REACTIVE POWER CONTROL AND TRANSMISSION LINE LOSS REDUCTION USING FACTS CONTROLLER

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ABSTRACT

Transmission line is the interconnected network with variable load connected with it. The variation of load or fault condition may drop or raises the grid voltage. The FACT controller are devices which suitable for control the power quality and voltage control due to unbalance load condition.

In this paper we introduce method of transmission line reactive power control by using FACT controller specially STATCOM and SVC controller. STATCOM is VSC based controller to regulate the voltage by varying the reactive power in a long transmission line. The effectiveness of SVC and STATCOM of same rating for the enhancement of power flow has been demonstrated.

The MATLAB simulink model of 500KV, 3000MVA transmission line use for analysis of FACT controller. Simulation result shows the better performance of FACT controller. Also performance analysis of SVC and STATCOM discuss in this paper for response analysis.

Keyword: - *FACTs, Reactive power control, SVC, STATCOM.*

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1. INTRODUCTION

The power system is associate degree interconnection of generating units to load centers through high voltage electrical transmission lines and in general is automatically controlled. It will be divided into 3 subsystems: generation, transmission and distribution subsystems. so as to produce cheaper electricity the freeing of facility, that can manufacture separate generation, transmission and distribution firms, is already being performed. At identical time electrical power demand continues to grow and conjointly building of the new generating units and transmission circuits is changing into harder attributable to economic and environmental reasons. Therefore, power utilities ar forced to have confidence utilization of existing generating units and to load existing transmission lines near their thermal limits. However, stability needs to be maintained in the least times. Hence, so as to control facility effectively, while not reduction within the system security and quality of provide, even in the case of contingency conditions such as loss of transmission lines and/or generating units, that occur oftentimes, and can most likely occur at the next frequency under freeing, a brand new management ways want to be enforced.

The future growth of power systems can trust a lot of on increasing capability of already existing transmission systems, rather than on building new transmission lines and power stations, for economic and environmental reasons. Ideally, these new management ought to be able to control voltage levels and flow of active and reactive power on transmission lines to permit for his or her secure loading, to full thermal capability in some cases, with no reduction o f system stability and security.

The location of STATCOM for power flow control in transmission system has been presented [1]. The FACTS devices are introduced in the power system transmission for the reduction of the transmission line losses and also to increase the transfer capability. STATCOM is VSC based controller to regulate the voltage by varying the reactive power in a long transmission line. The effectiveness of SVC and STATCOM of same rating for the enhancement of power flow has been demonstrated [2]. The modeling of converter-based controllers when two or more VSCs are coupled to a dc link has been presented [3].The optimal location of shunt FACTS devices in transmission line for highest possible benefit under normal condition and has been investigated [4].A shunt connected controllable source of reactive power, and two series connected voltage-sourced converters - one on each side of the shunt device was presented [5]. An overview of how series connected and combined series/shunt connected FACTS controllers are studied in an AC system has been highlighted [6]. The optimum required rating of series and shunt flexible ac transmission systems controllers for EHVAC long transmission lines by computing `optimum compensation requirement' (OCR) for different loading conditions has been demonstrated [7]. A series passive compensation and shunt active compensation provided by a static synchronous compensator (STATCOM) connected at the electrical centre of the transmission line to minimize the effects of SSR has been presented [8].A novel approach for damping inter-area oscillations in a large power network using multiple STATCOMs was given [9]. The effective utilization of FACTS device called unified power flow controller (UPFC) for power flow control was presented [10].

2. PROPOSED APPROACH

2.1 STATCOM

The STATCOM (or SSC) is a shunt-connected reactive-power compensation device that is capable of generating and/ or absorbing reactive power and in which the output can be varied to control the specific parameters of an electric power system. It is in general a solid-state switching converter capable of generating or absorbing independently controllable real and reactive power at its output terminals when it is fed from an energy source or energy-storage device at its input terminals. Specifically, the STATCOM considered in this chapter is a voltage-source converter that, from a given input of dc voltage, produces a set of 3-phase ac-output voltages, each in phase with and coupled to the corresponding ac system voltage through a relatively small reactance (which is provided by either an interface reactor or the leakage inductance of a coupling transformer). The dc voltage is provided by an energy-storage capacitor.

