International Journal of Scientific Research in Computer Science and Engineering
Research Paper
Vol.5, Issue.4, pp.41-44, August (2017)
E-ISSN: 2320-7639

Voltage regulation and reactive power compensation by SSSC based on 48-pluse GTO (VSC)

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Available online at: www.isroset.org

Received 14th Jun 2017, Revised 26th Jun 2017, Accepted 20th Jul 2017, Online 30th Aug 2017

Abstract—In this paper, the performance of power systems decreases with the size, the loading and the complexity of the system networks. This is related to problems with power oscillations, large power flow and voltage instability with inadequate control, so the power flow control plays a major role in power systems. In this paper SSSC series FACTS device are regulates system voltage by absorbing or generating reactive power and the control of active, reactive power flow and voltage well as damping power system oscillations in long transmission line. In this paper Simulation studies were carried out in the MATLAB simulation environment to observe the compensation achieved by the SSSC device. The system parameters such as voltage, current, active power and reactive power transmissions are observed when the SSSC is connected to the power system.

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

I. INTRODUCTION

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 thedegree 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. STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

Static synchronous series compensator (SSSC) is one of the important members of FACTS family which can be installed in series in the transmission lines. SSSC is very effective in controlling power flow in a transmission line with the capability to change its reactance characteristic from capacitive to inductive. Among all FACTS devices, static synchronous series compensators (SSSC) plays much more important role in reactive power compensation and voltage support because of its attractive steady state performance and operating characteristics. The SSSC using a voltage source converter to inject a controllable voltage in quadrature with the line current of a power network is able to rapidly provide both capacitive and inductive impedance compensation independent of the power line current. The SSSC injects a voltage Vs in series with the transmission line where it is connected.

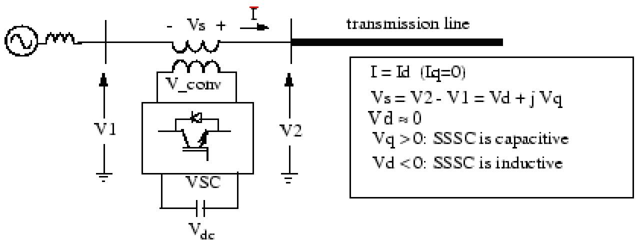

Fig.1Single line diagram of SSSC Configuration

III. RELATED WORK

As the SSSC 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 SSSC. 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 multiplepulse 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%. three-level 24-pulse SSSC with a constant dc link voltage and pulse width control at fundamental frequency switching validated the inductive and capacitive operations of the SSSC with satisfactory performance. The harmonic content of the SSSC current is found well below 5% as per IEEE standards. A simulation model of 48-pulse VSC based SSSC 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 and also investigated that the GTO based SSSC consisting a 48-pulse three-level inverter regarding minimal harmonic distortion. It has fine dynamic response and can regulate transmission system voltage efficaciously.

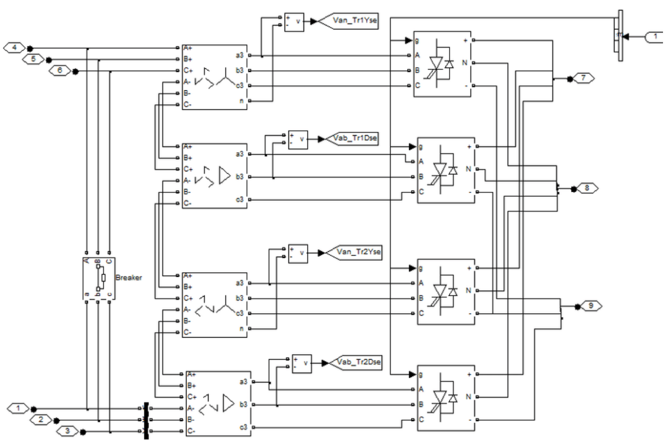

Fig 2: 48-pluse GTO (VSC)

