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DETECTION AND IDENTIFICATION OF FAULT IN TRANSMISSION LINES BASED ON ANN

Ahmed G. ABDULLAH *, **Mohammad A. IBRAHIM**, **Waseem Kh. IBRAHIM**

Northern Technical University, Technical Engineering College of Mosul, Iraq
* Corresponding author, e-mail: ahmed.g.alhealy@ntu.edu.iq

Abstract

Along with power transmission lines' efficiency, another crucial factor in electrical power transmission networks is reliability, which guarantees power transmission stability. One of the crucial and essential tasks for maintaining the continuity and stability of power transmission in transmission networks Capacity without any significant failures is identifying errors and malfunctions in power transmission lines as soon as possible. The goal of this article is to develop and apply ANN technology to overcome the obstacles faced by the electrical power transmission network. In order for the ANN to learn useful patterns and features from raw current measurements, pre-processing and feature extraction techniques are used during the training process. Real-time applications can benefit from the ANN's architecture, which is optimized for high accuracy, quick response times, and scalability. To validate the performance of the ANN-based fault detection system, extensive simulations are conducted using data from different transmission line scenarios, including various fault types that short-circuit. The results demonstrate the capability of the ANN model to accurately detect and classify faults, as well as disconnect the power grid after detect any fault. The results showed the accuracy and high speed of the proposed method using a neural network compared to traditional methods.

Keywords: (fault detection, fault identification, transmission line fault, MATLAB/Simulink, Artificial Neural Network)

1. INTRODUCTION

Transmission lines T.L form a crucial part of the electric power system and are susceptible to faults due to their exposure to many factors. Compared to other main components, transmission lines have a higher likelihood of experiencing faults.Line faults are the most frequent, as the lines are exposed to various environmental factors that can lead to issues. These factors include lightning strikes, trees falling on the lines, dirty insulators causing flashovers due to fog and salt spray, and mechanical failures of insulator strings caused by ice and snow loading [1]. In any time an electrical transmission line may suffer to failure, it needs to be located and the appropriate repairs need to be made in order to get the line's power back on as soon as feasible. The quality of power transmission is impacted by how long it takes to locate the electrical line issue spot. [2]. Malfunctions have a major effect on a very large increase in electrical current, which in turn causes very serious damage to the parts of the electrical network and interruption of the electrical supply, which results in a partial or total interruption of the electrical current to customers, factories, laboratories, and other important institutions, as well as a decrease in the amount of electricity supplied voltage level, which seriously harms electrical apparatus. For these reasons, finding and detecting the faults are crucial and essential for customers as well as electrical networks. Electrical network protection stages play a critical role in anticipating and promptly resolving network failures [3].

One of the most significant and extensively used key protection devices worldwide is the relay. It usually works in conjunction with a circuit breaker. Isolating the defective components of the power system from the healthy portion of the system that was in operation when the fault current occurred is the primary objective of power system protection. This guarantees that the system's healthy component operates as intended without seriously harming the system. It is crucial that the circuit breaker receives signals from the system at a very high speed. As a result, this issue is dependent upon the relay settings inside the system, particularly on how rapidly it can be configured to respond to any system errors[4].

The purpose of this study is to examine and evaluate the identification and detection of T.L system defects using Artificial Neural Network (ANN) technology. Transmission line defects can be effectively identified, isolated, and classified with the use of artificial neural networks. Because of the parallelism inherent in ANN, they can process data quicker than traditional methods. The application of this technology in the diagnosis of transmission line

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faults demonstrates its utility and inspires engineers to apply it to other power systems. This paper aims to develop an autonomous neural network-based learning system that can progressively learn in real time with the least amount of supervision. It also publishes practical strategies for the scheme's practical application, which includes error diagnosis and detection in any type of electric transmission system[5,6].

