LATEST TECHNOLOGY FOR TRANSMISSION LINE PROTECTION

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ABSTRACT

This paper presents a review of the developments in protection theme for cover of transmission lines. For a contemporary power grid, selective high speed clearance of faults on high voltage transmission lines is important and this survey indicates the economical and promising implementations for fault detection, classification and fault location in power cable protection.

The work exhausted this space favor processed relays, data communication technologies and alternative technical developments, to avoid cascading failures and facilitate safer, secure and reliable power systems. The main target of this paper is on the foremost recent techniques, like artificial neural network, formal logic, fuzzy-neuro, formal logic rippling primarily based and phasor measuring unit-based ideas yet as alternative standard strategies utilized in transmission line.

Keyword: - *ANFIS, Wavelet, ANN, transmission line protection.*

1. INTRODUCTION

Transmission lines are among the power system components with the highest fault incidence rate, since they are exposed to the environment. Line faults due to lightning, storms, vegetation fall, fog and salt spray on dirty insulators are beyond the control of man. The balanced faults in a transmission line are three phase shunt and three phases to ground circuits. Single line-to-ground, line-to-line and double line-to-ground faults are unbalanced in nature. On a transmission system the protective relaying system is incorporated to detect the abnormal signals indicating faults and isolate the faulted part from the rest of the system with minimal disturbance and equipment damage. This survey attempts to cover the various developments in digital relays for transmission line protection reported in the literature up to October 2010 and point to some of the references showing promising directions.

Rockefeller first presented the implementation of digital relaying in 1969 (Rockefeller, 1969). The advances in the very large scale integrated (VLSI) technology and software techniques led to the development of microprocessor based relays that were first offered as commercial devices in 1979 (Sachdev, 1979). Selective, high speed clearance of faults on high voltage transmission lines is critical to the stability of the highly complex, modern power system. In this respect, lot of work has been done to improve the performance of digital protective relays and in the use of intelligent techniques for analysis of faults and protective relay operations.

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. In terms of hardware, distance relays have evolved from electromechanical relays to static relays and to microprocessor based (digital) relays. When a fault occurs in an electrical transmission line, the distance relays detect the faulty line and type of fault but they may under reach/over reach depending upon pre-fault loading, fault resistance and remote end in-feeds. The impedance estimated by a digital distance relay reduces with the increase in the speed at which the estimate is obtained. Hence an impedance relay with a specified reach setting cannot operate at arbitrarily high speeds (Thorp *et al.*, 1979). The first installation of digital computer for relaying began in 1960's which made it possible to store information so that the relay engineer can control the

reach characteristics of a distance relay to suit the application and develop fault location algorithms (Gilcrest *et al.*, 1972; Rockefeller *et al.*, 1972; IEEE Std.37.114-2004, 2005). Such digital fault locators calculate the reactance of a faulty line estimated from the computation of voltage and current phasors at the line terminals (Sachdev *et al.*, 1988; Adu, 2004). But these fault location methods need some simplifying hypothesis to allow the fault distance calculation, affecting the accuracy of the results. The one terminal approach is simple and easy to implement (Takagi *et al.*, 1982; Guobing *et al.*, 2009; Xianyning Lin *et al.*, 2009; Eduardo De *et al.*, 2004) although the two-end algorithms which process signals from both terminals of the line are superior in comparison to the one-end approaches (Girgis *et al.*, 1992).

2. DIFFERENT TECHNOLOGY FOR TRANSMISSION LINE PROTECTION

The presence of series connected FACTS (flexiblc ac transmission system) devices like TCSC (thyristor controlled series capacitor), TCPST (thyristor controlled phase shifting transformer) and UPFC (unified power flow controller) etc. can drastically effect the performance of a distance relay in a two terminal system connected by a double-circuit transmission line. The control characteristics of the series connected FACTS devices, their locations on the transmission line, the fault resistance especially the higher ones make this problem more severe and complicated. The fault location with respect to the position of the FACTS devices also greatly influence the trip boundaries of the distance relay. For this purpose author present based on impedance calculations for relaying of double circuit transmission system with varying parameters [1] of the FACTS devices and location. The study reveals the adaptive nature of the protection scheme that necessities the use of an ANN based procedure for the generation of trip boundaries during fault conditions.

