BUCK-BOOST CONVERTER SIMULATION IN MATLAB/SIMULINK AND PCB DESIGN

Department of Electronics and Electrical Engineering

Visuno Naleo

224102115

M.Tech, Power engineering

1. BUCK-BOOST CONVERTER

A buck-boost converter is a DC-DC power converter that step up (boost) or step down(buck) a DC voltage level to achieve a different voltage level. It is a versatile power conversion topology commonly used in various applications including power supplies, battery charging, renewable energy systems and more.

The primary function of buck-boost converter is to regulate the output voltage regardless of variations in the input voltage within certain limits. This makes it useful in situations where the input voltage can fluctuate such as in battery-powered devices where the battery voltage droops over time.

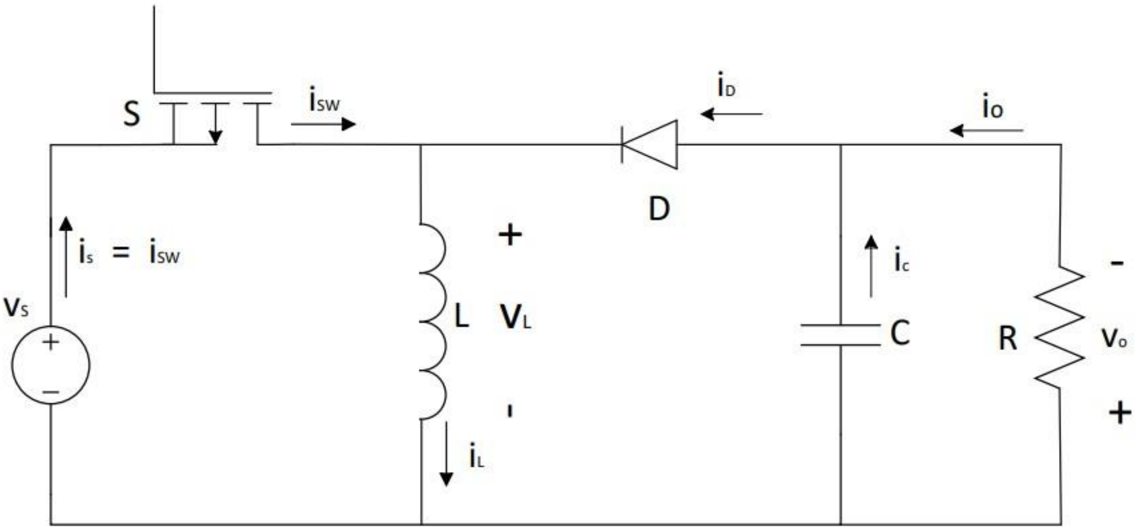


Fig.1: Circuit diagram of buck-boost converter.

1.1 **Buck mode**: When the input voltage is higher than the desired output voltage, the converter operates in the buck mode. In this mode, a switch is turned on and off at high frequency. When the switch is on, energy is transferred from the input to an inductor, storing energy in its magnetic field. When the switch is off, the stored energy is released to the output through a diode. This cycle of energy transfer results in a lower output voltage than the input voltage.

1.2 **Boost mode**: The converter operates in the boost mode when the input voltage is lower than the desired output voltage. The switch is again turned on and off at high frequency in this mode. When the switch is on, energy from an external source like a battery or the input source is stored in the inductor. When the switch is off, the energy is released to the output through the diode, resulting in a higher output voltage then the output voltage.

