3 PHASE FAULT LOCATION USING MATLAB NETWORK TECHNIQUE

A major project report submitted to

CHHATTISGARH SWAMI VIVEKANANDA TECHNICAL UNIVERSITY, BHILAI (C.G.), INDIA

For the partial fulfillment of the award of degree

BACHELOR OF ENGINEERING

In

ELECTRICAL & ELECTRONICS ENGINEERING

By

Shubham Pandey (3932515034)

Trivendra Malakar (3932515037)

Pankaj Kumar Verma (3932515020)

Under the Guidance of

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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

BHILAI INSTITUTE OF TECHNOLOGY, RAIPUR

Village – Kendri, Near Abhanpur, New Raipur – 493661 (C.G.) India

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DECLARATION

We the undersigned solemnly declare that the report of thesis work entitled **"3 PHASE FAULT LOCATION USING MATLAB NETWORK TECHNIQUE"** is based on our own work carried out during the course of our study under the supervision of **Prof. Sankalp Verma** Department of Electrical and Electronics, BIT Raipur.

We assert that the statements made and conclusions drawn are an outcome of the project work. We further declare that to the best of our knowledge and belief that the report does not contain any part of any work which has been submitted for the award of B.E. degree from this University.

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Mr. Shubham Pandey **Roll. No. 3932515034** **Enrl. No: AR1500**	**Mr. Trivendra Malakar** **Roll. No. 3932515037** **Enrl No: AR1532**	**Mr. Pankaj Kumar Verma** **Roll. No. 3932515020** **Enrl. No: AR1425**

BONAFIDE CERTIFICATE

This is certifying that Mr. Shubham Pandey, Mr. Trivendra malakar and Mr. Pankaj Kumar Verma are Bonafide student of the Department of Electrical and electronics Engineering of this institute, studying in VII semester (session 2015-2019).

This certificate is issued only enable students to submit major project in partial fulfilment of the requirement for award of the degree of Bachelor of Engineering in Electrical and Electronics Engineering from Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.)

(Dr. Piyush Kant Pandey)

Principal

CERTIFICATE

This is to certify that the work incorporated in this thesis entitled **“3 PHASE FAULT LOCATION USING MATLAB NETWORK TECHNIQUE** “is the report of project work carried out by **Mr. Shubham Pandey, Mr. Trivendra Malakar and Mr. Pankaj Kumar Verma** under my guidance and supervision for award of the degree “**Bachelor of Engineering”** in the Branch **Electrical & Electronics Engineering** from Chhattisgarh Swami Vivekananda Technical University, Bhilai (C.G.), India. To the best of my knowledge and belief the thesis

Embodies the work of the candidates themselves.

Has duly been completed.

Fulfils the requirement of the ordinance relating to B.E. Degree of the University.

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CERTIFICATE BY THE EXAMINERS

This is to certify that the project work entitled "**3 PHASE FAULT LOCATION USING MATLAB TECHNIQUE**" is the report of project work carried out by **Mr. Shubham Pandey, Mr.Trivendra Malakar and Mr.Pankaj Kumar Verma** in partial fulfilment of the requirement for award of the degree of Bachelor of Engineering in Electrical and Electronics Engineering.

It is understood that by approval, the undersigned do not endorse or approve any statement made, opinion expressed or conclusion drawn there in , but only approve the report for the purpose for which it is being Submitted.

Internal Examiner External Examiner

ACKNOWLEDGEMENT

This thesis is product of four semester of learning and dialogues with our project supervisor Prof. Sankalp Verma. We sincerely thank them for their numerous suggestions and commend their patience. It was an honor to have them as our project supervisor.

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ABSTRACT

An electric power system is a network of electrical components deployed to supply, transfer, and use electric power. An example of an electric power system is the grid that provides power to an extended area. In the control of electric power systems, especially in the wide area backup protection of electric power systems, the prerequisite of protection device's accurate, fast and reliable performance is its corresponding fault type and fault location can be detected quickly and defined exactly. So, for the exact analysis of the fault occurrence and for the further data processing of the network parameter after the occurrence of the fault we designed a specialized filter network for getting the clear output. And with the waveform analysis and further sampled data we can use some accurate algorithm for the fault detection based on that data.

LIST OF FIGURES

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Chapter **1**

INTRODUCTION

1 INTRODUCTION

The power system is a network which consists generation, distribution and transmission system. It uses the form of energy (like coal and diesel) and converts it into electrical energy. The power system includes the devices connected to the system like the synchronous generator, motor, transformer, circuit breaker, conductor, etc. Electricity generation covers the selection, design and construction of facilities that convert energy from primary forms to electric power.

Electricity generation is the process of generating electric power from sources of energy. For electric utilities in the electric power industry. It is the first stage in the delivery of electricity to end users, the other stages being transmission, distribution, energy using pumped – storage methods.

• Introduction of new accurate and reliable algorithm to locate the fault in TL is considered one of the big challenges due to many factors; each factor has different effect on individual algorithm. Therefore, different types of algorithms are adopted to avoid these effects.

• The algorithms cannot be affected by the changes in environment, network parameters, and other variables. There is a wide range of techniques because of the behavior of the system during the fault. Conventional methods such as parameter free, fault recorder, and digital relay were presented to locate fault in classical networks with simple components.

• The effects of other components were addressed in. Great efforts have been introduced in the past, various have been developed to improve fault location estimates.

