Contingency Analysis of a Power System by using Fuzzy Approach

Nagendra Prasad H K[1]
Pg Scholar
AIT, Chikmagalur

B Kantharaj[2]
Associate Professor
AIT, Chikmagalur

Kavitha K M[3]
Assistant Professor
AIT, Chikmagalur

Ramesh. E[4]
Assistant Professor
RIT, Hassan

Abstract--Operating the Power system is one of the major tasks for the electrical engineers. Due to increase in habituation on the consumption of electricity, the grandness of preventing the voltage collapse is increasing. The power system evaluation is processed to withstand the system during dangerous contingencies and to holdout to a normal or acceptable operating point, which is required for security analysis. To secure the power system a fast and accurate operation has to be performed. The causes for the demarcation assault and force out the system to enter into the emergency state can be known by steady state security assessment enabling the operating personnel. The blackouts due to voltage collapse caused by frequent line outages. Voltage stability margin of the system on the occurrent of specific contingency gives good information about the severity of the contingency of the system. This paper presents the contingency analysis of power system by using fuzzy approach. It uses Voltage Collapse Proximity Indicator i.e. L index. The proposed approach is tested under simulated condition on a Real bus system.

Key words: L-index, fuzzy, membership function, defuzzification, severity.

I. INTRODUCTON

A power system is a complex network which interconnected with costly equipments and with number of loads. Power system is said to be secure when it withstand under the abnormal conditions. The system is stressed by rapid increase in the load demand. Market driven modern power system are forced to operate close their limit. Some of the contingencies lead to failure in the system security which has resulted in the blackouts. Those harmful contingencies can be selected by detailed contingency analysis of the system. The harmful contingency is selected based on the ranking priority given after the evaluation contingency analysis. Contingency analysis is an important phenomenon of the power system security. The contingencies which are occurring to the system are more. The process of ranking the contingencies according to its severity is known as contingency ranking. In earlier days, the contingency analysis is carried out by using the algorithms considering bus voltage and line loadings. A tangent vector bunching technique is used for recognizing the severity condition of the system with respect to collapse at any loading condition. It is based on figuring of new voltage stability index. The second order information derived from the singular value decomposition analysis of the load flow Jacobian matrix is used to obtain the contingency ranking. For the computation of voltage collapse point, the implementation of both point of collapse method continuation method is carried out. This is method is used to identify the voltage instability problem and to find the solution for it. An approach of new fuzzy set theory is being proposed here for security ranking, as it is possible to incorporate. A fuzzy set is developed for contingency ranking using line flows and bus voltage deviations as post contingent quantities [1, 2].

Because of the voltage collapse the line outage occurs. The load ability margin gets reduced because of this mean, and the reduction in the load ability margin underneath each line outage condition ought to be given due care in the ranking process. Thos reduction in the voltage stability margin of the system as the natural event of particular contingency results in obtaining good information about the severity and the contingency of the system. By knowing stability margin, the condition of the system can get to known. The calculation of voltage stability margin serves up a good criticality of contingency index. Though the system pre contingency operating may be aside from the voltage collapse point, contingency will force the system propinquity of voltage collapse point. By using the static voltage collapse proximity indication the changes in voltage stability margin are outputted.

This paper employment L index as voltage collapse proximity indicator to evaluate the contingency ranking. The ranking is provided on the basis of composite index, where contingency index is the summation of the bus voltage and L index. The fuzzy approach is used to to decide the severity ranking of each line outages by combining the effect of bus voltage and L index. The fuzzy inference is tested under MATLAB9 Fuzzy Toolbox. The proposed approach is tested under simulated condition on Real bus system [1, 2, 3].

II. L INDEX AS AN INDICATOR

For versatile studies of power systems, the L index is used as voltage collapse proximity indicator. Among these many indices for voltage stability and voltage prevision, the L index provides reasonably consistent result. From this an accurate indicator and easily computed.