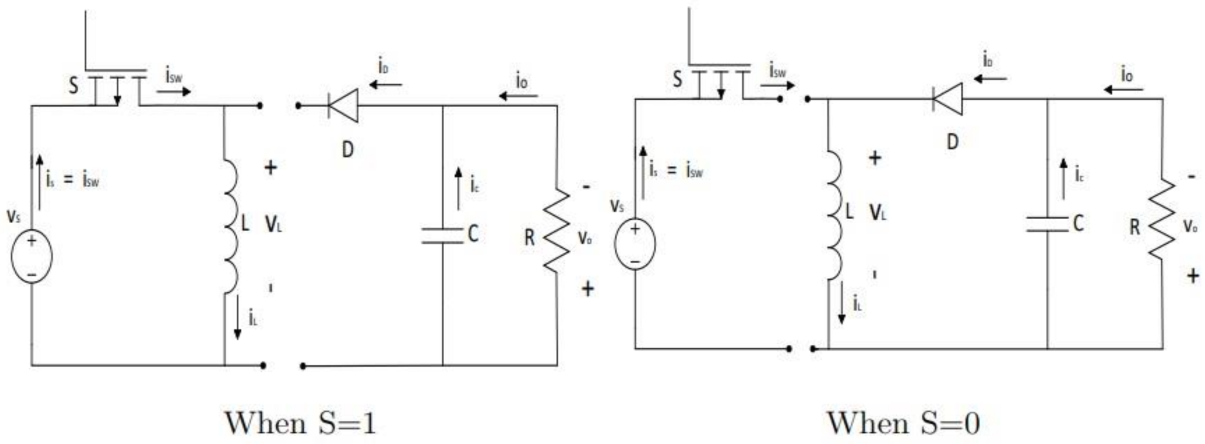


Fig.2: Modes of operation

2. Parameters used for simulation:

Input voltage-100V, duty ratio-1/3, load resistance-25**Ω**, switching frequency -50kHz.

$V_o = \frac{DV_{in}}{1-D}$; D = duty cycle

$L = \frac{R(1-D)^2}{2f}$

$C = \frac{DI_O}{\Delta V f}$

L = 112.2μF, C = 200μH

3. **MATLAB simulation**.

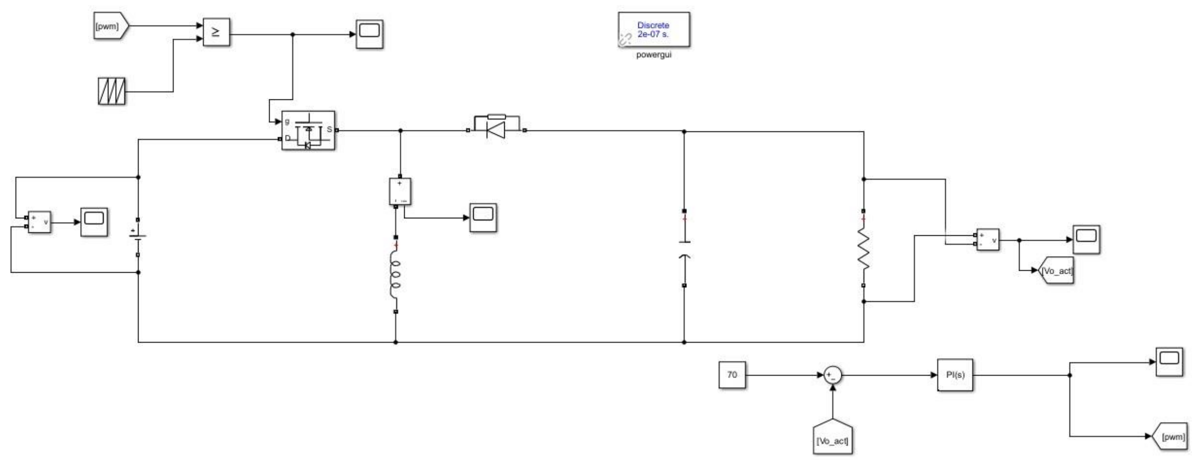


Fig.3: Circuit diagram of close-loop control of buck-boost converter

3.1 Transfer function of buck-boost converter.

$$G_{vd}(s) = \frac{V_O}{DD'} \frac{D'^2 - D\frac{L}{R}S}{LCs^2 + \frac{L}{R}s + D'^2}$$

Using PID tuning under control system designer block;

The value $K_p = 0$ and $K_i = 0.36135$

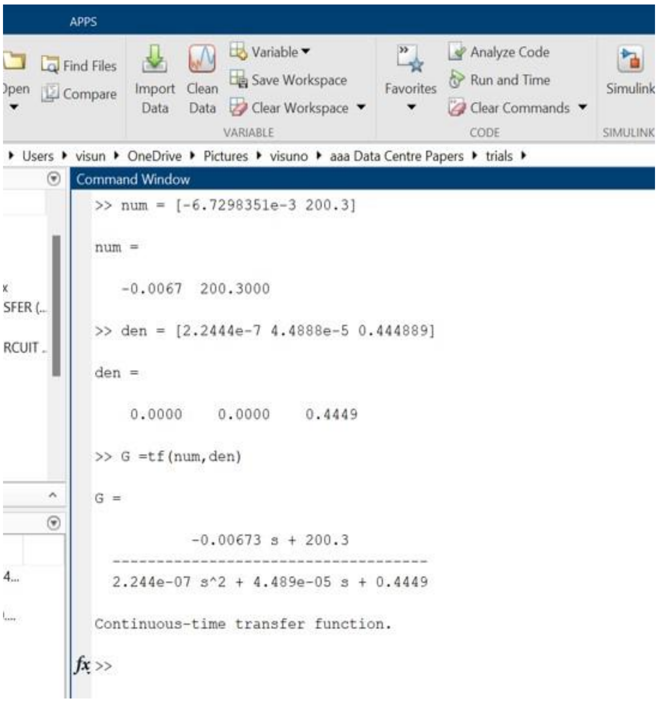


Fig.4: Transfer function.

