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PERFORMANCE COMPARISON OF IMPEDANCE AND MHO RELAY CHARACTERISTICS USING THE PSCAD

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Abstract: - *This paper will discuss and model the characteristics of the Mho relay and impedance Relay Characteristics. Modelling of Protective Relay offer an economical and feasible alternative to investigate the performance of relay and protection systems. In this paper Mho and Impedance relay characteristics type Protection system are modelled and simulated suing PSCAD/EMTDC Software. To study the performance of the relay characteristics, different type of faults (L-G, L-L, L-L-G etc.) at different locations are considered. Here the comparison of the relay characteristics under fault resistance is considered. Fast Fourier Transform (FFT) Block is used to extract the Fundamental component of the Frequency. In this paper the 220KV transmission line is modelled.*

Keywords: *- Mho relay, impedance Relay, Distance Protection, Fast Fourier Transform, fault Resistance, PSCAD/EMTDC.*

I.INTRODUCTION

This chapter introduces the fundamental operation of the distance relay and the theories of the transmission line protection. It also contains the description of the purpose and the background of the research. The stu dy focuses on the discrimination of the distance relay, mis-operation of the distance relay and the effect of disturbance to distance relay. One of the most precise important protective equipments employed in the power system are protective relays. These a re one of the most flexible economic and well known devices that provide a fast, reliable and inexpensive protection. Relay is defined by the IEEE as "an electrical device that is design to expound input conditions in a prescribed manners and after specified conditions are met, to respond to the cause contact operations or similar abrupt changes in associated electrical circuits "relay acquires signal from the power system (electrical, Mechanical, heat, pressure, etc.) and process them with a designed process or algorithm. IEEE defines the protective relay as "a relay whose fun ction is to detect defective/faulted lines or apparatus or other power conditions of an abnormal or dangerous nature and to initiate appropriate control circu it actions".

When a short circuit fault occurs on a transmission line, Distance relay gives protection and trips the circuit breaker by disconnecting the healthy section from the faulty section. To study the behaviour of the distance relay during short circuits, for designing the new prototype, to check and optimize the performance of the relay that already installed in the power system. To design a new relaying algorithm and to check the performance of the new relay equipment it is necessary to model the distance relay.

Relay model help engineers and consultants to select the relay types for particular application and analyse the performances .Researchers and engineers use relay model to investigate and improve the protection design and algorithm. Instead of using actual prototypes the manufacturer use relay model to expedite and economize the process o f developing new relays. The software models can be used for training young and inexperienced engineers and technicians. Thus, computer models of relays permit investigators to observe in a very detailed way the performance in each internal module of the relay. PSCAD/EMTDC is an electromagnetic transient analysis program developed by the Manitoba HVDC Research Centre. The program encompasses a wide variety of steady state and transient power system studies. The primary solution engine is EMTDC which represents and solve differential equations for the entire power system in time domain employing the electromagnetic transient algorithm proposed by Dommel. The graphical user interface is named as PSCAD and it provides a powerful means of visualizing the transient performance of the system. Together PSCAD and EMTDC provide a fast, accurate and flexible solution for the simulation of the electrical equipment or systems.

In this paper the concept of distance protection and impedance setting rule for three zones of transmission line are given in Section II. The Problems of Distance protection are described in section III. The conceptual and Mho relay model algorithm is described in section IV.The Problem formulation and System modelling presented in section V. also the result and discussion are given in section VI. At the last the Conclusion and Future scope is given in the section VII.

II. BASICS OF DISTANCE RELAY

Electrical power utilities use relay models to confirm how the relay would perform during system disturbances and normal operating conditions and to make the necessary corrective adjustment on the relay settings. The software models can be used for training young and inexperienced engineers and technicians. Thus, computer models of relays permit investigators to observe in a very detailed way the performance in each internal module of the relay.The protection is managed in overlapping zones. No part of the system is left unprotected. A comparison of the local signals enables the relay to decide which zone contains the fault. In this way the distance assessment is made from the relay location to the fault location. Distance relaying applies the principal of ratio comparison between the voltage and current which equates to the impedance.