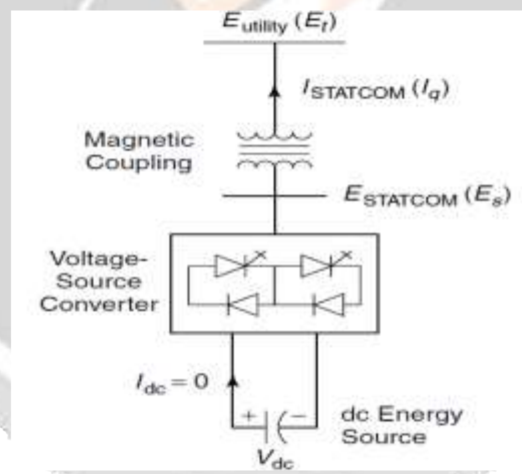

Fig 1:- A functional model of STATCOM

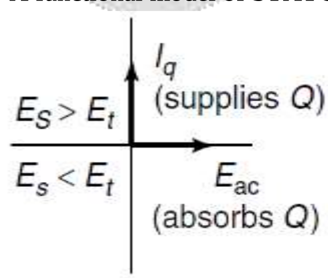

Fig 2:- STATCOM power exchange

STATCOM is seen as an adjustable voltage source behind a reactance. It means that the capacitor banks and shunt reactors are not needed for reactive-power generation and absorption, thereby it gives the STATCOM, a compact design. The equivalent circuit of the block diagram of VSC based STATCOM is shown in Figure 1.

A STATCOM can improve power-system performance in such areas as the following:

1. The dynamic voltage control in transmission and distribution systems;
2. the power-oscillation damping in power-transmission systems;
3. the transient stability;
4. the voltage flicker control; and
5.the control of not only reactive power but also (if needed) active power in the connected line, requiring a dc energy source.

Furthermore, a STATCOM does the following:

1. it occupies a small footprint, for it replaces passive banks of circuit elements by compact electronic converters;
2. it offers modular, factory-built equipment, thereby reducing site work and commissioning time; and
3. it uses encapsulated electronic converters, thereby minimizing its environmental impact.

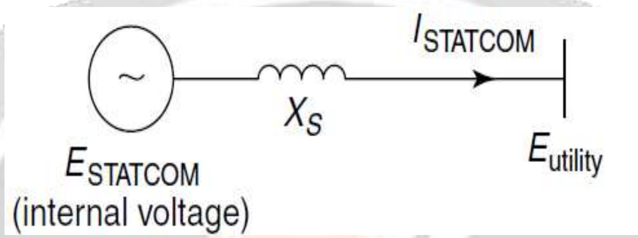

Fig 3:- Equivalent circuit of the STATCOM

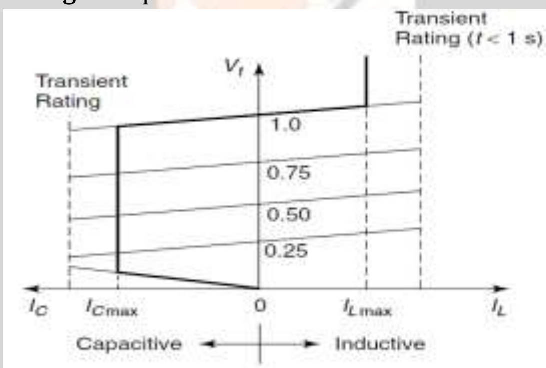

Fig 4:- V-I Characteristics of STATCOM

2.2. SVC

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: (1) Thyristor-controlled and Thyristor-switched Reactor (TCR and TSR); and (2) Thyristor-switched capacitor (TSC).

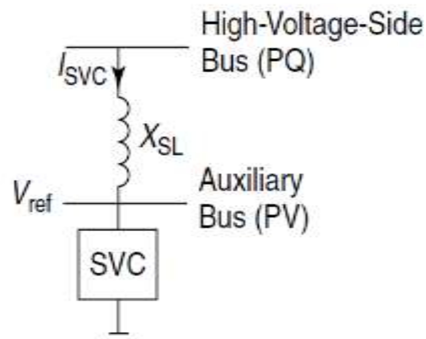

Fig 5:- The SVC models with slope representation using conventional power flow *PV* buses without coupling transformer

