International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 06 , June 2016
www.ijarse.com
IJARSE
ISSN 2319 - 8354

A FUZZY BASED HIGH STEP UP INTERLEAVED CONVERTER FOR HYBRID SYSTEM APPLICATION

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ABSTRACT

A novel high step-up converter, suitable for renewable energy system, is proposed in this paper with a voltage multiplier module composed of switched capacitors and coupled inductors, a conventional interleaved boost converter obtains high step-up gain without operating at extreme duty ratio. The configuration of the proposed converter not only reduces the current stress but also constrains the input current ripple, which decreases the conduction losses and lengthens the lifetime of the input source. In addition, due to the lossless passive clamp performance, leakage energy is recycled to the output terminal. Hence, large voltage spikes across the main switches are alleviated, and the efficiency is improved. Even the low voltage stress makes the low-voltage-rated MOSFETs be adopted for reductions of conduction losses and cost. A Isolated High Step Up DC-DC Converter for Solar Energy Harvesting using Fuzzy Optimization Algorithm with improved efficiency use of active clamp technique not only recycles the leakage inductor's energy but also constrains the voltage stress across the active switch, however trade-off is higher cost and complex control circuit is designed.

Keywords: *coupled inductor, high step – up converter, voltage gain, single switch, three phase inverter, grid connection.*

I. INTRODUCTION

Photovoltaic power-generation systems are becoming increasingly important and prevalent in distribution generation systems. A conventional centralized PV array is a serial connection of numerous panels to obtain higher dc-link voltage for main electricity through a dc–ac inverter. Unfortunately, once there is a partial shadow on some panels, the system's energy yield becomes significantly reduced .An ac module is a micro inverter configured on the rear bezel of a PV panel this alternative solution not only immunizes against the yield loss by shadow effect, but also provides flexible installation options in accordance with the user's budget .Many prior research works have proposed a single-stage dc– ac inverter with fewer components to fit the dimensions of the bezel of the ac module, but their efficiency levels are lower than those of conventional PV inverters. The power capacity range of a single PV panel is about 100W to 300W, and the maximum power point (MPP) voltage range is from 15V to 40V, which will be the input voltage of the ac module; in cases with lower input voltage, it is difficult for the ac module to reach high efficiency. However, employing a high step-up dc–dc converter in the front of the inverter improves power-conversion efficiency and provides a stable dc link to the inverter. When installing the PV generation system during daylight, for safety reasons, the ac module outputs zero voltage. Fig. 1 shows the solar energy through the PV panel and micro inverter to the output terminal when the switches are OFF. When installation of the ac module is taking place, this potential difference could pose hazards to both the worker and the facilities. A floating active switch is designed to isolate the dc current from the PV panel, for when the ac module is off-grid as well as in the non operating condition. This isolation ensures the operation of the internal components without any residential energy being transferred to the output or input terminals, which could be unsafe.

DC-DC converters are electronic devices used whenever we want to change DC electrical power efficiently from one voltage level to another as shown in Fig. 1. They are needed because unlike AC, DC can't simply be stepped up or down using a transformer. In many ways, a DC-DC converter is the DC equivalent of a transformer. DC-DC converters have a wide range of uses today and are becoming increasingly more important in everyday use. Dc power supplies are probably the largest use of the converters and are much more compact and efficient than the old method of conversion with transformers. The largest problem with these converters is still efficiency although there is also an interest to make these converters as small as possible and to control the heat dissipation. We have chosen to build the buck-boost converter because of its versatility and wide range of uses in today's market.

