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Development of Mho Type Distance Relay for Protection of Long Transmission Line using Matlab / Simulink Environment

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***Abstract*— The concept of this paper based on transmission line protection by using distance relay. To formulate this concept Matlab simulation is developed and prototype hardware is implemented for learning zone protection method. In proposed work SLG fault selected for testing the system.GUI was implemented for better understanding of zone protection and study the mho characteristic. In hardware system ATmega328 is involved as master controller for fault identification and zone protection and the same time plays the role of digital relay.**

Index Terms—Distance protection, Mho Distance relay, SLG Fault, Transmission Line, Graphical User Interface, ATmega328.

I. INTRODUCTION

The comprehension of protection schemes is crucial for electrical engineering students opted for power system subject. They must lay the groundwork with enough knowledge to work in the field of power utility or power related fields. Protection relays have a great deal of impact on power system's reliability and stability an also on the main components in power systems. Distance or impedance relay which is mainly used in transmission system is one of the protection relays used in power systems. Distance relay can be used as capital or backup protection. Numerical distance relays have been used widely as substitute for the static distance relays and electromechanical. The understanding on the operation of distance relay has become quite demanding as compared to other protection relays because of its complex theories and philosophies. The difficulties in the perception of distance relay occur when one is not able to the co-relate theory with actual operation of distance relays. In support of graphical user interface, it is aimed to minimize this problem thus enhances their interpretation [1].

Power transmission lines being attached with number of components of electrical power system Transmission line are situated in wide area these lines unfortunately struck with severe geographical as well as atmospheric condition due to this several faults took place. EHV lines are the very most important aspect in mass power transportation and to keep healthy operation continuously becomes very crucial task for Maintaining system reliability; maintain control voltage and other factor also. That is why prevention of transmission system is necessary in modern power system [2]. Distance relaying scheme is the key factor in protection system and it is become very economical to isolate the faulty section from the network and identify the faults in the provided region within less time it's very important task [3]. In Previous relaying scheme prediction of current was the main factor but that is not reliable one which fails at number of times and not responding instantaneously for entire protection of line.

However, over current relay co-ordination was quite unsupportive. Stepped distance relaying scheme universally adopted for the transmission line security since last fifty years the working of distance relay primary depend upon value of impedance which measured at the relay point [4][5].The voltage to current ratio of the fundamental components are measured at the relay unit and basis on this calculation of fault can be done. Transmission system is usually divided into number of parts and generally known as zones. A zone is consisting of relays, circuit breakers and other required components. The circuit breaker placed in system such way that it will isolate the affected zone quickly and keep rest of the part connected to supply power for users.

Electric power utilities often consider relay models to confirm how the relay would perform during systems disturbances and normal operating conditions and to make the essential remedial adjustment on the relay settings. The software models could be used for working out young and inexpert engineers and technicians. Thus, Computer models of relays permit investigators to scrutinize in depth the performance in each inside unit of the relay [6]-[8].

The basis for adaptive transmission protection and its implementation is introduced in various basic distance relaying schemes based on digital technology and the successive improvements in them are presented in [11] - [13] and the basic distance relaying schemes based on travelling wave phenomena are described.

The entire view of this paper to give knowledge about distance protection methodology with the assistance of matlab environment (software) and prototype hardware It is very challenging for electrical engineer candidate who choose protection subject for their field it is become essential for them to understand its philosophy. To satisfy this need in proposed work distance relays i.e. Mho characteristic was developed and its GUI was implemented using matlab software and actual realization of zones protection method hardware was developed to eliminate obstacles in learning the

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protection schemes. In this work simulation model of relay, transmission line and fault on line simulated. Apparent impedance block for zone detection is created because reach of relay depend on apparent impedance setting. In hardware as well as in simulation SLG fault was created and ATmega 328 is involved as master controller for fault identification and zone protection for validation of operation as digital relay scheme.

