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Effect of Fault Resistance and Load Encroachment on Distance Relay- Modeling and Simulation PSCAD/EMTDC

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Abstract: *Distance Relay is widely used a protective relay in a long transmission line. The Distance Relay achieves selectivity on the basis of impedance. As the impedance is proportional to the distance between the fault point and relay so the relay is directly indicates a distance of fault location. In this paper, three zones of distance relay with mho characteristics are modelled and simulated using PSCAD/EMTDC software. In this modelling single line to ground fault (SLG), line to line fault (LL) and three phase fault (LLL) considered at a zone1, zone2, zone3 respectively and also study the performance of relay characteristics during Load encroachment and Fault resistance. The test network used in this paper is 230 kV, 300 km radial transmission line systems.*
Keywords: *Distance relay, Fault resistance , Load encroachment, Symmetrical and unsymmetrical fault*

I. Introduction

The numerical distance relay is used in long transmission line nowadays. To study the behaviour of a distance relay during short-circuits, for designing new prototypes, to check and optimize the performance of relays that already installed in the power system, to design new relaying algorithms and to check the performance of the new relay equipment it is necessary to model the distance relay. Electric power utilities use relay models to confirm how the relay would perform during systems disturbances and normal operating conditions and to make the necessary corrective adjustment on the relay settings. The software models could be used for training young and inexperienced engineers and technicians. Thus, computer model of relays permit the investigators to observe each internal module of the relay. [1]

The Electromagnetic Transient Program (EMTP) was the first software that simulates the transient nature of power system [6].PSCAD/EMTDC software is an electromagnetic transient analysis program developed by the Manitoba HVDC Research Centre having a variety of steady state and transient power system studies [2].PSCAD is the 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 [3].

II. Distance Relay

Distance relays can be classified into phase relay and ground relays. Phase relays are used to protect the transmission line against phase faults (three phase, L-L) and ground relays are used to protect against ground faults (S-L-G, L-L-G). In order to detect any of the above faults, each one of the zones of distance relays requires six units. Three units for detecting faults between the phases and the remaining three units for detecting phase to earth faults [4].The setting of distance relays is always calculated on the basis of the positive sequence impedance.

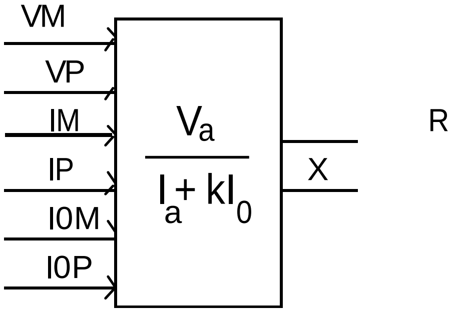


Fig.1 (a) Calculation the line to ground impedance block

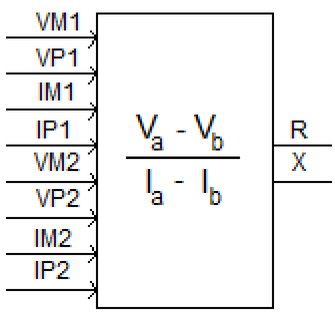


Fig.1 (b) Calculation the line to line impedance block

Fig.1 (a) and Fig.1 (b) computes line to ground impedance and line to line impedance. The output impedance is in a rectangular format (R and X), and is optimized for use with the mho circle. Where, k = (Z0-Z1) / Z1, Z0 and Z1 are zero sequence and positive sequence impedances.The distance relay operates in three zones. Zone
1cover 80-85% of the section to be protected in which it operates instantaneously. The zone 2 covers first line section plus approximately 50% of the next line section. The relay operates in zone 2 with 15 to 20 cycle time delay. Zone 3 is generally used to provide backup protection. Zone 3 operates with 50-60 cycle delay [7].

A. Mho Relay Algorithm

When a transmission line subjected to a fault, the voltage signals and current signals contain decaying dc components, higher order frequency components and lower order frequency components. The higher order frequency components can be eliminated using low pass anti-aliasing filters with appropriate cut-off frequency, but the anti-aliasing filters cannot remove decaying dc components and rejects lower order frequency components. This affects the performance of digital relay. Therefore, the Fast Fourier transform is usually used to remove the dc-offset components. [4]. After extracting fundamental component of voltage and current it will be converted into the sequence component.