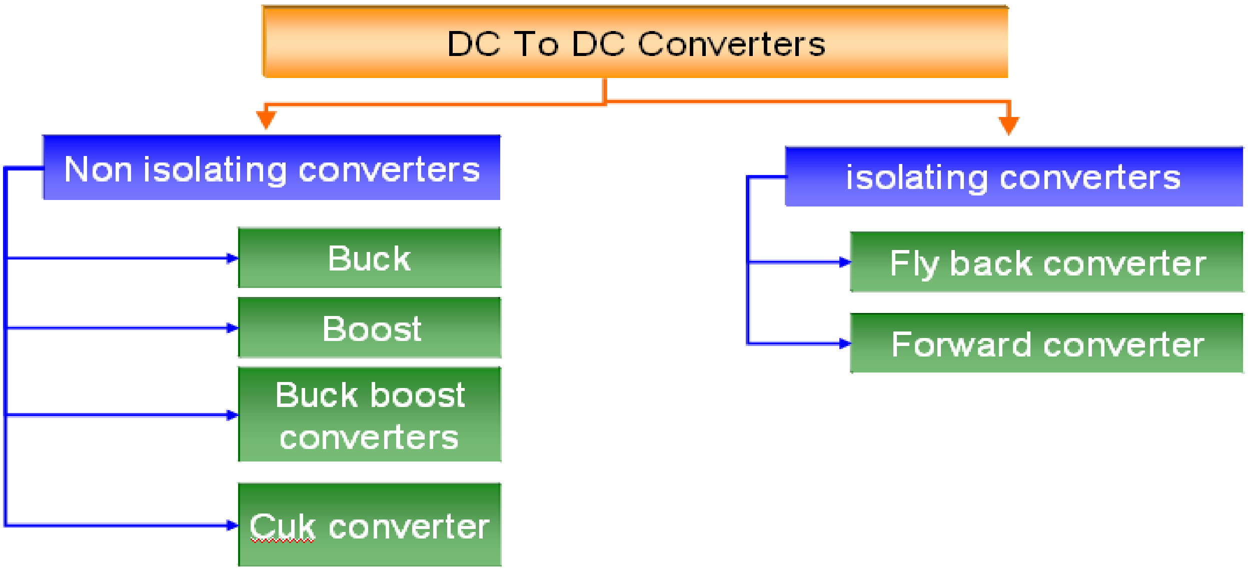

Fig 1 Block Diagram

In the circuit of buck converter as shown in Fig. 2 the transistor turning ON will put voltage Vin on one end of the inductor. This voltage will tend to cause the inductor current to rise. When the transistor is OFF, the current will continue flowing through the inductor but now flowing through the diode. We initially assume that the current trough the inductor does not reach zero, thus the voltage at Vx will now be only the voltage across the conducting diode during the full OFF time.

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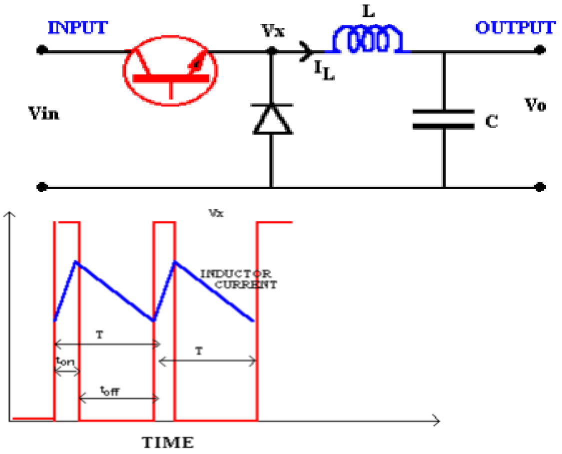

Fig 2 Circuit Diagram of Buck Converter and Voltage vs Time Graph of Buck Converter

To analyse the voltages of this circuit let us consider the changes in the inductor current over one cycle. From the relation

$$V_x - V_o = L\frac{di}{dt}$$

the change of current satisfies

$$di = \int_{ON}(V_x - V_o)dt + \int_{OFF}(V_x - V_o)dt$$

For steady state operation the current at the start and end of a period T will not change. To get a simple relation between voltages we assume no voltage drop across transistor or diode while ON and a perfect switch change. Thus during the ON time Vx=Vin and in the OFF Vx=0. Thus

$$D = \frac{t_{on}}{T}$$

the voltage relationship becomes Vo=D Vin Since the circuit is lossless and the input and output powers must match on the average Vo* Io = Vin* Iin. Thus the average input and output current must satisfy Iin =D Io These relations are based on the assumption that the inductor current does not reach zero.

