ENHANCEMENT OF VOLTAGE STABILITY IN 62-BUS SYSTEM USING FACTS DEVICE

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ABSTRACT: **Recent years, power systems undergo many problem among which voltage instability and voltage collapse are considered to be the major one. The main cause for these issues is the reactive power demand. The remedy for prevention and improvement of system voltage stability is provided by the implementation of FACTS device. In this paper, the voltage stability of Indian practical 62-bus utility system is analyzed using static methods of voltage stability analysis. The voltage bus ranking is made based on the participation factor of each bus and weak bus of the system is identified using MATLAB (PSAT).The weakest bus of the system is considered as the effective place for the location of FACTS device.**

Key words: **static methods, 62 bus utility system, voltage instability, MATLAB (PSAT).**

INTRODUCTION

Voltage stability is becoming a limiting factor in planning and operation of many power systems [1]. As the number of user increases, the load demand also increases linearly. Hence, concern for stability limits the transfer capability of the system, there is a need to ensure stability and reliability of the power system due to economic reasons. Different types of power system stability have been classified into rotor angle stability, frequency stability and voltage stability [2]. 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 (Kundur, 1994; and Yorino *et al.*, 2003). Voltage collapses are mostly initiated by a disturbance & problem has been one of the major problems facing the electric power utilities in many countries. In the initial stage the decrease of the system voltage starts gradually and then decreases rapidly.

NEED FOR FACTS DEVICE

Flexible Alternative Current Transmission System (FACTS) devices are used in order to minimize voltage instability problems. The application of FACTS devices is a very effective solution to prevent voltage

instability and voltage collapse due to their fast and very flexible control. This paper investigates the application of shunt FACTS controllers to improve the voltage stability of power system using MATLAB (PSAT).

VOLTAGE STABILITY ANALYSIS

Analysis methods of voltage stability problems are classified into two classes, static & dynamic analysis. Static voltage stability analysis method includes,

- Eigen value analysis/modal analysis.
- PV, QV curves.
- Continuation power flow analysis.
- Sensitivity analysis.
- Singular value decomposition, etc.

The P-V curves are the most widely used method of predicting voltage security. Disadvantage of using the minimum singular value index is the large amount of CPU time required in performing singular value decomposition for a large matrix.

Modal analysis can predict voltage collapse in complex power system networks. It involves mainly the computing of the smallest eigen values and associated eigenvectors of the reduced Jacobian matrix obtained from the load flow solution.

The common principle behind the continuation power flow is simple and easy. It employs a predictor-corrector scheme to find a solution path. It adopts locally parameterized continuation technique. It includes state variable load parameter, and step length for load parameter.

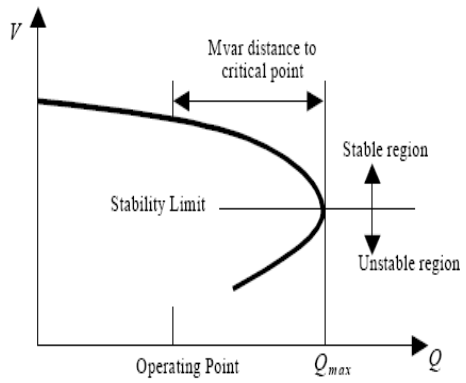


FIGURE 1:QV-CURVE

MODAL ANALYSIS

Modal analysis can predict voltage collapse in complex power system networks. It involves mainly the computing of the smallest eigenvalues and associated eigenvectors of the reduced Jacobian matrix obtained from the load flow solution. The eigenvalues are associated with a mode of voltage and reactive power variation, which can provide a relative measure of proximity to voltage instability. Then, the participation factor can be used effectively to find out the weakest nodes or buses in the system.

Modal analysis for voltage stability prediction can be done as follow:

1. Initiate the normal operating condition using the load flow analysis.
2. Perform the modal analysis to get the minimum eigenvalue.
3. Find the weakest bus in the power system.
4. Repeat the step 2 and 3 to do the real time monitoring.

BUS PARTICIPATION

Left and right eigenvectors corresponding to the critical modes in the system can provide information concerning the mechanism of voltage instability. Bus participation factors show the voltage stability of nodes in the power system. Bus participation factors show in a matrix form called participation matrix. The row of the matrix indicates the bus number and the matrix column indicate the system mode. The bigger value of the bus participation factor indicates the more affecting bus to the power system.

