International Journal of Advance Engineering and Research Development (IJAERD)
Volume 1,Issue 7,July 2014, e-ISSN: 2348 - 4470 , print-ISSN:2348-6406

Analysis of SVC and STATCOM for voltage regulation and transfer capability

Er. Sandeep Pal Singh[1],Er. Divya Gupta[2]

[1]*ECE, ACET Bhawanigarh, sandeep_seepa@yahoo.co.in*
[2]*EE, BBSBEC Fatehgarh Sahib, divya.gupta@bbsbec.ac.in*

Abstract- With the effect of restrictions on building new linesandgrowing demand, Transmission networks of modern power systems are becoming more stressed. One of the solutions of such a stressed system is the Flexible actransmission system (FACTS) devices.For the proper utilization of the existing network without sacrificing the desired stability margin; FACTS devices are the most efficient in a transmissionnetwork. For the controlling of voltage and power flow, the Flexible AC Transmission System (FACTS) such as Static VAR Compensator (SVC) and Static SynchronousCompensator (STATCOM) are the most efficient power electronic switching devices in power transmission networks. From the family of flexible AC transmission systems (FACTS), the static synchronous compensator (STATCOM) is a shunt device of this family.By the controlling an amount of reactivepower absorbed from or injected into power system, the STATCOM regulates its terminal voltage.STATCOM absorbs reactive power,when the voltage of system is high and it generates reactive power,when the voltage of system is low.In this paper,comparison between performance of SVC and STATCOM is done. The simulation result proves the effectiveness of these devices in improving power transfer capability.

Keywords: SVC, STATCOM, transfer, FACTS

I. INTRODUCTION

In present days, the electrical power system is facing many problems to the complexity increasing in their operation and structure. In the last few years, the power system instability is one of the problems that gotwide attention. In modern power systems, some of the problems occur due to the lack of new generation andtransmission facilities and over exploitation of the existing facilities by increase inload demand.Due to the industrial development at high rate, demand of electrical power is increasing rapidly at a very high rate [1]. It is necessary to increase the transmitted electric power withthe existing transmission facilitiesto meet this demand. Thus,in electrical power systems the power flow control is evident. With the increase in loading of transmission lines, after a major fault the problemof transient stability can become a transmission power limiting factor. Thepower systemshould be flexible for the smooth and stable operation. The demand load and electrical generation must balance atall times up to some extentin an ac power system. The power system is self regulating.The voltage and frequency drop,if generation is less thanload and thereby the generationminus transmission losses is equal tothe load. Butfor such a self regulation, there are only a few percent margins. So there arethe chances of system collapse. Generator excitation controller withthe excitation controlis not sufficient to maintain stability of the system for large faults occur near to generator terminals,but it can improve the transient stability for minor faults [4]. Thus, this requires a review of traditional methods and the creation of new ideas that achievea more efficient use of existing electric power system resources without affectingthe systemsecurity and system stability. In 1980s, a new approach introduced to solve the problem of designing and operating power systems byElectric Power Research Institute (EPRI); the proposed concept is known as Flexible AC Transmission Systems (FACTS). The main objectives of Flexible AC

Transmission Systems (FACTS) are to increase the control power flow and transmission capacityover designated transmission routes.FACTS are defined by the IEEEas "a power electronicbased system and other static equipment that provide control of one or more AC transmissionsystem parameters to enhance controllability and increase power transfer capability.”Typical applications of FACTS in power system for the improvement of steady-state power transfer capacity,damping of power system oscillations and reduction of temporary overvoltage, effective voltage regulation and control[2]. Some of the advantages of STATCOM are that in STATCOM, maximum inductive or capacitive current can be maintainedindependently of the ac system voltage and the maximum var generation or absorption changes linearly with ac system voltage while in SVC maximum inductive orcapacitive current decreases linearly with system ac voltage and maximum var output decreases with the square of voltage.STATCOM is more effective than SVC in improving transient stability of systembecause of its ability to maintain full capacitive output current at low system voltage.Response time is better than SVC.Active power control is possible in STATCOM. Installation space requirement of STATCOM is lesser as compared to SVC [1] [2][3].

II. STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

A Static synchronous compensator is a shunt-connected static var compensator whosecapacitive or inductive output current can be controlled independent of the ac system voltage [1]. In a STATCOM, the maximum compensating current is independent of system voltage.STATCOM regulates system voltage by absorbing or generating reactive power. The STATCOM concept was proposed by Gyugyi in 1976. Power Converter employed inthe STATCOM is of two types namely: Voltage Source Converter and Current SourceConverter. In Current source Converter, the direct current always has one polarity and the powerreversal takes place by the reversing of dc voltage polarity, but in Voltage Source Converterdc voltage have one polarity and the power reversing takes place by the reversing of dccurrent polarity. The power semiconductor devices requiresbidirectional voltage blocking capabilityused in current source converter and an additionaldiode must be connected in series with a semiconductor switchfor achieving this Characteristic which increases the cost of the system. In high power applications, Voltagesource converter can operate at high efficiency. Voltage source converter is Preferred over Current source converterbecause of the above reasons and in present days, it act as a block of a STATCOM that converts the dc input voltage at itsinput into three-phase set of ac voltages withcontrollable magnitude and phase angle [1].STATCOM is made from a coupling transformer, a dc energy storage deviceanda Voltage Source Controller.STATCOM is capable of exchanging reactive power with the transmission line because of its small dc capacitor, if this dc capacitor is replaced with dcstorage battery or other dc voltage source, the controller can exchange real and reactive powerwith the transmission system, extending its region of operation from two to four quadrants. Afunctional model of a STATCOM is shown in Fig. 1.

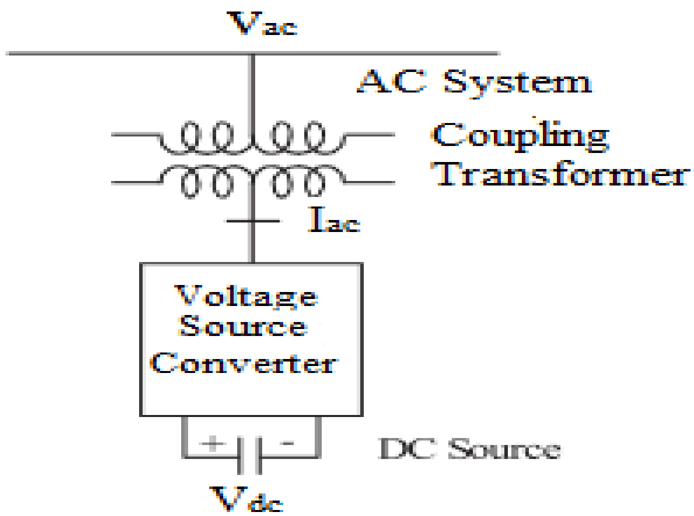

Fig. 1:Functional model of STATCOM

The relationship between fundamental components of the converter ac output voltage andvoltage across dc capacitor is given as where*k* is coefficient which depends upon on the converter configuration, number ofswitching pulses and the converter controls. The fundamental component of the converteroutput voltage i.e. *Vout*can be controlled by varying the dc voltage across capacitor which canbe done by changing the phase angle α of the operation of the converter switches relative tothe phase of the ac system bus voltage.

III. STATIC VAR COMPENSATOR

A static VAR compensator is a set of electrical devices for providing fast acting reactive power on high voltage electricity transmission networks [5] [6]. SVCs are part of the Flexible AC transmission system device family, regulating voltage, power factor and harmonics and stabilizing the system [7] [8]. Unlike the asynchronous condenser which is a rotating electrical machine, a static VAR compensator having no significant moving parts other than the internal switchgear. Prior to the invention of SVC, the power factor compensation was the preserve of large rotating machines such as synchronous condensers or switched capacitor banks [9]. The SVC is an automatic impedance matching device, designed to bring the system near to the unity power factor. SVC used as transmission SVC and industrial SVC. In the applications of transmission, the SVC is used to regulate the voltage of grid. If the load of the power system is leading, the SVC consumes VAR from the system by using thyristor controlled reactors. Under lagging conditions, the capacitor banks are automatically switched in, thus providing a higher system voltage. By connecting the thyristor controlled reactor, which is continuously variable, along with a capacitor bank step, the net result is continuously variable leading or lagging power. In industrial applications, SVCs are placed near to high and rapidly varying loads such as arc furnaces [5] [10].

IV.MULTI MACHINE POWER SYSTEM MODEL

The two power grids of rating 2600 MVA and 2300 MVA are connected by a 500-kV transmission line of 500-km long. The "natural" power flow on the transmission line is 930 MW from bus B1 to B3, when the STATCOM is not in operation. The location of STATCOM is at the midpoint of the line (bus B2).

The rating of the STATCOM is 100MVA. The STATCOM model shown is a phasor model of three-level PWM STATCOM. The impedance represents the transformer leakage reactance and the phase reactor of the IGBT Bridge of an actual PWM STATCOM. The functional model using STATCOM is shown in fig. 2.