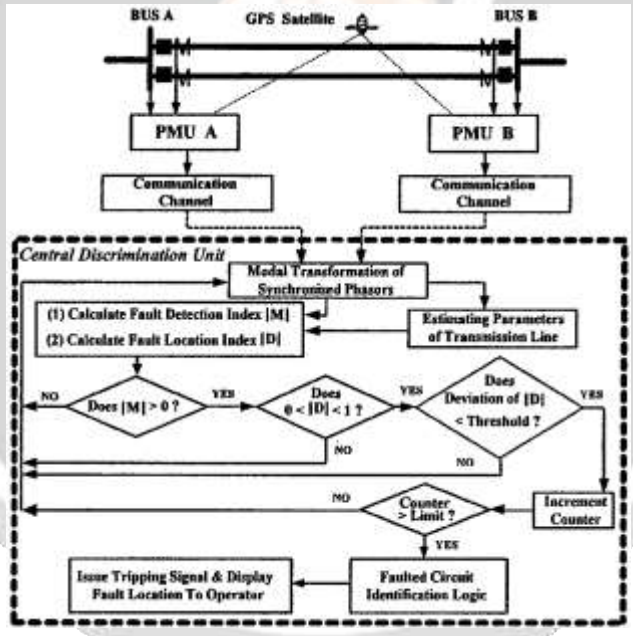

Fig 2:- Phasor measurement unit (PMU) based protection SYSTEM [2].

New adaptive phasor measurement unit (PMU) based protection scheme for both transposed and un-transposed parallel transmission lines [2] was presented. The development of the scheme is based on the distributed line model and the synchronized phasor measurements at both ends of lines. By means of eigenvalue/eigenvector theory to decouple the mutual coupling effects between parallel lines, the fault detection and location indices are derived. The two proposed indices are used in coordination such that the internal and external fault events can be distinguished completely. By on-line estimating the line parameters under the actual power system conditions, the proposed scheme will respond more accurately to power system faults. Extensive simulation results using EMTP have verified that the accuracy of the fault location achieved is up to 99.9%. The proposed protection system responds well and fast with regard to dependability and security.

The one of the technique consists [3] of a preprocessing module based on discrete wavelet transforms (DWTs) in combination with an artificial neural network (ANN) for detecting and classifying fault events. The DWT acts as an

extractor of distinctive features in the input signals at the relay location. This information is then fed into an ANN for classifying fault conditions. A DWT with quasi optimal performance for the preprocessing stage is also presented.

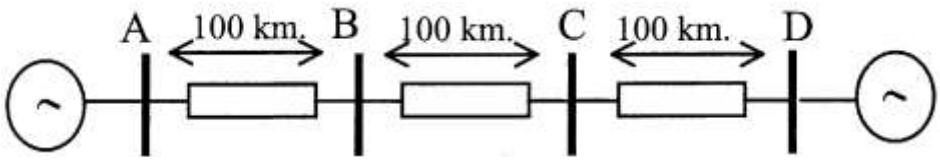

Fig 3:- ANN and wavelet based transmission line protection model [3].

The scheme depends on the three line voltages and the six line currents [4] of the two parallel lines at each end. Fault detection, fault discrimination, and calculation of the phasors of the measured signals are done by using wavelet transform (WT). By comparing the magnitudes of the estimated current phasors of the corresponding phases on both lines, internal faults on the parallel lines can be identified. Also, by calculating the distance element of the phases on which a disturbance is detected and having a very small current difference magnitude can enhance and strengthen the scheme.

One technology proposed [5] an integrated real time fault analysis tool for transmission line. The two primary techniques used in the fault analysis tool, fuzzy adaptive resonance theory (ART) neural network and synchronized sampling, can offer accurate fault detection, classification, internal/external fault differentiation, and fault location. The paper makes several extensions of the two techniques so that they can fit well in the realistic situations.

