COMPARATIVE ANALYSIS OF FAULT IDENTIFIACTION METHODS USING MATLAB/SIMULINK

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ABSTRACT

A methodology is presented to detect high- impedance faults in radial distribution feeders by means of fault identification methods reasoning. The proposed technique is based on the analysis of the feeder responses to impulse waves which are periodically injected at the feeder inlet. Secondary substations are usually equipped with short-circuit detectors only indicating that an over-current has occurred for a given line. In case of a fault, further information about type and location is required to recover an assured grid operation as fast as possible. Conventional algorithms for fault detection used in high voltage grids are not well suited because of the high uncertainties regarding current and voltage measurement in secondary substations.

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. The purpose is not to protect assets through a short-term generation of a trip signal to de energize a faulted section as fast as possible. The objective is to supply the grid operator with information about the fault prior to an on-site investigation. Transmission lines are most prone to occurrence of fault. Fault detection, direction estimation and faulty phase selection play a critical role in the protection for a transmission line. Accurate and fast fault detection and classification under a variety of fault conditions are important requirements of any protective relaying scheme. Fault identification and localization mainly includes the following aspects: type, direction, and distance. It is generally independent from protective relaying. The purpose is not to protect assets through a short-term generation of a trip signal to de-energize a faulted section as fast as possible. The objective is to supply the grid operator with information about the fault prior to an on-site investigation.

Secondary substations are often equipped with short-circuit detectors only indicating that a fault has occurred for the given line since reset. In case of a fault the operator will check these indications to identify and locate the fault, but any further information as well as a timeline of the events are not available.

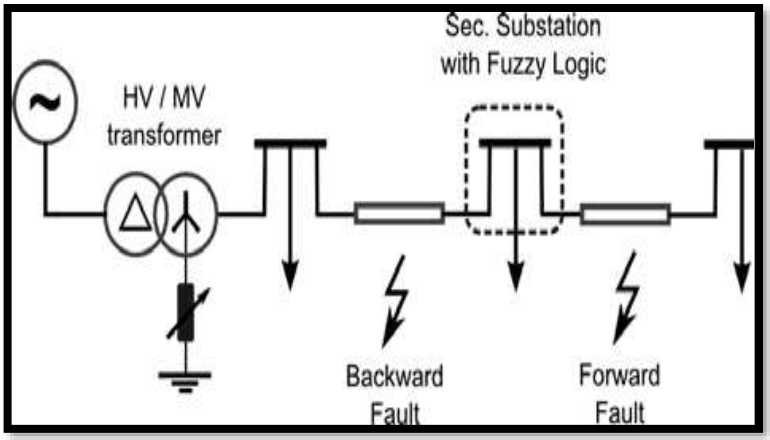


Fig: Scheme of a radial medium voltage feeder with the proposed fuzzy logic to detect fault type and direction

II. FAULT LOCATION TECHNIQUES

This section 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.

Fault Analysis

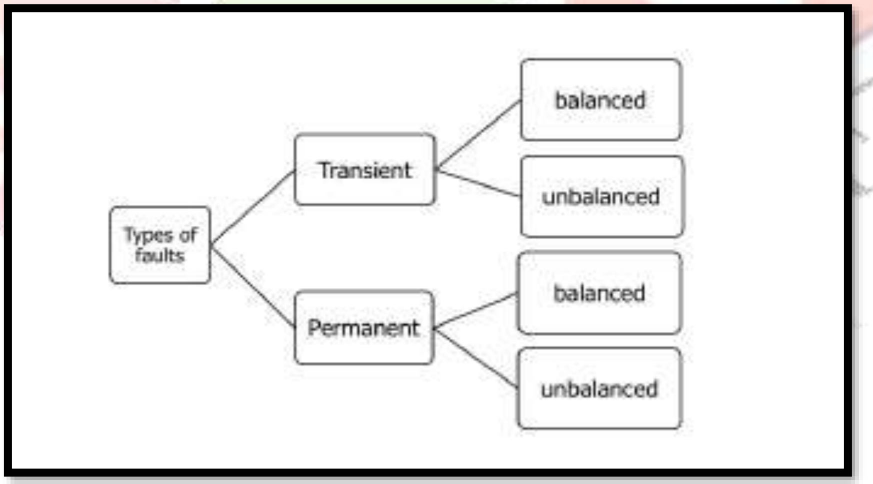
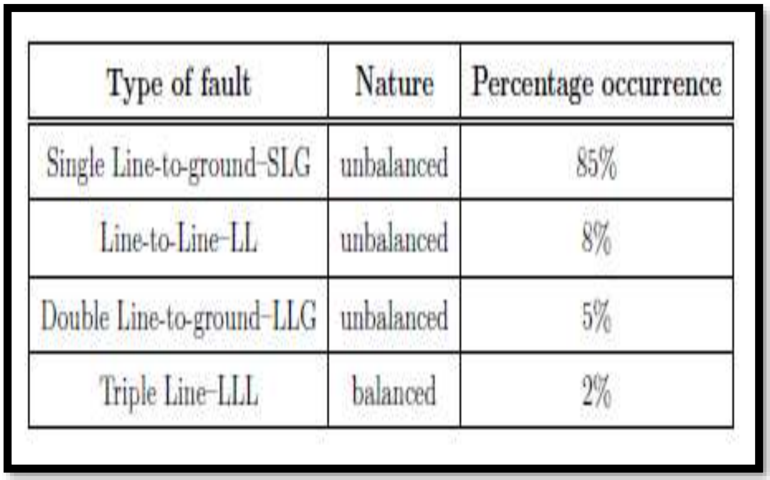


Figure: Classification of fault types in electrical power systems

A fault is an interruption to the normal flow of current in a circuit. Large currents flow across the lines in a faulted condition, which results not only in financial losses to the suppliers and inconvenience to the customers, but also in severe cases, a complete shutdown of the grid supply. According to the Nordic Grid report of the year 2013 and the data presented in IEEE journal, the most common to occur type of fault in electrical transmission lines remains to be the line to ground fault, but the most severe faults are still of three phase natures.



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%

Table: Statistics for fault types on transmission lines

There are broadly two types of faults in transmission lines – transient and permanent faults, as is shown in Figure 2.1. A transient fault is no longer present if power is disconnected for a short time and then restored. Many faults in overhead power lines are transient in nature and power system protection devices operate to isolate the area of the fault, clear the fault and then the power-line can be returned to service. Typical examples of transient faults include:

- momentary tree, bird or animal contact
- lightning strike
- conductor clashes

A permanent fault can cause lasting damage to the transmission lines. To counter a permanent fault, the line first has to be isolated and then correction has to be made to the line. Some examples of the fault of permanent nature are:

- direct lightning stroke on line
- man-made damage
- mechanical damage due to environment and age

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- a short circuit between one line and ground, often caused by physical contact, for example due to lightning or another storm damage.

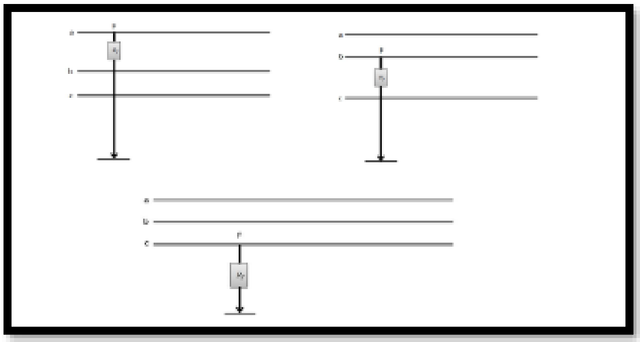


Figure 2.2: Single line to ground Fault

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

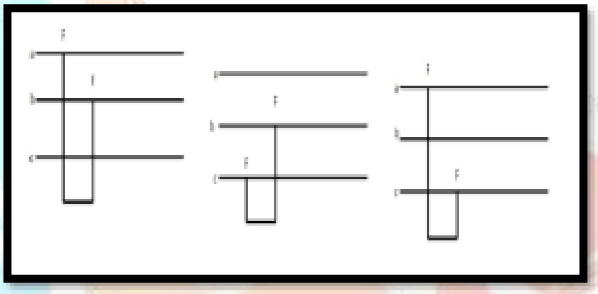


Figure: Line to Line Fault

- **Double line-to-ground** fault **-** two lines meet the ground and each other, commonly due to storm damage.

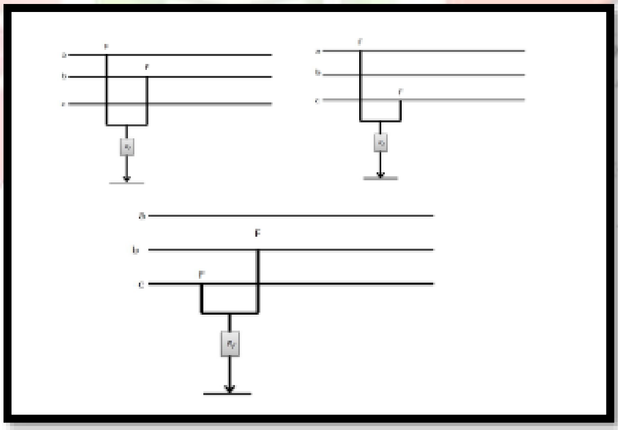


Figure : Double line to ground Fault

MODELLING AND SIMULATION

Fuzzy Interface System (FIS) Method

The overall schematic is also show above. The concept is based on sampled value of current and voltages. Calculation of zero sequence current, root mean square (RMS) value and total harmonic distortion (THD) is done. The resulting values are used for the fuzzy interface system that output the fault credibility as well as the most likely type and direction of fault as a function of time. The proposed fuzzy logic is extremely based on 9 input variables. those include root mean square (RMS) value for voltage and current of each phase as well as calculated the zero-sequence component. Furthermore, the total harmonic distortion harmonic (THD) of line current is an additional input variable. To obtain the result from fuzzy logic the methodology used is also called the fuzzy interface system. The FIS controller is a MAMDANI type FIS. The input variable of FIS system is below. Here the 9 input variables and 1 output variable. The list of input variable, number and type of membership function, the range of them are also show here,

Input variable	**Num. of MF**	**Type**	**Range**
I1	3	trimf	[0 4]
I2	3	Trimf	[0 4]
I3	3	Trimf	[0 4]
I0	2	Trimf	[0 2]
V1	4	Trimf,tramf	[0 1.5]
V2	4	Trimf.tramf	[0 1.5]
V3	4	Trimf,tramf	[0 1.5]
V0	2	Trimf	[0 2]
THD	2	Trimf	[0 10]