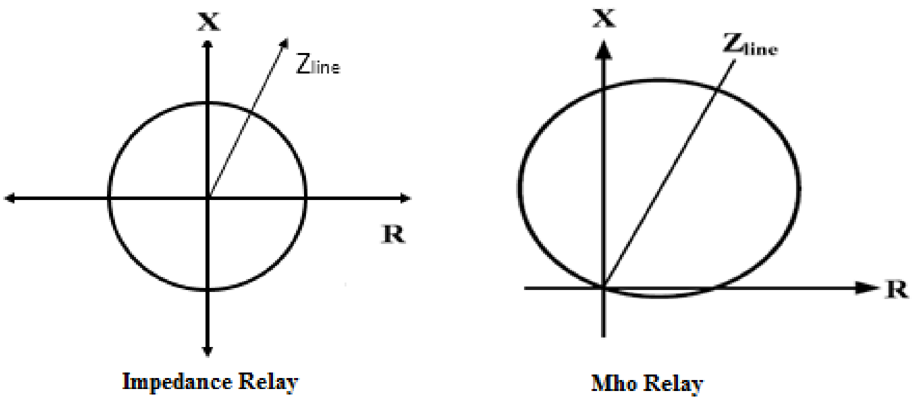

Figure 1 Distance Relay Characteristics [12]

2.1 Impedance seen by the distance relays

Distance relays are designed to protect power systems against four basic types of faults L-G, LL-G, LL and three phase fault. In order to detect any of above faults each one of the zones of distance relays require six units. Three units for detecting faults between the phases and the remaining three units for detecting phase to earth faults. The setting of distance relays is always calculated on the basis of the positive sequence impedance. Table 1 indicates fault impedance calculation formulae for all of the fault types.

TABLE 1. Fault impedance calculation 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 $k= (Z_0-Z_1)/Z_1$ Z0 and Z1 are the Zero sequence and Positive sequence impedance

2.2 Zones of Protections for Transmission line Protection.

Most of the transmission line protections are arranged into three protection zones. Each zone uses different protection sections.Figure2 shows the arrangement of the three protection zones. These protection zones are used to define the relay reach and their operation times.

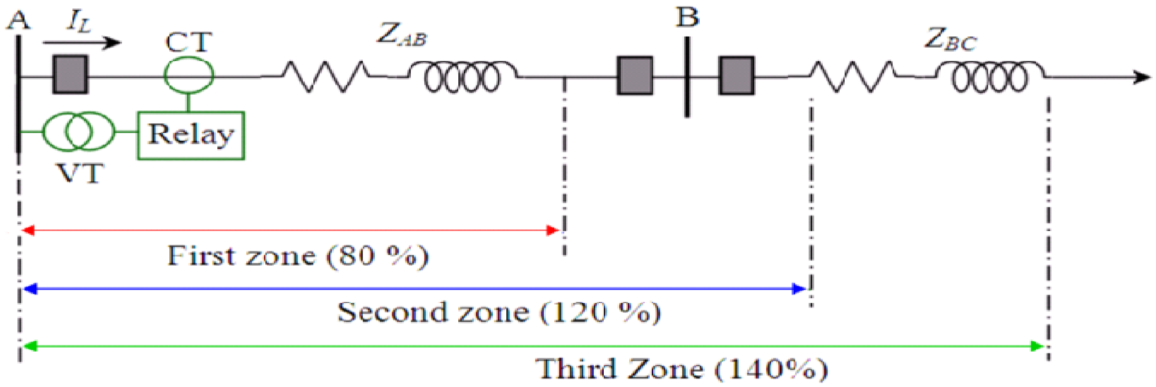

Figure 2. Three Protection zones of Transmission Line

Each protection zone is set to cover the predefined length of the transmission line. Typical selection of the zones in the transmission line protection is to cover the 80 to 90% of the transmission line in zone 1, 120-150% in zone 2 and 200 - 250 5 in zone 3. The relays operation times associated with each zone are different in zone 1, relay operates instantaneously, zone 2 is delayed to allow the zone 1 relay operate first. Zone 3 times allows the corresponding relays closer to the fault to operate first either in zone1 or zone2.The time step approach for different protection zones allows the relays closest to the fault to operate first. If they fail to operate, the relay located at the remote terminals that see the same fault as in zone 2 will still disconnect the failed component. If zone2 relay fails to operate, the relay located further away from the faulted line will operate next with the zone 3 setting.

