240. Comprehensive Study of Line Protection with Distance Relays

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Abstract

To transmit an enormous amount of power over a wide range of distances, transmission lines are used. As they are open to the atmosphere, so come across with various faults. Transmission line faults must be carefully perceived and isolated promptly to ensure a reliable power system and to comply with day-to-day customer demands. An extensive study, development and design of protection schemes have brought a noticeable improvement in the prevention of damage to transmission lines.
The main component which makes the power system stable, reliable and secure is the protection relay. The mainly used relay in transmission system is the distance relay which can be used as Primary or backup protection. Inclusion of capacitors in series with the transmission lines makes parts of the lines capacitive which may lead to voltage and current inversions, sub-harmonics, DC offset conditions and considerably change in the positive sequence impedance of the fault path due to series compensated lines causes the distance relay to maloperate. Various methods can be adopted to compensate such problems

Keywords: distance relay; series capacitors; transmission line protection; zones of protection

1. INTRODUCTION

The goal of power system protection is to seclude a faulty segment of power system from remaining one, so that it can work attractively with no severer harm because of fault current. To guarantee the most extreme profit for the extensive interest in the apparatus, and to ensure the reliable service for the users, the entire system must be kept in operation consistently without real breakdowns. The equipment embraced to recognize conceivable faults is termed to as protective equipment. A relay offers direction to detach a flawed part of the system. This paper provides information regarding the mainly used relay in transmission system i.e. the distance relay which can be used as Primary or backup protection.

2. FUNDAMENTALS OF POWER SYSTEM PROTECTION

A force framework is proficient to meet the present burden as well as has the adaptability to meet the future requests. Henceforth, utilization of defensive mechanical assembly is exceptionally essential in the electrical frameworks, which are relied upon to produce, transmit and appropriate force with slightest intrusions and rebuilding time. It can be all around perceived that utilization of defensive gear are extremely fundamental to minimize the impacts of shortcomings, which generally can slaughter the entire framework. [1]

2.1 BASIC REQUIREMENTS OFPROTECTION

An insurance mechanical assembly has three primary capacities/obligations:

- Safeguard the whole framework to keep up coherence of supply.
- Minimize harm and repair costs where it detects shortcoming.
- Ensure security of staff.

These prerequisites are fundamental, firstly for early discovery and restriction of flaws, and besides for brief expulsion of broken hardware from administration.
Keeping in mind the end goal to complete the above obligations, assurance must have the accompanying qualities:

- Selectivity: To identify and seclude the defective thing as it were.
- Stability: To leave every single sound circuit in place to guarantee progression or supply.
- Sensitivity: To recognize even the littlest deficiency, current or framework variations from the norm and work accurately at its setting before the issue causes unsalvageable harm.
- Speed: To work rapidly when it is desired to do as such, in this way minimizing harm to the environment and guaranteeing security to faculty.

To meet the greater part, insurance must be solid which implies it must be:

- Dependable: It should outing when desired to do as such.
- Secure: It should not go out when it shouldn't.

2.2 BASIC COMPONENTS OF PROTECTION

Power system is made out of different segments like, generator, transformer, bus bar and transmission line.
They are protected by defensive handing-off frameworks containing instrument transformers (ITs), protective relays, circuit breakers (CBs) and correspondence hardware.
In the event of a deficiency happening on a segment, its related defensive transfers ought to distinguish the issue and issue trip signs to open their related CBs to detach the blamed area from whatever is left of the force framework.[2]

3. RELAY OPERATING PRINCIPLES

All things considered, the framework is equipped for managing an assortment of natural and working effects that look like typical working conditions. The strange working conditions that the framework may experience are uncommon yet do happen. They incorporate lightning striking the transmission lines amid serious climate storms, over the top stacking and natural conditions, crumbling or breakdown of the hardware protection, and interruptions by people and/or creatures.
Thus, control frameworks may encounter intermittent flaws. The flaws might be characterized as occasions that have added to an infringement of as far as possible for the force framework parts with respect to protection, galvanic detachment, voltage and current level, power rating, and other such prerequisites. The shortcomings happen haphazardly and might be connected with any part of the force framework.
Thus, the force part encounters an extraordinary anxiety, and unless disengaged or de-empowered, the segment might be harmed destroyed. All in all, the more extended the duration of a shortcoming, the bigger is the harm. The flaw conditions may influence the general force framework operation since the blamed segment should be evacuated, which thusly may add to infringement of the security and/or stacking limits.
Last, however not minimum, the deficiencies may display an existence risk to people and creatures since the harm brought on by the issues may lessen wellbeing limits generally fulfilled for typical working conditions. Defensive transferring was presented by and by as ahead of schedule as the main force frameworks were concocted to ensure that flaws are distinguished and harmed parts are removed from administration rapidly.

