ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

Transmission Line Protection for Symmetrical and Unsymmetrical Faults using Distance Relays

V.Usha Rani[1], Dr.J.Sridevi[2]

Assistant Professor, Dept. of EEE, Gokaraju Rangaraju Institute of Engg.&Tech, Hyderabad, Telangana, India[1]

Professor, Dept. of EEE, Gokaraju Rangaraju Institute of Engg.&Tech, Hyderabad, Telangana, India[2]

ABSTRACT:The key challenge to the transmission line protection lies in reliably detecting and isolating faults compromising the security of the system**.**In this paper MHO Characteristics and Frequency Dependent (Phase) model type transmission line are modelled and simulated using PSCAD/EMTDC software.A Fast Fourier Transform block in PSCAD/EMTDC has been used to extract the fundamental component.Unsymmetrical and symmetrical faults at different zones were performed to study the performance of the relay characteristics and to investigate the consistency of the relay models generated with the proposed methodology. The test network used in this paper is 230kv transmission line systems.

KEYWORDS: Line protection, Mho relay, Symmetrical faults, Unsymmetrical faults, Zone protection.

I.INTRODUCTION

Importance of Transmission line Protection: 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 69kV to 765kV, and are ideally tightly interconnected for reliable operation. Any fault, if not detected and isolated quickly will cascade into a system wide disturbance causing widespread outages for a tightly interconnected system operating close to its limits. Transmission protection systems are designed to identify the location of faults and isolate only the faulted section. The key challenge to the transmission line protection lies in reliably detecting and isolating faults compromising the security of the system.The high level factors influencing line protection include the criticality of the, fault clearing time requirements for system stability, line length, the system feeding the line, the configuration of the line, the line loading, the types of communications available, and failure modes of various protection equipment.The Main objectives of Transmission line protection are minimizing the duration of a fault, service continuity, improved voltage regulation, reduced power losses, finally Quality output power. Withoutproper protection system, it is impossible to achieve above benefits.

When a fault occurs, the characteristic values may change from existing values to different values till the fault is cleared**.**Once the fault takes place, voltage and current values deviates from their nominal ranges.The faults in power system causes over current, under voltage, unbalance of the phases, reversed power and high voltage surges. This results in the interruption of the normal operation of the network, failure of equipments, electrical fires, etc.

In this paper, the performance of the relay characteristics for unsymmetrical and symmetrical faults at different zones were simulated using PSCAD software and analysed to investigate the consistency of the relay models**.** PSCAD is graphical user interface, provides powerful means of visualizing the transient behaviour of the systems. PSCAD/EMTDC provides a fast and accurate solution for the simulation of electrical power systems.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

II.SYMMETRICAL AND UNSYMMETRICAL FAULTS

Faults that occur in transmission lines are broadly classified into open and short circuit faults and again these can be symmetrical and unsymmetrical faults.In symmetrical faults, all the three phases are short-circuited to each other and often to earth. Such fault is balanced in the sense that the systems remain symmetrical, or the lines displaced by an equal angle. These arevery severe type of faults involving high currents and occur infrequently in the power systems. These are also called as balanced faults and are of two types namely L-L-L-G and L-L-L faults.Unsymmetrical faults are very common and less severe than symmetrical faults. These are mainly three types namely line to ground (L-G), line to line (L-L) and double line to ground (LL-G) faults.

III.DISTANCE RELAYS

Distance relay, which functions depending upon the distance of fault in the line. More specifically, the relay operates depending upon the impedance between the point of fault and the point where relay is installed. Distance relays are designed to protect power systems against basic types of faults LG, LL-G, LL and three phase faults. The basic principle of distance protection involves the division of the voltage at the relaying point by the measured current. The apparent impedance so calculated is compared with the reach point impedance. If the measured impedance is less than the reach point impedance, it is assumed that a fault exists on the line between the relay and the reach point. The reach point of a relay is the point along the line impedance locus that is intersected by the boundary characteristic of the relay. Since this is dependent on the ratio of voltage and current and the phase angle between them, it can be plotted on an R/X diagram. The fault impedance calculation formula for all types of faults are shown in Table 1.

