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High Performance Soft Switched DC-DC Boost Converter Suitable for PV Applications

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ABSTRACT: The conventional converters used in harvesting the energy from solar power have some drawbacks associated with them. In order to eliminate them a new soft switching scheme is proposed with ZVT and ZCT techniques to reduce the switching losses. In the proposed converter a new Active snubber cell is used for suppressing the transients in the dc-dc converter due to which voltage stress and current stress on a semiconductor switches is eliminated. The snubber cell consists of the auxiliary switch with diodes, capacitors associated with them. In additional to them a coupled inductor assembly is utilized for the transformation of the stress from switches to the output load. The stress transfer to load mainly depends upon the number of turns of the coil. The proposed converter is simulated using the MATLAB Simulink and the output voltage is obtained.

KEYWORDS: Zero Voltage Switching, Zero Current Switching, Zero Current Transition, Zero Voltage Transition

I.INTRODUCTION

All electronic goods require dc power to run and it is easy to be produced from ac–dc converters High speed switching causes electromagnetic interference (EMI) [1] and extra switching losses[2].In the Normally used converters current and voltage waveforms overlap in every switching action which is called as hard switching leads to overlap power loss at that time of switching, reverse recovery loss of diodes and parasitic capacitance discharge loss of the main switch which is taken into account for general power loss in switching process and damages the semiconductor switches. To overcome these drawbacks, soft switching techniques are used. The Soft switching techniques ZVT & ZCT provide high efficiency due to lowered or destroyed current or voltage stresses.

II.SURVEY ON EXISTING SYSTEM

`In the traditional converters operating on hard switching, where the current and voltage pulses goes from high to low value or from low to high value during the transition period, switching loss occurs. Also generate a substantial amount of Electromagnetic interference. These losses arise because of output capacitor of transistor, capacitance of diode[4] and diode reverse recovery[5][7]. From observation, it is seen that the switching loss is directly proportional to the switching frequency. So the higher switching loss limits the switching frequency to a minimum value. Because of wide spectral range of harmonics present in PWM [3][6] waveform, a high Electro Magnetic Interference (EMI) occurs. Current spikes caused by Diode recovery can also result in this EMI.

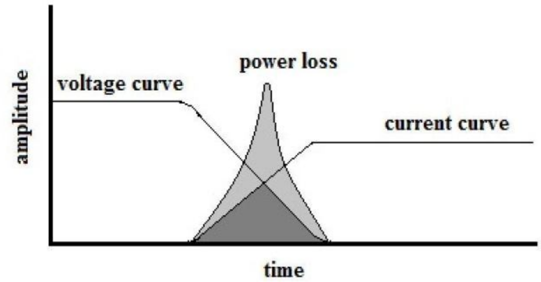

Fig 1. Power Loss in Hard Switching

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III.BLOCK DIAGRAM

The proposed converter block module is shown in the figure 2 .It consists of a solar panel as dc source as input supply. The main power switch is connected by means of the source inductance in parallel condition with an active snubber cell assembly connected to a load .The switching of the converter is controlled by means of the PI controller circuit. The snubber cell part in general consists of the inductor ,capacitor with an auxiliary switch for stress reduction in the circuit.

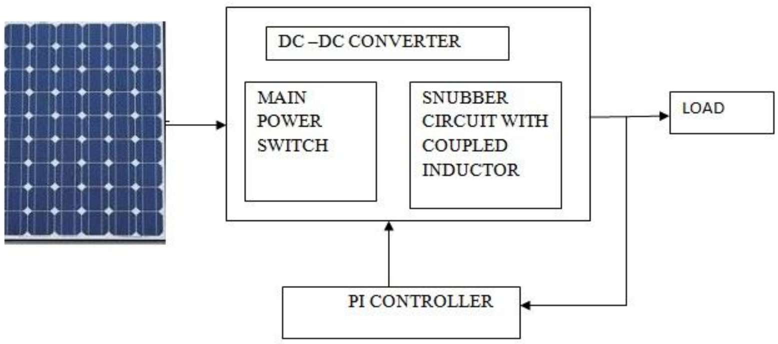

Fig .2 .Block Diagram of Proposed Converter.

