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Transmission Line Fault Detection and Classification by Using Artificial Neural Networks

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Abstract: The feed-forward neural network and the back propagation algorithm have been used to analyze the three process phases by detecting and classifying the fault. The artificial neural network (ANN) was trained and evaluated on multiple sets of field data from simulating faults at different fault scenarios (fault kinds and fault resistance) of 11 kV, 100 km in length. Empirical findings validate the effectiveness of this approach in precisely classifying faults on the transmission line. This method can be used to attain high fault classification accuracy.
Keywords: Artificial Neural network, Back propagation algorithm, Symmetrical fault, transmissson line, unsymmetrical fault**.**

I. Introduction

Transmission line faults refer to any disturbances or irregularities that occur during the functioning of electrical transmission lines. These deficiencies can result in power outages, equipment harm, and safety risks. Comprehending transmission line problems is essential for upholding the dependability and steadiness of power systems. A transmission line *fault* is an occurrence that deviates from the typical operating circumstances of a transmission line. This deviation can appear as a short circuit, an open circuit, or a ground fault. A fault in a power system or circuit refers to a malfunction that disrupts the regular flow of electric current. Problems are linked to anomalous fluctuations in the power system's current, voltage, and frequency. Typically, problems in power system networks arise from equipment insulation failure, line flashover caused by a lightning strike, or inadvertent improper operation. In conjunction with the back propagation method, the feed forward neural network is advantageous for fault detection and classification—the applications of artificial neural networks [1].

The fault's direction and direction of fault study on discrimination in transmission line protection has encompassed numerous methodologies and ideologies [2]. The author focuses on a 14-bus system tested using MATLAB programming to cause faults using the impedance technique. The detection and classification performance is evaluated using a confusion matrix, which results in a 100% accuracy rate [3]. Precisely positioning a defect is essential for safe guarding transmission lines and ensuring the uninterrupted flow of high-quality power. This is a practical approach for identifying problems using artificial neural networks [4]. The author has provided findings for both software and hardware components. Circuit breakers and relays were employed to isolate the fault and safeguard the entire system. Numerical relays have offered exceptional accuracy and precision thanks to their robust processing system and an extensive array of algorithms. Specifically, this model can identify the fault zone [5]. This study focuses on Artificial Neural Networks (ANN), utilized in various applications. Different types of neural networks are employed for specific applications. The author has discovered that artificial neural networks have proven effective in detecting and categorizing errors in the transmission system [6]. A 300km transmission line with a voltage of 25kV and a long-distance transmission line with high voltage is being utilized to test the effectiveness of the suggested fault detection system. This paper focuses on the hardware implementation of a neural network using the TMS320C6713 [7]. Artificial neural networks identify and categorize defects occurring on electrical power transmission lines. The suggested technique requires the input of three-phase currents and voltages from one end [8]. The need for electrical energy is constantly expanding. A high-phase order transmission system is feasible because of the rising expenses associated with acquiring the right of way. Six-phase transmission lines can transport a more significant amount of power at the same phase-to-phase voltage while cost-effectively utilizing the same right of way [9]. The utilization of evolutionary programming tools accomplishes the differentiation of various sorts of defects on transmission lines [10]. The transmission network can be monitored and analyzed using various advanced techniques, including impedance-based measurement, travelling wave phenomenonbased, artificial intelligence-based, and specialized techniques.[11] These methods detect, locate, and classify different types of faults in the network . [12] The program utilizes the high-frequency components of a specific set of local currents at one end of a safeguarded line to categorize transients occurring on the protected line and its neighboring lines. [13] This work presents an innovative approach using a support vector machine (SVM) to accurately detect and locate various faults in transmission lines inside the power grid. The system relies on phasor measurement unit (PMU) readings to identify faults occurring at any location.[14] This work thoroughly examines the techniques employed for identifying, categorizing, and pinpointing faults in transmission lines and distribution systems.[15] This research examines explicitly the application of artificial neural networks to fault detection, fault classification, fault placement, fault phase selection, and fault direction discrimination.

