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A RESEARCH PAPER ON THE DEVELOPMENT OF ANN BASED THREE PHASE FAULT CLASSIFIER USING FAULT-INTEGER MAPPING

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ABSTRACT

When two or more conductors come into touch with the earth or each other, a fault happens. More than 80% of all defects are believed to be ground faults, which are one of the major issues in power systems. The topic of this essay is the detection of defects in transmission lines for electric power. Artificial neural networks have been used to detect errors. The ANN is supplied with either signal characteristic that have been retrieved using specific measurement procedures or simply raw samples of the input signals. The design and development of a neural network model for a three-phase transmission line failure are done in this research article. We have seen the many fault kinds that can exist in a transmission line system. It has been examined for line-to-line and line-to-ground faults. The failure causes significant fluctuations in the transmission line's current and voltage. The NN model is trained using this data. A variety of training algorithms have been used to train the NN model. The Bayesian approach is shown to be the most effective, even if the NN network is performing satisfactorily and the error is decreasing with the number of epochs.

Keywords: Artificial Neural Network, Transmission Line Fault, Fault Detection, Etc.

I. INTRODUCTION

Frequent failures can occur in any of the components of a power system, including producing units, transformers, the transmission network, and/or loads. It is commonly recognised that defects can seriously interrupt supplies, destabilise the entire system, and even result in personnel casualties. Therefore, from an economic and operational standpoint, defect detection is of utmost importance. In order to take rapid corrective action before significant interruptions to the power supply occur, defects should also be found as quickly as possible, ideally in real time. Neurophysical models of human brain cells and their connectivity serve as the foundation for neural networks. Outstanding pattern recognition and learning skills are a defining feature of such networks. The neural networks' capacity to learn on its own is their main benefit. An initial set of accurate input and output values are given to the network. Once the necessary transformation has been learnt, it modifies the connection strength between internal network nodes. A set of output values are then generated by the network after it has simply been given input data.

An Artificial Neural Network (ANN) is a collection of simple neurons that are often coupled together and arranged in layers, drawing inspiration from biological structures. The feed-forward ANN structure, commonly known as the perceptron, is displayed. Each ith layer has Ni numbers of neurons, and the inputs to these neurons are linked to the neurons of the layer below. The excitation pulses are supplied into the input layer. An elementary neuron, to put it simply, is like a processor that generates an output by applying a straightforward non-linear operation to its inputs. Every neuron has a weight linked to it, and training an ANN involves changing the weights according to the training set. By changing the node weights, an Artificial Neural Network may learn to provide a response based on the inputs provided. So, in order to train the neural network, we require a set of data known as the training data set.

Neurophysical models of the connections between human brain cells serve as the foundation for neural networks. These networks have outstanding capacity for pattern identification and learning. The capacity of neural networks to learn on their own is one of its main advantages. The right input and output values are first given to the network. A group of basic neurons that are often linked in biologically inspired topologies and arranged in many layers is known as an Artificial Neural Network (ANN).

1. Block diagram of the proposed model

We have used MATLAB/ SIMULINK model of a 11kV -400V transmission line. Different types of fault is being generated by used a three phase fault of the block in the Simulink. Block diagram of the overall model of the system is shown in the figure below

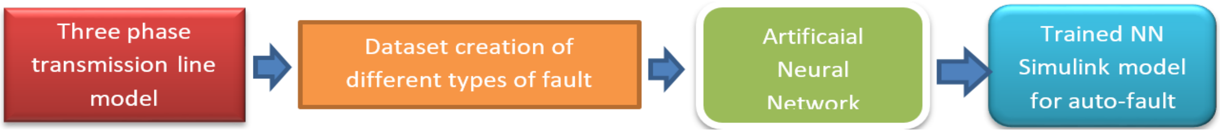

Figure 1: Block diagram of the proposed model

We have created a simulink model to obtain the dataset, practically these data can be obtained from the real transmission line subjected to the different types of Line to Line fault and Line to ground fault. The dataset from the model is created and stored in a separate variables in a MATLAB workspace. In the next section, three phase transmission line model is discussed.

