International Journal of Engineering Research and Development (IJERD) ISSN: 2278-067X
Recent trends in Electrical and Electronics & Communication Engineering
(RTEECE 17th – 18th April 2015)

Study of Power System Security in Indian Utility 62 Bus System

Sunil Malival[1]
[1]*Assistant Professor, ITM Universe, Vadodara*
[1]sunil.ee14@gmail.com

Abstract:- Deregulation of power system in recent years has changed static security assessment to the major concerns for which fast and accurate evaluation methodology is needed. Contingencies related to voltage violations and power line overloading have been responsible for power system collapse. This paper presents an Maximum Loading Margin for ranking of the contingencies expected to cause steady state bus voltage and power flow violations. The effectiveness of the proposed approach has been demonstrated on Indian Utility 62-bus power system.

Keywords:- Deregulated Power System, Maximum Loading Margin, Contingency, Power System Security, PSAT

I. INTRODUCTION

In deregulation power market system security is one of the challenging tasks due to competition and open access network. The security appraisal is an essential task as it gives knowledge about the system state in the event of contingency. Contingencies are expressed as a specified set of events occurring within a short duration of time, which actually indicates loss or failure of one or more components on power system [6]. In the event of an unplanned (or unscheduled) equipment outage, contingency analysis gives the operators an indication, of what might happen to the power system. It is basically a software application run in an energy management system, simulating a hypothetical test on a list of conjectural cases, which would create line flow, voltage or reactive power violations. These cases are identified and ranked in order of their severity using contingency ranking algorithm [6].Usually contingency analysis is segregated into three parts, contingency definition, selection and evaluation [4], but in present days the selection and the evaluation both steps are done in same segment. For more than three decades many work has been done on contingency selection specially, whose aim is to reduce the original long list of contingencies by selecting only the cases with severe limit violations. This selection is accomplished by mainly two methods, i.e., contingency ranking and contingency screening. The screening methods are local solution based analysis, which basically gives top priority to the most severe cases for detailed ac analysis, at the same time the non-critical cases are removed from the list [6].Another method is ranking method, which uses a system performance index as a scalar function to describe the effects of an outage on the whole network [4]. In the present work, the effort has been given on contingency ranking. At first the contingency list is processed, which contents those cases whose probability of occurrence is estimated sufficiently high. The list, which is normally large, is automatically translated into electrical network changes: normally generator and/or branch outages. Contingency evaluation using full AC load flow is then performed on the successive individual cases in decreasing order of severity. The process is continued up to the point where no post contingency violations are encountered, or until a specified time has elapsed.[4]

II. DIFFERENT RELIABILITY INDICES IN CONTINGENCY RANKING AND INDICATING VOLTAGE STABILITY

The reliability indices measure the ability of power system to deliver electricity to all points of utilization within the accepted standards and desired amount. These analyses evaluate the probability, frequency and duration of various system contingencies in view of random loads and remedial actions. Any probable operational constraints and load loss/curtailment are reflected in the reliability indices. These indices provide effective information regarding identification of system weaknesses, comparison for alternative system designs, and the justification of new facilities . Performance indices are used to predict proximity to voltage collapse have been a permanent concern in power system operation and design. These indices are used online or off-line to help operators determine the closeness of the systems from possible collapses.[4]. The various performance indices are

1. Continuation Power flow (CPF)
2. Loading Margin (λ)
3. Voltage Stability Index (L-index)

4. Real Power flow performance index
5. Reactive power flow performance index
6. Power Transfer Distribution factor (PTDF)
7. Generator shift factor
8. Line outage distribution factor

III. CONTINUATION POWER FLOW (CPF)

The general principle of CPF technique is that it employs a predictor-corrector scheme to find a solution path of a set of power flow equations formulated to include different load parameter. It starts from a known solution and uses a tangent predictor to estimate a subsequent solution corresponding to a different value of time varying load parameter . This estimate is then corrected by using the Newton-Raphson technique commonly employed in conventional power flow study. The above parameterization provides a means to identify the point along the solution path and helps avoiding the singularity in the Jacobian So the precise value of nose curves voltage V and loading parameter lc could be obtained.

