Designing and Modeling of High-Voltage Power Lines using Matlab / Simulation Techniques

Nagaraja Bodravara[1] , Usha V[2], Niharika M Gandoli[3] , Mamatha S Kambalimata[4] , Rajeshwari DV[5]
Department of Electrical and Electronics Engineering
Jain Institute of Technology, Davangere, India

***Abstract*: The paper is a representation of Electricity is becoming more abundant every day, and the capacity of electrical power transmission lines is being transferred from one location to another. The goal of this study is to identify and locate various problems on high-voltage transmission lines. Faults such as Single Line to Ground (LG), Double Line to Ground (LL-G), Three Line to Ground (LLL-G), and Line to Line can occur in a High Voltage Transmission Line (L-L). The power system components connected in the High Voltage Transmission Line are affected by these failures.**

To detect and identify defects, the full suggested model of High Voltage Transmission Lines is modelled in MATLAB program. Sim-system Power's block library provided the fault element. Using faults such as LG fault, LL-G fault, and LLL-G fault circuit design, the proposed research simulates a variety of operating and fault scenarios on UHV transmission lines.

Keywords: UHV stands for Ultra High Voltage. L-G stands for single line to ground fault, L-L for line to line fault, LL-G for double line to ground fault, and LLL-G for three line to ground fault.

I INTRODUCTION

Introduction to the electrical power systems, different types of faults occur, and the purpose of transmission line fault analysis and detection, as well as the assessment of voltage and line current, all take place in high voltage transmission lines. In the electrical power system, the voltage and current of transmission lines are crucial. The main aim is to look into the different forms of symmetrical and unsymmetrical faults that can be occurred in transmission lines in the power system, and we have used MATLAB software to find and analyse them. Methods for fault analysis and identify, location, and fault can be classified into the three categories as given below: Sub-transient, transient and steady state Components that are overlaid -based techniques, power-based approaches, and components that are power-based approaches. Three-phase symmetrical faults and three-phase unbalance faults on the transmission line are different in a three-phase power system. On the transmission line, faults

are divided into as L-G, LL-G fault, or LLL-G fault. In fault identified and analysis on high-voltage transmission lines aids in the selection and development of better protection purposes and transmission line protection.

1.1UHV TRANSMISSION LINE

Transmission line with mega voltage Ultra-high voltage (UHV) transmission lines carry power at voltages more than 800,000 volts (800 kV). Most transmission lines in the United States operate at voltages lower than 395 kV. In terms of overvoltage, critical equipment, shunt reactor operation mode, relay protection criteria, and system impact. The different characteristics of power frequency electric field intensity and the factors that affect them, as well as the calculation for power frequency electric field of transmission lines, are discussed. The power frequency is also investigated, as well as its characteristics. On transmission cables, there are also new restrictions for high-frequency electromagnetic fields and radio interference.

1.2 TRANSMISSIONNLINE FAULT

Transmission line faults are the most well-known faults, produced by falling trees on transmission line, lightning strokes, or guarding spark over, contributing for 85-87% of force framework faults. Because of their inherent attributes of being accessible to climatic conditions, overhead cables account for a major portion of transmission framework issues.

1.3 TYPES OF FAULTS

A transmission lines issue can be shunt, series, or both, a shunt fault supplying a current between at least two levels to the ground. Shunt problems happen whenever the protection between the stages, or earth, starts to break down. Shunt faults commonly occur in one of two ways: unexpected fluctuations in line voltage and current lightning strikes strike, birds, trees, or similar; or gradual deterioration of line protection. Will result in helpless parts and worn material that will age over time.

1.4 A TRANSMISSION LINE FAULT

Transmission line faults are widespread. A line-to-line fault is defined as a short circuit current caused by physical contact between two lines. 60-80 percent of all system failures are caused by line-to-line errors. Short circuit current between one phase and ground caused by physical contact. Line-to-ground problems make for 15–25% of all faults. A short circuit current between two lines and ground accounts for 5-15 percent of all faults. As shown, applying three equal impedances to the three phases results in a three phase system.
A symmetrical flaw. Balanced faults can be either solid or bolted. Line-to-line-to-line ground faults and faults without ground are 2 types of ground faults.

