ASSESSMENT OF POWER SYSTEM SECURITY USING CONTINGENCY ANALYSIS

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Abstract— In present scenario, the power system is becoming extensive and more multifaceted. It is important to predict the line flows and bus voltages for dissimilar operating circumstances and network topologies of a power system. Failure of any equipment's during its operation harms the reliability of the system, hence leading to outages. Cascading outages can have a catastrophic influence on power system security. Ensuring the safe and reliable operation of a power system requires assessing both the static and the dynamic operations of the power system. Transmission switching is conveyed as an optimization problem to regulate the most influential lines as candidates for the interruption. The off line analysis to predict the effect of individual incident is a tedious task as a power system contains a large number of components. A detailed security assessment is essential to deal with the possible failures in the system, its consequences and its remedial actions. The proposed method has been tested on IEEE39 bus system with various loading and outage conditions using the Mi - Power.

Keywords— Static and dynamic operations, cascading outages, reliability, Transmission Switching, Mi-Power

1. INTRODUCTION

In the modern era the electrical power systems are pushed to operate closer to their thermal limits due to the combination of increased energy consumption and various kinds of barriers to the extension of the existing transmission system. In the steady state security assessment of a power system, it is important to predict the line flows and bus voltages for various operating scenario and network topologies. For reliable, secure and continuous supply of electrical energy is an essential part of today's complex society.

The electrical power that can be transmitted between two locations in a network is limited by several security criteria such as voltage limits, lines thermal limits and stability limits. When power cannot be transmitted to a part of the network because of violating one or more of the mentioned security criteria, the system is said to be congested and consequently the market power problem is likely to occur [1]. Security is the ability of the system to resist any kind of the pre-selected list of contingencies without any consequences.

It is well known that power system is a complex network consisting of numerous equipment like generators, transformers, transmission lines, circuit breakers, etc. Failure of any of this equipment during its operation harms the reliability of the system, hence leading to outages. Transmission switching (TS) phenomena can be shown as economic

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benefits solutions, improve system reliability, and enhance the management of intermittent renewable resources [2].

Installation of redundant generation capacity or transmission lines is essential in order to make the system run even when any of its components fail. But, power system being dynamic in nature, does not guarantee that it will be 100% reliable. Further, such arrangement may not be cost-effective. Hence, a detailed security assessment is essential to deal with the possible failures in the system, its consequences and its remedial actions. This assessment is known as power system security assessment.

Method to Solve Load Flows:

We have different mathematical techniques used for load flow study are

- 1) *Gauss Seidel method*
- 2) *Newton Raphson method*
- 3) *Fast-Decoupled method*

Fast-Decoupled Method:

Decoupled method is a reduced form of NR method. The main advantage of the Fast Decoupled Load Flow (FDLF) as compared to the NR method is its reduced memory requirement in storing the Jacobean. There is not much of an advantage from the point of view of speed since the time per iteration of the FDLF is almost the same as that of NR method and it always takes more number of iterations to converge because of the approximation.

An important and useful property of power system is that the change in real power is primarily governed by the charges in the voltage angles, but not in voltage magnitudes. On the other hand, the charges in the reactive power are primarily influenced by the charges in voltage magnitudes, but not in the voltage angles.

2. CONTINGENCY ANALYSIS

“Unpredictable condition in the power system is known as contingency”. The operation and control of power systems in real time require that a number of supervisory functions be executed in the Control Center. First of all, the current operating condition of the system is obtained through state estimation from real time measurements and database information. Once the base case is known, the security analysis function is carried out. [7]-[11].

A power system which is operating under normal mode may face contingencies such as sudden loss of line or generator, sudden increase or decrease of power demand. These contingencies cause transmission lines overloading or bus voltage violations. Electrical power system voltage stability is receiving special attention these days. During the past two and half decades, it has become a major threat to the operation of many systems.

3. METHODOLOGY

Selection can be done in two popular methods they are:

- I). *Ranking Method (or) Indirect Method*
- II). *Screening method (or) Direct Method*
- II). *Screening method (or) Direct Method:*

In this direct method weightage of outages is specified based on priority and overloading of transmission lines [12].

Algorithm for list of contingencies:

- Step 1: Read the base case results.
- Step 2: Select the maximum %loaded transmission line among the base case results.
- Step 3: Select 1st line outage and run 1P1Q.
- Step 4: List out the number of transmission lines overloaded.
- Step 5: find the maximum %loading of outage condition &select the next outage of the line which is unique from the previous case and closing previous outage.
- Step 6: List the total number of transmission lines which are overloaded.
- Step 7: Check whether all overloaded transmission lines undergone 1P1Q method.
- Step 8: Arrange all the outages in descending order

Fig. 1 Flowchart for Outages, According to their Priority

4. RESULTS AND DISCUSSIONS

Mi-Power software has been utilized to identify the contingences which are most severe. Mi-Power is developed by Power research development Consultants (PRDC) Private Ltd. Mi-Power is armed with robust power system engine in the backend and a lucid top-notch Windows GUI in the front-end. Approach, technique & methodology employed are field proven & time-tested. Mi-Power contains tool boxes like Balanced

Load Flow, Three Phase Load Flow, Short Circuit, Transient Stability, Over Current Relay Co-ordination, Distance Relay Co-ordination Voltage Instability, Harmonic Analysis, Dynamic Stability etc. [13].

The main focus here is to perform the contingency analysis, by calculating the load flows and loading capabilities carried out using fast decoupled load flow (FDLF) under Mi-Power environment. The most severe contingency is then chosen from the contingency list and the corresponding power flows and bus voltages are analyzed for the entire system. The study has been carried out for the following modified IEEE-39 systems.

