CONTINGENCY ANALYSIS OF14 BUS SYSTEM USING POWER WORLD SIMULTOR(CASE STUDY)

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ABSTRACT

Contingency analysis technique is widely used to predict the effect of outages in power systems, like failures of equipment, transmission line, transformer failure etc. Power System contains the very large number of the network is a tedious task to determine the individual contingency in the offline analysis. In the power system, the violation of voltage and active and reactive power flow limits are selected only one Contingency to lead to the severe condition. The process of identifying these severe contingencies is referred to as contingency selection for each contingency. One of the essential aspects of modern power system security is the consideration of any contingencies arise due to planned or unplanned equipment outages leading to the system overload or abnormal system voltages. In this paper, contingency N-1 criterion with help of Power World Simulator of IEEE 14 bus system.

Keyword : - *Contingency Analysis, Single Outage Contingency, operating limits, Healthy Condition etc….*

1. INTRODUCTION

Contingency analysis is one of the major components in today's modern energy management systems. Contingency analysis is the study of the outage of elements such as transmission lines, transformers and generators, and investigation of the resulting effects on line power flows and bus voltages of the remaining system.[1].It represents an important tool to study the effect of elements outages in power system security during operation and planning. Contingencies referring to disturbances such as transmission element outages or generator outages may cause sudden and large changes in both the configuration and the state of the system. Contingencies may result in severe violations of the operating constraints. Consequently, planning for contingencies forms an important aspect of secure operation. [3]

Contingency analysis allows the system to be operated defensively. Many of the problems which occur in the power system can cause serious troubles within a short time if the operator could not take fast corrective action. Therefore, modern computers are equipped with contingency analysis programs which model the power system and are used to study outage events and alert the operators of potential overloads and voltage violations [3].

1.1 Modeling Contingency Analysis

Contingency Analysis involves simultaneous of each contingency on the base case model of the power system. There is three major difficulty are involved in this analysis. (a) It is difficult to develop an appropriate power system model. (b) Choice of the particular contingency (c) Difficult to compute power flow and bus voltage.

Contingency analysis process involves the prediction of the Large power system network failure that the effect of individual contingency selection becomes very tedious and time-consuming when the power system network is large. Practically, it is found that all the possible outages do not cause the overloads or under voltage in the other power system equipment. The process of identifying the contingencies that actually leads to the violation of the operational limits is known as contingency selection [1,3]. These indices are calculated using the conventional power flow for individual contingencies in an off line mode.

An unpredictable condition in the power system is known as a contingency. The impact of the occurrence of contingencies should be evaluated. This process, usually called contingency analysis, aims at detecting post-contingency operational limits violations. Power systems are operated so that overloads do not occur either in real-time or under any statistically likely contingency. The contingency analysis is required to operate the power system in such a way that power is delivered reliably. Within the constraints placed on the system operation by reliability considerations, the system will be operated most economically. The primary purpose of maintaining power system security is to keep power system operation under stable condition If the Single line failure of transmission line ot transformer or generator outage does not lead to cascade tripping.[2] This is often called maintaining system "security" Simulator is equipped with tools for analyzing contingencies in an automatic fashion Contingencies can consist of several actions or elements.[7]

1.2 Operating Limits[1,5]

For all the state and control variables must be within specified practical limits. These limits are dictated by specifications of power system hardware and operating constraints and described below.

(a) Voltage magnitude $|V_i|$ must satisfy the inequality, $|V_i|_{min} \leq |V_i| \leq |V_i|_{max}$.

This limit arise due to the fact that the power system equipment is designed to operate at a fixed voltage with allowable variations of ± 5 to ± 10 of rated values.

(b) Certain of δ_i (state variables) must satisfy, $|\delta_i - \delta_k| \leq |\delta_i - \delta_k|_{max}$

This constraint limit the maximum permissible power angle of the transmission line connecting buses "i" and bus "k" and it is imposed by considerations of stability.

