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SVC & UPFC for Voltage Stability Enhancement of TNEB Sixty Nine Bus System

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Abstract : Power systems of Tamil Nadu Electricity Board in recent years undergo many issues which includes, voltage instability and voltage collapse caused due to the result of reactive power demand. In Tamil Nadu, the prevention of voltage collapse and improvement of system stability is provided by shunt capacitor banks. In this paper, the voltage stability of TNEB sixty nine-bus utility system is found using PSAT. The severity ranking is made for each bus and weak bus of the system is identified using Eigen value analysis and QV sensitivity analysis. The weakest bus of the system is provided with SVC & UPFC which is the effective place for the location of such compensation device and hence stability is found to be enhanced.

Keywords : Sixty nine-bus TNEB system, PSAT, severity ranking, Eigen value analysis, SVC, UPFC.

1. INTRODUCTION

Power system stability is classified into rotor angle stability, frequency stability and voltage stability [2]. Increase in load demand and increased transfer of power between utilities have emerged for the concern regarding system voltage stability analysis. In restructured system era open access and increased system loading causes the power system vulnerable to voltage instability condition & causes several major disturbance. Complexity of the power system leads to its operation, very closer to its stability limits.

Voltage collapse is resulted due to the continuous failure of system components & instability. This is due to the inadequate supply of reactive power, peak load on transmission line, low source voltages, enlarged distance between voltage source and load centers. If the MLP (Maximum Load Point) (or) voltage collapse point is reached, the losses of reactive power will increase.

Voltage stability is defined as power system ability to maintain steady state voltage even after subjected to small or large disturbances. To prevent voltage instability and collapse, analysis of voltage stability is indeed important. The methods available for the analysis of voltage stability include static and dynamic type. The instability condition is presently focused by many researchers, in order to provide results for prevention of weak bus which cause instability. In weak bus of the system, the reactive power is limited & it causes decrease in voltage profile. Hence, before reaching weak bus point, the system can be saved from voltage collapse by implementation of SVC & UPFC.

2. NEED FOR SVC & UPFC

Conventional reactive power control can be used to provide steady state voltage control and enhance power system voltage stability. These devices, however, are based on electro-mechanical mechanisms thus preventing high speed and flexible control. Moreover, extensive use of these devices may cause some of the voltage control problems [2].

