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SIMULATION AND ANALYSIS OF TRANSMISSION LINE FAULT DETECTION AND LOCATION USING FUZZY LOGIC

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ABSTRACT: Fault detection in transmission line is very necessary for regulating the power system. If fault occur on transmission then the system is distorted. At the condition many types of relay are also used for detecting and disconnect the transmission line from the system. Here the impedance relay are also detect the fault in transmission line and depending on the value of the impedance up to the fault location impedance relay disconnect the line with it connected zone. But this type of relay will require a large time. In this paper we design the fuzzy logic controlled for detection and location of overhead transmission line fault. A fuzzy logic based fault location model for power systems is developed and simulated in this paper. The proposed simulation model is compared with the classical regulating systems in order to verify and show the advantages of the model and controller developed. The design process of the proposed fuzzy logic controller is given in detail step by step to show a direct and simple approach for designing fuzzy logic controllers in power systems.

I. INTRODUCTION

Electrical power systems are more frequently operated close to their technical limits due to the increase of renewable energy systems and distributed generation. Therefore they become more prone to fault occurrences. Especially the medium voltage grid is affected since it experiences the most significant changes. Therefore fault detection; identification and localization are of great concern for the distribution grid operators. Fault identification and localization mainly includes the following aspects: type, direction, and distance. It is generally independent from protective relaying.

II. CLASSIFICATION OF FAULTS AND FAULT LOCATION TECHNIQUES

This chapter presents the basics of fault analysis and fault locators. Distance relays are analyzed with respect to their effectiveness in fault location detection and a comparison is made with conventional fault locators using numerical algorithms. A comprehensive review of all of the different methods of fault location on power systems is presented in this chapter. The advantages and disadvantages of each method of fault location detection and techniques for deriving them is discussed, as is the need for special measures to ensure the accuracy of the results obtained from the fault locators under certain network topologies or fault conditions.

Type of fault	Nature	Percentage occurrence
Single Line-to-ground–SLG	unbalanced	85%
Line-to-Line–LL	unbalanced	8%
Double Line-to-ground–LLG	unbalanced	5%
Triple Line–LLL	balanced	2%

Fault Analysis

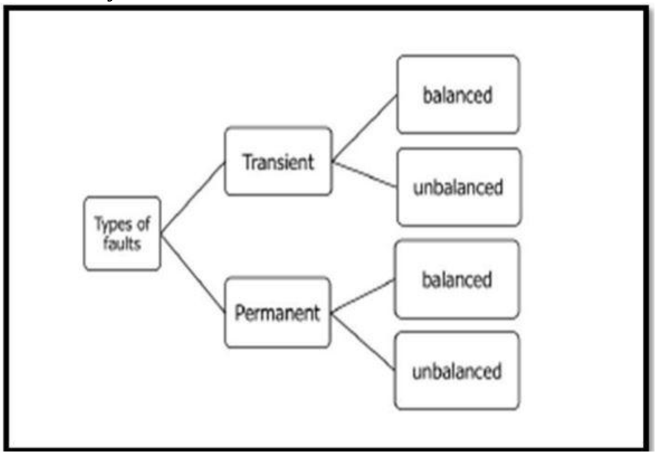


Figure Classification of fault types in electrical power systems

A symmetrical or balanced fault on a line affects each of its three phases equally. In transmission line faults, roughly 3-5% is symmetric in nature as seen in Table 2-1. This is in contrast to an asymmetrical or unbalanced fault, where the three phases are not affected equally. Common types of asymmetric faults and their causes are:

• Line-to-ground fault (Figure 2.2) - a short circuit between one line and ground, often caused by physical contact, for example due to lightning or other storm damage.

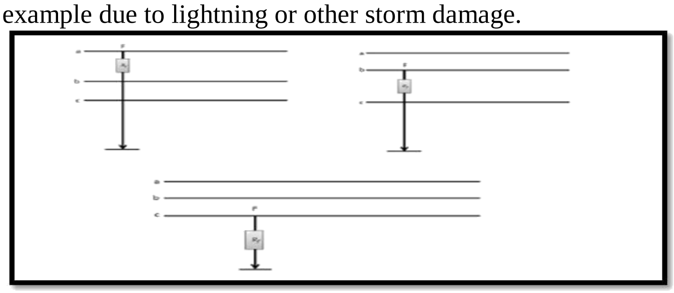


Figure Single line to ground Fault

• Line-to-line fault (Figure 2.3) - a short circuit between lines, caused by ionization of air, or when lines come into physical contact, for example due to a broken insulator.

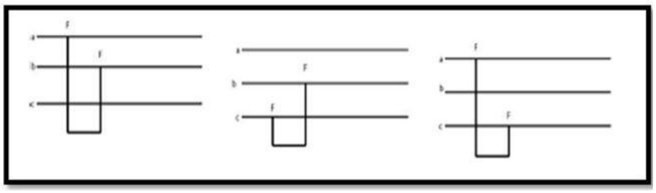


Figure Line to Line Fault

• Double line-to-ground fault (Figure 2.4) - two lines come into contact with the ground and each other, commonly due to storm damage.

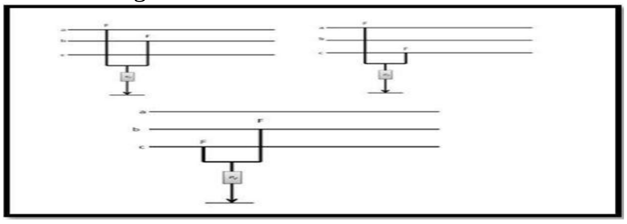


Figure Double line to ground Fault

III. FAULT LOCATION ALGORITHMS

Traditional line fault detection used to heavily rely on visual inspections of the faulted line parts resulting in long and tedious foot or aerial patrols. These methods were expensive and prone to more errors. Thus, the shift to automatic fault locators was not only desired, but also natural.

