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DC LINK VOLTAGE MODULATION OF A CONNECTED GRID SINGLE PHASE INVERTER

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Abstract. A PV system is an interesting sustainable energy. However, the efficiency and the effectiveness of the PV system is still a challenge. This is due to the fact that the PV system is composed of different parts which do not have same life span. The second most important component besides the panels is an inverter. Many topologies have been used in order to increase the efficiency and life span of the PV system. However, the used topologies have a complicated voltage or current control. This paper intends to present a cost effective PV converter with a reduced ripple at input and output with a film capacitor in the DC link. The topology is based on three phase module whose the left is used as boost converter. The two remaining legs are used as H-bridge inverter. The simulation of the topology done in MathCAD and Matlab will be shown in the paper.

Keywords: DC link voltage, polypropylene film capacitors, PV converter.

INTRODUCTION

With the recent proliferation of PV converter systems, it is also interesting to improve the topologies. Most of converters have been using electrolytic capacitors. However, due to its technology, the electrolytic capacitors have a low ripple current /capability [1]. For this reason and in order to reduce losses in the PV inverter technology, one should use the polypropylene film capacitors where it is possible. Nevertheless, the use of these capacitors, especially the use of the polypropylene film capacitors, requires a good study so that they can be cost effective [1]. The large scale production made the PV modules affordable. However, the total cost of a PV system is still a bit high. This is due to different factors, the PV converters, the grid connection, and labor work cost [4] and [5]. The PV converter control is not obvious and unique. Even for the basic converter topology, many variants are possible; the engineers may have a variety of converter controlling circuits [2], [6], [7] and [9].

Fig.1 presents a converter topology which is different from the common three phase converter. The topology can use one IGBT module [3]. The converter uses a three-phase inverter topology for a single phase injection. The capacitor C1 of 150-250 V is larger than C2. The capacitor C1 has to carry 100 Hz power pulsation in a 50 Hz grid. The voltage across C2 equals to C1 voltage when the grid voltage is low . C3, small compared to C1, is a part of the EMC filter. Q3 and Q4 are switched depending on the quadrant whereas Q5 and Q6 are switched depending on the quadrant and PWM modulated method. The topology offers a lot of advantages. The switching loss in Q1 is limited as the voltage across the C2 is lower than usual. The capacitor C2 carries a high ripple current but is a low loss type and it helps to reduce radio interference. The switching losses in Q5 and Q6 are limited since they do not switch on the top of the sine wave. Fig.2 shows the sequence of the duty cycles for the switches.

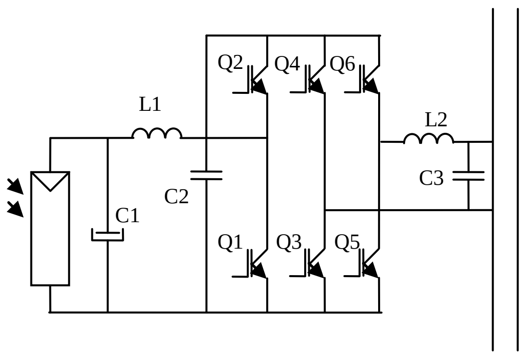
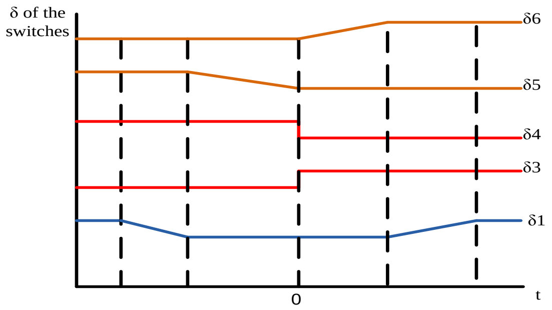


Fig.1 Single phase PV converter using a three-phase bridge



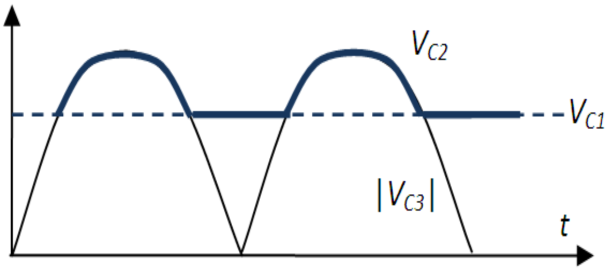


Fig.2 The PV converter switches behavior
x-axis: desired voltage at the output of the H-bridge
y- axis: the duty ratio of the switches to be operated.

Fig.3 Control voltage across C2

The slow leg Q3-Q4 permits to achieve a low EMI from PV to grid. However, the topology does have some disadvantages. The control of the convertor is not obvious, as one faces a non-linear 4th order circuit or even more when the grid impedance is considered. The reason is that C2 is a foil capacitance with low capacitance value. The inductors L1 and L2 play a big role in the PV converter. The current ripple is low at both input and output because the presence of the inductors. This makes the conversion smoother with less EMI (radio interference). The H bridge delivers the voltage to the grid at low grid voltage. When the C2 voltage is not sufficient the boost converter with Q1 increases the voltage across C2 [Fig.3]. This paper does put into consideration the controllability of the capacitor C2 in order to increase the efficiency, reliability and cost effectiveness of the PV converter.

AIMS OF THE PAPER

The paper targets to analyze the performance of the topology described in [Fig.1]. It will show how the DC link voltage must be modulated by controlling the current in inductor L2. In other words, the paper will focus on the current control of Buck/ Boost converter of the topology in [Fig.1] base on [Fig.2].

CONCLUSIONS

There is a possibility for a single phase grid injection to use a three-phase bridge topology while using the left leg as a boost converter and with reduced film type DC-link capacitor. However, the behavior tends to have a pronounced resonance for both boost and H-bridge converters. This pronounced resonance can be damped using the current control at L2 level. The reduced voltage stress can reduce the switching losses of the PV inverter.

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