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Review of Various Algorithms for Protection of Transmission Line

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Abstract-- **In a modern power system, selective high speed clearance of faults on high voltage transmission lines is critical. This study indicates the classification and fault location in power transmission line protection and efficient, promising implementations for fault detection. This paper reviews the most recent artificial intelligence (AI) techniques such as Artificial Neural Network (ANN), Fuzzy, Wavelet and Phasor measurement unit (PMU) as well as other conventional methods used in transmission line protection.**

Keywords: ANN, Fuzzy, Wavelet, ANFIS, Differential protection, Protection of Transmission Line.

I. INTRODUCTION

In an electric power system, a fault is any abnormal flow of electric current. Example, the fault in which current flow bypasses the normal load we called it as a short circuit. Open-circuit fault occurs if the circuit is interrupted by some failure. In three phase (3Ø) systems, a fault occurs between one or more phases and a ground, or also may arise only between phases. In "Ground Fault", the current follows the earth path.

In power systems, the protective devices will detect fault conditions and operate circuit breakers and other devices to limit the loss of service due to a failure. In a polyphase system, a fault may influence all phases equally which is a "symmetrical fault". When only some phases are affected, the resulting "asymmetrical fault" becomes more complicated to analyze due to the simplifying assumption of equal current magnitude in all phases has being no longer applicable. Analysis of such type of fault is more often simplified by using methods such as symmetrical components.

A symmetric or balanced fault affects each of the three phases equally. In the transmission line faults, roughly 5% are symmetric. Which upon comparison with asymmetric fault, three phases are not affected equally. In practical, mostly unbalance faults occur in power systems.

An asymmetric or unbalanced fault does not affect each of the three phases equally. Few Common asymmetric faults and their causes are:

- Line-To-Line - A short circuit between lines, caused by ionization of air, or when lines come into physical contact, for example as a result of a broken insulator.
- Line-To-Ground - A short circuit between one line and ground, very frequently caused by physical contact, for example as a result of lightning or other storm damage.
- Line To Line-To-Ground - Two lines come into contact with the ground (and each other), also usually because of storm damage.

Distance protection scheme is considered here and it depends on the fact that on occurrence of a fault, the distance between any point in the power system and the fault point is proportional to the ratio of voltage and current at that point. The techniques for protection of transmission lines can be broadly classified into the following categories

- Travelling-wave phenomenon based methods
- Impedance measurement based methods
- High-frequency components of currents and voltages generated by faults based methods
- Intelligence based method

Distance protection is considered covering various effects like high fault impedance, non-linear arc resistance and variable source impedance. Distance relaying principle, due to their high speed fault clearance compared with the over current relays is a widely used protective scheme for the protection of high and extra high voltage (EHV) transmission and sub-transmission lines. A distance relay estimates the electrical distance to the fault and compares the result with a given threshold, which determines the protection zone. There is a need for the measuring algorithms that have the ability to adapt dynamically to the system operating conditions such as changes in the system configuration, fault resistance and source impedances. Traditional trends since 90's, different techniques are under exploration to increase consistency, speed and precision of existing digital relays based techniques. For numerical protection main component is numerical relay. In the area of protection numerical relay (NR) is the latest development. These relays acquire the sequential samples of ac quantities in numeric (digital) data form through the data acquisition system, and process the data using the algorithm to calculate fault discriminate and make trip decision. These kinds of relay use algorithms for calculation of fault that why we called it as Numerical relay.

Differential protection is a method of protection in which an internal fault is identified by comparing an electrical condition at the terminals of the electrical equipments to be protected. The main component of differential protection scheme is a differential relay which operates when the phasor difference of two or more similar electrical quantities exceeds the pre-determined values. The drawback of differential protection is that it requires currents from the extremities of a zone of protection, which restricts its application to the protection of electrical equipment.

In this paper, various techniques for protection of transmission line are discussed mainly focuses on the various methods to achieve fault detection, classification and isolation in transmission line. Those techniques include – Artificial Neural Network Technique, Wavelet and Phasor Measurement Unit (Optimized Digital Filter), Fuzzy Technique etc. In a modern power system, high speed fault clearance is very critical and to achieve this objective different techniques have been developed.