III. PROBLEM OF DISTANCE PROTECTION

Many Problems affects the application of Distance Protection in power systems. These problems are listed as below

- The distance relay mal-operates during a power swing condition due to the reason that the apparent impedance in system may come inside the zone.

- Discrimination between the healthy load and a system fault condition which the distance relay must be able to identify these condition to prevent mal-operation. Due to fault resistance the relay may under reaches.

- **The fault may create problems for distance measurements because the value of the fault resistance makes to distance relay produces error apparent impedance which may be difficult to forecast.**

- The current in-feed from other transmission lines causes voltage drop on the fault resistance. Affect to distance relays to measure incorrect apparent impedance. This may contribute to incorrect calculation of the apparent impedance

Many a times it is impossible to investigate the mentioned topics on the real systems due to operation, security and economical restrictions. Several approaches and resources have been developed to overcome these difficulties. These include real time digital simulators (RTDS) and real time playback simulators (RTPS) and software packages for modelling protective relays.

IV. MHO RELAY ALGORITHM

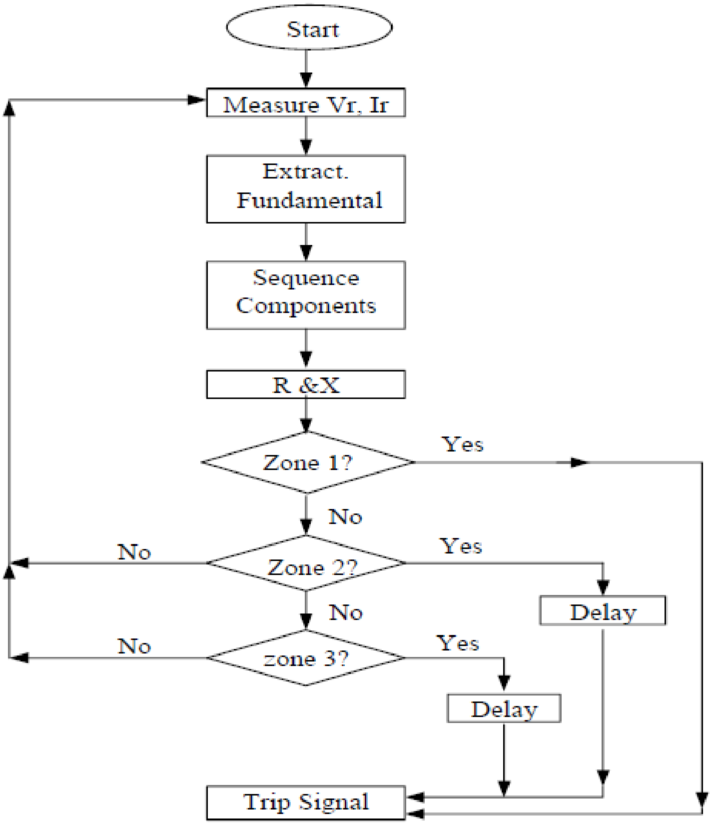

Figure 3. Algorithm for the Mho Relay Protection [1]

Figure 4.indicates the Fast Fourier Block of the PSCAD/EMTDC. The higher order harmonics can be eliminated using anti-aliasing low pass filters with appropriate cut off frequency, But the anti-aliasing filters do not remove decaying DC components and rejects low order frequency components. This affects the performance of the distance relay. Therefore discrete Fourier transform is used to remove the DC offset components. The fast Fourier algorithm is a fast algorithm for efficient calculations of DFT.

