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A new approach of Mho distance relay for Transmission line protection

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Abstract. The protection of transmission line is one of the important requirements of the modern power system network to protect the equipment and persons work on it. distance relay is one of the relays used to protect the transmission line where the input to the fuzzy based distance relay are the resistance and reactance of transmission line from relay to the fault location. These were calculated from the measured voltage and current. Mho type distance relay is proposed by using fuzzy logic methodology to protect the transmission line and to defeat under and over-reach problems. MATLAB-Simulink is used to model the relay and the test network, where the fault type is detected and four zones of fault location are provided, the trip signal is delayed according to the zone number. Also the (R-JX) plain is used to show the zone of fault in a simplified manner.

1. Introduction

Distance relay are widely used in transmission line protection by calculating the impedance between the relay and fault position from local measurement of current and voltage. There are different types of distance relay like admittance, mho, reactance, quadrilateral polarized-mho etc. Distance relay may be used for main or backup relay. The knowledge of operation manner of distance relay is very complex compared with other relays because of its philosophies and theories. MATLAB/Simulink is used to reduce this problem so as to increase our understanding of inside modeling, fault type detection, apparent impedance calculation, and zone number coordination. Fuzzy controller is one of the artificial intelligence controllers used because of its implementation with simple rule and membership. This controller theory has been implemented by Zadah since 1965, so as to reduce complexity of problems that concerned with uncertainties and need decision to solve these problems. The distance relay is provided with three phase voltage and current from measuring units and filtered to mitigate harmonic may be presented due to arcs when fault is occurred. The relay compare the calculated impedance with the setting impedance to decide the fault zone number so as to decide the delay time of relay to clear fault at that zone. In this paper a distance relay based on fuzzy controller technique has been implemented

2. Related works

In [1], the author implement fuzzy based distance relay in this paper to protect the transmission line. Where, the impedance is calculated by using samples of current and voltage signals. The Proposed simulation and system parameters changing influence such as fault type (three phase, line to line, line to ground and double line to ground). Distance relay work on pre selecting zones on transmission line and not operate when the fault is out of these regions. In [2], the mho distance relay was developed and accurate but to change the operation zone the relay constant should be changed. Numerical relay can



interface with circumferential devices, producing overall economy for the system protection equipment's. The data obtained from the relay were plotted on (R-X) plot. It was favorable for long transmission lines because they are least influenced by power surges. In [3], the author implement Fuzzy logic controller to evolve the execution of distance relay since it has shown massive refinement in the execution of many systems to protect the transmission lines and the result is obtained by using software packages.

3. Proposed distances relay

The formula used to calculate the impedance of the line is depended on the fault type as shown in table (1).

Table 1. formulas of impedance calculation

Fault type	Formula
AB	$(V_A - V_B)/(I_A - I_B)$
BC	$(V_B - V_C)/(I_B - I_C)$
AC	$(V_A - V_C)/(I_A - I_C)$
AG	$V_A/(I_A + (3 * K_0 * I_0))$
BG	$V_B/(I_B + (3 * K_0 * I_0))$
CG	$V_C/(I_C + (3 * K_0 * I_0))$
ABC	V_A/I_A

Where A, B and C is the three phase sample of the system

V_A = voltage of phase A, V_B = voltage of phase B, V_C = voltage of phase C

I_A = current of phase A, I_B = current of phase B, I_C = current of phase C

$$I_0 = V_S / (Z_0 + 2 * Z_1) \quad , \quad K_0 = (Z_0 - Z_1) / K * Z_1$$

Where V_S is phase voltage, Z_0 = zero sequence impedance, Z_1 = positive sequence impedance

K = depend on relay design may be 1 or 2 or 3

The two bus system, four parts of transmission line, simulated fault, load and distance relay can be seen in figure (1). The system data is presented in Appendix B.

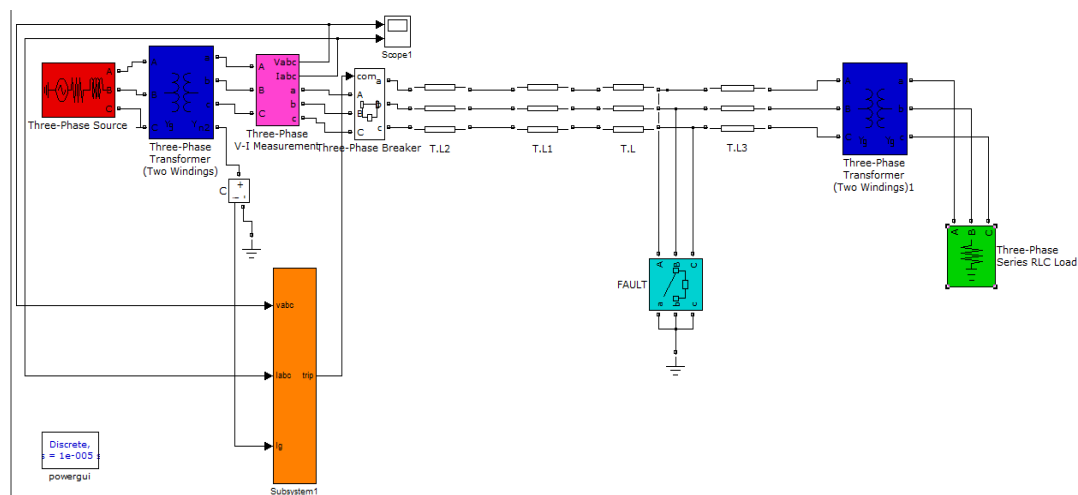


Figure 1. Simulink diagram of system

When a fault is occurred, the current will increase and the voltage will decrease from this concept a fault and calculation algorithm were detected. The fault resistance is zero. From the shape of voltage wave, It is seen that it contain dc offset and harmonic content that should be removed from voltage wave.

