PROTOTYPE TRANSMISSION LINE MODEL

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PROTOTYPE TRANSMISSION LINE MODEL

Major Project

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(Electrical Power Systems)

By

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Undertaking for Originality of the Work

I, **Nayan D. Joshi**, Roll No. **12MEEE31**, give undertaking that the Major Project entitled **" Prototype Tranmission Line Model"** submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Electrical Power System, Electrical Engineering**, under Institute of Technology of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

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Signature of Student

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CERTIFICATE

This is to certify that the Major Project Report entitled **Prototype Transmission Line Model** submitted by **Mr.Nayan D.Joshi(Roll No: 12MEEE31)** towards the partial fulfillment of the requirements for the award of degree in Master of Technology (Electrical Engineering) in the field of Electrical Power System of Nirma University is the record of work carried out by him under our supervision and guidance. The work submitted has in our opinion reached a level required for being accepted for examination. The results embodied in this major project work to the best of our knowledge have not been submitted to any other University or Institution for award of any degree or diploma.

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- Nayan D. Joshi
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ABSTRACT

Prototype Transmission Line Model project presents demo model of Transmission Line. It is scaled model of Transmission Line. The line models are designed for short, medium and long line. It is constructed for the use of laboratory experiment. This model is useful for the power system related experiment and also determines the line efficiency and line regulation. The model can simulate for different distance. (Short, medium and long). This model can be used to find out generalized constant parameter during open and short circuit test. The result gathered from testing the system and compared to calculating value. The demo prototype model will be helpful for study and experimental purpose.This project posed many challenges(like shunt compensation and ferrenti effect) this challenge are discussed in the dissertation. Some of challenge has easily implementable solutions while other still further research.

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Chapter 1

Introduction

1.1 Overview Of Tranmsission Line

A transmission line can be represented by the equivalent circuit for the solution of its performance under different operating condition, when the constant of the line are calculated or known the unit length.The main constant required are resistance, inductance and the corresponding inductive reactance, and capacitance and its capacitve reactance. Transmission line has four parameter resistance, inductance, capacitance and conductance. The inductance and capcitance are due to the effect of magnetic and electric field aroud the conductor. The resistance are best to find from the manufacture data.There are three ways in common practice to model power-lines.

1.2 Type Of Lines

1.2.1 Short Transmission Line

A short transmission line is modelled as having only a resistance and inductance in series with each other.This type line about 50mi to 80km. This model is commonly applied to distribution networks since the distance between connecting lines are relatively short. The longer the transmission line, the larger the capacitive eect. The capacitive eect represents the charge that is stored between the lines and the neutral.the figure show the short transmission line. [1]

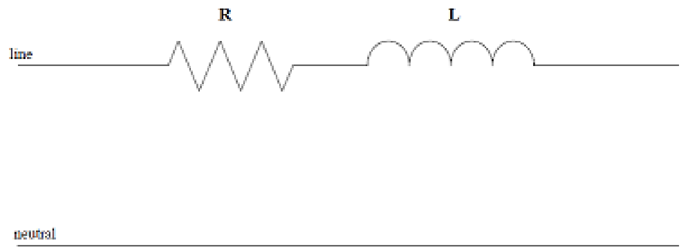


Figure 1.1: Short Tranmission Line

1.2.2 Medium Transmission Line

A medium transmission line is modelled as having resistance and inductance in series with each other. This type of length about 80km to 150km. There is a lumped capacitance present in the model at the start and the end of the line. The total capacitive value between line and neutral is divided by two and lumped for the capacitances show.[1]

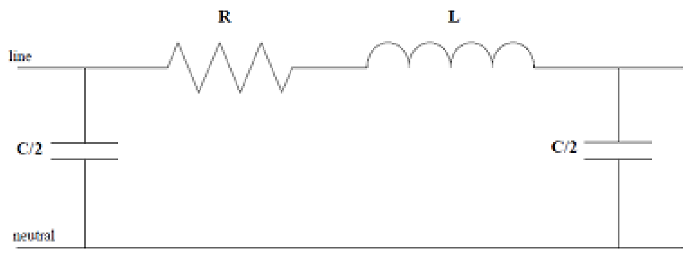


Figure 1.2: Medium Transmission Line

1.2.3 Long Transmission Line

The transmission line's length increases above 160km the medium line model does not provide an adequately accurate system. The reason for this is that the capacitance and inductance of a line increases over every section of the line as a whole.The model of the long transmission line is similar to that of the medium line model, butthe impedance are define differently.[1]

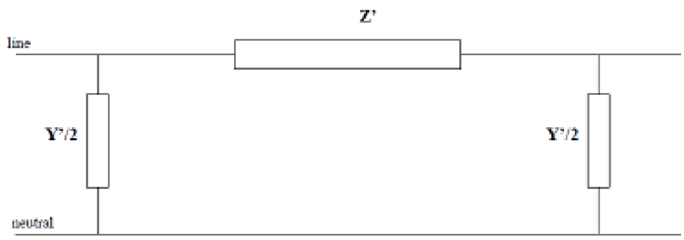


Figure 1.3: Long Transmission Line

1.3 Objective

The main aim of this project is to designed transmission line on panel. It will be useful for laboratory experiment and power related study. It is scaled-model of existing transmission line. This model can be use for understanding the effect on transmission line and determine the efficiency and regulation.

1.3.1 Scope Of Work

The work fulfills objective in following steps

(1) Indentify the transmission line parameter: calculate the transmission line parameter R,L and C using various method.

(2) Simulate the model transmission line on suitable software and see the line parameter exactly same for both simulation and practical implementation.

(3) Calculated generalized constant parameter(A,B,C and D) on panel

(4) Practical implementation done on panel.

(5) Use PIC Controller circuit to indicate and reflect on real line parameter.

(6) Calculated the Voltage Regulation,Line Efficiency and Line Loss while line

run on panel.

(7) Ferranti Effect , Series and Shunt Compensation Effect will be show on panel.

(8) We had seen equal voltage Distribution over a string of suspension insulator.

1.3.2 Outline Of Thesis

(1) Chapter- 1 includes introduction of transmission line. Type of line and its description.

(2) Chapter- 2 includes Literature review of this project. Project related Paper and its description include on these chapter.

(3) Chapter-3 includes transmission line parameter introduction and calculation of parameter.Also include the simulation and Scaled-model of transmission line.

(4) Chapter-4 includes hardware of these project practical implementation and comparison between the practical theoretical values. This chapter also understanding how to scale-up parameter using the controller.

(5) Chapter -5 include the conclusion of these overall project and future work of these dissertation.

