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# Power System Stability Enhancement Using FACTS Devices

**Ravinder Goud, Dola Gobinda Padhan, Naspuri Arun Raju**

***Abstract**: To utilize maximum cross section of installed power system conductors, the diversion of imaginary power should be must .With this; we can achieve maximum utilization of real power generated at the station. Generally preset passive inductive VAR generators may share conductor portion when low demand times. Active VAR generators are preferred to overcome this issue .Further control systems helps to determine the required VAR and type of VAR such that conduction period of switch varies according to the requirement of load which is very advantageous nature of active VAR generators. The simulink models of STATCOM and SVC are present in this paper. The results are analyzed accordingly in this paper.*

***Keywords: STATCOM, SVC, FACTS***

## I.INTRODUCTION

The power system studies always revolve around fundamental imaginary content diversion as well as harmonic suppression. Fundamental imaginary content can be called as a reactive power in general. With this additional imaginary power content, line will be overloaded far-before its real power delivery ability. It can lead to installation of new lines, transformers, protection and substations and distributed lines even though components have desired load delivery capability. If it happens, then cost, complexity, corridor increases which are undesired under any circumstances. Reactive power diversion from power system line by installing var generators was considered as primary choice rather installing new power system because of its simple nature. Similarly, harmonic suppression was preferred from decades over installing new power system. Of course, who will construct new power system for over loading due to this garbage harmonics as well as reactive power![3]

Two options were discussed to damp this useless dump.

1. By passing orders strictly to appliance manufacturers about making unity power factor devices.
2. Installing large dump generators

Both weren't possible because of their individual limitations. Penalty factor introduced discipline to the manufacturers. Of course, it can lead to reduced size of VAR generators which is needy.

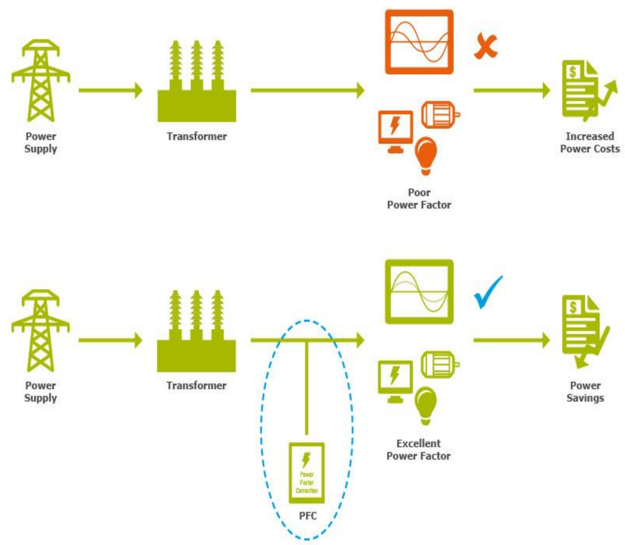


**Fig1. Overview diagram of system**

Static capacitors are not always best option to use. If they are designed for full load, then there exists a problem with no-load. They dump leading current to system which can increase additional loss which is undesired. Rotational VAR generators are suffering with starting problem. Of course it additionally requires friction and windage load from system to run on no-load. Rotor requires additional DC power for which we to use additional battery or conversion setup attached to armature supply which will increase complexity.

As power electronics was tremendously developed, static var generators are came into picture which had a lot of advantages when compared with past generators. It doesn't require any real power from system as it had its own large capacitor. It will act accordingly with load conditions. Its simple in construction. Act of sharing imaginary load is few milli-seconds. Switching to new load is also few milli-seconds.[4]

Static VAR generators are classified into

1. STATCOM
2. SVC

## II. SVC

Simple equivalent of SVC can be assumed as reactive power generator. As long as the SVC is in operation, the bus with which it is connected to act as a PV bus.[1]

Reactive power drawn by SVC connected at node j are given by

$$P_i=0;\ \ Q_i=-|V_i|^2 B_{SVC}$$

At the end of iteration p,

$$B_{SVC}^{(p+1)} = B_{SVC}^{(p)} + \Delta B_{SVC}^{(p)}$$

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$$B_{SVC}^{(p+1)} = B_{SVC}^{(p)} + (\Delta B_{SVC}/B_{SVC})^{(p+1)} * B_{SVC}^{(p)}$$

$$B_{SVC} = B_c - B_{TCR} = [1/(X_c X_l)][X_l - (X_c/\pi)\{2(\pi-\alpha)+\sin(2\alpha)\}]$$

