International Journal of Electrical and Electronics Engineers
Vol. No.7 Issue 02, July-December 2015
www.arresearchpublication.com
IJEEE ISSN 2321 - 2055

CONTINGENCY ANALYSIS USING FUZZY LOGIC

Usman Aliyu Magaji

M. Tech (Power System Engineering) Student, Sharda University, Greater Noida, (India)

ABSTRACT

The most important requirement and need of proper operation of power system is maintenance of the system security. The security assessment analysis is done to determine and to check till what extent a power system is in operable safe condition and will not enter to the serious operation. Power system security assessment helps in monitoring and in giving up to date analysis regarding currents, bus voltages, power flows, status of circuit breaker, etc. The system conditions are determined using ac power flows. The use of AC power flows is it gives information of power flows in terms of MW and MVAR, line over loadings and voltage limit violation with accurate values. Contingency selection or contingency screening is a process in which probable and potential critical contingencies are identified for which it requires consideration of each line or generator outage. For contingency screening several methods have been developed. The most widely used method for calculation of the performance index is based on the conventional method known as Newton Raphson load flow program but Fast Decoupled load flow program was used because it provides a fast solution to the contingency analysis since it has the advantage of matrix alteration formula that can be incorporated.

Contingency ranking is a procedure of contingency analysis in which contingencies are arranged in descending order, sorted out by the severity of contingency. Overall performance index (OPI) is calculated for determining the ranking of contingency. Overall performance index is the summation of two performance index, one of the performance indexes determines line overloading and other performance index determines bus voltage drop limit violation and are known as active power performance index PI_P *and voltage performance index* PI_V *respectively. Here in this proposed work the contingency ranking has been done with IEEE 14 bus system. But the system parameters are dynamic in nature, keeps on changing and may affect the system parameter that is why there is need of soft computing techniques for the prediction purpose. Fuzzy logic approach has been considered. With this soft computing technique, the prediction method helps in obtaining the overall performance index (OPI) with greater accuracy.*

Keywords: Contingency, Contingency Ranking, Performance Indices, Fuzzy Logic, Line Loading.

I. INTRODUCTION

The Fuzzy logic system (FLS) is a logic system which represents reasons and knowledge in a fuzzy manner for reasoning under uncertainty or describes in imprecise manner for human interpretation. Not like Boolean logic and classic logic which assumes that entire fact is either true or false, but fuzzy logic allows

Boolean logic to tackle with vague and imprecise expressions of human understanding. Not like the classic logic systems, it models the reasoning for imprecision model that plays important role in ability of human knowledge to 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 and when it is very much difficult to do evaluation for real time operation. Knowledge of human experts forms the base of the accuracy of fuzzy logic systems (FIS). 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 is mentioned in next Section.

1.1 Fuzzy Logic System (Fls)

A Fuzzy logic system (FLS) system defines the controlling action of a process by the use of simple If-Then rules. 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. 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.

1.2 Fuzzy Inference System

These systems are knowledge based systems which utilizes the following concepts; Fuzzy logic, membership functions and Fuzzy IF-THEN rules. The main component of Fuzzy Inference systems is shown below:

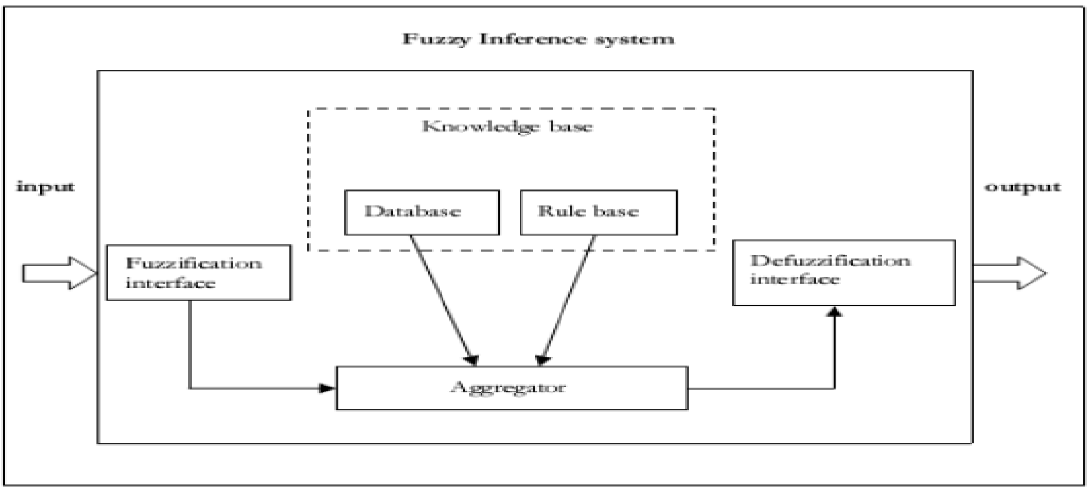

Fig. 1.1 Fuzzy Inference System

The internal structure of a Fuzzy Logic system (FIS) system is in Figure 1.2.

The main components of fuzzy inference systems are:

- Rule Base: contains all the fuzzy rules (if-then) rules.
- Data Base: is used for defining the membership functions.
- Aggregator: performs the operation based on fuzzy if –then rules.
- Fuzzification interface: here in this process converts crisp inputs values to linguistic values.
- Defuzzification interface: here in this converts the fuzzy results into crisp output values.

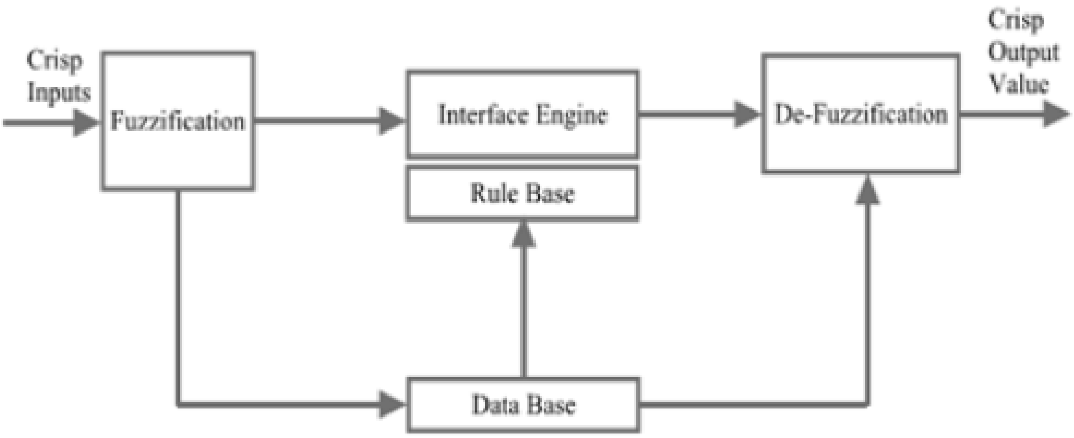

Fig. 1.2 Internal Structure of FLS

Below are the following procedures performed by FIS while processing the inputs. The main components of the FL system are:

II. FUZZIFICATION

The Fuzzy logic uses the linguistic terms and expressions instead of using numerical variables. The measured quantities are in real numbers values (crisp values). The conversion process of an input numerical variable into a linguistic variable output is known as fuzzification. It is the classification of input data variables into suitable linguistic expressions or sets.

2.1 Rule Base or Decision Making

This involves the control action which processes the knowledge of the control rules and the linguistic variable to obtain the fuzzified output. It has three different sub-components which are described below:

- IF part of rule (predecessor or antecedent) – fuzzy operators are used in it.
- THEN part of rule – implication from antecedent part to the subsequent part.
- Aggregation means accumulation of the subsequent of all rules. The output from each rule is aggregated to obtain the final output of the process. Some of the commonly used aggregation methods are Mamdani method type implication (Min-Max implication method), Lusing Larson method type implication and Sugeno method type implication. The Mamdani method implication is the most commonly used for processing of mapping specific input variable to specific output variable.

2.2 Defuzzification

It is here in this process that conversion of input variable i.e., conditional fuzzy control actions to a crisp values or to the non-fuzzy control action is done. The choice of defuzzification strategy is a comparison between intensity of computation and accuracy. Some of the commonly used methods used for defuzzification are Centre of Area method, Height method, Centre of gravity of largest area method and Mean of Maxima method. In this work Centre of Area defuzzification method is used for obtaining the results.