IV.PROPOSED SYSTEM

The operation of the proposed converter is done by two switches ,for one operation of main switch ,the auxiliary switch must turn on twice times for the reduction of stress on the main switch[10]. It comprises a twelve modes of operation for the boosting operation of the input voltage to an nominal level of value. The circuit diagram of the proposed converter is given below in figure 3.

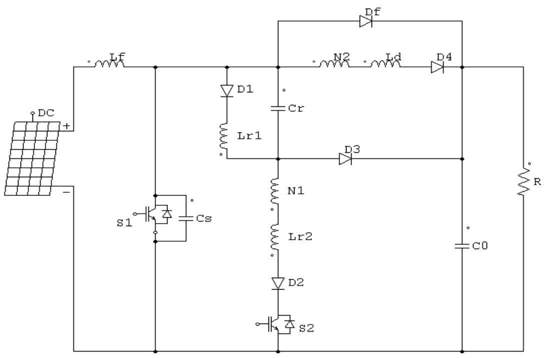

Fig 3.Circuit Diagram of Converter

V.DESIGN OF COMPONENT VALUES

. The values of the components used in snubber cell can be determined from the characteristic curves [4] that are obtained depending on the snubber inductance L_{R1} .The maximum value of the main switch current increases when the value of snubber inductance L_{R1} increases. It increases slightly when the value of C_s snubber capacitance increases .The value of the snubber inductance L_{sa} must be at least twice the value of snubber inductance L_{sb} in order to turn off the auxiliary switch S_2 with ZCT. This case can be defined as ($L_{R1} \geq 2*L_{R2}$.)The capacitor C_p is assumed to be the sum of parasitic capacitor of the main switch and the other parasitic capacitors incorporating it. The value of this capacitor is approximately 1–2 nf. A part of the switching power loss is gained back by the coupling inductance. Transform ratio plays a vital role by input and output turns. It is defined as ($N_1 \leq N_2 \leq 1,5 * N_1$) to provide efficiency

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improvement without any voltage stress. The main switch fall time must be smaller than ZCT time to provide perfect ZCT soft switching conditions. The chosen L_{R1}, L_{R2}, and C_S configure C_R value to provide ZCT soft switching. The switch $S2$ fall time must be smaller than $D2$ reverse recovery time to provide perfect ZCT switching.

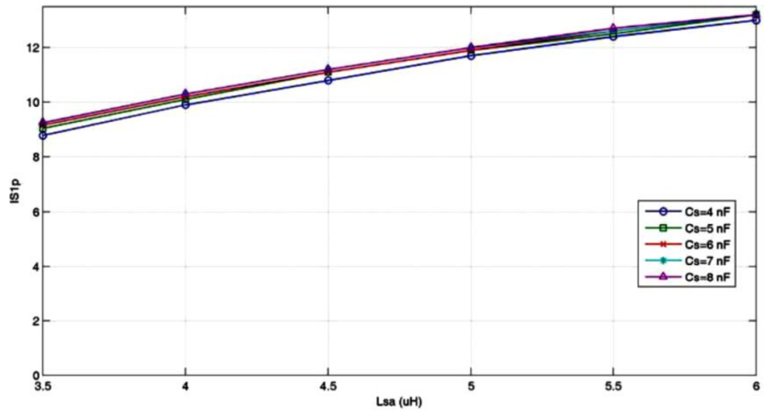

Fig 4.Maximum Current Variation through L_{R1}

VI .WORKING MODES OF CONVERTER

A. STEP 1:- At the beginning of this step, all switches are turned OFF. So $t = t0$, $iS1 = 0$, $i_{S2} = 0$, $i_{DF} = Ii$, $i_{LR1} = 0$, $i_{LR2} = 0$, and $v_{CR} = 0$ are valid. state so D_F conducts input current. Before $S1$, $S2$ switching signal is applied to start resonance in the snubber cell. While I_{DF} decreases, I_{S2} increases due to the resonance between $CR - LR1\ LR2$, and Switch $S2$ conducts current with ZCS., I_{S2} reaches to Ii and then, ZCS and ZVS turn off is provided for DF because of IDF falls to zero.