2. Simulink model of three phase transmission line

Simulink model of three phase transmission line is shown below

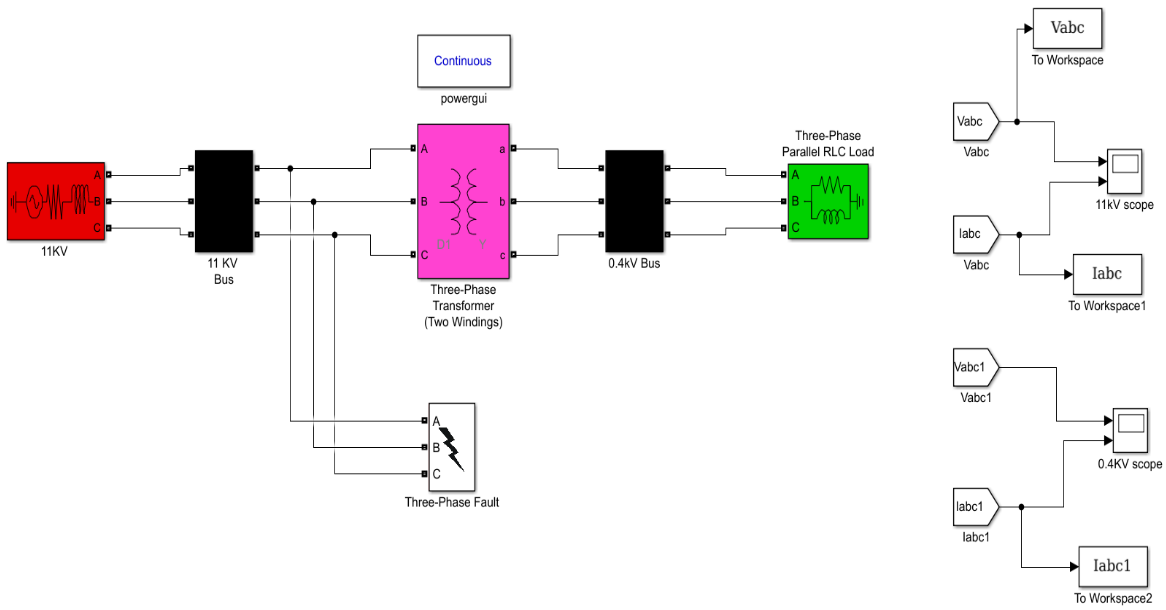

Figure 2: Simulink model of three phase transmission line

Parameters of 11kV three phase source is shown below

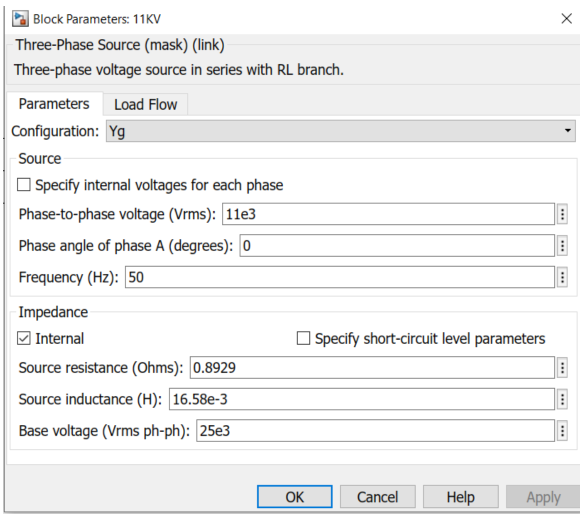

Figure 3: Block parameters of 11kV three phase source

It can be seen that the frequency chosen is 50hz , source resistance is 0.8929, source inductance is $16.8 * 10^3$ H and phase to phase base voltage is 25kV rms. Further three phase transformer with delta-star configuration is used to implement. Block parameters of the three phase transformer is shown below

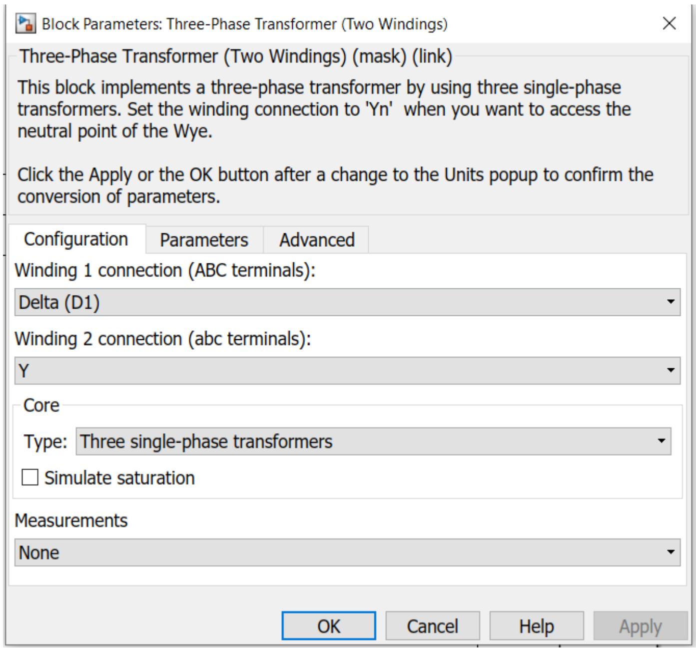

Figure 4: Block parameters of the three phase transformer

This transformer converts 11kv to the 400V. Voltage measurement block is shown below

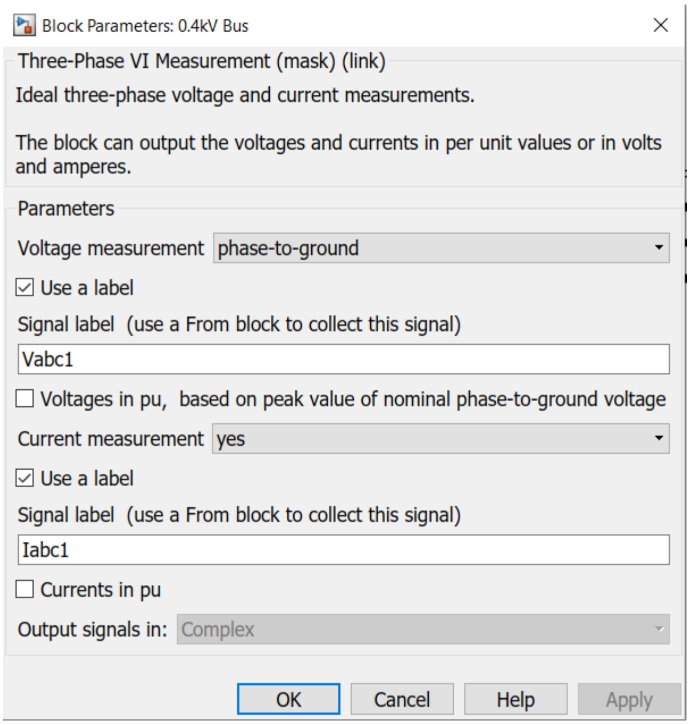

Figure 5: Voltage measurement block

Different types of fault have been created by using the three phase fault block of the Simulink. The block parameters of fault generation block is shown below. It can be seen that the three phase fault can be created by selecting phase A, phase B or phase C. This block also provides us to give switching time to create the error at the particular time.

