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Simulation Of High Voltage Gain Boost Converter For Battery Charging With PV System In A Single Stage Conversion

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Abstract: - The require for renewable energy sources is on the rise because of the sensitive energy crisis in the world today. Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides and geothermal heat. These resources are renewable and can be obviously replenished. Therefore, for all practical purposes, these resources can be considered to be never-ending, unlike diminishing conventional fossil fuels. In order to give support to the growing technology demand of renewable energy applications. This work presents a high voltage gain boost converter topology based on battery charging using coupled inductors and solar panels to decrease ripples in output voltage. The presented converter operates in Zero voltage switching (ZVS) mode for all switches. By using the novel concept of single –stage approaches, the converter be capable of generate a dc bus simultaneous charge of the batteries according to the radiation level. In this paper we can check the output voltage ripple in various MPPT techniques. Simulation is done by using the MATLAB/SIMULINK.

***Key words: -Battery Chargers, Interleaved boost converter with coupled inductors and switched capacitors, PV, MPPT Techniques*.**

I.INTRODUCTION

A Photovoltaic energy source is capable of solving the problems of global warming and energy exhaustion, caused by increasing energy consumption. There is no air pollution or waste, and no mechanical vibration or noise. The output power of the solar cell can be changed easily by the surrounding conditions, such as irradiation and temperature. To transmit the power from the PV array to the load with higher efficiency, the coupled conductor interleaved boost converter is introduced. The presented converter can minimize switching losses, and ripples reducing. One of the major concerns is the need of high output dc voltage bus (from 200 to 400v dc) which is necessary to supply inverters, UPS etc; from low input voltage levels. Now a days, non isolated dc-dc converters with high voltage gain uses in different applications. The proposed converters, use diodes and coupled windings instead of active switches to realize. To achieve a high step-up voltage ratio, transformer- and coupled-inductor-based converters are usually the right choices. Compared with an isolation transformer, a coupled inductor has a simpler winding structure, lower conduction loss, and continuous conduction current at the primary winding, resulting in a smaller primary winding current ripple and lower input filtering capacitance.

A coupled-inductor based converter is relatively attractive because the converter presents low current stress and low component count. However, for applications with low input voltage but high output voltage, it needs a high turn’s ratio, and its leakage inductor still traps significant energy, which will not only increase the voltage stress of the switch but also induce significant loss.The soft-switching techniques with variable switching frequency have been proposed to increase the switching frequency, reduce the size of power converters, and reduce the switching losses of the switching devices. The asymmetrical pulse width modulation (PWM) techniques were proposed in to achieve the zero-voltage switching (ZVS) feature at the power switch turn on instant. The active clamp techniques were presented in to achieve ZVS turn-on. The input current ripple of the dc-dc converters is inversely proportional to input inductor current value. So the large inductor value results in low ripple,on other increasing the inductor value the total weight of the converter gets increased and frequency increase. So without increasing the inductor value, the ripple should be reduced. Higher efficiency is realized by splitting the output current into n parts, substantially reducing I2R losses and inductor losses. The switched capacitors are included in order to improve the voltage gain of the converter. The advantages of interleaved boost converter are minimized current ripple, increased efficiency faster transient response, reduced electromagnetic emission and improved reliability. By using interleaving technique the ripples is reduced but the weight of the converter is not reduced. The new technique called coupled inductor interleaved boost converter technique is used. Here the ripples is reduced, and weight of the converter is reduced. Since the core is shared, and inductor was coiled in single core. This paper deals a single- stage switching non isolated dc-dc converter interconnecting battery charger, photovoltaic panels, and a high gain boost converter. A typical solar energy system utilize photovoltaic (PV) solar panel to convert the sunlight to electrical energy. A

Photovoltaic module is used powerful only when it operates at its most advantageous operating point (OP). At any moment the OP of a PV module depends on varying insolation levels, sun direction, irradiance, temperature, as well as the load of the system. The quantity of power that can be tracked from a PV array also depends on the operating voltage of that array. PV solar cells have relatively less efficiency ratings; thus operating at the MPP is desired because it is at this point array will operate at the highest efficiency. With constantly changing atmospheric conditions and load variables, it is very complicated to use all of the sun energy available without a controlled system.

