Proposal of Three-Phase Micro-Inverter for Residential Loads

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***Abstract*— In this work is shown the development of a three-phase micro-inverter using low cost IGBT power module, current and voltage sensors. The use of power module has some advantages compared to discrete switches like the no requirement of some integrated circuits for control and protection circuits becoming the circuit less expensive and more robust. The IGBT power module converter validation and tests were made with resistive and inductive loads connection.**

Keywords*— *grid-tie; CC/CA converter; power module; wind enegy; photovoltaic energy

I. Introduction

The CC-CA converters are commonly used as uninterruptible power supply, also known as uninterruptible power supply (UPS) for generating a controlled CA voltage at the output [1]. Other applications, is the connection to the mains and generating photovoltaic and wind systems, for it requires if a control algorithm for synchronization to the grid and energy flow control [2].

Today with the development of integrated circuit manufacturing technology, are built integrated dedicated power modules. The module used in this research work, it is IRAMS10UP60B, which has the advantage of being built six transistors (IGBT´s) connected in three-phase inverter bridge, fast recovery diodes to minimize the effects of electromagnetic interference, the drive circuit of IGBT’s with dead time and a circuit based on a thermal protection thermistor (International rectifier). This makes it possible to reduce the cost to be related to reducing the amount of external auxiliary circuits required for operating the power key. In addition to ensuring a more compact assembly, focused on adding new features and not in the drive module itself [3,4].

II. Three-Phase Micro-Inverter

The general objective of this research is the development of the prototype of a three-phase micro-inverter at low cost using an integrated power module - IRAMS10UP60B (Fig. 1), for application of low power wind or photovoltaic generation system.

Fig. 1. IRAMS10UP60B power module.

A. Metodology

This work used a DSP of Texas Instruments TMS320F28335 to generate the PWM pulses and acquire voltage and current signals for converter control. The steps of project development are listed below:

1. It was build a circuit to isolate the DSP digital outputs (3.3V) from the digital inputs of the power module (15V) using an optocoupler HCPL-2231 (Fig. 2).

2. It was build a circuit for signal conditioning to acquire current of the load using a current sensor ACS714 (Fig. 3). Is a hall effect sensor with output normalized between 0V and 5V. To compatibilizer the output signal voltage range of current sensor with the analog input of DSP was used a resistive divider to remap 0V-5V to 0V-3V.

3. It was build a circuit for signal conditioning to acquire voltage of the load using the isolated linear amplifier HCPL 7520 (Fig. 4). The circuit input voltage range is +/- 311V and the isolated output is 0V-3V (analog input of DSP).

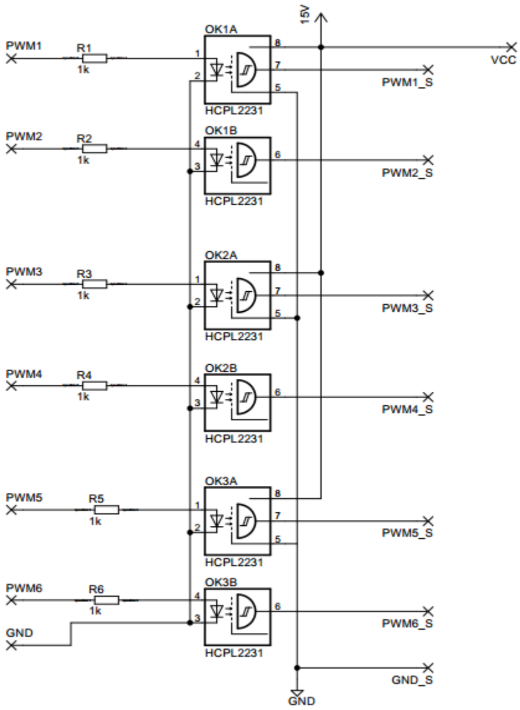

Fig. 2. circuit to isolate – HCPL 2231

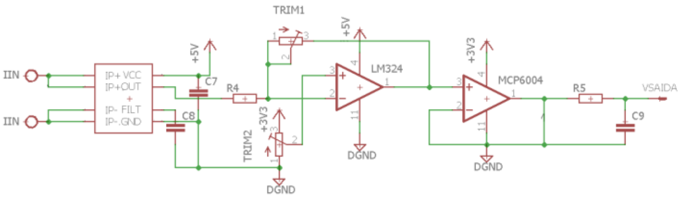

Fig. 3. Circuit for signal conditioning to acquire current

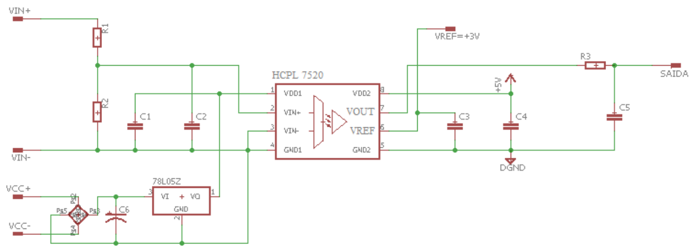

Fig. 4. Circuit for signal conditioning to acquire voltage

4. It was specified an inductor value following the equation (1). This formula ensures a filtering of the harmonics from the switching frequency:

$$L = V_s.(E - V_s) / (2\ f_{ch}.\ \Delta I) \qquad (1)$$

Where: **L** is inductance of inductor, $\mathbf{V_s}$ is the output voltage, **E** is the input voltage, $\mathbf{f_{ch}}$ is the switching frequency and **ΔI** is the ripple current.

