DOUBLE CIRCUIT TRANSMISSION LINE PROTECTION USING LINE TRAP & ARTIFICIAL NEURAL NETWORK MATLAB APPROACH

Abhilash G. Phiske[1], Alok Ranjan[2]

[1]PG Scholar, Department of Electrical Engineering, Wainganga College of Engineering and Management , Nagpur
[2]Assistant Professor, Department of Electrical Engineering, Wainganga College of Engineering and Management , Nagpur

---

Abstract - *The protection of double circuit transmission lines could be a difficult task. This paper presents a protection technique supported the high-frequency transients generated by the fault to hide nearly the entire length of double circuit line.*

For this purpose, befittingly designed line traps area unit put in at terminals of the protected line, and therefore the Artificial Neural Network with appropriate range of Neurons is employed to classify the faults supported the frequency spectrum of the RMS current and RMS voltage signals. In depth simulation studies indicate that the projected approach is well capable of discriminating differing types of faults and provides a really quick, secure, and reliable protection technique. The simulation model done in MATLAB simulink for system analysis. In this model 300 km, 25 KV, 50Hz transmission line power system model design with three zone bus bar system. One end bus bar data measurement utilized for three phase RMS voltage and current measurement. Also Neural Network training done for designed power system model using MATLAB Simulink.

Key Words: Line trap, ANN, RMS, fault classification, zone protection.

1. INTRODUCTION

An overhead conductor is exposed to the surroundings and therefore the chance of experiencing faults on the conductor is usually more than alternative main parts. Once a fault happens on a conductor, it's vital to find it and notice its zone so as to create necessary repairs and to revive power as shortly as doable. Distance relaying has been wide used for the protection of transmission lines. A distance relay must perform the twin task of primary and back-up protection. The first protection ought to be quick and with none intentional time delay. Back-up protection ought to operate if and on condition that corresponding primary relay fails. Distance relays area unit given multiple zones of protection to satisfy the demanding property and sensitivity needs. Zone one provides the quickest protection with no intentional time delay; the in operation time are often of the order of 1 cycle.

It is set to cover major portion of the line length owing to the problem in identifying between faults that square measure near remote bus. Zone two protections are delayed by co-ordination measure. Zone two is ready to shield primary line and additionally provides secondary protection to half portion of the adjacent line with 0.25–0.4 s delay. Setting of zone three is ready to hide complete primary and adjacent line and up to quarter line additionally with further delay. However, numerous conditions like remote in-feed currents, fault-path resistance and shunt capacitance degrades the performance of distance relays [1]. The present differential protection theme has been with success applied to shield the complete line. However, the relay settings square measure tough to come to a decision as a result of line-charging currents and unobvious current variation throughout high resistance faults. Any composite voltage and current measurements were accustomed improve relay sensitivity [2]. For quick fault clearance to enhance system stability, the relaying schemes supported traveling wave square measure planned [3, 4]. However, the techniques square measure tough to discover close-in and zero voltage faults. Numerous quite protection schemes for transmission lines are planned within the past for fault detection and classification (phase selection) and distance location [5–12]. However, these techniques estimate the direction of fault and its zone.

2. MATLAB SIMULATION MODEL

This project implementation will be done using MATLAB Simulink software. The major blocks will be design in MATLAB Simulink as follows:

- Simulation of transmission line using distributed parameter transmission line.
- Simulation of wavelet signal analysis block using wavelet toolbox.
- Simulation of complete double circuit based power system components using sim power system toolbox.
- Simulation of various transmission line faults and unbalance load condition for analysis of design protection scheme.
- Design of neural network for fault classification using neural network toolbox.

- Training of neural network for various simulated fault condition using neural network toolbox.

2.1. Main power system model

Figure 1 shows the complete MATLAB simulation model of 25 KV, 60 Hz transmission line having three zone separated by bus bar.

