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Dynamic Voltage Stability Improvement by Static Var Compensator

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Abstract* —Modern Power system is highly interconnected comprise of large number of different dynamic devices such as synchronous machines and loads. The power system is a highly nonlinear system that operates in a continuously changing environment; loads, generator outputs, and key operating parameters change continually. Power system is subjected to small and large disturbances due to change in load, change in transmission and distribution pattern, or due to fault on the system and low frequency trouble that cause loss of synchronism & eventual breakdown of whole system. The system and studying the results have given an indication that SVC are very useful when it comes to organize and maintain power system. SVC is the dynamic simulation system where it can adjust the distribution the system power flow among the transmission line quickly and smoothly, and there is no significant impact to other operating parameters of the system. At the same time, SVC can improve voltage stability, to keep down the instability and line oscillation problem

***Keywords-* Voltage Stability, SVC, FACTS**

I. INTRODUCTION

All In Large interconnected Power System, Low frequency oscillations are a common problem. For secure and stable operation of power system damping of oscillations is necessary. The High gain of AVR, Weak tie lines, small disturbances such as small changes in load or generation is causes of low frequency oscillations. These oscillations limit the power transfer of the transmission lines, may cause loss of synchronism and sometimes eventual break down of the power system. SVC devices are an effective means of damping these oscillations. SVC devices provides an additional control signal to the excitation system to damp oscillations. Facts devices simulation done on single machine to infinite bus and Multi machine system which are quite robust under different loading conditions In a power system, all components will be operating in parallel. Due to some fault or other equipped condition change, if one component derails from synchronism then it will involve the other components and thereby affecting the entire network. If we consider five generators operating in parallel and due to a fault if any one generator losses synchronism, certainly it will affect the other generators. Due to this, the whole system will undergo a drastic change. So, the faulty generator must be switched out immediately. If the faulty generator is not switched out immediately, then it will affect the voltage profile of the system. There will be large fluctuations in voltage and the consumer cannot operate his equipments more satisfactorily. Electrical power system is incomplete without the study of power system stability .

II. PROBLEM SUMMARY

In large interconnected power system instability of oscillations is a common problem. Power system is subjected to small and large disturbances due to change in load, change in transmission and distribution configuration or due to fault on the system. Weak tie line, small disturbances such as small changes in load or generation is cause of oscillations and due to this loss of synchronism and sometimes eventual break down of the power system.Maintaining the Integrity of the Specifications

III. BASIC CONCEPT AND DEFINATION

The ability to maintain stable operation in the presence of small disturbances is referred to in the power systems field as dynamic stability. Power system stability may be generally defined as that property of a power system that enables it to remain in a state of operating balance under normal operating conditions and to regain an acceptable state of balance after being subjected to a disturbance.

Dynamic stability, on the other hand, denotes artificial stability given to an inherently unstable system by automatic control devices. Dynamic stability is concerned with small disturbances lasting for times of the order of 10 to 30 seconds with the inclusion of automatic control devices.

A power system is continually subjected to changes in its load and operating conditions and it is essential that the system has the ability to maintain stable operation when subjected to disturbances power system is very complex and its dynamic stability characteristics are influenced by the complex interaction of its generating stations, transmission and distribution networks, its operating levels and loads. Before any understanding of the complexities of power system dynamic stability is possible, an appreciation of the fundamental dynamic characteristics of basic system components and the factors that influence them and their contributions to overall stability characteristics are essential. The purpose of this report is to very briefly look at the dynamic characteristics of generators, their prime movers and controls and highlight the way that their contributions to system dynamic stability are influenced by the operating conditions and system interconnections. Power system stability may be divided into two main categories depending upon the magnitude of the disturbances.teady state stability refers to the ability of the power system to regain synchronism after small and slow disturbance, such as gradual power changes. Transient stability is the ability of the system to regain synchronism after a large disturbance. The large disturbance can occur due to sudden changes in application or removal of large loads, line switching operations, faults on the system, sudden outage of a line, or loss of excitation. Transient stability studies are needed to ensure that the system can withstand the transient conditions following a major disturbance. Frequently, such studies are conducted when new generating and transmitting facilities are planned. Steady state stability is subdivided into static stability and dynamic stability. Static stability refers to inherent stability that prevails without the aid of automatic devices such as governors and voltage regulators.