Fault location techniques can be generally classified into the following main categories:

- based on fundamental-frequency currents and voltages, mainly on impedance measurement
- based on travelling wave phenomenon
- knowledge-based approaches
- based on high-frequency components of currents and voltages generated by faults

The most widely used FLAs can be split into two main groups: impedance based and travelling wave based. Impedance-based algorithms make use of the line parameters (such as resistance, inductance and conductance per unit length, and the line length) as well as voltage and current data from one or more line terminals to calculate the distance to the fault from a reference point or line terminal. Travelling-wave based algorithms utilize the theory that waves travel along a line from a fault at the speed of light to calculate the distance to a fault from a reference point and timing wave reaching the line terminal. More details on the types of fault location detection techniques are presented in the subsequent sections.

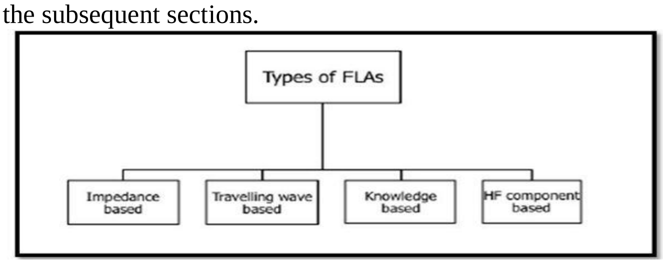


Figure: Types of Fault Location Algorithms

Impedance based Algorithms

Impedance based FLAs calculate fault distance using the per unit length impedance of the line, voltage and current data, and circuit analysis techniques, such as Kirchhoff's voltage and current laws. Single-terminal and two-terminal algorithms are the two main groups of impedance based FLAs. Single-terminal FLA (STFLA), often cited as the first and earliest class of FLA use voltage and current data from one end of the transmission line only. They determine the fault distance by calculating the impedance of the transmission line as seen from one line terminal and then using the line parameters to convert that value into a distance measurement.

Travelling Wave based Fault Location Algorithms

Travelling-waves occur after faults, switching, or lightning strikes. When a fault occurs along a transmission line, the voltage and current transients will travel towards the line terminals. By wave reflection theory, these transients will continue to bounce back and forth between the fault point and the two terminals for the faulted line until the post fault steady state is reached.

Since the travelling-waves move along the transmission line at the speed of light, by accurately measuring the time taken for the travelling-wave to propagate to the line terminals, the distance to the fault can be effectively found. An advantage of this method over impedance-based techniques is persistence to pre-fault line loading, fault and grounding resistance. Disadvantage of Travelling-wave Fault Location Algorithms (TWFLAs) is that they cannot be used on transmission corridors consisting of overhead lines and underground cables as the surge impedance changes drastically between them, resulting in large inaccuracies in the location of the fault.

Knowledge based Fault Location Algorithms

Uncertainty of line parameter affecting variables, such as length of cables and unknown fault resistance, coupled with the complex structure of distribution management systems tends to make fault location through impedance and travelling wave techniques inaccurate. As a result of this, knowledge-based technique for locating faults has receiving attention from researchers in the last few years. In general, the technique requires information such as substation and distribution switch status, line measurements, atmospheric conditions, and information provided by fault detection devices installed along the distribution feeders. This information is analyzed using artificial intelligence methods to locate a fault.

High Frequency component based Fault Location Algorithms

High-frequency transient signals generated in the range of Hz to kHz due to fault conditions can be applied to achieve high accuracy in fault location as shown in the work established in reference papers. This method of fault location detection, based on the high frequency voltage and current components, has been shown to be immune to power frequency phenomena such as power swings and current transformer saturations. This method mainly uses the fault-generated high-frequency signals, negating the problem of identifying multiple reflections of the travelling wave from bus-bars and the fault point, as is seen in the travelling wave based FLAs Problems associated with fault-inception angle are addressed as the high-frequency signals associated with the fault arc do not vary with the point on the wave at which the fault occurs.

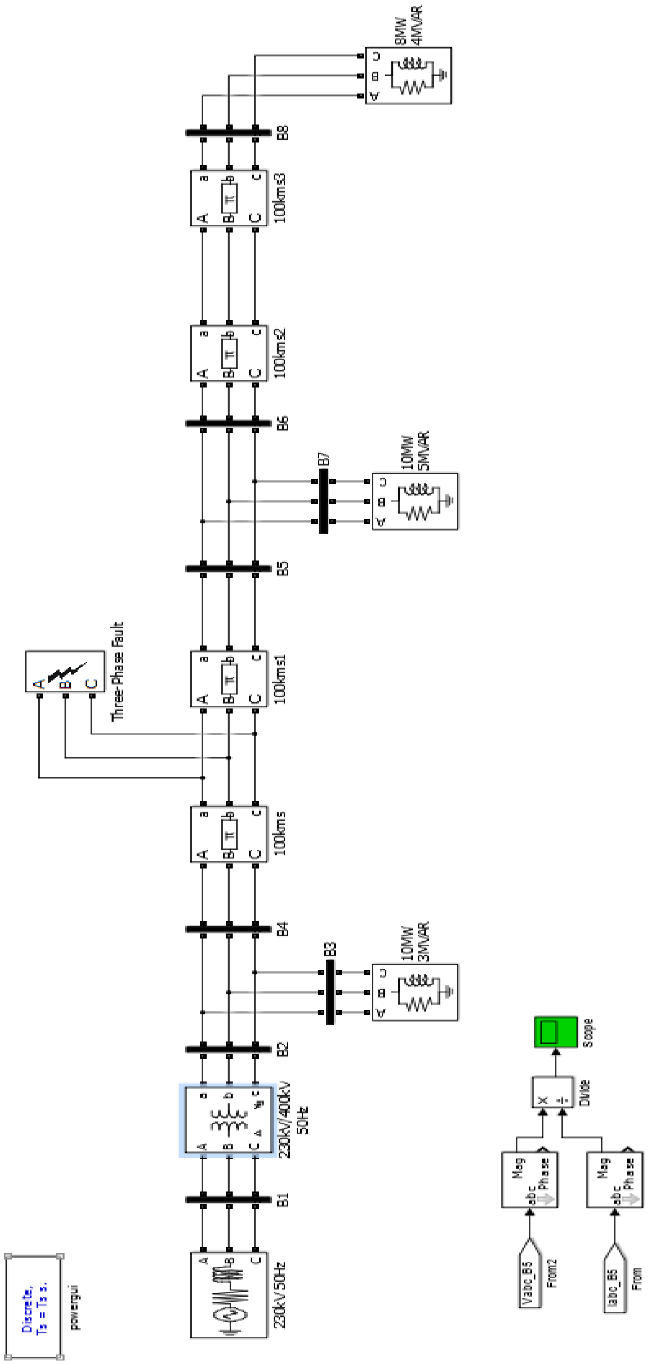
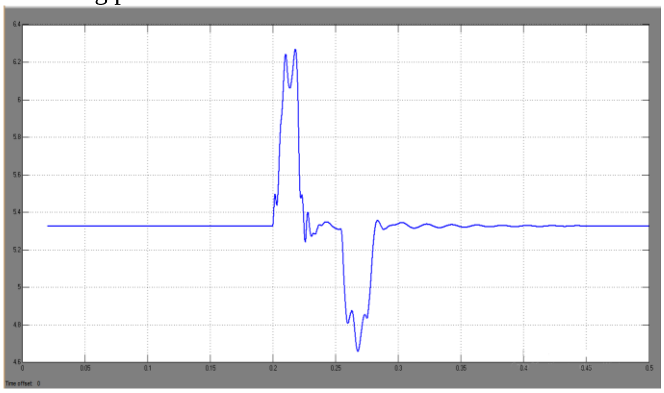


