

Voltage Regulation and Reactive Power Compensation by STATCOM based on 48-Pulse GTO (VSC)

Ajinkya Pachghare¹, R.M.Sahare²

Department of Electrical Engineering, Government College of Engineering, Amravati, Maharashtra, India¹

Department of Electrical Engineering, Government College of Engineering, Amravati, Maharashtra, India²

ABSTRACT: In this paper we presented STATCOM based on 48-pulse GTO for reactive power compensation and voltage regulation. Here we propose to tackle the existing problem in power transmission systems with multiple controller systems. The comprising a 48-pulse GTO(Gate Turn-Off) thyristor voltage source converter for combined reactive power compensation and voltage regulation of the electric grid network. This simulation of STATCOM are developed in MATLAB/simulink by utilizing the blocks from the power system block set mean while control system is modeled. The proposed work is to decouple the both voltage and current control strategy with two controllers by SATABCOM. This problem is ensure that the system operates in stable condition with STATCOM with various loads and the phase locked loop inherent delay has a great effect on dynamic operation of STATCOM and also is to regulate the proposed technique and to enhance the dynamic performance of STATCOM this proposed 48 pulse control schemes are validated.

KEYWORDS: Gate Turn-Off (GTO), Static Shunt Compensator (STATCOM), voltage source convertor (VSC)

I. INRODUCTION

Without electricity, modern society would cease to function. As the volume of power transmitted and distributed increases, so do the requirements for a high quality and reliable supply. At the same time, rising costs and growing environmental concerns make the process of building new power transmission and distribution lines increasingly complicated and time-consuming. Making existing lines as well as new ones more efficient and economical, then becomes a compelling alternative. Optimum power transmission and distribution also entails the reduction of transfer losses and provision of adequate power quality and availability at the receiving end. The purpose of transmission network is to pool power plants and load centers in order to minimize the total power generation capacity and fuel cost. In general, if a power delivery system was made up of radial lines from individual local generators without being part of a grid system, more generation sources would be needed to serve the load with same reliability and the cost of electricity would be much higher. In this point of view, transmission is an alternative to a new generation resources. As power transfer grow, the power system becomes increasingly more complex to operate and the system become less secure. It may lead to large power flows with inadequate control, excessive reactive power in various parts of the system and large dynamic swings between different parts of the system, thus the full potential of transmission interconnections cannot be utilized. Assuming that sufficient generated power is available, the challenge is to ensure the reliable operational performance of the delivery system, Reliable system operation requires coordinated management of both generation and transmission assets, since the pattern of generation strongly influences "loadability" of the transmission lines. Restructuring has greatly reduced the degree to which grid operators can manage the generation side of the relationship, so the emphasis here is upon enhanced system performance through improvements in transmission capabilities alone

II. STATCOM

The STATCOM is the static counterpart of the rotating synchronous condenser but it generates/absorbs reactive power at a faster rate because no moving parts are involved. In principle, it performs the same voltage regulation functions as the SVC but in robust manner because unlike the SVC, its operation is not impaired by the presence of low voltage. The STATCOM has superior performance during low voltage condition as the reactive current can be maintained constant. (In a SVC, the capacitive reactive current drops linearly with the voltage at the limit of capacitive susceptance). It is even possible to increase the reactive current in a STATCOM under transient conditions if the devices are rated for the transient overload. In 1976, Gyugyi discussed various switching power converters, which generating controllable reactive power directly without the use of ac capacitors or reactors. Functionality, from the standpoint of reactive power generation, their operation is similar to that of an ideal synchronous machine whose reactive power output is varied by excitation control. Like the mechanically powered machine these converters can also exchange real power with the ac system if supplied from a suitable, generally dc energy source. Because of these similarities with a rotating synchronous generator, they are termed Static Synchronous Generator (SSG). When SSG isoperated without an energy source and with appropriate controls to function as shunt-connected reactive compensator, it is termed, analogously to the rotating synchronous compensator (condenser) a Static Synchronous Compensator (STATCOM) or Static Synchronous Condenser (STATCON).

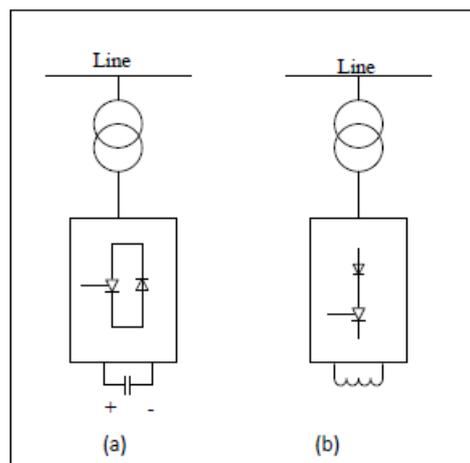


Fig-1: Static Synchronous Compensator (STATCOM) based on (a) Voltage sourced (b) current sourced converter

