Electrical Power and Energy Systems 33 (2011) 322–331

Contents lists available at ScienceDirect

Electrical Power and Energy Systems

journal homepage: www.elsevier.com/locate/ijepes

New control strategy for DSTATCOM without current sensors and its engineering application

An Luo [a,*], Lu Fang [a], Xianyong Xu [b], Shuangjian Peng [a], Chuanping Wu [a], Houhui Fang [a]

[a] College of Electrical and Information Engineering, Hunan University, Changsha 410082, China
[b] Hunan Electric Power Company Test and Research Institute, Hunan Electric Power Company, Changsha 410007, China

ARTICLE INFO

Article history:
Received 11 May 2009
Received in revised form 11 June 2010
Accepted 13 August 2010

Keywords:
DSTATCOM
Cascade loop control strategy
Voltage regulation
No current sensors
Voltage unbalance
Mathematical model

ABSTRACT

This paper analyses the negative sequence equivalent circuit of DSTATCOM in unbalanced distribution networks. A new control model of negative sequence voltage without current sensors based on instantaneous power balancing algorithm is deduced. To compensate for balanced and unbalanced voltages, a new cascade voltage loop control strategy, in which the negative sequence voltage control loop is parallel to the positive sequence voltage loop, is proposed. Then the mathematical model of the new cascade loop voltage control method is discussed. The DSTATCOM output voltage command is directly obtained from the bus voltage at the Point of Common Coupling (PCC) and the DC-side voltage via a simple algebraic algorithm based on power balance equation. In addition, the implementation costs can be reduced since current sensors are not required in the proposed control strategy. Simulation and industrial application results are presented to verify the validity of the proposed control strategy. It is successfully implemented in the DSTATCOM installed in the Lianyuan Iron and Steel Corporation in Hunan province of China.

1. Introduction

The issues of power quality in distribution networks, such as poor voltage regulation and voltage unbalance, have got more and more publicity [1–5]. Distribution Static synchronous compensator (DSTATCOM) based on voltage source converter (VSC) technology, which is one of custom power devices, has been used to correct power factor and regulate voltage at the Point of Common Coupling (PCC) [6,7]. The DSTATCOM has good operating performance under unbalanced voltage of distribution networks [8,9]. The achievements of their work are useful for the future in-depth studies.

The performance of the DSTATCOM is greatly dependent on its control strategy. Several investigations have been carried out on the control strategies of DSTATCOM. In [10,11], the sliding mode control strategy has been used to make the controller of DSTATCOM robust. Also, most of the conventional control schemes of DSTATCOM have several PI controllers. However, parameters adjustment of PI controllers is a complex task for the nonlinear system. In order to enhance the performance of DSTATCOM controller, computational intelligence (CI) techniques can be used. There are many attempts of using CI techniques in DSTATCOM control. Refs. [12,13] are based on artificial neural networks (ANNs). In Ref. [12], the PI controllers are replaced by ANN which is trained via a back propagation algorithm, but the training is carried out offline. In [13], the reference current generator adapts an ANN weights online and the DC-side voltage regulation is handled by conventional PI controllers. The control strategies mentioned above not only are adaptive to the system dynamics, but also can enhance the performance of controller in case of unexpected drastic system disturbances.

However, many control strategies for DSTATCOM are proposed based on the condition of balanced grid, the condition is not usually practical in the industrial application. The performance of DSTATCOM operating under unbalanced supply conditions has attracted much attention of scholars and engineers. Direct output voltage control of the DSTATCOM is proposed in [14] to regulate the voltage for unbalanced supply voltage in the distribution network. In [15], a new kind of noncurrent sensors method based on power balancing algorithm is proposed for direct output voltage control of the STATCOM. Although, this control method has fast response for fluctuating load and good voltage regulation in voltage sag, it is only suitable for balanced supply condition and the paper does not consider the unbalanced condition of the grid. In [16], a new cascade loop control method of DSTATCOM is proposed for compensating positive and negative sequence voltages. This control method can work well under all system conditions. However, six current sensors are required to implement the control strategy. That is to say, this control method is less economical in practical implementation.

* Corresponding author. Tel./fax: +86 07318823700.
E-mail addresses: an_luo@126.com (A. Luo), 2001xxy@163.com (L. Fang).

0142-0615/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ijepes.2010.08.029