II. Transmission Line Block Diagram

Neural networks are a crucial element of artificial intelligence and machine learning. They are a collection of algorithms inspired by the structure of the human brain, specifically developed to identify and comprehend patterns. They process sensory data using a form of machine perception, categorizing or grouping unprocessed input. Neural networks consist of interconnected nodes arranged in layers, similar to neurons in the human brain. Every stratum of nodes receives and handles data before transmitting it to the subsequent stratum.

The process of 'learning' in neural networks entails modifying the synaptic weights between neurons in response to the input data they are trained on. The procedure is referred to as training, and it usually entails providing the network with substantial quantities of labeled data and modifying the weights of connections between neurons to minimize the disparity between the network's output and the actual labels. Backpropagation is a commonly used method for updating the weights in a neural network. It involves propagating the error, the difference between the anticipated and actual output, backwards through the network.

2.1 Required Blocks for Transmission Line Fault Detection

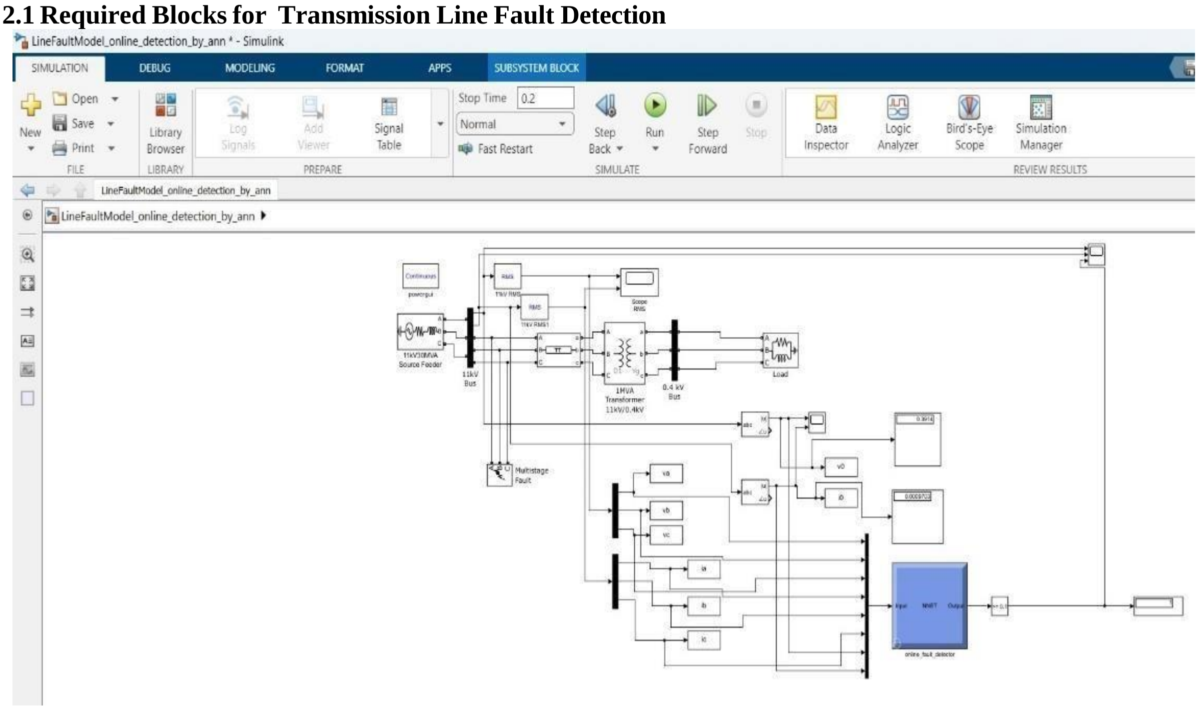

Fig: 2.1 Transmission line Fault Detection Simulink Model

Transmission lines are vulnerable to failures, including short circuits and line disruptions. MATLAB allows for the modeling and simulation of fault conditions, facilitating the analysis of their impact on the operation of the line. This enables the development of methods for detecting, isolating, and mitigating faults. MATLAB seamlessly interfaces with other engineering and simulation tools, enabling the combination of transmission line models with additional system components such as generators, transformers, and loads. This integration allows for thorough study and optimization of power transmission networks at the system level.

