IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

FAULT CLASSIFICATION AND LOCATION TECHNIQUES FOR TRANSMISSION LINES IEEE SYSTEM

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Abstract :- It is imperative to safeguard the transmission line against the unavoidable effects of defects, hence intelligent schemes for fault detection and classification must be implemented immediately. This article presents the use of artificial neural networks (ANN) to detect, identify, and classify faults on transmission lines with better zone reach settings. The inputs to the artificial neural network (ANN) are defined as the fundamental voltage and current magnitudes as determined by the Discrete Fourier Transform (DFT). Section 2, the most important area that needs to be secured, is where the relay is located. A variety of fault datasets, which were derived from the MATLAB simulation of several fault scenarios, including different types of faults at variable fault inception angles, fault locations, and fault resistances, were used to train and test the ANN. The simulation outcomes illustrated that the entire shunt faults including forward and reverse fault, it's section and phase can be accurately identified within a half cycle time. The advantage of this scheme is to provide a major protection upto 99.5% of total line length using single end data and furthermore backup protection to the forward and reverse line sections. This routine protection system is properly discriminatory, rapid, robust, enormously reliable and incredibly responsive to isolate targeted fault.

INTRODUCTION

Due to the extensive interplay of components in an electric power system, malfunctions or unintentional short circuit conditions may occasionally arise. Equipment and other power system components are harmed by the strong current flow that results from short circuits [1]. Protecting the transmission line from varied disturbances, faults, and their effects requires two critical components: precise fault distinction and precise fault type indication. One global short circuit protection scheme in a transmission line that serves as both main and backup protection is the distance relay While backup protection only kicks in in the event that the primary relay fails, primary protection operates as quickly and without delay as possible. Distance relay provides different protective zones according to the percentages of line impedances. Only 80% of the lines in Zone 1 are typically protected by the traditional distance relaying method; lines in Zone 2 are covered by 120% of the lines, and the longest remote lines are covered by Zone 3. It is configured to function with a double Zone 1 time delay. A number of factors, including shunt capacitance, distant in-feed currents, and fault-path resistance, can cause performance loss [2, 3].

An intelligent expert such as ANN may easily identify the defect that may have occurred in the transmission line [4]. A variety of transmission line protection techniques have previously been proposed to use high frequency noise produced by faults and NNs to identify and categorize faults. [5], first current travelling wave technique [6], wavelet transform [7], wavelet fuzzy mixed approach [8], the use of ANN architecture and digital signal processing ideas in high speed protective relaying, etc. [9], a modified Kohonen-type neural network used in a modular yet integrated approach [10], an ISODATA clustering algorithm-based combined supervised and unsupervised neural network [11], RBF NN with an OLS learning method [12], and a combined fuzzy neural network [13–16], wavelet analysis and ANN [17–19], and an ANN Approach [20–25].and ANN [31 synced phasor measurement units (PMU) [35, 36], radial basis neural network [33, 34], and Kohonen network technique [32]. These methods, however, were unable to determine the kind, direction, or defective component of the fault. The fault phases and types have not been identified in several ANN-based directional relaying algorithms [37–39].Although there are many clever techniques available for securing transmission lines, their usefulness is still limited by certain limitations. The main goal of this work is to provide an effective protection technique based on artificial neural networks (ANNs) that improves first zone reach setting and completes fault detection in half a cycle of time. Therefore, the two main goals of this study are to: (1) detect and categorize the fault; and (2) determine the fault's zone and direction (i.e., whether it is a forward or reverse fault). Here are further examples of the effects of changing various fault parameters, such as fault types, locations, inception angles, and resistances. Since this approach only uses one end of the data, a communication link is not required for the remote end of the data.