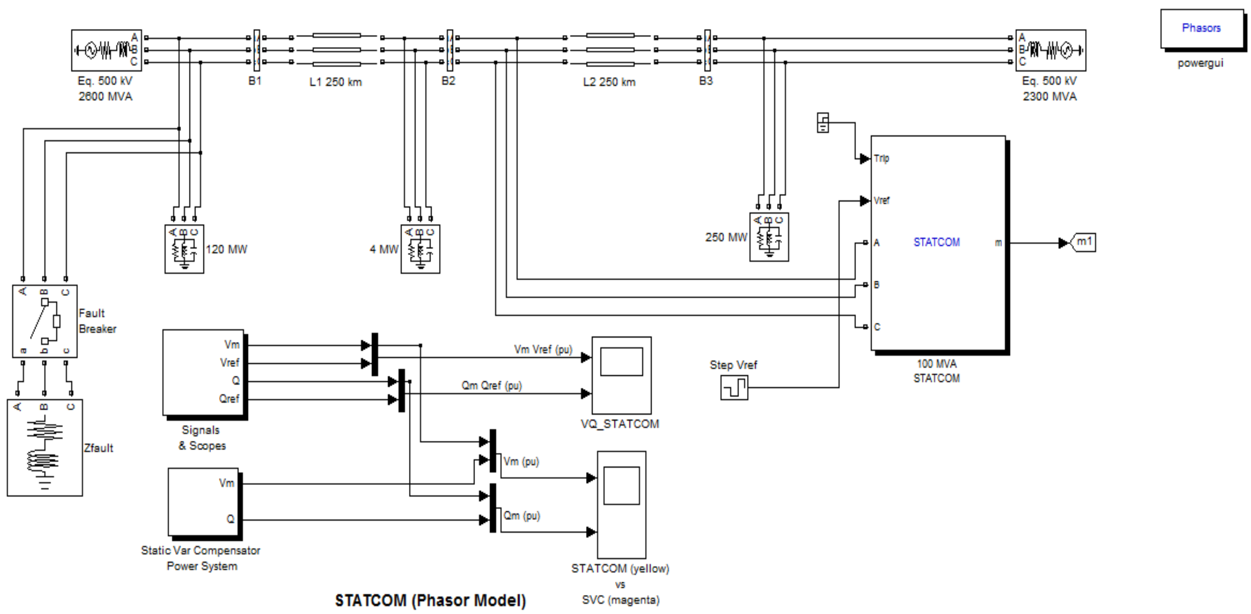

Fig. 2: Simulation test with FACT devices

The fig. 3 shows the model of signals and scopes. Here Vabc_B1, Iabc_B1, Vref, Vm, Qref, Qm, Id, Iq, Idref and Iqref are the signals in this model. PQ_L1, VI_STATCOM and IdIq are the scopes which show the graph as shown in figure 6, 7 and 8.

