# Boost converter operation analysis using soft and hard switching techniques

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***Abstract:*** *A new soft switching boost converter is proposed in this paper. The conventional boost converter generates switching losses at turn ON and turns OFF, and this causes a reduction in the whole system's efficiency. The proposed boost converter utilizes a soft switching method using an auxiliary circuit with a resonant inductor and capacitor, auxiliary switch and diodes. Therefore, the proposed soft switching boost converter reduces switching losses more than the conventional hard switching converter. The efficiency which is less in hard switching increases in the proposed soft switching converter using proposed method work on efficiency and switching speed for different solar applications.*

***Keywords*** **:-***soft switching boost converter , efficiency*

## I. INTRODUCTION

Boost converter is a DC to DC power converter. This converter is Capable of giving higher voltages at the load than the input voltage, so Boost converter is called Step up chopper**.** Boost converter contains at least two semiconductors (a diode and a transistor) and at least one energy storage element ( a capacitor , inductor or the two in combination). Filters mostly made of capacitors are normally added to this converter's output (load side filter) and input (supply side filter) to reduce voltage ripples**.** Power for the converter can be applied from suitable DC sources like batteries, solar panels, rectifiers and DC generators.

The average voltage output (Vo) in a step up chopper is greater than the voltage input (Vs). By law of conservation of energy the input power has to be equal to the output power (assuming no losses)

Input power (Pin) = output power (Pout)

Since, Vin<Vout in a boost converter, it follows then that the output current is less than the input current. Therefore in boost converter

Vin<Vout

Iin>Iout

The main working principle of boost converter is that the inductor in the input circuit resists sudden variations in input current. When switch is OFF the inductor stores energy in the form of magnetic energy and discharges it when switch is closed. The capacitor in the output circuit is assumed large enough that the time constant of RC circuit in the output stage is high. The large time constant compared to switching period ensures a constant output

voltage Vo(t) = Vo(constant).

**Soft switching technique**

The term "soft switching" is actually defined as "The operation of power electronic switches as Zero voltage switches (ZVS) or Zero current switches (ZCS). Soft switching is a convenient alternative of reducing losses in switches of Power electronics. We can get reduced switching losses and stress occurred in switch. The thermal operation gets easy and possibly low values of EMI can be achieved.

It is done by two methods:

- Zero Voltage Switching (ZVS)
- Zero Current Switching (ZCS)

**Advantages of soft switching**

• Lower losses (may be!)

• Allows high frequency operation

• Low EMI (may be!)

**Hard switching technique**

In hard switching method, to turn on the switch on, we have to give some value of voltage that is minimum 3.3 V. Hard switch usually takes more time to switch.

**Problems of Hard-Switching**

- Switching losses
- Device stress, thermal management
- EMI due to high di/dt and dv/dt
- Energy loss in stray L and C

**Possible Solutions (combination)**

1.Snubbers to reduce di/dt and dv/dt

- usually no change in losses (unless loss recovery )

2. Circuit layout to reduce stray inductances

3. Gate drive

- circuit layout
- turn on / off speeds

**4. Soft switching to achieve ZVS and/or ZCS**

## II. RELATED WORK

Now-a-days using increased switching frequencies are a better way to get efficient output in DC-DC converters. The advancements in technology of semiconductor fabrication is the reason behind the significant improvement in not only the capabilities of voltage and current but also the switching.The faster semiconductors working at high frequencies result in the passive components of converters like capacitors, inductors and transformers becoming smaller thereby reducing the total size and weight of the equipment and hence to increase power density.

In [1]a modular switched capacitor (SC)dc-dc converter based electrical drive system for battery electric vehicles is presented. It is noticed that due to high energy density of capacitors, SC converters can enable improved power density compared to conventional inductor based power- converters. From the results of this paper, it is shown that the SC converter topology based system is more efficient at heavy load. The SC converters reduce hardware space required. No additional cooling equipment is necessary.

In [2] it represents a new designprocedure for a bidirectional DC-DC LCL converter for potential MW range applications. Instead of a traditional high frequency transformer, two DC/AC converters and a passive LCL filter is used. By using soft switching operation, switching losses are minimized. Robust and stable operation by this proposed system.The main objective was to achieve higher voltage-step ratio to impose a strict limit on the capacitor voltage, to limit the fault currents and to propose a simple and effective way to control the LCL DC-DC converter.

