COMPENSATION OF FAULT RESISTANCE IN DISTANCE RELAY FOR LONG TRANSMISSION LINE

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Abstract - *By designing and simulating this project using the software PSCAD, it will show us how long transmission line distance protection behaves when faced with a fault resistance problem.*

In distance relaying, fault resistance is a crucial factor. If ignored, it could result in the internal flaws causing distance relays to malfunction. However, as a result of the overreaching occurrence, the unbalanced nature of loads and the asymmetry of lines can impact the effectiveness of the distance protection operation. Distance protection should possess the ideal quality of operating within faults that are included in the protection zone in order to carry out its function flawlessly and error-free. The project incorporates a new numerical distance relaying technique that is suggested to improve accuracy of these constraints and efficiency via fault resistance estimate in the distance protection process. This is accomplished by measuring the impedance from the relaying point to the fault point for various values of fault resistance for various types of faults [1] and finding the current & voltage at the relay position.

Key Words: **PSCAD, DISTANCE RELAYING ,CURRENT ANDVOLTAGE RELAY SYSTEM**

1.INTRODUCTION

It is necessary for the transmission lines to be protected by extensive and intricate protection measures in order to keep the impact of power outages on the affected region and time to a minimum. a safety measure implemented before the power system becomes unstable. Modern distance relays offer high-speed fault eradication. They are employed in situations where overcurrent relays slow down and when it is challenging to grade time overcurrent relays for complex networks. At 220 kV, 132 kV, and 400 kV, they are utilized to safeguard transmission and sub transmission lines. Distance protection would not be commercially feasible for 11 kV distribution lines and 66 kV transmission lines, thus over current relays are employed instead.

1.1 BASIC PRINCIPLE DISTANCE PROTECTION

A distance relay has the capacity to identify a problem within a predetermined range along a power cable or transmission line from its location. Each power line has a resistance and reactance per kilometer that are related to the design and construction of the line, so the overall impedance will depend on the length of the line. In order to compare current and voltage, a distance relay looks at these two values in light of Ohm's law.

Given that a transmission line's impedance is inversely proportional to its length, a relay that can measure a line's impedance up to a specific point (the reach point) is suited for distance measurement. In order to provide discrimination for faults that may occur in various line sections, distance relays are designed to only work for faults that occur between the relay position and the predefined (reach) point.

Divide the voltage at the relaying point by the observed current to understand the fundamentals of distance protection. A comparison between the reach point impedance and the estimated apparent impedance is made. When measured impedance is lower than reach point impedance, it is presumed that a fault exists on the line between the relay and the reach point

1.2 BASIC OF FAULT RESISTANCE

The four components of fault resistance are electrical equipment resistance, ground resistance, tower footing resistance, and arc (flashover at line insulator) resistance. An arc resistance is added to the fault path in the event of a flashover from phase to phase or phase to ground. Higher voltages significantly increase the arc resistance. The impedance of the line is raised by the addition of the arc resistance, resulting in a higher overall impedance that is seeded by the distance relay. When there are ground faults, the earth's resistance enters the fault route as well. The resistance of the ground includes the resistance of the tower, the resistance of the tower footing, and the earth return path. Fault resistance is the result of adding arc and earth resistance together. Since there is no earth resistance in the case of phase-to-phase failures, the fault resistance simply consists of arc resistance.

The Warrington formula [3] yields the arc resistance.

Rarc = 29 * 103 * l / I1.4

where I is the fault current in amps and l is the arc'slength in meters.

For phase faults, l will initially equal the conductor spacing, and for ground faults, it will equal the distance between the phase conductor and the tower. The cross winds that typically accompany a lightningstorm lengthen the arc.An electrical arc is an electrical breakdown that occurs when a medium's dielectric strength is exceeded; the kind of medium can affect the dielectric strength. While certain electrical arcing, such as that produced by welding,

plasma cutting, and arc lamps, may be controlled, thepower system should avoid arcing that is not under control. These characteristics could also cause significant harm, though, if no safety precautions are taken to identify the arc. Electric arcs on overhead wires can happen when the insulating element separating the conductor from the support breaks.