The proposed distance relay in figure 1 was constructed from the filtering, zone detection, fault classification and time delaying box as be seen in figure 2.

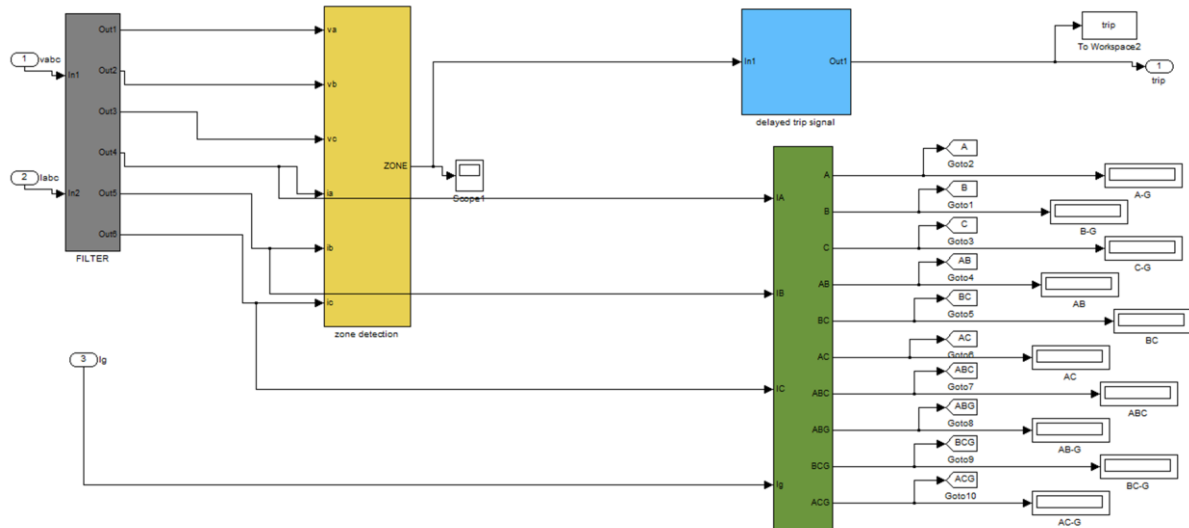


Figure 2. distance relay boxes

The filtering box contain discrete 2nd order filter of 50 HZ cut off frequency where the voltage and current are filtered to mitigate higher frequency as be seen in figure 3.

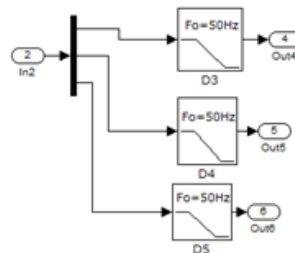


Figure 3. discrete filter

The output of the filter is passing to DFT to mitigate dc offset from the signal as be seen in figure 4.

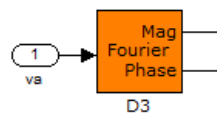


Figure 4. discrete Fourier transform

Fault zone detection contain three boxes to calculate the impedance for each fault type as be seen in figure 5.

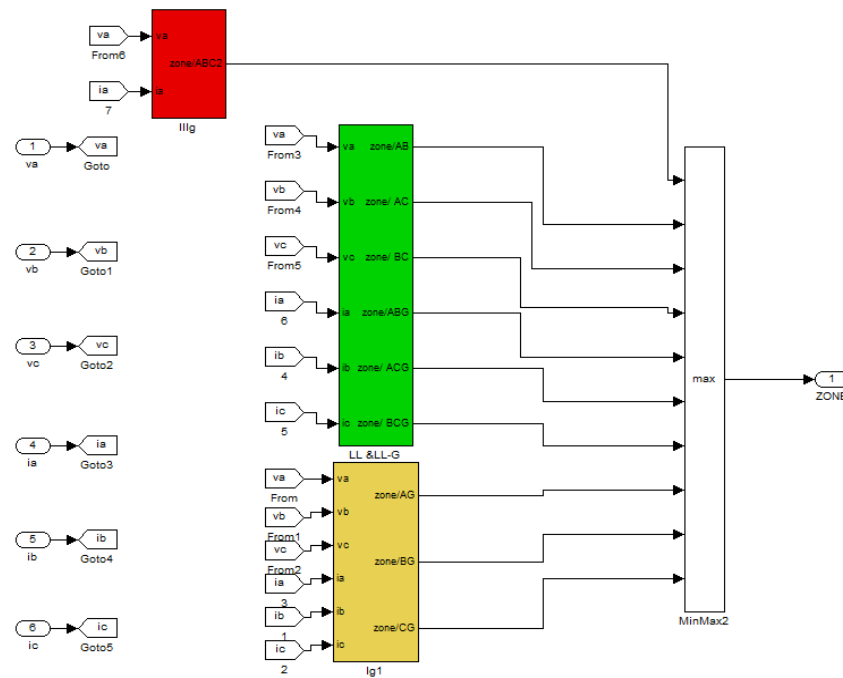


Figure 5. fault zone detection

In the box of (III-g fault), the zone decision is taken by using fuzzy logic controller as be seen in figure 6.