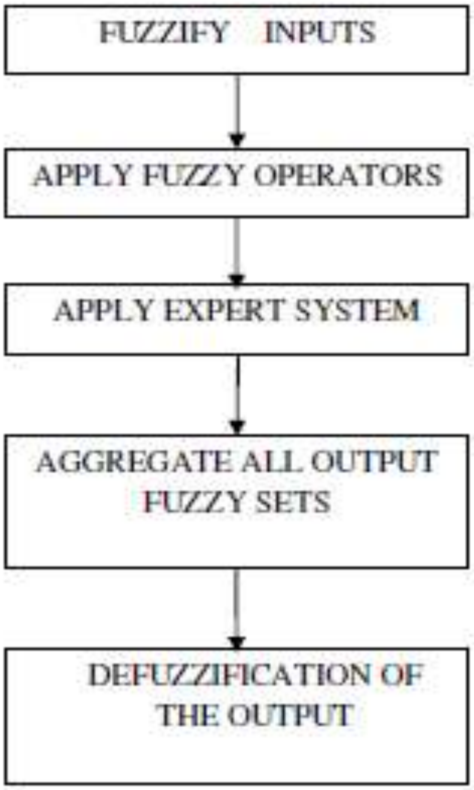
output variable	**Num. of MF**	**Type**	**Range**
ERR	3	trimf	[0 4]

Table: Details of Membership Function

Here all variable as voltage and current are also change according to type of fault and location of the fault. Here 26 fuzzy rules are also applied to obtain the given output. In surface viewer we can also see the 3-D graph between input and output variable. We can also see the rule viewer to how a change output according to input is also change.

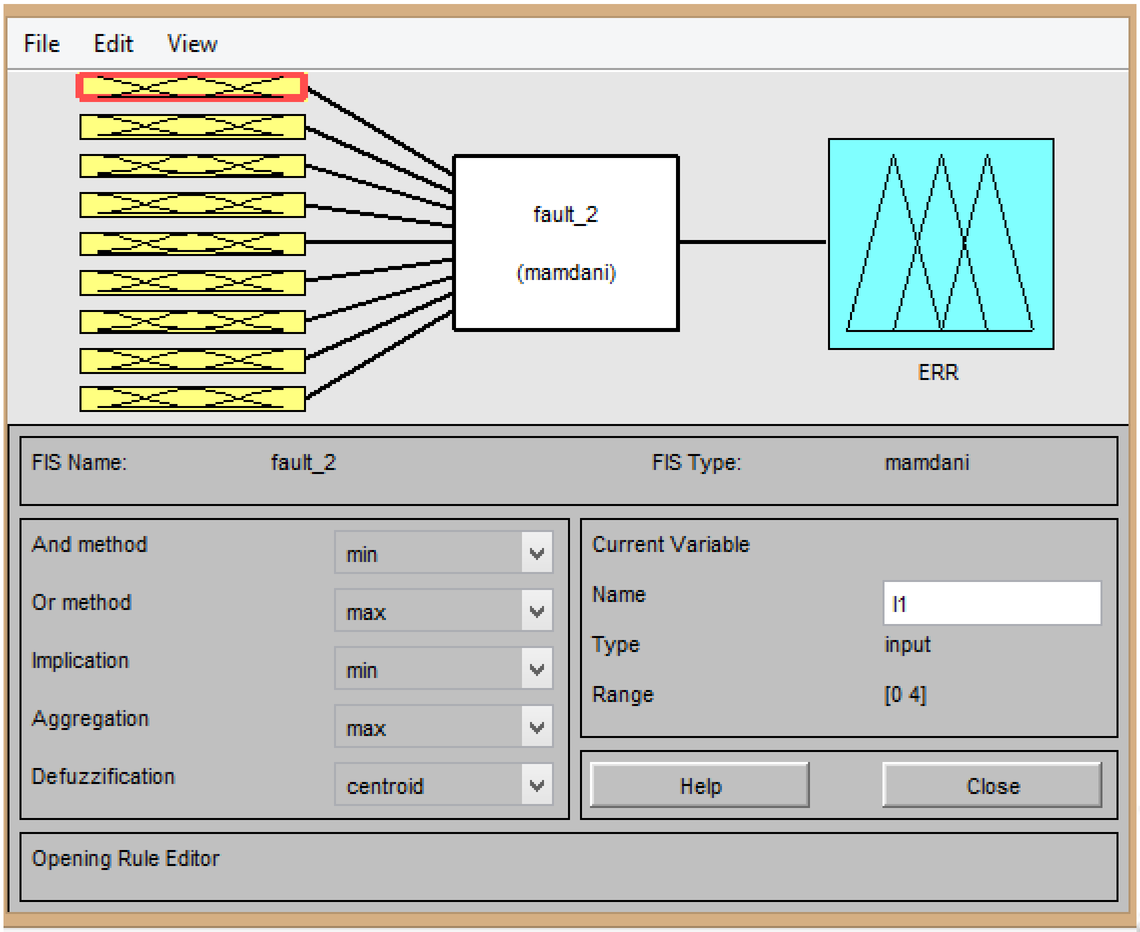
To successfully design a fault detection system using fuzzy logic, an understanding of the basic components of a fuzzy decision system is important. These include fuzzy logic concepts such as fuzzy sets and their properties, fuzzy rule base, and fuzzy inference system.

The Algorithm for the Design of the Fuzzy Inference System It includes the following:



Fuzzy Interface System (FIS) Editor:

This method of fault detection applies the three phase (A, B, and C) feeder currents and phase voltages as the inputs to the fuzzy inference system (FIS).



FIS Name: fault_2

FIS Type: mamdani

And method: min

Or method: max

Implication: min

Aggregation: max

Defuzzification: centroid

Current Variable

Name: I1

Type: input

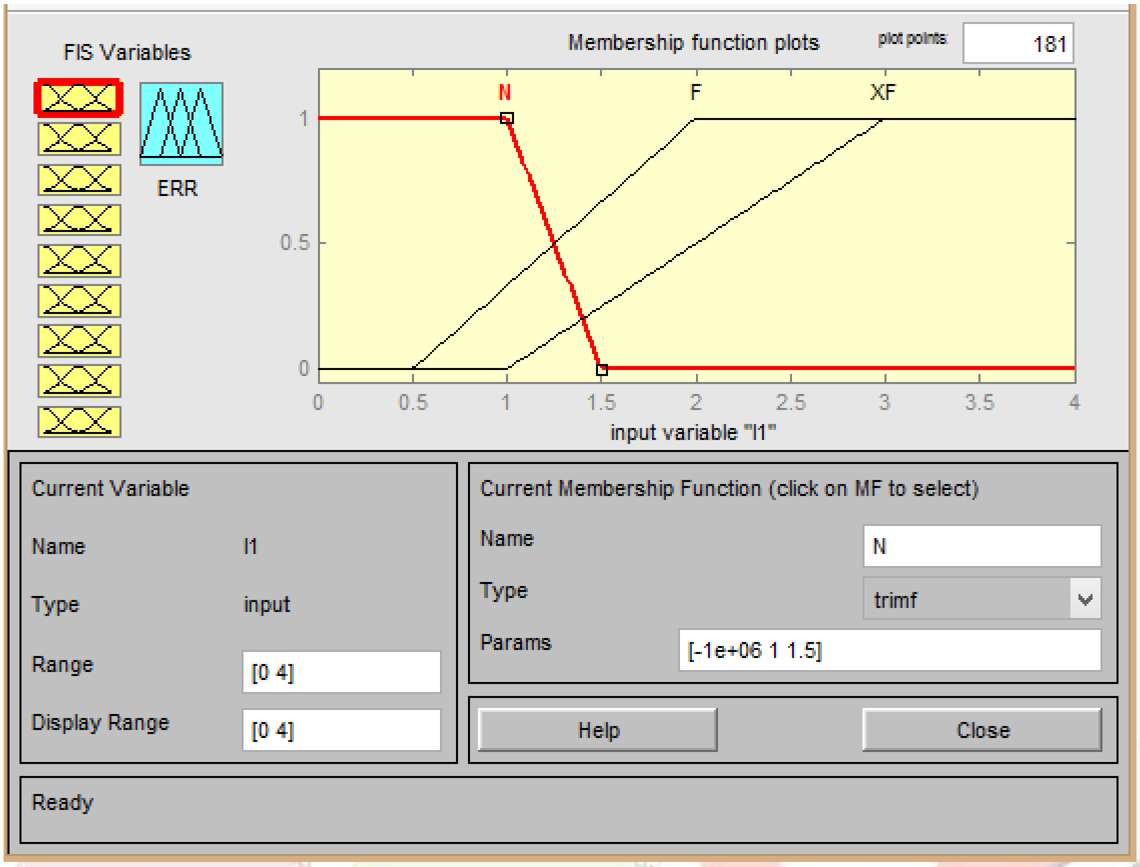
Range: [0 4]

Opening Rule 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.

