Analysis the Modeling and Control of Integrated STATCOM System to Improve Power System

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ABSTRACT- In this paper we analysis the Modeling and Control of Integrated STATCOM System to Improve Power System STATCOM (Static Synchronous Compensator) is a reactive power compensating device belonging to the family of flexible alternating current transmission system (FACTS) devices used as a shunt compensating device for regulating the voltage of the transmission line.

Key words: - STATCOM, Flexible alternating current transmission system (FACTS), Matlab

I. INTRODUCTION

Recent developments in electrical power systems such as deregulation, open access, and cogeneration may be creating transmission congestion and forced outages scenarios. Addition of new transmission lines is an almost impossible solution due to environmental and other considerations. Developing of new approaches to Power System Operation and Control are required for overload relief, and efficient and reliable operation. Supporting dynamic disturbances such as transmission lines switching, loss of generation, short-circuits and load rejection, needs there active control to be fast enough to maintain the desired voltage levels and the system stability .Flexible AC Transmission Systems (FACTS), besides the underlying concept of independent control of active and reactive power flows, are an efficient solution to the reactive power control problem and voltage in transmission and distribution systems, offering an attractive alternative for achieving such objectives. Originally, equipment based on thyristors, like TCR (Thyristor Controlled Reactor), TSC (Thyristor Switched Capacitor), and SVC (Static VAR Compensator) has been employed in solving these problems, but now equipment based on controlled switches such as GTO, IGBT and IGCT are common.

II. STATCOM

A Static synchronous generator operated as a shunt-connected static VAR compensator whose capacitive or inductive output current can be controlled independent of the ac system voltage. In the last decade commercial availability of Gate Turn-Off thyristor (GTO) devices with high power handling capabilities and the advancement of other types of power-semiconductor devices have led to the development of controllable reactive power sources utilizing electronic switching converter technology. Additionally, these technologies offer considerable Advantages over the existing ones in terms of space reductions and performance. The GTOs enable the design of a solid-state shunt reactive compensation equipment based upon switching converter technology. This concept is used to create a flexible shunt reactive compensation device named Static Synchronous Compensator (STATCOM) due to its operating characteristics similar to that of a synchronous compensator although without the mechanical inertia. STATCOM is a VSC based FACTS controller being widely used as dynamic shunt compensator to rapidly control the dynamics especially during stressed system conditions through generation and absorption of controllable reactive power in AC power transmission and distribution systems.

Basic Arrangement of Statcom

In an electric power system it is essential to balance the active and reactive power supply demand. If such balance is lost, the system frequency and voltage excursion may bring even to the power system collapse. Appropriate voltage and reactive power control is one of the most important factors for stable power system operation. The STATCOM provides fast and continuous capacitive and inductive reactive power supply to the power system. The STATCOM is a power electronic based Synchronous Voltage Generator (SVG) that, from a dc capacitor, generates a three-phase voltage in synchronism with the transmission line voltage, and it is connected to it by a coupling transformer. By controlling the STATCOM's output voltage magnitude, the reactive power exchanged between STATCOM and the transmission system, and hence the amount of shunt compensation, can be controlled.

Applications of the STATCOM

The STATCOM is a state-of-the-art Flexible AC Transmission System (FACTS) technology that uses advanced power semiconductor switching techniques to provide dynamic voltage support, system stabilization, increased system capacity, and enhanced power quality for transmission and distribution system applications.

1) Utilities with weak grid knots or fluctuating reactive loads.
2) Unbalanced loads.
3) Arc furnaces.
4) Wood chippers.
5) Welding operations.
6) Car crushers & shredders.
7) Industrial mills.
8) Mining shovels & hoists.
9) Power factor correction (Cos phi control).
10) Voltage control.
11) Active harmonics cancellation.
12) Flicker mitigation.
13) Unsymmetrical load balancing.
14) Effective voltage regulation and control.
15) Reduction of temporary over voltages.
16) Improvement of steady-state power transfer capacity.
17) Improvement of transient stability margin.
18) Damping of power system oscillations.
19) Damping of sub synchronous power system oscillations.

