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A Comparative Study of Symmetrical Method and Artificial Neural Network in Faults Detection in Power Transmission Lines

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Abstract:- The most challenges to electrical power system supply is mainly faults in transmission line and there is need for quick faults isolation in order to remove damages as a result of power outage. This paper compared together the two methods of symmetrical component method of (1) and artificial neural network method of (11) to determine their effectiveness. The two methods were subjected to simpower system,under normal and fault conditions using Akure – Ikeji Arakeji – Ilesha transmission line . Three phases were used, single line, double line, and line to line, all to the qround faults.In symmetrical component, faults in both the currents and impedance were detected, also in the artificial neural network both the faulty voltages and currents were detected. The comparison between the two methods show that the symmetrical component method, needs computation of faults in the impedance, this does not have genuine application for isolation of faults compared to artificial neural network method which has fault isolation application but no impedance calculation and have datathat gives correct results as quickly as possible. Also this method is very fast, effective and simple. Therefore, the artificial neural method is better because of it is simplicity and accuracy than the symmetrical component method.

I. INTRODUCTION

To make power transmission lines work effectively, there is need to detect and separate the faults which can cause damages and power outage and probably disallow the smooth flow of currents. For easy detection of electrical faults in the transmission line, it is necessary that a transmission line must have a well-protected detection system that has sensor and alarm that can quickly sense and alarm the faults for rectification so that the electrical power can be restored to the affected areas where the faults occurred (10) (11). According to (10), there are many factors contributed to the ineffectiveness of the transmission line system and these factors are collision of motor vehicles on the poles of the transmission lines, vandalization of the transmission lines, short circuiting cause by bridging of the lines when trees fall on them, and over loading. In addition, the single phase to ground, phase to phase and three phase to ground faults are common faults on transmission line (15). A fault is sensed on the transmission line when the normal free flow of current is disturbed and the intensity of the current drastically reduced and this can also be caused as a result of reduction in the insulation strength of the phase conductors surrounding the conductors (1). It is crystal obvious that any moment a fault occurs in the power system, both current and voltages will develop a transient dc component, high frequency transient component that compliment power frequency component. All these components will result to an increase in the faults of both voltages and currents and the system conditions, therefore, the insulation breakdown results to damage and short circuit current in the system (6). The reduction in the strength of the insulation is as a result of the excess current and transient in the impedances between the conductors and the earth. According to (7) and (8) , intelligent detection power system has been in used for past years and now and these are the artificial neural network system (ANNS) and the other non-intelligent detection power system is symmetrical component techniques (SCT). These two systems have been applied to several power system protection and operation for decade. In this paper, symmetrical components system and artificial neural network technique will be compared to know the most effective one. Among the whole faults that occurs in a complete power system, majority of faults occur on the transmission lines, because the transmission lines are branched over the places, longer length, expose to variable weather conditions and atmospheric disturbances (4) (6). To avoid uninterrupted power system supply, faults on the transmission lines must be detected and rectify to make the power system supply stable and steady to the end-users.

II. METHODOLOGY

Symmetrical components as used by (1) and artificial neural network method as used by (11) compared together to identify most effective method. Both methods were applied to the simpower system, used Akure-Ikeji Arakeji-Ilesha transmission line with faulty condition and normal condition. Three phases of line - line, line - ground and double line to ground faults were considered for fault conditions as used by (3). Using symmetrical component technique, currents, voltages and impedance faults were obtained as detected and classified faults. Also, when artificial neural network was applied, the voltages and currents for normal and faulty conditions were used for inputs of the selected network systems.

III. RESULTS AND DISCUSSION

Three phase voltages and currents value that corresponds to different categories of faults that obtained from the simpower system modeled Akure- Ikeji Arakeji-Ilesha transmission line are shown in table 1.

No	Phase Voltages			Phase Currents			Faults
1	**V(v1)**	**V(v2)**	**V(v3)**	**I1(A)**	**I2(A)**	**I3(A)**	**Faults**
2	**0.6500**	**0.6500**	**0.6500**	**0.2000**	**0.2000**	**0.2000**	**Nil**
3	**0.5000**	**0.5400**	**0.5100**	**0.1620**	**0.1350**	**0.1420**	**1 – g**
4	**0.4400**	**0.4200**	**0.4300**	**0.1500**	**0.1410**	**0.1200**	**2 – g**
5	**0.4100**	**0.4000**	**0.3900**	**0.1420**	**0.1300**	**0.1200**	**3 – g**
6	**0.4900**	**0.4600**	**0.1500**	**0.1250**	**0.1150**	**0.1200**	**1 – 2**
7	**0.4800**	**0.5200**	**0.4700**	**0.1380**	**0.1280**	**0.1100**	**2 – 3**
8	**0.4300**	**0.4500**	**0.4150**	**0.1200**	**0.1180**	**0.0950**	**3 – 1**
9	**0.4400**	**0.4200**	**0.4100**	**0.1500**	**0.1450**	**0.1350**	**1 – 2 – g**
10	**0.3900**	**0.3600**	**0.3200**	**0.1380**	**0.1250**	**0.1050**	**2 – 3 – g**
11	**0.3500**	**0.3200**	**0.3100**	**0.1100**	**0.1080**	**0.0850**	**3 – 1 – g**
12	**0.3600**	**0.3400**	**0.3200**	**0.1200**	**0.1050**	**0.0920**	**1 – 2 - 3**

Table 1: Phase voltages and Phase currents of the transmission line values.

