ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

EXAMINATION OF VOLTAGE STABILITY BY CONSIDERING CPF ALGORITHM WITH STATCOM UNDER CONTINGENCY

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ABSTRACT

The use of Continuation power flow (CPF) analysis is introduced in this paper as a means of assessing and analyzing the voltage stability and controlling power flow in large scale -systems. This method initially starts with system base values and progresses to the critical point while continuous maintaining stability even with single precision computation. In the event of transmission line and failure of transformer, the other branches may become overloaded, and there exits the system voltage fluctuations. This paper mainly aims the specific case of line contingency (emergency) and examines the impact STATCOM on various parameters like system voltage, reactive power, and voltage stability using the CPF Algorithm.
Keywords – *Continuation Power Flow; Contingency; STATCOM; Stability Index.*

1. INTRODUCTION

With an increase and variations in load Voltage stability is becoming a more severe issue as power systems get increasingly complicated. Because to the substantial number of major washouts occurs due to this phenomena, voltage difficulties recovers a source of great concern during the development and power systemsoperation and control. As a result, instruments for Voltage Stability Analysis (VSA) are required in today's Energy Management Systems (EMS).[1],[2],.

Indeed, from a various literatures proposed indices of voltage stability that included a power flow analysis of some kind [3],[4],[5],[6],[7][8]. A special issue addressed in the named analysis that at steady state limit (SL) load flow using Jacobian of Newton Rapson method becomes Divergent. In fact, the Critical point (CP) is defined and termed as steady state limit, and also viewed as power flow divergent of Jacobian flow.

Due to the above analysis the power flow solution nearer to critical parameters are pore to variations and inaccurate [9].

This article explains how to fight the Jacobian's divergence by sluggishly rewriting
the equations related with load flow and employing a closely studied follow-up technique [10]. The improved mathematical model is well-conditioned during the consequence, continuous flow of electricity, thus the variation and perturbations in accuracy caused by the unique Jacobian are not encountered.

The uninterrupted flow of electricity is based on solving a set of load flow equations using a predictor-corrector algorithm, which predicts and corrects the values of voltage and power at each point in the power system until a

Journal of Theoretical and Applied Information Technology
30th June 2023. Vol.101. No 12

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

set of converged solutions is obtained. Load constraints are also incorporated into these equations to ensure the safe operation of the power system. Effective load flow calculations, optimization algorithms, and load constraints are all necessary for the reliable operation of the power system. [11],[12]. It starts with a well-known resolution similar to a modified load parameter value as shown in Fig. 1[13].The outcomes of the similar Newton-Raphson approach employed for conventional power flow are then utilized to modify this calculation [14]. The limited parameterization discussed above provides a tool for characterizing specific points along the solution lane and demonstrates a crucial role in avoiding the Jacobian's divergence.

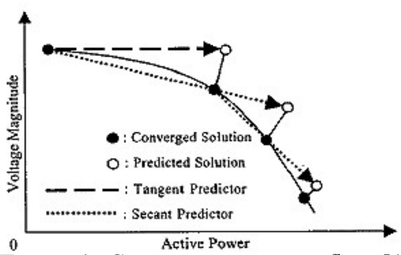

Figure 1: Continuation power flow [13]

Here [1] is considered for Voltage stability analysis by using CPF under contignecy as reference case.

2. MATHEMATICAL FORMULATION

To apply a locally parameterized acceptable technique for the power flow problem, with the addition of load parameter to the load flow equations is done. This load parameter represents the load at each node in the power system and allows for the analysis of how the power flow changes as the load changes.

One simple way to add a load parameter to the equations is to use a constant power load model, where the load at each node is represented as a constant power, which is a function of the voltage at that node. The complex power of the load at node i can be expressed as a function of the voltage and the load parameter λ. By introducing a load parameter λ, the load flow equations become parameterized and can be solved using a continuation technique, which involves solving a sequence of closely related problems as the load parameter λ is varied. This allows for the analysis of the behavior of the power flow as the load changes, and can help to identify potential problems or instabilities in the power system.

First let λ represent the load parameter such that$0 \le \lambda \le \lambda_{critical}$. Where $\lambda = 0$ corresponds to the base load and $\lambda = \lambda_{critical}$ corresponds to the critical load. We desire to incorporate λ into

$$0 = P_{Gi} - P_{Li} - P_{Ti}, P_{Ti} = \sum_{j=1}^{n} V_i V_j y_{ij} \cos(\delta_i - \delta_j - v_{ij})$$

$$0 = Q_{Gi} - Q_{Li} - Q_{Ti}, Q_{Ti} = \sum_{j=1}^{n} V_i V_j y_{ij} \sin(\delta_i - \delta_j - v_{ij}) \quad (1)$$

For consideration of each bus i of an n bus system, where the subscripts L indicates load bus, Ggeneration bus and T bus injection respectively. And $V_i \angle \delta_i$ and $V_j \angle \delta_j$ are the bus voltages of i and j buses respectively and $y_{ij} \angle v_i$is the (i, j)th element of Y_{BUS}. And the real and reactive powers at respective buses at ith bus as PLi and QLi terms in the load flow equations must be modified. This can be achieved by splitting each term to two components. Original load at ith bus denoted as P_{0i} and Q_{0i}, which represents first component. The second component represents change in the load parameter λ denoted as $P_{\lambda i}$ and $Q_{\lambda i}$. Thus,

$$P_{Li} = P_{i0} + \lambda (K_{Li} S_{\Delta base} \cos \psi_i)$$

$$Q_{Li} = Q_{Li0} + \lambda (K_{Li} S_{\Delta base} \sin \psi_i) \quad (2)$$

From above the terms are defined as
Initial (original) values of load at bus i, active and reactive respectively be P_{Li0}, Q_{Li0}, with change in load at ith bus be λ, with multiplier to designate the rate of load change be K_{Li}.
Ψ_i-power factor angle of load changeat bus i.
$S_{\Delta base}$-a given quantity of apparent power which is chosen to provide appropriate scaling of λ.
Along with known terms, the active power generation term can define as:

$$P_{Gi} = P_{Gi0}(1 + \lambda K_{Gi}) \quad (3)$$

From above equation at ith bus KGi is a constant used to specify the rate of change in generation as λ varies and With base case consideration ith busactive generation is P_{Gi} and KGi is a

Journal of Theoretical and Applied Information Technology
30th June 2023. Vol.101. No 12

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

constant defined the rate of change in generation as λ variation.