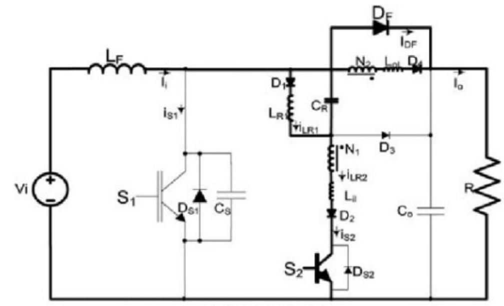

Fig 5 .Switch Step 1

B. STEP 2:-. A resonance occurs between $C_S - L_{R1} - L_{R2} - C_R$ due to CS discharge energy. The C_S transfers its energy to L_{R2} and L_{R2} transfers the part of energy to the output load. When V_{CS} is zero, ZVS turn on is provided for D_{S1}

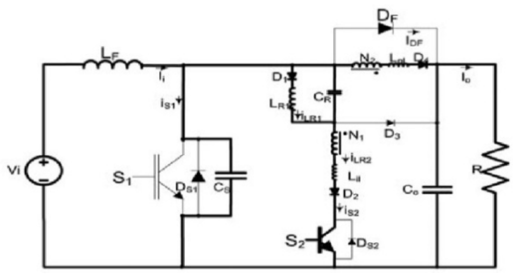

Fig 6. Switch Step 2

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C. STEP 3:- At $t = t2, D_{S1}$ is turned on, so it conducts the resonant current between $L_{R1} - L_{R2} - {}_{CR.}$ In this step, related formulas are valid. The resonant circuit equivalent impedance is represented as Ze.

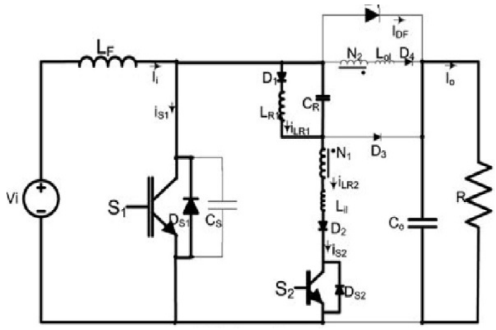

Fig 7.Switch Step3.

D. STEP 4:- For this interval $i_{S1} = Ii$, $i_{S2} = 0$, $i_{DF} = 0$, $i_{LR1} = I_{LR}$, $i_{LR2} = 0$, $v_{CR} = V_{CR}$ and $v_{CS} = 0$ are valid. While Ii passes through $S1$, a resonant starts between $L_{R1} - C_R - D_1$.

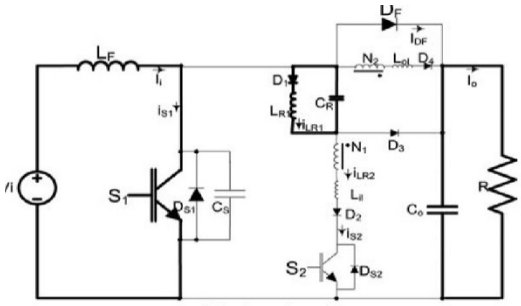

Fig 8.Switch Step 4

E. STEP 5:- At this step, Ii passes through $S1$ and snubber circuit is deactivated. As a dc–dc boost converter main inductance charges with Ii . PWM control lets the converter work as a conventional dc–dc boost converter.

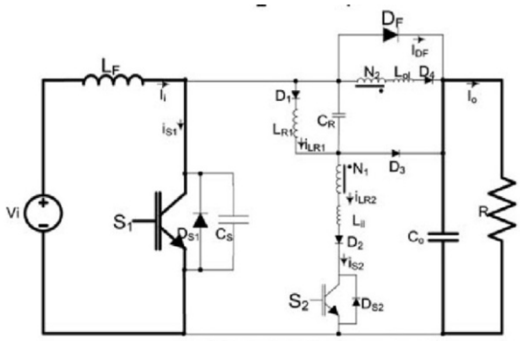

Fig 9 .Switch Step5

F. STEP 6:- For this step, $i_{S1} = Ii$, $i_{S2} = 0$, $i_{DF} = 0$, $i_{LR1} = 0$, $i_{LR2} = 0$, $v_{CR} = V_{CR}$ max and $v_{CS} = 0$ are valid. To turn off $S1$ with ZCT, $S2$ must be turned on. By applying switching signal to S_2, $LR2$ resonates with CR. Due to $LR2$, ZCS turn on is provided for $S2$. By the resonance i_{S2} increases and i_{S1} decreases. ZCS turn on is provided for D_{S1} when i_{S1} is zero. So, ZCT turn off is provided for $S1$. After cutting $S1$ switching signal, the difference between i_{LR2} and Ii passes through D_{S1}.