Phase 1=1, phase 2=2, phase 3=3, ground= g. (4)

If the impedance fault is less than the impedance setting of the impedance relay, the relay will send tripping signal to the circuit breaker to isolate the fault section (1)

IV. SYMMETRICAL COMPONENT METHOD

Figure 1 shows the three phase 1,2,3diagram of the transmission line as described below.

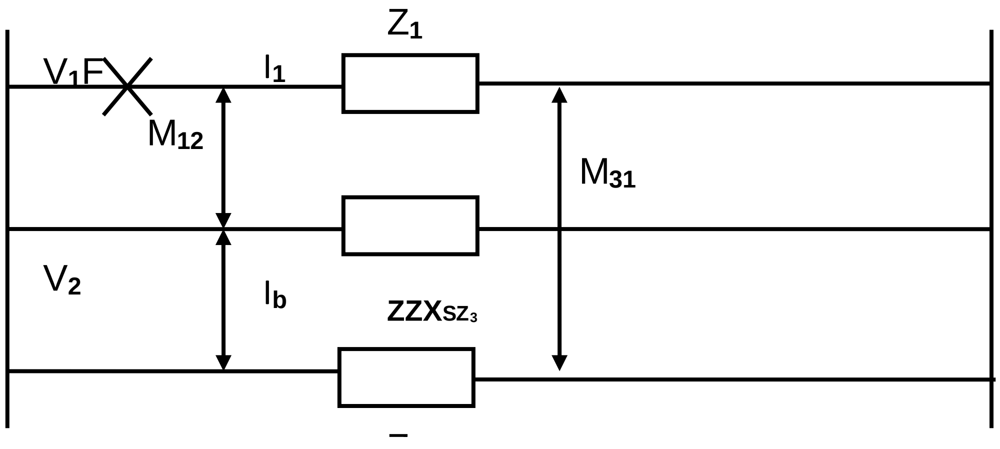

Fig. 1: Three-phase model of transmission line(1)

$I = I_1 + I_2 + I_3$
Z_1 = Positive impedance

Z_2 = Negative impedance
Z_0 = Zero impedance

For a fault transmission line, the positive and negative impedance are equal tozero impedanceand is connected to neutral ground.

The model of power system transmission line uses

$Z_1 = Z_2 = Z_3$

The positive impedance Z_1, is the impedance relay , and is used for the protection system.

$Z_1 = 0.0919$pu

$Z_2 = 0.1234$pu

When fault occurs on the transmission line, the positive impedance on the line will be shown by relay as faulty impedance and this will be displayed by its impedance setting. If it is less, this will send signal to the circuit breaker to identify and separate the faulty area. If it is greater or equal, the system will continue and no signal will be sent.

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Considering the inductances and the resistances on the line (L_1, L_2 and L_3).

Positive and zero resistances and inductances are given as

L_1	=	0.6330pu	R_1=5.420ΩΩ
L_0	=	1.8867pu	R_0=6.123Ω
L_1	=	0.9956pu	R_1=25.260Ω
L_2	=	0.9919pu	R_2=18.340Ω
L_3	=	0.9956pu	R_3=17.012Ω
L_{12}	=	0.4746pu	R_{12}=15.507Ω
L_{23}	=	0.4746pu	R_{23}=14.316Ω
L_{13}	=	0.3891pu	R_{13}=13. 901Ω

Self- reactance
X_{Sa} = 2.1549H
X_{sa} = 2.1469H
X_{sb} = 2.1549H

Total self- reactance on the positive impedance is
X_s = X_{sa} + X_{sb} = 2.1469 + 2.1549
= 5.3018H

Total self- resistance
R_S = $R_1 + R_2 + R_3$
= 25.260+18.340+17.012
= 60.612Ω

The Symmetrical mutual impedance is given as Zs**m**
Z_{Sm1} = 0.3527
Z_{SM2} = 0.3534
Z_{sM3} = 0.3444

The voltages, currents and impedance values as calculated for the three phase using symmetrical component technique does not have an application for identification of the faulted areas on the transmission line. It can only show the classifications of fault and its parameters.. This technique is not effective and accurate in detecting faults as one expected.

In the artificial neural network (ANN) method, table 1 show the values of the phase voltages and currents generated from power system block set using simpered system Akure-Ikeji Arakeji- Ilesha transmission line model. These are the input values of the selected ANN for each stage of the fault detection. The collected values are the expected output using ANN for fault detection.