The strategy used in this method is illustrated in Figure:1. Where, solution is initiated from a known equilibrium point (z1, l1) to compute the direction vector Dz1 and a change in Dl1 of the system parameter. This step is known as the predictor, since it generates an initial guess (z1+Dz1, l+Dl1) which is then used in the corrector step to compute a new equilibrium point (z2, l2) on the system profile. [4].

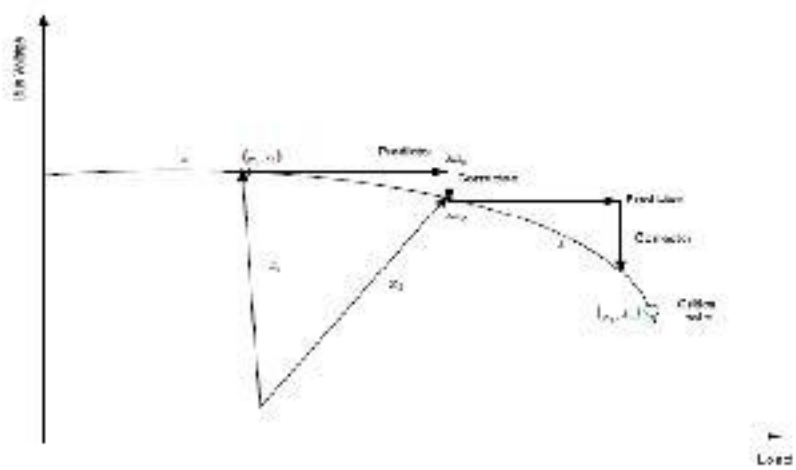

Fig. 1: Continuation Power Flow Concept

IV. LOADING MARGIN

The system loading margin is the amount of additional load increase for a particular operating point until the voltage collapses. This index is most widely accepted index to measure the voltage collapse. If the system load is chosen to be the variable parameter, then a system P-V curves can be drawn where the loading margin to voltage collapse would be the change in loads between the operating point and the nose of the curve. The changes in loading can be measured by the sum of the absolute changes in load powers. In this study loads are assumed to have constant power factor.There are several works in the area of contingency assessment techniques .All these techniques are focussed to assess the post contingency voltage stability indices. These procedures for voltage security assessment techniques involve mostly the evaluation of a large number of contingency cases and check for the voltage violations. However, for large systems, such approach would be prohibitively time consuming even for a single component contingency [4].

The maximum loading parameter is defined as λ_*, the base case power (BCP) would be:
BCP =Sum i (P_{Li}) (1)
Here; P_{Li} is the active load at all load buses.
Maximum loading condition (MLC) of system would be:
MLC = $(1+\lambda_*) \times$ BCP (2)
The available loading capability (ALC) would be:

$ALC = \lambda^* \times BCP$ (3)

The system loadability for base case and different contingencies is defined as the maximum power loading margin λ_c [4]. Where; $\lambda_c = 1+\lambda^*$ (4)