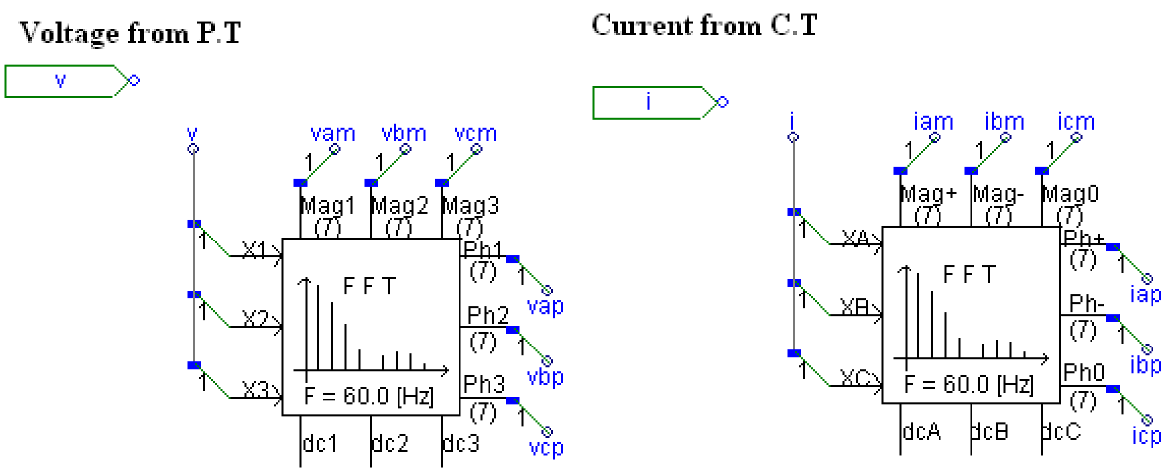

Figure 4 Fast Fourier Transform Block used in PSCAD

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V. EXPERIMENTAL SETUP OF PARAMETERS OF TRANSMISSION LINE

Models is a symbolically interpreter for the EMTP/PSCAD that has recently gained popularity for the electromagnetic transients' Phenomenon modelling .Modelling enables monitoring and controllability of power systems as well as some algebraic and relational operations for Programming. It models the system by describing the physical constants and /or the subsystems functionally for the target systems.

