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Using Wavelet for Finding Fault Place and Neural Network for Types of Facult in Transmission Lines

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Abstract— a transmission line has their own faults and they could be single phase, double phase and three phases to ground. There are different scheme which is related to modern relay that can work with re closer for protecting the faulted phases also there should be accurate selection for finding the right phase. This thesis shows right different scheme for detection and classification of faults on transmission line. The scheme is to use neural network and wavelet transform together, to choose a proper way for solving the problem. Wavelet transform has strong mathematical, very fast and accurate tools for transient signal in the transmission lines beside We use artificial neural network that can make a different between measured signal and associated signal that has different pattern. It can be done by using specific algorithm. This algorithm using time frequency analysis of faulted transient line with help of wavelet transform, and then this will followed to the artificial neural network for identify what phase is faced with the fault. Here we used MATLAB software for simulation of fault signals and verifying the correctness of the algorithm. There will be different types of fault type which is giving to the software and result will show that where and what phase is faced the problem.

Keywords— neural network, wavelet transform, fault identification and classification, transmission line.

INTRODUCTION

Transmission lines are lines with sharing same voltage and current with their specific length. These lines are used for transferring the electrical energy with accurate, reliability and security. There are different configurations of parallel lines which is mixed with the effect of mutual coupling and make their protection a challenging problem. With using Statistic we can say that, about 80% of the faults on transmission lines are transient in nature.

When we have abnormal transient over voltages, there will be a breaking down of the air which is surrounding the insulator. If the supply is interrupted, then these fault can be disappear and arc will allowed de-ionizing. There is another device that during these times is starting its role for the purpose of restoring transmission line to service subsequent to tripping of their associated circuit breakers due to fault [1].

As we know, most of the faults on transmission lines are single line to ground faults, relaying systems should be in position to clear the difference between these faulted phases. For this purpose, there should be an algorithm which correctly make different between single line to ground faults for the purpose of tripping a single pole and initiating three-phase tripping for another faults.

One of the most important things here is to select the right phase for avoiding unnecessary three phase tripping. In addition it is important to minimize the possibility of single phase faults spreading to other phases because when this issue is happened, there will be some problems: like make more time for clearance of single phase to earth faults and high speed decision making . In addition there are some other benefits like:

1. High speed of selecting the right phase
2. High speed clearance
3. Reducing the level of post arc gas
4. Reducing the dead time to achieve satisfactory extinction of the secondary arc [2].

There are some benefits that is related to the single phase tripping and also reclosing which will be:

I) High improvement of transient state stability.

II) When there are remote generating stations that are connected to the load center and they have one or two transmission lines, there will be improvements in system reliability & availability

III) It will reduce the switching of over voltages

IV) It will reduce the shaft *torsional* oscillation with large thermal units[3]

There is a common type of protection which is distance relay and it is based on the measuring the fundamental frequency of positive sequence impedance of the line. More than detecting the fault zone and directional discrimination, the distance relay can also measure elements perform the job of faulted phase selection. However, the jobs of ground distance units is to operate for double phase to ground faults and phase distance units is to operate for ground faults which is very close to the relay location.

Planners could not relay only to distance relay for determine the fault type, so they used different type of techniques like wavelet transform and neural network for finding faulted phase in EHV/UHV transmission lines and also they have developed these techniques over these years.

Methodology:

There are different methods that can help to find the place of fault, also to find the fault types. Here we can use wavelet transform as a one of the best tools to find the place of the fault which is send an signal throughout the transmission lines and with the measuring the time of returning that signal, find the place which the fault is happened. We can use another tools to find the types of fault which is neural network. When we run the modeling, there is another part which is coding it works with the modeling and they are match withc each other. So in the command line of the MATLAB we can see the place with considering the some more and les tolerance, and see that the fault is. When we need to choose the place of fault, which we need in the output of the program, we need to just change the numbers of sending and receiving end, which means the total amount of them should be equal to 300, because our transmission line is suppose to be 300 km.

Modeling:

Figure 7.1 is showing the modeling that we used for simulating the transmission line. As we can see, there are two there phase source which are connected to the transmission line in both side. Both sources have same quantity and they are 400kw.there is some other amount which is mentioned below.

Three phase source:

Parameter in left three phase source:

Phase to phase rms voltage (v): $400e^3$ Phase angle of phase A (degree) = 0 Frequency (HZ) = 50 Internal connection: Yg

3 phase short circuit level at base voltage (VA): $250e^6$ Base voltage (Vrms ph-ph): $400e^3$

X/R ration: 12.37/2.46

Parameter in right three phase source:

Phase to phase rms voltage (v) = $400e^3$ Phase angle of phase A (degree) = -15 Frequency (HZ) = 50 Internal connection: Yg

3 phase short circuit level at base voltage (VA) = $1915e^6$ Base voltage (Vrms ph-ph) = $400e^3$ X/R ration = 12.37/2.46.