V. TEST SYSTEM (INDIAN UTILITY 62-BUS SYSTEM)

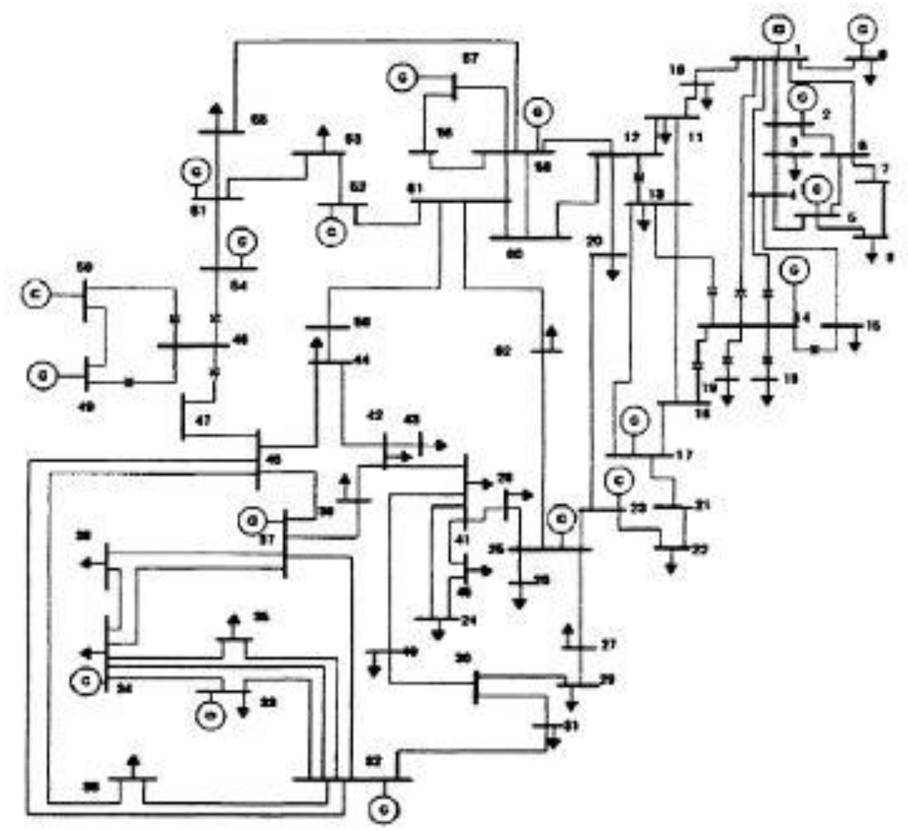

Fig. 2 : One line diagram INDIAN UTILITY- 62 bus System [12]

The indian Utility 62 bus system is shown in Fig.2. This test system contains 62 Buses ,89 Transmission lines , 11 Transformers , 19 Generators and 32 Loads. The system data is taken from the reference [12]. The base is 100 MVA.

VI. POWER SYSTEM ANALYSIS TOOLBOX (PSAT)

PSAT is a MATLAB toolbox for electric power system study and control. The command line version of PSAT is also GNU Octave compatible. PSAT includes power flow, continuation power flow, optimal power flow, small signal stability analysis and time domain simulation. [11].

All Operations can be assessed by means of graphical user interfaces (GUIs) and a Simulink –based library delivers an user friendly tool for network design. PSAT core is the power flow routine, which also takes care of state variable initialization. Once the power flow has been solved , further static and dynamic analysis can be performed. [11].

