Review on STATCOM

Manish Pradip Bhuse
(Dept. of Electrical Engineering, K.C.E's COE&IT , Jalgaon, INDIA, bhusemanish@gmail.com)

***Abstract*—**The renewable energy sources play an important role in electric power generation with growing environmental concern among them wind power is the most efficient way to generate electricity. Wind generation are far away from the grid most of the time, so the power was transfer to long distance. There are various types of issue like reactive power compensation, poor power factor and harmonic distortion in wind power output. In order to mitigate these problems the power electronics converters, like SVC, TCPST, DVR, UPFC, TCSC, and STATCOM are used. Among them STATCOM is the device having ability to inject and absorb reactive power fastley as per the system requirement.There are various control techniques are available for implement these problems. In these paper the application of STATCOM and various control technique for it are discuss.

Keywords—**static synchronous compensator(STATCOM), Voltage source converter (VSC), Inverse gate bipolar transistor (IGBT).**

1. INTRODUCTION

The rapid growth in electrical energy use, combine with demand for low cost energy, has gradually lead to the development of renewable energy sources. There are several types of renewable energy sources like wind energy, geothermal energy, tidal energy among them wind is the suitable way of generating the power because of its availability and initial cost. As we know that wind generation plant are away from the remote location most of the time. In order to transfer the bulk power from generating station to remote location it is necessary to use of transmission line to connect the load center and grid network. With a long distance of ac power transmission the reactive power is required to stabilize the system. There are various types of FACTS devices are used for reactive power injection among the various FACTS devices STATCOM is the device having ability to absorb or inject reactive power as per system requirement.

STATCOM is also called as Static Synchronous Compensator is connected in shunt with the grid network will provide the reactive power to the line only if the load is suffer from lack of reactive power at given bus location and vice versa[1]. STATCOM is a voltage source converter (VSC) device. The voltage source is in behind the reactor of the STATCOM. The symmetric arrangement of STATCOM consist of voltage source converter with DC link capacitor If suitable source is coupled across the DC capacitor, then STATCOM will provide active power to the line. Depending upon the amplitude of the voltage source, it will provide reactive power/ absorb reactive power [2]. The STATCOM will provide reactive power to the system when there will be increase in load it will also absorb the additional power when the load is suddenly remove from the system or fault occurs due to network failure in transient overload capability.

There are various control technique are used for controlling STATCOM these techniques are PI control technique, Fuzzy control technique, Bang-Bang current controller for STATCOM. In this paper various control technique for STATCOM are discuss.

The organization of the paper is as follows: section II provides an overview of power quality problems. Section III briefly describe STATCOM and its features; in section IV voltage source converter is describe while in section V various control technique for STATCOM is discuss. Section VI represents the conclusion.

2. POWER QUALITY ISSUE IN SYSTEM

A. Voltage spikes

Voltage spike is the transient behavior of natural voltage waveform appears for few micro seconds to millisecond it can damage the equipment due to its high surge. The equipment like circuit breaker, relay are fail to operate due to its small transient period voltage spike waveform shown in Fig 1.It is mainly happen due to disconnection of heavy load. This is caused due to lightning strikes, power outages, short circuit, tripping circuit breaker, inductive spikes etc.[4]

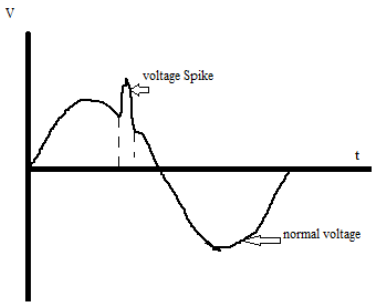


Fig.1 Voltage spike waveform.

B. RMS voltage variation

There are three types of variation in rms voltage like voltage sag, voltage swell & interruption. The voltage sag is a short duration of reduction in rms voltage and this is caused due to short circuit, starting of inductive load or overload etc., The fig 2 shows that the voltage sag happen when the rms voltage decrease between 10 to 90% of nominal voltage for one half cycle to one minute. The voltage sag happens due to Line to ground fault occurs, electric motor draws more current at start, lightning, falling of object in power line, sudden load changes etc.

