FAULT DETECTION AND PROTECTION OF TRANSMISSION LINE BY DISTANCE RELAY

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Abstract: - Protection of electrical power systems is the major issue in power industry and for the protection of these electric power systems, current differential relays are widely applied due to their inherent simplicity, excellent sensitivity on internal faults and high stability on external faults. This work represented the problems on transmission line in different type of zones. The conventional digital distance relay used for the protection of transmission lines fed from one end. Therefore, algorithm for digital distance relaying is presented for the station of errors produced by the conventional digital distance relay during a high resistance single line to ground fault or line to line fault. In this paper the algorithm is based on digital computation of impedance, which uses symmetrical components of three-phase currents and voltages measured at the local end only. The distance is divided into zone 1, zone 2 and zone 3. This paper may help to identify the fault on a transmission line and also help to improve the power factor of the system. The proposed algorithm has been tested using MATLAB/SIMULINK software for a single line-to-ground and line-to-line fault which consider wide variations in fault resistance, fault location, power factor, and short-circuit capacity of the source.

Keywords: - Distance, Mho, Zone Protection, etc.

1. INTRODUCTION

A power system is a complex network consists of generators, transformers, transmission and distribution lines and their protection system [1-3]. Different types of problem such as short circuit, noise effect and others are occurring in power system networks and due to this short circuit heavy current flow through the equipment working in the system causing damage of equipments [4-5]. Most of the equipments are very expensive in power system, so the whole power system can be considered as a very large capital investment. In power system terminology short circuits are commonly known as 'Fault'. To protect those equipments from such problems we need some protective arrangements.

These arrangements consist of protective relays and circuit breakers. If a fault occurs in the system, automatic protective device is required to isolate the faulty section and keep the healthy section in operation.

Relays are the protective devices are used in the power system protection. In the faulty condition relay operate and send the trip wave to breaker. In electrical fault condition the disturbance occurs in generated power and required power or may not full fill. So, to maintain the power system balance and reduce the damaged due to the faults we need to find the fault, isolate the faulty part is required. Maintaining continue electric power supply to customers is a main work for the power generation stations. In the power system, protective relays are responsible for discriminating between normal and fault conditions. The relays should detect the faults in 20 to 40 ms. Measurement of distance from the current and voltage waveform during the fault condition may have some errors and it is affect the stability of the relays. We must have to be careful when consideration of the output requirement of the current and voltage transformer. Cascade operation of the protective devices can raise the disturbance in the electricity supply system.

Protective relays act as the brain of any protective system that help to sense the problems in power system network and provide a command to the circuit breaker weather to trip or not. In this way the work of relay is to detect and locate a fault and provide a trip signal to the circuit breaker. Distance protection provides an excellent way of obtaining discrimination, selectivity, and speed of operation by allowing trip operation up to a certain range of distance. For protection of transmission line the distance type relay is used and this protection is managed in overlapping area. There is whole area is covered by the distance protection. A relay decides which zone contains the faults from the comparison of voltage and current signals. So, a distance measured from the relay location to the fault location. The main objective of this work is to analyze line-to-ground and line-to-line fault detection, impedance calculation and protection in different zone considering wide variations in system and fault parameters. Finally, feasibility of the proposed scheme has been tested using MATLAB/SIMULINK software.

2. RESEARCH METHODOLOGY

PSCAD also called a power system computer aided design program is a time based Simulink software or past working analysis of electronic system. PSCAD is a set of programs, which provide a graphical interface to the electromagnetic transients program. Also known as EMTDC. In 1976 the analysis of DC electromagnetic transient (EMTDC) were evolve and also rapidly developed with capability as well as possibility. To set up the whole simulation software there are some library in power system models already given in this. So this library gives a proper and rapid solution in the provided time for calculate and making program of power system and the network. In this Simulink model the more intelligent methods used for customize the quality of the supply for improve accuracy and efficiency and manual analysis takes time and its required special kind of knowledge.

Fast Fourier Transform

Due to the presence of harmonics resultant voltage and current graph in simulation are fluctuated, when error happened in power system. The current as well as voltage must consider at fundamental frequency to compute the apparent impedance. To overcome the harmonics from the resultant signal of current and voltage there are different types of phasor algorithms are evolve and stable the quality of power. FFT is used to remove DC component and harmonics and estimate the complex phasor element at fundamental frequency. As consider function of time, the FFT block in PSCAD is used to measure the fundamental component like magnitude and phase of the given input signal. Before the signal send to harmonic constituents block the signals are sampled. This given unit is developed with the aliasing type filter. These types of filters are used to reduce the extra noise and harmonics. Some information contain in the sinusoidal steady state component with 50Hz frequency by using impedance measurement in distance protection. Therefore, filtering is necessary to maintain part of the stable condition and to remove other items.

