A Review on Fault Diagnosis of Three Phase Transmission Line using Soft Computing Techniques

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Abstract— Transmission line among the other electrical power system component suffers from unexpected failure due to various random causes. Because transmission line is quite large as it is open in environment. A fault occurs on transmission line when two or more conductors come in contact with each other or ground. This paper presents a proposed model based on MATLAB software to detect the fault on transmission line. Fault detection has been achieved by using relay and Circuit Breaker based convention system. In this paper, some of the unconventional approaches for condition monitoring of power systems comprising of relay Breaker, along with the application of soft computing techniques like artificial neural networks, fuzzy logic, genetic algorithm and hybrid combinations based on these have been studied.

Key words: Transmission Line Faults, Artificial Neural Network, Fuzzy Logic, Genetic Algorithm, Transmission Lines Protection

I. INTRODUCTION

The objective of the faulted section diagnosis method is to identify faulted components in the power station e.g. generation units, power transformers, autotransformers, service transformers, buses and lines that based on the status of protective relays and circuit breakers. To reduce the outage time and ensure stable and reliable supply for electric power for customers, it is essential for control centers to quickly identify the faulted section in power system prior to start restoring actions. Therefore, the operators must have the capability to estimate and restore the faulted section in an optimal procedure. An effective diagnosis system is required to suggest the possible way to remove faults and assist the operator to protect the systems. Recently, the possibility of implementing the heuristic rules using expert systems has motivated extensive works on the application of expert systems in fault diagnosis. Considerable efforts have been made toward developing fault diagnosis system. Most of these efforts are based on Expert Systems (ES) [1 – 3]. Although ES based approach offers powerful solutions to the fault diagnosis, but it has shortcomings, e.g. the procedure of knowledge acquisition and knowledge base revision or maintenance is quite burdensome. In addition, dealing with the large amount of data is difficult due to the conventional knowledge representation and inference mechanisms. During the last two decades, much research work has been done for estimating the fault section diagnosis in a power system by using several artificial intelligence approaches. Such as, artificial neural networks [4, 5], genetic algorithm (GA) [6], fuzzy Petri nets [7,8], family eugenics based evolution theory [9] and immune algorithm [10]. However, the only work addressing the power plant control and fault diagnosis [11] that aimed to control and supervision the plant system control of the station but not related to the protection system of all station through generation units, transformers, buses and lines. Since there are some wrong and missed signals in a power system, which may be caused by data transmission error or loss, in addition to mal operation and no operation of circuit breakers or relays, uncertainty reasoning is highly recommended to diagnose the system's faulted section. Among the existing uncertainty reasoning approaches, the fuzzy relations approach is accurate, which applied on the power system that include the transmission lines and bus bars [12].

The techniques for protection of transmission lines can be broadly classified into the following categories

- Impedance measurement based methods
- Travelling-wave phenomenon based methods
- High-frequency components of currents and voltages generated by faults based methods
- Intelligence based method
- From quite a few years, intelligent based methods are being used for protection of transmission line.

In this paper, various techniques for protection of transmission line are discussed. The various techniques include – ANN, FUZZY, GENETIC ALGORITHM. For a modern power system, high speed fault clearance is very critical and to achieve this objective various techniques have been developed.

II. PROBLEM FORMULATION

The commonly model used for AC overhead transmission lines is called pi model network, Where shunt admittance has been even divided into two shunt elements connecting to both ends of a pi equivalent network.

A 735 KV, 300km long transmission line system connects with generator having capacity of 1500 MW is used to develop and implement the proposed architectures and algorithms for this problem. The simulation model of three phase transmission line is shown in fig. 1.

