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An Analysis of power system fault Classifier using neural network

***Abstract**. Fault is obviously a significant phenomenon for energy transmission in the distribution system because of the potentially harmful consequences that finally lead to economic crises. In order to verify their sustainability error experience, MATLAB and Simulink analyse the 3-phase power system in this article. An intelligent expert like a neural network may easily identify the defect that may have happened in the transmission line and categorize transmission issues on the power supply using artificial neural network (ANN). ANN is used to categories problems and generate a change status indication for the protection relay. This work proposes design strategies for fault recognition, classification, and isolation supported by state-of-the-art artificial intelligence and signal processing. Three-phase current and voltage from one end are taken as inputs in the proposed scheme. The Various simulations and signal analysis are performed in MATLAB environment.*

***Streszczenie.** Zwarcie jest oczywiście zjawiskiem istotnym dla przesyłu energii w systemie dystrybucyjnym ze względu na potencjalnie szkodliwe skutki, które ostatecznie prowadzą do kryzysów gospodarczych. Aby zweryfikować swoje doświadczenia związane z błędami w zakresie zrównoważonego rozwoju, MATLAB i Simulink analizują w tym artykule 3-fazowy system zasilania. Inteligentny ekspert, taki jak sieć neuronowa, może z łatwością zidentyfikować usterkę, która mogła wystąpić w linii przesyłowej i sklasyfikować problemy z transmisją w zasilaczu za pomocą sztucznej sieci neuronowej (ANN). SSN służy do kategoryzacji problemów i generowania wskazania stanu zmian dla przekaźnika zabezpieczeniowego. W pracy zaproponowano strategie projektowania rozpoznawania, klasyfikacji i izolacji uszkodzeń wspierane przez najnowocześniejszą sztuczną inteligencję i przetwarzanie sygnałów. W proponowanym schemacie jako dane wejściowe przyjmuje się prąd trójfazowy i napięcie z jednego końca. Różne symulacje i analiza sygnałów wykonywane są w środowisku* MATLAB. **(Analiza uszkodzeń systemu elektroenergetycznego. Klasyfikator wykorzystujący sieć neuronową**)

Keywords: Over current relay, Neural network, Fault classification, Artificial Neural Network, Fault location, Fault detection.
Słowa kluczowe: Przekaźnik nadprądowy, Sieć neuronowa, Klasyfikacja usterek, Sztuczna sieć neuronowa, Lokalizacja uszkodzeń.

Introduction

Power system protection and service recovery methods depend greatly on the ability to identify and locate faults. Effective fault isolation and protective relay operation are made possible by successful detection and location identification. Techniques for fault detection and location identification in distributed systems are extensively investigated. This paper uses over current relays to protect the electrical system and to identify fault locations and classify faults. In this paper, a defect detector, a classifier, and a fault location identifier are created using a neural network model [1].

Electrical system failures frequently result in major alterations to the system's parameters, including overcurrent, overload, or less, power factor, impedance, frequency, and the direction of the power source or current. Overcurrent protection is employed frequently since it is the most popular and the one that this thesis uses.

Protection relay is more than one preventive device that works after a fault occurs it helps minimizing the damage and prevent the power system. For the system to work properly, it is necessary to isolate the problem area fast with minimal system disruption [2]. Both operation error and improper operation can lead to major system disruption resulting in increased damage to equipment, increased risk to personnel and the potential for long-term service disruptions.

The power system relay algorithm typically starts with fault detection and moves on to classification in the second phase. Neural networks are employed in this study to categories and identify electrical system failure. This scheme's goal is to categories fault according to the following criteria:

1. Fault type
2. Fault Location

The classification of fault instances uses ten different fault kinds, such as a single three-phase fault error, a single L-G fault with three sets, three L-L faults, and three ground-line faults. The location of the fault is a crucial factor, particularly in high voltage power networks. Knowing where the fault is located makes it easier to quickly fix the problem and increases temporary stability. In the dissertation, a 10-kilometer transmission line is discussed for simulation purposes. Resistance is a crucial factor in repairing defects more quickly and restoring the power system to normal functioning.