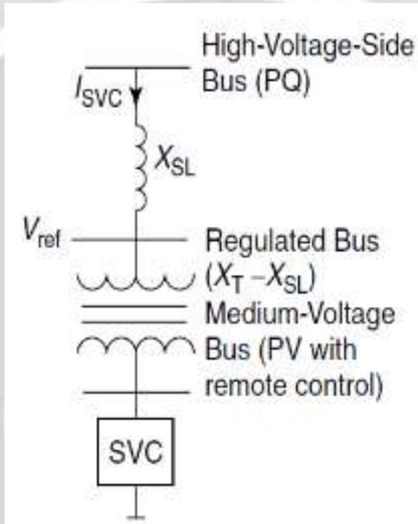

Fig 6:- The SVC models with slope representation using conventional power flow *PV* buses with coupling transformer

Reference Voltage, Vref This is the voltage at the terminals of the SVC during the floating condition, that is, when the SVC is neither absorbing nor generating any reactive power. The reference voltage can be varied between the maximum and minimum limits—Vref max and Vref min—either by the SVC control system, in case of thyristor-controlled compensators, or by the taps of the coupling transformer, in the case of saturated reactor compensators. Typical values of Vref max and Vref min are 1.05 pu and 0.95 pu, respectively.

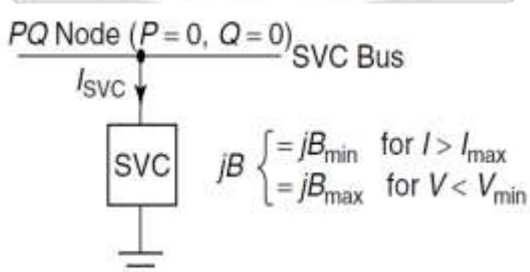

Fig 7:- The SVC model with slope for operation outside the control range.

Linear Range of SVC Control This is the control range over which SVC terminal voltage varies linearly with SVC current or reactive power, as the latter is varied over its entire capacitive-to-inductive range. Slope or Current Droop

The slope or droop of the V-I characteristic is defined as the ratio of voltage magnitude change to current-magnitude change over the linear-controlled range of the compensator.

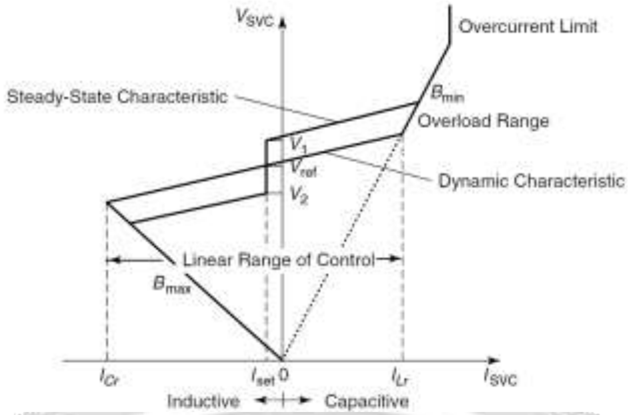

Fig8:- V-I Characteristics of SVC

3. SIMULATION MODEL

STATCOM has a rating of +/- 100MVA. This STATCOM is a phasor model of a typical three-level PWM STATCOM. STATCOM is having a DC link nominal voltage of 40 KV with an equivalent capacitance of 375 µF. The circuit diagram without compensation is shown in Figure5. In this circuit the power is directly measured in the 600km long transmission line at the three stages like sending end, middle and receiving end and also tabulated the result of voltage and reactive power in table1.The circuit diagram when STATCOM is connected at the middle of the long transmission line is shown in fig 8. Similarly the connections are made when the SVC is connected at the sending end and receiving end of the long transmission line shown in figure 6.