VI. TEST SYSTEM IN PSAT (INDIAN UTILITY 62-BUS SYSTEM)

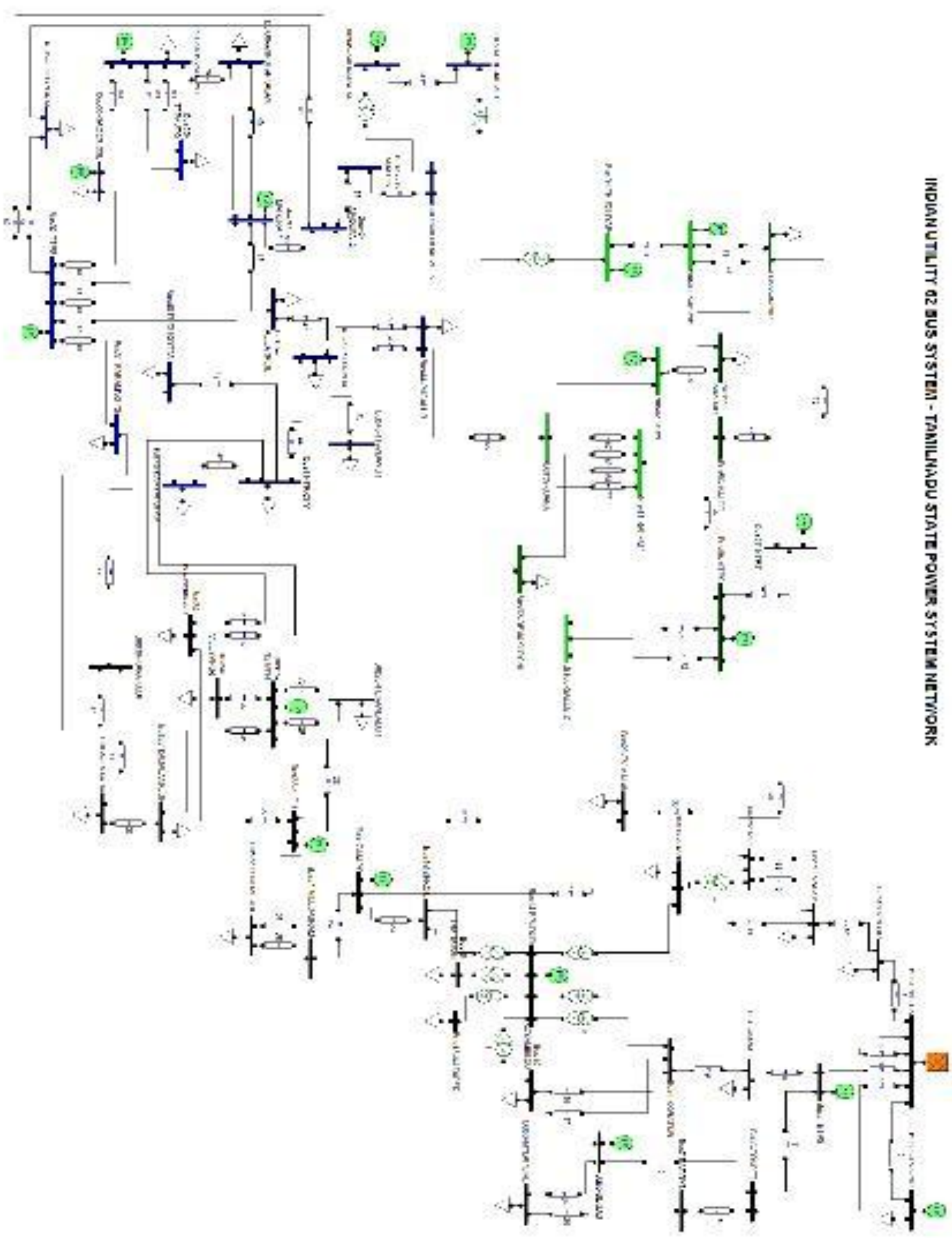

Fig. 3 : One line diagram INDIAN UTILITY- 62 bus System in PSAT

Table I: Line flow Precontingency and post-contingency cases

From Bus	To Bus	Line	Loading Margin	Most Severe Line	Pre-Contingency Power flow (MW)	Post-Contingency power flow (MW) (Outage of Line 20)
Bus1-NMTPS	Bus2 -ETPS	1	1.9106		-107.7800	-112.4503
Bus15-KOYAMBEDU	Bus4-KORATUR	2	0.0000		-86.0600	-84.3606
Bus12-SPET	Bus11-TVALAM	3	1.6846		35.8200	42.8407
Bus11-TVALAM	Bus10-MOSUR	4	1.0169	4	-78.1020	-71.5832
Bus5-BBGAS	Bus4-KORATUR	5	1.8938		103.8000	100.4923
Bus5-BBGAS	Bus6-TONPET	6	1.9068		68.2900	70.0385
Bus1-NMTPS	Bus4-KORATUR	7	1.9023		7.4000	3.6840
Bus8-MYLAPORE	Bus7-PARRYS	8	1.9045		-25.7900	-24.2315
Bus8-MYLAPORE	Bus5-BBGAS	9	1.9070		-83.2000	-84.7685
Bus16-SPKOIL	Bus11-TVALAM	10	0.0000		48.5700	48.2541
Bus17-MAPS	Bus16-SPKOIL	11	2.1280		80.7800	92.3843
Bus17-MAPS	Bus21-VILLUPURAM	12	1.8361		61.2900	48.1055
Bus21-VILLUPURAM	Bus22-CUDDALORE	13	1.8455		60.1100	47.3804
Bus23-NLC 1	Bus22-CUDDALORE	14	1.3618	8	4.2600	16.8818
Bus23-NLC 1	Bus24-EACHENKADU	15	1.3424	6	**151.6000**	**228.2470**
Bus23-NLC 1	Bus25- N2 MIN4	16	1.8893		16.4000	-93.3373
Bus25- N2 MIN4	Bus28-PERAMBALUR	17	0.0000		63.3900	63.3923
Bus7-PARRYS	Bus6-TONPET	18	1.9045		-25.8100	-24.2531
Bus26-VILLIYANUR	Bus25- N2 MIN4	19	0.0000		-116.0000	-116.0000
Bus27-KADALANKUDI	**Bus25- N2 MIN4**	**20**	0.5732	1	-132.4900	0.0000
Bus29-TVARUR	Bus27-KADALANKUDI	21	1.0250	5	-47.7000	54.1898
Bus30-KARAIKUDI	Bus29-TVARUR	22	1.9027		80.6100	94.0148
Bus20-TV MALAI	Bus23-NLC 1	23	1.3585	7	20.8018	0.2471
Bus12-SPET	Bus20-TV MALAI	24	1.8910		102.1400	81.0906
Bus13-ARANI	Bus17-MAPS	25	1.9030		-47.9100	-49.4580
Bus1-NMTPS	Bus10-MOSUR	26	0.9963	2	120.5300	113.8195
Bus24-EACHENKADU	Bus45-SAMYAPURAM	27	1.8618		48.2400	85.6829
Bus24-EACHENKADU	Bus41-TRICHY	28	1.8664		43.7600	81.0671
Bus41-TRICHY	Bus45-SAMYAPURAM	29	1.8814		-27.8600	-64.4466
Bus41-TRICHY	Bus40-PUDUKOTTAI	30	1.8827		**38.1800**	**111.0207**