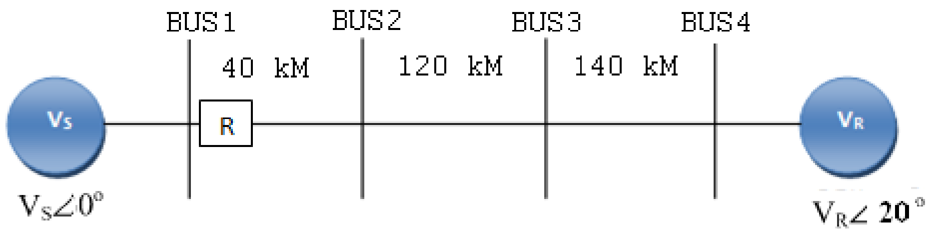

Figure 5 Single Line Diagram of Transmission Line in PSCAD

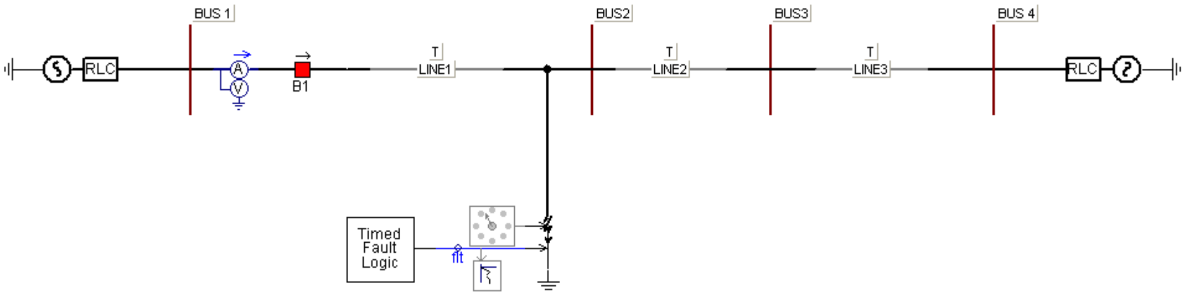

Figure 6 Systems Modelling of Transmission Line in PSCAD

Here in this paper in order to prove the digital distance relay an External fault is applied to the Power system with Phase A to Ground fault. Than with different fault is made at first and last section and try to get the results for different faults with R-X trajectory the following arrangement in PSCAD is used.

