WOLKITE UNIVERSITY

COLLEGE OF ENGINEERIG AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

FAULT LOCATION OF MV TRANSMISSION LINE BY USING DOUBLE ENDED IMPENDANCE METHOD

ATHESIS SUBMITTED TO COLLEGE OF ENGINEERING AND TECHNOLOGY, DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERINGIN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE BACHELOR OF SCIENCE OF DEGREE OF ELECTRICAL AND COMPUTER ENGINEERING (POWER STREAM)

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Declaration

We, the under signed, declare that this thesis entitled “fault location of MV transmission line using double ended impedance method ”, is our original work and to the best of my knowledge has not been presented for a degree by any other person, and that all the sources of material used for the thesis have been duly acknowledged.

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Statement of Certification

This is to certify that the thesis carried out by Jima Nigusu ;GetachewTyrone and NegaShibiru on the topic entitled: "Fault Location of MV Transmission Line Using Double Ended Impedance Method" is their original work and is suitable for submission for the award of Masters of Art Degree in Electrical and Computer engineering .

Advisor:-

Ashenafi Paulos (Mr)

Date & Signature

Acknowledgements

First; We would like to thank the department of electrical and computer engineering for giving us the opportunity to work on this research. We also grateful to Mr. Ashenafi Pawulos for his support and advice, especially for reorienting the topic of the thesis at the right time. we would like to thank all the colleagues of the department for the interesting discussions and great workingatmosphere.Finally, We wish to thank our family and friends for their unwavering support.

Abstract

The rapid growth of the electric power system has in recent decades resulted in an increase of the number of transmission lines and total power outage in Ethiopia. The challenge of a fast growing electrical grid has also resulted in huge increases of overhead lines and their total length. These lines are experiencing faults due to various reasons that cause major disruptions and operating costs of the transmission system operator (TSO). Thus, it's important that the location of faults is either known or can be estimated with reasonably high accuracy. This allows the grid owner to save money and time for inspection and repair, as well as to provide a better service due to the possibility of faster restoration of power supply and avoiding blackouts. This project, therefore, will presents two-ended impedance-based fault location algorithms and demonstrates its application in locating real world faults. To analyze methods, various types of faults will be modeled and simulated. Application and usefulness of the method will identified and presented in the thesis. This project will form a basis for choosing an appropriate fault location technique for electrical power transmission network. MATLAB/Simulink software will be used to implement the algorithms. The simulation results will demonstrate the validity of the suitable fault location method in transmission line.

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ACRONOMYS

OT= OPERATION TECHNOLOGY

PMU=PHASE MEASUREMENT UNIT

DFR=DIGITAL FAULT RECORDER

AG=PHASE A TO GROUND FAULT

BG=PHASE B TO GROUND FAULT

CG=PHASE C TO GROUND FAULT

AB= PHASE A TO PHASE B FAULT

BC=PHASE B TO PHASE C FAULT

AC=PHASE A TO PHASE C FAULT

ABG=PHASE A TO PHASE B GROUND FAULT

ACG=PHASE A TO PHASE C GROUND FAULT

BCG=PHASE B TO PHASE C GROUND FAULT

ABC=THREE PHASE FAULT

GDP=GROSS DOMESTIC PRODUCT

ZL1=POSITIVE SEQUENCE IMPENDANCE

ZL0= ZERO SEQUENCE IMPENDANCE

R=RESISTANCE

X=INDUCTANCE

VS=SENDING END VOLTAGE SOURCE

IS=SENDING END CURRENT SOURCE

If= FAULT CURRENT

CT=CURRENT TRANSFORMER

PT=POTENTIAL TRANSFORMER

M=PER UNIT DISTANCE TO FAULT

CHAPTER ONE

1.1INTRODUCTION

Modern society relies heavily upon complex and widespread electric grids for critical service capabilities such as healthcare, transportation, household heating and cooling, and industrial manufacturing to name a few. As our energy delivery systems (electric and other) age, natural disasters and man-made perturbations are expected to threaten grid integrity more often. Furthermore, urban infrastructure energy delivery networks are highly reliant on the electric grid and consequently, the vulnerability of infrastructure networks to electric grid outages is becoming a major national concern. Electric power transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation. Essentially an electrical grid is an interconnected network for delivering electricity from producers to consumers. It consists of generating stations that produce electrical power, high voltage transmission lines that carry power from distant sources to demand centers and distribution lines that connect individual customers or businesses. Transmission lines are a vital part of the electrical distribution system, as they provide the path to transfer power between generation and load. Transmission lines operate at voltage levels from 100kV to 1000kV and are ideally tightly interconnected for reliable operation. In recent years, advanced sensors, intelligent automation, hierarchical control, communication networks, and operations technologies (OT) have been integrated into the electric grid to enhance its performance and efficiency. These new OT devices allow for large amounts of information from numerous grid systems and transmitting needed information to operations personnel in a timely manner that could not be envisioned when previous generation and transmission systems were designed and built decades ago.

In recent years, power quality has become a main concern in power system engineering –with 85-87% of power system faults occur on distribution lines.However, the faults that occur on the transmission lines (the transmission grid) though fewer have a more significant and widespread impact on the consumers. The performance of a power system is affected by faults on transmission lines, which results in interruption of power flow. As the power transmission configurations (networks) become more complex quick detection of faults and accurate estimation of fault location is critical. The rapid dispatch of repair and restoration of supply voltage is essential for minimizing local and regional economic impacts, reducing overall power outages and improving customer satisfaction.

When a fault occurs in transmission line, it initiates a transition condition. Transients produce over currents in the power system, which can damage the power system depending upon its severity of occurrence. To avoid fault recurrences and the high cost associated with finding line faults, utilities endeavor for developing more accurate fault-locating methods. Transmission protection systems are designed to identify the location of faults and isolate only the faulted section of the network. The key challenge to the transmission line protection lies in reliably detecting and isolating faults compromising the security of the system – with significant accuracy. With the advent of OT devices, new measurement devices like phasor measurement unit (PMU), Digital Fault Recorders (DFR) are often used to provide detailed information on the health the grid. These OT advances in power system has led to massive volumes of data from the continuous monitoring of transmission lines. The massive volumes of data is both a blessing and curse- large amounts of data easily can overwhelm storage facilities, but with the advent of machine learning algorithmsthis opens potential to implement smart and robust fault location algorithms.

An electrical power system is a complex system comprising a large number of interconnected electrical components with the sole global aim of allowing the electrical power produced at various locations to reach the customers. Any electrical power system can be simplified into three main stages, namely, generation, transmission and distribution.Power system components in each of these three sections are all prone to failure but the vast majority of disturbances that cause the power system to operate outside normal conditions occur in the transmission and distribution sides of the network. The prime reason that explains why transmission networks experience more disturbances than other network components is because they expand over long distances and the long conductors are directly exposed to harsh climate conditions and external contacts. The overhead transmission lines are subjected to many types of faults. It is accurate and quickly faults detection and analysis; direction and distance location under a various types of fault conditions is an important requirement from the fault point of service restoration and flexibility. Thismethods to find out the fault detection, direction estimation and faults distance location can be classified into the different categories. When there is a different types of faults occurs in electrical power system and then in this process of overhead transmission line fault detection and analysis. Faults that generally occur in transmission networks are short circuit transients caused predominantly by vegetation, animal and weather effects such as tree contact, large birds short circuiting phases, creep age current through path created by rain or moisture and the buildup of contaminants. The other causes of faultsinclude lighting, wind damage, vehicles or aircraft colliding with the transmission towers or poles. These faults can be classified into four main categories namely single line to ground faults (AG, BG and CG), line to line faults (AB, AC, BC), double line to ground faults (ABG, ACG and BCG) and three phase faults (ABC).

Fault is simply defined as a number of undesirable but unavoidable incidents can temporarily disturb the stable condition of the power system that occurs when the insulation of the system fails at any point. Moreover, transient faults which are usually cleared by de-energizing and reenergizing the line, can cause minor damages on electrical networks which can later turn into permanent faults when line loading increases. Fault location, in this case, allows the network operator to identify weak points caused by transient faults on the network anddeploy maintenance personnel to reinforce the system during routine preventive maintenance. Therefore, fault location improves power system reliability by reducing the outage time on the network and also mitigates the occurrence of faults in the future.In the past fault locating approach is conventional, thus, the locating process is time consuming and might expose additional stress to the equipment during the switching on/off of a section. Due to these problems, many automated fault location methods have been introduced by researches to expedite the process of locating faults. An important objective of all the power systems is to maintain a very high level of continuity of service, and when abnormal conditions occur, to minimize the outage times. It is practically impossible to avoid consequences of natural events, physical accidents, equipment failure or miss-operation which results in the loss of power, voltage dips on the power system. So fault location and identification is very important issue in power system engineering in order to clear fault quickly and restore power supply as soon as possible with minimum interruption. This is necessary for reliable operation of power equipment and satisfaction of customer[11].

Fault location today known by regular fault locator based on microprocessor- protective relay, digital fault recorder (DFRs) or stand-alone fault locators. A fault locator is mainly the supplementary protection equipment, which apply the fault location algorithm for estimation distance to fault. Depending on the type of signals that the fault locator use, the fault location methods can be further classified into different categories. Impedance based fault location algorithms, generally classified as one-terminal methods and two terminal methods (synchronized or unsynchronized data from both terminals)[14].

The fault location is the focus in this study and the two method (single end method and double end method) will executed and compared according to error minimization. The need for accurate fault location techniques in the transmission grid is increasingly becoming more important.