Bus41-TRICHY	Bus42-ALUNDUR	31	1.9118		-58.9300	-58.7260
Bus43-THANJAVUR	Bus42-ALUNDUR	32	0.0000		-25.0000	-25.0000
Bus44-PUGALUR	Bus42-ALUNDUR	33	1.8565		**79.9700**	**91.2059**
Bus39-ALGARKOIL	Bus42-ALUNDUR	34	1.6591		35.5500	25.0267
Bus39-ALGARKOIL	Bus37- MADURAI 1	35	1.9819		-65.5500	-55.0267
Bus37- MADURAI 1	Bus38-ANNUPANKALAM	36	0.0000		111.0137	114.4609
Bus9-GPOONDI	Bus1-NMTPS	37	2.0413		12.2000	12.2020
Bus38-ANNUPANKALAM	Bus34-KAYATHAR	38	1.9060		-55.8900	-52.5026
Bus37- MADURAI 1	Bus34-KAYATHAR	39	1.9060		36.3300	47.8804
Bus35- TTPAUTO	Bus34-KAYATHAR	40	1.9056		-2.0500	-2.9861
Bus33-NAGERKOIL	Bus34-KAYATHAR	41	1.9057		9.5700	8.4255
Bus32-TTPS	Bus35- TTPAUTO	42	1.0040	3	**10.4970**	**104.0397**
Bus32-TTPS	Bus33-NAGERKOIL	43	1.9054		-6.7900	-7.9346
Bus32-TTPS	Bus31-PARAMAKUDI	44	1.3657	9	**39.2000**	**62.4418**
Bus30-KARAIKUDI	Bus31-PARAMAKUDI	45	1.8937		12.2700	-9.7197
Bus40-PUDUKOTTAI	Bus30-KARAIKUDI	46	1.9014		**13.0900**	**85.0835**
Bus36-TUTICORIN	Bus32-TTPS	47	1.9058		-7.5100	-4.5276
Bus1-NMTPS	Bus6-TONPET	48	1.9070		-48.1000	-50.8373
Bus32-TTPS	Bus37- MADURAI 1	49	1.9037		-7.1280	-9.9224
Bus32-TTPS	Bus34-KAYATHAR	50	1.9069		-21.3200	-33.6609
Bus46- MADURAI 2	Bus32-TTPS	51	1.9031		9.8600	12.9372
Bus36-TUTICORIN	Bus46- MADURAI 2	52	1.9020		-12.4800	-15.4724
Bus46- MADURAI 2	Bus37- MADURAI 1	53	2.0132		141.8800	149.3290
Bus44-PUGALUR	Bus46- MADURAI 2	54	1.8734		23.5000	32.8888
Bus44-PUGALUR	Bus59-UJANAI	55	1.8444		-212.4700	-233.0947
Bus59-UJANAI	Bus61-SALEM 1	56	1.8287		-215.0200	-236.2145
Bus60-SALEM 2	Bus61-SALEM 1	57	1.8910		55.5400	55.2333
Bus62-DEVIAKURCHI	Bus61-SALEM 1	58	1.9341		-141.5400	-116.7084
Bus6-TONPET	Bus2 -ETPS	59	1.9054		-6.0237	-5.4807
Bus25- N2 MIN4	Bus62-DEVIAKURCHI	60	1.8801		-48.2210	-23.6274
Bus61-SALEM 1	Bus58-MTPS	61	1.8365		-309.5800	-307.8817
Bus60-SALEM 2	Bus58-MTPS	62	0.0000		-202.8100	-201.7714
Bus55-INGUR	Bus58-MTPS	63	1.9027		-22.0250	-24.8983
Bus57-MTRT	Bus58-MTPS	64	1.8997		171.8480	171.8481