Developing a transmission line model in MATLAB provides a dynamic and adaptable method for examining, planning, and enhancing power transmission systems, making it a crucial tool for power system engineers, researchers, and educators.

III. Fault Detection by Artificial Neural Networks

3.1 Blocks for fault detection

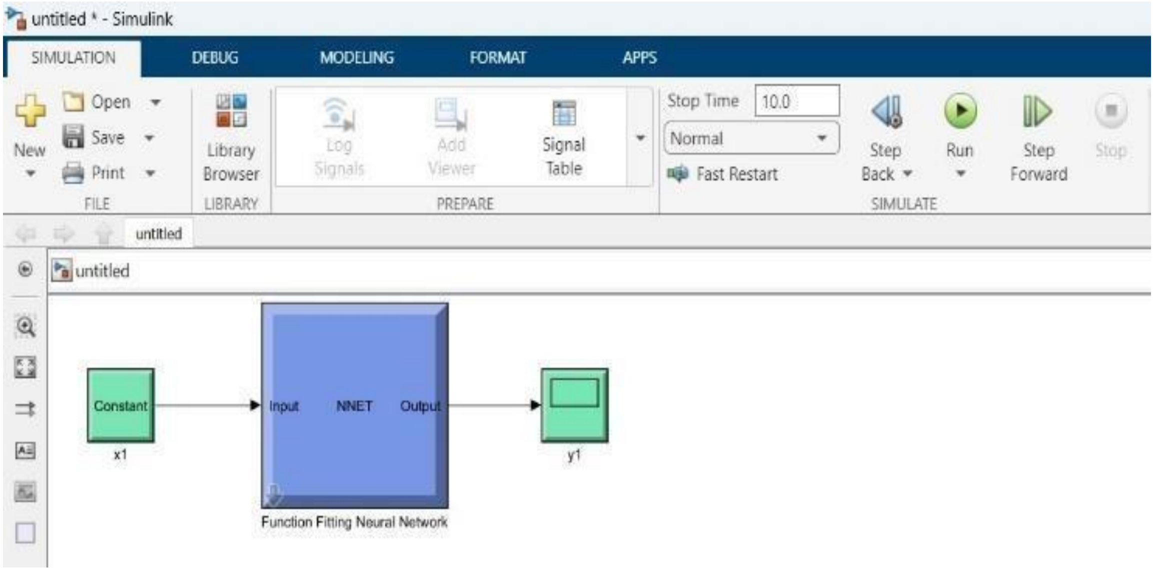

Fig 3.1 Sequence Analyzer Block

- **Signal Processing:** Examining and manipulating signals in either the time domain or frequency domain, such as applying filters, conducting spectrum analysis, or extracting features.
- **Pattern Recognition:** Conducting sequence analysis to identify patterns, themes, or abnormalities in the data stream.
- **Sequence Classification:** Sequencing classification involves categorizing sequences into distinct classes or categories based on their specific traits or attributes.

(b) Sine Wave

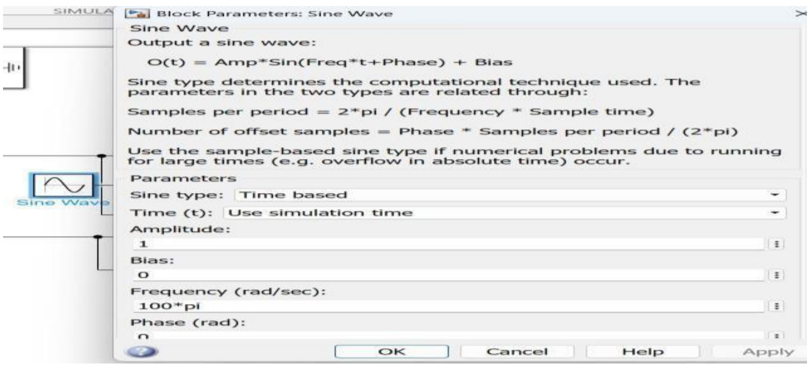

Fig: 3.2 Sine Wave Block

The Sine Wave block is a powerful tool in Simulink that allows engineers to generate sinusoidal signals as shown in fig 3.2. It is used for modeling, simulating, and analyzing many dynamic systems and signal processing applications.