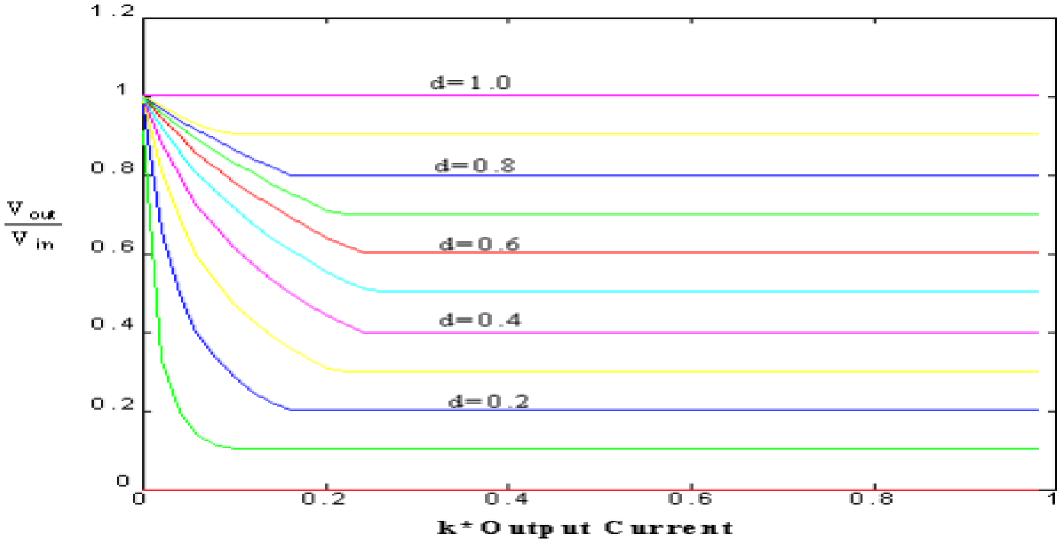

Fig 3 Output current Waveform

once the output current is high enough, the voltage ratio depends only on the duty ratio "d" as shown in Fig. 3.. At low currents the discontinuous operation tends to increase the output voltage of the converter towards Vin.

A boost converter (step-up converter) is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two in combination as shown in fig 4. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.

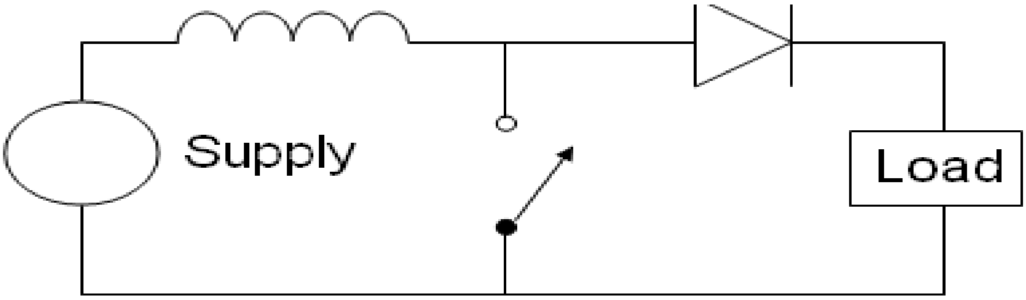

Fig 4 Circuit Diagram of boost converter

The key principle that drives the boost converter is the tendency of an inductor to resist changes in current. In a boost converter, the output voltage is always higher than the input voltage. When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores the energy. Polarity of the left side of the inductor is positive. When the switch is opened, current will be reduced as the impedance is higher. Therefore, change or reduction in current will be opposed by the inductor. Thus the polarity will be reversed (means left side of inductor will be negative now). As a result two sources will be in series causing a higher voltage to charge the capacitor through the diode D. If the switch is cycled fast enough, the inductor will not discharge fully in between charging stages, and the load will always see a voltage greater than that of the input source alone when the switch is opened. Also while the switch is opened, the capacitor in parallel with the load is charged to this combined voltage. When the switch is then closed and the right hand side is shorted out from the left hand side, the capacitor is therefore able to provide the voltage and energy to the load. During this time, the blocking diode prevents the capacitor from discharging through the switch. The switch must of course be opened again fast enough to prevent the capacitor from discharging too much. During the Off-state, the switch S is open, so the inductor current flows through the load. If we consider zero voltage drops in the diode, and a capacitor large enough for its voltage to remain constant, the evolution of I_L is: falls to zero during part of the period.

II. DESIGN OFPROPOSED SYSTEM

The proposed system advantages include error response is better than existing method, better steady state and dynamic performance, It facilitates the tracking of maximum power faster and minimize the voltage variation., better accuracy than other conventional system. The block diagram and the circuit diagram are shown in Fig 5 and 6 respectively.

