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The Effect of Fault Resistance on Distance Relaying Application

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Abstract- **The design and behavior of distance relay used for the protection of long transmission line is described in this paper. The relay was simulated using the model language in MATLAB. The operating behavior of the relay was assessed using two different simulated networks with both solid and resistive faults. The data generated by MATLAB SIMULINK describes the voltage and current signals at the relay location both immediately before and during the fault. The data is applied to the relay simulator, which than evaluates whether the impedance trajectory of the fault enters one or more of the operating zones. The results are presented in graphical form using an R-X diagram.**

Key word- **Protection, Distance relay, under reach, Fault resistance, Line impedance, Mho relay.**

I. INTRODUCTION

Distance relays are one of the most important protection elements in a transmission line.

These relays may sometimes be set based in percentages of the line impedances, for example a typical setting for zone 1 is 80% of the impedance of the line in order to not reach the remote end, the zone 2 can be set at 120% of the impedance of the line in order to dependably overreach the line, Zone 3 sometimes are disabled or set to cover an adjacent line as shown in figure.

Distance relays characteristics may be Mho, Quadrilateral, Offset Mho, etc. In the case of the quadrilateral characteristic or long reaching mho characteristics, additional care may be required to remain secure during heavy load.

In the case of parallel lines, the mutual coupling of these lines can cause distance relays to under reach and over reach. In some countries there criteria that a distance protection cannot reach fault in other voltage levels, because fault clearing times in sub transmission levels may be slower than fault clearing times at the transmission level.

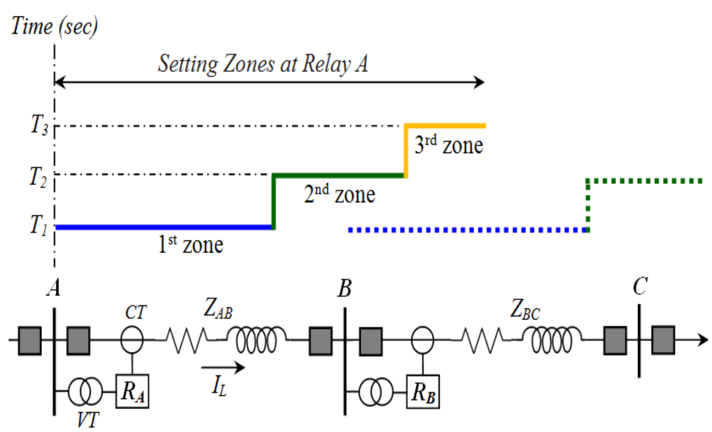

Fig. 1 Protection Zones of distance relay

Fig.1. Protection Zones of Distance relay

The problem of combining ***fast fault clearance*** with ***selective tripping*** of plant is a key aim for the protection of power systems. Distance protection, in its basic form, is a non-unit system of protection offering considerable economic and technical advantages.

II. UNDER REACH OF DISTANCE RELAY

The operation of such relay depends upon the predetermined value of voltage to currentratio. This ratio is nothing but impedance. Therefore a distance relay is also known as impedance relay. The relay will only operate when this voltage tocurrent ratio becomes less than its predetermined value.

Hence, it can be said that the relay will only operate when the impedance of the line becomes less than predetermined impedance (voltage / current). As the impedance of a transmission line is directly proportional to its length, it can easily be concluded that a distance relay can only operate if fault is occurred within a predetermined distance or length of line.
In developing distance relay equations, the fault under consideration is assumed to be an ideal (i.e., zero resistance) [4]–[3]. In reality, the fault resistance will be between two high-voltage conductors, whereas for ground faults, the fault path may consist of an electrical arc between the high-voltage conductor and grounded object. The fault resistance introduces an error in the fault distance estimate and, hence, may create unreliable operation of a distance relay [9].