(c) Product

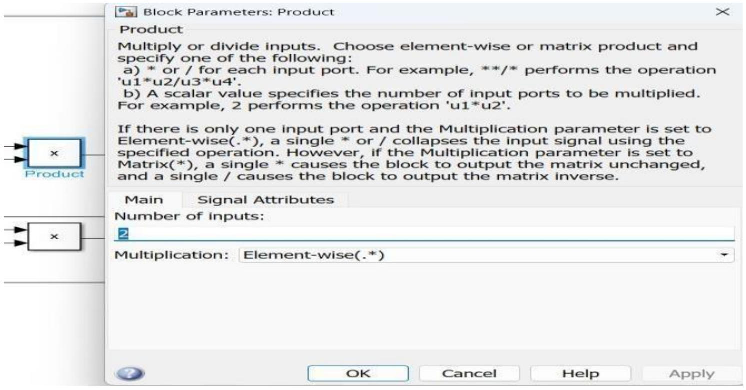

Fig: 3.3 Product Block

The Product block in Simulink as shown in fig 3.3 is a flexible tool that allows engineers to execute multiplication operations on signals. It enables engineers to manipulate signals, implement mathematical functions, and efficiently describe system behaviors.

(d) RMS:

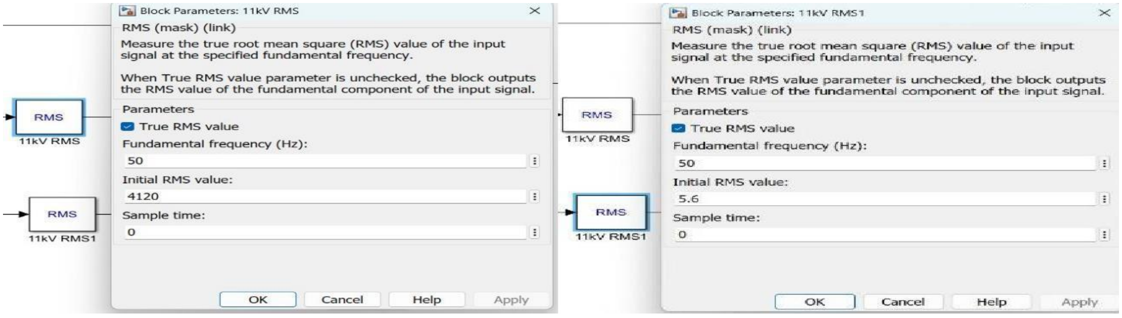

Fig: 3.4 RMS Blocks for voltage and current measurement

The RMS block in Simulink is a crucial tool for calculating the root mean square value of signals. It allows engineers to examine, process, and characterize signals in many engineering and scientific applications.

(e) Demux:

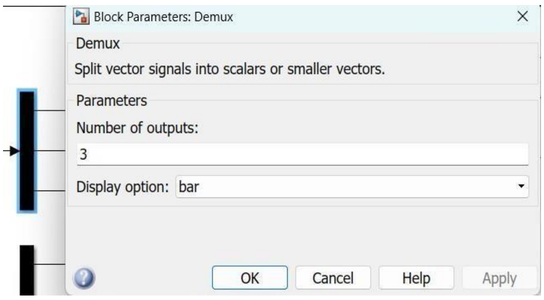

Fig: 3.5 Demux Block

The Demux block in MATLAB Simulink is used to divide a single input signal into many output signals. This allows users to send data to numerous destinations inside a Simulink model for additional processing, analysis, or interaction with external interfaces.

(f) To Workspace

The To Workspace block acts as a connection between Simulink simulations and MATLAB's scripting environment, allowing engineers to utilize MATLAB's comprehensive analysis, visualization, and processing tools to further investigate and comprehend system dynamics.