Artificial Neural Networks (ANNs) can be applied to detect and classify errors. It works well because it is a programming technique that can quickly resolve nonlinear issues.

Issues where information is available and in large format can treated. In addition, ANNs can learn from experience. They are widely accepted and used in error detection and classifies defects due to the following characteristics [5]:

a) Several line designs are feasible due to the wide range of potential lengths, including short, long, single circuit, dual circuit, etc.
b) Several techniques exist for quickly and accurately simulating networks under various power system conditions.
c) The condition of the power system changes following each disruption. The neural network can therefore take into account dynamic changes in energy systems.
d) ANN output that, depending on the formation, is very quick, reliable, and accurate [6], as its operation is reliant on a variety of very simple procedures.

Fault and its classification

Under typical circumstances, all equipment performs in equilibrium with busbar voltages and normal load currents within predetermined ranges. A system flaw has the potential to interrupt this state. An issue that prevents current from flowing normally is called a fault in a circuit. When a system's insulation breaks, a low impedance channel between phases or from a phase to ground results, causing a short circuit. This results in an excessive amount of current flowing through the circuit, necessitating the adoption of a protective device to avoid equipment damage [3]. Figure 1 shows the different types of fault in power system.

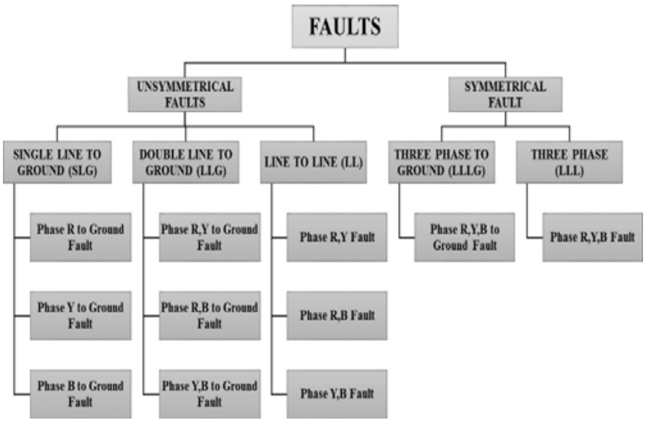

Fig. 1 Different power system faults

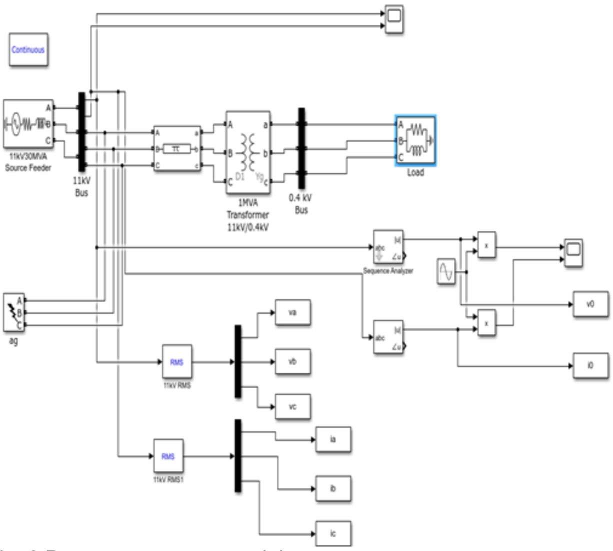

Fig. 2 Power system test model

A standard 11kV 30MVA three phase transmission line system with a three-phase parallel RLC load at one end was used as a test system for simulating, testing and deploying the proposed approach based on NNs. The system includes of an 11kv 30MVA source feeder coupled to an 11kV bus, which is connected to a 10km, three-phase pi transmission, which is connected to a 1MVA step down transformer. This setup enables the simulation and study of various problems at various locations along the transmission line. In order to obtain more precise results when utilizing the proposed technique on a very long transmission line, the line has been modelled using distributed type characteristics. The Sim Power Systems toolbox in Simulink in MATLAB is being used to simulate this power system model. Figure 2 displays a screen view of the model that was used to analyses and acquire the 360x8 training and test data sets.