Table 1: Fault Impedance calculations on different faults

Distance Element	Formula
Phase A	$Z_A = V_A/(I_A + 3kI_0)$
Phase B	$Z_B = V_B/(I_B + 3kI_0)$
Phase C	$Z_C = V_C/(I_C + 3kI_0)$
Phase A-Phase B	$Z_{AB} = V_{AB}/(I_A - I_B)$
Phase B-Phase C	$Z_{BC} = V_{BC}/(I_B - I_C)$
Phase C- Phase A	$Z_{CA} = V_{CA}/(I_C - I_A)$

Where, $k = (Z_0-Z_1) / Z_1$, Z_0 and Z_1 are zero sequence and positive sequence impedances.

Zones of Protection: To limit the extent of the power system that is disconnected when a fault occurs, protection is arranged in zones as shown in Fig.1. Ideally, the zones of protection should overlap, so that no part of the power system is left unprotected.For practical physical and economic reasons, this ideal is not always achieved, accommodation for current transformers being in some cases available only on one side of the circuit breakers. This leaves a section between the current transformers and the circuit breaker that is not completely protected against faults.Distance relays will have instantaneous directional zone 1 protection and one or more time delayed zones. Three protection zones in the direction of the fault are used in order to cover a section of line and to provide back-up protection to remote sections. Some relays have one or two additional zones in the direction of the fault plus another in the opposite sense, the latter acting as a back-up to protect the busbars. In the majority of cases the setting of the reach of the three main protection zones is made in accordance with the following criteria: Mho relay characteristics for three zones of protection as shown in the Fig. 1.Relay is located at A. Z1, Z2 and Z3 are the setting impedance of the mho relay for zone1, zone2 and zone3. AD is the total transmission line impedance divided into three zones AB, BC and CD.
Zone 1: This is set to cover between 80 and 85 per cent of the length of the protected line;
Zone 2: This is set to cover all the protected line plus 50 per cent of the shortest next line;
Zone 3: This is set to cover all the protected line plus 100 per cent of the second longest line plus 25 per cent of the shortest next line.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

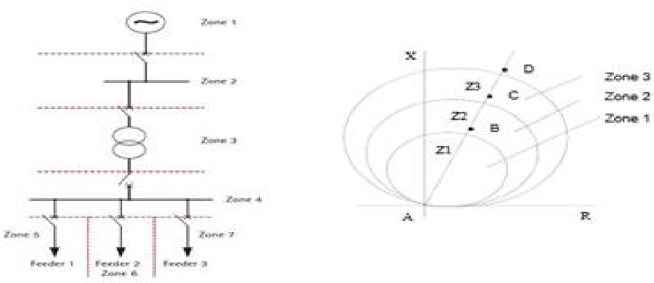

Fig. 1 Division of power system into protection zones and its Mho relay characteristics

IV. RESULTS AND DISCUSSIONS

The doubly fed transmission line has been represented using the Frequency Dependent (Phase) model, which operating at 230kV, 50 Hz. Relay is located at bus-1 as shown in Fig. 3. The source data is R=9.186 Ω, L=138mH and the transmission line positive sequence impedance is 0.12312+j0.663 Ω/km and zero sequence impedance is 0.08844+j0.2397 Ω/km

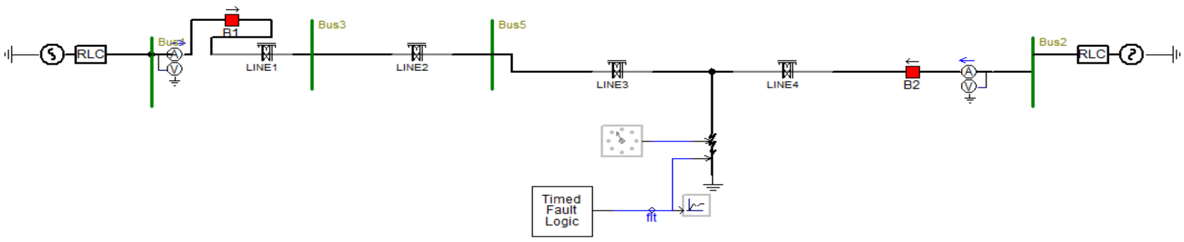

Fig. 2 Transmission Line model

When a transmission line is subjected to a fault, the voltage signals and current signals contain decaying dc components, higher order frequency components and lower order frequency components. This affects the performance of digital relay. Therefore, the Discrete Fourier transform is usually used to remove the dc-offset components. The Fast Fourier Transform is a fast algorithm for efficient computation of DFT. FFT reduces the number of arithmetic operations and memory required to compute the DFT. Fig. 4 shows mho relay modelling algorithm, which uses FFT block in PSCAD/EMTDC for extracting the fundamental frequency component.