• Most of the new research conducted for fault location used Adaptive Phasor Measurement Unit, Artificial Neural Network, Discrete Wavelet Transform, Wavelet Measurement errors, Pseudorandom Binary Sequence, Active Line

• Impedance, Traveling Waves, Support Vector Machine, and Computational Intelligence approach. methods, transient signals-based methods and superimposed components-based methods. Directional relays based on negative or zero sequence components or compensated post fault voltages are most common. These relays have inherent Some of the above-mentioned studies have strong and weak points. However, the cost and time spent in the location of faults may increase or decrease. Also, many of these algorithms do not apply to systems with compensation, which has a strong effect on distance estimation.

• Transmission lines are subjected to many kinds of faults. Accurate and fast fault detection; direction estimation and distance location under a variety of fault conditions is important requirements from the point of service restoration and reliability.

• The methods of fault detection, direction estimation and fault distance location can be classified into the following three categories: power frequency components-based methods, transient signals-based methods and superimposed components-based methods.

• Directional relays based on negative or zero sequence components or compensated post fault voltages are most common. These relays have inherent drawback of their inability to respond to all types of faults and slow operating time.

• To reduce the operating time, directional relays based on travelling waves have been proposed in Directional comparison protection scheme based on superimposed component has been developed in Crossley. Further estimation of accurate fault location can reduce the fault clearing time.

• But fault location depends upon fault resistance and remote end in-feed etc., which may result in poor discrimination between the faulty and healthy line especially in the case of faults near the remote end bus.

- In the direction of the fault on a transmission line has been determined by the ANN based network from the relative phase angles of instantaneous voltages and current phasors. However, it does not determine the fault location.

- A directional relaying algorithm based on relative phase angles between positive sequence fault components of voltages and currents has been developed for all types of faults. It does not identify the faulty phase and the distance to fault point.

Chapter 2

LITERATURE REVIEW

[1] A Comparative study of different signal processing techniques for Fault Location on Transmission Lines using hybrid Generalized Regression Neural Network blatancy, Anamika Yadav Department of Electrical Engineering N.I.T. Raipur C.G Travelling wave-based fault location uses arrival times of the fault generated travelling waves at the terminals of the line. These arrival times are extracted by using different signal processing tools like Discrete wavelet transform (DWT), S Transform (ST). The accuracy of fault location is highly influenced by the uncertainties in arrival time measurements. In this paper, an artificial neural network-based fault locator issued to deal with such uncertainties

[2] A Novel Wavelet-Neural Network Method for Fault Location Analysis on Transmission Lines by Reza Shariatinasab, Member IEEE Electrical and Computer Eng. Dept. University of Brigand.

This paper presents a technique, based on discrete wavelet transform (DWT) and back propagation neural network (BPNN), to find the fault location on single circuit Transmission lines. The proposed method has been applied to IEEE 9-bus test system. In order to go through this, MATLAB was used to apply DWT on the signal of fault currents of all the existed generators. The Duchies Four (db4) mother wavelet is employed to decompose the highfrequency component of fault signals.

[3] Fault Classification of Phase to Phase Fault in Six Phase Transmission Line by Ravi Kumar MTech (C. T:), Department of Electrical Engineering National Institute of Technology, Raipur.

This paper presents a fault classification technique based on Hear Wavelet Transform (WT) and Artificial Neural Network (ANN) for six phase transmission line against phase to phase faults. The approximation & detailed coefficients of voltage & current signals are extracted using Hear WT. The standard deviation (SD) of approximated coefficient of voltage & current samples is used as input to the neural network for classification purpose. Six phase transmission line is modeled and the proposed protection technique has been developed using the Simulink® and Sim power system toolboxes of MATLABR7.01

[4] Junyu Han; Peter A Crossley; School of Electrical and Electronics Engineering cation on mixed Overhead Line and Cable Transmission Networks". This per Deals with the Generation of Fault On the overhead line and analysis of fault using MATLAB

[5] J M. Oleskoviez; D.V. Coury; R.K. Agrawal; "A Complete Scheme for Fault Detection; Classification and Location in Transmission Lines using Neural Networks"; Development in Power System Protection; Conference Publication No.479; IEEE 2001.

This paper shows the usage of Artificial neural network in fault detection, fault classification.

[6] Chul-Hwan Kim; Young-Bum Lim; Woo-Gon Chung: Tae-Won Kwon; JomgYoung Hwang; IL-Dong Kim; "A study on the Fault Identification of Underground Cable Using Neural Networks"; IEEE Catalogue No. 95h 8130; 0-7803-2981-3/95This paper again shows the modeling of power system and fault detection of underground cable using Artificial neural network.

[7] Kunal Hasija; Abhishek Kumar; Shelly Vadhera and Anurag Kishorc; "Detection and location of faults in Underground Cable using Matlab Simulink ANN and Oread";978-1-4799-6042/14IEEE.

This paper shows the modeling of a power system in matlab Simulink and fault detection using Artifical neural network.

[8] Hanif Livani; and C. Yaman Evrenosoglu; " A machine learning and wavelet based fault location method for Hybrid Transmission Line" IEEE Transaction on Smart Grid; Vol. 5; No. I; January 2014.

This Paper completely Shows us the Power Automation On a grid System the Simulink uses the Machine learning process for making it fully autonomous.

Chapter **3**

PROPOSED THEORY

3.1 Electric power transmission

Electric power transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation. The interconnected lines which facilitate this movement are known as a transmission network. A wide area synchronous grid, also known as an "interconnection" in North America, directly connects a large number of generators delivering AC power with the same relative frequency to a large number of consumers. For example, there are four major interconnections in North America, transmission and distribution lines were owned by the same company, but starting in the 1990s, many countries have liberalized the regulation of the electricity market in ways that have led to the separation of the electricity transmission business from the distribution business.

