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DStatCom regulation by a fuzzy segmented PI controller

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ABSTRACT

This paper presents a segmented PI controller for the 84-pulses DStatCom connected to the electric power system (EPS) and subjected to several common disturbances in voltage and load levels. The 84-pulses signal is obtained by combining one twelve-pulses voltage source converter (VSC) with an asymmetric single-phase seven-level converter, adding an injection transformer. This structure allows a reduced VSC output's total harmonic distortion. The synchronizing strategy ties the DStatCom to the EPS in an automatic way, preventing phase and frequency problems. PI controllers exhibit good performance around nominal conditions but they do not tolerate severe disturbances. Thus, a segmented PI strategy based on the error and error's variation is utilized and selected according to fuzzy rules. Simulations demonstrate the appropriateness of the proposal.

1. Introduction

FACTS devices have been proposed for fast dynamic voltage, impedance, and phase angle control on high-voltage ac lines. The advent of such devices has given rise to a new family of power electronic equipment to control and optimize the power system dynamic performance, e.g., Static Synchronous Compensator (StatCom), Static Synchronous Series Compensator (SSSC), and Unified Power Flow Controller (UPFC). The use of series and shunt compensation devices has been widely accepted as the new generation of flexible reactive power compensation to replace other conventional reactive compensators, such as the Thyristor Switched Capacitor (TSC) and Thyristor Controlled Reactor (TCR). The application of this technology has opened new and better opportunities for an appropriate transmission and distribution control.

The series and shunt power systems compensation is used with the purpose of improving the operating conditions. Relative to the voltage, the compensation has the purpose of handling reactive power to maintain the bus voltages close to their nominal values, reduce line currents, and reduce the system's losses. For this purpose, the voltage magnitude in some buses may be controlled through sophisticated and versatile devices such as the DStatCom, with a conventional PI control.

Since power systems are highly nonlinear systems, with time varying configurations and parameters, the PI control design based on the power system linearized model cannot guarantee a satisfactory performance under all operating conditions. Thus, in this paper the use of a control adjustable to new circumstances is suggested. The DStatCom's voltage is regulated by an intelligent control with the purpose of helping to improve the power systems' voltage profile. A strategy that deals with error and error's variation to split the control action in small sections that can be easily controllable for assuring the best performance of a DStatCom under severe disturbances is carried out.

The DStatCom is a power electronic-based Synchronous Voltage Generator (SVG) able to provide fast and continuous capacitive and inductive reactive power supply. It generates a three-phase voltage in synchronism with the transmission line voltage from a DC energy source, and it is connected to the EPS by a coupling transformer. The regulation of the DStatCom's output voltage magnitude makes the control of the reactive power exchange between the DStatCom and the transmission system a feasible task. The DStatCom's basic structure consists of a step-down transformer, a three-phase voltage source converter (VSC), and a DC capacitor [1–5].

Pragmatically, there are three achievable strategies for constructing a VSC: (i) the multi-pulse; (ii) the multi-level; (iii) and the pulse-width modulation (PWM)[6]. In this paper the followed strategy for generating a 84-pulses output utilizes a combination of one twelve-pulses and one seven-level converter, besides one reinjection transformer for steadily attaining the required complete performance (Fig. 1).

The paper is organized as follows. The strategy for obtaining the 84-pulses VSC is presented in Section 2. A DStatCom's state space representation is exhibited in Section 3. Section 4 includes a general description of the VSC used as DStatCom synchronized to

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