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# Implementation of PV fed ZVS high voltage gain interleaved converter

[1]M. Devika Rani, Assistant Professor, PVP Siddhartha Institute of Technology, Vijayawada, India, devikamothukuri@gmail.com

[2]V.Sai Geetha Lakshmi, Assistant Professor, PVP Siddhartha Institute of Technology, Vijayawada, India, sahruda.v@gmail.com

**Abstract: At present there is a huge requirement of effective utilization of renewable energy. Available renewable energy needs a power electronic converter. The power electronic converter used in high power applications is Interleaved Boost Converter with smooth soft switching. The performance of interleaved power converters measured in terms of increased gain, efficiency, size, and reliability, power capability, switching time, current sharing and transient response. The efficiency can be improved by reducing inductor current through interleaving technique and alleviating voltage spikes. In automotive power conversion, where the input voltage is low and large voltage boost is required converter finds applications. This paper addresses the interleaved converter design which is controlled by a microcontroller and powered by solar panel.**

***Keywords* — Efficiency, gain, microcontroller, reliability, Renewable Energy, soft switching.**

## I. INTRODUCTION

Due to changes in climate, greenhouse effects, acid rain and exhaustion of fossil-fuel reserves the renewable energy has been thrust to be the source which overcomes many challenges in today's global scenario. Renewable energy is pollution free, maintenance free, clean and available in abundant Ohnishi et al. (1995). With the available PV modules and low voltage source the conversion efficiency is not achieved up to the expectations and hence for the standalone applications which are operating at high power levels may need more number of PV modules to be get connected in series to achieve high potential levels[1-2]. In order to improve the conversion efficiency DC-DC converters are incorporated to the available PV systems. To extract the maximum available power from the PV modules Maximum Power Point Tracking (MPPT) algorithm can be applied to the DC-DC converters.

There are three types of converters commonly used namely Buck, Boost, Buck-boost. These converters are used along with the MPPT algorithm for suitable requirements as discussed by Ho-sung et al. (2009).A DC-DC boost converter not only provides the controlled voltage to MPPT but also delivers an amplified output voltage out of the Photo Voltaic module. Moreover the current dynamics of the PV panels are very low and thus keeping the current ripple as much as low is a very important task. Even though there is a recurrent fluctuation in the output voltage of the PV array the output can be regulated by controlling the DC-DC converter [3].High step-up voltage gain with enhanced duty ratio can be attained by conventional boost converters. However there is some limitations in increasing the voltage gain values due to the losses in the inductor, active switch, filter capacitor and output diode. The output diode conducts only for a short time when the duty ratio is high for each switching cycle which results in a reverse recovery problems and the rating of the devices also get increases as discussed Tseng et al. (2004), Wai et al. (2005) and Li et al. (2007). Main design criterion for the DC-DC converters is the ability to produce The ability to produce a increases output voltage out of a low voltage input is the important design criterion for the DC-DC converters used in PV applications.

Efficiency and cost are the other important criteria's when designing the PV systems [1-3]. The efficiency plays more important when going for any renewable energy applications where the cost is one more factor to be noted in converter design. In order to obtain high efficiency, the converter must employ the simple circuit topology and should employ low cost components.

Ripple and isolation are two important criteria related to the converter. Ripple refers to the abnormality of the input and output voltage and current from a pure DC. Ripple occurs in converters due to Switching transients [4]. The amount of power delivered by the PV module is highly affected by the ripple voltage and high input current which will affect the proper operation of the MPPT algorithms. One more factor to be concentrated while designing a converter is the isolation. A DC-DC converters may be isolated or non-Isolated depending upon the design. By using a high frequency transformer Galvanic Isolation is

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possible in DC-DC converters or by using a low frequency output transformer. However these additional transformers increase the overall size, cost and weight of the converters with considerable increases in amount of losses. Hence galvanic isolation method is usually deserted for PV converter designs Li et al. (2007).

Many types of DC-DC converters are available in practice which delivers enhanced output voltage than the input voltage. The conventional topologies involves Boost, Buck-Boost, Cuk, Zeta Converters and Single Ended Primary Inductor Converter (SEPIC).