In this paper, the theory of distance protection and impedance set rule for zones are specified in section II. Zone protection scheme explain in III. The concept and Mho type distance relay model algorithm is explain in section IV, the transmission line is created in Matlab simulink is presented in section V, Also the result of simulation model and hardware model with different fault location are presented in section VI, In section VII, Conclusion is draft .

II. DISTANCE PROTECTION METHODOLOGY

Distance relays are designed to protect power system against two general types of faults symmetrical and unsymmetricals.This both types of faults further divide into L-G, L-L-G, L-L and L-L-L. In order to perceive any of the above faults, every one of the zone of distance relay required six units'. Three units for detecting faults between the phase and the remaining three units for detecting phase to ground fault. The setting of distance relay is always calculated on the basis of positive sequence impedance. Different types of characteristics are presents on distance relay such as mho, offset mho, reactance, quadrilateral, admittance, polarized-mho, etc. Each one of characteristics has its own function and theories behind [9] [10]. In this simulation distance relays distinguish characteristic was used i.e. Mho type distance relay the characteristic of this relay is shown in Fig. 1. Protective device measured the impedance between the affected lines from relay to fault point. Relay initially tresses the type of fault then calculate which type of algorithm should be used as apparent impedance. Different types of faults are presented in table1.

Table I: Fault Impedance Calculation on different fault situations

Fault Calculation	Algorithm
Phase A - Ground	ZA = VA / (IA + 3 k I0)
Phase B - Ground	ZB = VB / (IB + 3 k I0)
Phase C - Ground	ZC = VC / (IC + 3 k I0)
Phase A - Phase B	ZAB = VAB / (IA - IB)
Phase B - Phase C	ZBC = VBC/ (IB - IC)
Phase A - Phase C	ZAC = VAC/ (IC - IA)

Where:
A, B and C are the affected lines.
G is the ground fault.
VA, VB and VC shows the voltages
IA, IB and IC are the currents
Z0 = zero-sequence impedance
Z1 = positive-sequence impedance
k0 = residual compensation factor where, k0 = (Z0-Z1)/k Z1.
K value is 1 or 3.

III. ZONE WISE PROTECTION METHODS

Transmission line is divided into different zones for protection purpose as shown in Fig.2.

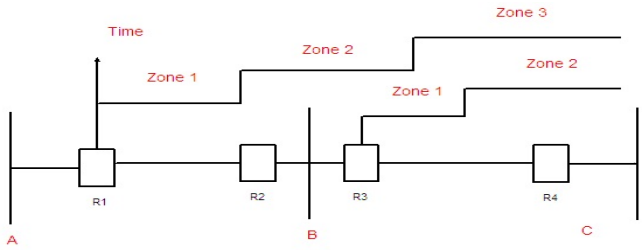

Fig.2. Transmission Line Zone Protection

In this work three zone protection schemes is explained and how this distance relay work as primary as well as backup relay is discussed below.

Zone 1: This is set for covering the line length 80 to 85 per cent of protected line and rest of the 15 – 20 percent is not consider due to some errors in instruments and occurring of transient at the time of faults etc.

Zone 2: The 15 – 20 percent of part covered in this zone and is set to cover all the protected line in addition 50 per cent of the shortest next line.

Zone 3: In this section relay will set to cover all the protected line plus 100 per cent of the second longest line in addition 25 per cent of the shortest next line. 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.

The distance relays setting for line protection are done on the substratum of the positive sequence impedance between the relay unit and the fault point. On the other hand, the settings of ground distance relays are carried out on the substructure of the zero-phase-sequence impedance. Hence, the corresponding distance or impedance is known as the reach of the relay and the relay is always connected on the secondary side of the CT and PT.

IV. MODEL ALGORITHM OF MHO RELAY

When fault occurred on transmission line there is a possibility of contained of dc components available in voltage and current signals, higher order frequency components and lower order frequency components.

