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Topic: Fault Detection and Identification of Three Phase Transmission System Using Intelligent Techniques

***Index Terms*—Wavelet Transform, Energy, Fuzzy Logic, Membership Function, Fuzzification, Defuzzification, Fault Detection, Fault Identification, Adaptive Neuro-Fuzzy Inference System, Fault Inception Angle, Artificial Neural Networks, Hidden Layers, Feed Forward Networks, Back Propagation Algorithm, Mean Square Error, Confusion Matrix, Clarke Transform, Fast Fourier Transform, Genetic Algorithm, Generalized Neural Network.**

ABSTRACT

Electrical transmission line is very prone to the faults whether overhead, underground or submarine, isolated or grid connected, conventional or smart. The probability of occurring of fault does not depend upon the voltage level of the transmission line. The security, reliability, continuity and power quality of the electrical power supply depend upon the speed of detection, classification of the faults and isolation of faulty section of the transmission line. The conventional methods of fault detection have provided the solution of the problem for decades but human interaction and interference is more in this case. Artificial intelligent techniques are also playing crucial role in detection, classification and restoring of power supply and minimizing the human interference. In this research the new techniques based upon artificial intelligent are developed and tested for three-phase transmission under transmission line parameters and different operating conditions.

The first objective is to detect and identify the faulty phase of three-phase transmission system using Fuzzy Decision Technique, which is based upon fuzzy logic. The data provided by sampling contain vast information about the nature of fault and it is not possible to make a conclusion from this data. The fuzzy logic, like human being can declare the type of fault from this data. The fuzzy logic deals with the problem in similar fashion as human do, this makes the fuzzy logic technique attractive. An algorithm is developed which utilizes the wavelet transform and fuzzy logic for detection and identification of the faults. The current of respective three phases at one bus is measured and sampled. The discrete wavelet transform (DWT) is used for analyzing the measured current signal analysis. The spectral energy of three phase currents and for zero sequence current is calculated. These spectral energies as inputs are fed into Fuzzy Decision System (FDS) with the help of membership functions. The membership functions are special tools adopted by the FDS to tackle the data. The choice of membership function depends upon the data input. The triangular membership functions are employed here for this purpose. The energy of current signal for each phase and zero sequence current is categories in two categories-high and low and fuzzy rules are defined for each and every possible fault, taking account the value of energy whether the spectral energy is high or low. Only four inputs are used in developing the FDS.

The second problem focuses on the application of artificial neural network (ANN) in fault detection and identification. The basics of artificial neuron are somewhat similar to the biological neuron, except the way of dealing of the problem and energy consumption in one calculation. A simple algorithm for fault classification of three-phase transmission line, which is based upon the wavelet transform and ANN is presented here. The three phase currents and voltages of one end are taken as inputs in the proposed scheme. The feed forward neural network

along with back propagation algorithm has been employed for training the ANN. A detailed analysis with varying number of hidden layers and by changing the number of neurons in each layer has been performed to validate the choice of the neural network. The different faults are simulated with different parameters to check the versatility of the method. The proposed method can be extended to the distribution network of the Power System also. The simulation results obtained, prove that the satisfactory performance has been achieved by all of the proposed neural networks and are practically implementable. It is also concluded that the Artificial Neural Networks are a reliable and effective method for an electrical power system transmission line fault classification and detection especially in view of the increasing dynamic connectivity of the modern electrical power transmission systems.

The third objective is detection and identification of Faulty Phase of the Three Phase Transmission System by using Adaptive Neuro-Fuzzy Inference System (ANFIS) method. ANFIS smartly choose membership function for the input *i.e.* according to the input data ANFIS decides the membership for the inputs. In the proposed work the three phase current samples of only one end of the transmission line for fault classification are considered, this makes the practical implementation of the scheme easy. Three phase currents of respective three phases at one end are measured, sampled and features are extracted using discrete wavelet transform. These features in the form of detail coefficients are then used as inputs to the ANFIS. The training information set is obtained by simulating three phase transmission system for ten different types of faults, using various values of fault resistances, fault location and fault inception angles. The accuracy of the presented method has been increased considerably as the training and testing data set of ANFIS for different operating conditions *e.g.* fault inception angle, fault resistance and ten different types of faults has obtained. The ANFIS employs four inputs and only one output for declaring the fault.

The fourth objective is to presents a bonafide approach *i.e.* synergetic Genetic Algorithm and Generalized Neural Network (GA-GNN) approach for fault classification of a three-phase transmission system. The Genetic Algorithm delivers better performance when they are clubbed with the Generalized Neural Network. This makes the application of GA-GNN more attracting than other available artificial intelligent methods. The voltage signals at generating bus of all three phases are acquired and processed under different operating conditions (healthy and unhealthy). Clarke Transform and Fourier Transform do the signal analysis for the proposed algorithm. The various types of fault data is summarized in a normalized matrix form and this normalized matrix is provided as input to the Fuzzy Logic and GA-GNN. The method has effectively adopted the Clarke Transform, Fourier Transform, Fuzzy Logic and GA-GNN efficiently for categorization of faults of a three phase transmission system. As only voltage signals at one bus of the transmission system are used for fault categorization, this makes the adaption and realistic implementation of the algorithm effortless. The correctness and preciseness of the presented method has been enhanced by synergising the qualities of fuzzy logic and GA-GNN and by increasing the training data set of GA-GNN of diverse realistic conditions *e.g.* fault commencement angle, fault resistance and ten different types of faults. The training time taken for the GA-GNN is comparative less and occupies less memory space of the system. The results obtained shows that the presented scheme is very effective and robust in classification of the different types of fault.