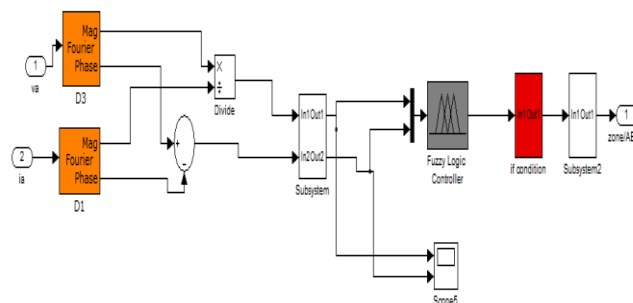
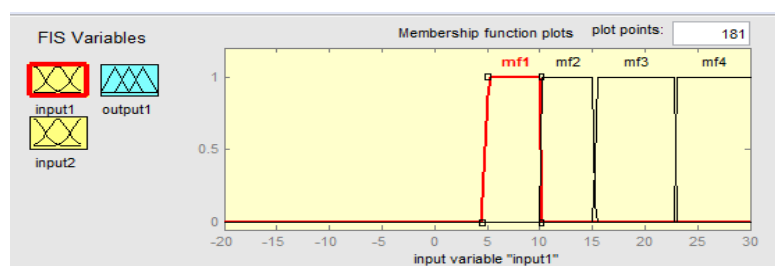


Figure 6. Three line to ground fault impedance

The membership function of fuzzy controller to decide the zone of three phases to ground fault be seen in figure 7.



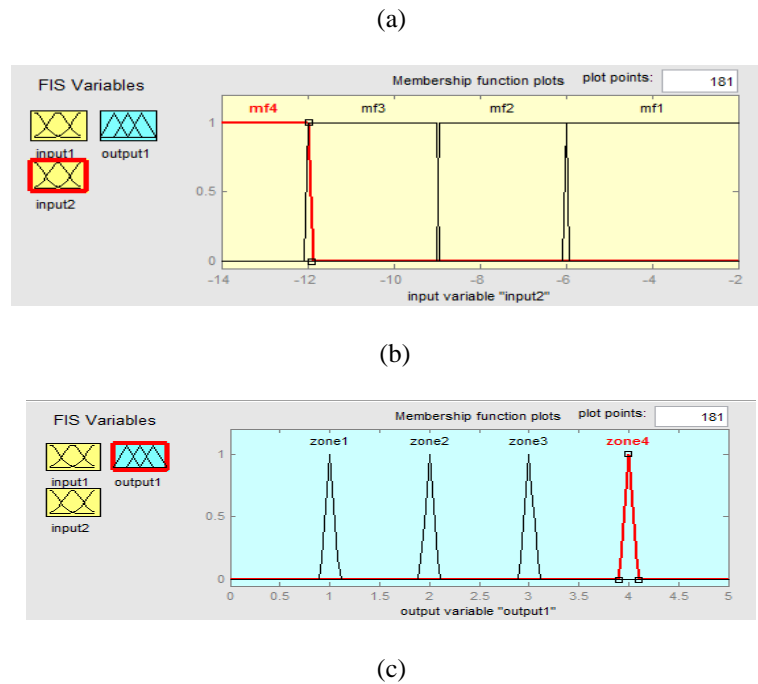


Figure 7. (a) real input membership function (b) imaginary input membership function (c) output membership function

In the box of (LL&LL-G), the zone decision is taken by using fuzzy logic controller be seen in figure 8.

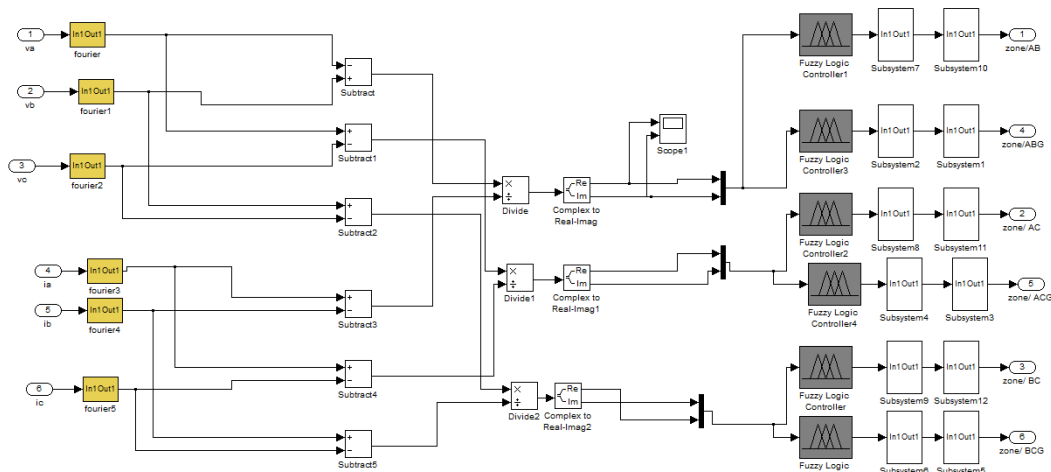


Figure 8. line to line& Double line to ground fault impedance

The membership function of fuzzy controller to decide the zone of line to line fault be seen in figure 9.