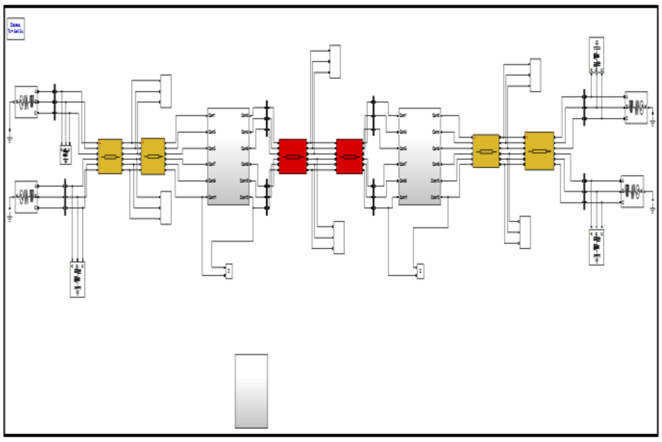

Fig -1: MATLAB simulation model of zone 1 of main power system

The main power system model divided into three zone having 120, 80 and 60 km of length. Figure 2 shows the zone 2 of main power system model in which two generator of 25KV, 100MVA fed transmission line system. Also transmission line provided with three phase RLC load.

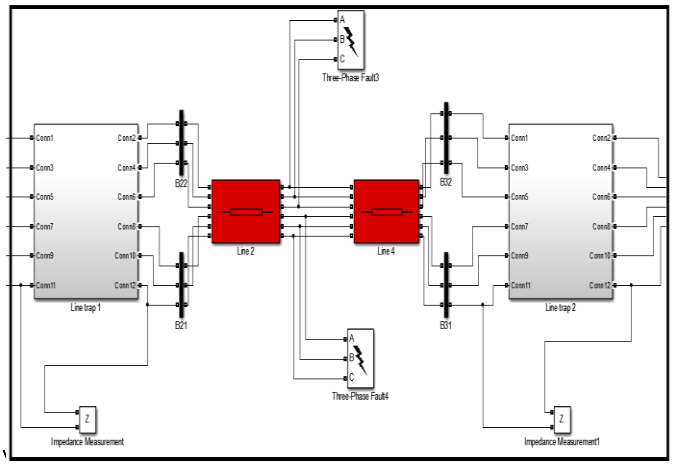

Fig -2: MATLAB simulation model of zone 2 of main power system.

Zone 2 of power system model consist of transmission line model of 80km length and at each end of line trap installed for high transient based protection of line. For impedance measurement of line trap, impedance measurement block connected across line trap. That block analyzed the impedance of line for different power system frequency and career frequency shown in figure 3.

Table -1: MATLAB Simulink parameter specification of power system

S.N.	MATLAB simulation block	Parameter specification of MATLAB block
1	Three-phase source 1,2,3,4	Phase to phase RMS voltage= 25 KV; Frequency = 50 Hz; Internal winding connection = start with neutral grounding; Three phase short circuit level at base voltage = 100 MVA; Base voltage = 25KV; X/R ratio = 2.
2	Three phase RLC load 1,2,3,4	Nominal phase to phase voltage = 11 KV; Nominal frequency = 50 Hz; Active power = 10 KW; Inductive reactive power = 10 KVAr; Capacitive reactive power = 100 VAr; Star connected load open grounded
3	Double circuit line 1,2,3,4,5,6	Number of phases = 6; Frequency used for RLC specification = 50 Hz; Positive sequence resistance per unit length = 0.068 Ohm/Km; Zero sequence resistance per unit length = 0.284 Ohms/km; Positive sequence inductance per unit length = 1.31 mH/Km; Zero sequence inductance per unit length = 4.02 mH/Km; Positive sequence capacitance per unit length = 8.85nF/Km; Zero sequence capacitance per unit length = 6.21 nF/Km; Line length depend on zone. Zone 1 (Line 1,2,) = 120Km; Zone 2 (line 3,4) = 80 Km; Zone 3 (Line 5,6) = 60Km.
4	Three phase fault	Fault types = LG, LL, LLG, LLL (AG, BG, CG, ABG, BCG, ACG, AB, BC, AC, ABC); Fault resistance = 0.001 Ohm; Transition time: Fault start time 0.4 sec and fault end time 0.6 sec; Snubber resistance = 1 MOhm.
5	Line trap subsystem	R1=0.5 Ohm; L1= 2 mH; R2= 50 Ohm; C2= 5nF; C1= 50