1.5 FAULT DETECTION

To ensure the electrical force framework, fault location and layout on transmission lines is a major task. Under competitive and freed situations, the force framework has recently gotten more perplexing. Insurance hand-off groups the "typical condition" of the force framework and arranges the type of shortfall. Data in the stage's impedance, current, voltage, and zero grouping identify the abnormal condition of the force framework.

II LITERATURE SURVEY

"The Transmission Line Fault identification, Classification and Location utilizing Wavelet Transform" this title was clarified by P. Balakrishnan, K. Sathiyasekar in the extended period of 2019[1]**.** This title depicted that work proposes another Wavelet Transform (WT) based Discrete Wavelet Transform (DWT) strategy for shortcoming discovery, grouping, and area of overhead transmission lines. Distinctive framework deserts in transmission lines, like LG, LLG, and LLLG, ought to be distinguished, arranged, and found rapidly. To produce the transient voltage and current sign in both time and recurrence area, the recommended approach utilizes voltage and current sign data from the force model in MATLAB. To recognize and arrange shortcoming unsettling influences, DWT with "db6" as a mother wavelet is used to record transient current signals and concentrate the high recurrence detail coefficient.

"The Protection of Series Compensated Double Circuit Transmission Lines Using Neural Networks and Fuzzy Logic " this title was proposed by Bhawna Nidhi, Ramesh Kumar, Amrita Sinha in the extended period of 2013[2]. Each transfer's essential capacity is to recognize and analyse flaws, just as to segregate the defective part as fast as doable. Defensive distance transfers, which utilize impedance estimations to survey the presence and area of issues, are no longer as exact after series capacitance is added on the line. For the security of series remunerated twofold circuit transmission lines, this recommended approach utilizes a neural organization and fluffy rationale. The genuine force framework status is assessed utilizing a Neural Network, which builds the security framework selectivity. Fluffy rationale is utilized in the dynamic cycle to show up at an appropriate stumbling choice.

S. Kincic; MiloradPapic in their work “The Effect of Compensation on the voltage of transmission lines" in the extended period of 2013[3] .He Described the effect of series remuneration on transmission voltages is explored in this work, and proposals for activity are given. The examination additionally shows how neglecting to comprehend the impacts of series pay on voltages can bring about functional issues. This examination has shown that relying upon the line stacking state and how the voltage control is arranged, series pay can bring about low or high voltages. In the event that the voltage toward one side of the capacitor isn't as expected oversaw, voltage issues on the opposite finish of the capacitor might happen. The affectability examination is done utilizing the GE PSLF program and depends on a completely supported WECC base situation. A transmission line with a voltage of 500 kV.This examination utilizes a 500kVttransmission line from Midpoint substation to Summer Lake substation (BPA) for instance. Idaho Power EMS group ran a field test on a similar line in June 2007 to survey the therapeutic activity plans (RAS) capacity with series bypassing. Lattice administrators who manage remunerated lines sand switching and out series capacitors would profit from the data gave here.

"A new concept Zone Protection for Compensated Double-Circuit Transmission Lines Using a Digital Distance Relaying Algorithm " this title was clarified by Ranjet Kumar; Amrita Sinha; G.K. Chaudhary in the year of**2013**[4] **.**The title depicted that series remunerated twofold circuit transmission lines, this review presents another advanced distance transferring strategy for first-zone assurance. To register the shortcoming distance, the new strategy utilizes information from one finish of the ensured twofold circuit links. The new methodology is demonstrated to be unaffected by load current, remote in feed, or source impedances. MATLAB/SIMULINK programming was utilized to a 400-kV, 300-km transmission line to approve the proposed approach. The proposed plan's adequacy is shown by re-enhancement results, which show that the greatest rate mistake is under 5%.

Subhra Jana; Abhinandan De in their work examine about the "Transmission line issue recognition and characterization utilizing wavelet investigation" in the time of **2013**[5] Depicts about Using current sign handling procedures, the review gives another strategy to distinguishing and characterizing power framework disappointments rapidly and precisely. Wavelet investigation of tricky voltage and current waveforms recorded at an appropriate checking area in a multi-transport power framework is utilized to gain fundamental data for shortcoming determination and characterization. The utilization of wavelet investigation helps with the exact grouping of various shortcoming designs. A multi bus framework was planned in MATLAB Simulink for a contextual analysis, and different issue sorts and mixes were simulated. The results show that the recommended strategy can classify a wide range of mistakes, including numerous problem