Such insulating elements include pins, strains, and others based on their voltage and the conductor's weight and support. In addition, when two phases of a line come into contact, arcing may also occur. For instance, the wind energy nearby causes the Phase R conductor and Phase Y conductor to come into contact. Direct contact between a conductor and the earth or another grounded object, such as a downed conductor, will result in an arc. Because not all of the electrical power produced is supplied to the designated loads, the arcing phenomena also results in a loss of energy for the power companies. When a foreign object comes into touch with a conductor, power is lost while being delivered to the load. As a result of the tiny current that passes through nearby items that provide high impedance in the current path to the ground, the typical relay, such as a distance relay, struggles to identify faults when they first arise. The issue arises when an arcing fault occurs close to the zone's end of the relay's range [7].

2. PROBLEM STATEMENT

Circuit breakers, switchboard panels, low voltage distribution boards, electrical appliances, and overhead wires are just a few of the places where thefault resistance might happen. In terms of overhead lines, single line to ground fault is the most frequent fault connected to the presence of resistance. The resistance of the arc (flashover at line insulator), the resistance of the tower footing, and the resistance of the ground make up the fault resistance. This type ofproblem, in particular, causes the conventional relayto experience high impedance arcing faults. due to the large impedance present in the current path, it ischallenging to identify the fault current. Flashovers are a component of the majority of frequent overhead line defects, including insulator failures and lightning strikes. Most impedance-type distance to fault locator algorithms were in some way by the non- linearity in the network caused by these arcs. However, the majority of fault locators developed today are based on the supposition that the defect has a constant resistance. Since fault resistance compensation is required for long transmission lines, it has become vital to research the phenomenon of fault resistance on overhead lines.

3 OBJECTIVE OF THE PROJECT

This project's primary goal is to analyze the impact of transmission line fault resistance dependent on fault distance. In addition, this study intends to compute fault resistance using a mathematical formula and identify the origins of the occurrence of fault resistance on transmission lines. Finally, this project was developed to compensate for fault resistance on the mho protection system based on the problem statement provided [1].

4 SCOPE OF THE PROJECT

Transmission line distance protection issues are brought on by fault resistance. First off, this project will only concentrate on single phase to ground faults, and not on any other kinds of faults. The next sort of protection strategy to be used is the polarized mho protection scheme. Modeling the failure resistance in transmission line-based schemes using the PSCAD/EMTDC software is successful. A straightforward power system with fault resistance can be used for the PSCAD simulations. permit analysis of several fault resistance types, including equipment resistance, ground resistance, and tower footing resistance.

5 LITERATURE SURVEY

5.1 DISTANCE PROTECTION OF TRASNMISSION LINE

We must fully comprehend the operating concepts and some issues linked with the protection schemes used on transmission lines in order to adequately address the issues related to fault resistance on transmission lines with distance protection scheme. If the fundamental ideas behind this plan are understood, required adjustments to the current distance protection plan can be made to address the issue caused by transmission line fault resistance. In general, there are three major types of transmission line protection schemes. The first is an overcurrent type protection strategy, followed by a differential type protection scheme and a last one known as a distance protection method. Pilot protection refers to the usage of a communications link for protection issues between ends of the transmission line in the context of power system protection. Distance protection schemes can be either non-pilot or pilot. Knowing the state of the line at both ends is advantageous when using pilot schemes. Phase comparison relaying method is one of the three types of approaches, or differential protection scheme. This differential approach examines the phase of the currents at both ends of the line to determine if there is a fault in the middle, as opposed to using distance relaying principles. There are numerous more protection system options outside the phase comparison protection scheme, some of which (distance relaying techniques) rely on impedance measurements. Stepped distance protection is a need for all techniques that consider impedance measurements. All other distance protection programs that are not pilot-based program are subject to the same type of notion.