3.1 TYPES OF FAULTS ON A THREE PHASE SYSTEM

The types of faults that can happen on a three-stage AC framework are appeared in Figure 1:

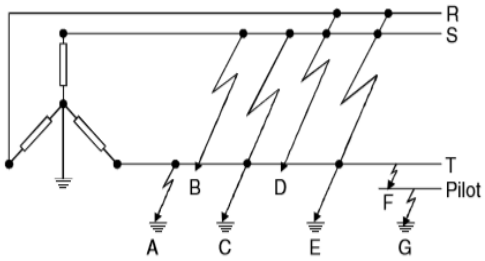

Fig.1. Types of faults on a three-phase system: (A) Phase-to-earth fault; (B) Phase-to-phase fault; (C) Phase-to- phase-to-earth fault; (D) Three-phase fault; (E) Three-phase-to-earth fault; (F) Phase-to-pilot fault(G) Pilot-to-earth fault

It will be noticed that for a stage to-stage blame, the streams will be high, in light of the fact that the flaw current is just restricted by the natural series impedance of the power system up to the point of fault (Ohm's law).
By outline, this inalienable arrangement impedance in a force framework is intentionally been as low as would be prudent to get most extreme force exchange to the customer so that superfluous misfortunes in the system are restricted along these lines expanding the appropriation proficiency. Thus, the shortcoming current can't be diminished without a bargain on the conveyance effectiveness, and further lessening can't be generous. Then again, the extent of earth deficiency streams will be dictated by the way in which the framework impartial is earthed. It is significant at this point it is conceivable to control the level of earth flaw current that can stream by the reasonable decision of earthing plans for the impartial. Strong impartial earthing implies high earth deficiency streams, being restricted by the characteristic earth flaw (zero arrangement) impedance of the framework, though extra impedance presented amongst nonpartisan and earth can bring about similarly bring down earth issue ebbs and flows.
As it were, by the utilization of resistance or impedance in the impartial of the framework, earth flaw streams can be built to be at whatever level fancied and are in this way controllable. This can't be accomplished for phase faults. [3]

4. ZONES OF PROTECTION

To restrain the degree of the power system that is detached when a fault happens, protection is organized in zones.

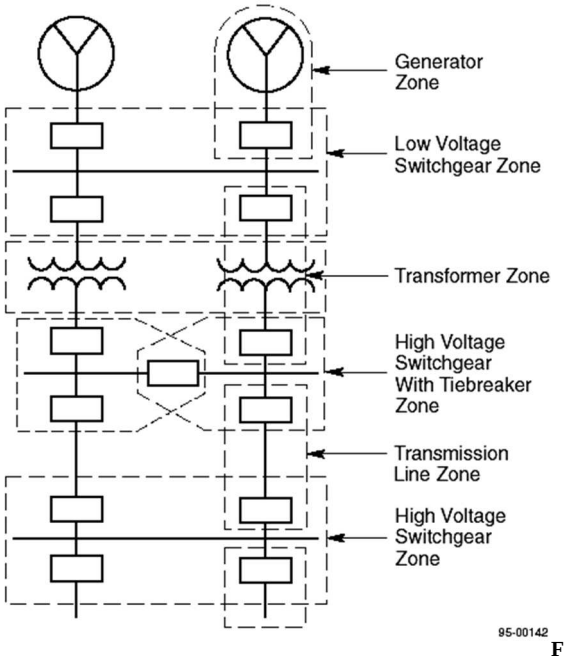

Fig. 2. Zones of protection

Zones are characterized for:

- Generators
- Transformers
- Buses
- Transmission and circulation lines
- Motors

Every zone is characterized by a closed, dashed line. Zone 1, for instance, contains a generator and interfacing prompts transformer. Now and again a zone may contain more than one part. For instance, zone 3 contains a generator – transformer unit and interfacing prompts a transport, and zone 10 contains a transformer and a line.

