Drexel University
Electrical and Computer Engineering Dept.
Energy Management Systems ECEP- 354

Transmission Line Parameters

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Educational Objective

The objective of this experiment is to learn how to obtain the transmission line parameters of a scaled-down transmission line.

Introduction

For this lab we will be performing open-circuit and short-circuit tests on a scaled-down transmission line in order to obtain the ABCD parameters as described below in the Theory section.

Theory

The A, B, C, D parameters are called *transmission parameters*. The steady-state terminal voltages and currents of a transmission line can be expressed in terms of the A, B, C, D parameters as follows:

$$V_1 = AV_2 + BI_2$$

$$I_1 = CV_2 + DI_2$$

where

$$\mathbf{A} = \frac{\mathbf{V}_1}{\mathbf{V}_2}\bigg|_{\mathbf{I}_2 = 0} \qquad \mathbf{B} = \frac{\mathbf{V}_1}{\mathbf{I}_2}\bigg|_{\mathbf{V}_2 = 0} \qquad \mathbf{C} = \frac{\mathbf{I}_1}{\mathbf{V}_2}\bigg|_{\mathbf{I}_2 = 0} \qquad \mathbf{D} = \frac{\mathbf{I}_1}{\mathbf{I}_2}\bigg|_{\mathbf{V}_2 = 0}$$

Laboratory Procedure

Warning: *The voltages and currents that are used during this lab may be much larger than you are use to working with in other Drexel laboratories. The voltage that will be used in this laboratory is 120 VAC Phase-to-Neutral (208 VAC Line-to-Line) voltage* *with currents as high as 20 amps (or higher if circuits are improperly connected!). Please take the proper precautions and use your head before touching any circuitry.* ***NEVER*** *change any circuit connections while the power supply is turned on. Also remember that capacitors can also hold a charge for a long time after the voltage has been turned off. Make sure capacitors have been discharged before handling them.*

For this lab we will be performing open circuit and short circuit tests on a scaled-down transmission line in order to obtain the ABCD parameters as described in the theory section above.

Each lab setup consists of a scaled-down transmission line, a visible disconnect switch, an auto-transformer, a three-phase voltage source, signal conditioning circuitry, and two RTU computers. This lab is designed to run with 2-3 students manning each lab station. There should be one student operating the sending end RTU, one student operating the receiving end RTU, and one student in charge of setting up the circuits. Students should take turns performing each of the above tasks.

Before starting the lab please trace though the circuit (shown in Figure 1) at your station and be able to identify the following equipment/accessories:

1) 2 Remote Terminal Unit (RTU) computers with the experiment program running.
2) Signal Conditioning Circuitry
3) Control Panel (120Vac source)
4) 1 Auto-Transformer
5) Visible Disconnect Switch
6) Scaled-Down Transmission Line
7) 1 PC Floppy disk to save your experiment data.

If you can not identify any of the above equipment please ask you TA for assistance.