ABOUT PSAT

PSAT is a Matlab toolbox for the electric system analysis and control. PSAT includes power flow, optimal power flow, continuation power flow, and small signal stability analysis and time domain simulation. All operations can be evaluated by mean of graphical user interfaces (GUI) and Simulink- based library provides an user friendly tool for network design. PSAT contains the power flow routine, which also takes care of states variable initialization. Once the power flow has been completed, further static and (/or) dynamic analysis can be executed. These routines are:

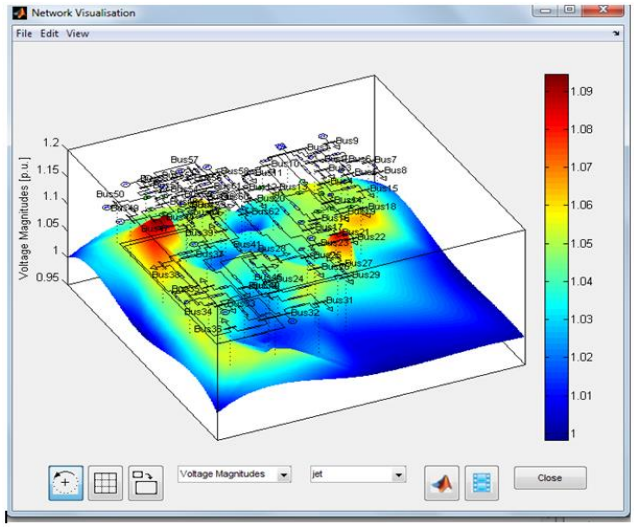
1. Continuation power flow;
2. Optimal power flow;
3. Small signal stability analysis;
4. Time domain simulations;
5. Phasor measurement unit (PMU) placement.

In the proposed solution we are experimenting with 62 bus system.

INDIAN UTILITY - 62 BUS SYSTEM

It consists of 19 generators, 89 (220 kv) transmission lines with 11 tap changing transformers. The total load demand is 2909 MW. The one line diagram of the system is shown in Figure 2.

Fig 3.voltage magnitudes of 62 bus syst



The power flow is run using newton raphson method. Eigen value analysis is made and minimum eigen value is calculated as shown in the figure 4.