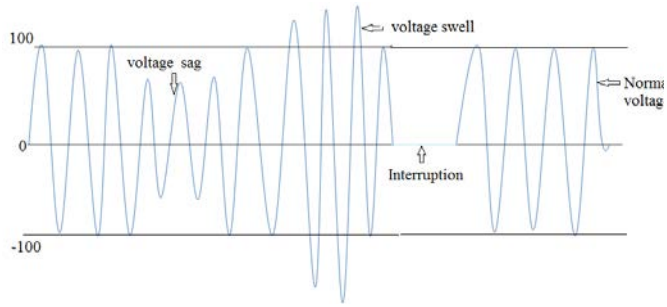


Fig.2 voltage sag, voltage swell and interruption

Voltage swell is defined as increase in RMS voltage level to 110-180% of nominal, at power frequency for duration of ½ cycles to 1 minute as shown in fig 2. These causes are happen due to large amount of load or large rating motors are shut down rapidly from the supply grid or system.

A voltage interruption is a large decrease in RMS voltage to less than a small percentile of the minimal voltage, or a complete destruction of voltage. Voltage interruptions may come from accidents like faults and component failures, or from planned downtime. Small voltage interruptions are typically the result of a failure of a switching device or unintentional operation of circuit breaker, fuse or recloser in response to faults and disturbances. Long disturbances are usually the result of programmed downtime, where part of an electrical power system is cut off in order to perform maintenance or repairs. [5]

C. Voltage Unbalance

Voltage unbalance is defined as the largest difference between the average RMS voltage and the RMS value of any single voltage phase divided by the average RMS voltage, usually expressed as a percentage shown in fig 3.Unbalanced loads or single-phase loads that are not evenly distributed between the phases of a three-phase system will cause voltage distortion. Usually the voltage disturbance is found within the capability. Other causes can be due to transformer impedance not coordinated on banked transformers or feasibly a power factor correction bank with a bad capacitor or blown fuse.[6]

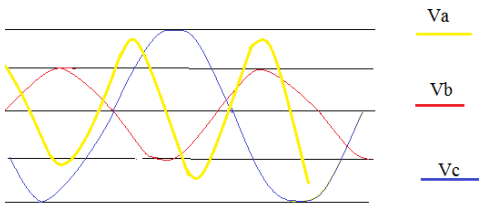


Fig.3 Voltage unbalances

D. Harmonic distortion

Harmonic voltages and currents in an electric power system are a result of non-linear electric loads. Harmonic frequencies in electric power grid are a common cause of power quality problems. Harmonics in power systems end result in enlarged heating in the equipment and conductors, misfiring in adjustable speed drives, and torque pulsations in motors. Decrease of harmonics is considered desirable following fig 4. Shows the harmonic distortion in power system

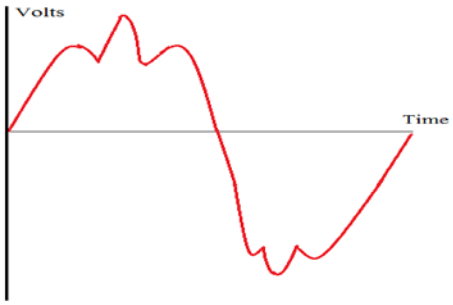


Fig 4. Harmonic distortion

.

3. OPERATION OF STATCOM

STATCOM is a principal shunt device of theFACTS family, which usages power electronics to regulate power flow and improve transient stability on power grids. The STATCOM is regulating the voltage and its terminal control by the amount of reactive power injected into or absorbed from the power system. The pure reactive power flows three phase voltages of the STATCOM must be maintained in phase with the system voltages [3]. The variation of reactive power is performed by means of a VSCconnected through a coupling transformer the schematic diagram of STATCOM is present in fig 5.