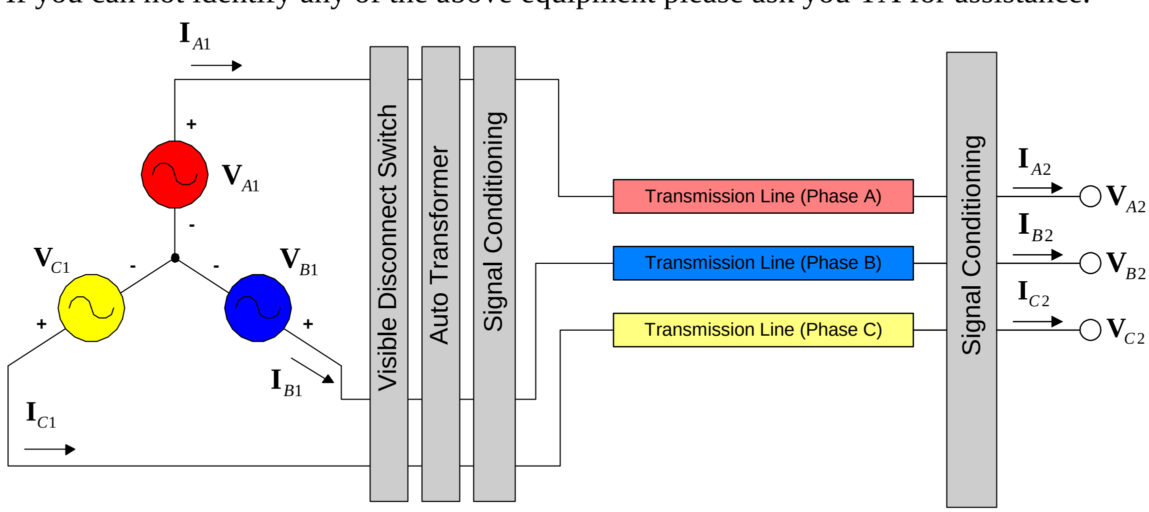


Figure 1: Lab Setup

A. Open Circuit and Short Circuit Tests

1. Make sure the power supply is off and the visible disconnect switch is open. Set each of the reactors in the transmission line to the 24 ohm tap setting. Make sure that the receiving end of the transmission line is left as an open circuit. See Figure 2 below:

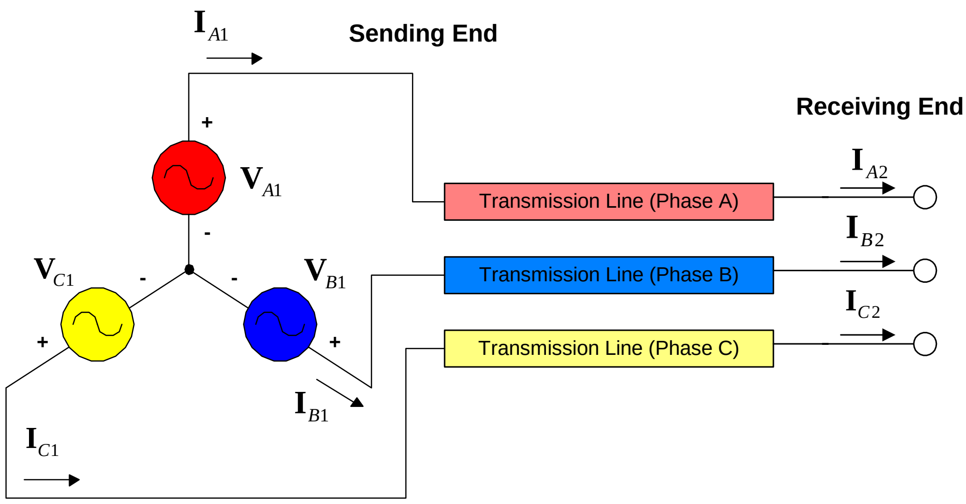


Figure 2: Open Circuit on Receiving Side (I_2=0)

2. Make sure that the auto-transformer is turned down to 0. Close the visible disconnect switch and turn on the power for the three-phase supply. Slowly turn up the transformer until the rated phase voltage of 120 Vrms is reached on the sending side.

3. Use each the RTU programs to record the voltage and current values at each end of the transmission line. The sending end RTU (on the left side) captures $\mathbf{V}_1$ and $\mathbf{I}_1$ and the receiving end RTU captures $\mathbf{V}_2$ and $\mathbf{I}_2$. Make sure you select the reading, which you are currently taking on the combo box located on the "Circuit Diagram Screen" of the RTU program. The value of the combo box tells the program what data you are currently recording so that it can place the data in the proper place on the spreadsheet. Ask TA for assistance if necessary.

4. Turn power off, open visible disconnect switch, and turn the auto-transformer down to 0. Short circuit the receiving end of the transmission line by placing two jumpers across the phases of the transmission line as shown in Figure 3 below.

5. Again make sure that the auto-transformer is turned down to 0. Close the visible disconnect switch and turn on the power for the three-phase supply. VERY slowly turn up the transformer until the current in each phase of the transmission line is 5 A.

6. Use each of the RTU programs to record the voltage and current values at each end of the transmission line. Again make sure you select the reading which you are currently taking on the combo box located on the "Circuit Diagram Screen" of the RTU program. The value of the combo box tells the program what data you are

currently recording so that it can place the data in the proper place on the spreadsheet.