The Membership Function for All Input and Output Variable



Current Variable

Name I1

Type input

Range [0 4]

Display Range [0 4]

Current Membership Function (click on MF to select)

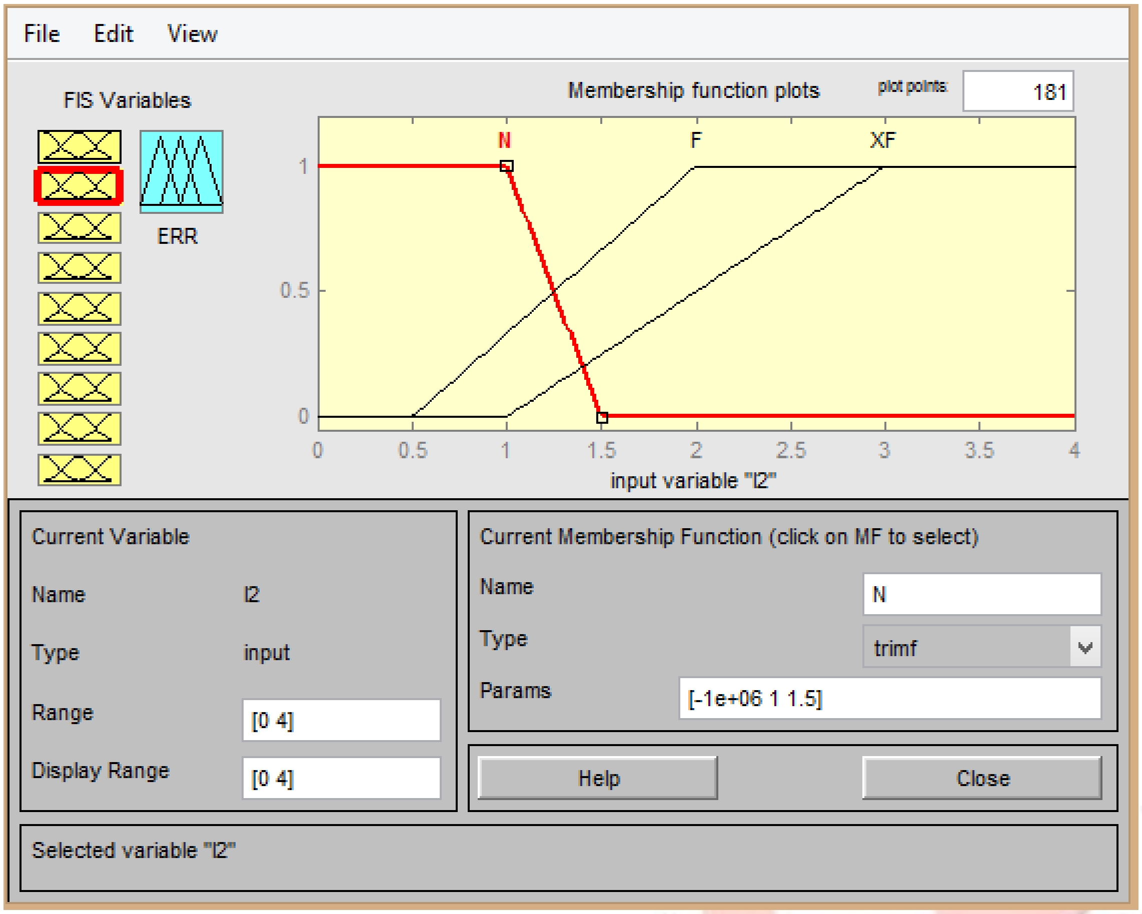
Name N

Type trimf

Params [-1e+06 1 1.5]

Ready

Figure: Membership Function for Input Variable I1.



plot points: 181

Current Variable

Name I2

Type input

Range [0 4]

Display Range [0 4]

Current Membership Function (click on MF to select)

Name N

Type trimf

Params [-1e+06 1 1.5]

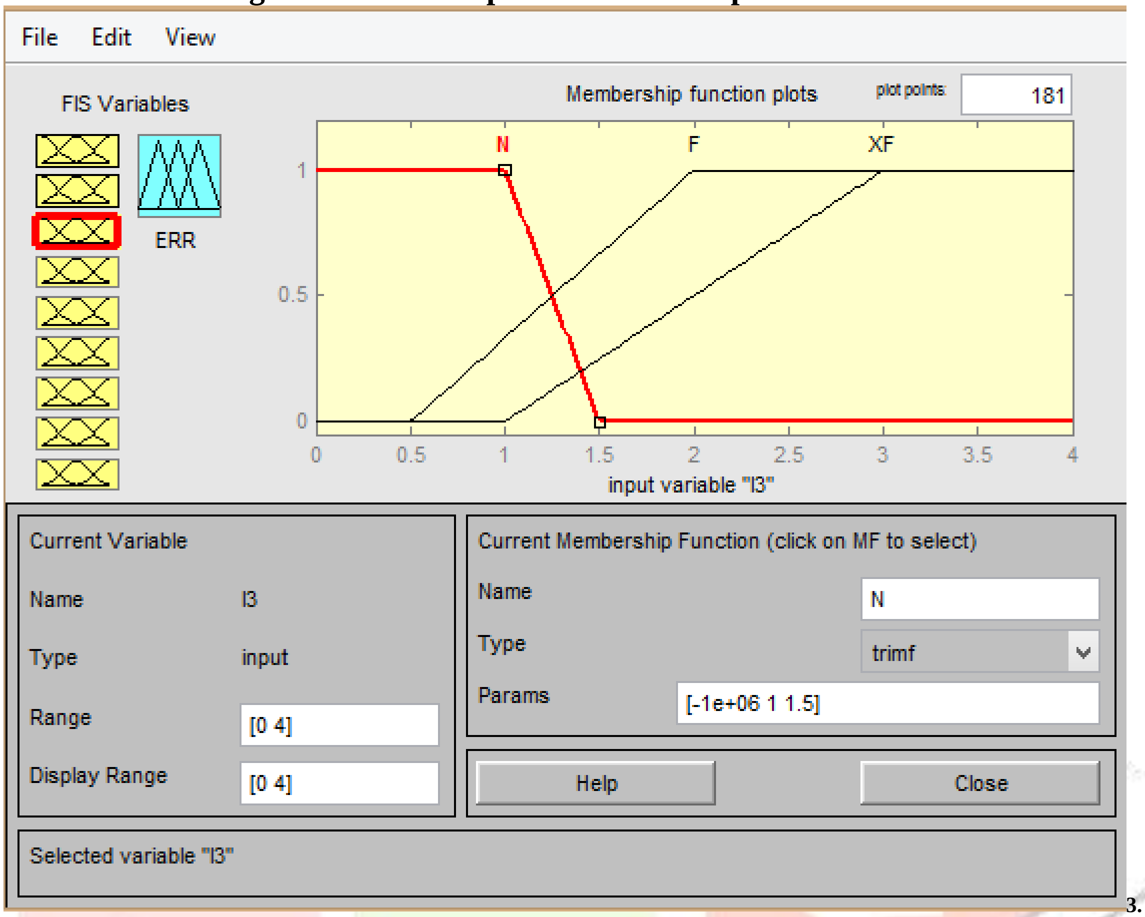
Selected variable "I2"

Figure:Membership Function For Input Variable I_2.

Simulation Model

The system model was performed using the Matlab/Simulink software version 9. Simulink is an environment for multi domain simulation and model-based design for dynamic and embedded systems [1]. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement and test a variety of time-varying systems including power, communications, controls, signal processing, etc. The simulations for the various types of faults were carried performed and the various values for both faulted and non-faulted current were taken and recorded. The following blocks were used in building the logical model for fault detection. In the transformer block, we specify the required parameters of the two-winding transformer. This block represents a real step-down transformer on the distribution network. The values are set to the per unit system.

Figure: Membership Function For Input Variable I



Current Variable

Name I3

Type input

Range [0 4]

Display Range [0 4]

Current Membership Function (click on MF to select)

Name N

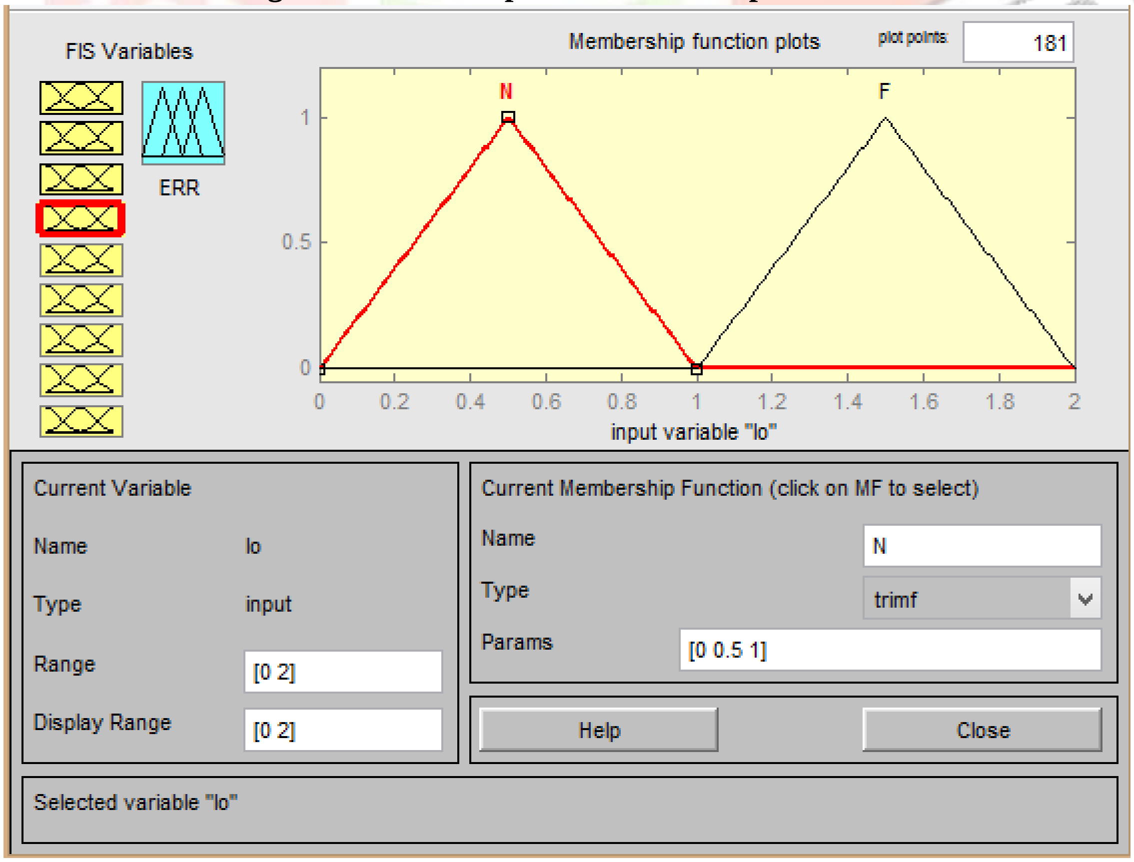
Type trimf

Params [-1e+06 1 1.5]

Selected variable "I3"

3.

Figure: Membership Function For Input Variable I_0.