Electric power systems have grown rapidly over the past fifty years. This has resulted in a large increase of the number of lines in operation and their total length. These lines experience faults which are caused by storms, lightning, snow, freezing rain. insulation breakdown and, short circuits caused by birds and other external objects. In most cases, electrical faults manifest in mechanical damage which must be repaired before returning the line to service. The restoration can be expedited if the location of the fault is either known or can be estimated with reasonable accuracy.

Fault locators, which provide estimates for the locations of faults. are useful when overhead lines are long and patrolling is time-consuming. Also, visual inspection isdifficult during adverse weather conditions. Fault locators could be relied on for obtaining the needed fault location estimates. They provide estimates for sustained as well as transient faults. Generally, transient faults cause minor damage that is not easily visible on inspection. Fault Locators help identify those locations for early repairs to prevent recurrence and consequent major damages. In this manner. fault locators make a definite contribution towards increasing the availability and secuntyof electric power systems. The subject of fault location has been of considerable interest to electric power utility engineers and researchers for over twenty-five years. Most of the research done so far, has been aimed at finding the locations of transmission line faults. This is mainly because of the impact of transmission line faults on the power systems and the time required to physically check the lines is much larger than the faults in the sub transmission and distribution systems. Of late, the location of faults on distribution systems has started receiving some attention as utilities are operating in a deregulated environment and are competing with each other to increase the availability of power supply to the customers. Also, distribution systems are being gradually automated and microprocessor based relays are being used for line protection. Therefore, development of an improved fault location technique is possible utilizing data that the relays are now able to collect.

1.2 Basics of Power System

Electric power systems are real-time energy delivery systems. Real-time meaning power is generated, transported, and supplied the moment light switch is turned on. Electric power systems are not storage systems like water systems and gas systems. Instead, generators produce the energy as the demand calls for it. Figure 1 shows the basic building blocks of an electric power system. Starting with generation, where electrical energy is produced in the power plant and then transformed in the power station to high-voltage electrical energy that is more suitable for efficient long-distance transportation. The power plants transform other sources of energy as well in the process of producing electrical energy. For example, heat, mechanical, hydraulic, chemical, solar, wind, geothermal, nuclear, and other energy sources are used in the production of electrical energy. High-voltage (HV) power lines in the transmission portion of the electric power system efficiently transport electrical energy long distances to the consumption locations. Finally, the remote substations are responsible for transforming this HV electrical energy for delivery on lower high voltage power lines called "Feeders" that are more suitable for the distribution of electrical energy. This electrical energy is again transformed to even lower voltage services for residential, commercial, and industrial consumption.

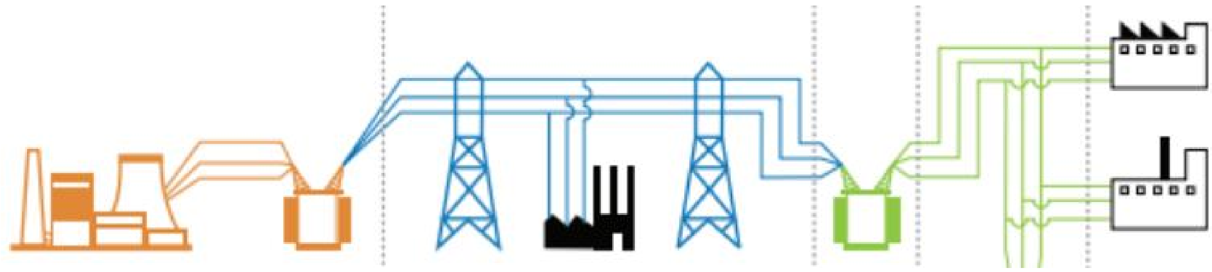

Figure 1:-Building Blocks of Electric Power System

The Power Generation and Distributions has four stages:

1) Generation: Power generation plants produce the electrical energy that is ultimately delivered to consumers through transmission lines, substations, and distribution lines. Electrical energy must be generated at the same rate at which it is consumed. A sophisticated control system is required to ensure that the power generation very closely matches the demand.

2) Transmission: Transmission lines are necessary to carry high-voltage electricity over long distances and connect electricity generators with electricity consumers. Transmission-level voltages are typically at or above 110,000 volts or 110 kV, with some transmission lines carrying voltages as high as 765 kV. Power generators, however, produce electricity at low voltages and the generation voltage is stepped-up to transmission voltages. To make high-voltage electricity transport possible, the electricity must first be converted to higher voltages with a step-up transformer.

3) Distribution: Distribution systems are responsible for delivering electrical energy from the distribution substation. Most distribution systems in the United States operate at primary voltages between 12.5 kV to 34.5 kV and some operate at lower distribution voltages such as 4kV. These low-voltage distribution systems are being phased out because of their relatively excessive cost for losses (low voltage requires high currents, which means high losses). These networks carry the power to consumer units like businesses or residential entities.

4) Load: This stage accounts for electrical energy used by various loads on the power system. Electricity is consumed and measured several ways depending on whether the load is

residential, commercial, or industrial and whether the load is resistive, inductive, and capacitive. The electrical network's or the grid's ability to supply a clean and stable power supply is very critical on day-to-day. High power quality ideally creates a perfect power supply that is always available, has a pure noise-free, sinusoidal wave shape and is always within voltage and frequency tolerances. A well-functioning power transmission network enables:

1) Economies of scale: The behavior of the electricity sector is directly related to economic factors such as Gross Domestic Product (GDP). In this manner, the demand for electricity be a "thermometer" of the market. As such, growth of the economy as well as increases in purchasing power and quality of life must be accompanied by improvements in the power system, with the objective being compliance with current and future situations.

2) Rural electrification: Extending electrical grids into countryside will not only help cater to residential houses for lighting and household purposes but also allows for mechanization of many farming operations especially in areas facing labor shortages.

3) Increased transmission reliability: Reliability refers to the extent to which customers have a continuous supply of electricity. As electricity cannot be easily stored, a reliable supply of electricity requires generators to produce electricity and the transmission and distribution networks to transport the electricity to customers in real time. Therefore, a good transmission system will ensure affordable, high-quality electric service is essential for modern life.

4) Decreased costs: Transmission network carries the high-voltage power from the generating sites to the distribution stations. The development and improvement of algorithms that allow the analysis and diagnosis of failures in transmission lines can have an important economic impact, for power utilities by reducing operation costs, as they enable the continuity and reliability of the electric sector.

5) Increases potential for power pools, markets and bulk power transactions: A reliable transmission network will enable more advanced methods of power transfers like power pool, bulk power transfers etc. It primarily helps tobalance electrical load over large network than a single utility by providing mechanism for interchange of power between two or more utilities.

1.3 Motivation

Due to the increasing complexities of modern power system networks, improving the existent protection functions and developing new ones have got much attention recently. The goal is to enhance the overall power system performance. A few years ago, the supplementary protection equipment such as fault locators has got little consideration compared with the main protection. Nowadays, these ones have an increasing attention resulting in remarkable investments for these purposes. The essential factors behind these new strategies are due to the competitive markets and new deregulation policies, in which the terms such as the continuity, dependability and reliability play an important role. New fault location requires more accurate and sophisticated computation routines. Thus, the need for particular fault location algorithms is obvious. The research for fault location methodologies is an attractive area till present in order to have a better understanding of the problem essence and to develop advanced solutions.

1.4 Problem Statement

Faults on power system transmission lines and distribution lines can he classified into two classes: open circuit fault and short circuit fault. The open circuit fault causes load power supply interruption while the short circuit fault is considered to be more dangerous due to the fact that the larger short circuit current may cause overheating or damage system equipment. Therefore short circuit faultsshould be discovered and located as fast and accurately as possible for fault removal and system recovery. generally faultoccur in transmission line are short circuit transients caused predominantly by vegetation, animal and weather effects such as tree contact, large birds short circuiting phases, creep age current through path created by rain or moisture and the buildup of contaminants. The other causes of faults include lighting, wind damage, vehicles or aircraft colliding with the transmission towers or poles. Due to the above stated problem, our customers do not get continuous services.So fault analysis; location and identification is very important issue in power system engineering in order to clear fault quickly and restore power supply as soon as possible with minimum interruption to give continuous services for our customers.

1.5 Objectives

1.5.1 General objective

The aim of this project is to locate a fault in transmission line in order to repair and restore a power supply in a short time to give continuous service for our customers.

1.5.2 Specific objective

- Develop a fast and accurate double-end fault location method based on system impedance estimation using fault transients as an alternative option for applications according to different fault conditions.
- Evaluate the proposed double-ended algorithms according to different system conditions and fault conditions.
- Simulate faults requiring fault location (line-ground, line-line, overloading, etc.)
- Compare, calculate and simulate results with valid data and information from the transmission lines fault.

1.6 Significance of the project

- To restoring power service
- To reduce outage time as much as possible
- To reducing maintenance times
- In order to increase power availability
- To improve power quality and avoiding future accident
- To save money and time for inspection and repair,
- To provide a better service due to the possibility of faster restoration of power supply and avoiding blackouts.

1.7 Scope of our Project

This work is limited to the design of an efficient system that will detect and locate the position of fault on transmission line. Mostly the fault that occurred on transmission line are:-line to line ;triple line to ground; triple line to fault and line to ground faults are a faults that is happened in overhead transmission lines. These faults affects transmission line if it is not cleared in time. In order to locate the position of fault in transmission line we use single and double ended impendance method which indicate exact spot of the transmission line where a fault had occurred.

1.8 Thesis outline

Chapter 2 investigate the previous work relating to online impedance measurement and the fault location algorithms based on impedance estimation.

Chapter 3 proposes a double-ended fault location method which directly uses the voltage and current fault transients measured from both the power supply side and the load side are discussed.