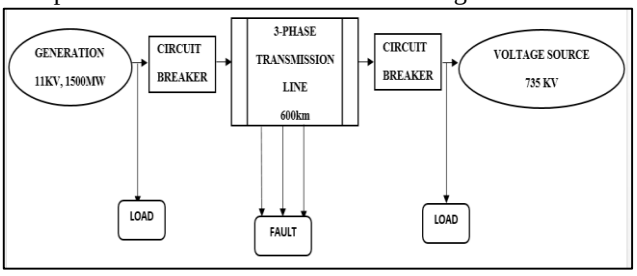

Fig. 1: Block Diagram of proposed scheme

III. INTELLIGENT CONTROL TECHNIQUE (FUZZY LOGIC BASED CONTROL)

Fuzzy logic systems are subjective and heuristic and in general, they are simpler than the wavelet transform or the neural network based techniques. The application of fuzzy logic for exploring complex, non-linear systems, diagnosis systems and other expert systems, particularly when there is

no simple mathematical model to be performed provides a very powerful and attractive solution to classification problems [19].This proposed scheme may not get widely affected by wide variety of pre-fault system loading level, fault level and fault distance far from relay point.

Fuzzy-logic based technique may be used to identify the various types of faults that usually occur in power transmission lines. Only three line currents are sufficient to implement this technique and the line currents at relaying point were first processed to discrete fourier transform. The angular differences between the obtained sequence components of fundamental during fault and pre-fault current phasors are used as inputs of the fuzzy logic system. In fuzzy logic inference system, singleton fuzzifier method and mamdani inference systems are usually employed to obtain the crisp output of the fault type. And, for defuzzification centroid method is the most considerable method to defuzzify the output [20]. The steps involved in fuzzy logic system (FLS) are as shown in fig below:-

In this technique, firstly, data is collected and then pre-processed. The next step is feature extraction which defines distinct pattern of data that is associated with a particular fault. It uses wavelet transform technique to extract feature of different faults. The wavelet transform generates wavelet coefficients which are non-linearly combined with fuzzy inference mechanism.

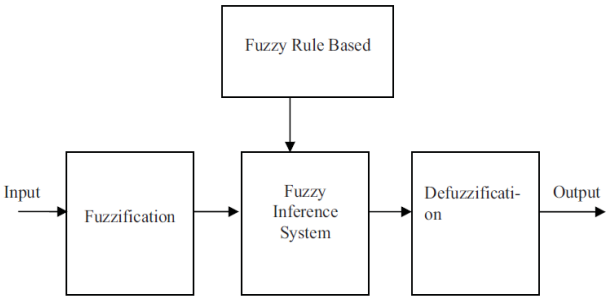

Fig. 2: Fuzzy logic based Fault classifier

Fuzzification is done to fuzzify the features which means it provides a special kind of flexible filtering, faster measuring algorithms that speed up the relays may be used [21].Then intelligent decision making is performed by comparing the fuzzified feature with the templates stored in knowledge base. And to measure robustness of the process, to terms are defined i.e. identifiability and detectability. These two measures aim at minimizing the sensitivity of detection performance to modeling uncertainties, errors and noise in the system. Detectability is the extent to which the presence of feature signature (smallest) is detected and is related to percentage of false alarms. Identifiabilty is the step which distinguishes between various feature modes once the feature is detected. Detectability and identifiablity depends upon number of factors which vary from one system to another. Learning is done to enhance the knowledge base which helps in detection and identification process.

IV. SMART CONTROL TECHNIQUE (ANN BASED CONTROL)

Artificial neural network is composed of number of inter-connected units (artificial neurons) and these networks are inspired by the learning processes that take place in biological systems. An artificial neural network is composed of many artificial neurons that are linked together according to specific network architecture. ANN has three layers i.e. input layer, hidden layer and output layer. ANN has primarily a high degree of robustness and ability to learn and have capability to work with incomplete and unforeseen input data [13].

Conventional distance relays may not operate correctly under certain conditions such as non-linear arc resistance, high impedance fault and variable source impedance. But if such relays are implemented with ANN, such problems can be addressed [14]. Also, ANN techniques can adapt dynamically to system operating conditions at high speed and solves the problem of reach and over-reach. Neural approach is considered to be fast, robust and accurate [15]. For protection of transmission line with ANN, it doesn't require any communication link to retrieve remote end data rather it takes data from local end only i.e. voltages and currents are taken from the bus bar. Then, pre-processing of obtained signal can be done to bring 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 finally through DFT filter to extract 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 include either of the neural network back-propagation or radial basis function for this task. Back propagation algorithm is the most widely used for such applications [16]. It is observed that the radial basis function neural network have ability to identify the precise fault direction more rapidly. This makes it suitable for the real-time purposes also[17].

