Three Phase Line Fault detection using Artificial neural network

Ms. Pallavi V. Pullawar[1], Dr.V.G.Neve[2]

[1]Assistant Professor, Electrical Engg.Dept., JCOET, Yavatmal, Maharashtra
[2]Associate Professor, Electrical Engg. Dept., JCOET, Yavatmal, Maharashtra

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Abstract - *A fault occurs when two or more conductors come in contact with each other or ground. Ground faults are considered as one of the main problems in power systems and account for more than 80% of all faults. This paper focuses on detecting faults on electric power transmission lines. Fault detection has been achieved by using artificial neural networks. Either signal features extracted using certain measuring algorithms or even unprocessed samples of the input signals are fed into the ANN.*

• *The most recent along with a few older samples of the signals are fed into the ANN.*

• *The most important factor that affects the functionality of the ANN is the training pattern that is employed for the same.*

Key Words: Artificial Neural Network, Fault Identification, System protection.

1. INTRODUCTION

Power systems are prone to frequent faults, which may occur in any of its components, such as generating units, transformers, transmission network and/or loads. It is well known that faults can cause significant disruption of supply, destabilize the entire system and may also cause injuries to personnel. Detection of faults is therefore of a paramount importance from economic and operational viewpoints. In addition faults should be detected as quickly as possible, in real time if possible, so that an appropriate remedial action can be promptly taken before major disruptions to the power supply can occur. Neural networks are based on neurophysical models of human brain cells and their interconnection. Such networks are characterized by exceptional pattern recognition and learning capabilities. The major advantage of the neural networks is its self-learning capability. First, the network is presented with a set of correct input and output values. Then it adjusts the connection strength among the internal network nodes until proper transformation is learned. Second the network is presented with only the input data, and then it produces a set of output values. An Artificial Neural Network (ANN) can be described as a set of elementary neurons that are usually connected in biologically inspired architectures and organized in several layers. The structure of a feed-forward ANN, also called as the perceptron is shown. There are Ni numbers of neurons in each ith layer and the inputs to these neurons are connected to the previous layer neurons.

The input layer is fed with the excitation signals. Simply put, an elementary neuron is like a processor that produces an output by performing a simple non-linear operation on its inputs. A weight is attached to each and every neuron and training an ANN is the process of adjusting different weights tailored to the training set. An Artificial Neural Network learns to produce a response based on the inputs given by adjusting the node weights. Hence we need a set of data referred to as the training data set, which is used to train the neural network

2. ARTIFICIAL NEURAL NETWORK

Neural networks are based on neurophysical models of human brain cells and their interconnection. Such networks are characterized by exceptional pattern recognition and learning capabilities. The major advantage of the neural networks is its self-learning capability. First, the network is presented with a set of correct input and output values.

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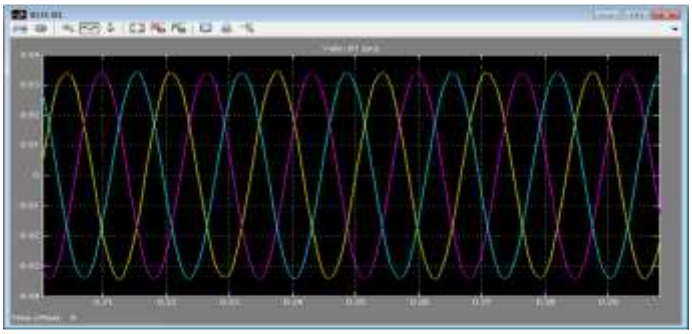