L. de Andrade; T. Ponce de Liao in their work was express that. “Impedance-based shortcoming area investigation for transmission lines" in the extended period of **2012**[6]**.** The present status of the workmanship for shortcoming area techniques in transmission lines dependent on impedance estimations is surveyed in this work. The verifiable inspirations for these techniques are examined. Likewise, a basic assessment is completed, exhibiting the advantages and disadvantages of every one of them just as their most famous applications. At long last, genuine flaws are utilized to give a similar examination between two of the most widely utilized methodologies, exhibiting the outcomes' affectability to changes in the line boundaries

M.M. Saha; E. Rosolowski; J. Izykowski was proposed the title called "An issue area calculation for series remunerated transmission lines consolidated in ebb and flow differential defensive transfers" in the extended time of **2011**[7]**.**in this title depicts that A calculation for distinguishing deficiencies on series-repaid transmission lines is introduced in this exploration. Both single-and twofold circuit series-repaid lines can profit from the strategy. The utilization of two-end synchronized current estimations performed by current differential assurance transfers, just as the expansion of privately estimated three-stage voltage, is being contemplated. It is being respected a more prevalent choice with the shortcoming area work worked in the differential transfers at both line closes. The method utilizes two subroutines for distinguishing flaws on specific line areas, just as a strategy for picking the right subroutine.

"Assurance of equal transmission lines utilizing wavelet change" was clarified by A.H. Osman; O.P. Malik in the extended time of **2004**[8]·in their work presents another strategy for working on the arrangement of issues associated with equal transmission line assurance. The strategy depends on the two equal lines' three line voltages and six line flows at each end. The wavelet change is utilized for shortcoming discovery, issue segregation, and working out the phasors of estimated signals (WT). Inside flaws on equal lines can be found by looking at the sizes of the anticipated current phasors of the comparing stages on both lines. The procedure can likewise be improved and reinforced by ascertaining the distance component of the stages on which an unsettling influence is distinguished and having an extremely small current contrast size. As per considers, a wide range of issues might be dependably analysed in under one pattern of the principal recurrence under different stacking conditions.

M. Solanki; Y.H. Tune in their work described that "Transient security of EHV transmission line utilizing discrete wavelet examination" in the extended period of **2003**[9].describes about research traces an original high velocity EHV transmission line insurance method. This work proposes a deformity discovery and order strategy dependent on ongoing discrete wavelet examination. The depicted methodology is principally cantered around the recognition of transient signs made by deficiencies. By looking at various wavelet properties of signs from every one of the three stages, the shortcoming not set in stone. ATP-EMTP and the MATLAB wavelet tool compartment are utilized in the reproduction. The discoveries show that the proposed calculation is speedy, productive, and reliable two of the most widely utilized methodologies, exhibiting the outcomes' affectability to changes in the line boundaries

III METHODOLOGY

The proposed system presents the design and analysis of various transmission line fault current.Which are caused by falling trees, lightning strokes, or insulator string failure. 85-87% of power system issues are caused by transmission lines. The Overhead lines are largely a result of transmission system failures due to their inherent characteristics. The Faults develop in various power systems in terms of atmospheric conditions.

The power system is classified as generating, transmitting and the distributing.

Proposes using MATLAB Simulation for model in detection and identification of ultra-high voltage transmission line faults. Different types of fault detection, as well as bus voltage and line current determination, are also used in High Voltage Transmission lines.

The objective is to identify the fault of long transmission line balance and unbalance faults in the electrical power system.

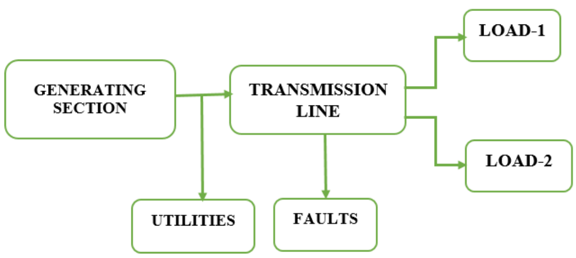


Fig 1. BlockdDiagram of High Voltage Transmission Line

The proposed method can be classified as transients-based method, power frequency components-based method and superimposed composed method, which can be used to locate fault analysis and detection, direction estimates, and fault distance locations.

In an electrical power system, two faults commonly occur: Symmetrical faults and Unsymmetrical faults on the transmission line. Faults are categorized as Line to Ground fault, double line to Ground fault, and triple line to Ground fault on the transmission line.