Figure: Simulation Model of 4oo KV, 400 Km Transmission Line

Waveform For Different Fault:

[1] Single Line to Ground Fault for Phase A:

When we create the single line to ground fault on Phase A from the 100km from the generating source by a fault creator the graph also show below. Here the fault voltage is increased up to 6.28 per unit in positive as well as negative direction. As same we have also create the waveform for remaining phases.



Figure=Waveform of Phase A-G Fault.

[2] Double Line to Ground Fault between Phase A and B:

By creating the double line to ground fault Between Phase A and Phase B, 100km from the source .We have see the graph. When the fault is creating the voltage magnitude from bus 5 is increase to 7.5per unit and decrease to 3.8 per unit. Here we can also obtain the output waveform for remaining phase as for Phase C consider.

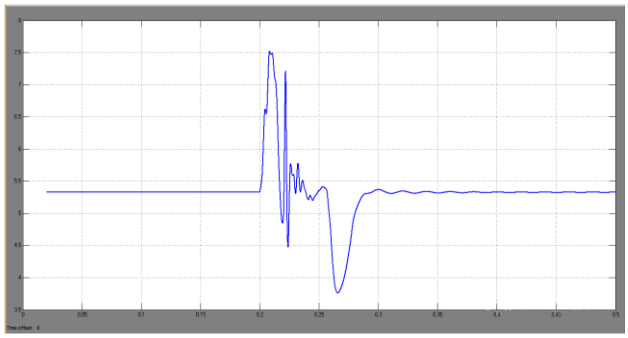


Figure: Waveform for Double Line to Ground Fault Between Phase A-B-G

[3] Line to Line Fault between Phase A and B:

Here By creating a line To line fault between Phase A and Phase B, from the 100km, the Graph will also show. When the Fault is creating the Voltage magnitude is also obtain from bus 5 the fault Voltage is Increased up to 6.6 in per unit and decreased to 4.52 per unit. Here We Can Also obtain the output waveform For the Reaming Conductor as C Phase.

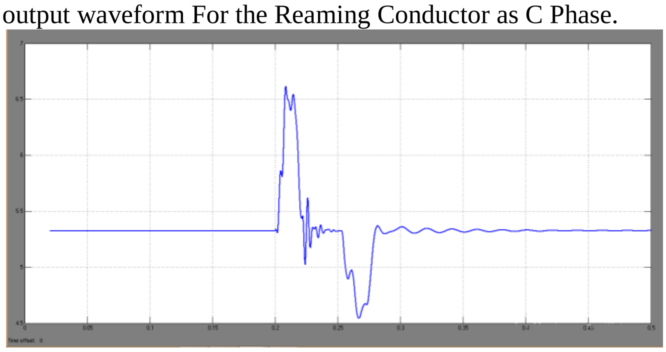


Figure: Waveform for Line to Line Fault Between Phase A-B

[4] Symmetrical Fault:
Here we have also see that the output waveform for unsymmetrical fault. But now, we see that the symmetrical fault between the all the Phases. By creating the fault on the transmission line the fault voltage is increased up to 10.8 per unit and decreased to 0.8 per unit.

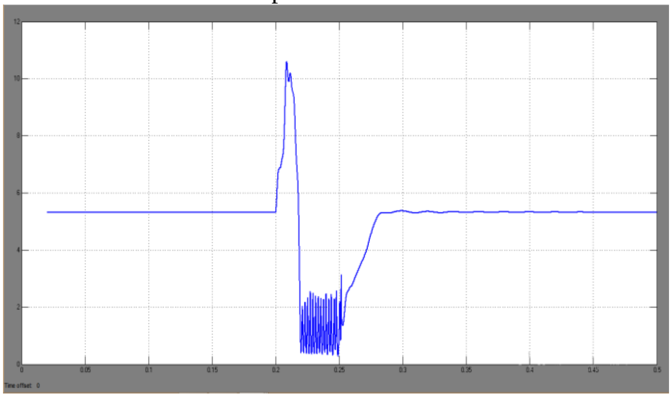


Figure: 2 Waveform For Symmetrical Fault

IV. FAULT LOCATION USING FUZZY LOGIC

The forecasting of future loads for a relatively large lead time (months to few years) is studied in long term load forecasting. Future load demand estimation is done for different lead times, ranging from few seconds to years. These different lead times are called forecasting intervals. Overestimation of the future load may lead to financial crisis, as more money will be spent on new building. Underestimation of load may cause troubles in supplying this load from the available electric supplies. There will be shortage in the spinning reserve of the system, and it may lead to a system which is insecure and unreliable system. Not much work is done on the long-term load forecasting, because years of economic and demographic data is required and it not be easy to gather data for so many years. Even if we collect data, this forecasting is complex in the sense that it is affected by environmental, economical, and social factors.

