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Energy Power Plant in Electric Power Distribution Systems Equipping With Distance Protection

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Abstract

This paper suggests the theory of distance protection criteria in power distribution systems for power plant generation. Multi-developed countries have energy power plants that placed in remote areas which are far from the grid line. Hence, they should be coupled to the low power transportation systems necessarily. While higher-rating relays are adopted to preserve feeders at power substations, fuses are merely obtainable outside on feeder channel. The safe system process, space protection is dispatched to save feeders. In this review, feeders with distance relays are equipped, together with over-current protection relays and fuses. Energy power plant having distance protection system is designed the implemented system was a 6-MW unit of compressed power energy reproduction. The sample feeder was shortened to be equal four-bus experiment feeder for transmitting resolution. The fault currents have chances adopted to form protecting regions of distance relays. Protection of the power line through the designed power plants for distance relaying can decrease problem in relay location because of the impedance-based location of the distance relay.

***Keywords**: Distance protection, Multiple source protection*

1. Introduction

Adopting Renewable Energy Systems (RES) such as Photovoltaic (PV), wind energy systems, systems, and small hydro turbines are increasing in electric networks [1]. This fund, which organizes one of the most important technologies among DGs, are typically smaller than conventional power plants and additional circulated from a geographic point of view, though the key part of electrical power is smoothly generated by conventional power plants, RES is the world's rapid increasing energy market [2-4]. Furthermore, the free enterprise of electric services based on the moderation of power business, growths the chance for further distribution of RESs and extra categories of DGs. Instead, the drawback of fossil fuels and their growing price, accompanied by the incomplete investment on creating new great power plants and communication lines, are the further causes that have added to the distribution of small power plants [5, 6]. These power plants can be connected to planned points of supply systems or near to load centers [7].

One of the key causes for this worldwide care is the environmental worries about the reaction of using traditional power plant. Although traditional power plants through fossil-based fuel have an important effect on the greenhouse radiation and universal warming, RESs position out as pure resources of energy [8, 9]. Electric power systems are inclined to faults, caused by different events such as tree contacts, accidents, natural disasters, and sabotage, among others. Consequently, low power quality indexes and economic losses are experienced. Major power flow from the power substation over supply feeders is decreased. This is the under the theory of distributed power generation. The local customers have to produce electricity for their personal. A distributed generation plant usually takes a traditional simultaneous generator. Consequently, renewable energy power generation that contains power grid, they should have

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linked to a power distribution feeder in country side predictably. Though the renewable energy plant can provide reactions to the financial argument of observation reason another difficult associated with consistency, security, and strength [10]. In this research, adoption of guiding overcurrent relays is explained. Since powers can be overturned their way in certain specific time, reversing overcurrent relays can be relevant. Hence, to put on this relay kind is not easy. Direction location of reversing overcurrent relays is challenging. An additional method is simple. Space relaying is attached to safeguard the supply for the power plants. Hence, consequences between put on these relays are matched and deliberated [10].

One important part of the electric distribution systems are the loads. These are affected by the voltage variations presented during fault situations. However, most of the authors consider static load models in the fault location methods, as these presented in, but these load models are adequate only in the steady state [11, 12]. Moreover, the load behaviour is dynamic and then adequate load models are first considered in. Nonetheless, these methods were not adequately analysed, because authors frequently avoid the time domain analysis, which causes significant impact on the locator performance. Finally, uncertainties associated with the system parameters, such as load model, fault type, fault resistance, among others, were not considered in the previous studies, where the dynamic load models and the time domain analysis were taken into account [13]. A new unidirectional radial power flow proposed in the time domain. Besides, uncertainties in the power distribution systems are considered to evaluate the robustness of the proposed technique. Furthermore, a correction load factor used to attenuate load uncertainties is also proposed. Moreover, a performance indicator proposed to estimate the fault location error is presented in this paper. Additionally, all the inherent characteristics of real power distribution system such as unbalanced network and loads, the presence of multi-phase laterals, capacitive effects and uncertainties in the system parameters are considered [14, 15]. In this paper, efficient and timely fault location techniques is reviewed to improve the information upon service continuity indexes on power distribution utilities.