The impedance seen by the relay is not proportional to the distance between the relay and the fault in general, because of presence of resistance at the fault location. The effect of fault resistance is shown in Fig. 2. Relay O is set for the protection up to Z. But if high resistance fault occurs than impedance seen by the relay is OZ' such that Z' lies outside the operating region of the relay, then the relay does not operate.[2]

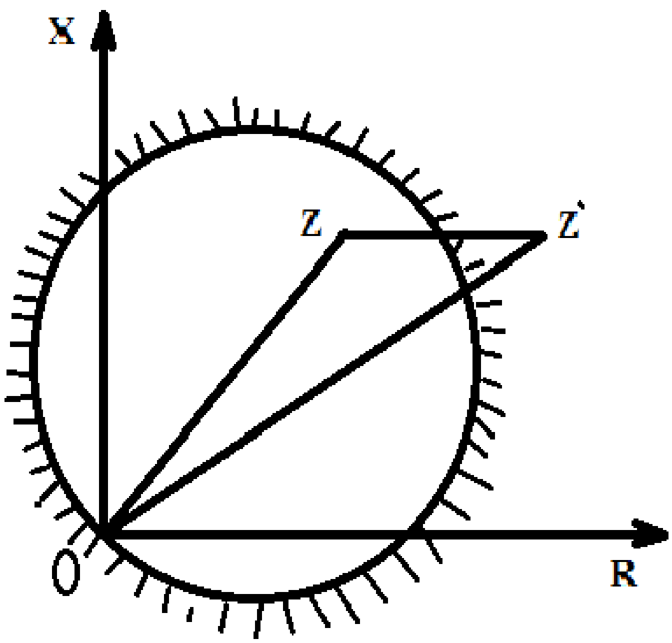

Fig. 2 under reach in Distance relay

In this paper, the design and behavior of distance relay used for the protection of long transmission line is described. The relay uses a Fourier filter to derive the voltage and current phasors. The problem of under reach in ground distance relays is occurs due to fault resistance. The results will show the effect of impedance with high fault resistance is accurately zoned or not.

III. POWER SYSTEM ESTABLISHMENT AND SIMULATION

SIMULINK/Power System Block set is used to create power system model for simulation. With the updated version of MATLAB/SIMULINK, the model development off power system components is onwards to perfection. Here, SIMULINK includes variant basic power components, which can be used to finish all kinds of power system network simulations.[5]

It is very easy to create power system in SIMULINK environment, which allows building a model by simple "click and drag" procedures. Because all of the electrical parts of the simulation interact with the SIMULINK"S extensive modeling library, it is not just possible to easily draw the power system network, but also to include its interactions with every electrical component. In addition, the simulation system of block components can set relation electrical parameters from MATLAB commands.[6].

One thing should be noted is that SIMULINK is more suitable for a small system for simulated tests. Execution speed of the simulation system will become slow when simulating system large. Luckily, the protective relays are for protection of one article of electrical equipment, so we just focus on protected equipment. Other equipment can be made in equivalent value. Therefore, by reducing the complexity of the simulation system, the simulation system result will be in high performance.

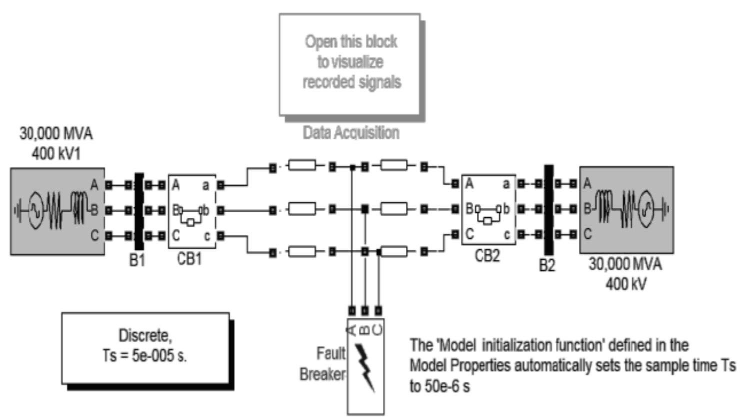

Fig.3. Sample power system network

The system parameters which have been used for simulation are given in appendix. The power system used for testing the distance relay is a part of a 400 kV power system as shown in fig.3. The system include two generating station with transmission line between them and its associated components. The relay is set to protect 90% of the line. The power system is modeled and different symmetrical and unsymmetrical faults at different location with solid and fault resistance along the line will perform.[1]

The different fault type and fault positions are as follows:

Fault type: a-g, b-g, c-g, a-b-g, b-c-g, a-c-g, a-b-c-g.

Fault Locations: 50km, 100km, 150km, 200km, 250km.