In [3] It is shown that with the advent of SiC technology, MOSFET ON-state resistance is reduced drastically. MOSFET device manufacturing for higher voltage and current has been encouraging. Due to wider band gap of silicon carbide compared to Silicon (Si), MOSFET made in SiC has considerably lower drift region resistance.

In [4] a detailed experimental hard switching characteristics of 15 kV SiC MOSFET is presented. These high voltage SiC devices enable simple two level converters for medium voltage (MV) voltage source converter topology. This paper shows the switching loss comparison of 15 kV SiC MOSFET with 15 kV SiC IGBT for the same dv/dt condition.

In [5] the paper presents a high gain dc-dc converter which is derived from a traditional SEPIC (single-ended primary-inductor) converter. These distributed generation systems are powered by sources such as fuel cell, photovoltaic (PV) systems and batteries. This consists of two conversion stages, in the first stage the low level voltage from the PV cell is converted to high level voltage by using a dc-dc converter. In the second stage the high level dc voltage is converted into AC voltage by using inverter. The main advantage of the SEPIC converter is continuous input current, which can be helpful in accurate PowerPoint tracking of solar cell The inductor less regenerative snubber that reduces switching losses and helps to attain soft switching (zero voltage and zero current switching) conditions.

## III. SIMULATION ENVIRONMENT AND RESULT ANALYSIS

**Boost converter circuit with R - load having MOSFET as a switch**

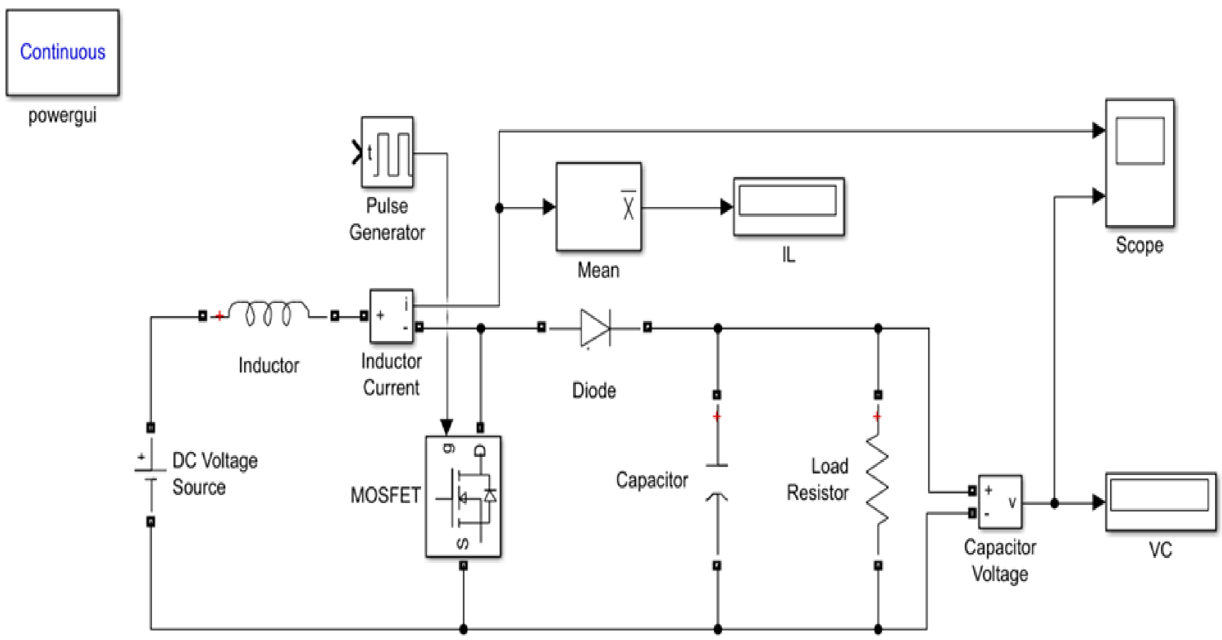



**Fig 1**- Simulink model of Boost converter circuit with R- load

Simulation specifications

Input Side

- Inductor (L) =1.5 mH
- Input voltage = 12 V

MOSFET ratings

- FET resistance = 0.1 Ω
- Internal diode resistance = 0.01 Ω
- Internal diode forward voltage = 0 V