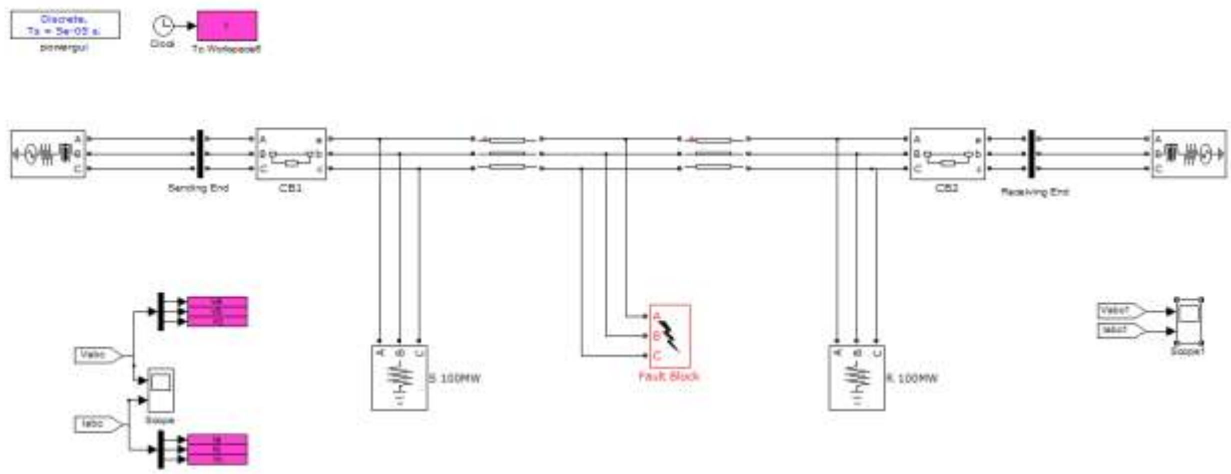


Figure 7.1 modeling of transmission line

Circuit breaker:

There is another element in this figure which is circuit breaker and in both circuit breaker the all amount is same and mentioned below. There is a short explanation for this block which is mentioned. Connect this block in series with the three-phase element you want to switch. You can define the breaker timing directly from the dialog box or apply an external logical signal. If you check the 'External control' box, the external control input will appear. Parameter for both circuit breakers:

Transition times(s) = [0.3]   Breaker resistance Ron (ohms) = 0.001   Snubbers resistance Rp (ohms) = $1e^{6}$

Snubbers capacitance Cp (Farad) = inf   Initial status of breakers: closed

Three phase series RLC load:

Another part is three phase series RLC load, there amount is same and mentioned below. Three phase series RLC load in both sides:

Configuration: Y grounded

Nominal phase to phase voltage Vn (Vrms) = $400e^{3}$ Nominal frequency fn (Hz) = 50   Active power P (W) = $100e^{6}$

Inductive reactive power QL (positive var) = 0   Capacitive reactive power QC (0) = 0

Distributed parameters line:

Another part is distributed parameters line, and their amount is almost same, the difference is only in line length in KM, and the reason is because of our line is about 300KM, so during the modeling we need to choose the place of the fault, so the total amount of these two block should be 300. For example if we need to show that the fault is happening in the 28KM we need to change the amount of other line length to 272KM. Rest of the amount in different part will be same during the modeling, but if we need to change the output of the signal, we can change each part. The explanation for this block is:

Implements an N-phases distributed parameter line model. The rlc parameters are specified by [N×N] matrices. To model a two-, three-, or a six-phase symmetrical line you can either specify complete [N×N] matrices or simply enter sequence parameters vectors: the positive and zero sequence parameters for a two-phase or three-phase transposed line, plus the mutual zero-sequence for a six-phase transposed line (2 coupled 3-phase lines). This block has these parameters amounts:

Number of phases [N] = 3   Frequency used for RLC specification (HZ) = 50

Resistance per unit length (ohms/km) [N×N matrix] or [i1 r0 r0m] = [0.0298 0.162]

Inductance per unit length (H/km) [N×N matrix] or [i1 l0 l0m] = [$1.05e^{-3}$ $3.94e^{-3}$]

Capacitance per unit length (F/km) [N×N matrix] or [c1 c0 c0m] = [$12.74e^{-9}$ $7.751e^{-9}$]

Line length (km): it is selective and the total amount of the both side should be equal to 300 because our transmission line suppose to be 300KM.   Measurements: phase to ground voltage

Three phase VI measurement:

Another part of the figure is three phase VI measurement. As we can see in the figure they are two, one in right and one in left. Their amount is almost same the difference is only in there label in signal label in voltage and current which in left the label is Iabc for current and for voltage is Vabc and in the right label for current is Iabc1 and for voltage is Vabc 1. The rest of things are same. Also there is an explanation for this block which is mentioned. Ideal three phase voltage and current measurements. The block can output the voltages and currents in per unit values or in volts and amperes.

Three phase fault:

Another part of the figure is three phase fault. With this block we can choose different types of fault and also resistance for ground. As we can see in that block, there are different phases (phase A, phase b phase C) and also ground fault that we can choose any one with or without ground. There is an explanation for this block which is mentioned and after that their parameter as well. Use this block to program a fault (short-circuit) between any phase and the ground. You can define the fault timing directly from the dialog box or apply an external logical signal. If you check the 'External control' box, the external control input will appear. Parameters:

Fault resistance Ron (ohms) = 8   Transition status [1, 0, 1 ...) = [1 0]   Transition times (s) = [0.04 0.042]

Snubbers resistance Rp (ohms) = $1e^6$ Sunbbers capacitance Cp(Farad) = inf   Measurement = none

There is another part in the modeling that we can see in figure 7.2, this part is consist of the two other sub part and they work together to give their signal to the scope to see the result.

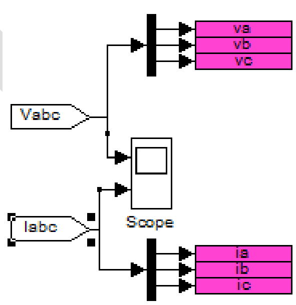


Figure 7.2 voltage and current block to scope

As we can see in the figure 7.2, there are two part which is consist of voltage and current and they gave their signals to the scope to show the result, also there are two other block which are connected to the voltage and current, they are three phase V-I measurement and their configuration is shown in figure 7.3, and we can see their connections.