Engineers design transmission networks to transport the energy as efficiently as feasible, while at the same time considering economic factors, network safety and redundancy. These network use components such as power lines. Cables, circuit breakers, switches and transformers.

3.2 Generators

Electric generators transform kinetic energy into electricity. This is the most used form for generating electricity and is based on Faraday’s law. It can be seen experimentally by rotating a magnet with in closed loops of a conducting material. Almost all commercial electric generation is done using electromagnetic induction, in which mechanical energy forces a generator to rotate.

3.3 Fault

In an electric power system, a fault or fault current is any abnormal electric current. For example, a short circuit is a fault in which current bypasses the normal load. An open-circuit fault occurs if a circuit is interrupted by some failure. In three-phase systems, a fault may involve one or more phases and ground, or may occur only between phases. In a "ground fault" or "earth fault", current flows into the earth. The prospective short-circuit current of a predictable fault can be calculated for most situations. In power systems, protective devices can detect fault conditions and operate circuit breakers and other devices to limit the loss of service due to a failure. In a polyphase system, a fault may affect all phases equally which is a "symmetrical fault". If only some phases are affected, the resulting "asymmetrical fault" becomes more complicated to analyses. The analysis of these types of faults is often simplified by using methods such as symmetrical components.

The design of systems to detect and interrupt power system faults is the main objective of power-system protection.

1. SYMMETRICAL FAULT

A symmetric or balanced fault affects each of the three phases equally. In transmission line faults, roughly 5% are symmetric. This is in contrast to an asymmetrical fault, where the three phases are not affected equally.

2. ASYMMETRICAL FAULT

An asymmetric or unbalanced fault does not affect each of the three phases equally. Common types of asymmetric faults, and their causes:

- Line-to-Line - a short circuit between lines, caused by ionization of air, or when lines come into physical contact, for example due to a broken insulator. In transmission line faults, roughly 5% - 10% are asymmetric line-to-line faults.
- Line-to-Ground - a short circuit between one line and ground, very often caused by physical contact, for example due to lightning or other storm damage. In transmission line faults, roughly 65% - 70% are asymmetric line-to-ground faults.
- Double Line-to-Ground - two lines come into contact with the ground (and each other), also commonly due to storm damage. In transmission line faults, roughly 15% - 20% are asymmetric double line-to-ground.

3.3 Conditioning circuit

Pre-processing of the three-phase voltage and current signals measured at one end only can significantly reduce the size of the neural network and improves the performance and speed of training process. The training patterns pre-processing process is depicted in Figure 4 and discussed in detailed in the following sub-sections. Computer relays use the phasor representing the fundamental frequency of a waveform sampled over a finite window. A discrete Fourier transform is the most common method to calculate the fundamental frequency components.

1 **Anti-Aliasing Filter**: The anti-aliasing filter removes the unwanted frequencies from a sampled waveform. If the Nyquist frequency corresponds to a sampling rate of N times per cycle, it also determines the highest order harmonic frequency in the waveform which can be estimated. Of particular concern is the fundamental phasor, which is used in relay applications. The anti-aliasing filter removes harmonics above half the Nyquist frequency to prevent corruption of the desired phasor. A simple 2nd-order low-pass Butter worth filter with cut-off frequency of 400 Hz has been used to filter the higher order harmonics.

2 **Sampling Rate**: Computer relays generally sample waveforms between 4 and 64 times per cycle. Reliable relaying decisions need to be made based upon at least 6 to 10 samples. A high sampling rate appears likely to produce a more accurate result. However, there must be enough time between samples to perform relay calculations. A sampling rate of 20 times per cycle seems to be good compromise, and is very commonly used. Three phase voltages and three phase current signals were sampled at sampling frequency of 1KHz.

3 **Discrete Fourier Transform**: Discrete Fourier Transform is used to convert sampled data into a representation of the fundamental frequency phasor.

4 **Normalization**: It should be mentioned that the input signals have to be normalized in order to reach the ANN input level (±1). A moving data window of one cycle length is used to select the post fault data as input to the artificial neural network. Data strings of 10 consecutive samples of fundamental

components of three phase voltage and current signals sampled at 1 MHz are found to be appropriate inputs to the proposed neural network based Directional Fault Distance Locator. This represents a moving data window length of 10 Ms. Training matrices were built in such a way that the network trained produces an output corresponding to the distance to fault point including its direction (forward or reverse).

Chapter **4**

MODELLING OF NETWORK IN SOFTWARE

4.1 SOFTWARE: -

MATLAB version 2017a.

Simulink – (simscape models).

4.2 PARAMETERS TAKEN FOR MODELING OF NETWORK :-

1. The power system is composed of two sections of 400KV single circuit transmission lines each of 100 km length.
2. The grids at both ends of the line are modelled by Thevenin equivalents: a voltage source with it short-circuit impedance represented by short circuit capacity of 1.2GVA and X/R ratio=8.
3. A load of 400kV, 50MW and 50MVAR rating is connected at the sending end bus1 through a separate transmission line of 100km.
4. The receiving end bus3 is directly connected to load of 400kv, 100MW and 100MVAR rating