Diode ratings

- Diode on state resistance = 0.001 Ω
- Forward diode voltage = 0.8 V

Other Specifications

- R- load = 3 Ω
- Switching Frequency = 4 kHz
- Filter capacitance = 250 μF
- Duty cycle = 50%

**Output voltage & current waveforms in Soft Switching operation**

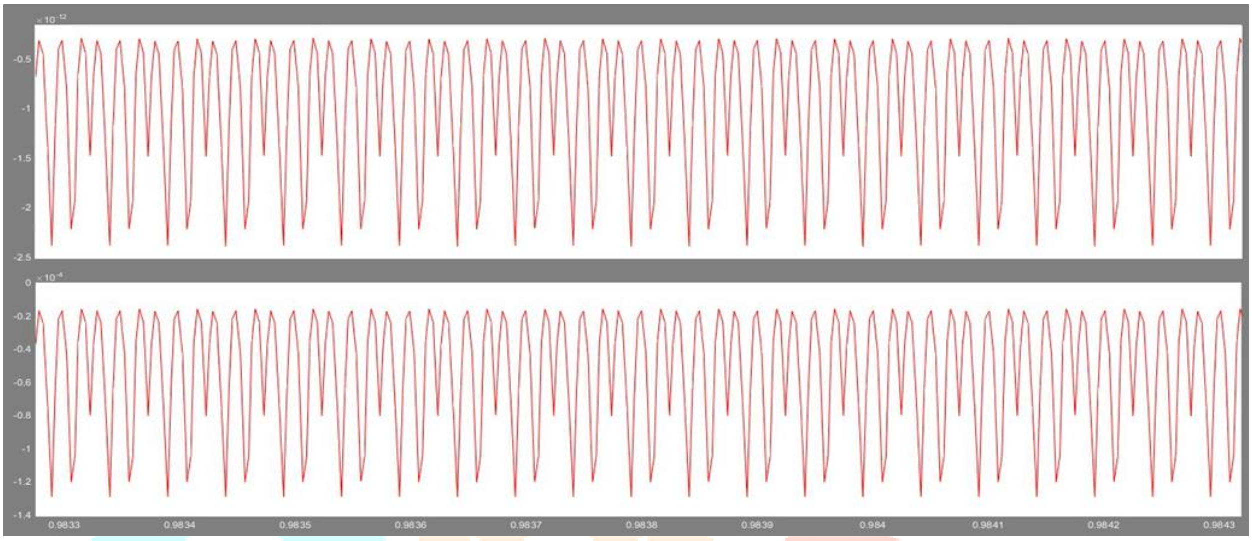


**Image 1-**Output waveforms of capacitor voltage and Inductor current in soft switching

- When the pulse generator has the value of pulse width, 25 then the MOSFET switch closely works as a soft switch and soft (ZVS) switching is characterized.
- As shown in image-1,This provides smoother output waveforms with less voltage spikes and thus it provides more efficient operation then the hard switching circuit of boost converter.
- When the pulse generator has the value of pulse width almost null then the MOSFET switch closely works as a hard switch and hard switching is characterized.
- This provides output waveforms with more voltage spikes and disturbance as shown in image -2. Thus, it provides less efficient operation as compared to the soft switching circuit of boost converter

