Fault Detection in Grid Connected Wind Energy Conversion Systems

P Aruna Jeyanthy, S N Rekha, D Devaraj

***Abstract**: This paper develops an artificial neural network-based implementation for detecting fault in grid connected Wind energy conversion system. The proposed algorithm that would predict the fault that occurs on the grid connected system is completely automated using the ANN algorithm. The fault in the grid is considered to implement the proposed algorithm for identify the fault. The automation is carried out using Back Propagation Network Algorithm (BPNA) and MATLAB based realization using Simulink and M-file functions is carried out and the results are tabulated. The efficient training algorithm and the testing is carried out on the grid connected WECS. The parameters accuracy of this algorithm is analyzed with previous implementations. The outcome of the proposed implementation provided satisfactory results.*

***Keywords** : Artificial neural network, fault identification, Grid connected wind energy system..*

I. INTRODUCTION

The countless extent of grid-connected wind energy conversion system requires improved fault classification methods, increased system efficiency and significant damage avoidance. The technical literature suggests many techniques for this purpose. If faults occur and are not corrected, then the entire system may damage, and it leads to the possibility of complete shunt down. Different quantitative strategies to analyse faults can be found in the literature of the most recent 20 years utilizing model-based techniques, pattern recognition, binary reasoning, or expert system. Grid connected system is very much important in electric power system. The power system was highly crucial owing to population growth in many nations, which resulted in a massive rise in the demand for electricity [1, 2]. In 1986 the identification of fault and diagnosis based on artificial neural network has been implemented [3]. ANN is an alternative way of providing information about faults. This method can autonomously store data by obtaining data from significant issues and has the features of associative memory. Through preparing the system with a lot of information in typical condition the data about issues can be figured out how to recognize the issue.

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About the use of ANN for fault detection a substantial literature has developed last so many years. Artificial neural systems have impressive potential when connected to the finding of synthetic procedures [4]. For classify 20 different fault in the plant, an ANN could use the information gathered from 418 senso rs in a stable chemical plant[5]. A simple fault classification method was developed based on radial basis function neural network with orthogonal-least squares learning procedure [6]. This can identify various patterns with respect to voltage and current but not having the capacity to identify the fault location. In [7] discrete wavelet transforms in combination with ANN based fault detection and classification was reported. Input signals feature extraction was done by using DWT and to classify the faults ANN was used.

To identify the fault location ERN is used with Wavelet Transform as a feature extraction method. The disadvantage of this method was it can only locate the balanced short circuit faults [8]. FIRANN (Finite Impulse Response ANN) technique was proposed in [9]. In order to get better result the training patterns from more than one relaying positioned were used for training FIRANN. To detect the fault with FIRANN voltage and currents samples of 2Khz were used. The open circuit fault detection of the converter in WECS has been carried out with ANN as a decision taking algorithm and DWT as a feature extraction technique. The prediction of fault is very simple with this method. The DWT coefficients are given as the input to the neural networks for training ANN [10].The early identification which would keep away from the shutdown of WECS which diminishes the down time and builds the power generation is the need of great importance .To facilitate these options in the WECS sensors are used [11], [12] Artificial neural systems are great example classifiers and have been appeared in a few reports to have the option to analyze the defective conditions.

II. PROCEDURE FOR PAPER SUBMISSION

Artificial neural networks (ANN) are computing systems that are inspired by the biological neural networks . These systems "learn" to operate functions by looking at ex amples, normally without any task specific rules being programmed.