Now the modified equations with substitution the resultant power flow equations the result is defined as

$$0 = P_{Gi0}(1+\lambda K_{KGi}) - P_{Li0} - \lambda(K_{Li} S_{\Delta base} yod\psi_i) - P_{Ti}$$
$$0 = Q_{Gi0} - Q_{Li0} - \lambda(K_{Li} S_{\Delta base} \sin\psi_i) - Q_{Ti} \tag{4}$$

3.CONTINUATION ALGORITHM TECHNIQUE

The problem is defined with a set of equations denoted by F with consideration of set of variables as shown below:

$$F(\underline{\partial}, \underline{V}, \lambda) = 0, \quad 0 \le \lambda \le \lambda_{critical} \tag{5}$$

Where δ represents the vector of bus voltage angles and V represents the vector of bus voltage magnitudes. And δ_o, V_o, λ_o defines as the base values of the solution within a range λ, as the solution path for the conventional power flow.

The mathematical equations implemented in continuation algorithm are represented as give below.

$$d[F(\underline{\delta}, \underline{V}, \lambda)] = F_{\underline{g}} d\underline{\delta} + F\underline{y} d\underline{V} + F_\lambda d\lambda = \underline{0} \tag{6}$$

$$|F_\delta \quad F_V \quad F_\lambda| \begin{vmatrix} d\underline{\delta} \\ d\underline{V} \\ d\lambda \end{vmatrix} = \underline{0} \tag{7}$$

$$\underline{t} = \begin{vmatrix} d\underline{\delta} \\ d\underline{V} \\ d\lambda \end{vmatrix}, \quad t_k = \pm 1 \tag{8}$$

This result in

$$\begin{vmatrix} \underline{F}_\delta & \underline{F}_V & \underline{F}_\lambda \\ & \underline{e}_k & \end{vmatrix} |\underline{t}| = \begin{vmatrix} 0 \\ \pm 1 \end{vmatrix} \tag{9}$$

$$\begin{vmatrix} \underline{\delta}^* \\ \underline{V}^* \\ \lambda^* \end{vmatrix} = \begin{vmatrix} \underline{\delta} \\ \underline{V} \\ \lambda \end{vmatrix} + \sigma \begin{vmatrix} d\underline{\delta} \\ d\underline{V} \\ d\lambda \end{vmatrix} \tag{10}$$

Where "*" stands for the expected solution for a future value of (loading) and is a scalar that represents the step size.

$$\underline{x} = \begin{vmatrix} \underline{\delta} \\ \underline{V} \\ \lambda \end{vmatrix}, \quad \underline{x} \in R^{2n_1+n_2+1} \tag{11}$$

A new set of equations with considering $x_k = \eta$, *η defined as an* k^{th} elements approximate value, then

$$\begin{vmatrix} F(\underline{x}) \\ x_k - \eta \end{vmatrix} = |\underline{0}| \tag{12}$$

The set of equations can now be solved using a slightly modified Newton-Raphson power flow method once an appropriate index *k* and value of *η*are selected.

$$x_k : |t_k| = \max\{|t_1|, |t_2|, \ldots\ldots |t_m|\} \tag{13}$$

Where *t* is the tangent vector with an equivalent dimension $m=2n_1+n_2+1$ and the index *k* resembles to the element of the tangent vector that is utmost.