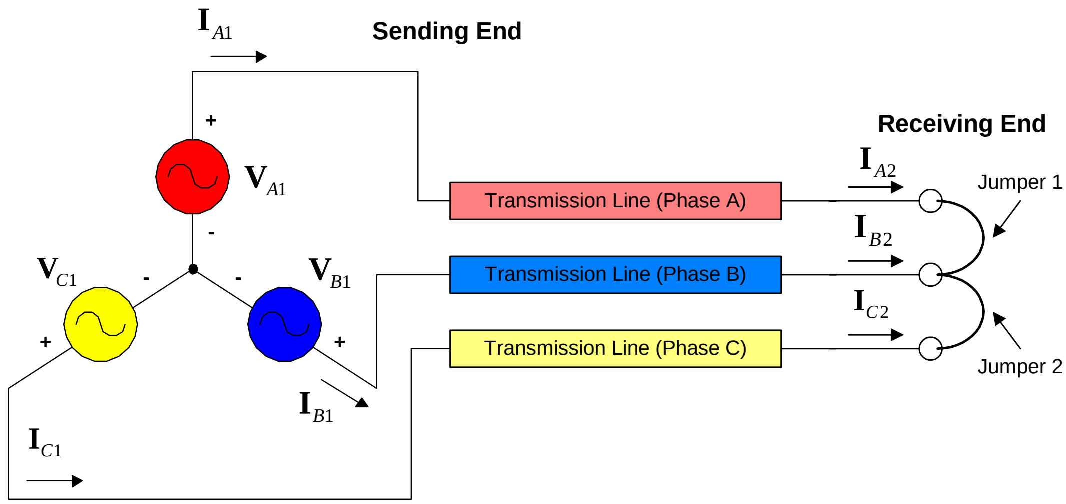


Figure 3: Short Circuit on Receiving Side (I_2=0)

7. Repeat steps 1-7 for the remaining six reactor tap settings on the transmission line (12, 6, 3, 2, 1, and 0.5 ohms). Use a current of 10 A for the short circuit tests for these remaining tap values. Ask the TA for assistance in changing the tap settings.

   *NOTE: When performing the short circuit tests for the smaller valued tap settings, you will only need to turn up the auto-transformer slightly in order to reach the 5 A current value. Always make sure that you start at zero on the auto-transformer to avoid an overcurrent situation.

8. Save your collected data to disk by selecting “Save Data to Text File” under the Data Logging menu on each of the RTU programs.

B. P-V Curve

1. Make sure the supply power is off and visible disconnect switch is open. Set the impedance of the line back to 24 ohms per phase. Hook up a wye-resistive load of 1 lightbulb per-phase to the receiving end of the transmission line (ask TA for assistance).

2. Close the visible disconnect switch and turn on the power supply. Adjust the auto-transformer until a phase voltage of 120 Vrms is reached on the sending-end side of the transmission line.

3. Record the phase A voltage and the total real power (receiving end only) by hand.

4. Repeat the readings for wye-resistive loads of 2, 4, 6, 8, 10, 12, 14, and 16 light bulbs per phase. There is no need to turn off the power before turning on more light bulbs.

Concluding Activities

1. Calculate the ABCD parameters for the transmission line for each of the tap setting values. Find the equivalent circuit for each of the 7 cases.

2. Plot P vs V using the data obtained during part B of the experiment.

3. Use ABCD parameter obtained from first section and data obtained from second section fill out the following table:

$\|V_2\|$	$\|I_2\|$	$\|V_1\|$	$\|I_1\|$	$\|V_1'^{(ABCD)}\|$	$\|I_1'^{(ABCD)}\|$	$Error_{(\|V_1\|)}$	$Error_{(\|I_1\|)}$

- **See the instructor for the details of the lab report.**

Quick Reference of Load Connections

A. Open Circuit and Short Circuit Tests

Load Settings:

a) Load 1 - 24 Ohm tap → Open Circuit Test → V1 = 120V
b) Load 2 - 24 Ohm tap → Short Circuit Test → I1 = 5A

c) Load 3 - 12 Ohm tap → Open Circuit Test → V1 = 120V
d) Load 4 - 12 Ohm tap → Short Circuit Test → I1 = 10A

e) Load 5 - 6 Ohm tap → Open Circuit Test → V1 = 120V
f) Load 6 - 6 Ohm tap → Short Circuit Test → I1 = 10A

g) Load 7 - 3 Ohm tap → Open Circuit Test → V1 = 120V
h) Load 8 - 3 Ohm tap → Short Circuit Test → I1 = 10A

i) Load 9 - 2 Ohm tap → Open Circuit Test → V1 = 120V
j) Load 10 - 2 Ohm tap → Short Circuit Test → I1 = 10A

k) Load 11 - 1 Ohm tap → Open Circuit Test → V1 = 120V
l) Load 12 - 1 Ohm tap → Short Circuit Test → I1 = 10A

m) Load 13 – 0.5 Ohm tap → Open Circuit Test → V1 = 120V
n) Load 14 – 0.5 Ohm tap → Short Circuit Test → I1 = 10A