**Output voltage & current waveforms in Hard Switching operation**

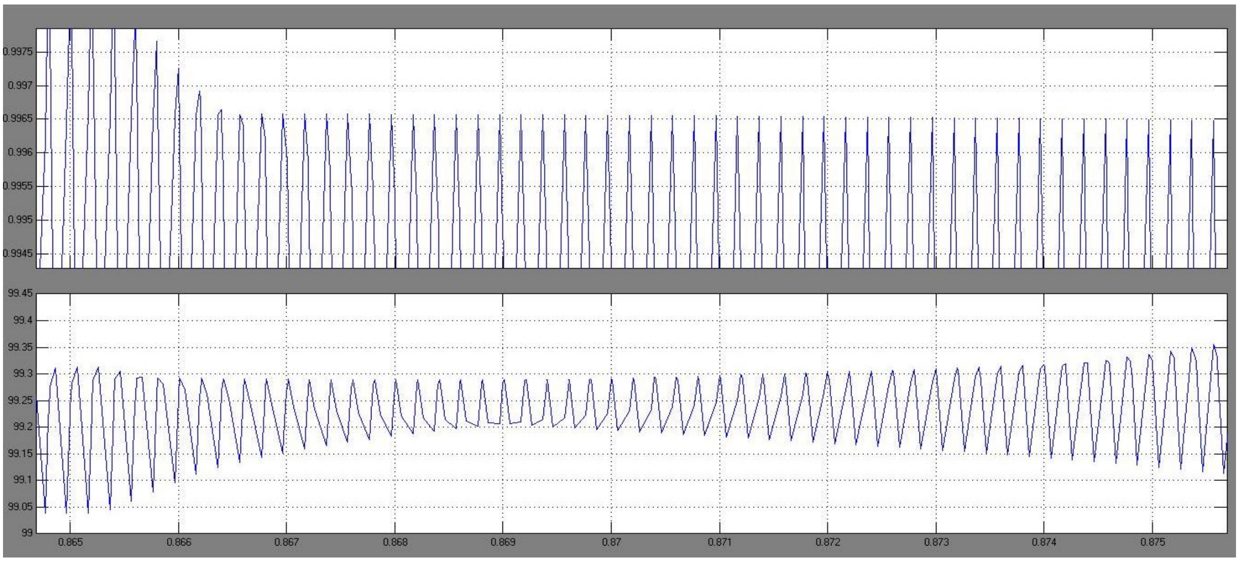


**Image 2-**Simulation Waveforms of capacitor voltage and inductor current in hard switching

**Final circuit analysis in PROTEUS software**

Hard switching operation of Boost converter