Fuzzy Interface System (FIS) Editor:

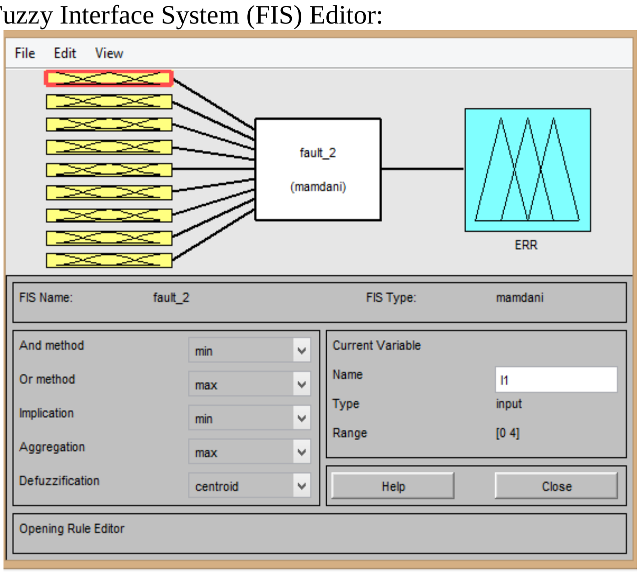


Figure: FIS Editor

Here total nine input variable and one output variable. This FIS system is also based on MAMDANI type. The maximum and minimum Value of each input variable is also show in Figure. Input variable are: I1, I2, I3, I0, V1, V2, V3, V0 and Total Harmonic Distortion.

3.2.2 The Membership Function for All Input and Output Variable

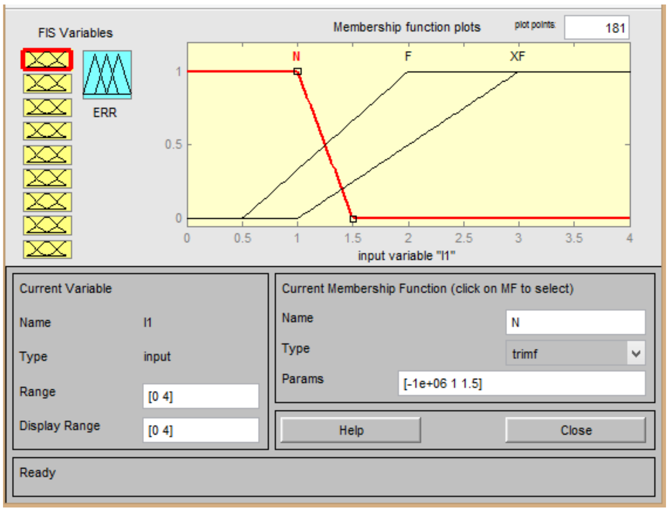


Figure: Membership Function For Input Variable I_1.

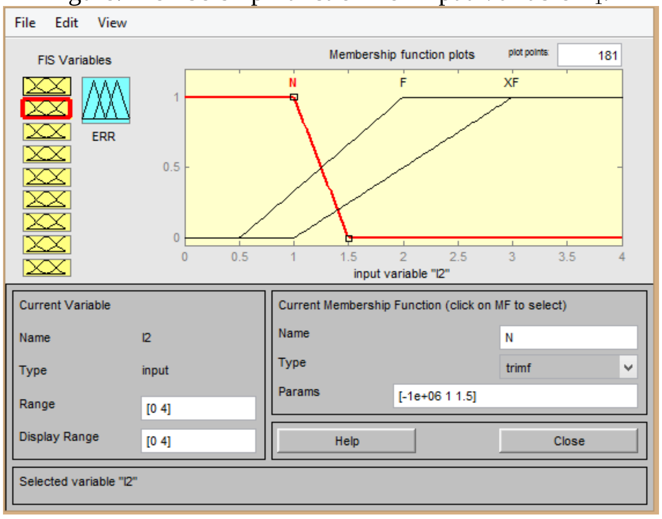


Figure: Membership Function For Input Variable I_2.

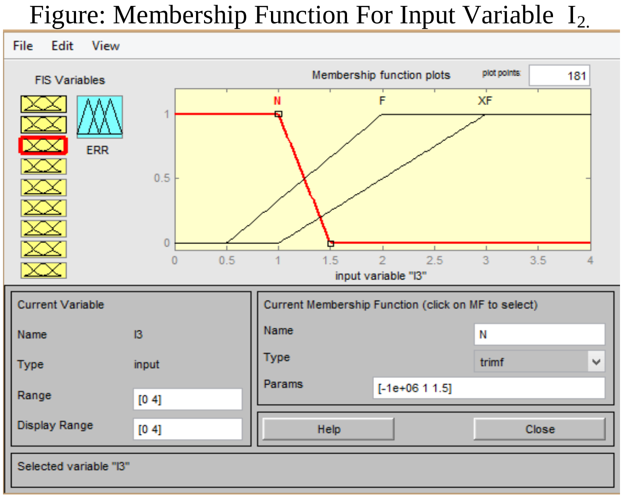


Figure: Membership Function For Input Variable I3.