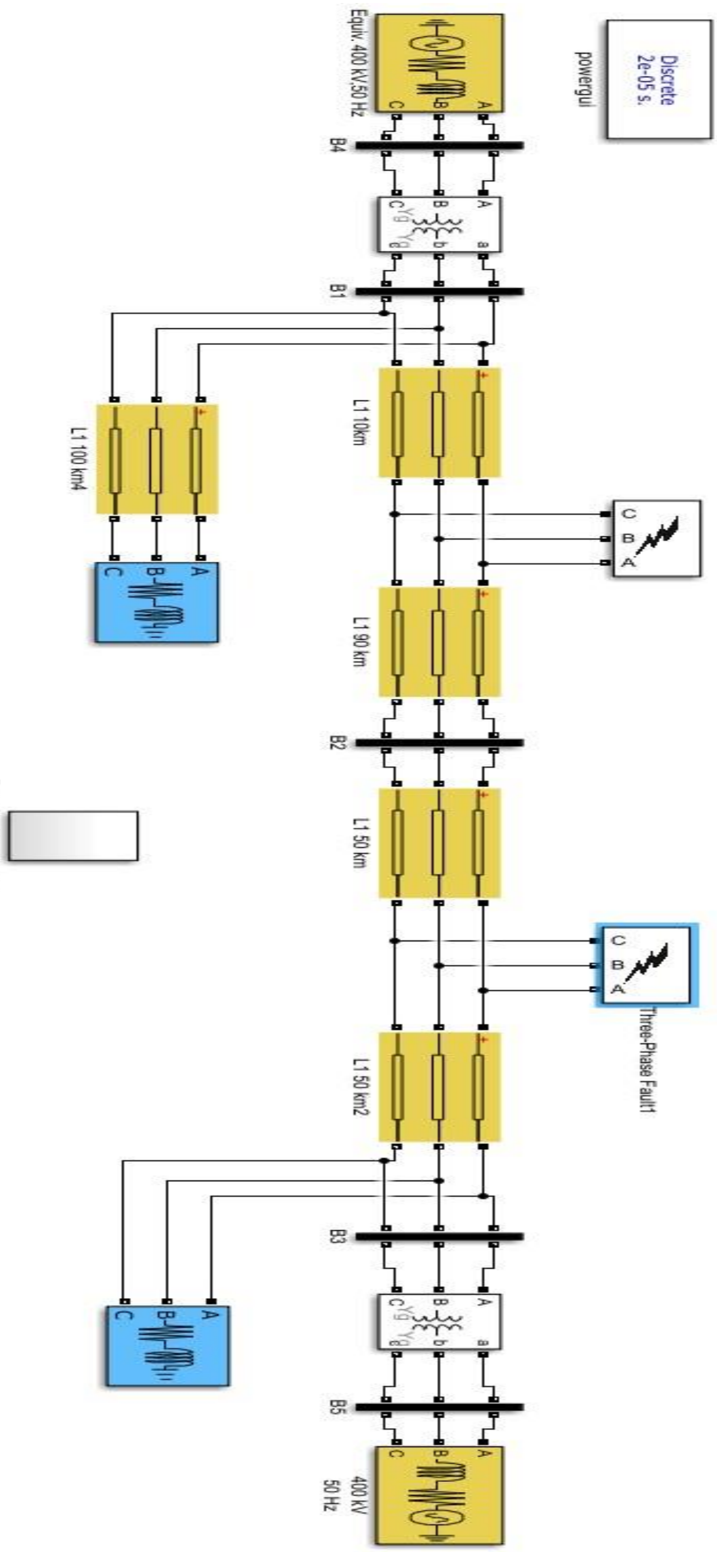

Fig 1. Simulink model of project

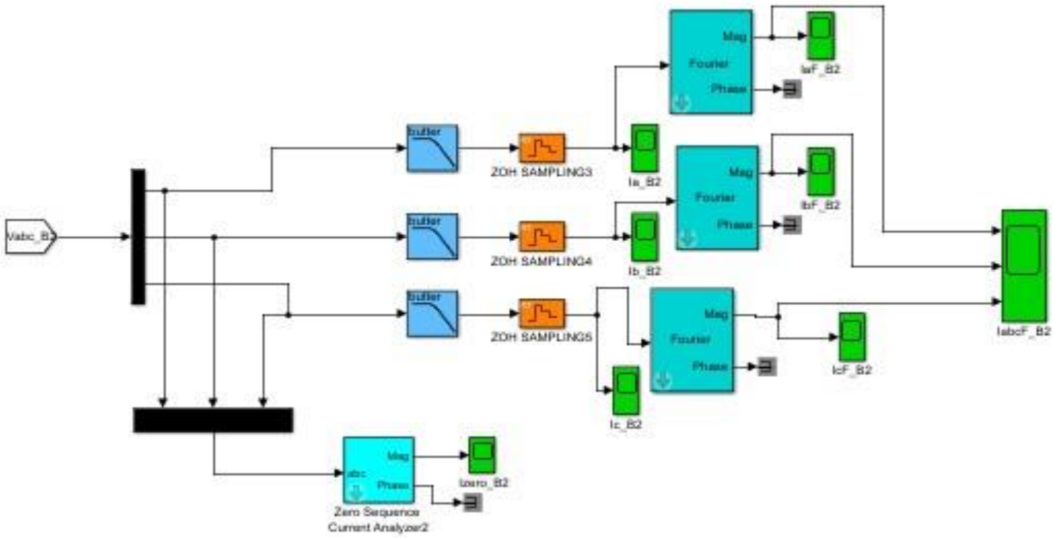

Fig 2. SIGNAL CONDITIONING CIRCUIT

The above circuit consists of following parameters which are mentioned below in the points:

i. A simple 2nd-order low-pass Butter worth filter with cut-off frequency of 400 Hz has been used to filter the higher order harmonics.

ii. A sampling rate of 20 times per cycle seems to be a good compromise, and is very commonly used. Three phase voltages and three phase current signals were sampled at a sampling frequency of 1 KHz

iii. Discrete Fourier Transform is used to convert sampled data into a representation of the fundamental frequency phasor.

iv. Normalization: It should be mentioned that the input signals have to be normalized in order to reach the ANN input level (±1).

