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REGULATING STATCOM FOR ENHANCED POWER SYSTEM STABILITY

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ABSTRACT: This paper proposes two control methodologies to ensure the static synchronous compensator (STATCOM) functions properly: adaptive voltage control and d-q axis control. The use of STATCOM is a dependable and practical method of keeping the power system steady. Because we just discussed it, the PI controller has control over reactive power, grid voltage, current, and the steady DC link voltage of the DC link capacitor. To execute the models, a program called MATLAB/SIMULINK is employed. Researchers examine how well the STATCOM performs in both regular and power system network problems. The results reveal that the STATCOM with the selected controller did an excellent job of maintaining the power system's stability in the network design by managing both bus voltages and reactive power.

Keywords: FACTS, PI controller, D-Q controller, static synchronous compensator (STATCOM), adaptive voltage control.

1. INTRODUCTION

Electricity is the most crucial factor in the growth of any developing country's economy. Because the power system is becoming increasingly industrialized, the current transmission networks are about to fail. As a result, a new transmission system must be developed. Politics, the environment, and the economy can all make it difficult to constantly create new transmission lines to free up above wires and offer adequate temporary security.

Taking all of these factors into account, this study attempted to improve the stability of the power system when FACTS devices were included. STATCOM was chosen from among the several types of FACTS devices because it responds rapidly and can correct both leading and lagging VAR. It was previously revealed that this STATCOM design features CASCADING VOLTAGE SOURCE INVERTERS, which set it apart. Each VSI employs SPWM to control the switching devices.

By cascading numerous inverters, a multilayer optimum modulation approach for STATCOMs, or static synchronous compensators, was made available. STATCOM has been successfully modeled using space vector theory, which has been investigated. Using this idea, voltage equations can be converted into DQ-axis frames. For high-power applications, a new STATCOM approach was developed that functions similarly to a simple frequency-switching-based 24-pulse, 2-level 100MVAR. A new model for a Distribution Static Synchronous Compensator (D-STATCOM) was proposed to achieve the desired voltage. It works with a Voltage Source Converter (VSC). In one work, adaptive PI control was utilized to demonstrate that control gains can be modified automatically in the event of a disturbance. This means that performance is always fulfilled, even if there are operational changes.

Assuming STATCOM is connected to the 33kV grid using standard control methods, a research was conducted to see whether Reactive Power Compensation will function. It was suggested that a fuzzy self-tuning PI controller in a STATCOM model be used to manage the voltage. This study provides a method for making power grids more stable. The primary purpose of this effort is to develop MATLAB/SIMULINK STATCOM controllers for network stability testing. Also, STATCOM activity has been observed following a power system network breakdown. The methodology of the entire investigation is discussed in further detail in Section II of this summary. Section IV discusses creating D-Q axis current-based STATCOM controllers and adjusting the voltage. Section III demonstrates the use of STATCOM in a power system network. Section V collects the simulation results and discussions that occurred after the paper work was implemented. The conclusion, which is a summary of the important points, appears in the final section.

2. METHODOLOGY

Figure 1 depicts the entire job plan. MATLAB/SIMULINK is used to create the first version of the power system network. The power, voltage, and current of the entire system are then tested. Following that, two independent STATCOM control plans are created. By comparing the observed V and Q values to the reference values, it is feasible to determine whether the system is stable. The simulation will end if the system is stable. If not, the PI controller's gains must be adjusted.

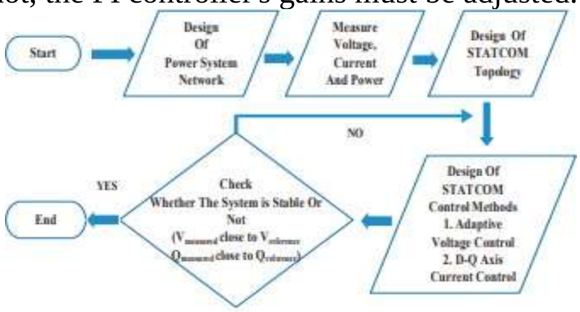

Fig.1 A diagram illustrating how to create STATCOM control plans.

3. IMPLEMENTATION OF STATCOM

The suggested STATCOM model was created using the MATLAB/SIMULINK tool. Figure 2 depicts it as a block design. A DC link capacitor is connected to a voltage supplied inverter (VSI). These two are connected to the power line via a transformer and an LC filter.

