EAST WEST UNIVERSITY

Department of EEE

Section: 01
Course Code: EEE304
Course Name: Electrical Power Systems

Course Instructor's Name: Dr. Khalid Imtiaz Saad (DKIS)
Assistant Professor,EEE,EWU

OPEN ENDED EXPERIMENT

Experiment Name: Verification of the Surge Impedance Loading Theorem
Performance Date: 28 August, 2023
Submission Date: 04 September, 2023

Submitted By(Group-01)

Kazi Iftier Rahman(2020-1-80-004)
Arpon Podder(2020-1-80-005)
Rohit Bhowmick(2020-1-80-006)
Md. Shahriar Hossain Shithil (2020-2-80-007)

SIGNED LAB MANUAL

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OBJECTIVE

The primary aim of this open-ended experimental investigation is twofold:

1. Formulating an experimental setup to validate the Surge Impedance Loading (SIL) Theorem.
2. Empirically confirming the Surge Impedance Loading (SIL) Theorem.

THEORY REVIEW

When a transmission line is loaded by being terminated with an impedance equal to its
characteristic impedance, the receiving end current is,

$$I_R = \frac{V_R}{Z_C} \quad \text{———(i)}$$

For a lossless line, Z_C is purely resistive, known as surge impedance.

If a lossless line is terminated being loaded with an impedance equal to its surge impedance, voltage and current at any point in the line are as follows:

$$V_S = V_R \cos\beta x + jV_R \sin\beta x = V_R\angle\beta x \quad \text{———(ii)}$$

$$I_S = jI_R \sin\beta x + I_R \cos\beta x = I_R\angle\beta x \quad \text{———(iii)}$$

From the above equations, it is observed that the magnitude of the voltage and current at any point in the line remains unchanged. Also, the angles of the voltage and current are linearly proportional to the distance from the receiving end.

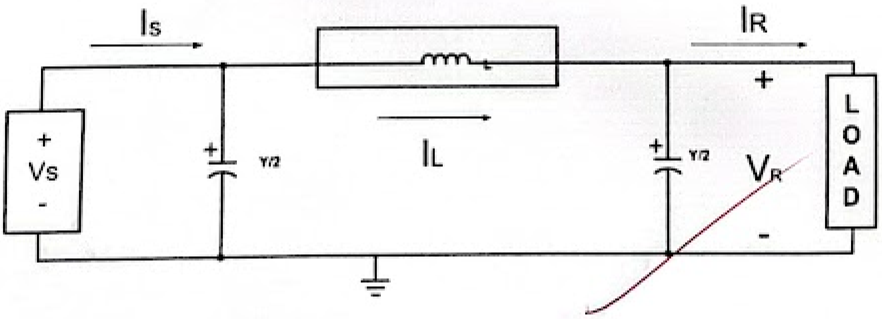

Figure 01: Per-phase equivalent circuit

EQUIPMENT LIST

1. IT-6000 – three phase variable power supply.
2. IT-6002 – line model.
3. IT-6004 – resistive load.
4. IT-6005 – inductive load.
5. IT-6035 – moving coil ammeter.
6. IT-6038 – moving iron voltmeter.

PRELAB WORKS

Complete the following tasks before the experiment day and fill up the appropriate columns of Table 2 in the datasheet. Also, have the detailed calculations checked by the instructor.

- Theoretically measuring the sending end voltage, receiving end voltage, sending end current, receiving end current.
- Use eqns. (i), (ii), (iii) to measure the sending end voltage, receiving end voltage, sending end current and receiving end current.
- Fill up the appropriate columns of Table 2 in the datasheet.

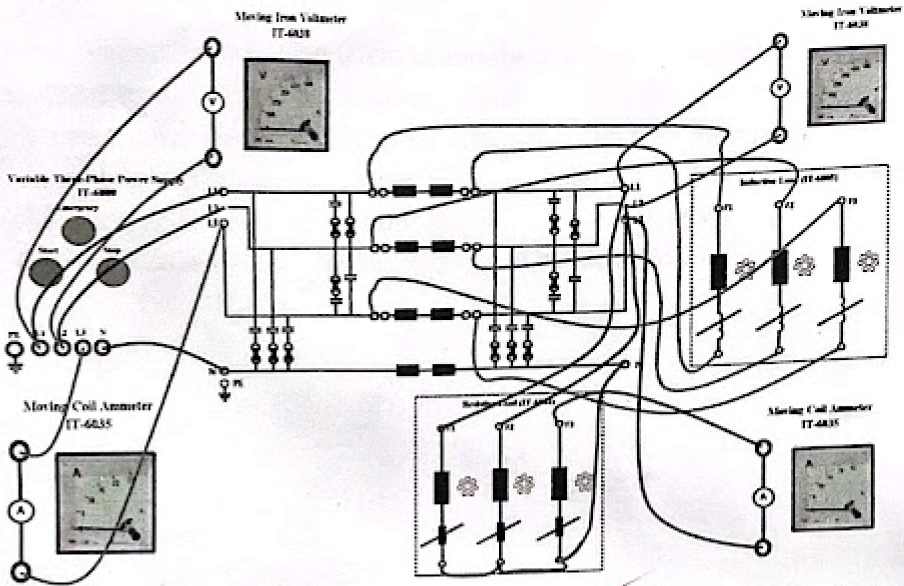

Figure 02: Connection diagram of open ended experiment for resistive loads

PROCEDURE

1. Connect the circuit as shown in Figure 02.
2. Rotate the knobs of the three-phase inductive load to CW position to make sending end voltage and receiving end voltage equal or quite close (position 1 to 7) in all the three phases.
3. Rotate the knobs of the three-phase resistive load to their full CW position to engage maximum loads in all the three phases.
4. Turn the power of the circuit by following the proper procedure.
5. Rotate the voltage knob of the three-phase variable power supply to increase the voltage until the receiving end voltage reaches 100 V.
6. Take the readings of the voltmeters and ammeters and write in the appropriate columns of Table 1 in the attached datasheet.