The respective three phase voltage and current samples are measured at terminal A using the RMS V-I measurement block from the Sim Power System toolbox. The transmission line has a length of 10 km, and the model is used to simulate different fault types at various points along its length using varying fault resistance values [8]. For research purposes, 50 Hz is taken into consideration.

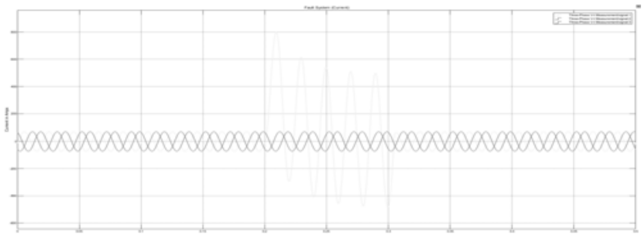

Fig. 3 Single L-G fault

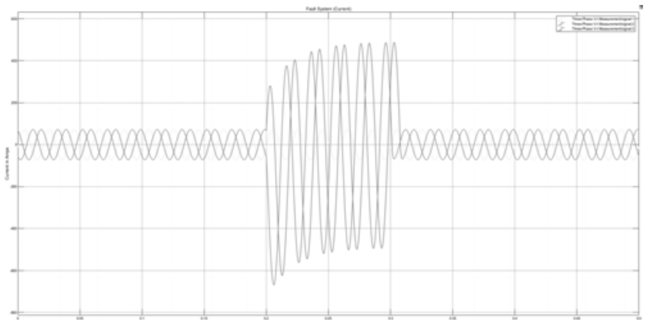

Fig. 4 L-L-G fault

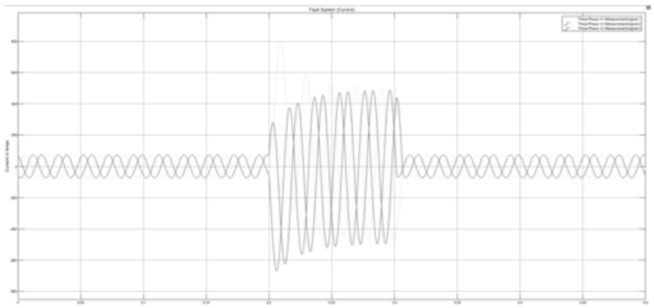

Fig. 5 Three phase fault

Fig. 6 Line-line fault

Table 1. Fault cases and its occurrence

Fault type	A	B	C	D
AG	1	0	0	1
BG	0	1	0	1
CG	0	0	1	1
ABG	1	1	0	1
BCG	0	1	1	1
ACG	1	0	1	1
AB	1	1	0	0
BC	0	1	1	0
AC	1	0	1	0
ABC	1	1	1	0
ABCG	1	1	1	1

Various faults have been created using the MATLAB/Simulink, three phase fault block like Single L-G fault, L-L-G fault, L-L fault, and three phase faults. Figures 3 to 6 depict the responses of the various faults. Table 1 shows the status of fault conditions in each phase

Modelling of overcurrent relay

It can rapidly develop protection relay algorithm program and protection relay model. Because they often exist in the same environment as far as interoperability is concerned, it is very easy to develop a handy graphical tool to build an interactive forward test system. One of the fantastic aspects of the Simulink package is the ease with which the produced model can be incorporated into a collection of blocks by only designing a subsystem for it. For the case of a complex system, this feature minimizes the utilization of space inside the file. Building several models is avoided because the created set of subsystem blocks can simply be copied and pasted into any area or file [9].