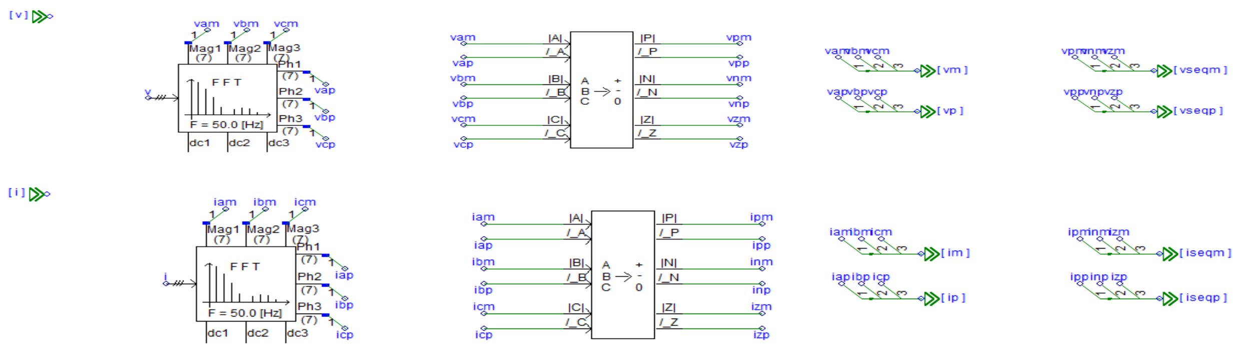

Fig.3 Fast Fourier Transform block in PSCAD

Setting of Mho relay:

Zone-1 = 53.95 Ω (80 % of protected line AB).
Zone-2 = 101.16 Ω (100 % of protected line AB + 50 % of the protected line BC).

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

Zone-3 = 151.75 Ω (100 % of protected line AB + 100 % of the protected line BC+25% of the protected line CD).

Impedance settings for the three zones are given in Table 2.

Table 2: Settings of Zones of Protection

Zone	R	X
1	9.84	53.04
2	18.46	99.48
3	27.7	149.2

To study the behaviour of the developed mho relay characteristics for symmetrical and unsymmetrical faults at different locations on the 230kV, 300km transmission line were simulated using PSCAD/EMTDC software. The behaviour of the mho relay is as explained here in after.

Case 1: - Unsymmetrical faults at different distances from the relay location

When Single line to ground fault was set on the 230kV, 300 km transmission line model at a distance of 60km from the location of bus-1, simulation results are shown in Fig. 4.

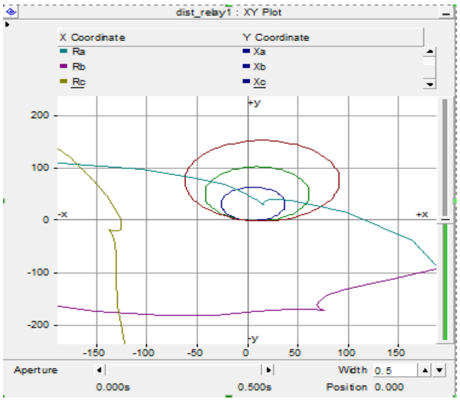

Fig.4LG fault at 60 km from bus-1 (zone 1)

When single line to ground fault was set on the transmission line model at a distance of 50kmfrom bus-3,simulation results are shown in Fig.5.

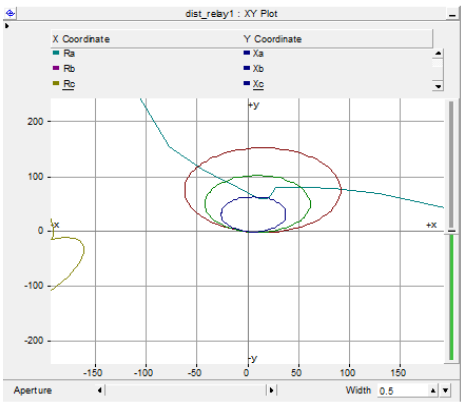

Fig.5 LG fault at 50 km from bus-3 (zone 2)