2. LITERATURE REVIEW

In recent years, many studies and research have focused on the artificial intelligent technique such as ANN , fuzzy logic in Determine the locations of faults and their accuracy in power T.L, in addition to distinguishing between the types of faults in these networks. Aditya, Pandey *et al.* [7] proposes a fault recognition system based on ANN for an 11 kV transmission line ,the system aims to detect and monitor different types of faults, including line to line, double line to ground, line to ground, triple line to ground faults and triple line, a MATLAB simulink model is developed to create fault conditions and generate data set for training the neural network ,the neural network is trained using current datasets under normal and fault conditions, and a target matrix is prepared based on the time duration of the fault in the current signal.

Khaled, Eouati, *et al.* [8] The author present a comparative study between identification and fault detection in electrical transmission lines using ANN and fuzzy. Simulation models are used to create various types of faults in transmission lines for testing purposes. An intelligent monitoring system called Intelligent Fault Diagnosis (IFD) is utilized, which makes use of voltage and current measurements as indicator data. The study finds that both the ANN and fuzzy logic approaches are robust, accurate, and reliable in detecting faults, determining the fault kind (open circuit or short circuit), locating the fault, and identifying the faulted phase.

Qian, Zhang., *et al.* [9] proposes a fault diagnosis method for power grids using variation mode decomposition (VMD) and convolutional neural network (CNN) techniques. The authors mention that traditional fault diagnosis methods for power grids have limitations in terms of accuracy and efficiency. The authors introduce VMD as a signal decomposition technique that can effectively extract fault features from power grid signals. The paper aims to combine VMD and CNN to improve the accuracy and efficiency of fault diagnosis in power grids.

K. Yuneela Chowdary *et al.* [10] presents a technique for detecting, locating, and classifying faults in transmission lines in a power system using (ANN) .The technique aims to reduce downtime in case of power failures and requires a robust and accurate fault location system .The execution of the technique is evaluated using measures such as Mean Square Error (MSE) and Regression (R) value. The paper demonstrates the satisfactory and acceptable results of the ANN models in detecting the presence of a fault (MSE: 1.462e-10, R: 1) and locating and classifying faults (MSE: 0.16178, R: 0.9818) in the transmission line.

A, Firos., Nisha, *et al.* [11] discusses the development of intelligent fault diagnosis techniques using Machine Learning (ML) models such as Support Vector Machine (SVM), Naive Bayes (NB), and Random Forest (RF) for classification and fault detection in power transmission lines. The NB model achieved the highest accuracy rate of 97.77%.

Supriya Kumari, *et al.* [12] the objective of this paper is to detect faults in transmission lines using (ANN).The ANN is trained with six input values, including the current and voltage values of the three phases. When a fault occurs, the ANN compares the (pre-fault) and (post-fault) values to determine the presence of a fault. MATLAB is used to simulate the ANN for fault detection.

R., Mohamad, Idris. *et al.* [13] analyses two methods for fault detection and classification: the Fuzzy Logic based method and the Wavelet Transform method. The Wavelet Transform method uses signal decomposition to identify significant differences between faulty and non-faulty inputs, while the Fuzzy Logic based method uses rules and conditions for fault identification. The paper aims to develop and simulate a combined method of Fuzzy Logic and Wavelet Transform based for fault classification, comparing it with the Radial Basis Function ANN method.

When comparing, discovering and identifying problems in long-distance electrical power transmission lines using the ANN method with other traditional methods, it was found that results with very high accuracy and speed in locating faults. Compared to what was mentioned, the neural network in this paper is used not only to detect malfunctions, but also to disconnect the network at the time of detecting the malfunction with very high accuracy, and this is something that was not addressed in the researches mentioned.

3. AIM OF THE STUDY

The main aim of this study is to develop a methodology for detection and identification of power transmission line faults ,as well as disconnicting the power grid immediatly after diticting any fault by using (ANNs). Through the use of this technology, faults and problems in electrical power transmission lines in electrical networks will be detected and identified, which extend over very large distances, were many problems and malfunctions occur when transmitting energy. (ANNs) are a useful tool for analyzing electrical signals and patterns linked to various transmission line fault types because they can recognize patterns and relationships from massive amounts of data.