The hardware configuration and software implementation are proposed in this techique. A comprehensive evaluation study is implemented to compare the proposed fault analysis tool with the traditional distance relay. Simulation results indicate that the integration exemplifies the advantages of both techniques and that the integrated solution has much better performance in different system conditions compared to distance relay. Both dependability and security of transmission line protection system are improved by using the proposed tool.

Two of the most expected objectives of transmission line protection are: 1) differentiating precisely the internal faults from external and 2) indicating exactly the fault type using one end data only. For this purpose one technique proposes an improved solution based on wavelet transform and self-organized neural network [6]. The measured voltage and current signals are preprocessed first and then decomposed using wavelet multi-resolution analysis to obtain the high frequency details and low frequency approximations.

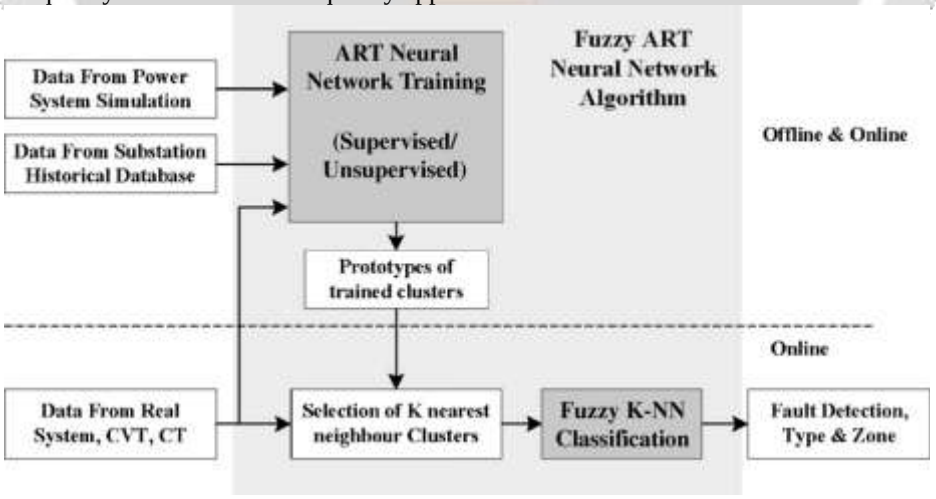

Fig.4.:- Application of Fuzzy ART neural network for fault detection and classification.

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The patterns formed based on high frequency signal components are arranged as inputs of neural network #1, whose task is to indicate whether the fault is internal or external. The patterns formed using low frequency approximations

are arranged as inputs of neural network #2, whose task is to indicate the exact fault type. The new method uses both low and high frequency information of the fault signal to achieve an advanced line protection scheme. The proposed approach is verified using frequency-dependent transmission line model and the test results prove its enhanced performance.

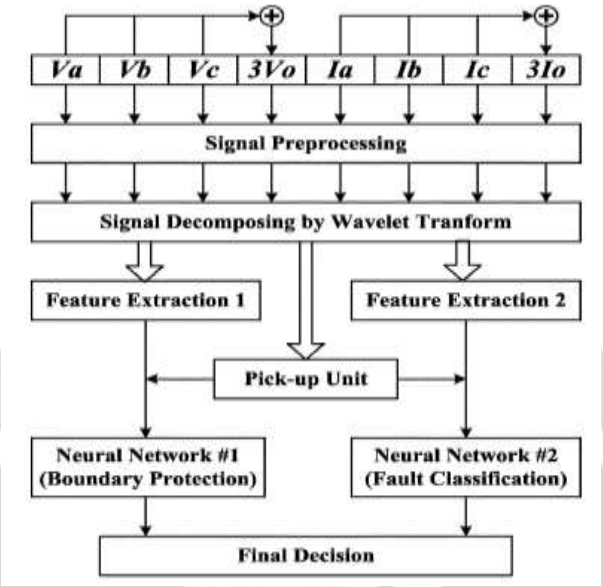

Fig.5:- Overview of the proposed protection scheme using wavelet transform & ANN [8].

