7.3. Consider the measurements taken in section 6.2, calculate the followings.

(a) Real power consumed by the load resistor (W)

(b) Real power loss in the transmission line (W)

(c) Total power loss (W)

(d) Efficiency $(\eta) = \frac{P_{load}}{P_{source}} \times 100\%$.

(e) Percentage voltage drop $(\%) = \frac{V_{load}}{V_{source}} \times 100\%$.

7.4. Compare the real power loss in the transmission line calculated in 7.2(b) and 7.3(b).

7.5. Compare the efficiencies calculated in 7.2(d) and 7.3(d).

7.6. Compare the percentage voltage drops calculated in 7.2(e) and 7.3(e).

7.7. Based on your results in 7.4 and 7.5, comment on the advantage of using transformers in power systems.

7.8. Based on your results in 7.6, comment on the advantage of using transformers in power distribution.

7.9. Explain at least two other possible power losses in the system. From the measurements, can you tell how much?