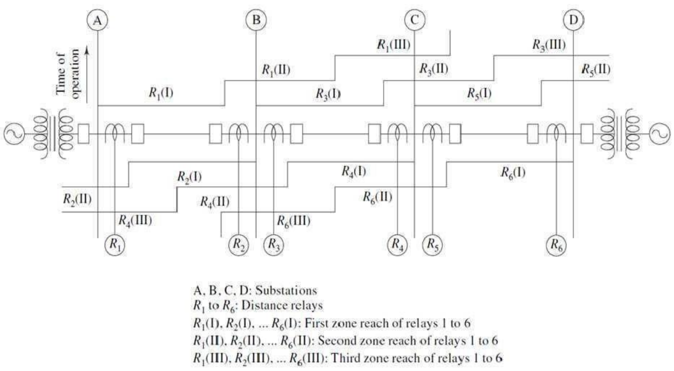


Figure 1 : Stepped Distance Chracteristics of distance Relay

The most important factor in the power system is the fault clearance time for any type of protective strategy. When protecting a transmission line utilizing non-pilot distance protection techniques, it is vital to rely on stepped zones of protection because impedance measurements are imprecise. With more than one zone, a distance protection technique enables to protect any specific piece of transmission line. Zone 1 protection immediately resolves Close in faults.About 80– 90% of the railway is protected under Zone 1. If a defect occurs at the far end of the line, the relay may not be able to determine whether it is actually on that segment of line or an adjacent section based on the accuracy of the impedance measurements. Therefore, it is desirable to allow for a delay in tripping for faults that the relay determines are within the upper limits of zones 1 and 2, or between 120 and 150 percent of the length of the line in question. The line's third zone serves as a backup for the lines next to it. By allowing for trip delays on zone 2 and zone 3 faults, zone 1 protection of the adjacent line can be operated during this period. The fault will be fixed in zone 2 if it is located at 95% of the line in question.

This plan's inclusion of a delay ensures adequate coordination and aids in the endeavor to prevent shutting down more line than is required to repair the fault. One relay can offer both primary and backup protection features thanks to distance protection schemes.

Figure above displays Distance relays with stepped distances divide the entire line into three zones for protection. Since the line is fed from both sides, 6 relays are employed to safeguard it from damage. R1,R3, and R5 are used in the same direction as the figure, while R2, R4, and R6 are used in the other direction. The distance protection relaying not only offers the protected line main protection but also time-delayed backup protection for the protected line as well as for nearby lines.

6 PROPOSED WORKS

6.1 OVERVIEW OF PROPOSED WORKS

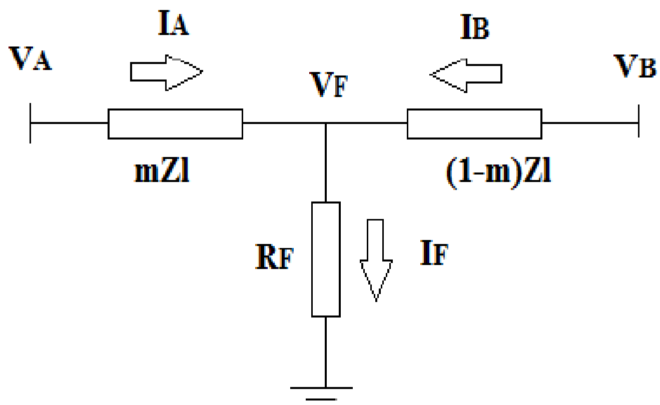
We must enhance the distance protection strategy inorder to address the challenges caused by fault resistance when it is utilized for long transmission lines, as was stated above. The impedance of the transmission line between the fault point and the relay point is used as the basis for the distance protection scheme's operation. Impedance is measured by determining the ratio of the voltage and current at the relay point. If fault resistance is present in the fault loop, it is important to subtract the fault resistance from the observed impedance in order to measure impedance accurately in transmission lines. The primary goal of this work is to identify the defect.