2. Distribution Systems

Distribution systems work in place of the connection starting the supply base station to the client. The method delivers nontoxic and consistent transmission of electric energy to several consumers through the facility region. Usual distribution systems create as the normal-voltage three-phase circuit, normally about 30–60 kV [16], and dismiss at below secondary three- or single- phase voltage normally lower 1 kV at the consumer's house, commonly at the meter. Supply feeder circuits regularly contain above and covered circuits in a combination of dividing materials from the station to the many customs. The circuit is intended round several supplies such as essential highest load, voltage, space to consumers, and other local situations for instance terrain, visual rules, or consumer necessities. These many branches off materials can be worked in outspread formation or as a circled structure, where double or extra measures of the feeder are attached regularly collected over a usually open distribution switch. High-density urban areas are regularly linked in a composite supply underground network so long as extremely laid off and dependable resources are attaching to consumers. Utmost three-phase systems are for bigger loads, for instance, commercial or industrial consumers. The three-phase systems are frequently strained as one line as displayed in the next distribution circuit drawing.

2.1. Distance Protection Principle

The principle of transmission line protection is distance protection, which comprises the separation of the measured voltage phase at the relaying point for the measured present phase. The impedance of apparently determined is related to the touch point impedance. If the measured impedance is below the touch point impedance, an error currently occurs on the line among the reach point and the relay is presumed. A careful application of the reach locations and skip times for the several zones of calculation enables proper coordination among space relays on a power system. The clear distance defence contains direct directional Zone 1 safety and further time stuck zones [17].

2.2. Multiple Sources Protection

The distance relays have the capacity to distinguish among faults arising in various portions of the system, controlled by the calculated of the impedance. Fundamentally, this condition associated with measuring the fault current that has realized by the relay protection, compared to the voltage at the relay position to regulate the impedance depressed the line error. A distance protection relays are used to regulate depend on the impedance of the line in positive order under secure [18]. Any error happened down flow the relay separates the line into dual parts. The main part that comes from the relay position to the error has an impedance that comparative to the distance between the relay position and the fault location. The fault location be able to be forecast by applying the impedance seen at that have seen in the relay position [7]. So that to fixed the relay distance, three different areas of protective are usually used. Figure 1 shows the distance protection zone. The first area (Zone 1) is considered to protection for a sector of the line secured whereas the second area (Zone 2) is applied as a backup protection of the following line sector. The last area (Zone 3) as well as is used as backup protection that is long-drawn-out to protection the section of the remote line sector. The next illustrate a step-by-step of relay distance location of every protection zone [8] regarding Figure 1. Furthermore, the distance relay usually has worked the principal of timer setting [7].

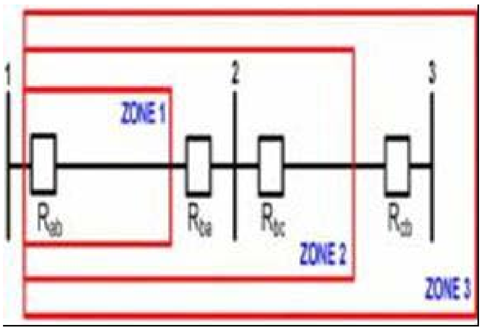

Figure 1. Distance protection

$$Z1:(80\%-85\%)\times Z12 \quad (1)$$

$$Z2:Z12+50\%\times Z23 \quad (2)$$

$$Z3:Z12+Z23+25\%\times Z34 \quad (3)$$

Where
K2 is the in feed constant of the line section2
K3 is the in feed constant of the line section3

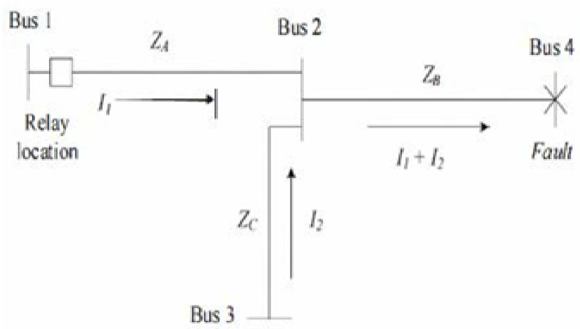

Figure 5. Example for in feed effect [7]