II. ARTIFICIAL INTELLIGENCE TECHNIQUES

A. *Artificial Neural Networks*

Over the past 15-20 years ANN techniques are under investigation, which can adapt dynamically to the system operating conditions at a high speed. Artificial neural network is composed of number of inter-connected units (artificial neurons) and these networks are inspired by the learning process that takes place in biological systems. The reach accurateness of an electromechanical, static or a microprocessor based distance relay is affected by different fault conditions and network configuration changes. An artificial neural network is composed of a number of artificial neurons that are linked jointly according to specific network architecture. ANN has three layers i.e. input layer, hidden layer and output layer Fig.1 shows the Simplified artificial neural network model. ANN has primarily a high degree of sturdiness and aptitude to learn and have potential to work with partial and unforeseen input data [1].

Various kinds of neural network such as multi-layer perception (MLP), recurrent, radial basis function (RBF), probabilistic neural network and other techniques are being applied for the fault classification and also the fault location.[2] An accurate algorithm for fault location estimation and direction detection of phase-to-ground faults on single circuit transmission line fed from sources at both ends is presented in [3].

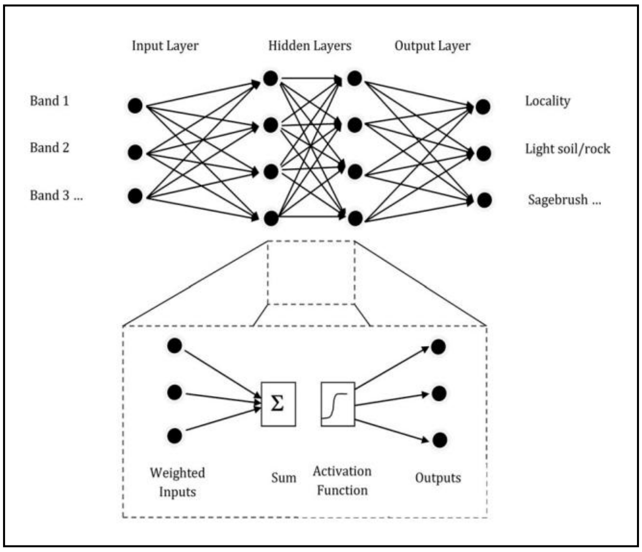

Fig 1: Simplified Artificial Neural Network model

ANNs can solve the overstretch and the under reach problems which are very regular in the conventional distance relay design. ANN makes use of samples of currents and voltages directly as inputs without calculation of phasor and related symmetrical components. The algorithm makes use of the fundamental components of three phase voltages and currents measured at one end only. The algorithm makes available automatic determination of fault direction (forward or reverse) and fault location after one cycle from the initiation of fault. For protection of transmission line with ANN, it doesn't necessitate any communication link to recover remote end data rather it acquires data from local end only i.e. voltages and currents are capture from the bus bar. Then, pre-processing of obtained signal can be done to pass it into ANN level. Signal which needs to be pre-processed has to be passed through certain steps which includes A/D conversion, anti-aliasing filtering, normalization (-1, +1) and in the end through DFT filter to dig out fundamental components of voltages and currents. Then, after obtaining inputs, ANN performs its function of fault detection, classification and isolation by considering different networks. These networks take different neurons for different layers and different activation functions between input and hidden layer and hidden and output layer to obtain desired output. These networks may consist of either of the neural network back-propagation or radial basis function for this task. Back propagation algorithm is the most extensively used for such applications [4].

The study of artificial neural networks as a substitute method to detect and categorize the faults on the transmission lines proved competitive with respect to accurateness. This method employs the phase voltage and phase currents (with respect to their pre-fault values) as its input. Different types of faults namely: single line to ground, line to line, double line to ground and three phase faults have been acquire and work has been carried out separately on each of these faults using ANNs.

B. Fuzzy Technique

Fuzzy-logic based technique perhaps used to identify the variety of types of faults that usually occurs in power transmission lines. Only three line currents are adequate to implement this technique and the line currents at relaying point were first processed to discrete Fourier transform. The angular variations between the obtained sequence components of fundamental during fault and pre-fault current phasor are used as inputs of the fuzzy logic system. In fuzzy logic inference system, singleton fuzzifier method and mamdani inference systems are classically employed to obtain the crisp output of the fault type. And, for defuzzification centroid method is the most substantial method to defuzzify the output [5].