When single line to ground fault was set on the transmission line model at a distance of 25kmfrom bus-5,simulation results are shown in Fig.6.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

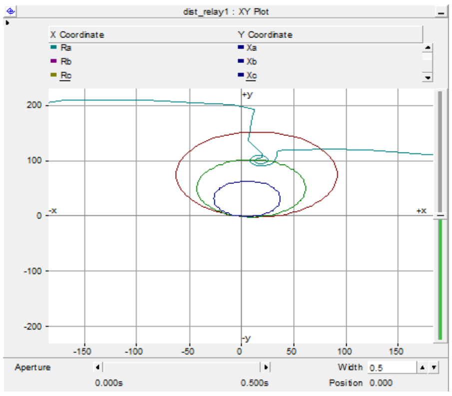

Fig.6 LG fault at 25 km from bus-5 (zone 3)

Double line to ground fault was set on the 230kV, 300 km transmission line model at a distance of 60km from the location of bus-1. Simulation results are shown in Fig. 7.

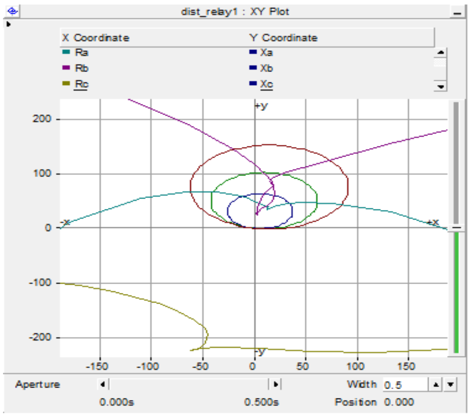

Fig.7LLG fault at 60 km from bus-1 (zone 1)

Double line to ground fault was set on the transmission line model at a distance of 50km from the location of bus-3. Simulation results are shown in Fig. 8.

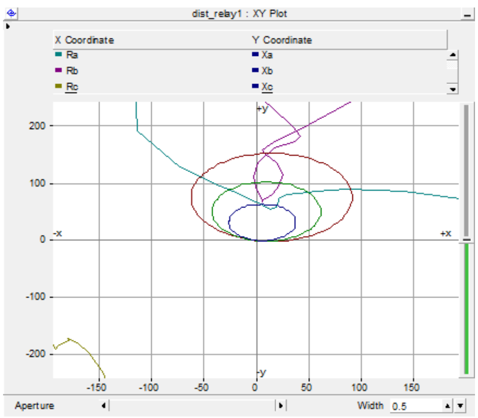

Fig.8LLG fault at 50 km from bus-3 (zone 2)

Double line to ground fault was set on the transmission line model at a distance of 25km from the location of bus-5. Simulation results are shown in Fig. 9.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

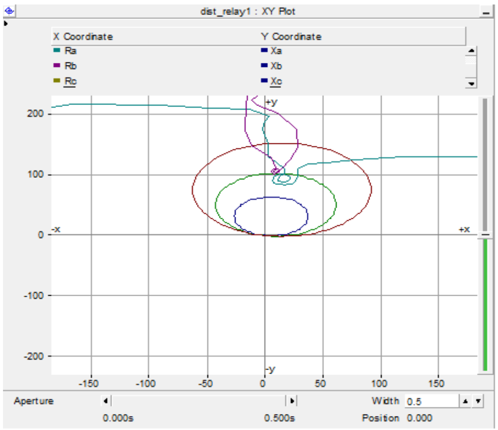

Fig.9LLG fault at 25 km from bus-5 (zone 3)

Case 2: - Symmetrical faults at different distances from the relay location

Three phase fault was set on the 230kV, 300 km transmission line model at a distance of 60km from the location of bus-1. Simulation results are shown in Fig. 10.

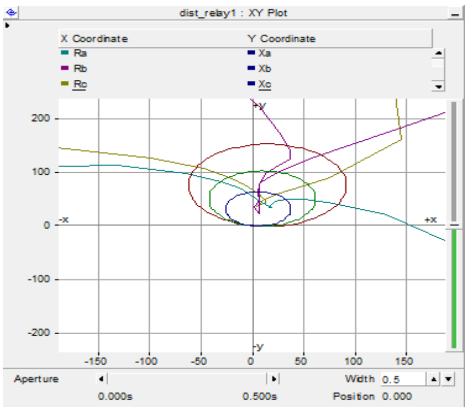

Fig.10LLL fault at 60 km from bus-1 (zone 1)

Three phase fault was set on the transmission line model at a distance of 50km from the location of bus-3. Simulation results are shown in Fig. 11.