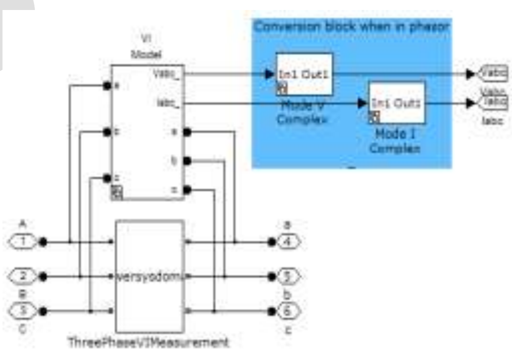


Figure 7.3 three phase VI measurement

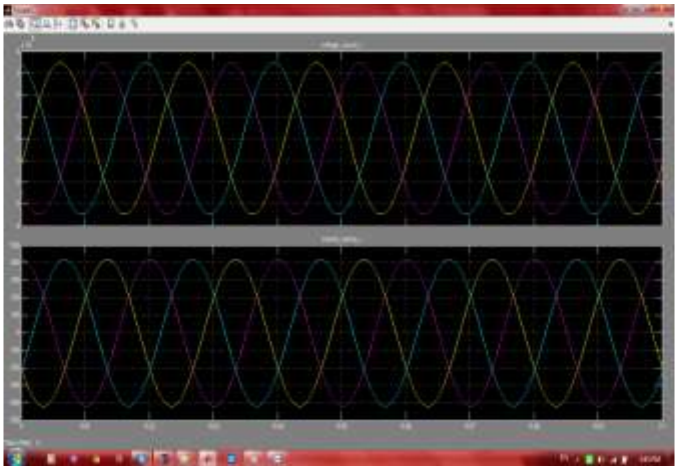


Figure 7.5 no fault condition in transmission line

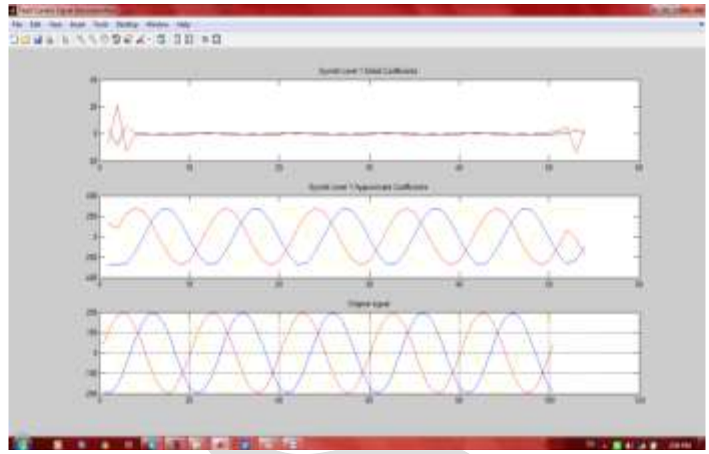


Figure 7.6 voltage, current and wavelet signal base on wavelet transform

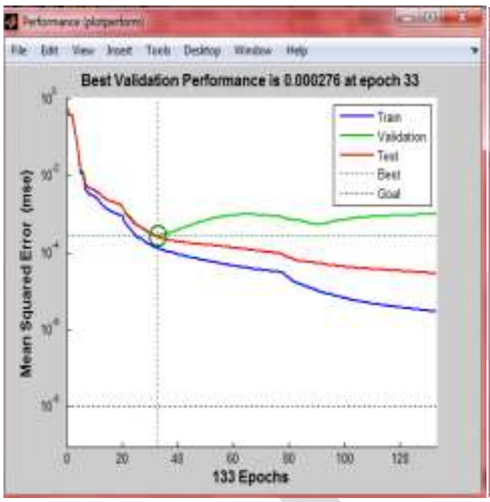


figure 7.8 performance

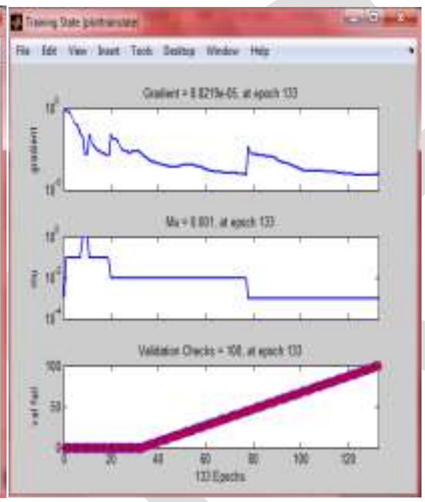


figure 7.9 Gradient and validation performance

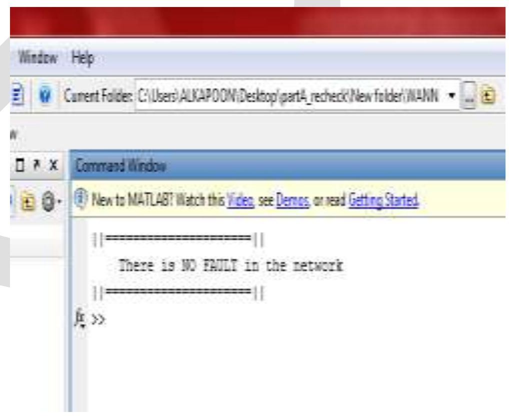


Figure 7.10 output of program

when there is no fault in the system, with the help of neural network and wavelet tarnsform, we can see that the out put of the coding, after runing show that there is no fault in transmission line as we can see in the figure 7.10.