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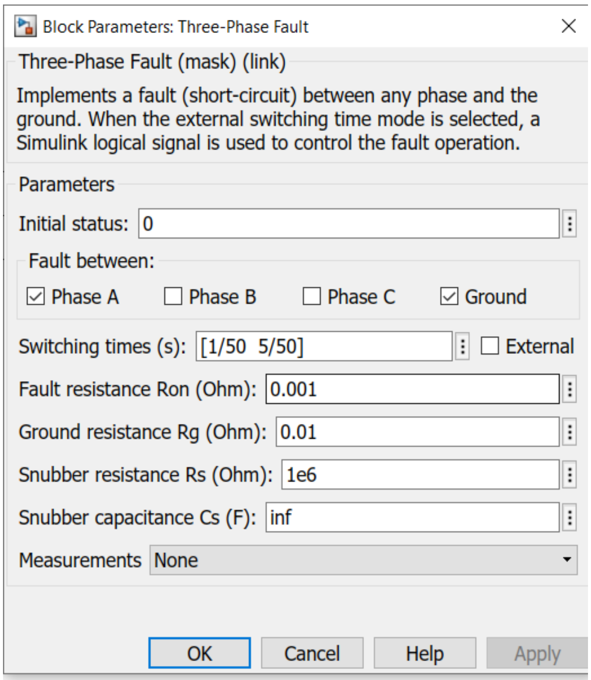

Figure 6: Block parameters of fault generation

3. Dataset creation

A dataset is a grouping or set of data. This collection is often displayed in a tabular format. Each column provides information about a distinct variable. In accordance with the stated question, each row represents a certain component of the data set. The management of data includes this. For unknown quantities like the height, weight, temperature, volume, etc. of an object or random integer values, data sets represent values for each variable. The output current of the three phase transmission line is measured to create a dataset. Voltage and current waveform during fault and no fault condition is shown in the scope output below. It can be seen that the current increases whenever a fault happens.

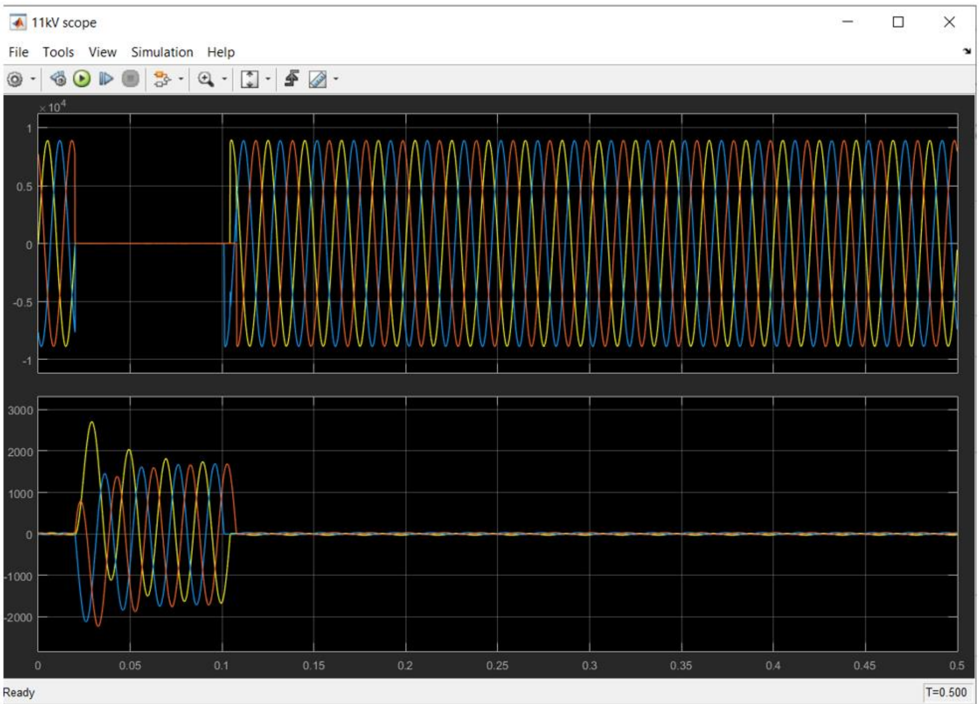

Figure 7: Voltage and Current waveform during fault and no fault condition

Screenshot of the part of dataset is shown below

2682.644	0.536461	-1146.82
2688.946	0.981403	-1194.33
2693.641	1.427759	-1241.33
2696.718	1.87509	-1287.78
2698.168	2.322954	-1333.63
2697.985	2.770908	-1378.83
2696.164	3.218511	-1423.34
2692.699	3.66532	-1467.1
2687.591	4.110894	-1510.06
2680.837	4.554793	-1552.19
2672.439	4.99658	-1593.44
2662.401	5.435817	-1633.76
2650.726	5.872072	-1673.11
2637.421	6.304913	-1711.45
2622.494	6.733914	-1748.74

Figure 8: Part of dataset

It can be seen that the Phase A and phase B current is having a maximum value, and phase B has minimum value So, there is no fault in phase B.