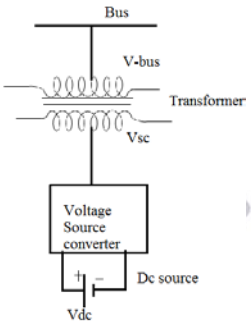


Fig5. STATCOM

The VSC uses forced commutated power electronics devices (GTO's or IGBT's) to synthesize the voltage from a dc voltage source. The operating principle of STATCOM is explained in Fig5. It can be seen that if V-vsc> V-bus then the reactive current Iq flows from the converter to the ac system through the coupling transformer by injecting reactive power to the ac system [7]. On the other hand, if V-vsc< V-bus then current Iq flows from ac system to the converter by absorbing reactive power from the system. Finally, if Voltage (vsc) = Voltage (bus) then no exchange of reactive power.The basic electronic block of the STATCOM is the voltage sourced inverter that converts an input dc voltage into a three-phase output voltage at fundamental frequency The STACOM employs an inverter to convert the DC link voltage Vdc on the capacitor to a voltage source of adjustable magnitude and phase. Therefore the STATCOM can be treated as a voltage controlled source The STATCOM can also be seen as a current-controlled source it consist of the inductance L and Resistance R Which represent the equivalent circuit elements of the step-down Transformer and the inverter will is the maincomponent of the STATCOM, d is the power angle of STATCOM and V is the effective output voltage of the STATCOM. The reactive power output of the STATCOM inductive or capacitive depending up on

the operation mode of the STATCOM. The construction controller of the STATCOM isused to operate the inverter in such a way that the phase angle between the inverter voltage and the line voltage is dynamically adjusted so that the STATCOM generates or absorbs the desired VAR at the point of fitting together. The period of the output voltage of the thyristor founded inverter, Vi, ismeasured in the similar way as the distribution system voltage, Vs.

4. VOLTAGE SOURCE CONVERTER

VSC is performing main role in operation of STATCOM it consist of six IGBT/MOSFET for operation. One side of the VSC is connected to the DC capacitor while other side connected to 3-phase AC system as shown below

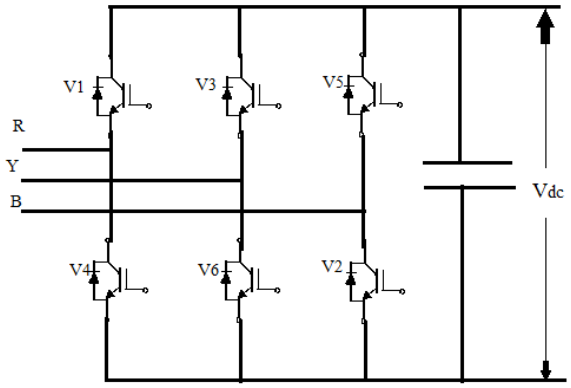


Fig. Voltage Source converter

When load voltage is drop down then VSC performing Inverting operation and supply power to the grid and vice versa. For smooth and controlled operation of VSC various pulse control technique are suggested

5. CONTROL TECHNIQUE OF VSC

There are various control technique are used for controlling STATCOM. PI control technique is used for regulating voltage and reactive power, for transient stability Fuzzy control is suggested. In order to control current Bang-Bang control is used.

1. *PI control technique for VSC*

PI control technique is used to regulate the system voltage and reactive power of VSC fig shows the PI controller for VSC. The control technique is depending up on the principal of a-b-c to d-q transformation. The output of PLL is used to measure the angle between direct axis and quadrature axis component of three phase voltage and current

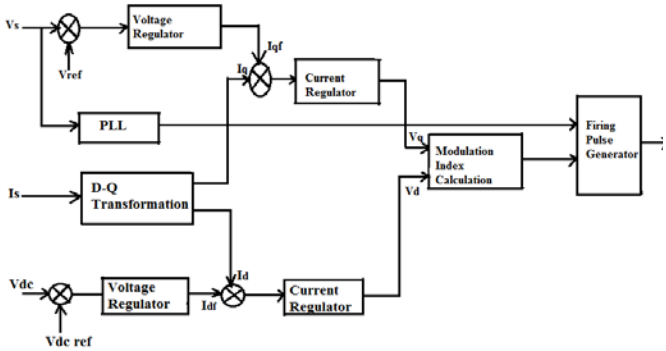
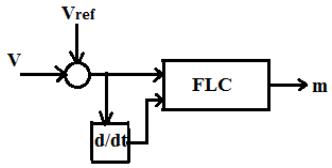


Fig. PI controller

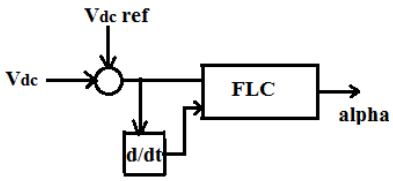
The external regulation loop consist of the ac voltage regulator provides the reference current (Iqf) for the current regulator that is always in quadrature with the terminal voltage to control the reactive power. PI control is employed for voltage control a supplementary regulator loop is added with the help of DC capacitor voltage.