It becomes essential to force the system to operate at its maximum power point. The solution for such a problem is to use a Maximum Peak Power Tracking MPPT system. A MPPT is normally operated with the use of a DC/DC converter. The converter is dependable for transferring maximum power from the solar PV module to the load. The simplest way of implementing an MPPT is to function a PV array under constant voltage and power reference to modify the duty cycle of the DC/DC converter. This will keep operation constant at or around the MPP.

There have been a number of algorithms developed for maximum power tracking. Our aim in this paper is to tackle the use of computer simulation in evaluating the performance of any MPPT algorithm for PV solar energy systems. The evaluation can be carries-out for different PV technologies and functioning environments. In particular, in this paper, we tackle this task using a familiar and widely-used simulation tool in various are as of science and engineering, namely, MATLAB. The tracking algorithm considered in this paper is the Perturbed and Observe (P&O) algorithm and Incremental conductance(IC) algorithm.

II. CONVENTIONAL TOPOLOGY

A. Conception of the Topology:

In less voltage side, the bidirectional feature of the topology allows the MOSFET bridge to be supplied by either the battery or the PV array. as well, the use of resonant capacitors in the full-bridge capacitors provides zero voltage switching (ZVS) of the switches. The integrated topology resulting from the boost converter is shown in Fig.1. The major benefit of this topology is the less voltage stress across the vigorous switches, less input current ripple, and ease, results in more efficiency. Some higher-voltage gain methods are supposed to consists of three dc links as shown in Fig. 2, where V_{DC3} feeds the inverter with a superior voltage than that of the remaining ones. According to the application, the battery stock and the photovoltaic panel can be connected to the less voltage side at V_{DC1} or V_{DC2}, depending on the available voltage levels. Considering typical applications under 2 kW, battery stock voltage levels can be 12, 24, or 48 V and photovoltaic panels can be arranged to set up a dc link with voltage level equal to about two times that of the former link.

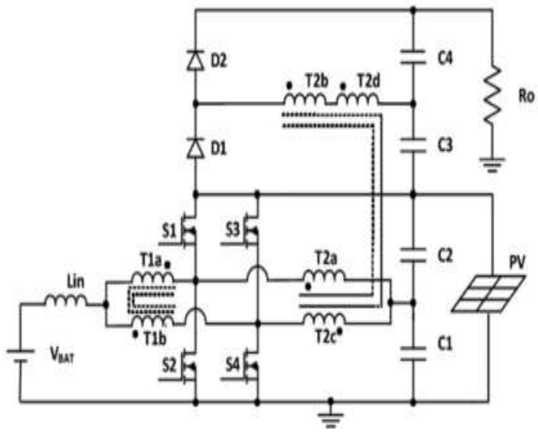

Fig1.proposed topology using PV array

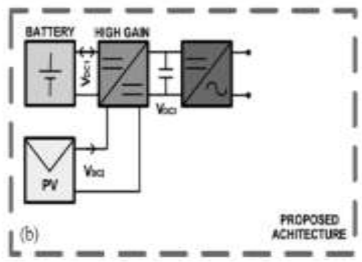

Fig2. Proposed Diagram

The projected topology is fashioned by one input inductor L_{IN}, four controlled power switches S_1–S_4, two rectifier diodes D_1 and D_2, coupled inductors and four output capacitors C_1–C_4. Although additional components are integrated, current sharing is maintained between (S_1, S_2, T_{1a}, T_{2a}) and (S_3, S_4, T_{1b}, T_{2c}). Then, besides the compact current stress through the components, the instant current during the turn OFF of the switches is drastically reduced for D >50%, thus leading to minimized switching losses. Within this context, it must be considered that there is no energy transfer from the input to the output during the second and fifth stages only. As a result, high efficiency is expected.