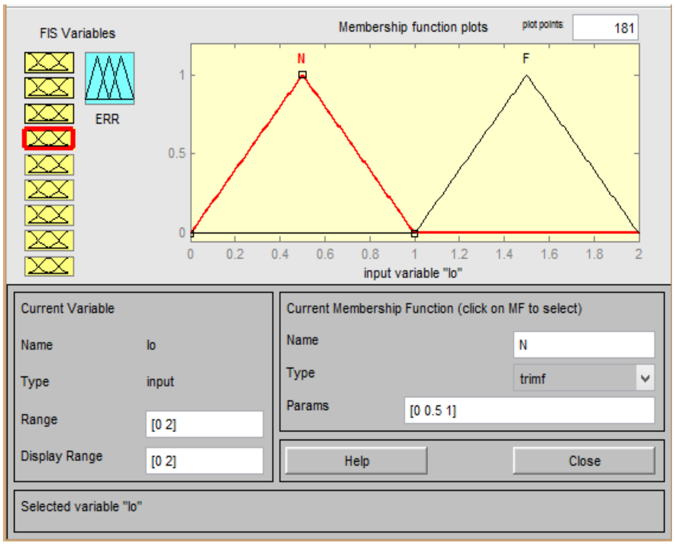


Figure: Membership Function For Input Variable I_0.

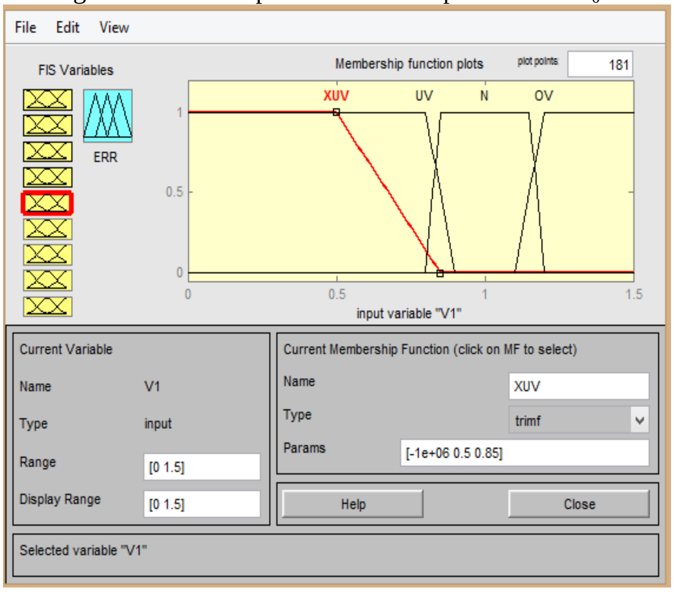


Figure: Membership Function For Input Variable V_1

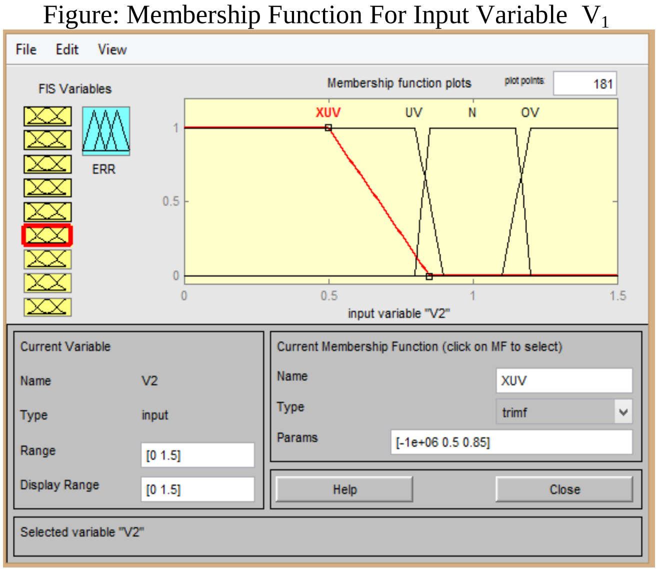


Figure: Membership Function For Input Variable V_2.

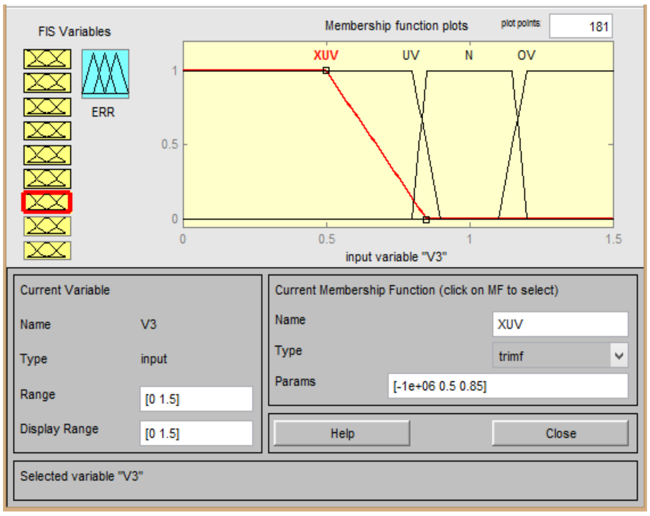


Figure: Membership Function For Input Variable V3.

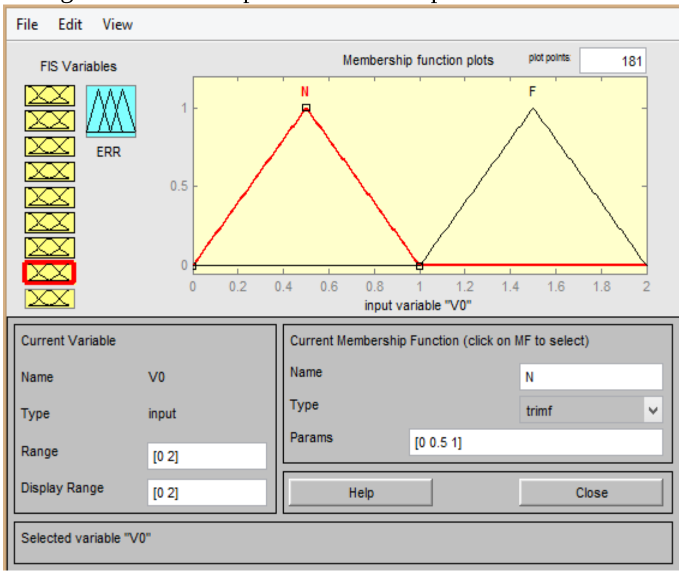


Figure: Membership Function For Input Variable V4.