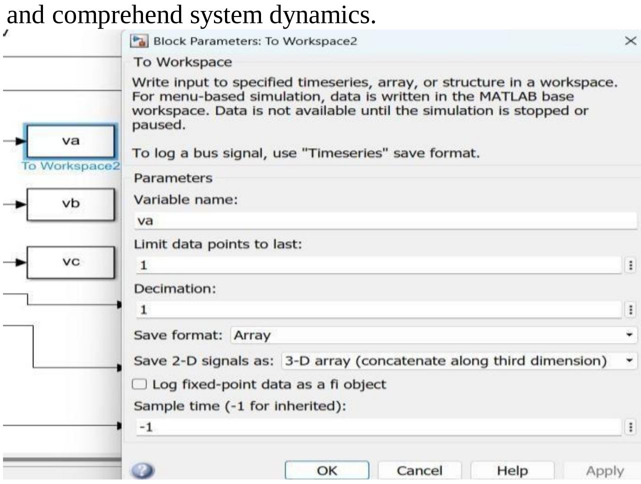

Fig: 3.6 to Workspace Block

IV. Results and Discussions

4.1 Waveforms of Bus Voltages and Currents:

When fault occurs across phase A then the variation of waveforms of voltage and current is shown in fig 4.1 similarly when fault occurs across phase b then fig 4.2 shows the variations.

(a) Bus Voltage and Currents with Fault (AG)

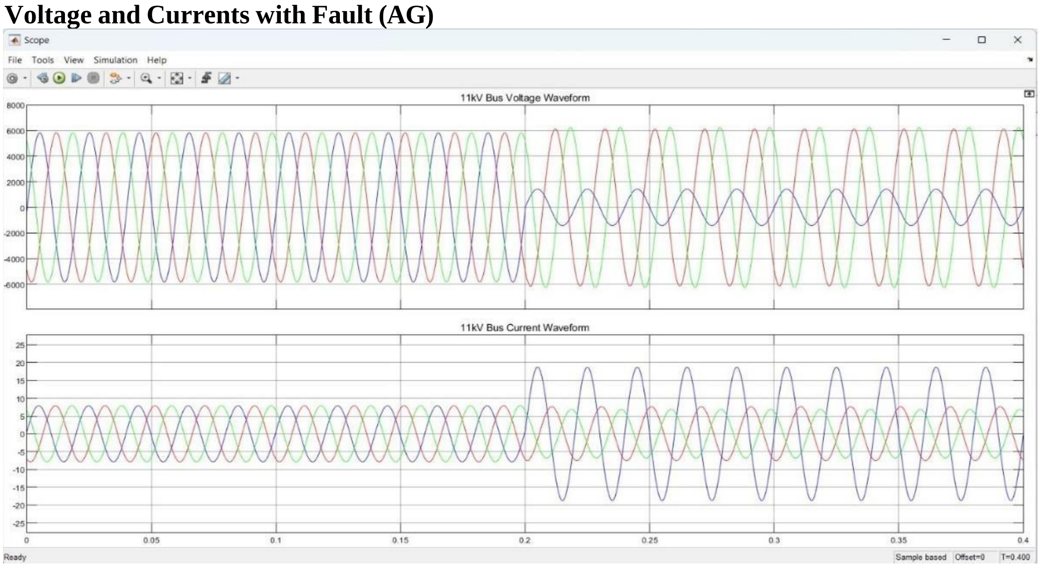

Fig: 4.1 Voltages and Currents with AG fault waveforms

(b) Bus Voltages and Currents with Fault (BG)