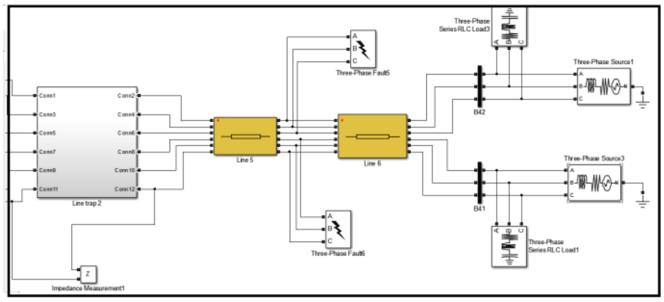

Fig -3: MATLAB simulation model of zone 3 of main power system

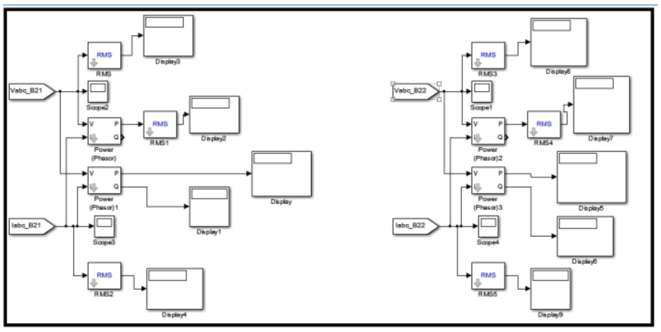

Fig -4: Bus bar 2 measurement subsystem

Figure 4 shows the bus bar parameter measurement subsystem, in which three phase RMS voltage of six phase of line and three phase RMS current of line. That subsystem measured the six phase voltage and current at normal condition and abnormal fault condition for generation of training data set for neural network training.

2.2. Neural Network subsystem

In this proposed approach Neural network use as classifier for fault type classification and fault zone identification. The data set for training neural network are six phase rms voltage and current utilized for training neural network. After training neural network, neural network block coupled with measurement subsystem for classification. Figure 5 shows the neural network system coupled with bus bar measurement subsystem. In future if any fault condition occurs then that time measurement subsystem send measure value to ANN input then ANN classify the fault type and fault zone based on training data set.

Figure 6 shows the simulation block of ANN1 for transmission line fault type classification. The inputs for ANN1 are six phase transmission line RMS voltage and RMS current. Based on input ANN1 generates the output based on training data set.

Figure 7 shows the internal configuration of layer 1 of ANN1 in which total 10 number of neurons with weights and bias value shown. The weight value updated based on input training data set for generation of target value which also decided by designer. All 10 neurons consist of activation function or transfer function which coupled using multiplexer for generation of single decision based on training data set.

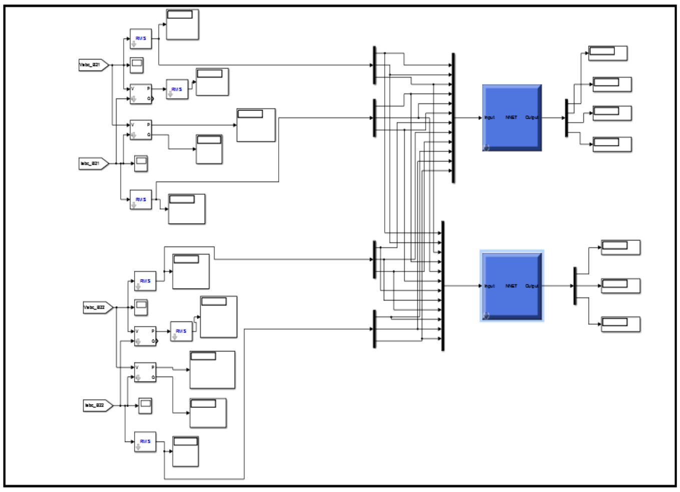

Fig -5: Measurement subsystem coupled with ANN for fault type classification and fault zone identification