For any DC-DC converter the voltage gain achieved is mainly limited by the parasitic of the component used Choi et al. (2011). The conduction losses ($I^2R$) will have a greater impact when the current and the power through the device increase [5-6]. Hence high gain converter topology is necessary to deliver the required voltage gain at high power.

High voltage gain with lower current ripple can be obtained by FIBC uniting a interleaved converter with two boost converters [6-7]. The paper is organized as follows. Main Block diagram and details of various components are discussed in section II. The Methodology is discussed in Section III. Hardware Circuit diagram and its description is presented in section IV. Output and conclusions are drawn in Section V.

## II. BLOCK DIAGRAM

The converter proposed in this work can also be called as an optimized two phase interleaved boost converter. For high step-up conversion proposed converter is integrated with MPPT controller. The main block diagram is shown in Figure1.

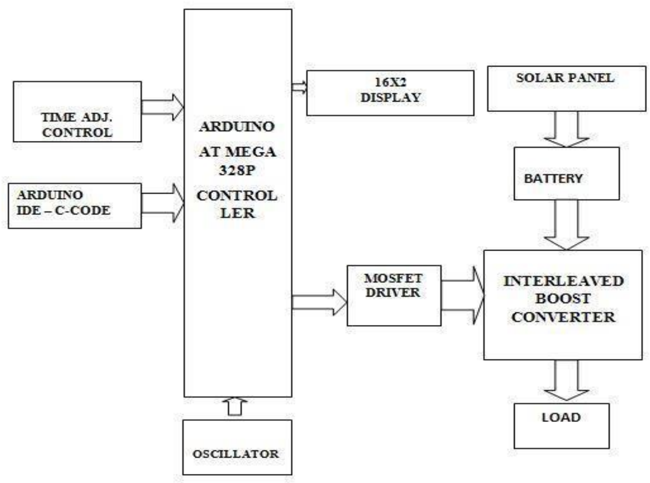


Figure1: Main Block Diagram

### A. Solar Panels:

Two 6v solar panels connected in series are used and the maximum power of 2.4watts can be able to obtain from the panel and it is connected to battery to store the power. This battery will acts as an input to the interleaved boost converter [2-4]. The proposed converter will take the supply from battery i.e. 8.5v and it can be boost up to 40-50v.

### B.ATmega 328P microcontroller:

According to the operation of proposed interleaved boost converter, the ATmega328P controller is dumped with the program. The frequency is changed by means of potentiometer which is connected to the microcontroller pins

As per the command received by the Mosfet driver thrugh program which is dumped in the microcontroller. The Mosfet driver will operates accordingly and drives the Mosfet or operates the Mosfet with respective duty cycle of 50%.

### C.LM 7805Series Voltage Regulator:

The LM 7805 series voltage regulator consists of three terminals which are aiding the regulator to make them useful in a wide range of applications. One of these is local on card regulation [11]. Based on the available voltages these regulators can be used in logic systems, instrumentation and other solid state electronic equipment. Basically these are designed as constant voltage regulators but with external components they can be used to obtain adjustable voltages and currents [12]. The LM7805 series regulator is available in aluminium to 3 packages which will allow over 1.5A load current if adequate heat sinking is provided

### D. Potentiometer:

Potentiometers are basically linear or rotary type. For obtaining adjustable supply voltage to a part of electronic circuits and electrical circuits, mainly rotary type is used. One of the examples of a rotary potentiometer is volume controller of a radio transistor where supply to the amplifier is controlled by rotary knob of the potentiometer.

### E. Liquid Crystal Display:

LCD's blocks or allows light to pass through by operating as a light valve. By applying electric field an image is formed and thereby chemical and pixel's light absorption properties are altered. As requested by the controller produced image can be modified using backlight into the screen output.

Interfacing LCD to the Microcontroller:

A 16 Character X 2 Line LCD Module is connected to the Parallel Port. The logic required to run them is on board so the LCD modules are most commonly used in various applications.