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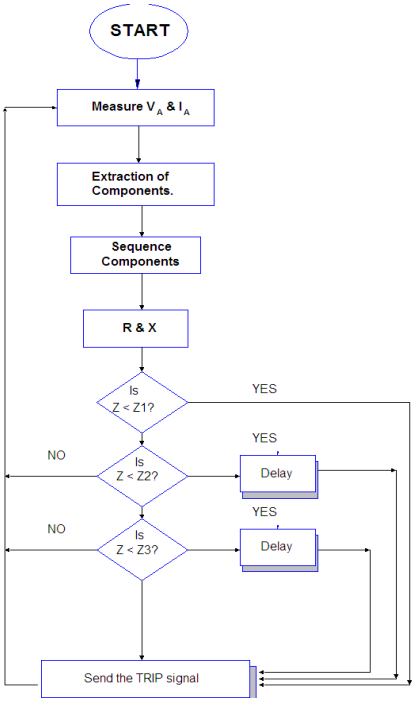

Fig.3. Mho Distance Relay Algorithm

From the flow chart shown in Fig.3 it is cleared that at the pre-processing stages, the anti-aliasing low-pass filter and the DC-offset elimination filter are implement for the extraction of the fundamental frequency component i.e. voltage and current magnitudes, which In turn is used for impedance calculations. For the fundamental frequency signals, the FFT method is used in the simulation. Low-Pass filters with a time constant of two cycles are used. The sampling frequency is 630.31 Hz. The transmission line length is 400 km. The phasor are estimated by full-cycle Fast Fourier Transform (FFT).

V. IMPLEMENTATION OF DISTANCE RELAYING SCHEME AND TRANSMISSION LINE

The single line diagram of transmission line is shown in Fig.4 and from single line diagram we can see distance relay is connected at local end and a three-phase load connected at near to the remote end this part is included in this modeling. For modeling of transmission line distributed parameter is used.

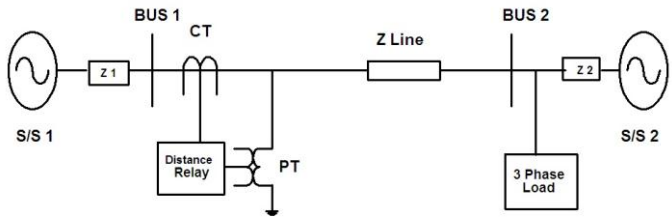

Fig.4. Single Line Diagram of Transmission Line

In this section, the Matlab / Simulink view of the distance relay is reviewed, which consists of two parts (blocks) as shown in Fig.5 and Fig.6 Here, both parts are summarized as follows:

1. In the signal processing block, the measured voltage (Va) and current (Ia) are the output of PT1 and CT1 at the relay point enter as inputs.
2. In the protection scheme block, the outputs of the first block enter as input parameters.

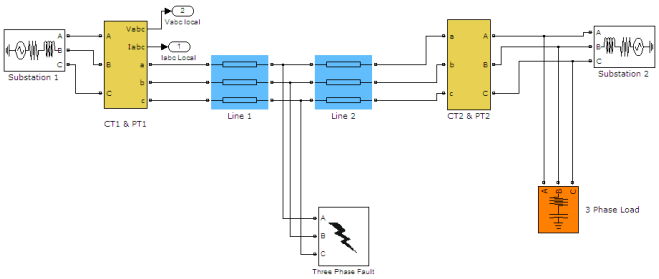

Fig.5. Matlab / Simulink View of Transmission Line

- *Signal Processing Block*

The components involved in this simulation are shown in Fig.6.The magnitude of voltage and current measured at the relay unit are the input parameters for the signal processing blocks. At this level, initially the input is processed to achieve 'Magnitude' and ' phase angle ' of the fundamental frequency. So, the final outputs of these blocks are transferred to the impedance calculation block as input parameters.