(c) The physical limitations of P and Q generator sources, P_{Gi} and Q_{Gi} are constrained as follows:

$|P_{Gi}|_{min} \leq |P_{Gi}| \leq |P_{Gi}|_{max}$, $|Q_{Gi}|_{min} \leq |Q_{Gi}| \leq |Q_{Gi}|_{max}$

Where P_L and Q_L are system real and reactive power loss.

2. N-K CONTINGENCY[2]

Here N is the number of element and k is the respective contingency applied to power system network and k=0, 1, 2,…, N.

If K=0 means that the system is a healthy condition (pre contingency state). If K=1, only one element out of service or Generating unit is trip or stop working. That is called the N-1 criterion. The "N-1" criterion is an "abstraction" representing equivalently a single contingency or the tripping of one element following a normative incident, like a three-phase short circuit. The difficulty of N-k contingency analysis lies in its combinatorial nature. The number of credible contingencies may vary depending on the level of analysis, a number of elements (N), and level of contingency. That is, the first level of contingency corresponds to N-1, the second level of contingency corresponds to N-2 and so on. Thus, In this paper we are taken case study on 14 bus System, In this system there are 3-Generator, 3-Transformer tapings and 20 Transmission line are in this system. Traditionally system dynamic security analysis is carried out on a few pre-selected contingencies in the time interval of several minutes In many instances the hazardous impacts of contingencies can be easily ignored until their occurrence because their probabilities of occurrence are quite low. However, multiple contingencies do occur consequences can be very severe, and these very practical facts motivate the objective of this case study, to analyze high-risk N-k contingencies for online security assessment.[2]

2.1 The Single Outage Contingency (N-1) Criterion [4]

The N-1 Criterion is outages of any one of the following contingencies :

- Loss of a single-circuit overhead interconnection or internal line, radial circuits which connect loads using a single overhead line or cable;
- Loss of a single transformer, except those which connect loads using a single radial transformer;
- Loss of a generator, whether grid-connected or embedded;
- Loss of Shunt devices such as Capacitor/Reactor/SVC etc.

The N-1 criterion is satisfied if, after a single system element has failed (e.g. transmission line, transformer, generating unit, etc.), the following Rules are observed:

- No breach of the limiting values for network operation variables (i.e. operation voltage, frequency) that may danger the security of the power system or lead to an unacceptable strain on equipment, damage, destruction or an inadmissible reduction in the life of the equipment.
- No any equipment or loading of transmission line have exceeded 100% of its operational thermal limit capacity.
- Interruptions of supply are avoided.

- Secondary tripping through activation of further protection devices on equipment not directly affected by the disturbance such that there is no risk of spreading the disturbance;
- There is no need to change or interrupt power transfers and generation dispatch.
- The loss of generating unit stability is avoided .

2.2 Contingency Analysis Results

In this paper, we discuss that, the taking different N-1 Contingency of IEEE 14 bus system. Power Flow method with considering Contingency, this is done by MATLAB but I use POWER WORLD SIMULATOR (16GSO). Also, I use IEEE-14 Bus system by taking any of Contingency, which is shown in the table.

Table -1: Different Contingency Assume of IEEE-14 Bus System

Case	Contingency	Faulted device	Bus –i	Bus- j
1	Fault 1	L6	3	4
2	Fault 2	T2	4	9
3	Fault 3	L19	12	13