In the above fig2. shows the transmission line model by using the MATLAB/Simulink. We have obtained the waveforms of the different bus sections.

The Simulink results are shown in the below voltage and current waveforms of different sections in per unit values.

1. Bus 1 parameters in stable condition.

The voltage waveform of the bus_1 is as shown below: -

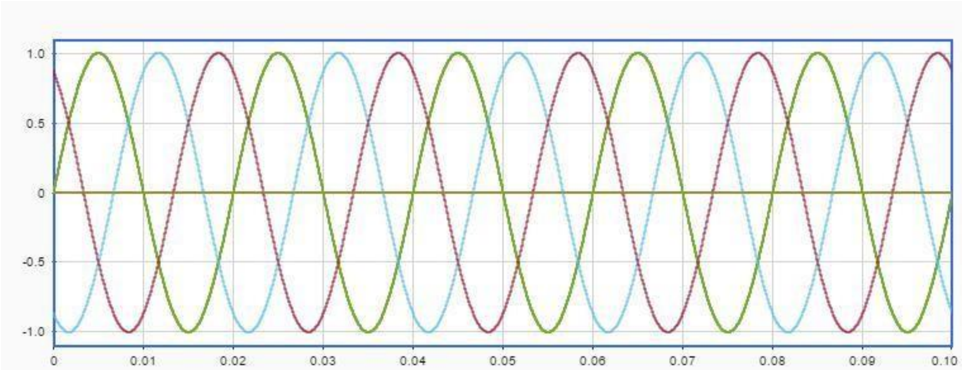

Fig 3. Voltage waveform (Vabc_b1)

The current waveform of the bus_1 is as shown below:

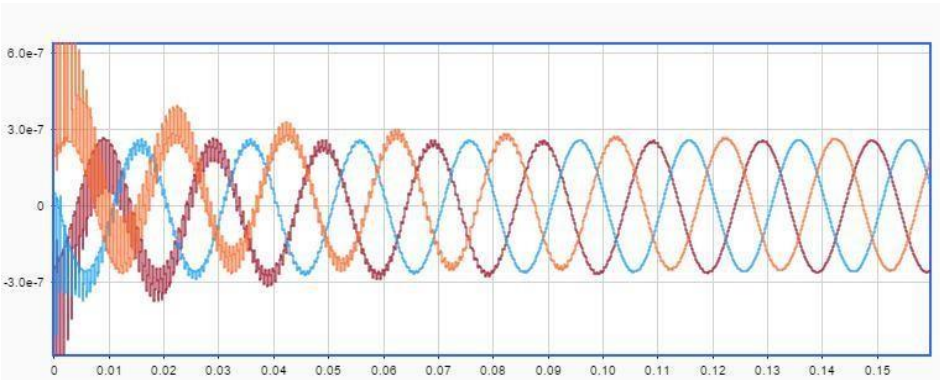

Fig 4. Current waveform (Iabc_b1)

2. Bus 2 parameters in stable condition.

The voltage waveform of the bus_2 is as shown below:

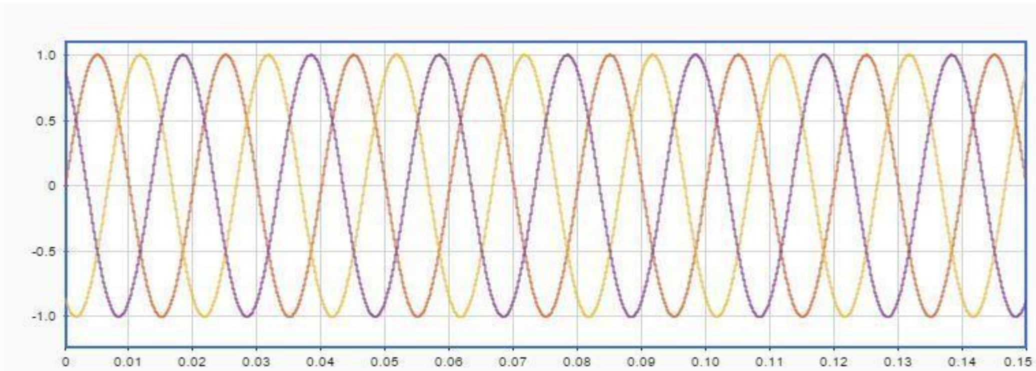

Fig 5. Voltage waveform (Vabc_b2)

The current waveform of the bus_2 is as shown below: -

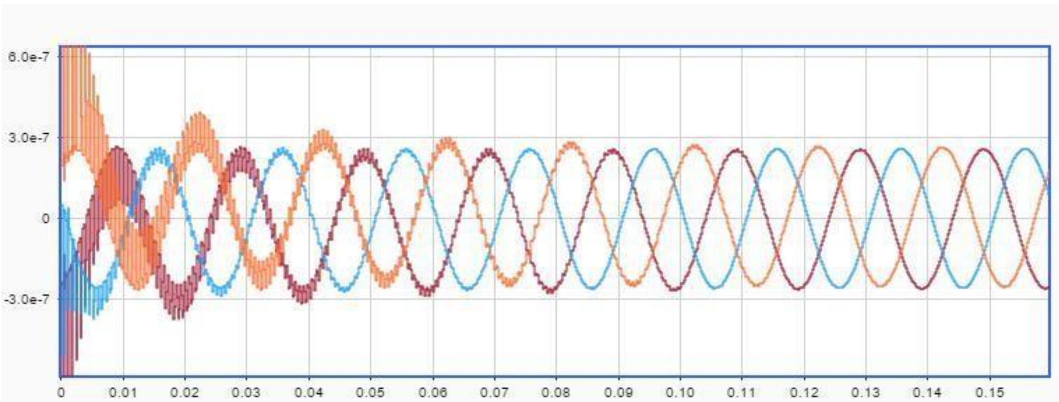

Fig 6. Current waveform (Iabc_b2)