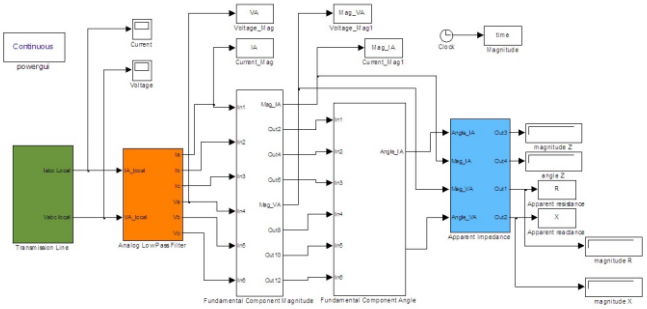

Fig.6. Matlab / Simulink View of Distance Relay with Transmission Line

- *Protection Scheme Block*

In this part, mho distance elements was developed with positive sequence components for the phase-ground fault and modeled. The relay calculates the apparent impedances of the fault loops, which are compared beside reactance and resistance limits determined by the relay settings as illustrated in the simulation.

VI. SIMULATION RESULTS

To analyze the behavior of implemented mho relay characteristics, faults are created at different locations on the 132kV, 400km transmission line and fault resistances of different values were used in Matlab / Simulink software. In this simulation presents some sample applications using the implemented GUI for the Mho type distance protection relay. The setting for zone 1, zone 2 and zone 3 are done on conventional methods which are explained earlier in this paper.

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- *SINGLE LINE TO GROUND FAULT WITHOUT FAULT RESISTANCE AT DIFFERENT LOCATION*

Single line to ground fault created on the 132kV, 400 km transmission line model at a distance of 100km, 320km and 375 km from the local end. Simulation results are shown in below Fig.7.1 to 7.3 in these characteristics Resistance is taken on X-axis and Reactance on Y-axis.