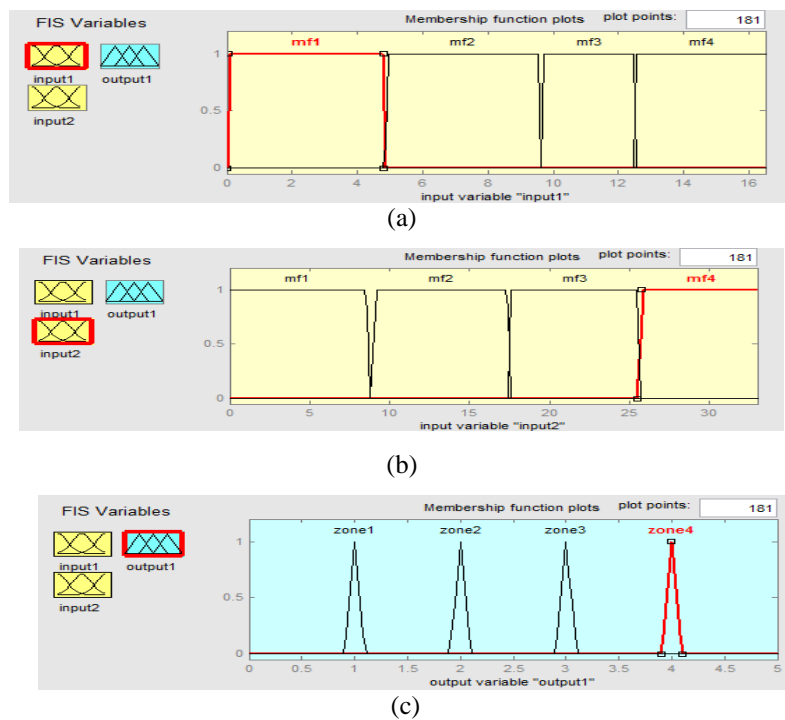


Figure 9. (a) real input membership function (b) imaginary input membership function (c) output membership function

The membership function of fuzzy controller to decide the zone of Double line to ground fault be seen in figure 10.

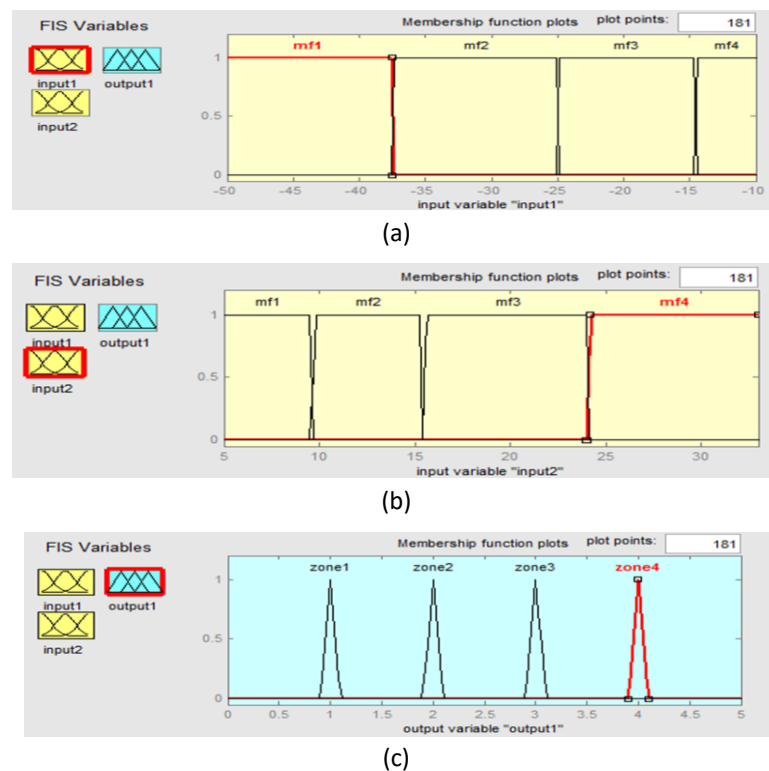


Figure 10. (a) real input membership function (b) imaginary input membership function (c) output membership function

In the box of (L-G fault), the zone decision is taken by using fuzzy logic controller be seen in figure (11). from the system data shown in appendix the values of K_0 , $Z_0 + 2Z_1$ were calculated as shown below.