Chapter 2

Literature Review

The transmission line transmits electrical power from one end of the line, sending end, to another, receiving end. A common method of analyzing this behavior is through parameterization and modeling of the transmission lines with passive components. The passive components used in this modeling are resistors, capacitors and inductors. The quantity of these parameters depends mainly on the conductors used in the lines and the physical or geometrical configuration of the lines. The conductors themselves will have certain characteristics such as resistance and reactance both in series from sending to receiving ends of the line and shunt from the line to electrical ground associated with them. In addition, there is inherently mutual inductance, or coupling, of the lines with respect to each other as they are bundled together or placed in close proximity to one another in a multi-phase system. This can all be taken into account through proper analysis and parameterization of the transmission lines. The transmission line model traditionally utilized in power-flow computation is a lumped parameter pi-model equivalent circuit. In digital computation the shunt elements and sometimes the series resistances are often times neglected in order to simplify the power flow equations and subsequently speed up the calculation times.

1) From the book of M.V.Deshpandey, understanding the fundamental basic concept like A,B,C,D the constants of transmission line, Works out from the book performance of transmission line, and then proceed to the design of transmission line of electrical. This book very helpful for the power system particularly design and project work.[1]

2) IEEE paper "Guide line for Transmission line Modeling" M. C. Tavares ' , J. Pissolato, C. M. Portela. This paper help to understanding the accuracy of a frequency dependent transmission line model. This papers also understanding how the transmission line parameter depend the frequency.The proposed methodology has been applied to our model and to some established models, allowing us to identify some inaccuracies very promptly.

3) IEEE Paper "A Laboratory Setup for a Substation Scaled Model" S. Mohagheghi, R.H. Alaileh. This paper presents a laboratory setup for a substation scaled model.However, the main challenge lies in developing scaled models of components that are mathematically complicated, such as the synchronous generators, or physically sizable, such as the transmission lines. This paper present the laboratory setup for power system studies that can accurately model a power system. One of the most unique characteristics of this laboratory setup is the way the transmission lines are modeled. The transmission lines are built using basic elements based on the design of a 2-mile 3-phase transmission line with neutral conductor.[2]

4) Disseratation of " Determining Transmission Line Parameters From Timestamped Data" this these completely helpful for the determine the parameter of the line, and understanding the simulink on MATLAB software. it is also helpful for the determine the parameters of a transmission line by using current and voltage measurements. The term line parameters refer to the inherent series resistance and inductance that is found on transmission lines.

5) A Thesis of ”Transmission Line Modeling for the Purpose of Analog Power Flow Computation of Large Scale Power Systems” This thesis proposes methods for modeling electric power transmission lines. this thesis also helpful for the lumped parameter pi-model equivalent circuit. In digital computation the shunt elements and sometimes the series resistances are often times neglected in order to simplify the power flow equations and subsequently speed up the calculation times.[2]

6) Data sheet for pic controller 18F4520 ”Microchip pic 18F4520 40 pin enhanched flash microcontroller with 10 bit Analog to Digital converter.” on these data sheet understanding the pin configuration description and their features.

7) LCD circuit data sheet on google website ”www.crystalfontz.com/products/2004K”on these data sheet understan the LCD circuit description. 16*4 LCD pin configuration and find how to interface LCD to controller pin.

Chapter 3

Line Parameter Calculation

Transmission line has four parameters namely resistance, inductance, capacitance and conductance. The inductance and capacitance are due to the effect of magnetic and electric fields around the conductor. The resistance of the conductor is best determined from the manufactures data, the inductances and capacitances can be evaluated using the formula.Generally conductance on transmission line neglecting.[1]

3.1 Resistance Of Transmission Line

The Resistance of a conductor is given by Ohms law as

$$\mathbf{R} = \frac{\rho \mathbf{l}}{\mathbf{A}} \tag{3.1}$$

where R= resistance

l= length

A= area of crossection of conductor

ρ= resistivity of the material

Conductivity of copper conductor at 100 percent are,

$$\rho = 1.724 \times 10^{-}8$$

Conductivity of hard drwan copper conductor at 97.3 percent are,

$$\rho = 1.78 \times 10^{-}8$$

Conductivity of aluminium conductor at 61 percent are,

$$\rho = 2.86 \times 10^{-}8$$

3.2 Inductance Of Transmission Line

The inductance of transmission line depend on the arrangment of conductor and their size. Theh conductor can be solid or standard, the single phase or three phase lines can be consist of conductor of uniform siz; the arrangment of the conductor can be symmetrical and equdistant or the spacing between the conductor unequl; each phase can have one or more conductor with suitable spacing. in each case inductance would be differ and a general apparoch is necessary to calculate it for the different arrangment. we can start withe the definiation of inductance in relation to flux linkage, develop the idea of self geometric mean distance(self-GMD) and geometric mean distance(GMD) between the conductors and obtain the general expression for the inductance of the line.where the inductance value is the line-to-neutral inductance given in H/m,

$$L = 2 \times 10^{-}7 \frac{GMD}{GMRL} \tag{3.2}$$

GMD or geometric mean distance is a measure of the mean distance between the three phases. This value is inuenced by the actual spacing and also whether there are two or more circuits in parallel. The geometric mean radius (GMR) is a measure of the mean radius of conductor per phase.

3.3 Capacitance Of Transmission Line

The capacitnce effect of short line has neligiable effect on the performance of short line, when the lines are long, capacitance has a predominate effect on the performance of the lines in terms of the efficiency, regulation and power factor under normal condition. it also effect the transient performance of the line. The capacitance of the line depend on the size of conductor and distance or spacing between the conductor. the calculation of the capacitance

$$C = \frac{0.0556}{ln \frac{GMD}{GMR}} (\mu F/Km) \tag{3.3}$$

3.4 Transmission line parameter determination

From the project three methods where considered for determining the parameters of the line from measured data.

3.4.1 Method-1

Method of approximating the line impedance value (Z_L).The line impedance value represents the series resistance and inductive reactance of the transmission line.

$$Z_L = \frac{(V_S - V_L)_{RMS}}{I_{RMS}} \tag{3.4}$$

The sending end voltage (V_S) is measured at the beginning of the power line in question, while the receiving end voltage(V_R) is measured at the termination of the line.V_S an V_R are subtracted discreetly from each other. The rms value of the resultant waveform or the equivalent voltage drop acroshe transmission line is recorded. The rms current can be either sending or receiving end values. For a short transmission line the sending and receiving end current is approximately the same. When medium and long transmission lines are being considered, the inuence of the line capacitance begins to have an influence on the model and thus the sending and receiving end current will dier in both magnitude and phase. Since the line models shown in the introduction is for phase to neutral values, the model only accounts for balanced system operation. In view of this, the practical implementation of the project needs to measure only one current and one voltage (phase to neutral) value. To test the method thoroughly all the phases will be considered.

