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ORIGINAL RESEARCH

A single-loop and current-sensorless control for on-grid seven-level photovoltaic microinverter

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Abstract

This paper proposes a single-phase transformerless photovoltaic (PV) microinverter for low and medium-voltage applications. The proposed approach comprises a suitable combination of multilevel boost/buck and H-bridge topologies with a current-sensorless control scheme, where the system controller only needs a straightforward-to-implement control loop to reach the desired attributes in solar PV conversion systems. Compared with other microinverters, this proposal significantly reduces the number of hardware components and required software resources, considerably attaining industrial and production advantages; guaranteeing: (i) a high DC elevation factor; (ii) an extraction of maximum power from solar PV panels; (iii) a multilevel output voltage; (iv) a low total harmonic distortion; and (v) a power factor close to unity. The multilevel microinverter's feasibility and effectiveness are assessed by a comprehensive mathematical model, whose simulation results are evaluated using MATLAB-Simulink, and the experimental results are validated by means of an on-grid low-scale prototype, generating a power capacity of 1.5 kW.

1 | INTRODUCTION

The massive advent of solar photovoltaic (PV) power generation has triggered the continuous improvement of the inverters' capabilities at residential, commercial and industrial levels. An even higher growth rate is expected, which is propelled by government plans to reduce the environmental effects of power generation from fossil fuels [1, 2]. Likewise, the continuous reduction of PV equipment costs also boosts this transformation [3].

This current trend is enhanced by the massive production of PV inverters, optimizing the exploitation of hardware and software resources [4]. In terms of hardware, the aim seeks developing power electronic converters with low cost, high efficiency, high power density, reduced number of sensors, and low harmonic distortion levels on the AC side [5]. Thus, transformerless voltage boosting and multilevel conversion techniques represent a paramount alternative to meet these requirements [6]. Meanwhile, the goal the software resources is to simplify the control algorithms, making them efficient and fast to achieve their straightforward implementation. The reduction of computational resources in digital filters, observers, or variable reconstruction systems, makes affordable the use of digital programmable devices in solar PV inverters, implying in these a lower cost.

1.1 | Literature review

Useful combinations of topologies, controllers and modulation strategies focused on single-phase PV systems have been reported in the technical literature. Among these, the multilevel inverters stand out for their low volume and cost

The generation of a multilevel waveform at the AC side can be achieved by employing various DC PV-Array sources. However, this approach requires constant monitoring of voltage and current channels at each PV-array, numerous power switches, and in some cases transformers to raise the voltage [7, 8]. In