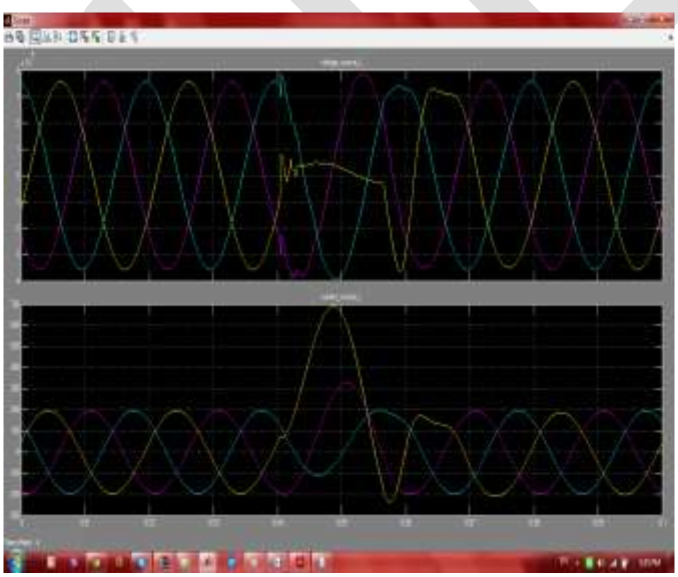


Figure 7.13 LG fault (fault between phase A and Ground)

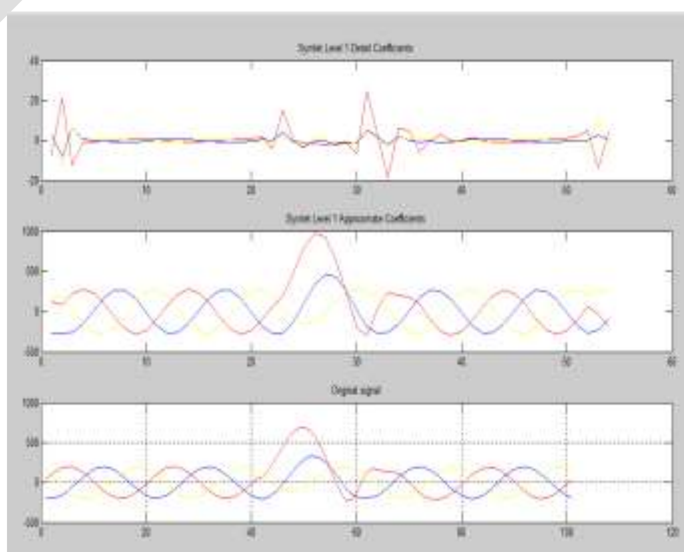


Figure 7.17 voltage, current and wavelet signal base on wavelet transform

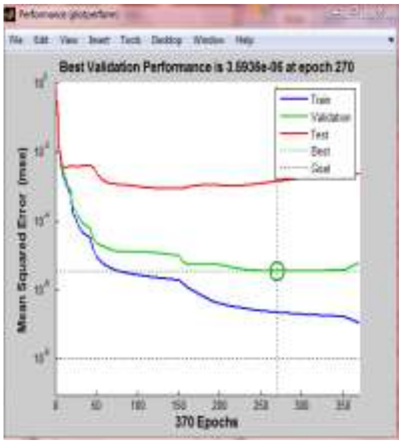


Figure 7.15 performance

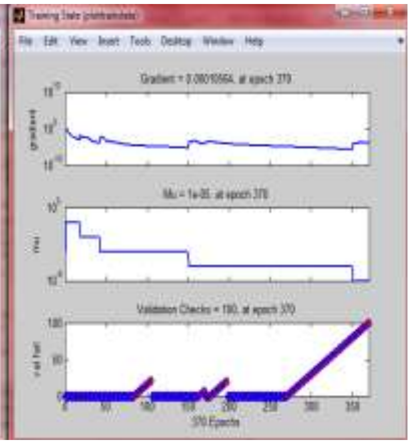


figure 7.16 Gradient and validation performance

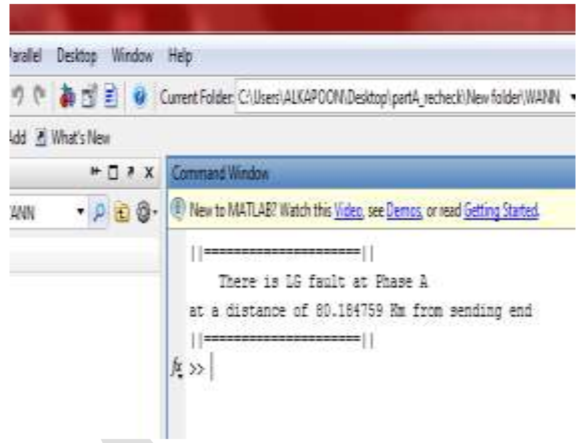


Figure 7.18 output of single phase to ground

After running the program, we can see that, in the output we have the result with respective place which fault happened. This result has some tolerance. It is shown in figure 7.18. We can see that in the output the correct phase and place is shown.

We can see this type of fault when two different phase, make a connection between each other and produce this type of fault. It is mentioned in figure 7.49.

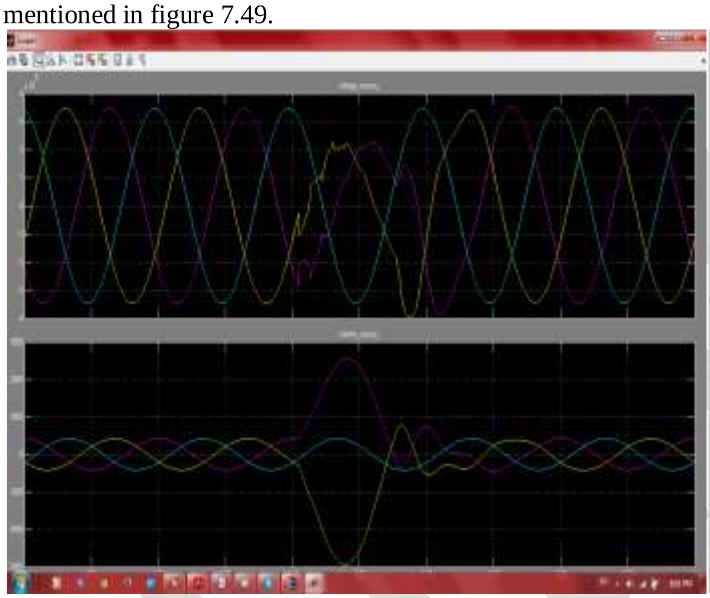


Figure 7.49 LL fault (fault between phase A and phase B)