IV. CLASSIFICATION OF POWER SYSTEM STABILITY

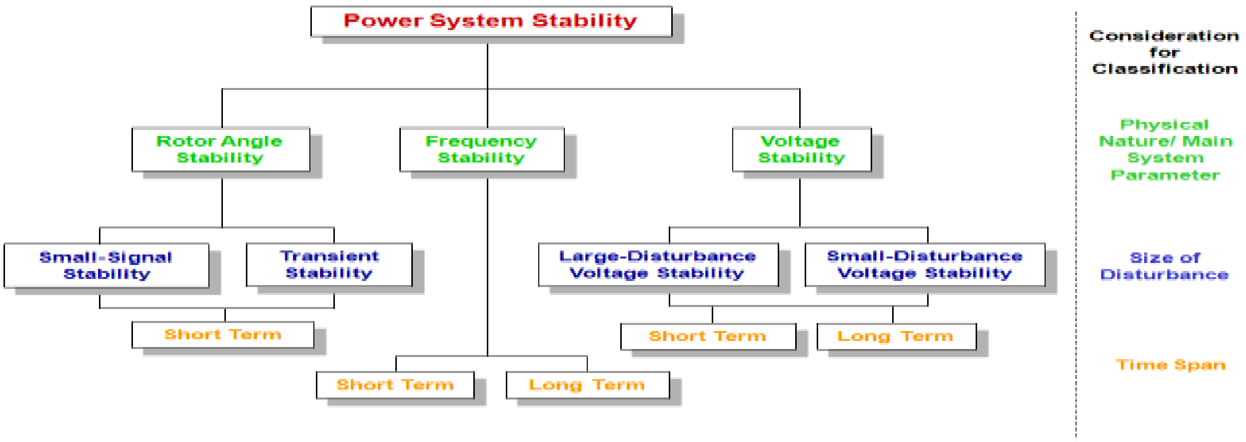

Fig.1 Classification of Power System Stability[1]

1..ROTOR ANGLE STABILITY

This refers to the ability of the synchronous generator in an interconnected power system to remain in synchronism after being subjected to disturbances. It depends on the ability of the machine to maintain equilibrium between electromagnetic torque and mechanical torque of each synchronous machine in the system. Instability of this kind occurs in the form of swings of the generator rotor which leads to loss of synchronism. [2]

2. FREQUENCY STABILITY

It refers to the ability of a power system to maintain steady frequency following a severe disturbance between generation and load. It depends on the ability to restore equilibrium between system generation and load, with minimum loss of load. Frequency instability may lead to sustained frequency swings leading to tripping of generating units or loads

During frequency excursions, the characteristic times of the processes and devices that are activated will range from fraction of seconds like under frequency control to several minutes, corresponding to the Response of devices such as prime mover and hence frequency stability may be a short-term phenomenon or a long-term phenomenon[4]. Though, stability is classified into rotor angle, voltage and frequency stability they need not be independent isolated events. A voltage collapse at a bus can lead to large excursions in rotor angle and frequency. Similarly, large frequency deviations can lead to large changes in voltage magnitude.

3.VOLTAGE STABILITY

It is the ability of the system to maintain steady state voltages at all the system buses when subjected to a disturbance. If the disturbance is large then it is called as large-disturbance voltage stability and if the disturbance is small it is called as small-disturbance voltage stability.

3.1.VOLTAGE STABILITY CLASSIFIED

- Large disturbance voltage stability
- Small Disturbance Voltage stability
- Sort term voltage stability

- Long term voltage stability

4. DIFFERENT FACTS DEVICES USED FOR COMPENSATION OF DYNAMICS VOLTAGE INSTABILITY

A flexible alternating current transmission system (FACTS) is system composed of static equipment used for the AC transmission of Electrical energy .It is meant to enhance controllability and increase power transfer capability of the network. It is generally power electronics based system [2].