2. *Fuzzy control*

Fuzzy control is the non-linear control used for controlling transient stability variation in control happen due to parameter condition. This feature of control logic is very helpful for power system application following fig shows the fuzzy controller.



a. Main control loop



b. Auxiliary control loop

The control technique for fuzzy logic is present here it consist of two control loop. The first loop use for controlling output voltage is also known as main controller it control output voltage by adjusting modulation index to regulate ac bus voltage. The auxiliary control loop control DC line capacitor voltage by adjusting phase angle alpha of VSC.

3. *Bang-Bang current controller*

Bang-bang controller is used for controlling current having basic operation depends on hysteresis current control. The Bang-Bang controller generates switching signal for VSC the controller having aim of providing correct switching signal to VSC following fig shows the Bang-Bang current controller.

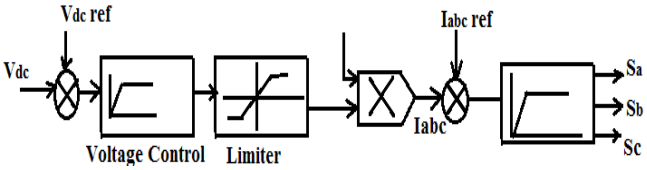


Fig . Bang-Bang controller

Here input Vdc is compare with ref Vdc and actual voltage is subtracted and signal is provided to limiter having aim to limit the voltage. The current control block in Bang-bang controller is received an input from reference and actual current is supplied to current control. In current control hysteresis control is used for generating on/off switching signal for IGBT.

6. CONCLUSION

Thus conclude that performance of STATCOM with various control technique For voltage source converter are discuss here, PI control technique is suggested for voltage and reactive power injection, Fuzzy control is used for transient stability disturbances while Bang-bang current controller is discuss for controlling hysteresis current. Among the various control technique Bang-Bang controller provide correct switching signal to the VSC. The proposed method is employed for switching pattern of IGBT device of STATCOM. The power supplied by STATCOM is proportional to network disturbances to improve voltage profile.

REFERENCES

[1] B.Singh, R.Saha, K.Al-Haddad, A.Chandra "Static Synchronous Compensators (STATCOM) : a review" Published in IET Power Electronics 22nd April 2008.
[2] M. Molinas, J. A. Suul, and T. Undeland, "Low voltage ride through of wind farms with cage generators: STATCOM versus SVC," IEEE Trans. Power Electron., vol. 23, no. 3, pp. 1104–1117, May 2008.
[3] T. Manokaran, B.Sakthivels and Mohamed Yousuf,"Cascaded Multilevel Inverter Based Harmonic Reduction in Statcom" International Journal of Engineering Science and Technology, Vol. 2(10), 2010.
[4] Pui Yung,Ka Nang Leung," An output- capacitorless Low-Dropout Regulator with Direct Voltage Spike Detection" IEEE journal of solid state circuits, Volume:45,issues:2 2010
[5] Yunus,A.M.S, Masoum,M.A.S, Abu-Siada, A. Applied Superconductivity," Application of SMES to Enhance the Dynamic
Performance of DFIG During Voltage Sag and Swell" IEEE Transactions on volume:22,Issues:4 2012.
[6] Changjin Liy, Dehong Xu, nan Zhu, Blaabjerg, Min Chen, "DC-VoltageFluctuation Through a DC-Capacitor Current Control for DFIG Converters Under Unbalanced Grid Voltage Conditions" IEEE
[7] Transactions on Power Electronics Volume:28, Issue:7 2013R.S. Dhekekar and N.V. Srikanth,"H-Bridge Cascade Multilevel VSC Control for Effective VAR Compensation of Transmission Line" 16th National Power Systems Conference, December.