Where $X_L = \omega L$ and $X_c = 1/(\omega C)$

Since, $Q_{SVC} = -V_i^2 B_{SVC}$, we can write

$$Q_i = -[(V_i^2)/(X_c X_l)][X_l - (X_c/\pi)\{2(\pi-\alpha)+\sin(2\alpha)\}]$$

$$\alpha^{p+1} = \alpha^p + \Delta\alpha^p$$

## III. STATCOM

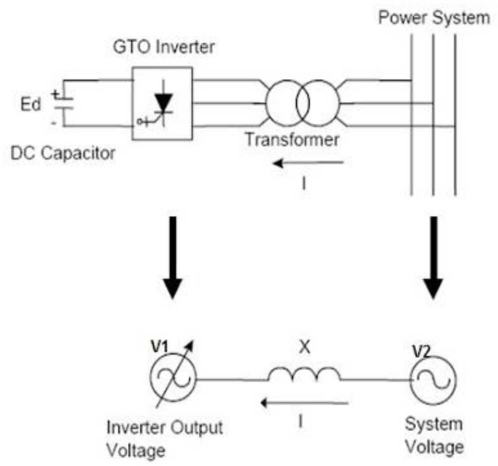


**Fig2. STATCOM**

Limitation in instant varying of capacitor voltage makes us to choose pulse width modulation instead of varying charge on capacitor. Since we have many width modulation methods, hence adoption became easier. Therefore easier closed loop adoption became possible. Even small change is possible with this closed loop system. Though transformer insertion adds additional reactive power and real power to system, chosen capacitor has capability to deliver required power content. PWM will increase fundamental when compared with dust of harmonics. However higher harmonic filters adopted to nearly nullify dust content. However small content of harmonics are present though we have taken care. Of course, it delivers load harmonics.[2]

Due to sine content, Discharged voltage in one half cycle is nullified other half cycle. However it needs to supply switch losses, eddy and hysteresis losses and small copper losses. In practical application, capacitor should de-energize to energize losses.

“To be supplied” load is ideally zero. Hence angle between inverter voltage and bus voltage is zero. Therefore game decided by magnitude of inverter voltage.

$$reac\ power\ recived\ at\ bus = \frac{E-V}{X} \times V$$

From above equation it is clear that

If E>V, then it delivers inductive reactive power.

If E<V, it delivers leading reactive power.

The main drawback is its limitation. We can call it as saturation of reactive power delivery. After saturation or limitation point, system cannot supply further value. Therefore, after this power system should have to supply excess.

## IV. CONTROL SYSTEM

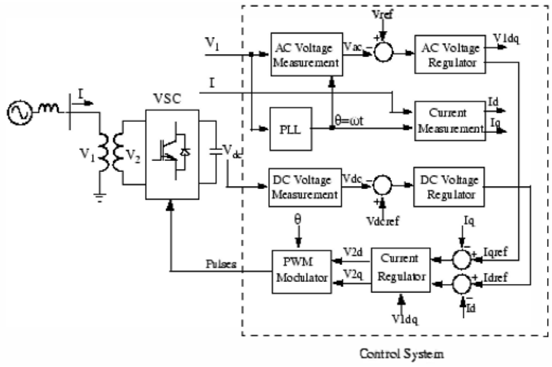


**Fig3. Control System of STATCOM**

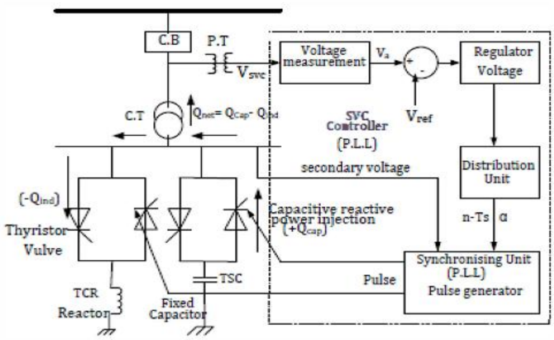


**Fig4. Control System of SVC**

One of the crucial points in these devices is synchronizing phase angle of imaginary current of load current with installed device current. Non sync phase angle system will lead to mal-performance system. It means that it acts against to the performance we aimed. To avoid this, we have to take care in phase angle of output of STATCOM. In manner, we have to take care in SVC. Manual detection and producing pulses accordingly is impossible task. This makes us to choose control system over manual detection. We employed control system to employ phase angle detection which makes control system to develop pulses accordingly.[5]