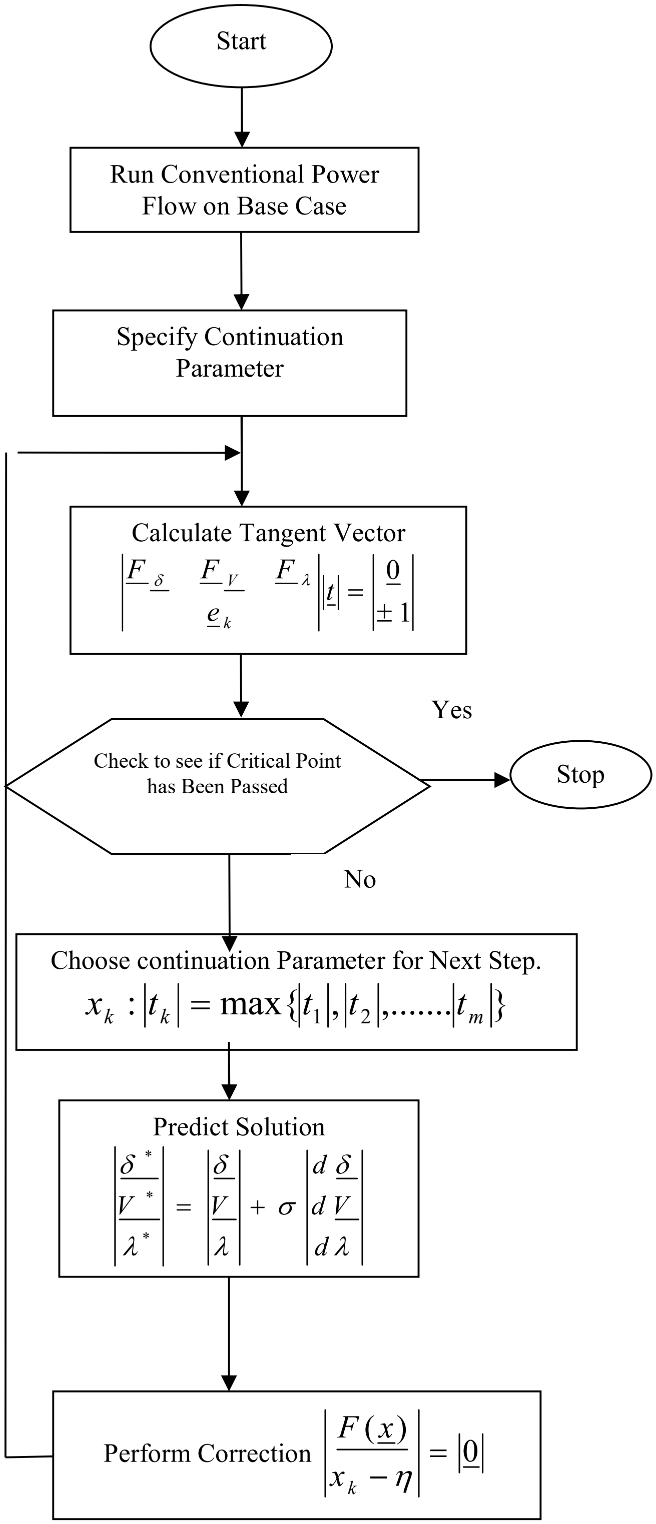

Figure 2: Flow chart for CPF

4. VOLTAGE STABILITY

In order to analyze the voltage stability, a voltage collapse proximity indication index must be determined. This index provides an approximation of the system's vulnerability to voltage collapse. The voltage collapse proximity indicator can be found using a variety of techniques. The L-index method suggested by Kessel and Glavitsch is one such approach. It is founded on analysis of load flow. Its value is between 0 and 1 (no load condition) (voltage collapse). The bus in the system that has the highest L-index value will be the most at risk. be reflected in the following phrase:

$$I_{bus} = Y_{bus}.V_{bus} \quad (14)$$

By segregating the load buses (PQ) from generator buses (PV), above Equation can write as

$$\begin{bmatrix} I_G \\ I_L \end{bmatrix} = \begin{bmatrix} Y_{GG} & Y_{GL} \\ Y_{LG} & Y_{LL} \end{bmatrix} \begin{bmatrix} V_G \\ V_L \end{bmatrix} \quad (15)$$

where I_G, I_L *and* V_G, V_L represent currents and voltages at the generator buses and load buses.

Rearranging the above equation we get:

$$\begin{bmatrix} V_L \\ I_G \end{bmatrix} = \begin{bmatrix} Z_{LL} & F_{LG} \\ K_{GL} & Y_{GG} \end{bmatrix} \begin{bmatrix} I_L \\ V_G \end{bmatrix} \quad (16)$$

$$F_{LG} = -[Y_{LL}]^{-1}[Y_{LG}] \quad (17)$$

The L-index of the j^{th} node is given by the expression

$$L_j = \left| 1 - \sum_{i=1}^{N_g} F_{Ji} \frac{V_i}{V_j} \angle \left(\theta_{ji} + \delta_i - \delta_j \right) \right| \quad (18)$$

The stability index is given by minimum singular value of jacobian.

5. MODELLING EQUATIONS OF STATCOM

STATCOM'S inclusion raises the order of the Jacobian and tangent vectors as well as the power equations for the continuous power flow. STATCOM Jacobian is used in place of conventional Jacobian [21]. The following voltage source representation is assumed as the basis for the power flow equations for the STATCOM.

$$E_{vR} = V_{vR}(\cos \delta_{vR} + j \sin \delta_{vR}) \quad (19)$$

After carrying out some composite operations, the subsequent active and reactive power equations are found for the converter and bus k, correspondingly

$$P_{vR} = V_{vR}^2 G_{vR} + V_{vR} V_k [G_{vR} \cos(\delta_{vR} - \theta_k) + B_{vR} \sin(\delta_{vR} - \theta_k)]$$

$$Q_{vR} = -V_{vR}^2 B_{vR} + V_{vR} V_k [G_{vR} \sin(\delta_{vR} - \theta_k) - B_{vR} \cos(\delta_{vR} - \theta_k)]$$

$$P_k = V_k^2 G_{vR} + V_{vR} V_k [G_{vR} \cos(\theta_k - \delta_{vR}) + B_{vR} \sin(\theta_k - \delta_{vR})]$$

$$Q_k = -V_k^2 G_{vR} + V_{vR} V_k [G_{vR} \sin(\theta_k - \delta_{vR}) - B_{vR} \cos(\theta_k - \delta_{vR})] \quad (20)$$

Using these power equations, the linearized STATCOM model is given below, where the voltage magnitude V_{vR} and phase angle δ_{vR} are taken to be the state variables

$$\begin{bmatrix} \Delta P_k \\ \Delta Qk \\ \Delta P_{vR} \\ \Delta P_{vR} \end{bmatrix} = \begin{bmatrix} \frac{\partial P_k}{\partial \theta_k} & \frac{\partial P_k}{\partial V_k} V_k & \frac{\partial P_k}{\partial \delta_{vR}} & \frac{\partial P_k}{\partial V_{vR}} V_{vR} \\ \frac{\partial Q_k}{\partial \theta_k} & \frac{\partial Q_k}{\partial V_k} V_k & \frac{\partial Q_k}{\partial \delta_{vR}} & \frac{\partial Q_k}{\partial V_{vR}} V_{vR} \\ \frac{\partial P_{vR}}{\partial \theta_k} & \frac{\partial P_{vR}}{\partial V_k} V_k & \frac{\partial P_{vR}}{\partial \delta_{vR}} & \frac{\partial P_{vR}}{\partial V_{vR}} V_{vR} \\ \frac{\partial Q_{vR}}{\partial \theta_k} & \frac{\partial Q_{vR}}{\partial V_k} V_k & \frac{\partial Q_{vR}}{\partial \delta_{vR}} & \frac{\partial Q_{vR}}{\partial V_{vR}} V_{vR} \end{bmatrix} \begin{bmatrix} \Delta \theta_k \\ \frac{\Delta V_k}{V_k} \\ \Delta \delta_{vR} \\ \frac{\Delta V_{vR}}{V_{vR}} \end{bmatrix} \quad (21)$$

Due to the inclusion of STATCOM the local parameterization vector can be changed as

$$\underline{x} = \begin{vmatrix} \underline{\delta} \\ \underline{V} \\ \underline{Tvr} \\ \underline{Vvr} \\ \lambda \end{vmatrix}, \quad \underline{x} \in R^{2n_1+n_2+1} \quad (22)$$

