Contingency Analysis of Fault and Minimization of Power System Outage using Fuzzy Controller

A. Sathish Kumar, M. Saravanan, N. Joshna, G. Seshadri

Abstract: *In power systems, voltage stability perform the major role in design and its operation. Major system failures are occur due to voltage variability and breakdown. To meet and compensate the rising power demand of regular usage in modern trends, transmission networks are enormously loaded which create the voltage instability. Contingency analysis is a recognized energy managing tool. It calculate the violation in the transmission line. In this paper a computational controller fuzzy system is suggested to handle the transmission line outage and overload in other branch kind of problems in Power system. The efficiency of power transmission system with fuzzy controller is inveterate by computation of various parameters of transmission bus under different loading situations. For the contingency analysis the transmission power flow several methods have been developed. Fast Decoupled load flow program is the effective method which provides a fast and effective solution to the contingency analysis in the transmission system and also it is incorporate with matrix alteration formula which gives additional advantage for the system.*

Keywords: Fuzzy Logic, Voltage stability, Contingency Analysis, non-linear system.

I. INTRODUCTION

The power system is a complicated network consist of numerous components like generators, isolators, switches, bus-bars, transmission lines, relay, transformers, circuit breakers etc. If fault occur in any one of these apparatuses in power system throughout its process affects the consistency of the power system and leads to transmission issues and outages. Several methods have been developed in several years to state this problem but computation time has been recognized as the constraint making the process incompetent.

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Contingency analysis is define the set of event occur in short duration of time and also it identify failure one or more components in power system [1]. The security and consistency is enriched in power system with the help of contingency analysis [2]. Contingency analysis is a simulation investigation method which associate various problem in power system, come up with the optimal response under circumstances situation [3]. Fuzzy controller is the effective tool to solve the different types of problem in power system [4]. A Fuzzy logic system (FLS) system defines the controlling action of a process by the use of simple If-Then rules [5]. It describes the algorithm for controlling the process as fuzzy relation between information to be controlled which is on the process condition and the controlled action [6,7]. Therefore it provides a linguistic expression or fuzzy model, developed based on human interpretation, human logic and understanding. Instead of providing a mathematical model it provides linguistic expressions for human experience and understandings. The control action of Fuzzy Logic system (FIS) is determined by evaluating linguistic rules with simple set of rules. It does not require mathematical expression or model to define the linguistic rules, but it only depends on complete and systematic understanding of process which needs proper controlling technique. The model used in Fuzzy Logic system (FIS) can be of single input and single output or multi-input and multi-output type. With the use of membership functions and linguistic inputs, fuzzy IF-THEN rules can understand the human's reasoning. This is done by the use of fuzzy inference systems.

II. PROCCEDING TECHNOLOGY

2.1 MODELLING AND TECHNIQUES OF CONTINGENCY ANALYSIS

Since contingency analysis contains the simulation for each contingency on the basic method of the power system, three most important complications are involved in this analysis. First is the complicate to produce the appropriate power system model. Second is the optimal of which contingency case to reflect and third is the complicate in calculating the power flow and bus voltages which indications to enormous time consumption in the Energy Management System.Contigency analysis is the precious methods to identify the faults in the power system and regulate the transmission line power flow .The power flow compensation and fault identification is the important factors in power system.

2.2 CONTINGENCY INVESTIGATION USING SENSITIVITY ISSUES

The problematic of reviewing several possible outages develops very problematic to solve if it is preferred to present the results rapidly. One of the quietest ways to provide a fast calculation of probable overworks is to use sensitivity issues.

These issues show the uneven change in line flows for variations in generation on the network formation and are resultant from the DC load flow. These issues can be resulting in a variety of ways and basically occur in to two types:

- Generation Shift Issues [1]
- Line Outage Distribution Issues [1]

The **generation shift issues** are nominated a_{li} and have the subsequent definition:

$$a_{li} = \frac{\Delta f_l}{\Delta P_i} \qquad (1)$$

ΔPi is exactly remunerated by an conflicting change in compeers at the reference bus, and that all other producers keep on stable.

a_{li} issue then signifies the sensitivity of the flow on line l due to a change in compeers at bus i. If the initiator was producing Pi^o MW and it was lost, it is represented by ΔPi, as the new

$$\Delta P_i = - P_i^o \qquad (2)$$

$$f_l = f_l^0 + a_{li} \Delta P_i \text{ for } l = 1 \ldots L \qquad (3)$$

The **line outage distribution issues** are used in an alike manner, only they put on to the challenging for overloads when transmission circuits are lost.

$$d_{l,k} = \frac{\Delta f_l}{f_k^0} \qquad (4)$$

III. CONTINGENCY SELECTION

Contingency investigation practice contains the prediction of the effect of specific contingency cases, this practice becomes very dreary and time overriding, when the power system network is prodigious. In directive to improve the above problematic contingency broadcast or contingency selection progression.

