Fast Current Control Strategy of PWM Inverter used for 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 report 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. This model is used to design an efficient control strategy based on the control of the Magnitude and phase angle of the switching pattern. Simulated results obtained with MATLAB are also presented

Key words: Reactive power, PWM Voltage Source Converter, 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 re locatable.
- 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

Static Synchronous Compensator (STATCOM) is a primary shunt device of the FACTS family, which uses power electronics to control power flow and improve transient stability on power grids. The STATCOM regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. The variation of reactive power is performed by means of a voltage source convertor (VSC) connected on the secondary side of a coupling transformer. The VSC uses forced commuted power electronics devices (GTO's or IGBT's) to synthesize the voltage from a dc voltage source.

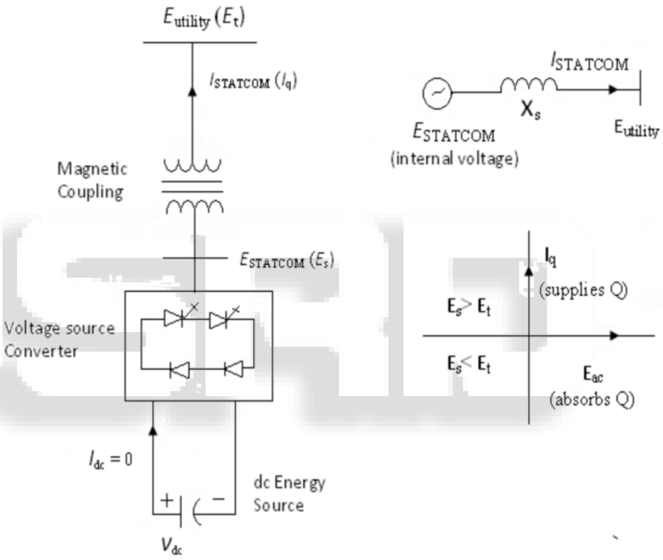

Fig. 1: operating principle of STATCOM

The operating principle of STATACOM is explained in Fig. It can be seen that if Es> Et then current Iq flows from the counter to ac system through reactance and converter generates capacitive reactive power for ac system. On the other hand, if Es< Et then current Iq flows from ac system to the converter and converter absorbs inductive reactive power from ac system. 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 special interconnection transformers typically with three level inverters are used to build a 48 step voltage wave form.
- 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 kilo-hertz.

III. TYPES OF VOLTAGE-SOURCED INVERTER

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

$$ed = kVdc\ cos\alpha$$

$$eq = kVdc\ sin\alpha$$

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 report used Inverter type I with PWM techniques.

IV. MATLAB SIMULINK MODEL FOR STATCOM

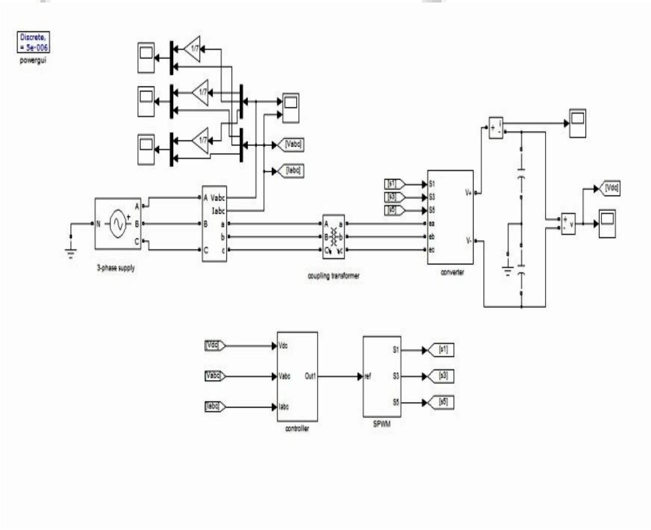

Fig. 2: Matlab Simulink Model

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 micro-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