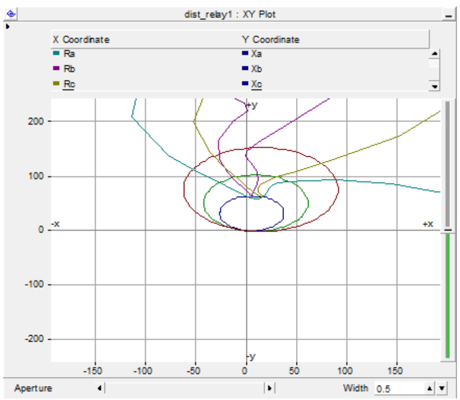

Fig.11LLLfault at 50 km from bus-3 (zone 2)

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

Three phase fault was set on the transmission line model at a distance of 25km from the location of bus-5. Simulation results are shown in Fig. 12.

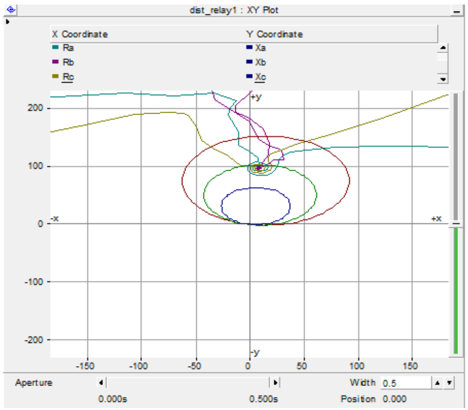

Fig.12LLL fault at 25 km from bus-5 (zone 3)

Three phase to ground fault was set on the 230kV, 300 km transmission line model at a distance of 60km from the location of bus-1, bus-3 and bus-5. Simulation results are shown in Fig. 13.

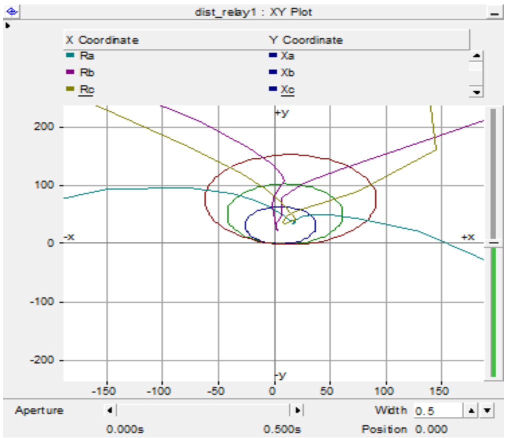

Fig.13LLLG fault at 60 km from bus-1 (zone 1)

Three phase to ground fault was set on the transmission line model at a distance of 50km from the location of bus-3. Simulation results are shown in Fig. 14.

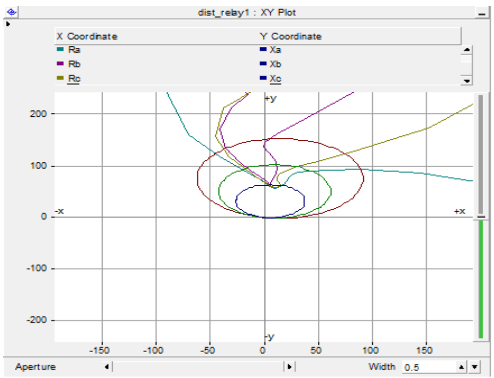

Fig.14LLLGfault at 50 km from bus-3 (zone 2)

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

Three phase to ground fault was set on the transmission line model at a distance of 25km from the location of bus-5. Simulation results are shown in Fig. 15.