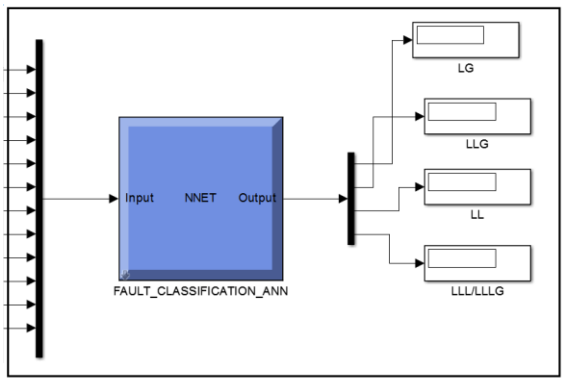

Fig -6: ANN model for Fault type classification

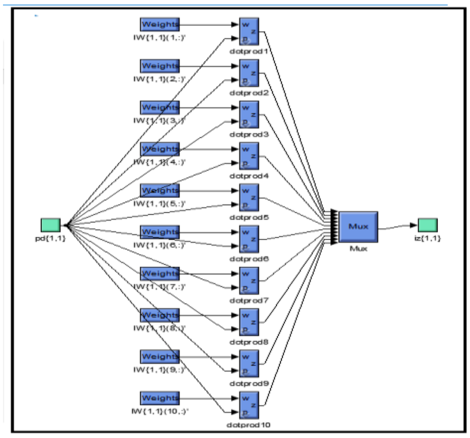

Fig -7: Architecture of layer 1 of ANN for fault type classification shows weights with value

3. MATLAB SIMULATION RESULTS

3.1. Result from line trap

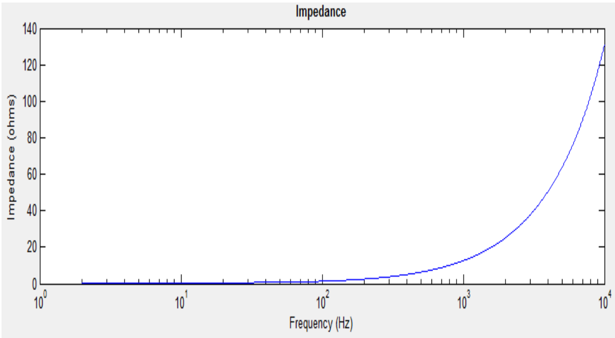

Fig -8: Impedance of line trap at high frequency transients

The main function of the line trap is to present high impedance at the carrier frequency band while presenting negligible impedance at the power system frequency. The high impedance is required to reduce the carrier signal attenuation due to the division among the several transmission lines terminated at the same bus.

Figure 8 shows that line trap is present high impedance at the carrier frequency of 100 kHz while presenting negligible impedance at the power supply frequency 50 Hz.

3.2. Power system voltage and current

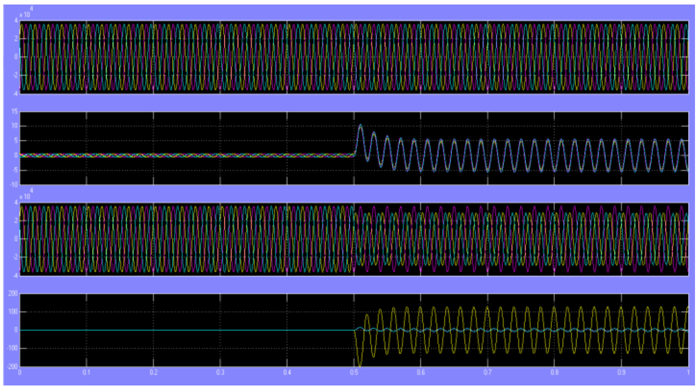

Fig-9: Six phase RMS voltage and RMS current waveform when LG (AG) fault takes place on line at 100km in zone 1 from reference bus bar B22

Figure 9 shows the six phase transmission line voltages and current waveform when LG fault takes place on line at 100km in zone 1 from reference bus bar 2. First and third waveform shows the three phase voltage Vabc and Va'b'c' while second and third waveform shows the three phase current of double circuit line Iabc and Ia'b'c' respectively.

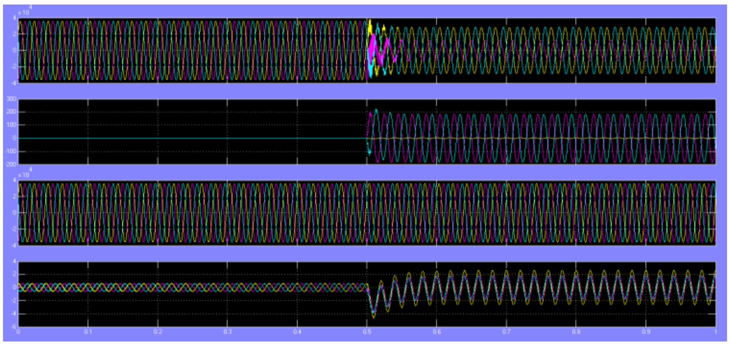

Fig-10: Six phase RMS voltage and RMS current waveform when LLG (B'C'G) fault takes place on line at 80 km in zone 1 from reference bus bar B22.