2.3. Backup Protection System Based on Wide Area Information

A network of backup system protection depends on widespread area information, such as 11 traditional protection of distance [19]. It characterizes one to eleven. Therefore, backup protection system depends on widespread information area is to develop the network to make remote trip-out throughout. Widespread area backup protection and Local traditional distance protection works in parallel, without exchange information among them. It means, circuit breaker concurrently obtains trip command of wide area backup protection and local traditional distance protection [20]. One to ten distance protection is adjusted by three-stage traditional distance protection. Such as transformer protection. The timing of operation of II, III section protection is bigger than timing operation of coordinated line protection or adjacent device. Simultaneously, a traditional distance of protection required to make protection that comes the maximum swing period. Widespread backup protection system we need to put every side of current and voltage signals upload to the cloud, soon after process and analyses all the electrical information in the cloud and lastly trip issue command that related circuit breaker. Because of widespread area backup Protection and local traditional distance protection function in parallel, whereas keeping the traditional distance protection independence, this result enhanced sensitivity, reliability, and rapidity of backup protection [10]. In outlook of the local has a complete distance protection system, wide-area backup protection system should be positioned in the high- performance backup protection. Widespread backup protection system comprises three parts which are distance protection component, oscillation recognition, treatment and re-setting of operating time.

2.4. Distance-protection Behaviour During Large Transient

Distance protection relays calculate the impedances on-line on the basis of current and voltage measurements for the protected line [21, 22]. The DP relay in our following considerations is called DP1. Under no-fault conditions, DP1 is measuring the ‘‘load" impedance (point ‘‘1" in Figure 2). Under fault conditions, the selectivity of the DP is maintained by various tripping zones with different R-X-impedance reaches and time delays. In the situation of a fault occurrence in undeleted zone 1, an immediate trip follows in this circumstance our method is not the point of the discussion. In the situation of a fault outside zone 1, the impedance might jump from the ‘‘load" to one of the outer zones (2 or 3) and the fault might be cleared with a certain time delay. The longer the delay time, the larger the acceleration of the generator rotors that are present [7]. For fault clearing we can distinguish two cases: (a) the fault will be cleared by DP1; (b) the fault will be cleared by some other protection relay in the grid and DP1 should not trip. In (a) no post-fault ‘‘scenario” is measured by DP1. In scenario (b) the measured impedance of DP1 jumps from point ‘‘2” to point ‘‘3a” (i.e., outside the protection zones) or to point ‘‘3b” (i.e., inside the protection zones). Points ‘‘3a” and ‘‘3b” Figure 2 are the starting points of the post-fault impedance trajectory that correspond to larger rotor angles, larger power flows and possible lower voltages, compared to the pre-fault (i.e., load) values. Depending on the amount of acceleration of the generator rotors, large rotor-angle excursions and large power swings occur. During these transient phenomena the impedance measured by DP1 can also move inside the protection zones again (as in case ‘‘3a” blue-dashed1 trajectory) or even remain inside the protection zones (in case ‘‘3b” red-dotted trajectory) for a dedicated time duration. If this dwell time is longer than the zone-specific trip delay time, then an unwanted line tripping after the fault clearing might occur.

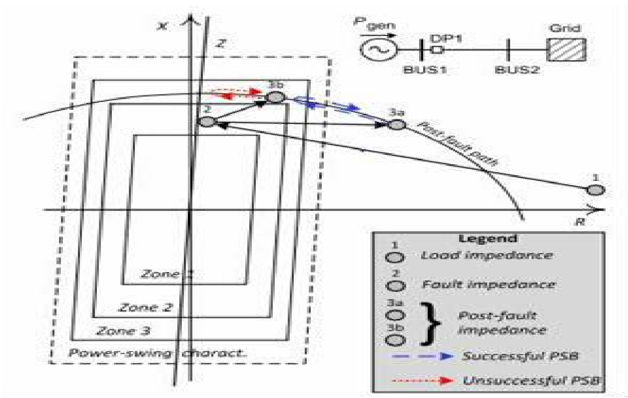

Figure 2. Transitions from the load (1) to fault impedance (2) and to post-fault impedances (3a, 3b)