Since there are three phase, the possible combination of fault are $2^3 = 8$. By creating faults, an integer from 0 to 7 is mapped as shown below

Phase 1	Phase 2	Phase 3	Integer value
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

Figure 9: Mapping of faults to an integer value

Final dataset is shown below

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A	B	C	D
31.59112	-4.55908	334.5919	5
44.68799	-4.94648	371.4698	5
59.34956	-5.3266	406.9435	5
75.55269	-5.69907	440.9834	5
93.27273	-6.06351	473.5616	5
112.4836	-6.41956	504.6514	5
133.1578	-6.76688	534.2275	5
155.2665	-7.10513	562.2662	5
178.7793	-7.43396	588.7451	5
203.6647	-7.75306	613.6437	5
229.8897	-8.06211	636.9425	5
257.4202	-8.3608	658.624	5
286.2206	-8.64885	678.672	5
316.2544	-8.92596	697.0719	5
347.4837	-9.19187	713.811	5
379.8696	-9.4463	728.8777	5
413.3719	-9.68902	742.2626	5
447.9497	-9.91978	753.9574	5
483.5607	-10.1384	763.9557	5
520.1619	-10.3445	772.2528	5
557.7092	-10.5381	778.8456	5
596.1577	-10.7189	783.7325	5
635.4616	-10.8867	786.9138	5
675.5742	-11.0413	788.3914	5

Figure 10: Final dataset with integer mapping

4. Neural Network Creation

A neural Network has been created using NN tool of the MATLAB. It can be seen on the figure below that dataset has been used as the input and output during the Network creation.

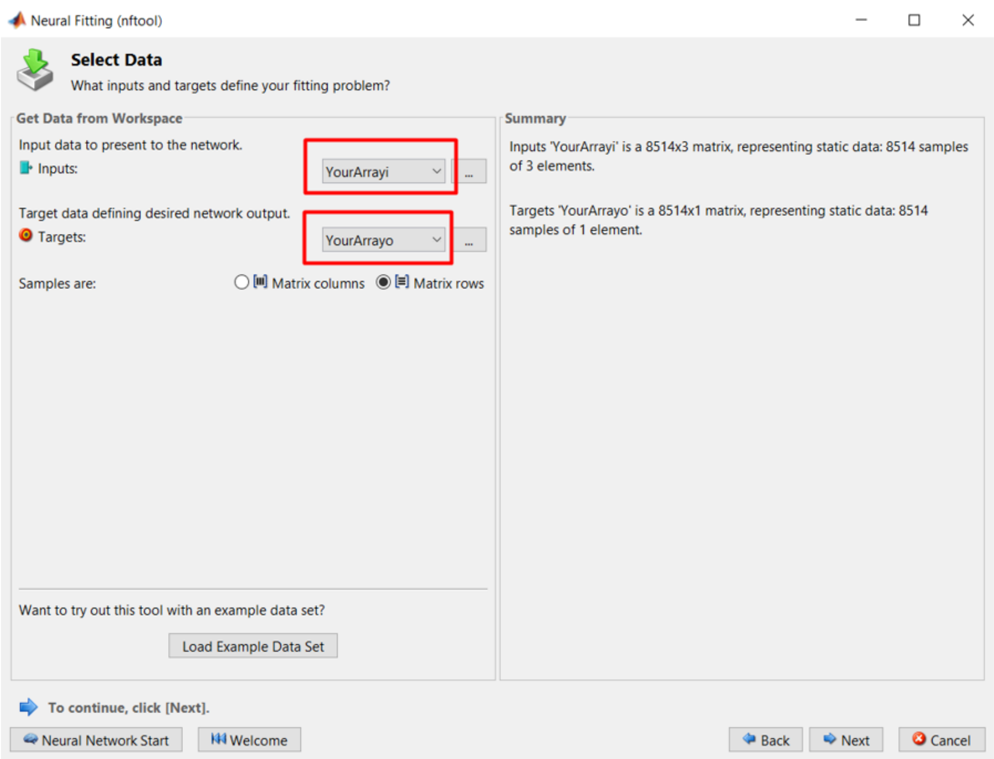

Figure 11: Dataset entance in MATLAB

Next, 70% of the dataset is used for the training, 15% is used for the validation and 15% is used for the testing as shown below