Chapter 4 design and simulation of our project is performed by using simulink. further examine the experimental results by using a Matlab simulation model which has the same parameters as the experimental system. Then, with the continence that the simulation can produce similar results under the same fault situations, conditions that the proposed method cannot be demonstrated by the experimental equipments are investigated.

Chapter 5 concludes the thesis by summarising the research work investigated and developed, knowledge gained and the contributions made to this research field. The employment of the fault location method into bigger and more detail distribution systems and transmission systems, and also the possibility of arc faults are considered and future work are discussed.

CHAPTER TWO

LITERATURE RIVIEW AND THEORY

2.1 Literature Review

This project review different literatures, journals, research papers and books related to one-ended & double-ended fault location algorithms of transmission line, such as; A research paper of "Fault Location Algorithms in Transmission Grids" by MattiasHarysson, published in 2014, states, compares and evaluates different methods for classification of fault type and calculation of conventional one-side and two-side based fault location algorithms for distance to fault estimation.

- A journal of "An Overview of Impedance-Based Fault Location Techniques in Electrical Power Transmission Network" by GaniyuAdedayoAjenikoko&Segun, OlufemiSangotola, which were published in 2014, discusses an overview of impedance- based fault location techniques in electrical power transmission network. Fault location techniques reviewed include the variance-based sensitivity method, the one ended impedance method such as Takagi method, Modified Takagi method, Erikson method, the two-ended impedance based method (synchronized and unsynchronized) two-ended method and unsymmetrical current-only two-ended method. The result of this paper shows that the simple reactance technique is the simplest of all the impedance - based fault location techniques.
- A journal of "Impedance-Based Fault Location in Transmission Networks: Theory and Application" in 20xx by SWAGATA DAS and SURYA SANTOSO, presents the theory of one-ended (simple reactance, Takagi, modified Takagi, Eriksson) and two-ended (synchronized, unsynchronized, and current-only) impedance-based fault location algorithms and demonstrates their application in locating real world faults.
- A journal paper of SushmaGhimire, "Analysis of Fault location methods on transmission lines" published in 2014, discussed the application and usefulness of each methods of fault location in the thesis. It is found that Impedance-based methods are easier and more widely used than traveling-wave methods.

2.2 Transmission Line Fault

Transmission system line faults are the most common faults, triggered by falling trees, lighting strikes or insulator string flashover and 85-87% of power system faults are occurring in the transmission lines. Most of the transmission system faults occurs on overhead lines, due to their inherent characteristics of being exposed to atmospheric conditions. Faults occur in the power system of various causes. For example, lightning strike can overload the system's components and result in a breakdown of the insulation in overhead lines.

The impedance of source connections are often very low, resulting in large currents flowing during faults. The energy contained in a fault current can quickly create excessive heating or forces to components and can result in divesting explosions of equipment. Short-circuit causes, over short interruptions with voltage dips damage the grid and creating major disturbances and cost. Faults occur in many different forms depending of the fault type and the algorithm for calculating distance to fault will therefore vary. Faults on transmission overhead lines are in majority temporary single phase to ground, arcing faults.

A power system fault can either be shunted, series or combination of both type, shunt fault providing a current flow between two or more phases, or to earth. Shunt faultsoccurs through a breakdown of insulation between the phases, or earth. Shunt faults often occur in two different ways; abrupt changes of the lines voltage and current characteristic, due to lighting strike, birds, and threes or similar; or slowly deterioration of the lines insulation. Slow deterioration of insulation will gradually create poor components and worn material that will age over time. Sometimes the difference between slow changes and abrupt faults is not strictly clear. It's possible to talk about faults that occur suddenly, but have evolved over longer period of time. Failure like this is typical faults that are caused by phases to phase merging, due to strong wind. When a fault occurs, the fault current will increase in magnitude, the total amplitude of fault current during a fault depends upon a variety of factors, such as fault type, network, fault resistance, failure causes load currents, short circuit levels etc. Typical shunt faults are presented below.Fault in which the balanced state of the network are called unsymmetrical or unbalanced faults. The most common faults are single-to-line to ground faults line-to-line faults and double-line to-line faults. All of these are unbalanced fault or asymmetric fault. Common fault on a transmission line:

2.2.1Line-to-line fault:-short circuit between lines caused by physical contact between two lines 10-15% of all fault in the system line-to-line faults (For example, broken conductor or strong wind).

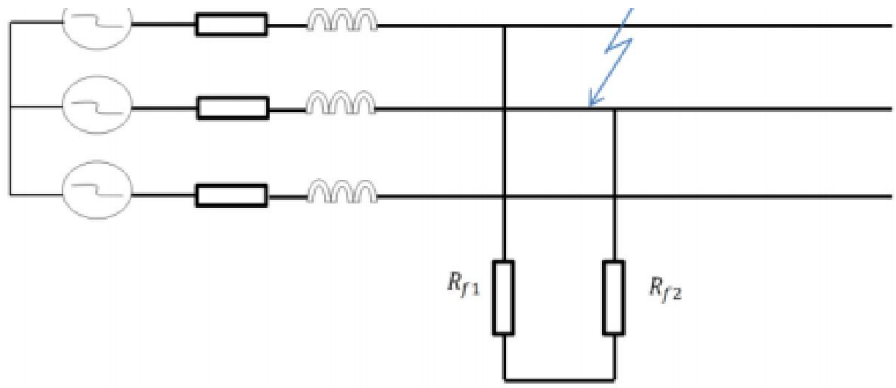

Figure 2:-Line-to-line fault

2.2.2 Line-to-ground fault:–short circuit between one phase and ground caused by physical contact, 75-80% are line-to-ground fault. (Ex. lightning and external factors).

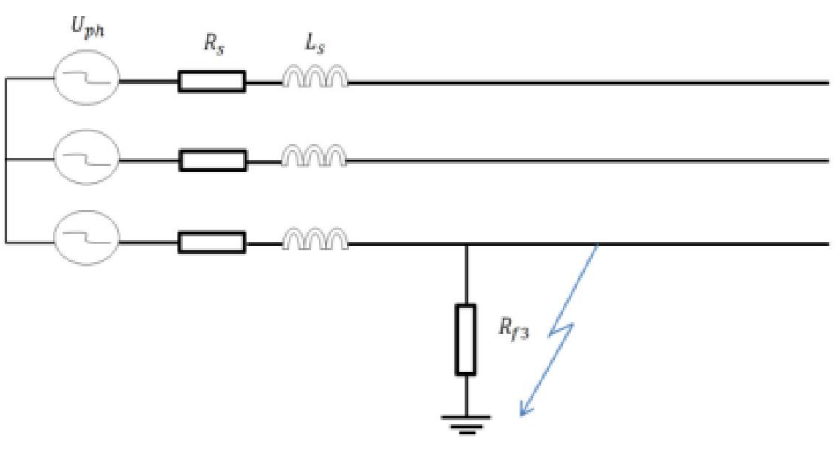

Figure 3 :- Line-to-ground fault

2.2.3 Line-to-line-to ground fault:– short circuit of two line and ground, and 5-10% are line line-to line to ground faults. (Ex. external factors)

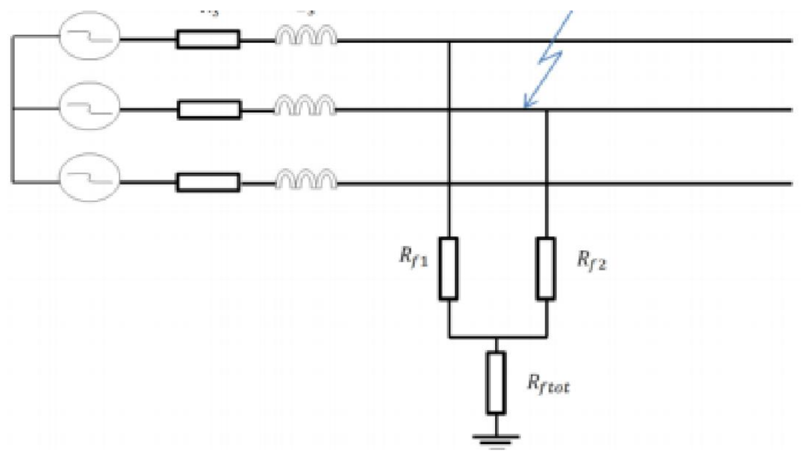

Figure 4Line-to-line-to ground fault

A three phase symmetrical fault is caused by application of three equal impedances to the three phases. Balanced faults are categorized in two fault types called solid or a bolted fault. These faults can be of two types: Line-to-line-to-line ground fault or without ground. Since all the three phases are affected, the system remains balanced. A balanced fault in the transmission system is very uncommon and only 5 % of the system fault is three phases fault.The two types of balanced faults are:-

2.2.4Line-to-line-to-line fault:-This fault mainly occurs due to the breakdown of the insulation between the three phases and the earth. It is also a symmetrical fault which means that the symmetrical current flows through all the three phases. The probability of occurrence of this type of fault in overhead lines and cable power transmission circuits is about 2-3%.

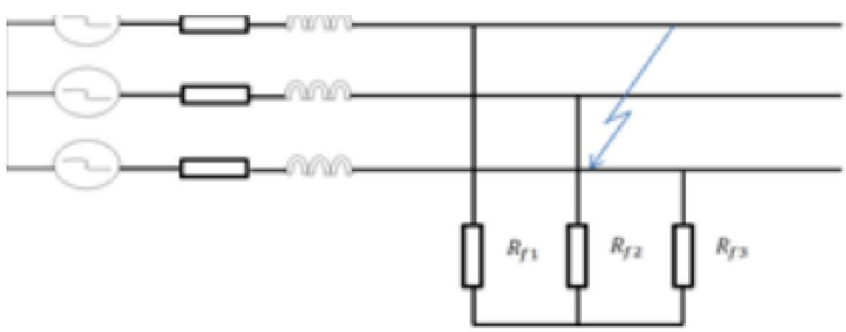

Figure 5:- Line-to-line-to-line fault

2.2.5 Line-line-line-ground fault:-This fault mainly occurs due to the breakdown of the insulation between the three phases and the earth. It is also a symmetrical fault which means that the symmetrical current flows through all the three phases. The probability of occurrence of this type of fault in overhead lines and cable power transmission circuits is about 2-3%.