In fuzzy logic based protection system, accurateness cannot be guaranteed for wide variations in system conditions. So therefore a more reliable and secure relaying algorithm during real time implementation is necessary for classifying the faults under a variety of time-varying network configurations. The fuzzy-neuro approaches are responsive to system frequency changes and require large training sets and a large number of neurons affecting their accurateness and swiftness in protecting large power networks.

The operation principle of fuzzy logic controller is analogous to a human operator. It performs the identical actions as a human operator does by fine-tuning the input signal looking at only the system output.

Fuzzy logic has three steps as shown in Fig. 2:

1. Fuzzification (Converting crisp values into fuzzy values).
2. Inference mechanism (Rule base and If-Then rules).
3. Defuzzification (Converting fuzzy values into crisp values).

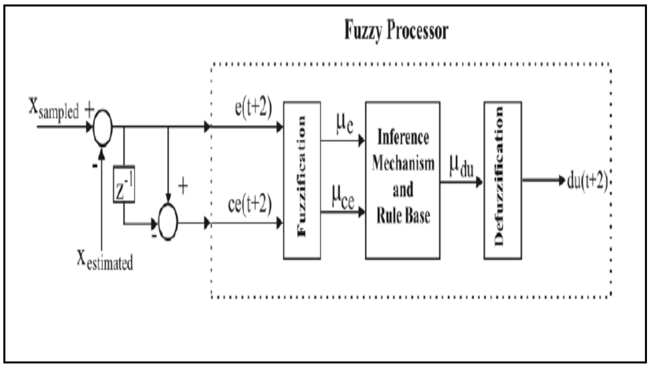

Fig 2. Step of Fuzzy logic Based Controller

Fuzzification is the first step of fuzzy logic, where the genuine measured input values are mapped into fuzzy values through membership functions. To create a fuzzy control system, membership functions were first build up for the input variables “error” and “change of error”. These membership functions could be defined by functions like triangular, sigmoid, gauss, bell-shaped, etc. In fuzzy logic, it is vital for a variable to belong to a membership function with a relative membership degree. This gives the variables a “weighted” membership in a membership function. A variable can have a weighted membership in quite a lot of membership functions at the same time. Secondly, fuzzified values were processed in the fuzzy inference system to define appropriate control action. Output of the fuzzy inference step is also fuzzy. Finally, the resultant fuzzy numbers signifying the controller output were converted into crisp values. This was the last step of the fuzzy control, which is called defuzzification [6]. Adaptive neuro-fuzzy inference system (ANIFS) is the advanced application of artificial intelligence which was introduced recently for protection of transmission line. ANIFS can be viewed as fuzzy system, neural network or fuzzy-neural network. A fuzzy neural network is a knowledge machine that finds the parameters of a fuzzy system (i.e., fuzzy sets, fuzzy rules) by exploiting approximation techniques from neural networks. This technique is divided into three different tasks of fault detection, classification and isolation. With this technique, less operating time and reduced mean-squared error can be achieved.

C. Wavelet Technique

A protection scheme based on transient directional principle was anticipated for transmission line protection. The wavelet transform was used to extract the travelling fronts of the current transients deriving from the faults. The models required to replicate the protection scheme was implemented in an EMT type simulation program. The performance proposed method was put side by side against the conventional differential protection method using a test network simulated in the EMT simulation environment. Simulation results give us an idea about that proposed method can recognize faults in the busbar zone in less than a quarter of a power cycle and confirmed its sturdiness against CT saturation and other conditions that cause problems to conventional bus differential protection.[7]

The conception of wavelet transform based approach for transmission line fault classification that is a uncomplicated and effectual fault detecting approach based on wavelet transform. The hasty change of current component of fault current for power system can be perceived by using Haar and db1 wavelet. The fault detection indicator also can accomplish the task of faulted phase selection. The simulation studies reveal that the proposed algorithm is feasible for transmission line protection to the fault such as L-G, L-L, L-L-G, L-L-L, and L-L-L-G faults in different location.[8]

The capabilities of wavelets are pretentious owing to the existence of noises riding high on the signal and the problem lies in identification of the most fitting wavelet family that is more fairly accurate for use in computing fault location. Majority of the wavelet based techniques employ multi-level wavelet decomposition, which requires multi-level filtering followed by complex computations. Wavelet transform will arise as a powerful tool in transmission line protection provided further work is done in plummeting the algorithm complexity, computational burden and response time. method for fault detection and classification in transmission line using wavelet transform in concurrence with Support vector machine (SVM) and feed forward neural network is describe in [9].

