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Voltage Profile Improvement Using Static VAR Compensator in Power System

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Abstract: **This paper presents the MATLAB (PSAT) simulation of an IEEE 14 bus system to compute the load flow solution by using Newton Raphson method. L-index method is used as the measuring unit in predicting the voltage stability condition in the system. The SVC is a shunt device of the FACTS groups widely used to efficiently utilize the existing power system and to enhance the stability of the power system.**

***Keywords*: IEEE 14 bus system, SVC, MATLAB (PSAT), L-index.**

1. INTRODUCTION

Power system stability has been recognized as an important problem for secure system operation since the 1920s. Many major blackouts caused by power system instability have illustrated the importance of this phenomenon. As power systems have evolved through continuing growth in interconnections, use of new technologies and controls, and the increased operation in highly stressed conditions, different forms of system instability have emerged. For example, voltage stability, frequency stability and inter area oscillations have become greater concerns than in the past. This has created a need to review the definition and classification of power system stability. A clear understanding of different types of instability and how they are interrelated is essential for the satisfactory design and operation of power systems. Power system stability is the ability of an electric power system, for a given initial operating condition, to regain a state of operating equilibrium after being subjected to a physical disturbance, with most system variables bounded so that practically the entire system remains intact. The power system is a highly nonlinear system that operates in a constantly changing environment, loads, generator outputs and key.

Flexible Alternative Current Transmission System (FACTS) devices are used in order to minimize voltage instability problems. FACTS devices generally consist of Static Synchronous Compensator (STATCOM), Static VAR Compensator (SVC), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Control (UPFC).

Examining the studies on FACTS devices in the literature shows that these devices have helped solve negative situations in signal stability analysis caused by static and dynamic loads in multi bus power systems [1]. It was also seen that voltage instability problems caused by deactivation of lines can be successfully managed by FACTS devices.

2. MODELING OF POWER SYSTEM

In this paper, a 14-Bus standard power system is prepared. The modelling is done in MATLAB/SIMULINK software tool. It consists of five Generator buses. Usually bus no.1 is considered as slack bus. In this system, power flow is studied using Newton-Raphson Iteration method.

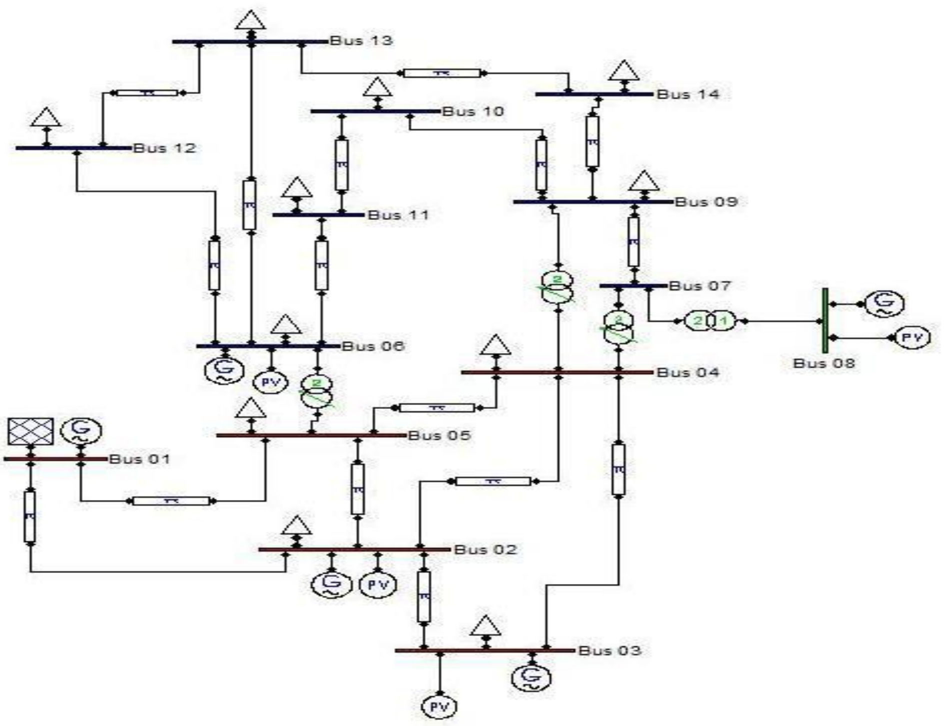

Fig: 1. - Modelling of IEEE 14-bus Power System

3. VOLTAGE STABILITY INDEX

The Voltage Stability Index abbreviated by Lij and referred to a line is formulated in this study as the measuring unit in predicting the voltage stability condition in the system. The mathematical formulation to speed up the computation is very simple. The Lij is derived from the voltage quadratic equation at the receiving bus on a two bus system. The general two-bus representation is illustrated in Fig. 2