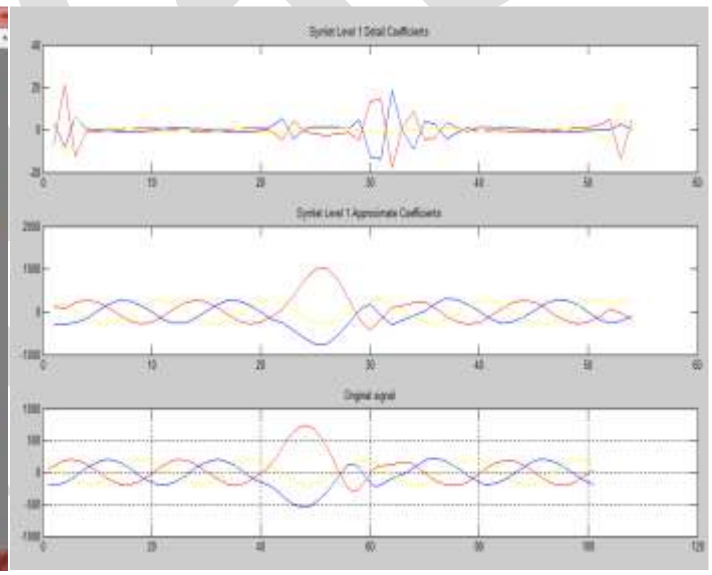


Figure 7.53 voltage, current and wavelet signal base on wavelet transform

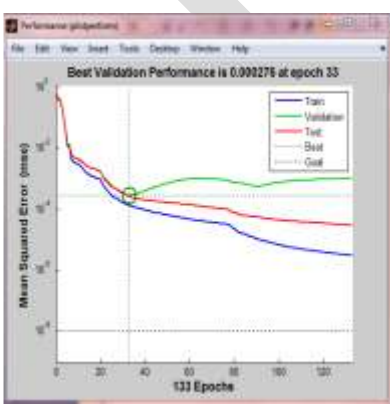


Figure 7.51 performance

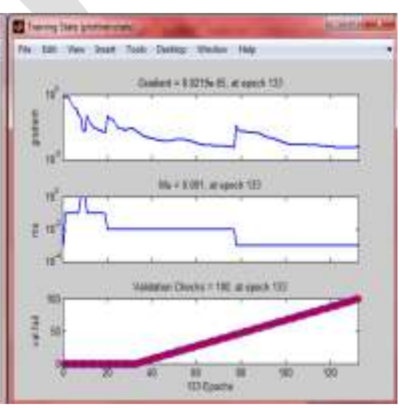


figure 7.52 Gradient and validation performance

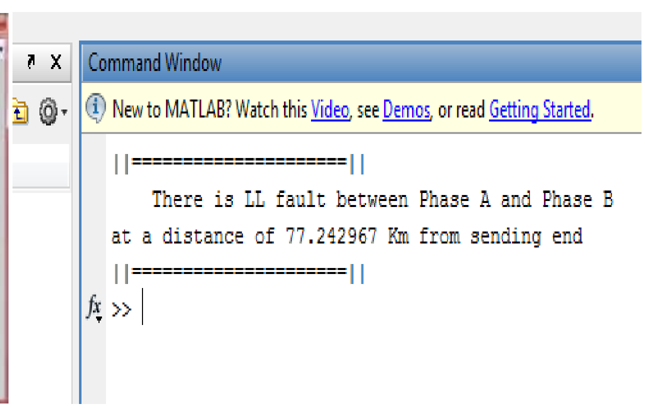
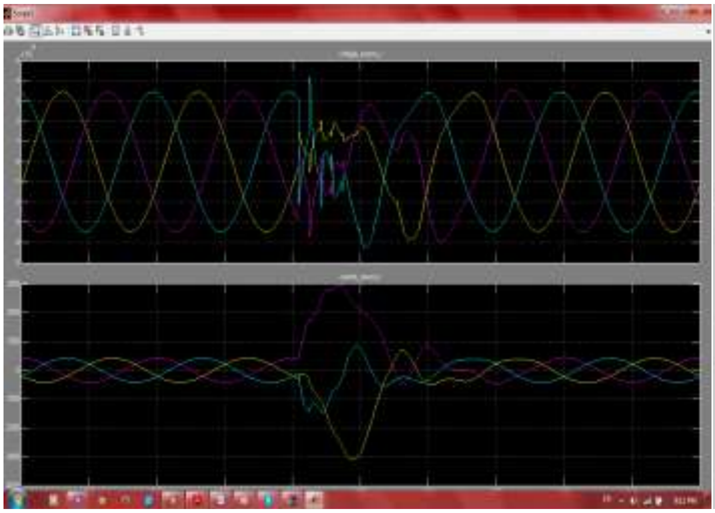


