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Power System Contingency Ranking Using Compensation Factor In Performance Index

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ABSTRACT :

Security of the power system is determined by its ability to withstand contingencies (disturbances) without interruption of power supply. Security assessment is done off-line in which steady state and dynamic performance of the system, for the given operating conditions are analyzed using simulation. Contingency analysis is one of the security assessments, which involves an extensive search for contingencies that create operating limit violation and is also performed to determine the impact of the potential contingency on the remaining power system. For analysis, each possible contingency that might occur in the power system is considered. Contingency ranking is the process of ranking the contingencies depending on the impact (severity) it creates on the power system. Performance Index (PI) is one of the severity index used for contingency ranking. For performance index calculated using low order exponent terms, misclassification of contingencies occurs. Using higher order terms, misclassification can be eliminated but it requires a lot of computational space, time and efficiency for large power system. The proposed method uses a term in the performance index formula called compensation factor to eliminate misclassification. Appreciable results are obtained using the above method in IEEE 5 bus and IEEE 14 bus system.

Keywords: contingency ranking, Performance Index (PI), masking effect, compensation factor

I. INTRODUCTION

Deregulation of electricity market has created a lot of changes in the way electric power system operates. All the systems of the electric utilities are being utilized to the maximum level to obtain maximum benefit. Power system components are being operated near their security margin which causes much concern to the Power system engineer. Power system security is given paramount importance in the present energy scenario than the past. Power system security denotes the ability of the power system to withstand contingencies without interruption of power supply [1]. Security assessment is done both online and offline. Online security assessment is carried out in Energy Management System (EMS) at the control center periodically to ensure that all components in the power system operate within their security margin [2]. In online security assessment computational time plays a major role as fault clearance should take place within a specified time frame after the occurrence of the fault or else clearance of the fault is of no use. Offline security assessment is done for the purpose of power system expansion planning, improvement of power system security using FACTS devices. Contingency analysis is one of the security assessments used widely in both online and offline. Contingency ranking is a process of ordering the potential contingencies according to their severity. Based on the value of the severity index, contingencies are ranked. Performance Index is the widely used method to rank contingencies but the disadvantage of using PI is the misclassification of contingencies which is termed as masking effect. In order to eliminate the masking effect, various methods are being proposed in the literature. The fuzzy logic optimization technique is used to eliminate the masking effect [3]. Using higher order terms in the Performance Index formula reduces masking effect but requires a lot of computational time. One of the methods is partitioning the whole power system into smaller power systems and contingencies that might occur in the smaller system are ranked and then a final list of contingency ranking is prepared for the whole system. In this paper, the performance index formula is modified by the inclusion of a factor named compensation factor and contingencies are ranked based on the value obtained from the modified Performance Index formula.

II. CONTINGENCY ANALYSIS

Contingency analysis is the process of evaluating various system variables of the power system under contingent conditions such as outage of lines, generator etc. This paper considers line outage contingency only. Load flow analysis is used to evaluate system variables such as voltage, voltage angle, line power flows. The obtained data are checked for limit violation. In this paper DC load flow analysis and Fast Decoupled Load Flow Analysis (FDLF) technique is used for contingency ranking. The results obtained using both the techniques are compared. Contingency analysis consists of three stages contingency definition, contingency selection and contingency evaluation. Contingency definition is the process of forming the contingency list which includes all possible contingencies that might occur in the power system. Contingency screening or contingency selection is the process of identifying the contingency that actually leads to violation of operating limits. The contingencies are ranked based on the value of the severity index of each contingency. Contingency evaluation consists of taking remedial actions to mitigate limit violations caused by the considered contingency. Performance index is one of the severity indices used to rank contingency according to the impact it causes in the power system.

III. PERFORMANCE INDEX

The actual state of a power system is defined by a set of N system variables. N denotes the number of buses in the power system. In order to indicate the severity of the contingencies and to rank them relative to each other the set of system variables must be transformed into a scalar value called the performance index (PI).