Mode I [t0, t1]: S2- ON State, S1 begins to turn ON, The diodes Dc1, Dc2, Db1, Db2, and Df1 are reversed biased, the series leakage inductors Ls quickly release the stored energy to the output terminal via fly back–forward diode Df2, and the current through series leakage inductors Ls decreases to zero. Thus, the magnetizing inductor Lm1 still transfers energy to the secondary side of coupled inductors. The current through leakage inductor Lk1 increases linearly and the other current through leakage inductor Lk2 decreases linearly.

Mode II [t1, t2]: Here both the power switches S1 and S2 remain in ON state, and all diodes are reversed biased. Both currents through leakage inductors Lk1 and Lk2 are increased linearly due to charging by input voltage source Vin.

Mode III [t2, t3]: The power switch S1 remains in ON state, and the other power switch S2 begins to turn off. The diodes Dc1, Db1, and Df2 are reversed biased. The energy stored in magnetizing inductor Lm2 transfers to the secondary side of coupled inductors, and the current through series leakage inductors Ls flows to output capacitor C3 via fly back–forward diodeDf1. The voltage stress on power switch S2 is clamped by clamp capacitor Cc1 which equals the output voltage of the boost converter. The input voltage source, magnetizing inductor Lm2, leakage inductor Lk2, and clamp capacitor C_{c2} release energy to the output terminal; thus, VC1 obtains a double output voltage of the boost converter.

Mode IV [t3, t4]: the current i_{Dc2}has naturally decreased to zero due to the magnetizing current distribution, and hence, diode reverse recovery losses are alleviated and conduction losses are decreased. Both power switches and all diodes remain in previous states except the clamp diode D_{c2}

Mode V [t4, t5] :the power switch S1 remains in ON state, and the other power switch S2 begins to turn ON. The diodes D_{c1}, D_{c2}, D_{b1}, D_{b2}, and D_{f2} are reversed biased. The series leakage inductors Ls quickly release the stored energy to the output terminal via fly back–forward diode D_{f1}, and the current through series leakage inductors decreases to zero. Thus, the magnetizing inductor Lm2 still transfers energy to the secondary side of coupled inductors. The current through leakage inductor L_{k2}increases linearly, and the other current through leakage inductor L_{k1} decreases linearly.