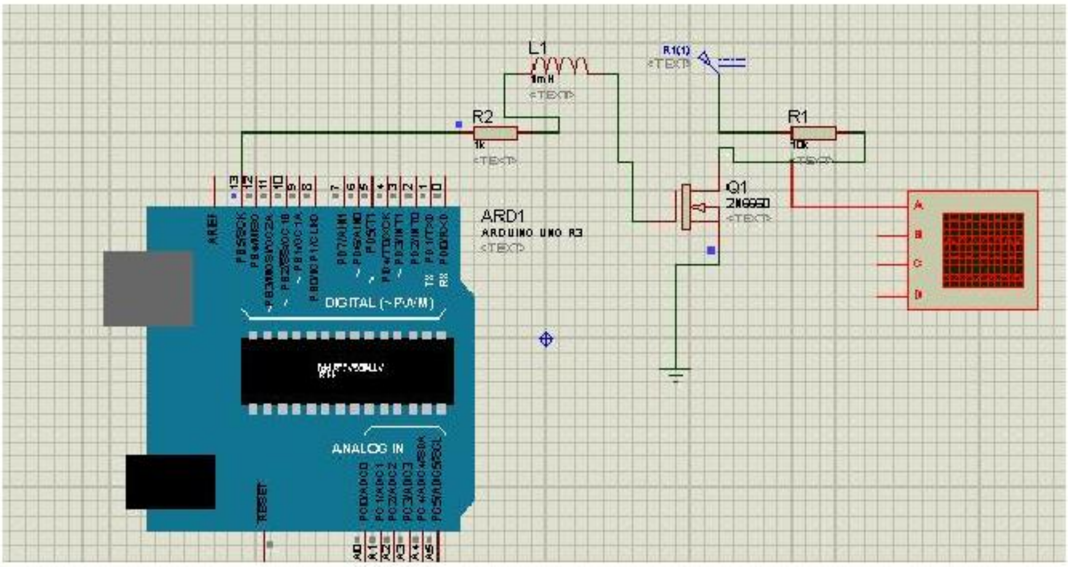



**Image 3**- schematic design of boost converter using hard switching operation

Output voltage waveforms of boost converter for hard switching

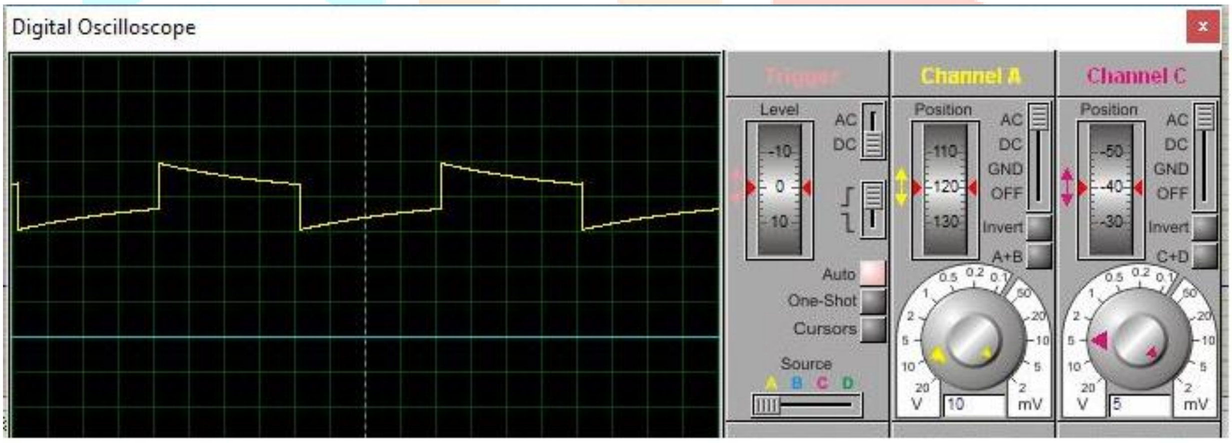



**Image 4**- output voltage waveforms of boost converter for hard switching

Soft switching operation of boost converter