The tangent vector can be changed as

$$\begin{vmatrix} \underline{F}_{\underline{\delta}} & \underline{F}_{\underline{V}} & \underline{F}_{\underline{Tvr}} & \underline{F}_{\underline{Vvr}} & \underline{F}_{\lambda} \\ & & e_k & & \end{vmatrix} \left|\underline{t}\right| = \begin{vmatrix} 0 \\ \pm 1 \end{vmatrix} \quad (23)$$

The prediction step equation can be changed as

$$\begin{vmatrix} \underline{\delta}^* \\ \underline{V}^* \\ Tvr^* \\ Vvr^* \\ \lambda^* \end{vmatrix} = \begin{vmatrix} \underline{\delta} \\ \underline{V} \\ \underline{Tvr} \\ \underline{Vvr} \\ \lambda \end{vmatrix} + \sigma \begin{vmatrix} d\underline{\delta} \\ d\underline{V} \\ d\underline{Tvr} \\ d\underline{Vvr} \\ d\lambda \end{vmatrix} \quad (24)$$

6.RESULTS AND DISUSSIONS

Table 1: With multiple contingency 39-31,21-65,18-71with out STATCOM [1]							
Change in load (λ)	**Voltage magnitude at bus 75**	**Voltage angle at bus 75**	**L-index Value maximum**	**L-index at bus 75**	**Stability Indicator**	**Loss of Power-Active**	**Loss of Power-Reactive**
0.0015	0.9999	-0.6755	0.5283	0.2026	0.0603	2.1327	6.8401
0.0045	1.0016	-0.6819	0.5272	0.2024	0.0603	2.1399	6.8880
0.0090	1.0041	-0.6916	0.5249	0.2021	0.0603	2.1546	6.9871
0.0150	1.0074	-0.7044	0.5216	0.2016	0.0603	2.1774	7.1442
0.0225	1.0116	-0.7205	0.5174	0.2011	0.0603	2.2091	7.3695
0.0285	1.0158	-0.7365	0.5126	0.2006	0.0602	2.2509	7.6768
0.0330	1.0199	-0.7526	0.5081	0.2003	0.0602	2.2952	8.0125
0.0360	1.024	-0.7687	0.5039	0.2002	0.0601	2.3419	8.3768
0.0375	1.0281	-0.7848	0.5001	0.2003	0.0601	2.3910	8.7696
0.0375	1.0323	-0.8008	0.4966	0.2006	0.0600	2.4426	9.1910
0.0360	1.0364	-0.8169	0.4934	0.2011	0.0599	2.4967	9.6411
0.0330	1.0405	-0.8330	0.4905	0.2017	0.0599	2.5533	10.1199
0.0285	1.0446	-0.8491	0.4879	0.2025	0.0598	2.6124	10.6274
0.0225	1.0486	-0.8652	0.4855	0.2035	0.0597	2.6739	11.1638
0.0150	1.0527	-0.8813	0.4835	0.2046	0.0596	2.7380	11.7291
0.0060	1.0567	-0.8974	0.4817	0.2059	0.0595	2.8045	12.3233
-0.0045	1.0608	-0.9134	0.4802	0.2073	0.0595	2.8736	12.9463

Realistic Indian 75 bus test system is used as input in this paper. The uttarpradesh-75 bus system is represented by this real-world test system. At bus -75, the voltage magnitude and voltage angle are seen. With the change in load(λ)., the voltage's magnitude and angle will change

The value of λ depends on knee point, its value increases there after the knee decreases. Multiple contingencies are applied by detaching the lines connected between 39-31, 21-65, 18-71. The results are considered in the both the cases with and without STATCOM inclusion of STATCOM are discussed.

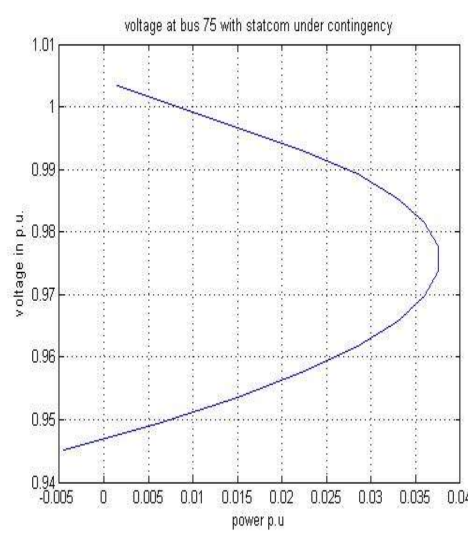

Figure 3. Voltage at bus 75 with STATCOM

Journal of Theoretical and Applied Information Technology
30th June 2023. Vol.101. No 12

