CONTROL STRATEGIES FOR MULTIPLE STATIC VAR COMPENSATORS IN LONG DISTANCE VOLTAGE SUPPORTED TRANSMISSION SYSTEMS

Nelson Martins[1] Senior Member IEEE　**Nilo J.P.Macedo**[2]　**Leonardo T.G. Lima**[3]　**Herminio J.C.P. Pinto**[1]

[1] CEPEL, Caixa Postal 2754, 20.001, Rio de Janeiro, RJ, Brazil
[2] FURNAS Electricity Co., R. Real Grandeza, 219, 22.283, Rio de Janeiro, RJ, Brazil
[3] IME, Dept. of Elect. Eng., Pç. Gal. Tibúrcio, 80, 22.290, Rio de Janeiro, RJ, Brazil

Abstract – This paper addresses the small–signal stability and control problems associated with a long distance voltage supported AC transmission system. Linear techniques are used for the control design of multiple static VAR compensators along the transmission system. Different voltage control strategies are investigated and additional stabilizing signals are designed using frequency response techniques. A new centralized control strategy is proposed and its performance is shown to be superior to the traditional individual bus voltage control. Linear time responses to step disturbances are included to illustrate the performances of the different control strategies investigated.

Keywords – small signal stability, long distance AC transmission, electromechanical oscillations, stabilizing signals, static VAR compensators, centralized control, eigenvalues, frequency response techniques, control system design, FACTS devices

I. INTRODUCTION

Static VAR compensators (SVC) provide dynamic voltage support, damp electromechanical oscillations and increase power interchange limits in electrical power systems. Techniques for determining the most suitable SVC location and for additional stabilizer signal design have been described [1, 2, 3, 4, 5].

The coordinated design and tuning of multiple SVC's in a long distance voltage supported transmission system is a highly complex engineering problem. There is no established methodology for the simultaneous design of multiple controllers in large electrical power systems. One possible solution is to adopt a conventional structure for the various SVC's and tune their parameters through an eigenvalue based design procedure supported by good field experience [6]. The conventional single–machine–infinite bus equivalent has worked well when tuning generator excitation control stabilizers (PSS) in large systems [7]. The PSS's in a multimachine environment usually show robust performance and low dynamic interaction. This is not the case with SVC's or any other FACTS devices, all of which have a high speed of response. In a multiple FACTS environment, there may be a high dynamic interaction between these devices, and their tuning must therefore be done in a more coordinated manner [8,9].

This paper presents a new centralized voltage control strategy for multiple SVC's in a long distance transmission system. This strategy yields a single controller structure, which can be rigorously designed through single–input–single–output (SISO) frequency response techniques. The centralized control strategy is shown to be more robust [3,10] regarding structural and operating point changes in the system than the traditional control scheme (individual bus voltage control).

92 SM 589-2 PWRS A paper recommended and approved by the IEEE Power System Engineering Committee of the IEEE Power Engineering Society for presentation at the IEEE/PES 1992 Summer Meeting, Seattle, WA, July 12-16, 1992. Manuscript submitted January 28, 1992; made available for printing May 13, 1992.

Eigensolutions, frequency response techniques and linear step response results were used in the control design work reported in this paper. The centralized control strategy demands the feedback of numerous remote bus voltages and frequencies to each SVC. This required the development of very general and flexible routines to model user–defined controllers in the simulation package. The telecommunication delays associated with the use of remote signals were also adequately modeled.

The notations adopted in the paper are defined as used. The symbol Δ used to denote an incremental change from a steady–state value is omitted in this paper for brevity.

II. THE VOLTAGE SUPPORTED AC TRANSMISSION SYSTEM

Figure 1 shows the basic configuration of the long distance voltage supported AC transmission system analyzed in this paper.

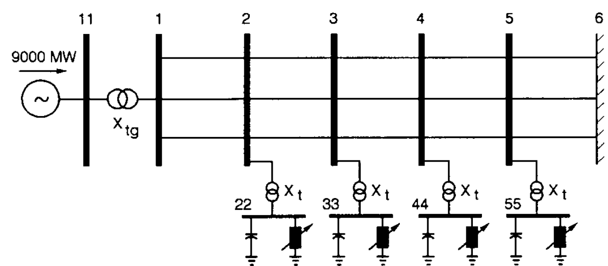

Figure 1. Voltage Supported AC Transmission System

The system contains a 9600 MVA power plant connected to an infinite bus through three long distance 765 kV circuits. Each line section has about 320 km, yielding a total transmission length of 1600 km. The complete data of this system, which are typical for EHV systems, are given in the Appendix.

The generation dispatch considered yielded an operating point with a large angular displacement (175°) between the generator field voltage and the infinite bus voltage. Figure 2 shows the phasor diagram of system voltages for the base case.

For the base case operating point the system shows an unstable eigenvalue $\lambda = +10.891$ in the absence of dynamic voltage control (all reactive compensation along the system are modeled by passive components). This positive real eigenvalue denotes a condition of high aperiodic instability due to the lack of synchronizing torque between the generator and the infinite bus.

The dynamic voltage control obtained through the use of adequately designed SVC's along the transmission line, together with properly tuned stabilizing signals, makes it possible to stabilize and obtain a good performance from this system. The