Fig 1: At normal condition

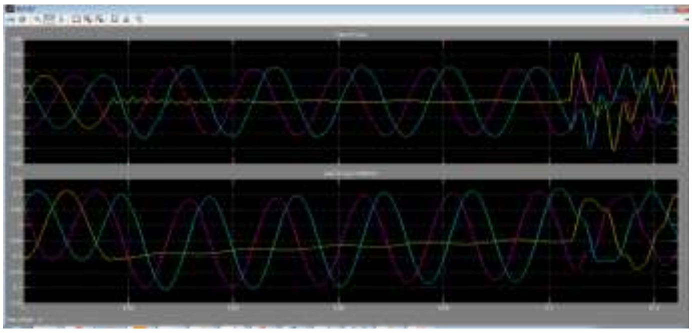

Fig 2: At abnormal condition

3. EXISTING SYSTEM

Electric power Transmission lines are characterized by very lengthy transmission lines and thus are more exposed to the environment. Consequently, transmission lines are more prone to faults, which hinder the continuity of electric power sup loss of electric power generated and loss of economy. Quick detection and classification of a fault hastens its Clearance and reduces system downtime thus, improving the security and efficiency of the network. Thus, this project focuses on developing a single artificial neural network to detect and classify a fault on Nigeria 33-kV electric power transmission lines. This study employs feed forward artificial neural networks with back propagation algorithm in developing the fault detector-classifier. The transmission lines were modeled using SimPowerSystems toolbox in Simulink and simulation is done in MATLAB environment. The instantaneous voltages and currents values are extracted and used to train the fault detector-classifier. Simulation results have been provided to demonstrate the efficiency of the developed intelligent systems for fault detection and classification on 33-kV Nigeria transmission lines. The performance of the detector-classifier is evaluated using the Mean Square Error (MSE) and the confusion matrix. The systems achieved an acceptable MSE of 0.00004279 and an accuracy of 95.7%, showing that the performance of the developed intelligent system is satisfactory. The result of the developed system in this work is better in comparison with other systems in the literature concerning Nigeria transmission lines.

This model was simulated in Simulink. The voltage and current signals were measured using the three phase V-I measurement block. The transmission line (line 1 and line 2) together is 140 km long and various shunt faults were simulated between 1 km and 140 km at a step of 2 km. The resistances used are 0.25, 0.5, 0.75, 5, 10, 20, 30 and 50 ohms. The model was used to generate the whole set of data for training the neural network for the development of the IFDC. For the purpose of fault detection and classification, ten fault cases plus no fault case were simulated and 6 x 6,160 sample data were obtained. The three phase voltage and current waveforms were generated and sampled at a frequency of 1.5 kHz. This choice of the sampling frequency was based on the results of series of the experiments carried out using different frequencies that are at least twice the fundamental frequency (50 Hz). Consequently, there are 30 samples per cycle and these samples were not made to be fed into the ANN in its raw state. Hence, it has to undergo a preprocessing stage called feature extraction and scaling. This, in turn, reduces the overall size of the neural network and advances the time performance of the network. Meanwhile, the fault was created at 0.04s which corresponds to the 55th sample.

DISADVANTAGES

- Harmonic compensation performance of not deteriorated
- plied, increa Unstable system
- Dynamic response is low

4. PROPOSED SYSTEM

A 400 kV transmission line system has been used to develop and implement the proposed strategy using ANNs. A one-line diagram of the system that has been used throughout the research. The system consists of two generators of 11 kV each located on either ends of the transmission line along with a three phase fault simulator used to simulate faults at various positions on the transmission line. The line has been modeled using distributed parameters so that it more accurately describes a very long transmission line.

This power system was simulated using the SimPowerSystems toolbox in Simulink by The MathWorks. A snapshot of the model used for obtaining the training and test data sets is shown. The three phase V-I measurement block is used to measure the voltage and current samples at the terminal A. The transmission line (line 1 and line 2 together) is 200 km long and the three-phase fault simulator is used to simulate various types of faults at varying locations along the transmission line with different fault resistances. Figure 7. Snapshot of the studied model in Sim Power System The values of the three-phase voltages and currents are measured and modified accordingly and are ultimately fed into the neural network as inputs.

