ISSN: 2454-4248
155 – 159

Reliability Based Priority Allocation of Contingencies in a Complex Power System Network

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Abstract: Power system network consists ofsynchronous generators, transmission lines, shunt capacitors, transformers and loads. The reliability of a complete system depends on individual components reliability performance. Reliability study of a network deals with the interruptions of network. The failure of components depends on whether conditions, ageing effects, other components failure and parameter limit violation. The effect of failure on reliability performance of a system is different for every contingency. The only probability of a failure of a component does not decide the severity of failure on the power system but also depends on the rating of component. In this paper, the state probability and severity index due to the failure of each component of a thirty bus interconnected power system network is calculated and then the reliability performance based priority of contingency is investigated.

Keywords:*Reliability, Availability, Unavailability, Load flows, Compensators and Contingency*

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I. INTRODUCTION

Power system consists of synchronous generators, transmission lines, transformers, shunt capacitors etc. Synchronous generators are the source of active and reactive power. High rating generator failure damages is more compare to low rating device. So, while considering failure of generator it is necessary to consider active power rating of generator. Transmission line transforms power from generating station to distribution substation. The MVA power flow effect is the severity of failure. Transformer MVA flow is effect the severity of failure. Similarly the Mvar capacity of shunt capacitor affects the severity of failure. So, it is necessary to give the priority of contingency in order to operate a power system network very effectively.

II. PROBLEM FORMATION:

This paper presents the allocation of reliability based priorities for different contingencies that may occur in power system network. Before giving priority it is necessary to run load flow to knowthe power flow through transmission lines. A severity index is proposed to give priority of contingencies.

A) Component Reliability Model

All the components of power system network such as synchronous generator, transmission line, and transformer are modeled using two-state (up state and down state) reliability model and shown in Figure. 1([1]-[3]).The probability of a component being in the up ste and down state is called availability (A) and unavailability (U) of component respectively. The availability and unavailability of a component can be calculated based on its average failure rate λ (f/yr) and average repair rate μ (repairs/yr). The following equations are used to calculate A and U [10].

$A=\mu / (\lambda+\mu)$ ------(1)
$U= \lambda / (\lambda+\mu)$ -----(2)

B) System Reliability Parameters

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After finding the availability and unavailability of each component, the probability of each state of a system is calculated. The probability of each state of a system with P number of total components and with N number of components failure can be calculated using the Equation 3 [10].

$$P_j = \prod_{i=N+1}^{P} A_i \prod_{i=1}^{N} U_i \quad (3)$$

Where, i is the contingency state,A_i and$U_i$is the availability andunavailability of component i,

C)Severity Filtering Index

An index known as a severity filtering index is used to evaluate the effect of a particular contingency on the reliability of a complete system . This section describes the procedure used to evaluate severity index due to the failure of synchronous generator, shunt compensator, transformers and transmission lines.([4]-[8])

i)For failed generators,the severity filtering index is the product oftotal active power capacity of the failed generator for the normal state and its state probability.
ii) For shunt capacitor failure,the severity filtering index is the product of failed shunt capacitor Mvar rating and itsstate probability
iii) For transformers/ transmission lines failure,the severity filtering index is the product of MVA flow through transmission lines/ transformer and its state probability. The following steps are used to evaluate severity index due to failure of each component.

Step 1:Find availability and unavailability of each component
Step 2: Find the probability of each state of a system
Step 3: Run load flows of an interconnected power system network.
Step 4 :Find severity index of a system due to failure of each component
Step 5: Based on severity index give rank in increasing order.(Higher severity index indicates more effect on reliability performance of the system)

III. Case Study

The procedural steps explained in the above section applied to a thirty-bus electrical interconnected system shown in Figure 1 [9]. The details of a system are as follows: Number of generators: 6, Number of load buses: 24, Number of 2 winding transformers: 2 ,Number of shunt compensators: 2 and Total lines: 41 (Transmission lines and transformers). Table 1 and Table 2 show the reliability data of generators, Transmission lines and transformers.