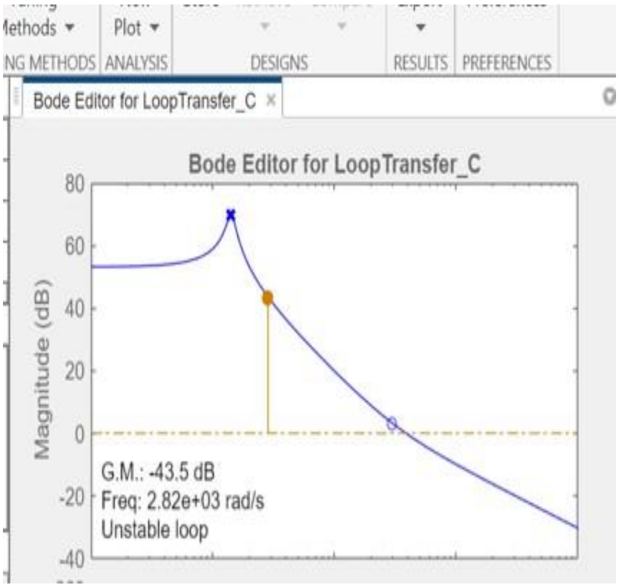


Fig.5: Bode plot of plant before compensator.

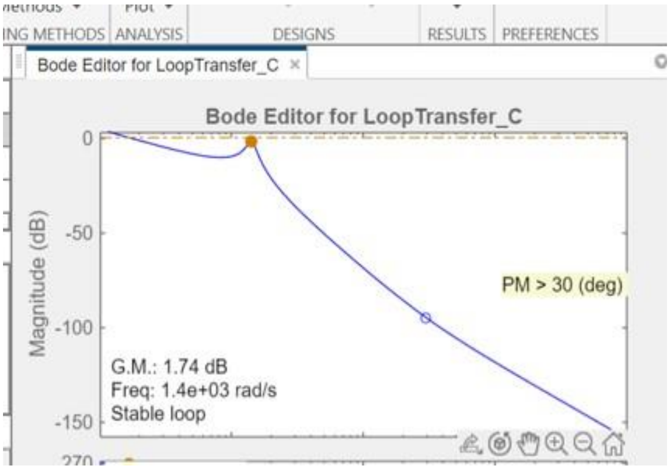


Fig.6: Bode plot of plant after compensator.

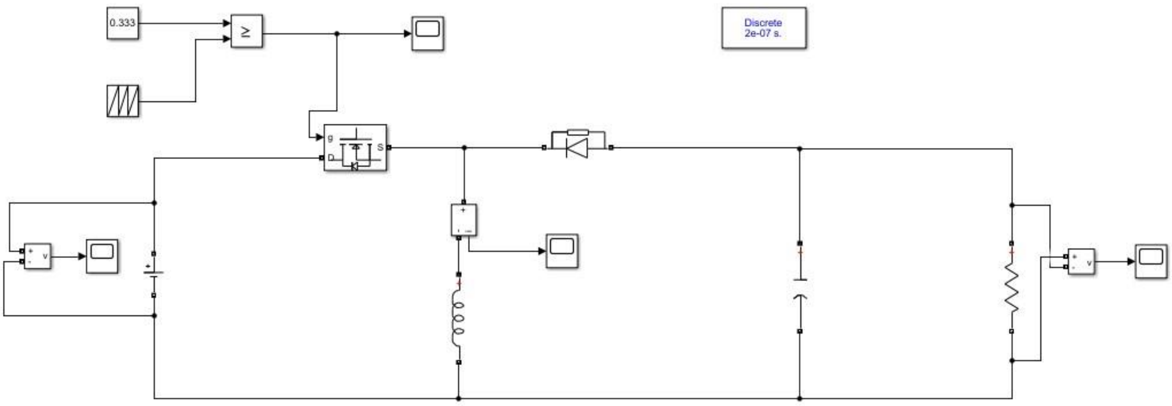
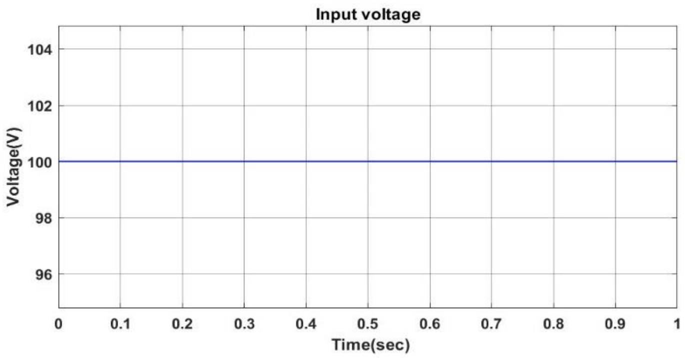