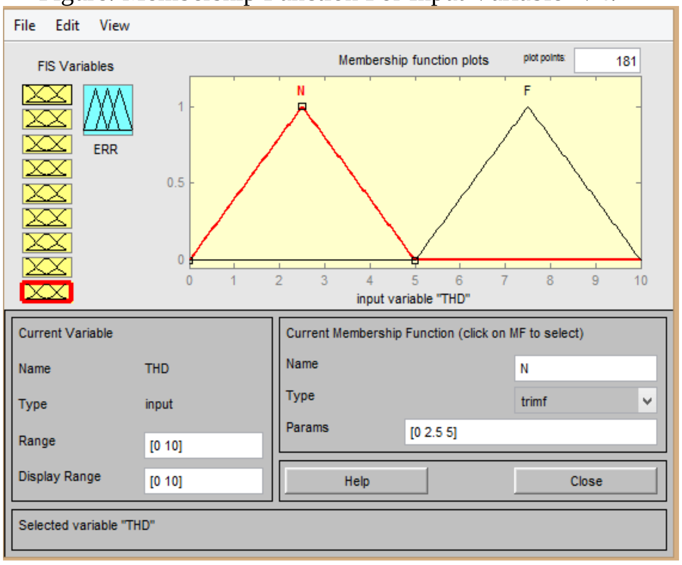


Figure: Membership Function For Input Variable THD.

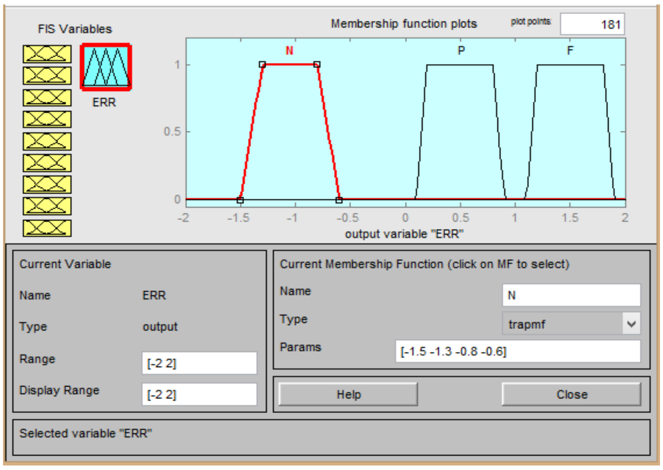


Figure: Membership Function For Input Variable ERR.

3.2.3 Rules for Fuzzy Interface System

Here, Total 26 rule viewer are also used for fuzzy interface system. according to each RMS value of voltage and RMS value of current and also a total harmonic distortion for line current are additional input variable. The upper rule N define by N=normal operation condition and corresponding the value of -1 on the fault credibility scale. For each fault type there are at least two rules. The one symbolist define with P, is roughly define as indicate potentially a fault corresponding to F, is devein the rule more precisely and can lead up to a value of 1. It is also possible to define multiple rule for the same fault type. A group for rule related to a certain fault type is called rule composition in the following.