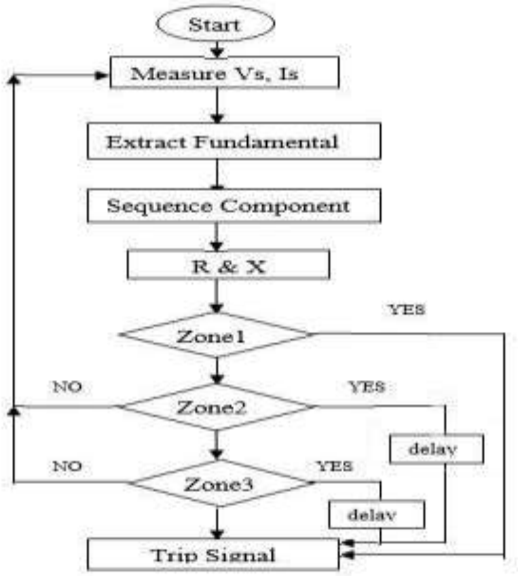


Fig. 2 Mho relay modeling algorithm

The measured impedance by the distance relay is compared with set impedance. If the measured impedance is less than set impedance to any of the three zones than distance relay will operate in that zone and give the trip signal to the circuit breaker.

III. Simulation Result

In this paper three phase 230kV, 300 km, and the single circuit radial transmission line are considered. zone1 cover 80km , zone 2 cover 150 km ,and zone 3 cover 220km of transmission line length. The LG, LL, LLL faults occur at 0.20 sec. The distance relay operates in zone1 instantaneously; zone2 operates with 20 cycle delay and zone 3 operates with 60 cycle delay. The system details are given in the Appendix.

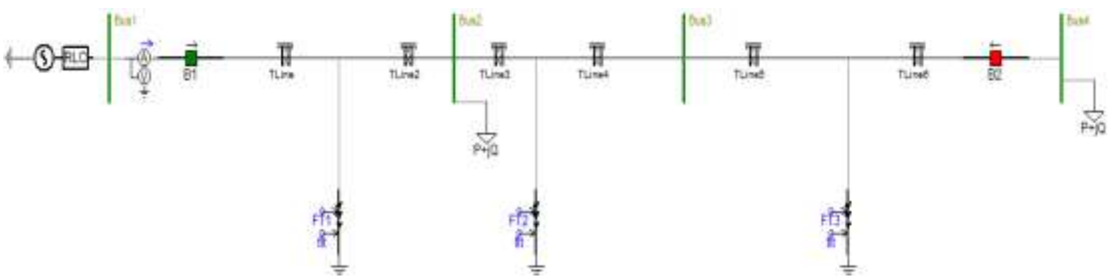
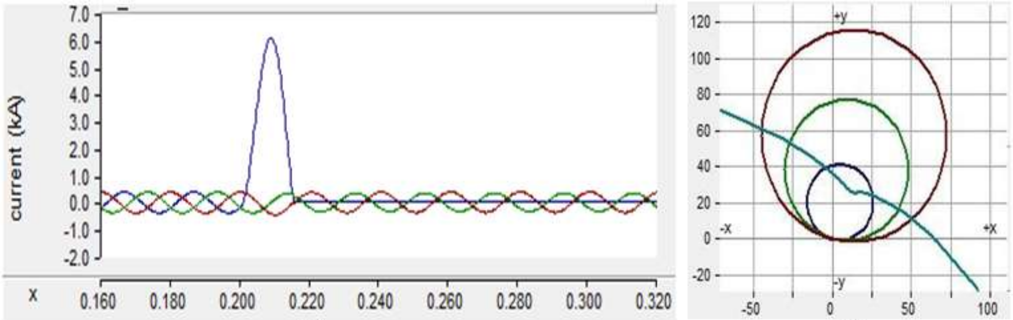


Fig.3 Simulated System

A. **Single Line to Ground Fault**

Single line to ground fault is created in phase A. Fault occur at a 0.2 sec,40km from bus1 in zone1.

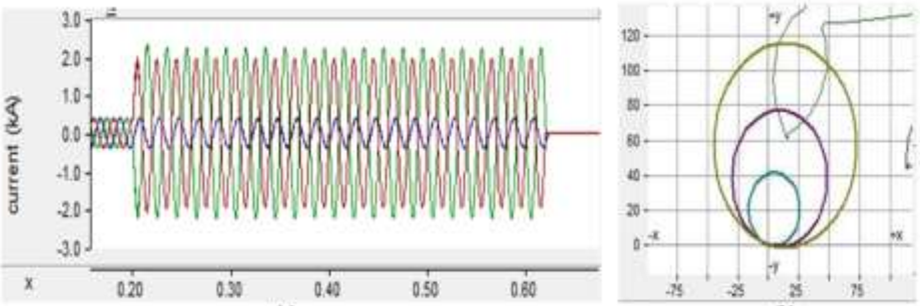


(a) (b)

Fig.4 line to ground fault at zone1 (a) fault current (b) trajectory of load impedance

B. **Line to line fault (B-C fault)**

Consider fault occurs on line B and line C. Fault occur at a 0.2 sec, 120km from bus1 in zone2.