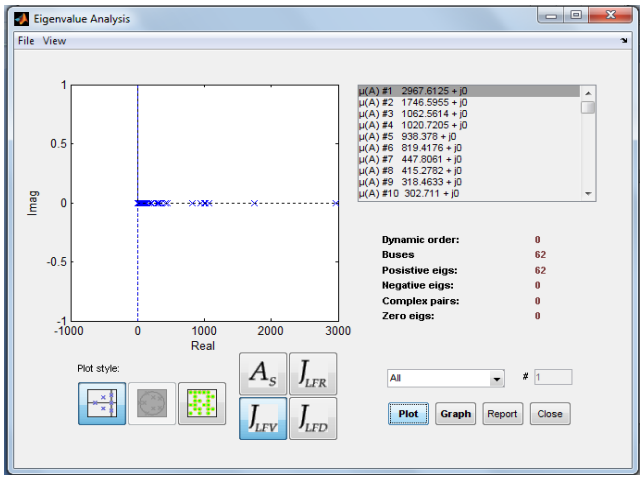
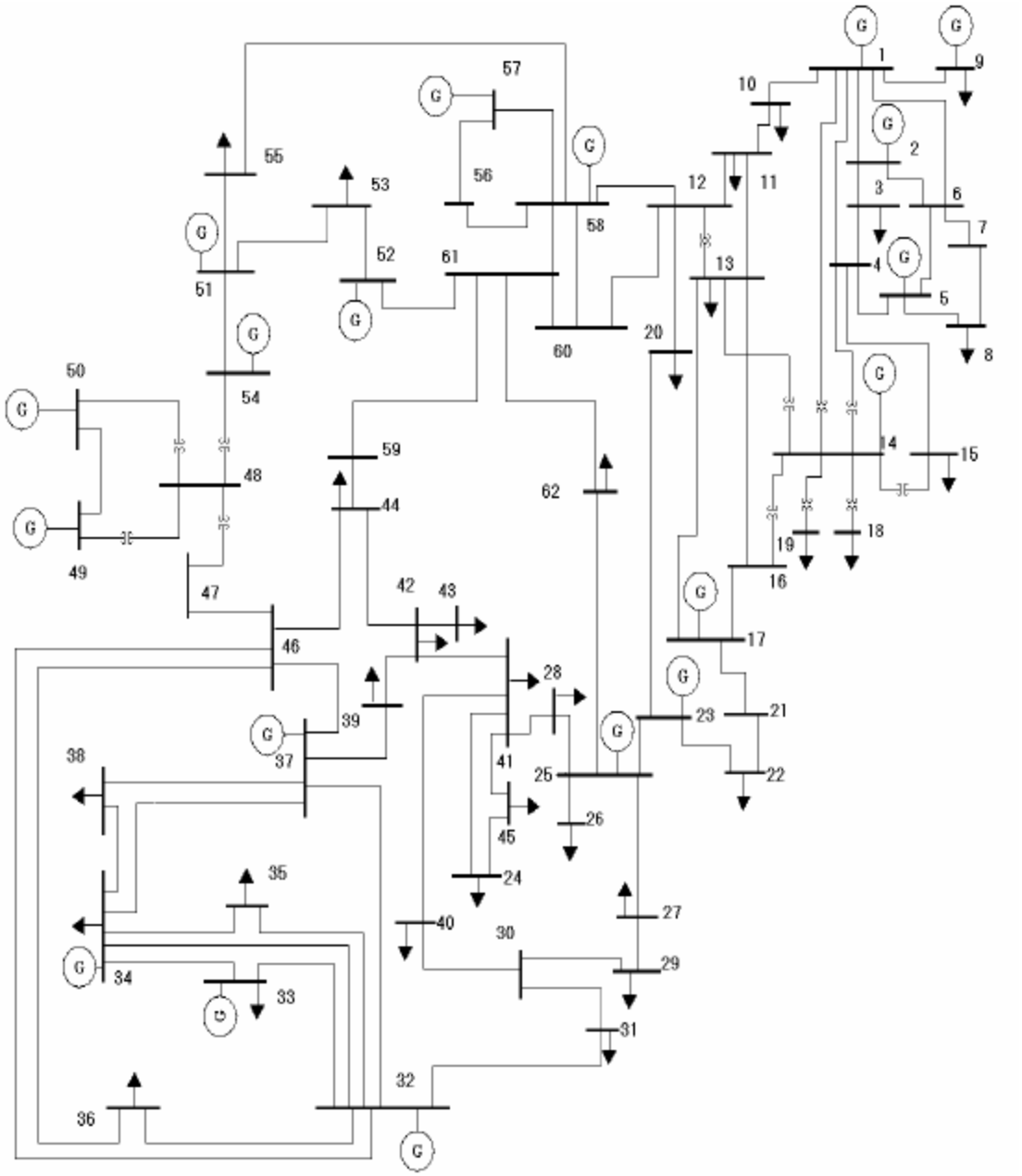


Figure 2: SINGLE LINE DIAGRAM OF INDIAN 62-BUS UTILITY SYSTEM



RESULTS AND DISCUSSION

The eigenvalue of the reduced Jacobian matrix identify different modes through which the voltage of system could become unstable.

The magnitude of the eigenvalues provides a relative measure of the proximity to instability. If $\mu i > 0$, the *i*th modal voltage and *i*th modal reactive power variation are along with the same direction, indicating that the system is voltage stable. If $\mu i < 0$, the *i*th modal voltage and *i*th modal reactive power variation are along with the opposite direction, indicating that the system is voltage unstable. In this sense, the magnitude of μi determines the degree of stability of the *i*th modal voltage. In Indian utility 62 bus system, 11bus buses have minimum eigen values below 50 as shown in the figure 5.The minimum value among 11 values is 7.8788.Participation factor is calculated for this corresponding eigen value.

The highest value of participation factor indicates the weakest bus of the system. Ranking of buses is made as shown in figure 6 and the bus corresponding to highest participation factor is found to be the bus 46.