An ANN is based on a set of artificial neurons consisting of linked units or nodes that loosely model the neurons in biological brain. Each link can convey a signal from one artificial neuron to another. An artificial neuron capable of receiving a signal process it and then transfer signal to connected artificial neurons. A counterfeit neuron that gets a sign can process it and afterwards signal additional artificial neurons associated with it

The signal at a connection between artificial neurons is a re al number in common ANN implementations and some nonlinear function of the sum of the inputs is used to calculate the output of each artificial neuron. The edges are the connection between artificial neurons. Weight is to adjust the connection between artificial neurons and edges to proceeds the learning process. The quality and strength of the signal at a connection make the increase or decrease in weight.A threshold is fixed for artificial neurons . The aggregate signal crosses the threshold then only the signal is sent.Artificial neurons are typically assembled into layers. Signal may pass multiple times each layer before reaching the output layer and various types of transformations performed on the input by different layers. The structure of ANN is represented in Fig.1

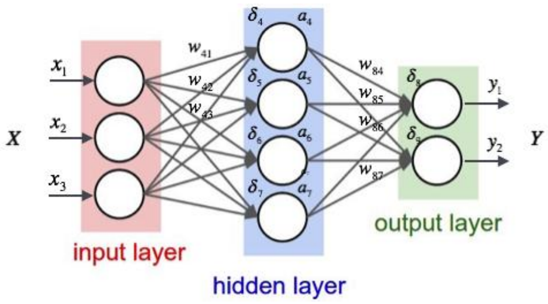

Fig-1 Structure of ANN

III. PROPOSED METHODOLOGY

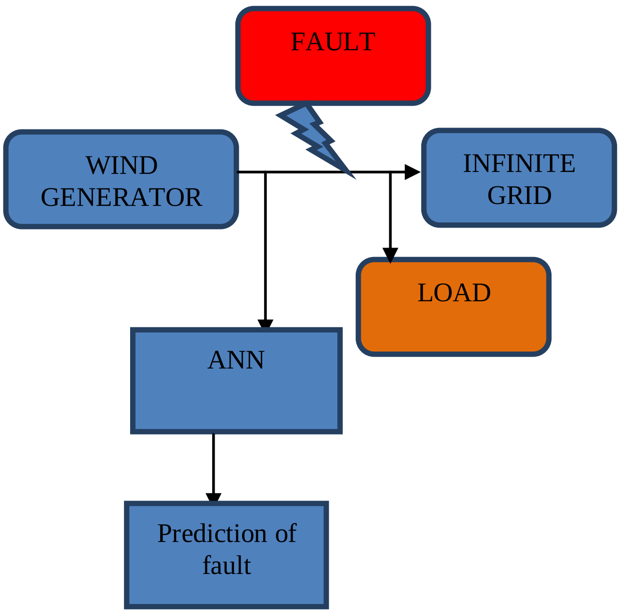

Fig.2 The block diagram.

The Fig.2 represents the block diagram of the proposed methodology.An infinite grid connected with wind generator. The voltage rating of the grid is taken as 230 KV. Different loads are connected to the load. The fault has been created in the grid. The proposed system is to find out the fault. Artificial neural network is used to detect the fault. Voltage variation during the fault condition is used as the identification parameter to decide on the type of fault. All the possible fault in the grid are generated to train the ANN