Fig.7: Open loop configuration of Buck-boost converter.

4. Simulation results.



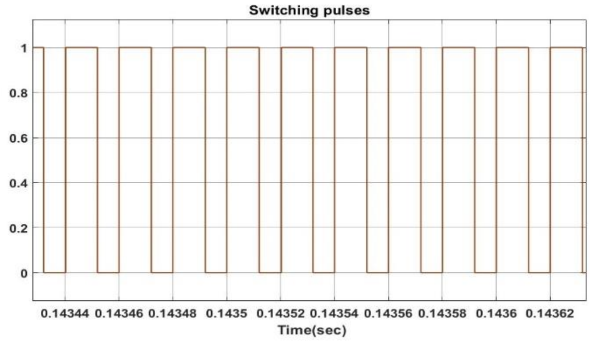


Fig.8: Input voltage for both open and close-loop.

Fig.9 Switching pulses for close-loop control.

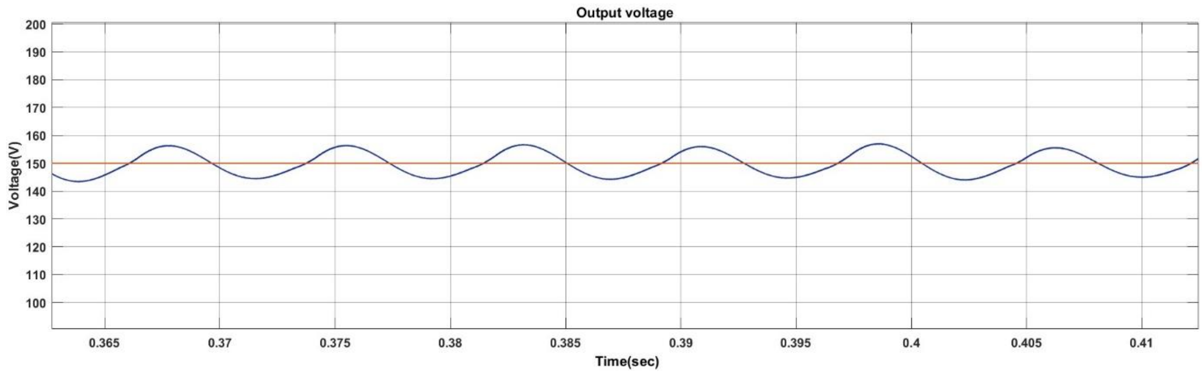


Fig.10: Reference voltage(orange line), actual output voltage(blue).

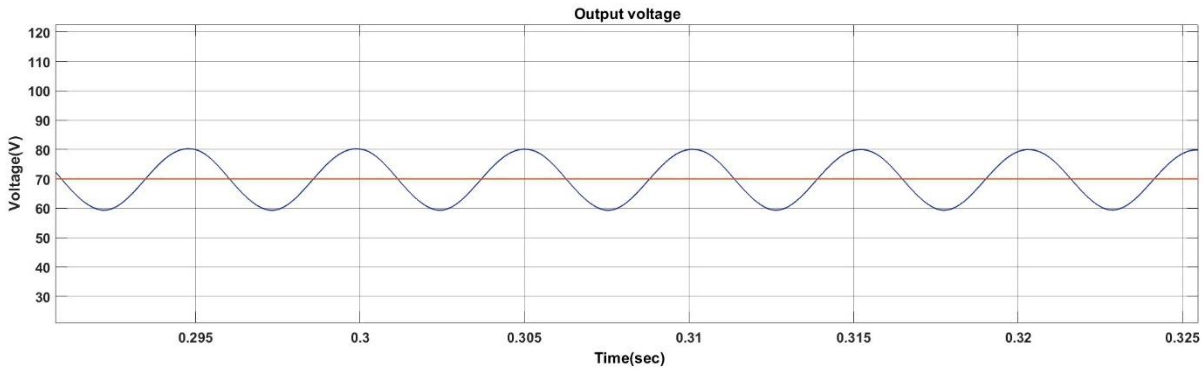


Fig.11: Reference voltage(blue), actual output voltage(blue).