Power system under study

Two line segments totaling 200 km are part of the power system network, an existing 400 kV transmission line network. The single line schematic in Figure 1 illustrates the 200 km single circuit, three phase, 400 kV transmission line that makes up the power system network under investigation. Power is transferred to the 400 kV grid at bus B4 via four 500 MW producing stations and three 210 MW generating stations connected at bus B1. A 17 km transmission line connects the two 210 MW generating stations at bus-2. Subsequently, the power is transmitted over a distance of 199 kilometers to the 400 kV grid at bus-3. In order to simulate the remote end infeed and to replicate the thevenin equivalent source of the interconnected grid, a second three phase source with 400 kV and 50Hz is attached to bus-3. Given that the proposed relay is located at bus-2, the directional relaying principle can be applied by treating section-1, which is 17 km long, as the reverse line section as perceived by the relay, and section-2, which is 199 km long, as the primary section that has to be safeguarded. Three phase fault breakers were used to simulate different kinds of shunt failures.

Proposed ANN based fault detector, section estimator and fault classifier

The suggested plan addresses classifying and fault section estimate in protective relaying duties. An artificial neural network (ANN) for classification and another for section estimation have been built. These networks enable the identification and categorization of all 10 shunt faults, as well as the assessment of their section/zone and direction, with the use of just one terminal data. To demonstrate the resilience of the suggested plan, simulations involving various power systems and fault scenarios were run. The current study's performance evaluation was done with the aid of the MATLAB program. For this job, a transmission line (400 kV) measuring 216 km and divided into two zones that are fed from both ends as mentioned in the preceding section has been selected.

There are four different types of shunt faults that can happen in a transmission line: LG, LL, LLG, and LLL. MATLAB software was utilized to construct a preferred power system model in which these failures were simulated. At bus-2, the three-phase voltage and current were measured. After being captured at 1 kHz, these signals were run through an analog filter. In order to exclude higher order harmonics from the signal, the analog filter is a Butterworth low pass filter of order 2, with a pass band edge frequency of 480 Hz. Later, the fundamental components of voltage and current were calculated using a single complete cycle recursive DFT. These signals were then given to an ANN for training, testing, and validation after being normalized in the range of -1 to +1.

The flow chart for proposed absolute protecting scheme based on ANN was presented in Fig. 2.

The design process of the ANN based relay goes through the following steps:

a) Selection of inputs and outputs for ANN.

b) Simulation of different fault cases to form training and test data sets.

c) Architecture and training of ANN with appropriate training data sets.

Selection inputs and outputs for ANN

The deviations of the registered voltages and flows signals in the time space are very noticeable and explicit under verity of issue conditions. Planning a quick and dependable ANN based transfer worries about the varieties of current and voltage signals when the occurrence of issue. Different frequency components of signals show up when faults occur, and the DC magnitude decreases as time goes on. Furthermore, various non-essential recurrence parts changed for various shortcoming areas. In order to train an ANN, it is necessary to preprocess and extract the useful features from the input data because the ANN's performance is dependent on the characteristics of the input and output. Figure depicted the instantaneous voltage and current signals for the three phases. 3 during an AG fault at 5 km in Section 2 with a fault resistance of 0.001, the faulty phase current begins to increase and the voltage signal begins to decrease in magnitude after 61 milliseconds. The fundamental components of voltage and current signals following DFT preprocessing are depicted in Figure 4. The magnitudes of the fundamental components (50 Hz) of three-phase voltages and currents assessed at the relay location at a single end of the line were used as the inputs to the network. As a result, as shown in Equation, there are six total inputs to ANN for fault detection, classification, and estimation. 1). Post issue tests (10) of principal parts of 3-stage voltage and current signs were separated for shaping the info lattice of ANN preparing as displayed in Eq. (2).