T he line reactance can have a leading or lagging component that it adds to the load current. This will depend on the loading on the line. This means that the absolute value of current measured on the one side of the line can be either smaller or larger than that of the other side. It was found that the larger of the two currents gives the best estimate of the total current through the series resistance and inductance. The drawback of this method is that only the impedance magnitude of the line is determined and excludes the phase angle. If the phase angle is not known the exactportion of the line impedance that represents resistance and reactance can not be determined. The X/R ratio of the transmission line can be used to approximate the resistance and the reactance from the impedance value. The approximate ratio between the inductive reactance and the resistance of a transmission line. This is provided by the manufacturer. It should be kept in mind that this is only an approximation, because the inductance and resistance of a line vary depending on a number of factor. [7]

3.4.2 Method-2

A different method that was considered involved determining the total impedance as seen from the sending end (Z_T , i.e. the line and load impedance). At the same time the impedance at the receiving side must be calculated (Z_{load}). This constitutes the load impedance. Z_T and Z_{load}

$$Z = \frac{V_{RMS}}{I_{RMS}} \tag{3.5}$$

In Equation the rms voltage and current is the sending end values when ZT is calculated and the receiving end values when Zload is calculated. By working out the active (P) and reactive power (Q) on both the sending and receiving sides the value of the angle between the voltage and current is determined.

$$\theta = tan^-1(\frac{Q}{P}) \tag{3.6}$$

This angle is used to separate the impedance values into the resistive and reactive components. This is easily subtracted from each other to determine the line parameter values.[7]

3.4.3 Method-3

This method uses the two-port ABCD parameter that is defind. The ABCD parameters give the relationship between the voltage and currents at two points. For a transmission line this means that the ABCD parameter represent the inuence that the capacitance, inductance and resistance of the line has on the voltage and current values measured at the sending and receiving sides. The relationship is given by the following equations.

The following equation are sending voltage and current:

$$V_S = AV_r + BI_r \tag{3.7}$$

$$I_S = CV_r + DI_r \tag{3.8}$$

$$V_R = DV_r - BI_S \tag{3.9}$$

$$I_R = AV_S + CI_S \tag{3.10}$$

where,

A= cosh (γ l)

B= $Z_C sinh(\gamma$ l)

C= $\frac{1}{Z_C} sinh(\gamma$ l)

$D = cosh(\gamma$ l)

This method is very useful since the impedance is given as a value with an angle. This means that the resistance and inductance is given as separate values. This is also the only method that gives the shunt admittance (y), from where the capacitance can be calculated.

3.5 LINE PARAMETER CALCULATION

It is essential to find out the efficiency and regulation of a transmission line right at the design stage. the design of transmission line must have the knowldge of transmission line is necesssary.

Theae all parameter are calaculating some approximation based, so it was not a actual, but it will naturally effect on actulally line. follwing section to justify the approximate parameter calculation.[7]

3.5.1 Resistanace Of Transmission Line

First we calculte resistance of all three line. here all parameter calculate at real line voltage , current and power, the same parameter implementation on 230V supply.

Also we calculate resistance by method-1, but it also some approximation base.
Example: For a short line 33kV delivers load 1MW and at distance 10Km. Power factor 0.8 lag.
so, current

$$I = \frac{P}{V cos\Phi} \tag{3.11}$$

$$\text{I}= \frac{1000*10^3}{33*10^3*0.8} = 37.87\text{AMP.}$$

Now, resistance R=$\frac{\rho l}{a}$
form Standard Wire Gauge table the Area will be taken as 15.7 mm^2

$$\text{so, R}= \frac{1.724*10^-8*10*10^3}{15.7*10^-4};$$
$$0.109\frac{\Omega}{m}$$
$$\text{R} = 10\Omega$$

Example: For a MEDIUM line 110kV delivers load 10MW and at distance 100Km. Power factor 0.8 lag. From equation 3.11

$$\text{I}= \frac{10*10^6}{110*10^3*0.8}$$
$$\therefore 113.6\text{AMP.}$$

Now, resistance R=$\frac{\rho l}{a}$
form Standard Wire Gauge table the Area will be taken as 45.6 mm^2

$$\text{R}= \frac{1.724*10^-8*100*10^3}{45.6*10^-4};$$
$$0.248\frac{\Omega}{m}$$
$$\therefore \text{R} = 24\ \Omega$$

Example: For a LONG line 220kV delivers load 70MW and at distance 150Km. Power factor 0.8 lag.
From equation 3.11

$$\text{I}= \frac{70*10^6}{220*10^3*0.8}$$
$$\therefore 230\text{AMP.}$$

Now, resistance R=$\frac{\rho l}{a}$
form Standard Wire Gauge table the Area will be taken as 94.6 mm^2

R= $\frac{1.724*10^-8*150*10^3}{94.6*10^-4}$;

$0.273\frac{\Omega}{m}$

$\therefore$ R = 41Ω

Resistance for short, medium and long are 10Ω , 20Ω and 40Ω respectively.

3.5.2 Inductance Of Transmission Line

For calculating the inductance of line we are used any of above method, for simplyfing Method-2 give the considerable result. we can use method-3 also, but it quite lengthy. so, here method-2 used for calculating the Inductance of line.

Here some approximation taken to solve the inductance calculation. for example here capacitor take for medium and long line are 12μ F and 25 μ F respectively.now we see the calculation of inductance,

Line Impedance

$$Z_L = \frac{V_{RMS}}{I_{RMS}} \tag{3.12}$$

Load Impedance

$$Z_{LOAD} = \frac{V_{RMS}}{I_{RMS}} \tag{3.13}$$

By working out of active and reactive power determine the angle between voltage and current.

$\theta = tan^-1(\frac{Q}{P})$

So, total impedance of line are:

$$Z_L = (Z_T cos\theta_T - Z_{load} cos\theta_{load}) + j(Z_T sin\theta_T - Z_{load} sin\theta_{load}) \tag{3.14}$$

▶ Short Line

Short line has 210V(33kV) deliver the load 120W(1MW) and reactive load 3.14Ω(50Ω) form above formula $Z_L = 350$

$Z_{LOAD} = 410$

θ= 1.49

so, total inductive reactance are:

$$X = (Z_T sin\theta_T - Z_{load} sin\theta_{load}) \tag{3.15}$$

$\therefore$ X=9.10Ω

▶ Medium Line

Medium line has 220V(110kV) deliver the load 200W(10MW) and reactive load 3.14Ω (1000Ω)

From equation 3.12 $Z_L = 252.87$

Now, form equation 3.13

$Z_{LOAD} = 167$

θ= 1.08

so, total inductive reactance are:

X=(Z_T sin$\theta_T - Z_{load} sin\theta_{load})(Capacitance taken as 265.39\Omega)$

$\therefore$ X=15.27Ω

▶ Long Line

Long line has 230V(220kV) deliver the load 300W(70MW) and reactive load 10Ω (10000Ω),

form above formula $Z_L = 113.8$

Z_{LOAD}=180.6

θ= 2.12

so, total inductive reactance are:

X=(Z_T sin$\theta_T - Z_{load} sin\theta_{load})(Capacitance taken as 138.46\Omega)$

$\therefore$ X=37.97Ω

So, the Inductor on transmission line has 30mH for a Short Line, 60mH for a Medium Line and 120mH for a Long Line.

