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ANN BASED OPEN CONDUCTOR FAULT DETECTOR FOR PROTECTION OF TWO PARALLEL CIRCUIT TRANSMISSION LINES

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Abstract - *The protection of power system is one of the most vital aspects in electrical system operation. Two Circuit Parallel Transmission lines are widely used to Transfer bulk amount of Power from Generating Station to Load Centre and increases the power system capability. In this Paper, an artificial neural network-based protection scheme for DETECTOR/CLASSIFIER of two parallel circuit transmission lines against open conductor fault is presented. A 765 kV double circuit transmission line of 300 km length has been simulated using MATLAB 13.0.1.*

Key Words: Artificial Neural Network, Fault detector/classifier and distance locator, doubly feded transmission line.

1. INTRODUCTION

The most integral part in a power system is transmission line, the production of electricity and its usage, the transmission line play an most important role. An overhead transmission line is one of the main components in every electric power system, it is the link between the electricity power production and usage[1]. A transmission line is either single circuit or double circuit configuration, in typical three phase AC system. The double circuit is preferable over single circuit for its ability to carry more power. Also, double circuit introduces a level of redundancy, where in case of failure in one of the circuit, the other circuit should be able to maintain the power supply. Therefore, in modern power systems parallel transmission lines have been extensively used.

The simulation studies for detection high impedance fault using neuron wavelet is present in[1].faulted phase current signal measured at relay location are proposed as input to train the artificial neural network is present in[2].A fault classifier based k-nearest neighbor algorithm is present in [3].A cooperating analysis based on adaptive resonance theory is employed in high impedance fault [4]. A fault classifier based back propagation neural network architecture is proposed in[5]. A high tech digital distance relaying scheme are used for shunt fault is present in [6].Earthed and un-earthed inter circuit fault are investigated using fuzzy logic is present in[7].A single neural network for fault distance location for all shunt fault is proposed in [8].A novel low order harmonics current pattern for high impedance fault arc detection and discrimination in[9]. A novel fault location and protection scheme has been present provide the distribution network with DG is present[10].A mathematical morphology, called the decomposed open-close alternative sequence for the detection high impedance fault is proposed in [11]. The calculation and analysis for the open conductor fault based on the twelve on the sequence component method is proposed in [12].

This paper present application of neural-network is a multilayered neural network which is used to identify and classify the open conductor faults and to estimate the faulted location. Two neural networks have been created. Neural network -1 detects the type of fault (single phase open, two phase open or three phase open), identifies the faulted phase. The neural network-2 estimates the location of fault. Both the neural networks are fed with fundamental and Instantaneous frequency components of voltage and current signals of each circuit i.e. total 9 and 27 inputs have been used. The output of neural network-1 consist of three phases of both the circuits i.e. total six, to determine which phase is faulted (open). The output of neural network-2 is the location of fault in km. Both the neural networks are trained with Levenberg-Marquardt training algorithm. NEURAL NETWORK TOOLBOX of MATLAB is used to implement the neural network based open conductor fault detector, classifier and locator.

2. POWER SYSTEM NETWORK SIMULATION

The Single line system of the power system under study is shown in figure.1. This single line diagram is used as a FD (fault detects) / classifies the open conductor faults at which the fault occurs in the circuit-1 or in the circuit-2. And FL (fault locators) locates the faulted distance in which open conductor faults occur as shown in figure1.

