Voltage Improvement Using SHUNT FACTs Devices: STATCOM

Chandni B. Shah
PG Student
Electrical Engineering Department, Sarvajanik College Of Engineering And Technology, Surat, India
shahchandni31@yahoo.com

***Abstract* - Shunt Flexible AC Transmission System (FACTS) devices, when placed at the mid-point of a long transmission line, play an important role in controlling the reactive power flow to the power network and hence both the system voltage dips and Voltage swells. This Paper represent modeling aspect of STATCOM (Static Synchronous Compansator) which correct voltage dips or voltage swell and observe Reactive power compensation during different voltage magnitude and time interval. The power circuit of a STATCOM and distribution network are modeled by using blocks from Power system block set while Control circuit modeled by simulink blocks.**

***Index Terms*— STATCOM (Static compensator), PLL (Phase Lock Loop), Instantaneous Active and Reactive power Component**

I. INTRODUCTION

The Use of power electronics based apparatus at various voltage levels in electrical energy system is becoming increasingly widespread due to fast progress in power electronic technology. Recent development of power electronics introduces the use of FACTs devices in power system. FACTs device are capable of controlling network condition, this unique feature of FACTs devices can be exploited to improvement of power quality problems i.e. voltage sag, voltage swell and transient stability of a system.

The most majority disturbance that causes problem for electronic equipment is voltage sags as shown in figure 1. Voltage sag is defined as decrease in RMS value of voltage in range of 0.1 to 0.9 p.u Voltage Sag are huge problems in industries and they have been found especially troublesome because they are in random events lasting only a few cycles.

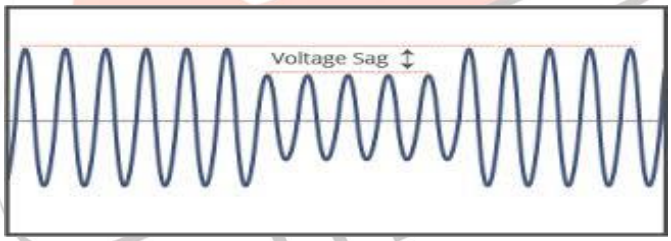

Figure 1 Waveform of Voltage Sag

Reactive power compensation is an important issue in electrical power system and shunt FACTs device play an important role in controlling the reactive power flow to power network.

The present paper deals with the simulation of distribution STATCOM along with the associated details of the circuit design. In this Work a PI controller has been suggested and added to the system to control its operation during some disturbances.

II. STATCOM MODEL

A. Introduction to FACTs

Flexible AC transmission systems, Called FACTs, got in the recent years a well known term for higher controllability in power systems by means of power electronics devices. Several FACTs devices have been introduce for various application worldwide. The development of FACTs device has started with growing capabilities of power electronic components [1].

The basic application of FACTS devices are:
- Voltage Control
- Reactive power compensation
- Stability Improvement
- Power flow control
- Increase of transmission capability

B. Basic Operation

STATCOM is a device, which use to generate or absorb reactive power. the basic electronic block of STATCOM is Voltage Source Inverter that converts an input dc voltage into three phase output voltage at fundamental frequency. It consist coupling transformer, a voltage source inverter and dc capacitor. A capacitor is use to maintain dc voltage to the inverter. The steady state power exchange between the voltage source inverter and the ac system is mainly reactive. A functional Model of STATCOM is shown in Figure.

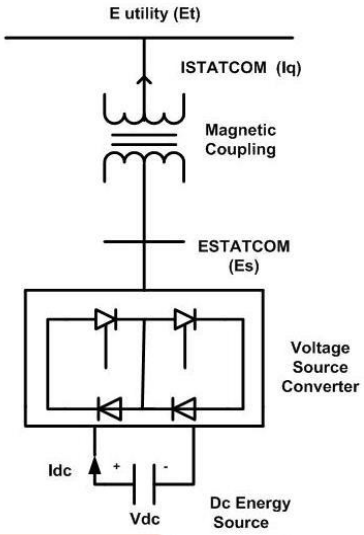

Figure 2 STATCOM Model

The amplitude of the converter output voltage controls the reactive power exchange between converter and ac system. If the amplitude of the output voltage of a voltage source converter is above the amplitude of the voltage of ac system than it will generate capacitive reactive power and if amplitude of the output voltage of a voltage source converter is below the amplitude of the voltage of ac system than it will absorb inductive reactive power.