Figure 7.54output of double phase with each other



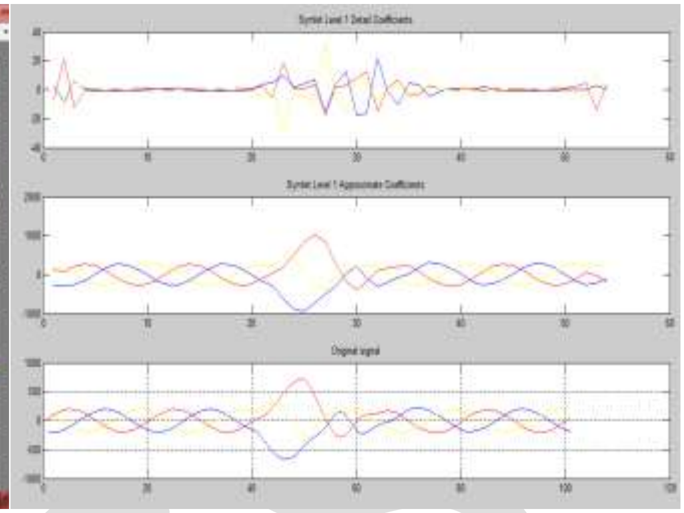
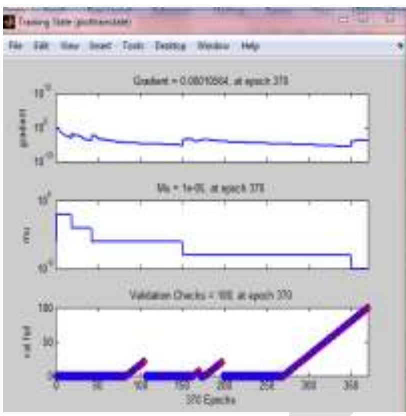
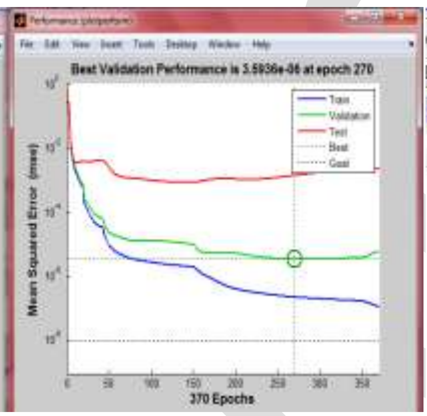
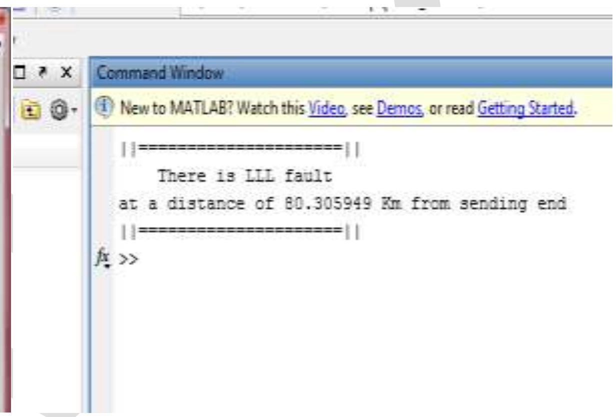


Figure 7.67 LLL fault (fault between phase A, phase B and phase C)

Figure 7.71 voltage, current and wavelet signal base on wavelet transform



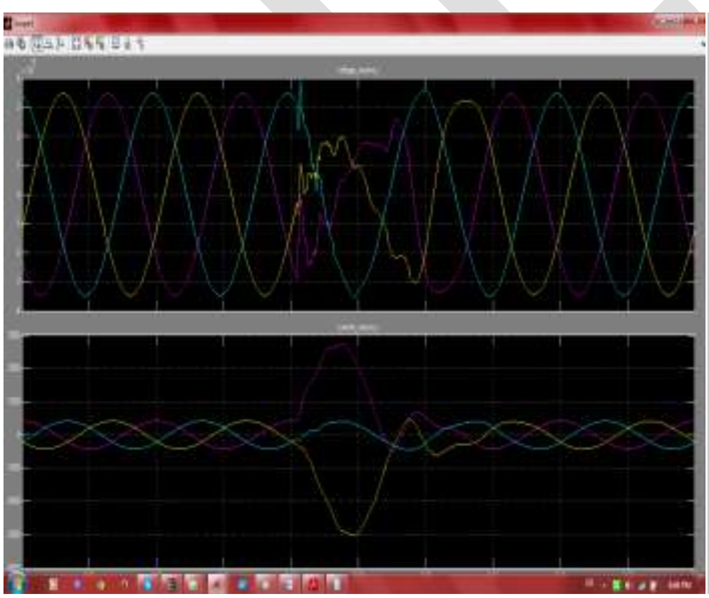




Here in figure 9 and figure 12 we will see the result for 2 phase to ground and three phase to ground.

Figure 7.72 outputs of three phases with each other

In this stage, we choose phase A and B when they made a connection with each other to ground and take the output result. The result is shown in figure (7.31).



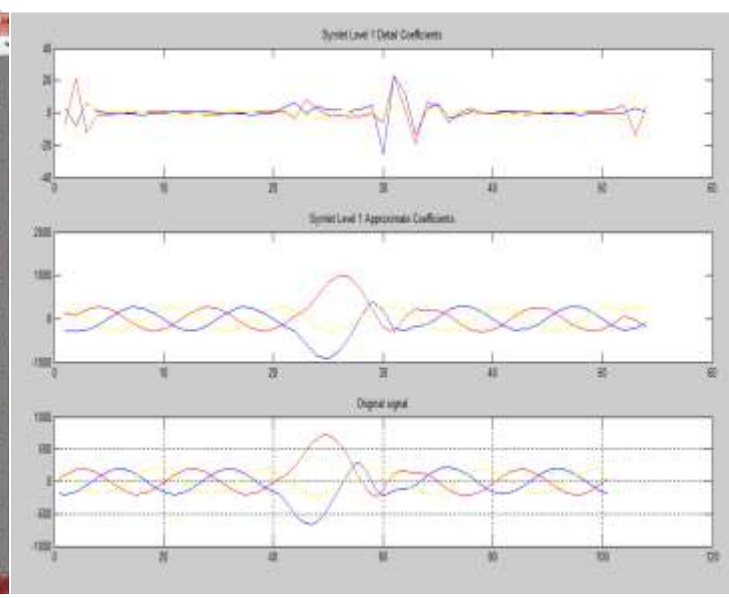


Figure 7.31 LLG fault (fault between phase A and B to Ground)