The process of recognizing the contingencies that really leads to the desecration of the operational bounds is known as contingency selection. The contingencies are selected by manipulative a kind of severity catalogues known as Performance Catalogues (PC). These catalogues are suggested by using the earlier regulate the power flow algorithms for discrete contingencies in an off line mode. Based on the values achieved the contingencies are graded in a way where the highest value of PI is ranked first.

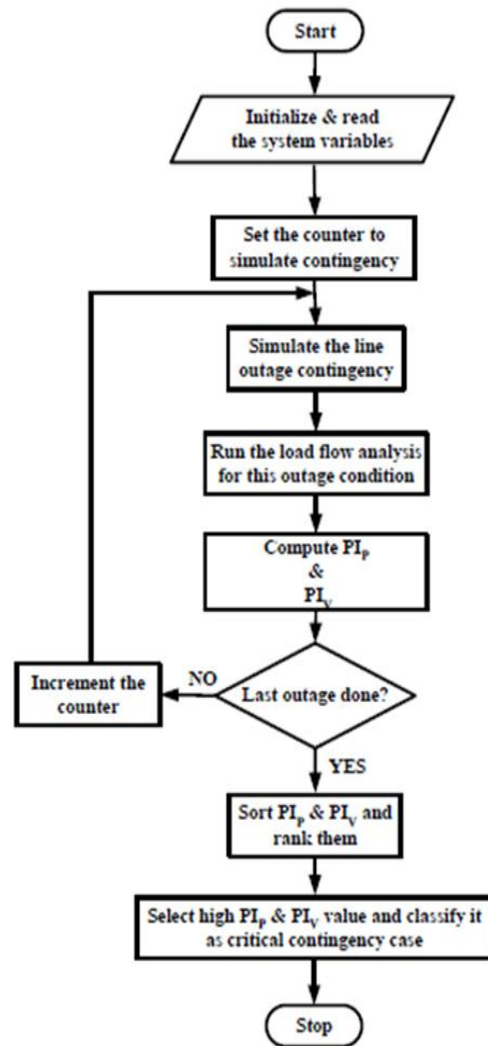$$PI_P = \sum_{i=1}^{L} \left(\frac{P_i}{P_{imax}}\right)^{2n} \qquad (5)$$

Fig. 1. Flow Chart for Contingency Selection

3.1 DC POWER FLOW METHOD

This method is centered on DC power flow method to simulate contingencies. DC Load flow method, Line resistances are being neglected but in this method the reactive power flows is ignored for the modelling of system only the real power flows is used.

$$\text{Impedance } Z = r + jx \qquad (6)$$
$$\text{Inverse of impedance } Y = G + jA \qquad (7)$$

This method is the real part of the power flow equations are measured, that is the effect of reactive power Q is ignored and bus voltages are presumed to be 1 p.u. The matrix A' is computed on the basis that all the resistances are zero.

3.2 Z-MATRIX METHOD

Z-Matrix is developed with bus impedance matrix which associate with base system and it is adjusted by either removals or additions of lines. Z-matrix method is the inverse method of bus admittance matrix. Z-matrix method of contingency analysis in the power system is to introduce an unreal current into any one of the buses in the transmission

system which is associated with the damaged part in the transmission line is to be replaced. In this method, when the component is being removed or replaced, current value of all the bus are set to be zero. This effective practice creates throughout the system a current flow pattern that will change in the same mode as the current flow pattern in the AC load flow solution. Z-matrix method of contingency analysis is very effective as comparable to DC load flow method.

3.3 STABILITY OF VOLTAGE COMPUTATION INDEX

Voltage stability computation method is used to determine the various lead and lags of voltage in the transmission system. The value of L-index arrays from no load condition to Voltage collapse if referred as 0 and 1.

