Design Of Transmission Line Model

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ABSTRACT

Transmission lines happen to be one of the important subjects in Electrical Power System. The theoretical concepts learned in the class room cannot be verified in a laboratory. This paper describes a laboratory setup of the scaled model of a transmission line built in the electrical department of KDK college of engineering, Nagpur. Data taken from transmission line system of 25MVA, 200km at a voltage level of 143KV is employed as transmission system model example taken from modern power system analysis. The laboratory experimental setup scaled down by using per unit normalization from 143KV to 400V in laboratory. Applying normalization to the parameter of transmission line, the value of resistance, inductance and capacitance of transmission line are calculated. The development of laboratory model to perform experiments which will teach undergraduate students the different aspects of power system operation. This paper discusses the steps involved in the design and development of laboratory model of transmission line.

Keyword : - *Transmission line; laboratory model & testing.*

1. INTRODUCTION

An electric power system consists of three principle divisions: the generating, the transmission line and the distribution systems. The transmission lines are the connecting links between the generating stations and the distribution and lead to other power system are interconnection. The important consideration in the design and operation of the transmission line are the determination of voltage drop, line losses and efficiency of transmission line. values are greatly influenced the line constant r, l and c of the transmission line.

The performance of transmission line is govern by its parameter-series resistance R and inductance L, shunt capacitance C and conductance G. The resistance R is due to the fact that every conductor offers opposition to the flow of current. The inductance L is due to the fact that the current carrying conductor is surrounded by the magnetic line of force. The capacitance of the line is due to the fact that the conductor carrying current forms a capacitor with the earth which is always at lower potential than the conductor and the air between them forms a dielectric medium. The conductance is mainly due to the flow of leakage current over the surface of the insulator especially during the bad weather.

2. CHARACTERIZATION OF TRANSMISSION LINE

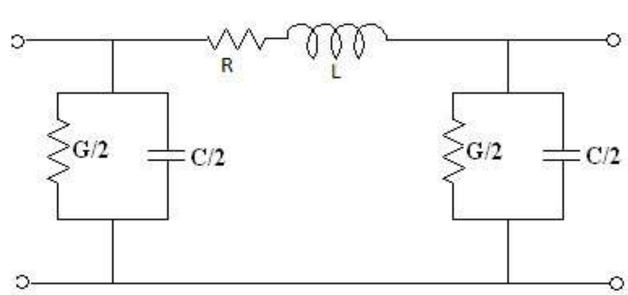

Fig -1: Circuit representation of a transmission line using π section

The transmission line is generally characterized by a few parameters like R (series resistance), L (series inductance), C (shunt capacitance), G (shunt conductance), measured per unit length and Z0 (characteristic or surge impedance) and γ (propagation constant). Conventionally, R, L, G and C are bunched to be named as primary constants while Z_0 and γ are classified as secondary constants. A transmission line may electrically be represented as a circuit consisting of series resistance R. and series inductance L along with shunt capacitance C and leakage conductance. When the circuit elements are assumed to be lumped with impedance Z in series and admittance Y in shunt having lumped single parameters like resistance, inductance and capacitance, then equivalent representation is called lumped parameter representation. Though, transmission line parameters are distributed throughout the entire line, the lumped parameter representation can be used to get clearer understanding of concept involve figure.1 shows a π section representation of transmission line.

The magnitude and the phase of a travelling wave is governed by the complex quality γ. In other words, γ governs the propagation of component waves. It is, therefore, called the propagation constant. The real part of propagation constant is α . It determines the change in magnitude per unit length of the line of the wave, and is termed attenuation constant. It is expressed in nepers per unit length. β is the imaginary part of the propagation constant. It determines the change in phase of the wave per unit length of the line.