Modern distance relays offers high-speed fault clearance. They are utilized where over current relays become low, and there is difficulty in grading time for complicated networks. During a fault on a transmission line the fault current increases and the voltage at the fault point decreases. V and I are measured at the location of CT'S and VT'S. The voltage at VT location depends on the distance between the VT and the fault. If fault is nearer, measured voltage is lesser. If fault is farther, measured voltage is more. Hence by considering constant fault resistance, each value of V/I measured from relay location corresponds to distance between the relaying point and the fault along the line. Hence such protection is called Impedance protection or Distance protection. The distance protection is high speed protection and is simple to apply. As the function of relays are described, the algorithm for fault detection and faulted-phase selection is given below.[10]

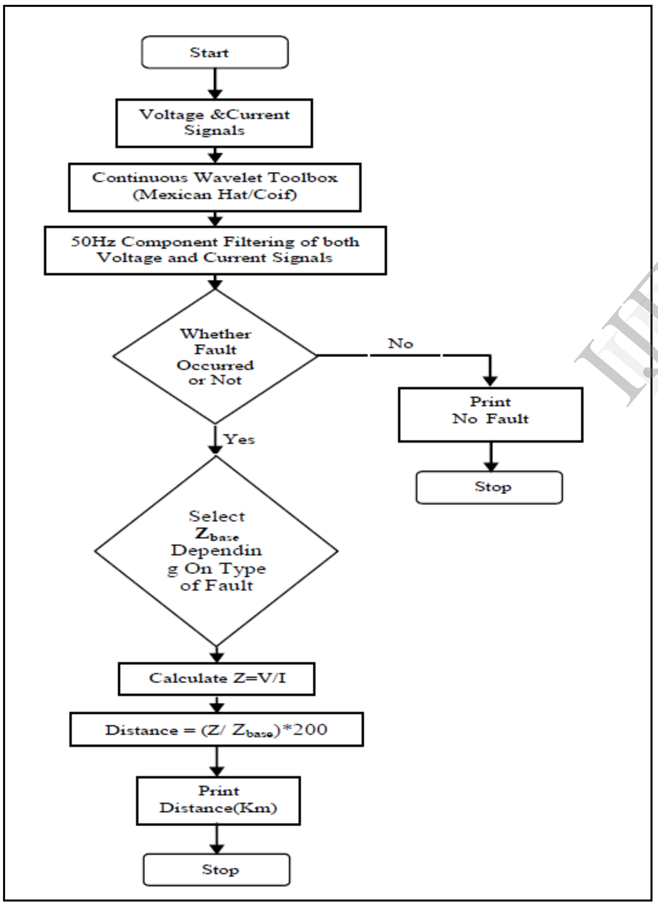

Fig 3. Algorithm for fault detection and faulted-phase selection

The proposed scheme is stand on values of both the current signal and voltage signals from one end. It is shown that the proposed technique precisely classifies the fault type in spite of erratic fault resistances and erratic loading conditions. The scheme is proved to be precise and proficient when compared to the schemes implemented earlier for the classification of faults.

D. PMU Technique

A fault location method for two-terminal multi section composite transmission lines, which combine overhead lines with underground power cables, using synchronized phasor measurements acquired by global positioning system (GPS) based phasor measurement units (PMUs) or digital relays with embedded PMU or by fault-on relay data synchronization algorithms. A novel fault section selector is anticipated to select the fault line section in advance.[11] The anticipated method has the capability to locate a fault no matter where the fault is on overhead line or underground power cable. The adopted method has a solid theoretical groundwork and is undeviating and straightforward in terms of computational convolution. Both extensive simulation results and field test results are offered to demonstrate the success of the proposed scheme. The anticipated method has already been put into operation in the Taiwan power system since the year 2008. Up to the present, the proposed method yields excellent performance in practice.