2.3 Fuzzy Logic Approach For Power System Contingency Ranking

The results of post contingent state of line power flows and voltage indices are obtained using Fast decoupled load flow method .The membership functions for these post contingent quantities are first recognized and defined and with these formed membership functions, the computation of overall performance index is done to obtain the contingency ranking The method is as described. For each post contingent quantities which is obtained by the conventional load flow method is known by different linguistic variable and with the membership function associated with it. The inputs to the fuzzy inference system are line loadings, and voltage profiles indices and the outputs to the same FIS are the severity indices, which are computed using the simple set of rules of Fuzzy.

The post contingent quantities of line flows and bus voltage must be expressed in fuzzy set rules notation first, and then only it can be further processed for reasoning rules of fuzzy logic.

2.4 For Line Loadings

Each post-contingent quantity of line loadings in percentage is obtained and with Fuzzy set notation is divided into four categories. They are:

Lightly loaded with, 0-50% of load is regarded as (LL), Normally loaded, 50-80% of load is regarded as (NL), Fully loaded 85-100% of load is regarded as (FL), Overloaded, above 100% of load is regarded as (OL).

Similarly the membership functions for the output of these quantities have also been described using Fuzzy set notation and is divided into four categories for the evaluation of the severity of a post-contingent quantity. They are:

(i) Less severe (LS),
(ii) Below severe (BS),
(iii) Above severe (AS) and
(iv) More severe (MS)

And the Fuzzy rules, meant for defining severity indices of post-contingent quantities of line loadings for evaluation are:

Input variable	**Output variable**
Active Power	OPILL
LL,NL,FL,OL	LS,BS,AS,MS

After getting severity indices for all lines loadings, the overall performance index (OPILL) of the line loading for a particular line outage is obtained using the following expression:

$OPILL=\sum w\, SI,$

Where,

w= is defined as weighting coefficient of the severity index.

PI= Performance Index for a post-contingent quantity.

The weighting coefficient used for different severity indices used are:

W = 0.25 for performance index which is Less Severe (LS).

= 0.50 for performance index which is Below Severe (BS).

= 0.75 for performance index which is Above Severe (AS).

= 1.00 for performance index which is Most Severe (MS).

The effect of these weighting coefficients which are multiplied means that overall performance indices (OPILL) is first dominated by fourth category of performance index (MS) next by third, second and first category of severity index respectively. The severity of a system with contingency occurring in it is indicated by overall performance index.

III. FOR BUS VOLTAGE PROFILES

In this, each post-contingent quantity of bus voltage profiles are classified into three categories as described using Fuzzy set notations. They are:

(i) Low voltage, below 0.9 pu of the voltage (LV)

(ii) Normal voltage, 0.9-1.02 pu of the voltage (NV) and

(iii) Over voltage, above 1.02 pu of the voltage (OV).

The severity of a post-contingent quantity is also divided into three categories using Fuzzy set notations. The evaluation is done by using output membership functions:

(i) Below severe (BS),

(ii) Above severe (AS) and

(iii) More severe (MS)

Fuzzy rules, which are used for evaluating of performance indices of post-contingent quantities of voltage profiles, are:

Input Variable	Output Variable
Voltage	OPIVP
LV,NV,OV	BS,AS,MS

After getting the performance indices of all the voltage profiles, the overall performance index (OPIVP) of the bus voltage profile for a particular line outage is computed using the following expressions.

OPIVP =$\sum$ w SI,

The weighting coefficient used for indicating the severity indices are

w = 0.30 for BS (Below Severe)

= 0.60 for MS (Most Severe)

= 1.00 for AS (Above Severe)

After obtaining the performance indices and overall performance index for the line loadings and bus voltages profile indices are computed by using the respective fuzzy rules. The overall composite overall performance index (OCOPI) is obtained by adding the two overall performance indices.

After figuring out the overall performance index for each contingency, the contingency list is obtained .From the list it can be inferred that the overall performance indices for those contingency cases with a severity index which exceeds a pre-specified value are listed out and the ranking is done according to the network composite overall performance index.

OCOPI=OPILL + OPIVP.

3.1 Methodology For Fuzzy Logic Approach

The important steps involved in this approach for contingency ranking is as follows:

a) For the given system, consider a single line outage at a time, load flow study is performed to determine bus voltage profiles and line loadings.

b) Using trapezoidal membership function, the bus voltage profiles and line loadings are represented in fuzzy set notation.

c) Performance index of line loadings and bus voltage profiles are also represented in fuzzy set notation.

d) Then using Fuzzy-If-Then rules overall severity index for bus voltage profiles and line loadings is obtained.

e) The overall performance index is computed using the formula:

OCOPI=OPILL + OPIVP.

f) For the entire line outage contingency the above procedure is repeated outages and the contingencies are ranked in the decreasing order of overall performance index and thus it helps in measuring of actual severity of contingency.