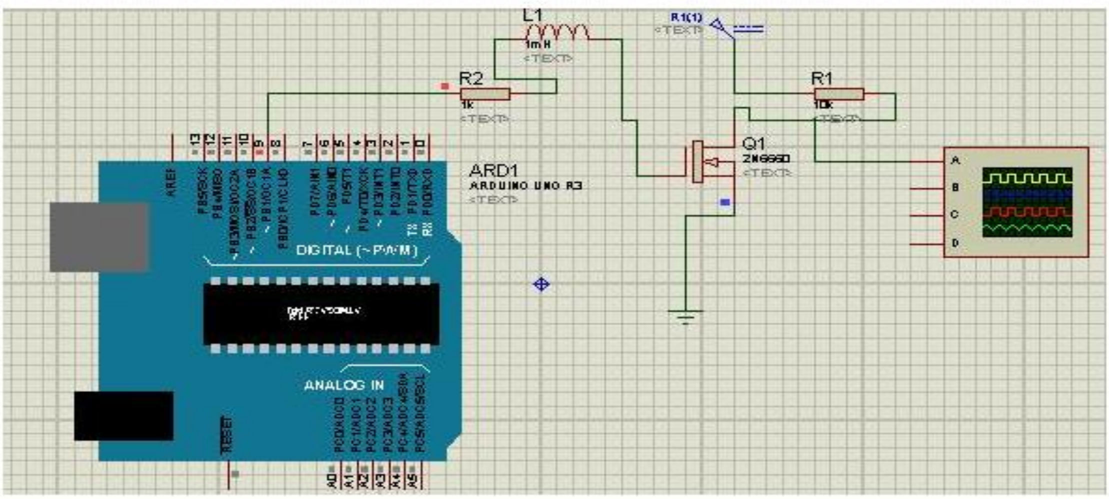



**Image 4**- schematic design of boost converter using soft switching operation

Output voltage waveforms

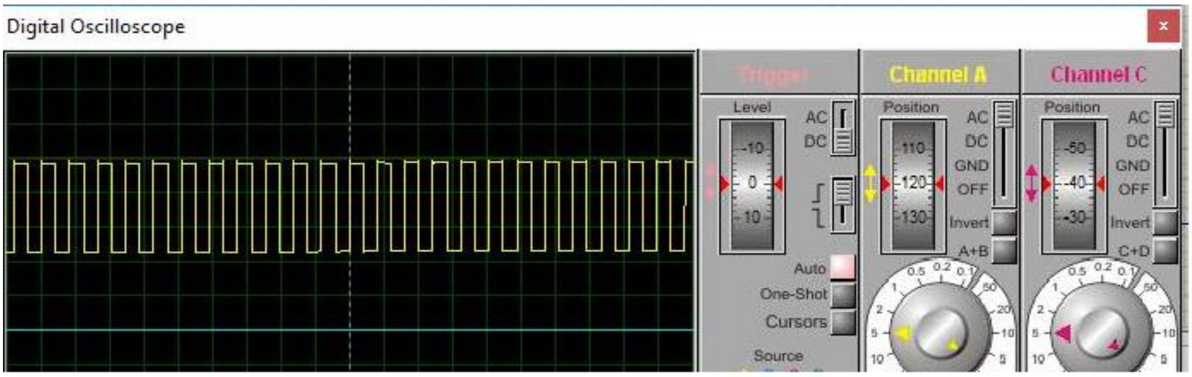
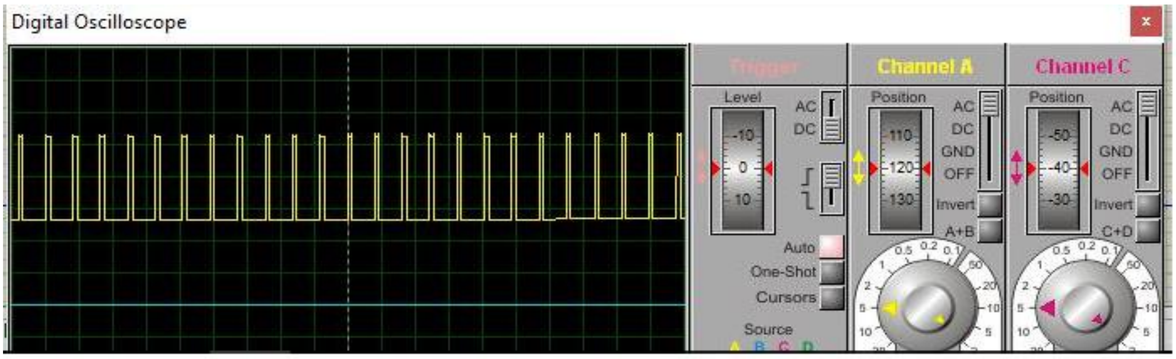
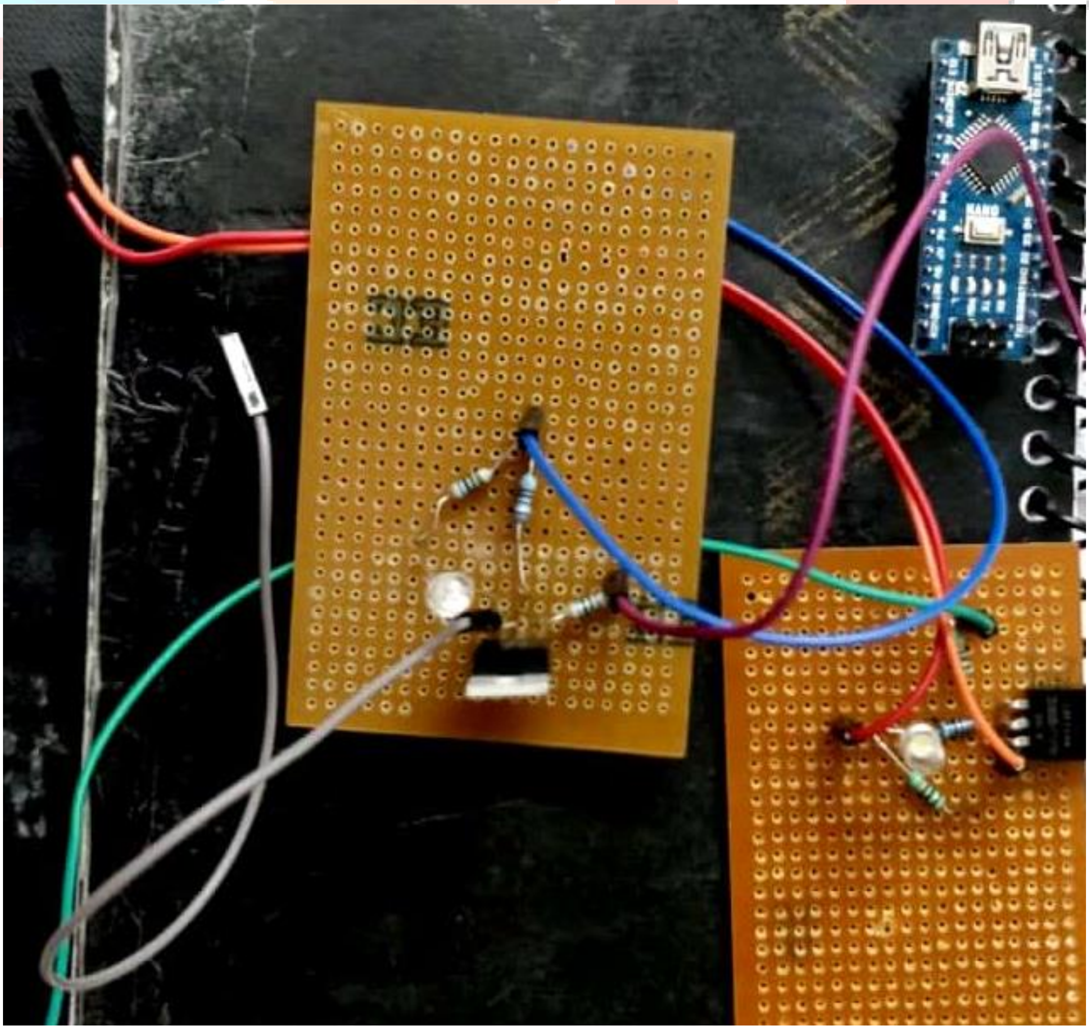