In order to prevent unwanted tripping during power swings, an additional functionality, i.e., power-swing blocking (PSB), is provided in the form of an additional outer zone, defined by the so-called ‘‘power-swing characteristic", in Figure 2 represented by a dashed-line polygon. The principle of PSB is based on the fact that during a power swing the impedance is gradually changing, while at the moment of a fault’s occurrence the impedance ‘‘jumps” immediately to a fault- impedance point. So, when the time needed for an impedance to cross the area from the power-swing characteristic to one of the tripping zones exceeds a certain value, the PSB is activated and tripping is blocked [17]. Some alternative methods also exist [17]. In case ‘‘3a", the crossing of the area between the power-swing characteristic and tripping zone 3 is not immediate and the PSB is activated. In case ‘‘3b" the post-fault impedance trajectory does not cross the power-swing characteristic and the PSB is not activated. An unwanted tripping of the line is possible if the dwell time is longer than the zone-specific trip delay time. It should be noted that some modern DP relays have advanced PSB algorithms that analyse the shape and the speed of the trajectory and can also detect power-swing phenomena such as in case "3b". In this case the unwanted tripping will not occur, consequently, there is no need for a consideration of these relays in this method. Normally, an assessment of unwanted tripping is performed by repeating the numerical simulations for various fault- clearing times. This might be time-consuming and has limited potential for on-line implementation. Time-domain numerical simulations cannot be avoided when accurate analyses are required, like in the testing of power-swing blocking functions [20].

2.5. Power System and Sample Synchronization

In the following, a single MV feeder is considered that is supposed subdivided into a number of segments. Each line segment is equipped with two distance relays, respectively placed at its termination. It is expected that every relay is attached to a circuit breaker that displays reclosing abilities. When mistake takes place, the safeguard system must sense and separate only the find fault with line section. The expected MV radial system can feed any type of load (linear and nonlinear). Moreover, the reflected power system may show beside the line a number of spread generators (besides the main equivalent source), usually related to nodes occurred by MV/LV transforming positions. It is also expected that the distribution system can be run in islanded type if local DG generation is extra than load request [23].

2.7. The Digital Identification Algorithm

Consider basic taken factor model of a find fault with part of an MV power line attaching bus 2 to bus 3 as in Figure 9. The expected error is a regular three-phase short circuit [24, 25].

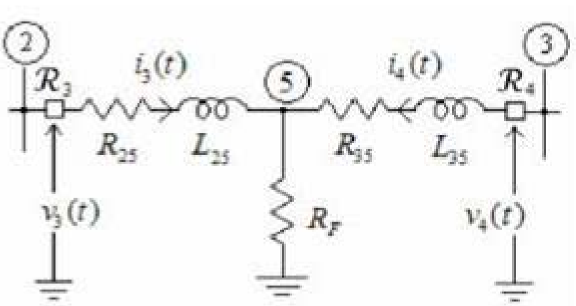

Figure 9. Electrical scheme for a pair of synchronized relays the total resistance/inductance of the power line

R_{23} and L_{23} respectively, so that R_{35}, L_{35} can be expressed in terms of R_{25} and L_{25} as shown in Equation 6.

$$\begin{aligned} R_{35} &= R_{23} - R_{25} \\ L_{35} &= L_{23} - L_{25} \end{aligned} \tag{4}$$

4. Conclusion

This paper has been reviewed by the renewable energy plant for the typical distribution system which is tested and proposed some kinds of the protection system. the implemented protection system was overcurrent relays, directional relays and distance protection relays, the effective of all these kind of protection strategies have been reviewed, different kind of protection has their own advantage and disadvantage , for instance, the complexity, implementation, response, selectivity and sensitivity, cost, all these were the criteria that the different scheme of protection system been discussed.