4. MATERIALS AND METHOD

The data for this study was picked up from the Terco Company, a Swedish company that operates a 136-kilometer overhead electrical transmission line. This transmission line's Terco prototype was used for the research; Table 1 shows the pertinent data. Figure 1 shows the transmission line prototype. A variety of fault scenarios were used to evaluate the multipurpose relay model. Terco (MV1420) T.L was included in the protection scheme design, and the MATLAB/Simulink were used for the implementation process.

Fig. 1. Transmission line model (MV1420)

Table 1. Transmission line characteristics of Terco-prototypes

Parameters	Terco company
Length of transmission line	136 km
Rating power	13MW
Rating voltage	220-240V three phase (corresponding to 77Kv)
Rating current	5A (corresponding to 100A)
Resistance of the line	1.5 ohms
Reactance of the line	3.15 ohms
Inductance of the line	10.03 mH
Capacitance to earth	4 μF
Mutual line capacitance between phase	8 μF

One of the most important reasons for using ANN is the speed of response, as well as the possibility of easily training the neural network to do what is required of it. The ANN is capable of learning and has the ability to generalize [14]. The most crucial aspect of this approach is its capacity to comprehend and grasp the behaviour of the model through extensive data training, producing acceptable and desired outputs. Consequently, a variety of issues can be detected using the ANNs method [15,16]. "nnstart" GUI matlab was used to train the suggested relay-based ANNs under various configurations by back-proogation algorithm. The amount of hidden neurons through the hidden layer was finally discovered by optimization method [17].

In this article two models for ANN are proposed one for detecting and classifying the faults, and the other model is for disconnecting the power grid. Figure 2a depicts the suggested proposed ANN's internal first structure which is responsible for detect and classifying the fault, it have three inputs (rms three phase line currents), 20 tansig hidden layer, and 11 output which represent the faults type (symmetrical and unsymmetrical faults) these signals are displayed on scope (0 normal case no fault or 1 abnormal case which represent fault). Figure 2b show the ANN second structure which is responsible for disconnect the electrical network immediately after sense any fault. This ANN structure has the same input for first structure, 10 sigmoid hidden layer, and one constant output (0 no fault or 1 represent all type of faults) , the output of this network is directly connected to main circuit breaker.

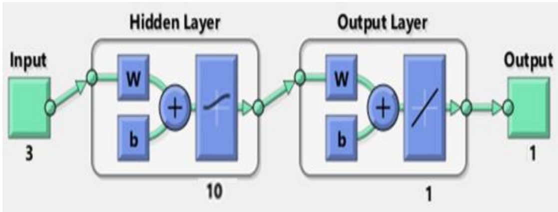

Fig. 2a. Suggested ANN's internal first structure

In order to train the ANNs, Many example pattern were taken from matlab simulated circuit tested under normal and faulty case (all transmission line symmetrical and unsymmetrical fault). Figure 3, show the matlab ANN's performance training state.