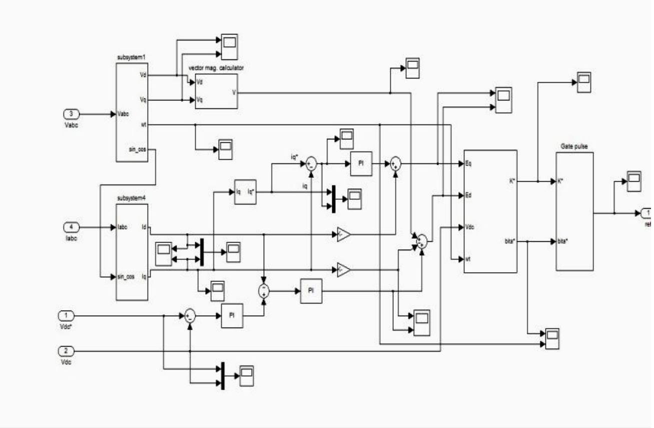

Fig. 3: Matlab Simulink Model of Controller

VI. RESULTS

Simulation parameters:-
Phase voltage-110
Fundamental frequency-50HZ
Carrier frequency-2250HZ
Coupling transformer-0.5KVA
C=220µF
Transformer Rs=1.6ohm &L=0.009MH

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

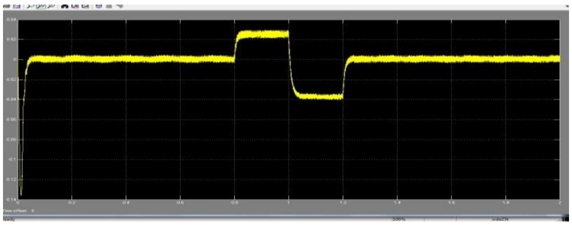

Fig. 4: Reactive current

B. Capacitor voltage

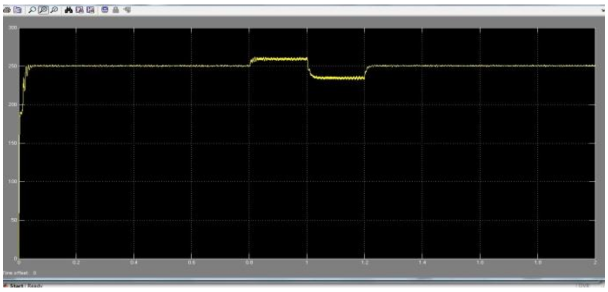

Fig. 5: Capacitor Voltage Vdc

VII. CONCLUSION

There is every induction that high performance static var compensator will be an important part of power transmission system in future . high performance static VAR compensator which employs a three phase voltage source inverter has been presented. The proposed system has thoroughly been modelled and analyzed. The mathematical model derived in this report is the key of the development of the decoupled control scheme and an important contribution for future power transmission systems studies.

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. The steady state and transient simulated results obtained have confirm the applicability of the proposed scheme and have led to a proper design of a simple and fast controller for reactive power applications.

REFERENCE

[1] C. Schauder, H. Mehta, “Vector analysis and control of advanced Static VAR compensators”, IEEE Proceedings, vol. 140, pp. 299-306, 1993.

[2] K. R. Padiyar Department of Electrical Engineering Indian Institute of Science Bangalore-560 012’ FACTS CONTROLLERS IN POWER TRANSMISSION AND DISTRIBUTION

[3] Naveen Goel, R.N. Patel, *Member, IEEE*, Saji T. Chacko Genetically Tuned STATCOM for Voltage Control and Reactive Power Compensation International Journal of Computer Theory and Engineering, Vol. 2, No. 3, June, 2010

[4] Pablo Garcia Gonzalez, Aurelio García-Cerrada, “Control System for a PWM-Based STATCOM”, IEEE Transactions on Power Delivery, vol. 15, no. 4, pp. 1811-1817, 2000.

[5] Fatima Tahri, Ali Tahri, Azzedine Draou, Benyounes Mazari, “Decoupled Control Strategy Applied to an Advanced Static VAR Compensator-Modelling and Analysis”, *IEEE ISIE*, vol. 6, pp. 9-12, 2006.