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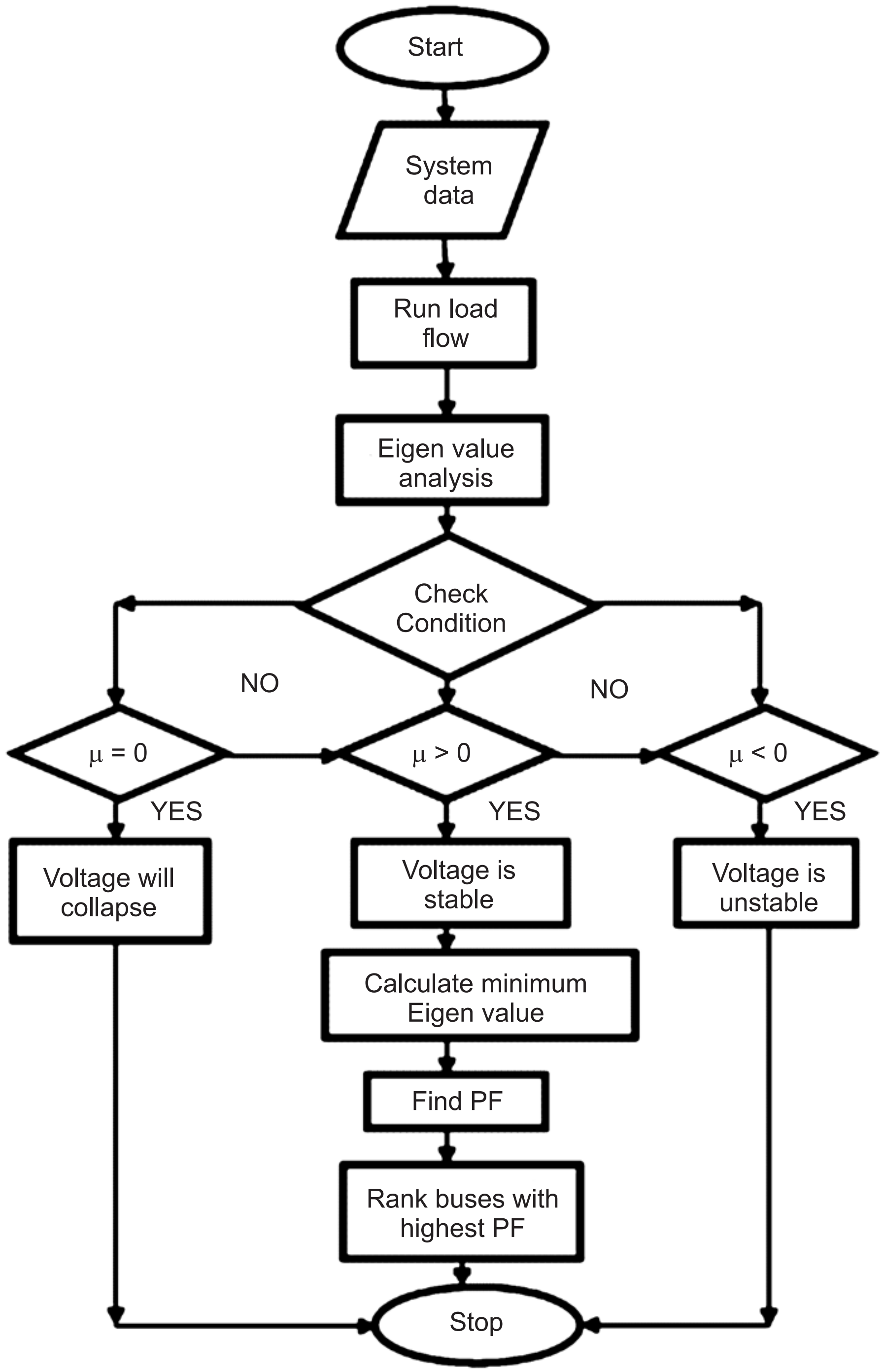

Figure 1: Procedure for Eigen value analysis

Static Var Compensator (SVC) & Unified Power Flow Controller (UPFC) is used in order to minimize voltage instability problems. Application of such compensation device is a effective solution for voltage instability and voltage collapse problems. Usually, FACTS devices will be placed in normal operating condition of system. The optimal usage of that device can be obtained by placing them under weak bus condition. This paper investigates the application of shunt FACTS controllers to improve the voltage stability of power system using MATLAB (PSAT).

3. PSAT (POWER SYSTEM ANALYSIS TOOLBOX)

PSAT is a toolbox for analysis and control of electric power systems. PSAT includes power flow, OPF, small signal stability analysis, Eigen value analysis & QV sensitivity analysis. Graphical user interfaces

(GUIs) and a Simulink based library is provided for user friendly tool for system design[6]. After power flow has been completed, further voltage stability can be analyzed.

4. FACTS DEVICE IN TAMILNADU

TCSC with fixed series compensation at 400 KV transmission line was the first FACTS device to be installed in India, between Kanpur (Uttar Pradesh) and Ballabgarh (Haryana) in northern grid. This was followed by the installation of FSC-TCSC at Kalpakkam – khammam 400KV DC 364 km line in Andhra Pradesh & Ranchi-Sipat 400KV DC 376 km transmission line.

In Tamil Nadu,Theni&Kodikuruchi, 220 KV substation was proposed with the STATCOM project of 57.75*2 crore estimation followed by Udumalpet,400KV system was proposed with the SVC project of 211.75 crore estimation.