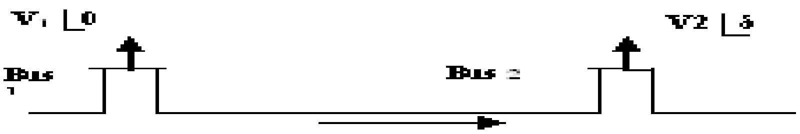

Fig.2 Two bus system

From the figure above, the voltage quadratic equation at the receiving bus is written as:

$$V_2{}^2 - \left(\frac{R}{X}\sin\delta + \cos\delta\right)V_1V_2 + \left(X + \frac{R^2}{X}\right)Q_2 = 0 \qquad ..... (1)$$

Setting the discriminate of the equation to be greater than or equal to zero:

$$\left[\left(\frac{R}{X}\sin\delta + \cos\delta\right)V_1\right]^2 - 4\left(X + \frac{R^2}{X}\right)Q_2 \geq 0 \qquad ...... (2)$$

Rearranging Eq. 2, we obtain:

$$\frac{4Z^2Q_2X}{(V_1)^2(R\sin\delta - X\cos\delta)^2} \leq 1$$

Taking the symbols 'i' as the sending bus and 'j' as the receiving bus, Lij can be defined by:

$$L_{ij} = \frac{4Z^2Q_JX}{V_1{}^2(R\sin\delta - X\cos\delta)^2}$$

Where:

Z = line impedance

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X = line reactance,

Qj = reactive power at the receiving end

Vi = sending end voltage

Any line in a system that exhibits Lij closed to unity indicates that the line is approaching its stability limit and hence may lead to system violation. Lij should always be less than unity in order to maintain a stable system. Lij is termed as voltage stability index of the line. At collapse point, the value of Lij will be unity. Based on voltage stability indices, voltage collapse can be accurately being predicted. The lines having high value of the index can be predicted as the critical lines, which contribute to voltage collapse. At or near the collapse point,voltage stability index of one or more line approach to unity. This method is used to assess the voltage stability. Line voltage stability index is used to calculate the proximity of the operating point to voltage collapse point by the L- Index pointed by

Voltage Stability Analysis (VSA) is performed to predict the point of voltage collapse using the proposed Lij. It is performed on an IEEE 14–bus system. Initially, a load flow program was developed to obtain the power flow solution. The results are used to calculate the Lij for each line in the system. The load flow analysis is performed from base case to convergence. All load buses in the system are consecutively tested in order to determine the overall system performance accurately. Results from this experiment indicate the point of voltage stability, weak bus and critical lines in the system. The critical line refers to a particular bus and is determined by the Lij value close to 1.00. Lij was computed for each line in the system for every line. Results for voltage stability analysis aiming to determine the voltage stability condition, weak bus and load ranking in the system. VSA was conducted on the system by evaluating Lij for each line.

4. IMPLEMENTATION OF SVC ON IEEE 14-BUS POWER SYSTEM

In this paper, SVC is modelled as fixed shunt capacitor. & connected to most sensitive bus (Here bus No. 14) in a 14-bus system.

In this case, the SVC is connected to bus no.14 & load is changed to 10% & 20% of its original value