B. Operation Principle

First Stage:-This stage begins when S_1 is turned OFF, causing a current stream through the antiparallel diode of switch S_2, allowing the turn ON in the ZVS mode. At this instant, S_3 is turned OFF, and S_4 is turned ON. The current flowing through the input inductor "I_{IN}" increases gradually and is equally shared between the two switching cells reducing the connected stresses of the vigorous semiconductors. The current in the primary side T_{2a} gradually decreases, while the current through T_{2c} gradually increases. This stage stops when the currents in T_{2a} and T_{2c} attain zero, and the current through S_2 is equal to that through S_4.

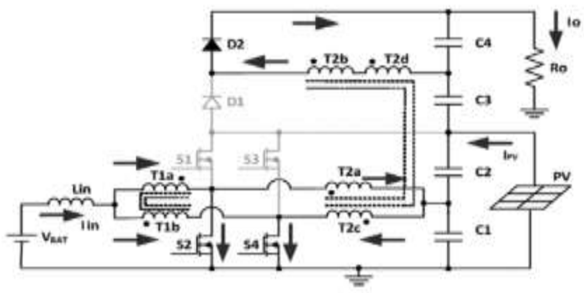

fig.3(a)

Second Stage:-Current "I_{IN}" still gradually increases and is uniformly shared through the commutation cells. In addition, all the rectifier diodes are reverse biased. The current through

T_{2a} and T_{2c} remains at same. This period stops when S4 is turned OFF.

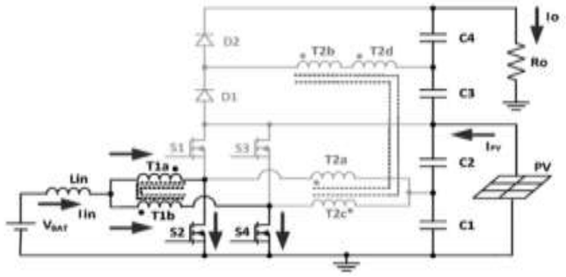

fig.3(b)

Third Stage:-This step starts when S_4 is switched OFF, resulting the current to pass through the anti-parallel diode of S_3, allowing the switched on in ZVS mode. At this stage, S_2 is previously switched on. The current passing through the input inductor 'I_{IN}' gradually decreases, whereas the currents through T_{1a} and T_{1b}gradually increases and decreases, respectively. The current in the primary side T_{2a}gradually decreases, while the current through T_{2c}gradually increases. This mode ends when S_4 is switched ON and S_3 is switched OFF.

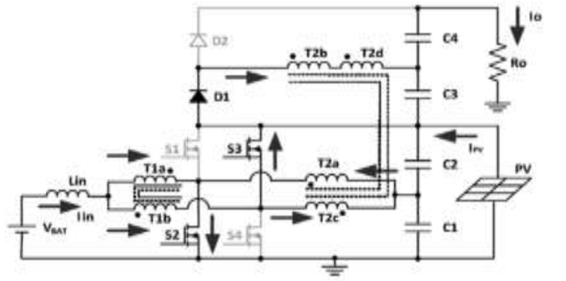

Fig.3(c)

Fourth Stage:-This step starts when S_4 is ON. When S_2 is switched ON, the input current "I_{IN}" gradually increases, and so do the currents through T_{1a} and T_{1b}. Also, the current through S_4 increases and has pass in the reverse direction. The current through T_{2a}gradually increases, whereas the one through T_{2c} decreases. This mode ends when the currents in T_{2a} and T_{2c} attain zero, and the current pass through S_2 is identical to the one in S_4.