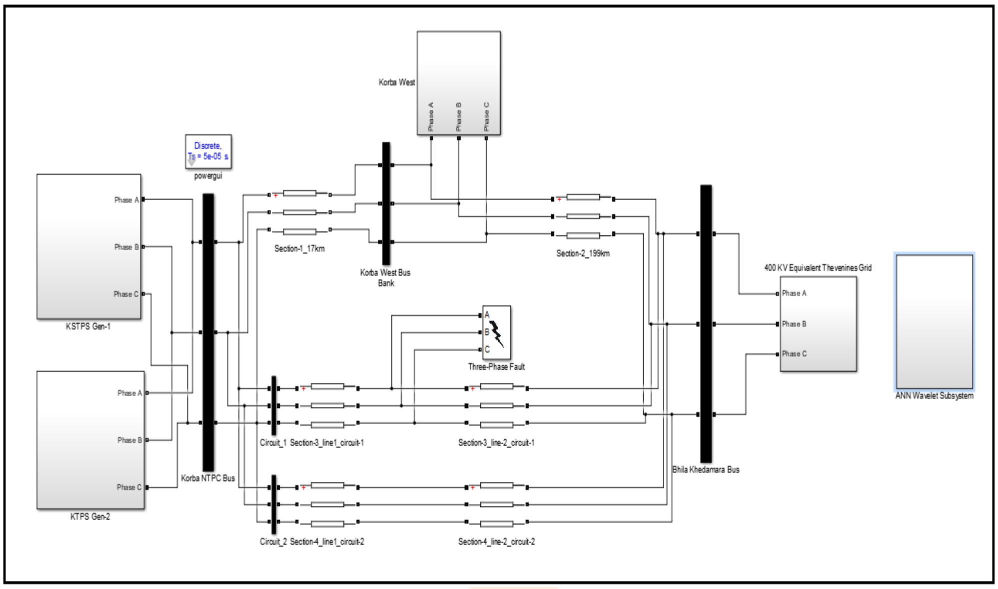

Figure 1 matlab simulation for transmission network

RESULTS AND DISCUSSIONS

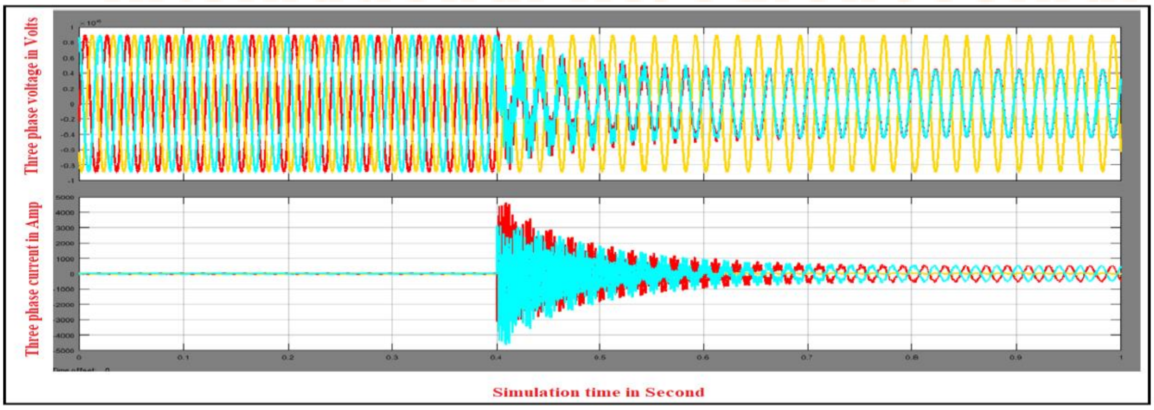

Figure 2: Three phase voltage and current of transmission line circuit 1 of double circuit line during double line fault occurs at 0.4 second simulation time on circuit-1 from 55 km of reference bus bar in volts and lower Y-axis shows the three phases current in ampere.

Here, it is observed that the double line to ground fault LLG-ACG causes the voltage of the A and C phases to drop after 0.4 seconds and the currents of the same phases to increase. Figure 3 depicts the transmission line circuit 2's three-phase voltage and current during a double circuit fault, which happens on circuit 1 at 0.4 seconds during simulation time on a 55 km reference bus bar. The three phase voltage is displayed in volts on the upper Y-axis, while the three phase current is displayed in amperes on the lower Y-axis. Here, it is observed that the double line to ground fault LLG-ACG causes the voltage of the A and C phases to drop and the currents of the same phases to increase after 0.4 seconds.