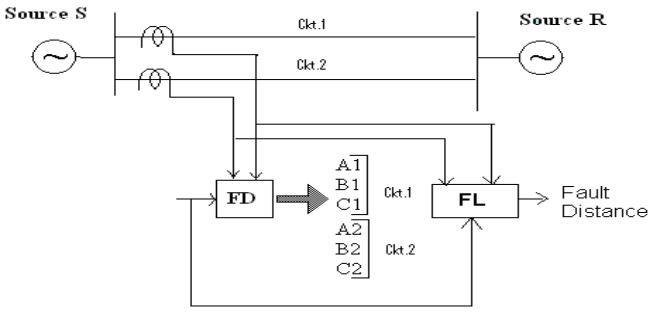

Fig -1: Single line diagram of Power System under Study

Model shown in figure.2 is simulated using MATLAB tool box , this power system is 765 kV, 60Hz doubly feded supply from sending end to receiving end and vice-versa, having pre-fault power flow angle is 40□sho rt circuit capacity of 20GVA and X/R ratio is 10. This doubly feded transmission line is bifurcated into two parts, of total length is 300 Km transmission line. In this system six circuit breaker are installed in transmission line CB1, CB2, CB3, CB4, CB5 and CB6. The open conductor fault is simulated using the two circuit breakers (CB2 for Circuit-1 and CB5 for circuit 2) and five voltage and current measurement devices are B1, B2, B3, B4, and B5 at each bus in p.u.

Table -1: DOUBLE CIRCUIT LINE PARAMETER

Positive sequence resistance R1,Ω/KM	0.01809
Zero sequence resistance R0,Ω/KM	0.2188
Zero sequence mutual resistance R0m,Ω/KM	0.20052
Positive sequence inductance L1,H/KM	0.00092974
Zero sequence inductance L0,H/KM	0.0032829
Zero sequence mutual inductance L0m,H/KM	0.0020802
Positive sequence capacitance,C1,F/KM	1.2571e-008
Zero sequence capacitance,C0,F /KM	7.8555e-009
Zero sequence mutual resistance C0m,FΩ/KM	-2.0444e-009

3. NEURAL NETWORK BASED FAULT DETECTION/ CLASSIFICTION AND LOCATOR.

Two neural network architectures have been developed for detection/classification for sending end and receiving end respectively, so that both the network detect the fault simultaneously and the faulted section can be disconnected. In double circuit transmission line the design process of the ANN based fault detector and classifier goes through the following steps:

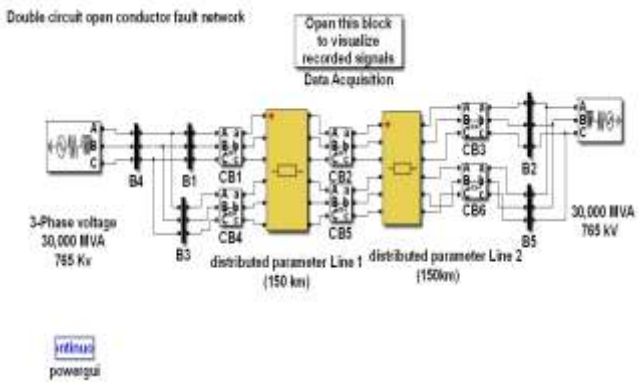

Fig -2: Power system simulated in MATLAB 13

In figure.3 shows the voltage and current waveforms during no-fault condition

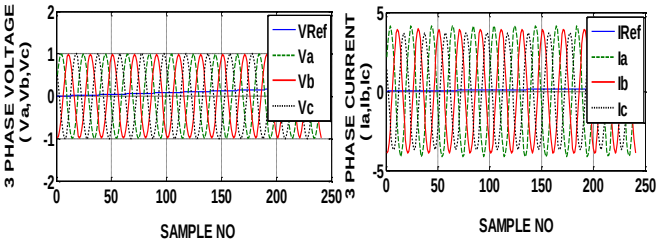

Fig-3: Three phase voltage and current wave form under no fault condition

In figure.4.shows the voltage and current waveform of three phase current open conductor fault waveform in which A1B1C1 is the faulted phase at distance of 60 Km in circuit-1 from sending end to receiving end.

