An ANN based Relay Design for Identication Faults of 400kv High Voltage AC Transmission Line

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ABSTRACT
This Paper Presents the modelling and identification of faults of a 400KV high voltage AC transmission line by using PSCAD/EMTDC Software and design an ANN Based distance relay in MATLAB NNTOOLBOX. The ANN Based distance relay which can differentiate the fault conditions from normal operating conditions. The Artificial neural network technique allowed us to analyse the performance of relay at various faulted condition and Produced a trip signal if a fault is generated and no trip Signal otherwise. In this paper feed forward neural network is developed in MATLAB using supervised training and delta learning rule for obtain the best Performance of the relay. The simulation result shows that the proposed scheme is able to identify all the faults on transmission line with great selectivity, reliability and sensitivity.

Keywords
EHV transmission line, fault identification ANN techniques, Feed forward techniques, PSCAD, MATLAB.

1. INTRODUCTION
Transmission line Protection is a very important issue to protect the electric power system. In transmission line faults [1] occurs due to several reason. In practice the most common type of fault is the single line to ground fault. Other types which occurs less frequently are three-phase faults, phase to phase faults, and two-Phase to ground faults. The demand for electricity is ever increasing. It is Important to supply quality electrical Power continuously for industrial, business and residential usage. While failure to supply electricity to residential areas might result in dis comport to those dwelling in them, dis continued supply to business and industrial areas will result in loss of Productivity as well as business. Power system faults only can cause dis continued supply, they can damage the power system equipment that is costly to replace. ANN is powerful in Pattern recognition and classification. [2] They pass excellent features. Transmission line Protection is a very important issue to safe guard the electric power system. Among the components of an electric power system, the transmission line is the most Susceptible element to experience faults. Different kinds of faults can occur between a conductor and ground, basically 1. Single line-to-ground-faults. 2. Phase-to ground faults, 3. 3-Phase faults. The sampled current and voltage data are used to locate and classify the fault involving the line. Distance relaying techniques have attracted considerable attention for the protection of transmission lines. The Principle of these techniques is the measurement of Impedance at a fundamental frequency between the relay location and the fault point. Voltage and current data are used for this purpose. The proposed analysis involves the ANN techniques, [3] where the threshold values are employed to identify faults on the transmission line.

1.1. Protective relays
Transmission lines are a necessary part of power systems due to the reason mentioned before. There are two types of transmission lines, overhead and underground, the former being the most commonly used. The overhead transmission lines are susceptible to faults caused by short circuits between phases or between phase and ground. The majority of faults in power systems occur in the transmission lines. When a fault occurs, the transmitted current rises above the normal operating current. This can cause thermal damage to all other electrical equipment. To reduce the adverse effects of faults, protective relays are included as part of power systems. Relays or protective relays detect abnormal power conditions and return the power system to normal operative conditions (Horowitz, 1995). Upon detecting a fault in the relay protection zone, the relay activates the circuit breaker to clear and isolate the fault. In a radial system where there is only one source for multiple loads, the supply will discontinue until the problem causing the fault is fixed. To minimize blackout, it is a common practice to use network of power systems where multiple sources are available in connections for multiple loads.[4]

1.2. Objective :
The aims of this project are to develop a software module acting as a protective relay using neural network techniques. The ANN Software module employs the back-propagation method to recognize the waveform patterns of impedance in a transmission line. It produces a trip signal if a fault waveform is recognized and no-trip signal otherwise. The input waveforms are generated using PSCAD. The waveform patterns are generated for unsymmetrical and symmetrical faults that occur on a varied distance in the transmission line. The generated waveforms then are used as training and testing date for the ANN software. The ANN software is simulated using the Neural Network Toolbox of MATLAB Version 2010-b Release 12

.2. Problems at convention method
The traditional distance relay subjected to mal-operation in the form of over-reaching or under-reaching. The accuracy of an electro-mechanical, static or a microprocessor based distance relay is affected by fault condition and network configuration changes. The travelling wave based method does not perform well for faults close to the relaying point. So overcome the problem on traditional method need a technique which has the ability to adapt dynamically to the system operating condition such as changes in the system configuration. Ann has the ability to adapt dynamically to the system operating condition Neural network is beneficial when compared to the other mathematical approaches because of its of In this project ANN utilizes samples of currents and voltage directly as inputs without computation of Phasors and related symmetrical.