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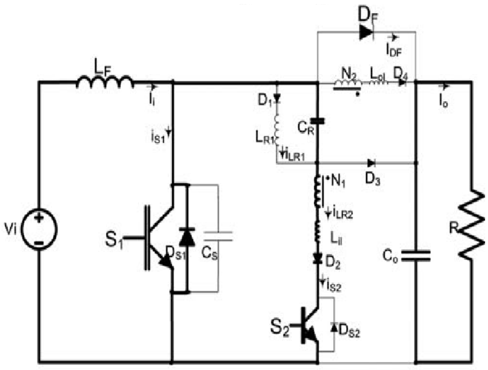

Figure 10 .Switch Step6

G. STEP 7: - Here, i_{S1} = 0, i_{S2} = I_{LR2} max, i_{DF} = 0, i_{LR1} = 0, i_{LR2} = I_{LR2} max, v_{CR} = 0 and v_{CS} = 0 assumptions are initial values. So, $D1$ is turned on, while v_{CR} becomes positive. As a result, $C_R - LR2 - LR1$ conduct a new resonance current. In auxiliary switch path, i_{LR2} decreases to input current and then i_{DS1} = 0 is valid with ZCS turnoff.

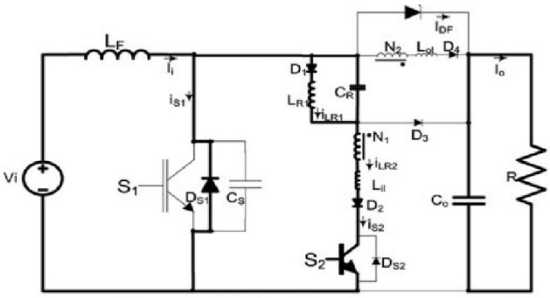

Figure 11 Switch Step7

H. STEP 8:.-For this interval, for $S2$. i_{S1} = 0, $iS2 = Ii$, i_{DF} = 0, i_{LR1} = I_{LR1}, i_{LR2} = Ii, v_{CR} = V_{CR} , and v_{CS} = 0 assumptions are true. Now, another resonance starts through $CS - CR - LR1 - LR2$ with input current. By the time i_{LR2} = 0, D_{s2} is turned on during the reverse recovery time of $D2$, so now $S2$ switching signal can be cancelled. Hence, ZCT turn off process is completed.

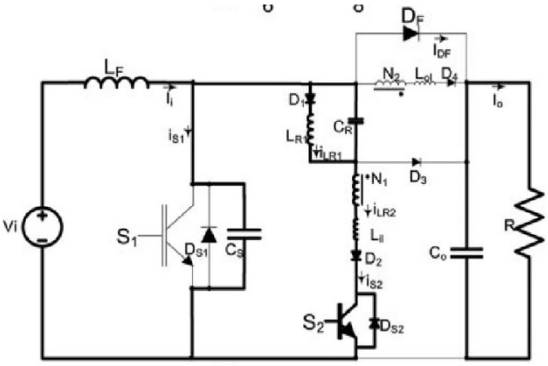

Figure 12. Switch Step 8

I. STEP 9:- In this step, i_{S1} = 0, i_{S2} = 0, iDF = 0, i_{LR1} = i_{LR2} = 0, $vCR = V_{CR}$ and $vCS = V_{CS}$ definitions are accepted., two closed loop are valid. While input current charges C_S, a new resonance starts between $D1 - LR1 - C_R$. At the end of this step, D_3 is turned ON as the sum of v_{CS} and v_{CR} voltages exceed the output voltage.