3.5.3 Capacitance of Transmission Line

form the simulation and laborartry experiment the capacitnor valuetaken as approximation, we know that for short line capacitance effect will be neligiable. so, Medium and Long line due to long distance capacitor will be in picture. Also the compensation required for medium and long line.

here we take capcitor valur for medium line are $15\mu F$ and long line are $25\mu F$

Following table describe the calculating the R,L and C parameter

Table I: Line Parameter

Line	R(Ω)	L (mH)	C (μF)
Short	10	30	0
Medium	20	60	15
Long	40	120	25

3.6 Scaled-Down Line

3.6.1 Short Transmission Line

Short transmission line deliver 1000kW at 33kV at 0.8p.f. total resistance and reactance 10ohm and 9.42ohm respectively.

line length 10 Km

so for short 33 kV line calculating

line current = 37.87A

sending end voltage = 33.56kV

sending end power factor angle = 36.97

Line loss = 14.34kW

Efficiency = 98.58

Regulation = 1.5

Same parameter for 210V, 50Hz line deliver 120W at 0.8p.f.

Line current = 0.65A

Sending end voltage = 2V

Line Loss = 4.22

Efficiency = 97.5

Regulation = 2.6

3.6.2 Medium Transmission Line

Medium Transmission Line deliver 10MW at 110kV at 0.8p.f. total resistance and reactance 20ohm and 18.84 ohm.respectively. Capacitance 10μ and line length 100kM

Receiving end line current = 113.6A

Sending end voltage = 111.54kV

Sending end line current= 45.45A

Line loss = 258.09kW

Efficiency = 97.56

Regulation = 1.4

Same parameter for 220V, 50Hz line deliver 200W at 0.8 p.f.

Receiving end line current = 1.27

Sending end line current = 0.87

Line loss = 15.25W

Efficiency = 93

Regulation = 3.6

3.6.3 Long Transmission Line

Long Transmission line deliver 70MW at 220kV total resistance and reactance 40ohm and 37.68ohm. respectively.

capacitance 27.5μ and line length 200km

Receiving end line current = 230A

Sending end voltage= 221kv(approx.)

Sending end line current = 115A

Line loss = 2.11MW

Efficiency = 97.06

regulation = 1.8

Same parameter for 230V, 50Hz line deliver 300W at 0.8 p.f.

Receiving end line current = 1.20A

Sending end voltage= 242V(approx.)

Receiving end line current = 1.27A

Sending end line current=0.87A

Line loss = 30.27

Efficiency = 90.8

regulation = 5.2

3.6.4 Simulation

1) Short Line
2) Medium Line
3) Long Line

3.6.5 Short Line Simulation

Figure show the simulate the short line as the calculating the parameter of transmission line. Various methods are used to calculating parameter accuratly by means of Voltage and Current measurment taken by either side of line. These parameter are simulated on the setup describe below.

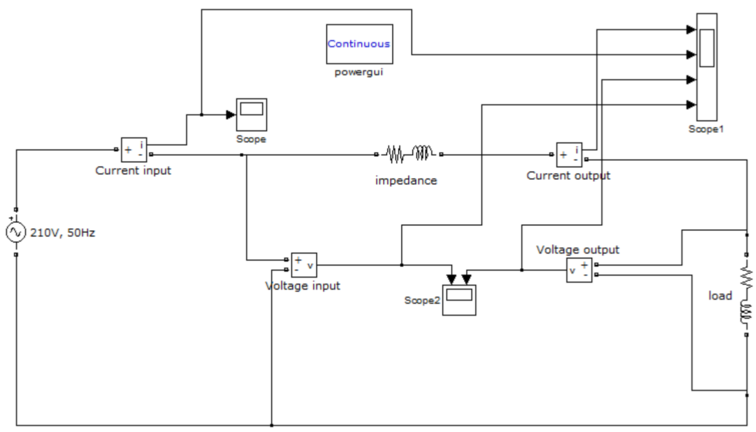


Figure 3.1: Short Transmission Line Model

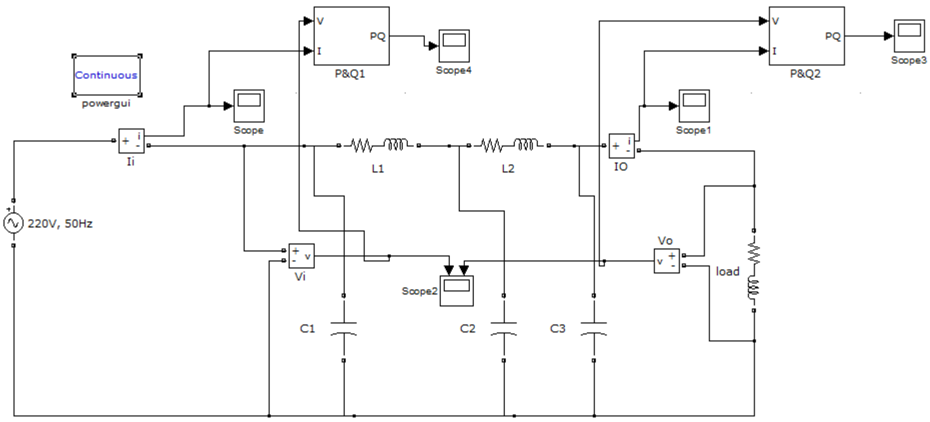


Figure 3.2: Medium Transmission Line Model

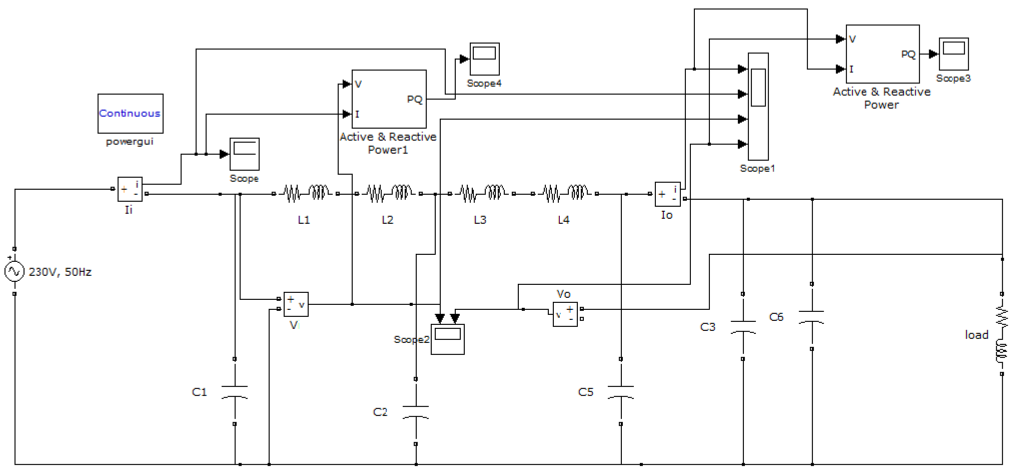


Figure 3.3: Long Transmission Line Model

Following table represent the generalized constant parameter(A,B,C and D). these parameter are genrally complex quantities.

B in Ω

C inω

A and D dimesion less,

So, A=D

$\because$ AD-BC =1

Following table are saw that the constant parameter, there taken at performed the open and short circuit test medium and long line experiment.