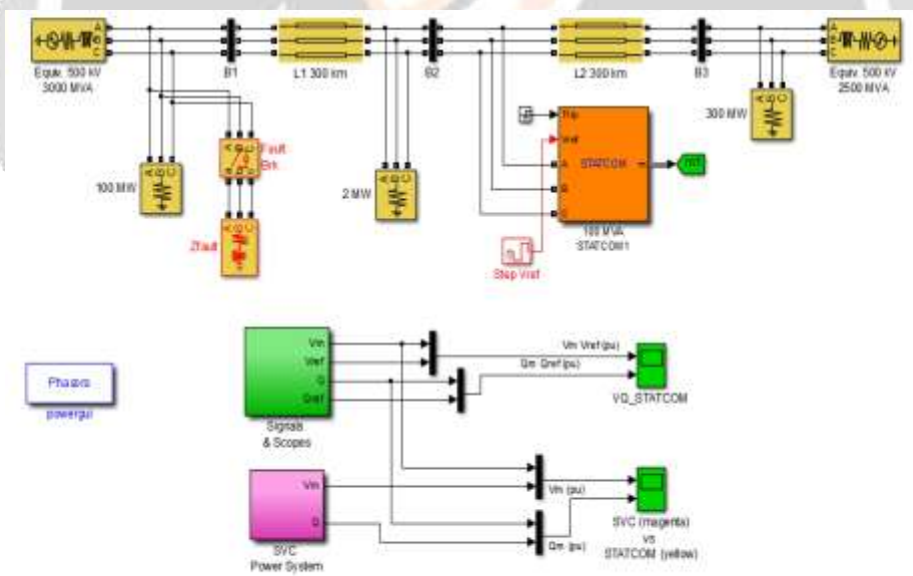

Fig 9:- MATLAB simulation model for STATCOM compensated line

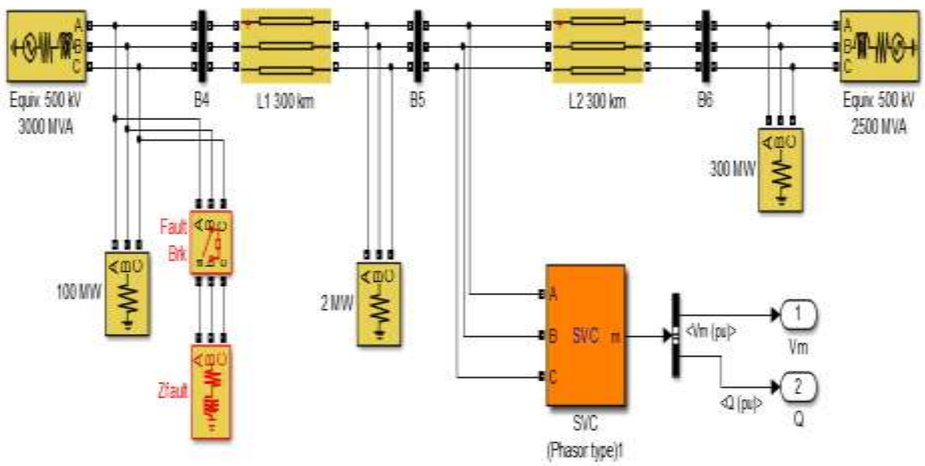

Fig 9:- MATLAB simulation model for SVC compensated line.

5. SIMULATION RESULT

We will now compare our STATCOM model with a SVC model having the same rating (+/- 100 MVA). If you double-click on the "SVC Power System" (the magenta block), you will see a SVC connected to a power grid similar to the power grid on which our STATCOM is connected. A remote fault will be simulated on both systems using a fault breaker in series with a fault impedance. The value of the fault impedance has been programmed to produce a 30% voltage sag at bus B2.Before running the simulation, you will first disable the "Step Vref" block by multiplying the time vector by 100. We will then program the fault breaker by selecting the parameters "Switching of phase A, B and C" and verify that the breaker is programmed (look at the "Transition times" parameter) to operate at t=0.2 s for a duration of 10 cycles. Check also that the fault breaker inside the "SVC Power System" has the same parameters. Finally, set the STATCOM droop back to its original value (0.03 pu).