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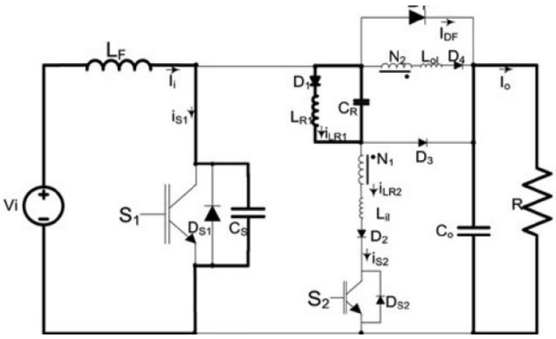

Figure 13. Switch Step9

J. STEP10:-For this interval, $i_{S1} = 0$, $i_{S2} = 0$, $i_{DF} = 0$, , $i_{LR2} = 0$, v_{CR} and $v_{CS} = Vo - V_{CR}$ assumptions are true. The input current passes through C_S, $LR1$, and C_R with a new resonance. When $i_{LR1} = 0$, C_S and Co store all.

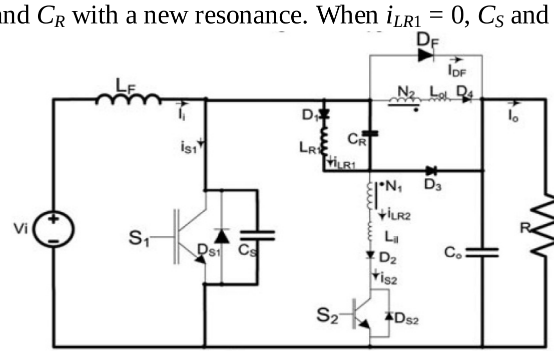

Figure 14.Switch Step10

K. STEP11:-In this mode, at $t = t12$, $i_{S1} = 0$, $i_{S2} = 0$, $i_{DF} = 0$, $iL_{R1} = 0$, $i_{LR2} = 0$, and $vCS = Vo - V_{CR}$ are accepted. While C_R is discharged, input current charges C_S.

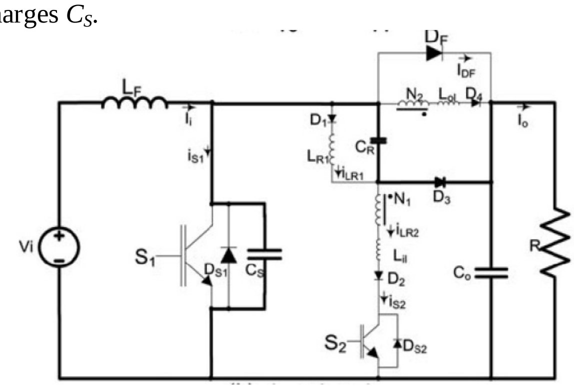

Figure15. Switch Step11

L. STEP 12:- D_F conducts input current to the output load as a part of the conventional boost converter. At last, one switching section is completed. A new switching section can be started with new switching steps.

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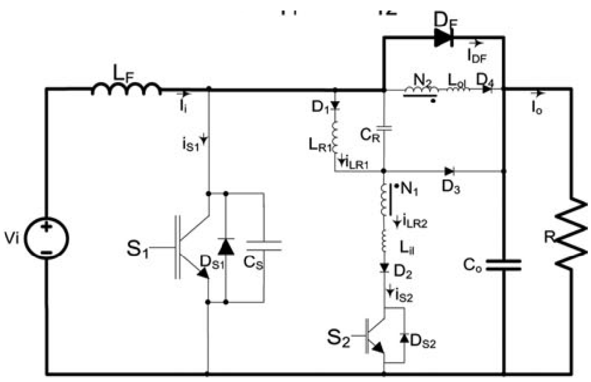

Figure16. Switch Step12

VII .SIMULATION

The simulation of the proposed converter is done using the MATLAB SIMULINK option to verify the output boosted voltage and other waveforms associated with them. The circuit diagram of the converter modelled using simulink is shown in fig17. The value of the components used for the simulation is obtained from the above conditions as discussed above.