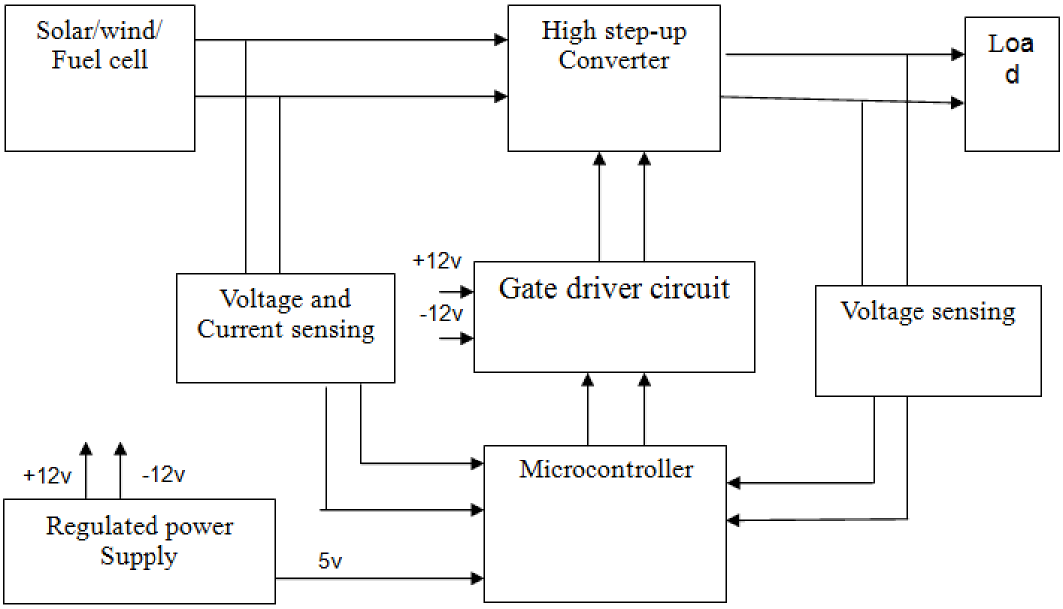

Fig 5 . Block Diagram

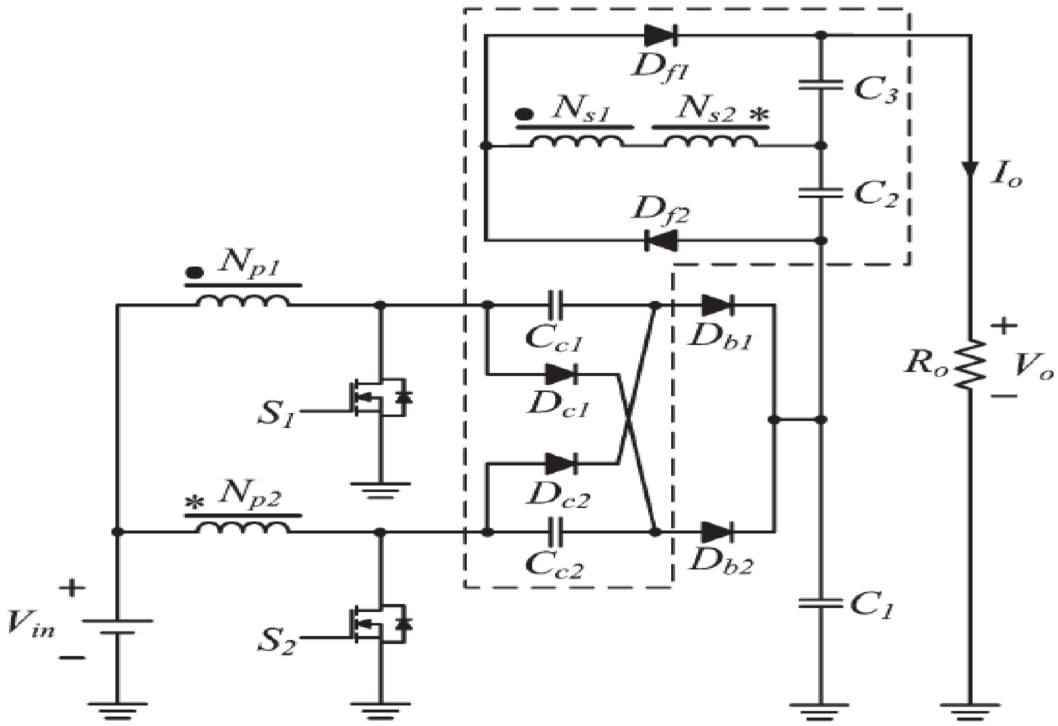

Fig 6. Circuit Diagram

International Journal of Advance Research in Science and Engineering
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Mode VI [t5, t6]: both of the power switches S1and S2 remain in ON state, and all diodes are reversed biased. Both currents through leakage inductors L_{k1} and L_{k2} are increased linearly due to charging by input voltage source Vin.

Mode VII [t6, t7]: the power switch S2 remains in ON state, and the other power switch S1 begins to turn off. The diodes D_{c2}, D_{b2}, and D_{f1} are reversed biased. The energy stored in magnetizing inductor Lm1 transfers to the secondary side of coupled inductors, and the current through series leakage inductors flows to output capacitor C_2via fly back–forward diode D_{f2}. The voltage stress on power switch S1 is clamped by clamp capacitor Cc2 which equals the output voltage of the boost converter. The input voltage source, magnetizing inductor Lm1, leakage inductor L_{k1}, and clamp capacitor C_{c1} release energy to the output terminal; thus, V_{C1} obtains double output voltage of the boost converter.

Mode VIII [t7, t8]: the current i_{Dc1} has naturally decreased to zero due to the magnetizing current distribution, and hence, diode reverse recovery losses are alleviated and conduction losses are decreased. Both power switches and all diodes remain in previous states except the clamp diode $D_{c1.}$ The advantages include High Voltage gain is achieved. Efficiency of the system is improved, isolated topology is implemented. Fuzzy improves the accuracy than the normal method. Close loop voltage regulation is possible.