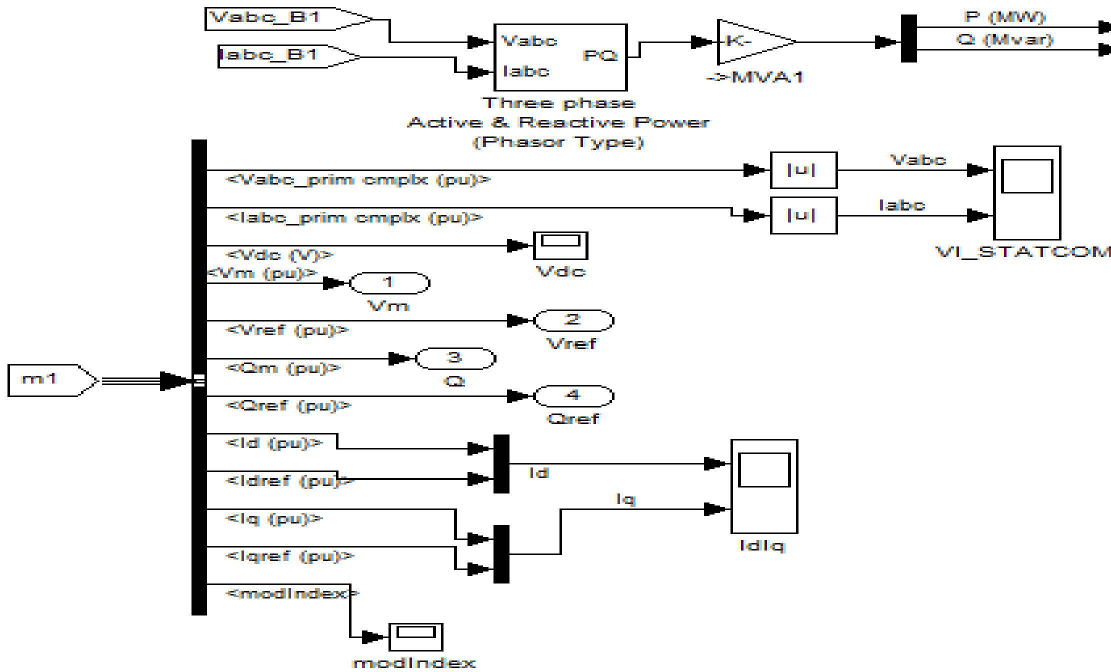

Fig. 3: Signal and Scopes

The Fig. 4 shows the model of SVC power system. The two power grids of rating 2600 MVA and 2300 MVA are connected by a 500-kV transmission line of 500-km long. A Fault occurs between the grid and bus bar B4 in the connected load. The Static Var Compensator is connected between the bus bar B5 and B6.

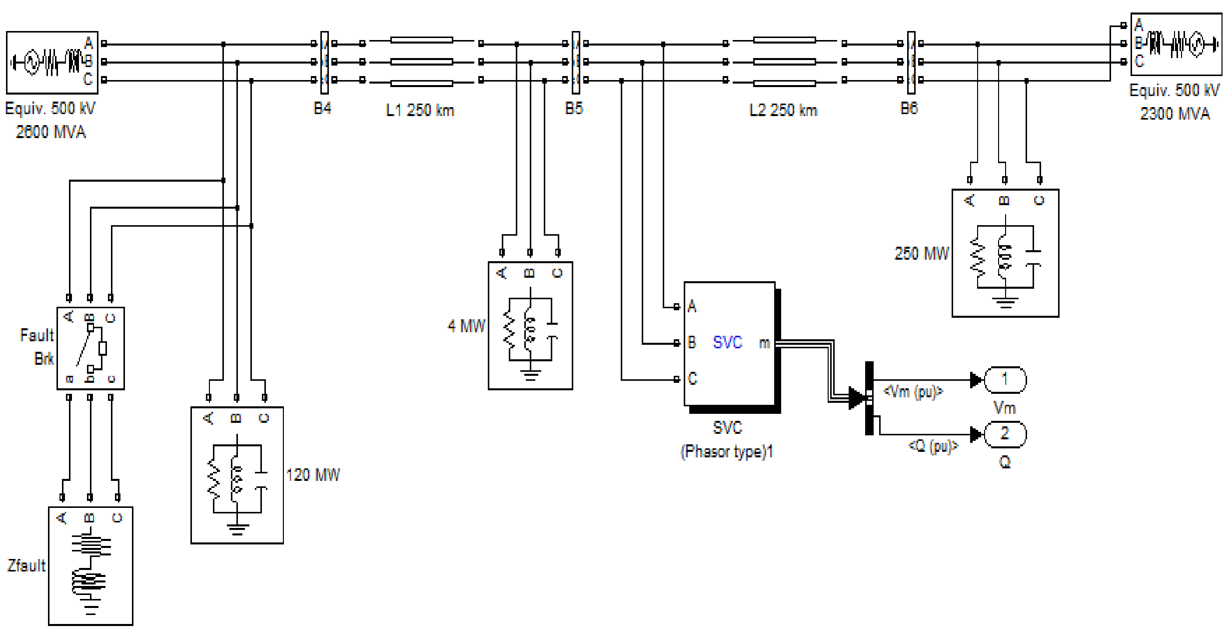

Fig. 4: SVC Power System

V. SIMULATION AND RESULT

The simulation shows the result of the model through the scope. VQ_STATCOM scope shows the graph of active and reactiveVm, Vref and Qm, Qref in Fig. 5. The first graph showstheVref signal along with the measured positive-sequencevoltageVm at the STATCOM bus. The second graph shows the reactive power Qm absorbed or generated by the STATCOM. We found that the closed-loop time constant ofQm signal the is about 20 ms.The time constant depends on thestrength of power system at B2 of the STATCOM. The impact of the regulator gains can be seen by the multiplication of two gains of Vac Regulator by two and the simulation gives the faster response with a small overshoot.Now the comparison between STATCOM models with a SVC model having the same rating 100 MVA is done.By clicking on the SVC Power System block, a SVC connected to a power grid similar to the power grid on which our STATCOM is connected is observed.On both systems using a fault breaker, a remote fault will be simulated in series with fault impedance. The graph of Vm and Qm between the SVC and STATCOMis shown in the Fig. 6. The first graph shows the comparison of Vm between the SVC and STATCOM and the second graph shows the comparison of Qm between SVC and STATCOM. During the 10-cycle fault, a key difference between the SVC and the STATCOM can be observed. The reactive power generated by the SVC is -0.48 pu and the reactive power generated by the STATCOM is -0.71 pu. The graph between active power, P (MW) and reactive power, Q (Mvar) is shown in Fig. 7. The graph between voltage and Current with STATCOM is shown in Fig. 8.The graph between Id and Iq is shown in Figure 9.