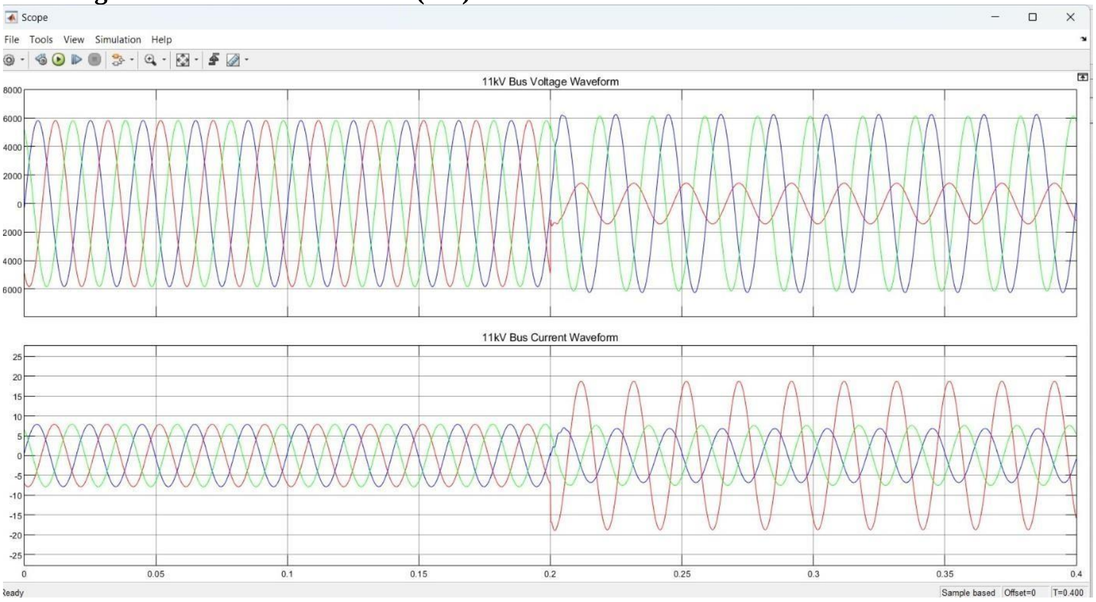

Fig: 4.2 Voltages and Currents with BG fault waveforms

4.2 Outputs when Fault detected using ANN:

When fault occurs across phase A then the variation of waveforms of voltage and current is shown in fig 4.3 similarly when fault occurs across phase b the the variations is shown in fig 4.4.

