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Control and simulation of static condenser

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***Abstract*— A Static Compensator is a device that can provide reactive support to a bus. It consists voltage sourced converters connected to an energy storage device on one side and to the power system on the other. In this paper, the conventional method of PI control is compared and contrasted with various feedback control strategies. A linear optimal control based on LQR control is superior in terms of response profile and control effort required. These methodologies are applied to an example power system.**

***Keywords*— Controller design, Stat Com, voltage regulation.**

I. Introduction

The use of facts devices in a power system can potentially overcome limitations of the present mechanically controlled transmission systems. By facilitating bulk power transfers, these interconnected networks help minimize the need to enlarge power plants and enable neighboring utilities and regions to exchange power. The stature of FACTS devices within the bulk power system will continually increase as the industry moves toward a more competitive posture in which power is bought and sold as a commodity. As power wheeling becomes increasingly prevalent, power electronic devices will be utilized more frequently to insure system reliability and stability and to increase maximum power transmission along various transmission corridors. The static synchronous compensator, or Stat Com, is a shunt connected FACTS device. It generates a balanced set of three phase sinusoidal voltages at the fundamental frequency, with rapidly controllable amplitude and phase angle. This type of controller can be implemented using various topologies. However, the voltage-sourced inverter, using GTO thyristors in appropriate multi-phase circuit configurations, is presently considered the most practical for high power utility applications. A typical application of this type of controller is voltage support.

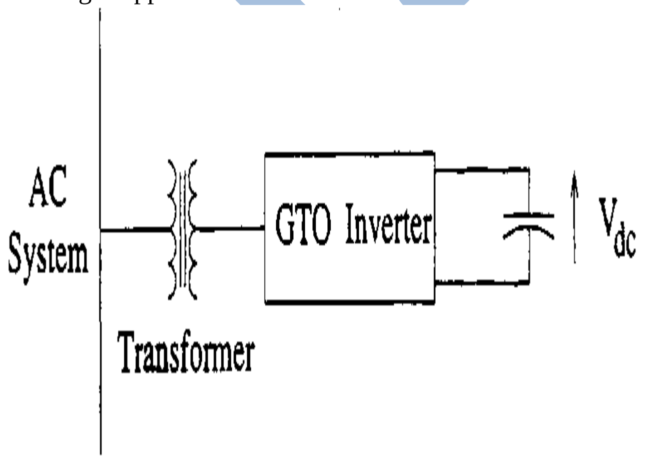

Fig. 1. Connection of a StatCom to a bus.

voltage. The inverters are connected to a capacitor which carries the DC voltage. In practice, conventional proportional-integral control is typically used to achieve automatic voltage regulation. The standard response time is typically chosen to be on the order of a hundred microseconds.

II. MODELING OF THE STATCOM

The equivalent circuit of the StatCom is shown in Fig. 2. In this circuit, the resistance in series with the inverter represents the sum of the transformer winding resistance losses and the inverter conduction losses. The inductance represents the leakage inductance of the transformer. The resistance in shunt with the capacitor represents the sum of the switching losses of the inverter and the power loss in the capacitor. The inverter block represents a lossless transformer.

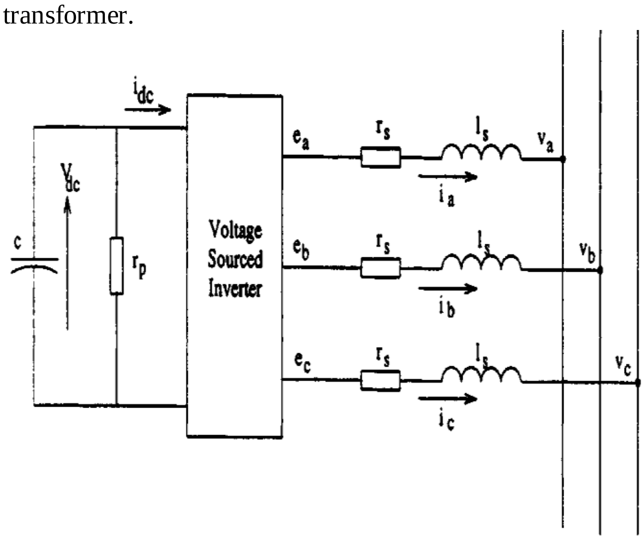

Fig. 2. Equivalent circuit of StatCom.

Pole-Placement Methods

The dynamic response of a linear system is governed by the magnitude and location of its eigenvalues, or poles. The response of a system may be affected by relocating some, or all, of the system poles. Common usages of pole placement control is to stabilize an unstable system by moving one or more poles from the right-half complex plane to the left, increasing damping of system response by increasing the magnitude of certain poles, or changing oscillatory frequency by manipulating the complex part of poles. In many cases, it is not desirable, or feasible, to adjust the placement of the majority of the system poles. Therefore, it is desirable to move only those eigenvalues which significantly impact the dynamics of interest.

III. STATCOM PLACEMENT

The primary function of a StatCom is to provide voltage regulation within the power system. To provide the best performance, a StatCom should be placed at those buses which provide high voltage response for incremental changes in reactive power injection. This approach can be used to determine the placement of a StatCom by increasing the system loading pattern until the minimum singular value is sufficiently small. This may be accomplished using the continuation power flowor similar method [7].At this critical loading point, the relatively large elements of left singular vector will correspond to those system buses which are highly sensitive to reactive power injections. StatComs placed at these buses will provide the most effective voltage regulation. The control methodologies proposed in this paper can be extended to a system with more than one StatCom by considering each device individually. As noted previously, there is very little coupling between the StatCom dynamic states and the remaining power system states, thus control design is effected only negligibly by the presence of other Stat Coms in the system.