The power system in problem consists of two 865 KV single lines with a total length of 300 kilometres. The singles are fed from 13.8 KV generators, as shown in the block diagram.

We collected and analysed and detected fault currents, and will provide information on the fault's type. The Ultra high voltage transmission line consists of 865kV. The generator that is located on the transmission line as well as a three-phase use to simulate faults on the ultra-high-voltage transmission line at midpoint. The distributed parameter defines the faulted on UHV transmission line.

TYPES OF FAULTS:

Unsymmetrical or unbalanced faults occur when the network's balanced state is disrupted. Line to ground faults, line to line faults, and double line to ground faults are the most common. All of these are examples of unbalanced or asymmetric faults.

When any one of the phase of a transmission line develops a connection with the ground due to ice, wind, falling trees, or another occurrence, this sort of fault occurs. Seventy percent there are problems in all transmission lines. When a person makes a mistake like this, it's referred to as one conductor meets the neutral wire or falls to the ground.

As a result of high winds, one phase may come into contact with another, causing a Line-to-Line fault problems account for 15% of all transmission line failures. If a bird were to land on one transmission line and touch their wings to transmission line, or if a tree were to fall on both electricity lines.

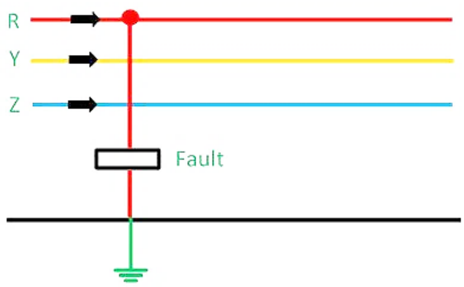


FIG 2. Line to Ground Fault.

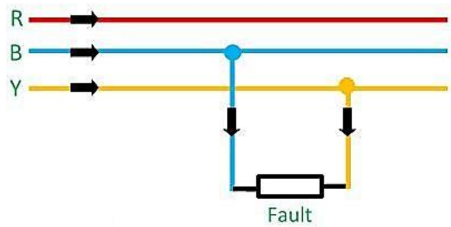


FIG 3. Line to Line Fault.

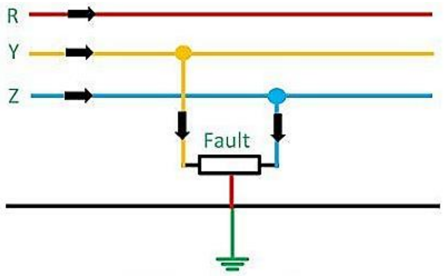


FIG 4. Double Line to Ground Fault.

In a double line to ground fault, the two lines come into touch with each other as well as the ground. The likelihood of such faults is close to ten percent. The symmetrical and unsymmetrical faults primarily occur at the generator terminal, the open circuit and short circuit faults occur in the distribution system.

For signal time fluctuations, the positive sequence reactance must be computed.

$$\mathbf{x(t)} = \{\left(\frac{1}{Xd''} + \frac{1}{Xd'}\right) e^{\frac{1}{fd''}} + \left(\frac{1}{Xd''} + \frac{1}{Xd'}\right) e^{\frac{1}{fd'}} + \frac{1}{Xd}\}\text{-}1 \quad \ldots (1)$$

Where **X_d'', X_d', X_d** are direct axis sub-transient reactance, Transient reactance and synchronous reactance

FAULT ON A TRANSMISSION LINES:

Short circuit current between lines generated by physical contact between two lines is referred to as a line-to-line fault. Line-to-line faults account for 60-75% of all system faults (e.g., a broken conductor or severe wind). - Line-to-ground fault — a short circuit between one phase and ground generated by physical contact. Line-to-ground faults account for 15–25% of all faults. Line-to-line-to-ground fault — short-circuit of two lines and ground, and 5-15 percent of line-to-line-to-ground faults are line-to-line-to-ground faults. (For instance, external factors) Because faulty power systems lack three phase symmetry, per phase analysis cannot be used to solve them. It is initially converted into its symmetrical components in order to detect fault currents and fault voltages. This is accomplished by substituting three phase fault current with the total of three phase zero sequence sources, three phase positive sequence sources, and three phase negative sequence sources. Each circuit is solved using a per phase analysis technique known as a sequence network. All the sequence components of fault voltages and currents for a double line-to-ground fault are determined in this section.