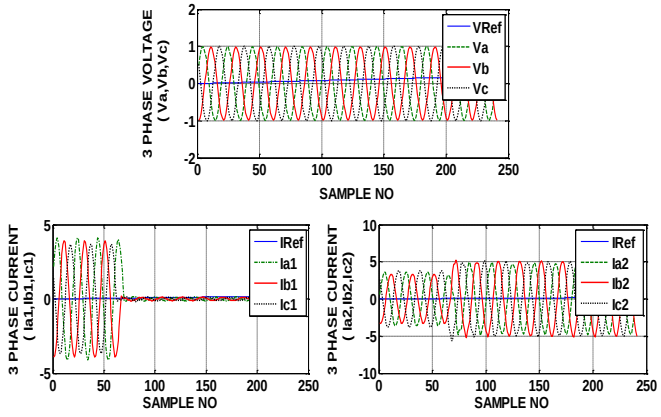

Fig-4: Three phase voltage and current wave form of Circuit-1 and Circuit-2 during three phase (A1B1C1) open conductor at 60 km from sending end

A. Preparation Of The Training Data Set

The training data set of an ANN contains the necessary information to map the input patterns to corresponding output patterns. The training data set affects the speed of training and the performance of a neural network. The training data set of an ANN for the two bus system contains the combinations of different fault conditions .The training patterns were generated by simulating different kinds of faults on the power system. Fault phase, fault location were changed to obtain different training patterns. Each type of single phase open, double phase open and three phase open conductor fault at each distance for ckt-1 and ckt-2 (A1, B1, C1, A1B1, B1C1, A1C1, A1B1C1, A2, B2, C2,A2B2, A2C2, B2C2, A2B2C2) at different fault locations line length. The fault classification and location task shown in table.4.1.

For fault detection and Classification the input ANN Network is designated as fundamental (FD11, FD22) at sending end and also at receiving end and instantaneous value (IN11) at sending end. In this input network to the neural network FD11 and FD22 and IN11 have 3 voltages and 6 Currents for the open conductor fault detection and classification. The magnitudes of the fundamental and Instantaneous of post fault samples of each phase voltages and currents measured at the different open faulted location is[Va,Vb,Vc, Ia1,Ib1,Ic1,Ia2,Ib2,Ic2] , have been selected as input to neural network for circuit-1 and circuit-2. Thus total 9 inputs are given to neural network for fault detection and classification.

X= [Va, Vb, Vc, Ia1, Ib1, Ic1, Ia2, Ib2, Ic2] (1)

The output of neural network consist of three phases of both the circuits i.e. total six provided by the classification and detection of both the three phase double circuit line

Y1= [A1, B1, C1, A2, B2, C2] (2)

B.ANN Architecture And Training

Table -2: Training Open conductor fault pattern

Fault type	A1,B1,C1-A1B1,B1C1,A1C1-A1B1C1 A2,B2,C2-2-A2B2,B2C2,A2C2-A2B2C2
Fault location in Km	2,20,40,60,80,100,120,140,160,180 ,200,220,240,260,280,299
Fault inception angle	0-360 (Degree)
Pre-fault power flow angle	45 (Degree)
Fault type	A1,B1,C1-A1B1,B1C1,A1C1-A1B1C1 A2,B2,C2-2-A2B2,B2C2,A2C2-A2B2C2