IV. POWER SYSTEM DESCRIPTION

The test system is a simple power system 230-kV network grid equipped with the SSSC and its novel controller, which connected in series with the transmission system. Modeling the SSSC compensator, including the power network and its controller in MATLAB/Simulink environment, requires using “electric blocks” from the power system blockset and control blocks from thr Simulink library. A 70 Mvar SSSC device is connected to the 230-kV grid network. Fig. 3 shows the single line diagram that represents the SSSC and the 230/33-kV grid network. The feeding network is represented by an its equivalent Thevenin (bus B1) where the voltage source is a 230 kV with 10 000 MVA short circuit level with a resistance of 0.1 p.u. and an equivalent reactance of 0.3 p.u. followed by the 230-kV radial transmission system connected to bus B2. The full system parameters are given in Table II. The SSSC FACTS device consists mainly of the 48–pulse GTO-voltage source converter model that is connected in series with the transmission line at Bus B1 by the coupling transformer T1. The dc link voltage is provided by capacitor C, which is charged with an active power taken directly from the ac network. The novel full 48-pulse GTO-VSC model results in less harmonic distortion than other 6-, 12-, and 24-pulse converters or functional models usually used to represent SSSC device operation.

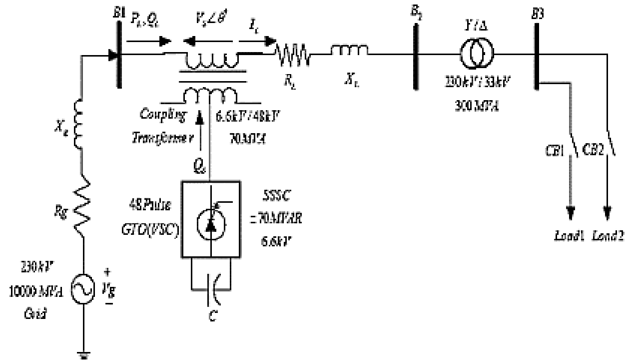

Fig 3: Radial 230-kV test sample power system.

V. 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 SSSC 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 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 (Iqref) 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 Kp=12 and Ki=3000. The current regulator is also PI controller with Kp=5 and Ki=40. The PLL system generates the basic synchronizing-signal that is the phase angle of the transmission system voltage and he selected regulation-slope determines the compensation behavior of the SSSC device. To enhance the dynamic performance of the full 48-pulse SSSC 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 Vdc 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 SSSC 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 SSSC converter voltage lag 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 SSSC.

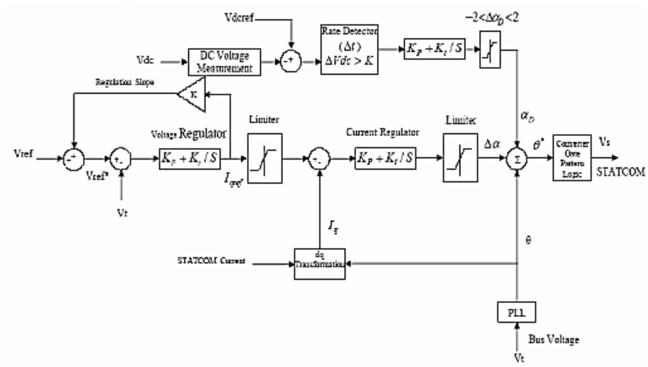

Fig. 4. Novel SSSC d-q decoupled current control system.

VI.SIMULATION DIAGRAM OF SSSC AND RESULTS

The novel decoupled control strategy for the SSSC is also validated in both capacitive and inductive operating modes when the system is subjected to severe disturbances of switching electric loads contingencies.

A. Capacitive Operation

The base power selected 300 MVA, and the base voltage selected 230 kV. The SSSC device operates in capacitive mode with Xref = -0.15 p.u. The grid voltage is calculated at 1.013 p.u., and the load on bus B3 is an inductive load with(P=0.5 p.u. and Q= 0.15p.u.) (at rated voltage). This load is connected from the start of the simulation; the SSSC device is switched into the transmission line at t=0.1 with a level of compensation S= 60%, i.e., the SSSC was set to compensate about 60% of the transmission line total reactance by injecting a capacitive voltage. Therefore, X_S = -0.6X_L. The dynamic simulation results are obtained for the SSSC voltage phase, dc capacitor voltage, the SSSC device reactive power, and the effective injected reactance are shown in Fig.3. The SSSC device is connected at time t= 0.1 s, while only load 1 (P=0.5 and Q=0.15) is attached to the system. At t= 0.5 s, load 2 (P = 0.235 and Q=0.135) is switched on for a duration of 0.4 s and then disconnected At t=0.9s. Due to this inductive load, the SSSC operates in the capacitive mode with phase angle of at almost. The SSSC device while operating in this capacitive mode also injects an equivalent capacitive reactance of in series with the transmission line. When load 2 is switched on, the capacitor and, therefore, the reactive power are increased in order to satisfy the specific. Since the SSSC device is in the capacitive mode, the injected voltage lags the line current by-90. A very small deviation from -90 makes the real power flow from the TL to the SSSC dc-side capacitor in order to compensate the real power losses of coupling transformer and the GTO switching. The effect of the capacitive series compensation on the power flow and bus voltage. where the bus voltage increased from 0.94 to 1.025p.u. during attaching only load 1 and to 1.04 p.u. when both load 1 and load 2 are connected; also, the SSSC device enhances the line power transfer by increasing the real power from 0.44 to 0.52 p.u.