5. DISTANCE PROTECTION OF TRANSMISSION LINE

Distance protection, in its essential structure, is a non-unit arrangement of protection offering extensive monetary and specialized focal points. Not at all like phase and neutral overcurrent security, is the key advantage distance protection that its deficiency scope of the ensured circuit is for all intents and purposes autonomous of source impedance varieties.
Distance protection is similarly easy to apply and it can be quick in operation for shortcomings situated along a large portion of a secured circuit. It can likewise give both essential and remote move down capacities in a solitary plan. It can undoubtedly be adjusted to make a unit insurance plan when connected with a flagging channel. In this structure it is prominently appropriate for application with rapid auto reclosing, for the master.[4]

5.1 PRINCIPLES OF DISTANCE RELAYS

Since the impedance of a transmission line is corresponding to its length, for distance estimation it is suitable to utilize a relay for measuring the impedance of a line up to a foreordained point (the achieve point). Such a hand-off is depicted as a separation hand-off and is intended to work just for shortcomings happening between the transfer area and the chose achieve point, therefore giving segregation for issues that may happen in various line areas.
The essential guideline of distance protection includes the division of the voltage at the transferring point by the deliberate current. The obvious impedance so computed is contrasted and the achieve point impedance. In the event that the deliberate impedance is not exactly the achieve point impedance, it is accepted that a flaw exists on hold between the transfer and the achieve point.
The achieve purpose of a relay is the point along the line impedance locus that is crossed by the limit normal for the transfer. Since this is subject to the proportion of voltage and current and the phase angle between them, it might be plotted on an R/X diagram. The loci of force framework impedances as seen by the hand-off amid shortcomings, power swings and load varieties might be plotted on the same outline and in this way the execution of the transfer within the sight of framework deficiencies and unsettling influences might be contemplated.

5.2 SIGNIFICANCE OF R-X Diagram

By and large, all electromechanical relays react to one or a greater amount of the conventional torque delivering input amounts: (a) voltage, (b) current, (c) product of voltage, current and the angle θ between them and (d) a physical or outline drive, for example, a control spring. Comparable contemplations hold for strong state transfers also. For separation hand-off, investigating the reaction of the hand-off for all conditions is troublesome on the grounds that the voltage changes for every flaw, or shifts for the same blame however with various framework conditions.
To determine this trouble, it is normal to utilize a R–X graph. By using just two amounts, R and X (or Z and θ), we maintain a strategic distance from the perplexity presented by utilizing the three amounts E, I and θ. There is

an extra huge preferred standpoint in that the R–X outline permits us to speak to both the transfer and the framework on the same chart.
The working normal for an impedance hand-off on V-I plane. It is as a straight line. By alteration, the slant of the working trademark can be changed.
The more advantageous method for portraying the working normal for a distance relay is by method for 'Impedance diagram' or R-X graph. Since the hand-off works for certain quality, not exactly the set estimation of, the Z working trademark is a circle of sweep Z.
Any estimation of Z_f not exactly the range of the circle produces positive torque. Any estimation of If more than the range, of circle delivers a negative torque and hand-off does not work. This is a principle paying little heed to stage point amongst V and I.[5]

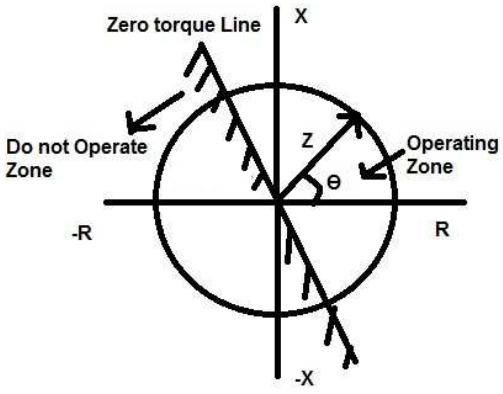

Fig.3. R-X Diagram of impedance relay

5.3 DISTANCE PROTECTION

Essential separation security will contain one immediate (Zone 1) and one or additional time postponed zones (Zone 2, Zone 3, Zone 4 …). Common reach and time settings for a 3-Zone separation security are demonstrated as follows:

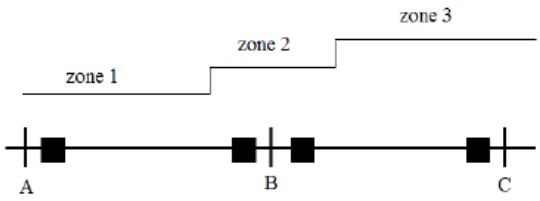

Fig.3. Protective zones

It ought to be noticed that, computerized distance relays may have up to six zones, some set to quantify in the opposite course.