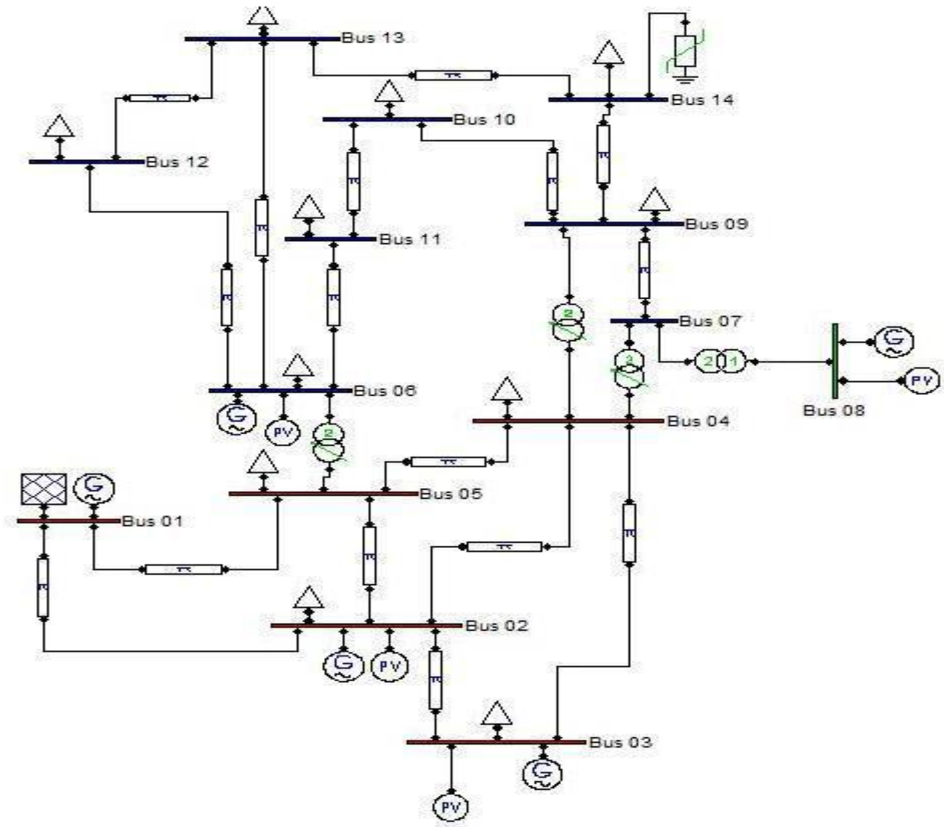

Fig.3.- Modelling of IEEE 14-bus Power System with SVC on bus 14th bus

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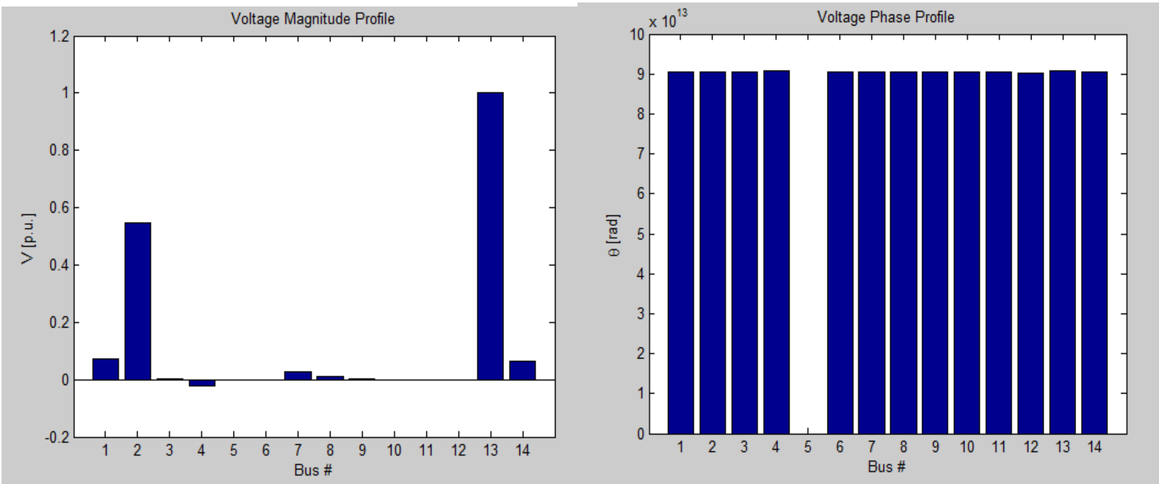