### F. Crystal Oscillator:

A crystal oscillator is an electronic oscillator circuit that is used for the mechanical resonance of a vibrating crystal of piezoelectric material. It will create an electrical signal with a given frequency. This frequency is commonly used to

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keep track of time for example wristwatches are used in digital integrated circuits to provide a stable clock signal and also used to stabilize frequencies for radio transmitters and receivers. Quartz crystal is mainly used in radio-frequency (RF) oscillators

**G. Battery:**

A device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy is battery. One of the general types of electrochemical cell is dry cell. It has the electrolyte immobilized as a paste, with only enough moisture in it to allow current to flow. Unlike a wet cell, a dry cell can operate in any orientation without spilling, as it contains no free liquid.

H. Dc Load:

The dc gear motor is chosen as a load. The specifications of the gear motor are 12v, 300 rpm. Based on application requirement to design own power supply electronic loads are very useful. This load will act as a constant current load and it draws certain amount of current without dissipating too much of heat.

I. Interleaved Boost Converter: Interleaved boost converter (IBC) is one of such converter which consists of several identical boost converters connected in parallel and controlled by interleaved method, which has same switching frequency and phase shift.

Interleaved Boost Converter operating modes:

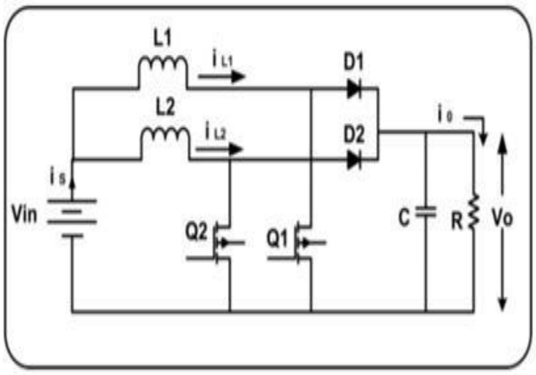


Figure2: Basic Circuit of the Converter

The schematic diagram of two phase interleaved boost converter is as shown in Figure2. It contains inductor L1 in parallel with inductor L2, switch Q1 in parallel with another switch Q2, diode D1 in parallel with diode D2, thereby forming two parallel channels between input and output circuits. All identical components are used for the circuit to obtain interleaving operation [6]. Two switches are provided the gate signal which is out of phase by 180°.

Considering peak inductor ripple current as 20% of the average inductor current, the inductor value is obtained using the expression A[8]. Dmax is maximum value of duty cycle which 0.75 and Vmin is the minimum of input voltage (100V).

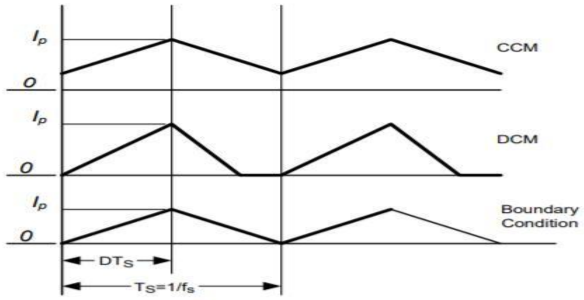


Figure3: Inductor Current Waveforms

MODE 1: During mode 1 the switches Q1 and Q2 are switched on and the diodes D1and D2 are under off condition. Figure4 shows the equivalent circuit for this mode 1

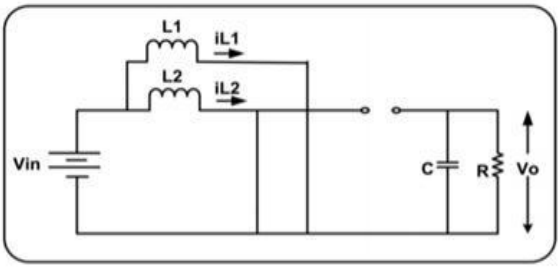


Figure4: Equivalent Circuit during Mode 1

MODE 2: During mode 2, the switch Q1 is in on condition and switch Q2 is in off condition and D1 is in off condition and D2 is in on condition respectively. The Figure5 represents the operation under mode 2