Figure 7.35 voltage, current and wavelet signal base on wavelet transform

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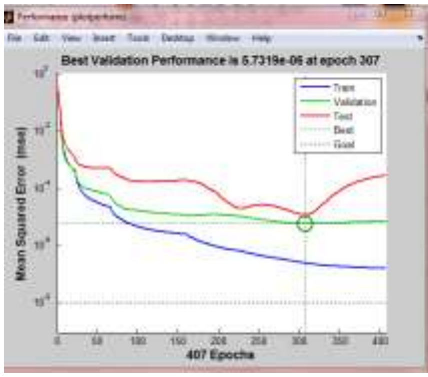

Figure 7.33 performance

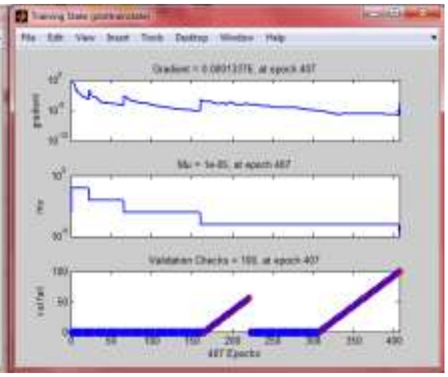

figure 7.34 Gradient and validation performance

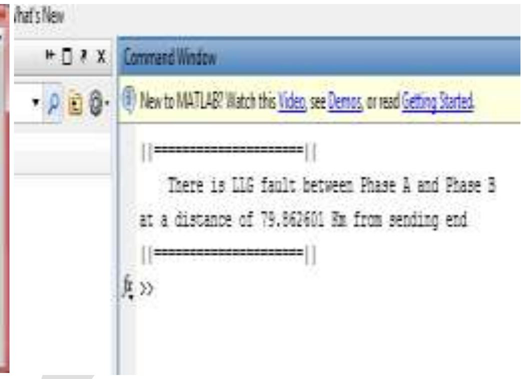

Figure 7.36 output of double phase to ground

As we saw in the figure (3.36), there is right selection of the phase with some tolerance in place of fault.

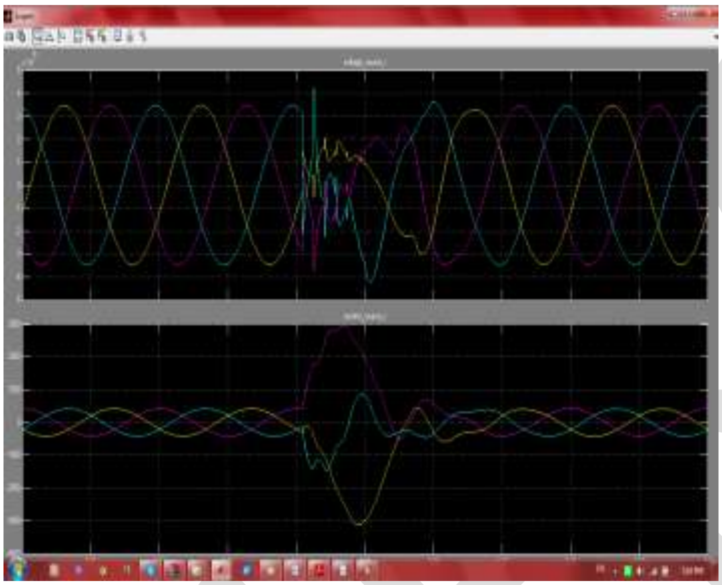

Figure 12. LLLG (phase A, phase B and phase C to ground) fault on the transmission line