## V. RESULT

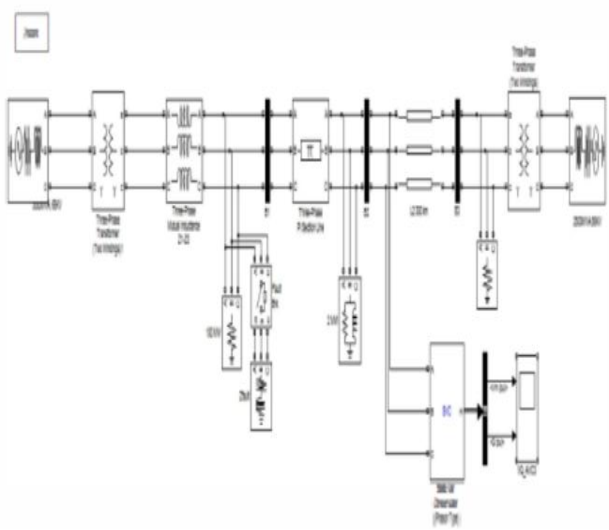

**Fig. 5 SVC Model Transmission Line**



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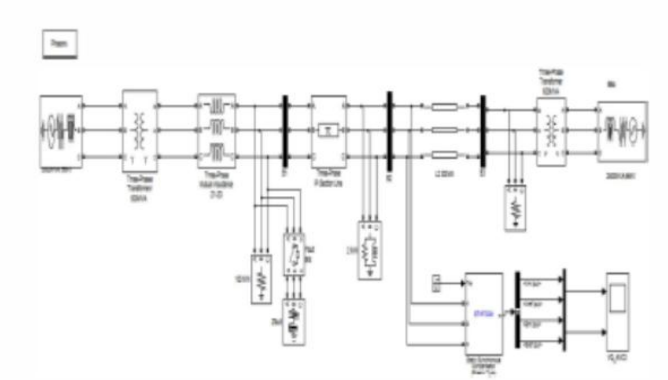