Table II: Constant Parameter

GENERALIZED CIRCUIT CONSTANT	MEDIUM	LONG
A=$\frac{V_S}{V_r}$,when I_r=0	0.944	0.820
B=$\frac{V_S}{I_r}$,when V_r=0	27.48	51.22
C=$\frac{I_S}{V_r}$,when I_r=0	0.0016	0.008
D=$\frac{I_S}{I_r}$,when V_r=0	0.98	0.89

► Following figure show the Prototype Transmission Line Model.

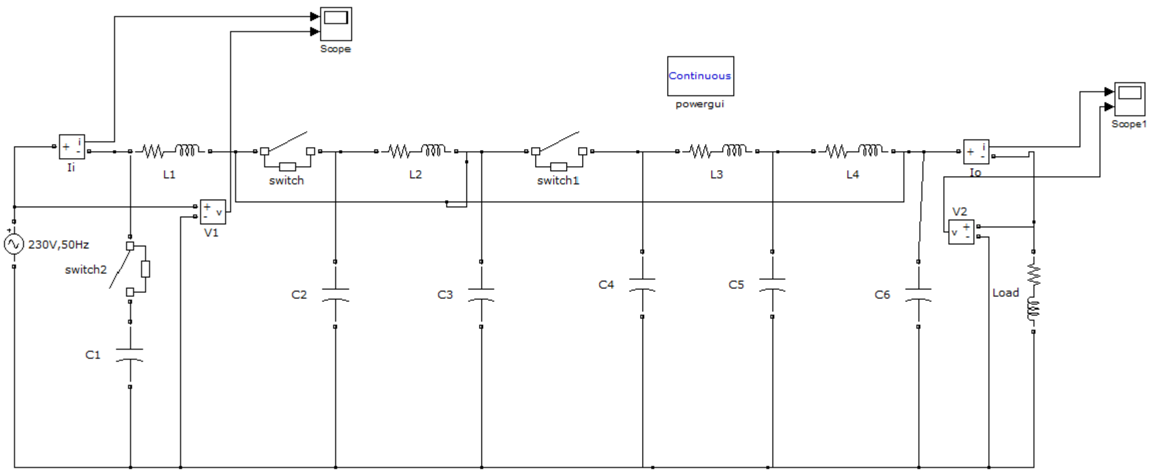


Figure 3.4: Transmission Line Model

3.7 REAL TRANSMISSION LINE CALCULATION

3.7.1 Real Short Line Simulation

A 1-Phase 33kV, 50Hz, transmission line 10km, load 1000kW at 0.8 p.f.lag at the receving end. the resistance of the line 10Ω and reactance is 9.42Ω.

3.7.2 Real Medium Line Simulation

A 1-Phase 110kV, 50Hz, transmission line 100Km, load 10MW at 0.8 p.f.lag at the receving end. the resistance of the line 20 Ω and reactance is 18.84Ω. Suscpetance per phase kilometer=0.6Ω

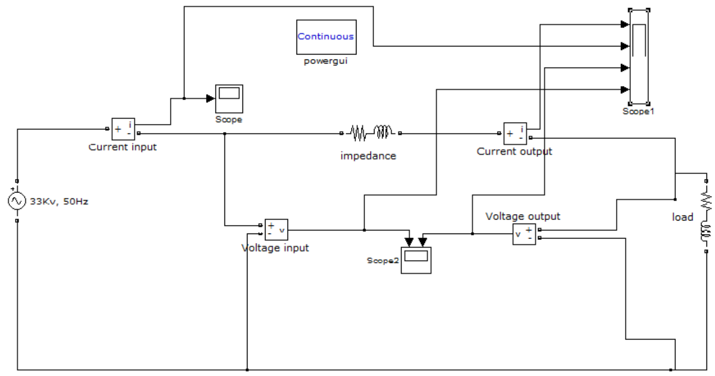


Figure 3.5: Short Line Model

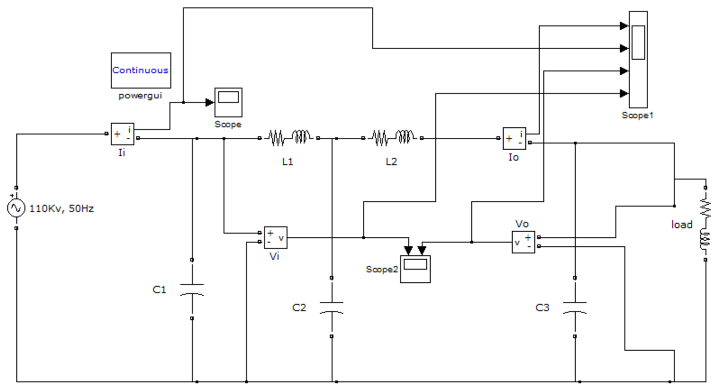


Figure 3.6: Medium Line Model

3.7.3 Real Long Line Simulation

A 3-Phase 220kV, 50Hz, transmission line 200km, load 70MW at 0.8 p.f.lag at the receving end. the resistance of the line 40Ω and reactance is 37.68 Ω. Suscpetance per phase kilometer=0.6Ω

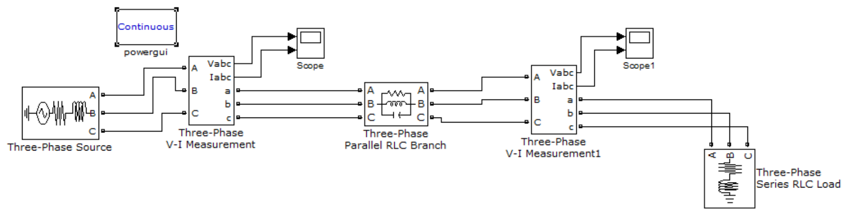


Figure 3.7: Long Line Model

Table III: Real Line Simulink Data

Line	V_S(kV)	V_R(kV)	I_S(A)	I_S(A)
Short	33.5	33	36	36
Medium	111.5	110	56	45
Long	221	220	115	112

3.8 Discussion Of Result

The voltage and power across result an actual power line is very high when compared to the setup used in the laborartry. For transmission line a low inductance and capacitace value would have a measurble infulance on the voltage and current measured in the laborartry. The problem is that with capacitance smaller resonat will occur in the current waveform, this prominately effect will show the medium and long line. The following tables show the comparision between calculating and practical value

Table IV: Error Introduced on Short Line

Line	V_s	V_r	I_s	I_r
Calculating value	210	204	0.56	0.56
Practical Value	210	205	0.5	0.5

Table V: Error Introduced on Medium Line

Line	V_s	V_r	I_s	I_r
Calculating value	220	210	0.80	1.22
Practical Value	220	208	0.87	1.28

Table VI: Error Introduced on Long Line

Line	V_s	V_r	I_s	I_r
Calculating value	230	215	1.20	2.02
Practical Value	230	212	1.87	2.15

Chapter 4

Practical Implement

The Trasnmission line demo model completely laborartory experiment. Main aim to design the short, medium and long transmission line on the panel. all three line operate under the different voltage. the short line approximately the 40km, medium line approximately the 150km and long line approximately the 300km long. in this project main aim to essential find out the effeicency and regulation of transmission line right at design stage. if these parameter do not fall with in allowable limits. the design must be changed to bring them within limits. the knowladge of performance of transmission line is necessary.