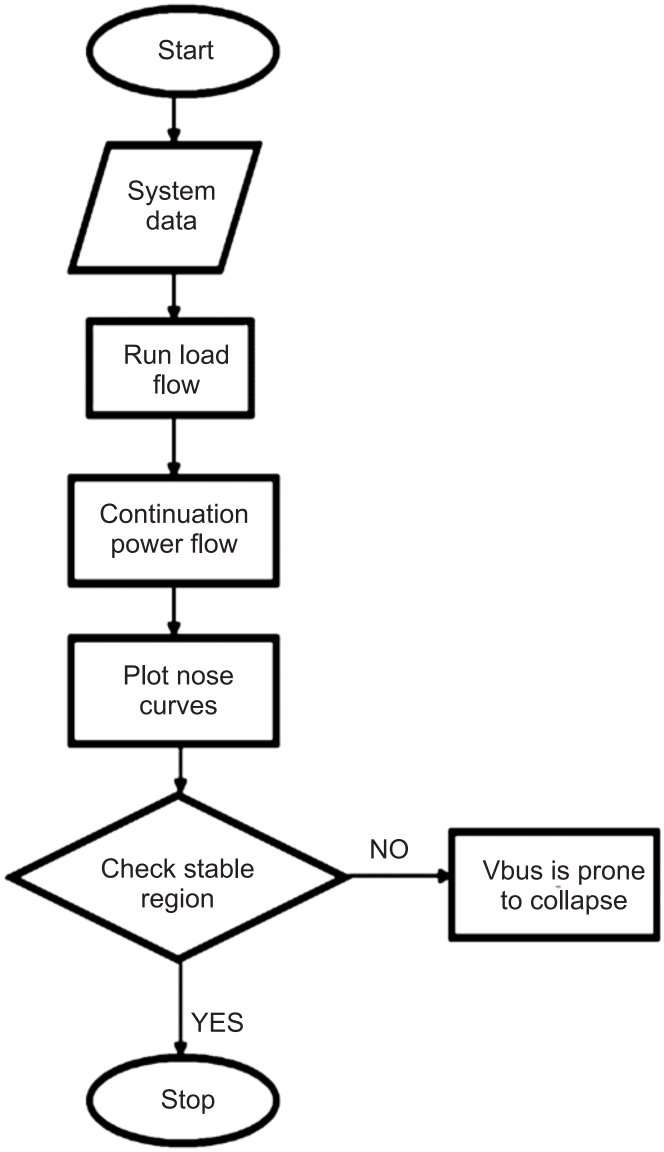

Figure 2: Procedure for CPF analysis

5. EIGEN VALUE ANALYSIS

This can predict voltage collapse in large system networks, which computes the minimum Eigen values of the reduced Jacobian matrix. The values are associated with voltage and reactive power variation, followed by the participation factor, which is used effectively to predict the weakest buses in the system. The highest value of the bus PF indicates the more affecting bus to the system.

6. TNEB 69 BUS SYSTEM

69-bus TNEB system consists of 13 generators, 99 transmission line with 55 loads. Voltage stability analysis is made using PSAT. Power flow is done using Newton Raphson method. The Eigen value analysis for 69-bus system with minimum Eigen values is shown in the figure 3.It is found to be 16.09039.Among various methods of load flow analysis, which is also called as power flow study ,is mainly used for the analysis of power system under normal steady state operating condition. It includes Gauss Seidel method, Newton Raphson method and fast decoupled method.

First method is slow in convergence. Next two methods are applicable for power flow. Fast decoupled method is suitable only for power system with transmission lines having high X/R ratio. Therefore, Newton Raphson method is commonly used for load flow analysis.

If the reactive power decreases voltage will decrease. As the voltage decreases current value increases to maintain power supplied, thereby causing the power system to extract more reactive power & voltage reduces further. If the current value increases too high, transmission lines go off line, overloading other lines & potentially it results in cascading failure. Various methods of static method can be applied for the identification of weak or vulnerable voltage bus of the power system involved.

Power flow analysis is followed by Eigen value analysis of TNEB system.The condition for Eigen values indicates that if the Eigen value $\mu = 0$: voltage will collapse, $\mu > 0$: voltage is stable and $\mu < 0$: voltage is instable. The Eigen value analysis of 69-bus system indicates that all the Eigen values are positive ,that is, $\mu > 0$. Participation factor is calculated for corresponding Eigen value.