**Image 5–**output voltage waveform of boost converter for soft switching




## IV. HARDWARE IMPLEMENTATION



**Hardware specifications**

- Input side resistance Resistance= 1 KΩ
- Output side resistance= 10 KΩ

1. Irfz44n Power MOSFET ratings
    - Drain to source breakdown voltage = 55 V
    - Continuous drain current =49 A

2.Aurdino Nano microcontroller

3.LED lights

**Output voltage waveform of boost converter using hard switching operation**

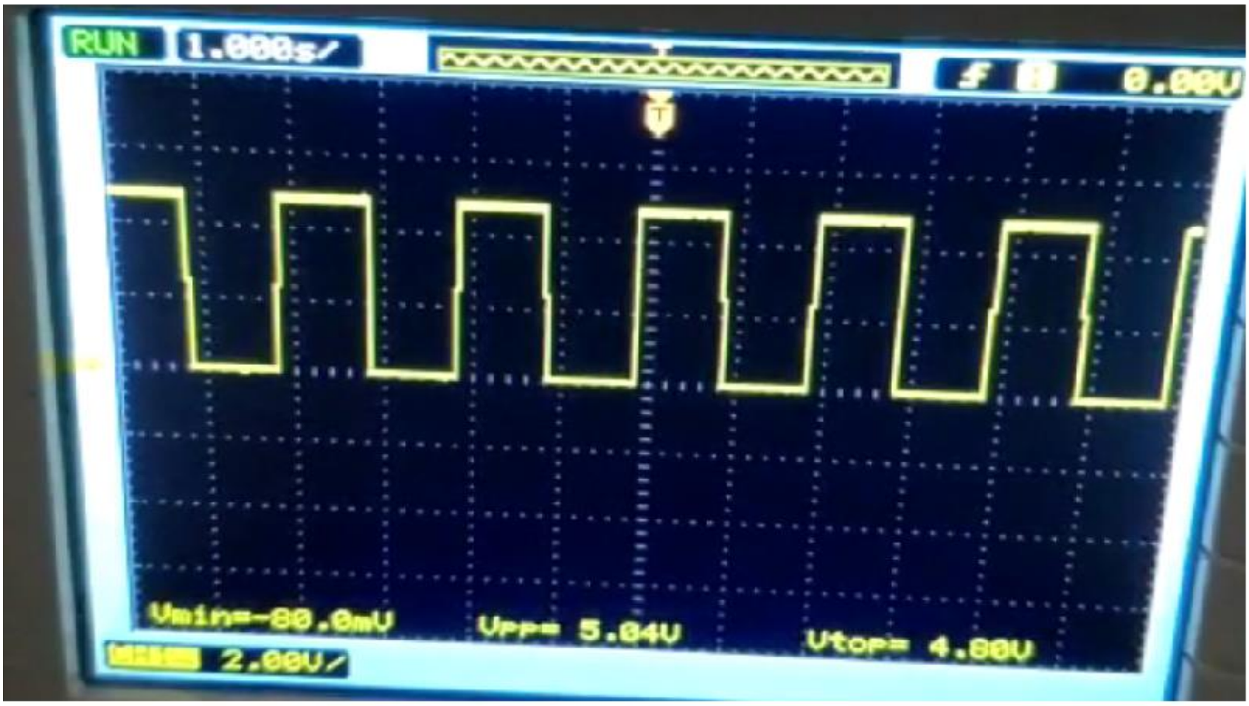