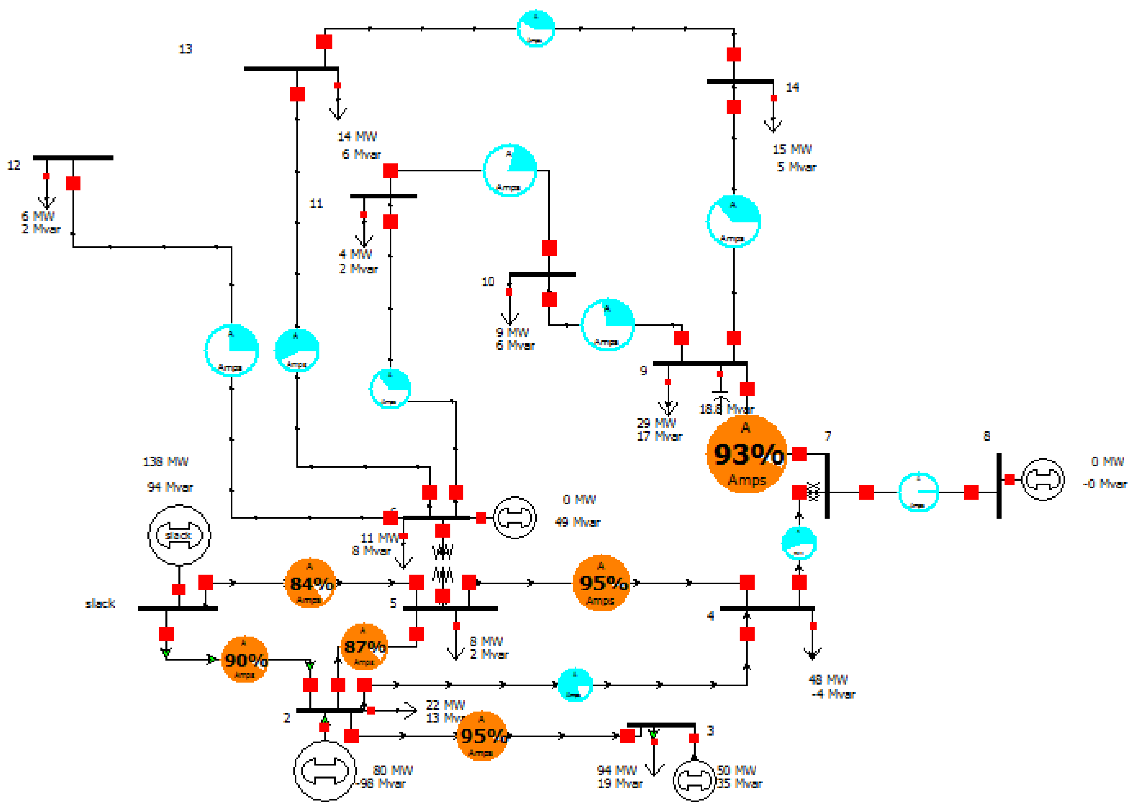

Fig -1: Power World simulator with 14 Bus system in Healthy Condition

CASE-1: From Bus 3 to Bus 4 Transmission Line, L6 is open or faults occurs Contingency-1:-

The Bus Records of IEEE-14 Bus System with Contingency-1, Contingency-2, Contingency-3 are in table no.5. Here only one contingency of figure is available in this paper but all other contingencies have figure and table too.

