Automated Transmission Line Laboratory Equipment

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Abstract- *Transmission lines happen to be one of the important subjects in electrical power system curriculum. Unfortunately, the theoretical concepts learnt in the classroom cannot be verified in a laboratory. The development of the laboratory model to perform experiments is very much essential. So in this regard the designing and development of laboratory model for transmission line is very helpful. Moreover, the MATLAB based simulation of the designed line is also performed. This model will be helpful for finding out voltage regulation as well as to observe voltage profile on transmission line. Along with online monitoring of parameters, demonstration of Ferranti effect is done. The design, fabrication, real-time monitoring /automation of transmission line is performed using LABVIEW. Power factor measurement and correction is also included in the system.*

Keywords- Automation, Ferranti effect

I. INTRODUCTION

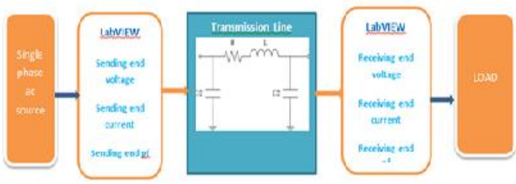
Transmission line is an inevitable part in the power system. It transmits huge amount of power from the generating station to the point where it is utilized. There are several theoretical concepts and assumptions for analysing various components in the power system, among them transmission lines are not an exemption. They are of different categories, short transmission lines, medium transmission lines, long transmission lines according to the distance to which the electrical power is being transmitted. For the same, there are T-modelling and Pi-modelling methods by which various parameters of the transmission line, voltage profile, Ferranti effect etc can be determined.

Since the voltage and current that the transmission line deals with is very large, there are many limitations to study it by direct inspection. The same difficulty is there for conducting experiments on the same. In order to visualize the current and voltage in electronic Circuits, a circuit can be arranged on a bread board and visualize it using CRO or DSO. But in electrical domain large voltage and currents are present. If it is possible to bring the electrical circuit on to the table top, the analysis will be much easy. The same case exists for transmission lines as well.

If the high voltage lines are brought to a simple table top device, it will be more convenient for the analysis and no more it exist only with concepts and imaginations. One should be able to see its sending end voltage and current, receiving end voltage and current, various transmission line parameters. Ferranti effect is the one which is broadly studied in the power system, if it is able to observe the same it can make the studies more clear. When an Inductive load is connected there will be a lag in the power factor. It will be better if this lag is observable and can design a capacitor Bank which could compensate for this lag.

The aim is to bring a long transmission line which carries huge current and enormously large voltage on to a table top set up on which the studies can be experimented. As it is a mini model there will be no risk of danger like an actual transmission line. By varying the applied voltage it is able to observe how it influence the parameters of the transmission line. The transmission line simulator makes use of the Pi-modelling method in which the resistance, inductance and capacitance of the transmission line is considered as lumped parameters for the accurate construction of the transmission line.

Ultimately the whole setup is automated with LABVIEW which will make the experiments more easy. Instead of dealing with the hardware directly the automation software can be made useful as in actual power system automated with PLC SCADA.



Block diagram of the proposed equipment

II. LITERATURE SURVEY

The workincludes developing a scaled down laboratory model of transmission line. This transmission line model will be put in practice to perform different power system experiments. This scaled down model is developed from the actual parameters of the KORADI – BHUSAWAL transmission line of 400kV and 351km long. These parameters are scaled down to 7.188 KVA and 415 VOLTS in a single circuit design. For developing this model for transmission line, parameters such as series resistance and inductance, shunt capacitance given in per km are used. It is decided to represent entire length using six Pi sections consisting of resistance, inductance and capacitance. Thus each Pi section is representing 30km line length. By using the following data the various quantities related to transmission line model is calculated.

III. TRANSMISSION LINE

Transmission lines are classified into three categories :

A. Short Transmission Lines
B. MediumTransmission Lines
C. Long Transmission Line

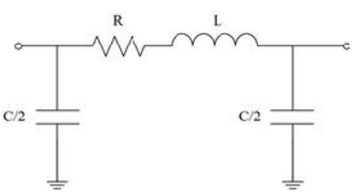
A transmission line having a length up to 60 km and 20kV is considered as a short transmission line. In short transmission, line capacitance is neglected because of small leakage current, and other parameters (resistance and inductance) are lumped in the transmission line.

A transmission line having a length up to 160 km& 20 kV-100kV is considerd as a medium transmission line. The parameters (Resistance, Capacitance& Inductance are distributed uniformly along the line.

A transmission line having a length above 160 km and 100kV is considerd as a long transmission line. In a long transmission line, parameters are uniformly distributed along the whole length of the line.

IV. PI MODELLING

In the nominal pi model of a medium transmission line, the series impedance of the line is concentrated at the center, and half of each capacitance is placed at the center of the line. The nominal Pi model of the line is shown in the diagram below.