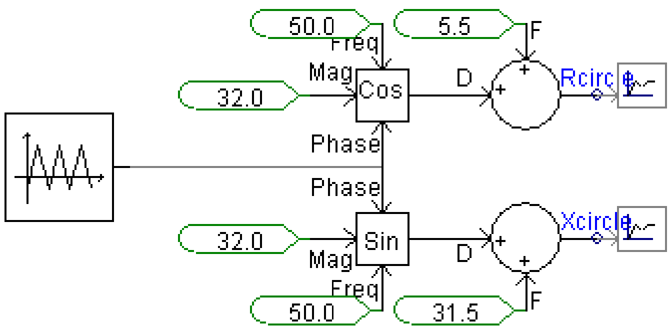

Figure 7 Relay plotting logic in PSCAD

VI. SIMULATION RESULTS

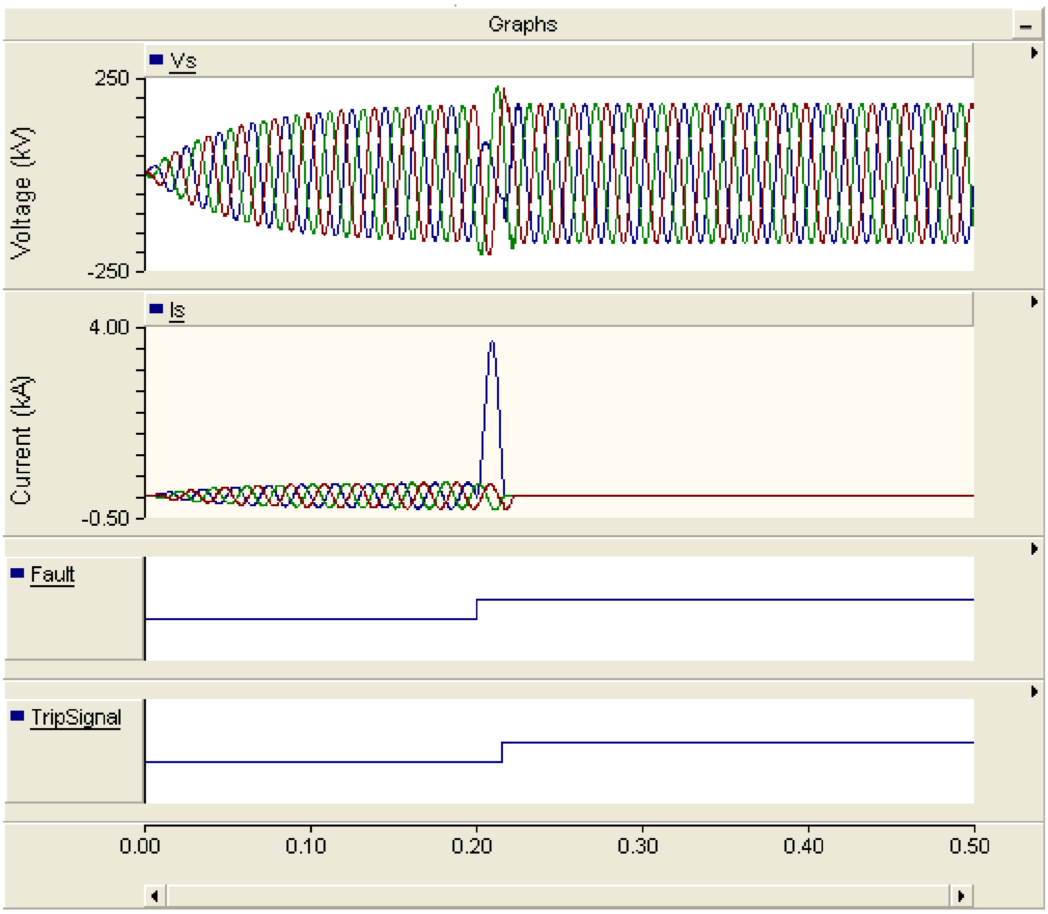

Figure 7 Waveform for the L-g Fault Mho Relay

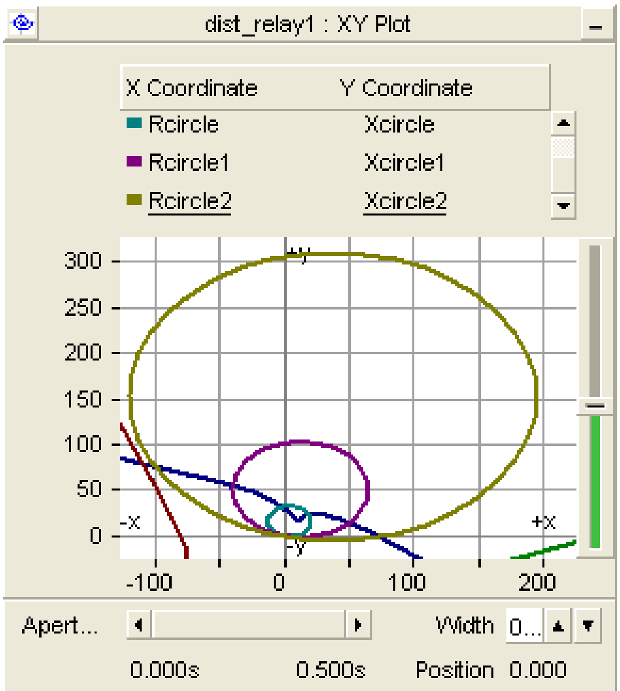

Figure 8 Line–Ground Faults for Mho relay

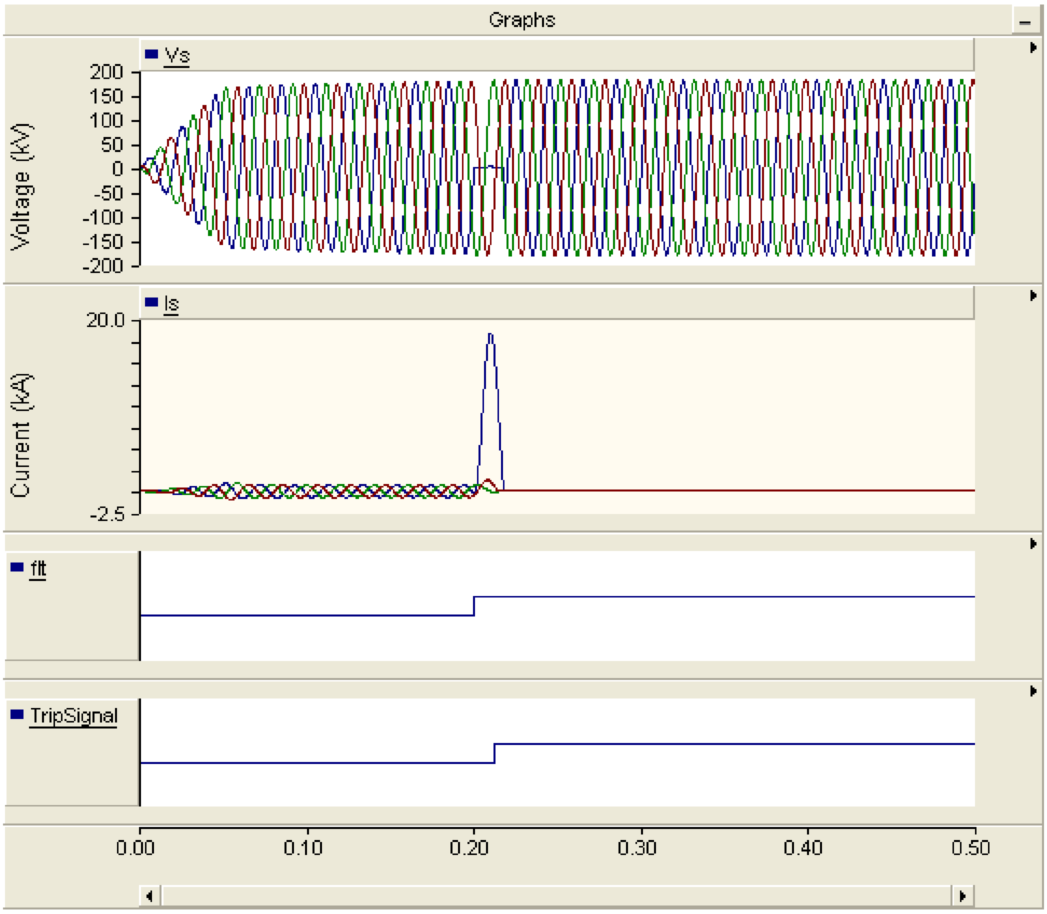

Figure 9 Waveform for the L-g Fault Impedance Relay

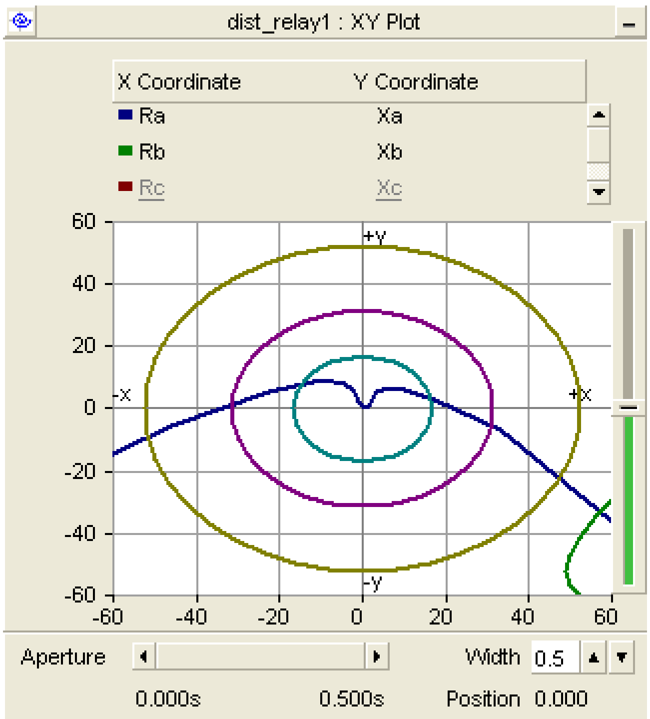

Figure 10 Line–Ground Faults for Impedance Relay

Results for Fault Resistance

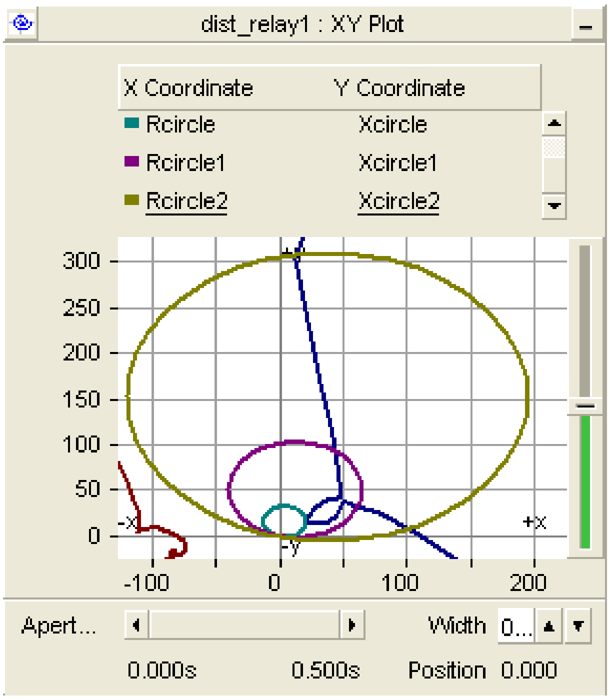

Figure 11 L-G fault for Rf = 28Ω

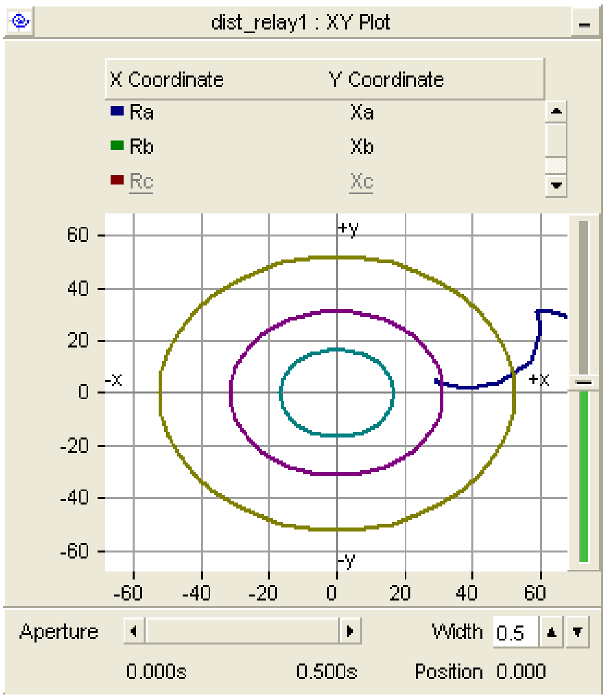

Figure 12 L-G Fault r Rf= 28Ω

- Figure 8 above shows the trajectories of the apparent impedance and the waveforms of the voltages current and trip signal of the MHO relay for the same system with L-G faults applied within the zones of the distance protections so the fault made in the first zone so fault impedance lies in this zones.