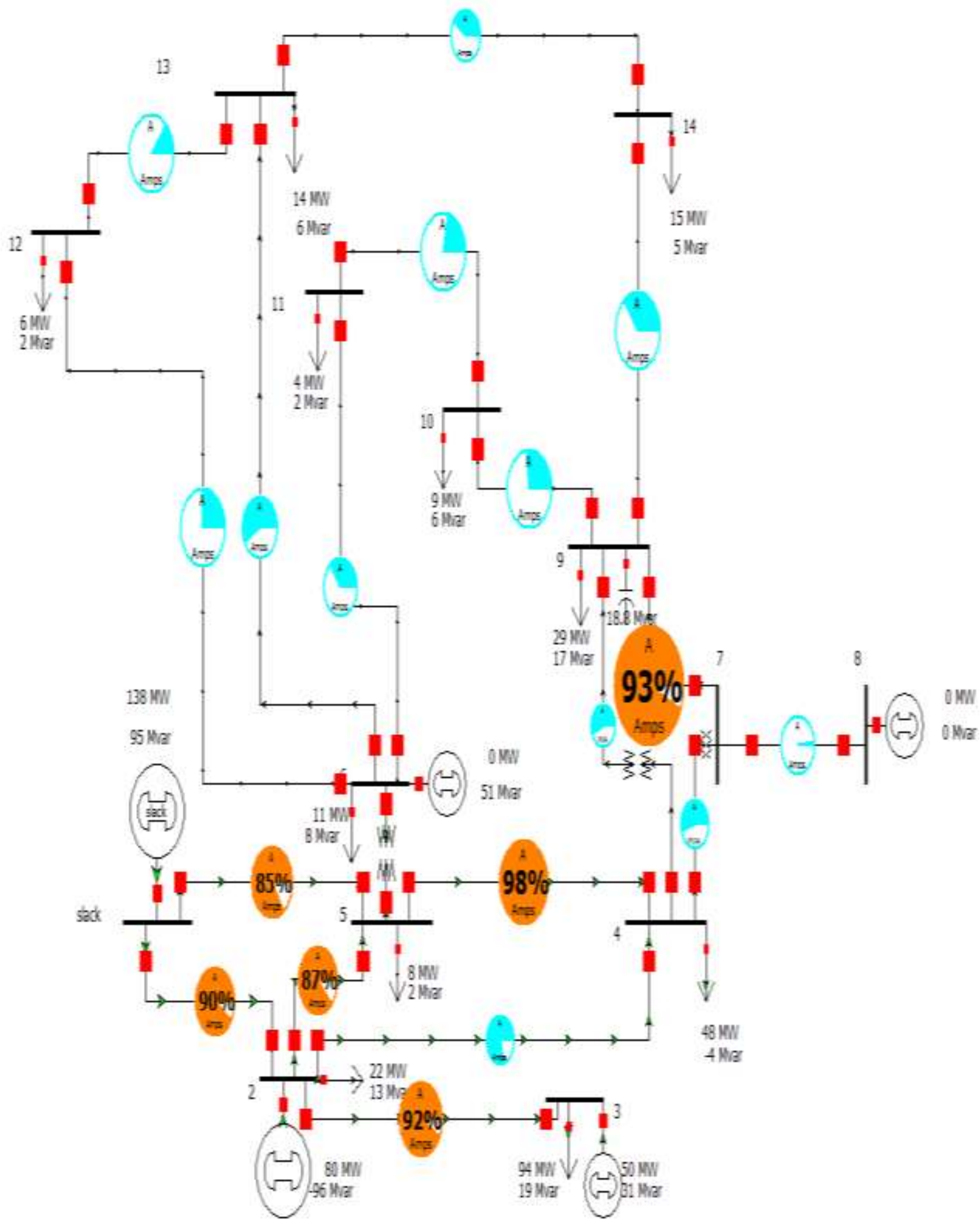

Fig -2: Power Flow for IEEE-14 Bus System with Contingency-1

Table -2: Line Records of IEEE-14 Bus System with Contingency-1

From Bus No	To Bus No	P MW	Q Mvar	MVA	% of MVA Limit (Max)	MW Loss	Mvar Loss
1	2	81.5	80.1	114.3	95.3	2.3	4.21
1	5	56.2	15.3	58.3	89.7	1.65	4.49
2	3	45.2	-9.5	46.2	92.3	0.99	2.32
2	4	51	-8.9	51.8	79.7	1.55	2.26
2	5	41.3	-14	43.6	87.3	1.07	1.57
5	4	45	19.6	49.1	98.2	0.32	0.38
4	7	29.4	6.4	30.1	54.7	0	1.85
4	9	17	5.5	17.9	55.9	0	1.71
6	5	-42.2	32.1	53	96.3	0	6.15
11	6	-6	-2.1	6.4	35.8	0.04	0.08
6	12	7.6	2.4	8	25	0.08	0.16
6	13	17.3	6.6	18.5	57.8	0.23	0.45
7	8	0	-0.5	0.5	1.5	0	0
7	9	29.4	5.1	29.8	93.2	0	0.98
9	10	6.5	5.6	8.6	26.8	0.02	0.06
9	14	10.4	4.5	11.3	35.4	0.17	0.35
10	11	-2.5	-0.3	2.5	21.1	0.01	0.01
12	13	1.5	0.6	1.6	13.2	0.01	0.01
13	14	4.7	0.9	4.8	40	0.04	0.08
Total Loss						8.48	27.12