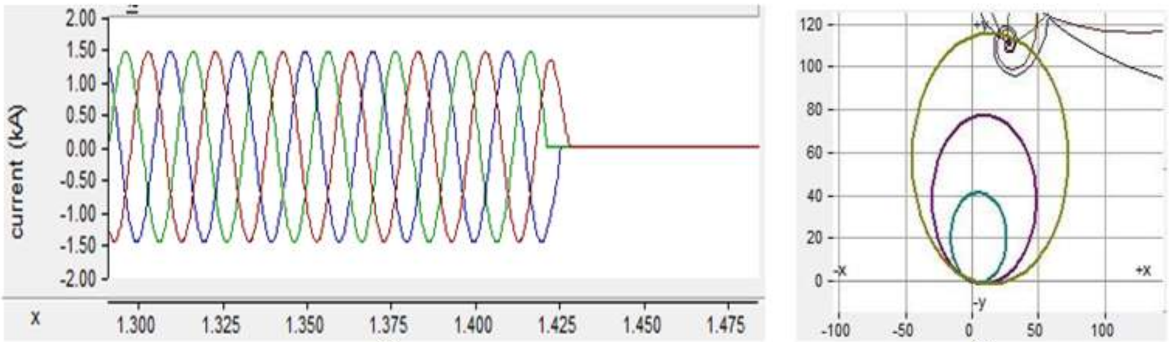


(a) (b)

Fig.5 line to line fault at zone2 (a) fault current (b) trajectory of load impedance

C. **Three phase fault**

Three phase fault occur at 0.2 sec with fault resistor 2 Ω.Distance relay will give the tripping signal to circuit breaker at 60 cycle delay and so CB is operated at 1.4 sec shown below fig.



(a) (b)

Fig. 6 three phase fault at zone3 (a) fault current (b) trajectory of load impedance

IV. Effect Of Fault Resistance And Load Encroachment On Distance Relay

The reach of mho relay is affected in spite of the presence of fault resistance as shown in the Fig. 7 AB is the line to be protected, due to fault resistance BC impedance is seen by the relay going out of the zone. Therefore mho relay under reaches because of fault resistance [5].

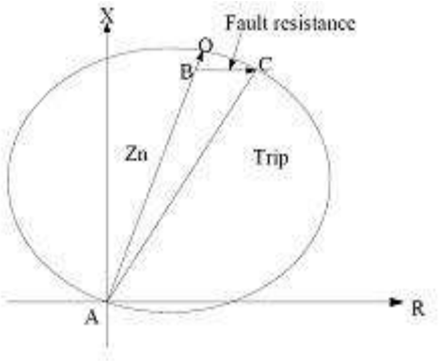
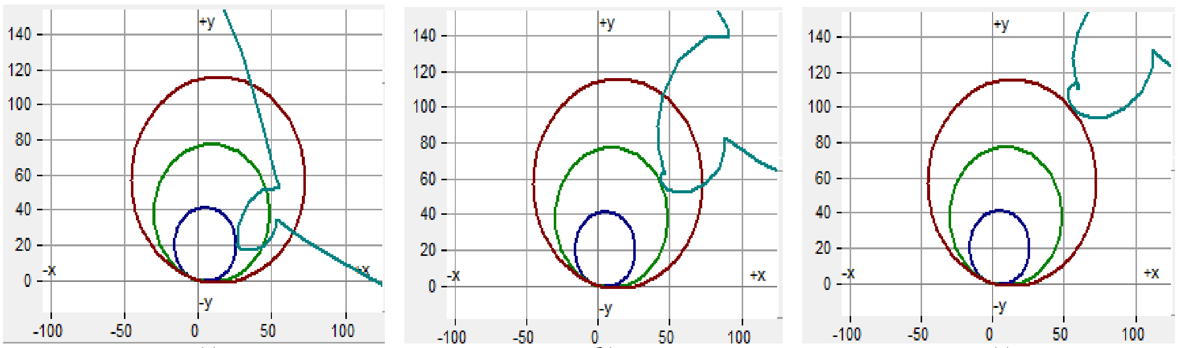


Fig. 7 Effect of fault resistance on reach of the relay

A. **Simulation result for single line to ground fault with effect of fault resistance**

When the single line to ground fault occurs 60 km from bus1 in zone1 if the fault resistance is 25 Ω, the relay detects the fault in zone2 instead of zone1. And if the fault occurs 130 km from bus1 in zone 2 with fault resistance 33 Ω, the relay detects the fault in zone 3 instead of zone2. And also, if the fault occurs 216 km from bus1 in zone 3 with fault resistance 28 Ω, the relay will not operate. Thus, in these entire three cases mho relay will under reaches due to fault resistance.