The highest value of participation factor indicates the weakest bus of the system. Ranking of buses is made and the bus corresponding to highest participation factor indicates the weakest bus of the system.

The lowest Eigen value ranking of buses is made as shown in figure and the bus corresponding to highest participation factor is found to be the bus 69. Hence bus 69 is identified as weakest bus and is more prone to voltage instability and voltage collapse. This place is considered for the location of FACTS device.

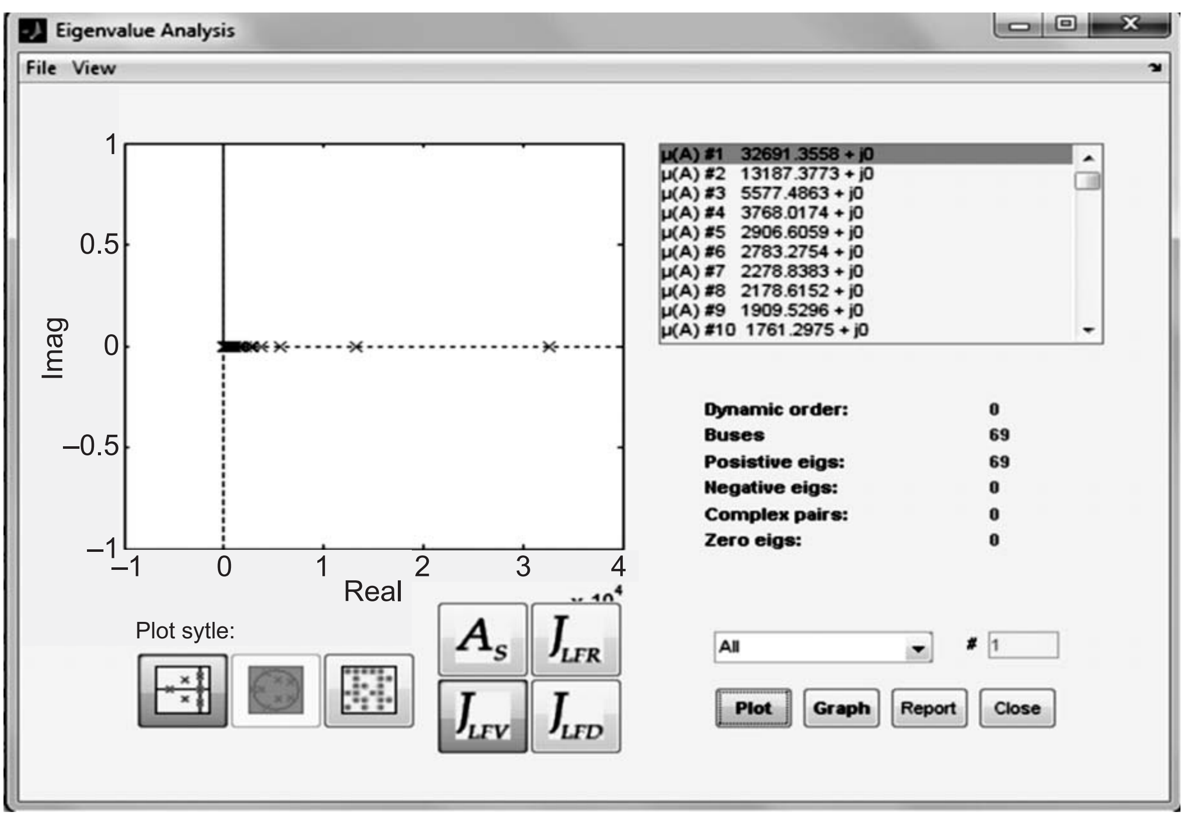