$$X_{L0} = (2 * \pi * f * L) * 25 = 32.4 \text{ ohm}$$

$$X_{c0} = \frac{1}{(2 * \pi * f * L)} * 25 = 10266736 \text{ ohm}$$

$$X_{L1} = (2 * \pi * f * L) * 25 = 7.33 \text{ ohm}$$

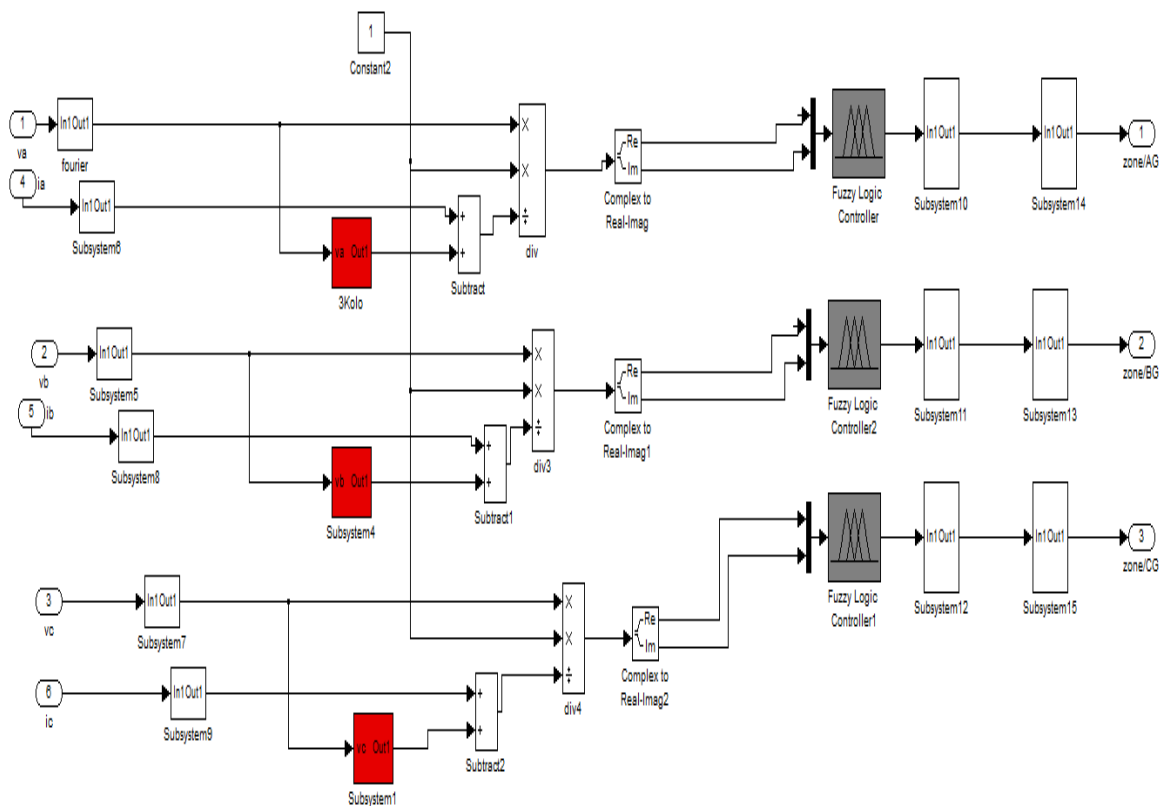
$$X_{c1} = \frac{1}{(2 * \pi * f * L)} * 25 = 6246269.3 \text{ ohm}$$

$$Z_0 = R_0 + j(X_{L0} - X_{c0}) = 10266703 \angle -1.57$$

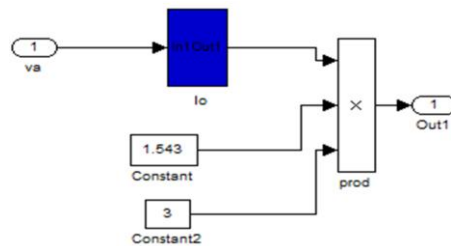
$$Z_1 = R_1 + j(X_{L1} - X_{c1}) = 6246261 \angle -1.57$$

$$K_0 = \frac{Z_0 - Z_1}{KZ_1}, K_0 = \frac{10266703 \angle -1.57 - 6246261 \angle -1.57}{6246261 \angle -1.57} = 1.543$$

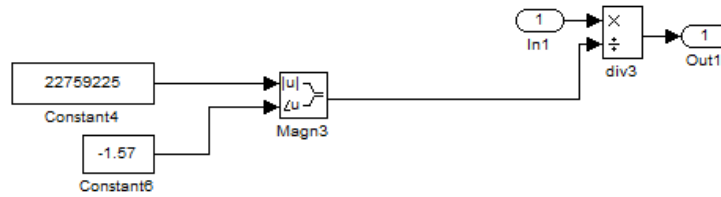
$$I_0 = \frac{V_a}{Z_0 + 2Z_1}, Z_0 + 2Z_1 = 10266703 \angle -1.57 + 2 * (6246261 \angle -1.57) = 22759225 \angle -1.57$$



(a)



(b)

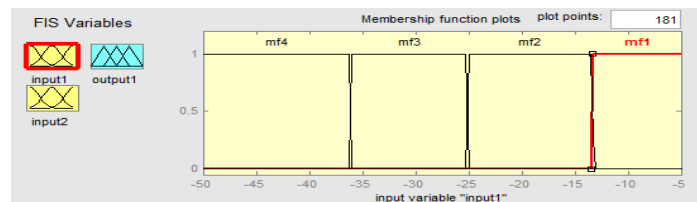


(c)