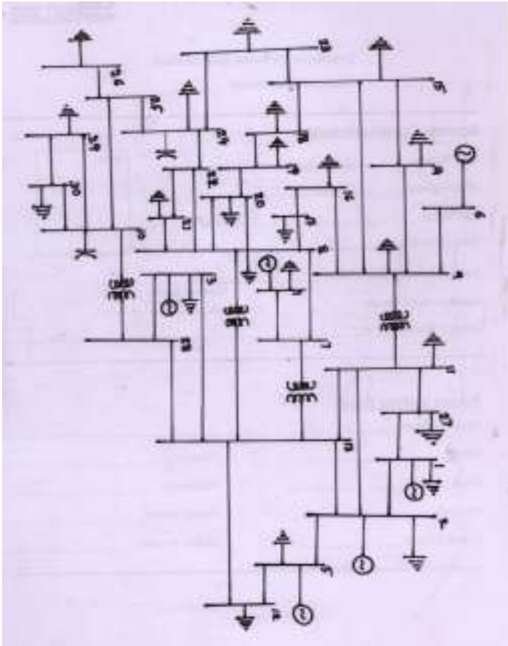

Figure 1:30 Bus system

Table 1: Reliability Data of Generators

Bus No.	Gen. No.	λ	μ
2	2	6.0	194.67
3	3	6.0	194.67
4	4	4.5	219.00
5	5	6.0	194.67
6	6	6.0	194.67

Table 2: Reliability Data of Transmission Lines and Transformers

S.No	From Bus	To Bus	λ	μ
1	1	2	1.0	876
2	1	27	1.0	876
3	2	5	1.0	876
4	2	11	1.0	876
5	2	13	1.0	876
6	3	13	1.0	876
7	3	28	1.0	876
8	4	7	1.0	876
9	5	12	1.0	876
10	6	9	1.0	876
11	7	8	1.0	876
12	8	17	1.0	876
13	8	20	1.0	876
14	8	21	1.0	876
15	8	22	1.0	876
16	9	14	1.0	876

17	9	15	1.5	876
18	9	16	1.5	876
19	10	25	1.5	876
20	10	29	1.5	876
21	10	30	1.5	876
22	11	13	1.5	876
23	11	27	1.5	876
24	12	13	1.5	876
25	13	28	1.5	876
26	14	15	5.0	876
27	15	18	5.0	876
28	15	23	5.0	876
29	16	17	5.0	876
30	18	19	5.0	876
31	19	20	1.5	876
32	21	22	1.5	876
33	22	24	1.5	876
34	23	24	5.0	876
35	24	25	5.0	876
36	25	26	1.5	876
37	29	30	5.0	876
38	7	13	5.0	876
39	8	13	5.0	876
40	9	11	1.5	876
41	10	28	1	876

As discussed earlier to find severity filtering index it is necessary to have MVA flow through transmission lines.A direct inspection method is used to evaluate Y-Bus and Newton Raphson (NR) load flow method is used to calculate the voltage profile at different buses, MVA power flow through transmission lines and transformers and they shown in Table 3 and Table 4 respectively. PSSE software is used to perform NR load flow studies,