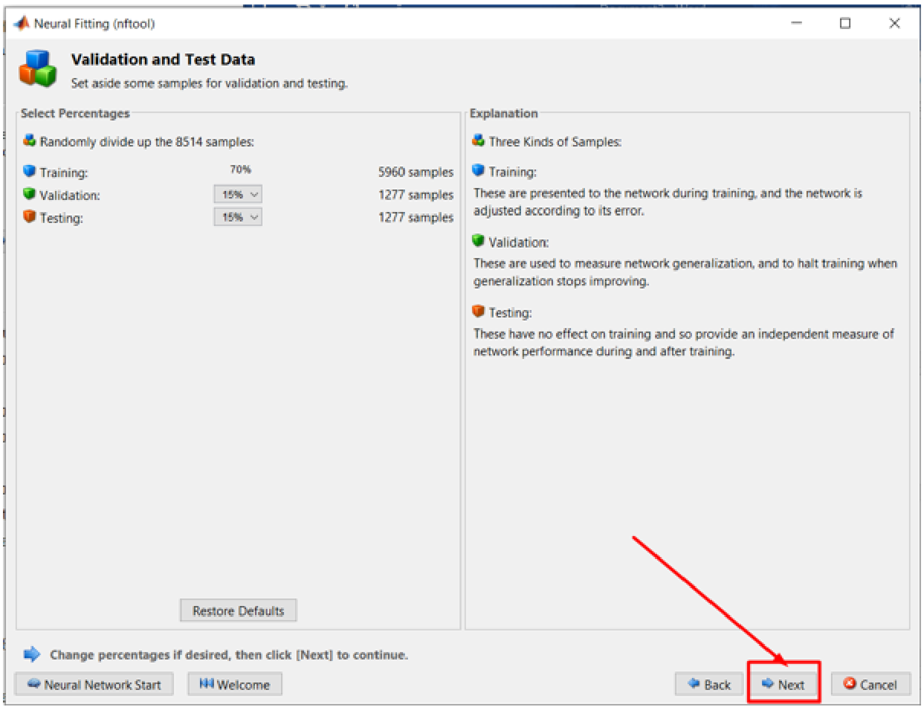

Figure 12: Testing and validation of Neural Network

Neural network of 10 neurons has been selected as shown in the figure below

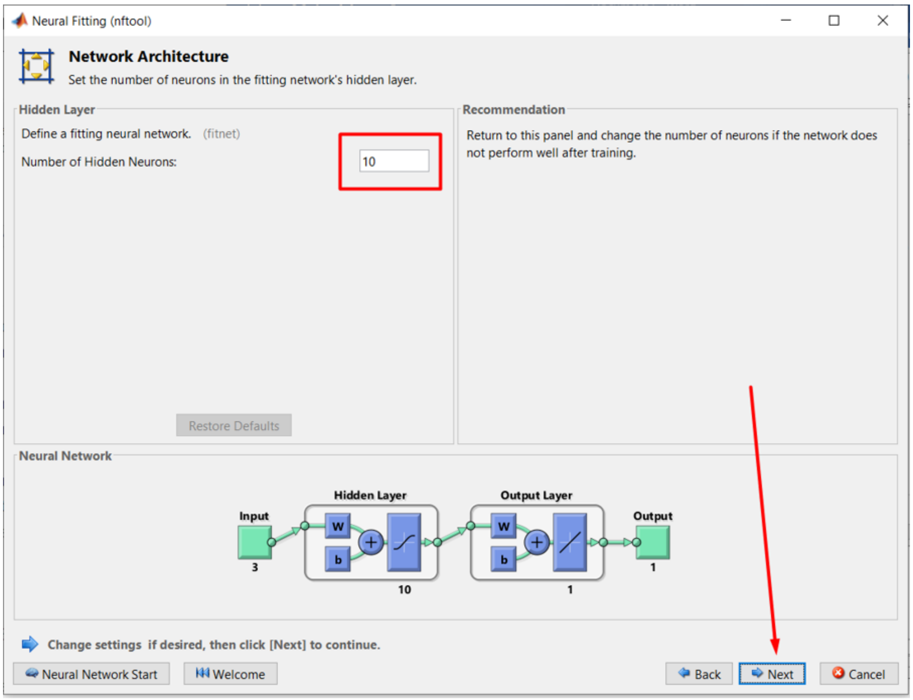

Figure 13: Number of neurons selection

5. Algorithm used

Early in the 1960s, the Levenberg-Marquardt method was created to address nonlinear least squares issues. By minimising an objective stated as the sum of the squares of the errors between the model function and a set of data points, least squares problems are created when fitting a parameterized mathematical model to a set of data points. The least squares goal is quadratic in the parameters of a model whose parameters are linear. Through the resolution of a linear matrix equation, this objective may be reduced with regard to the parameters in a single step. An iterative solution strategy for the least squares issue is needed if the fit function's parameter values are not linear. We have started training the neural network using Levenberg-Marquardt algorithm as shown below