3. ARTIFICAL NEURAL NETWORK

Like its counterpart in the biological nervous system, a neural network can learn and therefore can be trained to find solutions, recognize patterns, classify data, and forecast future events. The behavior of a neural network is defined by the way its individual computing elements are connected and by the strength of those connections, or weights. The weights are automatically adjusted by training the network according to a specified learning rule until it performs the desired task correctly.

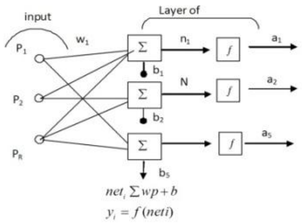

Fig. 1. ANN Network

3.1. Back Propagation:

Back Propagation is a specific technique which is used a supervised learning rule for multi-layers perceptions that operates by calculating the value of the error function for a known input, then back propagating the error from one layer to the previous one. Each neuron has its weights adjust so that it reduces the value of the error function reduces the value of the error function until a stable state is reached.[5] During training, each input is forwarded through the intermediate layer until outputs are generated. Each output to get the errors that will be transmitted backwards to the intermediate layer that contributes directly to the output. Based on these errors, the weights are updated. This process is repeated layer by layer until each node in the network has received on error signal that describes its relative contribution to the total error. Weights adjustment using back propagation algorithm. Back Propagation is a systematic method for training multi-layer artificial neural network. Being a gradient decent method it minimizes the total square error of the output computed by the net. [6]

3.2. Training and Learning Functions:

Training and learning functions are mathematical procedures used to automatically adjust the network's weights and biases. The training function dictates a global algorithm that affects all the weights and biases of a given network. The learning function can be applied to individual weights and biases within a network. Neural Network Toolbox supports a variety of training algorithms, including several gradient descent methods, conjugate gradient methods, the Levenberg-Marquardt algorithm (LM), and the resilient back propagation algorithm (Rprop).[7]

Step -1 : Initialize weights (not zero but small random values are used)

Step-2 : While stopping condition is false, do step – 3-7

Step -3 : For each bipolar training pair S:t; perform steps 4-6

Step – 4 : Set activation of input units Xi=Si, for I = 1ton .

Step – 5 : Compute net input to output unity-in = b+Σxiwi.

Step – 6 : Update bias and weight I =1 ton

Wi (new) = wi (old) + α (t – y-n) xi

b (new) = b (old) +α (t – y-n)

Step – 7 : Test for stopping condition

The stopping condition may be when the weight change reaches small level or number of iterations etc.

Step – 8 : Finally apply the activation to obtain the output y.

$$y = f(y-in) = \begin{cases} 1 if \quad y-in \rangle 0 \\ -1 if \ y-in \langle 0 \end{cases}$$

4. Simulation Of Pscad/Emtdc

This Chapter Discusses The Faults Generation Using Pscad. The Fault Cases Are Simulated Using Pscad Version 4.00.[8] The Fault Types Are Generated Are.

1. Single – Phase To Ground Faults. (Lg)
2. Double – Phase To Ground Faults. (Llg)
3. Three Phase To Ground Faults (Lllg)

The Fault Types Are Simulated By Changing The Fault Type Parameter In The Faults.[9] The Fault Inception Angle Are Varied By Varying The Time To Apply Fault Parameter In The In The Timed Fault Logic Module. The Fault Location Is Varied By Changing The Length Parameter Of The Transmission Line. The Result Of Each Simulation Is Saved In A File With Distinctive Name Reflecting Its Fault Case. When A Fault Case Is Simulated, The Wave Form Saved Includes Its Transient State.[11] To Remove The Transient State, The Simulation Is Run From A Standard File. The Saved File Contains Data In Columns. The First Column Is Time, The Rest Of The Column Are The Data Output. In This Simulation Three Data Types Are Saved: V_{1rms}, I_{1rms}, Z_{1rms} In One File. In This Simulation All Are Internal Type's Faults. In Time Fault Logic We Can Apply Time To Fault And Duration Of Fault. After All The Fault Cases Are Collected, Data Are Collected Data Set From Pscad Environment From Text File Using Met Lab Code.