The numerical value of propagation can be determined by the relation

$$\gamma = \sqrt{(zy)}$$

$$\gamma = \sqrt{(r + j\omega l)(g + j\omega c)}$$

3. DESIGN OF TRANSMISSION LINE MODEL

The works include developing the scale down laboratory model of transmission line. This transmission line model is now put in practice to perform different power system experiment. For developing this model the transmission line parameter such as series resistance and inductance, shunt capacitance gives in per kilometer length are used. The resistance and inductance are connected in series forming series impedance. While the capacitance existing between the conductor to neutral for three phase line length of the line. Therefore the capacitance effect introduce complication in transmission line calculation. The transmission system of 25 MVA, 200 Km at voltage level of 143 KV is employed as transmission system model [3].The laboratory experimental setup model is downscaled by using per unit from 143 kV to 400 V in laboratory. By considering the power supply from laboratory at voltage level of 400 V. For the experimental setup protection, the fuse is used as protective device of experimental setup. For measurement, the input variables such as voltage, real power, and current can be measured using meter. The power ON indication is provided to indicate the supply availability. The Two 100 km line segments can be interconnected as per the user requirement. The model is facilitated with the load connection terminals where the load (Max: - 2kVA) can be connected to the transmission line laboratory setup.

Fig -2: Experimental model of transmission line model

A. Transmission line ratings

The transmission system of 25 MVA, 200km at voltage level of 143 kV is used as transmission line model [ref.3]*
The ratings of transmission line are as follows:
Voltage rating of the line: 143KV
Resistance = $0.11\ \Omega$
Series inductance = $0.3895\ \Omega/\text{km}$
Shunt capacitance =$0.3386\Omega/\text{km}$

The current in the line is calculated as:

Current: $I=\frac{P}{\sqrt{3}V}$
I=100.93 Amp

Series Inductance:
$X_L=2\pi FL$
L=0.001240632 H/Km

Shunt Admittance: $Y=\omega C$
Y=2.9531E-06 mho/Km

Shunt Capacitance:
$X_C=\frac{1}{2\pi FC}$
C=9.40479 f/km

Propagation constant:
$\gamma = \sqrt{LC}$
$\gamma = 3.41583E - 06$

B. PER UNIT VALUES OF TRANSMISSION LINE

Per unit values of Resistance

$$R_{PU} = R\left(\frac{\text{Base MVA}}{(\text{Base KV})^2}\right)$$

$$R_{PU} = 0.0003144809\ \Omega$$

Per unit values of Inductive Reactance

$$X_{PU} = X_L\left(\frac{\text{Base MVA}}{(\text{Base KV})^2}\right)$$

$$X_{PU} = 0.0004762561\Omega$$

C. MODEL CALCULATION

$$P = \sqrt{3}\,V \times I$$

$$P = 1.385\ \text{KVA}$$

$$R_{SD} = R_{PU} \times Z_{PU}$$
$$R_{SD} = 0.015591 \frac{\Omega}{km}$$

$$X_{LSD} = X_{PU} \times Z_{PU}$$
$$X_{LSD} = 0.055218 \frac{\Omega}{km}$$

$$L_{SD} = \frac{X_{LSD}}{2\pi f}$$
$$L_{SD} = 0.0001757 \frac{H}{km}$$

$$C_{SD} = \frac{\gamma^2}{L_{SD}}$$

$$C_{SD} = 0.0000000664 \frac{F}{km}$$

$$Z = \frac{V}{I}$$
$$Z = 115.94\,\Omega$$

D. LINE PARAMETERS FOR 100 KM LINE MODE

The line parameters for each pi section are then calculated as
Follows:

$$R_L = R_{SD} \times 100$$
$$R_L = 1.55\,\Omega$$

$$L_L = L_{SD} \times 100$$
$$L_L = 0.175\,H$$

$$C_L = C_{SD} \times 100$$
$$C_L = 3.3\mu f$$

4. PERFORMANCE TESTING

The performance of a transmission line model was then tested and a laboratory panel is then prepared for conduction of following:

1) Ferranti effect
2) Voltage profile on transmission line
3) ABCD parameters of transmission line
4) Voltage regulation

5. CONCLUSION

We have taken the standard values of transmission line as we cannot apply this standard values to our experimental setup. So we are scaling down these values of standard transmission line for our experimental setup. We calculated the values of resistance, inductance and capacitance so that we can apply these scaled down values to our experimental. This paper explains development of laboratory model of transmission line and also steps involved in design, fabrication and testing of transmission line. The reactive power exchange cannot seen because of the limitations of the metering facilities. However, the effect can be seen by measuring the voltage at the receiving end. The developed laboratory model of transmission line is used for performing the experiments related to transmission for undergraduate and postgraduate students. Further, the same model will be used to develop the laboratory setup for demonstration of different series and shunt FACTS devices.

6. REFERENCES

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