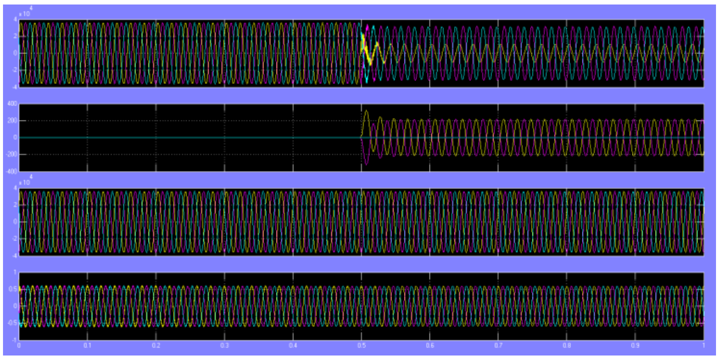

Fig-11: Six phase RMS voltage and RMS current waveform when LL (AB) fault takes place on line at 60 km in zone 2 from reference bus bar B22.

3.3. Result from Neural Network

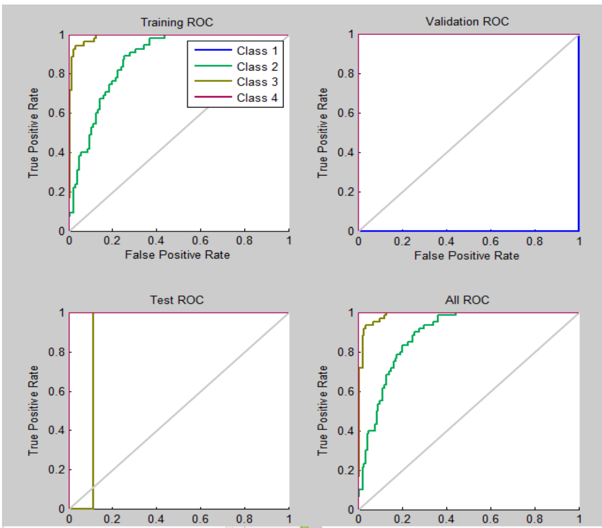

Fig-12: ROC after successful training of ANN1 for transmission line fault classification.

The receiver operating characteristic (ROC) is a metric used to check the quality of classifiers. For each class of a classifier, roc applies threshold values across the interval [0,1] to outputs. For each threshold, two values are calculated, the True Positive Ratio (the number of outputs greater or equal to the threshold, divided by the number of one targets), and the False Positive Ratio (the number of outputs less than the threshold, divided by the number of zero targets).

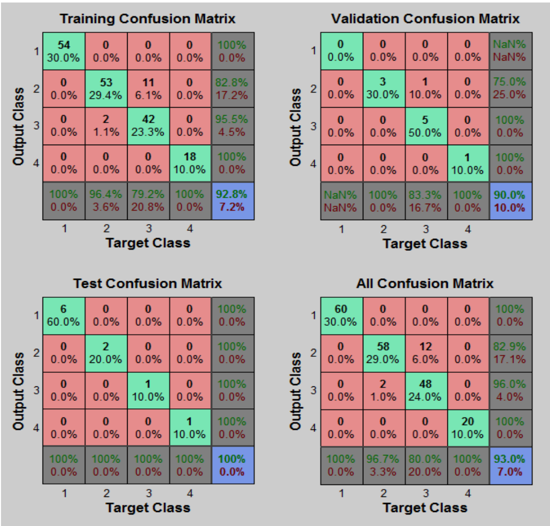

Fig-13: Confusion matrix after successful training of ANN1 for transmission line fault classification

Figure 13 shows that 93% data are perfectly classify the fault and remaining fault case data not classify using neural network 1. It means that for remaining 7% data set neural network was in confusion state for classify the fault.

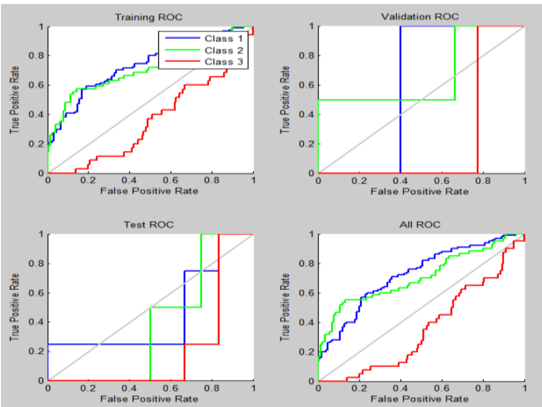

Fig-14: ROC after successful training of ANN2 for transmission line fault zone identification

Figure 15 shows that 61.5 % data are perfectly classify the fault zone and remaining fault case data not classify using neural network 2. It means that for remaining 48.5 % data set neural network was in confusion state for classify the fault zone.