6.2 Alogirithim of Proposed Scheme

The fault site is estimated using a two-terminal technique [1]. The source impedance parameters are not required by the algorithm, and the estimated fault location is unaffected by the fault resistance value. Single Line to Ground (SLG) fault location computation is represented by Equation (1), and the

$$m = \frac{V_A - V_B + \left(\frac{I_B}{3}\right)(Z_1 + Z_2 + Z_0)}{\frac{(I_A + I_B)}{3}(Z_1 + Z_2 + Z_0)}$$

SLG fault situation at a phase line is depicted in Fig 2 Where M= Fault of Location Estimation Z1= Postitive sequence impedance Z2= Negative sequence impedance Z0 = zero sequance impedance VA= Phase to ground voltage for local substation VB = Phase to ground voltage for remote substation IA = Phase current from local substation IB = Phase current from remote substation



Single line to ground fault Fig 2.1

The corresponding sequence network connection foran SLG fault as observed from a nearby substation terminal is shown in Fig. 2.7. Fault voltage; VF at the fault point can be computed using (2) from the output of fault location calculated using (1). Using (3), the fault resistance value was then directly determined. Current from both substations will flow into the fault spot during a fault state and then return to their respective sources. Therefore, when calculating fault resistance, the contribution of current from remote substation must be taken into account.

$$V_F = V_A - m(Z_1 + Z_2 + Z_0)I_{A0}$$

Where;

IA0 = Zero sequence component of phase current fromlocal Substation.

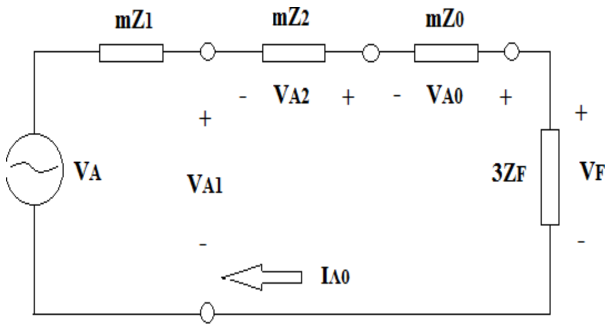


Fig.2.2. Sequence network connection as seen from local substation terminal

$$V_F = V_A - m(Z_1 + Z_2 + Z_0)I_{A0}$$

$$R_F = \frac{V_F}{I_A + I_B}$$

Where

RF = Fault resistance

VF= Fault voltage between fault point and ground

IA= Phase current from local substation

IB = Phase current from remote substation

After the relay calculated the fault resistance, next step is to compensate the effect of fault resistance on Mho type distance relay. This is done first by measuring the apparent impedance at the relaying point. The measurement of apparent impedance is done by using (4).

The apparent resistance, R and reactance, X are the real and imaginary values of (4) respectively.

Where k0= residual compensation factor and k0 =

$$Z = \frac{V_A}{I_A + 3k_0 I_0}$$

(Z0-Z1)/kZ1.

IO= Zero sequence component of neutral current After that, the apparent resistancewillbesubtracted with fault resistance

R compensated = R – RF

Where R compensated = Compensated ApparentResistance

R= Measured Apparent Resistance

A Fault resistance has different influences on distance relay depending on the mode ofoperation, location of Fault and distance of fault from the relaying point.

The following are the fundamentals of the research of distance protection:

The relay only uses local measurements, and the standard techniques are used for fault detection, phase selection, and direction detection.

- Relay determines the location of the fault by calculating the harmonic level or measuring the DC component of the current signal.
- Based on the location of the fault, the algorithm predicts the fault voltage between the fault point and ground.

7 EXPECTED OUTCOMES OF PROPOSED WORK

Distance protection and fault resistance compensation are key strategies for our power system, as we covered previously. It is not possible to compensate for fault resistance while using a distance protection strategy, hence an adaptive distance scheme will be developed. A fault resistanceissue will be solved by an adaptive distance protection technique. Identifying whether the issue is before or after the capacitor bank is important before adjusting the voltage of the capacitor from the observed voltage. Various techniques, such as the use of the DC component of the current signal, will provide an idea of that, and this algorithm will be used to compute the precise fault site.

8 SIMULATION WORK IN PSCAD

8.1 Introduction of PSCAD

WHAT is PSCAD?