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

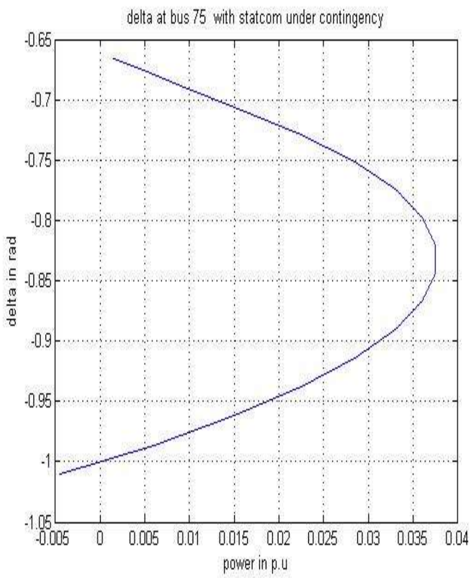

Figure 4. Angle at bus 75 with STATCOM under contingency

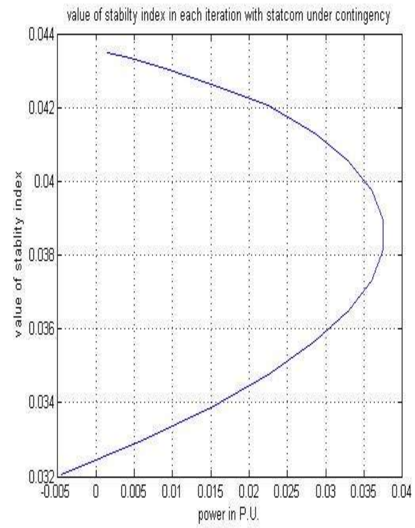

Figure 6. Stability index with STATCOM under contingency

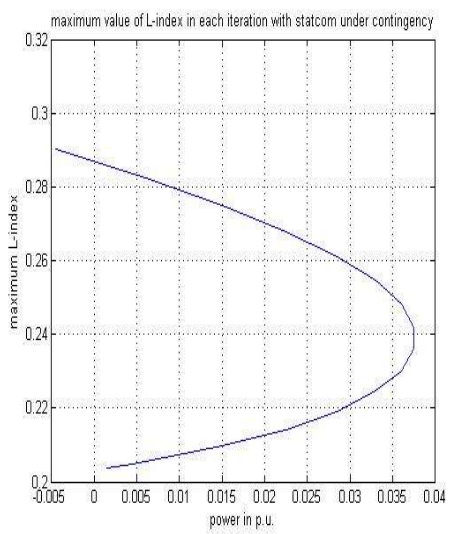

Figure 5. Maximum L index with STATCOM under contingency

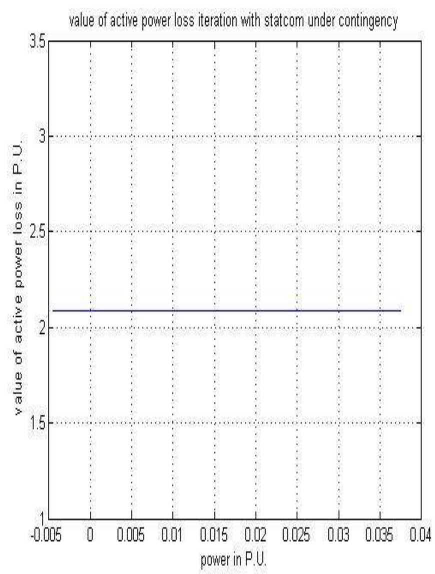

Figure 7. Value of active power loss with STATCOM under contingency

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

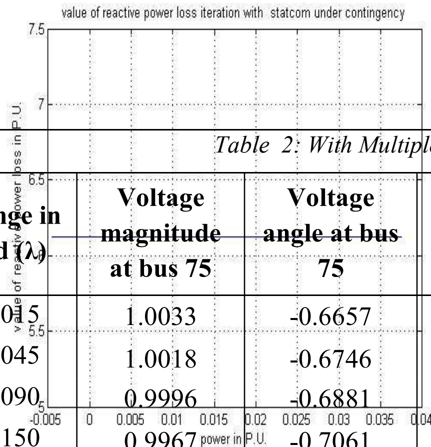

Figure 8. Reactive power loss Value with STATCOM under contingency

Here the obtained result of this analysis is compared with the results obtained for without inclusion of STATCOM [1].

From the result obtained several conclusions

Table 2: With Multiple Contingency 39-31,21-65,18-71with STATCOM

Change in load (λ)	Voltage magnitude at bus 75	Voltage angle at bus 75	L-index Value maximum	L-index at bus 75	Stability Indicator	Loss of Power-Active	Loss of Power-Reactive
0.0015	1.0033	-0.6657	0.2038	0.1601	0.0435	2.0842	6.1244
0.0045	1.0018	-0.6746	0.2048	0.1609	0.0434	2.0842	6.1244
0.0090	0.9996	-0.6881	0.2068	0.1626	0.0431	2.0842	6.1244
0.0150	0.9967	-0.7061	0.2099	0.1651	0.0426	2.0842	6.1244
0.0225	0.993	-0.7287	0.214	0.1686	0.042	2.0842	6.1244
0.0285	0.9892	-0.7514	0.2192	0.173	0.0413	2.0842	6.1244
0.0330	0.9854	-0.7743	0.2246	0.1774	0.0405	2.0842	6.1244
0.0360	0.9816	-0.7973	0.2302	0.1819	0.0398	2.0842	6.1244
0.0375	0.9777	-0.8204	0.236	0.1866	0.039	2.0842	6.1244
0.0375	0.9738	-0.8436	0.242	0.1912	0.0382	2.0842	6.1244
0.0360	0.9698	-0.867	0.2481	0.196	0.0373	2.0842	6.1244
0.0330	0.9658	-0.8906	0.2545	0.2009	0.0365	2.0842	6.1244
0.0285	0.9618	-0.9142	0.2611	0.2058	0.0356	2.0842	6.1244
0.0225	0.9577	-0.9381	0.268	0.2109	0.0348	2.0842	6.1244
0.0150	0.9536	-0.962	0.2751	0.216	0.0339	2.0842	6.1244
0.0060	0.9494	-0.9862	0.2825	0.2213	0.033	2.0842	6.1244
-0.0045	0.9452	-1.0105	0.2901	0.2267	0.0321	2.0842	6.1244

has made. With step perturbation in load, the inclusion of STATCOM there is a vast change in watt-full and watt-less components of power losses with change in potential magnitude and phase angle under several multiple contingency by detaching the lines connected between 39-31, 21-65, 18-71 there is an improvement in stability index, improvement in voltage profile and reduction in the true power loss and apparent power losses.

This method of Continuation Power flow does not applicable for distribution systems as this method uses basics of Newton Raphson method.