IV. RESULT

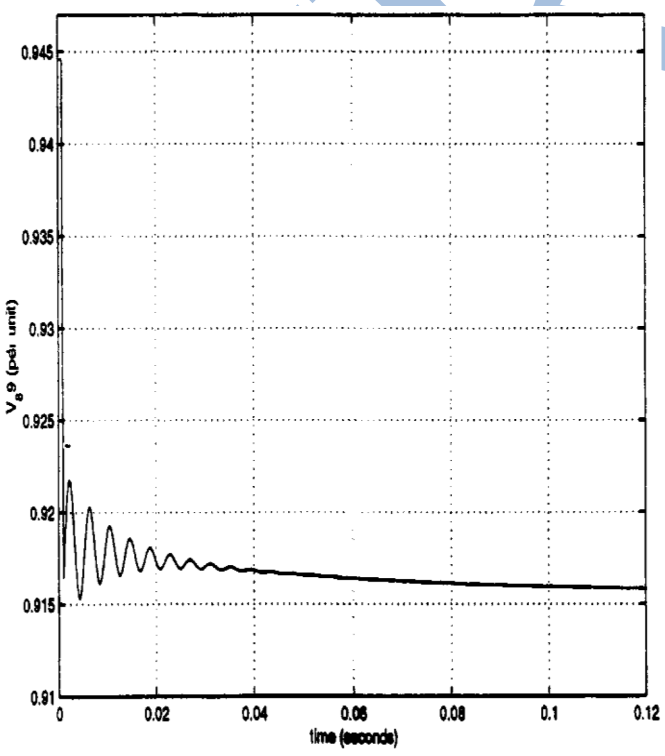

Fig. 3. Uncontrolled voltage response at bus 86.

The PI control system was designed for a desired settling time of 0.1 seconds. The desired voltage set point is the initial voltage value of 0.9445 pu.

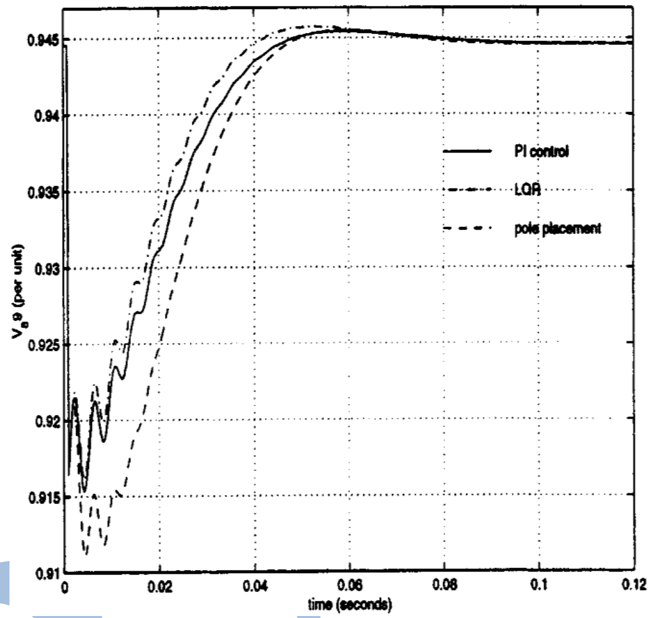

Fig. 4. Controlled voltage response at bus 86.

The pole placement control system was also designed for a desired settling time of 0.1 seconds, with a reference voltage set point of 0.9445 pu.

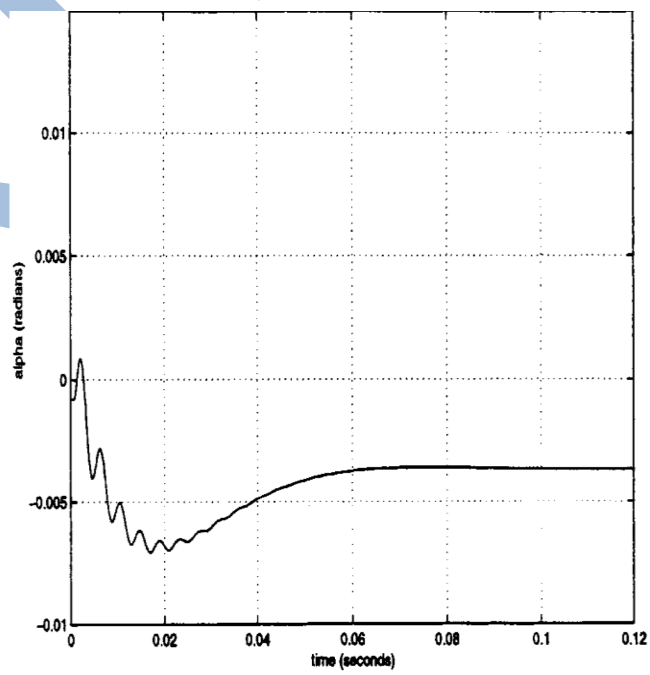

Fig. 5. PI control—control angle

V. CONCLUSION

The modeling of a StatCom for power system applications is presented in this paper. Three types of state feedback controllers are developed and compared. One of the main advantages of these approaches is that the nearly linear behavior of the StatCom response enables linear control methods to be effectively employed. This allows a wide range of design strategies to be explored with linear tools, while a nonlinear simulation need only be applied during the final stages of design to substantiate the control.

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