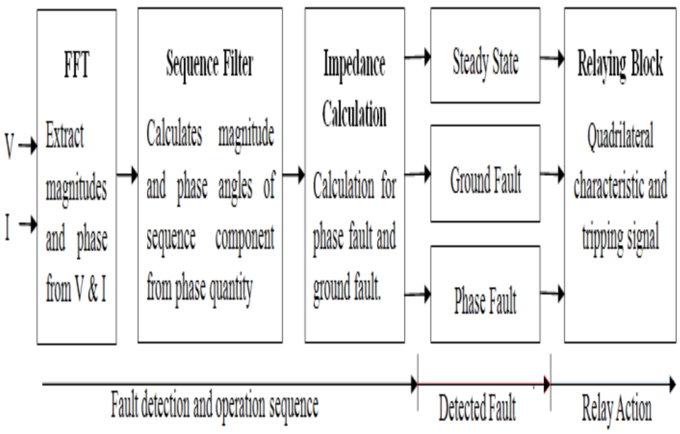
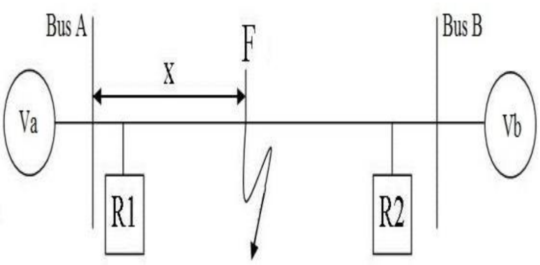


Figure4.1: Block diagram distance relay model in PSCAD

Calculation of impedance

The two bus system like bus A and bus B in one line graph with part of network was showed below. Error with the resistance Rf happened with X% at the point F of line from A bus.



Fault like phase to ground (line A to earth), connected relay find the impedance of transmission given below equation till the point X. (Fault resistance = 0)

$$X * Z1 = \frac{Var}{IAR + Ko * IOR}$$

In equation, Var and IAR are equal to voltage and current respectively. It is measured at the point of relay.

I_{OR} = current of zero sequence

K_0 given in equation,

$K_0 = \frac{Z0-Z1}{Z1}$

Z0 and Z1 is the sequence component.

With the consideration of RF, the measure value of impedance written in equation,

$Zr = x*Z1+\frac{If}{Ir} Rf$

For AB fault assumption,

$x*Z1 = \frac{VAR-VBR}{IAR-IBR} = \frac{VABR}{IABR}$

For SLG fault:-

Va = Va1+Va2+Va0
= IA1*Z1+IA2*Z2+IA0*Z0
= IA1*Z1+IA2*Z1+IA0*Z1-IA0*Z1+IA0*Z0
= $Ia*Z_1+Ia0*(Z0-Z_1)$

Than the relay seen the impedance is given

Zseen= Va/Ia= Va / Ia+k*Ia0

Where Z1, Z2, Z0 are sequence impedances Z1=Z2 for transmission lines and k=(Z0-Z1)/Z1.

For LL fault:-

Va1-Va2=(Ia1-Ia2)*Z1

Zseen= (Va1-Va2)/ (Ia1-Ia2).

Mho Relay Algorithm

Every protective area is set to cover the appropriate length of the power network. The standard selections of location in the network protection cover 80 to 90% of the line area 1. 12 - 150% in area 2 and 200-250% in third area. The performance time associated with every location is different form first area, the transfer applies there. Still, allocation 2 is delayed to allow area 1 transfer to run first. Area 3 delays time for allows the appropriate relays closer for the fault to work first otherwise occurs at the Zone-1, Zone-2. Time setting is processed to the individual zone to allow the relay closest to the fault operates first and other is use to backup. If the nearest relay is not working properly than connected relay locate at the back up terminal. This relay saw the error in the area after the fault will still disconnected the failed component. And somehow the zone-2 relays is not work than the located relay aside from the fault line will work in zone 3.

3. PROPOSED SYSTEM MODELLING

Proposed simulation model for analysis of faults and protection of different zone is shown in Fig. 1. This model consists of generating station, transmission section and load centres. Transmission line protection is very important issue in electrical power system because 83-86% of electrical power system faults are occurring in overhead transmission lines. Any fault in a power system network results in severe economic losses and reduces reliability of the electric system.