Fig.4. – Voltage Profile & Voltage phase profile without SVC

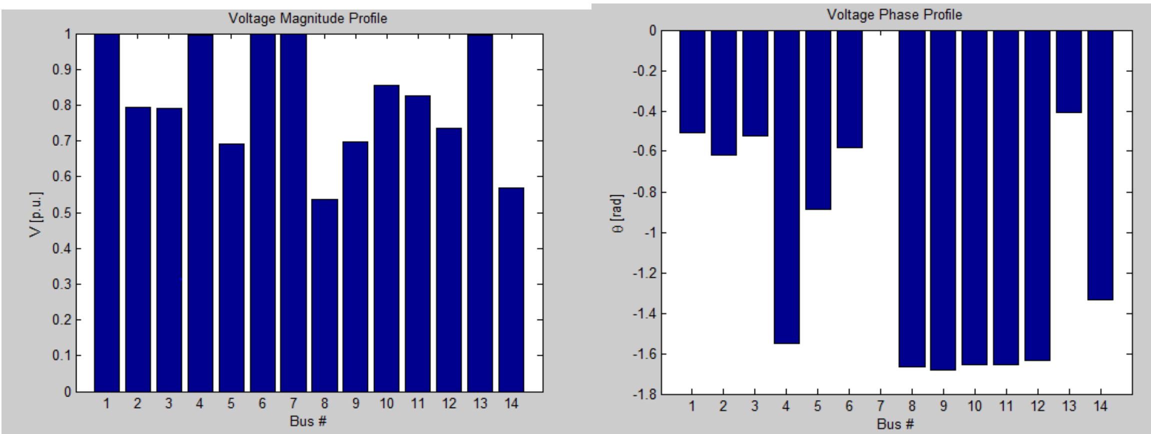

Fig.5. – Voltage Profile & Voltage phase profile with SVC

5. RESULTS AND DISCUSSION

Table 1: Result without SVC

Bus No.	Voltage (p.u.)	Phase (rad)	P. Gen (p.u.)	Q. Gen (p.u.)	P. load (p.u.)	Q. load (p.u.)
1.	1	1	9.8063	4.2768	0	0
2.	1	-0.47141	0.81945	7.171	0.81945	0.61459
3.	1	-0.62136	0	3.1475	0.81945	0.61459
4.	0.15571	-0.67533	0	0	0.81945	0.61459
5.	0.53328	-0.55797	0	0	0.81945	0.61459
6.	1	-1.5979	0	10.682	0.81945	0.61459
7.	0.41155	-0.94161	0	0	0	0
8.	1	-0.72485	0	1.5781	0	0
9.	0.0001	-1.3085	0	0	0.81945	0.61459
10.	-16.8355	-1.6166	0	0	0.81945	0.61459
11.	0	-1.6716	0	0	0.81945	0.61459
12.	0.50003	-1.682	0	0	0.81945	0.61459
13.	-1e-005	-1.6714	0	0	0.81945	0.61459
14.	-0.08659	-1.6141	0	0	0.81945	0.61459

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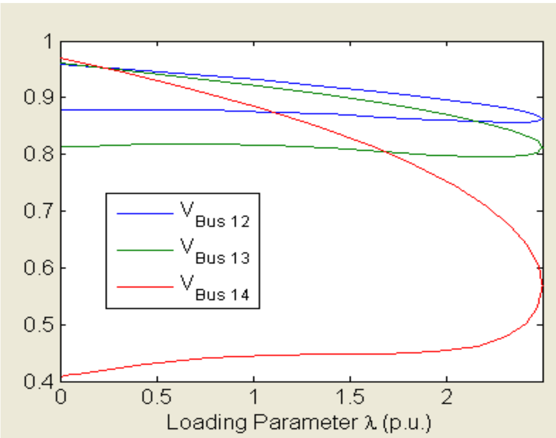
Table 2: Result of Changes in Integrated System with SVC

Bus No.	Voltage (p.u.)	Phase (rad)	P. Gen (p.u.)	Q. Gen (p.u.)	P. load (p.u.)	Q. load (p.u.)
1.	0.99752	0	8.2246	3.1249	0	0
2.	0.99633	-0.40954	1.1159	5.8731	1.0337	0.77526
3.	0.99839	-0.50921	1.1159	2.9147	1.0337	0.77526
4.	0.79483	-0.61754	0	0	1.0337	0.77526
5.	0.7917	-0.52446	0	0	1.0337	0.77526
6.	0.99488	-1.5483	1.1158	9.6964	1.0337	0.77526
7.	0.69285	-0.88544	0	0	0	0
8.	0.99891	-0.58191	1.1159	1. 631	0	0
9.	0.569	-1.3341	0	0	1.0337	0.77526
10.	0.53585	-1.6683	0	0	1.0337	0.77526
11.	0.69815	-1.6885	0	0	1.0337	0.77526
12.	0. 85543	-1.6577	0	0	1.0337	0.77526
13.	0.82457	-1.6539	0	0	1.0337	0.77526
14.	0.73551	-1.6344	0	0	1.0337	-0.86094