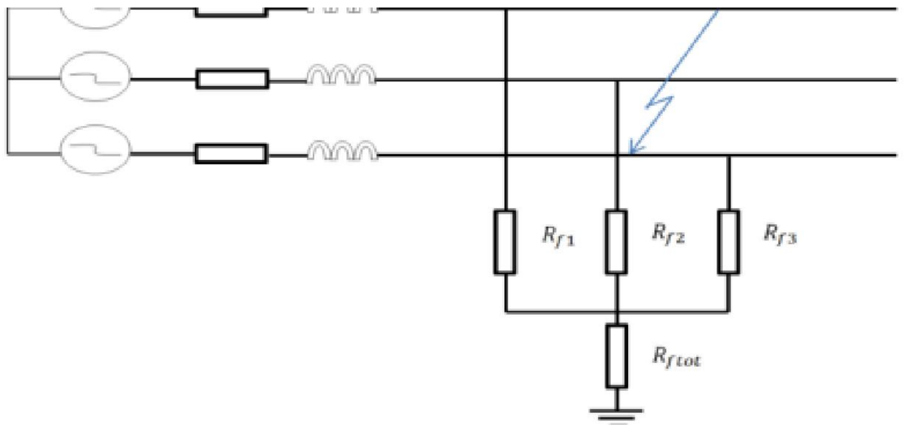

Figure 6:- Line-line-line-ground fault

3.5Transmission Line Faults Analysis and Detection

The overhead transmission lines are subjected to many types of faults. It is accurate and quickly faults detection and analysis; to direction and distance location under a various types of fault conditions is an important requirement from the fault point of service restoration and flexibility.transmission lines not only effects the all equipments and it's also effect the electrical power quality. So, it is necessary to determine the types of fault and location of fault on the transmission line and clear the faults as soon as possible in order not ca use some damages. A flash over, lightning strikes to birds, wind, snow and ice load lead to short circuits.When the deformation of insulator materials are also to occurs a short circuit faults. Thus it is essential to detect and compare the fault quickly and separate the faulty part of the overhead transmission line. We locating the ground faults quickly they are more important for safety, economy and electric power quality. Now this transient wavelet or waveform based fault analysis, detect and compare the faults levels of wavelets of each phase and zero sequence currents and thus detecting, comparison and classifying the faults. Figure below shows the block diagram of transmission line fault analysis.

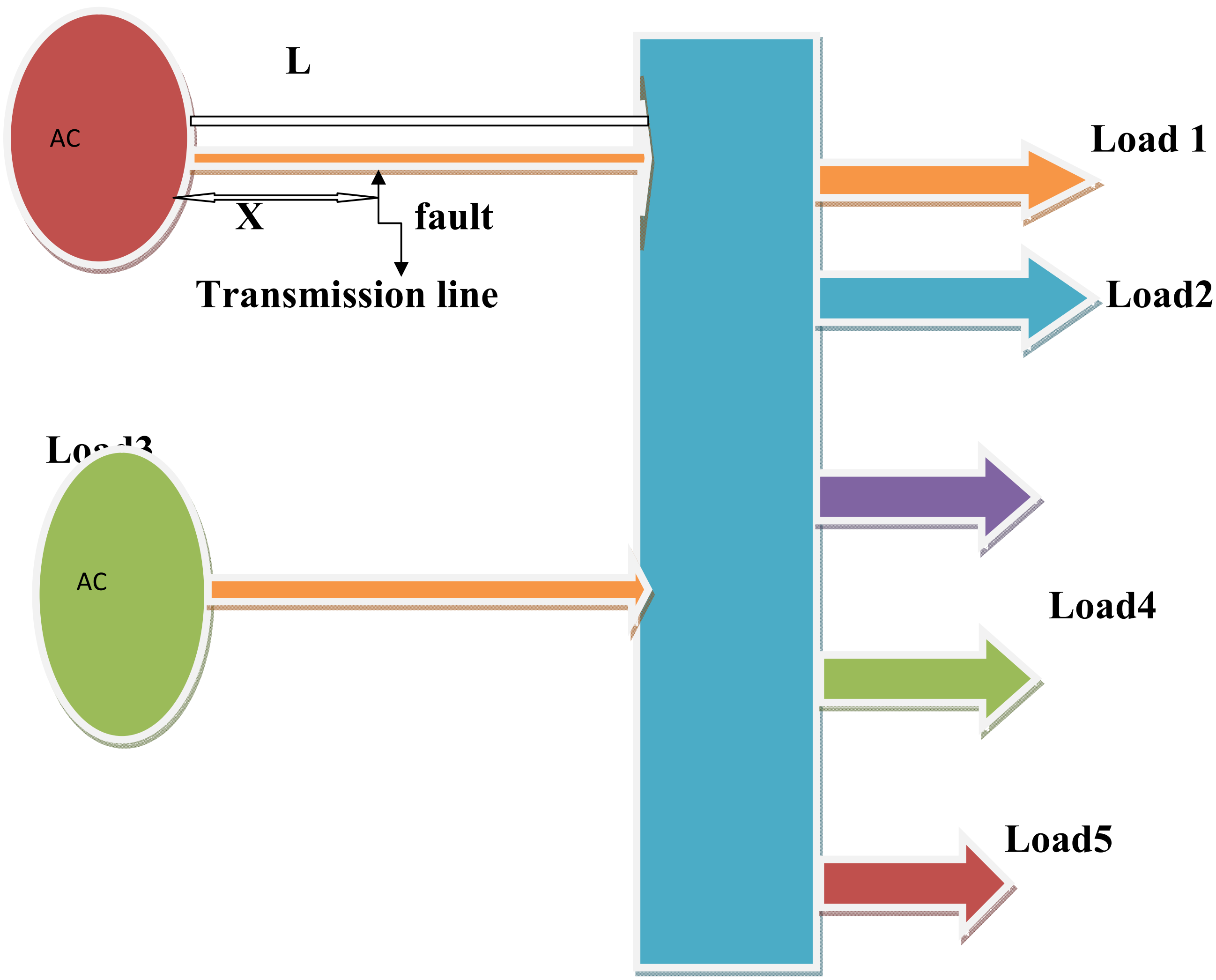

Figure 7:- Show the block diagram of transmission line fault analysis

Fault current analysis and detect are most important issue in electrical power system engineering in order that to clear faults quickly and restores electrical power supply as possible as with minimum interruption. When a fault occurs on an electrical high voltage transmission line for its most important to detect and analysis to compare and find its located in order to make for its necessary quality repairs and to restore power as possible as and time needed to determine the faults at a point along with their line will affect the quality of the electrical power delivery.

2.2.6 Broken conductor fault

Other faults like broken conductor faults are series faults which involve a break in one or two of the three conductors of a three phase power system. In this case, the fault is an unsymmetrical series fault and thus, the theory of symmetrical components was revisited. A series fault is an abnormal condition, since the impedance in the three phases is not equal When one or two phases of a balanced overhead three-phase line open it creates unbalance in the system and may result in high unbalanced currents and voltages. Such condition usually occurs when the conductor of a transmission line is broken or damaged. Broken conductor faults are usually caused by variable weather condition and climate influences to the power grid. Conductor icing is a comprehensive physical phenomena determined by meteorically factors, temperature fluctuation, humidity, wind and other weather factors. A knownphysical phenomenon in when cold weather accumulate ice on the conductor, and when the ice suddenly drops the dynamic effect of the transmission line will cause major electrical and mechanical failure.Electrical failure between adjacent conductors and the ground lead to flashover or electrical shock. From a mechanical view, high amplitude vibrations may break one conductor or more and this will result in large unbalance in the phases.

2.2.7 Arcing Faults

At a high voltage flashover in voltage magnitude, an arcing fault may occur and cause fault situation on the transmission grid. An arcing fault can be considered as a current dependent resistance with three zones. Area closes the adjacent points can be described as a voltage drop independent of current magnitude, arc is spreading if there is space Available. If the flowing current through the arc is high the arcing fault through ionization becomes more powerful and the resistance lower. The fault resistance is much larger in the main part of the arc than in the end points.An electrical arc is affected by magnetic forces and wind, but also the heat extension during the development of an electrical arc. Because of this, its length will increase over time, and if the condition is right the arc may escalate through the conductors and cause short circuits. In the initial phase of an arc fault the arc’s length will be extended, and so over until a disconnection occur. Flashover and arc faults on overhead lines caused by power surges (e.g. Lightning) usuallyoccur over the isolators because the arc distance is shortest at these points. In a short circuit causes the acing resistance is very low compared to the impedances, especially during the fault measurement time of a protective. To calculate the maximum fault current the acing resistance sets to zero. This is because a nonlinear arc resistance causes a certain harmonic content in the fault current that protective relay must accept.