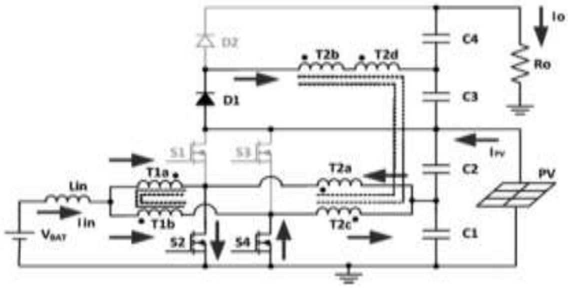

Fig.3(d)

Fifth Stage:- This mode is same to the second one. In this mode, "I_{IN}" is still gradually increasing and is equally shared among the commutation cells. Besides, all the rectifier diodes are reverse biased. The current passing through T_{2a} and T_{2c} remain same. This mode stops when S_2 is switched OFF.

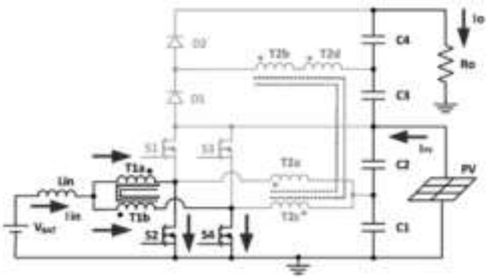

Fig.3(e)

Sixth Stage: -

This stage begins when S_2 is switched OFF, resulting a current pass through the antiparallel diode of S_1, allowing its switch ON in the ZVS mode. At this instant, S_3 is previously switched OFF and S_4 is switchedON. The current passing through the input inductor "I_{IN}" gradually decreases. The current in the primary side T_{2a}gradually increases, while the current through T_{2c} decreases gradually. This mode ends when the currents through T_{2a} and T_{2c} become zero, and the current through S_2 is same to the one through S_4. After this stage, a new switching cycle begins from the first stage.

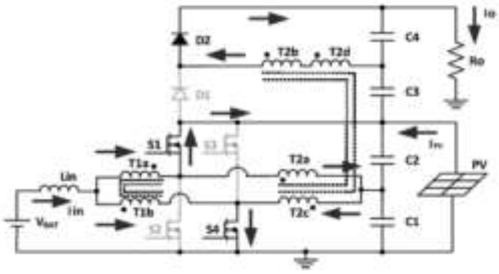

Fig.3(f)

Control Strategy:

The approach described in Fig.4 can be used in the proposed converter, where it is required to measure only three quantities that are the PV panel voltage V_{PV}, the PV panel current I_{PV}, and the voltage across the battery stock V_{BAT}.

Let us assume that constant power is believed to be injected in the inverter stage. Considering that the battery has a low charge, the MPPT can be performed in any radiation and output power condition. The power difference is obviously transferred to or from the battery and the inverter can easily support the resulting dc-bus voltage variation. If the battery is fully charged, the MPPT is not performed and the operation point is changed until the battery current becomes zero.

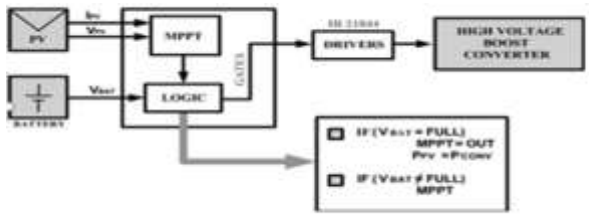

Fig.4. proposed converter

Table. I

Technical parameters

Switching frequency fs	25kHz
Input voltage V_{IN}	24V
Output voltage Vout	200V
Load power Po	500W
Input Inductance L_{IN}	100uH
Leakage Inductance L_K	1uH
Output Capacitors C1,C2,C3,C4	100uF

Perturb and Observe (P&O):

In this algorithm a slight perturbation is introduce system in Fig5. This perturbation causes the power of the solar module changes. If the power increases due to the perturbation then the perturbation is continued in that direction. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses. When the steady state is reached the algorithm oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small and acts moving the operating point of the module to that particular voltage level. It is observed that there some power loss due to this perturbation also the fails to track the power under fast varying atmospheric conditions.