A. Mathematical expression

For a given power system, the voltage –stability L-index is computed using load flow results is as below,

$$L_j = \sum_{i=1}^{g} \left(F_{ji} \frac{v_i}{v_j} \right) \quad (1)$$

Where j = g+1,….,n

Right hand side is complex quantities. The values F_{ji} are complex and are obtained by Y-bus matrix, and is given by

$$\begin{bmatrix} Ig \\ Il \end{bmatrix} = \begin{bmatrix} Ygg & Ygl \\ Ylg & Yll \end{bmatrix} \begin{bmatrix} Vg \\ Vl \end{bmatrix} \quad (2)$$

The complex current and voltage vectors at the generator nodes are given by I*g*, I*l* ,V*g* and V*l*.[Ygg], [Ygl], [Ylg], [Yll] are corresponding portions of the network.

III. FUZZY

An approach based on fuzzy set theory is being proposed here for contingency analysis. As it is possible to incorporate past experience and heuristic in the analysis. It provides an effective fuzzy frame work for the analysis. The fuzzy logic is effectively applied in various fields such as the broad fields of system control, optimization, information processing, diagnosis, system analysis, decision support and planning [2, 3, 4].

Most of the references have proposed the contingency analysis based on only one variable such as voltage or line flows. However if we choose only one variable, it may gives wide results and which may results in the misranking. Due to rapid increase in compensating devices which leads to rise the voltage level to the normal level when also lacking the adequate reactive power. This paper proposes a method of contingency analysis by considering voltage variable and L-index. The fuzzy approach uses L-index as a voltage proximity indicator in addition to bus voltage. Before processed by reasoning rules the voltage profiles and L-index are expressed in fuzzy set notation. Fuzzy rules are evaluate the severity of each post contingent quantity. The severity is determined by evaluating the composite index. The composite index is the summation of voltage and L-index. The Fuzzy Interference Structure FIS is tested under MATLAB9 Fuzzy toolbox [1,3].

A. Bus voltage profile

The bus voltage profiles are divided into three categories using fuzzy set notations.

i) Low voltage : Effect of the contingency doesn't have much impact on the system (below 0.95 p.u.)
ii) Normal voltage : Effect of contingency may or may not have effect over the system (0.95 to 1.05 p.u.)
iii) Over voltage : Effect of contingency will cause the voltage instability (above 1.05 p.u.)

This is the offline analysis performed on various load conditions. For describing the voltage profiles Trapezoidal membership function is used as shown in Figure1.

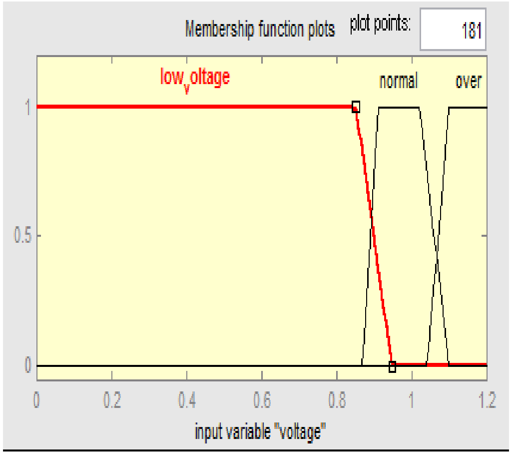

Fig. 1 Membership functions for bus voltage profiles

B. L-index profile

The L-index are devided into five categories using fuzzy set notation.

i) Very small : 0.18
ii) Small : 0.62 to 0.76
iii) Medium : 0.42 to 0.56
iv) High : 0.62 to 0.76
v) Very high : 0.82 to 1.0

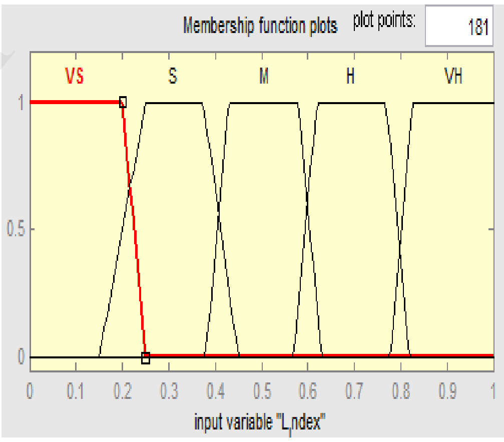

Fig. 2 Membership functions for L-index

Fuzzy rule :

A fuzzy control rule is a fuzzy conditional statement in which the antecedent is a condition and the consequent is a control action. In this work Mamdani control is used. Rules are framed for all possible combination of the membership function. Since there are three inputs SI_L(m=1) and SI_{VP}(m=2) 2 member ship functions are framed in fuzzy tool box.