IV. SIMULATION RESULTS

Table 1.Simulation results for l-g faults

Sr. No	Fault type	Fault location (Km)	Actual value (Ω)		Measured value (Ω)	
			R_{act}	X_{act}	R_{mes}	X_{mes}
1	l-g	45	1.240	15.890	1.240	16.880
2	l-g	90	2.390	33.120	2.480	33.750
3	l-g	135	3.720	50.120	3.710	50.630
4	l-g	240	6.560	89.900	6.600	90.000

Table 2.Simulation results for l-l-g faults

Sr. No	Fault type	Fault location (Km)	Actual value (Ω)		Measured value (Ω)	
			R_{act}	X_{act}	R_{mes}	X_{mes}
1	l-l-g	45	1.240	16.770	1.23	16.87
2	l-l-g	105	2.90	39.25	2.87	39.37
3	l-l-g	135	3.6	50.6	3.71	50.62

Table 3.Simulation results for l-l-l-g faults

Sr. No	Fault type	Fault location (Km)	Actual value (Ω)		Measured value (Ω)	
			R_{act}	X_{act}	R_{mes}	X_{mes}
1	l-l-l-g	45	1.2	15.8	1.23	16.87
2	l-l-l-g	90	2.44	33.3	2.47	33.7
3	l-l-l-g	135	3.70	50.0	3.71	50.6
4	l-l-l-g	240	6.5	89.9	6.60	90

The value of compensated and uncompensated fault impedances seen by the phase to ground relay element is depicted in Fig. 4–5. It is observed that if the compensated fault impedance is used, the relay of fault is located exactly in its proper zone. Whereas, if the uncompensated impedance is used the fault impedance is misoperated and located out of its zone inaccurately located in its zone.

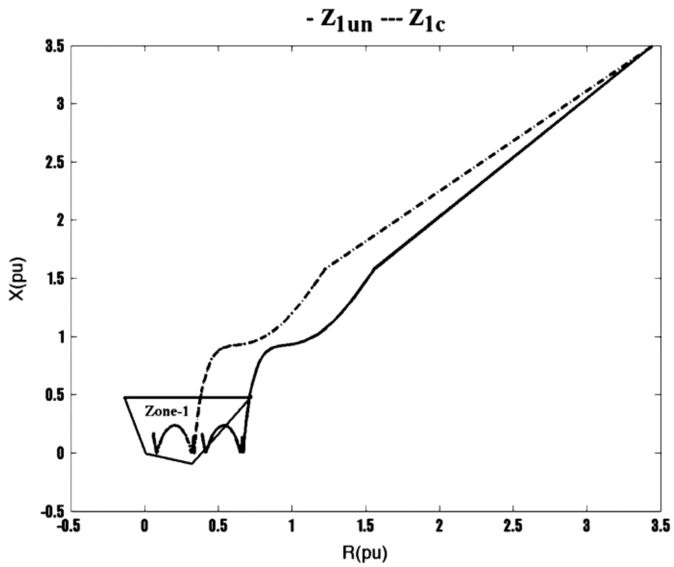

Fig.4. fault impedance trajectory for l-g fault at 45km.

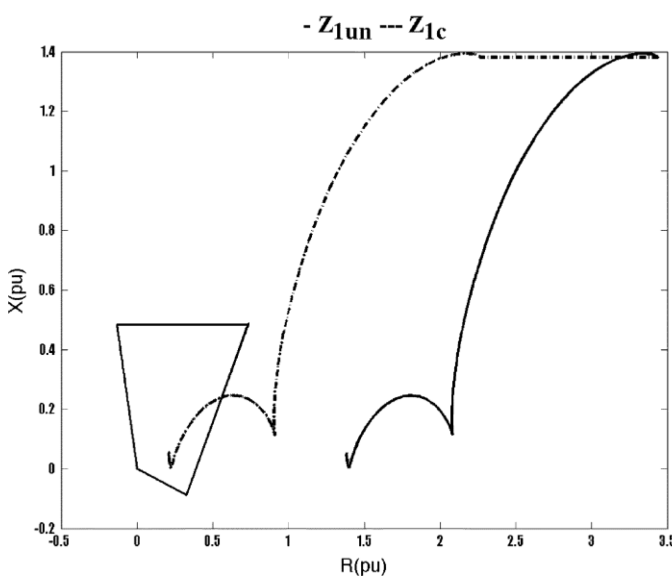

Fig.5. fault impedance trajectory for3 l-g fault at 150km.

V. CONCLUSION

The design and behavior of distance relay used for the protection of long transmission line is described in this paper. The relay was simulated using the model language in MATLAB/SIMULINK.

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From the result it is conclude that underreach problem occurs in distance relaying application due to high fault resistance in line to ground fault.

So for designing the operating equation of distance relay during ground fault, value of fault resistance must be compensated or consider.

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