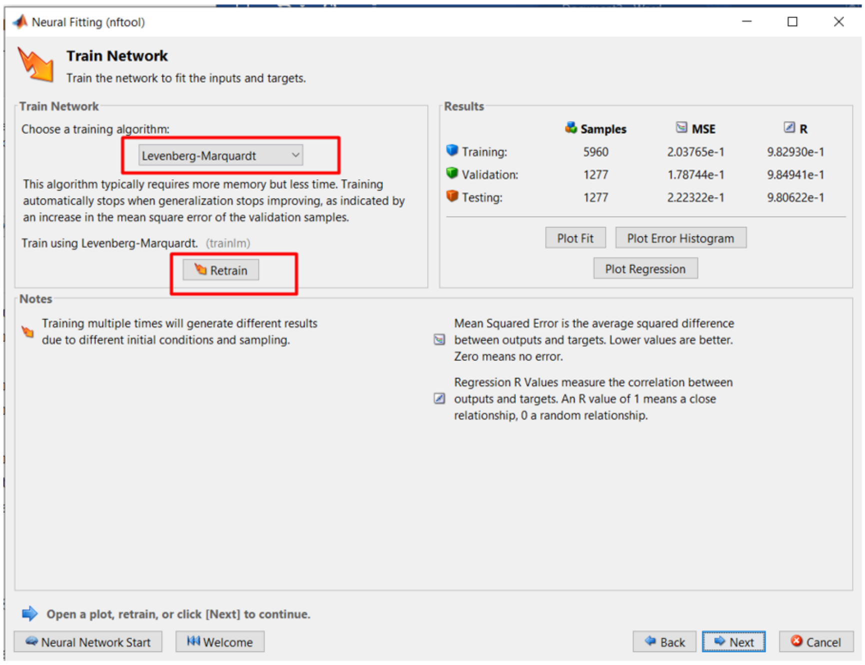

Figure 14: Selection of algorithm

6. Simulation results:

After training, the resulting network can be in four ways as shown in the figure below

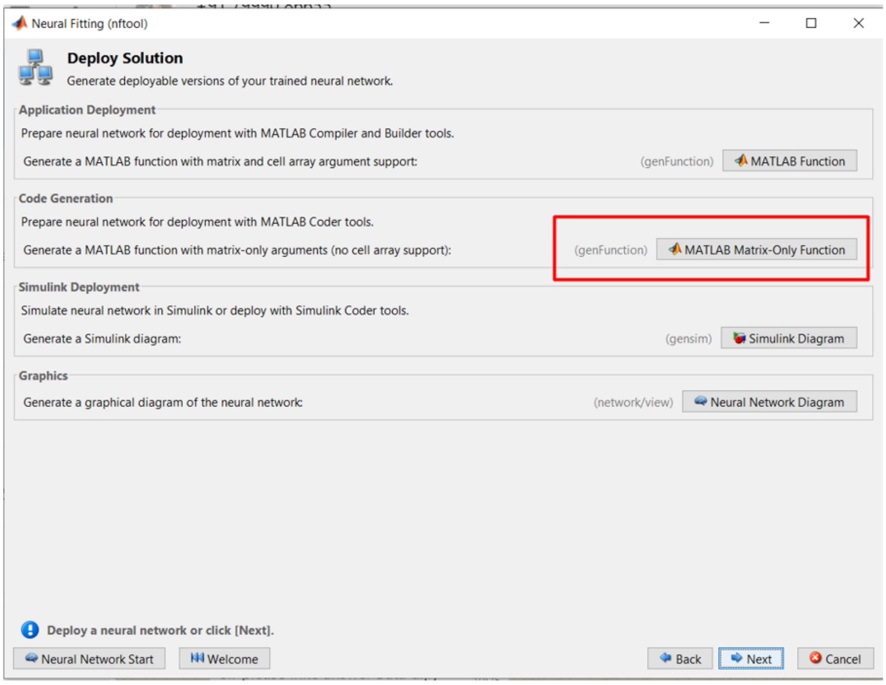

Figure 15: Deployment of the Neural Network

We have used the output in the function form to eavaluate the performance of the model. Given below is the result obtain by running the MATLAB function created from the NN model. Obtained Neural network is shown below

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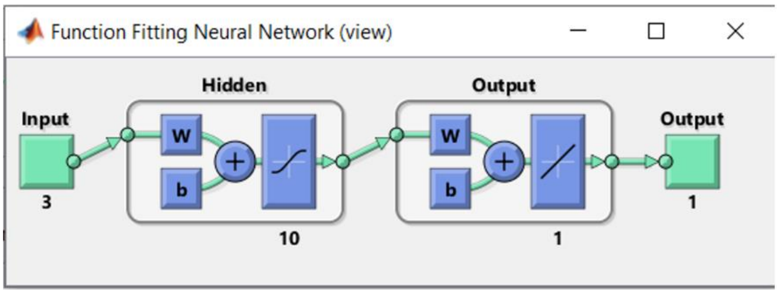

Evaluating from this function

```
>> myNeuralNetworkFunction(1000,1000,1000)

ans =

    6.8744

>> myNeuralNetworkFunction(2,5,1000)

ans =

   -0.8801
```

Figure 16

It can be seen that the when the input 1000,1000,1000 has given as the input arguments in the function then output obtain is 6.88 which is close to 7. 7 in binary is 111, it means that there is a fault in phase A, phase B and phase C. When the input to the function is changed to 2, 5, 100, output obtained is -0.88, magnitude of 0.88 is close to decimal 1. Decimal 1 in three bit is 001. It means there is a fault in phase C only and it can be seen that the phase C current is very high.