III. PRINCIPLE OF REACTIVE POWER CONTROL

The principle of control reactive power via STATCOM is amount of type (capacitive/inductive) of reactive power exchange between the STATOM and the ac system can be adjusted by controlling STATCOM output voltage with respect to that of the system voltage. Three phase Instantaneous active and reactive power can be calculated using following equation:

$$P = V_a * I_a + V_b * I_b + V_c * I_c \quad \text{..... (1)}$$

$$Q = 1/\sqrt{3} * (V_{bc} * I_a + V_{ca} * I_b + V_{ab} * I_c) \quad \text{..... (2)}$$

IV. SIMULATION AND RESULTS

Three phase programmable voltage source which of voltage amplitude in range of [1.0, 1.12, 0.94, 1.0] p.u and Time range [0, 0.4, 0.6, 0.8]. Three phase programmable Voltage source and three phase series RL branch is connected with B1 and three phase parallel resistive load of 2 MW is connected with Bus B2 as shown in simulation model figure 3. Here distribution STATCOM is connected at Bus B3 through a 25/2 kv coupling transformer. Sample time 2e-6 is applied.

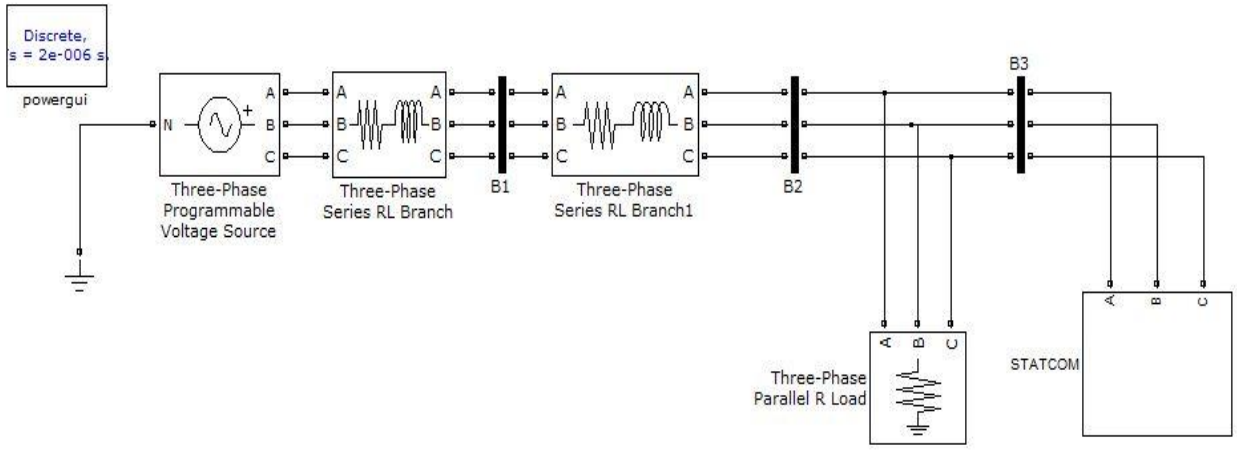

Figure 3 Simulation Model

Control Strategy:

A STATCOM have different control modes for voltage regulation and harmonic distortion. Vector control technique is employed as the control strategy [2]. The vector control technique provides fast control of the d-axis and q-axis currents, id and iq. In voltage regulation mode, the STATCOM absorbs/injects reactive power in order to regulate the bus voltage to the voltage reference value that is set in the controller. The voltage regulation is done by controlling the q axis current which controls the reactive power flow. The d-axis current loop is used to regulate the DC link voltage