Also, with the help of adaptive setting of distance relay if it is implemented with ANN, zone settings can be extended and sensitivity of protection can be increased, enhancing system security. Thus, ANN helps in protection of transmission line against different fault conditions. The ANN relay can operate correctly when faced with different fault conditions as well as network changes presenting a much better performance if compared to ordinary relays [18].Thus; it provides fast and reliable operation. ANN tool opens a new benchmark to relay philosophy, which would be widely investigated in order to some various problems associated with distance protection of transmission lines.

V. (ADVANCED CONTROL TECHNIQUE) GENETIC ALGORITHM TECHNIQUE

A Genetic Algorithm (GA) is a search algorithm which is based on the mechanism of natural selection and natural genetics. The fundamental principle involved behind this is that the fittest member of a population has the highest probability for survival. There is a fitness value associated to each chromosome. The better the solution the chromosome represents, the larger its fitness and its chances to survive and produce offspring. In this context, the objective function establishes the basis of selection.

The GA depends on two basic kinds of operators: genetic and evolutionary. Genetic operators, namely crossover and mutation, are responsible for establishing how

individuals exchange or simply change their genetic features in order to produce new individuals. Evolutionary operators deal with determining which individuals will experience crossover or mutation. Essentially, a GA tries to minimize or maximize the value presumed by the fitness function. In many cases, the development of a fitness function can be based on this return and can represent only a partial evaluation of the problem. Additionally, the algorithm must be fast, because it will analyze each individual from a population and its successive generations. Thus, Genetic Algorithm (GA) solves optimization problems based on natural selection principles.

For distance protection of transmission line, the fundamental values of currents and voltages are obtained from power system simulation. The first step is to detect the fault and for this purpose, the current signals are stored in memory. With the occurrence of new sample, it is compared with the corresponding sample one cycle earlier. If change is greater than certain value, the fault condition is detected. The next step is digital filtering and for this GA algorithm is utilized to estimate the fundamental frequency phasors. Then, fault classification is done to choose the voltage and current involved in fault adequately to calculate the apparent impedance seen by distance relay. The apparent impedance and fault distances are calculated for various types of fault conditions. Finally, the calculated apparent impedance is proportional to distance to the fault, protection zone is inferred.

Various conditions may be considered such as different types of faults, faults resistances and fault distances. Better performance is obtained with GA as compared to conventional techniques [23].

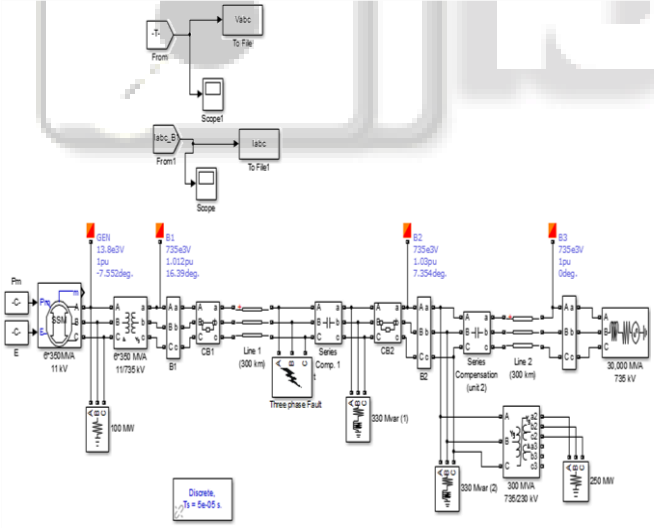

Fig. 3: Simulation model of three phase transmission line

The simulations for the various types of faults were carried performed and the various values for both faulted and non-faulted current were taken and recorded. The following blocks were used in building the logical model for fault detection. The model used in simulink to study the response of the Transmission Line with Circuit Breaker is shown below. The analyses are done for two different operating conditions and according to the type of various waveforms are evaluated. And the variation in voltage and the currents are analyzed. The value of voltages and currents are calculated by taking the data.