III. RESULTS AND DISCUSSIONS

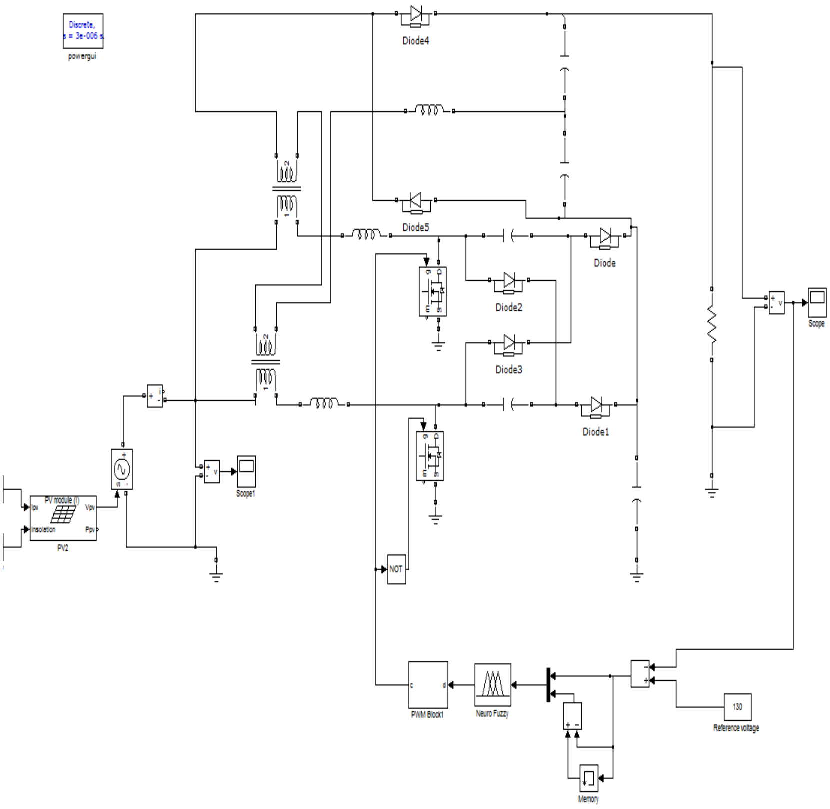

Fig 7. Circuit Diagram of Existing Simulation

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Fig 8 Waveform of Existing Simulation