Table -3: Line Records of IEEE-14 Bus System with Contingency-2

From Bus No	To Bus No	MW From	Mvar From	MVA From	% of MVA Limit (Max)	MW Loss	Mvar Loss
1	2	81.4	80.2	114.3	95.2	2.29	4.2
1	5	56.4	14.3	58.2	89.6	1.65	4.47
2	3	46.1	-9.6	47.1	94.2	1.03	2.49
2	4	49.8	-11.1	51	78.5	1.5	2.1
2	5	41.5	-15.3	44.2	88.4	1.1	1.64
3	4	0.9	3	3.1	7.3	0.01	-1.69
5	4	39.1	15.8	42.1	84.3	0.24	0.11
4	7	40.2	11.1	41.7	75.9	0	3.53
6	5	-48.5	31.8	58	105.5	0	7.37
11	6	-9.8	-2.2	10	56.5	0.1	0.21
6	12	8.1	2.3	8.5	26.5	0.09	0.18
6	13	19.3	6.7	20.4	63.8	0.28	0.54
7	8	0	-2.4	2.4	7.7	0	0.01
7	9	40.2	10	41.5	92.1	0	1.91
9	10	2.8	5.5	6.2	19.2	0.01	0.03

9	14	8	4.5	9.1	28.5	0.11	0.23
10	11	-6.2	-0.3	6.3	52.5	0.03	0.08
12	13	2	0.5	2	17	0.01	0.01
13	14	7.1	0.9	7.2	60.1	0.09	0.19
Total Loss						8.54	27.61

Table -4: Line Records of IEEE-14 Bus System with Contingency-2

From Bus No	To Bus No	MW From	Mvar From	MVA From	% of MVA Limit (Max)	MW Loss	Mvar Loss
1	2	81.8	80.1	114.4	95.4	2.3	4.22
1	5	56	14.4	57.8	89	1.63	4.37
2	3	46.5	-9.6	47.5	94.9	1.05	2.56
2	4	50.5	-10.5	51.5	79.3	1.53	2.2
2	5	40.8	-15	43.5	87	1.06	1.54
3	4	1.2	3.6	3.8	8.4	0.01	-1.68
5	4	44.6	17.1	47.7	95.4	0.3	0.32
4	7	29.5	7.4	30.4	55.3	0	1.88
4	9	17.1	5.9	18.1	56.6	0	1.74
6	5	-42	31.2	52.3	95.1	0	5.99
11	6	-6.1	-1.8	6.3	35.5	0.04	0.08
6	12	6.1	1.7	6.4	19.9	0.05	0.1
6	13	18.5	7	19.8	61.8	0.26	0.51
7	8	0	0.3	0.3	0.8	0	0
7	9	29.5	5.2	30	93.7	0	0.99
9	10	6.5	5.8	8.7	27.2	0.02	0.06
9	14	10.6	4.8	11.7	36.5	0.17	0.37
10	11	-2.6	0	2.6	21.3	0.01	0.01
13	14	4.5	0.6	4.5	37.7	0.04	0.07
Total Loss						8.47	25.33