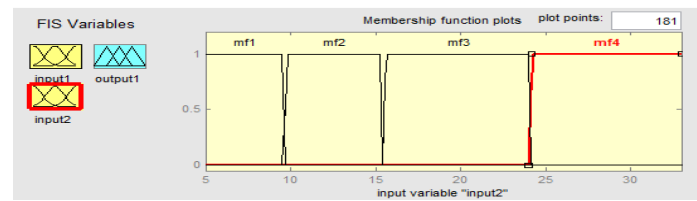
Figure 11. (a) Single line to ground fault impedance (b) $(3 * K0 * I0)$

$$(c) I0 = VS / (Z0 + 2 * Z1)$$

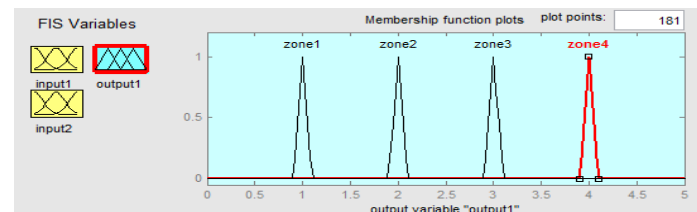
The membership function of fuzzy controller to decide the zone of Single line to ground fault impedance be seen in figure 12.



(a)



(b)



(c)

Figure 12. (a) real input membership function (b) imaginary input membership function (c) output membership function

The construction of fault type box be seen in figure (13-14)

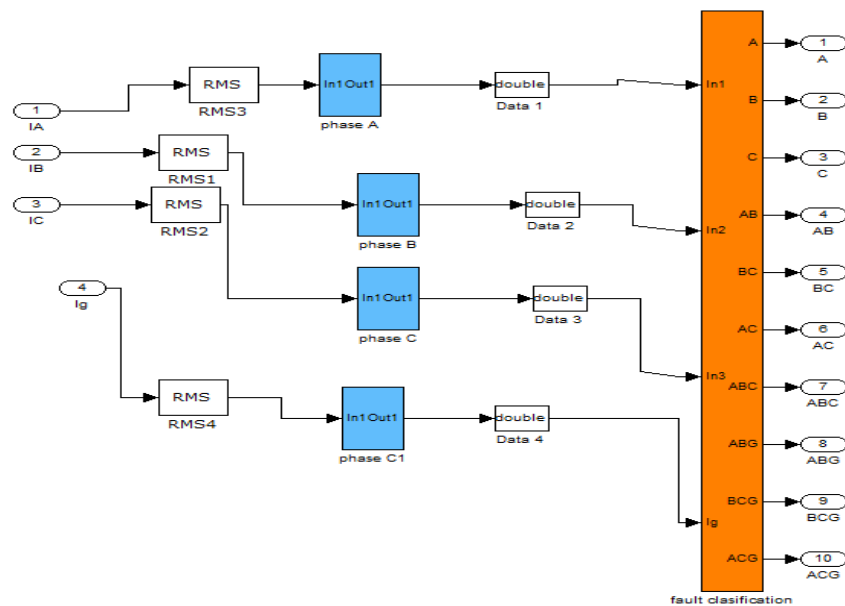


Figure 13. fault classification

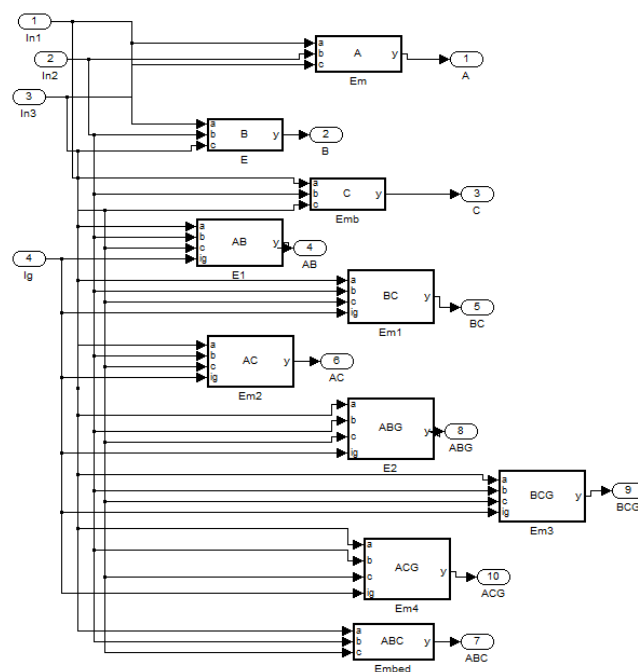


Figure 14. subsystem of fault classification

The construction of delaying trip signal box be seen in figure 15.

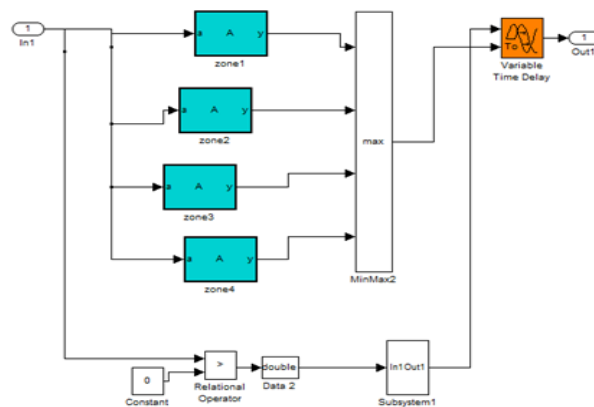
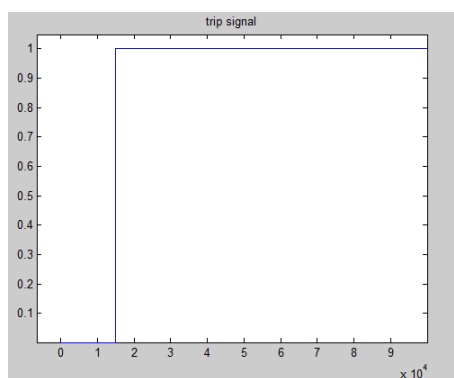