A diode that acts against parallelism is linked to the VSI's six insulated gate bipolar transistor (IGBT) switches. Each phase contains a low-pass AC filter to prevent the flow of harmonic currents induced by IGBT switching.

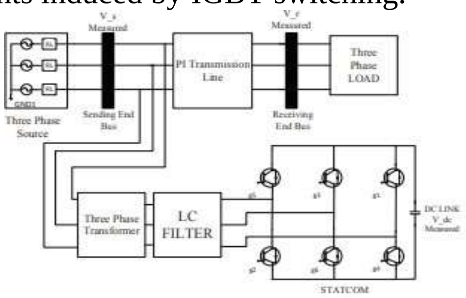

Fig.2. An illustration of the STATCOM's electrical link

4.STATCOMCONTROLSTRATEY

Adaptive PI Voltage Control-

To model the bus voltage, a STATCOM based on adaptive PI voltage management is used. The STATCOM controller is constructed in the modeling application MATLAB as a self-governing module. This gadget is known as the PI controller. Figure 3 depicts the block diagram for STATCOM's flexible PI voltage controller. To establish the bus voltage, subtract the DC link voltage (Vdc measured) from the standard value (Vdc reference). This returns Vdc_error.

This error is being delivered as data to a PI controller. The voltage at the sending end is measured again (Vs_measured), and Vs_error is calculated by subtracting that amount from the voltage at the receiving end (Vs_reference). For these estimates, per unit (PU) units are utilized. This error signal was fed into another PI device. The outputs of the two PI controllers are utilized to calculate the orthogonal components (Vq and Vd). The magnitude and angle inputs are delivered to the Sinusoidal Pulse Width Modulation (SPWM) technique via the PI controllers' two outputs. Figure 4 shows how SPWM is utilized to generate gate signals for IGBTs.

The carrier wave, a triangular wave with a fixed frequency and unit amplitude, and the modulating signals are juxtaposed. When using the SPWM method, the following formulas are employed to calculate the sine wave's magnitude (Vmag) and phase angle.

$$Vmag = \sqrt{(V_d^2 + V_q^2)} \quad (1)$$

$$angle = \tan^{-1}(V_q/V_d) \quad (2)$$

Angle and Vmag are utilized to calculate the reference signals. Contrast this signal with the triangle signal. The sent signal has a frequency of 5 KHz. This section of the circuit transmits messages to the IGBTs in the inverter so that they can ignite.

D-Q Axis Current control-

Figure 3 demonstrates that the purpose of modeling this current control approach (DQ axis control) of STATCOM is to maintain the reactive power of the power system network under control. This controller is likewise planned and built using MATLAB/SIMULINK. STATCOM values are divided into two components. The first is in phase with the bus voltage, while the second is in quadrature with it. The PI controllers provide standard values for the shunt currents (D and Q), which are subsequently subtracted from the observed values. The phase angle (_sh) and value (Vm_sh) of the injected voltage, which are the D and Q parts of the shunt voltages, are provided by the PI controllers:

$$Vm\_sh = \sqrt{(V^2_{shd} + V^2_{shq})} \quad (3)$$

$$\alpha\_sh = \tan^{-1}(V_{shd} / V_{shq}) \quad (4)$$

Vshd and Vshq are the reverse voltages for the d and q orthogonal components, respectively.

4. SIMULATION

In MATLAB/SIMULINK, you may create a network of power system components and simulate the results. Later simulation experiments demonstrate the outcomes before and after using the d-q axis control method, the adaptive PI voltage regulated approach, and the STATCOM link in great detail. Figure 4 depicts a simulation model of the network of STATCOM-connected power systems. Table I contains a list of all the model's values.

Table 1.Simulation Parameters

Parameters	Values
Source Voltage	25 KV (r.m.s), 50 Hz
Load Voltage	25 KV (r.m.s), 50 Hz
Transmission Line	50 Hz, R= 0.01273 ohms/km , L = 0.9337 x 10^{-3} H/km, C= 12.74 x 10^{-9} F/km, Length 100 km.
DC link capacitor	4700 uF
Transformer	Primary Winding (600V), Secondary Winding (25KV)
LC and RL Filter	R= 5 ohm, L=10 mH, C= 2500 uF

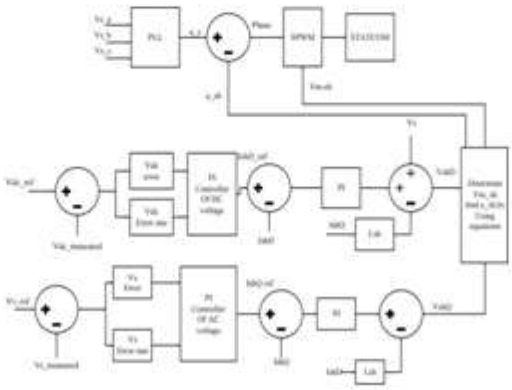

Fig.3 Based on the STATCOM D-Q axis driver.

