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# Grid Connected Solar Microinverter with interleaved Flyback Converter

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## Abstract

Renewable power sources are the best way to reduce the effect of green house gases and thereby global warming. Among them solar power may be seen as the most reliable due to its availability. But the solar PV system is expensive. So the main objective of this work is to develop a solar PV system which is cost effective without compromising on the efficiency of the system. The optimal operating point of each PV panel is different depending on the solar irradiation and temperature on the panel. In a string of panels the power of the entire string can be optimized and not on panel by panel basis. This paper focuses on power optimization tracking of individual PV panels using a single stage interleaved flyback converter. The proposed converter is having high voltage conversion ratio when compared to an ordinary buck boost converter. A detailed study conducted in this paper explains the practical and theoretical techniques for making the PV cells to work most efficiently all the time. A practical approach is made in this paper using the MATLAB atmosphere and to prove the quality of the theoretical concepts hardware results are also provided. The result proves that the efficiency of the entire system can be improved by optimizing each panel and the reduction of conversion stages helps to make the system more cost effective.

**Keywords:** Electromagnetic Capability, Electromagnetic Interference, Maximum Power Point Tracking, Photovoltaic

## 1. Introduction

Global warming and its effects are the main topics of the current world because of its threat towards the environment and human beings. Numbers of environmental agreements are in effect to reduce the emission of green house gases. Developed countries are more efficiently trying to control the situation. Renewable energy sector like wind, solar, tide etc. can contribute a lot to the reduction in green house gases. If a comparison between renewable sources is conducted, solar power may be the most reliable due to its availability. For the power generation from sun light, photovoltaic panels can be used and the only emission related with it is from the production of its components. Once solar panels are installed they start to produce electricity from the sun light without any emission. The main advantage of this type of installation is its easiness in installation i.e. it can be installed in any place like roofs deserts etc. It can also be used for the electrification of rural places where there is no electrical networks. But the main disadvantage related to this type of power generation is the lower efficiency[1,2].

There are some things we have to consider before interfacing a solar inverter with power grid. One thing is that we should make sure the solar inverter is operating at MPP. Another thing is the alternating current injection into the grid[3].

## 2. Microinverter

A microinverter is formed by integrating an inverter into a solar panel as shown in Figure 1. It also improves system reliability from 3 to 15 years by reducing temperature of converters and removing fans[4]. Efficiency can be improved by replacing hard switching with soft switching and also reduces heat dissipation. This in turn helps to eliminate electrolytic capacitors. Another advantage

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of grid connected system is the elimination of batteries. Microinverters are mainly low powered[5,6].

Usually in grid connected solar microinverter system, a single stage full bridge inverter is used[7,8]. But it has got certain disadvantages. One is that it may not be able to handle a wide range of input voltage. So to eliminate this disadvantage two stage topologies are used[9]. But this makes the system costly. So here we propose a simple single stage topology.

## 2.1 Proposed Method

The single stage proposed topology using interleaved flyback converter shown in Figure 2 converts the panel output to alternating current. To suppress Electromagnetic Interference, EMI or EMC filter is used. It also provides impedance between output of inverter and the grid. The MPPT algorithm and fault control is executed by the microcontroller. As PV panel has to be designed for longer life there are two things we cannot compromise, high efficiency and reliability[10,11].

Electrolytic capacitor is used as a restricting component inside an inverter. It produces a ripple current which in turn increases temperature. And this ripple current can be reduced by interleaved flyback converter. For the maximum power point detection current from flyback MOSFET and voltage from the panel is measured[12]. In interleaved converter two flyback converters are used to