III. SYSTEM DEVELOPMENT

As the STATCOM is a solid-state voltage source converter coupled with a transformer tied to a line can injects reactive current or power to the system to compensate the voltage-dip. The Voltage-Source Converter (VSC) is the main building block of the STATCOM. It produces square voltage waveforms as it switches the direct voltage source ON and OFF. The main objective of VSC is to produce a near sinusoidal AC voltage with minimum waveform distortion or excessive harmonic content. This can be achieved by employing multiple pulse converter configuration. To obtain the multiple-pulse converters i.e. 12- pulse 24-pulse and 48-pulse VSC a two four or eight 6-pulse VSC can be used with the specified phase shift between all converters. A 48- pulse VSC can be used for high power applications with low distortion because it can ensure minimum power quality problems and reduced harmonic contents. A 48-pulse GTO based VSC can be constructed using two (24-pulse GTO based) converters shifted by 7.5° from each other. In this kind of converters there is no need of AC filters due to its low harmonic distortion content on the ac side. This new multiple-pulse converter configuration produces almost three phase sinusoidal voltage and maintains THD (Total Harmonic Distortion) well below 4%. a three-level 24-pulse STATCOM with a constant dc link voltage and pulse width control at fundamental frequency switching validated the inductive and capacitive operations of the STATCOM with satisfactory performance. The harmonic content of the STATCOM current is found well below 5% as per IEEE

standards. Simulation model of 48-pulse VSC based STATCOM FACTS devices. This full model is validated for voltage stabilization reactive power compensation and dynamic power flow control. It produces a sinusoidal AC voltage with minimal harmonic distortion from a DC voltage with variable loads. Also investigated that the GTO based STATCOM consisting a 48-pulse three-level inverter regarding minimal harmonic distortion. It has fine dynamic response and can regulate transmission system voltage efficaciously.

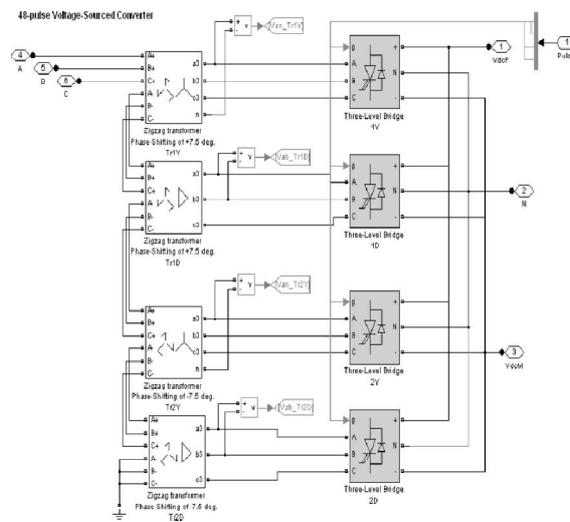


Fig-2: 48-pulse GTO (VSC)

IV. DECOUPLED CURRENT CONTROL SYSTEM

The new decoupled control system is based on a full d-q decoupled current control strategy using both direct and quadrature current components of the STATCOM ac current. The decoupled control system is implemented as shown in Fig. A phase locked loop (PLL) synchronizes on the positive sequence component of the three-phase terminal voltage at interface Bus 2. The output of the PLL is the angle that is used to measure the direct axis and quadrature axis component of the ac three-phase voltage and current. The outer regulation loop comprising the ac voltage regulator provides the reference current (I_{qref}) for the current regulator that is always in quadrature with the terminal voltage to control the reactive power. The voltage regulator is a proportional plus integral PI controller with $K_p=12$ and $K_i=3000$. The current regulator is also PI controller with $K_p=5$ and $K_i=40$. The PLL system generates the basic synchronizing-signal that is the phase angle of the transmission system voltage and the selected regulation-slope determines the compensation behavior of the STATCOM device. To enhance the dynamic performance of the full 48-pulse STATCOM device model, a supplementary regulator loop is added using the dc capacitor voltage. The dc side capacitor voltage charge is chosen as the rate of the variation of this dc voltage. Thus, for a fixed selected short time interval, the variation in V_{dc} the magnitude is measured, and any rapid change in this dc voltage is measured and if this change is greater than a specified threshold K , the supplementary loop is activated. The main concept is to detect any rapid variation in the dc capacitor voltage. The strategy of a supplementary damping regulator is to correct the phase angle of the STATCOM device voltage, with respect to the positive or negative sign of this variation. If, the dc capacitor is charging very fast. This happens when the STATCOM converter voltage lags behind the AC system voltage; in this way, the converter absorbs a small amount of real power from the ac system to compensate for any internal losses and keep the capacitor voltage at the desired level. The same technique can be used to increase or decrease the capacitor voltage and, thus, the amplitude of the converter output voltage to control the var generation or absorption. This supplementary loop reduces ripple content in charging or discharging the capacitor and improves fast controllability of the STATCOM.