Figure 3: PSAT window showing Eigen values

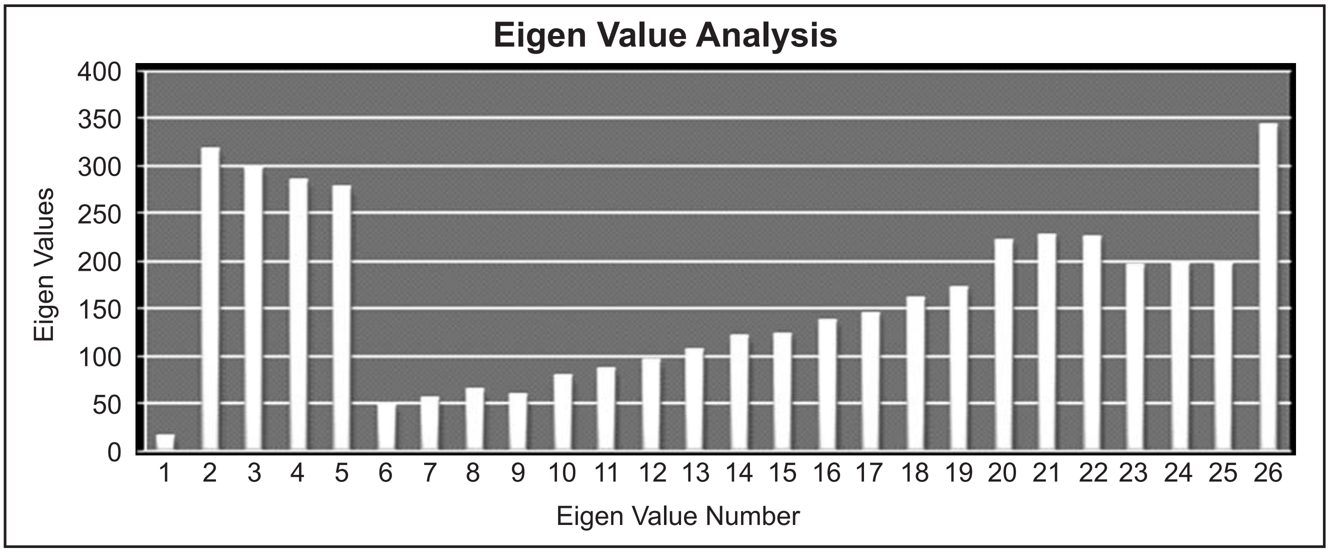

Figure 4: Minimum Eigen values

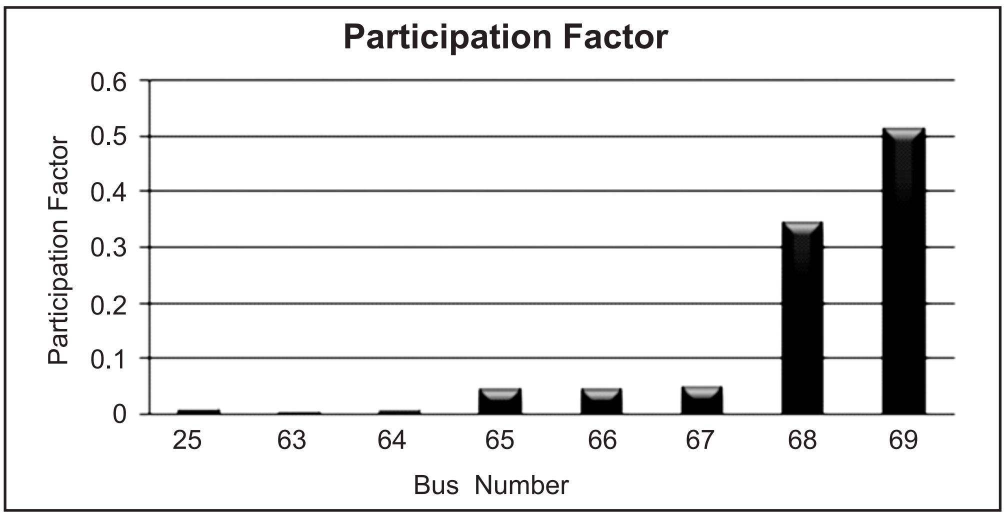

Figure 5: Ranking of participation factor

7. INSTALLATION OF SVC & UPFC

UPFC provides greater flexibility, response is faster and better performance when compared with SVC and other FACTS devices. The stability is more with UPFC than the case when the SVC is inserted in the system. UPFC is placed in bus number 68& 69 for the prevention of voltage collapse and voltage instability.