4.1 TYPES OF FACTS DEVICES

1. Static var Compensator (SVC).
2. Thyristor Controlled Series Capacitor (TCSC).
3. Static Synchronous Series Compensator (SSSC).
4. Static Compensator (STATCOM).
5. Unified Power Flow Controller (UPFC).

5.STATIC VAR COMPENSATOR

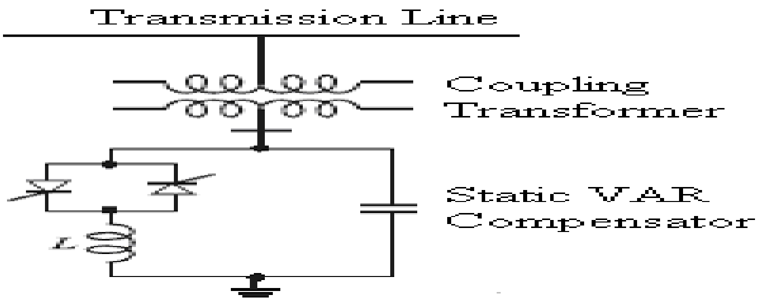

Fig.2. Configuration of SVC [6]

SVC is a shunt variable admittance and can be placed at the terminal bus of a transmission line or middle of a long line.SVC is static var compensator that can feed capacitive or inductive current with the power system so as to maintain or control specific power variable typically the control variable is the system bus voltage.
SVC is a shunt devices that consist typically of one thyristor controlled reactor and several thyristor switched capacitor. Filters should be also considered because they can produce reactive power [6].
The capacitor can be switched ON or OFF only so current through reactor can be varied from zero to the rated current. A static VAR compensator is a set of electrical devices for providing a fast-acting reactive power on high voltage electricity transmission networks. SVCs are part of the Flexible AC transmission system device family, regulating voltage, power factor, and harmonics and stabilizing. The system. A SVC is a automated impedance matching device, which is designed to make the system near unity power factor. The SVC is basically used in two situations. First of all it is connected to the power system to regulate the transmission voltage and is connected near large industrial loads to improve power quality. Among the FACTS controllers, Static Var Compensator (SVC) provides fast acting dynamic reactive compensation for voltage support during contingency events which would otherwise depress the voltage for a significant length of time. SVC also dampens power swings and reduces system losses by optimized reactive power control.

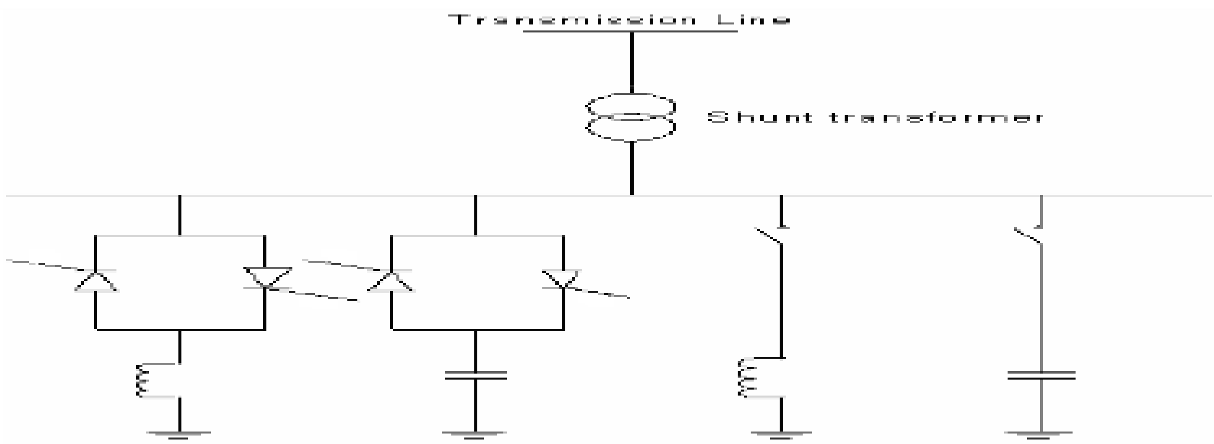

Fig.3. Single Line Diagram of SVC[18]