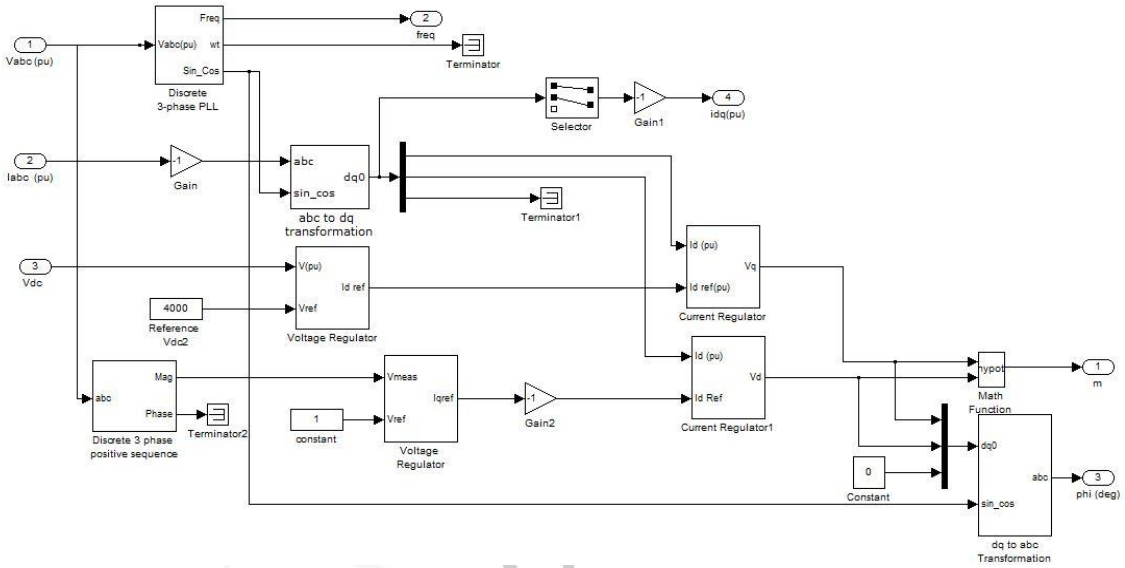

Figure 4 Control Strategy

A. *Without STATCOM*

Observe Voltage and Current of phase A at Bus 2 , nature of waveform as shown in simulation results here reactive power comparison operation of distribution system with / without STATCOM .RMS value of voltage is calculated using discrete RMS value block .Three phase Instantaneous Active and reactive Power measurement is used to observe how much Reactive power compensation is achieved.

Simulation Results: Here during the time t= 0 to t=0.4 sec voltage magnitude is 1 pu , during time interval of t=0.4 to 0.6 it will create voltage swell condition and when time t=0.6 to 0.8 voltage magnitude create dip condition as shown in a figure 5. Rms voltage of bus B2 is observed shown in a figure 6.

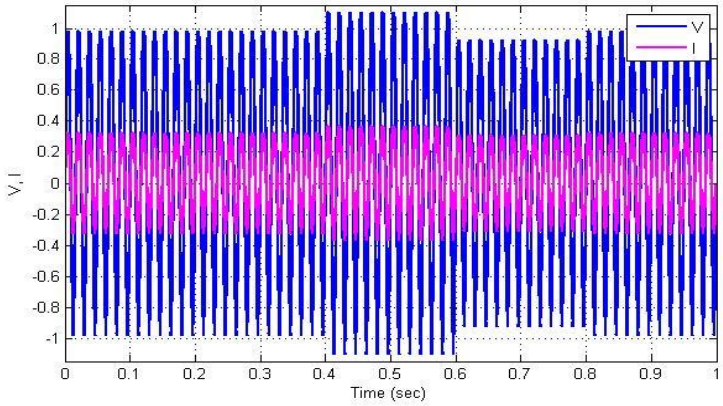

Figure 5 Waveform of Voltage and Current of Phase A

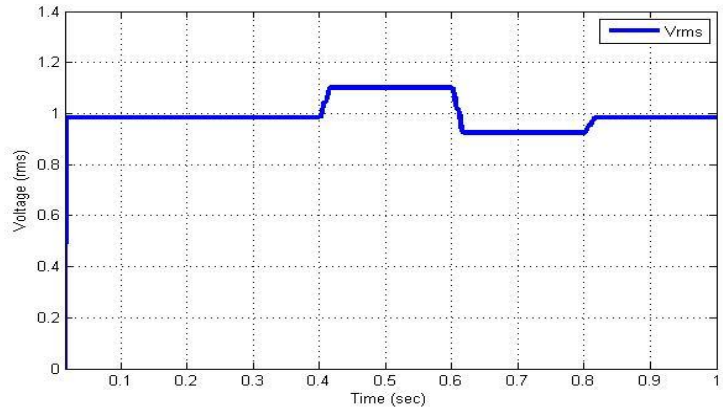

Figure 6 Waveform of RMS voltage

B. *With STATCOM*

Operation of 3 Mvar distributions STATCOM is observed when it is connected to a bus B2 . When STATCOM is in operation voltage sag and voltage swell condition can be improved as shown in a figure 8.

