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Design and Implementation of a Robust Current Controller for Single-Phase Inverters Connected Electrical Network via a damped LCL filter for Renewable Energy Systems

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Abstract

A renewable energy source plays an important role in electricity generation. Various renewable energy sources like wind, solar, geothermal, ocean thermal, and biomass can be used for generation of electricity and for meeting our daily energy needs. Energy from the sun is the best option for electricity generation as it is available everywhere and is free to harness. This paper deals with the design and implementation of a current controller for a single-phase voltage-fed inverter connected via an LCL filter. In this proposal, a single-phase micro-inverter connected to the power grid based on a complete bridge topology and the effects presented by the inclusion of a notch filter in the external voltage control mesh were analyzed. The proposed control improves the harmonic rejection capacity of the single phase inverters connected to the electric grid for application in photovoltaic panels, which is based on an alternative control structure and the proper selection of the LCL filter feedback current. The inclusion of a high order filter such as LCL in place of the traditional inductive filter provided greater capacity and attenuation of the unwanted components. However, the resonance from this filter impairs the stability of the system, requiring the inclusion of passive or active damping techniques. With the notch filter acting on the system, the current injected into the network had a substantially better total harmonic distortion index (THD), mainly due to the elimination of the 120 Hz ripple, meeting the requirements of international standards such as IEEE 1547.
In addition, the control of the system proved to be robust and efficient, keeping the steady state error close to zero even in the event of voltage sinking and variations in the frequency of the network.

Key words

Electric power. Harmonic distortion. Imbalance. Quality electricity. Renewable energies. photovoltaic system.

1. Introduction

The installed capacity of the Brazilian electric power matrix is of the order of 132 GWP, with hydroelectric power being predominant and representing approximately 65% of this capacity [1]. However, Brazil has an extensive area not covered by the public electricity network where more than 10 million people live. The conventional energy system does not have the structural conditions to meet this demand, but the country has several rural electrification programs through small autonomous systems, in which photovoltaic technology predominates [2]. Photovoltaic systems connected to the grid can be designed as systems to be integrated to buildings supplying energy demand and delivering excess energy to the grid or as large power plants that deliver all converted energy to the grid. The analysis of the behavior of photovoltaic installations connected to the grid is necessary for the knowledge and learning of these systems in order to develop the technology and make it a viable alternative within the energy system of the country[3-6].
In this paper, we discuss the design and implementation of a current controller for a single-phase inverter powered and connected through an LCL filter, see the configuration used in figure 1. In this proposal, a single-phase micro-inverter connected to the electric grid was analyzed based on a topology in complete bridge and the effects presented by the inclusion of a notch filter in the external voltage control mesh.

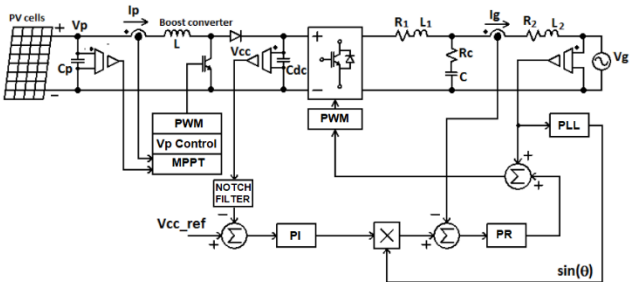

Fig. 1. PV system connected to the grid

The inverter c.c./c.a. converts the power into direct current from the photovoltaic arrangement in power, in alternating current that, under normal conditions (acceptable quality), will be injected into the electric distribution network. The development of electronic power technology has allowed a considerable increase in cc / cc conversion efficiency, together with increased reliability and cost savings. The inverters currently used in SFCR incorporate control functions that influence the operation of the system, such as: maximum power point follower, connection or disconnection of the network