Current Variable

Name Io

Type input

Range [0 2]

Display Range [0 2]

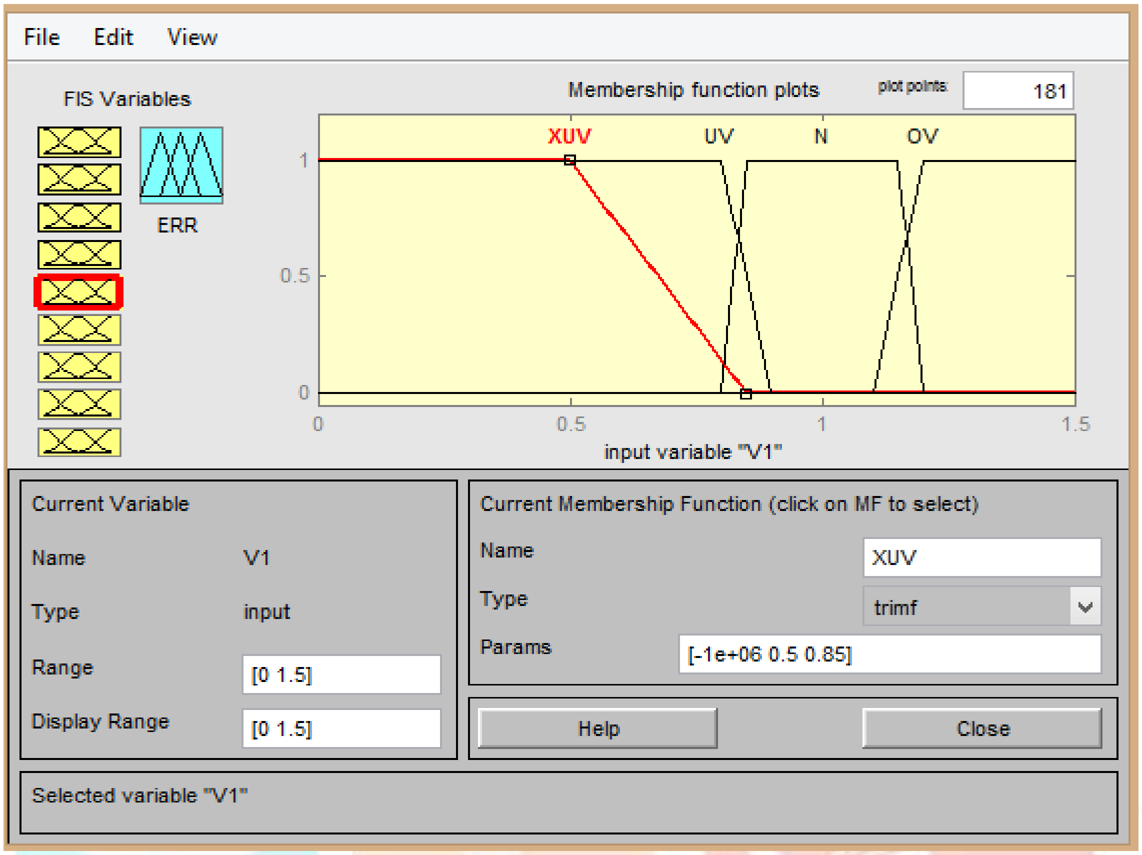
Current Membership Function (click on MF to select)

Name N

Type trimf

Params [0 0.5 1]

Selected variable "Io"



plot points: 181

Current Variable

Name V1

Type input

Range [0 1.5]

Display Range [0 1.5]

Current Membership Function (click on MF to select)

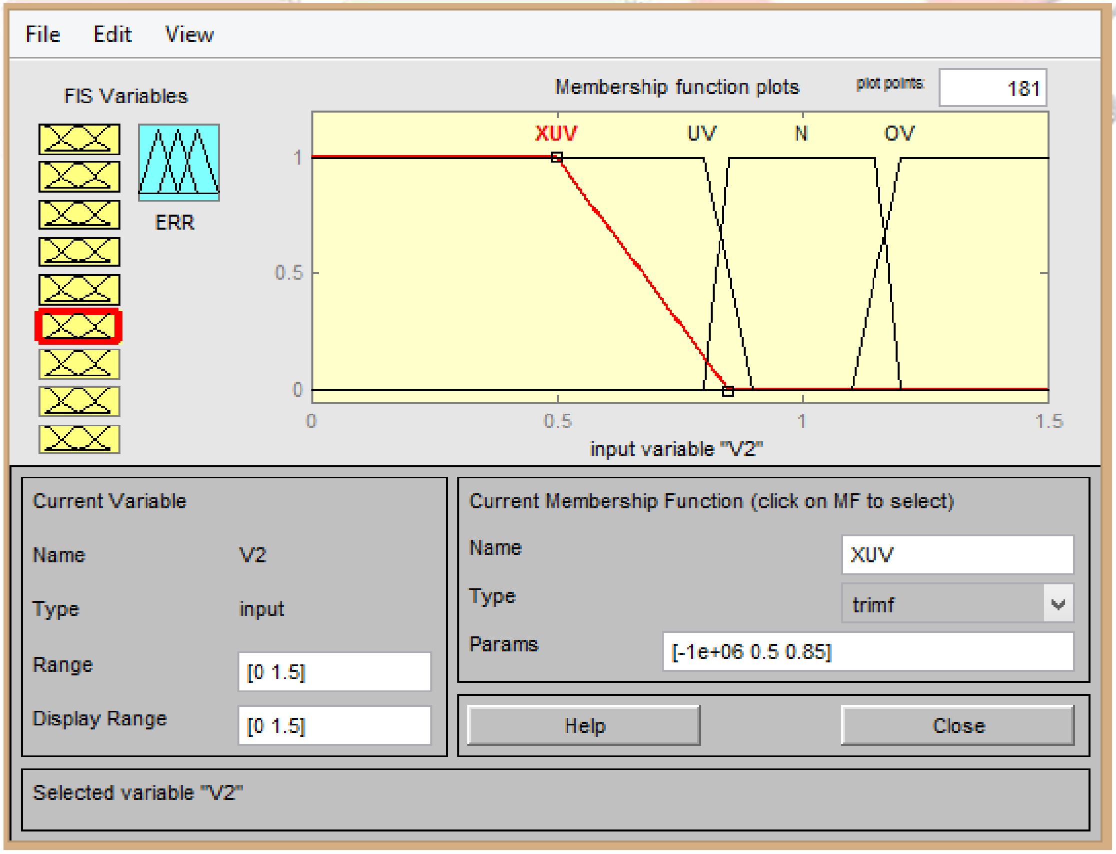
Name XUV

Type trimf

Params [-1e+06 0.5 0.85]

Selected variable "V1"

Figure: Membership Function for Input Variable V_1



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Current Variable

Name V2

Type input

Range [0 1.5]

Display Range [0 1.5]

Current Membership Function (click on MF to select)

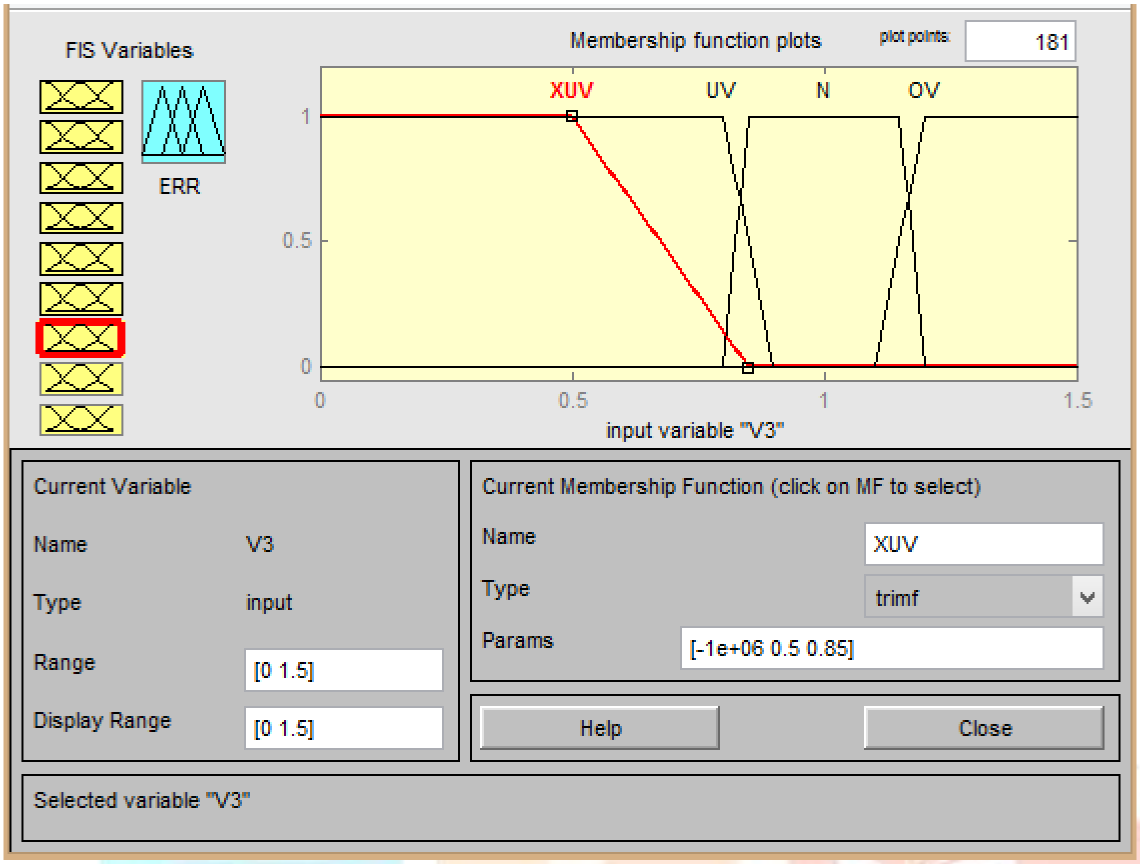
Name XUV

Type trimf

Params [-1e+06 0.5 0.85]

Selected variable "V2"

Figure: Membership Function for Input Variable V_2.