As a measure of the impact of each contingency on the system, the PI should essentially have two aspects. They are distinction of actual critical outages from non critical outages and prediction of the relative severity of critical outages. Consequently, the impact of each contingency on the power system is directly measured by the post outage performance index. Thus, the PI serves as a penalty function for limit violations. PI_p reflects the violation of line active power flow.

$$PI_P = \sum_{SL} \left(\frac{W_i}{2n}\right) * \left(\frac{P_i}{P_i^{max}}\right)^{2n} \quad (1)$$

P_i is the active power flow in line i. P_i^{max} is the maximum active power flow in the line i. n is the exponent term. SL is the set of overloaded lines for the considered contingency condition. W is the weight factor. The value of PI is small when less number of lines is overloaded and it is large when more number of lines is overloaded. According to the value of PI obtained for each line outage case, contingency ranking is made in descending order (contingency with highest value of PI takes the first place in ranking).

IV. MASKING EFFECT

The ideal case of contingency selection is reached, if all actual critical contingencies are ranked at the top of the contingency list. But in general, PI based algorithms can hardly approach the ideal case because of the masking effect. This effect leads to a misclassification of contingencies and thereby leads to an incorrect judgment of the actual system state.

The performance index calculated using eq. (1) for 2n=2 in most cases provide a good measure for determining the severity of the transmission line contingencies. However, in some instances, particularly when a single line gets overloaded and at the same time loading of other lines decreases, the value of the performance index decreases and the overloading of a single line may not be recognized. This phenomenon is called as masking effect.

In this paper two methods are used to eliminate masking effect and the results obtained are compared. Using higher values of the exponent in performance index is the conventional method. This method gives appreciable results but requires a lot computational time which is a major constrain in large power system. This approach can be justified by observing that the performance index of eq. (1) can be likened to the p-norm. As is well known, as p tends to infinity the p-norm becomes the ∞-norm. PI equation based on vector norm formulation is given below

$$PI_P = \left(\sum_{SL}\left(\frac{W_i}{2n}\right) * \left(\frac{P_i}{P_i^{max}}\right)^{2n}\right)^{1/2n} \quad (2)$$

Theoretically masking effect can be removed only when the exponent is equal to infinity but practical simulation have shown that masking effect is appreciably reduced for exponent equal to 20 [4].

The discrepancy in ranking can be eliminated at low value of exponent using the proposed method. This method requires study of the considered power system under various operating conditions. Two factors are considered for the calculation of compensation factor. Aggregate of these two factors gives the value of the compensation factor. The criterion for one of the factors is voltage rating of the considered line which is to be removed for the purpose of analysis. By analyzing the results obtained previously, it is found that when a high voltage line is removed, it causes overloading of the nearby lines but removal of the low voltage line does not causes overloading of the neighboring lines. Hence, compensation factor (C1) is given high values for high voltage lines and low values for low voltage lines. These values are chosen using trial and error method. The criterion for another factor is aggregate of the available transfer capability of the lines connected to the same bus as of the outage line (First bound neighbors). For compensation factor (C_2), low values are given, if available transfer capability of the first bound neighbors is greater than the capacity of the outage line and high values are given, if available transfer capability of the first bound neighbors is less than the capacity of the outage line. This is because of the fact that when available transfer capability of the first bound neighbors is greater than the outage capacity then the probability of overloading of the surrounding lines is low and vice versa. The Performance Index formula becomes

$$PI_P = C_K * \sum_{SL}\left(\frac{W_i}{2n}\right) * \left(\frac{P_i}{P_i^{max}}\right)^{2n} \quad (3)$$

$$C_k = (C_1 + C_2)/2 \quad (4)$$

C_k is the compensation factor for K^{th} line.

V. CONTINGENCY RANKING FOR IEEE 5 BUS SYSTEM

DC load flow analysis and FDLF analysis is carried out in IEEE 5 bus system using Power World Simulator (PWS).