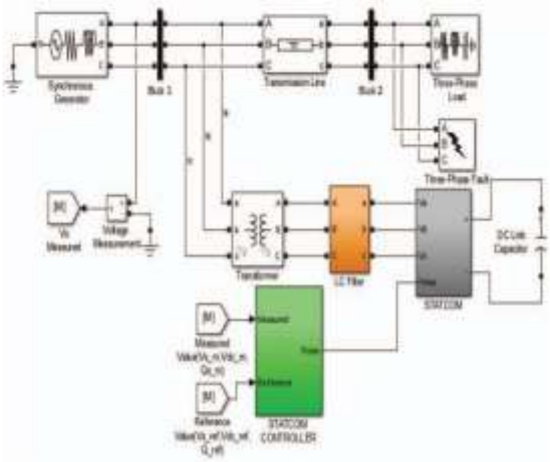

Fig.4 A Simu Link Model connects the Power System and STATCOM.

5. RESULTS AND DISCUSSIONS

Connecting STATCOM to the power system network is used in this section to test how effectively the suggested controls operate. A. The simulation results for the Adaptive PI Voltage Control technique The Adaptive PI Voltage Control approach was used to manage the voltage. Take a look at Figure 5. The voltage increased from 1 p.u. before connecting the STATCOM to 1.05 p.u. after connecting it. The modeling results for real and reactive powers, with and without STATCOM, are shown in Figures 8 and 6. It has been discovered that the real power flow, 9.2 MW, remains constant with or without STATCOM. This is due to the fact that STATCOM only controls voltage and not actual power. This isn't always true for reaction time. When STATCOM was not present, reactive power was observed to be -2.2 MVAR. When STATCOM was added to the system, the reactive power flow reduced to -1.09 MW.

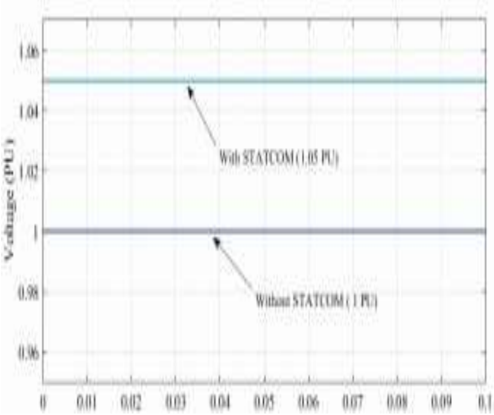

Fig.5 The voltage on the STATCOM network is being altered.

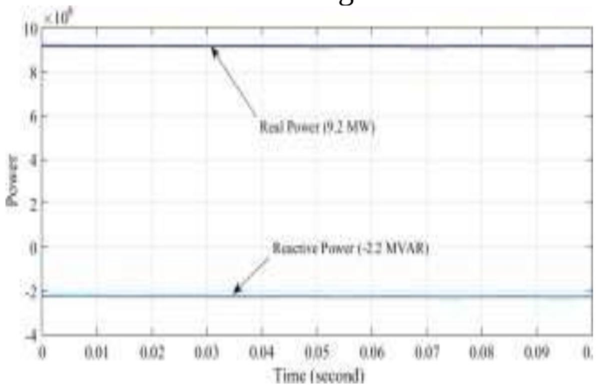

Fig.6 Real and reactive power (without STATCOM)

6. CONCLUSION

With adaptive PI voltage management and D-Q axis-based STATCOM, the power system network in this study could send and receive data more effectively. The simulation revealed that both of these STATCOM control approaches performed admirably. The adjustable voltage control method has been shown by increasing the voltages on the network bus. Before joining STATCOM, the bus voltage was 1.0 p.u. and then increased to 1.05 p.u., which is the reference number. The reactive power flow through the D-Q axis PI-based STATCOM has decreased significantly, causing real power to grow. Before the STATCOM was attached, reactive power was 1 p.u., but it reduced to 0.48 p.u. later. These two control strategies were also tested using simulations that were not working properly. The symmetrical and asymmetrical challenges were resolved by including STATCOM into the system, as demonstrated in the simulation section.

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