5.1 Simulation Result from STATCOM

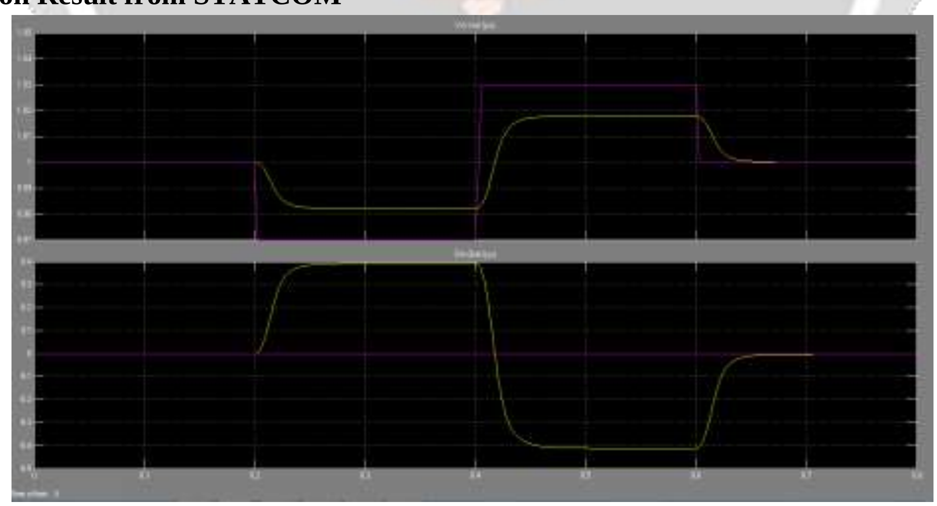

Fig 10:- STATCOM compensated transmission line parameter

5.2 Simulation result from SVC connected line

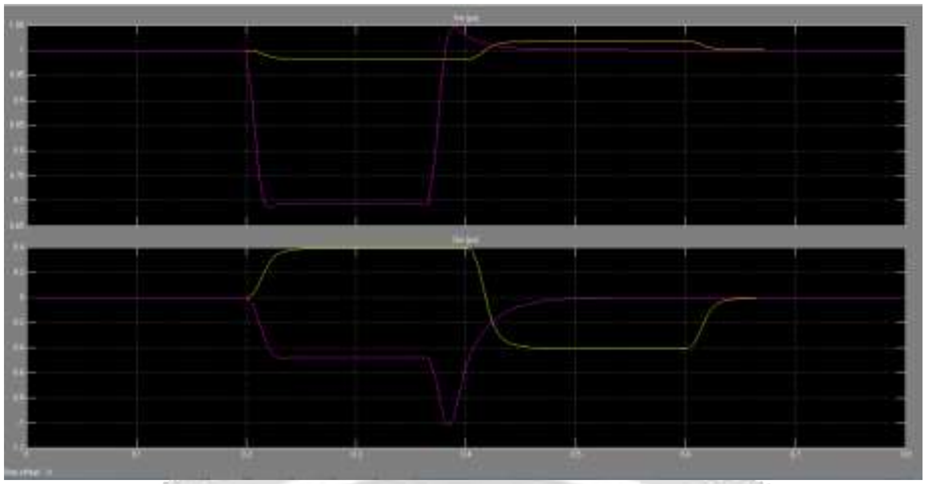

Fig 10:- SVC compensated transmission line parameter

The first graph displays the measured voltage Vm on both systems (magenta trace for the SVC). The second graph displays the measured reactive power Qm generated by the SVC (magenta trace) and the STATCOM (yellow trace). 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. We can then see that the maximum capacitive power generated by a SVC is proportional to the square of the system voltage (constant susceptance) while the maximum capacitive power generated by a STATCOM decreases linearly with voltage decrease (constant current). This ability to provide more capacitive power during a fault is one important advantage of the STATCOM over the SVC. In addition, the STATCOM will normally exhibits a faster response than the SVC because with the voltage-sourced converter, the STATCOM has no delay associated with the thyristor firing (in the order of 4 ms for a SVC).

6. PERFORMANCE ANALYSIS

6.1 STATCOM analysis

In that section, we can analyzed performance of STATCOM. The response time for voltage changes of STATCOM varies based on regulator gain. When the regulator gain increases then response time of STATCOM for variation of voltage is quick whereas regulator gain decreases then response time of STATCOM for variation of voltage is slow as shown in figures 11-14.