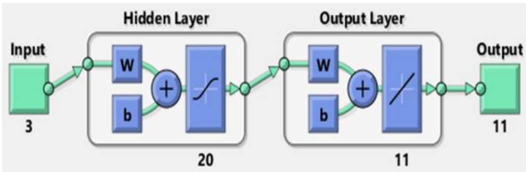

Fig. 2b. Suggested ANN's internal second structure

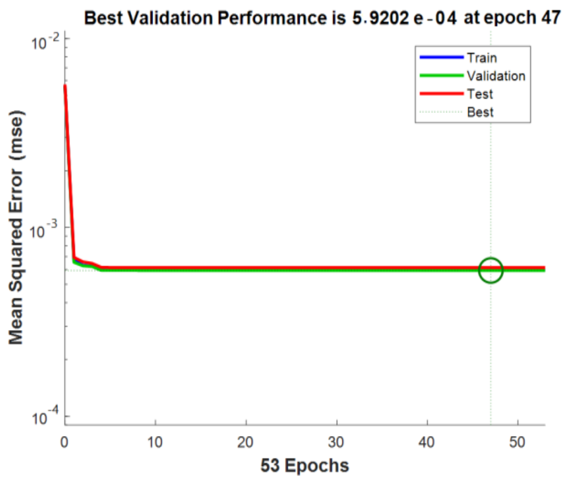

Fig. 3. Trained ANN performance state

6. SIMULINK MODEL

Figure 4 depicts the Matlab Simulink modelling circuit for the power 136-kilometre-long overhead electricity transmission line which was referred in paragraph 4 with two proposed model for ANNs, main circuit breaker and three phase fault block.

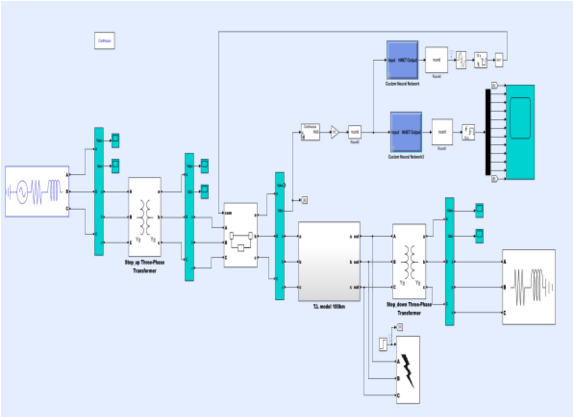

Fig. 4. Simulink model of the power system

7. RESULTS AND ANALYSIS

After training the two proposed model of ANNs in MATLAB, the trained network's Simulink model is generated. These models are used to put the neural network through its paces under all various symmetrical and unsymmetrical fault scenarios.

In order to note the power grid and classify the faults, as well as to ensure the correct operation and results of the proposed neural network, the results are displayed on scope screen in fig. (4) which show 12 signal. The first signal is describe the fault thats applied on the power grid ,0 mean normal (no fault) ,1 mean fault applied. The next other signals from 2-11 is show the fault type 0 mean no fault, 1 mean fault case. The last signal show the three phase line currents, which show normal currents before the fault, abnormal currents case through the fault and zero currents after disconnect the grid. In this article all types of faults were taken and tested.

Table (2) describe all the figures cases and results. In figure (5.a) single line to ground fault is applied on transmission line at 0.1msec, the fault is discover and classify by the first structure of ANN at 0.2msec, also the power grid is disconnected at 0.208msec by the second structure of ANN. Figure 5.b show the zoom of the last signal which illustrate the three phase line currents before, through the fault and after disconnect the network. Under typical conditions, the neural network output remains at 0 as specified in the target matrix, the neural network output is set to 1 until the fault is fixed after it forms at a particular time instant. Figure (6) and figure (7) illustrate the single line to ground fault (b-g), (c-g) respectively, Figure (8) to figure (10) illustrate the line-to-line fault on phase (a-b), (a-c) and (b-c) respectively. Figure (11) to figure (13) show the double line to ground fault (a-b-g), (a-c-g) and (b-c-g) respectively. Figure (14) display the triple line fault.

Table 2. Results description

Figure no	Fault type	Time of fault applied (sec)	Time of fault diagnostin (sec)	Time of disconnect the network (sec)
5-a	Single line to ground (a-g)	0.1	0.2	0.208
6	Single line to ground (b-g)	0.1	0.2	0.207
7	Single line to ground (c-g)	0.1	0.2	0.21
8	Line to Line (a-b)	0.1	0.2	0.205
9	Line to Line (a-c)	0.1	0.2	0.207
10	Line to Line (b-c)	0.1	0.2	0.207
11	Double line to ground (a-b-g)	0.1	0.2	0.206
12	Double line to ground (a-c-g)	0.1	0.2	0.208
13	Double line to ground (b-c-g)	0.1	0.2	0.207
14	Three line (a-b-c)	0.1	0.2	0.206