The fuzzy rules is as shown in Table 1.

Table 1 Fuzzy rules

Post contingent quantity	Severity Index
L index : VS S M H VH	VLS LS BS AS MS
Voltage : VL NV OV	MS BS AS

Note :- VLS- very Less, LS-Less severe
BS-below severe, AS- above severe, MS- more severe

C. Severity Index of Post Contingent Quantities

The output membership for bus voltage profile is also divided into three categories using fuzzy set notation. As the linguistic variables are imprecise, each linguistic variable covers a range rather than a single severity index

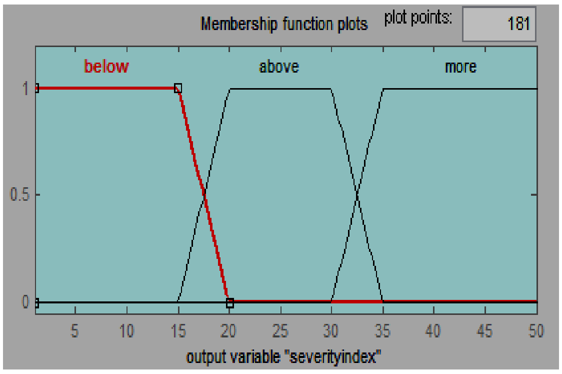

Fig 3 Membership function for severity index of bus voltage profile

The output membership functions used to evaluate the severity of L index are divided into five categories using fuzzy set notation. Trapezoidal membership function is used for describing a linguistic variable.

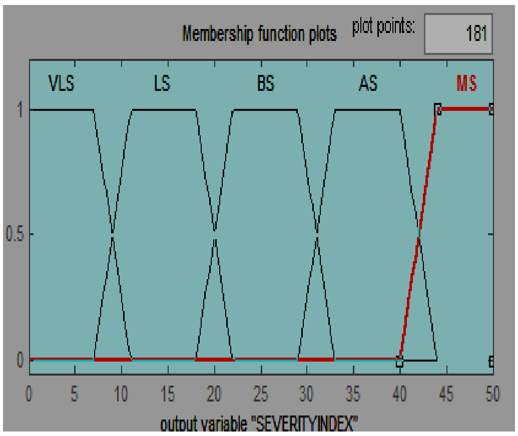

Fig 4 Membership function for severity index of L index

The overall severity index (composite index) for a particular line outage is given by,

$CI = SI_L + \Sigma\ SI_{VP}$;

Where, SI_L is the severity index of L index for a particular line outage

ΣSI_{VP} is the sum of severity index of all bus voltage profiles for a particular line outage.

IV. METHODOLOGY

The major steps for the approach is as follows,

1. For the given system, To determine bus voltage profiles, considering a line outage at a time, load flow study is performed
2. L index is computed using table 1 and is used as post contingent quantity.
3. Assuming trapezoidal membership function.
4. The bus voltage profiles and L index are represented in fuzzy set notation.
5. Severity index of L index and bus voltage profiles are also represented in fuzzy set notation.
6. Using Fuzzy-If-Then rules overall severity index for bus voltage profiles and L index is determined.
7. The Fuzzy Inference System is tested in MATLAB 9 Fuzzy Toolbox.
8. Composite index is found using the formula $CI = SI_L + \Sigma\ SI_{VP}$
9. The above procedure is repeated for all the line outages and the contingencies are ranked based on composite index.