IV. IMPLEMENTATION OF THE PROPOSED METHODOLOGY

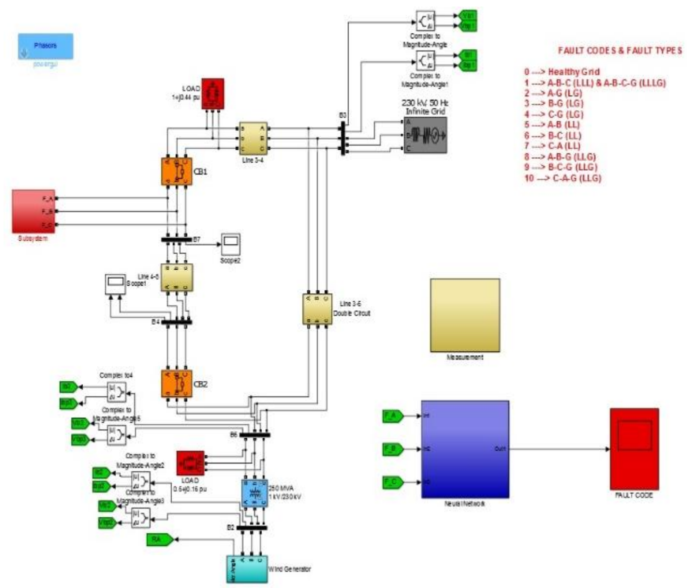

Fig.3 MATLAB implementation

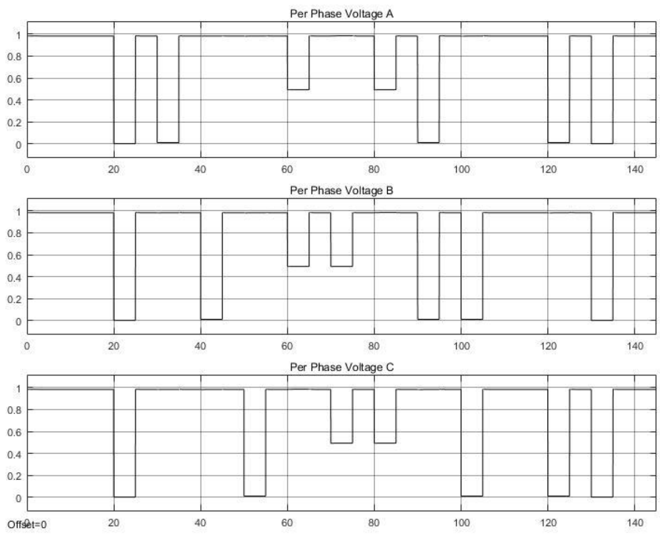

Fig 4 Phase voltages during fault (Training data-Input)

To train the ANN faults have been created in the system and data were collected, the collected data

was given as target for ANN for the corresponding inputs, inputs are the phase voltages. Phase Voltages at fault location for different Faults given in the following Fig. 4 was measured and used as input for training the ANN.
Fault codes were used to identify the type for fault, in order to train the ANN the fault codes are assigned as target for ANN.

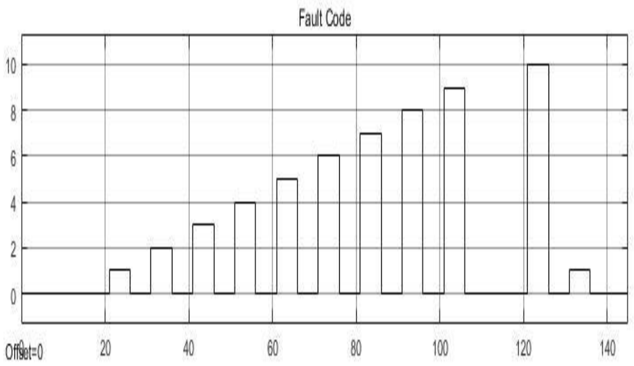

Fig 5 Fault Codes (Training data-Target)

Fig.5 represents the fault codes to identify the faults in order to train the ANN. Fault code and the corresponding type of fault is represented in table 1

Table -I: Fault code v_s Fault type

Fault Code	Fault Type
0	Healthy Grid
1	ABC (LLL) & ABCG (LLLG)
2	AG (LG)
3	BG (LG)
4	CG (LG)
5	AB (LL)
6	BC (LL)
7	CA (LL)
8	ABG (LLG)
9	BCG (LLG)
10	CAG (LLG)
0	Healthy Grid

Once the ANN had been trained the same model is imported into the Simulink environment to decide the type of fault occurred. Simulink model is given in fig 6.

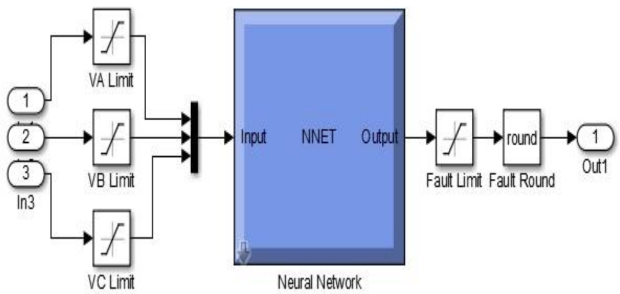

Fig.6Trained ANN in Simulink

V. FAULT DIAGNOSIS WITH ANN

To validate the developed model, a LLG fault at 21^{st} second of start of simulation was created. The developed ANN

system had displayed the fault code '9' meaning BCG (LLG) fault has occurred in the system. Thus, the ANN is found to be working with great accuracy. When the fault is rectified after one second the fault code is switched back to the healthy gird mode (0).