MODIFIED IEEE-39 BUS SYSTEM:

The system consists of overall 39 buses with 11 two winding transformers, 35 transmission lines, 19 loads and 10 generators, chosen slack bus as 39 bus [14].

Fig 2 Modified New-England IEEE39 Bus System

As shown in Figure 2 a transformer has discarded from IEEE-39 bus system between 20th and 19th bus due to connectivity problem and considered it as a transmission line. If we consider it as a transformer, an ideal transformer should be chosen. Complexity and cost of the system increases. Load flow analysis are carried out based on fast decoupled load flow for the modified IEEE-39 bus system. It gives fast convergence, reliable results and requires less memory. By using the fast decoupled method we can find the power flows flowing in a system. Then we can find whether the transmission line is overloaded or not. Table II and III represent the load flow results for modified IEEE-39 bus system.

Table I. Load Flow Results

S.no	Voltage	Angle
Bus1	1.0578	-1.18
Bus2	1.0399	-2.91
Bus3	1.0186	-7.18
Bus4	0.9806	-9.98
Bus5	0.9761	-9.93
Bus6	0.9757	-9.64
Bus7	0.9698	-11.04
Bus8	0.9708	-11.11
Bus9	1.0265	-4.45
Bus10	0.9781	-6.3
Bus11	0.977	-7.43
Bus12	0.9489	-7.2
Bus13	0.9785	-6.84
Bus14	0.9853	-8.02
Bus15	0.9964	-7.21
Bus16	1.0143	-5.22
Bus17	1.025	-6.11
Bus18	1.0221	-6.96
Bus19	0.9988	0.64
Bus20	0.9922	-0.32
Bus21	1.0161	-2.76
Bus22	1.0329	1.81
Bus23	1.0333	1.59
Bus24	1.0218	-5.11
Bus25	1.0485	-1.79
Bus26	1.0629	-3.76
Bus27	1.0419	-5.98
Bus28	1.0573	-0.28
Bus29	1.0477	2.52
Bus30	1.0475	-0.55
Bus31	0.982	-9.8
Bus32	0.9831	1.44
Bus33	0.9972	8.13
Bus34	1.0123	4.84
Bus35	1.0493	6.68
Bus36	1.0635	9.52
Bus37	1.027	4.91
Bus38	1.0265	9.48
Bus39	1.03	0

Table II. % Loading

S.no	Transmission	%
1	Bus1 - Bus2	33.8
2	Bus1 - Bus39	52
3	Bus2 - Bus3	103.9
4	Bus2 - Bus25	68.2
5	Bus3 - Bus4	75.6
6	Bus3 - Bus18	14
7	Bus4 - Bus5	12
8	Bus4 - Bus14	105.4
9	Bus5 - Bus6	37.7
10	Bus5 - Bus8	46.9
11	Bus6 - Bus7	53.6
12	Bus6 - Bus11	114.5
13	Bus7 - Bus8	9.4
114	Bus8 - Bus9	91.7
15	Bus9 - Bus39	84.4
16	Bus10 - Bus11	112.3
17	Bus10 - Bus13	53.5
18	Bus13 - Bus14	54.6
19	Bus14 - Bus15	35.4
20	Bus15 - Bus16	105.5
21	Bus16 - Bus17	55.6
22	Bus16 - Bus19	89.8
23	Bus16 - Bus21	80.8
24	Bus16 - Bus24	34.6
25	Bus17 - Bus18	47.3
26	Bus17 - Bus27	32.6
27	Bus21 - Bus22	90.9
28	Bus22 - Bus23	12.2
29	Bus23 - Bus24	85.6
30	Bus25 - Bus26	38
31	Bus26 - Bus27	80.1
32	Bus26 - Bus28	42.2
33	Bus26 - Bus29	76.5
34	Bus28 - Bus29	117.3
35	Bus19 - Bus20	26

OUTAGES BASED ON %LOADING AND PRIORITY:

Under normal condition 6 lines are overloaded. Using 1P1Q method, contingency analysis is carried out based on %loading of the line and Priority based technique by considering line outage distribution factor. Select the maximum %loading transmission line, open it and perform load flow analysis. We will get another set of maximum %loading lines. Find the maximum %loading of outage condition & select the next outage of the line which is unique from the previous case and closing previous outage. Repeat the procedure until all the over loaded transmission lines undergone 1P1Q method.

Table III. Ranking based on % loading

<u>Line numbers</u>	<u>Lines outages</u>	<u>%Loading</u>	<u>Ranking</u>
1). L8	4 to 14	256	1
2). L33	26 to 29	193.5	2
3). L34	28 to 29	179	3
4). L18	13 to 14	166	4
5). L16	10 to 11	165.9	5
6). L12	6 to 11	165.7	6
7). L4	2 to 25	160.9	7
8). L31	26 to 27	159.5	8
9). L3	2 to 3	158.9	9
10). L17	10 to 13	158.4	10
11). L5	3 to 4	151.4	11
12). L20	15 to 16	149	12
13). L21	16 to 17	137.5	13
14). L15	9 to 39	133.9	14
15). L14	8 to 9	133.9	15
16). L19	14 to 15	130.6	16
17). L25	17 to 18	127.6	17
18). L2	1 to 39	110.1	18
19). L1	1 to 2	102.2	19
20). L10	5 to 8	101.6	20

Based on their % loading capabilities and priority technique, rankings are assigned for every overloaded transmission line. Table 3 represents list the maximum possible outages in modified IEEE-39 bus system.

5. CONCLUSION

In this paper ranking is assigned for every outage condition. With the help of 1P1Q method contingency analysis is carried out. Maximum % loadings are identified. Ranking are assigned based on %loading and priority based technique. Techniques are

implemented on modified IEEE-39 bus network (New-England Power System) using Mi-Power. 20 lines undergo the outage condition in modified IEEE-39 bus system.

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