Static Var Compensator is "a shunt-connected static Var generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system (typically bus voltage)". SVC is based on thyristors without gate turn-off capability. The operating principal and characteristics of thyristors realize SVC variable reactive impedance. SVC includes two main components and their combination: Thyristor-controlled and Thyristor-switched Reactor (TCR and TSR); and Thyristor-switched capacitor (TSC). TCR and TSR are both composed of a shunt-connected reactor controlled by two parallel, reverse-connected thyristors. TCR is controlled with proper firing angle input to operate in a continuous manner, while TSR is controlled without firing angle control which results in a step change in reactance. Thyristor switched reactor and Thyristor Switched Capacitor both are trying to stable the voltage instability problem by generating and absorbing the reactive power in the system. By doing this simultaneous absorption and discharge of reactive power this FACTS device is stabilizing the voltage.

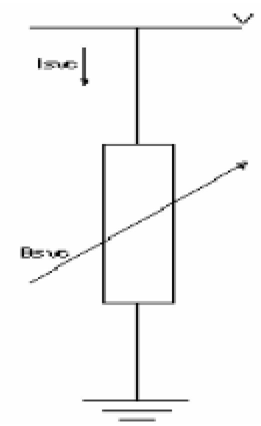

Fig.4. Equivalent Circuit Diagram of SVC [8]