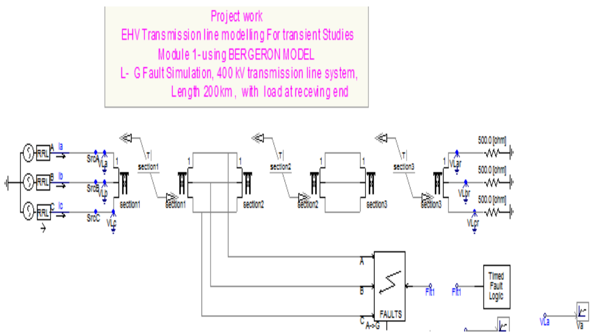

Fig. 2. Power System Model In Pscad

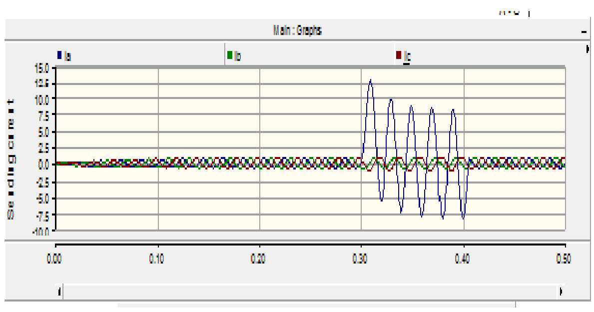

Fig. 3. Current Wave Form During L-G Fault.

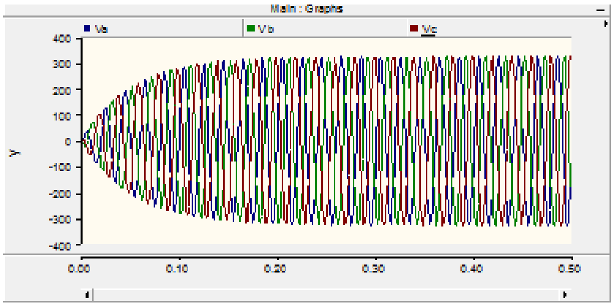

Fig. 4. VOLTAGE WAVE FROM DURING LG FAULT.

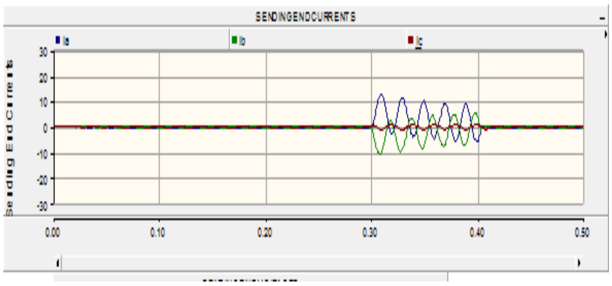

Fig. 5. CURRENT WAVE FROM DURING LLG FAULT.

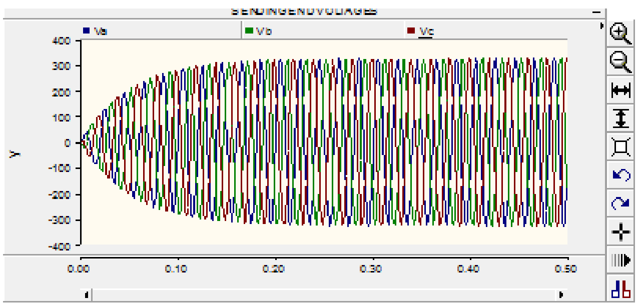

Fig. 6. VOLTAGE WAVE FROM DURING LLG FAULT.

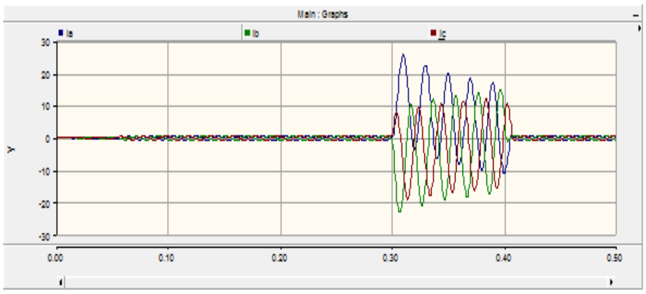

Fig. 7. CURRENT WAVE FROM DURING LLLG FAULT.