3. Bus 3 parameters in stable condition.

The voltage waveform of the bus_3 is as shown below: -

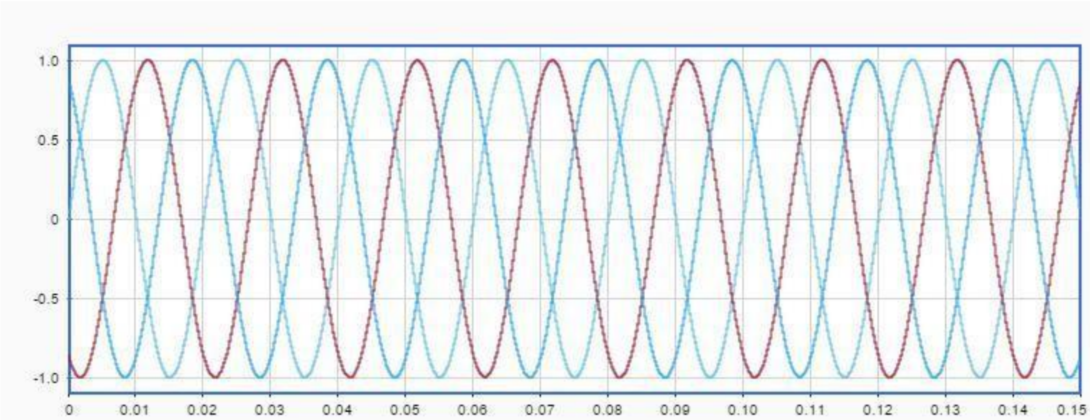

Fig 7. Voltage waveform (Vabc_b3)

The current waveform of the bus_3 is as shown below: -

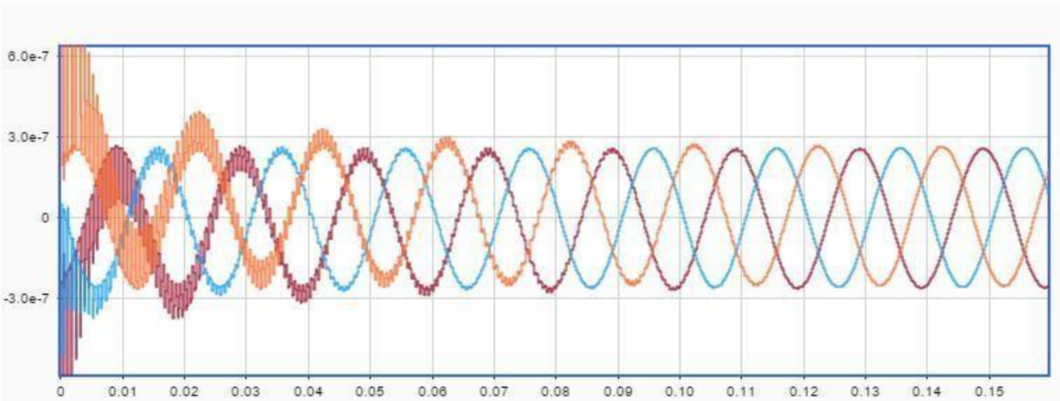

Fig 8. Current waveform (Iabc_b3)

i. Selection of Inputs and Outputs of Neural Network

One factor in determining the right size and structure for the network is the number of inputs and outputs that it must have. The lower the number of inputs, the smaller the network can be. However, sufficient input data to characterize the problem must be ensured. The inputs to distance relay are mainly the voltages and currents, thus three phase voltage and current signals fundamental components have been used as
input to ANN based relay.

Thus the total no. of inputs X for the neural network are 18:

X= [Va1, Va2, Va3, Vb1, Vb2, Vb3, Vc1, Vc2, Vc3, Ia1, Ia2, Ia3, Ib1, Ib2, Ib3, Ic1, Ic2, Ic3]

ii. ANN Architecture

Once it was decided how many input and output the ANN should have, the number of layers and the number of neurons per layer and the training algorithm were considered. It was concluded that the most suitable training method for the architecture selected was based on the Levenberg–Marquardt (LM) optimization technique. Single layer network with 18 inputs and 8 and 7 neurons in hidden layer for FL1 and FL2 respectively and 1 in the output layer were found to be suitable. In this case number of neurons in input and output layers are fixed 18 and 1 respectively. Numbers of neurons in hidden layer are 8 and 7 for FL1 and FL2 respectively.

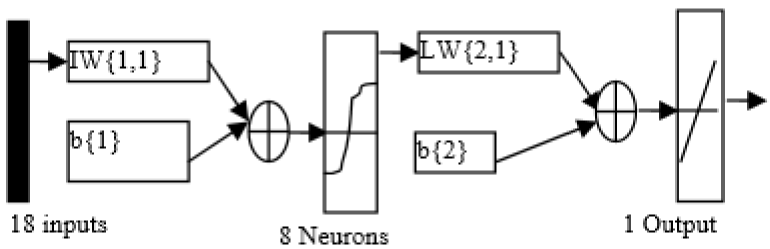

Fig 9. ANN architecture.

iii. Training Process

Each type of single line to ground fault at both sections (AG, BG, CG) at different fault locations between 0-100% of line length, fault resistance (0,100Ω) and fault inception angles (0 & 90°) have been simulated. From each fault cases ten numbers of post fault samples has been extracted to form the total fault patterns 2160 and 20 samples of no fault situation are also added to form the training and testing data sets for neural network for the fault location estimation task. Both the networks for fault direction estimation were trained using Levenberg–Marquardt training algorithm of neural network toolbox of MATLAB with the mean squared error set goal at 1e-04.