Table 3.: MVA Flow Through Transmission Lines

S.No	From Bus	To Bus	P flow (MW)	Q flow (MVAR)	MVA Flow
1	1	2	60.1	8.4	60.68
2	1	27	30.8	6.3	31.43
3	2	5	54.8	7.1	55.25
4	2	11	18.6	3.1	18.85
5	2	13	25.7	7.9	26.88
6	3	13	32.2	31.6	45.11
7	3	28	9.1	8.6	12.52
8	4	7	8.7	27.1	28.46
9	5	12	19.6	11	22.47
10	6	9	53.1	37.5	65
11	7	8	29.6	15.4	33.36
12	8	17	2.5	6.0	6.5
13	8	20	4.6	4.4	6.36
14	8	21	6.6	3.7	7.56
15	8	22	12.9	8.5	15.44
16	9	14	9.5	1.7	9.65
17	9	15	25	5.1	25.51
18	9	16	15.4	2.3	15.57
19	10	25	4.7	5.7	7.38
20	10	29	6.2	1.7	6.42
21	10	30	7.1	1.6	7.27
22	11	13	30.8	23.4	38.68
23	11	27	28	6.4	28.722
24	12	13	42.9	0.4	42.90
25	13	28	9	2.6	9.36
26	14	15	3.2	0.2	3.206
27	15	18	10.5	1.0	10.54
28	15	23	9.1	0.6	9.11
29	16	17	11.6	0.2	11.60
30	18	19	7.2	0.2	7.20
31	19	20	2.4	3.6	4.32
32	21	22	4.7	2.9	5.522
33	22	24	1.9	0.7	2.02
34	23	24	5.8	1.2	5.922
35	24	25	1.1	3.2	3.38
36	25	26	3.5	2.4	4.24
37	29	30	3.7	0.6	3.748

Table 4: MVA Flow Through Transformers

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S.No	From	To	MVA flow	MVA limit
1	7	13	24.61	31.5
2	8	13	12.61	16
3	9	11	18.06	20
4	10	28	20.64	25

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From the results of load flow it is observed that, total active load is 283.4MW, total active generation is 289.37MW, Total losses is 5.9762 MW and total reactive load is 92.5 MVAR. The Severity filtering index for generating unit is calculated and shown in Table 5.

Table 5: Severity Filtering Index for Generating unit

Generator number	P_i	Severity filtering Index	Rank
2	0.02230	1.4495	1
3	0.02230	1.0035	2
4	0.01477	0.3692	5
5	0.02230	0.5575	4
6	0.02230	1.2265	3

Similarly the Severity filtering index for transmission lines and transformers are calculated and placed in Table 6. Figure 2 shows the severity index and rank of different generators.

Table 6 :Severity Filtering Index for Transformers andTransmission lines.

From	To	Pi	Severity filtering Index	Rank
1	2	0.000826	0.050122	9
1	27	0.000826	0.025961	19
2	5	0.000826	0.045637	11
2	11	0.000826	0.015570	29
2	13	0.000826	0.022203	23
3	13	0.000826	0.037261	14
3	28	0.000826	0.010342	35
4	7	0.000826	0.023508	22
5	12	0.000826	0.01856	26
6	9	0.000826	0.05369	8
7	8	0.000826	0.027555	18
8	17	0.000826	0.005369	41
8	20	0.000826	0.005253	43
8	21	0.000826	0.006245	38
8	22	0.000826	0.012753	34
9	14	0.000826	0.007971	36
9	15	0.000826	0.021071	24
9	16	0.000826	0.012861	33
10	25	0.000826	0.006096	39
10	29	0.000826	0.005303	42
10	30	0.000826	0.006005	40
11	13	0.000826	0.031950	16
11	27	0.000826	0.023724	21
12	13	0.000826	0.035435	15
13	28	0.000826	0.007731	37
14	15	0.004130	0.013241	32
15	18	0.004130	0.043530	12
15	23	0.004130	0.037624	13
16	17	0.004130	0.047908	10
18	19	0.004130	0.029736	17
19	20	0.000826	0.003568	45
21	22	0.000826	0.004561	44
22	24	0.000826	0.001669	46
23	24	0.004130	0.024458	20
24	25	0.004130	0.013959	31
25	26	0.004130	0.017511	27
29	30	0.004130	0.015479	30
7	13	0.004130	0.130095	6
8	13	0.004130	0.066080	7
9	11	0.000826	0.016520	28
10	28	0.000826	0.020650	25