2.2.8 External Faults

Lightning faults and faults caused by trees are the most common faults on overhead lines. In the transmission grid lightning faults are dominate because the overhead line here are more tree secured. Losses in overhead lines are resistive and the created losses can be seen as a series resistance at the overhead lines end points. Current flow in overhead line creates a magnetic field around the conductor in overhead lines is this called line reactance. Reactance between the conductor's phases and to ground creates an electrical field; this can be seen as a capacitance. Lightning's fault usually appears when lightning strikes a phase conductor directly, but there are also other places where a lightning strike can create a fault, depending of the size of earth resistance and lightning's voltage amplitude. When a lighting fault occurs on an overhead line an arcing will occur over insulators, phases and insulator bracket. If the isolator bracket is connected to ground, a ground fault has occurred. Ground fault can be either single-phase or multiphase fault, depending how many phases involved. Ground fault voltages into a properly grounded network have low value for cases where all three phases are involved; if the ground fault voltage phase voltage reaches a high level earth fault has occurred.

CHAPTER THREE

3.FAULT LOCATION METHODS IN TRANSMISSION LINE

3.1 Revision of Different Fault Location Methods

Faults can occur in any point of the power system, and the most exposed parts are overhead transmission lines. Regarding the distribution system, transmission lines perform the most important part that is to transfer electric power from the generating station to load centers. Since the development of the distribution and transmission system, power system engineers have been an object for locating and detecting faults. As long as the fault detected in short duration, it provides a good service for protecting the apparatus as well as an open way for disconnecting the part where this incident happened at fault, and with the help of this, it gives safe way to the system from any damages. So it is needed to detect the fault otherwise due to fault it causes any disturbance which further tough time to the interconnected system that based on limitation.

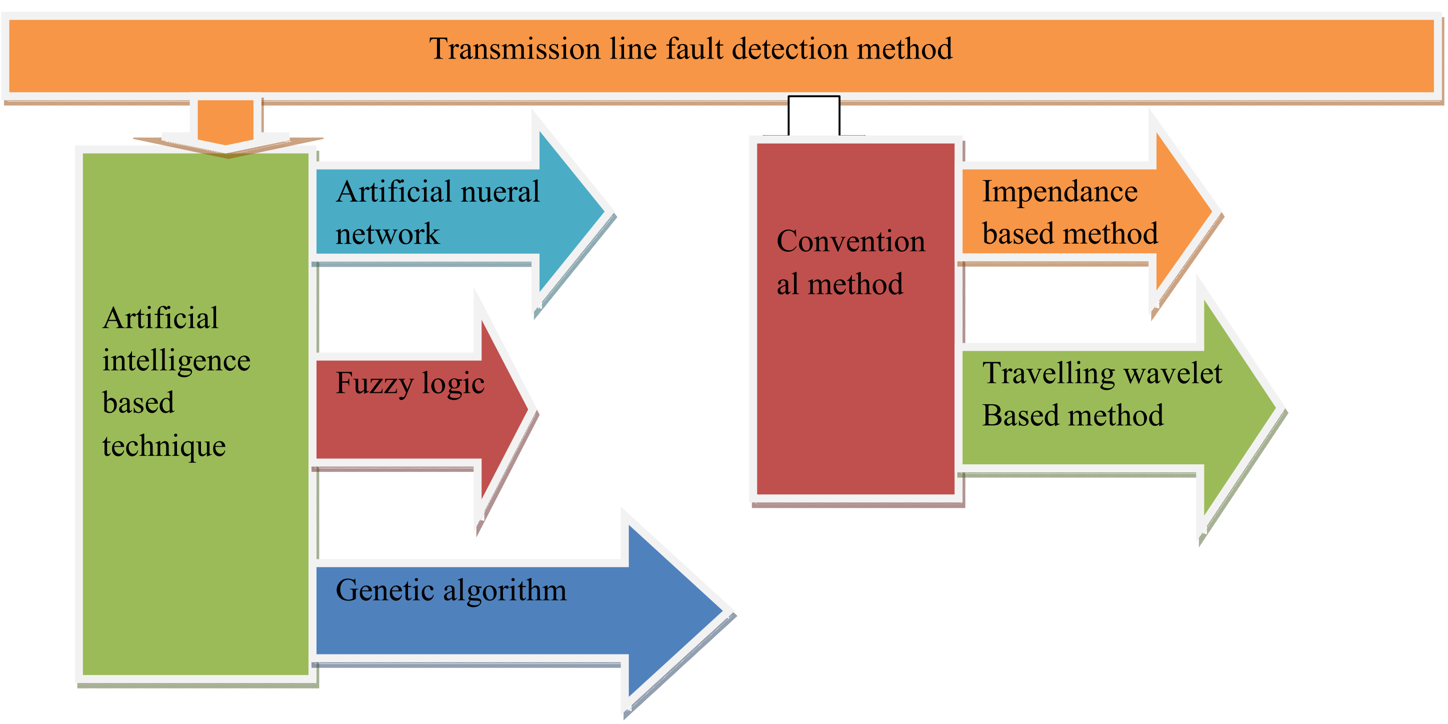

Figure 8 :- Types of fault location technique

3.2 Impendance based method

3.2.1 Reactance Based Algorithm

Novosel simple reactance method, algorithms reported in extend simple reactance method by making assumptions to eliminate effect of remote in feed and fault resistance. One-ended impedance methods of fault location are standard feature in most numerical relay. The reactance fault location algorithms depend on accurate values of the positive(ZL1) and zero –sequence impedance (ZL0) to determine locations of faults on the transmission line. The positive and zero-sequence impedance of the transmission line can be verified when a fault location relay is installed at each end of the transmission line. The positive-sequence impedance has verified that it can be used to check the values of the zero sequence impedance of the line as used by each relay. The method also uses the value of voltage drop from one side bus bar of the line, and the value of current depend of type of fault and symmetrical components. Transmission line impedance (Z) is typically dominated by the reactive components (X) and the fault impedance is typically dominated by the resistive components (R).

3.2.2 Takagi method

Takagi impedance based algorithm, with uses of pre-fault and fault data. Use pre-fault and fault data to reducing the effect of load flow and minimizing the effect of fault resistance Fault location algorithm by Takagi method calculates the reactance of faulty line using one terminal voltage and current data of the transmission line. When a fault occurs on a transmission line the data of pre-fault current are stored immediately and the fault phases are selected. The Takagi method introduces superimposed current to eliminate the effect of power flow. This method assume constant current load model and require both pre-fault and post–fault data.

3.2.3 Fault location Algorithm by Saha

A fault point in a three phase transmission line is determined by measurement of current and voltage data at both side of the transmission line. In this algorithm the fault type; single-phase/multi-phase ground fault/phases-to phase fault is determined and the parameters in a quadric equation are used to calculate distance to fault on a transmission line. The equation is based from the electrical relationship, between the complex values of the line impedance, the source impedance, and current and voltage. The equation eliminates the use of fault resistance and possible zero-sequence components. The parameters are determined by the type of fault and the equation is solved by means of a numerical square root method. Fault location equation by Saha, notify that the values for (Vs), (Is) and Ifs are different for each fault type.

3.2.4 Fault Location Algorithm by Wyszynski

Fault location algorithms by Wyszynski are based on standard calculations of line resistance; reactance and the correction error by the fault resistance. The algorithm utilizing the general fault loop model and the general formula of calculation fault current, and the apparent resistance and reactance measurement at one end of the line. In cases of interphase short-circuits the fault resistance in general very low, therefore the expected errors are also limited. In cases of ground fault high fault resistance may be assumed; hence the errors affect the precision of short circuit location .The general formula of the algorithm uses calculation of fault loop model of resistance and reactance measured by the fault recorder or distance relay.