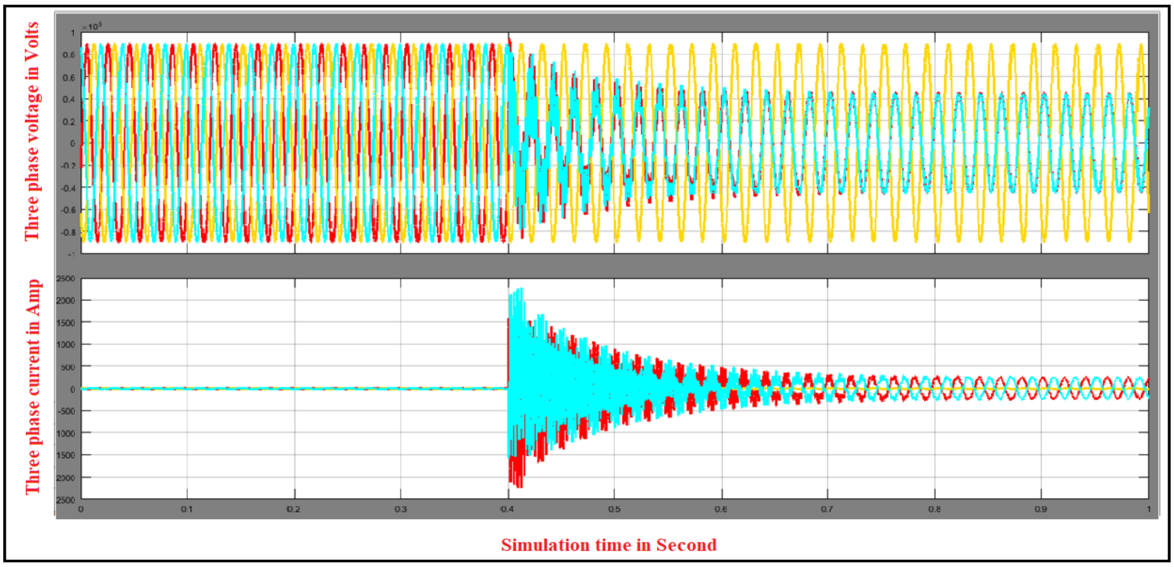

Figure 3: Three phase voltage and current of transmission line circuit 2 of double circuit line during double line fault occurs at 0.4 second simulation time on circuit-1 from 55 km of reference bus bar

Correction subsystems for ANN output.