Figure 15. delaying trip signal blocks

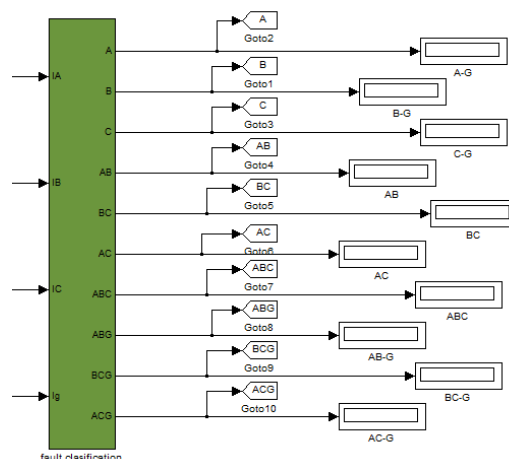
3.1 case study:

Case1:

when a three phase to ground fault at 0.1 sec and 25 km on the transmission line. The designed Delay time = 0 sec as be seen in figure 16 (a) And the Fault type is presented in figure 16 (b)



(a)



(b)

Figure 16. (a) trip signal (b) fault type

And the zone of the fault location is presented in figure 17.

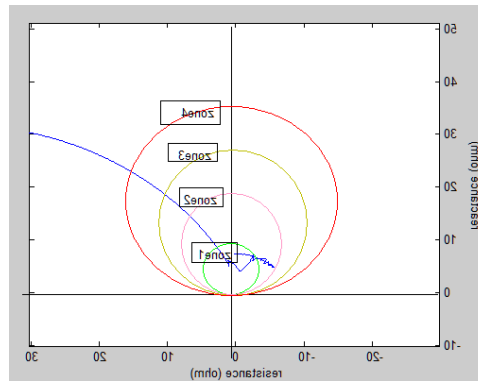
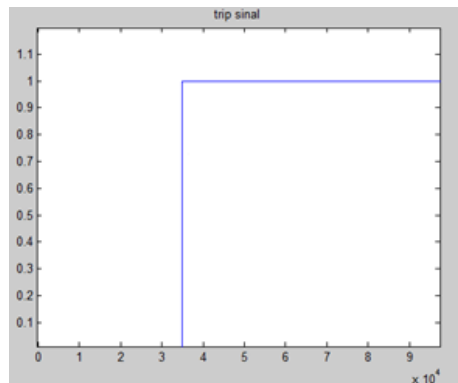


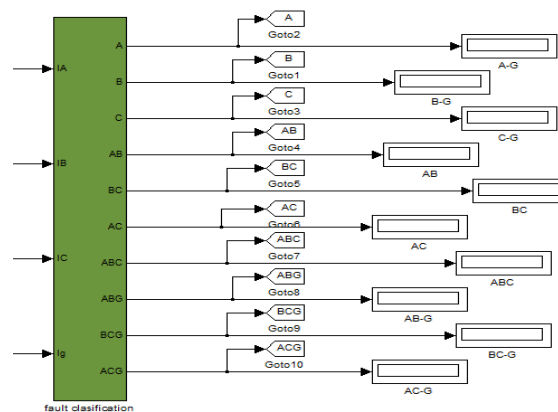
Figure 17. $(R - jX)$ plain

Case2:

when a three phase to ground fault at 0.1 sec at 50 km position on the transmission line, The designed Delay time = 0.2 sec as be seen in figure 18(a) and the fault type is presented in figure 18(b) .



(a)



(b)

Figure 18. (a) trip signal (b) fault type

And the zone of the fault location is presented in figure 19.

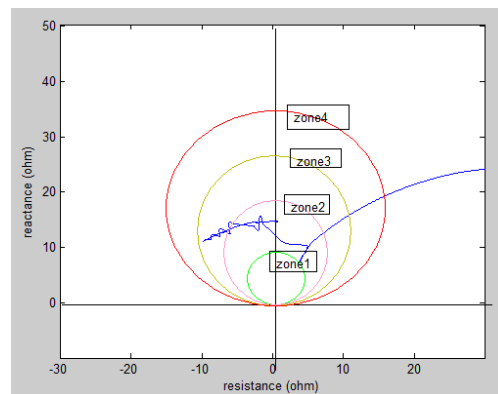
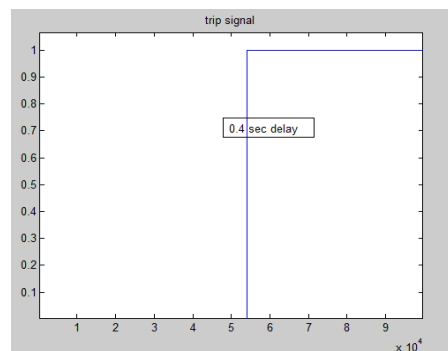