Assume that phase's b and c are linked to ground through the fault impedance Z_f. The fault current on phase an is Ia = 0 for a double line to ground fault.

The current and voltage (to ground) conditions at the fault are expressed as

$$\left.\begin{matrix} I_a = 0 \\ \text{or} \quad I_{a1} + I_{a2} + I_{a0} = 0 \end{matrix}\right\} \qquad (1)$$

$$V_b = V_c = Z^f (I_b + I_c) = 3Z^f I_{a0} \qquad (2)$$

The symmetrical components of voltages are given by

$$\begin{bmatrix} V_{a1} \\ V_{a2} \\ V_{a0} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \\ 1 & 1 & 1 \end{bmatrix}\begin{bmatrix} V_a \\ V_b \\ V_b \end{bmatrix} \qquad (3)$$

From which it follows that

$$V_{a1} = V_{a2} = \frac{1}{3}[V_a + (\alpha + \alpha^2)V_b] \qquad (4)$$

$$V_{a0} = \frac{1}{3}(V_a + 2V_b) \qquad (5)$$

From Equation (4) and (5)

$$V_{a0} - V_{a1} = \frac{1}{3}(2 - \alpha - \alpha^2)\, V_b = V_b = 3Z^f I_{a0}$$

or

$$V_{a0} = V_{a1} + 3Z^f I_{a0} \qquad (6)$$

From Equation (1), (2) and (3), we can draw the sequence networks as shown in Figs.3.4a and b. The reader may verify this by writing mesh and nodal equations for these figures.

3.4 SEQUENCE NETWORK FOR DOUBLE LINE TO GROUND FAULT:

The application of three equal impedances to the three phases causes a three-phase symmetrical fault, as demonstrated in (Figure 6). Solid faults and bolted faults are two different types of balanced faults. There are two categories of flaws: Without ground or line-to-line ground fault. The system remains balanced since all three phases are involved. A balanced fault in the transmission system is extremely rare, accounting for about 5% of all system faults.

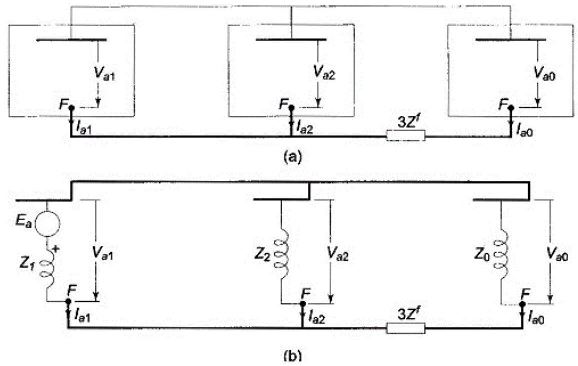


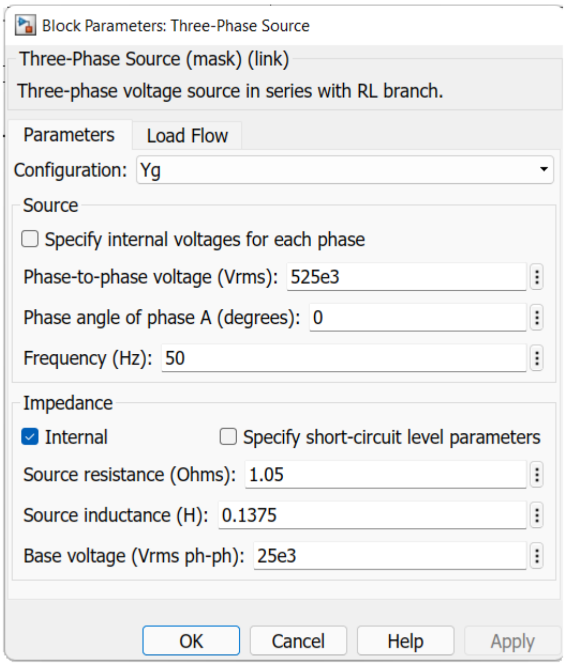
FIG 5. 1sequence Diagram for Double Line to Ground Fault