REPORT

Submit a report on this experiment within the deadline announced in the class. The report should contain the following items:

1. A cover sheet containing the usual information such as your name, student ID, course code, course title, experiment no., title of the experiment, date of performance and date of submission.
2. Experimental datasheet, checked and signed by the instructor.

EXPERIMENT DATA SHEET

Experiment Name	Verification of the Surge Impedance Loading Theorem
Group No.	01
Date of Performance	28/08/2023
Signature of the Instructor	28/8/23

Table 1: Comparison between theoretical results and experimental results

Load Position	*Inductive Load Impedance*	*Resistive Load Impedance*	*Sending End Voltage, V_S*	*Receiving End Voltage, V_R*	*Sending End current, I_S*	*Receiving End Current, I_R*
2	3		230	232	0.2	0.25

Table 2: Comparison between theoretical results and experimental results

Criteria	*Theoretical Value (TH)*	*Experimental Value(EV)*	*Error(%)=* $\frac{\lvert TH-EV\rvert}{\lvert EV\rvert}$
Sending End Voltage, V_S	299.99V	230V	0.00434%
Receiving End Voltage, V_R	230V	232V	0.86%
Sending End current, I_S	0.2189A	0.2 A	9.45%
Receiving End Current, I_R	0.2189 A	0.25 A	12.44%

THEORETICAL CALCULATION

For resistive load position 2, inductive load position 3,

Capacitance, $C = 5\mu F$

$$Z_C = \sqrt{\frac{L}{C}} = \sqrt{\frac{1.84}{5\times10^{-6}}} = 606.63\Omega$$

$$V_R = 230\text{V}$$

$$V_R(per\ Phase) = \frac{230}{\sqrt{3}}V = 132.79V$$

$$I_R = \frac{V_R}{Z_C} = \frac{132.79}{606.63}A = 0.2189A$$

$$\beta = \omega\sqrt{LC} = 2\pi f\sqrt{LC} = 2 \times \pi \times 50 \times \sqrt{1.84 \times 5 \times 10^{-6}}$$
$$= 0.953\, rad/m = 0.953 \times 10^{-3}\, rad/m$$

$$\beta l = 0.953 \times 10^{-3} \times 360 = 0.34308\, rad = 0.34308 \times \frac{180}{\pi} = 19.657°$$

$$V_S = V_R cos(\beta l) + jV_R sin(\beta l) = 132.79cos(19.657°) + j132.79sin(19.657°)$$
$$= 132.79\angle 19.657°\, V$$

$$V_S(Line\ to\ Line) = 132.79 \times \sqrt{3} = 229.99V$$

$$I_S = jI_R sin(\beta l) + I_R cos(\beta l) = j0.2189 \times sin(19.657°) + 0.2189 \times cos(19.657°)$$
$$= 0.2189\angle 19.657° A$$

MODIFICATIONS

Since the transmission line machines we have in our lab are lossy lines because of resistance in the line, to ignore the resistance in the transmission line we used inductive loads separately so that we can make the transmission line lossless.

COMPARISON BETWEEN THEORETICAL RESULTS & EXPERIMENTAL RESULTS

Parameters	Theoretical Value (TH)	Experimental Value (EV)	Error(%)= $\frac{\lvert TH-EV \rvert}{\lvert EV \rvert} \times 100\%$
V_S	229.99V	230V	0.00434%
V_R	230V	232V	0.86%
I_S	0.2189A	0.2A	9.45%
I_R	0.2189A	0.25A	12.44%

COMMENT

The theoretical values of surge impedances are verified by comparing the computed and experimental results on simple structures. The difference of theoretical and experimental value of voltages are V_S=0.00434% and V_R=0.86% which is less than about 5%. There shouldn't have been any difference in magnitude of voltages since our error came out to less than 5% so it holds up well. It can be seen from the values of current that the errors of these are more than 5%. The values are respectively I_S= 9.45% and I_R=12.44%. The difference comes from the different electromagnetic field around the vertical conductor influenced mainly by the electric fields. Also the surge characteristics have some influence on the type of the lightning current with the presence of ground surface and without the ground surface. The electric fields associated with the currents propagating the vertical conductor aid current lead wire.

DISCUSSION

The objective of this experiment was to transition the transmission line from a lossy state to a lossless state in order to facilitate testing of the Surge Impedance Loading theorem. Through a combination of theoretical calculations and experimental findings, we successfully met our experiment goals. As a result, we are able to demonstrate the validity of the Surge Impedance Loading theorem through this experiment. Looking at the experimental values, we notice that the voltage error is negligible but the current error is high due to some of our mistakes.