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EFFICIENT CURRENT CONTROL STRATEGY FOR PWM INVERTER UTILIZED IN ADVANCED STATIC VAR COMPENSATOR (STATCOM)

#1T.Rambabu , Assistant Professor,
#2V. Satyavardhan Rao, Assistant Professor,
#3M. Prathima, Assistant Professor,
Department of Electrical and Electronical Engineering,
SAI SPURTHI INSTITUTE OF TECHNOLOGY, SATHUPALLY, KHAMMAM.

ABSTRACT:-

The Advanced Static VAR Compensator (STATCOM) extracts reactive current from a transmission line using a high-power self-commutating inverter. The STATCOM connects an energy-storage device, such as an inductor or capacitor, to three-phase AC power lines via a self-commutating static inverter. This inverter is designed to primarily extract reactive current from the lines. This study focuses on the modeling and management of a self-contained DC bus STATCOM system that employs a three-phase PWM voltage source inverter. To limit the amount of logic software and hardware required, the STATCOM system uses a programmable PWM voltage wave shaping pattern represented by the d-q transform. The inverter system may adjust for both leading and trailing reactive power from the load linked to the power supply. MATLAB simulation results are also included.

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

I. INTRODUCTION

FACTS (Flexible AC Transmission Systems) controllers can help to overcome the drawbacks of electromechanically controlled transmission systems. The shunt connected static compensator is an improved version of the static VAR compensator (STATCOM) that replaces switching capacitors and controlled reactors with a voltage source inverter (VSI). STATCOM has some technical advantages over SVC, despite the fact that it uses self-commutated power semiconductor devices like GTO and IGBT, whereas SVC uses thyristor devices.

- Faster response.
- The removal of large passive components, such as reactors, minimizes the necessary area.
- Inherently movable and versatile.
- The gadget may link to genuine power sources including fuel cells, batteries, and SMES (superconducting magnetic energy storage).
- In the case of low voltage applications, a Static Synchronous Compensator (STATCOM) beats a Static Var Compensator (SVC) due to its capacity to maintain a steady reactive current. When the capacitive susceptance threshold is reached, the reactive current in an SVC decreases proportionally with voltage. If the devices can withstand temporary high loads, it is possible to raise the reactive current in a STATCOM during transient conditions. The maximum reactive current in a Static Var Compensator (SVC) is determined by the capacity of passive components such as capacitors and reactors.

II. OPERATING PRINCIPLES OF STATCOM

A voltage source converter converts a direct current (DC) input voltage to a three-phase output voltage with a fundamental frequency. A STATCOM is made up of a Voltage Source Converter (VSC), a coupling transformer, and a DC voltage source, either a capacitor or a battery.When a battery is used, the gadget and the alternating current system exchange active power at the same time. A capacitor, on the other hand, only exchanges reactive power. The fundamental configuration of the STATCOM is demonstrated in

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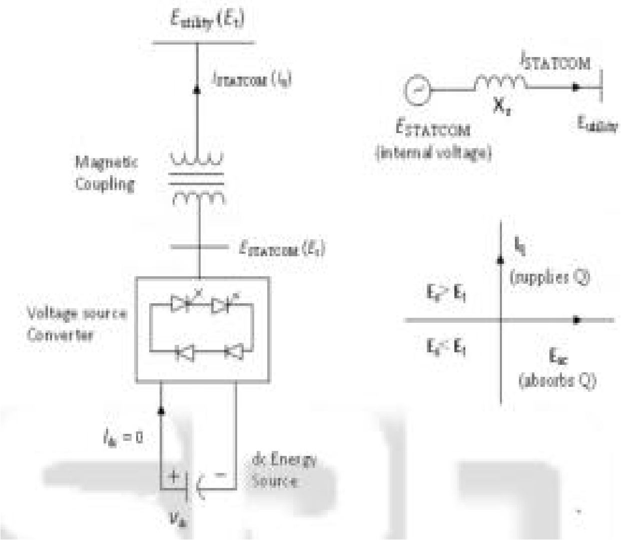

Fig. 1: operating principle of STATCOM

The amplitude of the converter's three-phase output voltage, Es, can be changed to regulate reactive power exchange between the converter and the alternating current system. As a result, the converter is deemed to be operating in capacitive mode when the output voltage amplitude exceeds the utility bus voltage, Et, and current flows from the converter to the AC system via the reactance. This creates capacitive reactive power. When the magnitude of the output voltage, Es, is less than the utility voltage, Et, the converter switches to inductive mode. Currently, the AC system delivers electrical current to the converter, which absorbs inductive reactive power from the AC system. To recapitulate, when the source voltage (Es) equals the total voltage (Et), no reactive power is transferred.