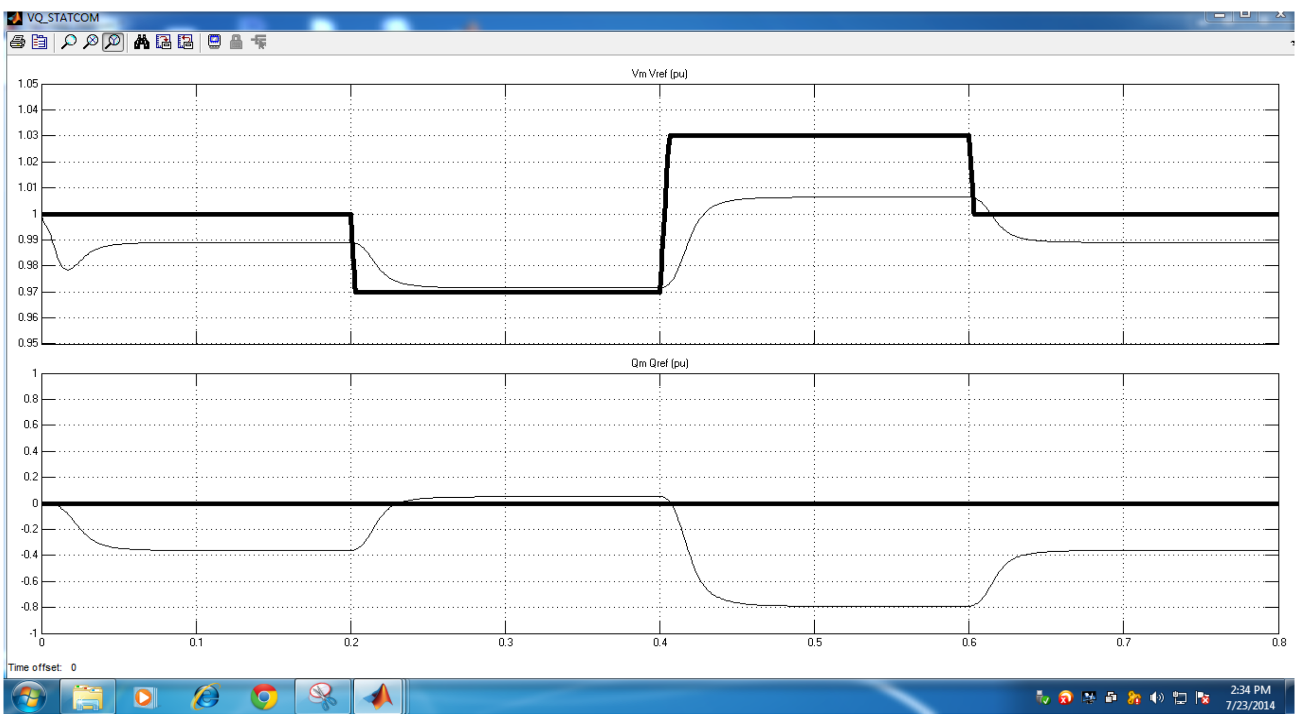

Fig. 5: Graph of Vm, Vref and Qm, Qref

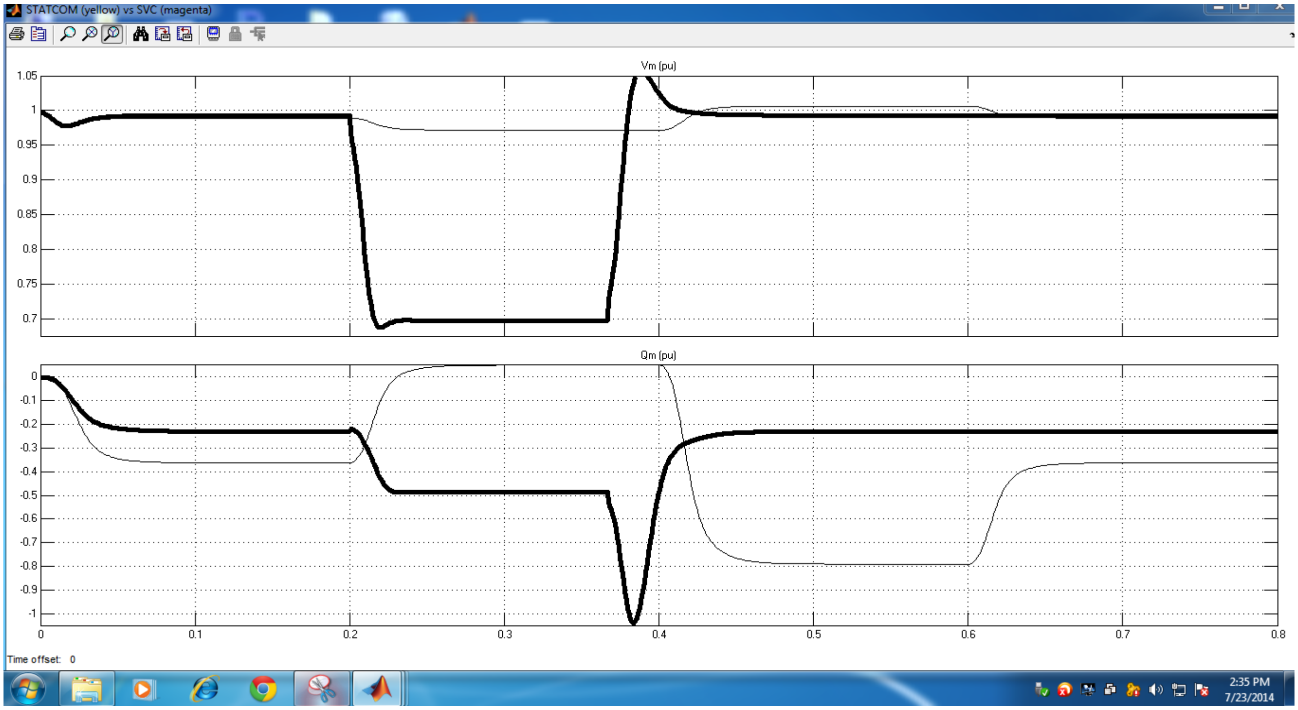