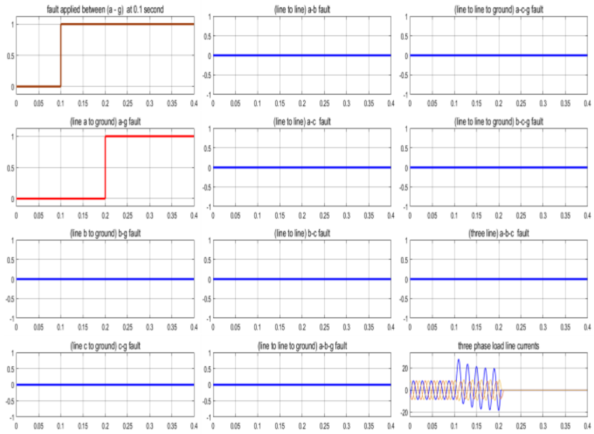

Fig. 5a. line to ground (a - g) fault

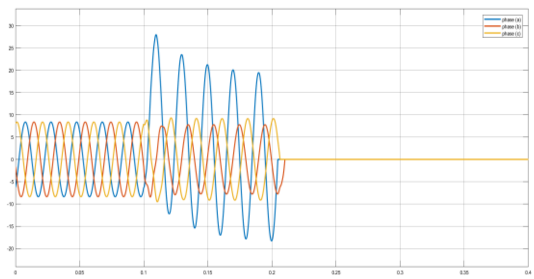

Fig. 5b. Zoom of three phase line currents when line to ground (a - g) fault is applied