IV. FUZZY INFERENCE SYSTEM

The Fuzzy interference system is a kind of logic system which signifies causes and acquaintance in a fuzzy manner for the system reasoning under indecision and describes in inaccurate manner for human interpretation. This fuzzy logic is extremely differ then Boolean logic and classic logic method these method assume the precise the variable in true or false, but the fuzzy logic method is effective method for the fault identification and provide precise solution which understand an estimated or inexact answer for a question which is based on store of knowledge which is approximate, not complete or totally unreliable. It is the best approach and way to go for fuzzy logic when it is too difficult to encode a mathematical model which may exist or does not exist Therefore it is as good as like validity of rules. Fuzzy logic system which is based on certain rules is used for power system contingency ranking, but before that a small description, overview of fuzzy logic system. These structures are information based systems which exploits the concepts of Fuzzy logics.The main component of Fuzzy Inference systems is shown below:
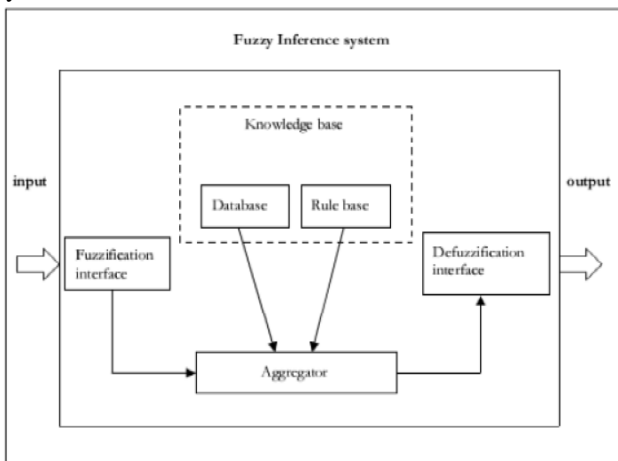

Fig. 2. Model of fuzzy interference

Major components in fuzzy inference systems are:
- LawBase: encompasses all the fuzzy rules rules.
- Data Base: used to define the membership functions.
- Aggregator: finalizes the process based on fuzzy rules.
- Fuzzy interface: process changes crisp inputs values to linguistic values.

- Defuzzification interface: renovates the fuzzy results into crisp output.

Four components perform the major role in fuzzy power flow structure they are fuzzy law base, database, fuzzy interface and defuzzification interface. In fuzzy rule base repetition, the parameters at each knob of the system are fuzzy interface computes and per-unit ΔHp and ΔHq. For the crisp input signals in fuzzy these parameters to be selected ,the parameter which refer as maximum power is $\Delta Hpmax$ which regulate the mapping range at every iteration it transmutes input signals into an reliable measure of dissertation. The fuzzified input signal switched into a reliable fuzzy signal ΔHr *fuz* or ΔHs *fuz* with the help of seven linguistic variables

Breadth and center of fuzzified signal is intended as:
Large Negative : $[\Delta Hmax/14, -3\Delta Hmax/4]$,
Medium Negative : $[\Delta Hmax/14, -\Delta Hmax/2]$,
Small Negative : $[\Delta Hmax/14, -\Delta Hmax/4]$,
Zero : $[\Delta Hmax/7, 0]$,
Small Positive : $[\Delta Hmax/14, \Delta Hmax/4]$
Medium Positive : $[\Delta Hmax/14, \Delta Hmax/2]$
Large Positive : $[\Delta Hmax/14, 3\Delta Hmax/4]$.

Fuzzy base laws agreed with the linguistic variables:
Law 1 : if ΔH*fuz is* Large Negative then ΔX*fuz* is Large Negative
Law2 : if ΔHfuz is Medium Negative then ΔX*fuz* is Medium Negative
Law3 : if ΔH*fuz* is Small Negative then ΔX*fuz* is Small Negative
Law4 : if ΔH*fuz* is Zero then ΔXfuz is Zero
Law5 : if ΔH*fuz* is Small Positive then ΔXfuz is Small Positive
Law6 : if ΔH*fuz* is Medium Positive then ΔXfuz is Medium Positive
Law7 : if ΔH*fuz* is Large Positive then ΔXfuz is Large Positive

In the fuzzy system at in each iteration of Fuzzy rules, state vector ΔX is completely proportional to power vector ΔH. Fuzzy signals ΔH*fuz* are lead to process logic, which produce the fuzzy output signals ΔX*fuz*, based on the earlier lawbase and are signified in the fuzzy input signals similar to seven linguistic. ΔX*fuz* is refer the output fuzzy signals which directed to the defuzzification interface to perform the following tasks:

At every iteration ΔX*max* is the maximum remedial action of state variables which decide the range of scale mapping which maintain the stability of the output signals.