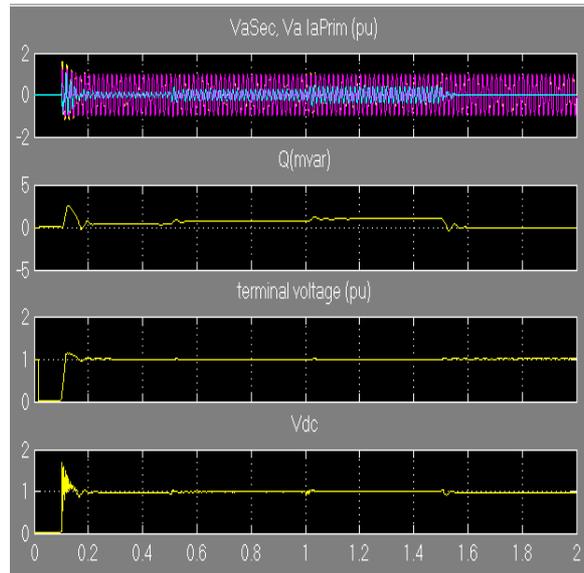
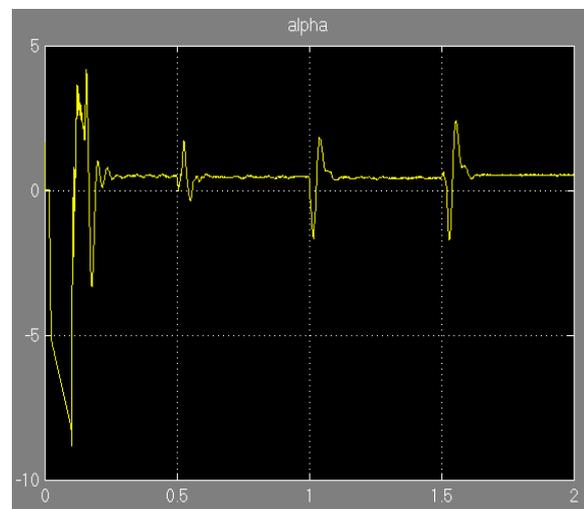


Fig 5: Result of STACOM



VI. CONCLUSION

The paper presents a novel full 48-pulse GTO voltage source converter of STATCOM a FACTS device. These full descriptive digital models are validated for voltage stabilization reactive compensation and dynamically power flow control using three novel decoupled current control strategies. The control strategies implement decoupled current control based on a pulse width modulation switching technique to ensure fast controllability minimum oscillatory behavior and minimum inherent phase locked loop time delay as well as system instability reduced impact due to a weak interconnected ac system

REFERENCES

- [1] M. S. El-Moursi and A. M. Sharaf, "Novel Controllers for the 48-Pulse VSC STATCOM and SSSC for Voltage Regulation and Reactive Power Compensation" *IEEE TRANSACTIONS ON POWER SYSTEMS*, VOL. 20, NO. 4, NOVEMBER 2005
- [2] C. Schauder and H. Mehta —Vector analysis and control of advanced static var compensator| in Proc. Inst. Elect. Eng. Int. Conf. AC DC Transmission 1991 pp. 299–306. Paper no. 345.
- [3] D.Soto and C. Green —A comparison of high-power converter topologies for the implementation of facts controllers| *IEEE Trans. Indust. Electron.* vol. 49 no. 5 pp. 1072–1080 Oct. 2002.
- [4] K. K. Sen —SSSC—static synchronous series compensator: Theory modeling and application| *IEEE Trans. Power Del.* vol. 13 no. 1 pp. 481–486 Jan. 1998.
- [5] R. M. Mathur and R. K. Varma Thyristor-Based FACTS Controllers for Electrical Transmission Systems. Piscataway NJ: IEEE Press 2002.
- [6] Sahoo A. K. Murugesan K. Thygarajan T. —Modelling and Simulation of 48-pulse VSC based STATCOM using Simulink's Power System Blockset| Proceedings of *India International Conference on Power Electronics* pp. 303-308 December 2006.
- [7] Huang S. P. Li Y. J. Jin G.B. Li L. —Modelling and Dynamic Response Simulation of GTO based STATCOM| Proceedings of the *International Conference on Electrical and Control Engineering* pp. 1293-1296 June 2010
- [8] X.-P. Zhang, —Advanced modeling of the multicontrol functional static synchronous series compensator (SSSC) in Newton power flow,| *IEEE Trans. Power Syst.*, vol. 18, no. 4, pp. 1410–1416, Nov. 2003.
- [9] Y. Liang and C. O. Nwankpa, —A new type of STATCOM based on cascading voltage-source inverter with phase-shifted unipolar SPWM,| *IEEE Trans. Ind. Appl.*, vol. 35, no. 5, pp. 1118–1123, Sep./Oct. 1999.