Figure 5: minimum eigen values

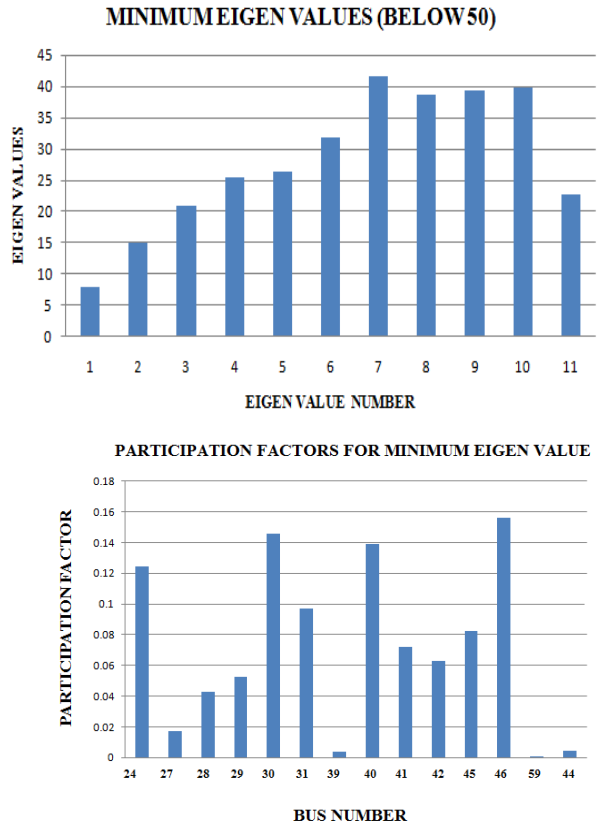


Figure 6: participation factors

INSTALLATION OF STATCOM:

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).

Shunt type controller is of two types: STATCOM & SVC. Reasons for preferring STATCOM are:

1. Greater flexibility.
2. Faster response.
3. Superior function characteristics.
4. Betterperformance.

STATCOM

STATCOM is the "Static Synchronous Controller". It is defined as "A static synchronous generator operated as a shunt connected static VAR controller whose capacitive or inductive output current can be controlled independent of the ac system voltage". It is the important type of controller because it can work as voltage source converter and also as current source converter. It can also be used as active filter for reducing or absorbing the harmonics. Layout of STATCOM is as shown in figure 7.

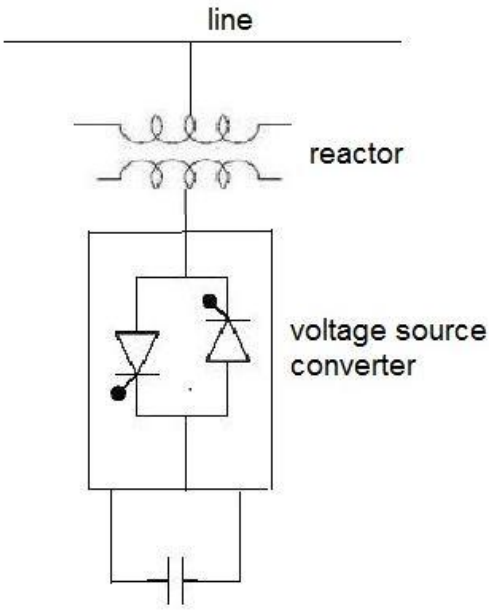
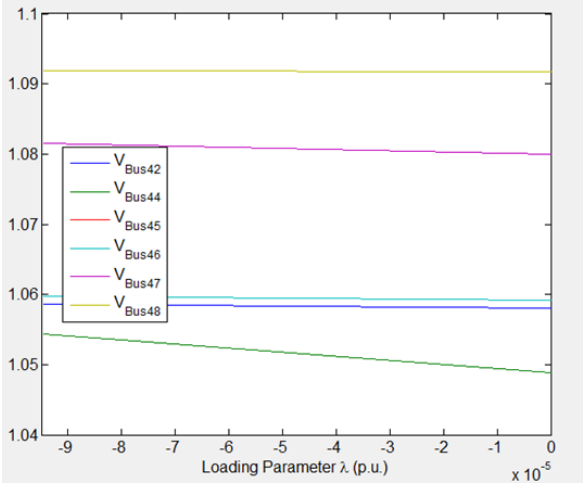


Figure 7: STATCOM layout

STATCOM is placed in bus number 46 for the prevention of voltage collapse and voltage instability. Improved PV curves after placing STATCOM is shown in figure 8.

Figure 8:PV curves after installation of STATCOM



CONCLUSIONS

In this paper, The Modal analysis technique is applied to 62 bus system. This investigate the stability of the power systems and computes the smallest eigenvalue of reduced Jacobian matrix using the steady state system model. The magnitude of the smallest eigenvalue gives shows how close the system is to the voltage collapse. Then, the participating factor identifies 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. STATCOM 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 after compensation and the improvement is verified using PSAT and the result shows

that the maximum loading point improves with STATCOM thereby the system stability is enhanced.

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