A direct current (DC) voltage source is supplied by a capacitor attached to the voltage source converter's (VSC) direct current side. Two VSC technologies can be used to preserve capacitor charges while adapting to transformer and VSC bases:

Voltage Source Converters (VSC) typically operate at a few kilohertz and use IGBT-based PWM inverters or GTO-based square wave inverters to generate a sinusoidal waveform from a direct current (dc) voltage source.

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 cosα

eq =kVdc sinα

The variable α indicates the difference in phase between the inverter and line voltage vectors. The variable k is a factor that compares the DC-side voltage to the peak amplitude of the phase-to-neutral voltage at the inverter's AC-side terminals. It is critical to understand the differences between the two major types of voltage-sourced inverters that STATCOM systems can use.

To maintain control, Inverter Type I enables real-time adjustment of both α and k. The 'ed and 'eq components can be changed independently as long as the voltage direct current (vdc) remains at an optimal level. This functionality can be achieved via a variety of pulse-width modulation (PWM) techniques.

Transmission line STATCOMs are mostly focused on Inverter Type II. The only control input that may be altered is the angle, α, of the inverter voltage vector, while k remains fixed.

This article used PWM approaches to create type I inverters.

IV. MATLAB SIMULINK MODEL FOR STATCOM

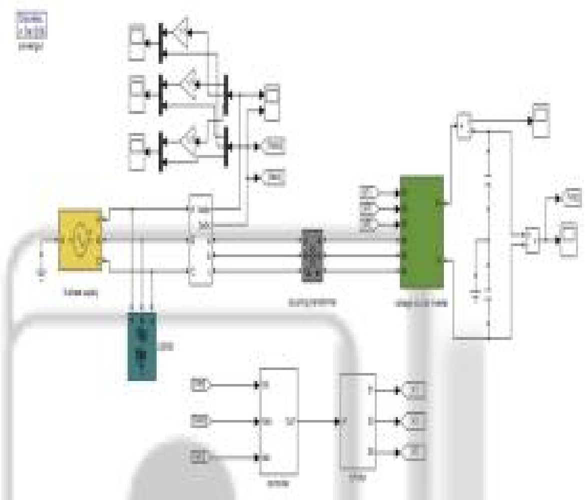

Fig. 2: MATLAB Simulink Model

V. CONTROLLER

STATCOM's control logic is based on the current control decoupling technique.The controller detects the three-phase voltage provided to the

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PLL and calculates the phase angle of the supply voltage in order to synchronize the phase angle's frequency with the input voltage. The measured voltages and currents are transformed from abc to dq, yielding the real voltage and current (Vd, Id) and reactive voltage and current (Vd, Iq).

To generate the reference voltage, the controller employs two current control loops and one voltage control loop. The voltage controller loop accepts the error between the reference DC voltage (Vdc*) and the measured DC voltage as inputs and routes them via a PI controller to retrieve the reference ID. The PI controller in the current control loop controls the difference between the reactive current Iq and the intended reference reactive current Iq. The error between the actual current (Id) and the desired reference current (Id) is fed into the second current control loop and then to the PI controller. The voltage of the inverter, represented by Eq and Ed, is then changed using voltage and current control loops that adjust the reactive current Iq and the actual current Id. The controller then generates reference signals that vary in direct current voltages, inverter voltages, and phase angles. The reference waves are compared to a triangle waveform, which generates gate pulses. Figure 3 depicts the MATLAB simulation of the controller.

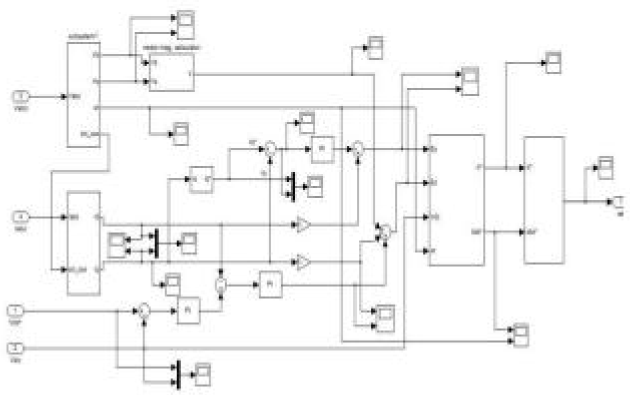

Fig. 3: MATLAB Simulink Model of Controller

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 capacitive loads are present, the amount of reactive current increases, while inductive loads cause it to decrease. Figure 4 depicts an equilibrium state in which the reactive current is nil.