From Thevenin's equivalents, we can write from Fig. 5(b)

$$I_{a1} = \frac{E_a}{Z_1 + Z_2 \| (Z_0 + 3Z^f)}$$

$$= \frac{E_a}{Z_1 + Z_2(Z_0 + 3Z^f)/(Z_2 + Z_0 + 3Z^f)} \qquad (7)$$

IV. SIMULATION MODEL OF PROPOSED SYSTEM:



From the simulation circuit the Voltage-current measurements blocks are used to measure the voltage & current sample at source end. The high voltage transmission line, which lineis 500 Km long. Here in this modelling and simulation of three phase fault simulator is used to simulate various types of faults. In high voltage transmission line faults are:

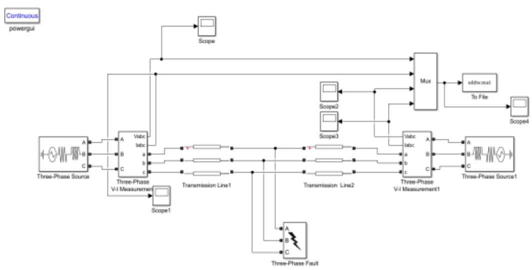


Fig 4.1Simulation Model of Proposed System.

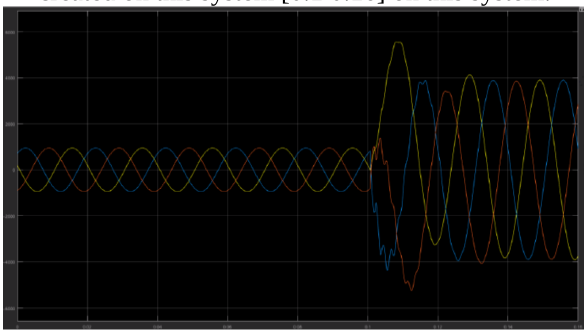
Table-1: Comparison of Output Line to Ground fault, double line to ground fault, and Triple line to ground faults Current Analysis

Sl.No	Types Of Faults	Distance	Current Valve
1	L-G	500KM	1PU
2	LL-G	500KM	1PU
3	LLL-G	500KM	1PU

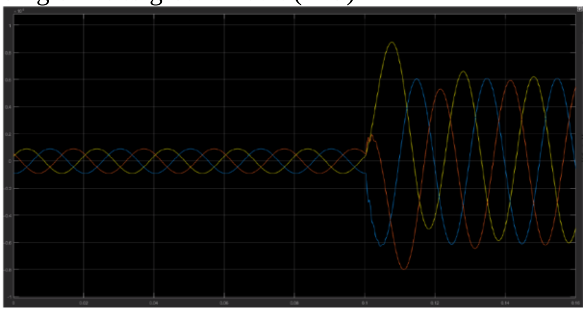
Table-2: Comparison of Input Line to Ground fault, double line to ground fault, and Triple line to ground faults Current Analysis

Sl.No	Types Of Faults	Distance	Input Fault Current
1	L-G	500KM	6 PU
2	LL-G	500KM	9.5 PU
3	LLL-G	500KM	14 PU

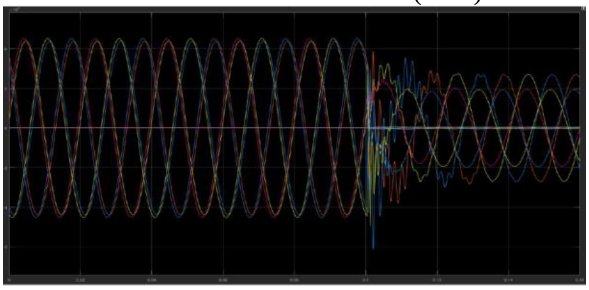
The input phase current of the system is 525kv, frequency 50, Line fault model this can be simulate single line to ground fault, double line to ground fault, line-to-line fault, three phase fault, and multi stage faults, among others. In Transmission line signal, a three Phase, 60 Hz, 525e3 kV is 200 kilo meter long. The line inductance is [0.0208 0.1148] mph/km per phase and its capacitance is [[12.9e-95.2e-9] μF/km per phase. The load connected on this system 550 kV, three phase L-L-G fault created on this system [0.1 0.16] on this system.