The SimPowerSystems toolbox has been used to generate the entire set of training data for the neural network in both fault and non-fault cases. Faults can be classified broadly into four different categories namely:

1. Line to ground faults
2. line to line faults
3. double-line to ground faults
4. three-phase faults.

Outline of The Proposed Scheme Although the basic concept behind relays remains the same, the digital technology has had a significant influence on the way relays operate and have offered several improvements over traditional electromechanical relays. The main goal of this chapter is to design, develop, test and implement a complete strategy for the fault diagnosis as shown in Fig 8. Initially, the entire data that is collected is subdivided into two sets namely the training and the testing data sets. The first step in the process is fault detection. Once we know that a fault has occurred on the transmission line, the next step is to classify the fault into the different categories based on the phases that are faulted.

Normal Condition:

Three-phase current signals (A blue, B green and C red colours) and its detail coefficients at no fault condition. It is seen that when there is no fault, detail coefficients for all three phases are near to reach zero and only appears is the ending effect of daubechies wavelet which is also very small. Energy of the signal, maximum normal value and threshold detail coefficient for normal condition is shown in table 1 below.

Three-phase current signals (A blue, B green and C red colours) and its detail coefficients at no fault condition. It is seen that when there is no fault, detail coefficients for all three phases are near to reach zero and only appears is the ending effect of ANN which is also very small. Energy of the signal, maximum normal value and threshold detail coefficient for normal condition is shown in table 1 above. In the following cases, it will be seen that energy if signal and maximum norm value helps in detecting the fault while threshold detail coefficient helps in classifying the fault.

Table -1: Maximum value, Energy and Threshold detail coefficient of three phases

PHASES	PARAMETERS	VALUES
A	Maximum norm	0.5414
	Energy of Signal	3.886e0055
	Thre.D.cefficient	0.839
B	Maximum norm	0.5415
	Energy of Signal	3.909e005
	Thre.D.cefficient	0.743
C	Maximum norm	0.5414
	Energy of Signal	3.88e0055
	Thre.D.cefficient	0.459