Synchronized phasor measurements are becoming vital element of wide area measurement systems used in advanced power system monitoring, protection, and control applications. Phasor measurement units (PMUs) are power system devices that provide harmonized measurements of real-time phasor of voltages and currents. Harmonization is achieved by same-time sampling of voltage and current waveforms using timing signals from the Global Positioning System (GPS) Satellite. PMUs technology provides phasor information (both magnitude and phase angle) in real time. The advantage of referring phase angle to a global reference time is helpful in confining the wide area snap shot of the power system. Effective use of this technology is very useful in extenuating blackouts and learning the real time behaviour of the power system. With the encroachment in technology, the micro processor based instrumentation such as protection Relays and Disturbance Fault Recorders (DFRs) integrate the PMU module along with other existing functionalities as an comprehensive feature.[12]

A pure sinusoidal waveform can be represented by a unique complex number known as a phasor. Consider a sinusoidal signal

$$x(t) = X_m \cos(wt + \phi) \quad (1)$$

The phasor representation of this sinusoidal is given by

$$x(t) = \frac{X_m}{\sqrt{2}} e^{j\phi} = \frac{X_m}{\sqrt{2}} (\cos\phi + j\sin\phi) \quad (2)$$

The signal frequency w is not explicitly stated in the phasor representation. The magnitude of the phasor is the rms value of the sinusoid $X_m/\sqrt{2}$ and its phase angle is ϕ, the phase angle of the signal in (1). The sinusoidal signal and its phasor representation given by (1) and (2) are illustrated in Fig. 4.

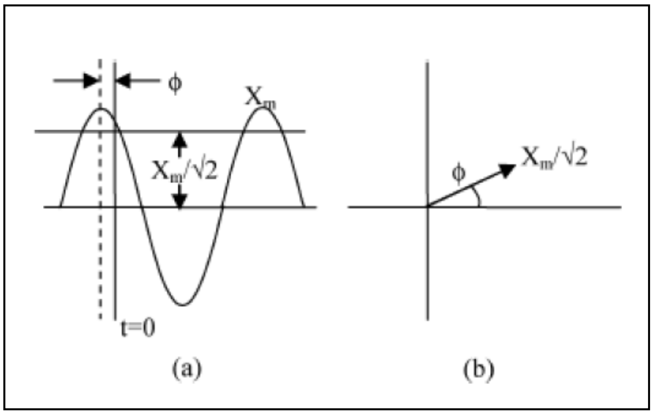

Fig. 4. Phasor representation of a sinusoidal signal. (a) Sinusoidal signal. (b) Phasor representation

Positive phase angles are measured in a counterclockwise direction from the real axis. Since the frequency of the sinusoidal is implicit in the phasor definition, it is clear that all phasor which are included in a single phasor diagram must have the same frequency. Phasor representation of the sinusoidal implies that the signal remains stationary at all times, leading to a constant phasor representation. These concepts must be modified when practical phasor measurements are to be carried out when the input signals are not constant, and their frequency may be a variable

Harmonized phasor measurements facilitates in advancing the power system protection methods. PMUs enable the early fault discovery in the system, allowing for the quick isolation of the faulted segment preventing the power outages. Harmonized phasor measurement provides us with time track of the state variables and several of their derivatives over an observational interval, so it fabricates simpler to predict the instabilities or outcome of a power swing or transients or any other interruption using reasonably good and simplified models. With these predictions, decent protection decisions can be taken by the operator. This leads to the conception of adaptive relaying, where the protection functions changes according to the changing power system conditions. Phasor measurement unit encompasses high potential to be efficiently utilized by the power system utilities to advance the overall existing technology. Considering its accurateness and swiftness in the measurement of the phasor and other parameters, it will materialize as a elementary component in smart grids. [13]

This technique is also robust against power swings circumstances due to load variations and fault clearances and has potential to differentiate transients and permanent faults. PMU based relay operates swift and precisely. This method removes the effect of system capricious such as fault resistance, source impedance and power swings on the decision made by distance relay. A digital filter based solution is anticipated to remove the redundant disturbances using digital filter design techniques. In addition, the required property of a measuring algorithm in protective relaying is to trace a given feature of signal (such as magnitude and phase) that may provide as a initial quantity for certain operating principles, which changes hurriedly due to faults in a power system.