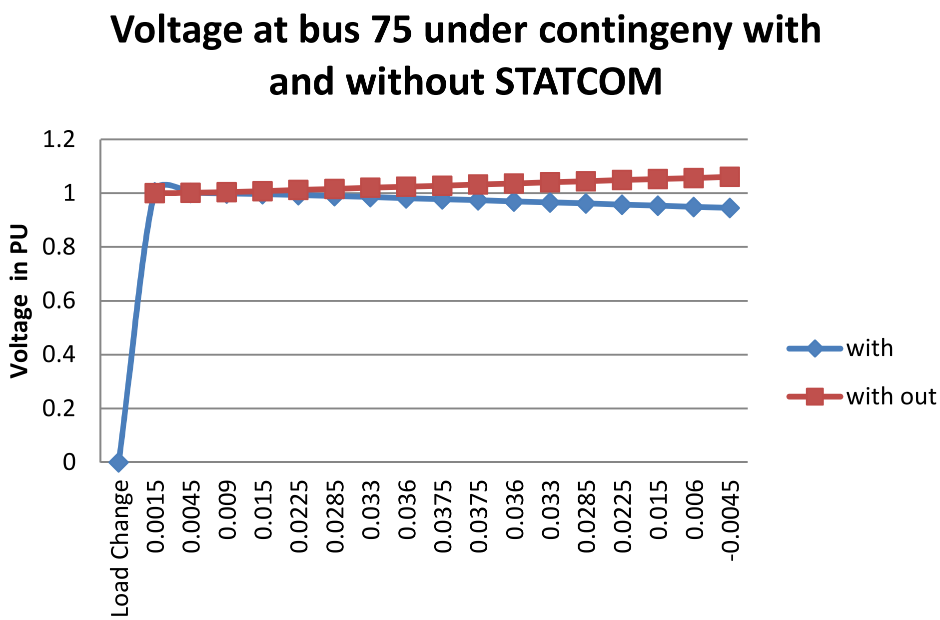

Figure 9. Value of Voltage at bus 75 with and without STATCOM under contingency

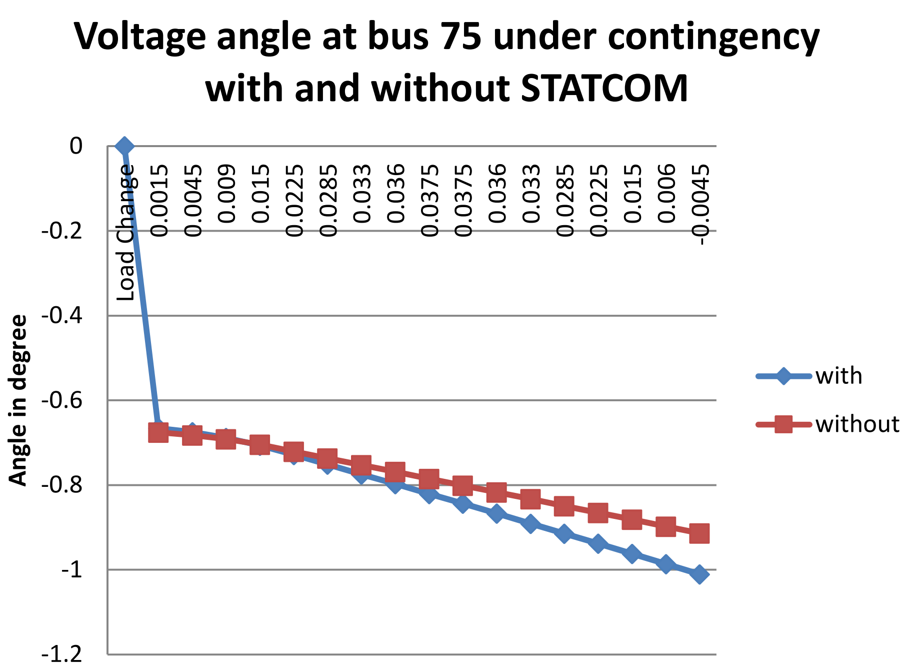

Figure 10. Value of Voltage angle at bus 75 with and without STATCOM under contingency