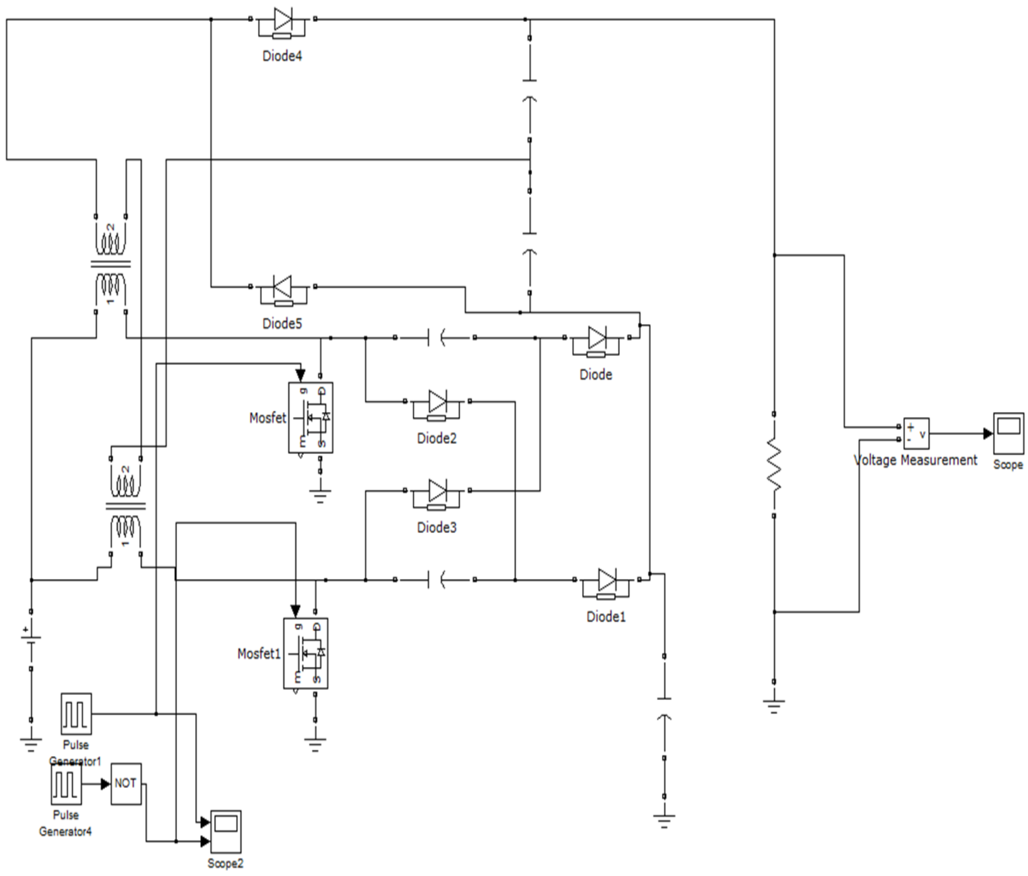

Fig 9. Circuit Diagram of Proposed Simulation

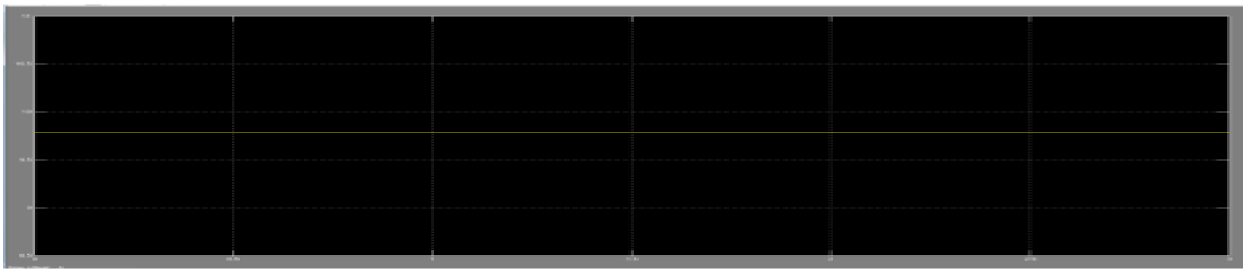

Fig 10. Output waveform for PV Cell

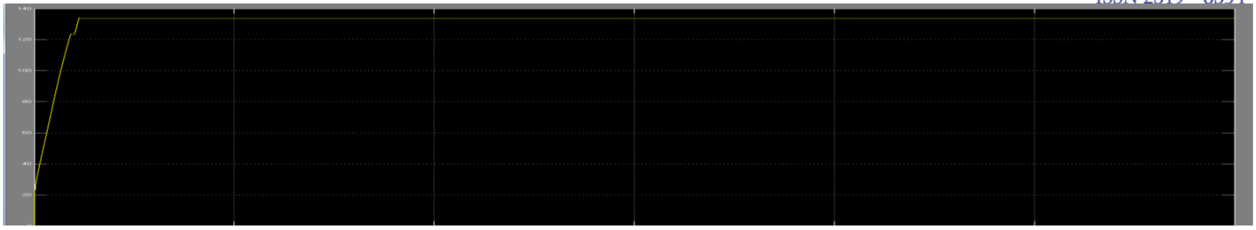

Fig 11. Output Voltage Waveform

HARDWARE AND RESULT

Fuzzy Logic Controller (FLC) is chosen as a controller for this paper because it consist several advantages compared to the other classical controller. The advantages of FLC are such as simplicity of control, low cost and the possibility to design without knowing the exact mathematical model of the process. We can use either solar/wind/fuel cell as a source for input side. The Gate driver circuit is provided with +12v supply. The Fuzzy controller is dumped in microcontroller and is given +5v supply.