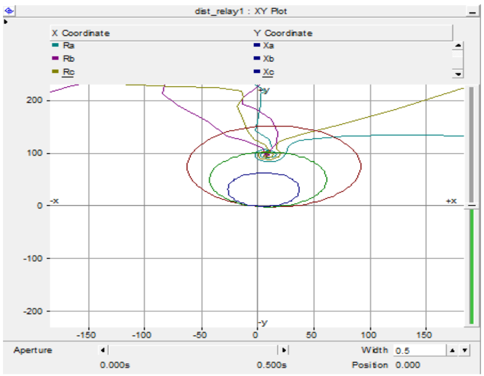

Fig.15LLLG fault at 25 km from bus-5 (zone 3)

The voltage and current waveforms of a Transmission line model for Three Phase fault are shown in Fig.16

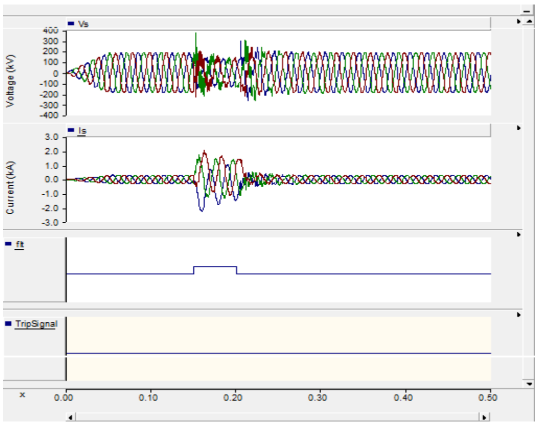

Fig.16 Voltage and Current waveforms for Three Phase fault

V.CONCLUSION

In this paper doubly fed transmission line has been considered to study the mho relay characteristics using PSCAD. The performance characteristics of mho relay have been evaluated at different locations with symmetrical and unsymmetrical faults. Different case studies have been presented to illustrate the response of mho relay characteristics at various zones with different types of faults. The voltage and current waveforms of a transmission line are presented to evaluate the response due to the fault.

REFERENCES

[1] Vijay H. Makwana, Bhavesh R. Bhalja , "A New Digital Distance Relaying Scheme for Series-Compensated Double-Circuit Line During Open Conductor and Ground Fault",IEEE Transactions on Power Delivery ,Volume: 27, Issue: 2, April 2012.

[2] V.H. Makwana , B. Bhalja, "New adaptive digital distance relaying scheme for double infeed parallel transmission line during inter-circuit faults" , IET Generation, Transmission & Distribution ,Volume: 5, Issue: 6, June 2011

[3] G. Sudha,T. Basavaraju, "A comparison between different approaches for fault classification in transmission lines," IEEE Trans.ISSN:0537-9989, 20-22 Dec. 2007.

[4] D.L. Waikar , S. Elangovan , A.C. Liew, "Fault impedance estimation algorithm for digital distance relaying",IEEE Transactions on Power Delivery ,Volume: 9, Issue: 3, Jul 1994.

[5] Tomislav Bujanovic ,Prasanta Ghosh, "Adaptive algorithm for microprocessor based distance relays in smart grid ",IEEE Trans. Smart Energy Grid Engineering (SEGE), 2016.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

[6] M.P.Thakre, V.S.Kale, "Distance Protection for long transmission line using PSCAD",International Journal of Advances in Engineering & Technology, ISSN: 22311963, Jan. 2014.

[7] Armando Guzman, Joe Mooney, "Transmission Line Protection System for Increasing Power System Requirements", International Symposium Modern Electric Power Systems (MEPS) Wroclaw, Poland ,September 2010.

[8] J.F. Liu,P.L. Wilson, Rohitha Jayasinghe "A PSCAD/EMTDC based simulation study of protective relay", Developments in Power System Protection,Eighth IEE International Conference ,Volume: 1, 2004.

[9] Mayurkumar B. Bhalani & Ajay M. Patel, "Evaluation Of Ground Fault In Distance Protection Of Transmission Lines Using Impedance Correction Algorithm" ,International Journal of Electrical and Electronics Engineering Research (IJEEER), Vol. 4, 43-50, Issue 3, Jun 2014.

[10] Anurag Choudhary, "PSCAD Simulation High Resistance Fault in Transmission Line Protection Using Distance Relay", The Engineering Journal of Application & Scopes, Volume 1,Issue 1, March 2016

[11] Hadi H. Alyami, "Protective Relay Models for Electromagnetic Transient Simulation", International Journal of Innovative Research in Advanced Engineering (IJIRAE), ISSN: 2349-2163, Volume 2, Issue 1,January 2015