The EMTDC electromagnetic transient simulation engine has a robust and adaptable graphical user interface called PSCAD (Power Systems Computer Aided Design). In a fully integrated, graphical interface, PSCAD assists the user in schematically building a circuit, running simulations, analyzing the results, and managing data. Additionally, the user can change system parameters during a simulation run and see the results as the simulation is running thanks to online charting features, controls, and meters. PSCAD is comprehensive software that includes a library of simulation models that have been pre-programmed and validated, ranging from simpler passive elements and control functions to more intricate models, such as electrical equipment, FACTS devices in their whole, transmission lines, andcables. In the absence of an existing model, PSCAD offers options for creating unique models. For instance, primitive models can be built from start in a flexible design environment, or existing models can be pieced together to build a module to create bespoke models.

The PSCAD master library contains the following typical models:

• Mutually connected windings, similar to those in transformers; • Frequency-dependent transmission lines and cables; • Capacitors, resistors, and

inductors; Thyristors, Diodes, and GTOs are examples of analog and digital control devices. Other components include DC and AC machines, exciters, governors, stabilizers, and inertial models.

8.2 FEATURES OF PSCAD

The following list of new and improved features to beaware of is not all-inclusive:

The main new feature in this edition is Multiple Instance Modules (MIM).

• EMTDC Runtime Configuration: The term "runtime configuration" refers to a group of modifications made to the EMTDC system dynamics structure and component design methodologies in order to enableMIM support.

• Improved Searching: There are now better searching options. X Path, a query language for choosing nodes in an XML document, serves as the foundation for the background search engine at the moment.

• Support for Fortran Compilers: PSCAD X4 now comes with the new G Fortran free FORTRAN 95 compiler. Please take note that GNU FORTRAN 77, the previous free compiler, is no longer maintained.

8.3 MODELLING OF DISTANCE PROTECTIONRELAY

The distance protection relay circuit, the signal processing stage, and the protection scheme stage are the three components that make up the transmission line modeling. An illustration of a distance protection relay circuit is shown in Figure

3.5 below. A single line diagram of the circuit, which is a three-phase system, may be seen. The three phase transmission line follows the line model sinceit is the most accurate model available in this software and the resistance varies with the conductor's length.

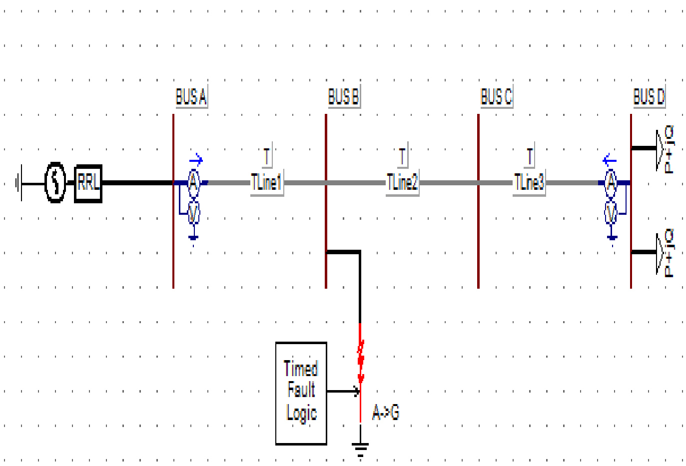


Figure 3 Distance Protection Relay Circuit

Setting of the mho relay is

Zone-1 = 64.95 Ω (80 % of protected line 1).