5. SIMULATION MODEL OF SINGLE MACHINE INFINITE BUS BAR

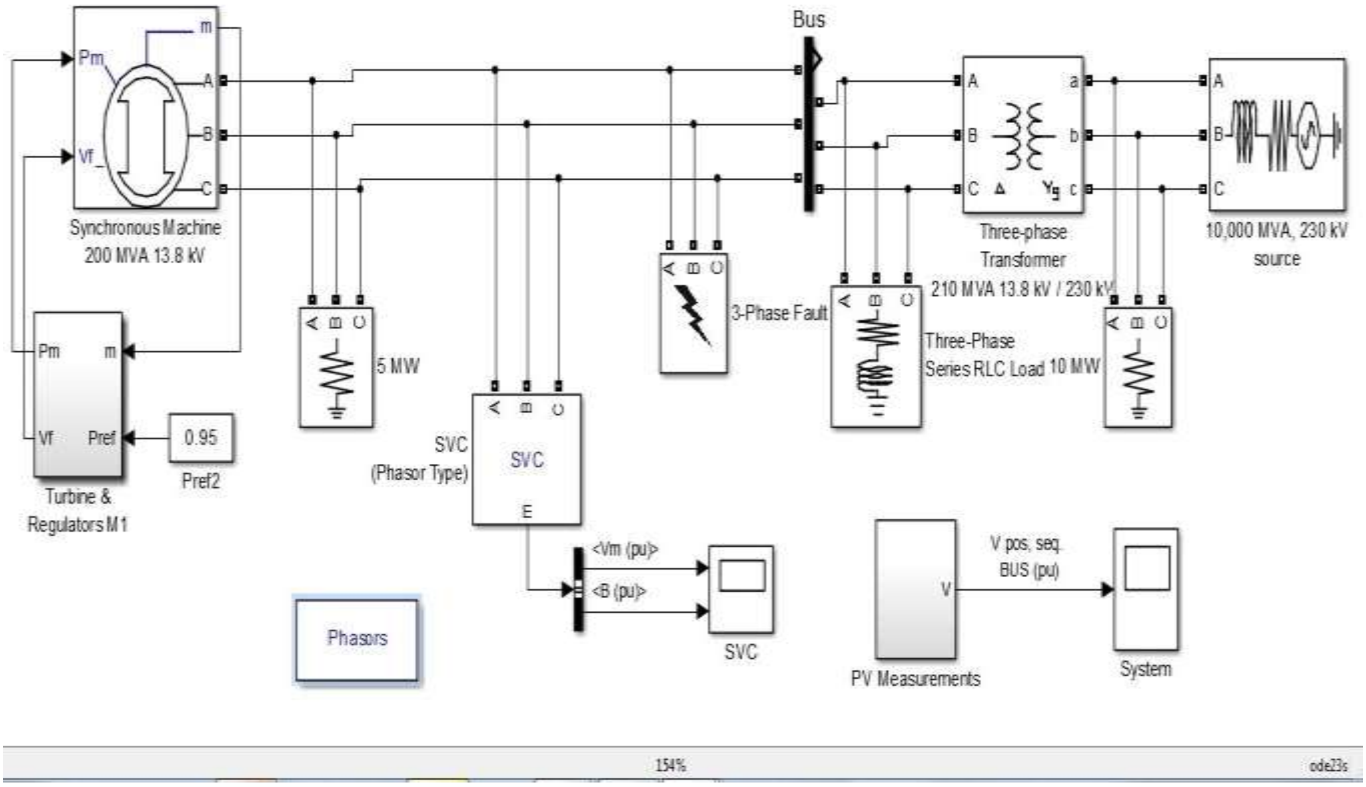

Fig.5.Single machine infinite bus bar Model

5.1.SIMULATION RESULT

5.1.1.Single Machine Infinite Bus bar Normal Condition Result

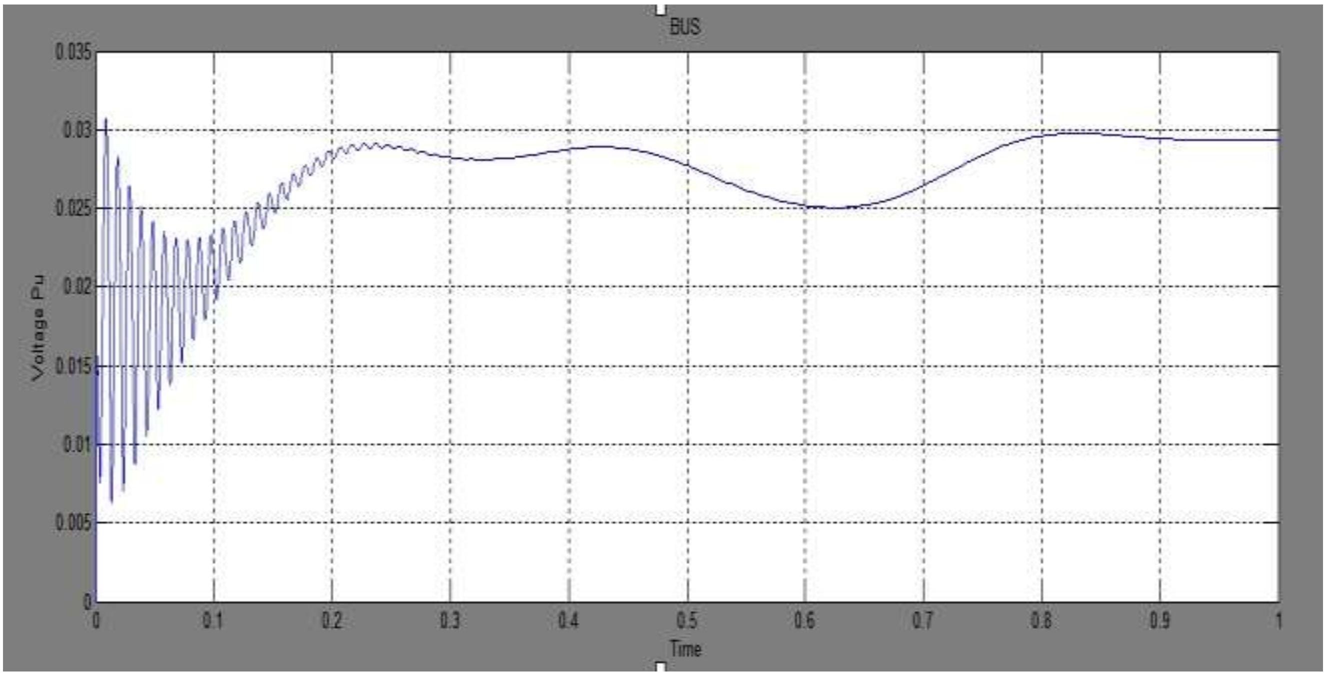

Fig.6.SMIB Waveform Of Voltage P.u V/S Time (During Normal Condition) without SVC