**Image 8** -output voltage waveform of boost converter for hard switching

**Output voltage waveform of boost converter using hard switching operation**

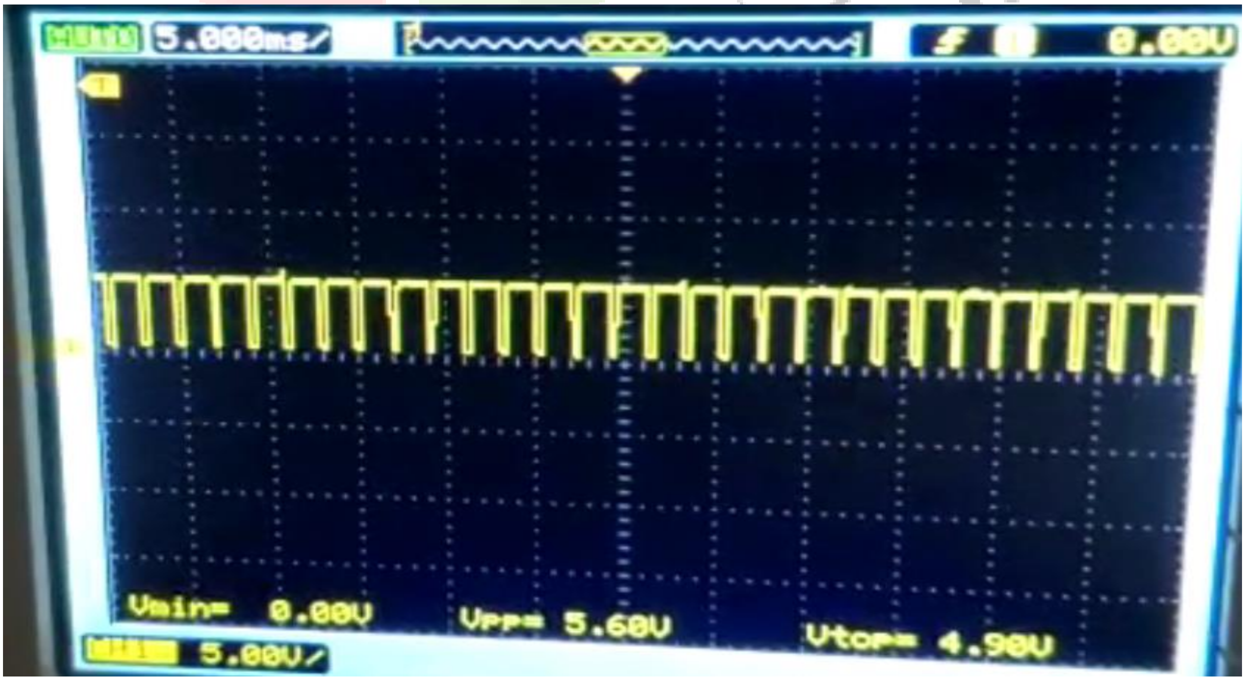



**Image 9-** output voltage waveform of boost converter for soft switching

# V. CONCLUSION

From this analysis it is concluded that the overall output performance of boost converter can be improved using soft switching technique. The operation of the circuit gets smoother and faster by operating the power semiconductor switches at zero Voltage Switching (ZVS) or Zero Current Switching (ZCS).

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