V. TRANSMISSION LINE MODELLING

Actual Transmission Line ratings:

MVA rating: 375 MVA
Voltage rating of line: 400Kv
Resistance: 0.027 Ω / km
Inductive reactance: 0.334 Ω / km
Capacitive reactance: 0.296 MΩ / km
Frequency: 50 Hz

$I_{ph} = \frac{S}{V_L\sqrt{3}} = 541.26$ A

$Z_{ph} = \frac{V_L}{I_{ph}\sqrt{3}} = 546.67\Omega$ /km

$L = \frac{X_L}{2\pi f} = 1.0631$mH

$C = \frac{1}{2\pi f X_C} = 1.075 \times 10^{-8}$ F

$Y = C = 3.37$ μΩ / km

$\gamma = \sqrt{LC} = 3.38 \times 10^{-6}$

$R_{PU} = R\,\frac{MVA_b}{KV_b^2} = 6.32 \times 10^{-5}\Omega$

$X_{LPU} = X_L\,\frac{MVA_b}{KV_b^2} = 7.8281 \times 10^{-4}\ \Omega$

Scaled down model for 3.594 KVA and 415 V:

$I_{ph} = \frac{S}{\sqrt{3}V_l} = 5$ A

$Z_b = \frac{V_L}{\sqrt{3}I_{ph}} = 47.92\ \Omega$

$R_{SD} = R_{PU} \times Z_b = 3.03$ mΩ / km

$X_{LSD} = X_{LPU} \times Z_b = 0.0375$ Ω / km

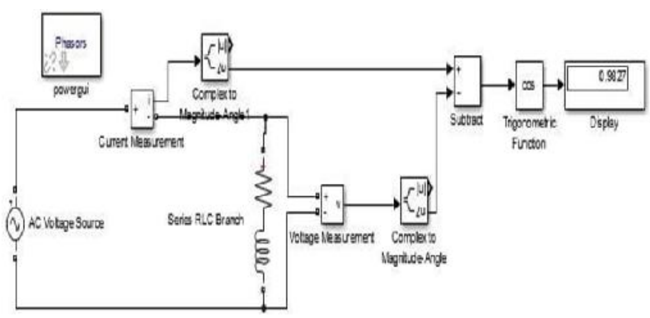
$L_{SD} = \frac{X_{LSD}}{2\pi f} = 1.194 \times 10^{-4}$ H

$C_{SD} = \frac{\gamma^2}{L_{SD}} = 9.568 \times 10^{-8}$ F

Each Pi section represents 30 km of the transmission line. The line parameters for each Pi section is:

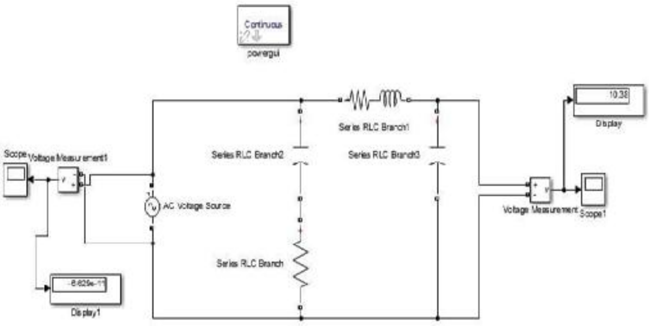
$R_L = R_{SD} \times 30 = 90.9$ mΩ
$L_L = L_{SD} \times 30 = 3.582$ mH
$C_L = C_{SD} \times 30 = 2.8704$ µF

$\frac{C_L}{2} = 1.4352$ µF



Simulation of power factor measurement

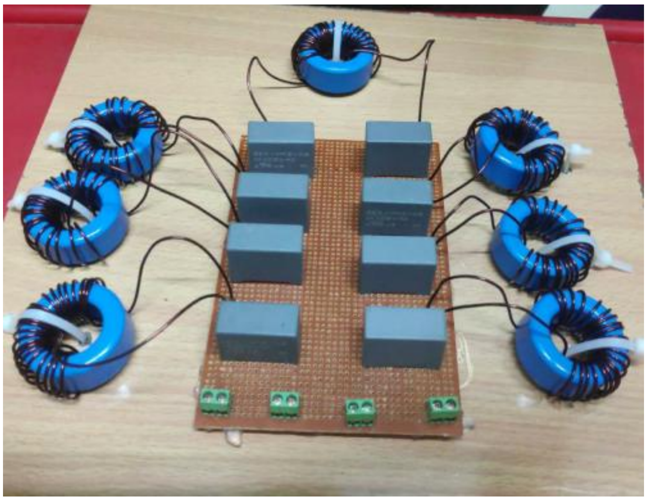
R = 5 Ω
L = 3 mH
Pf = 0.9827



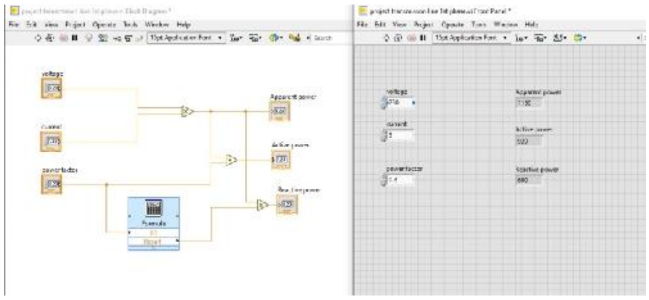
Simulation of Ferranti effect

Input = 325.269 V
Output = 343 V

The proposed system was automated with the LabVIEW software which could make the operation of the equipment more easier.



The hardware constructed with the proposed modelling is shown above.The hardware is automated with LABVIEW software. The automated equipment can work as a transmission line which can be used in the power system lab to conduct experiments, to visualizer variation of transmission parameters according to the voltage variation, how the power factor changes with loading etc.



Determination of apparent power,active power and reactive power with LabVIEW

V. IMPROVEMENTASPERREVIEWER COMMENTS

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VI. CONCLUSION

Using the actual transmission line parameters a laboratory based de-scaled model can be fabricated. This model helps the students/research scholars to design various laboratory experiments for enriching the theoretical concepts. In this project work the Ferranti effect demonstration, voltage measurement, voltage profile observation of transmission line are to be conducted . The de-scaled model gives approximately same results as that of the original transmission line.

By using the LABVIEW software the automation can be implemented in the laboratory based panel which helps the students to understand the remote control & operation of the power system

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