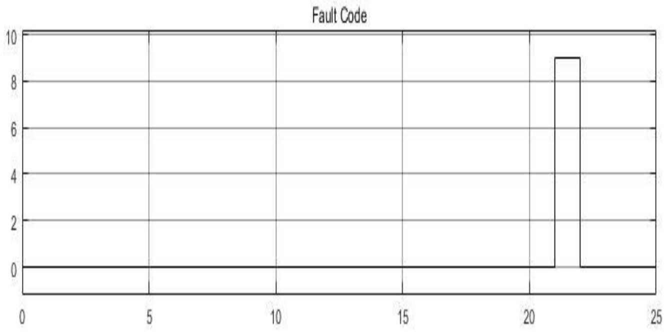

Fig.7 Diagnosed Fault

Diagnosed fault is represented in fig.7. The fault code 9 indicates BCG(LLG) fault. At the time of BCG fault, the corresponding magnitude of voltage is noted, from the diagnosis it is understood that the fault affects the stability of the unaffected phase as well.

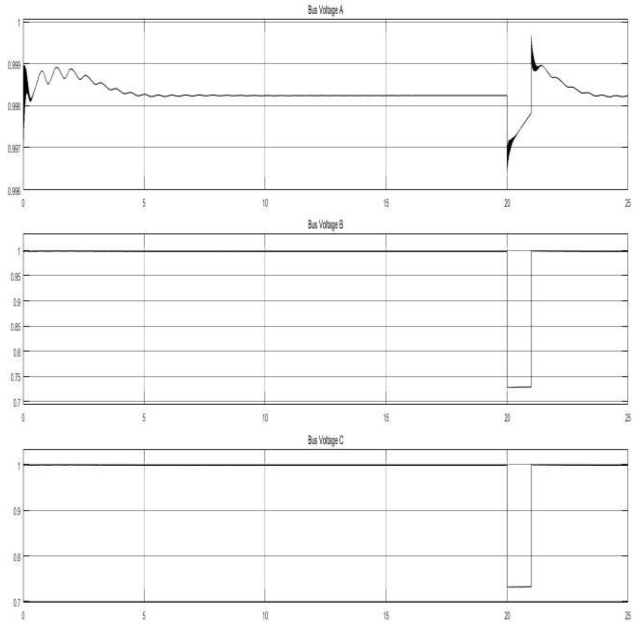

Fig.8 Grid Voltage magnitude during fault

The following wave form shows the change in phase of the grid voltage during fault

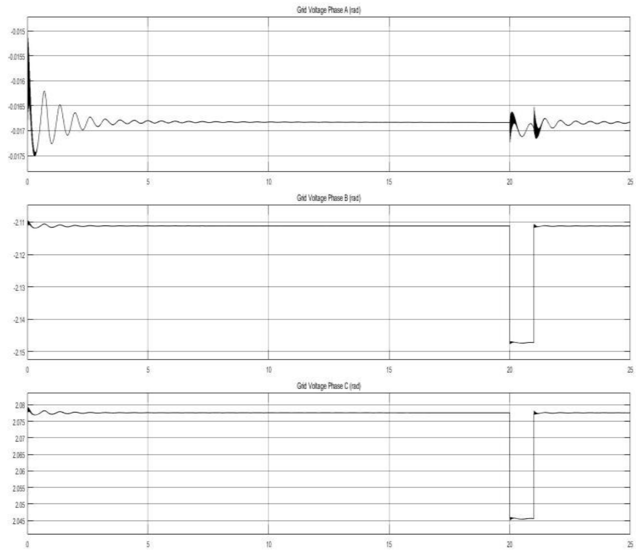

Fig.9 Grid Voltage phase during fault

The following wave form shows the change in magnitude of the grid current during fault.