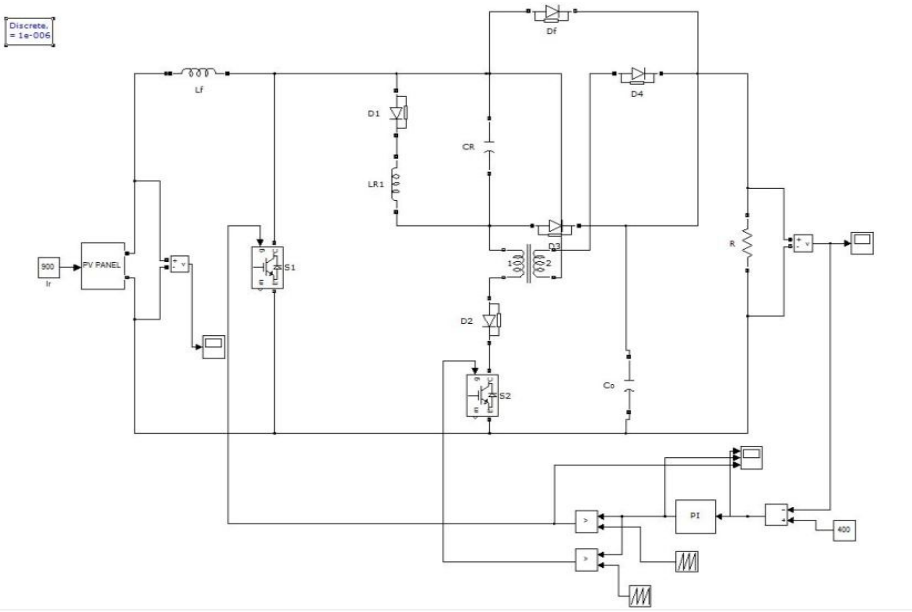

Fig 17.Simulink of Proposed Converter

The output voltage of the proposed converter is obtained with input as around 105V from the solar panel and the output voltage boosted up to 400V as shown in below figures 18&19.the output current of the simulation is around the 4amps.

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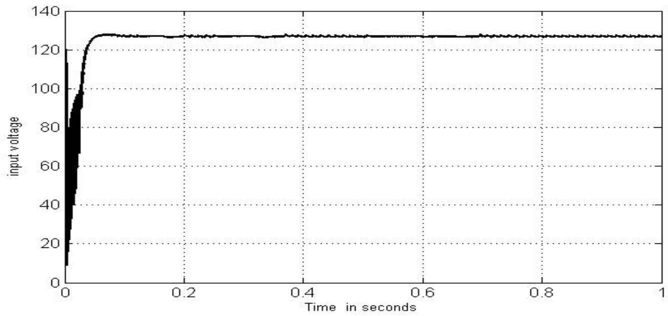

Fig 18Input Voltage from Solar Panel

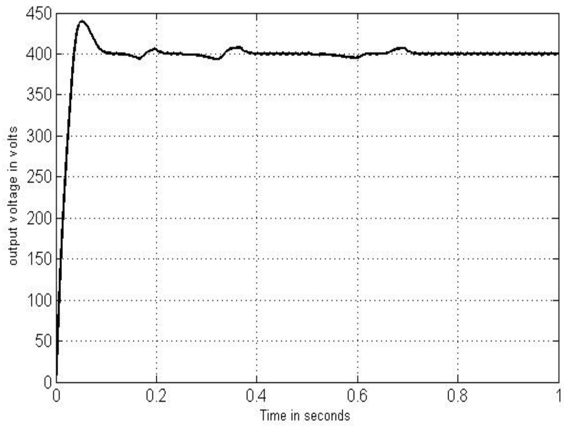

Fig 19. Output Voltage.

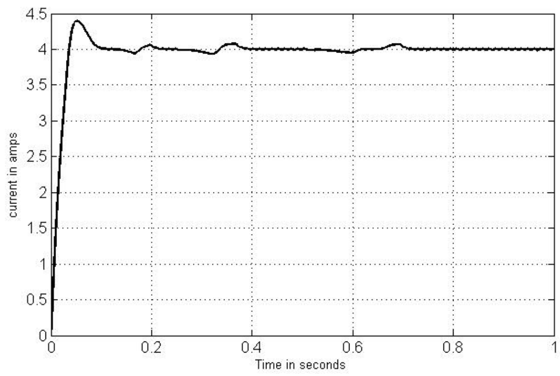

Fig 20 Output Current.