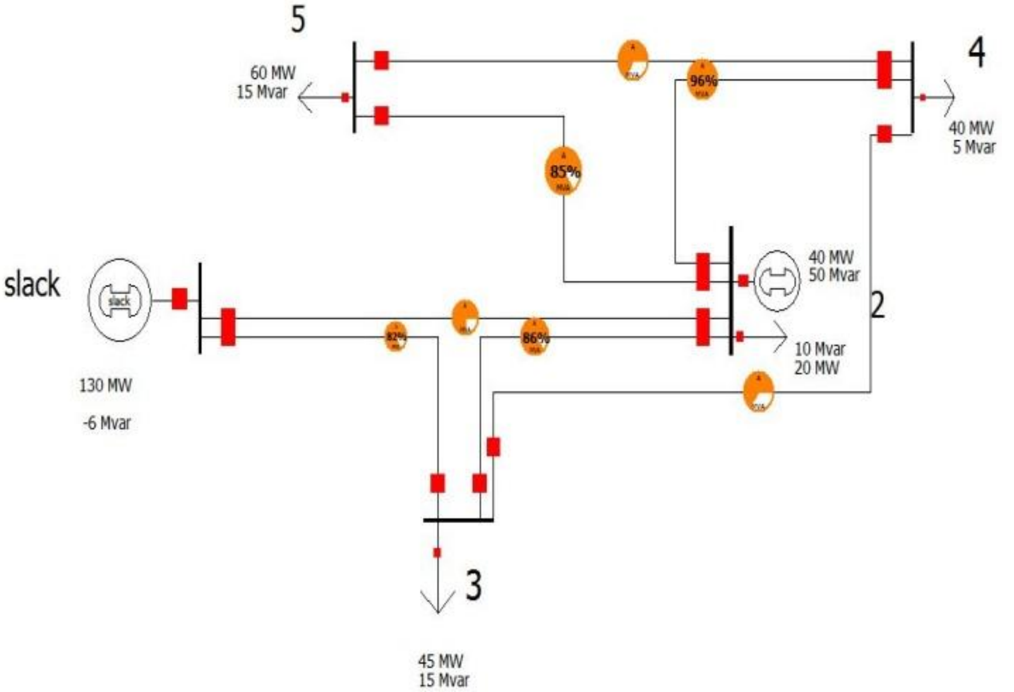

Fig.5.1. IEEE 5 bus system- base case load flow analysis using FDLF

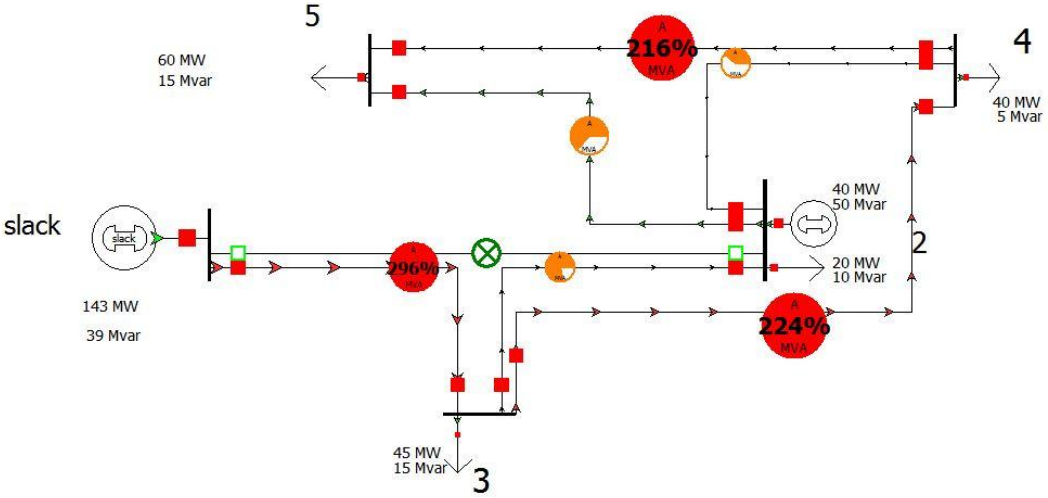

Fig.5.2. IEEE 5 bus system – line outage 1-2

Contingency ranking for IEEE 5 bus system using DC load flow analysis and FDLF technique is performed in Power World Simulator (PWS). Performance Index is calculated for 2n=2, 2n=20 and 2n=2 with compensation factor. The obtained values are tabulated in table 5.1.

Table.5.1. Contingency ranking in IEEE 5 bus system

Lines	DCLF	FDLF			DCLF	FDLF		
	PI(2n=2)	PI(2n=2)	PI(2n=20)	PI'(2n=2)	PI(2n=2)	PI(2n=2)	PI(2n=20)	PI'(2n=2)
1-2	8.2578	9.8139	1.5158	9.8139	2	2	2	2
1-3	3.4257	3.9552	1.2730	3.1641	3	3	3	3
2-3	1.8947	2.3907	1.1239	0.7172	6	5	6	6
2-4	3.0057	2.3983	1.1292	0.7194	4	4	5	5
2-5	23.3272	25.6539	2.1376	20.5231	1	1	1	1
3-4	1.9483	2.3815	1.196	1.9052	5	6	4	4
4-5	1.8401	2.1857	0.0566	0.6571	7	7	7	7

Using DC load flow analysis, MW flow on each line is obtained and Performance Index is calculated. There are misranking among contingencies. This is mainly due to the computational inaccuracy in the calculation of power flow. There is a huge variation in the values of MW flow in each line obtained from FDLF and DC load flow. From the results obtained it can be seen that line outage 2-5 is the most severe contingency in the test system considered. It causes overloading of 5 lines. Line outage 4-5 does not cause any overloading of the lines.

V1. CONTINGENCY RANKING FOR IEEE 14 BUS SYSTEM

In IEEE 14 bus system, load flow analysis is carried out using FDLF and DC load flow analysis. For the given operating condition, the high voltage lines are heavily loaded even under normal working condition. Outage of a high voltage line causes overloading of nearby lines. Hence, compensation factor for these lines should be higher than the low voltage lines as these lines are viable to create a critical contingency. Fig.6.1. and Fig.6.2. show the loading condition of all the lines under normal and contingent condition.