Bus57-MTRT	Bus56-MALCO	65	1.9057		47.5900	47.5929
Bus58-MTPS	Bus56-MALCO	66	1.9052		-47.4900	-47.4993
Bus52-GOPI	Bus61-SALEM 1	67	1.9057		-2.9100	-4.8875
Bus52-GOPI	Bus53- ARASUR	68	1.9003		27.5100	29.4955
Bus51-KUNDAH	Bus55-INGUR	69	1.8692		72.6600	69.7395
Bus3-MANALI	Bus2 -ETPS	70	1.8954		-76.4000	-72.2824
Bus51-KUNDAH	Bus53- ARASUR	71	1.6070	10	224.5600	222.5323
Bus54- THUDILIYAR	Bus51-KUNDAH	72	0.0000		217.8500	212.7331
Bus50- UDUMALPET	Bus49- KADAMPARAI	73	1.9050		-34.6200	-34.6245
Bus48- UDUMALPET 2	Bus47- SEMBATTY	74	1.9654		155.1800	160.6393
Bus46- MADURAI 2	Bus47- SEMBATTY	75	1.9356		-141.0860	-145.5069
Bus12-SPET	Bus60-SALEM 2	76	1.9164		-145.4300	-144.7230
Bus58-MTPS	Bus12-SPET	77	1.9086		21.1690	21.0698
Bus4-KORATUR	Bus3-MANALI	78	1.8996		-36.3180	-32.2037
Bus4-KORATUR	Bus14-SPUDUR	79	1.8854		60.8230	51.4161
Bus14-SPUDUR	Bus19- THARAMANI	80	0.0000		130.7400	130.7448
Bus14-SPUDUR	Bus18-KADAPERI	81	0.0000		121.1400	121.1410
Bus14-SPUDUR	Bus16-SPKOIL	82	1.8972		-31.5100	-43.2085
Bus14-SPUDUR	Bus15- KOYAMBEDU	83	1.9094		69.8000	71.5177
Bus13-ARANI	Bus14-SPUDUR	84	1.8697		-56.0000	-41.3625
Bus1-NMTPS	Bus14-SPUDUR	85	0.0000		166.5000	101.0753
Bus12-SPET	Bus13-ARANI	86	0.0000		28.2600	41.4965
Bus49- KADAMPARAI	Bus48-UDUMALPET 2	87	0.0000		179.2400	179.2483
Bus48- UDUMALPET 2	Bus50-UDUMALPET	88	0.0000		-127.2700	-127.2808
Bus48- UDUMALPET 2	Bus54-THUDILIYAR	89	0.0000		-150.0330	144.5816

As Table II indicates the loading margin for transmission lines are used to select severe transmission line. Also in table II top 10 list of severe transmission line is mentioned.
So, we have to analyse only top list of severe transmission line. From results Transmission line 20 which is connected between **Bus27-KADALANKUDI to Bus25- N2 MIN4** is most severe according to loading margin.
Table II Pre-Contingency Power flow or base case power flow and after contingency or outage of most severe line 20 power flow is listed.
From the results of power flow we observed that many of the transmission line is overloaded or heavy flow due to outage of transmission line no.20.