ADVANTAGES

- Low order harmonic distortion is reduced
- Stable system
- High efficiency

5. COMPUTATIONAL

The Simulink power network model as shown in the below fig 3

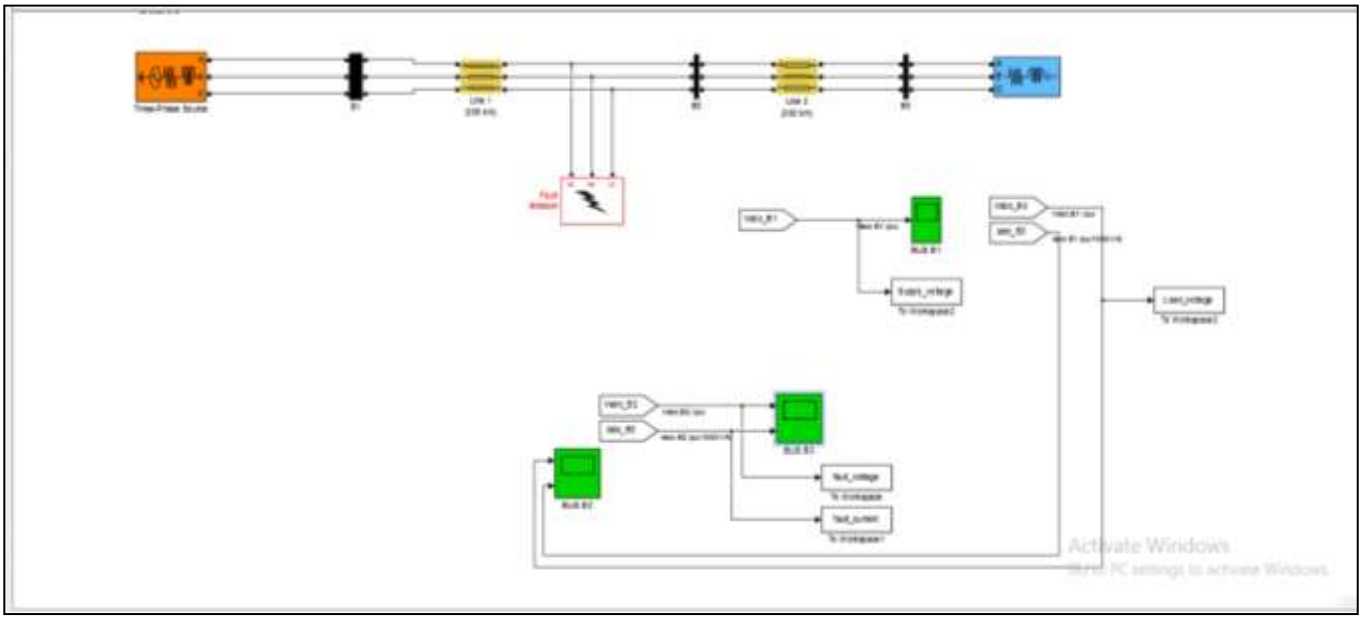

Fig 3: Simulink Model

6. RESULT AND DISCUSSIONS

FAULTS

- In an electric power system, a fault or fault current is any abnormal electric current. For example, a short circuit is a fault in which current bypasses the normal load.
- An open-circuit fault occurs if a circuit is interrupted by some failure.
- In three-phase systems, a fault may involve one or more phases and ground, or may occur only between phases. In a "ground fault" or "earth fault", current flows into the earth.
- The prospective short-circuit current of a predictable fault can be calculated for most situations. In power

systems, protective devices can detect fault conditions and operate circuit breakers and other devices to limit the loss of service due to a failure.

Unsymmetrical Fault

1. Single line - Ground fault

A fault between one line and ground, very often caused by physical contact, for example due to lightning or other storm damage. In transmission line faults, roughly 65% - 70% are asymmetric line-to-ground faults. The effect of single line to ground fault on the various buses are as follow in figure 3,4 & 5.

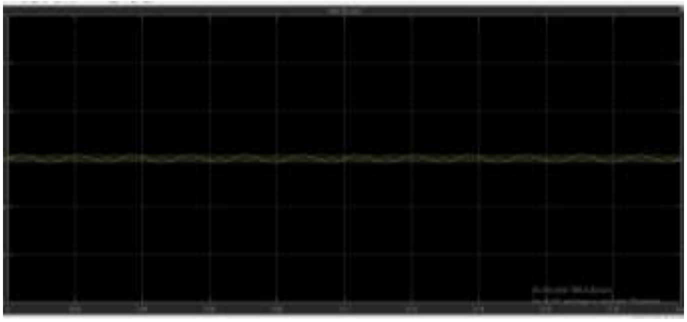

Fig 3: Waveform On Normal Condition At Bus B1

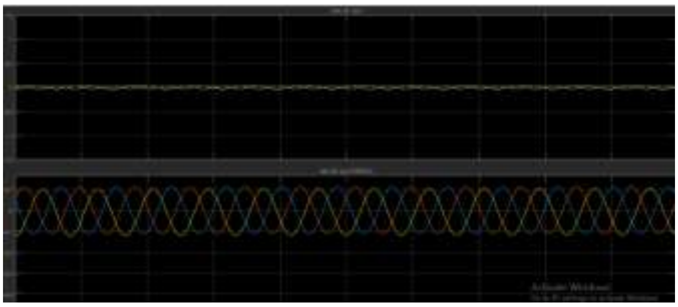

Fig 4: Waveform on Normal Condition at Bus B2

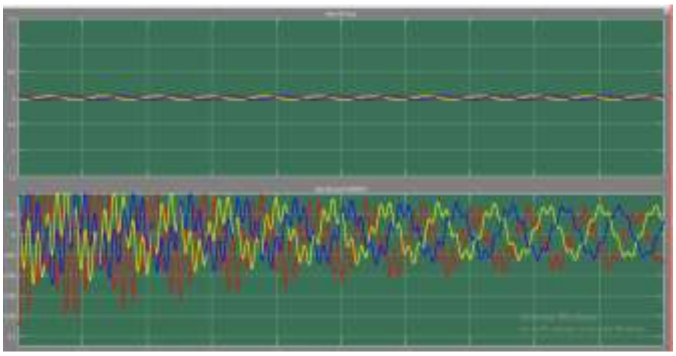

Fig 5: phase A to ground fault at bus B3

2. Double line - Ground fault

*T*wo lines come into contact with the ground (and each other), also commonly due to storm damage. In transmission line faults, roughly 15% - 20% are asymmetric double line-to-ground.. The effect of double line to ground fault on the various buses are as follow in figure 6, 7 & 8