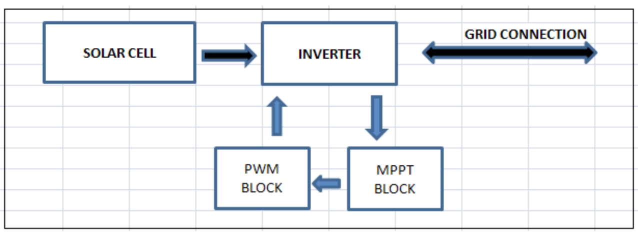


**Figure 1.** General layout of a grid-connected solar microinverter system.

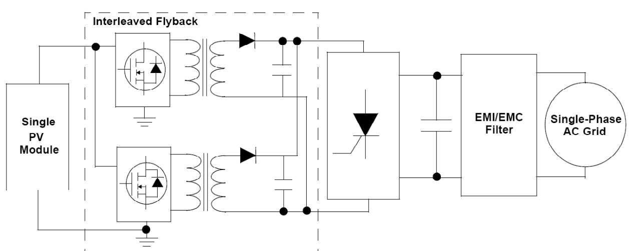


**Figure 2.** Interleaved flyback converter.

overcome some limitations of single stage converter such as larger magnetic core and higher current ratings of semiconductor devices.

The DC input from the PV module is given to the flyback converter. The two fly back converters are180 degrees out of phase and the interleaving operation is accomplished by these two flyback converters as shown in Figure 3.

The diodes D1 and D2 are in a blocking state when the MOSFET is turned ON. It is because the voltage applied across the diode is reverse biased from the transformer secondary winding. The output capacitor supplies the load current.

A voltage is produced in the secondary windings when MOSFET is turned OFF. This in turn will forward bias the output diodes. The secondary current which is sine modulated will produce a current in the output capacitors.

The main thing associated with grid-connected system is that it should maintain unity power. Take $V_{ac}$ as the inverter output, $V_L$ as the voltage drop across inductor and $V_{grid}$ as the grid voltage. From these we get $V_{ac} = V_{grid} + V_L$

$$V_{ac} = (V_{grid} + j)\ \omega.\ L.\ I_{ac}. \tag{1}$$

$$I_{ac} = V_{ac} - V_{grid} / (j.\ \omega.\ L) \tag{2}$$

# 3. Simulation Analysis and Results

## 3.1 Simulation Analysis

The main objective of this paper is to develop a model to test the performance of microinverter. The simulink will be consisting of a Solar cell, Inverter, Filter connection,

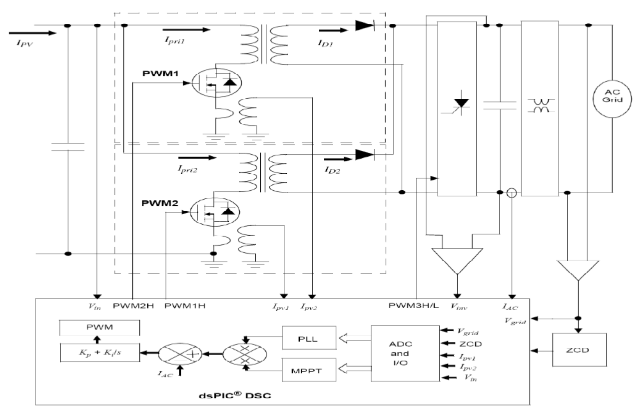


**Figure 3.** Measurement of grid voltage required for PLL.

Grid connection, Feedback loop, MPPT block and Inverter Firing block.

So in this paper a model is proposed and is made in MATLAB Simulink. The MPPT control block generates the reference constant value using the MPPT algorithm under test.

The output from the PV panel is DC voltage. This DC voltage has to be converted to AC before feeding into the grid. The inverter converts the DC voltage from the panel to AC voltage and feeds into the grid. The Figure 4 shows the output waveform from an inverter.

The output voltage and current waveforms are given in Figure 5. The second graph shows the inverter output. The first graph shows the output voltage waveform. The inverter output is filtered to obtain the sine wave. The third graph shows the current output.