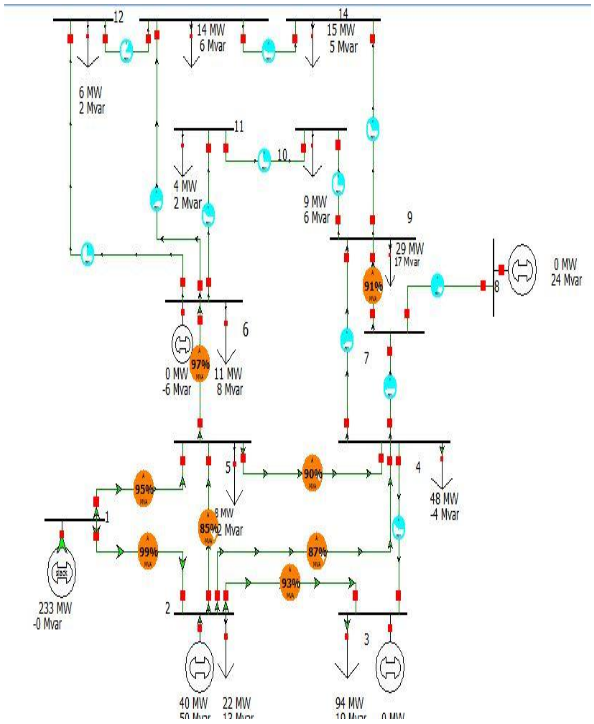

Fig.6.1. IEEE 14 bus system – base case load flow analysis using FDLF

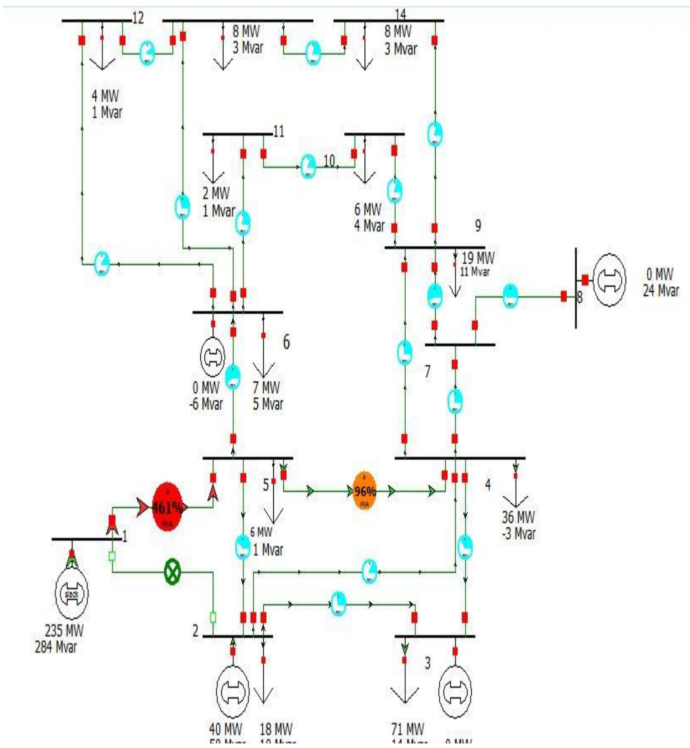

Fig.6.2. IEEE 14 bus system line outage 1-2

Line outage 1-2 causes overloading of only one line but this line is very heavily overloaded. The Power World Simulator software (PWS) gives an alarm message that the outage of line 1-2 causes a blackout. Hence, this is the most critical contingency in the system.

Contingency ranking for IEEE 14 bus system using DC load flow analysis and FDLF technique is performed in Power World Simulator (PWS). Performance Index is calculated for 2n=2, 2n=20 and 2n=2 with compensation factor. The obtained values are tabulated.

Table.6.1. Contingency ranking in IEEE 14 bus system

Lines	DCLF	FDLF			DCLF	FDLF		
	PI(2n=2)	PI(2n=2)	PI(2n=20)	PI'(2n=2)	PI(2n=2)	PI(2n=2)	PI(2n=20)	PI'(2n=2)
1-2	6.1795	9.4070	1.7415	14.1105	1	2	1	1
1-5	3.8556	3.9379	1.4075	4.3317	4	3	3	3
2-3	4.7760	1.8434	1.2617	2.0278	2	9	4	6
2-4	2.5693	3.7997	1.2421	3.2298	6	4	5	5
2-5	1.1451	1.9067	1.0409	1.8114	7	8	11	8
3-4	0.7626	1.2883	1.0634	1.4171	8	12	9	11
4-5	2.8022	3.5146	1.1929	3.8661	5	5	7	4
4-7	0.4453	1.2823	1.0479	1.0899	10	13	10	12
4-9	0	1.3160	1.0387	1.8216	-	11	12	7
5-6	4.0573	13.0887	1.4418	11.1254	3	1	2	2
6-11	0	0	0	0	-	20	20	20
6-12	0	0.9873	0.9152	0.7405	-	14	15	14
6-13	0.2756	1.5337	0.9722	0.7668	11	10	13	13
7-8	0	0.5446	0.8955	0.4084	-	19	16	19
7-9	0.2620	3.4732	1.2097	1.7366	12	6	6	9
9-10	0	0.9261	0.9226	0.6946	-	15	14	15
9-14	0.5782	1.9165	1.1915	1.4379	9	7	8	10
10-11	0	0.8758	0.8331	0.4379	-	18	19	18
12-13	0	0.8841	0.8431	0.4421	-	16	17	16
13-14	0	0.8766	0.8377	0.4383	-	17	18	17

Using compensation factor in performance index formula reduces masking effect to a considerable level. It can be noted that as system size increases the efficiency of the proposed method reduces.