(a) (b) (c)

Fig. 8 Effect of fault resistance during LG fault (a) zone1 fault (b) zone2 fault (c) zone3 fault

B. **Simulation result of load encroachment**

The change in transmission network structure or shifting the power flow from one line to another under steady-state operating conditions may cause the positive-sequence impedance to enter the zone 3 characteristics of a distance relay. This phenomenon is referred to as load encroachment. [6] If the load is increased from the maximum load ability limit of distance relay [8] then impedance seen by the relay during this overload condition will be less than their set impedance and so distance relay will mal-operate in zone 3.
In this paper to create the load encroachment condition for the relay at bus1, the load at bus2 is increased 259 MW/phase and 150 MVAR/phase.

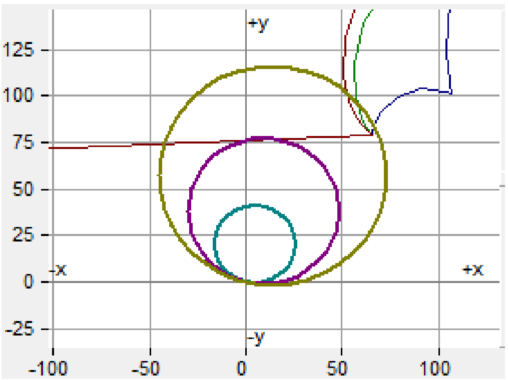


Fig. 9 Effect of load encroachment of distance relay

V. Conclusion

In this paper modeling and simulation of the distance relay is done using PSCAD/EMTDC software. The performance characteristics of mho relay were evaluated at different locations with a different type of fault. Due to the fault resistance present, distance relay saw more impedance rather than actual so relay will be under reach. If the load is increased from the maximum load ability of the relay then distance relay will maloperate in zone3.

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APPENDIX

Parameter	Value	Unit
System Voltage	230	kV
System Frequency	50	Hz
Line Length (AB, BC, CD)	100	km
Line Positive Seq. Series Impedance	0.1236 + *j*0.5084	Ω/km
Line Positive Seq. Cap. Reactance	0.29473	MΩ × km
Line Zero Seq. Series Impedance	0.451 + *j*1.3277	Ω/km
Line Zero Seq. Cap. Reactance	0.51013	MΩ × km
Sources Positive Seq. Impedance	0.6 + *j*18.28	Ω

References

[1]. Sherwali, Hamid, and Matlab-Modelling Abdlrahem. "Programming and Simulations." (2010). [2] Introduction to PSCAD/EMTDC V3, Manitoba HVDC Research Centre Inc., Canada, 2000.
[2]. Muller, Craig, and P. Eng. "Power system computer aided design user's guide." *Manitoba HVDC Research Centre* (2005).
[3]. Abdlrahem, Abdlmnam A., and Hamid H. Sherwali. "Modelling of numerical distance relays using MATLAB." *Industrial Electronics & Applications, 2009. ISIEA 2009. IEEE Symposium on*. Vol. 1. IEEE, 2009.
[4]. Thakre, M. P., and V. S. Kale. "DISTANCE PROTECTION FOR LONG TRANSMISSION LINE USING PSCAD." *International Journal of Advances in Engineering & Technology* 6.6 (2014): 2579.
[5]. Jin, Ming, and Tarlochan S. Sidhu. "Adaptive load encroachment prevention scheme for distance protection." *Electric Power Systems Research* 78.10 (2008): 1693-1700.
[6]. Schweitzer III, Edmund O., and Jeff Roberts. "Distance relay element design." *proceedings of the 46th Annual Conference for Protective Relay Engineers, College Station, TX*. 1993.
[7]. Rincon, Cesar, and Joe Perez. "Calculating loadability limits of distance relays." *Protective Relay*
[8]. *Engineers, 2012 65th Annual Conference for*. IEEE, 2012.