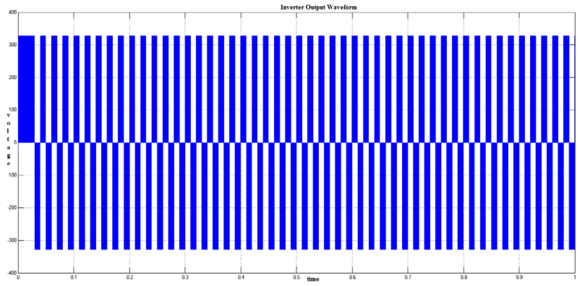


**Figure 4.** Inverter output waveform.

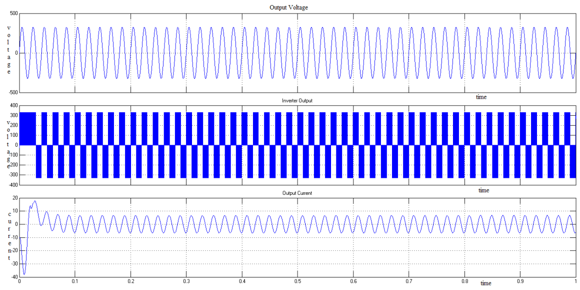


**Figure 5.** Output voltage and current waveforms.

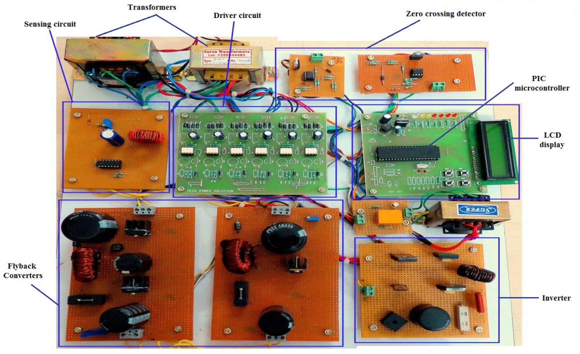


**Figure 6.** Hardware implementation.

## 3.2 Results

The hardware implementation of proposed method is shown in the Figure 6.

The output waveforms obtained from hardware implementation is shown below in Figures 7, 8 and 9.

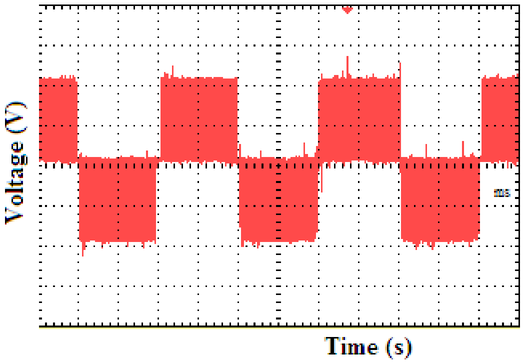


**Figure 7.** Inverter output voltage waveform before filtering.

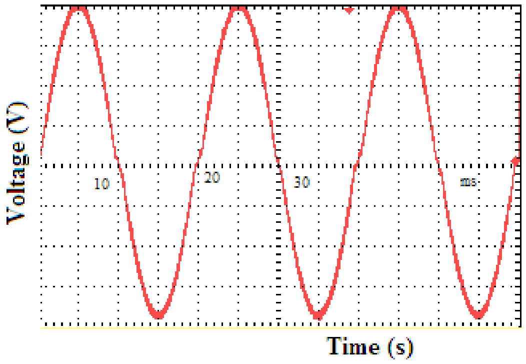


**Figure 8.** Inverter output voltage waveform after filtering.

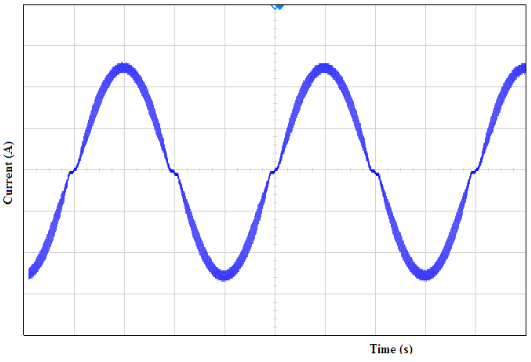


**Figure 9.** Output current waveform.

## 4. Conclusions

A study on grid connected PV system using microinverter with interleaved flyback converter is carried out in this paper. A modified algorithm is used for maximum power point tracking. In this paper an inverter is designed with minimum number of conversion stages. Also the number of power devices used in this inverter is less. This in turn reflects in the total cost of the system. The simulation result give an alternating current with less distractions and experimental results are provided to prove the same.

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