Table II: Voltage Profile (P.U)

Buses	Voltage Profile (P.U) (Pre-Contingency)	Voltage Profile (P.U) (Post-Contingency)
Bus1-NMTPS	1.0500	1.0500
Bus2 -ETPS	1.0500	1.0500
Bus3-MANALI	1.0512	1.0512
Bus4-KORATUR	1.0566	1.0566
Bus5-BBGAS	1.0500	1.0500
Bus6-TONPET	1.0458	1.0458
Bus7-PARRYS	1.0448	1.0448
Bus8-MYLAPORE	1.0435	1.0435
Bus9-GPOONDI	1.0500	1.0500
Bus10-MOSUR	1.0052	1.0053
Bus11-TVALAM	0.9808	0.9808
Bus12-SPET	1.0266	1.0267
Bus13-ARANI	1.0447	1.0446
Bus14-SPUDUR	1.0500	1.0500
Bus15- KOYAMBEDU	1.0622	1.0622
Bus16-SPKOIL	1.0349	1.0348
Bus17-MAPS	1.0500	1.0500
Bus18-KADAPERI	1.0343	1.0343
Bus19- THARAMANI	1.0722	1.0722
Bus20-TV MALAI	1.0256	1.0260
Bus21-VILLUPURAM	1.0442	1.0450
Bus22-CUDDALORE	1.0409	1.0412
Bus23-NLC 1	1.0500	1.0500
Bus24- EACHENKADU	1.0301	1.0219
Bus25- N2 MIN4	1.0500	1.0500
Bus26- VILLIYANUR	1.0272	1.0272
Bus27-KADALANKUDI	1.0177	0.7140
Bus28-PERAMBALUR	1.0402	1.0402
Bus29-TVARUR	1.0005	0.7396
Bus30-KARAIKUDI	1.0092	0.9380
Bus31-PARAMAKUDI	1.0143	0.9776
Bus32-TTPS	1.0500	1.0500
Bus33-NAGERKOIL	1.0500	1.0500
Bus34-KAYATHAR	1.0500	1.0500
Bus35- TTPAUTO	1.0494	1.0494
Bus36-TUTICORIN	1.0482	1.0482
Bus37- MADURAI 1	1.0500	1.0500

8

Bus38-ANNUPANKALAM	1.0378	1.0378
Bus39- ALGARKOIL	1.0399	1.0355
Bus40-PUDUKOTTAI	1.0068	0.9632
Bus41-TRICHY	1.0071	0.9858
Bus42-ALUNDUR	1.0096	0.9904
Bus43-THANJAVUR	1.0011	0.9817
Bus44-PUGALUR	1.0218	1.0132
Bus45-SAMYAPURAM	1.0113	0.9925
Bus46- MADURAI 2	1.0488	1.0486
Bus47- SEMBATTY	1.0422	1.0412
Bus48-UDUMALPET 2	1.0661	1.0660
Bus49-KADAMPARAI	1.0500	1.0500
Bus50-UDUMALPET	1.0500	1.0500
Bus51-KUNDAH	1.0500	1.0500
Bus52-GOPI	1.0500	1.0500
Bus53- ARASUR	1.0199	1.0199
Bus54-THUDILIYAR	1.0500	1.0500
Bus55-INGUR	1.0347	1.0348
Bus56-MALCO	1.0500	1.0500
Bus57-MTRT	1.0500	1.0500
Bus58-MTPS	1.0500	1.0500
Bus59-UJANAI	1.0333	1.0281
Bus60-SALEM 2	1.0460	1.0456
Bus61-SALEM 1	1.0473	1.0465
Bus62-DEVIAKURCHI	1.0462	1.0469

As observed from the results (Table II) base case or pre-contingency voltage profile and which is in specified limits. But after outage of transmission line 20 Voltage is affected at every bus expect PV Buses because PV buses itself control reactive power and so voltage profile of the system.

Table III Total Real Power Losses –Indian Utility 62 Bus system

	Base Case or Pre-Contingency Case	Post-Contingency Case (Outage of line 20)
Real Power Loss (MW)	**68.2401 MW**	**82.23 MW**

Table IV Total Reactive Power Losses –Indian Utility 62 Bus system

	Base Case or Pre-Contingency Case	Post-Contingency Case (Outage of line 20)
Reactive Power Loss (MVAR)	**-95.7181 MVAR**	**-18.28 MVAR**

As from the Results of Real and Reactive power Losses in both pre-Contingency and post-contingency cases we observed that Real power Loss is increased from 68.24 MW to 82.23 MW after outage of transmission line 20.