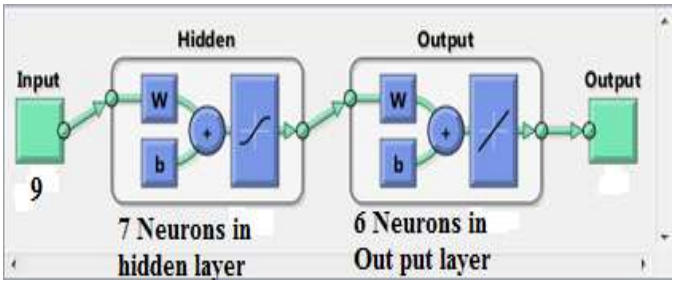

Fig-5:Detailed structure of the ANN for detection and classifier

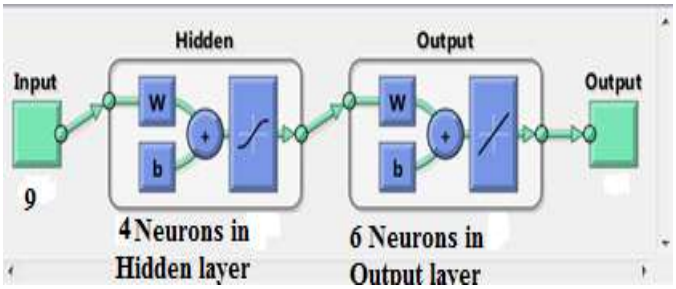

Fig-6: Detailed structure of the ANN for detection and classifier

4. TEST RESULT OF OPEN CONDUCTOR FAULT DETECTOR/CLASSIFIER AND LOCATOR

ANN based open conductor fault detector/classifier was tested using data sets from sending end to receiving end (total 860 fault patterns). For fault detection the input data are fundamental (FD11, FD22) and instantaneous value (IN11). The network was tested and validated by presenting different single phase, double phase and three phase open conductor faults with varying fault locations (Lf 0-299KM) and fault inception angles (Φi= 0-360).

The time of operation of ANN based fault detector/classifier can be calculated as follows:

Fault occurred at sample no = 55

Fault detected at sample no = 66

Sample no. required for detection/classification = 66-55 = 6

Time of operation= samples no. required for detection/classification x sampling time

A fault occur in phase A2B2C2 in circuit-2 from receiving end to sending end in FD22 at 165 km as shown in figure.7

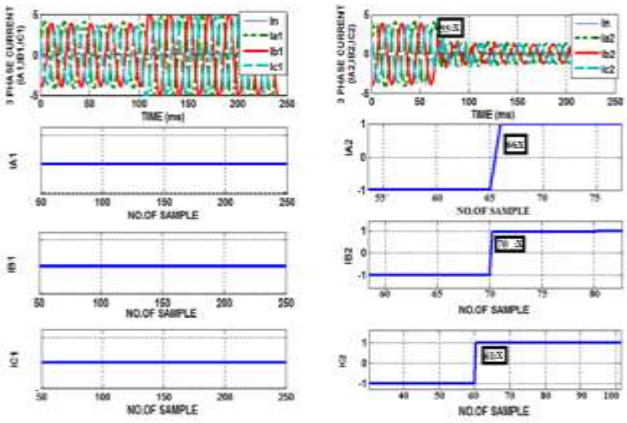

Fig-7: Test result of following three phase A2B2C2 open conductor faults in Circuitt-2 at 165 km with fault inception time 0.00498 sec.

To analyze the effect of inception angle and location, a single phase open conductor fault on phase C1 of circuit-1. The fault was simulated at 25 km 20.825 ms and test results of FD11 shown in figure.8.are

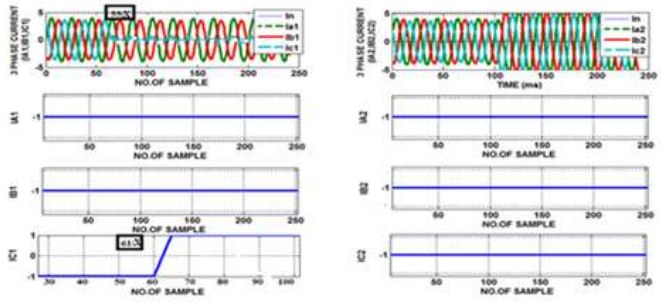

Fig-8: Test result of following single phase C1 open conductor faults in Circuit-1 at 25 km with fault inception time 0.0048 sec.

A fault occur in phase B1 in circuit one from sending end to receving end in FD11 at 215 km as shown in figure.9

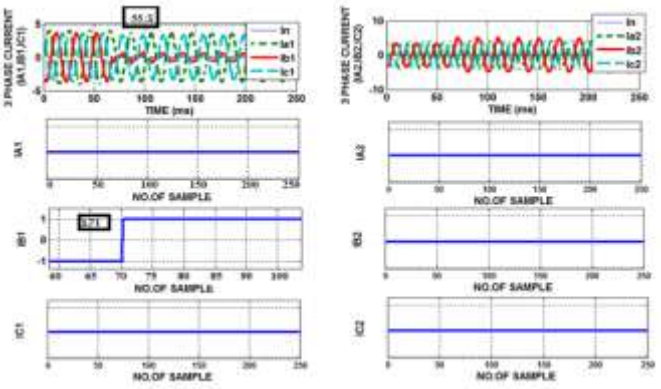

Fig-9: Test result of following single phase B1 open conductor faults in Circuit-1 at 215 km with fault inception time 0.01328 sec.