$$\Delta Hmax_1 1/\Delta Xmax = dHI/dXI \qquad (8)$$

$$\Delta Xmax = (\Delta HI/\Delta XI)^{-1} \Delta Hmax, I \qquad (9)$$

In the maximum real or reactive power deviation of the system ,real or reactive power equation are proposed as H*I* at node -*I*, angle of voltage (or) magnitude of voltage at node-Width referred as X*I* and ΔX*fuz* is the center of the Gaussian membership functions is redesigned in alike way and are listed as:

Large Negative	: $[\Delta X max/14, -3\Delta Xmax/4]$
Medium Negative	: $[\Delta Xmax/14, -\Delta Xmax/2]$
Small Negative	: $[\Delta Xmax/14, -\Delta Xmax/4]$
Zero	: $[\Delta Xmax/7, 0]$
Small Positive	: $[\Delta Xmax/14, \Delta Xmax/4]$
Medium Positive	: $[\Delta Xmax/14, \Delta Xmax/2]$
Large Positive	: $[\Delta Xmax/14, 3\Delta Xmax/4]$.

The centroid of area defuzzification policy is accepted and the fuzzy state vector is updated as $X^{i+1} = X^i + \Delta X^I$

V. SOFTWARE IMPLEMENTATION

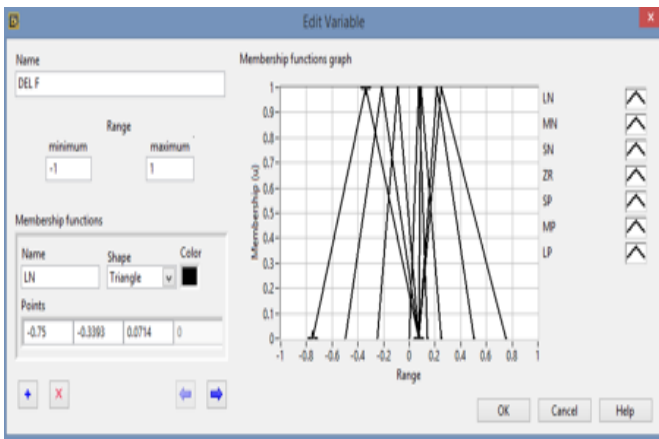### 5.1 FUZZY LOGIC REGULATOR MEMBERSHIP FUNCTION INPUT SIGNAL:

Fig. 3.Membership function input Signal.

Membership function is a curvature that establish every point in the input space is signified to a membership value. The fig.3 refer the membership signal of input signal, the membership function is adjusted based upon the variation of input signal by proper fixing the range for positive and negative value for the signals which increase the accuracy and limit the processing time. Based upon the range positive and negative value iteration time is reduce which increase the system reliability. The fuzzy Membership functions characterize parameter is acceptable in the either form of discrete or continuous in the fuzzy set.

5.2 FUZZY LOGIC CONTROLLER MEMBERSHIP FUNCTION OUTPUT SIGNAL:
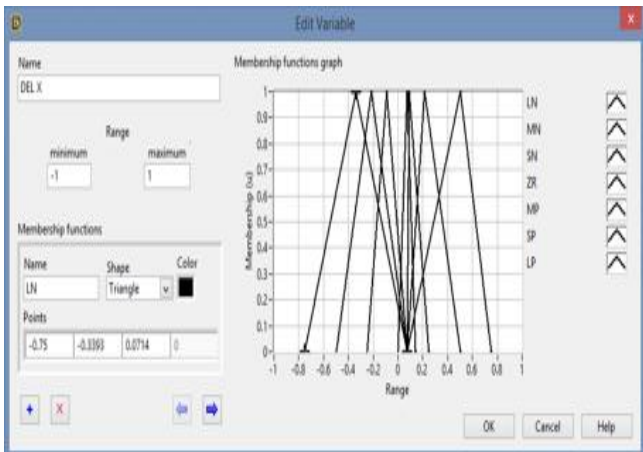

Fig. 4. Output Signals of fuzzy membership function.

In the fig.4 refers the output signal of fuzzy membership function. The output of fuzzy membership function is perform based upon the range and variation of the input signal. Based upon the range positive value and negative value of the input signal, output signal membership value gets tuned. The accurate value and proper tuning increase the stability of the signal and reduce the iteration timing of the system.