In [14] simulation results of the study are presented which shows that the technique is capable of absolutely abolishing the DC offset, to the highest degree improving the reliability of the full-cycle DFT algorithm. Moreover, the performance of the anticipated algorithm has been tested under transient and dynamic power system conditions, which are vital for the protective relaying applications.

III. CONCLUSION

Most recent methods proposed by many researchers for transmission line protection have been reviewed. In the implementation of digital relaying, a lot of work has been done to enhance the performance of digital protective relays. Different techniques are quite successful such as ANN, fuzzy logic and wavelet analysis. In this paper different techniques are studied so as to design the magnitude base PMU digital relay technique for exact control in transmission line protection system for high effectiveness which is suitable for real time usage. Taking the benefit of the proposed methods and algorithms the new protection schemes shall be designed for bus bar protection.

IV. REFERENCES:

[1] V. Coury, D. C. Jorge, "Artificial neural network approach to distance protection of transmission lines", IEEE transactions on power delivery, vol.13Issue.1,pp.102-108,January 1998.

[2] Surender Kumar Yellagoud, Munjuluri Sree Harsha, Bhamidipati Sridhar, "More accurate and fast fault identification on power networks using artificial neural networks ", International Journal of engineering and advanced technology, Vol.2,Issue.5, pp.207-214,June 2013.

[3] Anamika Yadav, A.S. Thoke, "Transmission line fault distance and direction estimation using artificial neural network", International Journal of Engineering, Science and Technology, Vol.3, No.8, pp.110-121, June 2011.

[4] Eisa Bashier M. Tayeb Orner AI Aziz AlRhirn, "Transmission line faults detection classification and location using artificial neural network", IEEE International Conference pp.1-5, september 2012.

[5] Kaveh Razi, M Tarafdar Hagh and Gh. Arabhian., "High accurate fault classification of power transmission lines using fuzzy logic", 8th International power Engineering Conference, IEEE Explore, pp.278-281,2010.

[6] K. Erentur, "A New Digital protective relay based on fuzzy logic and value estimation" Iranian Journal of Science & Technology, Trans. A, Vol.29,pp.267-276 ,2005.

[7] N. Perera, A.D. Rajapakse, D. Muthumuni, "Wavelet based transient directional method for busbar protection" International Conference on power system, pp 14-17,June 2011.

[8] Rameshkumar. C. Mishra, P. M. Deoghare, "Analysis of transmission line fault by using wavelet", International Journal of Engineering Research and Technology, Vol.3, Issue.5, pp. 270-276, May 2014.

[9] Ch.Madhavi, M. Bala Subbareddy,D. Srilatha, "Transmission line protection using wavelet transform", International Journal of Engineering, Science and Technology, Vol.2, Issue.11,pp. 2168-2176, November 2013.

[10] B. Ravindhranath Reddy, Dr. M. Vijay Kumar,Dr. M.Surya Kalavathi,Y. Venkata Raju, "Detection & localization of faults in transmission lines using wavelet transforms(Coif Let & Mexican Hat)" Journal of Theoretical and Applied Information Technology vol.3, Issue.4 pp 99-104, November 2009.

[11] Abdolhamid Rahideh, Mohsen Gitizadeh, Sirus Mohammadi , "A Fault location technique for transmission lines using phasor measurements" International Journal of engineering and advanced technology, Vol.3, No.1, pp 241-248, October 2013.

[12] Bindeshwar Singh , N.K. Sharma , A.N. Tiwari , K.S. Verma, and S.N. Singh, "Applications of phasor measurement units (PMUs) in electric power system networks incorporated with FACTS controllers," International Journal of Engineering Science and Technology ,Vol. 3, Issue.3, pp.64-82,2011.

[13] K. S. Chandragupta Mauryan, V. Ramkumar, "Phasor measurement units in power system networks - A Review", International Journal of Advanced Information and Communication Technology, Vol.1,No.1, pp 2348-2354,May 2014.

[14] Hamid Bentarzi, Abderrahmane Ouadi,,Abdelkader Zitouni., "Distance Protective system performance enhancement using optimized digital filter," Recent Researches in Circuits, Systems, Mechanics and Transportation Systems.