II. RESULT ANALYSIS

Error histogram obtained is shown below

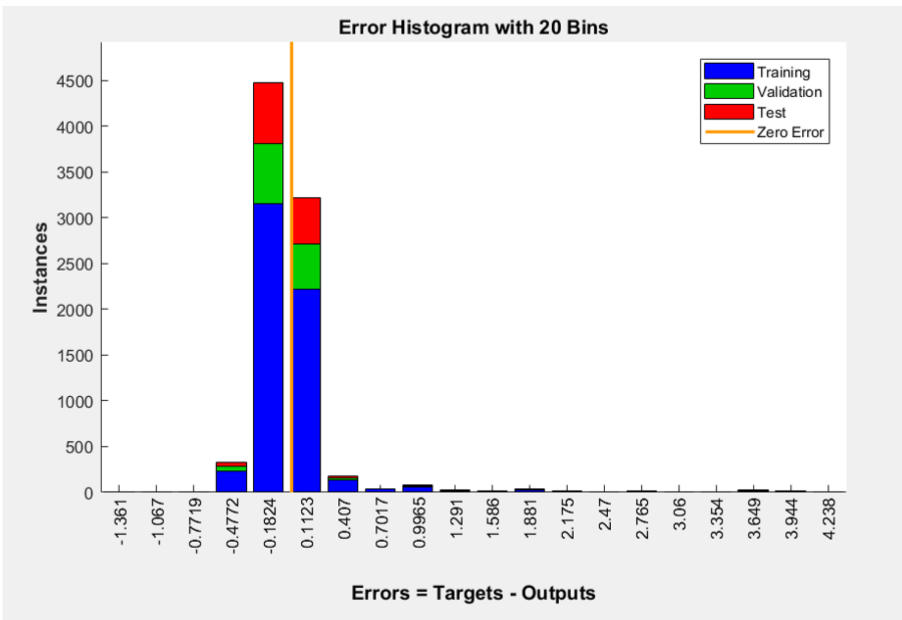

Figure 17: Error histogram

Figure 16 Generated neural network

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It can be seen that error is about 0.1824 and it is satisfactory. The neural Network training performance is shown below,

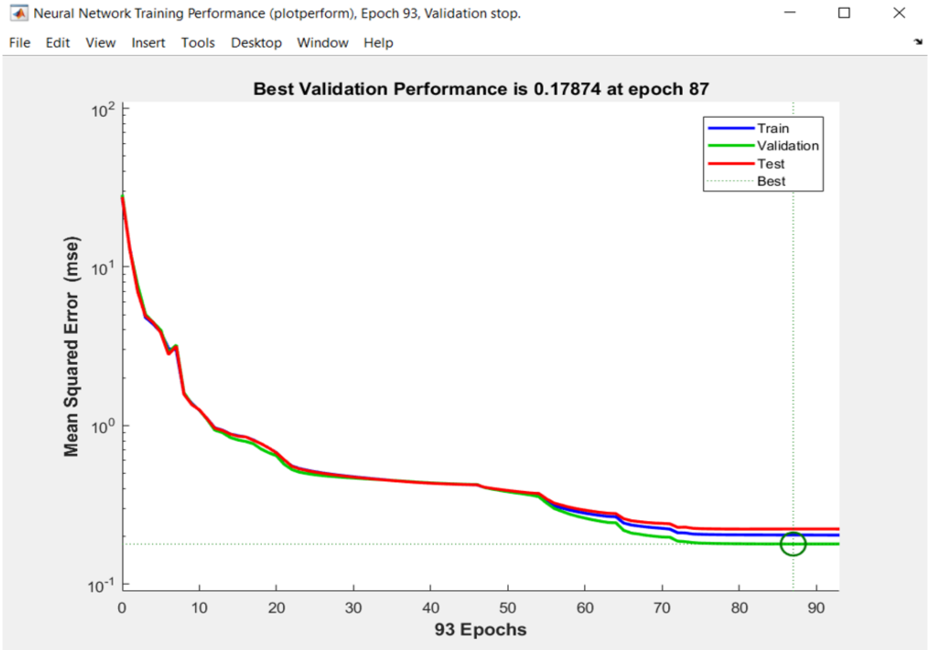

Figure 18: Validation performance

It can be seen that the best validation performance is 0.17874

III. ALGORITHM COMPARISON

Results of Neural Network has been evaluated by using three different type of algorithm.