Transmission Line Models are designed to study the performance of lines. The line parameters are calculated by considering the 100-Km length, single circuit, 3-Ph., transposed conductors, and 0.4 kV line voltages. This demo panel prepare for studying or understanding the characteristics of the line. For the same three lines (short, medium and long) are fetched on the panel.One of the most unique characteristics of this laboratory setup is the way the transmission lines are modeled. These high-fidelity modules replace the traditional series R-L models of the transmission lines that are normally used for experimental studies in power system laboratories.[8]

The series impedance of the line is represented by a resistance in series with an inductance. This is quantified per unit length as follows:

$$Z = R + j\omega l \tag{4.1}$$

The series resistance r and the series inductance l are quantified respectively as ohms per unit length and henrys per unit length. The term represents the operational angular frequency of the AC power system in radians per second. The resulting impedance of the inductor is therefore dependant on the operational frequency of the system. In this thesis lower case letters will be used for distributed parameters and upper case letters for lumped parameters. The shunt elements of the line model consist of a capacitance and resistance in parallel with each other. The admittance of this shunt element is quantified by:

$$Y = g + j\omega l \tag{4.2}$$

4.1 Design loading Rheostat(variable resistance)

(1) Material used for loading Rheostat

The following material are commonly used for making the coils of lading rhesotats.

Constantan(Eureka)

Composition : It is an alloy of 60 copper and 40 nickel.

properties

its electrical resistivity is 0.46 to 0.53 $\times 10^{-6}$

its maximum permissible temperature is 500^oC.

its melting point is 1000^oC

its temperature coefficient of resistance is 0.00002.

its ductile and can be drawn into thin wires.

[2] Nichrome

Composition : it is an alloy of Nickle(Ni) 75 to 78 Chromium(Cr) 20 to 23 and little of Iron(Fe).

its properties 1.27*10^-6 Ω -m at 20^oC.

it has high mechanical strength.

it is and can be drawn into thin wires.

its temperature coefficient of resistance is nearly equal to zero.

it is silver white in colour.

(2) Determination of the size of resistance element for a particular current capacity, the size of element or wire can be determined

I= Current carrying capacity, A

θ= maximum permissible temperature rise,

ρ= resistivity of the element

l= length of element,m

d= Diameter of element,mm

λ = Specific heat dissipation,W/m^2.^{o}C

Now, loss to be dissipated = I^2R

Resistance of element,

$$R = \frac{\rho l}{A} \tag{4.3}$$

$\rho l\ \pi/4d^2$

if we use constantan wire :

ρ= 0.5 Ω/m/mm^2

Taking θ=100^{o}C.$\lambda = 20W/\mathrm{m}^2$

k=$\sqrt{(\frac{\pi^2}{4} * \frac{20*100}{0.5} * 10^{-3}}$

I=3.2 $d^{1.5}$

Taking θ=150^{o}C.$\lambda = 20W/\mathrm{m}^2$

k=$\sqrt{(\frac{\pi^2}{4} * \frac{20*150}{0.5} * 10^{-3}}$

I=3.9 $d^{1.5}$

if we use nichrome wire :

ρ= 1.2 Ω/m/mm^2

Taking θ=100^{o}C.$\lambda = 20W/\mathrm{m}^2$

I=2 $d^{1.5}$

Taking θ=150^{o}C.$\lambda = 20W/\mathrm{m}^2$

I=2.5 $d^{1.5}$

with the help of size of wire can be deermined.from the table of SWG nearest standard size can be selected.

The wire is wound over a manderal. generally the spacing between the coils of loading rheostat is taken 3 times the diameter of mandrel.

4.1.1 Design a loading rheostat to carry 5Amp. and dissipate 100W continuously

$$I = 3.2d^{1.5} \tag{4.4}$$

where d = 1.346 mm

from Table Standard Wire Gauge has nearest diameter is d= 1.32 mm, SWG No 19, a= 0.811mm^2

now Resistance ,

R= $\frac{p}{I^2}$

$\frac{100}{25} = 4\ \Omega$

Also $R = \frac{\rho l}{a}$

Length of wire required, l= $\frac{Ra}{\rho}$

$\frac{40.811}{0.5}$

l= 6.4m

From Table for SWG No 19

Mandrel diameter , D= 12.5mm

maximum length of coil = 300mm

$\frac{Turns}{meter} = 360$

length of turn = 48mm (π+0.5)12.5, former thickness= 0.5mm

Length of wire in each coil = $300 * 10^-3 * 360 * 48 * 10^-3$

$$Noofcoilrequired = \frac{lengthofwirerequired}{lengthofwireineachcoil} \tag{4.5}$$

$\frac{6.4}{5.184}$= 1.23

spacing between coils = 3*D

$\therefore$ 3 * 12.5 $\therefore$ 37.5

height of box= 300mm

total surface of the box exculding bottom

[2(150*300)+2(220*300)+(150*220)]*10^-6

= 0.255m^2

4.2 Design of Chock Coil to carry the 5Amp. current

Design a chock coil to be connected across 240V, 50Hz supply and to carry a current of 5Amp. The length of gap 2cms

V= 240 Volts

f= 50 Hz

I= 05 Amp.

l_g= 2cm

$$B_g^2 A_i = \frac{\mu_0 V I}{2\pi f l_g} = K \tag{4.6}$$

k= 2.4*10$^-$4

$Nowtakingvaluesof$B$_g$ from 0.2T to 0.8T and calculate the corresponding values of

$_I$

Plot a graph B_g vs $_I$

From the graph critical value of B_g=0.30 T and corresponding value of

$A_i = 2 * 10^-5m^2$

Gross area of core,

$$A_{gi} = \frac{A_i}{stackfactor} \tag{4.7}$$

$\therefore$ A_{gi}=0.222 $* 10^-4$

here square cross section

so width of limb, A=$\sqrt{A_{gi}}$ = 5mm

maximum MMF required for the airgap

$$AT_g = \frac{B_g * l_g}{\mu_0}$$

$$AT_g = 5570$$

assume AT for iron parts AT_i=10 $\perp$ of AT_g

Total AT required= 1.1 AT_g= 6127

Number of turns, N=$\frac{AT}{I}$= 1225

Assuming synthetic enmalled round copper conductor for the winding and current density δ=2.4A/mm^2

area of conductor, a=$\frac{I}{\delta}$ = 2.08 mm^2

diameter of bare conductor = 1.6285 mm

from the table swg nearest diameter of the conductor d= 1.70mm

Diameter of insulated conductor, d_1=1.810 mm

Area of conductor with insulation

a$'=\frac{\pi}{4}d_1^2$=2.573

assuming the height of the winding 120mm

Turns per layer height wise,$N_h = \frac{h'_f}{d_1}$ =66

Turns per layer depth wise, $N_d = \frac{N/2}{N_h}$=9

Depth of coil d'_f= N_d*d_1=17mm

actual depth of coild_f=d'_f+5mm= 22mm

actual height of coilh'_f=h'_f+10mm= 130mm

length of mean turnL_{mt}=2(A+d_f) = 2(15+220.07)=0.074m

Total length of wire

l = N*L_{mt}

$\therefore$ 1225*0.07=85m

Resistance of coil $R = \frac{\rho l}{A}$

$\frac{1.724*10^-8*85}{2.573*10^-6}$

0.5 Ω

4.3 PIC Controller

We are making the prototype transmission line model for study and laboratory experiment. It will be necessary to show the real line parameter and effect on actually line, but we are working on supply voltage only 230V, 50Hz. So, what we done we scale up voltage, current and power at actually voltage for short, medium and long line voltage, current and power. So, it will be necessary to use some microcontroller circuit to scale up our normal voltage and current. Here we used Pic Controller 18F4520 to scale up parameter.[9]

4.3.1 PIC 18F4520

(1) 2 internal ADC are necessary.