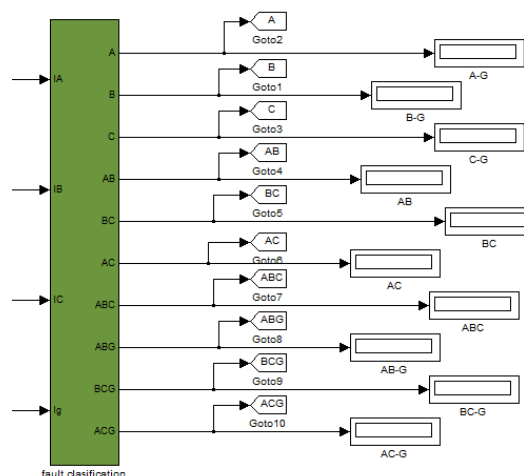
Figure 19. ($R - jX$) plain

Case3:

when a three phase to ground fault at 0.1 sec at 75 km position on the transmission line, The designed Delay time = 0.4 sec as be seen in figure 20(a) and the fault type is presented in figure 20(b).



(a)



(b)

Figure 20. (a) trip signal (b) fault type

And the zone of the fault location is presented in figure 21.

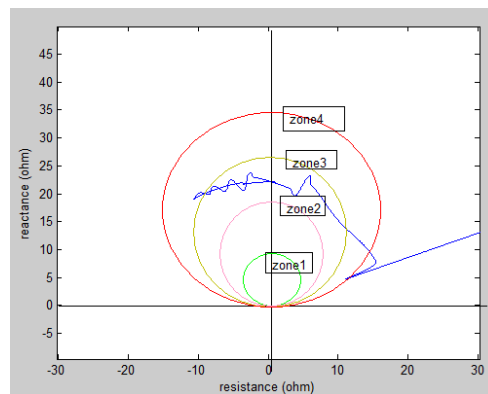
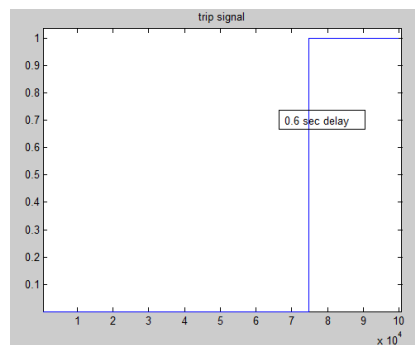


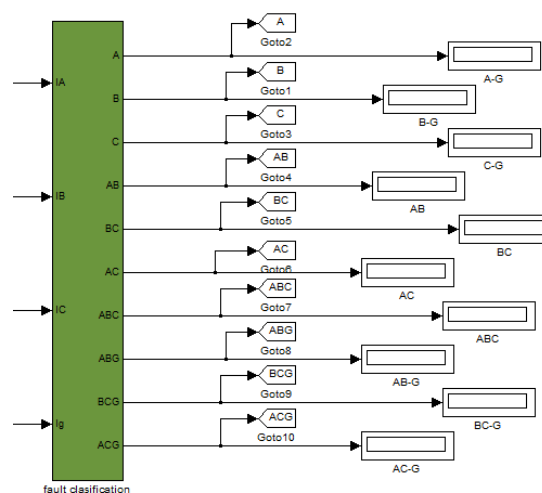
Figure 21. ($R - jX$) plain

Case4:

when a three phase to ground fault at 0.1 sec at 100 km position on the transmission line, The designed Delay time = 0.6 sec as be seen in figure 22(a) and the fault type is presented in figure 22(b) .



(a)



(b)

Figure 22. (a) trip signal (b) fault type

And the zone of the fault location is presented in figure 23.

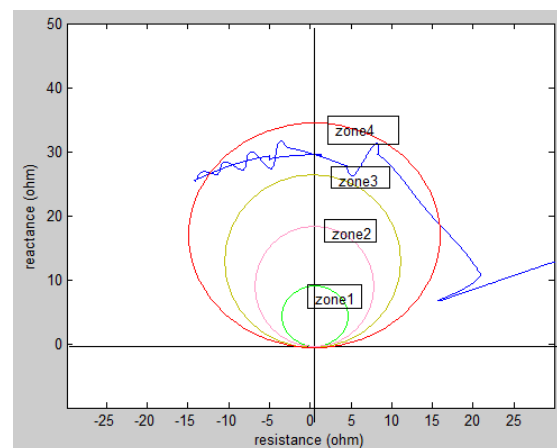


Figure 23. ($R - jX$) plain

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Appendix

overall system data

Generator = 13.8

Transformer1 = 15 MVA, 13.8 KV/115KV, step up, star-star

Transformer2 = 15 MVA, 115KV /13.8KV, step down, star-star

Load = 10 MW

Transmission line

Length = 100 KM

Frequency = 50 HZ

Positive and negative resistance = 0.01273 ohm/KM

Zero sequence resistance = 0.3868 ohm/KM

Positive and negative inductance = 0.0009337 H/KM

Zero sequence inductance = 0.0041264 H/KM

Positive and negative capacitance = 12.74×10^{-9} F/KM

Zero sequence capacitance = 7.751×10^{-9} F/KM