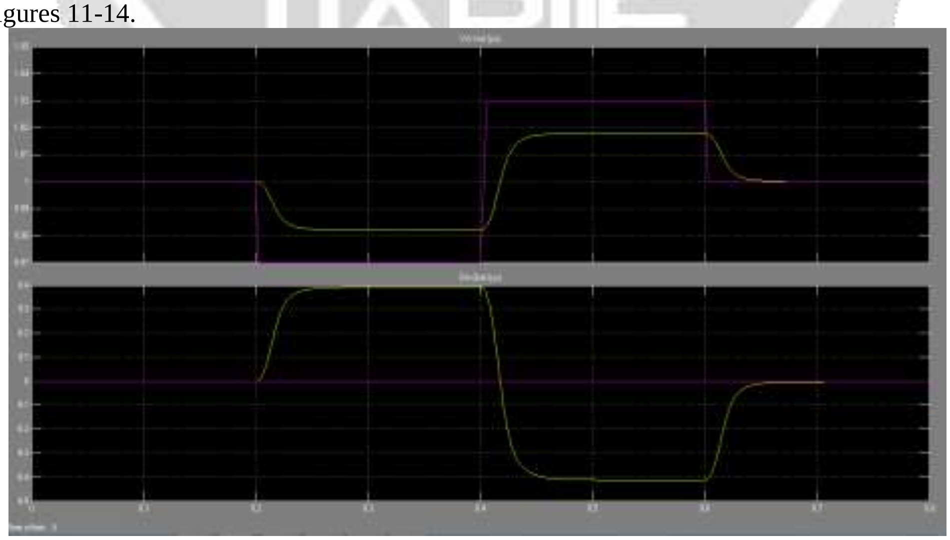

Fig 11:- STATCOM response when gain Kp=5 and Ki=1000

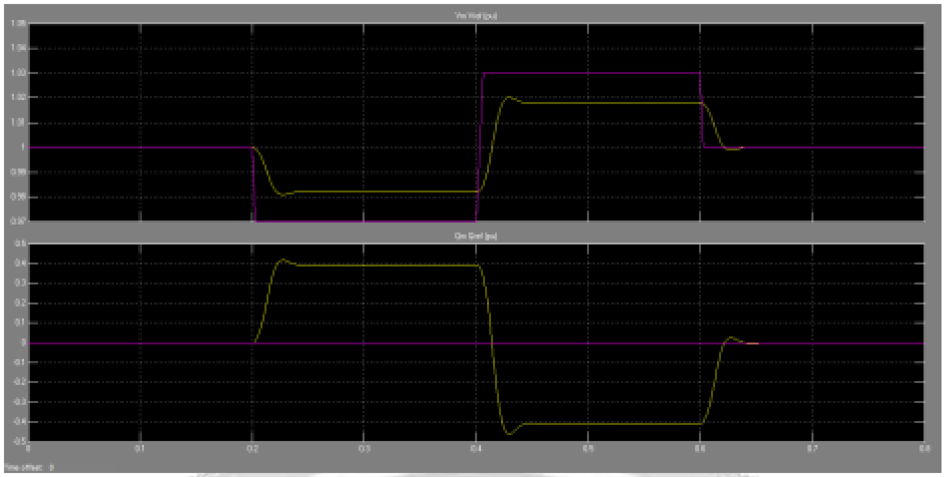

Fig 12:- STATCOM response when gain Kp=10 and Ki=2000

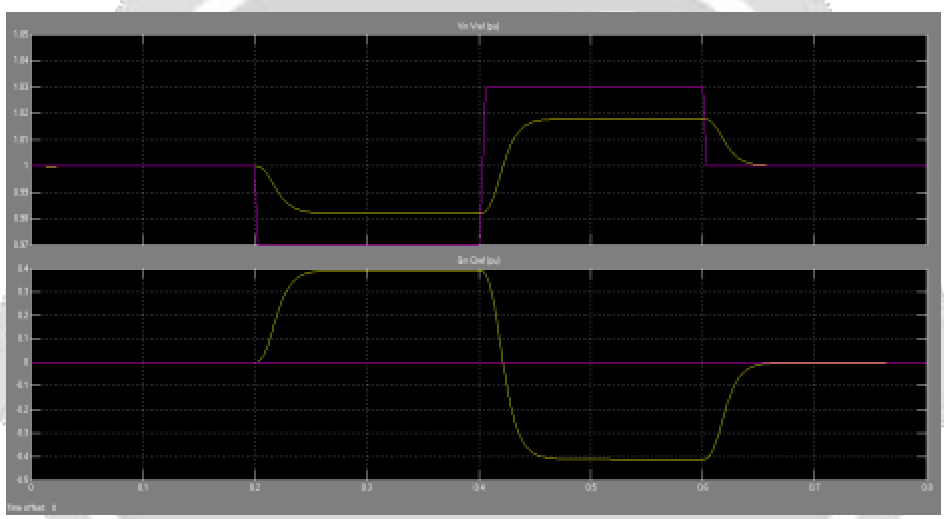

Fig 13:- STATCOM response when gain Kp=2 and Ki=800

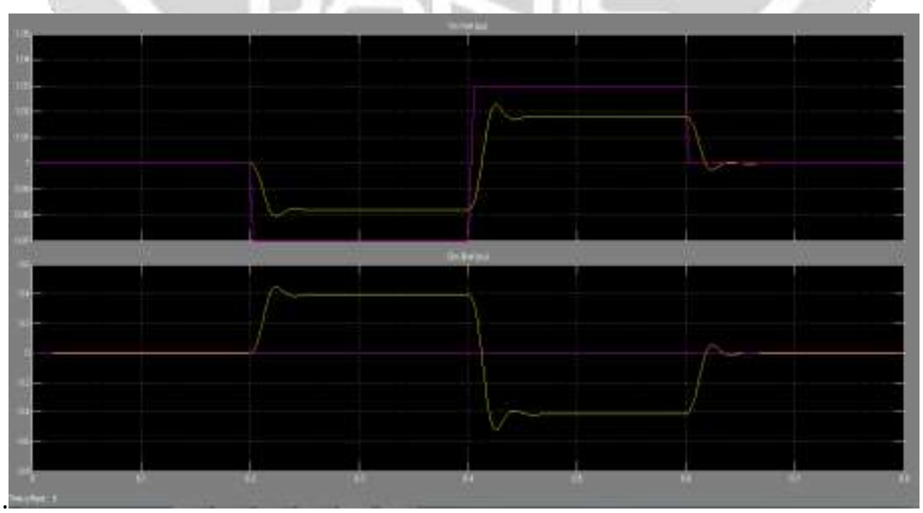

Fig 14:- STATCOM response when gain Kp=15 and Ki=3000

6.2 SVC analysis

In that section, we can analyzed performance of STATCOM. The response time for voltage changes of STATCOM varies based on regulator gain. When the regulator gain increases then response time of STATCOM for variation of voltage is quick whereas regulator gain decreases then response time of STATCOM for variation of voltage is slow as shown in figures 15-18.