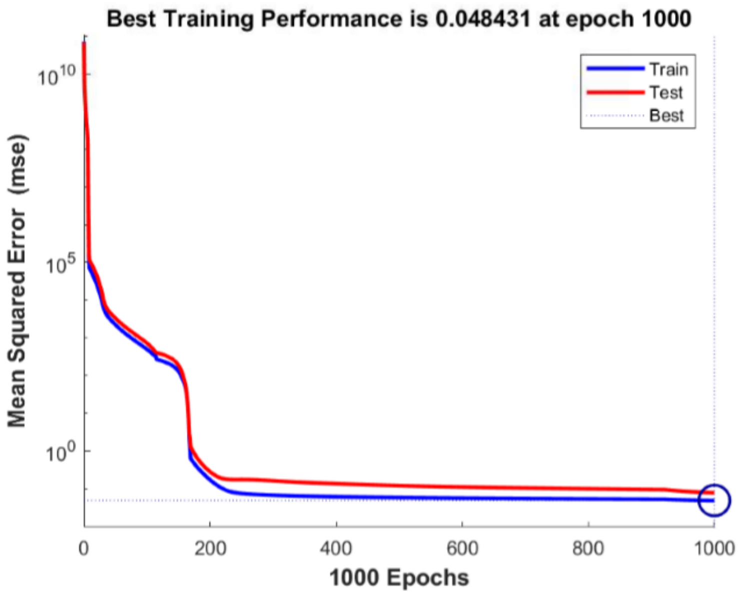

Fig 10. ANN performance plot.

Chapter 5

RESULT AND DISCUSSION

The Simulink results are shown in the below voltage waveforms of different TYPE OF FAULT in per unit values: -

5.1 VOLTAGE WAVEFORMS OF BUS 2 AT THE TIME OF FAULT WITHOUT CONDITIONING CIRCUITS: -

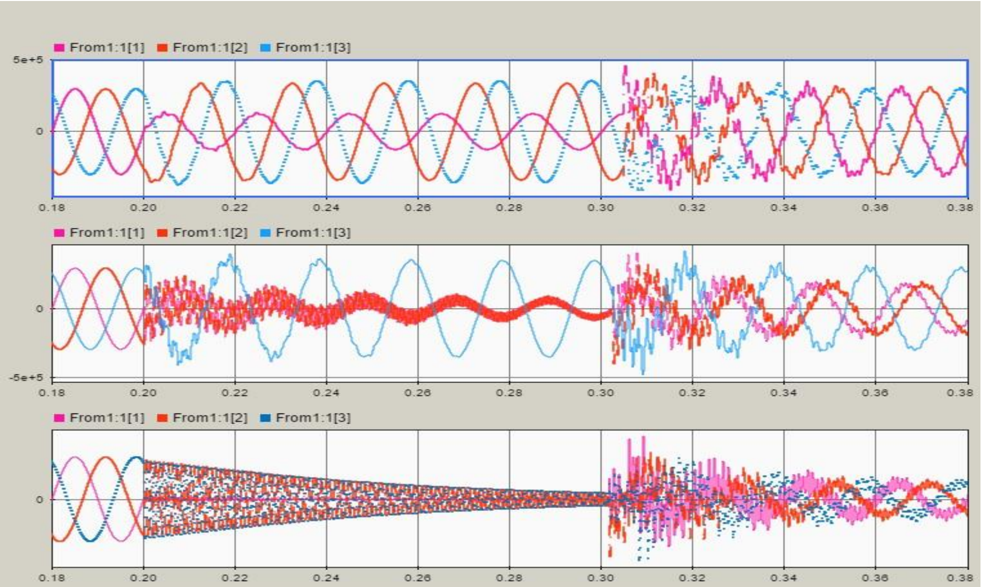

Fig 11. Types of fault without conditioning circuit

- Here the fault occurs from 0.2 sec to 0.3 sec, i.e. the total duration of fault is 10 milieus decided by us and generated with the help of the fault block.
- In the above fig. we can see that the first most waveform is of the Single Line to Ground Fault in which one of the lines voltage dropped and rest of the phases have a voltage swell.
- The second waveform is of the Double Line to Ground Fault in which two of the line's voltage dropped and rest of the phases have a voltage swell.
- The first most waveform is of the symmetrical Fault in which all lines voltage dropped.