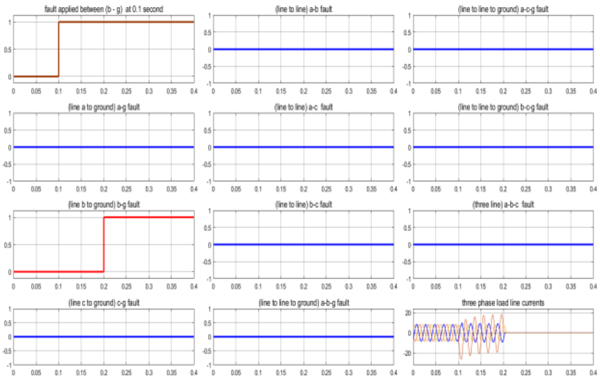

Fig. 6. line (b) to ground (g) fault

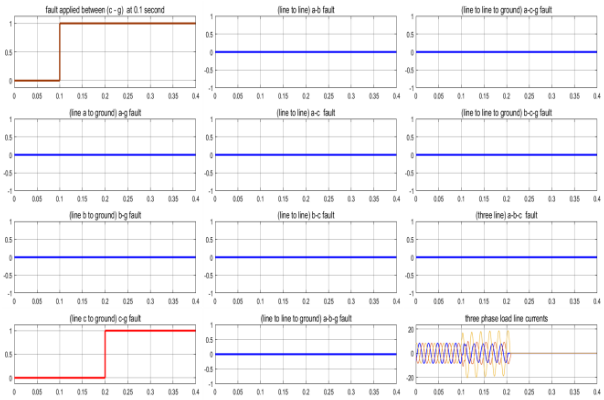

Fig. 7. line (c) to ground (g) fault

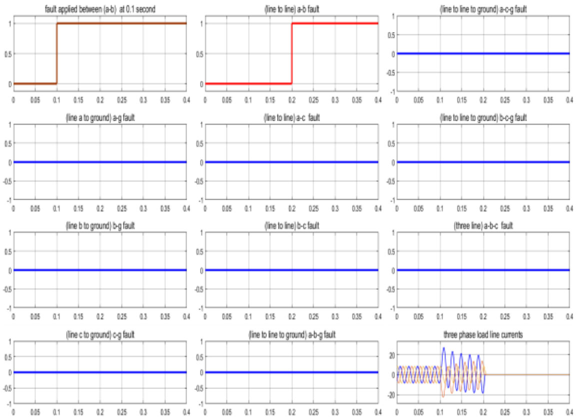

Fig. 8. line to line (a - b) fault

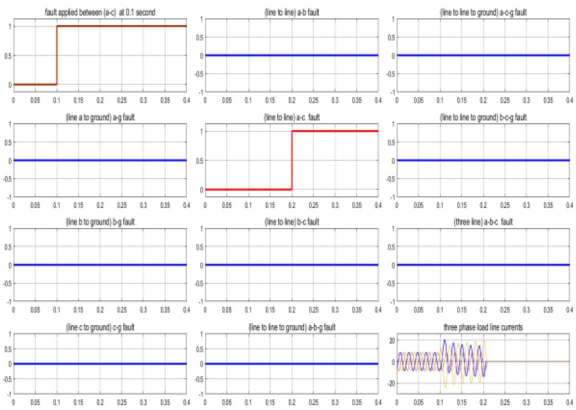

Fig. 9. line to line (a - c) fault

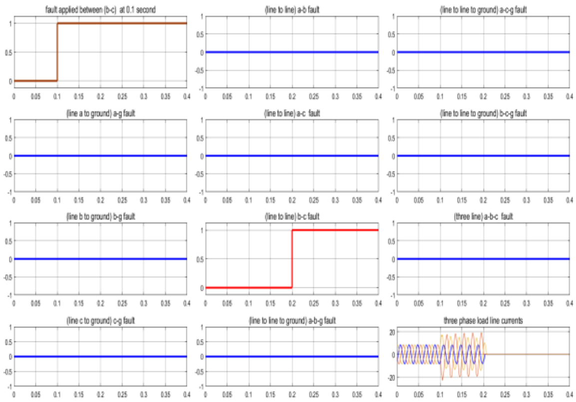

Fig. 10. line to line (b - c) fault

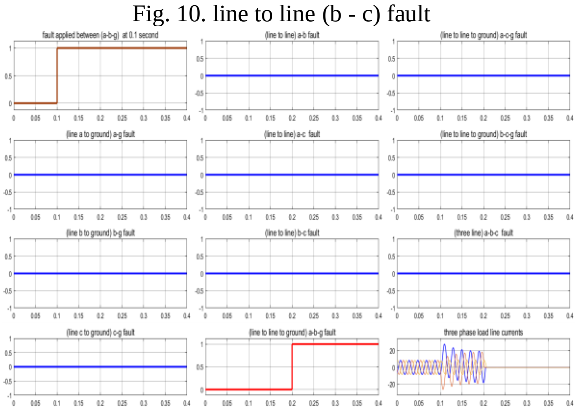

Fig. 11. line to line to ground (a-b-g) fault.