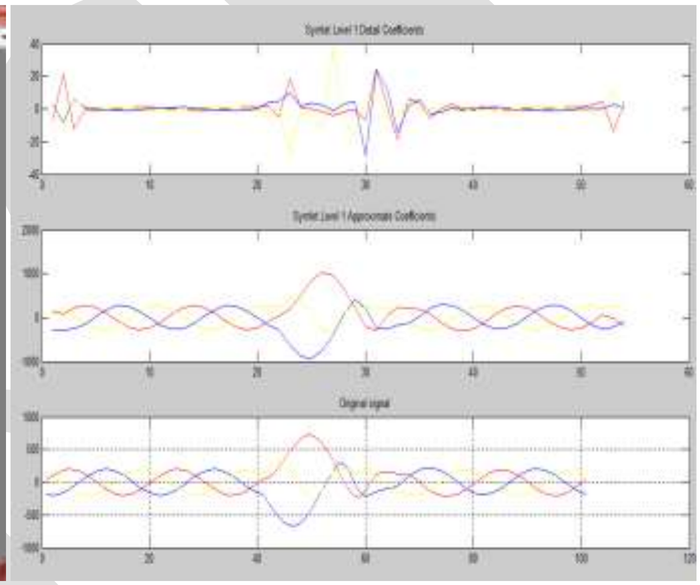

Figure 7.77 voltage, current and wavelet signal base on wavelet transform

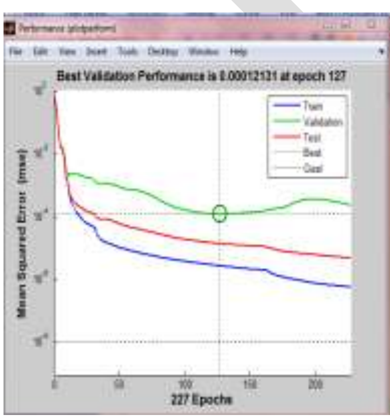

Figure 7.75 performance

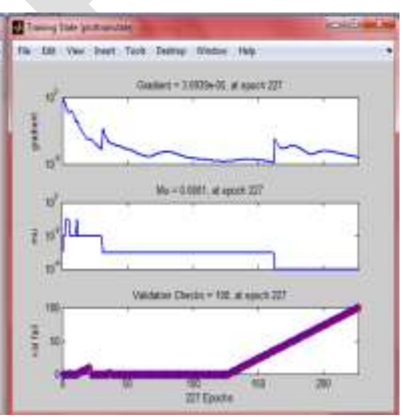

figure 7.76 Gradient and validation performance

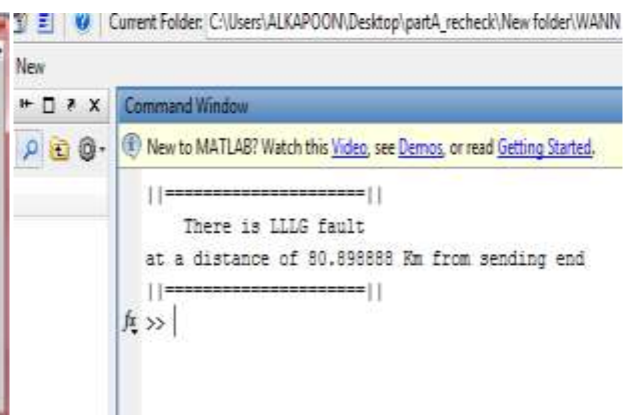

Figure 7.78 output of double phase to ground

Analysis of results

This simulation is done in 300 km transmission line with different type of fault and location of fault with using MATLAB simulation software.

As we have seen, there was some tolerance in finding the place of fault. During each modeling, there was some percentage error, which is collected in next tables.

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Table 7.1 Percentage errors as a function of fault distance and fault resistance for the ANN chosen for one line to ground fault location

Serial No:	**% Error vs. Fault Distance (Fault Resistance = 20 Ω)**			**% Error vs. Fault Distance (Fault Resistance = 60 Ω)**		
	Fault Resistance (Ω)	**Measured Fault Location**	**Percentage Error**	**Fault Distance (Km)**	**Measured Fault Location**	**Percentage Error**
1	24	24.39	0.153	49	50.46	0.51
2	74	74.48	0.187	99	100.02	0.33
3	124	124.02	0.03	149	152.03	1.05
4	174	174.08	0.02	198	200.57	0.79
5	224	224.81	0.203	248	253.79	1.63

Table 7.2 Percentage errors as a function of fault distance and fault resistance for the ANN chosen for double line to ground fault location.

Serial No:	**% Error vs. Fault Distance (Fault Resistance = 20 Ω)**			**% Error vs. Fault Distance (Fault Resistance = 60 Ω)**		
	Fault Resistance (Ω)	**Measured Fault Location**	**Percentage Error**	**Fault Distance (Km)**	**Measured Fault Location**	**Percentage Error**
1	24	24.43	0.167	49	52.76	1.25
2	74	74.17	0.05	99	100.02	1.03
3	124	124.09	0.026	149	151.03	0.68
4	174	174.15	0.043	198	200.89	0.89
5	224	224.29	0.11	248	253.79	1.52

Table 7.3 Percentage errors as a function of fault distance and fault resistance for the ANN chosen double line with each other fault location.

Serial No:	**% Error vs. Fault Distance (Fault Resistance = 20 Ω)**			**% Error vs. Fault Distance (Fault Resistance = 60 Ω)**		
	Fault Resistance (Ω)	**Measured Fault Location**	**Percentage Error**	**Fault Distance (Km)**	**Measured Fault Location**	**Percentage Error**
1	24	24.03	0.012	49	50.16	0.29
2	74	74.29	0.12	99	100.42	0.74
3	124	124.57	0.123	149	151.03	1.11
4	174	174.13	0.038	198	200.89	0.55
5	224	224.74	0.265	248	254.19	1.63

Table 5.5 Percentage errors as a function of fault distance and fault resistance for the ANN chosen for three phase fault location.

Serial No:	% Error vs. Fault Distance (Fault Resistance = 20 Ω)			% Error vs. Fault Distance (Fault Resistance = 60 Ω)		
	Fault Resistance (Ω)	**Measured Fault Location**	**Percentage Error**	**Fault Distance (Km)**	**Measured Fault Location**	**Percentage Error**
1	24	24.41	0.16	49	50.31	0.37
2	74	74.16	0.046	99	102.02	1.009
3	124	124.42	0.25	149	151.27	0.69
4	174	174.59	0.20	198	200.89	0.53
5	224	224.36	0.1433	248	252.74	1.18

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CONCLUSIONS
This thesis worked on finding different types of fault in transmission lines with the help of two different materials. Neural network is used to find the different types of fault when wavelet transform is used to find the place of the fault. All types of fault is studied and modeled in this thesis. We can change the place and the types of fault by choosing in the modeling. All part of modeling is done with considering the transmission lines in 300KM length. As we have seen in modeling, we used the (10.20.10.5.5) neural network, and it means it has 10 inputs, 20 hidden layer1, 10 hidden layer2, 5 output layers and 5 outputs. This shape of neural network can be different and is up to the types of network, but here we used this type. The important thing about this thesis is, finding the place of fault which is done here

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