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REVIEW ARTICLE

CONTINGENCY RANKING IN POWER SYSTEMS

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ABSTRACT

A performance index (PI) is computed for each single line contingency using both conventional and Fuzzy based approach. To obtain the magnitudes of various parameters, a computer aided power system study software package which employ iterative methods are used. This paper presents an approach using fuzzy logic to evaluate the degree of severity of the conventional contingency and to eliminate the masking effect in the technique.

INTRODUCTION

Contingency analysis allows systems to be operated defensively. The operator cannot take action fast enough when many of the problems that occur on a power system that causes serious trouble within fraction of time period leading to cascading failures. Because of this aspect of system operation, modern operations computers and SCADA systems are equipped with contingency analysis programs that model possible system troubles before they arise. A scalar function called Performance Index (PI) which measures system stress is used in the calculation of the contingency ranking. A real power and voltage performance index is calculated which evaluates the severity of contingency derived from the current overload of lines. The operating state of the system is a function of time. It keeps on changing due to variation in load level at various buses or due to rescheduling of generation. To keep the system secure, it is imperative to know the impact of unplanned outages in advance so that suitable preventive / control measure scan be taken if necessary.

Experiment

The solution algorithm for real power and voltage contingency ranking is as follows:

1) Solve a load flow for base case.
2) Remove single line.
3) Calculate the numerical value of performance index by considering real power flow and voltage of the line.

Conventional Performance Index

$$PI(V) = \sum_{I=1}^{nB} \left[\frac{V_{IBASE} - V_{INEW}}{V_{IBASE}}\right]^{2n} 2$$

Where nB = number of Buses.

4) Rank the contingencies from their PI values.
5) Repeat step 2 and 3 for different contingencies

It is possible that some severe contingencies may be left out and also some not so severe contingencies may be ranked. There may be some other severe conditions are existing between each ranking. So this unmasking of severity between the two rankings is obtained with the fuzzy based approach.

$$FPI(P) = \sum_{I=1}^{nL} \left[\frac{P_{IBASE} - P_{INEW}}{P_{IBASE}}\right] 1$$

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$$FPI(V) = \sum_{I=1}^{nB} \left[\frac{V_{IBASE} - V_{INEW}}{V_{IBASE}} \right]^2$$

Last ten years onwards fuzzy system application have received increasing attention in manufacturing industries, heavy industries, transportation systems, water supply systems. The applications are mainly for controllers, diagnosis, optimization and planning. In fuzzy set, the degree of belief of every fuzzy subset from "belong to set" to "not belong to set" are represented in a gradual transition which is called membership function. Membership function is representing the degree of belief of every subset in the universe of discourse in a number between 0 and 1.Several membership function shapes can be used to develop fuzzy contingency ranking such as triangular, trapezoidal, sigmoid, bell function. In this case trapezoidal membership function shapes were used and indicated in Figure 1is usually expressed by the characteristic points a, b, c, d such that the fuzzy number under study can assumed any value between a and d, but values within the range b and c are most likely to place.

Fuzzy Representation of contingency ranking

The four characteristic points a, b, c, d are selected between each two rankings represents performance indices. Membership functions used to evaluate the severity of contingency ranking is divided into five categories using fuzzy set notation. Here the inputs are real power and voltage indices whereas the outputs are severity indices.

Fuzzy set notations are

Very small 0 - 0.2 (VS)
Small 0.2 - 0.4 (S)
Medium 0.4 - 0.6 (M)
Large0.6 - 0.8 (L)
Very Large 0.8 - 1.0 (VL)

Table 1. Line Outage by Fuzzy PI

S.No	Line	ContingencyIndex	Rank	
			Normal	Fuzzy
1	L 5-6	N 22.5582	1	M
2	L 7-9	N 10.9672	2	M
3	L 6-13	N 10.9436	3	VS
4	L 9-14	N 6.38889	4	L
5	L 2-3	N 6.06941	5	S
6	L 4-5	N 5.97986	6	S
7	L 1-2	N 4.40003	7	M
8	L 4-7	N 4.33718	8	L
9	L 9-10	N 4.07555	9	L
10	L 6-12	N 3.51125	10	M
11	L 4-9	N 3.28596	11	VS
12	L 6-11	N 3.00918	12	L
13	L 7-8	N 2.33240	13	M
14	L 2-4	N 1.80524	14	M
15	L 13-14	N 1.31060	15	S
16	L 10-11	N 0.41654	16	M
17	L 1-5	N 0.04980	17	VL
18	L 12-13	0.62199	18	M
19	L 2-5	0.7261	19	L
20	L 3-4	0.897784	20	L

"Table 1" explains the single line contingency ranking using Fuzzy performance index for IEEE 14 bus. Line 5-6 most severe and next comes Line 7-9. "Table 2" explains the contingency ranking using fuzzy performance index for five bus systems on voltage base. Line 1-2 has the largest contingency index value and hence more severe. Next comes Line 2-5

Table 2. Line Outage by Fuzzy PI

Sl No	Line	ContingencyIndex	Rank	
			Normal	Fuzzy
1	L4-5	0.017249	1	S
2	L2-4	0.018528	2	M
3	L3-4	0.021594	3	L
4	L2-3	0.049564	4	M
5	L1-3	0.056666	5	M
6	L2-5	0.143946	6	M
7	L1-2	0.418303	7	M

"Table 3" explains the contingency ranking for five bus system on voltage base. Line 1-2 has the largest contingency index value and hence more severe. Next comes Line 2-5.

Table 3. Line Outage by Conventional PI

Sl No	Line	Contingency Index	Rank
1	L2-4	0.000112	1
2	L4-5	0.000156	2
3	L3-4	0.000294	3
4	L1-3	0.000826	4
5	L2-3	0.00099	5
6	L2-5	0.010262	6
7	L1-2	0.043826	7

Conclusion

The most critical and harmless outage scenarios for five bus and IEEE 14 bus systems are calculated by both conventional and fuzzy based analysis. Most critical contingencies can be identified correctly by using fuzzy based ranking system than conventional system. This method eliminates the masking effect of conventional methods of contingency ranking effectively.

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