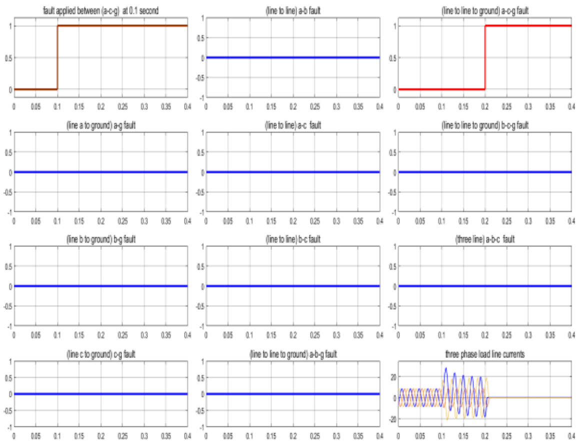

Fig. 12. line to line to ground (a-c-g) fault

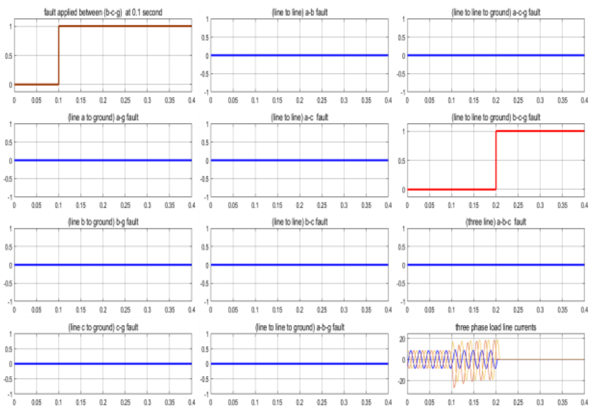

Fig. 13. line to line to ground (b-c-g) fault

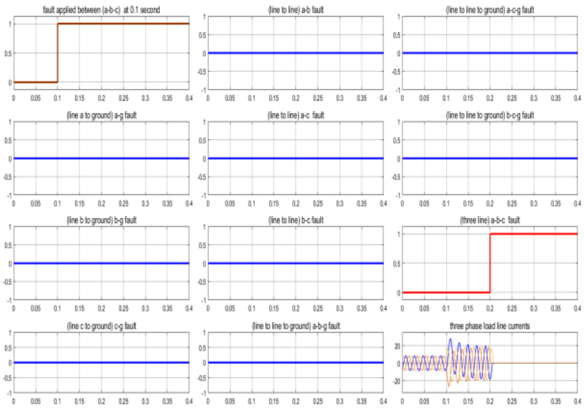

Fig. 14. three line (a-b-c) fault

8. CONCLUSION

In this article, the use of Artificial Neural Network (ANN) for the detection, identification of faults in power transmission lines (T.L) as well as disconnecting the grid power is studied. a data for 136-km transmission line laboratory (Terco-type) is used to simulate the T.L in Matlab Simulink . The results show that the ANN-based fault detection and identification systems have the ability to accurately and quickly detect faults, classify them, and locate them on the transmission line, as well as disconnect the power grid through the main three phase circuit breaker at once after detect any fault. The electricity network is protected by using ANN to monitor power transmission lines in those networks, in addition to using ANN to analyse it in real time for work, and this in turn leads us to no power outages. Another good advantage provided by the use of ANN in networks is electrical power transmission is the absence of manual inspection of the electrical networks, and it also reduces their maintenance costs very highly. In the future, the systems that rely in their operation will use ANN technology with high accuracy in identifying problems and errors that happen in the power T.L in the electrical networks. The method uses an ANN for fast and reliable fault detection. Encouraging results obtained in evaluating the performance of the proposed scheme. Neural network based analysis provides faster solutions without degrading accuracy.

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Ahmed G. ABDULLAH
Received the B.E.E. degree in Electrical power technique engineering in 2005, and the M.Sc. degree in power electronics and control in 2008, both from the Technical Engineering College of Mosul, Northern Technical University, Iraq. He is currently a Senior Lecturer in the same college. His research interests include power electronics converter control, PV systems, and Artificial intelligent.
Contact: ahmed.g.alhealy@ntu.edu.iq.

Mohammad A. IBRAHIM
Received bachelor's degree from the Northern Technical University 2005 in Electrical Engineering, master's degree from the Northern Technical University in (2011) in Electrical Power Technologies Engineering. Currently, he is working as a lecturer in the Electrical Power Engineering specializing, at Northern Technical University, Technical Engineering College of Mosul-Iraq.
Contact: mohammed.a.ibrahim1981@ntu.edu.iq.

Waseem Kh. IBRAHIM
Obtained his B.Sc. (2004) in Electrical Power Engineering Technology from Northern Technical University (NTU) and M.Sc. (2016) from Bahçeşehir University (BAU) Istanbul, Turkey, in Electrical and Electronic Engineering degree. Currently, he is working as assistant lecturer in the Electrical Engineering, specializing in Electrical Power Protection, in Northern Technical University (NTU)/ Technical College of Engineering, Mosul-Iraq.
Contact: waseem_kh82@ntu.edu.iq