3.3 Block diagram of the proposed system

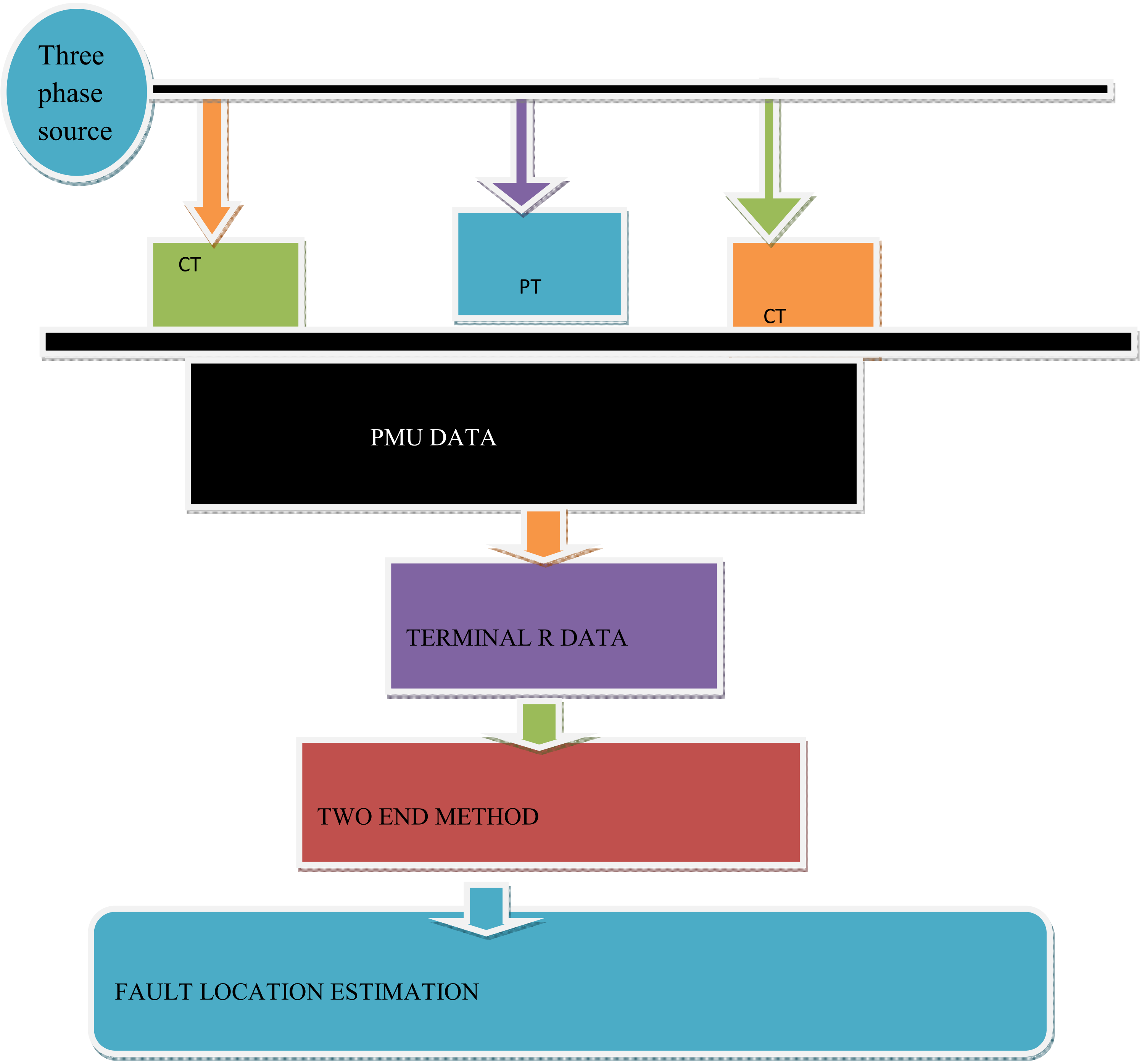

Figure 9 :- Flow Chart of the Fault Location Estimation Algorithms

3.4 WORKING PRINCIPLE OF OUR PROJECT

Each substation in the power system has potential transformers (PT) and current transformers (CT) to monitor the three-phase bus voltages and line currents.PTs are placed at each bus to measure the bus voltage and CTs are placed at both ends of each line connected to all the buses. The PT and CT are connected to a PMU at the corresponding bus. The PMUs convert these analog quantities to their equivalent phasor quantities.One-ended impedance based fault location algorithm estimate distance to fault with the use of voltages and current at a particular end of the line.Single ended algorithm calculates the fault location using apparent impedance from one end to the fault. It take data from one end terminal only and calculate the position of a fault point. We need to measure phase to ground voltages and current in every phase to locate the fault type in this algorithm. In addition, the application of PMUs and synchronized phasor measurements improves the accuracy of the fault location estimation.

3.5 Algorithm studied

3.5.1 Two-Ended Fault Location Algorithm

This section introduces a double-ended fault location algorithm for Medium-voltage, overhead transmission lines. The algorithm uses synchronized voltage and current measurements from both ends of the line.Two-ended fault location estimation isfundamentally similar to the one-terminal algorithm. But the method can improve the accuracy of fault distance measurements significantly by using data from the two ends of the line to cancel the effect of fault resistance and in feed . Two end and multi-end fault location algorithms divided in two main categories, unsynchronized and synchronized measurement. The algorithmsprocess signals from both terminals of the line and a large amount of information is utilized. Therefore, performance of thetwo-end algorithms generally superior in comparison to the one-end approaches. In double ended method, we minimize the effect of fault resistance and other factors which affect the accuracy of fault location. We don’t need to recognize the type of fault in order to calculate the location of the fault. So rather than using zero sequence, we can use +ve sequence components which minimizes the effect of zero sequence components.

In double ended method, we minimize the effect of fault resistance and other factors which affect the accuracy of fault location. We don't need to recognize the type of fault in order to calculate the location of the fault. So rather than using zero sequence, we can use +ve sequence components which minimizes the effect of zero sequence components. The only drawback is it requires a mean of communication to gather the data of remote end which can currently be done using GPS technology whereas in the single end method line terminal, relay or devices collecting data is enough. Double ended method takes more time but it is quick enough to be used by a human. The response time is in seconds. We must synchronize the collected data from both the ends before starting analysis [15].

Advantages

- Have line length accuracy of + 1-2% (more accurate than one-ended)
- More accurate than one-terminal methods
- Able to minimize or eliminate the effects of fault resistance, loading, and charging current.
- Positive Sequence components are used instead of zero sequence,
- eliminating the adverse effect of zero-sequence components
- Fault type identification is not needed Pre-fault data is not needed

  Drawback

- The data from both ends must be collected at one location Required Equipment and data Double ended method may require the following equipment to abstract the data from a system for calculation:
  - Measuring devices that gives 3 ph. voltage and current in each phase like Microprocessor based relays
  - Communication equipment
  - Data collecting equipment or a tech person at the central site for collection of data and calculation of fault location.

:

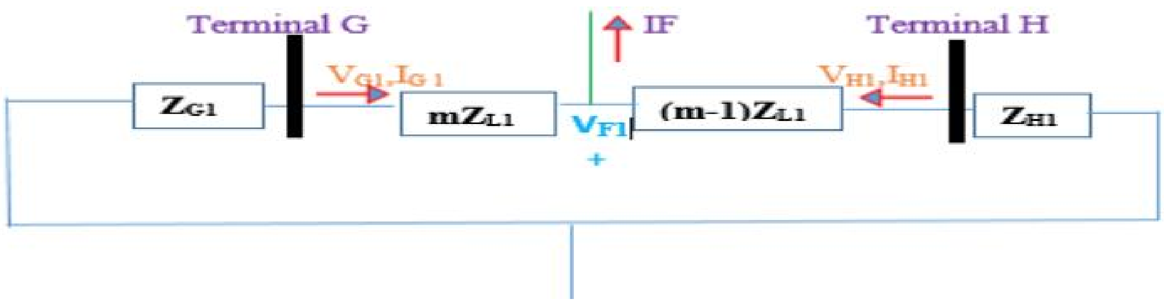

Figure 10:-Positive-sequence network during an unbalanced fault

To illustrate the fault locating principle, consider the negative-sequence network during an unbalanced fault. VF1is the positive-sequence voltage at the fault point F and can be calculated from terminal G and H as:

Terminal G: VF1 = VG1 − mZL1IG1 …eqn 1

Terminal H: VF1 = VH1 − (1 − m)ZL1IH1…eqn 2

Voltage VF1 is equal when calculated from either line terminal. Therefore, equating (1)

and (2), the distance to fault (m) can be computed as:

m = (VG-VH+IH1*ZL1)/(IG+IH)ZL1

CHAPTER 4

4.MODELING AND SIMULATIONRESULTS OF OUR SYSTEM

4.1 Design of system modeling for double ended method

4.1.1The parameter used for double ended fault location method

Three phase voltage source 33kv
Line lengh 80km
Frequency 50HZ
Source resistance 0.8929 ohms
Source inductance 16.58e-3 H
For three phase pi section line :-
Positive and zero sequence resistance ohm/km [0.01273 0.3864]
Positive and zero sequence inductance H/km [0.9337e-3 4.1264e-3]
Positive and zero sequence capacitance F/km [12.74e-9 7.751e-9]
Resistance of transmission line 0.01273ohm/km
Reactance of transmission line 0.009337H/km