Current Variable

Name V3

Type input

Range [0 1.5]

Display Range [0 1.5]

Current Membership Function (click on MF to select)

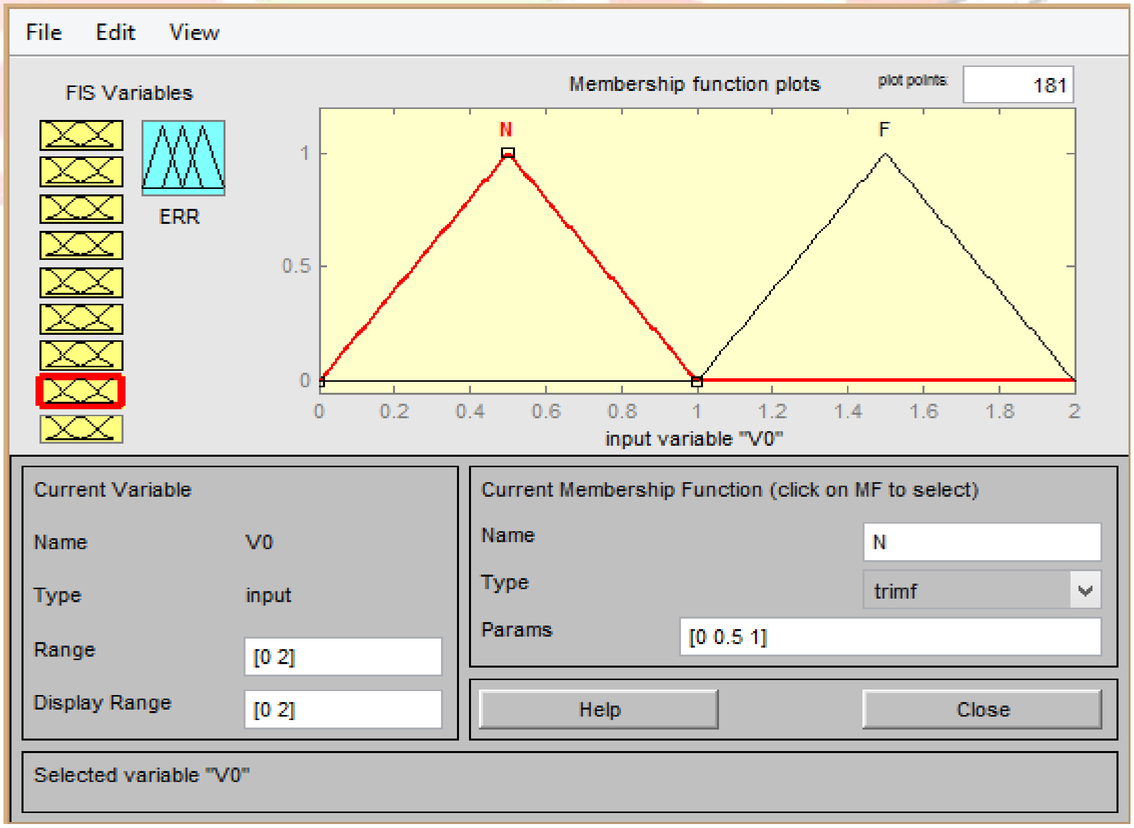
Name XUV

Type trimf

Params [-1e+06 0.5 0.85]

Selected variable "V3"

Figure: Membership Function for Input Variable V_3.



Current Variable

Name V0

Type input

Range [0 2]

Display Range [0 2]

Current Membership Function (click on MF to select)

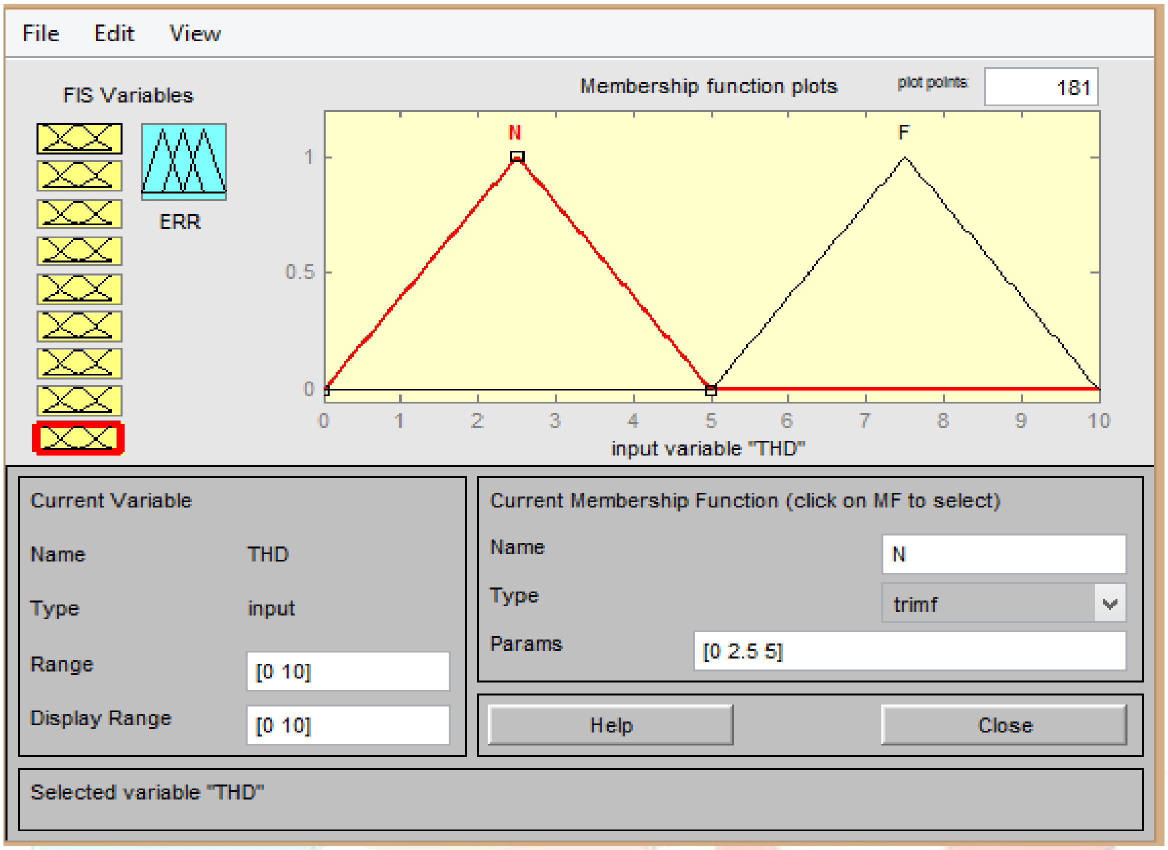
Name N

Type trimf

Params [0 0.5 1]

Selected variable "V0"

Figure: Membership Function for Input Variable V_4.



plot points: 181

Current Variable

Name THD

Type input

Range [0 10]

Display Range [0 10]

Current Membership Function (click on MF to select)

Name N

Type trimf

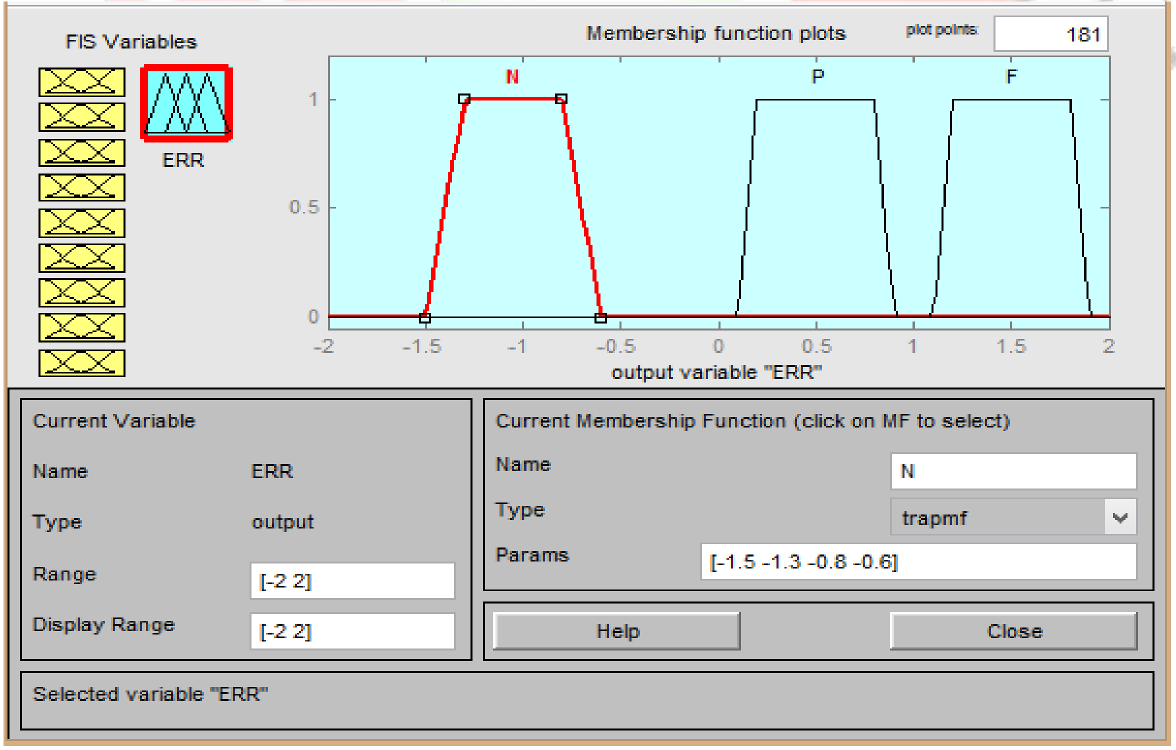
Params [0 2.5 5]

Selected variable "THD"

Figure:Membership Function for Input Variable THD

.

Figure: Membership Function For Input Variable ERR



plot points: 181

Current Variable

Name ERR

Type output

Range [-2 2]

Display Range [-2 2]

Current Membership Function (click on MF to select)

Name N

Type trapmf

Params [-1.5 -1.3 -0.8 -0.6]

Selected variable "ERR"