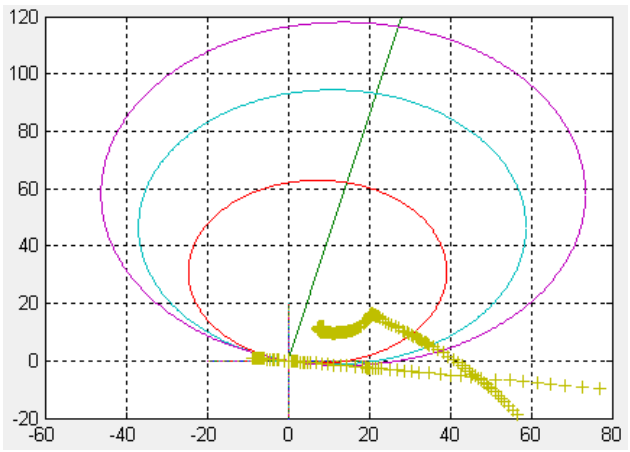

Fig .7.1 Fault created at 100 km from relay location

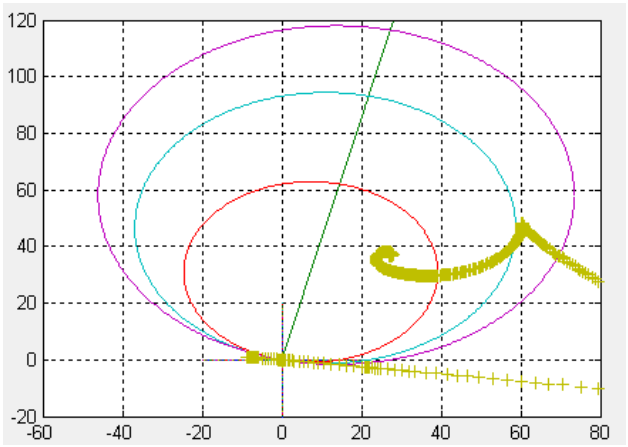

Fig .7.2 Fault created at 320 km from relay location

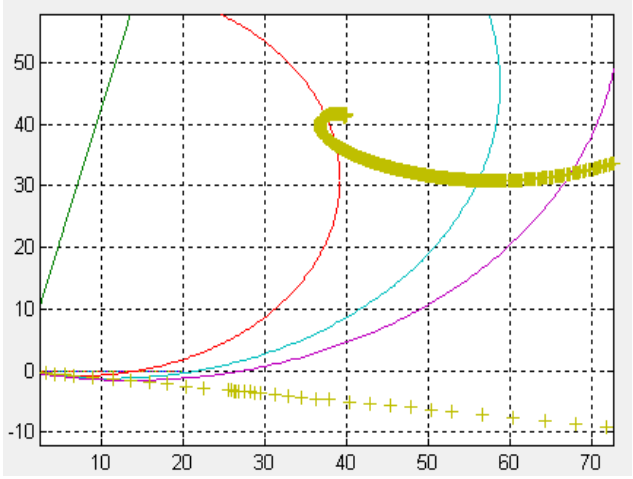

Fig .7.3 Fault created at 375 km from relay location

- *SINGLE LINE TO GROUND FAULT BY CONSIDERING FAULT RESISTANCE*

By using different fault resistance values here Single line to ground fault applied at a location of 250Km and 335Km from local end. Simulation results are shown in Figures when the fault resistance is 10 Ω and 15 Ω respectively the relay detects the fault in zone 2 instead of zone1 and in zone 3 instead of zone 2. So, increment in magnitude of fault resistance, impedance seen by the relay lies in the different zones as shown in the below Fig.7.4 to 7.6 Here, we can say that mho distance relay under reaches because of increment in fault resistance magnitudes.

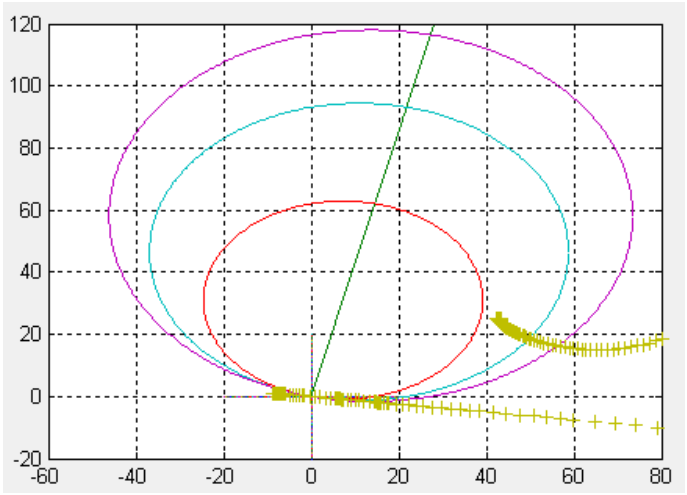

Fig .7.4 Fault created at 250 km from relay location when fault resistance is 10Ω

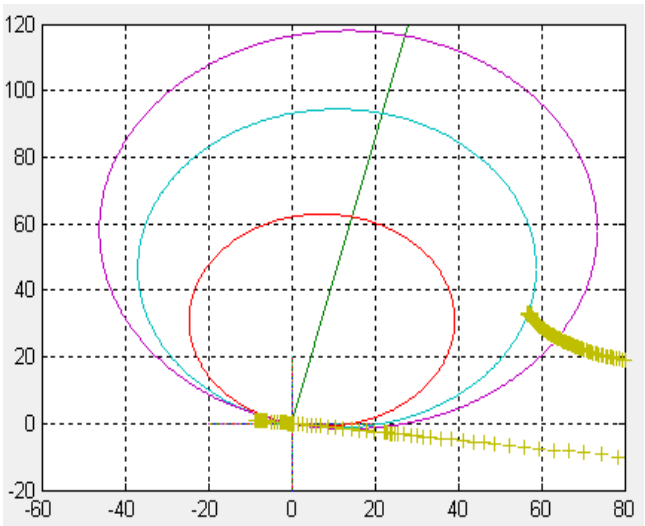

Fig. 7.5 Fault created at 335 km from relay location when fault resistance is 20Ω