Fig5 Perturb and Observe Algorithm

Perturb and observe method does not take account of the rapid change of insolation level and assume as a modify in MPP due to perturbation and ends up manipulating the wrong MPP. To avoid this problem we can use incremental conductance method.

III.PROPOSED TROPOLOGY

Incremental Conductance: Incremental conductance method uses two sensors, that is voltage and current sensors to sense the output voltage and current of the PV array. Algorithm works by comparing the ratio of derivative of conductance with the instantaneous conductance. When this instantaneous conductance equals the conductance of the solar then MPP is reached. The basic equations of this method are as follows and algorithm in fig6

$$\frac{dI}{dV} = -\frac{I}{V} \quad ,at\ MPP \qquad (1)$$

$$\frac{dI}{dV} > -\frac{I}{V} \quad ,left\ of\ MPP \qquad (2)$$

$$\frac{dI}{dV} < -\frac{I}{V} \quad ,right\ of\ MPP \qquad (3)$$

Where I and V are the PV array current and voltage respectively. The left-hand side of the equations represents the Inc Cond of the PV module, and the right-hand side represents the instantaneous conductance. when the ratio of change in the output conductance is equal to the negative output conductance, the solar array will operate at the MPP. In other words, by comparing the conductance at each sampling time, the MPPT Will track the maximum power of the PV module. Here we are sensing both the voltage and current simultaneously.

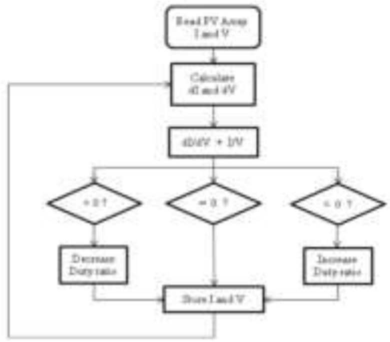

Fig6 IC Algorithm

Design Analysis:

The functions of main components of high gain DC-DC boost converter power stage are discussed and the individual values are determined to meet the project specification. The conduction mode of power stage is determined by input voltage, output voltage, output current and value of inductor. The input voltage, output voltage, load current are defined by project specification.

1)Static Gain for D > 50%: The output voltage can be obtained as

$V0 = V_{C1} + V_{C2} + V_{C3} + V_{C4}$

V_{c1}=24v V_{c2}=D. VBAT /(1-D)=0.5x24/91-0.5=24V

Ts=1/f=1/25Khz=40

The normalized load current "α."

$$\propto = \frac{4.n.Io.Ls}{Vbat.Ts}$$

=4x1x1.2x1e-3//1e-3/(24x40x1o^-3)=2.5

The power equation is: P= V*I

The calculation of output current requires to supplying 500W power to the load.

$I_{out}=P_{out}/V_{out}$=500/200=2.5

The load resistor is calculated by ohm's low:

$R_{out}=V_{out}/I_{out}$=200/2.5=80

Given Duty cycle=0.5

The mutual inductance (M) between two coupling inductors is:

$$K=M/\sqrt{L1 * L2}$$

IV.SIMULATION RESULTS

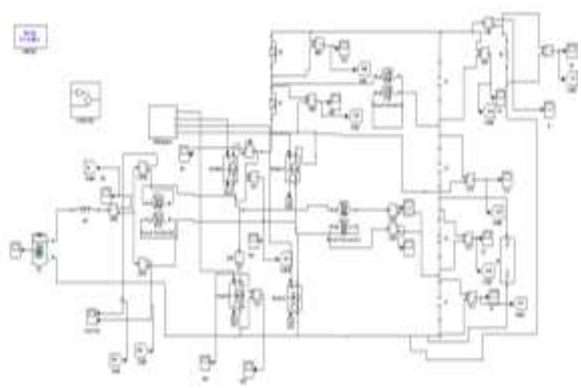

Fig.7.Simulation Diagram of High Voltage gain boost converter using a pv array

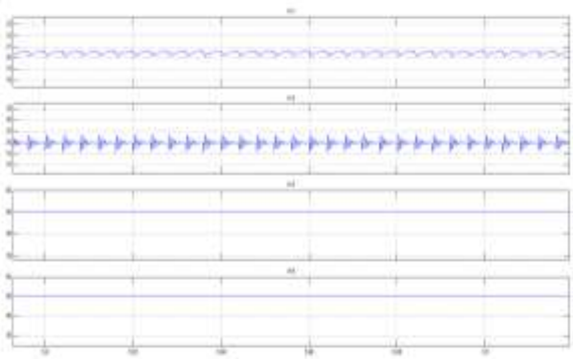

Fig.8.Voltage across the output capacitors Waveforms

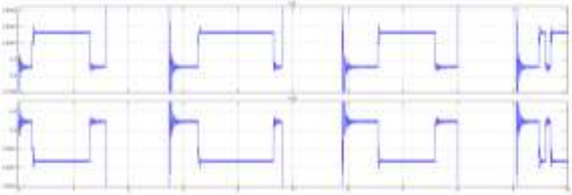

Fig.9. Voltage across D1 and D2 Waveforms

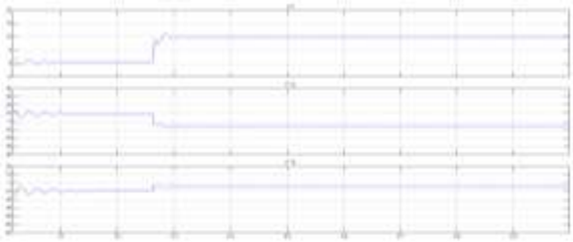

Fig.10.Input currents and currents through the switching cells waveforms

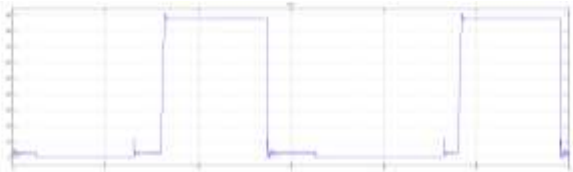

Fig.11. Voltage through S1 waveforms

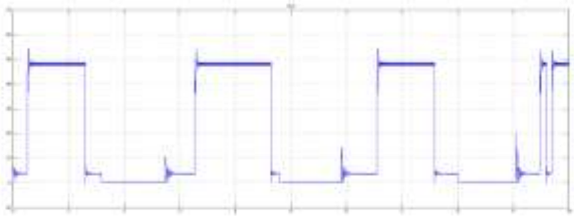

Fig.12. voltage through S2 Wave Forms

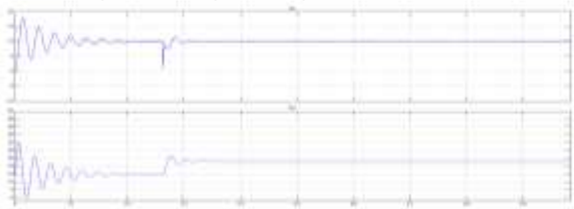

Fig.13.V_{PV} I_{PV} of pv cell Wave Forms

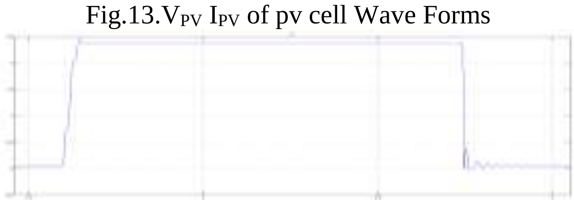

Fig.14.Output current Waveforms

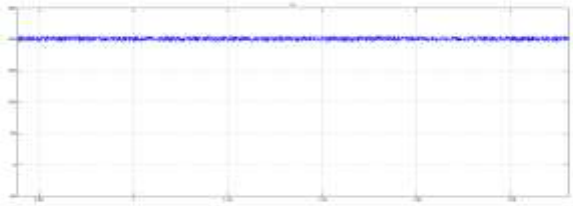

Fig.15. Ripples On output voltage Wave Forms using P&O method

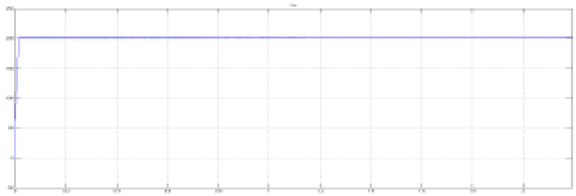

Fig.16. Ripple Free On output voltage using Incremental Conductance(IC) method

Efficiency Testing:

The following efficiency testing was conducted in a closed loop configuration. The efficiency was calculated by the total power out divided by total power into the circuit.

Calculate the efficiency at full load condition by calculate the input power and output power.

Efficiency in percentage = $\frac{output\ power}{input\ power}$X100

At full load the output power = Vo * Io