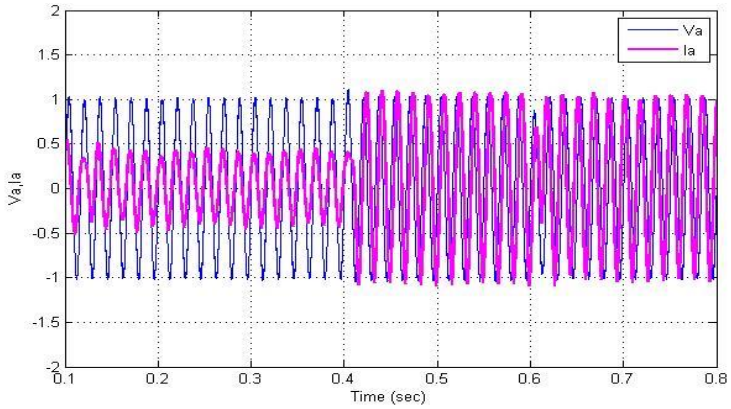

Figure 7 Waveform of Voltage and current of Phase A

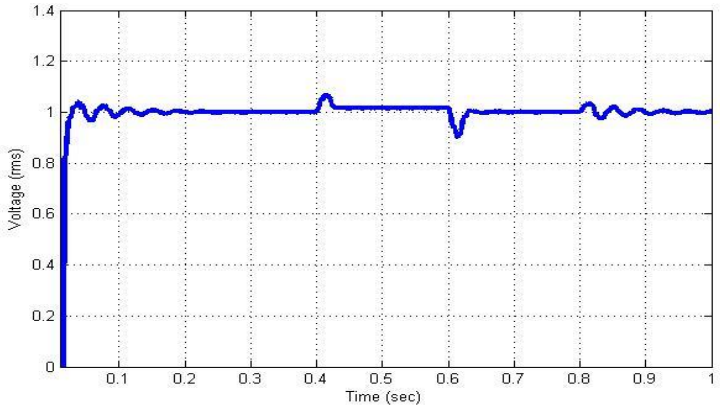

Figure 8 Waveform of RMS voltage

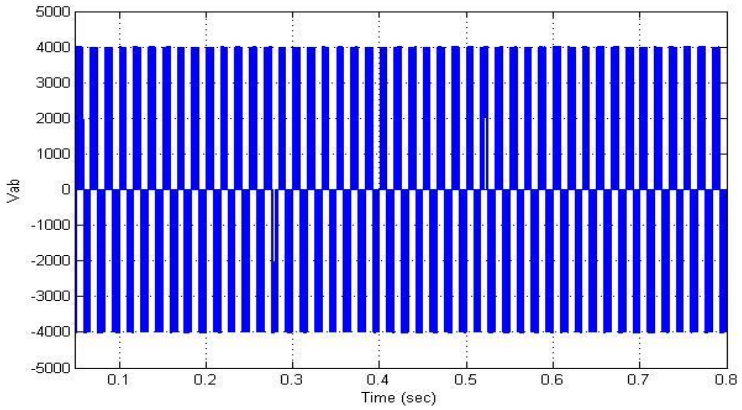

Figure 9 DC Capacitor Voltage

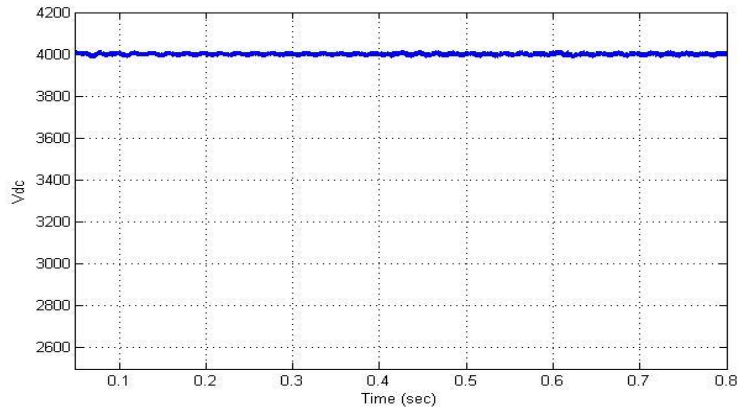

Figure 10 DC Capacitor Voltage

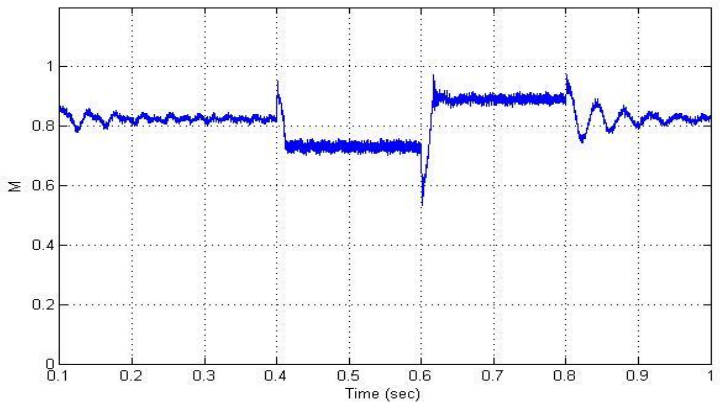

Figure 11 Waveform of Modulation Index

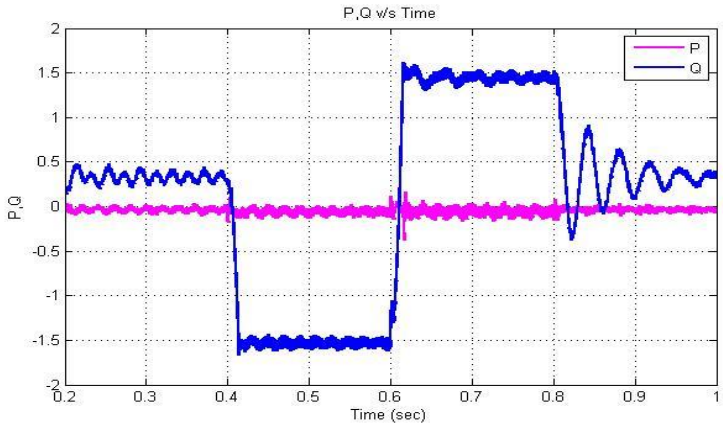

Figure 12 Waveform Of Active and Reactive Power

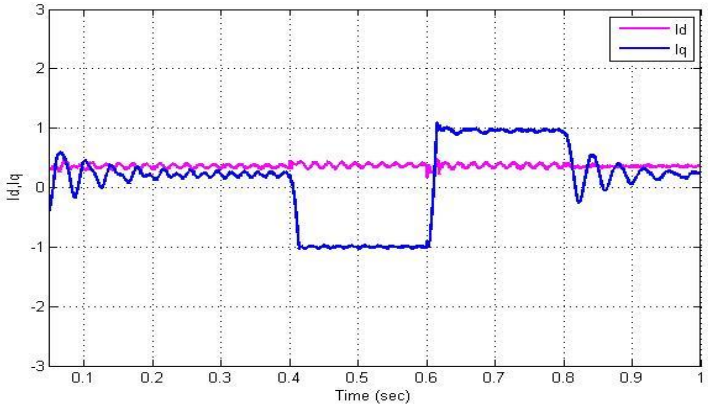

Figure 13 Waveform of Current Id and Iq

By using PQ theory Instantaneous active and reactive power, modulation index, inverter voltage also observed as shown in above figures.

V. CONCLUSION

From simulation result it can be concluded that when Output Voltage of a converter is Less Then Bus Voltage then Converter absorbs Reactive Power and If Output Voltage of a converter is greater than Bus Voltage then converter generates Reactive Power. DSTATCOM can be used to correct voltage sag or voltage swell of any inductive network.

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