5.2 VOLTAGE WAVEFORMS OF BUS 2 AT THE TIME OF FAULT AFTER USING CONDITIONING CIRCUITS: -

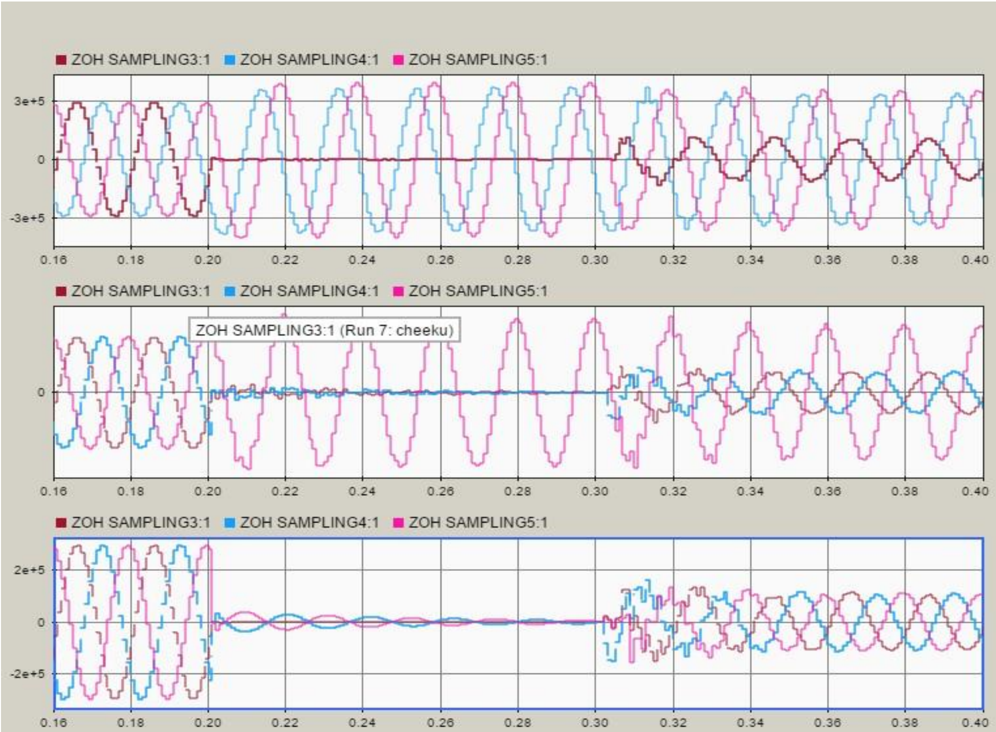

Fig 12. Types of fault with conditioning circuit

- Here the fault occurs from 0.2 sec to 0.3 sec, i.e. the total duration of fault is 10 milisec decided by us and generated with the help of the fault block.
- In the above fig. we can see that the first most waveform is of the Single Line to Ground Fault in which one of the lines voltage dropped and rest of the phases have a voltage swell.
- The second waveform is of the Double Line to Ground Fault in which two of the lines voltage dropped and rest of the phases have a voltage swell.
- The first most waveform is of the symmetrical Fault in which all lines voltage dropped.

5.3 The Desired and Actual output of FL-1 obtained after training with the Levenberg–Marquardt training algorithm, fault location estimation network is:-

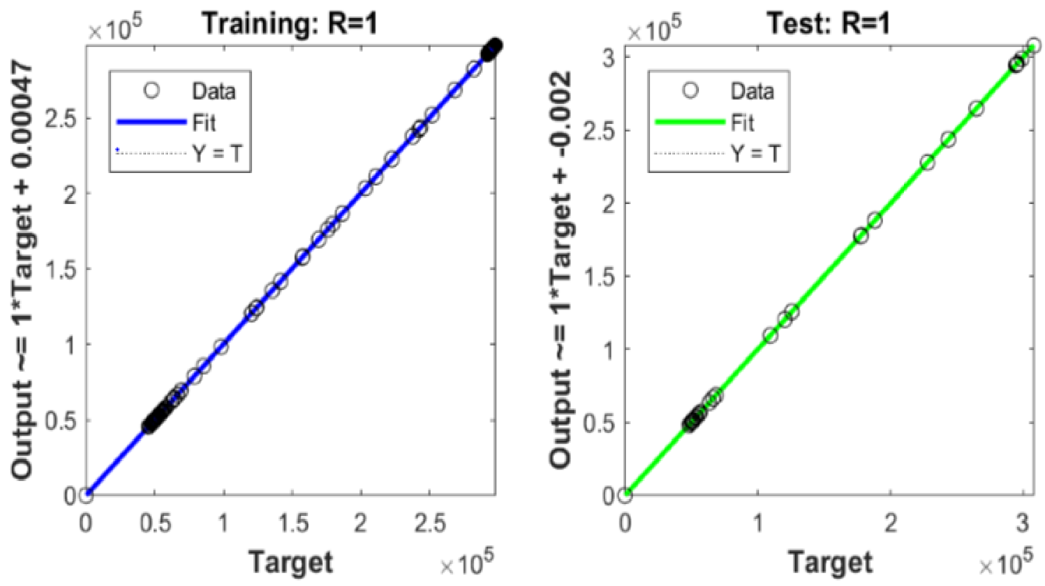

Fig 13. ANN output characteristics.

Chapter **6**

CONCLUSION

6. Conclusion

Overall our project deals with the study of protection of a power system from faults. Also, the effect of the fault in the protective system.

After MATLAB simulation of the transmission line model, it was observed that the voltage and current waveforms that we are obtaining in per unit parameters are in healthy condition. And are ideal state parameters for the analysis of the stable condition of our transmission line model.

Hence, we obtained reference values of voltage and current for fault analysis and further process.

Chapter **7**

FUTURE SCOPE

7. FUTURE SCOPE: -

This can be used for further analyzed as: -

1) Can be interface with new algorithms such as digital multiplier, ANFIS, etc.

2) Can be implemented with the system having live line supply and effective in the fault localization techniques.

3) Implemented for making system the power system for easy maintenance.

4) We can interface this system in nuero-fuzzy logic for the fault clearance.

5) This method can be used in smart-grid system.

This system can be implemented in a few years with recent development in technology as a modern and efficient way is neither too expensive nor too complicated to use on daily basis.

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