Fast Current Control Strategy Of Pwm Inverter Used For Advanced Static Var Compensator (Statcom)

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Abstract— The Advanced Static VAR Compensator (STATCOM) uses a high power self-commutating inverter to draw reactive current from a transmission line. The STATCOM is based on the principle that a self-commutating static inverter can be connected between three-phase AC power lines and an energy-storage device, such as an inductor or capacitor, and controlled to draw mainly reactive current from the lines.

This paper deals with the modelling and control of an STATCOM system with self controlled DC bus which employs a three phase PWM voltage source inverter. The STATCOM system is modelled using the d-q transform and employs a programmed PWM voltage wave shaping pattern to simplify the logic software and hardware requirements. The inverter system can compensate leading and lagging reactive power supplied by the load connected to the supply. Simulated results obtained with MATLAB are also presented.

Keywords: Reactive power, PWM Voltage Source inverter, STATCOM.

I. INTRODUCTION

The use of FACTS (Flexible AC Transmission Systems) controllers can potentially overcome disadvantages of electromechanically controlled transmission systems. The shunt connected static compensator was developed as an advanced static VAR compensator (STATCOM) where a voltage source inverter (VSI) is used instead of the controllable reactors and switched capacitors. Although VSI require self-commutated power semiconductor devices such as GTO, IGBT, etc, unlike in the case of variable impedance type SVC which uses thyristor devices, there are many technical advantages of a STATCOM over a SVC.

− Faster response.
− Requires less space as bulky passive components (such as reactors) are eliminated.
− Inherently modular and relocatable.
− It can be interfaced with real power sources such as battery, fuel cell or SMES (superconducting magnetic energy storage).
− A STATCOM has superior performance during low voltage condition as the reactive current can be maintained constant while in an 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 an SVC, the maximum reactive current is determined by the rating of the passive components – reactors and capacitors.

II. OPERATING PRINCIPLES OF STATCOM

Voltage Source Converter converts an input dc voltage into a three phase output voltage at fundamental frequency. A STATCOM consists of VSC, a coupling transformer and a DC voltage source (Capacitor or Battery). If a capacitor is used the steady state power exchange between the device and AC system will be reactive only, whereas a Battery is used active power also exchange will takes place. Basic structure of STATCOM is shown in Fig. 1: operating principle of STATCOM

The exchange of reactive power between the converter and the AC-system can be controlled by varying the amplitude of the 3-phase output voltage, Es, of the converter. Therefore, if the amplitude of the output voltage is increased above that of the utility bus voltage, Et, then the current flows through the reactance from the converter to the AC system and the converter generates capacitive-reactive power and is said to operate in capacitive mode.

If the amplitude of the output voltage, Es, is decreased below the utility voltage Et, then the current flows from the AC system to the converter and the converter absorbs inductive reactive power from the AC system and it is said to operate in inductive mode. Finally, if Es= Et then there is no exchange of reactive power.

A capacitor connected on the DC side of the VSC acts as a dc voltage source. In order to compensate for transformer and VSC bases and to keep the capacitor charges, the following two VSC technologies can be used:

VSC using GTO based square wave inverters and VSC using IGBT based PWM inverters use PWM technique to synthesize a sinusoidal waveform from a dc voltage source with a typical chopping frequency of a few kilohertz.

III. TYPES OF VOLTAGE-SOURCED INVERTER

Neglecting the voltage harmonics produced by the inverter, we can write a pair of equations for \( ed \) & \( eq \).

\[
\begin{align*}
ed &= kVdc \cos \alpha \\
eq &= kVdc \sin \alpha
\end{align*}
\]
where, k is a factor for the inverter which relates the DC-side voltage to the amplitude (peak) of the phase-to-neutral voltage at the inverter AC-side terminals and α is the angle by which the inverter voltage vector leads the line voltage vector. It is important to distinguish between two basic types of voltage sourced inverter that can be used in STATCOM systems.

Inverter Type I allows the instantaneous values of both α and k to be varied for control purposes. Provided that vdc, is kept sufficiently high, ‘ed’ and ‘eq’ can be independently controlled. This capability can be achieved by various pulse-width-modulation (PWM) techniques.

Inverter Type II is of primary interest for transmission line STATCOMs. In this case, k is a constant factor and the only available control input is the angle, α of the inverter voltage vector.

In this paper used Inverter type I with PWM techniques.

IV. MATLAB SIMULINK MODEL FOR STATCOM

![Fig. 2: MATLAB Simulink Model](image)

V. CONTROLLER

In our model of STATCOM, the control logic is based on current control decoupling strategy. The controller senses the three phase voltage which is applied to PLL and generates the phase angle of the supply voltage such that, the frequency of the phase angle will be the same as of the input voltage frequency. The sensed voltages and sensed currents are transformed from abc to dq transformation which results into real voltage and current Vd, Id and reactive voltage and current Vd, Iq respectively.

The controller uses two current control loops and a voltage control loop to generate the reference voltage. In voltage controller loop, error of reference DC voltage (Vdc*) and sensed DC voltage is given to PI controller as an input for getting reference Id. In current control loop, in PI controller error of the reactive current Iq and reference reactive current Iq is controlled. While, in second current control loop, error of real current Id and reference real current Id is given to PI controller. Then the inverter voltage Eq and Ed are controlled using voltage and current control loops along with varying reactive current Iq and real Id. The controller then generates reference waves with varying DC voltage, inverter voltages and phase angle. These reference waves are compared with triangular wave and gate pulses are generated. The MATLAB simulation of the controller is shown in Fig. 3.

VI. RESULTS

- Simulation parameters:-
  - Phase voltage-220
  - Fundamental frequency-50HZ
  - Coupling transformer-10 KVA
  - C=500µF
  - Transformer Rs=1 ohm & L=0.005MH

A. Reactive current:

When load is capacitive then reactive current is increased and when load is inductive reactive current decreases while, in balanced condition reactive current is zero as shown in Fig. 4.

![Fig. 4: Reactive current](image)

B. Capacitor voltage:

Reactive power changes are observed by capacitor voltage. the variation in capacitor voltage is shown in fig.5.

![Fig. 5: Capacitor Voltage Vdc](image)

C. Capacitor Side DC Current:

The simulated dc current on both leading mode and legging mode shows in fig.6-7.
D. Phase voltage and Current:
When there is change in reactive current the phase shift in line current for both capacitive mode and inductive mode is shown in Fig.8.

VII. CONCLUSION
In this Paper, a High Performance Static Var Compensator has been Presented. The Proposed System has thoroughly been Modelled and Analyzed. The Mathematical Model Derived in This Paper is the Key Of The Development Of the Decoupled Control Scheme. The ASVC With the Presented Control Scheme has Fast Dynamic Response for Generating Or Absorbing Reactive Power. Programmed PWM Switching Pattern is used as a Means Of Reducing The Size Of Reactive Components and to have a High Quality Reactive Power in Compensation. Detailed Simulation Studies Are Carried Out to Demonstrate the Effectiveness Of The Control Scheme.

REFERENCE