Fig. 6  STATCOM Model Transmission Line

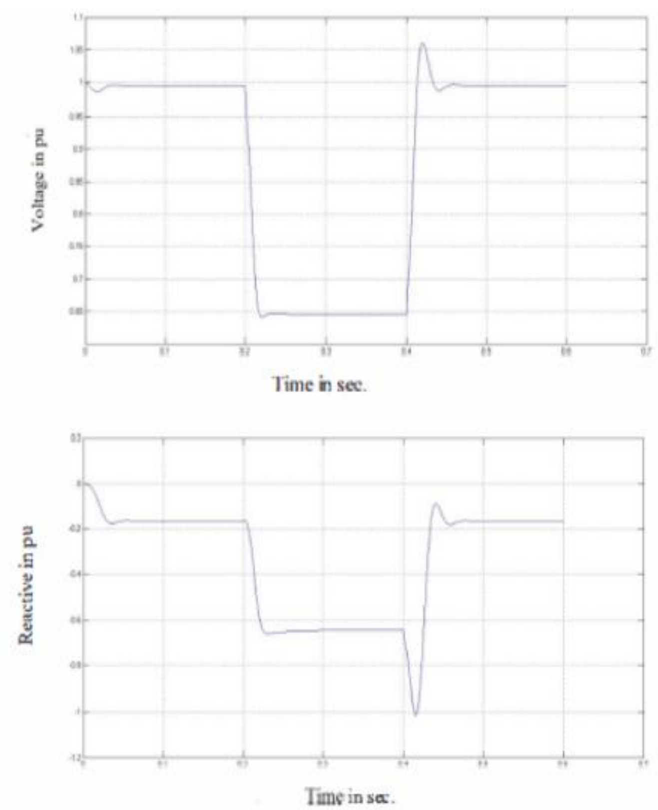


Fig. 7 STATCOM Dynamic Response

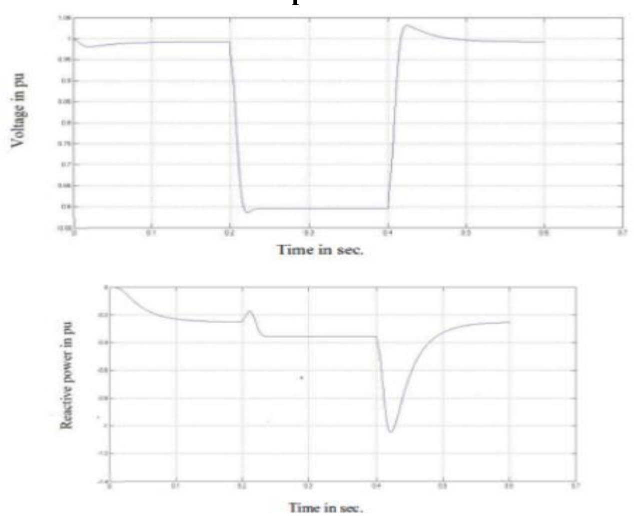


Fig. 8 SVC Dynamic Response

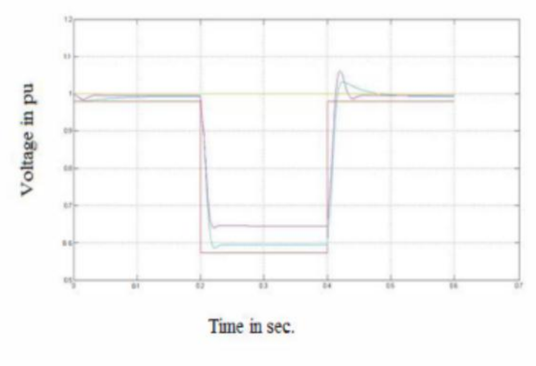


Fig. 9 Voltages of common model

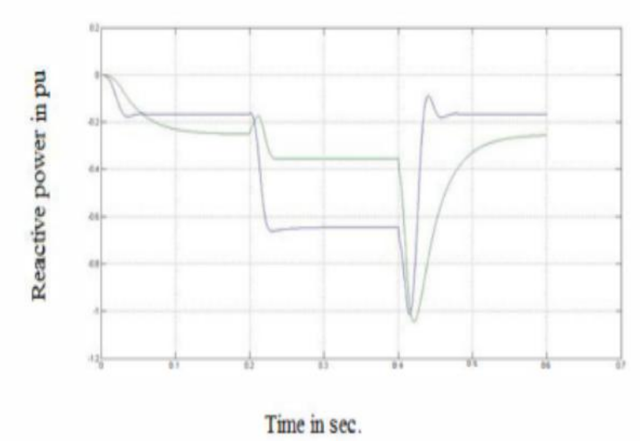


Fig. 10 Reactive Power of ST ATCOM & SVC

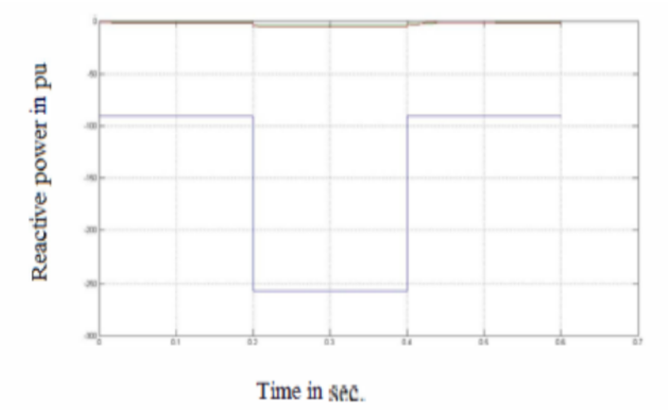


Fig. 11 Reactive Power of Transmission Line

## VI. CONCLUSION

Comparative performance of system was analyzed before installation of devices with after installation of devices. Analysis of dynamic response of SVC and STATCOM shows us improved performance of power system. We observed here good transient time of devices. We here concluding that system stability was far better when system was connected with facts devices.

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