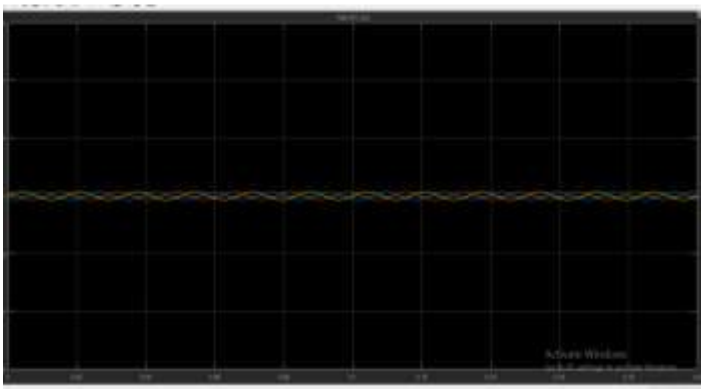

Fig 6: Waveform on Normal Condition at Bus B1

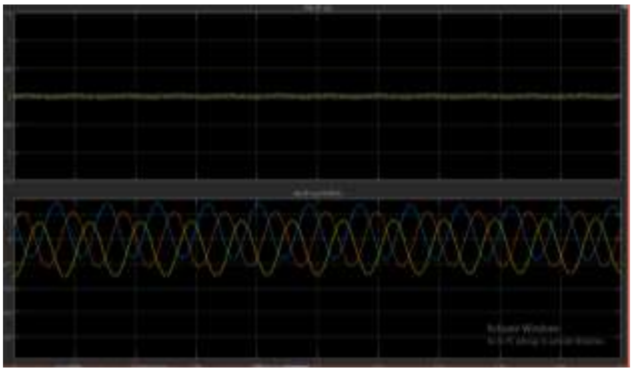

Fig 7: Waveform on Normal Condition at Bus B2

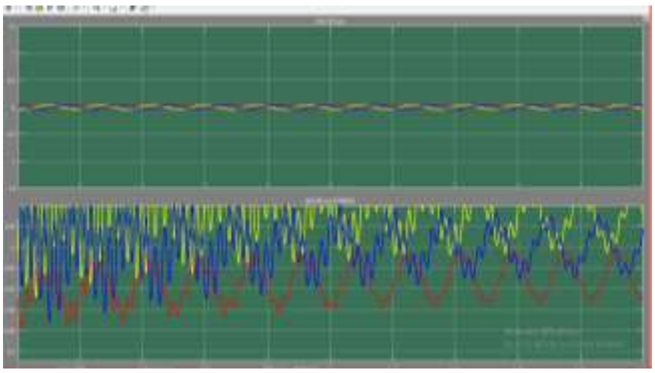

Fig 8: Double phase to ground fault B3

3. Line – Line fault

A short circuit between lines, caused by ionization of air, or when lines come into physical contact, for example due to a broken insulator. In transmission line faults, roughly 5% - 10% are asymmetric line-to-line faults.. The effect of line to line fault on the various buses are as follow in figure 9, 10 & 11