In a power system faults can be caused by equipment failures such as transformers, rotating motors, generators, other electrical equipments. Human errors and adverse environmental conditions are also responsible for power system faults. To ensure a healthy and stable power supply, it is necessary to investigate the reason for faults in transmission line for particular zone and provide necessary protection system against faults. Therefore, measure the condition of voltage, current and impedance are important issue for analysis of faulty and healthy line. In our proposed model we consider the condition of voltage, current and impedance before and after fault to design the relay logic circuit. We consider three zone of total transmission line in our model.

For zone 1 the impedance is kept below 25 ohms. If the fault impedance is measured by the relay below 25 ohms then relay will send a signal that fault is occurred at zone 1. For zone 2 the impedance is kept between 25 ohms to 55 ohms. If the fault impedance is measured by the relay between 25ohms to 55ohms then relay will send a signal that fault is occurred at zone 2. For zone 3 the impedance is kept as above 55 ohms. If the fault impedance is measured by the relay above 55 ohms then relay will send a signal that fault is occurred at zone 3. The effect of the faults current in feed at the bus bars will affect the relay impedance to be higher than the actual impedances to the fault. And this effect may occur in setting the zone 3. Large Ohmic setting are given to the third zone in order to obtain the remote protection. Such experience has result in restrict the use to the third zone relaying.

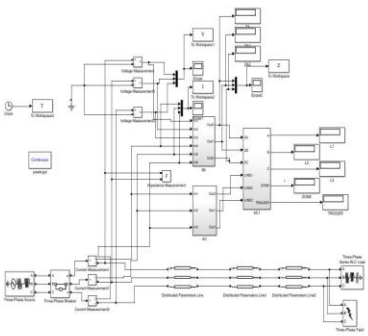


Fig-1 Proposed simulation model for analysis of faults and protection of different zone

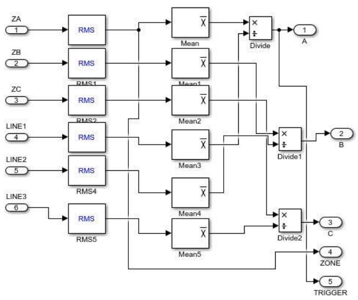


Fig.-2 Impedance Control System

4. SIMULATION AND RESULTS

The simulation results of normal condition of the voltage and current wave diagram of three phase transmission line are shown in Fig. 3 and 4. It is seen that during normal condition voltage and current amplitude are same in all lines and phase difference maintain 120 degree among them. Load current fundamental component is active component Ilα at zero crossing of β components of voltage components. DC link voltage maintain DC bus control block. It consists of PI controller input of error and sensed voltage.

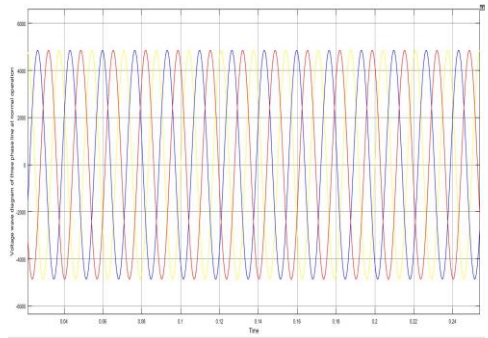


Fig. 3: Voltage wave diagram of three phase line at normal operation

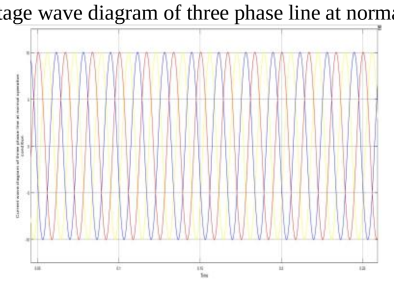


Fig. 4: Current wave diagram of three phase line at normal operation condition.

(a) Line to ground (L-G) fault at Zone 1: When fault occurs in a transmission line it creates a very low impedance path for the current flow. This results in a very high current being drawn from the supply, causing tripping of relays, damaging insulation and components of the equipments.

At three phase transmission line when fault is occurred at zone 1 from line A to ground, the amplitude of voltage of line A reduced to zero and current of that line rise to very high value which was measured from 78A to 400A during the period of fault. At that time the voltage and current value of other lines remain unchanged. The voltage and current wave diagram during line A-to-ground fault are shown in Fig. 5 and Fig. 6. The line to ground fault occurs when one conductor falls to the ground or contact the neutral conductor. The 70 – 80 percent of the fault in the power system is the single line-to-ground fault.