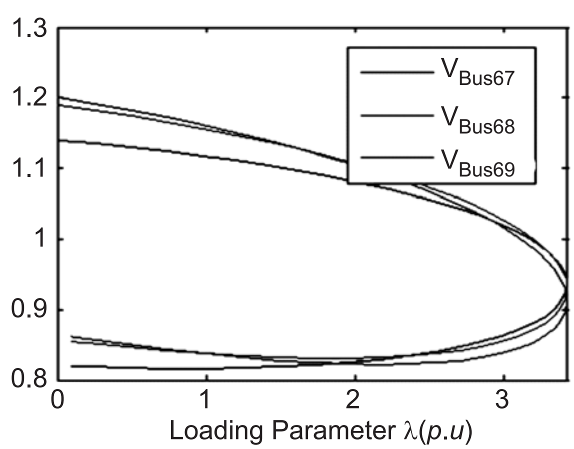

Figure 6: PV curves without SVC & UPFC

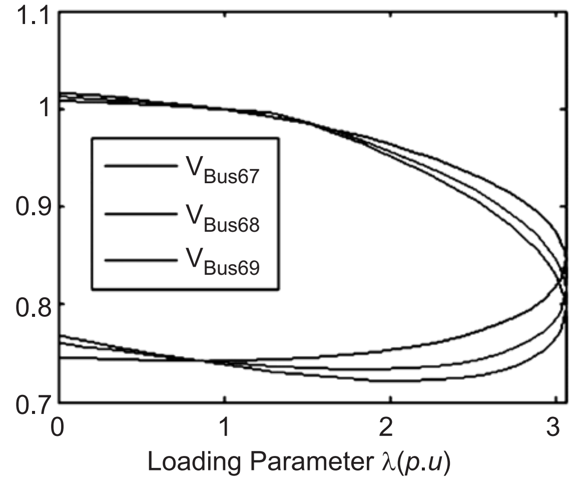

Figure 7: PV curves with SVC

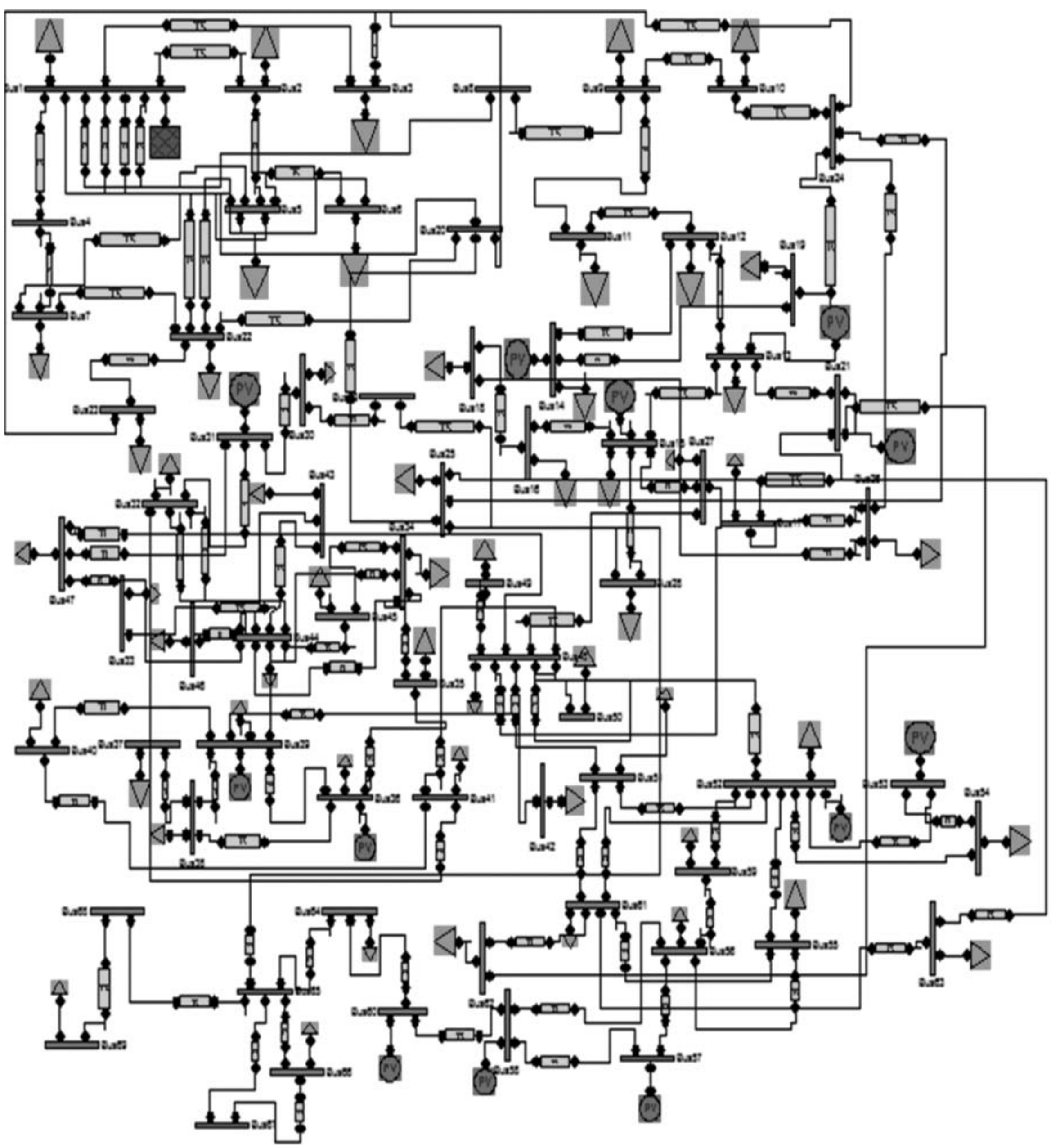

Figure 8: PSAT simulink diagram of TNEB 69 bus system

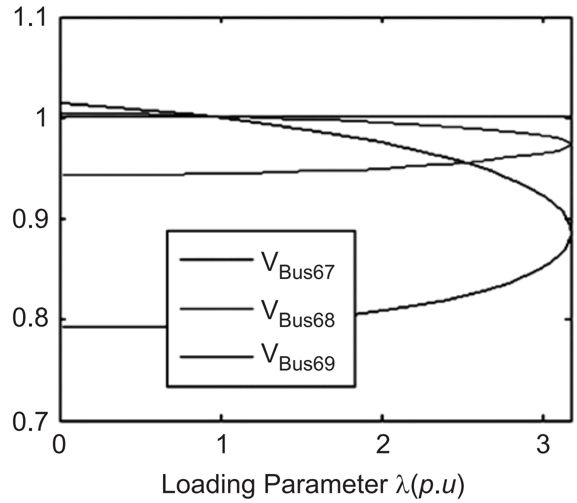

Figure 9: PV curves with UPFC

8. CONCLUSION

In this paper, TNEB 69-bus system is investigated for the voltage stability and the minimum Eigen value of reduced Jacobian matrix is computed using the steady state system model. This shows the closeness of the system is to the voltage collapse. Further, the participating factor is calculated and the weak buses in the system associated to the minimum Eigen value is 68 & 69. The obtained results show the weak buses that contribute to voltage instability or voltage collapse. SVC is placed at bus 69 so as to improve the voltage profile.

Similarly UPFC is placed between the buses 68 &69 , hence PV curves/nose curves are plotted for the bus more sensitive to voltage collapse before & after compensation and hence the system stability is found to be enhanced.

9. REFERENCES

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