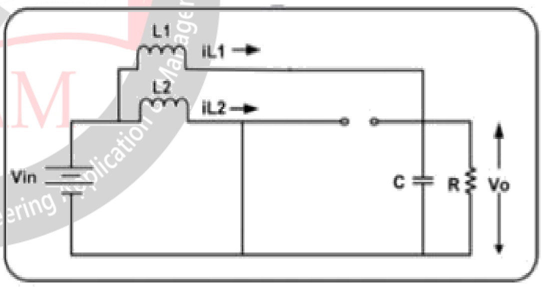


Figure5: Equivalent Circuit during Mode 2

MODE 3: During mode 3, the switch Q1 is in off condition and switch Q2 is in on condition and corresponding diodes D1& D2 are in on and off conditions respectively.Figure6 shows the equivalent circuit for this mode 3

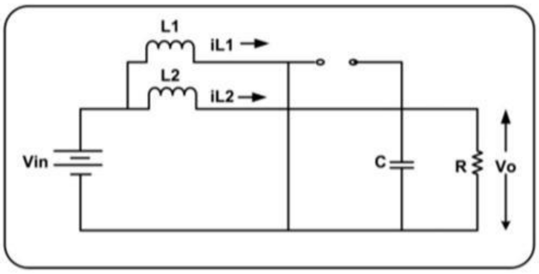


Figure6: Equivalent Circuit during Mode 3

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## III. METHODOLOGY

Interleaving benefits input-capacitor ripple-current cancellation. The two power stages operating 180° out of phase provide a two-to-one reduction in peak-to-peak ripple current. Because the interleaved-boost converter's combined input-ripple current equals that of the single-phase converter, the two-phase design's individual-phase ripple currents can each be twice as large as that of the single-phase design.

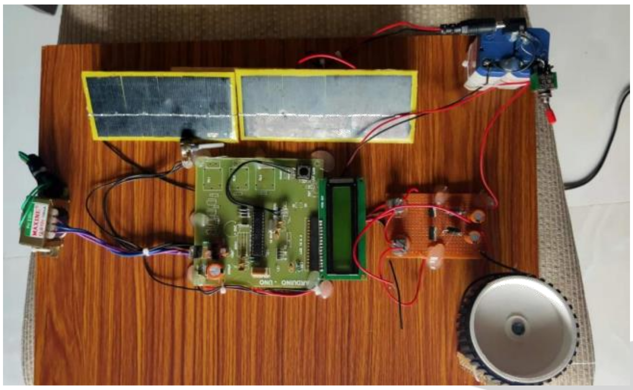

Figure7: Total hardware kit

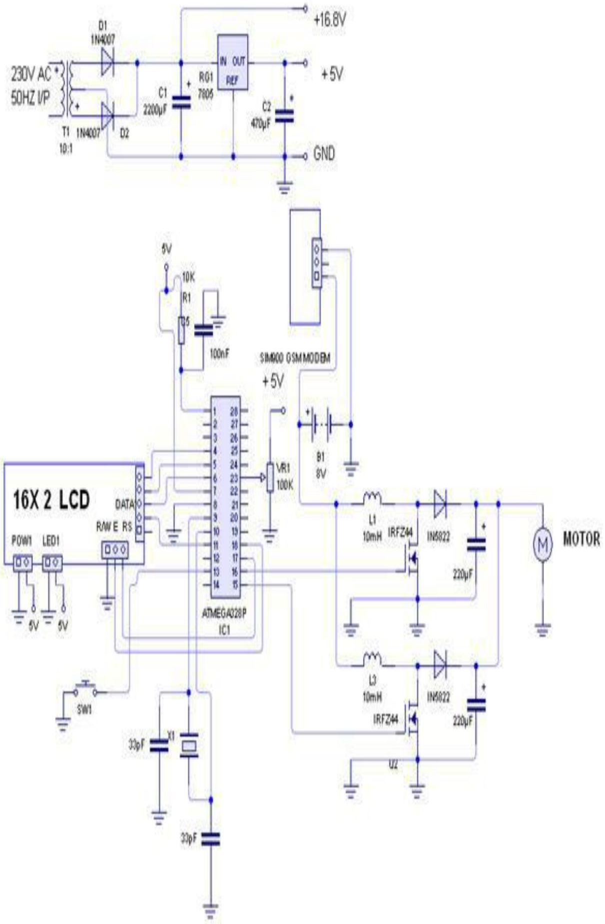


Figure8: Circuit Diagram of Total Hardware Kit

The individual interleaved power stages operate at the same frequency as the single-phase design, 100 kHz, but the effective input- and output-ripple frequency is 200 kHz.