The advanced Application of Artificial Intelligent Approaches was introduced recently in Protection of Transmission line in Electric Power Systems (EPS). These approaches started with introducing Fuzzy Logic (FL) in the last decades of the last century. Furthermore, Artificial Neural Network (ANN) was introduced to tackle different problems in EPS. One of these important problems is the Protection of Transmission line with different lengthes. In one of proposed research, the application of Adaptive Neuro-Fuzzy Inference System (ANFIS) for Distance Relay Protection for long Transmission line in Electrical Power systems (EPS) [7] will be introduced. The proposed approach focuses on fault detection, classification, and location in long Transmission lines. Furthermore, all these issues will be addressed in details. The ANFIS can be viewed as a fuzzy system, a neural network or fuzzy neural network. The objective of this paper is applying the ANFIS technique on protection of long Transmission lines. It aims; firstly, to detect the fault occurrence in very short time and isolate the faulty section of the long transmission lines. Secondly to classify the fault type and deduce which of the three phases are exposed to the fault. Finally, locating the fault will be achieved easily even the procedure here is completely different from short and medium transmission lines. The input data of the ANFIS detection units are firstly derived from the fundamental values of the voltage and current measurements (using digital signal processing via Fourier transform).

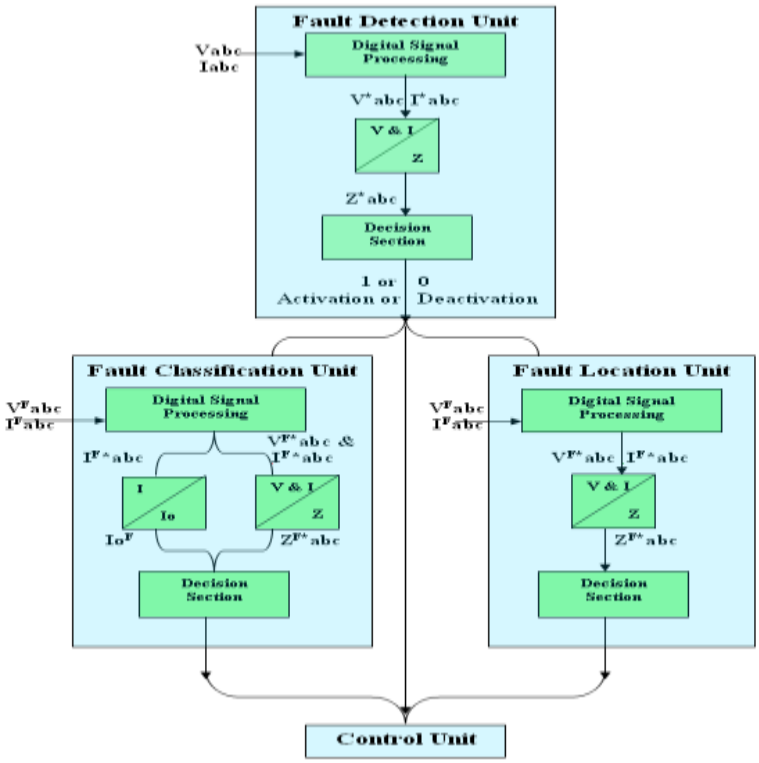

Fig.6:- The Proposed Protection scheme uses ANFIS [7].

Current differential protection relays are widely applied to the protection of electrical plant due to their simplicity, sensitivity and stability for internal and external faults. The proposed idea has the feature of unit protection relays to protect large power transmission grids based on phasor measurement units [8]. The principle of the protection scheme depends on comparing positive sequence voltage magnitudes at each bus during fault conditions inside a system protection center to detect the nearest bus to the fault. Then the absolute differences of positive sequence current angles are compared for all lines connecting to this bus to detect the faulted line. The new technique depends on synchronized phasor measuring technology with high speed communication system and time transfer GPS system. The simulation of the interconnecting system is applied on 500 kV Egyptian network using Matlab Simulink. The new technique can successfully distinguish between internal and external faults for interconnected lines. The new protection scheme works as unit protection system for long transmission lines. The time of fault detection is estimated by 5 msec for all fault conditions and the relay is evaluated as a back-up relay based on the communication speed for data transferring.