Table -5: Line Records of IEEE-14 Bus System with Contingency-1,2 and 3

	Contingency-1		Contingency-2		Contingency-3		No Contingency (Healthy Condition)	
Bus Number	**Volt (p.u)**	**Angle (Deg)**	**Volt (p.u)**	**Angle (Deg)**	**Volt (p.u)**	**Angle (Deg)**	**Volt (p.u)**	**Angle (Deg)**
1	1.06	0	1.06	0	1.06	0	1.06	0
2	1	-1.75	1	-1.75	1	-1.76	1.045	2.56
3	1	-7.12	1	-7.22	1	-7.28	1.01	4.57
4	0.98832	-7.24	0.99281	-7.16	0.99147	-7.22	1.0413	11.19
5	1.00254	-6.29	1.00466	-6.33	1.00455	-6.28	1.0451	12.3
6	1	-11.96	1	-12.84	1	-11.91	1.0698	5.7

7	0.99913	-10.73	0.99568	-11.93	1.00046	-10.71	1.061	-3.85
8	1	-10.73	1	-11.93	1	-10.71	1.09	0.33
9	0.99409	-12.59	0.9856	-14.51	0.99527	-12.58	1.0699	2.55
10	0.98728	-12.81	0.97999	-14.55	0.98825	-12.79	1.0966	-4.38
11	0.98995	-12.54	0.98596	-13.85	0.99044	-12.51	1.082	-5.23
12	0.98469	-12.93	0.98419	-13.89	0.98819	-12.7	1.0921	-6.45
13	0.98018	-13.03	0.97869	-14.05	0.97888	-13.05	1.0767	-8.52
14	0.96879	-13.92	0.96317	-15.47	0.9689	-13.93	1.0626	-11.23

3. COMPARISION OF POWER FLOW WITH AND WITHOUTCONTINGENCYOF 14 BUS SYSTEM

The comparison Graph of power flow with and without contingency are follows:

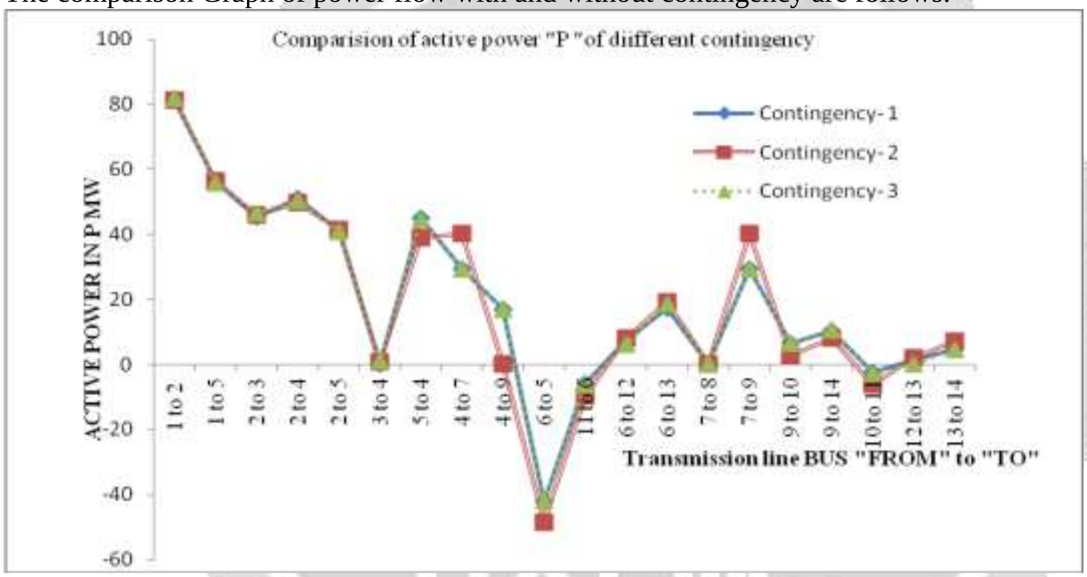

Chart -1: Comparison of active power "P "of different Contingency

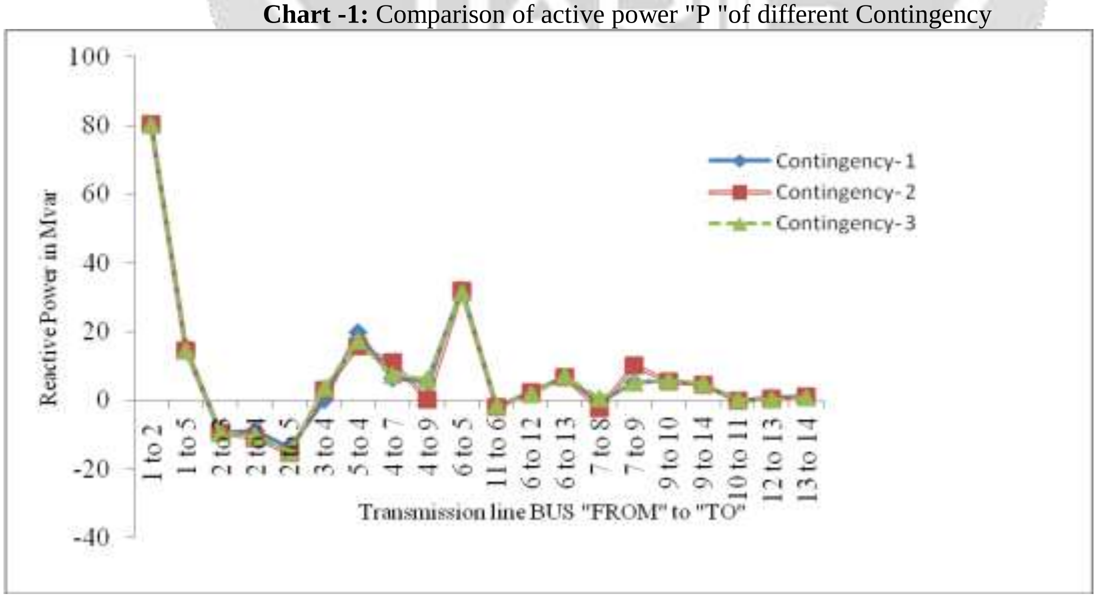

Chart -2: Comparison of active power "Q "of different Contingency

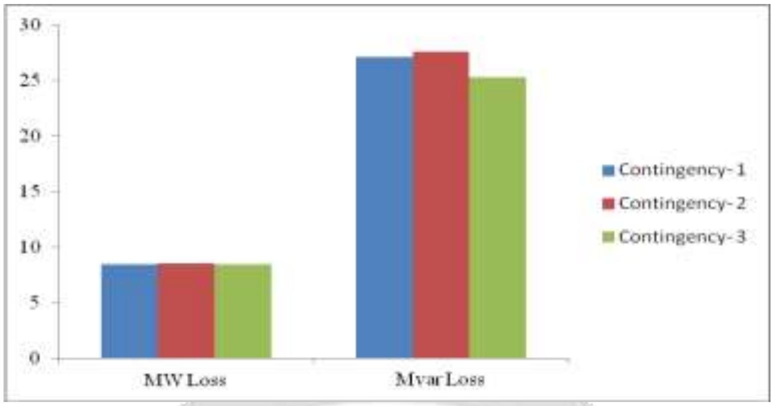

Chart -3: Comparison of Total Loss in MW and Mvar of different Contingency

4. CONCLUSIONS

In 14 Bus system, Contingency analysis is performed and the weaknesses of the transmission system have been detected. Presently, only single Contingency occurred at a time but it might not be correct or any of the set of multiple contingencies occurs. The Contingency analysis is performed for the given 14 bus system and it is noticed that in Case 1, when the line from bus 3 to bus 4 were to open, the flow of all the transmission line change. It may also be noted that bus voltage magnitudes also get affected. In case 2, due Transformer (T2) outage result in the change in line flows and bus voltages. Same way open Line from bus 12 to bus 13 and observed the different data. In this paper, only N-1 Contingency may apply at a time. So in 14 bus system, there are 26 different case and resolving power flow and voltage data of different bus. To find the effects of outages contingency analysis techniques are used.

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