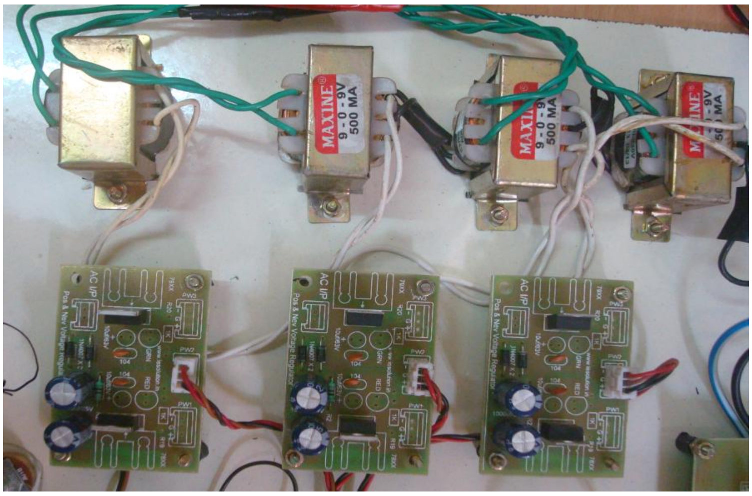

Fig 12. Hardware Implementation

The microcontroller is a digital device; it is mandatory to supply +5V DC supply. The supply from the battery or the AC supplies are to be regulated to +5V DC in order to feed the microcontroller. The microcontroller output is given to the opt coupler. When the light source is emitted the switch is closed and the switch becomes short circuit and the output signal is given to the comparator. When the light source is not emitted the switch is open and the output signal is given to the comparator. The output of the opt coupler is given to the inverting terminal of the comparator and the reference voltage is given to the Non inverting terminal by adjustable voltage regulator. If the inverting terminal output is 1 then the switch is closed and the negative supply is passes from the comparator to the push pull amplifier. The push pull amplifier consist of NPN and PNP transistor If the output of the comparator is positive then the NPN transistor will allow the signal and the LED (red colour) will be indicated. If the output of the comparator is negative then the PNP transistor will allow the signal and the LED (green colour) will be indicated. If the positive supply is given to the Gate terminal of the MOSFET then it will be turn ON. PIC microcontroller is widely used for experimental and modern applications because of its low price, wide range of applications, high quality and ease of availability. It is ideal for machine control applications, measurement

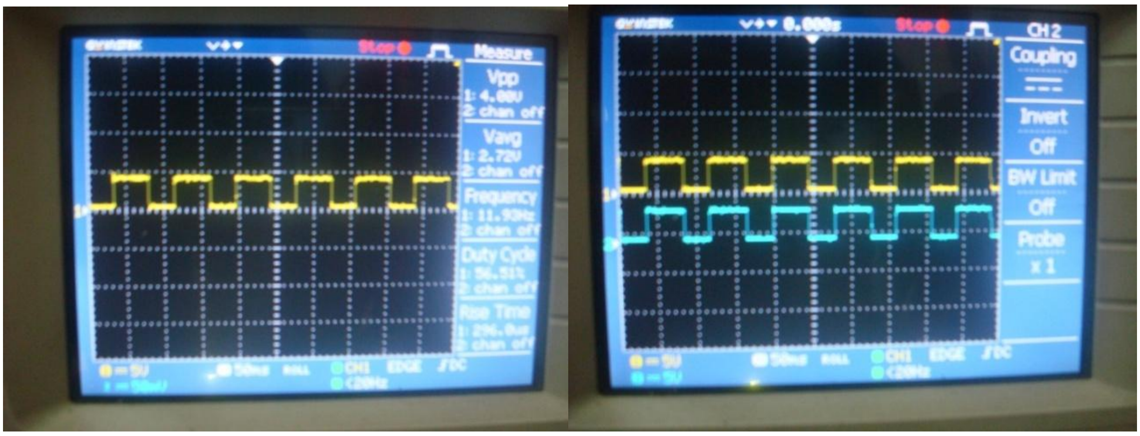

Fig 13. Output Waveform with Single port and with Double Port high step up converter

CONCLUSION

An Isolated High Step up DC-DC Converter for Solar Energy Harvesting using Fuzzy Optimization Algorithm with improved efficiency can be achieved through implementing this method. Therefore this method obtains high output with high efficiency. Because of it's low cost due to less complicity of components used here for greater outputs. The THD value per phase voltage of three phase inverter output without filter is 1.74% with grid connection system. In this same configuration with 2nd order filter connected of three phase inverter output, the THD value reduced to 0.08%. The future scope is the PWM techniques use d for three phase inverter are sinusoidal PWM, Third -harmonic PWM, 60 degree PWM, space vector PWM, any one PWM will use.

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