Power Quality Improvement by Using Direct Current Control Method of STATCOM – A Review

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Abstract: *This paper introduced the working principle of STATCOM, by using this method direct current control of triangle carrier wave to detect both the harmonic and the basic reactive power. By using MATLAB software to complete the model of STATCOM, The simulation diagram and experimental results improved the effectiveness and feasibility of direct current control method, and tracking performance also better, accurately, fast response and steady state compensation effect.*

Keywords: STATCOM, Power Quality, Direct Current Control, Instantaneous Reactive Power, MATLAB/Simulink.

1. Introduction

With the rapid development of industry, the requirements of electric power quality are becoming stricter, how to improve the reliability, controllability and rapidity of modern power system has become an urgent problem to be solved. Static Synchronous Compensator (STATCOM) is the central device of modern Flexible AC Transmission Systems, compared with the traditional reactive power compensation device, STATCOM has the advantage of fast response, absorb reactive continuous, harmonic current, low loss, small size, etc. Therefore, STATCOM has become an important development direction of reactive power and harmonic compensation device's research.

There are many researches on the control design of STATCOM. The literature analysis the direct current control method of voltage outer, the current inner structure static Var generator and simulate the control method. The literature give the reason and the solution of high voltage across the capacitor when device emits pure capacitive reactive power, Simulation gives the simulation waveform of the system emits inductive and capacitive reactive current and the voltage across the capacitor under the control of direct current method. The literature which application of instantaneous power detection theory to collect real-time power decoupled into active and reactive component, using the relation of the power and switch quantity to control active and reactive power through the simulation verified the effectiveness of control. The simulation results can be further improved. This paper studies the working principle of STATCOM, According to the triangular carrier direct current control method to build MATLAB simulation model validation and study, verify its effect of control and By the STATCOM working, it transforms DC side voltage into the output voltage of AC side with the electrical network frequency, which is equivalent to a voltage type inverter, it is equivalent to amplitude and phase controlled AC voltage source here. The actual phase equivalent circuit and phase diagram as shown in Figure 2(a) & 2(b), taking into account loss of the circuit; it can be considered the loss as resistance which connect reactor. The grid voltage and the output AC voltage of STATCOM is VS and VSTA, the voltage of compensation

2. Working Principal of STATCOM

The basic principle of STATCOM is self commutated bridge circuit through the reactor or directly parallel to the grid, a properly adjusted bridge circuit in AC side output voltage amplitude and phase, or directly control the AC current, can make the circuit to absorb or emit to meet the requirements of the reactive current, achieve the purpose of dynamic reactive power compensation. According to the structure of STATCOM, it can be divided two types: voltage bridge type circuit and the current bridge type circuit. In fact, due to the reasons of operational efficiency, practical uses is mostly voltage bridge type circuit, so STATCOM specifically refers to Using self commutation voltage bridge circuit as a dynamic reactive power compensation device. Device main circuit structure as shown in Figure 1, Power switch devices use the switch device IGBT which have the capacity of self-switching-off.
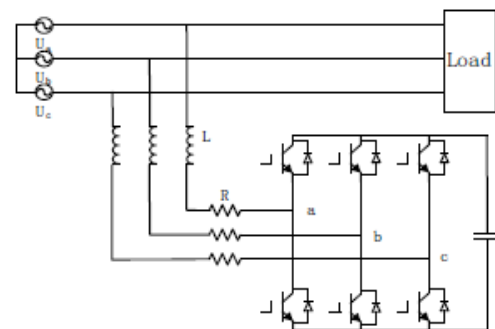

Figure 1: The main circuit structure of STATCOM

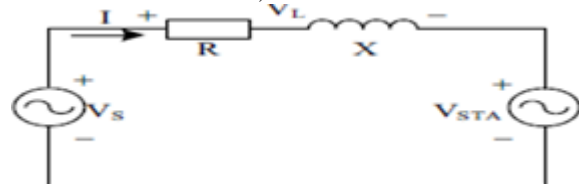reactance is VL, the reactor equivalent impedance is R, inductive reactance is X, electric current is I

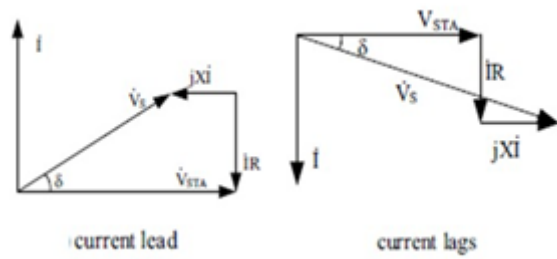**Figure 2(a):** Phase equivalent circuit.

Figure 2(b): Phase diagram.

As Figure 2(b) shows that, the phase difference of the voltage Vs and current I is not 90°, it is smaller than 90° with a δ angles, grid provides power to supplement the circuit loss, when VSTA> Vs, current leads the voltage, STATCOM is equivalent to a continuous adjustable capacitor, It is a capacitive mode of operation, absorb reactive power; when the VSTA<Vs, current lags the voltage, STATCOM is equivalent to a continuously adjustable inductance, It is perceptual mode and absorb reactive power.

