Multistring Five-Level Inverter With Novel PWM Control Scheme for PV Application

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Abstract—This paper presents a single-phase multistring five-level photovoltaic (PV) inverter topology for grid-connected PV systems with a novel pulsewidth-modulated (PWM) control scheme. Three PV strings are cascaded together in parallel configuration and connected to a five-level inverter to produce output voltage in five levels: \(v_{dc} = +1/2V_{dc}, V_{dc}, -1/2V_{dc}, \) and \(-V_{dc}\). Two reference signals that were identical to each other with an offset that was equivalent to the amplitude of the triangular carrier signal were used to generate PWM signals for the switches. DSP TMS320F2812 is used to implement this PWM switching scheme together with a digital proportional–integral current control algorithm. The inverter offers much less total harmonic distortion and can operate at near-unity power factor. The validity of the proposed inverter is verified through simulation and implemented in a prototype. The experimental results are compared with a conventional single-phase multistring three-level grid-connected PWM inverter.

Index Terms—Grid-connected, multilevel inverter, multistring, photovoltaic (PV), pulsewidth-modulated (PWM) inverter, proportional–integral (PI) current control.

I. INTRODUCTION

A S THE WORLD is concerned with fossil-fuel exhaustion and environmental problems caused by conventional power generation, renewable energy sources, particularly solar and wind energy, have become very popular and demanding. Photovoltaic (PV) sources are used today in many applications because they have the advantages of being maintenance and pollution free [1]. Solar-electric-energy demand has grown consistently by 20%–25% per annum over the past 20 years, which is mainly due to the decreasing costs and prices. This decline has been driven by the following: 1) an increasing efficiency of solar cells; 2) manufacturing-technology improvements; and 3) economies of scale [2]. A PV inverter, which is an important element in the PV system, is used to convert dc power from the solar modules into ac power to be fed into the grid.

A general overview of different types of PV inverters is given in [3] and [4]. This paper presents a multistring five-level inverter for PV application. The multistring inverter shown in Fig. 1 is a further development of the string inverter, where several strings are interfaced with their own dc–dc converter to a common dc–ac inverter [5]. This is beneficial, compared with the centralized system, because every string can be controlled individually. Thus, the operator may start his/her own PV power plant with a few modules. Further enlargements are easily achieved because a new string with a dc–dc converter can be plugged into the existing platform. A flexible design with high efficiency is hereby achieved [3]. In this paper, a five-level inverter is used instead of a conventional three-level pulsewidth-modulated (PWM) inverter because it offers great advantages, such as improved output waveforms, smaller filter size, lower electromagnetic interference, lower total harmonic distortion (THD), and others [6]–[12].

This paper proposes a single-phase multistring five-level inverter topology. It consists of three strings of PV arrays connected to their own dc–dc boost converter. An auxiliary circuit comprising four diodes and a switch is configured together with a conventional full-bridge inverter to form this topology. A novel PWM control scheme is introduced to generate switching signals for the switches and to produce five output-voltage levels: \(v_{dc} = +1/2V_{dc}, V_{dc}, -1/2V_{dc}, \) and \(-V_{dc}\) (assuming that \(V_{dc}\) is the supply voltage). This inverter topology uses two reference signals instead of one to generate PWM signals for the switches. Both reference signals \(V_{ref1}\) and \(V_{ref2}\) are identical to each other, except for an offset value that is equivalent to the amplitude of carrier signal \(V_{carrier}\), as shown in Fig. 2.

Because the inverter is used in a PV system, a proportional–integral (PI) current control scheme is employed.