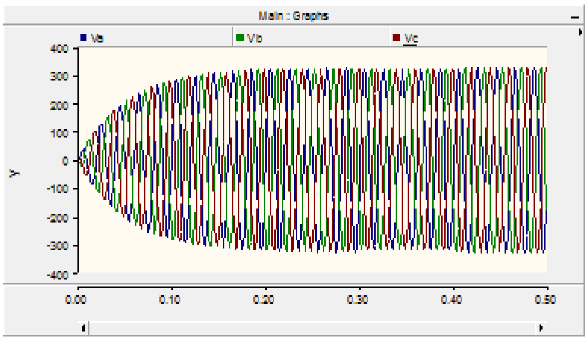

Fig. 8. VOLTAGE WAVE FROM DURING LLLG FAULT.

5. RESULTS AND DISCUSSION

This Project Presents The Modelling And Identification Faults Of A 400 Kv High Voltage AC (HVAC) Transmission Line By Using PSCAD/EMTDC Software. T-Section Model Is Presented In Figure1 Is Used To Create The Transient Model For Generation Of Transients During Various Types Of Faults. The Further Investigation Of This Transients Is Carried In MATLAB Determine The Type Of Fault Via The Concept Of ANN.

5.1. TRANSMISSION LINE MODELS

5.1.1. T-Section Model:

To Model A 210km Overhead Transmission Line In T-Section Model Using PSCAD Software, Three Identical Pi-Sections Are Connected Series To Obtain An Approximately Model Of Distributed Parameter Line. Each Pi Section Represents 70 Km Of Transmission Lines, Which Give The Total Length Of 160 Km Overhead Transmission Lines. Three Different Models Transmission Line Fault Are Considered In This Work

1. Single Line Fault
2. Double Line To Ground Fault
3. Three Phase Short Circuit.

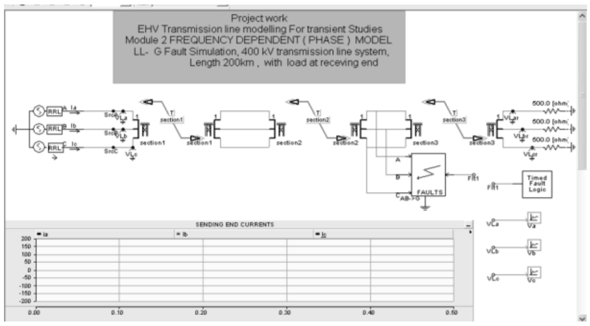

Fig. 9. PSCAD Model For LL-G Fault.

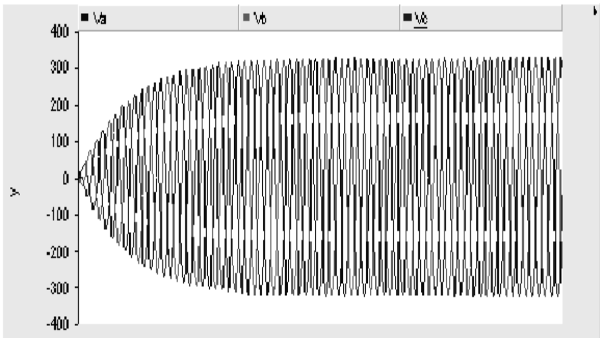

Fig. 10. Sending End Voltages For LLG Fault

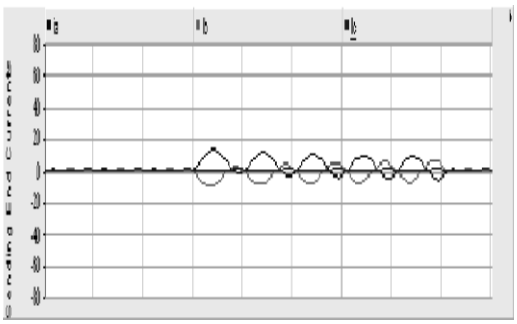

Fig. 11. Sending End Currents LLG Fault

Fig. 10 and Fig. 11 represent the sending end voltage and currents during a LLG fault at distance of 140Km from the Sending End.