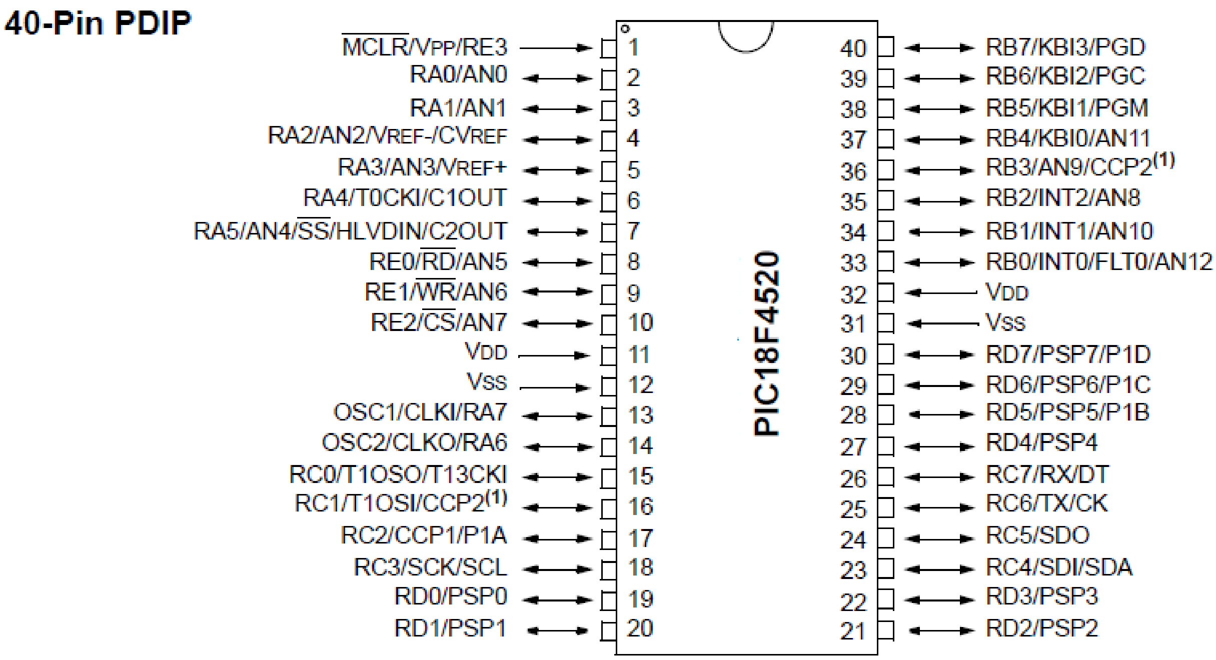
AT89C52/51- not available has no internal oscillator. ATMEGA- available. PIC18F4520- available.

2) Availability.

The programming software of PIC18F4520 is easily available on official website.

Programmer/debugger PICKIT3 is comparatively cheap.

The compiler of ATMEGA is WinAVR which is available in pirated form. [10]



[h]

Figure 4.1: Pin Diagram

4.3.2 Power Supply Circuit

Figure show the pin diagram of Pic 18F4520. It has 40 pin IC. It will work as 5V DC supply, So first we convert the 230V to 5V DC supply, and current high source sink to 25mA. Now it will be necessary to make up 5V Dc supply to give the controller start up. Following diagram for 230V to 5V Dc supply, here we used LM7805IC for voltage regulator. 5V DC supply dirctly given controller on program counter to Pin number 1(MLCR)

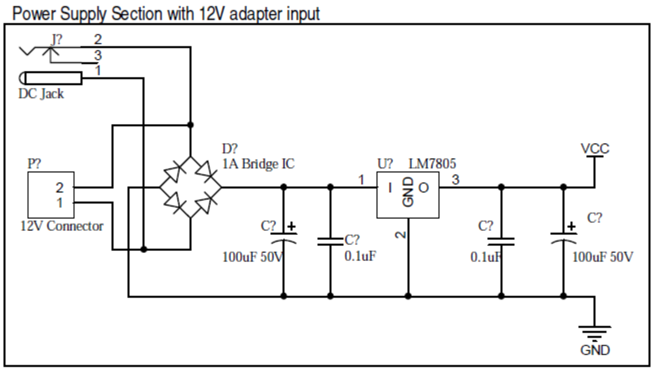


Figure 4.2: Power Supply Circuit

4.3.3 Potential Transformer

We use the 230/5V step down transformer, so our 230V convert to 12V ac supply. 12V convert on DC, then potential divider circuit used. Finally 5V dc supply to give the controller analog pin RA0/AN0, then find the counter for 5V DC supply, how many counts controller for 5V supply, according count make a program to scale up voltage as our requirement.

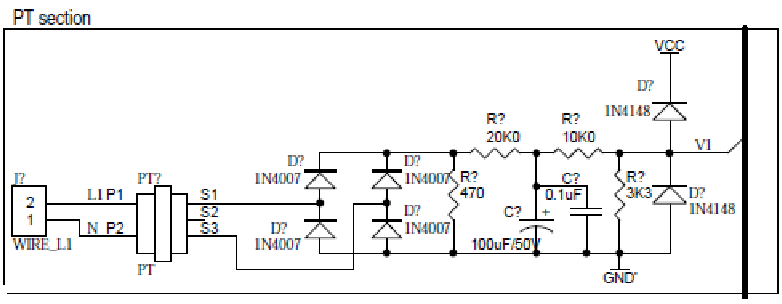


Figure 4.3: Potential Transformer to Controller Circuit

4.3.4 Current Transformer

Current sense on controllers are big issues, because controller current operating capacity only 250mA. In our circuit maximum current on load is 5A. So its again potential divider circuit use. Now current become in sense of voltage because V=IR, We have current and resistance output become voltage. This voltage gives to controller analog pin RA1/AN1.