4.1 Single line to ground Fault (L-G)



4.2. Double line to Ground Fault (LLG)



4.3 Triple to Ground Fault (LLL-G)

4.4 RESULTS OF PROPOSED WORK

In this paper we have discussed the fault on different locations along the high voltage transmission line for various types of the faults. Now we can analyse and identify the active power, reactive power, current and voltage of the transmission line at various types of fault condition. In each case the phase of the 865kV high voltage transmission line for voltage and current are changed and also the impedance from the high voltage transmission line is not change and the whole modelling and experimental work are in MATLAB software.

4.4.1 LINE TOGROUND FAULT AT INPUT SIDE:

We created the Line to Ground fault at the time of [0.1- 0.5] sec, the transmission end voltage and current response. Here we have simulation and Modelling on Line to Ground fault occurs and their one of the phase is short to the ground and the fault impedance is not zero. When their Output wave form shows therise of current on Line to Ground fault occur on high voltage transmission line.

4.4.2 WITHOUT FAULT

When we perform balance input to a high transmission line and there is no fault in the line, and the current and voltage will be visa-versa. These are the reference values. These variables are changed, and their phase is considered as faulty.

V.CONCLUSION

In this paper, we investigate the location of faults on high voltage transmission lines using MATLAB software and the Sim-power system tool in Simulation detect the fault and analysis on a 440 kV transmission line of 300km. Travelling wave properties of high voltage transmission lines were discussed. High voltage transmission lines now have four types of faults: Line-Ground (L-L), Double line – Ground (LL-G), Triple line-Ground (LLL-G) and L-L-L. This simulation and experimental analysis takes a 300 km distance into consideration, as well as several forms of faults, such as line to ground faults, double line to ground faults, triple line to ground faults, and L-L-L faults, are detected and analysed on this paper to their recommended work.

In this paper, we discuss earth fault analyses which have already been undertaken at various locations along the high voltage transmission line for different forms of faults. Now we can monitor and detect the active power, reactive power, current, and voltage of a transmission line system under different fault current. The phase of the 865kV transmission line is altered for voltage and current in each scenario, but still the impedance from the high voltage transmission line is not changed, and the entire modelling and experimental work is performed in MATLAB software.

REFERENCES

[1] Kincic and Papic, "Impact of series compensation on the voltage profile of transmission lines," Power and Energy Society General Meeting (PES), 2013.

[2] S. A. Kumar, R. and G. Chaudhary, "A new digital distance relaying algorithm for first-zone protection for series- compensated double-circuit transmission lines," Advances in Computing and Communications (ICACC), 2013.

[3] .R. E. Saha, M.M. and J. Izykowski, "A fault location algorithm for series compensated transmission lines incorporated in current differential protective relays," The International Conference on Advanced Power System Automation and Protection, pp. 706-711, 2011.

[4] Osman and O. Malik, "Protection of parallel transmission lines using wavelet transform," IEEE Transactions on power delivery, vol. 19, no. 1, 2004.

[5] B. K. G. V. S. Ashok, V. and V. Murthy, "Identification and classification of transmission line faults using wavelet analysis," ITSI Transactions on Electrical and Electronics Engineering, vol. 1, no. 1, pp. 117- 122, 2013.

[6] N. V. P. C. Roshni, U. and R. Srinivas, "Location of faults in transmission line using fast flourier transform and discrete wavelet transform in power systems," Undergraduate Academic Research Journal (UARJ), 2012.

[7] M. Solanki and Y. Song, "Transient protection of EHV transmission line using discrete wavelet analysis," Power Engineering Society General Meeting, IEEE, 2011

[8] K. R. Nidhi, B. and A. Sinha, "Neural network and fuzzy logic based protection of series compensated double circuit transmission line," International Journal of Engineering Research and Applications (IJERA), 2013.

[9] L. Andrade and T. deLeao, "Impedance based fault location analysis for transmission lines," Transmission and Distribution Conference and Exposition (T&D), 2012 IEEE PES, 2012.

[10] B.P. Saravanababu, K. and K. Sathiyasekar, "Transmission line faults detection, classification, and location using discrete wavelet transform," International Conference on Power, Energy and Control (ICPEC), 2013.

[11] O.A.S.Youssef, "Fault classification based on wavelet transform," Transmission and Distribution Conference and Exposition IEEE/PES, 2014.

[12] K. M. S. M. Reddy, R.B. and C. Prasanth Babu, "Fault detection, classification and location on transmission lines using wavelet transform," Electrical Insulation and Dielectric Phenomena, 2009.