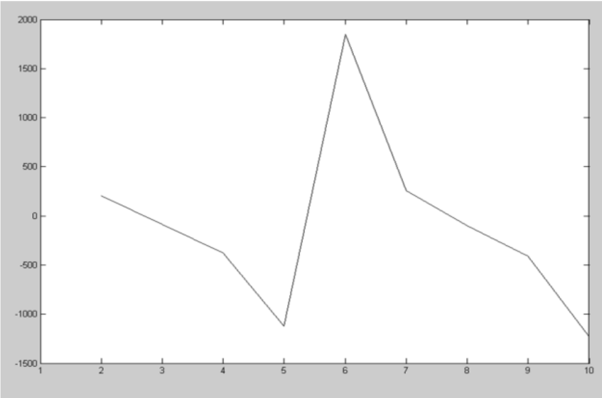

Fig. 12. Plot of Sample Points no fault

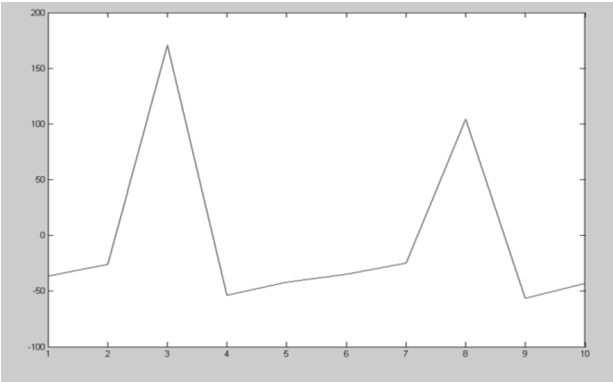

Fig. 13. Plot of Sample Points - Fault LG

Figure.12. and Figure.13. shows the Plot of the 10 sample points corresponding to no fault and LG fault conditions respectively. The transients in Figure.12. and Figure.13. are generated by using the sampling window program written in **MATLAB**

6. ANN-BASED RELAY SIMULATION

The artificial neural networks (ANNs) provide a very interesting and valuable alternative to conventional fault identification methods because they can deal with the most complex situations which are not defined sufficiently for deterministic algorithms to execute. ANN can also handle nonlinear tasks. They are parallel data processing tools capable of learning functional dependencies of data. They are robust with respect to incorrect or missing data. Fault Identification based on ANN is not affected by change in the system operating conditions. ANNs also have high computation rates, large input error tolerance and adaptive capability The training sets for the ANN are formulated considering various conditions including different fault classes. Different ANN structures are tested for various training strategies. The process is continued by training various network sizes and minimum cost function (mean squared error or MSE) values.

6.1. Network Design Flow:

The work flow for this project has six primary steps. (Data collection, while important, generally occurs in PSCAD environment, so it is step 0.)

1. Collect data.
2. Create the network.
3. Configure the network.
4. Initialize the weights and biases.
5. Train the network.
6. Validate the network.
7. Use the network.

6.2. Network Architecture:

There is no particular formula to choose suitable network architecture for an application. The suitable network size is found by trial and error. Small sized network may not be enough to map the function, but bigger sized network may not be a better choice as well. By trial and error, it was found that the suitable network size for ANN relay with 20 inputs and 1 output was a network with two hidden layers of size 15 and 5. This network was chosen over a network with one hidden layer of 15 nodes. The number of hidden layers might play role in the convergence of the MSE based on the simulation result.

6.2.1. ANN Relay Architecture:

The network simulation resulted in the ANN relay architecture with an input layer of 10 nodes, 2 hidden layers of 40 and 1 nodes and an output layer of 3 node as shown below for LG-Fault.

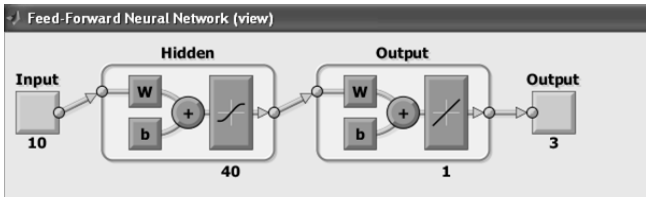

Fig.14. ANN Relay Architecture for LG-fault.