The general diagram of the implemented system is shown in Fig. 5.

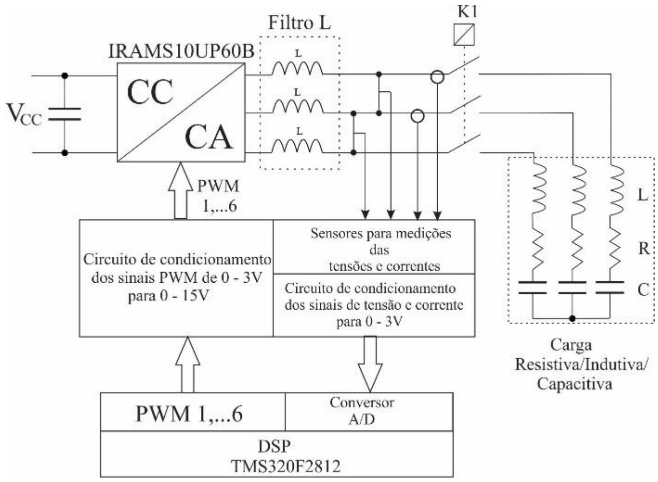

Fig. 5. System diagram

III. Results

The purpose of this study is to evaluate the IRAMS10UP60B to control the voltage and frequency to be constant, at the output of the inverter. Initially (Fig. 6), the output voltage of the inverter with no-load operation is shown. Figure 7 and 8 shows the results of the voltage and phase current with the inverter operating with loads: resistive and inductive.

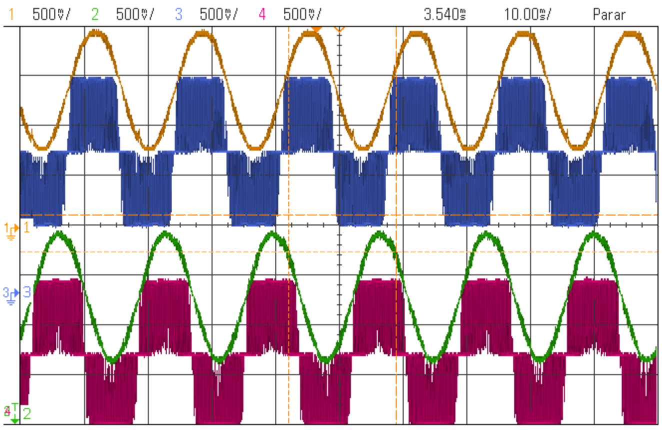

Fig. 6. Converter with no load

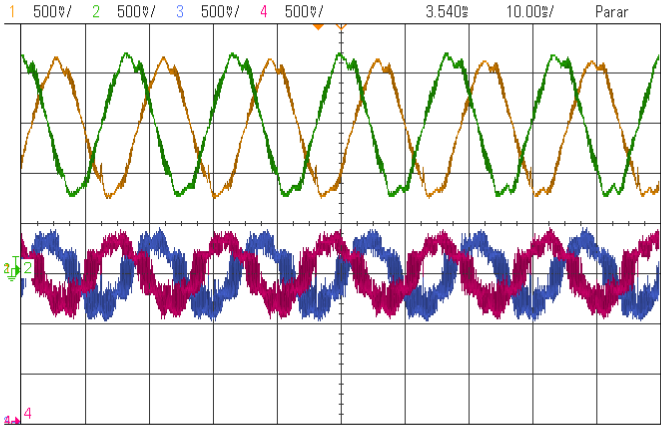

Fig. 7. Converter with resistive load

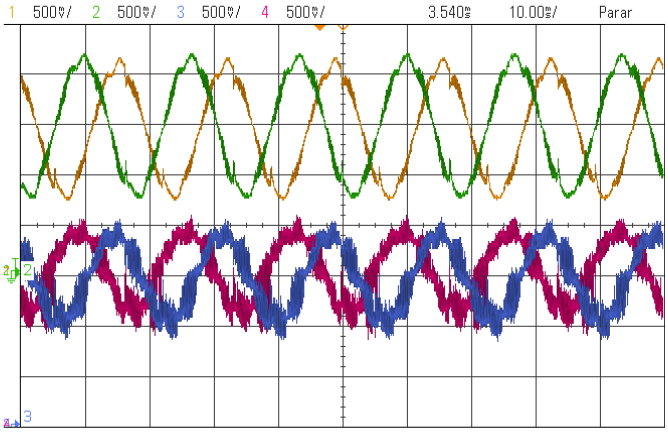

Fig. 8. Converter with indutive load

Based on the tests of the inverter using the power module IRAMS10UP60B, operating without load and with resistive and inductive load, it is possible to observe its correct operation, observing the results of the voltages and line currents. It was also verified the correct operation of the circuits of the sensors, the PWM signal conditioning and measuring voltage and current.

IV. Conclusions

This paper presented the development of a three-phase micro-inverter using low cost IGBT power module. The inverter was made by an integrated dedicated power module named IRAMS10UP60B. In which, it has the advantage of being built, with: six transistors (IGBT´s) connected in three-phase inverter bridge; fast recovery diodes to minimize the effects of electromagnetic interference; drive circuit of IGBT's with dead time, and; a circuit based on a thermal protection thermistor.

For the validation tests were made with resistive and inductive loads connection, verifying its operation correct, as well as, the circuits of the sensors, the PWM signal conditioning and measuring voltage and current.

Acknowledgment

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