A. Modeling of relay

To model the RMS measurement an overcurrent relay and various switching elements are used and an integrator is also used to switch the operation of the overcurrent relay. Switch 1 is connected to the RMS measurement and switch 2 is connected to the integrator which will test the given overcurrent setting. 40 amps has been given as the maximum overcurrent setting in constant 1, if a fault occurs and the current automatically exceeds the overcurrent setting, the relay signals the breaker is open[7]. For signal generation, different switch boxes are used to open the circuit breaker

B. Working of relay

The current is sent to the block of the relay protection algorithm after being given its rms value. The trigger value and the current value are compared by this block. The relay tells the circuit breaker to open when the input current is greater than the trip value. For example under normal conditions if the measured RMS current is not more than 40 amps and the state of switch 1 is false then the output of switch 1 will be "0" and the integrator output will also be " 0". integrator output is compared with switch 2 and when known to be false switch 2 is made to give output "1" so condition is false the output will be "1" so. The circuit breaker remains closed and there will be no interruption of the current in the circuit. This is an operation under normal conditions. When a three-phase earth fault occurs, the measured RMS current will be greater than the overcurrent setting and the same current flows through switch 1 as long as the condition is true. After that, integration begins, which can take some time to reach value. Switches. Once the process is complete, the integrator has been reset to its original position.

C. Final model

The designed relay is made up of a three subsystem. The three-phase current I_a I_b I_c is then measured and each is fed to a separately modeled overcurrent relay to check for any fault currents, then the output is passed to the AND logic gate for Given the set output based on the final output, the overcurrent relay sends the signal to the circuit breaker.so the final relay system is shown in figure.7.

The electrical system is constructed using the Simulink environment with the addition of other components. We utilised the Simulink three-phase fault block library to simulate error. Circuit breakers and other components are built-in. additionally, the relay is called from the library. The aforementioned artificial neural network is used to detect categorization problems and provide information to controllers after being trained with the data from the cases below. [8]. The controller is set up to separate the generator head from the load in a manner similar to the Simulink model. The final fault location steps are shown in figure.8.The training data of AG,BG,CG,AB,AC,BC,ABG,ACG,BCG,ABC is shown in figure.9.

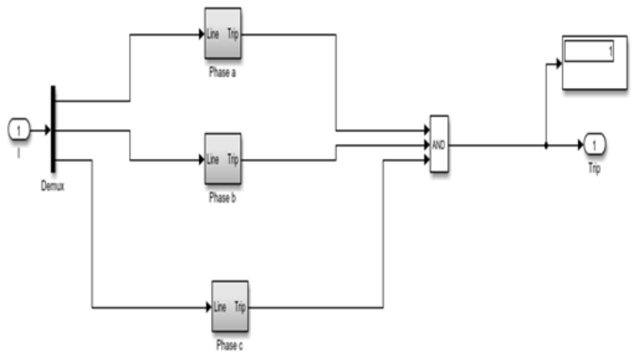

Fig. 7 Final model of overcurrent relay

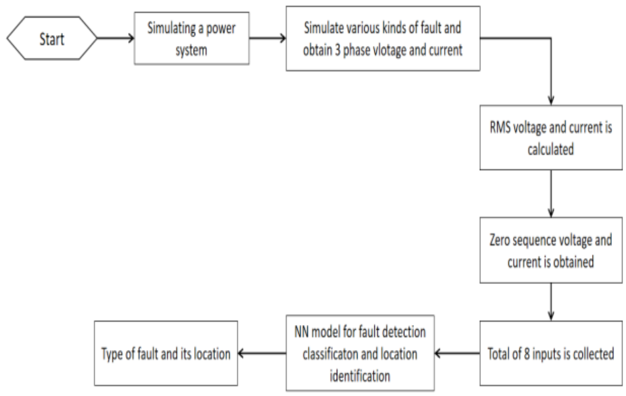

Fig. 8 Work flow of the Neural Network model

	1	2	3	4	5
1	0	0	0	0	10
2	1	0	0	1	10
3	0	1	0	1	10
4	0	0	1	1	10
5	1	1	0	1	10
6	1	0	1	1	10
7	0	1	1	1	10
8	1	1	1	1	10
9	1	1	1	0	10
10	1	1	0	0	10

Fig. 9 Training data

The first four column of the t data are used to classify the fault and the last column is used to find the location of the fault shown in figure.10.