The interleaved-design calculation used a frequency of 100 kHz and twice the ripple current of the single-phase design, yielding half the inductance .Because the two-phase design's effective input-capacitor ripple current was the same as that of the single-phase design, the two designs used an equal number of input capacitors. Ripple cancellation allows a choice of which components to reduce in number. Using two inductors, each having the same value as that in the single-phase design, halves the input-capacitance requirements. In a boost design, however, the inductor requirements are generally more critical than those of the input capacitors. Interleaving benefits the output capacitors in about the same way as it affects the input capacitors.

## IV. RESULTS

The interleaved boost converter is designed for switching frequency of 50KHz. Switching pulse obtained have 180 degree phase shift for interleaving operation[9-10]. The input voltage range taken is 5-10V. The nominal voltage of 5V is taken as input to the converter. The load resistance of 32 ohm is selected to which power of 6-8Watts is given. Duty cycle of 0.5 is taken for the switching MOSFET. The state space analysis is done for open loop operation of interleaved boost converter. By changing the width of the pulse output voltage can be controlled.

| Pulse width (microsec) | Input(volts) | Output(volts) |
|---|---|---|
| 25 | 8.53 | 52.4 |
| 125 | 8.53 | 42.3 |
| 199 | 8.53 | 40.2 |

Table1: Observations at different instants of pulse widths

The input source of 8v battery is connected to the interleaved boost converter and the pulse width is set for 1 micro second. The output 52.4v is obtained for this instant. The dc gear motor which is connected as load will rotates with more speed

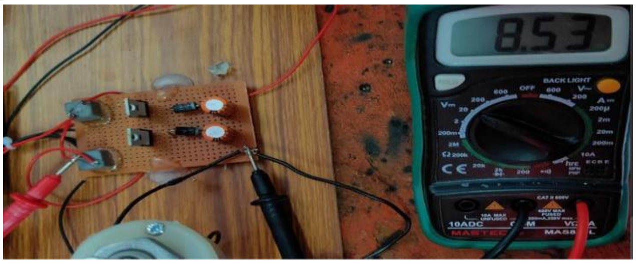


Figure9: Applied Input Voltage

**OUTPUT**

**CASE 1**

For CASE 1, with variation in the pulse width of 25 microseconds, an output voltage of 52.4 V is obtained.The source voltage is maintained at 8.53V


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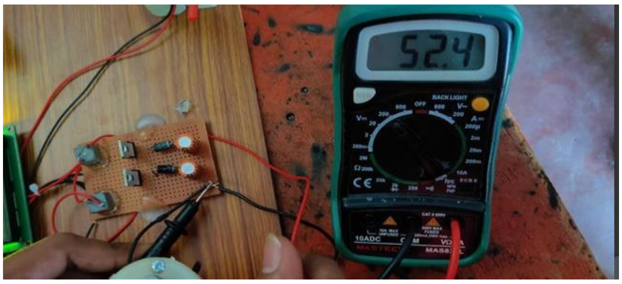


Figure10: Output voltage for pulse width 25 microseconds

**CASE 2**

For CASE 2, with variation in the pulse width of 125 microseconds, an output voltage of 42.3 V is obtained. The source voltage is maintained at 8.53V.Increasing the pulse width will decrease the output voltage with constant irradiation at input side.


Figure11: Output voltage for pulse width 125 microseconds

**CASE 3**

For CASE 3, with variation in the pulse width of 199 microseconds, an output voltage of 40.2 V is obtained. The source voltage is maintained at 8.53V.Further increasing the pulse width will decrease the output voltage with constant irradiation at input side.