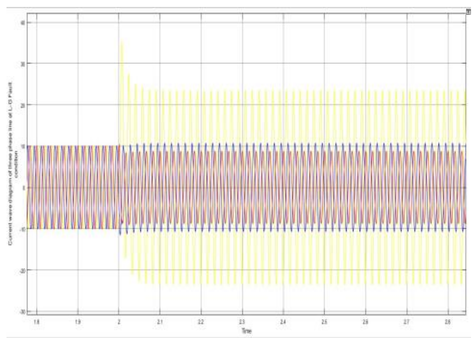


Fig. 5: Current wave diagram of three phase line during L-G fault at zone1

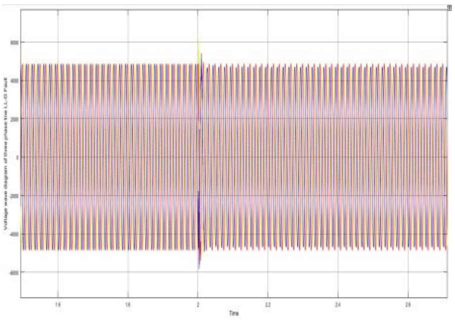


Fig. 6: Voltage wave diagram of three phase line during LL-G fault at zone1

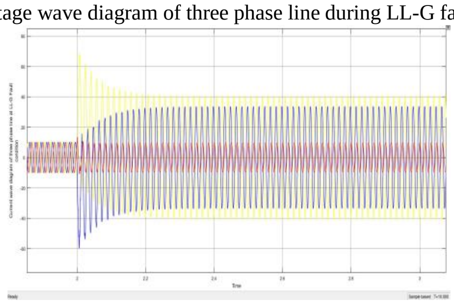


Fig. 7: Current wave diagram of three phase line during LL-G fault at zone1

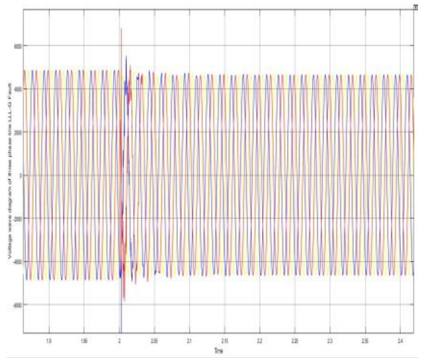


Fig. 9: Voltage wave diagram of three phase line during LLL-G fault at zone1

(b) Line to ground (L-G) fault at Zone 2: Now consider fault is occurred at zone 2 between line A and ground. Wave diagram of voltage and current of transmission line during fault of line A to ground fault are shown in Fig. 7 and 8. Generally, a single line-to-ground fault on a transmission line occurs when one conductor drops to the ground or comes in contact with the neutral conductor. Such types of failures may occur in power system due to many reasons like high-speed wind, falling off a tree, lightning, etc.

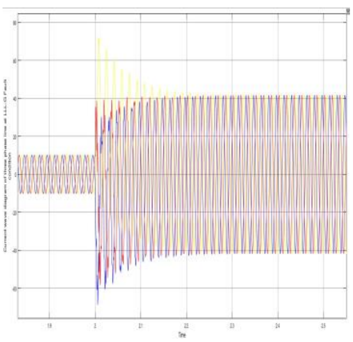


Fig. 10: Current wave diagram of three phase line during LLL-G fault at zone1

(c) Triple Line to Ground (LLL-G) fault at Zone 1: Analysis of faults between line A and line B at zone 1 is studied. It is seen that voltage of line A and line B reduced and current rises to higher value. Wave diagram of voltage, current and impedance of transmission line during fault occur between line A-to-line B at zone 1 are shown in the figures-9 and 10. Impedance of line A and line B also reduced from 90 Ω to almost zero after L-L fault. When fault occurs generally voltage goes down where current increases up to several times of rated current. Current increases because it get low resistance path and during fault condition, resistance available is only by line and ground (Zg) which has very low value.

5. CONCLUSION

This paper studies the basic faults that generally occur in transmission line of a power system and their protection scheme using the distance relay. This paper with investigation of novel fault detection for the protection of transmission line. To reduce or overcome these faults the protective devices are used in power system. In this Paper, for long transmission line distance protection relays is used. When faults occurs the distance relay identify the fault and send the signal to connected circuit breaker. So, the circuit breaker clears the fault or isolates the faulty part in transmission line. Here an 11kv transmission line is taken into consideration and a Simulink model is designed for the line by MATLAB/Simulink. Simulation results are showed the voltage, current and impedance change of transmission line before and after line to ground and line to line faults at different zones. Simulation results verify the effectiveness of the proposed approach. This research may be help to identify the faults in large scale of three phase transmission line at different zones, able to protect valuable equipments as well as human life in a power system.

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