VIII .HARDWARE UNIT

The microcontroller in general operates in the small range of operating voltages with the source of DC supply voltage. The higher level of voltage cannot be direct fed up to the controller circuit so it must be regulated before providing to it. The transformer steps up or steps down the input line voltage and isolates the power supply from the power line. The rectifier section converts the alternating current input signal to a pulsating direct current. For this reason a filter section is used to convert pulsating dc to purer ,more desirable form of dc voltage. The final section ,the regulator does just what the name implies. It maintains the output of the power supply unit at a constant level in spite of large changes in the load current or input line voltages .The filter section is a network of resistors , capacitors or inductors

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control the rise and fall time of varying signal and makes at constant level. Thus the microcontroller implemented with PI controller coding is used for effective turn on & turn off of switches in main circuit board.

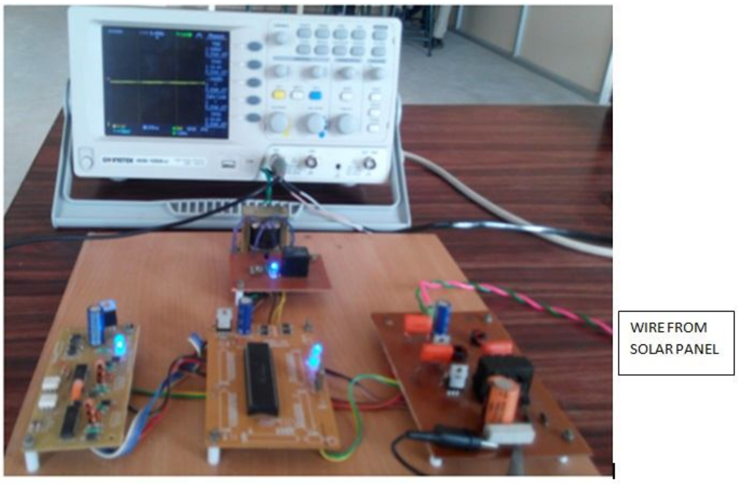

Fig 21. Hardware Module

The hardware output obtained from the above dc-dc boost converter for low power prototype modelling with input 9.47V and the output voltage is boosted around19.7V which is shown in the fig 22&23.

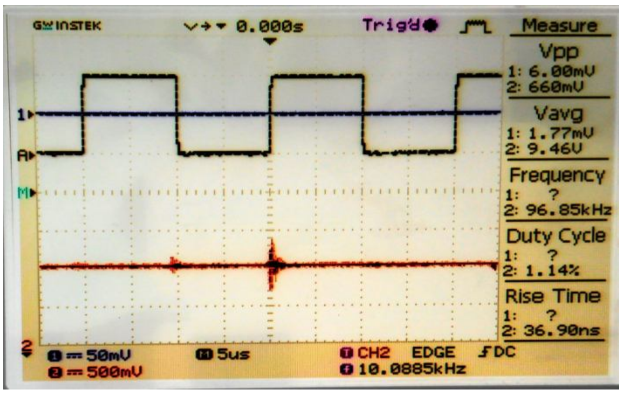

Fig22. Input Voltage from Solar-9.46V

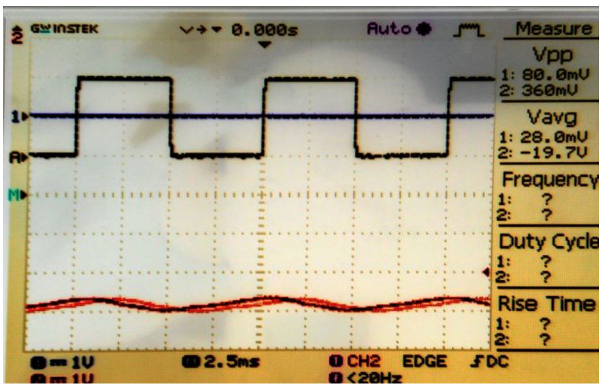

Fig 23.Output Boosted Voltage -19.7V

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VI.CONCLUSION

The ZVT and ZCT based DC-DC boost converter for the photovoltaic application is fed with single active snubber cell to the both main and auxiliary switches for stress reduction in them. The normally used converters had stress of twice the time of input current values which was now eliminated in the proposed system. Due to the reduction of the switching losses and transfer of the stress by means of coupled inductor topology provides the higher performance of the converter making it suitable for solar powered systems .Finally the power loss is gained back form reverse recovery loss of diode, capacitive discharge by means of the soft switching making efficient operation of the converter..

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BIOGRAPHY

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