Fig. 4: Reactive current

B. Capacitor voltage:

Variations in capacitor voltage indicate changes in reactive power. Figure 5 displays voltage fluctuations across the capacitor.

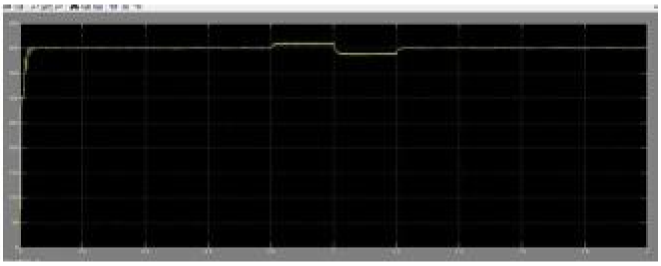

Fig. 5: Capacitor Voltage Vdc

C. Capacitor Side DC Current:

Figure 6-7 shows the simulated direct current (dc) in both leading and lagging modes.

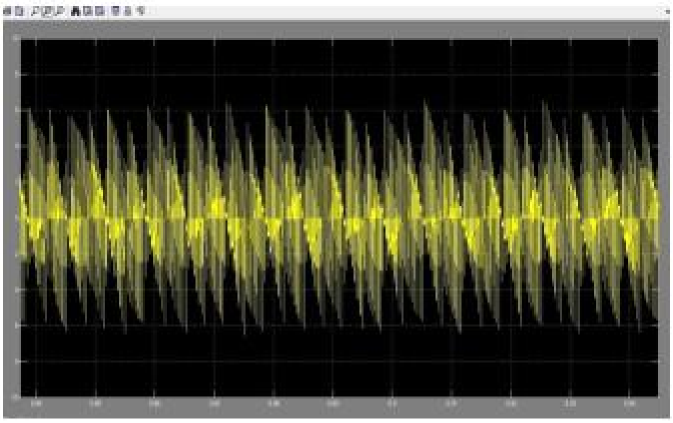

Fig. 6: Leading Mod

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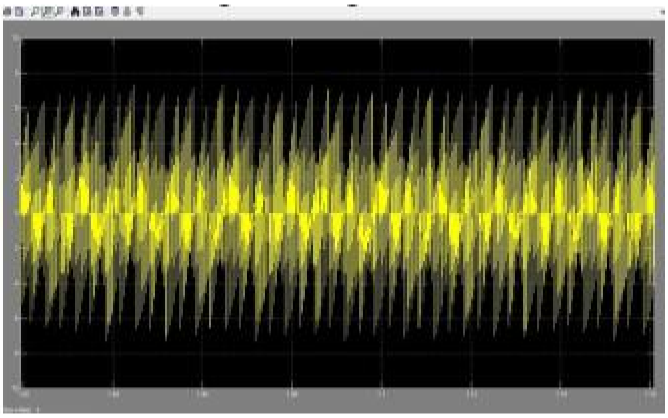

Fig. 7: Legging Mode

D. Phase voltage and Current:

Figure 8 shows the phase shift in line current for both capacitive and inductive modes in response to a change in reactive current.

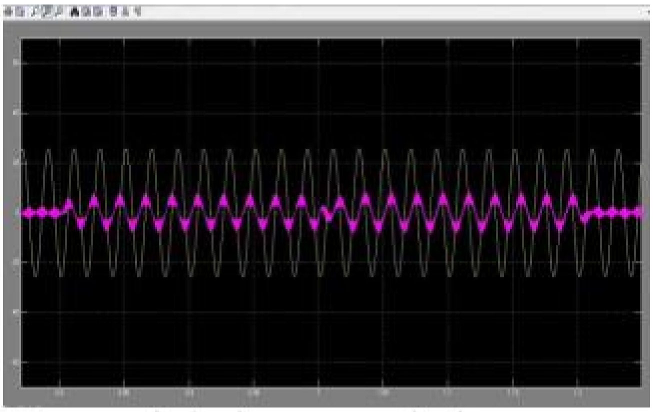

Fig. 8: Phase Current and Voltage

VII. CONCLUSION

This study presents a High Performance Static Var Compensator. The proposed system has been thoroughly analyzed and simulated. The mathematical model developed in this study plays a significant role in the creation of the decoupled control scheme. When using the given control system, the ASVC can produce or consume reactive power in a timely and responsive manner. Programmed PWM switching patterns can be used to minimize the size of reactive components while successfully compensating for high-quality reactive power. A complete simulation analysis is carried out to illustrate the efficiency of the control technique.

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