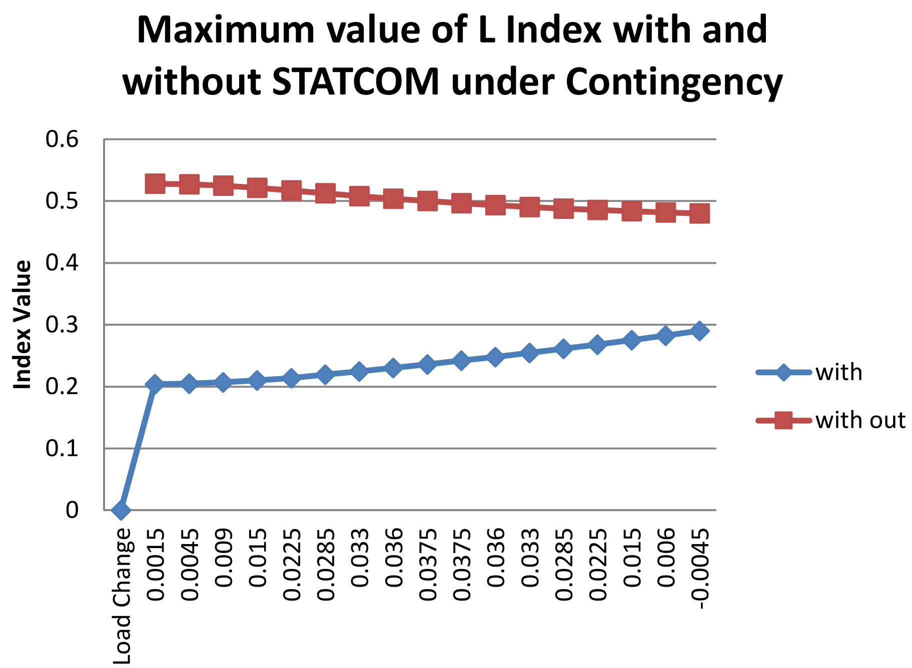

Figure 11. Maximum value of L index with and without STATCOM under contingency

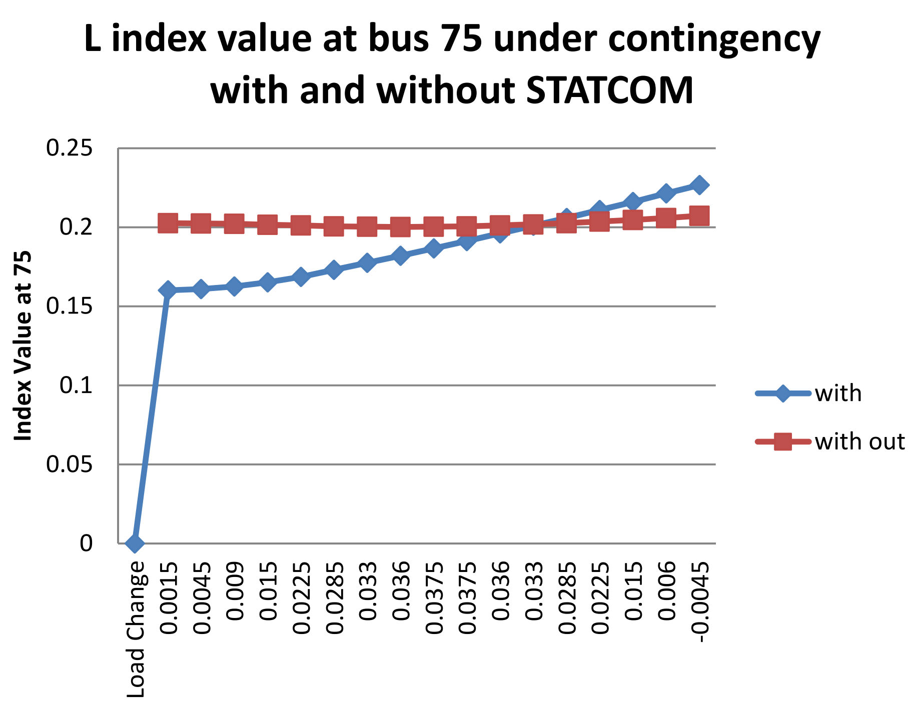

Figure 12. Value of L index at bus 75 with and without STATCOM under contingency

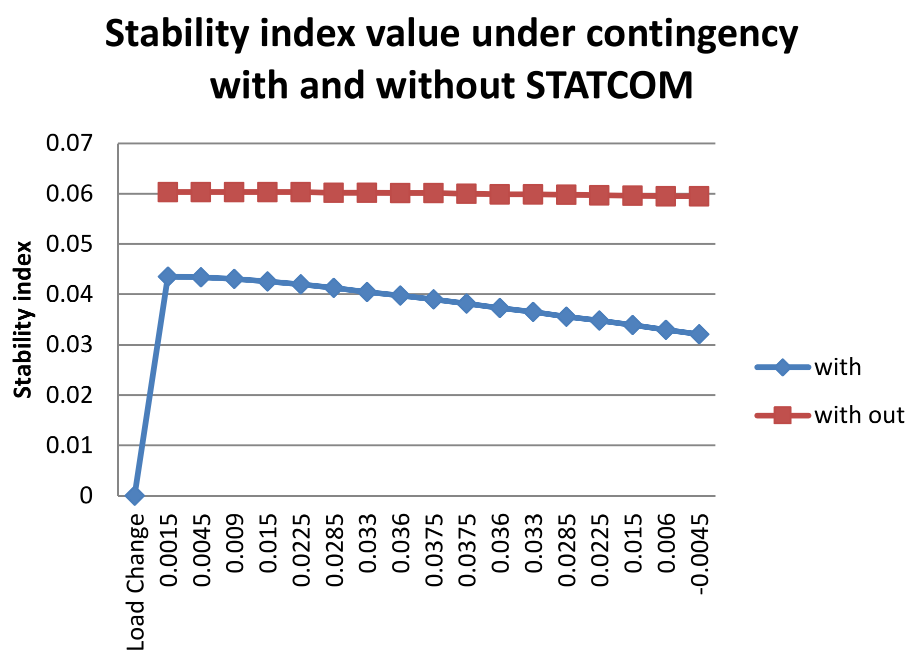

Figure 13. Value of Stability index with and without STATCOM under contingency

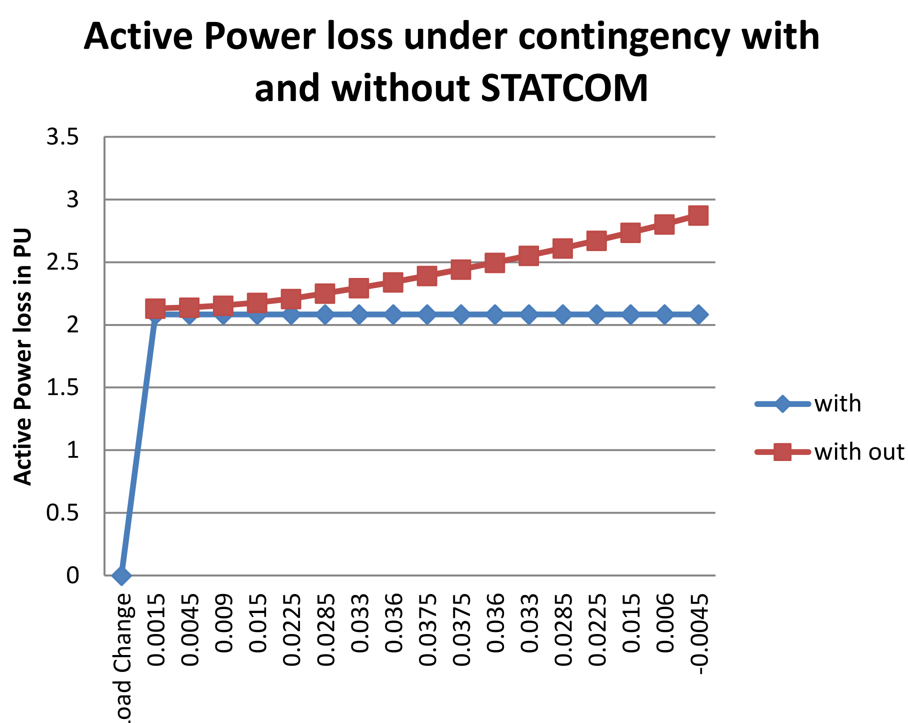

Figure 14. Value of Active Power loss with and without STATCOM under contingency

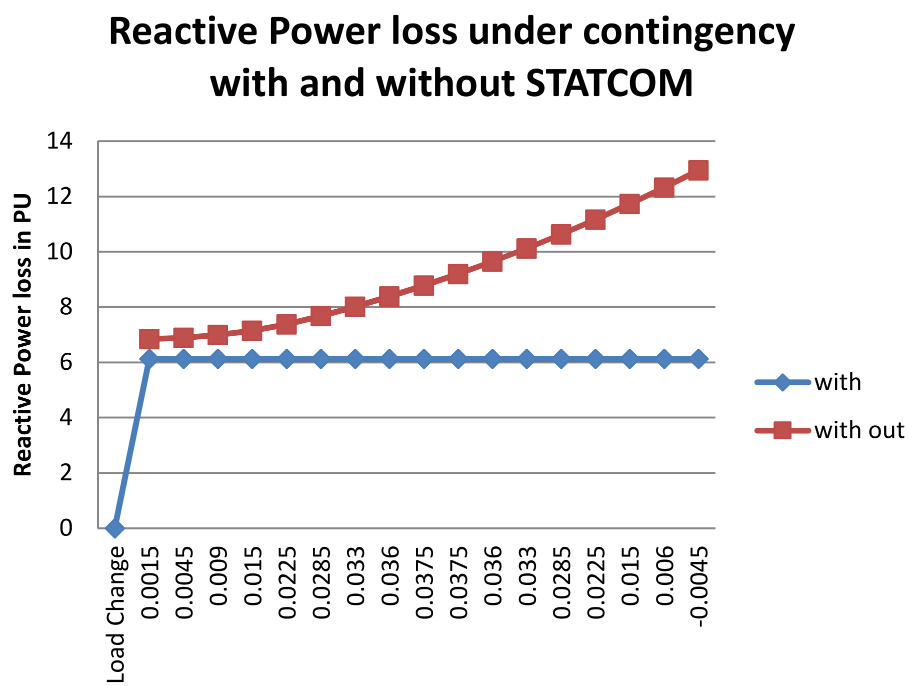

Figure 15. Reactive Power loss Value with and without STATCOM under contingency

6. CONCLUSION

The example provided in this paper demonstrates both the CPF's capacity and its effectiveness. For many outcomes of burden fluctuation, solutions tracks up to and beyond the CP have been established. Variance is never a problem in any of the situations, unlike with the traditional Newton-Raphson power flow. This paper discusses the voltage profile and power losses for multiple contingencies using a CPFA with and without inclusion of STATCOM. we can also conclude that by inclusion of STATCOM stability, voltage profile improved and losses reduced.

REFERENCES

[1] Madhavi Gudavalli, Harika Vemulapalli, Kumar Cherukupalli, Voltage Stability Analysis Using Continuation Power Flow Under Contingency, Journal of Theoretical and Applied Information Technology 31st May 2021. Vol.99. No 10, PP: 2373-238.

[2] S. Sarkar, G. Saha, G. Pal, and T. Karmakar, "Indian experience on smart grid application in blackout control," in Proceedings of the 2015 National Systems Conference (NSC), Noida, India, December 2015.

[3] Blackout of 2003: Description and Responses. [Online]. Available: http://www.pserc.wisc.edu/.

[4] X. Wang, G.C. Ejebe, J. Tong, & J.G. Waight, Preventive/Corrective Control for Voltage Stability Using Direct Interior Point Method, IEEE Transaction on Power Systems, Vol. 13, No. 3, August 1998, pp. 878-883.

[5] Performance Indexes for Predicting Voltage Collapse, EPRI EL-6461, Project 1999-10, Electric Power Research Institute, July 1989.

[6] B. Gao, G. K. Morison, and P. Kundur,"Voltage stability evaluation using modal analysis," IEEE Transactions on Power Systems, vol. 7, no. 4, pp. 1529–1542, 1992.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[7] Dobson and H. D. Chiang, "Towards a theory of voltage collapse in electric power systems," Systems& Control Letters, 13, 1989, pp.253-262.