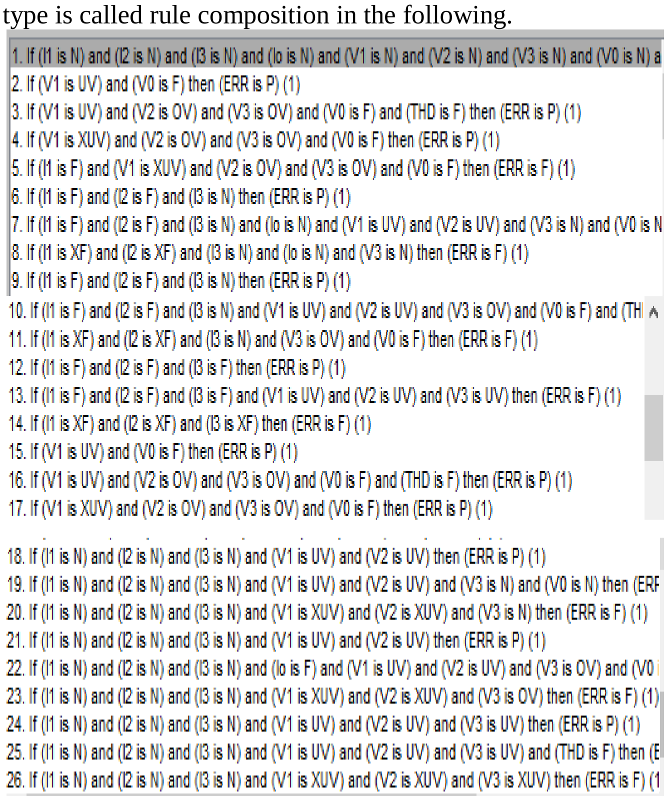

1. If (I1 is N) and (I2 is N) and (I3 is N) and (Io is N) and (V1 is N) and (V2 is N) and (V3 is N) and (V0 is N) a
2. If (V1 is UV) and (V0 is F) then (ERR is P) (1)
3. If (V1 is UV) and (V2 is OV) and (V3 is OV) and (V0 is F) and (THD is F) then (ERR is P) (1)
4. If (V1 is XUV) and (V2 is OV) and (V3 is OV) and (V0 is F) then (ERR is P) (1)
5. If (I1 is F) and (V1 is XUV) and (V2 is OV) and (V3 is OV) and (V0 is F) then (ERR is F) (1)
6. If (I1 is F) and (I2 is F) and (I3 is N) then (ERR is P) (1)
7. If (I1 is F) and (I2 is F) and (I3 is N) and (Io is N) and (V1 is UV) and (V2 is UV) and (V3 is N) and (V0 is N
8. If (I1 is XF) and (I2 is XF) and (I3 is N) and (Io is N) and (V3 is N) then (ERR is F) (1)
9. If (I1 is F) and (I2 is F) and (I3 is N) then (ERR is P) (1)
10. If (I1 is F) and (I2 is F) and (I3 is N) and (V1 is UV) and (V2 is UV) and (V3 is OV) and (V0 is F) and (TH
11. If (I1 is XF) and (I2 is XF) and (I3 is N) and (V3 is OV) and (V0 is F) then (ERR is F) (1)
12. If (I1 is F) and (I2 is F) and (I3 is F) then (ERR is P) (1)
13. If (I1 is F) and (I2 is F) and (I3 is F) and (V1 is UV) and (V2 is UV) and (V3 is UV) then (ERR is F) (1)
14. If (I1 is XF) and (I2 is XF) and (I3 is XF) then (ERR is F) (1)
15. If (V1 is UV) and (V0 is F) then (ERR is P) (1)
16. If (V1 is UV) and (V2 is OV) and (V3 is OV) and (V0 is F) and (THD is F) then (ERR is P) (1)
17. If (V1 is XUV) and (V2 is OV) and (V3 is OV) and (V0 is F) then (ERR is P) (1)
18. If (I1 is N) and (I2 is N) and (I3 is N) and (V1 is UV) and (V2 is UV) then (ERR is P) (1)
19. If (I1 is N) and (I2 is N) and (I3 is N) and (V1 is UV) and (V2 is UV) and (V3 is N) and (V0 is N) then (ERR
20. If (I1 is N) and (I2 is N) and (I3 is N) and (V1 is XUV) and (V2 is XUV) and (V3 is N) then (ERR is F) (1)
21. If (I1 is N) and (I2 is N) and (I3 is N) and (V1 is UV) and (V2 is UV) then (ERR is P) (1)
22. If (I1 is N) and (I2 is N) and (I3 is N) and (Io is F) and (V1 is UV) and (V2 is UV) and (V3 is OV) and (V0
23. If (I1 is N) and (I2 is N) and (I3 is N) and (V1 is XUV) and (V2 is XUV) and (V3 is OV) then (ERR is F) (1)
24. If (I1 is N) and (I2 is N) and (I3 is N) and (V1 is UV) and (V2 is UV) and (V3 is UV) then (ERR is P) (1)
25. If (I1 is N) and (I2 is N) and (I3 is N) and (V1 is UV) and (V2 is UV) and (V3 is UV) and (THD is F) then (E
26. If (I1 is N) and (I2 is N) and (I3 is N) and (V1 is XUV) and (V2 is XUV) and (V3 is XUV) then (ERR is F) (1

Figure: FIS Rules

3.3 Simulation Model:

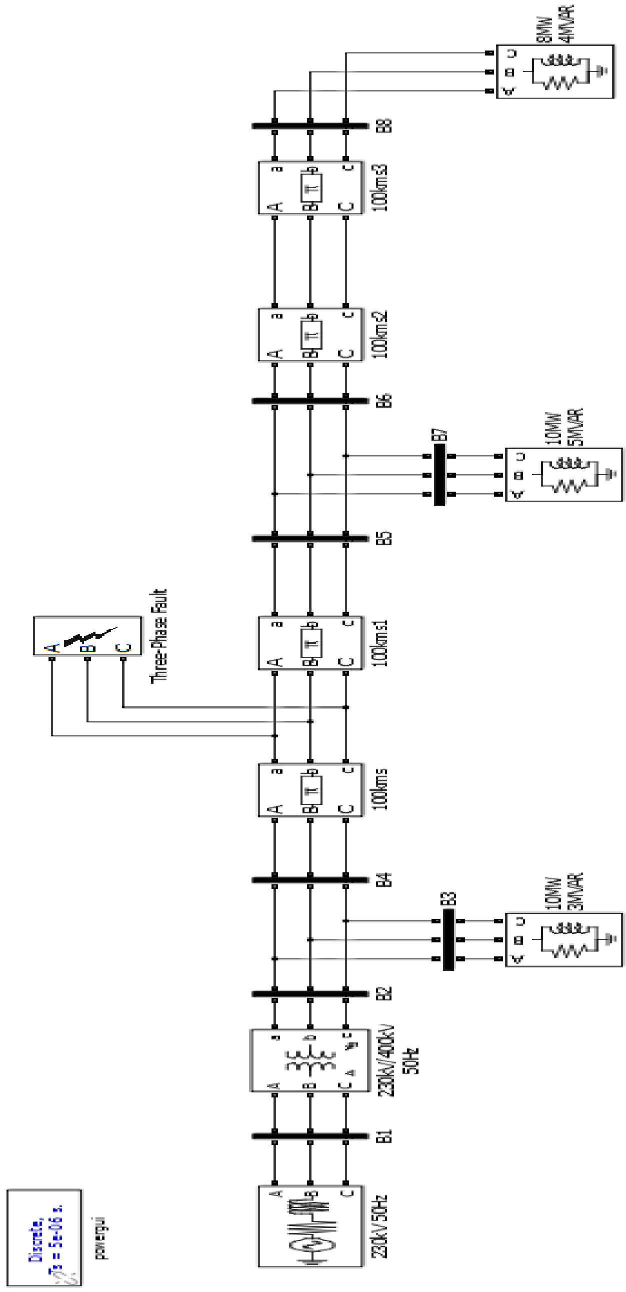
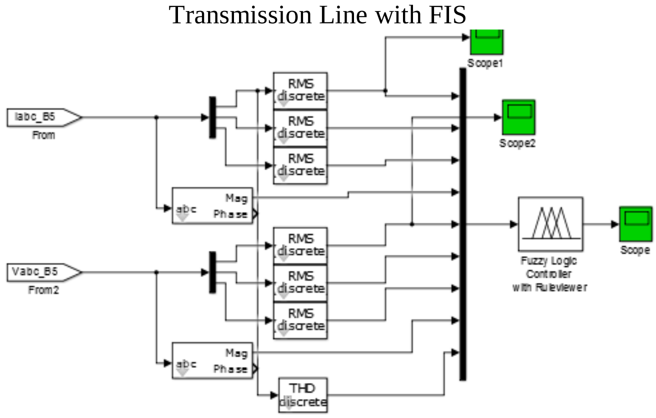