5.1.2.SMIB Waveform Of Voltage P.u V/S Time (LG Fault) without SVC

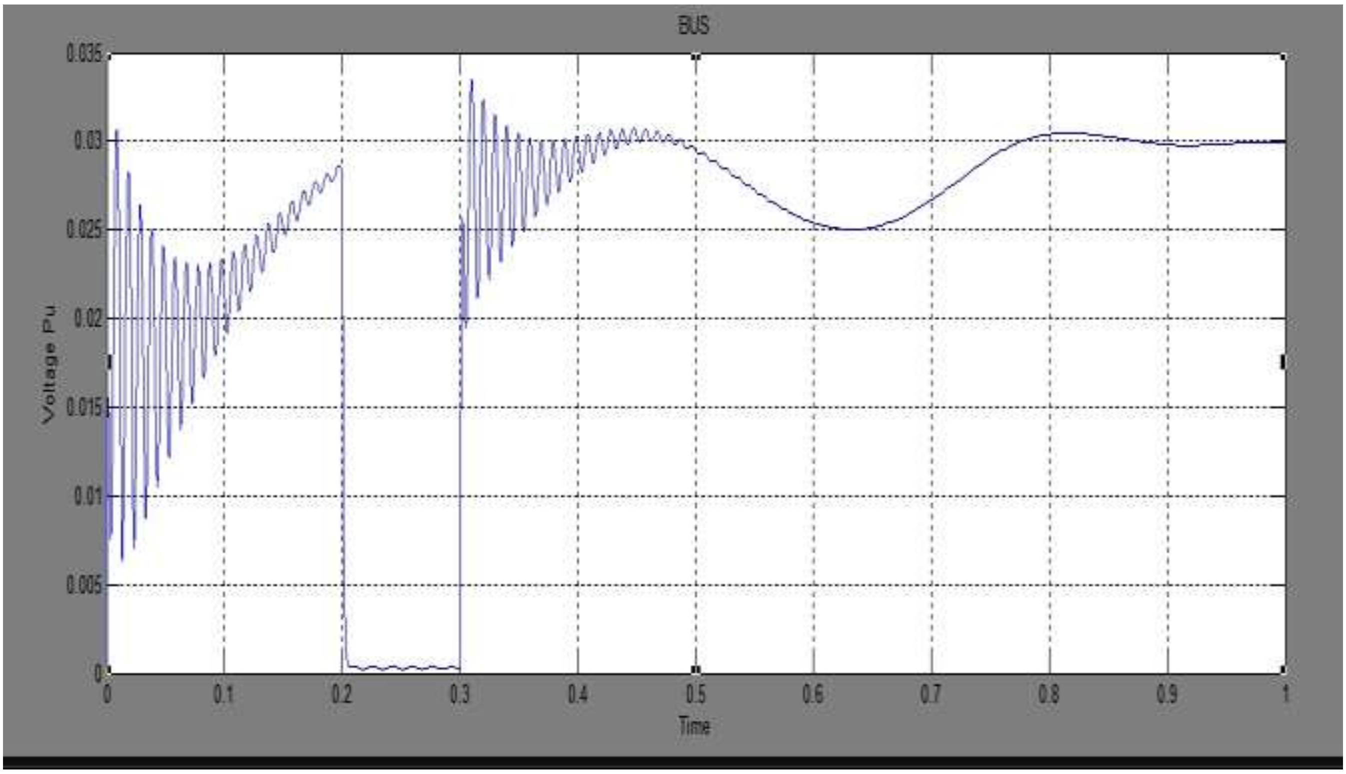

Fig.7.SMIB Waveform Of Voltage P.u V/S Time (LG Fault) without SVC

5.1.3.SMIB Waveform Of Voltage P.u V/S Time (LG Fault) with SVC

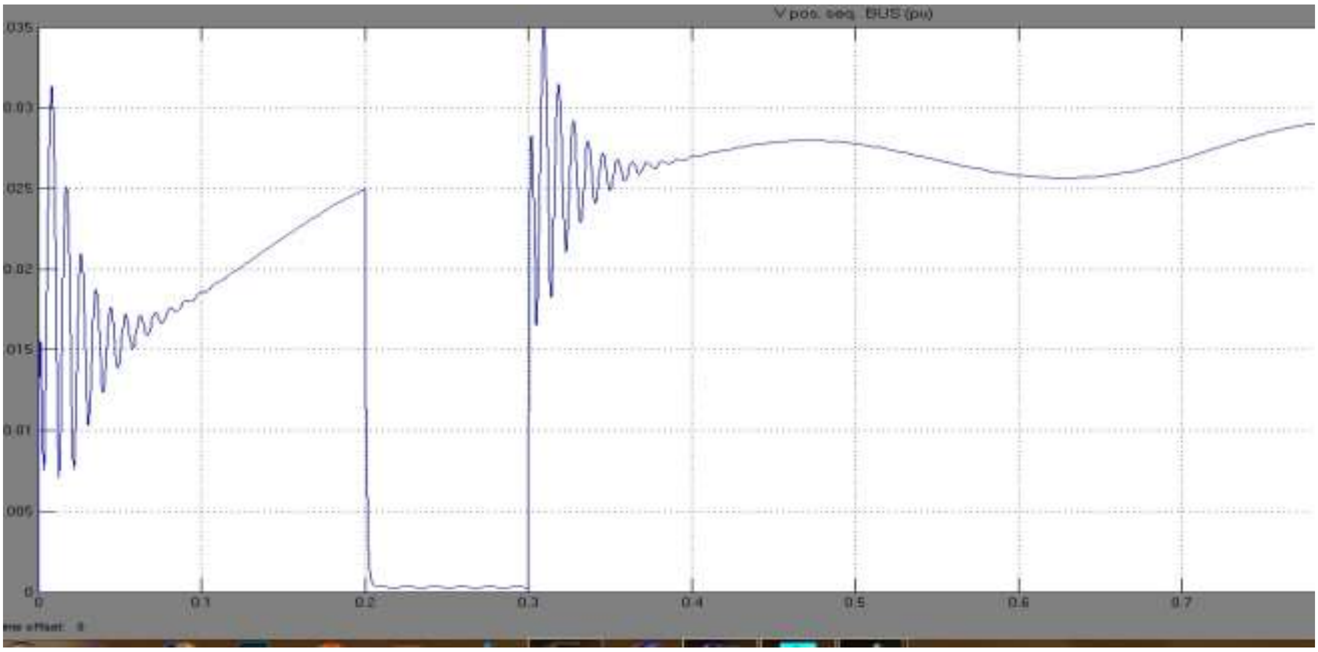

Fig.8.SMIB Waveform Of Voltage P.u V/S Time (LG Fault) with SVC

6.CONCLUSION

By studying the results have given an indication that SVC are very useful when it comes to organize and maintain power system. SVC is the dynamic simulation system where it can adjust the distribution the system power flow among the transmission line quickly and smoothly, and there is no significant impact to other operating parameters of the system. At the same time, SVC can improve system stability, to keep down the instability and line oscillation problem

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