Title: Voltage-Oriented Control-Based Three-Phase, Three-Leg Bidirectional AC–DC Converter with Improved Power Quality for Microgrids

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Published Journal Name: Energies

Type of Publication: Journal

Volume: 16 Issue 17

Publisher: MDPI

Publication Date: 25/08/2023

ISSN: 1996-1073

DOI: https://doi.org/10.3390/en16176188

URL: https://www.mdpi.com/1996-1073/16/17/6188

Other Related Info.: Page 1-32, ISI and Scopus indexed

Abstract:

Renewable energy sources (RESs) and energy storage schemes (ESSs) integrated into a microgrid (MG) system have been widely used in power generation and distribution to provide a constant supply of electricity. The power electronics converters, particularly the bidirectional power converters (BPCs), are promising interfaces for MG infrastructure because they control the power management of the whole MG system. The controller of BPCs can be designed using several different control strategies. However, all the existing controllers have system stability, dynamics, and power quality issues. Therefore, this study demonstrates the development of an LCL-filtered grid-connected bidirectional AC–DC converter's (BADC) control strategy based on voltage-oriented control (VOC) to overcome these issues. The proposed VOC-based inner current control loop (ICCL) is implemented in synchronous dq-coordinate with the help of proportional-integral (PI) controllers. An observer-based active damping (AD) is also developed in order to estimate the filter capacitor current from the capacitor voltage instead of directly measuring it. This developed AD system helps to damp the resonance effect of the LCL filter, improves system stability, and also eliminates the practical challenges of measuring capacitor current. The proposed controller with AD is able to realize bidirectional power transfer (BPT) with reduced power losses due to the elimination of passive damping and improved power quality, system dynamics, and stability. The mathematical modeling of the suggested system was developed, and the structure of the system model was established in the MATLAB/Simulink environment. The performance of the proposed system was validated with real-time software-in-the-loop (RT-SIL) simulation using the OPAL-RT simulator for a 16 kVA converter system. The real-time (RT) simulation results show that the BADC with the proposed control scheme can provide better dynamic performance and operate with tolerable total harmonic distortion (THD) of 2.62% and 2.71% for inverter and rectifier modes of operation, respectively.