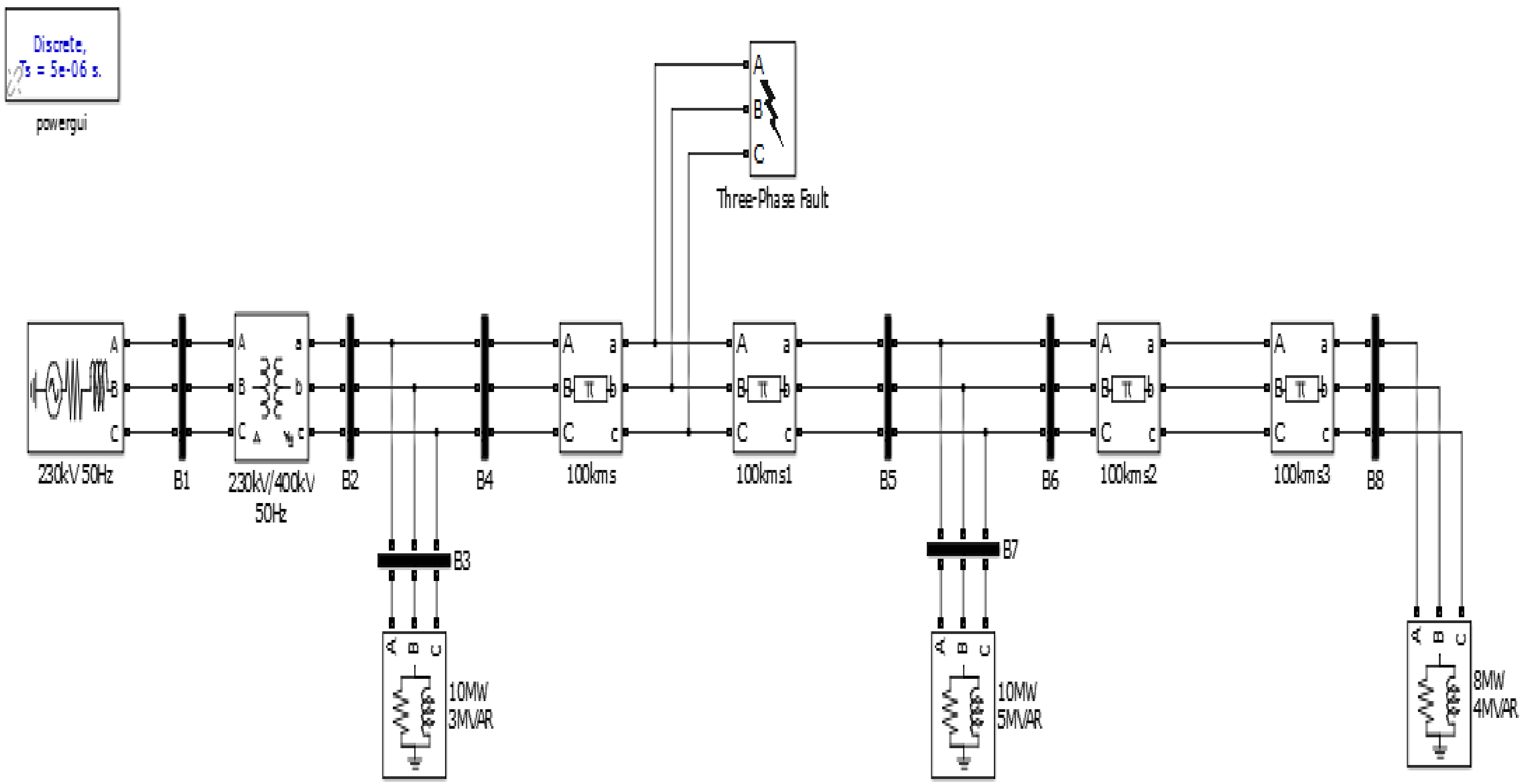
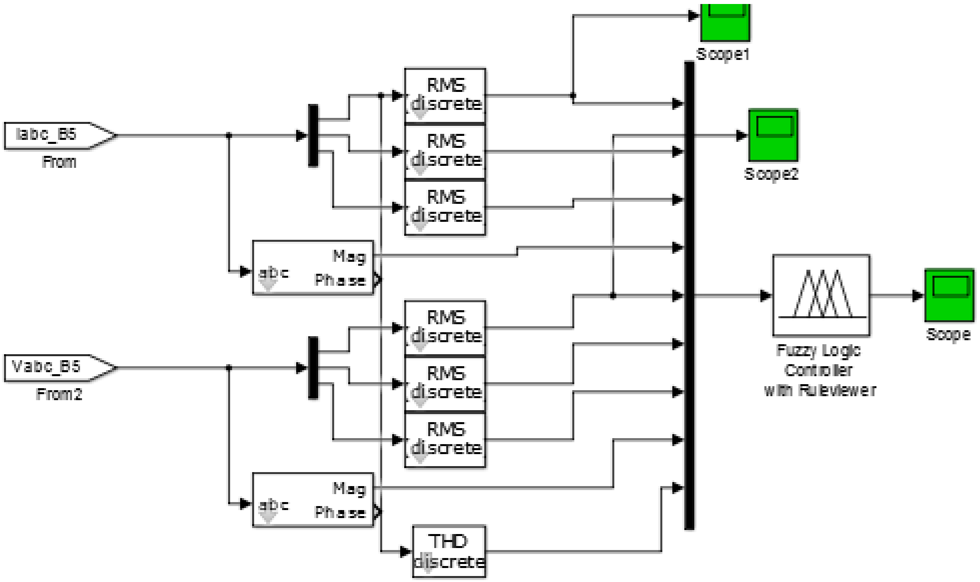


Figure: Simulation Model of 4oo KV, 400 Km Transmission Line with FIS



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.

Result for Symmetrical and Unsymmetrical Fault for FIS

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

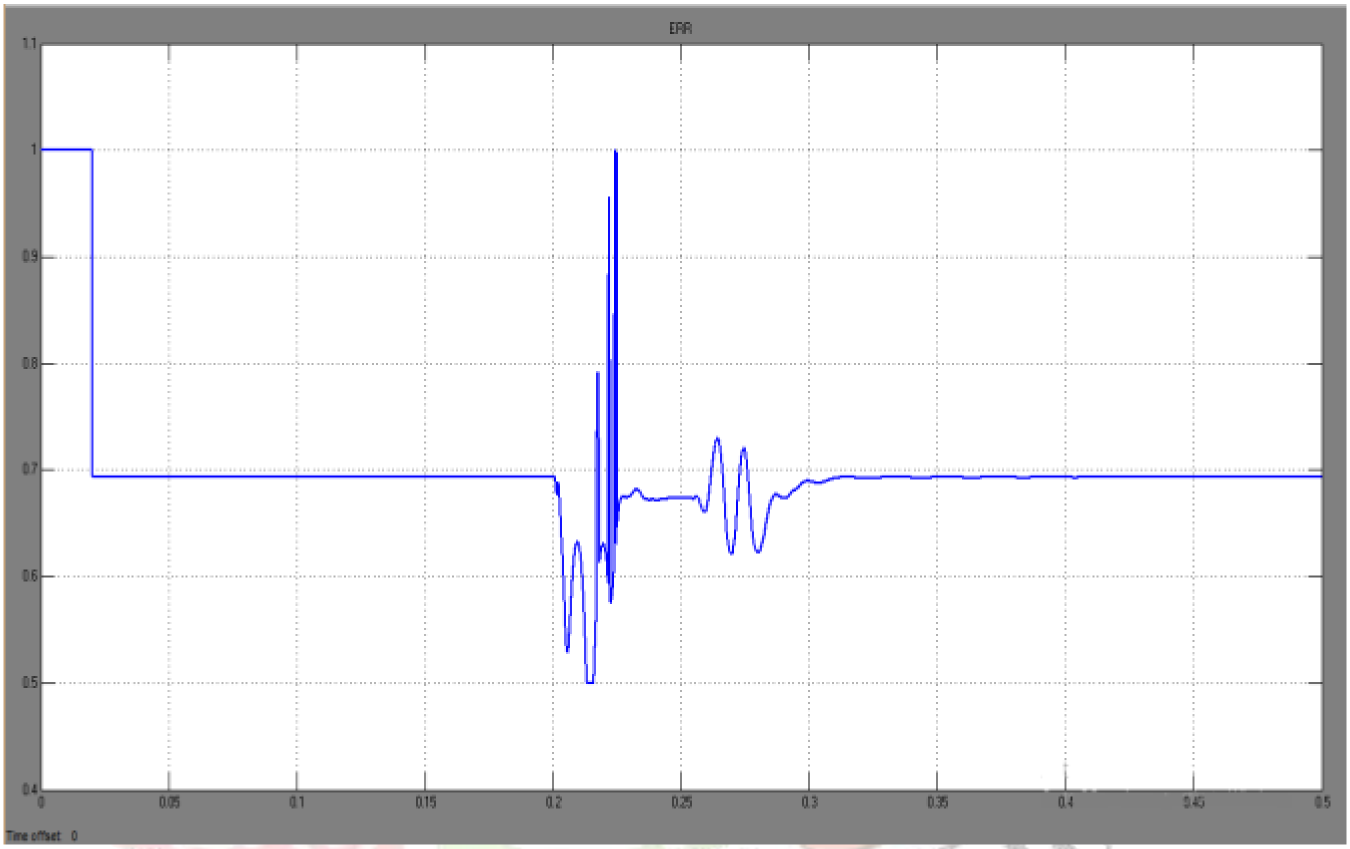


Figure: Output for single line to ground fault (A-G)

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

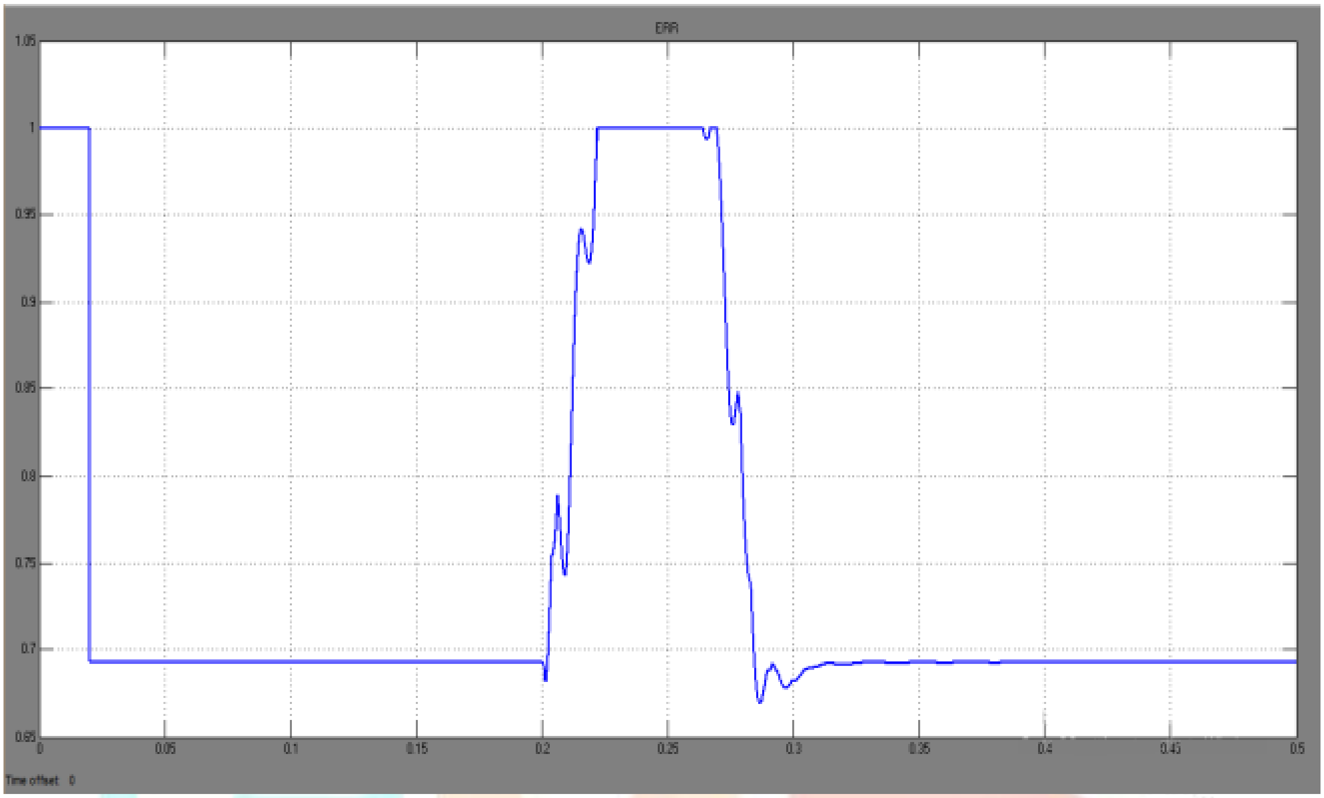


Figure: Output for Double line to ground fault (A-B-G)