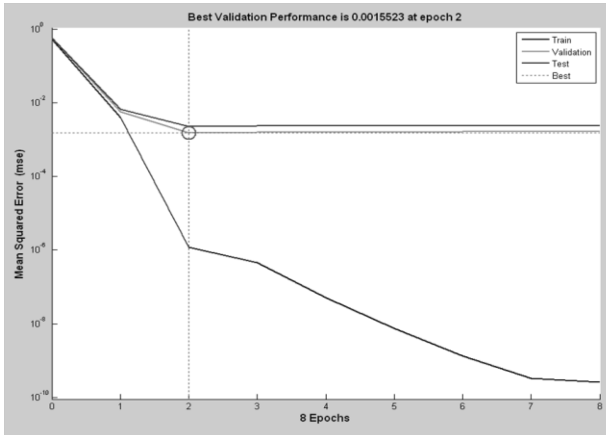

Fig. 15. ANN performance curve for LG-fault

Table 1. Training Parameters

S.No	Parameters	Algorithm
1.	Data division	Random
2.	Training Function	Levenberg-Marquardit Training method
3.	Performance	Mean least squared Error

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The network simulation resulted in the ANN relay architecture with an input layer of 10 nodes, 2 hidden layers of 40 and 2 nodes and an output layer of 3 node as shown below for LLG- Fault.

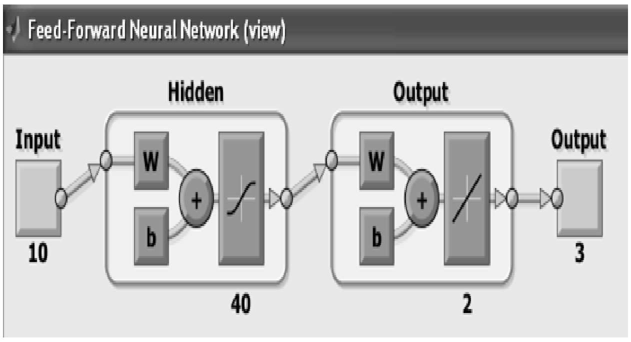

Fig. 16. ANN Relay Architecture for LLG-fault.

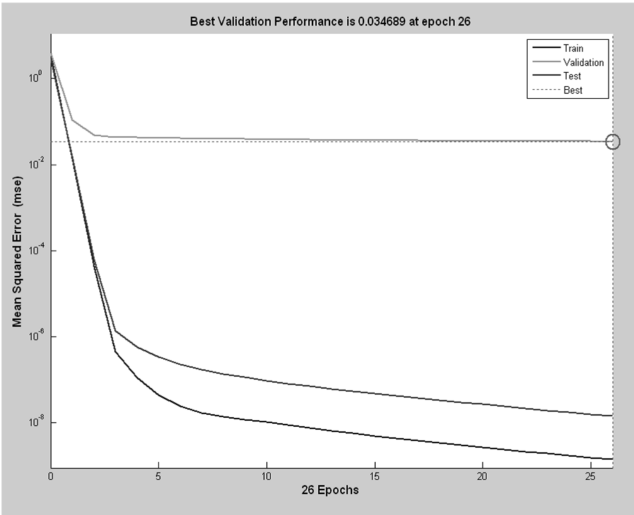

Fig. 17. ANN performance curve for LLG-fault.

The above Performance results are reasonable because of the following considerations:

1. The final mean-square error is small.
2. The test set error and the validation set error has similar characteristics.
3. No significant over fitting has occurred by iteration 26 (where the best validation performance occurs).

7. CONCLUSION

Simulation result shows that the proposed protection scheme based on ANN was very much efficient and also encouraging. Based on the test system, the different operation conditions and various faults are tested. It is independent of fault type, switching angle and generation mode; not influenced by change in fault resistance and location distance. Single-line ground fault with high fault resistance can also be detected correctly. The proposed protection scheme has good selectivity, reliability and sensitivity.

8. FUTURE SCOPE OF THE WORK :

The project used ANN as the intelligent technique for classification of faults this can further be enhanced by the use of SVM. The project used the PSCAD based models for the generation of transients during various types of Fault, the same can also be investigated by using the T- section and Pi section models in MATLAB. The project can be extended for double circuit line which contains six conductors. Further wavelets based method of fault identification can also be carried. This can be compared with the FFT based approaches in transient analysis.

9. ACKNOWLEDGMENT

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