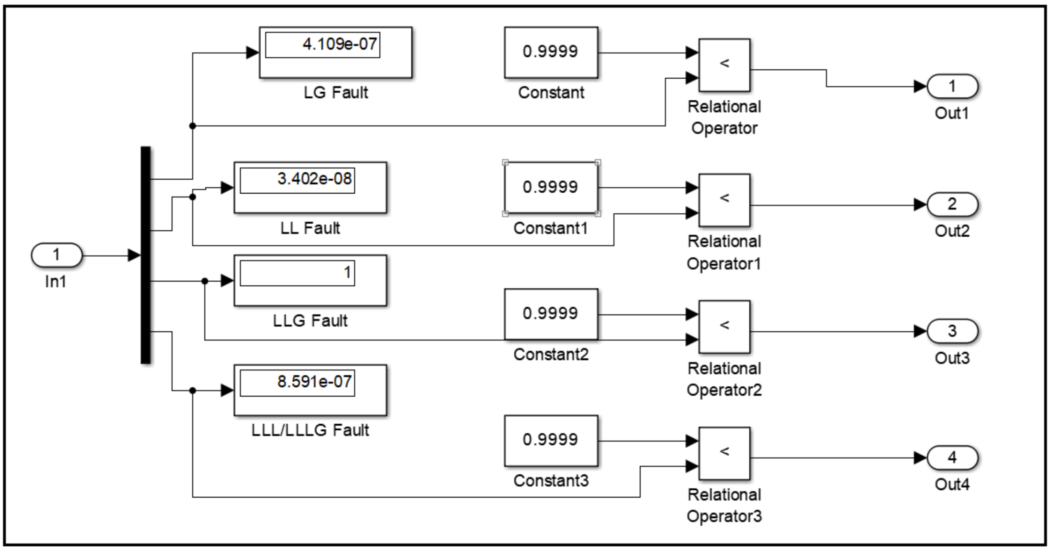

Figure 4 ANN-1 Output correction subsystem model in matlab simulink

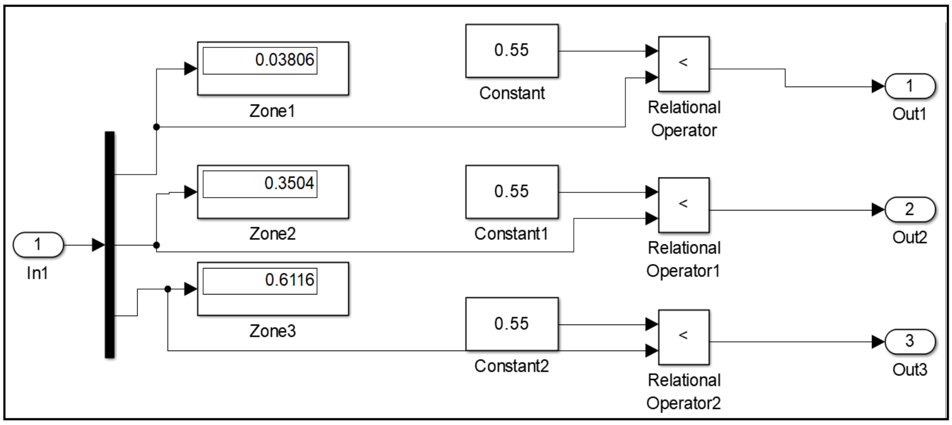

Figure 5: ANN-2 Output correction subsystem model in matlab simulink

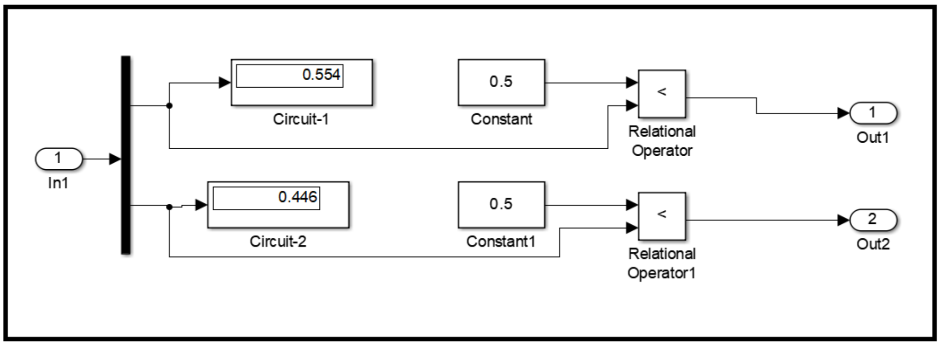

Figure 6: ANN-3 Output correction subsystem model in matlab simulink

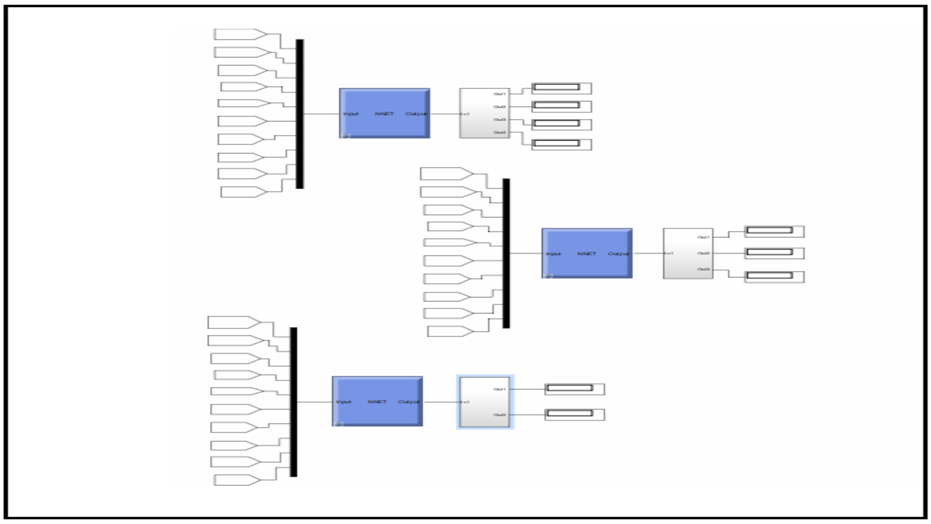

Figure 7: ANN-1, ANN-2 and ANN-3 connected in matlab simulink after training

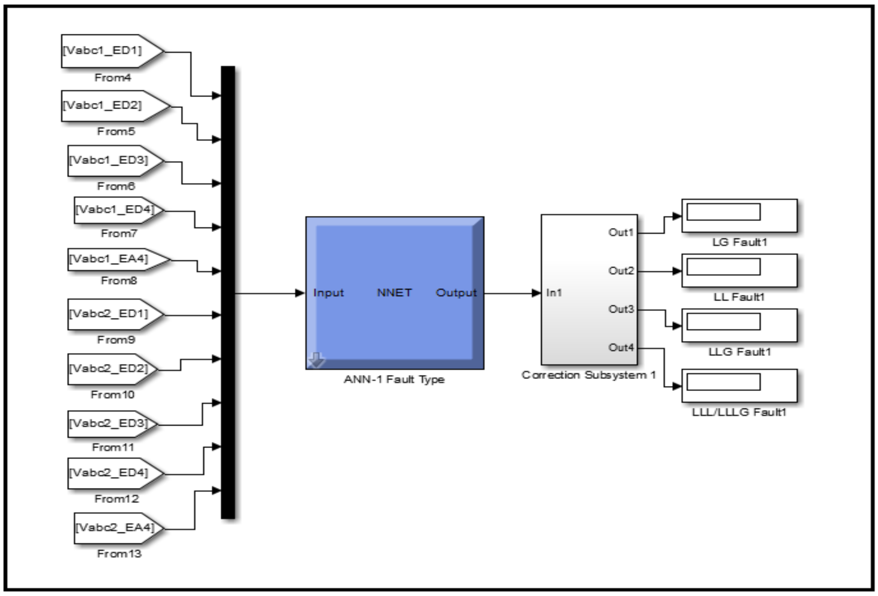

Figure 8: ANN-1 Structure in MATLAB Simulink

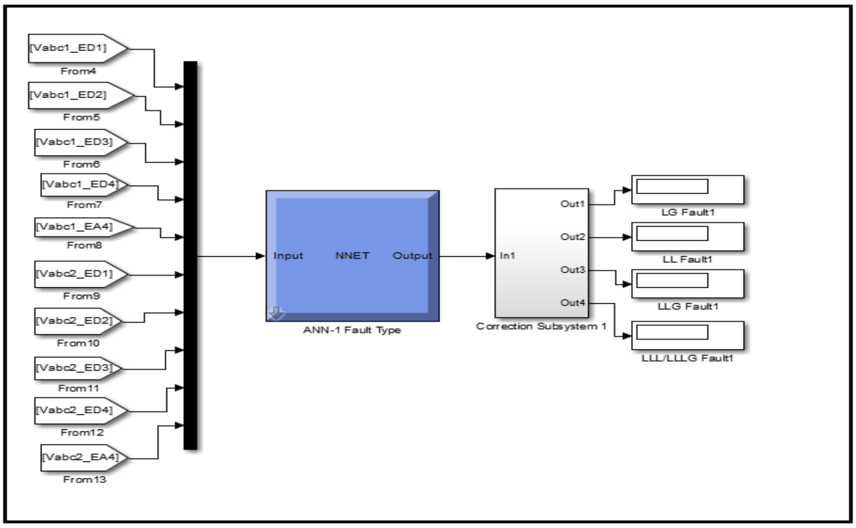

Figure 9: ANN-2 Structure in MATLAB Simulink

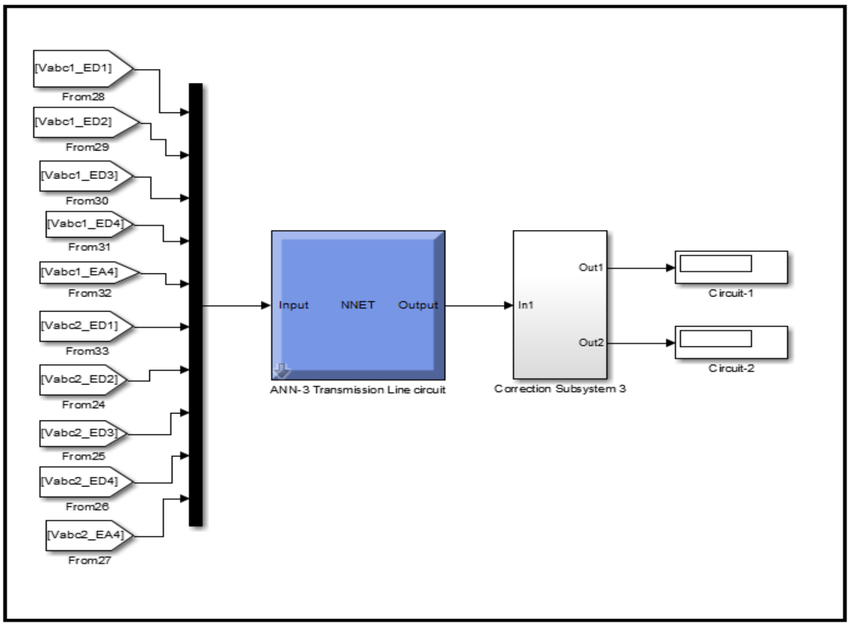

Figure 10: ANN-3 Structure in MATLAB Simulink

The confusion matrix for ANN-3 after it was successfully trained is depicted in Figure 4. In this case, it can be seen that ANN-3 correctly classified 96 of the 180 data in the set. Additionally, 102 data samples enter the ANN-3 confusion state. Be that as it may, utilizing ANN-3 result rectification subsystem model effectiveness of brain network is accomplished upto 90%.

The Receiver operating characteristics (ROC) of ANN-3 are depicted in Figure 5, with the Y-axis representing the true positive rate and the X-axis representing the false positive rate. In which Dim blue variety line shows the circuit-1 flaws cases target yield information and dark variety line shows