Fig. 6: Graph between STATCOM and SVC

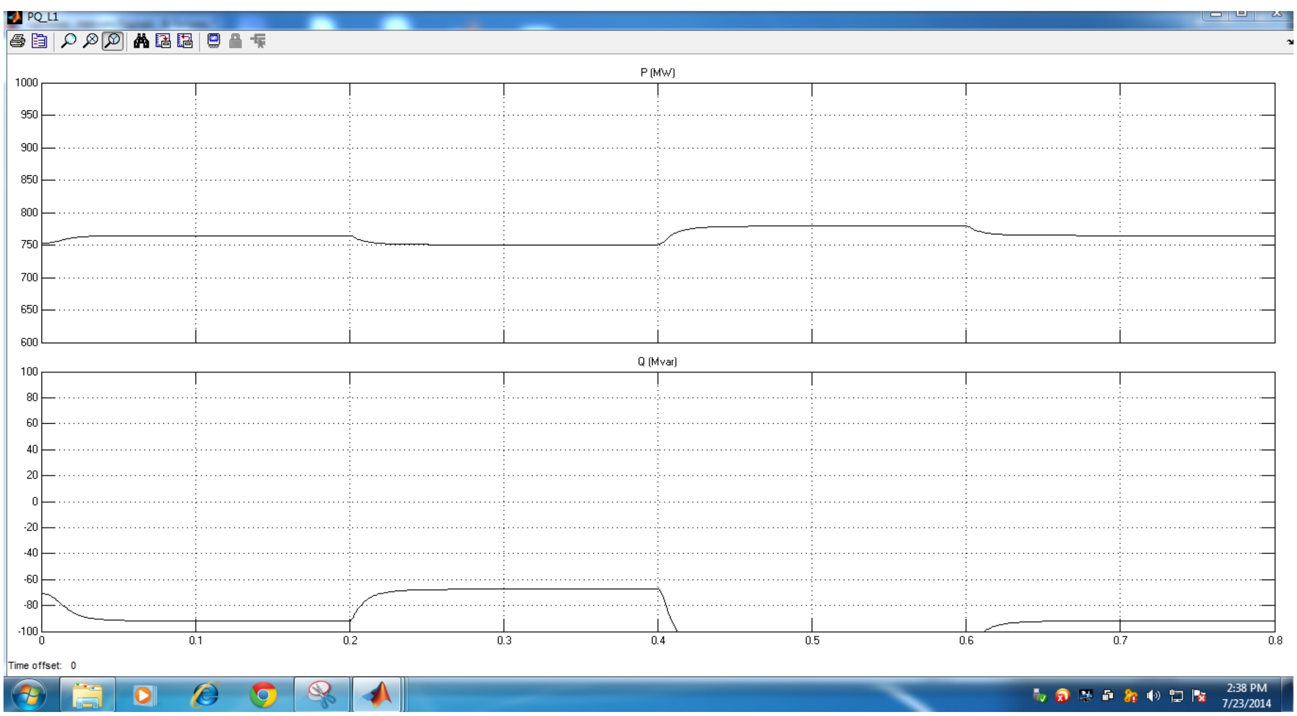

Fig. 7: Graph between P (MW) and Q (Mvar)