- Figure 9 shows that the waveforms for the IMPEDANCE Relay system with L-G fault applied within the zones of the distance protections so the fault made in the first zone so fault impedance lies in its zones.
- Figure 11 and 12 shows that the waveforms for the system with L-G fault applied within the zones of the distance protections with fault resistance conditions so that the fault made in the first zone relay shows the delayed trip command in second zone so relay under reaches.

VII.

VIII. CONCLUSION AND FUTURE SCOPE

In this paper the MHO and IMPEDANCE Relay characteristics are developed. The Performance characteristics of the Mho and IMPEDANCE were evaluated for the L-G fault and under the fault resistance. The Detailed conclusion is as follows

- ✓ This Paper help the Young and inexperienced engineers or Researchers to carry out their work for Power System Protection
- ✓ This Paper Concludes that the results shows that the fault impedance may fall in the zones where impedance was less than set impedance.Mho relay is not much affected by the fault resistance as compared to impedance Relay

FUTURE SCOPE

Here in this paper the faults are made to analyse the behaviour of the Mho relay is considered. But the students are able to do the same procedure for the other type of characteristics like Offset Mho, Quadrilateral, lenticular etc. Students can also show the comparison of the different Relay characteristics with and without fault resistance.

APPENDIX

Voltage	=	**220 kV**
Frequency	=	**50 Hz**

Transmission Line Parameters

Positive Sequence Impedance	=	**0.1236 + j0.5084 Ω/km**
Zero Sequence Impedance	=	**0.451+1.327 Ω/km**

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