Waveform for Line to line Fault (A-B)

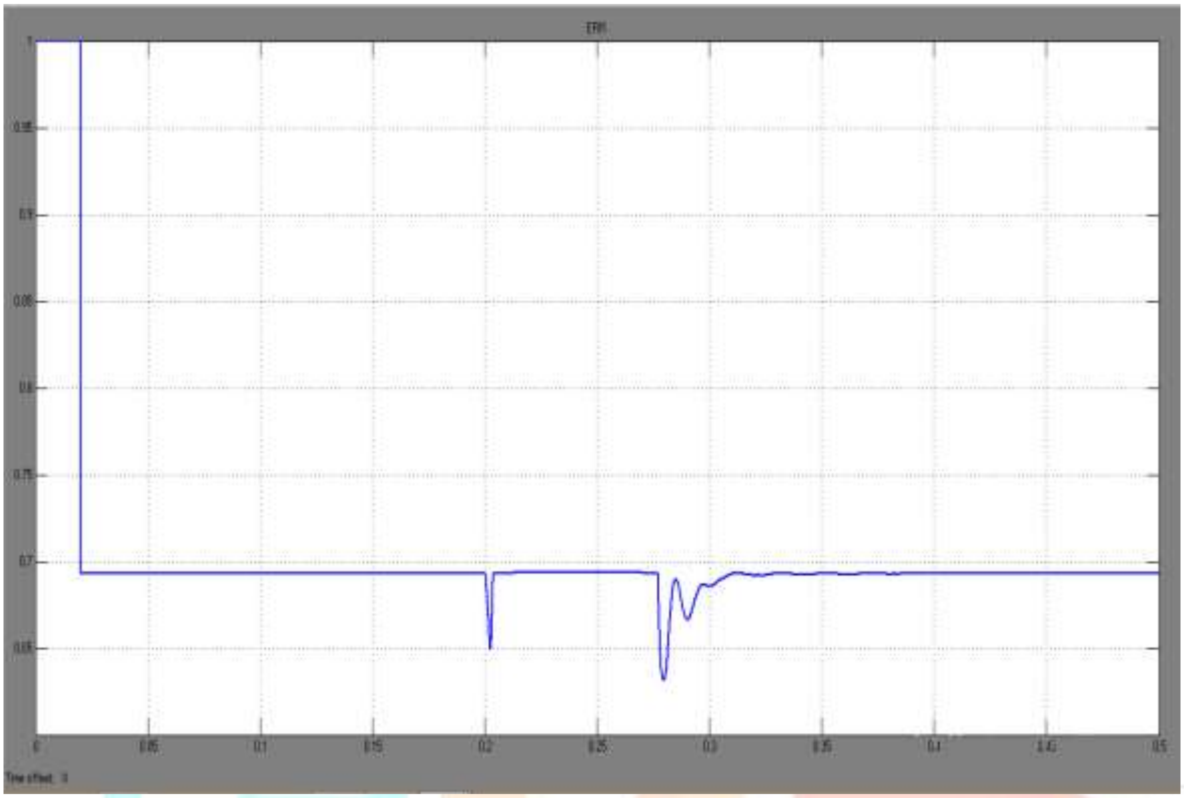


Figure: Output for Line-Line Fault (A-B)

Waveform for symmetrical Fault:

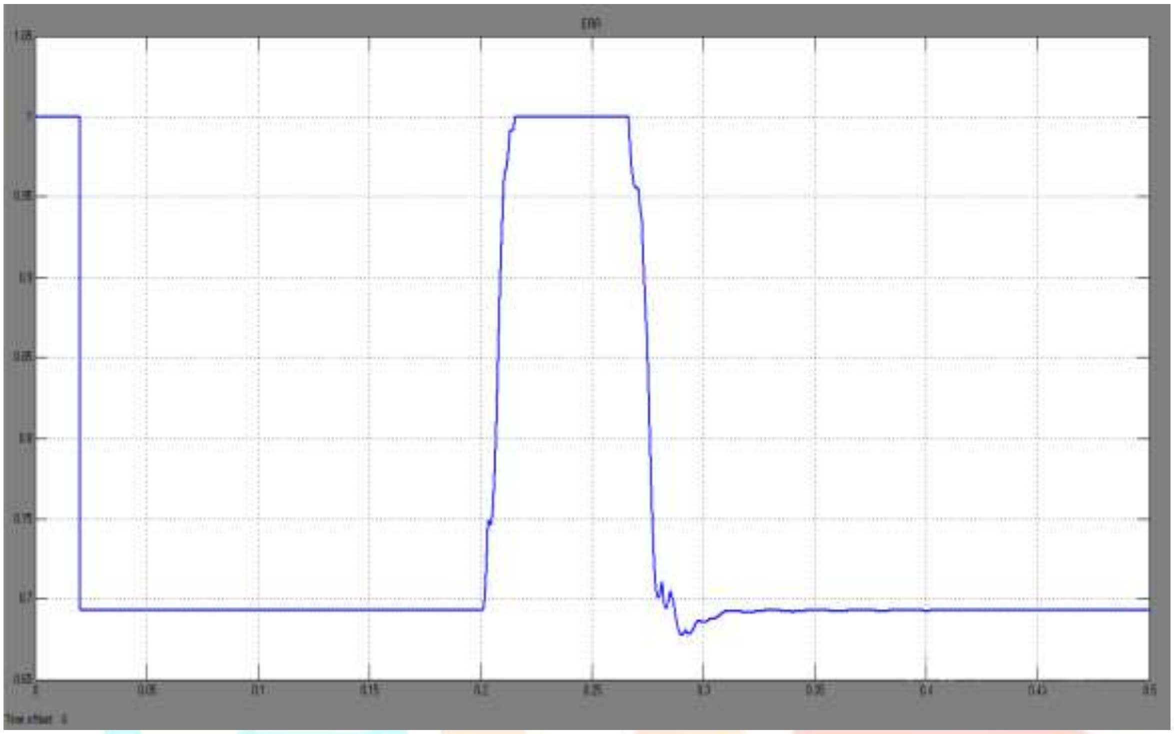


Figure:Output for Symmetrical Fault (A-B-C)

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 from 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

Fuzzy logic Controller Based Matlab Model

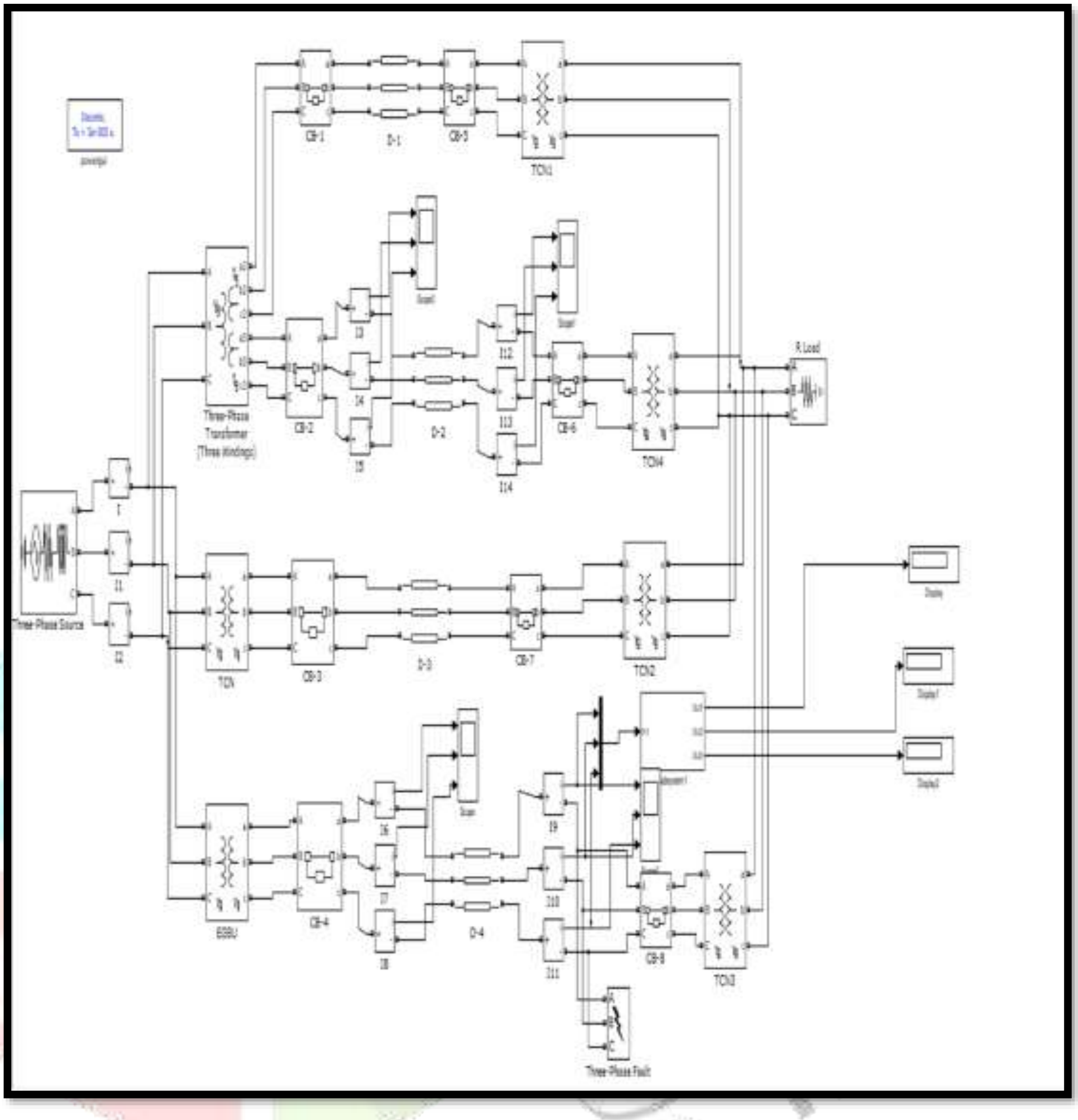


Fig Proposed System of Fuzzy Logic controller for fault identification

per unit. All the result is in microsecond. And to compare those result to reality switchyard system the we also used the conventional impedance method to compare the result. The result obtains by those method is 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.