VI. SIMULATION RESULTS

Fault type	Line A(PU)	Line B (PU)	Line C(PU)
No Fault	14.3 to -14.1	14.3 to -14.0	14.0 to -10.0
A-G Fault	35.6 to -19.0	22.7 to -17.5	15.5 to -17.4
B-G Fault	16.9 to -13.8	21.3 to -30.4	17.4 to 13.82
C-G Fault	17.5 to -20.8	15 to -14.9	20.5 to -32.0
AB fault	51.5 to -22.4	16.0 to -37.5	14.0 to -14.0
BC fault	14.0 to -14.2	38.15 to -33.2	26.6 to -25.0
AC fault	36.8 to -14.2	14.0 to -14.0	22.12 to -49.8
AB-G fault	51 to -25.7	13.2 to -38.1	16.5 to -14.15
BC-G fault	14.8 to -19.3	34.6 to -36.1	26.3 to -34.42
AC-G fault	45 to -15.9	15.9 to -14.3	20.4 to -45.6
3 phase fault	51.3 to -18.2	23.5 to -46.8	25.9 to -40.68
3phase-G fault	51.1 to -17.9	26.1 to -40.91	25.2 to -46.25

Table 1: Peak to Peak Value of Current for Different Fault Condition

Following fig. Shows the result of Current for Different Fault Conditions with Circuit Breaker, The magnitude of currents is in per unit and Time is in second.

A. Current Response in Transmission Line

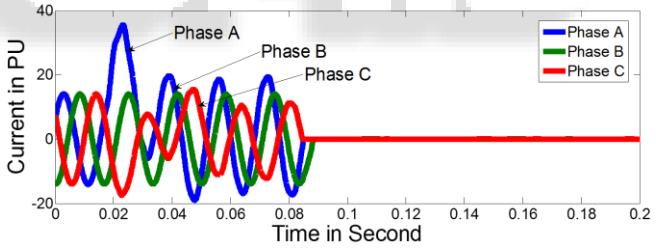

Fig. 4: Current Response of System for SLG Fault (Phase A)

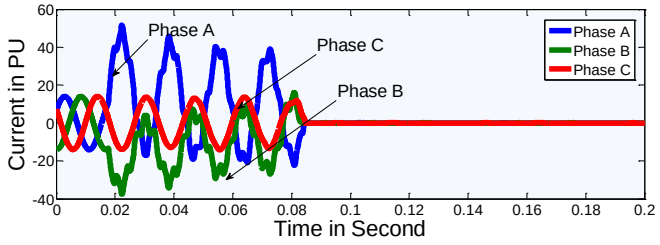

Fig. 5: Current Response of System for LL fault (phase AB)

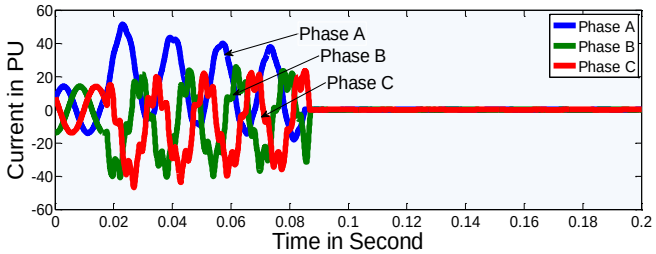

Fig. 6: Current Response of System for LLL fault (Phases ABC)

VII. CONCLUSION

The proposed method uses a relay breaker based scheme for fast and reliable fault detection. Various Asymmetric fault (Single line to ground and double line to ground fault) are simulated and an Breaker based algorithm is used for detection of these faults. Performance of the proposed scheme is evaluated using various fault types and encouraging results are obtained. The simplicity of this design based on fuzzy logic, causes a drastic reduction in loss on distribution systems due to prolonged outages of feeder downtime during faulted conditions.

Due to the flexibility of the neural networks which accept any real values (highly correlated or independent) as an input, resistant to errors in the training data and fast evaluation. The results obtained demonstrate that the performance of the back-propagation (BP) neural network architecture was highly satisfactory. Neural networks, in general, provide a reliable and an attractive alternative approach for the development of a protection relaying system for the power transmission systems.

Further work can be carried out by developing detection system to detect other asymmetric and symmetric fault.

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