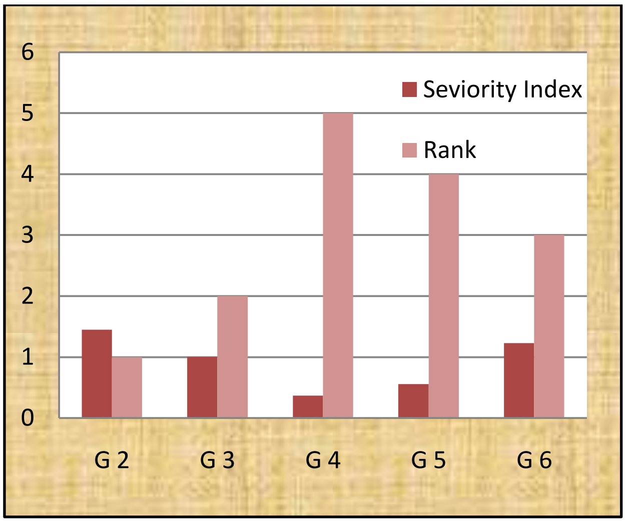

Figure 2. Severity Index and rank of Different Generators.

Nomenclature

λ– Average Failure rate in failures/yr
μ- Average Repair rate in
Ai- Availability of component i
Ui–Unavailability of component i
Pi. - State probability

IV. Conclusions:

Even through state probability is high for other contingencies the severity due to failure of generator 2 is high and followed by generator 3 and generator 6. The orderof severity of contingencies due to failure of generator number is 2,3,6,5 and 4.The severity index indicates the significance effect on a system due to failureof a particular component of a system and the proper precaution can be taken by the operators for the effective operation of a system.

REFERENCES

[1] Wenping Qin, Peng Wang, Xiaoqing Han and Xinhui Du, “Reactive Power Aspects in Reliability Assessment of Power Systems”, IEEE Transactions on Power Systems, Vol 26, No.1, February 2011.
[2] Wenping Qin, Peng Wang, Xiaoqing Han and Fanhua Meng, “Risk analysis of Power Systems for both real and reactive power”, J. Mod. Power Syst. Clean energy (2013) 1(2): 150-158, DOI 10.1007/s40565-013-0016-0.
[3] P. L. Noferi and L. Paris, “Effects of Voltage and Reactive Power Constraints on Power System Reliability”, IEEE Transactions on Power Apparatus and Systems, vol. PAS-94, No. 2, March / April 1975.
[4] S. K. Parida, S. N. Singh and S. C. Sri Vastava, “Voltage Security Constrained Localized Reactive Power market”, IEEE, 2016.

[5] Naoto Yorino, Mehdi Eghbal, E. E. EI-Araby and Yoshifumi Zoka, “Dynamic Security Constrained VAR Planning for Competitive Environments”, IEEE, 2008.

[6] R. N. Allan, R. Billinton, A. M. Beripohl and C. H. Grigg, “Bibliography on the application of Probability Methods in Power System Reliability Evaluation”, IEEE Transactions on Power Systems, Vol. 14, No. 1, February 1999.J. Bedrij, “Carry-select adder, ”*IRE Trans. Electron. Comput*, pp.340–344, 1962.

[7] Y. S. Haruna, G. A. Bakare and U. O. Aliyu, “Adaptive static Load Shedding Schemes for Nigerian Grid System based on Computational Intelligence Techniques”, IEEE, 2014.

[8] Abbas M. Abed, “WSCC Voltage Stability Criteria, Under Voltage Load Shedding Strategy and Reactive Power Reserve Monitoring Methodology”, IEEE, 1999.

[9] M.A.PAI, ”Computer Techniques in Power System Analysis” Tata McGraw Hill Education Private Limited, SecondEdition, pp.228-231

[10] Roy Billinton, Ronald N.Allan, “Reliability Evaluation of Power Systems” Springer Publication, Second Edition.