the Circuit-2 issue cases yield information. Here it is seen that all varieties information line are lie in Obvious positive rate zone. However, gray color crosses a diagonal line in some instances, resulting in a false positive rate similar to that of blue color. As a result, partial data are classified as relationships between all 180 input cases and all 180 targets.

CONCLUSION

Fault section estimation and classification are among the protective relaying tasks addressed by the proposed plan. A fault classification ANN, a transmission line fault zone identification ANN, and a line faulted circuit number detection ANN are the three that have been developed. With the assistance of these organizations, arrangement, location, ID of zone of a wide range of 10 shunt blames, its part/zone and heading can be surveyed by the utilizing simply one terminal information. To demonstrate the robustness of the proposed scheme, simulations were carried out on various power systems and fault conditions. The MATLAB 2023a software was used for the current study's performance evaluation. This work has chosen a 400 kV transmission line that is sectionalized into two zones and has been fed from both ends, as described in the previous section. The transmission line's various shunt fault types include LG, LL, LLG, and LLL in each section. MATLAB 2023 software was used to create a preferred power system model that simulated these faults. At the circuit-1 and circuit-2 bus bars, the voltages and current of the three phases were measured. The wavelet multi-resolution analysis subsystem was used to analyze these voltage signals from circuits 1 and 2. The Daubechies Db3 mother wavelet with four orders was then used to perform these wavelet multi-resolutions. As a result, the three-phase voltage outputs of circuits 1 and 2 following multi-resolution analysis are the Norms unit signals Detail D1, D2, D3, D4, and Approximation A4. Following that, the details and approximation signal are calibrated for normalization or constant values in order to generate training data sets for each of the three ANN types. The fundamental components of 3-phase voltage signals are taken into account as input in this paper's ANN-based fault type classification, fault zone identification, and faulted transmission line circuit number proposals. Using a large number of fault cases and a variety of fault parameters, the proposed ANN-based method was evaluated. The results of the tests show that the proposed schemes can accurately classify faults with an efficiency of 99 percent. Additionally, the efficiency of ANN-2 for fault zone identification is 63%, and the efficiency of ANN-3 for faulted transmission line circuit detection is 53%.

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