	1	2	3	4	5	6	7	8
1	230.8386	230.8387	230.8386	6.1551	6.1891	6.1393	3.7414e-10	1.3309e-09
2	271.1486	255.4023	0.2046	465.4920	469.6581	483.0900	161.6352	564.4925
3	255.3843	0.2045	271.1460	421.0507	430.2828	415.5452	161.6205	573.3439
4	0.2042	271.1308	255.3981	423.5756	408.9997	414.1168	161.6192	555.5923
5	276.0544	0.1536	0.2602	324.9913	338.7039	325.9748	130.0649	448.7110
6	0.2588	276.0552	0.1527	322.6821	330.0398	351.7152	130.0653	460.2452
7	0.1519	0.2596	276.0588	374.0756	354.4981	356.8937	130.0669	454.8121
8	0.2141	0.2157	0.2154	22.5208	22.8477	29.4180	2.1731e-11	2.1737e-11
9	0.2141	0.2157	0.2154	22.5208	22.8477	29.4180	2.1424e-10	5.8599e-10
10	230.8394	115.2355	115.6034	1.6445	24.6747	24.1835	0.0011	0.0040

Fig. 10 xdata

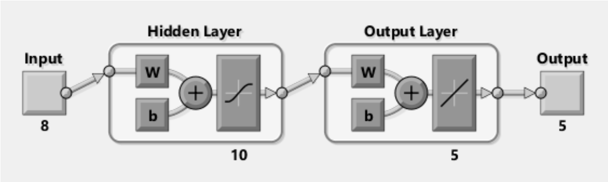

Fig. 11 Developed Neural Network model

The neural network is trained using the first segment of the data set, referred to as the training dataset and displayed in Fig. 11, by computing the slope and updating the network weights. Until a specific fault number causes the network to converge [9]. The network uses this validation and validation dataset throughout training [10] (it is merely utilized as input data without defining output value), and validation mistakes for the entire validation set are monitored during training to treat [11]. As a result, the first portion of the fixed date is known. The performance of the ANN model in MATLAB's Simulink is shown in Figure 6. The data is used in three ways by the MATLAB Simulink toolbox for the neural network [12].

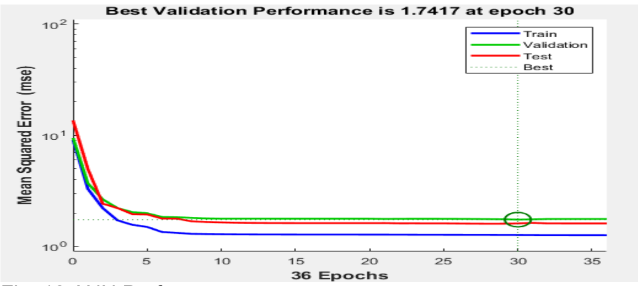

Fig. 12 ANN Performance

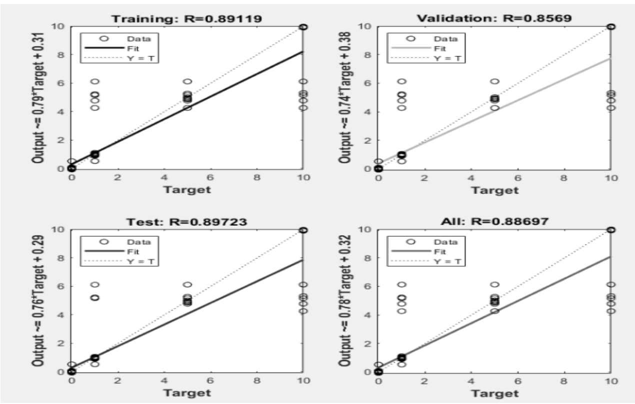

Fig. 13 Regression fit of the output vs the targets for the network

Result

Figure 8 shows the result of neural network in a power system model. A fault AB is generated in the power system using three phase fault.