Also Reactive power loss is increase due to outage of transmission line.

So, for Single Contingency (Transmission line outage) Power flows ,Voltage profile at every buses and Real and Reactive Power loss is affected.

VII. CONCLUSIONS

In this paper, the method for contingency ranking using PSAT was proposed. The proposed algorithm has been applied to Indian Utility 62-Bus system. The study of contingency ranking and analysis is very important from the view point of power system security. Here we have obtain the contingency ranking for Indian Utility 62 Bus system. For Indian Utility 62 Bus system line number 20 connected between Bus27-KADALANKUDI to Bus25- N2 MIN4 is most severe line among all 89 Transmission lines. Table 1. shows the contingency ranking for Indian Utility 62 Bus system This identification being able to significantly improve the secure performance of power systems and to reduce the chances of failure of system. Good planning helps to ensure that reliability and security of the system. Contingency ranking analysis helps the power system engineer to give the most priority to notice or monitoring the line flows to which line and monitoring other lines flow in descending order.

ACKNOWLEDGMENT

We are extremely grateful to the Electrical Engineering Department, ITM Universe,Vadodara for extending all its facilities. We humbly extend our sense of gratitude to our faculty members, laboratory staffs, library staffs and administration of this institute for providing us their valuable help and time in congenial working environment.

REFERENCES

[1]. R.Manikandan, M.Bhoopathi“Contingency Analysis in Deregulated Power Market”International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering,Vol. 2, Issue 12, December 2013 [2]Arthit Sode-Yome and Kwang Y. Lee “Neural Network Based Loading Margin Approximation for Static Voltage Stability in Power Systems”, IEEE Transactions on Magnetics.

[2]. Sourav Basu, Chandramouli Gupta, Sumana Chowdhuri“Voltage Stability Margin (VSM) and Maximum Loading Point (MLP) Of A Multi-Bus System Before and After Compensation”International Journal of Engineering Research and Development ,Volume 5, Issue 7 (January 2013), PP. 30-35

[3]. Tika R. Limbu ,Tapan K. Saha ,“Comparing Effectiveness of Different Reliability Indices in Contingency Ranking and Indicating Voltage Stability”,School of Information Tech. & Elect. Engineering University of Queensland Brisbane, Australia.

[4]. D. S. Javan, H. Rajabi Mashhadi and M. Rouhani“Fast Voltage and Power Flow Contingencies Ranking using Enhanced Radial Basis Function Neural Network”,Iranian Journal of Electrical & Electronic Engineering, Vol. 7, No. 4, Dec. 2011

[5]. M. K. Maharana, Samrat Malakar“Sensitivity Based Network Contingency Ranking Using Newton Raphson Power Flow Method”,International Journal of Scientific Engineering and Technology,Volume No.4 Issue No.2, pp : 45-49

[6]. Namami Krishna Sharma,Sudhir P. Phulambrikar, Manish Prajapati, Ankita Sharma“Contingency Ranking and Analysis using Power System Analysis Toolbox (PSAT)”,International Conference on Recent Trends in Applied Sciences with Engineering Applications ,Vol.4, No.6, 2013

[7]. Toshi Mandloi , Anil K Jain, “A Study of Power System Security and Contingency Analysis”,International

[8]. Journal of Scientific Research Engineering & Technology (IJSRET), Volume 3, Issue 4, July 2014

[9]. Veenavai Mishra ,Manisha Khardenvis,“Contingency Analysis of Power System”,International Conference on Emerging Frontiers in Technology for Rural Area (EFITRA) 2012

[10]. Salah Eldeen Gasim Mohamed, Abdelaziz Yousif Mohamed , Yousif Hassan Abdelrahim“Power System Contingency Analysis to detect Network Weaknesses” ,Zaytoonah University International Engineering Conference on Design and Innovation in Infrastructure 2012

[11]. F.Milano, “Power System Analysis Toolbox” ,Version 2.1.6,Software and Documentation (2008) http://shodhganga.inflibnet.ac.in/bitstream/10603/1221/18/18_appendix.pdf