Zone-2 = 121.16 Ω (100 % of protectedline AB + 50 % of the protected line 2) Zone-3 = 182.52 Ω (100 % of protectedline AB + 100 % of the protected BC +25 % of the protected line 3)

Zone	R	X
1	7.33 Ω	27.425 Ω
2	13.738Ω	51.385 Ω
3	24.675Ω	92.30 Ω

Table 1 Resistance & Reactance of Different Zone

8.4 SIGNAL PROCESSING STAGE

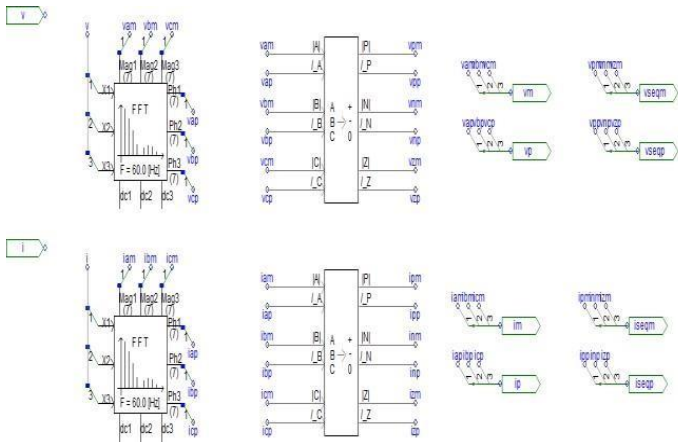


Figure 4 Input Data Processing Stage Systems

The signal is being processed at this point. A few of the parts required for the distance relay system are shown in Figure 4.7. Fast Fourier Transform is used for the "Online Frequency Scanner" rather than Discrete Fourier Transform. Instead of using DFT, this FFT offers a quicker and more effective data processing method. The voltage and current signals contain fading DC components with higher order frequency and lower order frequency when a transmission line has a fault. This FFT component's job is to retrieve the source signal's fundamental magnitudes and phases. The extracted data will then be turned into positive, negative, and zero sequence using "Sequence Filter" once the signal has been extracted using FFT. In order to be used for a mho impedance relay, the transformed data will then be combined once again according to their phase.

8.5 PROTECTION STAGE SCHEME

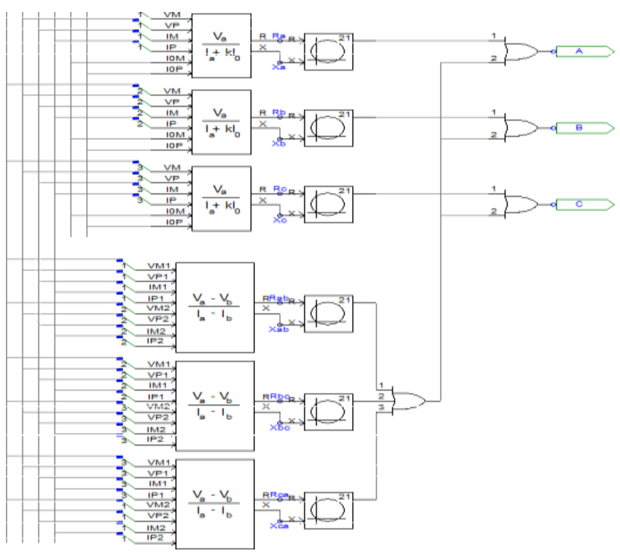


Figure 5 Polarized Mho Protection Scheme Stage

As illustrated in Figure 5, the system requires six protection units in order to detect all fault types including line-ground, double line-ground, line-line, and three-phase faults. Three of these units measure line to ground impedance, while the remaining three measure line to line impedance. Therefore, all of the input used in the PSCAD program comes from the extracted databased on the Signal Processing Stage, and the unit components are already available. The "mho circle" will then be connected to each unit's output. If the OR gate output will be showing "1" than there is the reach of the distance relay and if the OR gate output will be showing "0" than there is fault out of relay characteristic.

9 CONCLUSION

A common transmission line protection strategy is distance protection. Nonlinear properties of the mho relay cause a number of issues with impedance measurement in the distance protection system when it is employed with fault resistance in the transmission line. Instead of using the traditional distance protection technique, an adaptive one should be employed to address this issue. During adaptive distance protection, the fault resistance line can be adjusted in angle while the fault resistance is calculated and made up for using the line impedance. Relay characteristics can be altered if fault resistance changes line impedance. Relay can adjust for changes in line impedance and function in accordance with its genuine impedance value in an adaptive distance protection scheme.

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