3.2 Test Results Using Fuzzy Logic

The fuzzy approach is applied and is tested on IEEE 14 bus systems.

The post contingent quantities are first obtained using Fast decoupled load flow method, and then these quantities are fuzzified using fuzzy set notation. With the use of simple IF- THEN rules, rule base form has been made and overall performance index has been obtained.

This logic has been carried out in Matlab environment and the outputs have been obtained. After obtaining the overall performance index ,which is combination of overall performance index of line loadings and overall performance index for voltage profile, it is arranged in decreasing manner indicating the severity of contingencies.

Table 1.1: For IEEE 14 Bus System

Outage	OPIP	OPIVP	OPI	Ranking
1	96.2019	151.1413	247.3432	16
2	96.6866	132.7781	229.4647	19
3	97.6086	158.7695	256.3781	11
4	115.6861	122.2550	237.9411	18
5	96.4969	147.5746	244.0715	17
6	101.6117	157.3918	259.0035	9
7	97.7995	157.6713	255.4708	12
8	137.3049	149.3197	286.624	2
9	96.4989	155.5821	252.081	14
10	99.8579	160.1452	260.003	7
11	114.2900	135.6979	249.9879	15

12	139.5220	133.5081	273.0301	4
13	96.5310	165.1978	261.7288	6
14	97.3242	125.9913	223.315	20
15	96.2613	163.2490	259.5103	8
16	121.2223	156.1825	277.4048	3
17	**188.2364**	**130.0279**	**318.2643**	**1**
18	96.3205	155.8524	252.1729	13
19	112.1647	150.6582	262.8505	5
20	101.2017	157.5832	258.7849	10

IV. CONCLUSION

Fuzzy logic has been used for the contingency ranking of line outages of power system. The proposed method assures the ranking to be more realistic. This method provides very useful and important information about the effects of contingency on system and thus helps the operational engineers in taking prior and necessary actions and steps to avoid any unavoidable situations occurring in a power system.

V. SCOPE FOR FUTURE WORK

The followings can be taken up for further study and analysis:
This prediction technique can be further implemented for higher bus systems and the prediction technique can be further extended to other soft computing techniques and further comparisons can be made.

REFERENCES

[1]. A.J. Wood and Wollenberg, "Power generation, operation and control,"2nd Edition, John and Wiley & Sons Ltd, 2009.

[2] P. Marannino, A. Berizzi, M. Merlo, G. Demartini, "A Rule-based Fuzzy Logic Approach for the Voltage collapse Risk Classification", IEEE Power Engineering Society Winter Meeting, Vol. 2 , pp. 876-881,2002.

[3]. P.R. Bijwe, M. Hanmandlu, V.N.Pande, "Fuzzy power flow solutions with reactive limits and multiple uncertainties", Electric Power systems Research, No. 76, pp.145-152, 2005.

[4]. A. Narendranatha Udupa, D. Thukaram, K. Parthasarathy, "An expert fuzzy control approach to voltage stability enhancement", Electrical Power and Energy Systems, No. 21, pp.279-287, 1999.

[5]. N. Yadaiah, A. Ganga Dinesh Kumar, J.L. Bhattacharya, "Fuzzy based coordinated controller for power system stability and voltage regulation", Electric Power systems Research, No. 69, pp.169-177, 2004.

[6]. Contingency analysis in Power system. Amit kumar Roy.

[7]. V. Mirinda and J.T. Saraiva, "Fuzzy Modelling of Power System Optimal Load Flow", IEEE Transactions on Power Systems, Vol.7, No.2, pp. 843-849, May 1992.

[8]. Ching-Tzong Su and Chien-Tung Lin, "A New Fuzzy Control Approach to Voltage Profile

Enhancement for Power Systems", IEEE Transactions on Power Systems, Vol. 11, No. 3, pp. 1654-1659, August 1996.

[9] Stott B and Alsac O, "Fast decoupled load flow", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-91, No. 5, pp. 859-869, May 1974.