Table 1:-The parameter value used in our project

4.1.2 Simulation diagram of fault location using double ended method

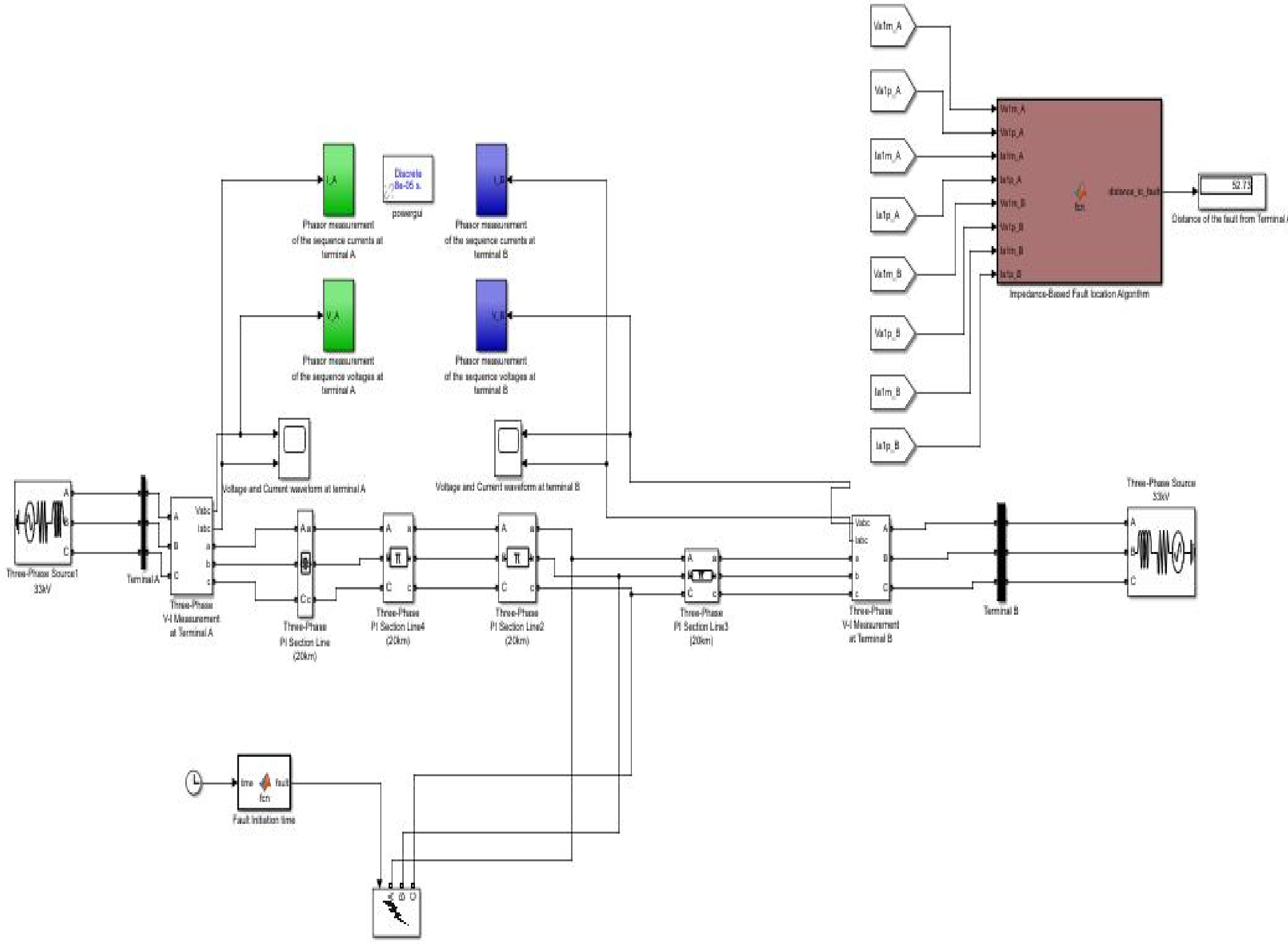

Figure 11:-simulation result of fault location on double ended method

in order to simulate our project we use the matlab code. Also we design our project by using simulinkmatlab. The material that are used for design of double ended fault location method are:- three phase source; three phase V-I measurement; three phase fault; three phase pi section line; matlab function ; fourier transform and scope.

4.1.3 Components of the Modeling for double ended method

- The transmission line:-three-phase π -section line is used to represent the transmission line. A fault at random per unit length (m) from the measuring equipment is assumed to occur. The fault location is generated randomly, each time the model is running, and is displayed by the "numeric display block" mentioned as "exact fault location".

- A three-phase voltage source:-block to supply the simulated line.
- Three phase measuring:-is blocks to measure the three phase line and load current and voltage values.
- A numeric display:- is block to indicate the calculated random per unit length of the fault location (m).
- Measurement block:- This block is used to measure three-phase voltages and currents in a circuit. When connected in series with a three-phase element, it returns the three phase-to-ground voltages and line currents. The block can output the voltages and currents in per unit values or in volts and amperes.

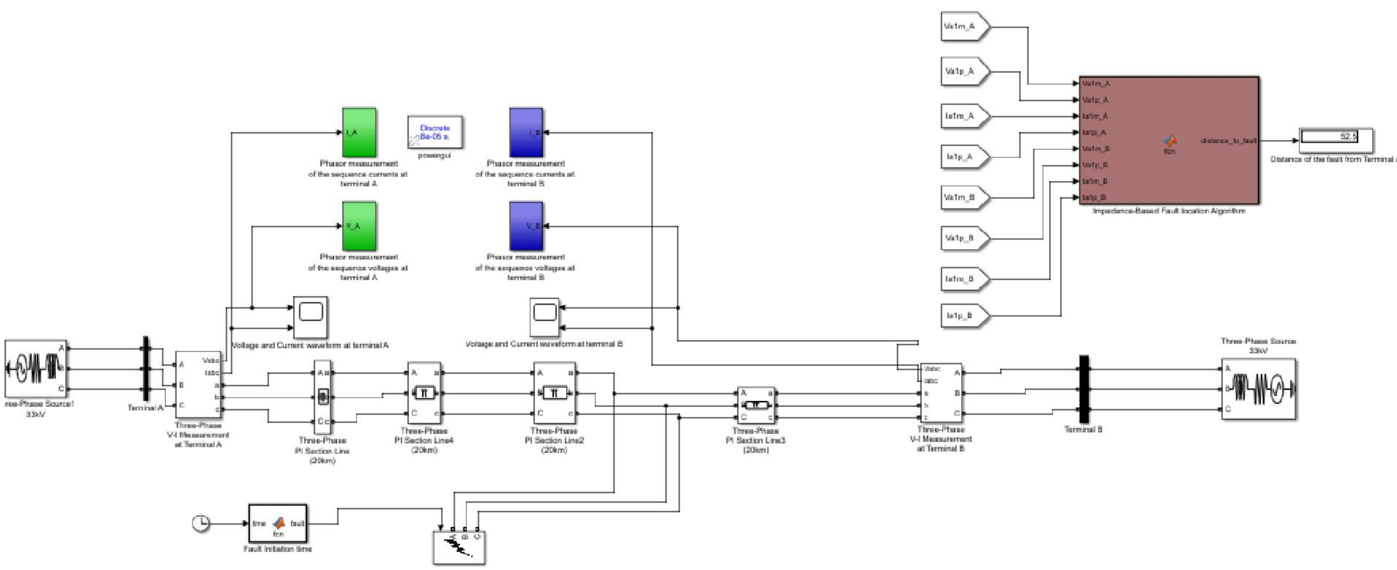

Figure 12:-Simulation result of double line to ground fault using double ended method

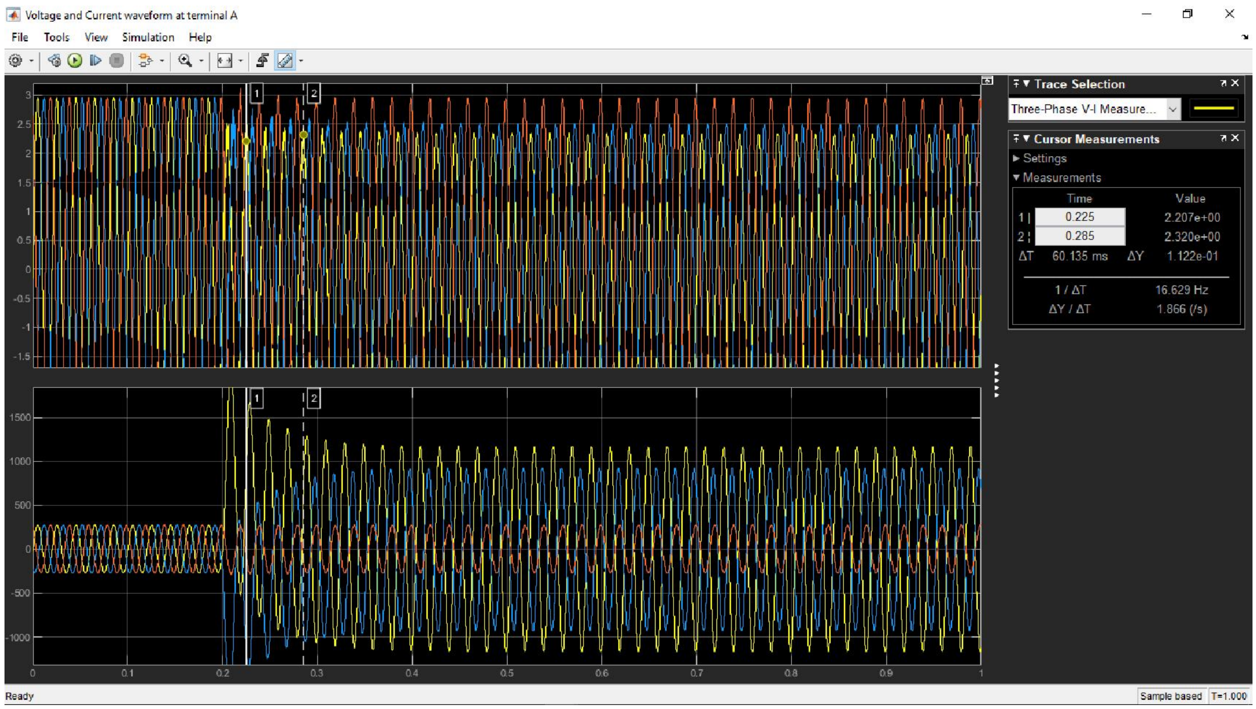

Figure 13:-Simulation result of voltage and current waveform at terminal A

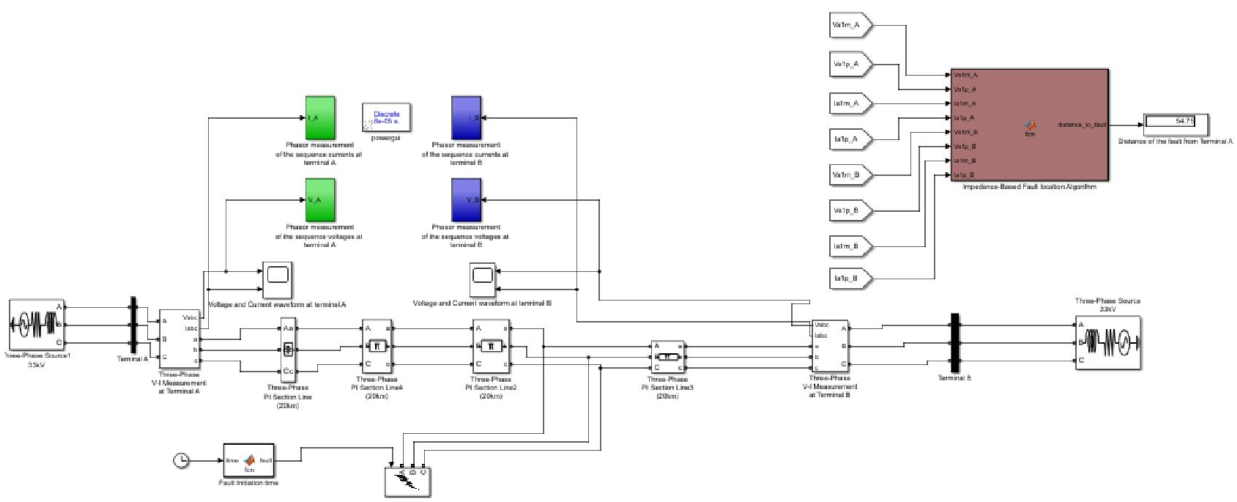

Figure 14:-Simulation result of triple line to ground fault using double ended method