3. Strategy Of STATCOM Direct Current Control

The control method of STATCOM has two kinds: current indirect control and direct control, current indirect control takes STATCOM as a voltage source, through the control of AC voltage wave phase and amplitude which produced by the inverter side to indirect control of AC side current. By adjusting the phase difference δ of the output voltage and the system voltage, or in combination with the control pulse width θ to compensation system; Direct current control uses track PWM technology on current instantaneous value to feedback control. As a result of indirect current control method is relatively simple, the control precision is not high, slow response speed, and the direct current control method response is fast and control precision is high, so It can achieve the effect which the indirect control cannot achieve, therefore, this article adopts the direct current control method.

Figure 3 is the block diagram of the instantaneous reactive and harmonic current detection method, in which I_a, I_b, I_c is a three-phase load currents, U_{dcref} is DC side voltage reference value, U_{dc} is the detected DC side voltage. firstly, transform I_a, I_b, I_c into α-β phase coordinates through abc three-phase coordinate, so get i_p and i_q, The process compose of a phase voltage U_a and through the lock link PLL acquisition to get the sine and cosine signals which has the same phase voltage as a phase. In order to obtain the harmonic current and reactive power signal, disconnect the reactive channel i_q (and i_q=0), and the DC control signal and the filtered signal are compared with active i_p as active channel signal i_p*, after inversing coordinate into abc three phase coordinates, calculate the fundamental active current signal.
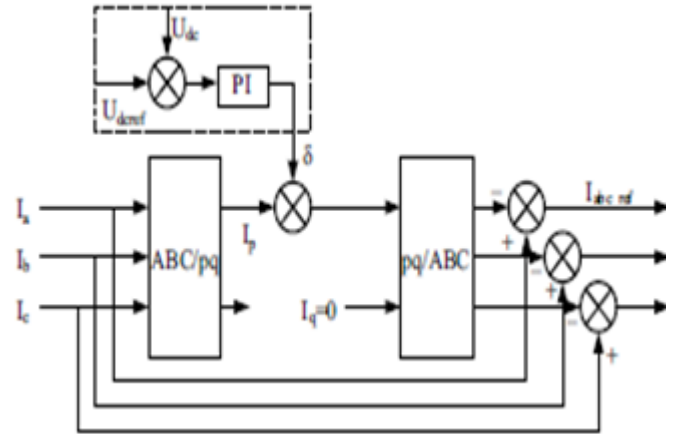

Figure 3: Instantaneous reactive and harmonic current detection.

Tracking PWM control technology can use the hysteresis comparison method; it also can be used triangle wave comparison. In the link of modulation, switch frequency varies with the compensation current in the hysteresis modulation, which causes the great pulsating current and switching noise, while using the triangle wave modulation method, switching frequency is equal to the triangular carrier frequency, pulse current is small, and the output voltage of less harmonic content. Based on the above advantages, this paper adopts the triangular wave comparison.

Triangle wave comparison control compared the detected deviation between the current actual value and reference value with the high frequency triangular carrier phase pulse, the pulse as the inverter switching device to control signal, resulting in the inverter output to obtain the desired current waveform, the control process is shown in figure 4.
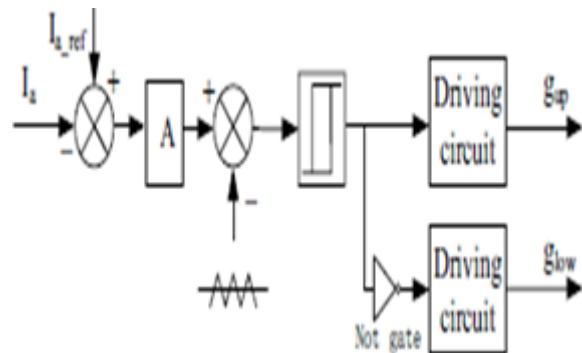

Figure 4: Triangle wave comparison

Figure 4 shows that control mode is different to the use of other triangular wave as carrier wave of PWM control, it does not directly command signal compared with a triangular wave, but through the deviation of the command current and compensation current to the amplifier A and then compared with a triangular wave. Amplifier A often uses proportional integral amplifier. It is composed of a control system which can make the deviation signal control at minimum.

The triangular carrier direct current control method which can realize the simultaneous compensation of reactive power and harmonic, and the DC side voltage control can make the DC side voltage to remain stable, so as to achieve a stable, accurate compensation effect.

4. Conclusion

This paper analysis the basic working principle of STATCOM as well as the triangle wave modulation direct current control method, using the MATALB simulation software to build simulation model, a detailed analysis of the STATCOM rectifier load circuit of reactive and harmonic compensation characteristics. The simulation results show that, STATCOM adopts direct current control strategy of reactive power and harmonic current fast tracking effect, the system reactive power and harmonic has good compensation characteristics.

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