Figure: 3.17: Simulation Model of 4oo KV, 400 Km Transmission Line with FIS



The Fuzzy logic controller circuit is same also conventional impedance method were input as a fuzzy logic controller are voltage and current from the bus number 5.Were the magnitude and phase angle are also calculated. Those value are also added to fuzzy logic controller rule viewer and obtain result of all type fault.

3.2.4 Result for Symmetrical and Unsymmetrical Fault for FIS

[1] Waveform for Single Line to Ground Fault (A-G)

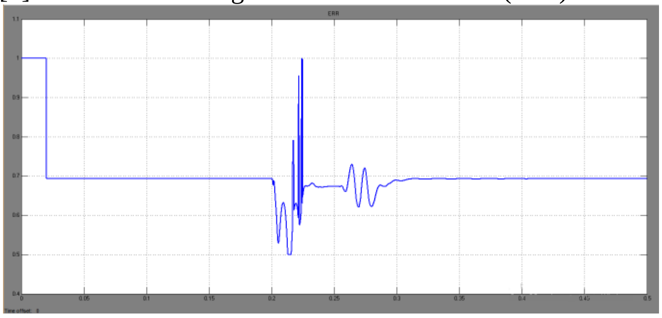


Figure: 3.18: Output for single line to ground fault (A-G)

[2] Waveform for Double Line to Ground Fault (A-B-G)

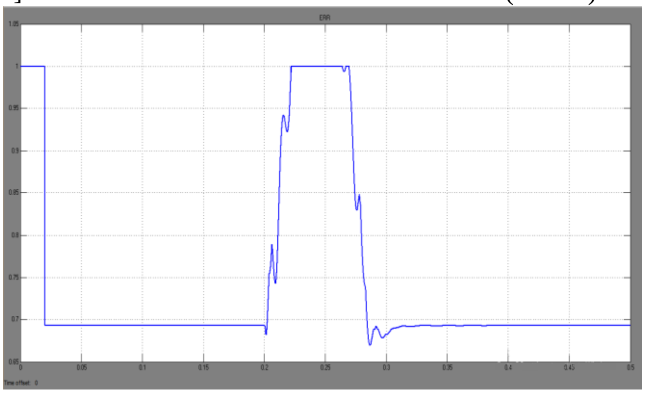


Figure: 3.19: Output for Double line to ground fault (A-B-G)

[3] Waveform for Line to line Fault (A-B)

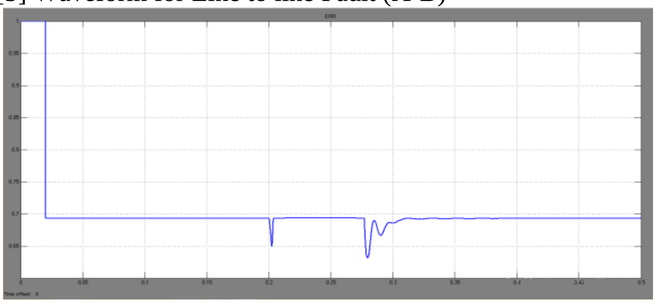


Figure: 3.20: Output For Line-Line Fault (A-B)

[4] Waveform for symmetrical Fault:

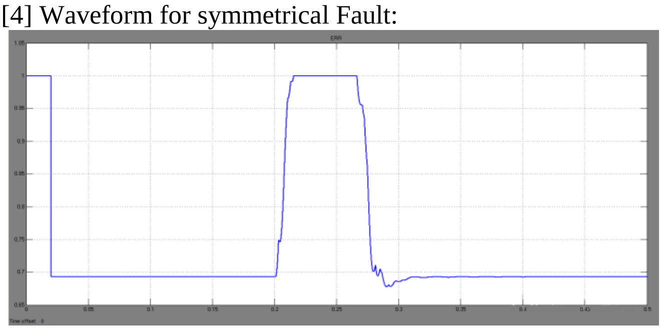


Figure: 3.21: Output For Symmetrical Fault (A-B-C)

V. SUMMARY AND RESULT ANALYSIS

Here, we have also obtained the result by creating the different fault on the overhead transmission line conductor. Here,From the fuzzy output fro a single line to ground fault the fault voltage is increased up to 1 per unit and decreased to0.5 per unit. For double line to ground fault the fault voltage is increase to 1 per unit and decreed to 0.68 per unit. For line to line fault the fault voltage is increased to 1 per unit and decreed to 0.63 per unit. And for a symmetrical fault the fault voltage is increased to 1 per unit to 0.68 per unit. All the result are un microsecond. And to compare those result to reality switchyard system the we also used the conventional impedance method to compare the result. the result obtain by those method are also show. Here fuzzy logic network can be used as a benchmark system and by comparing the result obtain by the fuzzy logic to a conventional impedance method to locate the location of fault on the 400km long transmission line.

VI. CONCLUSION

I used MATLAB software for analysis and design of Detection and Identification and Location of fault by impedance method. Considering the best features of MATLAB software I use 400km transmission line with one source and three load system in simulink model. Considering the protection of transmission line time is very important for Detecting, Identifying and Locating of fault, I concluded from this work that conventional Impedance method is requires more time for detecting and location of fault on transmission line. Using Fuzzy Logic with best membership functions Detection and Identification and Location of fault give better result with less time than conventional method.

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