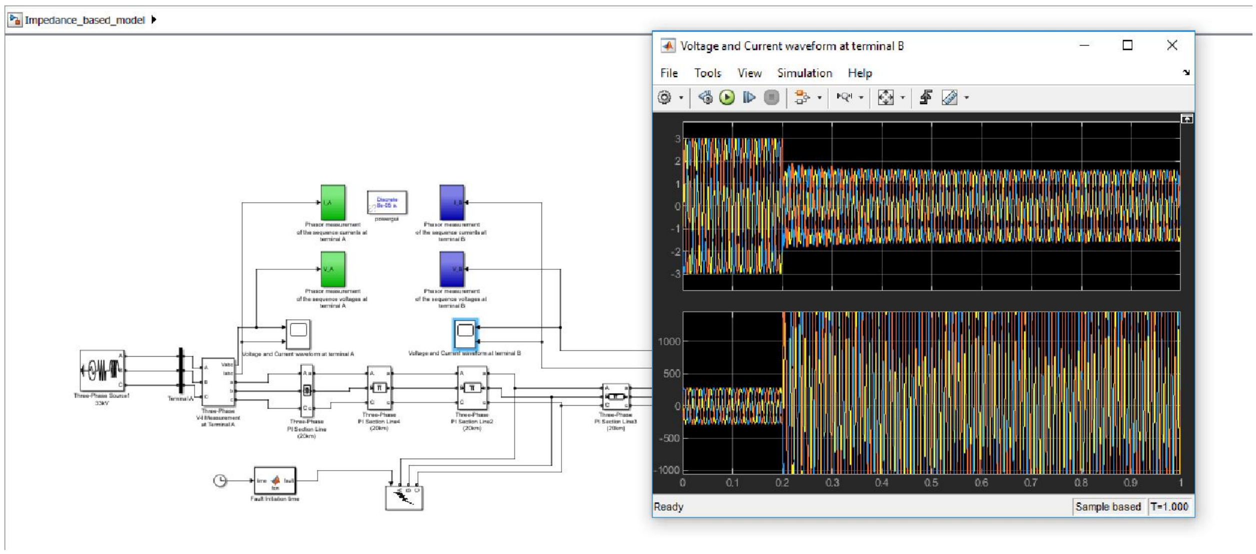

Figure 15:-Simulation result of voltage and current wave form of triple line to ground fault using double ended method with its position

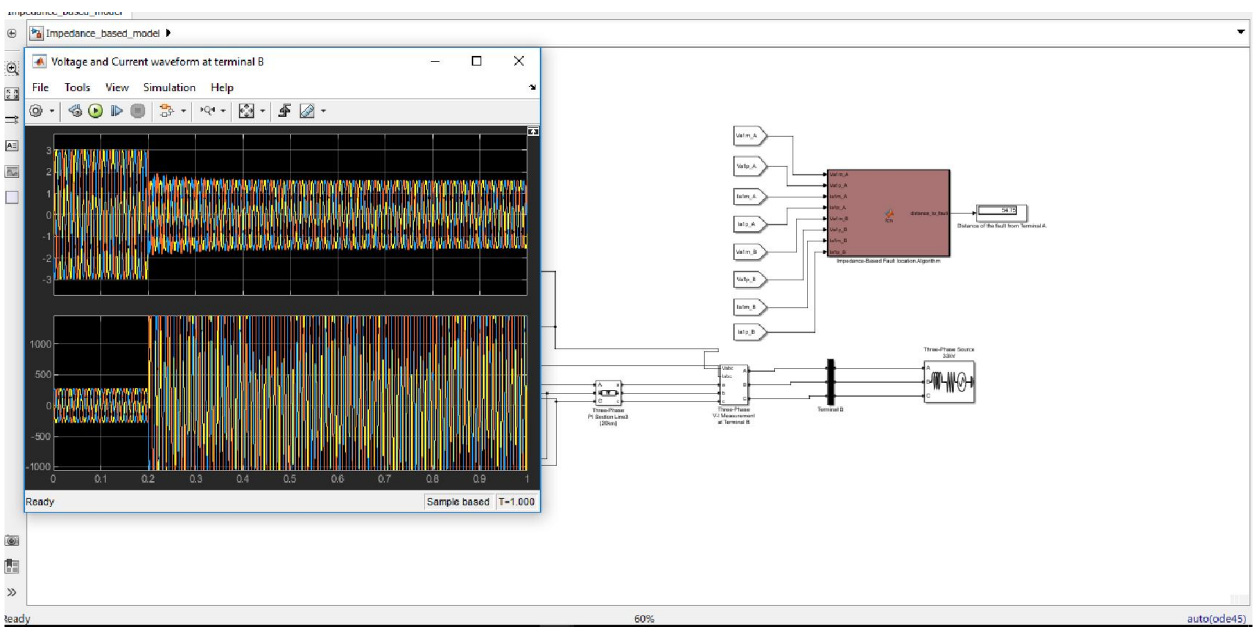

Figure 16:-Simulation result of voltage and current wave form of triple line fault using double ended method with is position

Chapter five

5.1Conclusions

The amount of transmission fault is growing and changing the network condition both in normal operation and during fault occurrences. The topic of this work involves intermittent and mechanical short circuit faults condition. There is an increased focus on reducing faults and calculate distance to fault to reducing the durations and cost for non -delivered energy. A more automated distance to fault calculation is considered to reduce outage times and research time of fault causes. Distance to fault algorithm´s accuracy depends upon many different reasons and some algorithms are usually specified for a given type of fault, in design and structure related to occurring factor (fault resistance, zero-sequence system, ground system etc.) included in the analysis. Among analyzed technique, background information and evaluated algorithms is this problematic fundamental, especially when ground faults occur. In reality, the zero–sequence system will be varied towards different impedances and resistances to ground impact on verifying soil conditions. By using double ended impendance method our project should be simulated and verified in order to understand the methodology behind the fault handling and data verification. The extensive literature survey that underlies this thesis can be a good start for further development. This report will form the basis for a comprehensive and important future work in meteorological aspects and impacts at the different fault situations on overhead line.

5.2 Recommendation

Power system fault in transmission line is the main problem which needs a significant concern to everyone power system. When fault occur in the transmission line it will damage many equipment and system blackouts may occur also, so we have to concern how to maintain those faults if it's happen in the transmission line and to maintain any fault in the system, fault location and identification method must be applied to protect equipment and to improve the quality and reliability of power supply. By using these methods we can minimize the power interruption time. So the loyalty of government increases with the customer. Finally; we have to recommend applying the fault location and identification method in our country instead of traditional method, because it improves the development of our country in a significant way.

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Appendix

```
functiondistance_to_fault = fcn(Va1m_A, Va1p_A, Ia1m_A, Ia1p_A, Va1m_B, Va1p_B,
Ia1m_B, Ia1p_B)

line_length = 80;
R= 0.01273;        %pu resistance of transmission line
X= 0.0009337;      %pu inductance of transmission line

%...Acquiring the sequence voltage and current values at both
%terminals...%
% For terminal A
a1= Va1m_A;   %magnitude of voltage at Bus A
b1= Va1p_A;   %voltage phase at Bus A
a2= Ia1m_A;   %current magnitude at Bus A
b2= Ia1p_A;   %current phase at Bus A
% For terminal B
a3= Va1m_B;   %magnitude of voltage at Bus B
b3= Va1p_B;   %voltage phase at Bus B
a4= Ia1m_B;   %current magnitude at Bus B
b4= Ia1p_B;   %current phase at Bus B

% Calculation of the coefficients
coeff1= R*a2 - X*b2;   %coefficient1
coeff2= R*b2 + X*a2;   %coefficient2
coeff3= R*a4 - X*b4;   %coefficient3
coeff4= R*b4 + X*a4;   %coefficient4

% Solving(A1)sin(delta) + (A2)cos(delta)+ A3 = 0

A1 = (-coeff3*a1)-(coeff4*b1)-(coeff1*a3)-(coeff2*b3)+(coeff1*coeff3)+(coeff2*coeff4);
A2 = (coeff4*a1)-(coeff3*b1)-(coeff2*a3)+(coeff1*b3)+(coeff2*coeff3)-(coeff1*coeff4);
A3 = (coeff2*a1)-(coeff1*b1)-(coeff4*a3)+(coeff3*b3);

delta = zeros(30,1);              % Synchronization angle at k iteration
New_delta = zeros (31, 1);   % Synchronization angle at k+1 iteration

New_delta (1) = 0;

for k= 1:30
delta(k)= New_delta(k);
% Solving the iterative equations
f1 = A2*cos(delta(k)) +A1*sin(delta(k)) + A3;
f2 = A1*cos(delta(k))-A2*sin(delta(k));

New_delta (k+1) = delta(k)-(f1/f2);
```

```
%difference= abs(New_delta(k+1)-delta(k));
%Calculating the per unit distance m
Distance_m =(a1*sin(New_delta(k+1))+b1*cos(New_delta(k+1))-
b3+coeff4)/(coeff1*sin(New_delta(k+1))+coeff2*cos(New_delta(k+1))+coeff4);

%fault distance from terminal A.
Distance to fault = distance_m * line_length;

end
```