Since STATCOM is a FACTS device that uses a DC source along with power electronics devices for producing three-phase voltage, it can cause interference on the fundamental sine wave of the system at frequencies that are multiples of the fundamental.

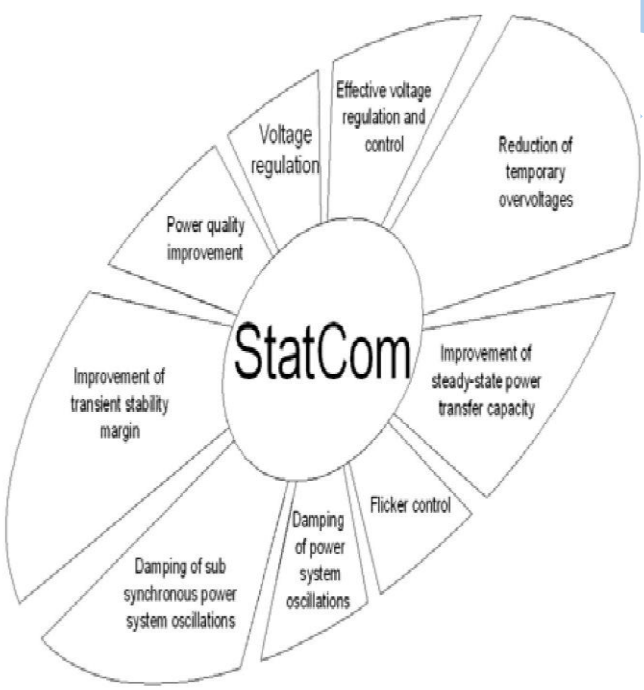

Figure-1 Typical applications of the STATCOM

III. INVERTERS

The word 'inverter' in the context of power-electronics denotes a class of power conversion (or power conditioning) circuits that operates from a dc voltage source or a dc current source and converts it into ac voltage or current. The 'inverter' does reverse of what ac-to-dc 'converter' does. Even though input to an inverter circuit is a dc source, it is not uncommon to have this dc derived from an ac source such as utility ac supply. Thus, for example, the primary source of input power may be utility ac voltage supply that is 'converted' to dc by an ac to dc converter and then 'inverted' back to ac using an inverter. Here, the final ac output may be of a different frequency and magnitude than the input ac of the utility supply. In this irrespective of power flow direction, 'inverter' is referred as a circuit that operates from a stiff dc source and generates ac output. If the input dc is a voltage source, the inverter is called a voltage source inverter (VSI). One can similarly think of a current source inverter (CSI), where the input to the circuit is a current source. The VSI circuit has direct control over 'output (ac) voltage' whereas the CSI directly controls 'output (ac) current'. Shape of voltage waveforms output by an ideal VSI should be independent of load connected at the output. Phase-controlled converters, when operated in the inverter mode, are called line-commutated inverters. But line-commutated inverters require at the output terminals an existing AC supply which is used for their commutation. This means that line-commutated inverters can not function as isolated voltage sources or as variable frequency generators with DC power at the input. Therefore, voltage level, frequency and waveform on the AC side of line-commutated inverters can not be changed.