1. Levenberg-Marquardt
2. Bayesian Regularization
3. scaled conjugate Gradient

The results obtained from the Levenberg MArquard algorithm is shown below

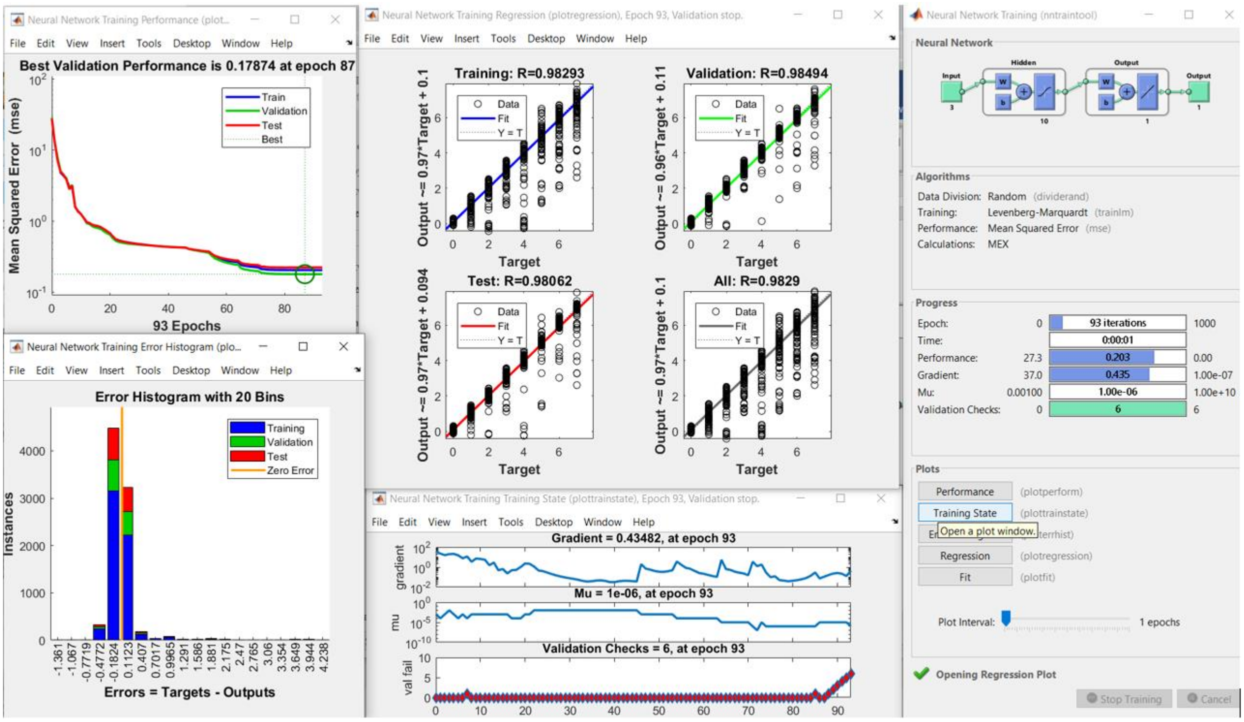

Figure 19: Results obtained from the Levenberg Marquard algorithm

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The results obtained from the Bayesian Regularization algorithm is shown below

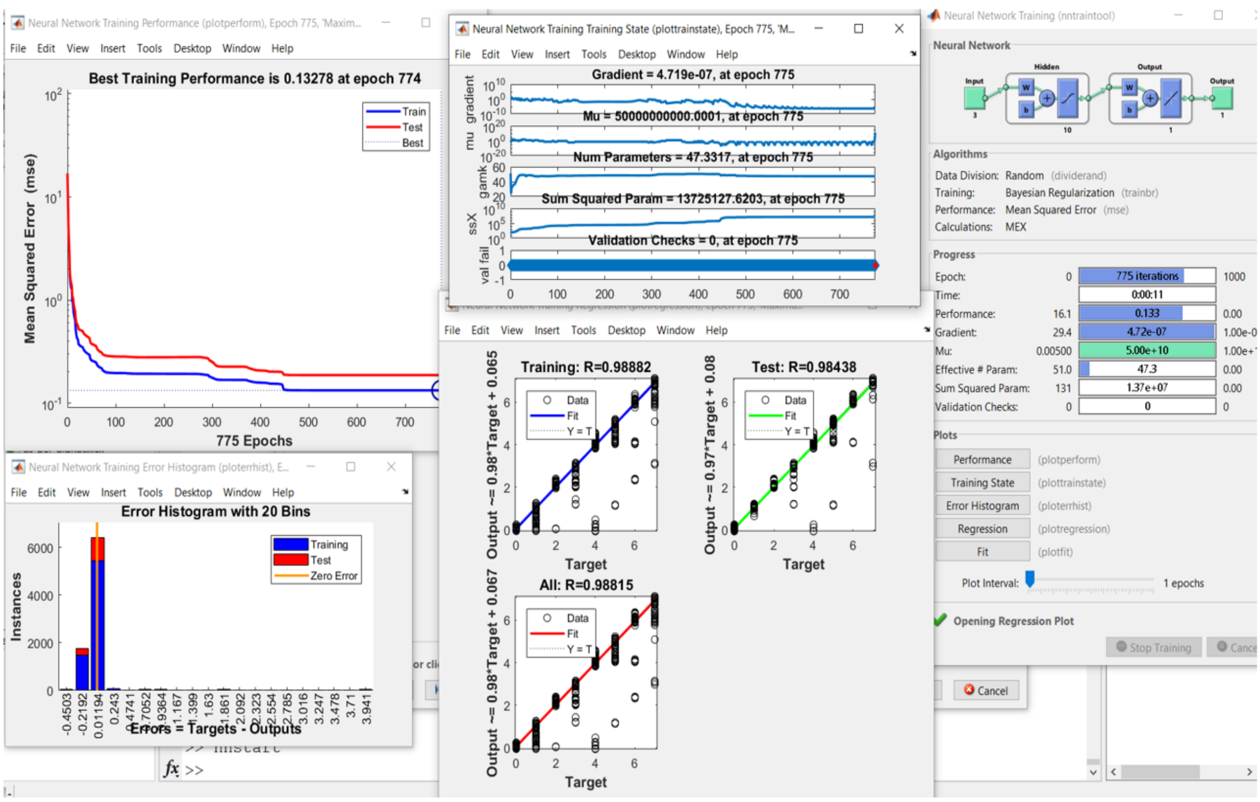

Figure 20: Results obtained from the Bayesian Regularization algorithm

IV. CONCLUSION

In this research paper, the design and development of Neural Network model for three phase transmission line fault is done. We have seen the different types of fault present in the transmission line system. Line to Line and Line to ground fault has been reviewed. During the fault, the current and voltage on the transmission line changes tremendously. This information is used to train the NN model. NN model has been trained with different types of training algorithm. It has been found that the NN network is working satisfactory and the error is reducing with the number of epoch, it has been found that the Bayesian algorithm is providing the best Regression coefficient. In future different Artificial Neural Network technique in the recent decade has seen a great development and modern tools and different algorithm based on the comparative study can be used to detect, classify and isolate the fault.

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