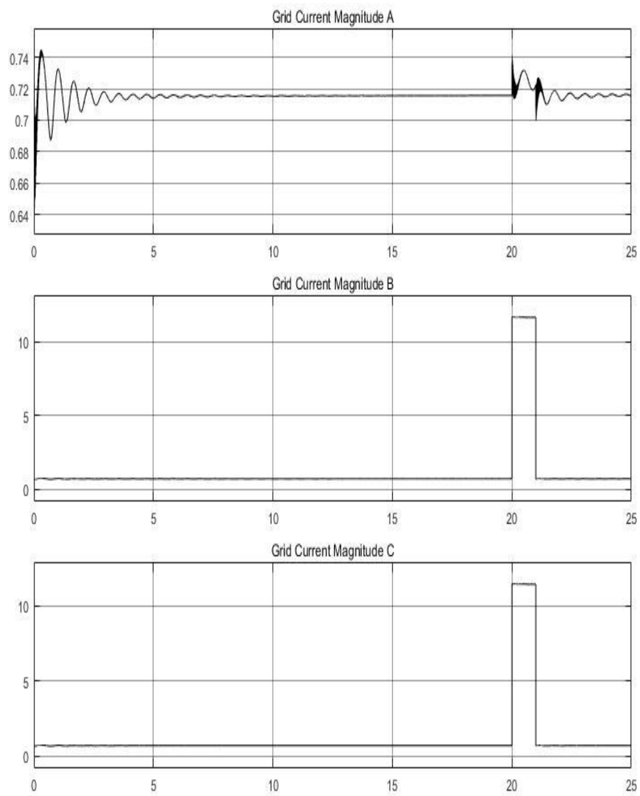

Fig.10 Grid Current Magnitude during fault

The following wave form shows the change in phase of the grid current during fault.

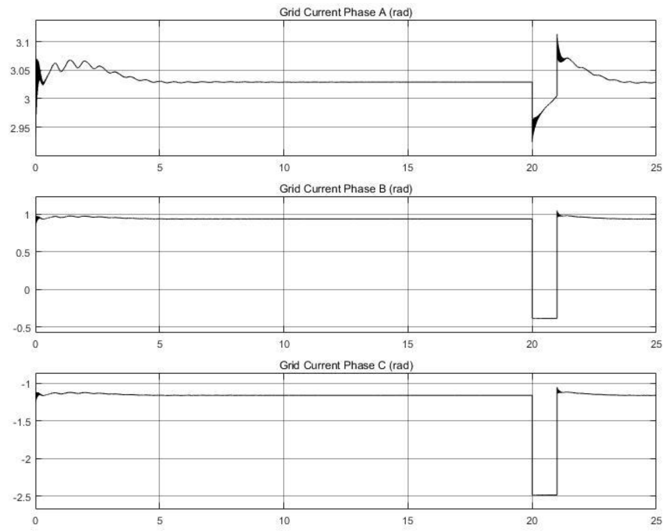

Fig.11 Grid Current Phase during Fault

The following wave form shows the change in Load angle of wind generator during fault

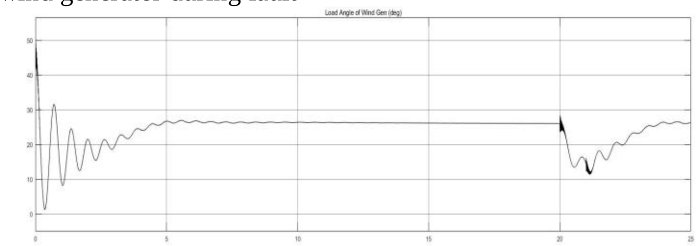

Fig.12 Load angle of wind generator during fault.

VI. CONCLUSION

A novel approach to detecting, classifying and locating faults in WECS connected grid was suggested. The trained ANN performs the different tasks of identifying faults, classifying them. The algorithm used to train ANN is very efficient and simple. 10 types of fault in the grid connected system are identified with trained system. Thus the magnitude of voltage and current waveforms are plotted during the fault. The results show that the fault prediction with ANN is satisfactory.

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