IV. FACTS DEVICES

Modern power systems are highly complex and are expected to fulfill the growing demands of power wherever required, with acceptable quality and costs. The economic and environmental factors necessitate the location of generation at places away from load centers. The restructuring of power utilities has increased the uncertainties in system operation. The regulatory constraints on the expansion of the transmission network has resulted in reduction of stability margins and increased the risks of cascading out ages and blackouts. This problem can be effectively tackled by the introduction of high power electronic controllers for the regulation of power flows and voltages in AC transmission networks. This allows 'flexible' operation of AC transmission systems whereby the changes can be accommodated easily without stressing the system. Power electronic based systems and other static equipment that provide controllability of power flow and voltage are termed as FACTS Controllers. Flexible AC Transmission System (FACTS) -Alternating current transmission systems incorporating power electronic-based and other static controllers to enhance controllability and increase power transfer capability. FACTS Controller-A power electronic-based system and other static equipment that provide control of one or more AC transmission system parameters. It is to be noted that power electronic controllers were first introduced in HVDC transmission for not only regulation of power flow in HVDC links, but also for modulation to improve system stability (both angle and voltage). The technology of thyristor valves and digital controls was initially extended to the development of Static Var Compensator (SVC) for load compensation and voltage regulation in long transmission lines. In1988,Dr.Narain G. Hingorani introduced the concept of Flexible AC Transmission Systems (FACTS) by incorporating power electronic controllers to enhance power transfer in existing AC transmission lines, improve voltage regulation and system security without adding new lines. The FACTS controllers can also be used to regulate power flow in critical lines and hence, ease congestion in electrical networks. FACTS do not refer to any single device, but a host of controllers such as:

1 SVC (Static VAR compensator),
2 Thyristor Controlled Series Capacitor (TCSC),
3 Static Phase Shifting Transformer (SPST),
4 And newer controllers based on Voltage Source Converters (VSC)-
5 Static synchronous Compensator (STATCOM),
6 Static Synchronous Series Compensator (SSSC),
7 Unified Power Flow Controller (UPFC),
8 Interline Power Flow Controller (IPFC) etc.

V. RESULT

The STATCOM model has been simulated as a reactive power compensator in MATLAB environment for voltage regulation and power factor correction. The simulated results show an acceptable performance. During steady state performance, analysis of voltage and current harmonic spectra has been carried out with the help of FFT tools in MATLAB for determining THD levels under various operating conditions and the results show reasonably low harmonics interference. The reference line voltage V* is set to 1.0pu, 1.03pu, 0.97pu and 1.03pu at the instant of 0s, 0.22s, 0.42s, 0.60s respectively. In the voltage control loop presuming that STATCOM would be operated as a voltage regulator. With the DC capacitor (C) pre-charged and total simulation time set at 0.60sec, the performance of the compensator corresponding to a load of 70MW 0.85pf (lag) at132kVisstudied.