5.3 OUPUT VALUE FUZZY LAWSET

The fuzzy rules are framed based upon the if-then conditions. The if-then condition rules tuned the signal of sysem. Input of the de-fuzzification ΔH values refers magnititude of both negative and positive signals. The law of fuzzy if-then validate the input signal based upon the fuzzification the regulate the output signal.it implement the shape of the signal and all the fuzzy set is being framed based upon the fuzzy rules.
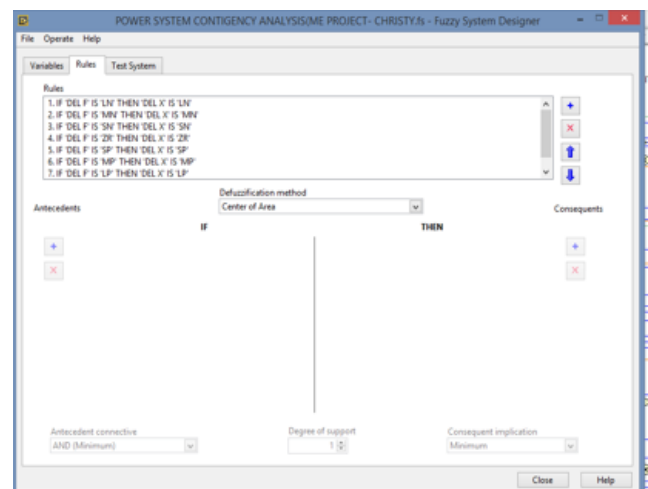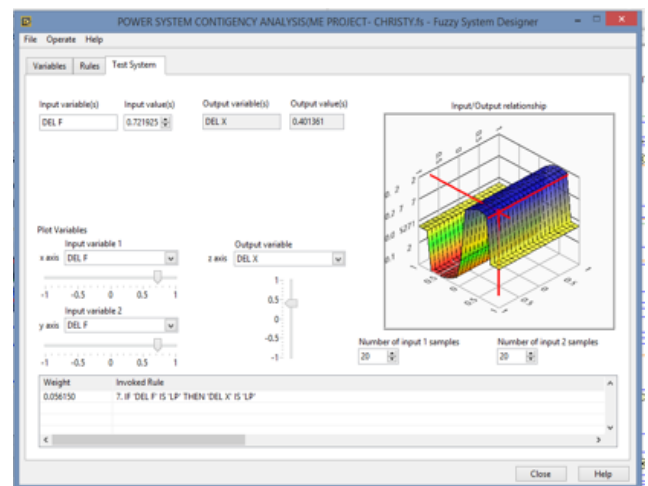

Fig. 5. Law set for graph.

Fig. 6. Test system Input/ Output relationship.

In the Fig.6 shows the test system relationship of input/output signal. Input value is based on the value assigned for the input variable ΔG similarly the output value is obtained based upon the value assigned for the output variable ΔX.
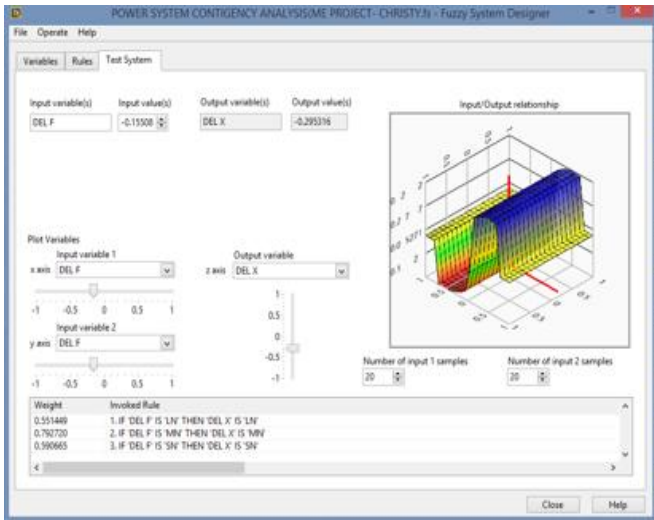
Fig. 7. Test system Input/ Output relationship.

VI. CONCLUSION

The line outages of power system contingency status analyzed by using Fuzzy logic. The proposed method offers very valuable and imperative statistics about the possessions of contingency on power system and providing provisions of operational engineers in taking preceding and necessary preparations and steps to evade any unescapable states taking place in a system. Power flow method based on Fuzzy logic has been suggested which regulate angles and voltage magnitude at various transmission buses of power system. The fuzzy controller with triangular membership functions is reduce the more number of iterations requirement for the power transmission method. The proposed fuzzy logic based contingency analysis in the transmission system is provide overall CPU time requirement is very less and accurate.

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