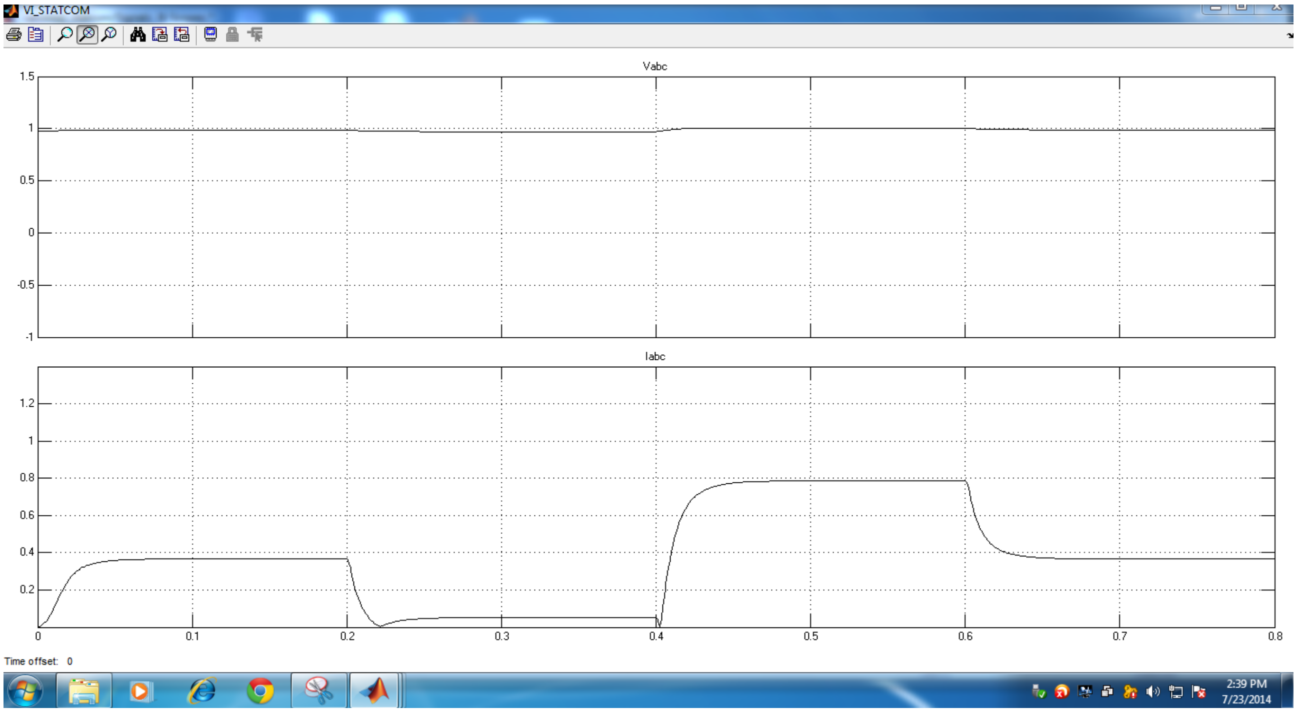

Fig. 8: Graph between voltage and Current with STATCOM

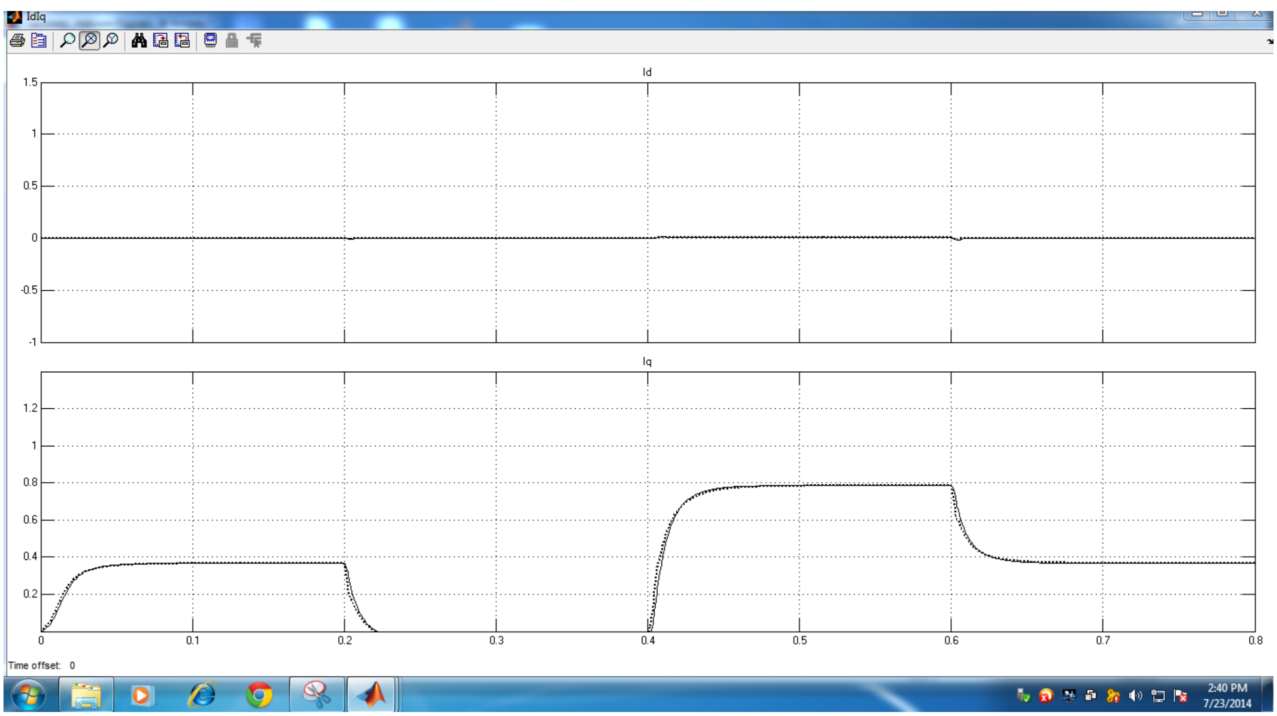

Fig. 9: Graph between Id and Iq

VI. CONCLUSION

This paper based on the applications of SVC and Statcom. The models of using STATCOM and SVC are implemented and tested in the MATLAB/Simulink software. These models are used for the voltage stability analysis. The effects of the FACT devices such as SVC and STATCOM are shown in grarh. The best performance is achieved by introducing Fact devices which compensates the reactive power. Its conclusion is that by introducing the FACT devices such as STATCOM and SVC, the system perfomance, voltage regulation and transmission capability also improves.

REFERENCES

[1] Hingorani and N.G.Gyungi – "Understanding Facts Devices"- IEEE Press, 2000.
[2] X. P.Zhang and B.Pal, "Flexible AC Transmissions systems:Modelling and Control", Springer Berlin Heidelberg, New York.