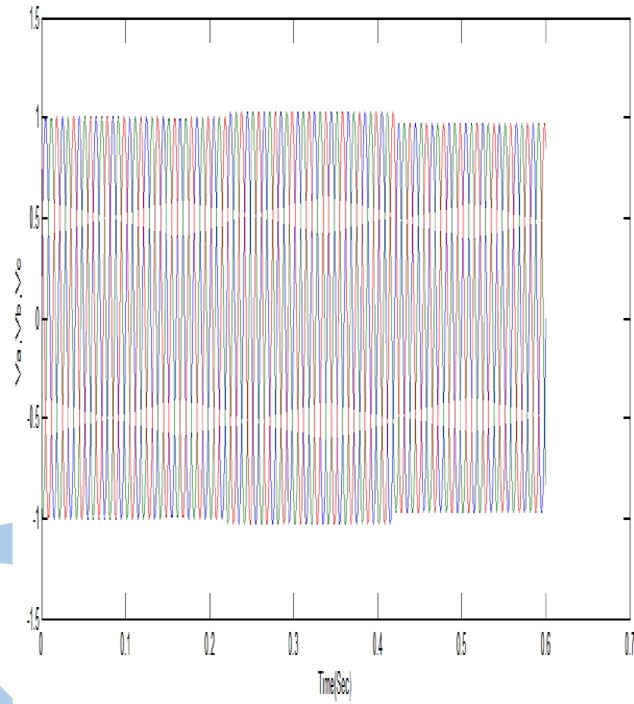

Figure-2. Three phase instantaneous voltages

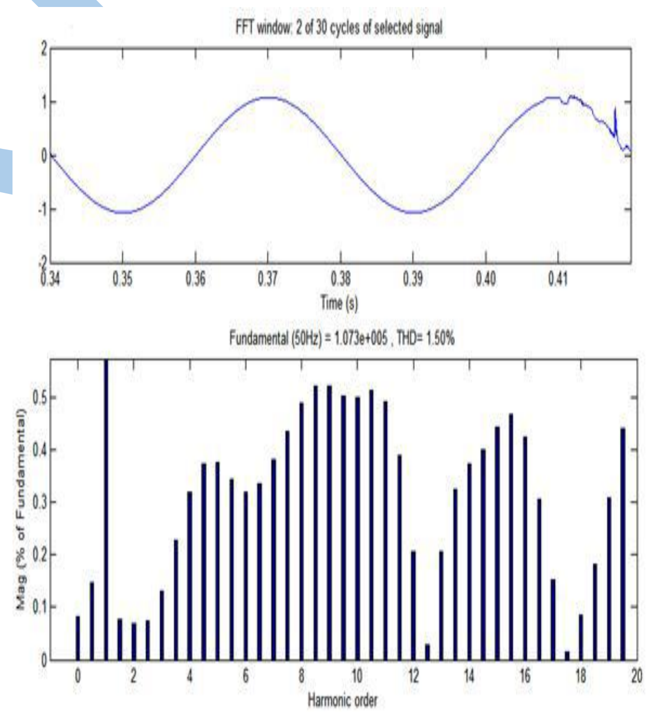

Figure-3. Voltage (Va) Spectrum in Capacitive mode

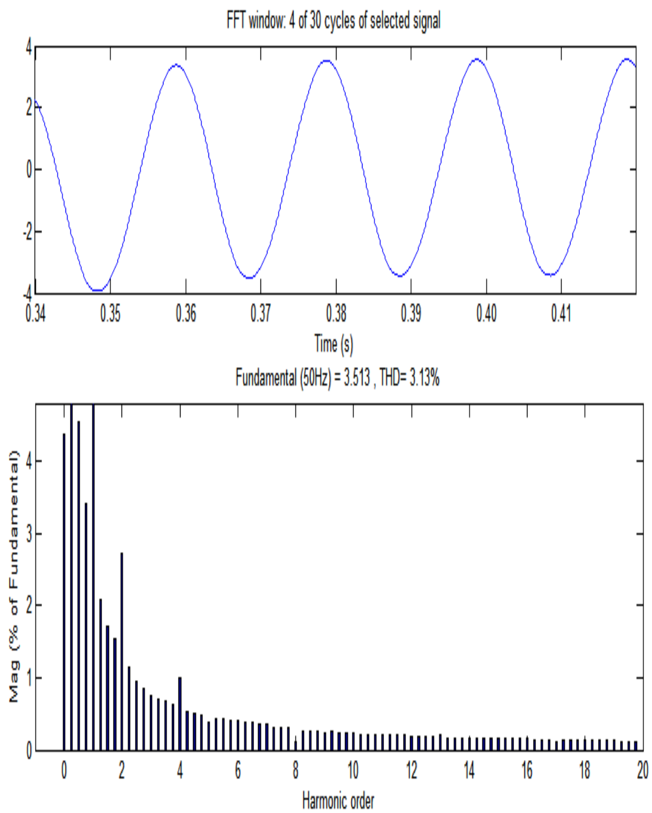

Figure-4 Current (Ia) Spectrum in Capacitive mode

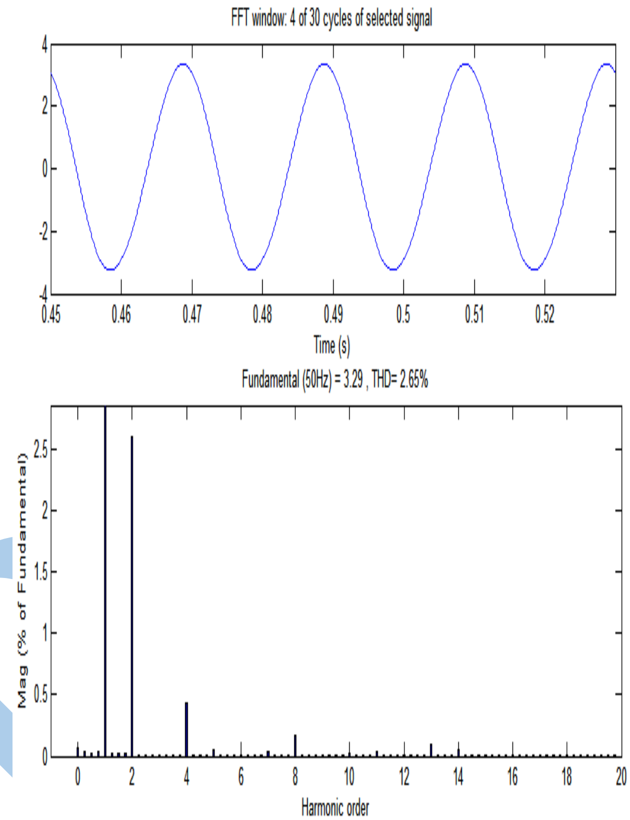

Figure-6. Current (Ia) Spectrum in Inductive mode

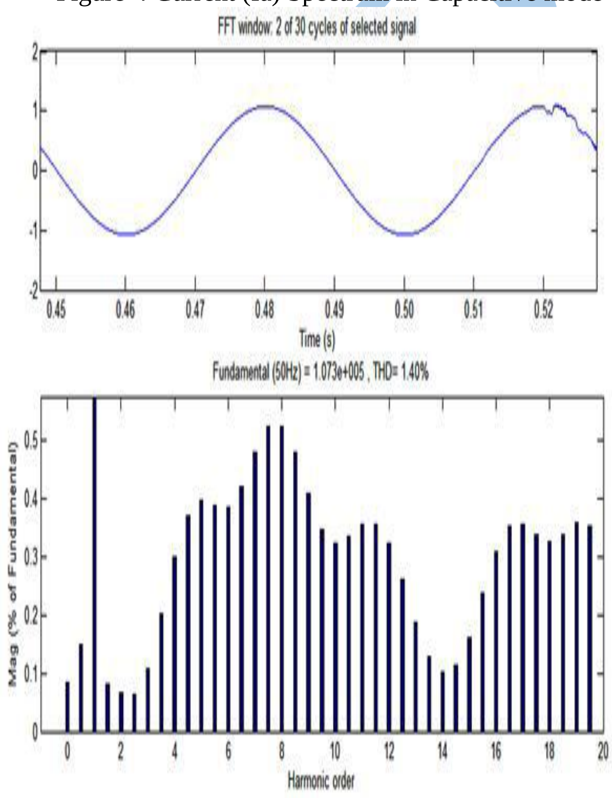

Figure-5Voltage (Va) Spectrum in inductive mode

VI. CONCLUSION

A new type of multi-pulse STATCOM having two stages of magnetic circuit is evolved. The first stage of magnetic circuit is used for setting-up VSC output AC voltage to line voltage level, while other magnetic circuit is used for roviding phase shift to the output voltage of stage-1 magnetic circuits, which in turn sets an electromagnetic coupling with AC system at PCC (Point of Common Coupling). These magnetic circuits are also work to mitigate the harmonics of the order of 5th, 7th, 11th, 13th and higher order. This model is designed with two elementary 6-pulse GTO-VSCs connected in parallel across the DC capacitor used as energy storage, and interfacing magnetics configured in two stages. It also contained the tow PI-controllers, one of them is named as inner current control loop and another is outer voltage control loop. The compensator has been simulated to regulate voltage for an inductive load in electrical network as well as power factor correction to unity. Basic operating characteristics of the model as illustrated shows it’s satisfactory and improved performance. As we have seen the performance of STATCOM working as voltage regulation mode as well as unity power factor correction var control mode. And by seeing the results of THDs of voltage and current spectrum we can say that STATCOM performs much better while working in voltage regulation mode as compare to the unity power factor correction in var control mode. Although

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