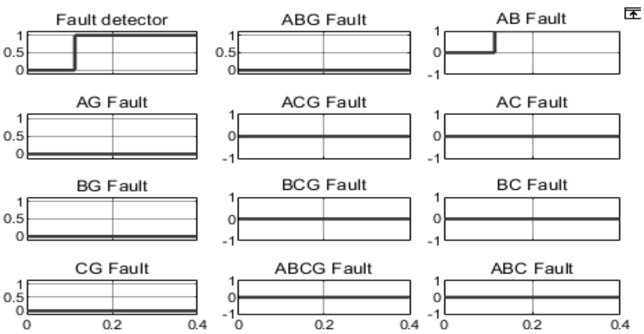

Fig. 14 Fault result

Fig. 15 Fault Location Graph

From Figure15 shows the fault occurring location at 5th km of the distribution system. The display shows the accurate location of the fault in power system model.

Table 2. Fault cases in training and testing purpose

Parameters	Training data	Testing data
Fault type	LG(AG,BG,CG)LLG(ABG,BCG, ACG),LL(AB,BC,CA), LLL(ABC)	LG (AG, BG, CG), LLG (ABG, BCG, ACG), LL (AB, BC, CA), LLL (ABC)
Fault location	(1,5,10) Total location=3	Different fault location between 1-10 km
Fault resistance	0.1,10,104 Total fault cases =360	0.1,10,100 Total fault cases =60

Table.2 shows the training and testing data of the various fault cases with respect to fault location and fault resistance.

Table 3. Response for LL, LLL, LG, LLG faults

Fault Type	Fault Resistance	Fault Location	A	B	C	G
AG	10	1	1	0	0	1
BG	0.1	5	0	1	0	1
CG	10	10	0	0	1	1
ABG	0.1	5	1	1	0	1
BCG	100	10	0	1	1	1
ACG	100	1	1	0	1	1
AB	10	5	1	1	0	0
BC	0.1	1	0	1	1	0
AC	10	10	1	0	1	0
ABC	0.1	10	1	1	1	0
ABCG	100	5	1	1	1	1

Table.3 shows the testing cases of the various fault cases with respect to fault location and fault resistance.

Conclusion and Future Scope

This paper suggests fault detection and classification based on neural network, part recognition (direction distinction), default Faulty phase selection and classification scheme which takes into account the basic elements of 3 phase voltage and current signal as input. By adjusting various parameters, the suggested neural network-based methodology has been evaluated with several fault scenarios. The test results demonstrate that the suggested relay programmes can offer both main and backup protection. The suggested neural network-based approach will be effective. The proposed technique is a prospective candidate for an efficient protection mechanism since, according to the results of an exhaustive study, it is capable of reliably defending the transmission line against a range of fault scenarios. Furthermore, when tested with real-time fault events, the suggested scheme successfully pinpoints the problematic part and its direction. As a result, it can also be used to defend the networks of actual power systems.

Following are some significant inferences that may be made from the study: Neural Networks are an Effective and Reliable Power Supply Method classify and locate system line faults, taking into account the contemporary power transmission systems increased dynamic connection, Prior to choosing a neural network for a real application, its performance, distinct neural network topology, and learning methodology should all be carefully taken into account then gets accurate results. The propagation network was chosen for the suggested strategy because it functions effectively when trained with a sizable training data set that is available in the power system. The scope of ANN's applications justifies more research. By creating proper intelligent algorithms, fault detection and categorization can become intelligent by nature. If we have computers with fast computation speeds and data processing capabilities, it can accomplish this.

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