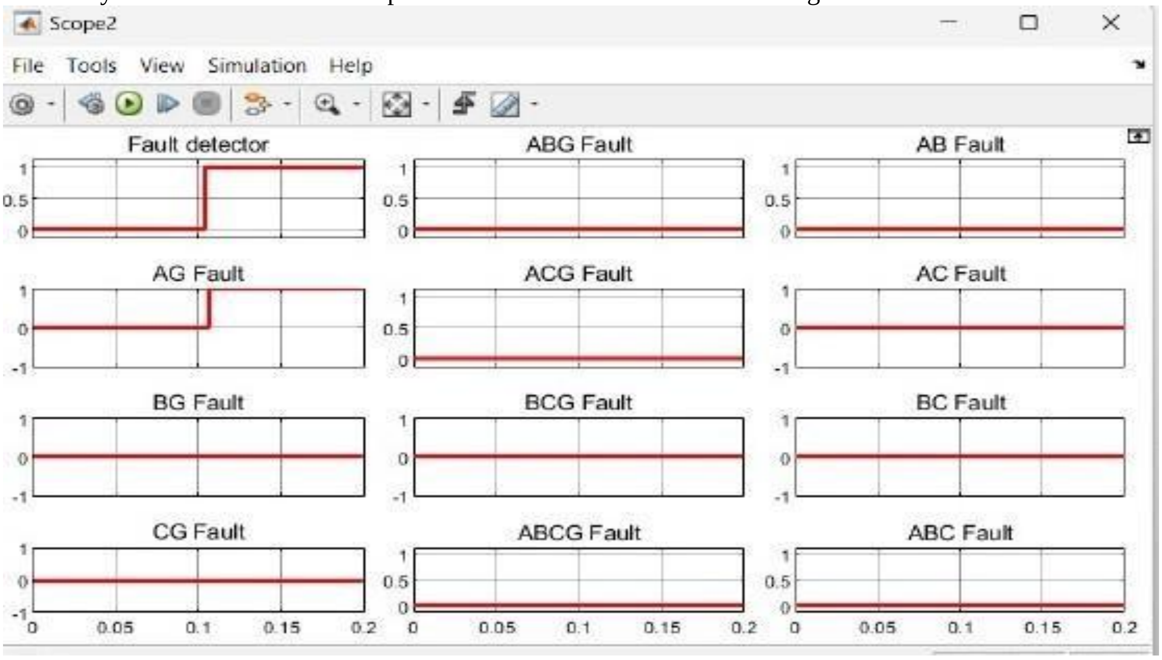

Fig: 4.3 Fault Detected and AG Fault Classified

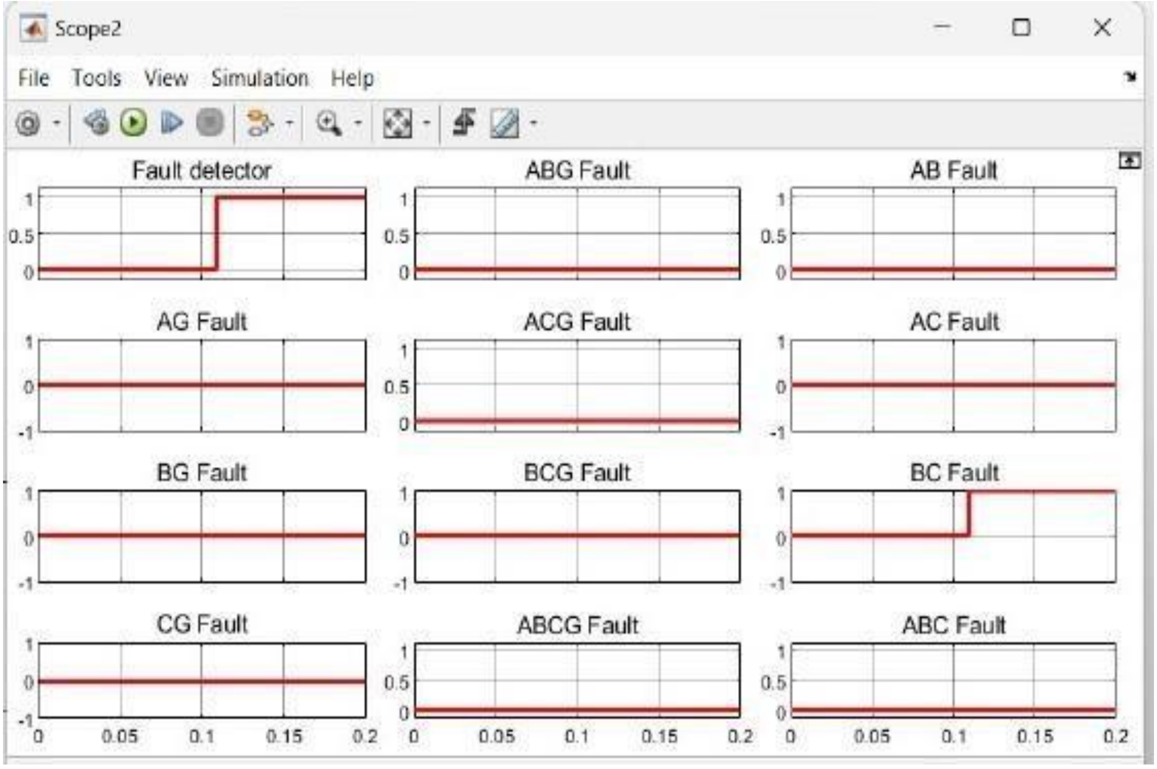

Fig: 4.4 Fault Detected and BC Fault Classified

Conclusion

This paper provides a thorough examination of the use of neural networks in MATLAB for detecting and classifying faults in transmission lines. By utilizing diverse neural network topologies and employing feature extraction approaches, our research has successfully showcased encouraging outcomes in precisely identifying and categorizing distinct problems in transmission lines. our research highlights the capability of MATLAB-based neural networks as valuable instruments for improving the dependability and effectiveness of transmission line operations. By enabling prompt identification and categorization of faults, these systems can help to minimize periods of inactivity, decrease expenses related to maintenance, and guarantee the reliability of power distribution networks.

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