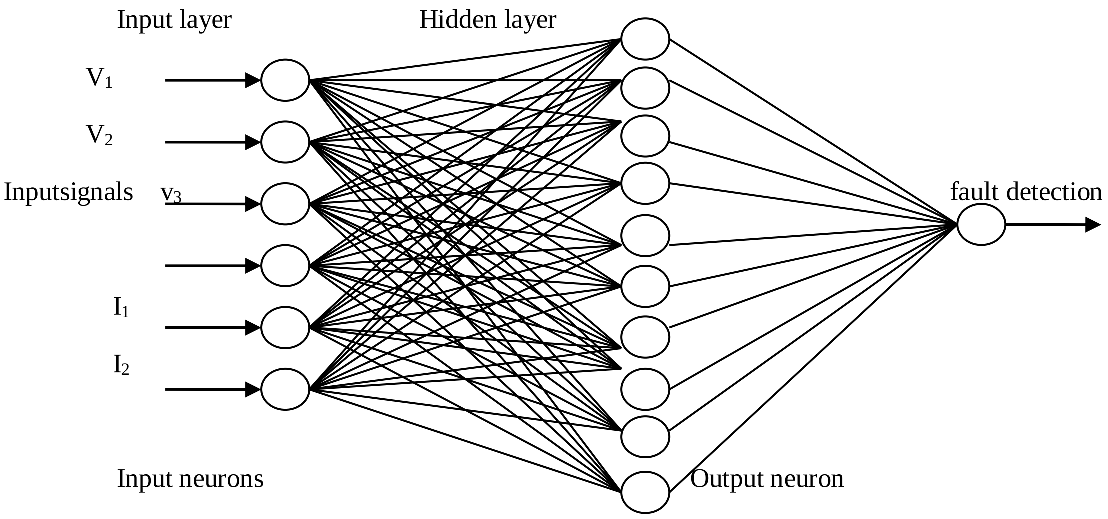

Fig. 1: BP neural network for fault detection in the power system transmission line (9).

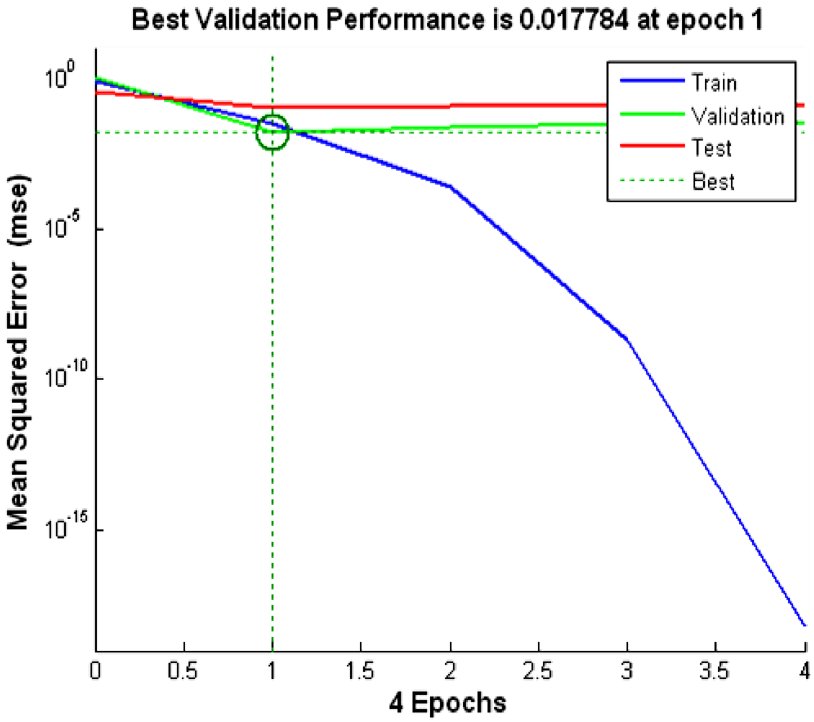

Fig. 2: Performance graph for faults detection

The neural network performance of figure 2 show that since the network output and collected values converged and produced error that is almost zero and was able to classify correctly both the normal and faulty conditions, this signifies that the detection of fault on the transmission line were perfect and successful.

No	Action	Faults regression	%
Detection	0.01650	0.6725	92.02
Classification	0.03705	-	68.50
Isolation	0.01120	0.43348	82.21

Table 2: Results of Artificial neural network fault diagnosis

The Comparison between the Symmetrical Component method and Artificial Neural Network Method.

The symmetrical component technique needs the calculation of the fault impedance and the fault diagnosis but the calculation must come before the fault diagnosis. This involves large calculations of fault parameters that gives room to inaccurate results as a result of numerous errors created. Symmetrical component method has no application for fault isolation while the artificial neural network does not require the calculation of fault impedance but the values of voltage and current are needed. In short time, ANN can assess large data, process it and give very accurate result, therefore, compared to the symmetrical component techniques, it is very fast, simple and easy to understand.

V. CONCLUSION

This work showed that the ANN method can easily be applied in power system transmission line to obtain the faulty conditions which can be implemented for the protection of the transmission line system. It is very simple, easy to understand, fast and very accurate in the determination and analysis of faults in the power system transmission lines compared to the symmetrical component method. Therefore, artificial neural network method is very effective and the best method.

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