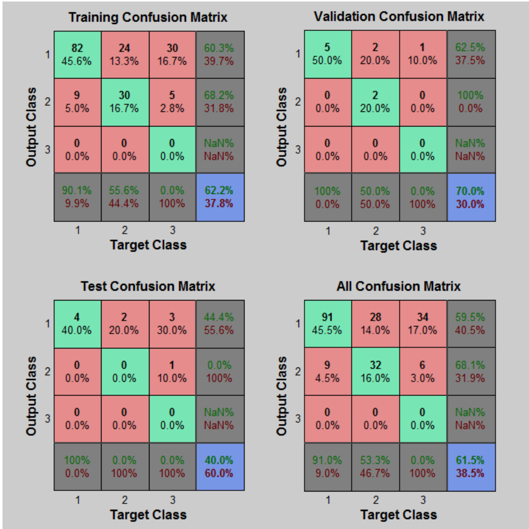

Fig-15: Confusion matrix after successful training of ANN2 for transmission line fault zone identification.

4. CONCLUSION

The protection of double circuit line difficult due to self mutual inductance and mutual inductance effect of transmission line conductor during loading condition. This mutual inductance affects the protection of transmission line using distance relay approach due to the over reach and under reach operation of line. For eliminating this difficulty ANN approach for classification of line and line zone classification utilized. The proposed approach using ANN classify the transmission line fault upto 93% while fault zone identification done upto 75% only. Also line trap installed at main protection zone of double circuit line for providing the protection from high transient surge.

REFERENCES

[1] Aggarwal, R. K., Xuan, Q. Y., Johns, A. T., Li, F., & Bennett, A. (1999). A novel approach to fault diagnosis in multicircuit transmission lines using fuzzy ARTmap neural networks. IEEE transactions on neural networks, 10(5), 1214-1221.

[2] Dash, P. K., Pradhan, A. K., Panda, G., & Liew, A. C. (2000, January). Digital protection of power transmission lines in the presence of series connected FACTS devices. In Power Engineering Society Winter Meeting, 2000. IEEE(Vol. 3, pp. 1967-1972). IEEE.

[3] Eissa, M. M., & Masoud, M. (2001). A novel digital distance relaying technique for transmission line protection. IEEE Transactions on Power Delivery, 16(3), 380-384.

[4] Gracia, J., Mazon, A. J., & Zamora, I. (2005). Best ANN structures for fault location in single-and double-circuit transmission lines. IEEE transactions on power delivery, 20(4), 2389-2395.

[5] Jain, A., Thoke, A. S., & Patel, R. N. (2008). Fault classification of double circuit transmission line using

artificial neural network. International Journal of Electrical Systems Science and Engineering, 1(4), 750-755[6] Jain, A., Thoke, A. S., Koley, E., & Patel, R. N. (2009, December). Fault classification and fault distance location of double circuit transmission lines for phase to phase faults using only one terminal data. In Power Systems, 2009. ICPS'09. International Conference on (pp. 1-6). IEEE.

[7] Jain, A., Thoke, A. S., & Patel, R. N. (2009, December). Double circuit transmission line fault distance location using artificial neural network. In Nature & Biologically Inspired Computing, 2009. NaBIC 2009. World Congress on (pp. 13-18). IEEE.

[8] Jain, A., Thoke, A. S., & Patel, R. N. (2009, December). Double circuit transmission line fault distance location using artificial neural network. In Nature & Biologically Inspired Computing, 2009. NaBIC 2009. World Congress on (pp. 13-18). IEEE.

[9] Apostolopoulos, C. A., & Korres, G. N. (2011). A novel fault-location algorithm for double-circuit transmission lines without utilizing line parameters. IEEE Transactions on Power Delivery, 26(3), 1467-1478.

[10] Yadav, A., & Swetapadma, A. (2014). Improved first zone reach setting of artificial neural network-based directional relay for protection of double circuit transmission lines. IET Generation, Transmission & Distribution, 8(3), 373-388.