V. TEST RESULTS

The proposed approach is tested under simulated condition on Real system at Hassan district, Karnataka state, India. A.C load flow is carried out to identify the heavily loaded lines based on Voltage Collapse Proximity Indicator. The Real system consists of 2 incoming lines of 220kv and maximum rating of 40MW, 2 buses, 5 feeders (loads). Contingency screening is carried out to identify all the heavily loaded lines. On contingency screening 5 transmissions line outages are considered for ranking of Bus system and Real system.

Simulations were carried out to compute bus voltage profiles and L index for all the contingencies listed in the Table 2, 3 and 4 shows the ranking using Fuzzy approach for 100% and 80% load of Real Bus system. Fuzzy approach gives effective contingency ranking under different loading and line outage conditions. The following table shows the ranking based on L index and Minimum Singular Value of load flow Jacobian matrix using Fuzzy approach.

Table 2: Contingency Ranking Based on L index using Fuzzy Approach for Real Bus system: 100% load

Rank	Load Line outage	SI_V(SUM)	SI_L	CI
7	1	0.803	0.996	0.80433
6	2	1.004	0.7787	1.0036
3	3	1.125	0.63383	1.1242
2	4	2.0814	0.1928	2.0767
5	5	1.029	0.7902	1.0289
8	1 & 2	0.756	0.7745	0.7566
4	2 & 3	1.055	0.3963	1.0541
1	3 & 4	2.1361	0.0932	2.1899

(Note: values in pu,)

Table 3: Contingency Ranking Based on L index using Fuzzy Approach for Real Bus system: 80% load

Rank	Load Line outage	SI_V(SUM)	SI_L	CI
5	1	0.8	0.998	0.80
4	2	0.816	0.958	0.8163
2	3	0.825	0.981	0.8259
1	4	0.869	0.479	0.8690
3	5	0.817	0.912	0.8171
8	1 & 2	0.612	0.956	0.6127
7	2 & 3	0.632	0.917	0.6321
6	3 & 4	0.672	0.353	0.6721

(Note: values in pu,)

Table 4: Comparison of Contingency Ranking using Fuzzy Approach based on L index and MSV for Real Bus System

Load line outage	100% Load Ranking	100% Load MSV	80% Load Ranking	80% Load MSV
1	7	7	5	5
2	6	6	4	4
3	3	3	2	2
4	2	2	1	1
5	5	5	3	3
1 & 2	8	8	8	8
2 & 3	4	4	7	7
3 & 4	1	1	6	6

(Note: values in pu,)

By analyzing the above results, it can be observed that the contingency ranking deciding by using L-index and MSV are same. Ranking the contingencies by using these index gives very useful information about the contingency impacts of the system and helps in taking the necessary actions.

VI. CONCLUSION

Fuzzy approach is used to evaluate the composite index by combining the effect of voltage profile and L-index. Fuzzy approach gives effective contingency ranking under different loading conditions. Fuzzy provides an effective framework for the analysis. Through proper tuning the membership functions in fuzzy, the method can mimic the operator performance by conducting contingency ranking.

REFERENCES

1. Zakir hussain, Zhe Chen, Paul Thogersen, " Fast and precise method of contingency analysis ranking in modern power system", 2011 IEEE Jordan Conference on Applied Electrical engineering and computing technologies (AEECT).
2. A.Y. Abdelaziz, A.T.M. Taha, M.A. Mostafa, A.M.Hassan, "Fuzzy Logic Based Power System Contingency Ranking", I.J. Inelligent systems and applications, 2013,03,1-12
3. Manjaree pandut. Laxmi Srivastava, Jayadev Sharma, "Voltage contingency ranking using fuzzified mulitilayer perceptron ", Electrical power system research 59 (2001) 65-73.
4. H.R. Baghaee, M.Abedi," calculation of weighting factors of static security indices used in contingency ranking of power systems based on fuzzy logic and analytical hierarchical process", Electrical Power and Energy systems 33(2011) 855-860.
5. Yogesh Kumar Bichpuriya P K Kalra, Ajay Kumar Saxena Dr, "Synergism of MW and Mvar Losses for Contingency Ranking Using Fuzzy Approach", International Journal of Emerging Electrical Power Systems, Vol 5,Issue 1, 2006, Article 3.