From the continuation power flow results as in the Fig. 7 shows PV curves for 14-bus test system without shunt compensation devices. The system presents a collapse or Maximum Loading Point, where the system Jacobian matrix become singular at λmax = 2.82 p.u. Based on largest entries in the right and left eigenvectors associated to the zero eigenvalue at the collapse point, bus 14 is indicated as the "critical voltage bus" needing Q support.



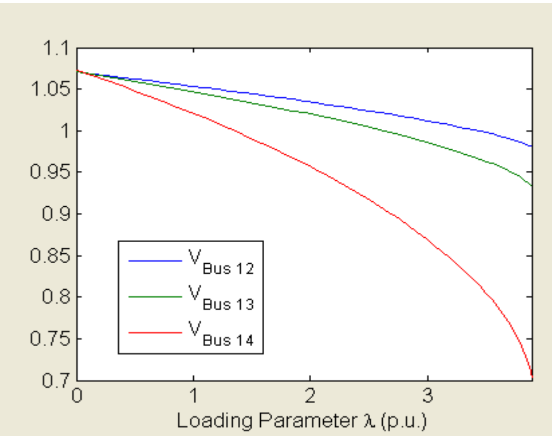


Fig 6: PV curves without compensation device **Fig 7: PV curves with SVC**

In order to get a rough estimate of reactive power support needed at the weakest bus and corresponding loading margin for a given load and generation direction, a static synchronous compensator with no limit on reactive power was used at the weakest bus. Based on collapse analysis bus 14 is targeted as the first location for SVC.

Table 3: L-indices

Bus no.	L-index Without SVC	L-index With SVC
2	0.591	0.315
3	0.462	0.327
4	0.65	0.453
11	0.81	0.292
12	0.76	0.51
13	0.56	0.32
14	0.25	0.172

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By SVC in order to improve the voltage profile as shown in Table 3. The L-index of each load bus was performed with and without SVC as shown in Table 3.

6. CONCLUSIONS

In this paper, The Modal analysis technique is applied to investigate the stability of the power systems and that method computes the smallest eigenvalue and the associated eigenvectors of the reduced Jacobian matrix using the steady state system model. The magnitude of the smallest eigenvalue gives us a measure of how close the system is to the voltage collapse. Then, the participating factor can be used to identify the weakest node or bus in the system associated to the minimum eigenvalue. The obtained results agreed about the weakest buses that contribute to voltage instability or voltage collapse. SVC is used as the compensator so as to improve the voltage profile after the prediction of the voltage collapse. PV curves are plotted for the bus more sensitive to voltage collapse both before and after compensation and the improvement is verified using PSAT and the result shows that the maximum loading point improves with SVC thereby the system stability is enhanced.

REFERENCES

[1] CIGRB. workine group 38-01, Task Force No. 2 on SVC" Static VAR Compensators.". I. A. Enrimez. EL. 1986.

[2] Dharamjit, D.K. Tanti " Load Flow Analysis on IEEE 30 bus System" International Journal of Scientific and Research Publications, Volume 2, Issue 11, November 2012 1 ISSN 2250-3153.

[3] Bindeshwar Singh, N. K. Sharma and A. N. Tiwari, and S.P. Singh "Incorporation of FACTS Controllers in Newton-Raphson Load Flow for Power Flow Operation, Control and Planning: A Comprehensive Survey" Bindeshwar Singh et. al. / (IJCSE) International Journal on Computer Science and Engineering Vol. 02, No. 06, 2010, 2117-2124.

[4] N. Mithulananthan, M. M. A. Salama, C. A. Can˜izares and J. Reeve "Distribution system voltage regulation and var compensation for different static load models" International Journal of Electrical Engineering Education 37/4.

[5] Abdel-Moamen "Newton-Raphson TCSC Model for Power Flow Solution with Different Types of Load Models" 14th International Middle East Power Systems Conference (MEPCON'10), Cairo University, Egypt, December 19-21, 2010, Paper ID 250.