[3] Tan, Y.L "Analysis of line compensation by shunt connected FACTS Controllers: a comparison between SVC and STATCOM.", IEEE proceedings on Power Engineering Review, Vol 19, No 8, pp:57-58, Aug1999.
[4] L.Cong, Y.Wang"Co-ordinated control of Generator excitation and STATCOM for Rotor angle stability and voltage regulation enhancement of Power systems." IEEE Proc Gen Trans Distrib Vol. 149, No 6, pp: 659-666, Nov 2002.
[5] De Kock, Jan; Strauss, Cobus(2004). Practical power Distribution for Industry, Elsevier, pp. 74-75.
[6] Deb, Anjan K. Power line Ampacity System. CRC Press, pp.169-171.
[7]Song, Y. H. Johns, A. T. Flexible ac transmission systems. IEE.
[8]Hingorani, N. G. &Gyugyi L, Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems, IEEE.
[9] Ryan, H. M. (2001). High Voltage Engineering and Testing, IEE, pp. 160-161
[10] Arriliaga J.; Waston, N. R. Power System Harmonics. Wiley, pp - 126
[11] Padiyar K. R. (1998). Analysis of Sub Synchronous Resonance in Power Systems, Springer, pp. 169 - 177
Padiyar, K. R. (1998). *Analysis of Subsynchronous Resonance in Power Systems*. Springer. pp. 169–177.