Po = 200.3*1= 200.3W

$P_{in}=V_{in} * I_{in}$

P_{in}=24*11.6= 278.4W

Efficiency =500.3/278.4*100=94%

Voltage (Vo)Ripple calculation:

$$V_{ripple}=\frac{V_{max}-V_{min}}{V_{avg}}*100$$

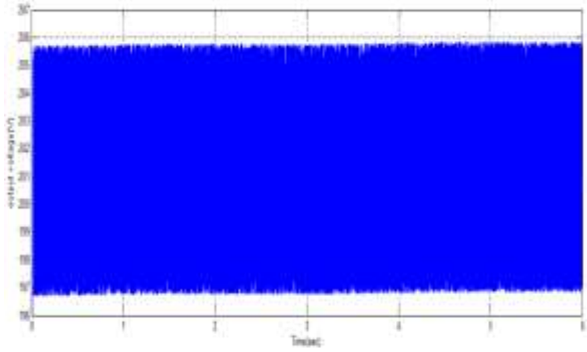

Fig.15. output voltage ripple by using P&O method

For P&O method: From fig.15

V_{ripple}= ((206-197)/201.5)*100 = 4.74%

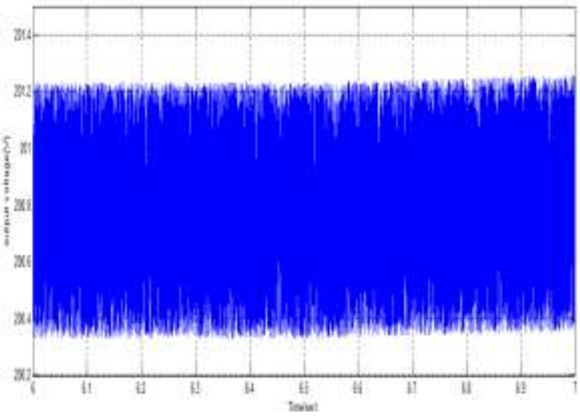

Fig.16. output voltage ripple by using IC method

For IC method: From fig.16

V_{ripple}= ((201.2- 200.1)/200.65)*100 = 0.54%

From ripple calculation we can conclude that P&O method has 4.74% ripple voltage, and IC method has 0.54% ripple. So incremental conductance method is best one among these two.

V.CONCLUSION

The boost converter is able to operating at 25 KHz. The boost converter attains a constant 200V output when it is experiences at maximum load i.e. 80Ω and has voltage inputs of 24V. In addition, the boost converter minimized the switching peak current from reduced by using current limiting inductor, decreasing the reverse recovery losses and attains high step up voltage gain with duty cycle ratio of 0.5.As a whole, the boost converter achieved an efficiency above 90% with high voltage gain at an operating frequency of 25kHz. Here using two MPPT techniques i.e. P&O and IC. Among these two incremental conductance method has low ripple of output voltage.

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