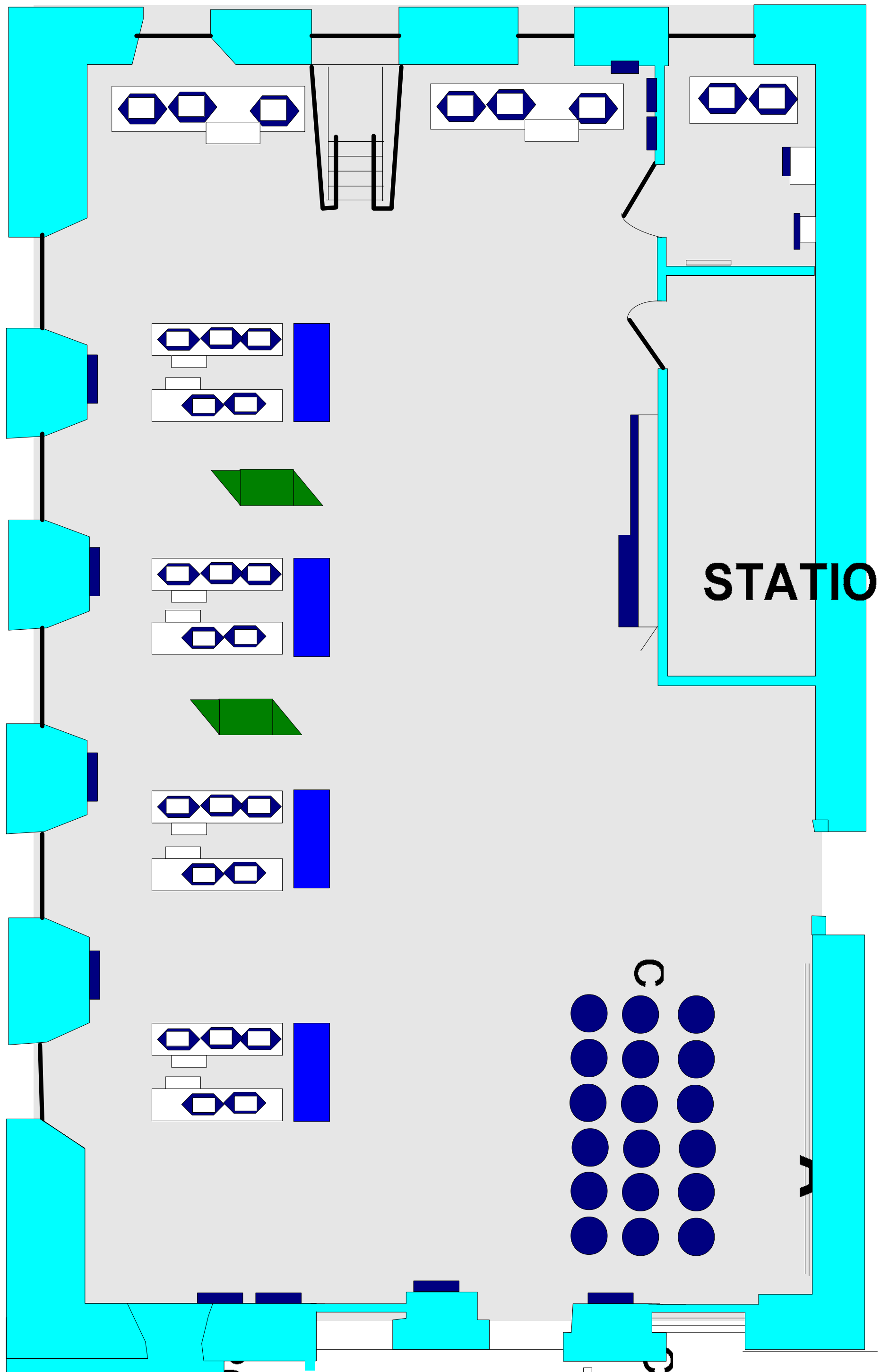
B. P-V Curve

Load Settings:

24 Ohm tap, V1 = 120V

a) Load 20 - 1 bulb on phases A, B and C
b) Load 21 - 2 bulbs on phases A, B and C
c) Load 22 - 4 bulbs on phases A, B and C
d) Load 23 - 6 bulbs on phases A, B and C
e) Load 24 - 8 bulbs on phases A, B and C
f) Load 25 - 10 bulbs on phases A, B and C
g) Load 26 - 12 bulbs on phases A, B and C
h) Load 27 - 14 bulbs on phases A, B and C
i) Load 28 - 16 bulbs on phases A, B and C

Appendix:



Lab Layout