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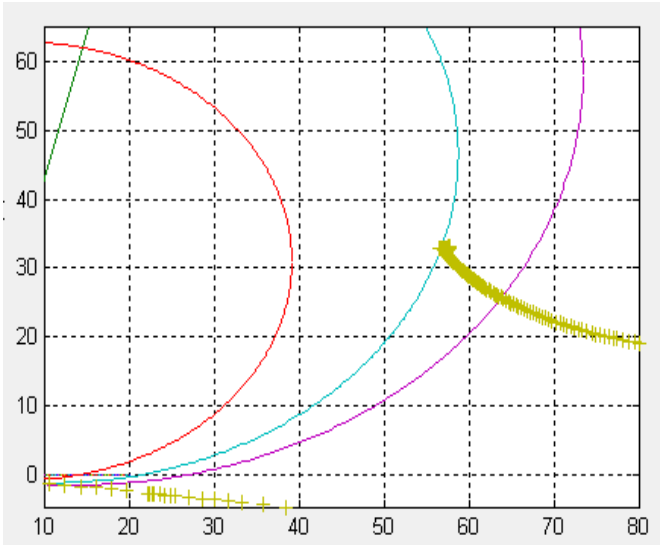

Fig. 7.6 Expanded view of fault trajectory occurred at 335 km from relay location when fault resistance is 20Ω

- *TRANSMISSION LINE HARDWARE RESULTS*

The behavior of long transmission line with digital relay can be observed on developed hardware the Fig.8 shows the proposed distance protection relay control circuitry. Faults are created at different locations on 400km transmission line, single phase AC supply were used in laboratory. In this hardware PI sections were used to formed transmission line and each section is of 100Km. The setting for zone 1, zone 2 and zone 3 are done on conventional methods and as we said only single phase supply were used and only phase to ground fault were possible results which we got are shown in Fig.8.1 to 8.4 from these figures we can see the three different cases for normal condition, fault in zone 1, zone 2 and fault in zone 3 and LCD display which in circuitry show the value of voltage, current and apparent impedance as well as fault distance and fault location.

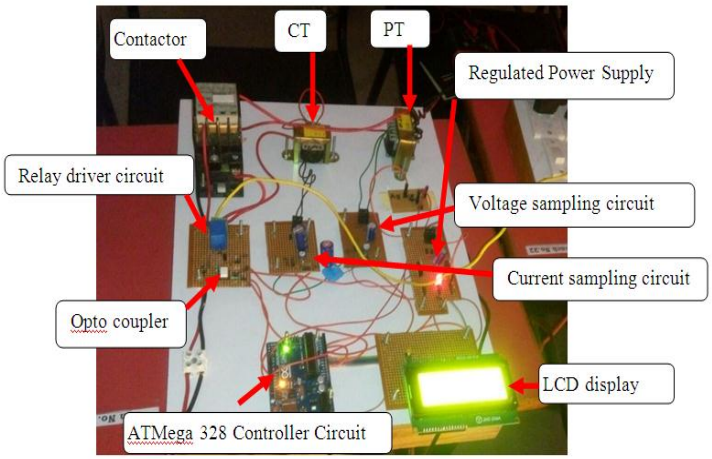

Fig. 8 Proposed distance protection relay with ATmega 328 Hardware Implementation

Fig. 8.1 when fault is not applied on transmission line.

Fig. 8.2 when fault is applied on transmission line at 100Km.

Fig. 8.3 when fault is applied on transmission line at 200Km.

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Fig. 8.4 when fault is applied on transmission line at 300Km.

VII. CONCLUSIONS

The microcontroller based distance relays was developed and designed and this can function as digital type distance relay and at same time simulation was implemented using MATLAB. Numbers of simulation test have taken on working model. The performance of mho relay was tested at different locations with single line to ground fault. The implemented mho type distance relay characteristics can be used for study purpose for under graduates students and also for technical personal who is work with power system. By performing different fault location cases the developed mho characteristics show behavior of the system at the time of fault, with and without fault resistances. The fault resistance causes the relay to under-reach.

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