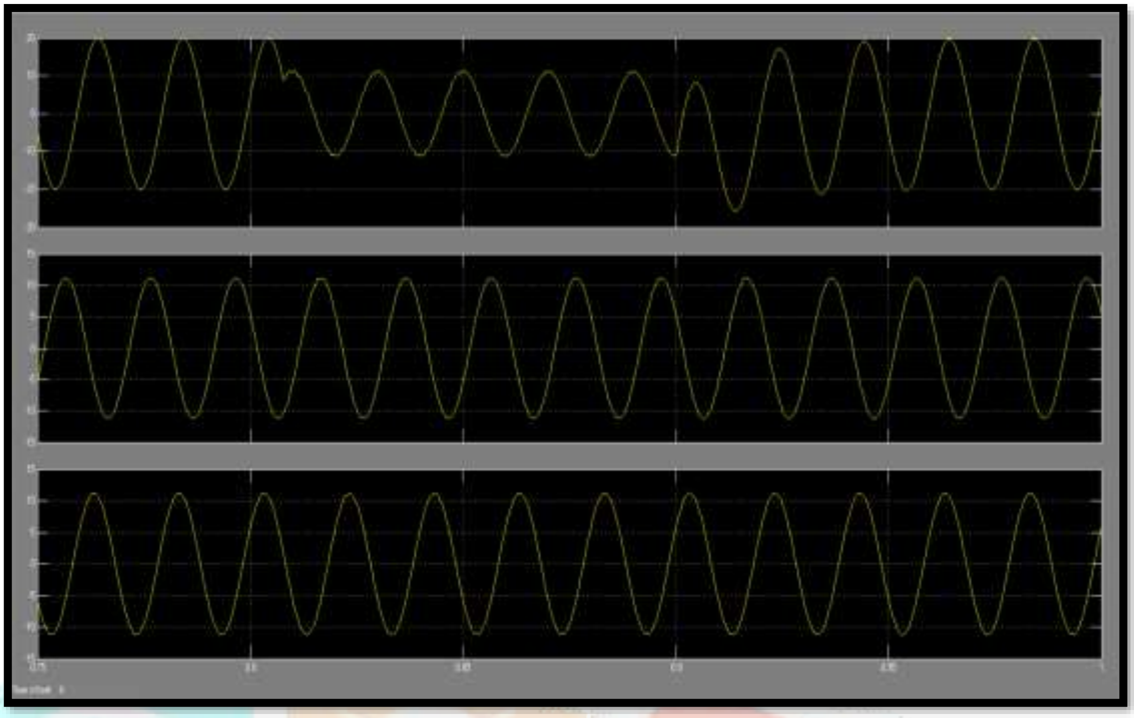


Fig Line-Ground Fault

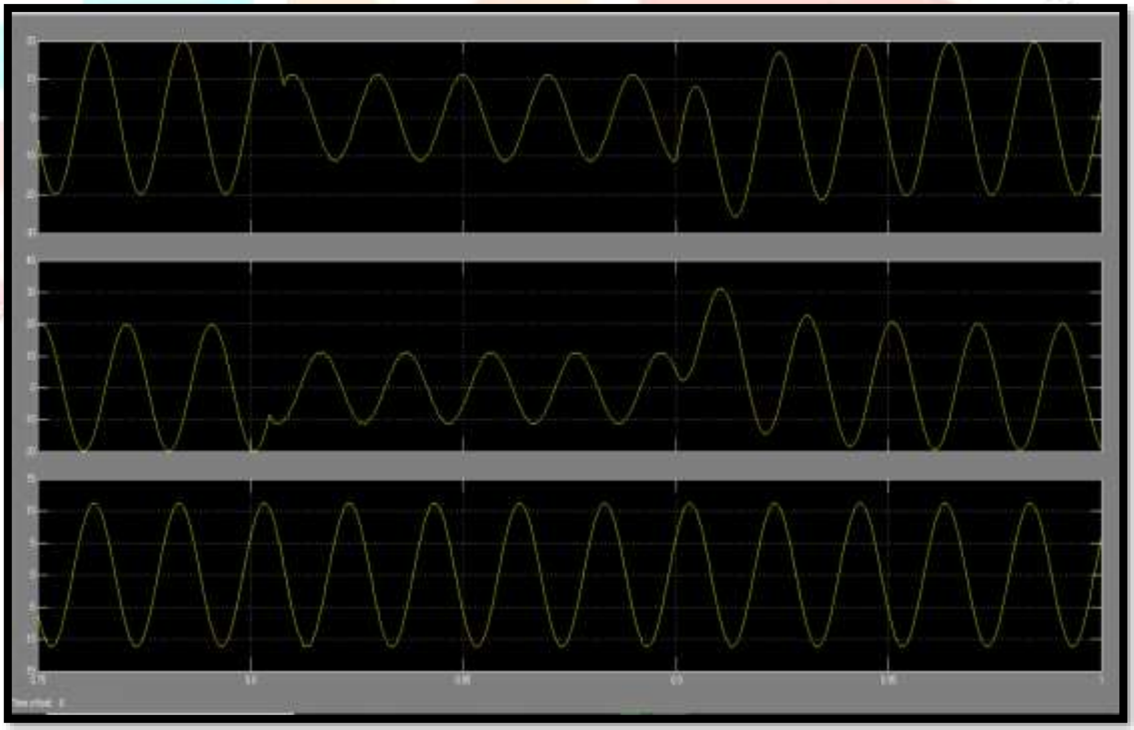


Fig Line-Line to ground Fault

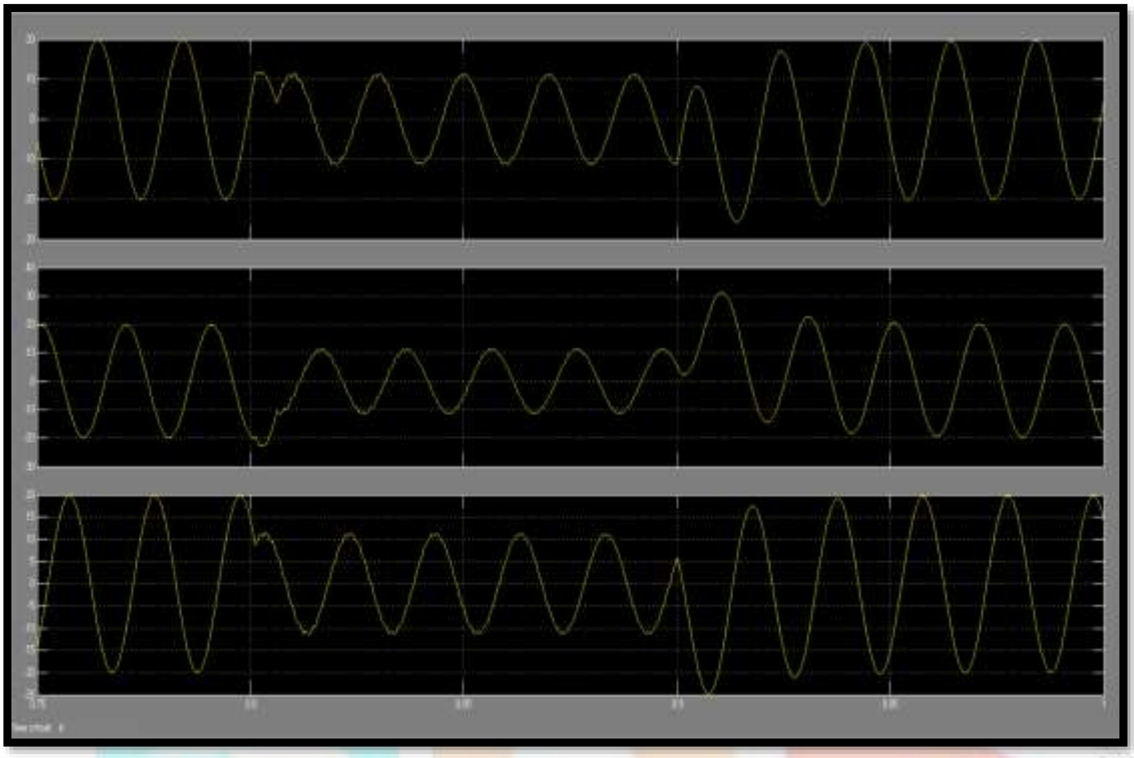


Fig Line-line-Line Fault

The three-phase load block implements a three-phase load, which is either purely resistive or inductive. Other blocks such as the display block, scope, circuit breakers and measurement blocks were also A fault detection system based on fuzzy logic has been designed in this work. This design was tested on a real radial power distribution network using real data and Matlab/Simulink software. It was able to detect single line to ground fault, phase to phase fault, double line to ground fault, and three phase faults. It has been shown that faults could occur in radial distribution systems with all possible combinations; hence the importance of the fuzzy membership functions in capturing the various combinations. The simplicity of this design based on fuzzy logic, means a drastic reduction in load loss and energy loss on distribution systems due to prolonged outages leading to longer feeder downtime during faulted conditions. used in building the logical model for simulation.

Comparison of Fault Identification Methods

Performance Parameters	Z Impedance Method	Takagi Algorithm	Fuzzy Logic

Calculation	Very Complicated	More Calculation	Less Calculation
Accuracy	Less	Less	High
Performance	Less	Medium	High
No. of Iteration	More	So many Iterative calculation	Less
Fault Clearance Time	Little high	Low	Very Small
Effectiveness	Medium	Medium	High

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. The symmetrical fault method gives better results except for asymmetrical faults with a fault resistance in two-end fault location algorithms. Basic two-end method has the best results at asymmetrical fault with a fault resistance. Both of these methods have acceptable accuracy for any fault, but if the fault type is predetermined and the suitable two-end fault location method is chosen, then the fault location estimation error is minimized. 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.

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