VII. CONCLUSION

Contingency selection process is a tedious work and it takes a lot of computational time. The main aim of contingency selection is to separate the critical contingency from non-critical contingency. For this purpose, Performance Index is calculated for each line outage using FDLF and DC load flow analysis. DC load flow analysis gives approximate values of power flow and Performance Index calculated using these values leads to misranking of contingencies. Hence it is preferable to use FDLF to know the line power flow. The Fast Decoupled method offers a uniquely attractive combination of features which is advantageous over established methods, including Newton's in terms of speed, reliability, simplicity and storage. Performance index calculated for 2n=2 is subjected to masking phenomenon. Hence, higher order exponent are used but it requires a lot of computational time. For a low value of exponent, Performance Index with compensation factor avoids masking effect to a considerable level. The principle of this method depends on the simple correlations between the pre-contingency line flows of the outage line and its first order neighbors. Performance Index is calculated for 2n=2, 2n=20 and 2n=2 with compensation factor in both IEEE 5 bus system and IEEE 14 bus system. From the simulations of the proposed method it is found that as the system becomes larger, the efficiency of compensation factor method reduces. This is mainly because many conditions have to be considered for the calculation of C_k, for which study of the considered power system should be done. Fuzzy logic optimization technique can be used to get an optimized C_k.

In IEEE 5 bus system, only one criterion is considered for the calculation of compensation factor. Ideal case of contingency ranking is obtained at low value of exponent using C_k. In IEEE 14 bus system, two conditions are considered. By including more number of criteria and by using optimization technique, an optimal value of C_k can be obtained and hence masking effect can be reduced to a greater extent.

REFERENCE:

[1] Kip morison, Lei wang and Prabha kundur, September/October 2004," Power System Security and Assessment", IEEE Power System Security and Energy Magazine.

[2] Stott B, Alsac O and Monticelli A.J, Dec 1987, " Security Analysis and Optimization", Proc. IEEE, vol 75, No. 12,pp.1623-1644.

[3] Ayodogan ozdemir and Charan singh, 2001,"Fuzzy Logic Based MW contingency ranking against masking problem", Proc.IEEE.

[4] K.F. Schafer, J.F. Verstege, May 1990,"Adaptive Procedure for Masking Effect Compensation in Contingency Selection Algorithm", IEEE Transactions on Power Systems, VO1.5, No.2, pp.539-546.

[5] G.C. Ejebe and B.F. Wollenberg, Jan/Feb 1979,"Automatic Contingency selection", IEEE Trans. on PAS, Vol.PAS-93 (1974), pp.859-869.

[6] B.Scott and et.al, May 1973," Fast decoupled load flow", IEEE Trans.(Power Apparatus and Systems).

[7] Yuan-Yin Hsu and et al., Aug 1992,"Fuzzy set based contingency ranking", IEEE Transaction on power systems,vol 7,No. 3.

[8] Irisarri and et al., April 1981," An Automatic contingency selection method for online security analysis", IEEE Trans. On power Apparatus and System.

[9] Ming Chen, 2011,"Contingency re-definition and its application to power system security analysis", Power Systems Conference and Exposition (PSCE),IEEE/PES DOI: 10.1109/PSCE.2011.5772458.

[10] Mishra, V.J., Khardenvis M.D.,2012 "Contingency analysis of power system", Electrical, Electronics and Computer Science (SCEECS), 2012 IEEE Students' Conference on DOI: 10.1109/SCEECS.2012.6184751.