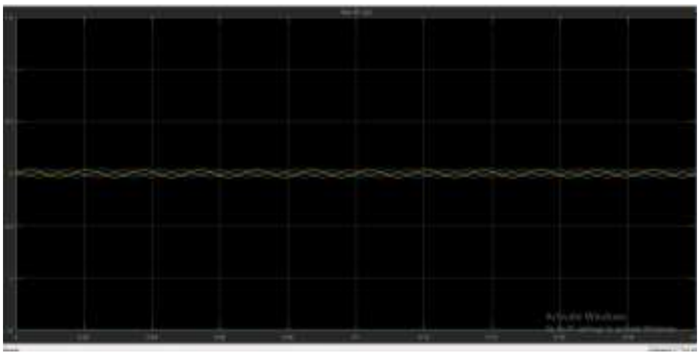

Fig 9: Waveform on Normal Condition at Bus B1

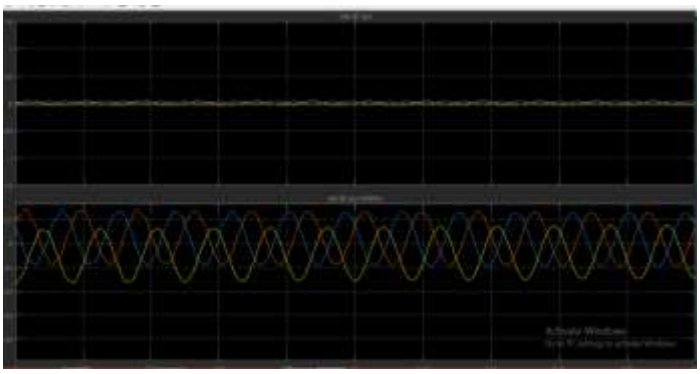

Fig 10: Waveform on Normal Condition at Bus B2

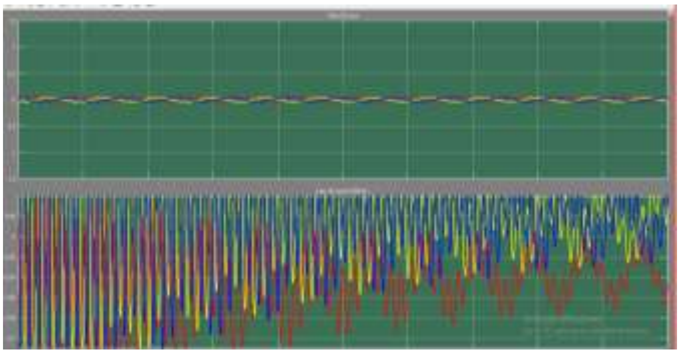

Fig 11: triple line fault at bus B3

Unsymmetrical Fault

1. Three phase fault

2. A symmetric or balanced fault affects each of the three phases equally. In transmission line faults, roughly 5% are symmetric.

3. This is in contrast to an asymmetrical fault, where the three phases are not affected equally. These faults rarely occur in practice as compared with unsymmetrical faults. Two kinds of symmetrical faults include line to line to line (L-L-L) and line to line to line to ground (L-L-L-G).

4. A rough occurrence of symmetrical faults is in the range of 2 to 5% of the total system faults. However, if these faults occur, they cause a very severe damage to the equipment even though the system remains in balanced condition.