Figure 12: Output voltage for pulse width 199 microseconds

## V. CONCLUSION

The analysis and design of interleaved boost converter for photovoltaic application is done. The input voltage of 5V is boosted to output voltage of 50V using interleaving technique. The operation is performed under open loop condition. The system is able to deliver the power to the load with high efficiency. The IBC has more advantages like high efficiency, low ripple etc. when compared to the conventional boost converters. This IBC can be applied to the grid connected system with the inverter circuit for converting DC to AC. The proposed interleaved boost converter is also suitable for the applications such as high-efficiency converters, a power-factor-correction circuit, and battery chargers for the applications such as high-efficiency converters, a power-factor-correction circuit, and battery chargers.

## VI. FUTURE SCOPE

In this paper, the effect of a coupled inductor on both the inductor and the output current ripple is studied in great detail. From the analysis, it was shown that the coupling coefficient should be high enough to effectively reduce the inductor current ripple. It was also shown that enough leakage inductance is required to minimize the output current ripple of the converter. It is inferred that Interleaved Boost Converter has higher Efficiency than Conventional Boost Converters. Future work is to design a system of Three Phase Interleaved Boost Converters for Complete Ripple Cancellation.

## REFERENCES


[1] Gules, R., Pfitscher, L.L., Franco, L.C.: 'An interleaved boost DC–DC converter with large conversion ratio'. *IEEE Int. Symp. Industrial Electronics*, 2003, pp. 1–5

[2] P.-W.Lee,Y.-S.Lee, D. K.W. Cheng, and X.-C. Liu,―Steady-state analysisof an interleaved boost converter with couples inductors, *IEEE Trans.Ind.Electron.*, vol. 47, no. 4, Aug. 2000

[3] M.Subramani, Mr.K.Karthikeyan (2014) ― An Interleaved Boost DC-DC Converter for High Voltage AC and DC Applications, *IJAREEIE*, Vol 3, Issue 4, April 2014.

[4] Ching-Ming Lai, High-Efficiency Modular High Step-Up Interleaved Boost Converter for DC-Microgrid Applications, *IEEE, Vol 48, No. 1, JANUARY/FEBRUARY 2012, Member, IEEE, Ching-Tsai Pan, Member, IEEE, and Ming-Chieh Cheng, Student Member, IEEE*

[5] Y. P. Siwakoti, F. Blaabjerg, and P. C. Loh, "High Step-Up Trans-Inverse (Tx− 1) DC–DC Converter for the Distributed Generation System," *IEEE Transactions on Industrial Electronics*, vol. 63, pp. 4278-4291, 2016.

[6] Shahin, A. Hinaje, M. Martin, J. P. Pierfederici, S. Rael, S. Davat, B., "High voltage ratio DC-DC converter for fuel-cell applications", *IEEE Trans. Ind. Electron*, 57(12): 3944-3955 (2010).

[7] Gules, R., Pfitscher, L.L., Franco, L.C.: 'An interleaved boost DC–DC converter with large conversion ratio'. *IEEE Int. Symp. Industrial Electronics*, 2003, pp. 1–5.

[8] R.N.A.L. Silva, G.A.L. Henn, P.P. Praca, L.H.S.C. Barreto, D.S. Oliveira Jr.,F.L.M. Antunes (2008) ― Soft Switching Interleaved Boost Converter with High Voltage Gain, *IEEE*, 2008.

[9] K. Latha Shenoy, C.Gurudas Nayak, Rajashekar P Mandi, "Design and Implementation of Interleaved Boost Converter", International Journal of Engineering and Technology (IJET),2017

[10] Ajit T N ,"Two Stage Interleaved Boost Converter Design and Simulation in CCM and DCM" International Journal of Engineering Research & Technology (IJERT),July-2014

[11] S. Nahar and M. B. Uddin, "Analysis the performance of interleaved boost converter," 2018 4th International Conference on Electrical Engineering and Information & Communication Technology (iCEEiCT), Dhaka, Bangladesh,2018,pp.547-551, doi: 10.1109/CEEICT.2018.8628104

[12] A. Thiyagarajan, S. G. Praveen Kumar and A. Nandini, "Analysis and comparison of conventional and interleaved DC/DC boost converter," Second International Conference on Current Trends In Engineering and Technology - ICCTET 2014, Coimbatore, 2014, pp. 198-205, doi: 10.1109/ICCTET.2014. 6966287.


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