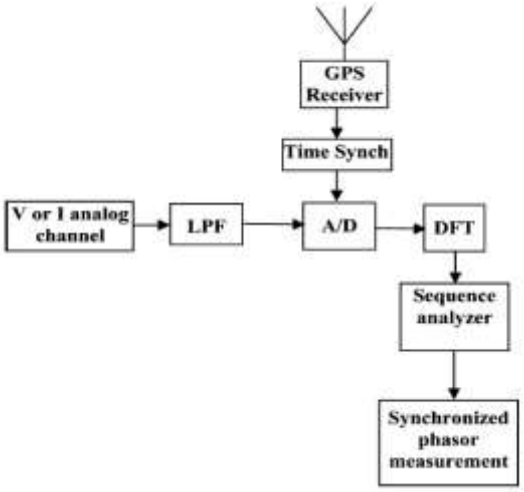

Fig.7:- Synchronized phasor measurement block diagram [9]

A new approach based on combined Wavelet Transform-Extreme Learning Machine (WT-ELM) technique for fault section identification (whether the fault is before or after the series capacitor as observed from the relay point), classification and location in a series compensated transmission line [9] was [resented. This method uses the samples of fault currents for half cycle duration from the inception of fault. The features of fault currents are extracted by first level decomposition of the current samples using discrete wavelet transform (DWT) and the extracted features are applied as inputs to ELMs for fault section identification, classification and location. The feasibility of the proposed method has been tested on a 400 kV, 300 km series compensated transmission line for all the ten types of faults using MATLAB simulink. On testing 28,800 fault cases with varying fault resistance, fault inception angle, fault distance, load angle, percentage compensation level and source impedance, the perfor- mance of the proposed method has been found to be quite promising.

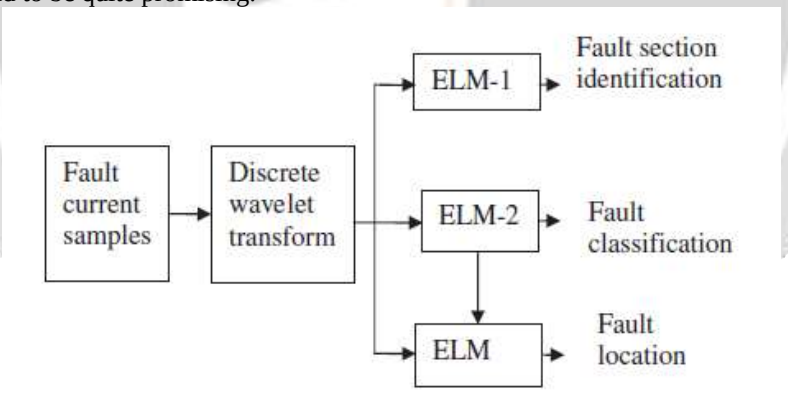

Fig. 8:- Block diagram of the proposed method for protection of series compensated transmission line using WT-ELM [9].

3. CONCLUSION

A review of transmission line protection is done through this paper. Since the implementation of digital relaying, a lot of work has been done to improve the performance of digital protective relays, but in the context of reformation in the power industry and operation of transmission lines close to the stability limits, new tools and algorithms are needed to maintain system reliability and security within an acceptable level. The ANN, fuzzy logic, genetic algorithm, SVM and wavelet based techniques have been quite successful but are not adequate for the present time varying network configurations, power system operating conditions and events. Therefore, it seems that there is a significant scope of research in AI techniques which can simplify the complex nonlinear systems, realize the cost effective hardware with proper modification in the learning methodology and preprocessing of input data and which are computationally much simpler. Also development of reliable software and communication system will pave the

way for better relaying and fault location performance using multi terminal synchronized phasor measurement based on GPS. This paper is an effort to present the most comprehensive set of references on the subject of recent techniques in transmission line protection.

4. REFERNCES

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