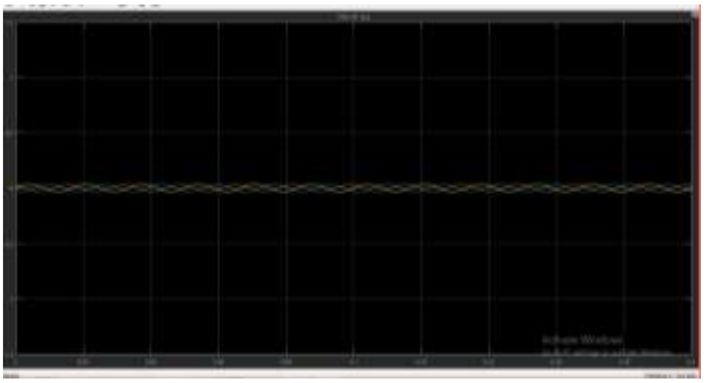

Fig 12: Waveform on Normal Condition at Bus B1

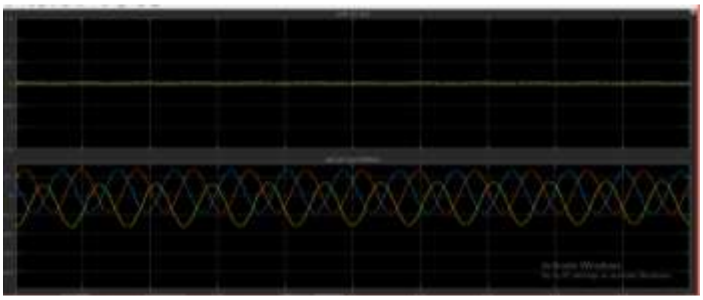

Fig 13: Waveform on Normal Condition at Bus B2

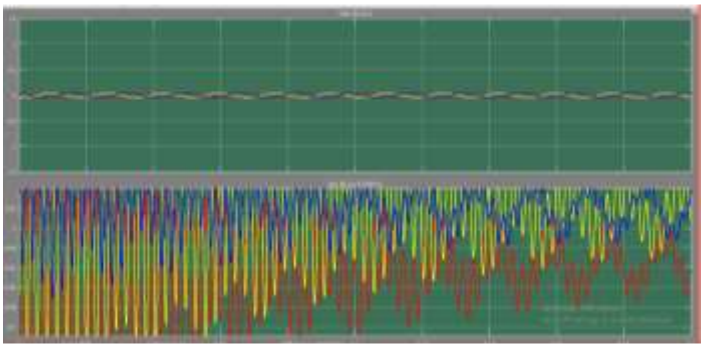

Fig 14: three phase to ground fault at bus B3

7. ADVANTAGES

- ANN have the ability to learn and model non-linear and complex relationship, which is really important because in real life, many of the relationships between inputs and outputs are non-linear as well as complex.
- ANNs can generalize after learning from initial inputs and their relationships, it can infer unseen relationship on unseen data as well, thus making the model generalize and predict and on unseen data.
- Unlike many other predication technique, ANN dose not impose any restrictions on the input variables.
- Ability to work with complete knowledge. After ANN training, the data may produce output even with

incomplete information. The loss of performance here depend on the important of the missing information.

- Having fault tolerance. Corruption of one or more cell of ANN does not prevent it form generating output. This feature makes the network fault tolerant.

8. DISADVANTAGES

- Hardware dependence : artificial neural networks required processor with parallel processing power, in accordance with there structure. For this reason, the realization of the equipment is dependent.
- Un accepted behavior of the network: this is the most important problem of ANN. When ANN produces a probing solution, it does not give a clue as to why nd how. Space this reduces trust in the network

9. APPLICATIONS

- The Project used the MATLAB based models for the detection, classification and phasor estimation during various types of Fault, the same can also be investigated by using the MATLAB.
- Distance relaying can be used in both distribution and transmission level.
- Image compression – neural network can receive and process vast amouts of information at once, making them usefulvin image compression. With the internet explosion and more sites using more images on there sites, using neural networks for image compression is worth a look.

10. CONCLUSION

Classification is done by making compression of the current signal by energy ratio method keeping the approximation with no change, which calculates the threshold details coefficients. If, for two faulty phases, this value is same, then the fault is double phase and on the contrary, if this value are different, then the fault is double phase to ground

This paper has studied the usage of neural networks as an alternative method for the detection of faults on power transmission lines. The methods employed make use of the phase voltages and phase currents (scaled with respect to their pre-fault values) as inputs to the neural networks. Various possible kinds of faults namely single line-ground, line-line, double line-ground and three phase faults have been taken into consideration into this work and separate ANNs have been proposed for each of these faults. All the neural networks investigated in this paper belong to the back-propagation neural network architecture. A fault scheme for the transmission line system, right from the detection of faults has been devised successfully by using artificial neural networks. To simulate the entire power transmission line model and to obtain the training data set, MATLAB R2010a has been used along with the SimPowerSystems toolbox in Simulink. In order to train and analyze the performance of the neural networks, the Artificial Neural Networks Toolbox has been used extensively. Some important conclusions that can be drawn from this paper is: Neural Networks are indeed a reliable and attractive scheme for an ideal transmission line fault scheme especially in view of the increasing complexity of the modern power transmission systems. It is very essential to investigate and analyze the advantages of a particular neural network structure and learning algorithm before choosing it for an application because there should be a trade-off between the training characteristics and the performance factors of any neural network. Back Propagation neural networks are very efficient when a sufficiently large training data set is available.

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