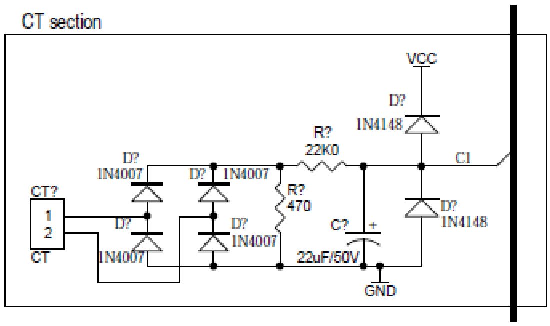


Figure 4.4: Current Transformer to Controller Circuit

4.3.5 Controller to LCD Interface

Liquid crystal display interface with controller 18F4520. We are execute program in controller and display result on display. Here we used 16*4 LCD, the feature decription show on data sheet. (ref.). out of 16 pin on lcd we used 4 pin (V1, C1, SW1 AND SW2) calculating VOLTAGE, Current And Select Switch and Enter Switch from the programming , D4 to D7 taken from controller pin RD4 TO RD7. Remaining RS and E pin from RD2 and RD3 respectively. So, we have used 10 pin from controller to lcd display. Here we show the basic circuit diagrm to Controller to LCD interfacing on PCB.[9]

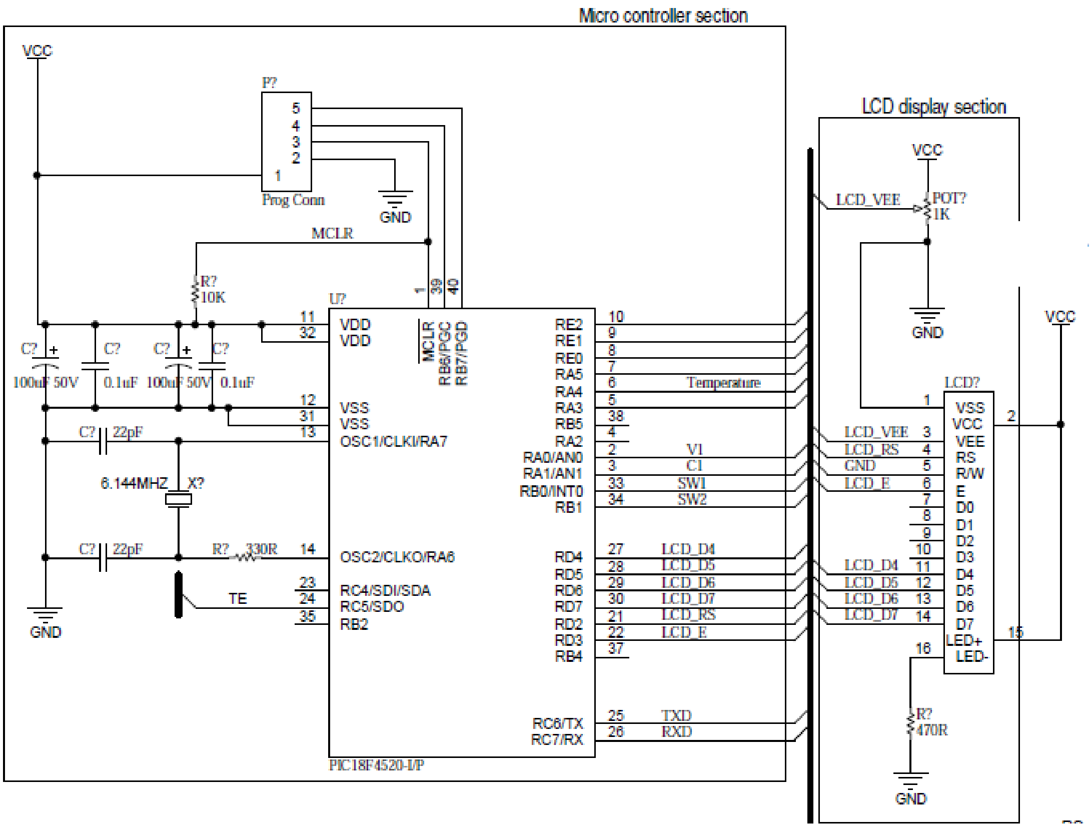


Figure 4.5: Controller Circuit to LCD interface

Figure show the diagram interfacing controller through to LCD display. The controller program logic use based on counter on controller when voltage sense by P.T. and current sense by C.T. SW1 and SW2 indicate the select and enter value. Suppose we press select switch, display indicate 33kV, 110kV and 220kV. If we want to run short line then press the enter switch on 33kV, line will be operate at 33kV (actually voltage on line 210V AC). If we line operate on no load then the current will be zero. As same for medium line we fixed voltage 110kV (actually voltage on line 220V AC) and for long line fixed voltage 220kV (actually voltage on line 230V AC). indicate on display 40A at per 0.5A. Also the display indicates power (multiplex voltage and current). during the line operate we will also see the actually voltage, current and power at source to load.

Chapter 5

Discussion Of Result

This project presents laborartry experimental studies basic introduction of transmission line, Efficiency, Regulation, Generalized constant parameter and effect on line. This report invistigtion to determine the following result:

1 Transmission Line Losses:

in this model we determine the how much losses on line. Generally we calculate the loss I^2R in these model the current directly taken from display.Resistance of the wire multiplying the cross sectional area by the length and multiplying by the resistivity of material.

$\Rightarrow$ line loss 10W for short line at 210V and 13kW at 33kV.

$\Rightarrow$ line loss 15.08W for medium line at 220V and 258.09kW at 220V.

$\Rightarrow$ line loss 30W for long line at 230V and 2.11MW at 220kV.

2 Voltage Regulation:

From NoLoad to FullLoad give the voltage regulation on line.

$\Rightarrow$ Voltage Regulation 2.5 at 210V and 1.5 at 33kV.

$\Rightarrow$ Voltage Regulation 3.5 at 220V and 1.4 at 110kV.

$\Rightarrow$ Voltage Regulation 5.2 at 230V and 1.8 at 220kV.

3 Efficiency:

Output divide the Input give the Efficiency of line.

$\Rightarrow$Efficiency on short line 97.5 at 210V and 98.58 for 33kV.

$\Rightarrow$ Efficiency on medium line 93 at 220V and 97.56 for 110kV.

$\Rightarrow$ Efficiency on lonag line 91 at 230V and 97.06 for 220kV.

4 Constant Parameter:Generally constant A,B,C and D parameter determine by open and short circuit test on medium and long line practical implmentation.

5 Ferrenti Effect

In these model the Receiving end Voltage is more then the Sending end Voltage under a No-Load condition. So, Ferrenti Effect would be show on this model.

5.1 Conculsion

This report ivistigtion to determine the line parameter. its obtain the impedance of the line to varying the length. These model will be helpful for studying transmission line and determine the line efficiency, regulation of line on load, impedance and admittance of line, generalized constant parameter and ferrenti effect of line.

5.2 Future Work

⇒ In these project would be also see the Skin Effect, if we will be change the supply frequency the RMS voltage on oscilloscope change.
⇒ With help of Variable Inductor and Capacitor we are able to see the Series Resonance condition.

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