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References

[1] Sen R, Bhattacharyya SC. Off-grid electricity generation with renewable energy technologies in India: An application of HOMER. *Renewable Energy.* 2014; 62: 388-98.
[2] Bullivant TJ, Lew SA, Tierney KJ, inventors; Milspray, LLC, assignee. *Renewable energy system*. United States patent US 8,539,724. 2013.
[3] Baghdadi F, Mohammedi K, Diaf S, Behar O. Feasibility study and energy conversion analysis of stand-alone hybrid renewable energy system. *Energy Conversion and Management*. 2015; 105:471-9.
[4] Khare V, Nema S, Baredar P. Solar–wind hybrid renewable energy system: A review. *Renewable and Sustainable Energy Reviews.* 2016; 58: 23-33.
[5] Apergis N, Payne JE. Renewable energy, output, CO 2 emissions, and fossil fuel prices in Central America: evidence from a nonlinear panel smooth transition vector error correction model. *Energy Economics*. 2014; 42: 226-32.
[6] Pfenninger S, Keirstead J. Renewables, nuclear, or fossil fuels? Scenarios for Great Britain's power system considering costs, emissions and energy security. *Applied Energy.* 2015; 152: 83-93.
[7] D. Uthitsunthom, T. Kulwora wanichpong. *Distance Protection of a Renewable Energy Plant in Electric Power Distribution Systems*. International Conference on Power System Technology. 2010.
[8] McGlade C, Ekins P. The geographical distribution of fossil fuels unused when limiting global warming to 2 [deg] C. Nature. 2015; 517(7533): 187-90.
[9] Lee S, Speight JG, Loyalka SK, editors. Handbook of alternative fuel technologies. crc Press; 2014.
[10] P.M. Anderson, Power System Protection, IEEE Press., McGraw-Hill, 1999.
[11] Dashti R, Sadeh J. Accuracy improvement of impedance-based fault location method for power distribution network using distributed-parameter line model. *International Transactions on Electrical Energy Systems.* 2014; 24(3): 318-34.
[12] Herrera-Orozco A, Mora-Flórez J, Pérez-Londoño S. An impedance relation index to predict the fault locator performance considering different load models. *Electric Power Systems Research.* 2014; 107: 199-205.
[13] J Horak, W Babic. *Directional Overcurrent Relaying (67) Concepts.* IEEE Rural Electric Power Conference. 2006.
[14] HH Zeineldin, E.F. El-Saadany, M.M.A. Salama. *Protective Relay Coordination for Micro-Grid Operation Using Particle Swarm Optimization*. International Conference on Power Engineering. 2006; 152-157.
[15] I. Chilvers, N. Jenkins, P. Crossley. *Distance relaying of IlkV circuits to increase the installed capacity of distributed generation.* IEE Proceedings - Generation, Transmission and Distribution. 2005; 152(1): 40-46.
[16] McDonald JD, Wojszczyk B, Flynn B, Voloh I. Distribution systems, substations, and integration of distributed generation. *In Electrical Transmission Systems and Smart Grids.* Springer New York. 2013: 7-68.
[17] L. Blackburn. Protective Relaying: Principles and Applications, Marcel Dekker, 1987.
[18] S.G. Srivani, VK. Panduranga, c.R. Atla. *Development of three zone quadrilateral adaptive distance relay for the protection of parallel transmission line*. IEEE International Conference on Industrial Technology. 2009.
[19] Ziegler G. Numerical distance protection: principles and applications. John Wiley & Sons; 2011 Feb 8.
[20] G. Boyle. Renewable Energy: Power for Sustainable Future, Oxford University Press, 2000.
[21] Tziouvaras DA, Hou D. *Out-of-step protection fundamentals and advancements.* InProtective Relay Engineers, IEEE. 2004 57th Annual Conference for 2004; 282-307.

[22] Brunello G, KASZTENNY B. *Distance Protection of Series Compensated Lines Problems and Solutions*. In28 TH Annual Western Protective Relay Conference, Spokane. 2001.

[23] Gers, Juan M, Edward J. Holmes. Protection of Electricity Distribution Networks, IEE Press. 2004.

[24] Zhizhe Z, Deshu C. An adaptive approach in digital distance protection. *IEEE Transactions on Power Delivery*. 1991; 6(1): 135-42.

[25] Liang F, Jeyasurya B. Transmission line distance protection using wavelet transform algorithm. *IEEE Transactions on Power Delivery*. 2004; 19(2): 545-53.