A fault occur in phase C2 in circuit two from sending end to receving end in IN11 at 105 km as shown in figure.10.

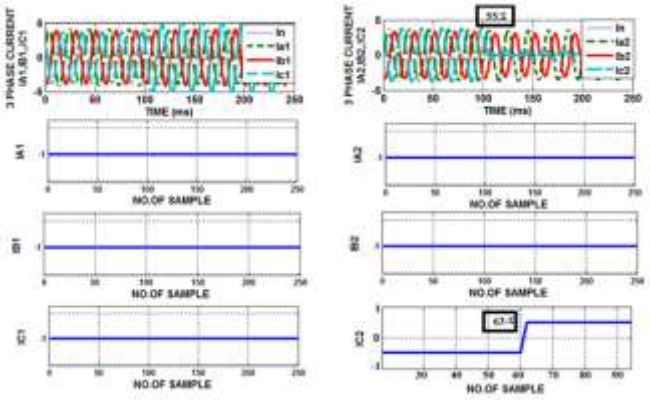

Fig-10: Test result of following single phase C2 open conductor faults in Circuitt-2 at 105 km with fault inception time 0.00664 sec.

Table-.3. Desired output of ANN based fault detector & classifier

Fault type	Phase	A	B	C
Single phase open	A1	1	0	0
	B1	0	1	0
	C1	0	0	1
Two phase open	A1B1	1	1	0
	B1C1	0	1	1
	A1C1	1	0	1
Three phase open	A1B1C1	1	1	1
Single phase open	A2	1	0	0
	B2	0	1	0
	C2	0	0	1
Two phase open	A2B2	1	1	0
	B2C2	0	1	1
	A2C2	1	0	1
Three phase open	A2B2C2	1	1	1

5. TEST RESULT OF ANN FAULT LOCATER

ANN Based fault Locator to detected, they fault location different types of open conductor fault occurred in transmission line at different location.

Open conductor fault occurred at 20 km in circuit one A1 phase for sending end to receiving end at FD1.as shown in figure.8.

Time of operation= samples no. required consecutive sample x sampling time

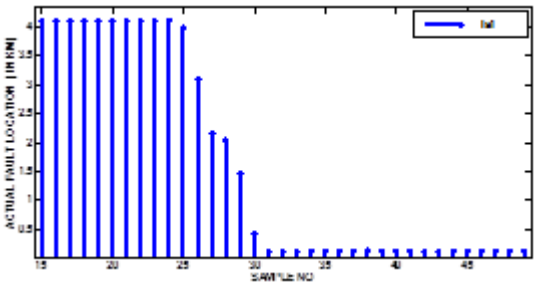

Fig.11-: Plot is obtained for Test result of FD-1 during phase A1 at 20km from sending end of circuit-1 with fault inception time =. 0.0096 sec

6. CONCLUSIONS

Artificial neural network based double circuit transmission line fault detector classifier and fault locator estimator modules were developed and tested. The output of fault detector and classifier contains six outputs. These are A1 B1 C1 A2 B2 C2. These outputs are either 1 or 0 for internal or external faults respectively. The double circuit doubly fed 765KV, 60 Hz transmission line system connected by 300 km long transmission line simulated using MATLAB Simpowersystem and Simulik toolbox for various types of faults with different system conditions and parameters mainly varying the fault inception time, and fault location.

The Neural network toolbox of MATLAB has been used extensively in offline studies. The neural network architecture used in study is a multilayer neural network with Backpropogation technique (Levenberg-Marquardt algorithm for fault detection, classification).Although training of Neural networks takes a long time(offline) but once trained, its output is almost instantaneous making it suitable for "online"applications. The results presented on the performance of the ANN based fault detection, classification and location estimation technique.

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