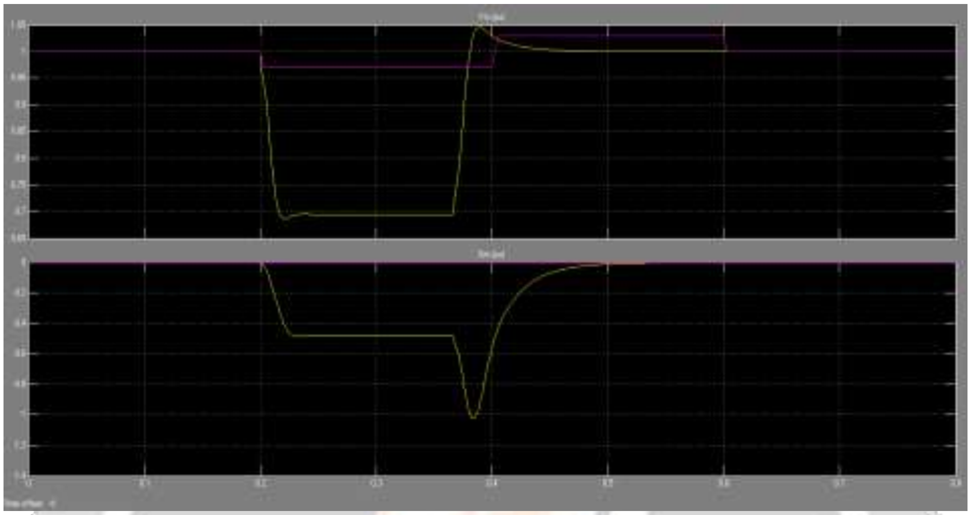

Fig 15:- SVC response when gain Kp=3 and Ki=500

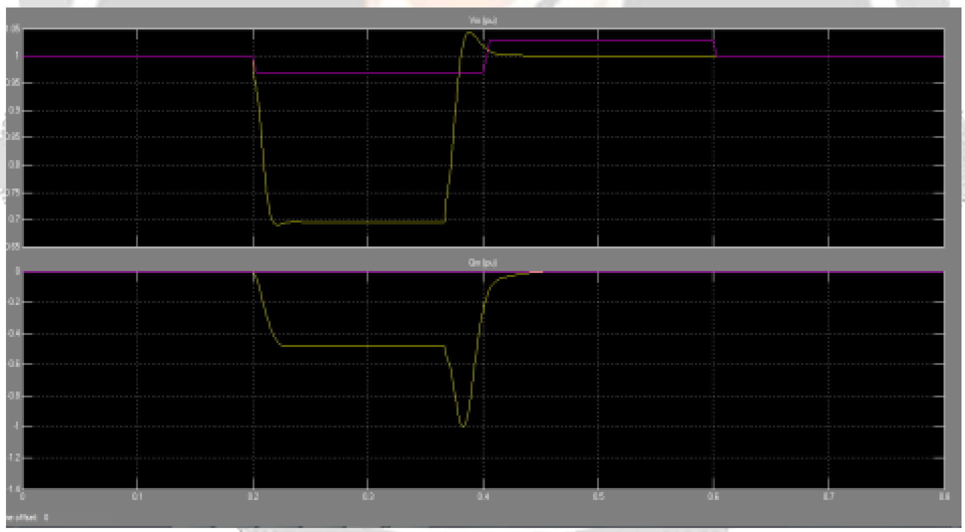

Fig 16:- SVC response when gain Kp=6 and Ki=1000

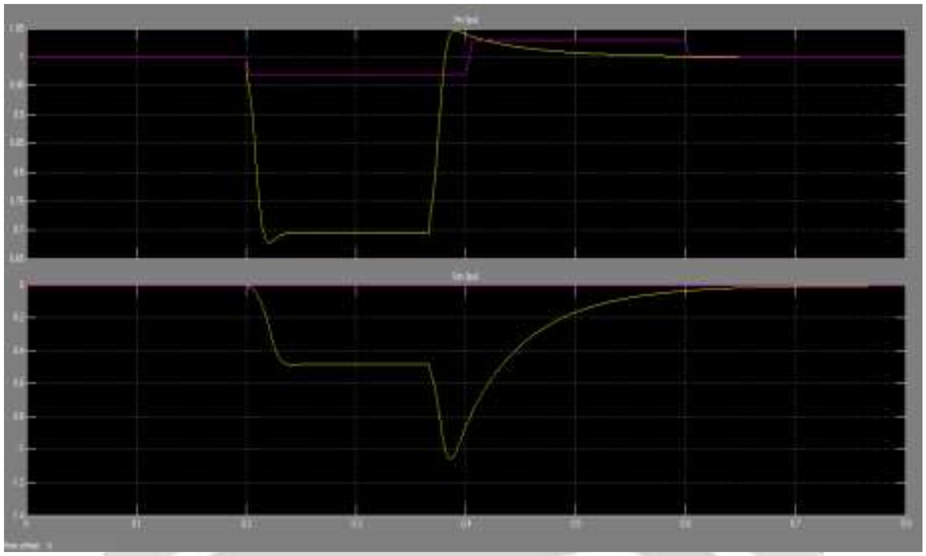

Fig 17:- SVC response when gain Kp=1 and Ki=200

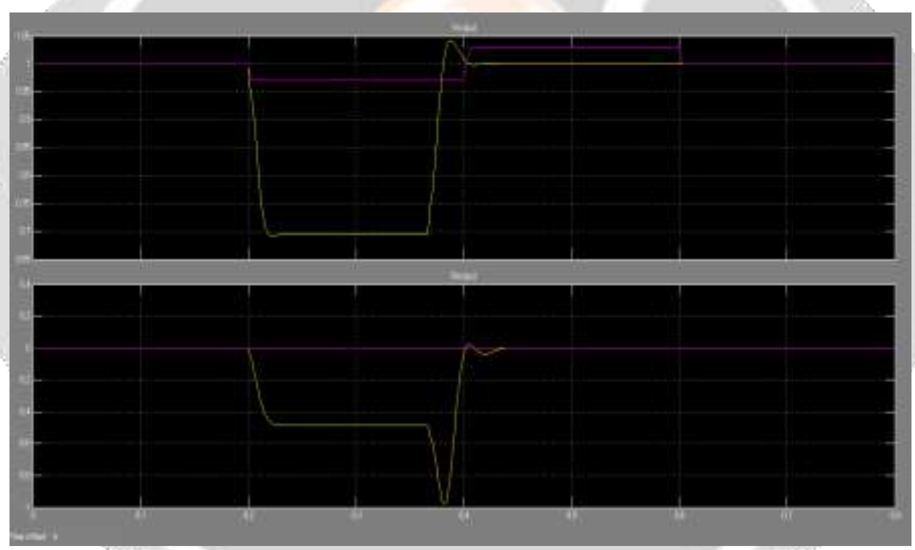

Fig 18:- SVC response when gain Kp=12 and Ki=1500

6. CONCLUSION

STATCOM and SVC are connected at the various locations such as sending end, middle and receiving end of the transmission line. Based on a voltage source converter, the statcom regulates system voltage by absorbing or generating reactive power. The results are obtained with and without compensation using matlab/simulink environment. The simulation results reveal that the reactive power obtained for STATCOM is better when compared with SVC at the middle of the transmission line.

7. REFERENCES

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