B. Inductive Operation

To validate the inductive operation of the SSSC device, the capacitive load is connected to the Bus B3 in order to test the performance of the SSSC device while operating in the inductive mode. The digital simulation is carried out again under the same switching conditions of switching time with capacitive load at the same rated voltage. The grid voltage is 1.013 p.u. This is due to a slight overvoltage, which may occur sometimes. The simulation is carried out considering an inductive load 1 with (P =0.167 and Q = 0.017) (at rated voltage) while this load is fully connected from the start point of the digital simulation. In the case of an overvoltage, an inductive series compensation is required to decrease the voltage at load bus. When load 2 (a capacitive load with P=0.6 and Q= -0.45) is switched in at t=0.5 s for a duration of 0.4 s to the distribution network, this causes an overvoltage, so the inductive compensation is also required. The SSSC device is switched to the transmission line at t=0.1 s with a level of compensation S= 100%, i.e., the SSSC was set to inject an equivalent inductive reactance equal to the line reactance. The X_{ref} was selected at 0.25 p.u. The SSSC device is switched to the power system at t= 0.1 s, and the dc capacitor is charged by the real power flow from the transmission line to the dc-side capacitor. When load 2 is switched on at t=0.5 s, the SSSC device operates in the inductive mode, and the series injected voltage leads the transmission line current by 90. The SSSC device provides a fast inductive series compensation for the power system. The inductive series compensation plays a vital role in decreasing the overvoltages that occur due to the capacitive load. The 48-pulse voltage source converter SSSC provides the required reference compensation to enhancethe maximum transmission power transfer with harmonic contentand better power quality.

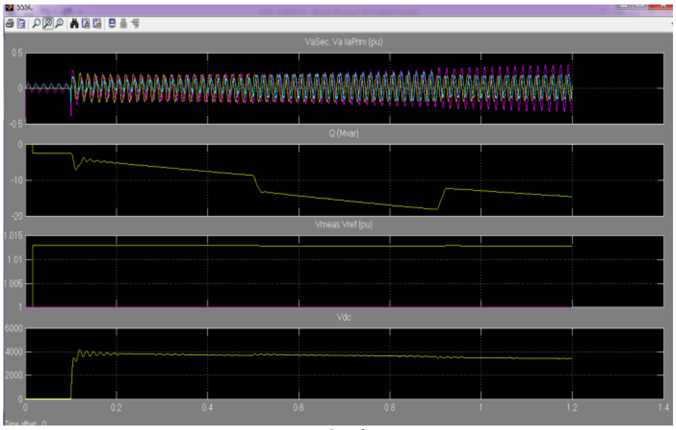

Fig 5: Result of SSSC

VII. 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 Electronicspp. 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 Engineeringpp. 1293-1296 June2010

[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] A. H. Norouzi and A. M. Sharaf, "*An auxiliary regulator for the SSSCtransient enhancement*," in Proc. IEEE 35th North Amer. Power Symp.,Rolla, MO, Oct. 2003.

[10] K. K. Sen, "*SSSC-static synchronous series compensator: Theory, modeling, and applications*," IEEE Trans. Power Del., vol. 13, no. 1, pp. 241–246, Jan. 1998.

[11] X.-P. Zhang, "*Advanced modeling of the multicontrol functional static synchronous series compensator (SSSC) in Newton power flow*," IEEETrans. Power Syst., vol. 18, no. 4, pp. 1410–1416, Nov. 2003