[8] R. A. Schlueter, A. G. costi, J. E. Sekerke. and H. L. Forgey, "Voltage Stability and Security Assessment," EPRI Report EL-5%7, Project 1999-8, August 1988.

[9] V. Ajjarapu and C. Christy, "The Application of aLocally parameterized Continuation Technique to theStudy of Steady State Voltage Stability," Proceedingsof 21st Annual North American Power Symposium,Rolla, Missouri, October 1989.

[10] V. Ajjarapu, Computational Techniques for Voltage Stability Assessment and Control, Power Electronics and Power Systems Series, Springer, 2010.

[11] Werner C.Rheiboldt, & John V. Burkardt, A locally parameterized continuation process,ACM Trans. On Mathematical Software, Vol. 9, no. 2, 1983, pp 215-235.

[12] Mehmet B. Kesk_n, "Continuation power flow and voltage stability in power systems," A Thesis Submitted to the Graduate School of Natural and Applied Sciences of Middle East Technical University, Sep2007.

[13] Ajjarapu, V., and Christy, C.,The continuation power flow: A tool for steady state voltage stability analysis, IEEE Trans. Power Syst., 1992, 7, (1), pp. 416-423.

[14] Hiroyuki Mori, Souhei Yamada ,Continuation power flow with the Non-Linear Predictor of the Language's Polynomial Interpolation formula, Meiji University, 2002 IEEE.

[15] Saadat, H.,Power system analysis, (McGraw-Hill, Singapore, 1999)

[16] Chi-Tsong,Chen Linear System Theory and Design,(Oxford University, 1999)

[17] Song, H., Kim, S., Lee, S., Kwon, H., and Ajjarap, V., Determination of interface flow margin using the modified continuation power flow in voltage stability analysis, IEE Proc-Gene. Transm. Distrib. Vol. 148, No.2, March 2001. pp 128-132.

[18] HAQUE, M. H., Use of V-I characteristic as a tool to assess the static voltage stability limit of a power system, IEE Proc.-Gener. Transm.Distrib., Vol. 151, No. 1, January 2004

[19] T.VanCutsem and C.Vournas , Voltage Stability of Electric Power Systems, Power Electronics and Power Systems International Series in Engineering and Computer Science, Springer, 2007.

[20] S.Raju, G.Madhavi, Optimal Location and Parameter Settings of TCSC under Single Line Contingency using PSO Technique, International Journal of Scientific & Engineering Research, Volume 5, Issue 3, March-2014.

[21] Acha, E., Fuerte-Esquivel, C.R., Ambriz-Perez, H. and Angeles-Camacho, C. (2004), "FACTS Modelling and Simulation in Power Networks", John Wiley & Sons, Chichester.