6. THE CHOICE BETWEEN IMPEDANCE, REACTANCE, OR MHO

Since ground resistance can be so variable, a ground separation transfer must be essentially unaffected by substantial varieties in deficiency resistance. Thus, reactance transfers are for the most part favoured for ground handing-off. For stage flaw handing-off, every sort has certain favourable circumstances and detriments.
For short line areas, the reactance sort is favoured for the reason that a greater amount of the line can be secured at fast. This is on the grounds that the reactance hand-off is basically unaffected by curve resistance which might be huge contrasted and the line impedance. Then again, reactance-sort separation transfers at specific areas in a

framework are the well on the way to work undesirably on extreme synchronizing power surges unless extra hand-off hardware is given to avert such operation. The mho sort is most appropriate for stage deficiency transferring for more lines, and especially where serious synchronizing-power surges may happen. It is the most drastically averse to require extra gear to anticipate stumbling on synchronizing-power surges. At the point when mho transferring is changed in accordance with secure any given line segment, its working trademark encases minimal space on the R-X outline, which implies that it will be minimum influenced by anomalous framework conditions other than line shortcomings; as such, it is the most specific of all separation transfers. Since the mho transfer is influenced by bend resistance more than whatever other sort, it is connected to longer lines. The way that it consolidates both the directional and the separation measuring capacities in one unit with one contact makes it exceptionally dependable.

The impedance relay is more qualified for stage shortcoming handing-off for lines of moderate length than for either short or long lines. Curves influence an impedance transfer more than a reactance hand-off however not exactly a mho hand-off. Synchronizing-power surges influence an impedance hand-off not exactly a reactance transfer yet more than a mho hand-off. In the event that an impedance-transfer trademark is counterbalanced, to make it an altered hand-off, it can be made to look like either a reactance hand-off or a mho hand-off however it will dependably require a different directional unit.

There is no sharp isolating line between ranges of utilization where some kind of separation hand-off is most appropriate. Really, there is much covering of these zones. Additionally, changes that are made in frameworks, for example, the option of terminals to a line, can change the kind of hand-off most appropriate to a specific area. Thus, to understand the fullest abilities of separation handing-off, one ought to utilize the sort most appropriate for every application. Now and again much better selectivity can be acquired between transfers of the same sort, at the same time, if transfers are utilized that are most appropriate to every line, diverse sorts on nearby lines have no apparent antagonistic impact on selectivity.

7. REASONS FOR INACCURACY OF DISTANCE RELAY REACH

In a perfect world we would have jumped at the chance to set the compass of the separation hand-off to 100% of the line area. In any case, it is impractical to get the precise scope of 100% by and by. There is constantly sure measure of vulnerability and vagueness about the real reach. Different contributing elements for this uncertainty in reach are:

- Inexactness in CT and PT proportions.
- Uncertainty about line parameters (line parameters are occasionally measured, they are figured from line information).
- Difference of line parameters with barometrical conditions.
- DC counterbalance in flaw current.
- Transient reaction of capacitive voltage transformers (CVT).

Out of these elements DC off-set and CVT transient reaction cause over-reach. Different variables may bring about mistake on either side. In this way, there is dependably a probability of over-compass. On the off chance that the range of separation hand-off is acclimated to 100% then over-compass will bring about loss of selectivity with the separation assurance of the following segment. This can't go on without serious consequences on account of EHV lines. Consequently, it is a typical practice to set the span of separation assurance i.e. around 80 to 90% of the line segment. This leaves 20% to 10% of line without essential assurance. Along these lines, a complete plan of separation security has advanced, giving essential assurance to the line segment under thought and in addition move down to the following line area. [5]

8. LIMITATIONS OF DISTANCE RELAY

The majority of the transmission lines are ensured utilizing ordinary phasor based separation transfers that work in view of voltage and current signs, measured locally. The nearness of arrangement capacitors can make anomalous framework conditions (voltage reversals, current reversals, sub-music and DC balances) that conceivably prompt unintended operation of conventional distance relays. [6]

9. CONCLUSION

Hence, the distance relays are the most emphasizing and flexible in operation**.** They are superior to overcurrent relays because they are less affected by variations in magnitude of short-circuit-current and hence the changes in generating capacity and in system configuration can be withstood.

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APPENDIX

A. Symbols

- Impedance (Z)
- Reactance (X)
- Resistance (R)
- Phase angle (Θ)