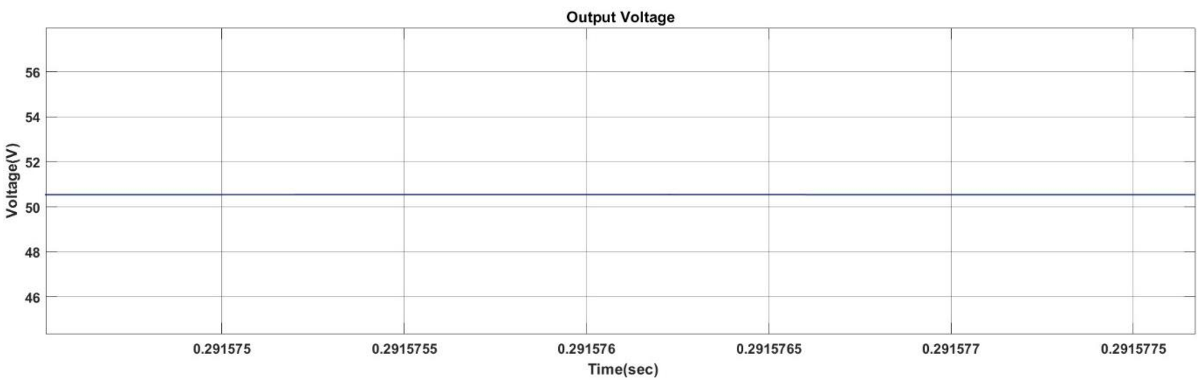


Fig.12: Output voltage waveform for open loop configuration

5. PCB design using EAGLE

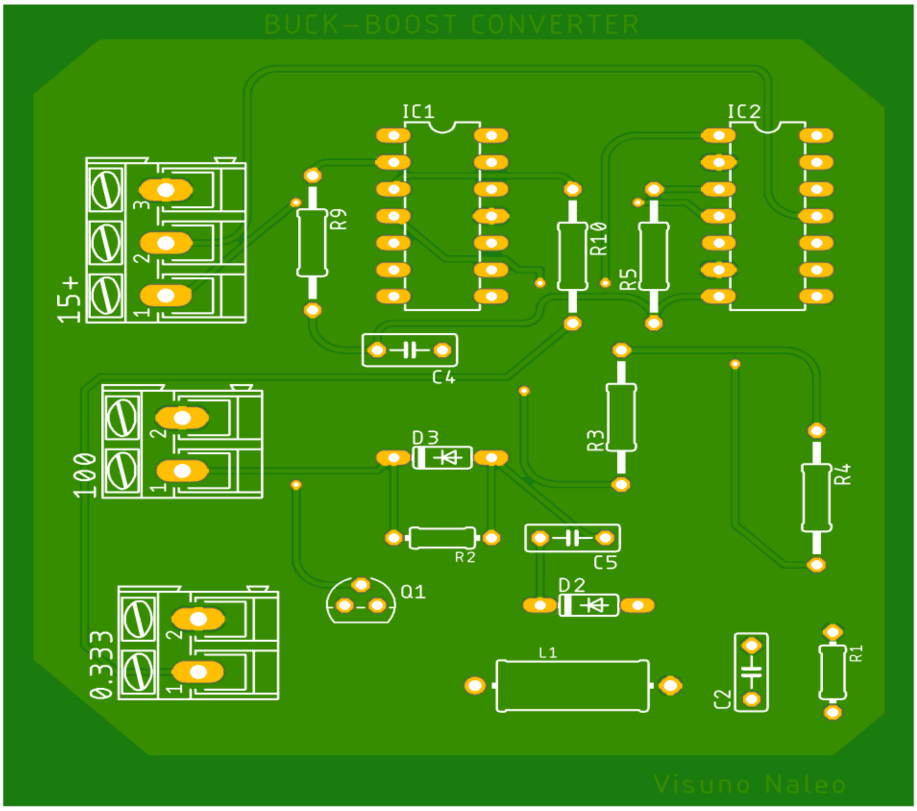


Fig.13: PCB of buck-boost open loop.

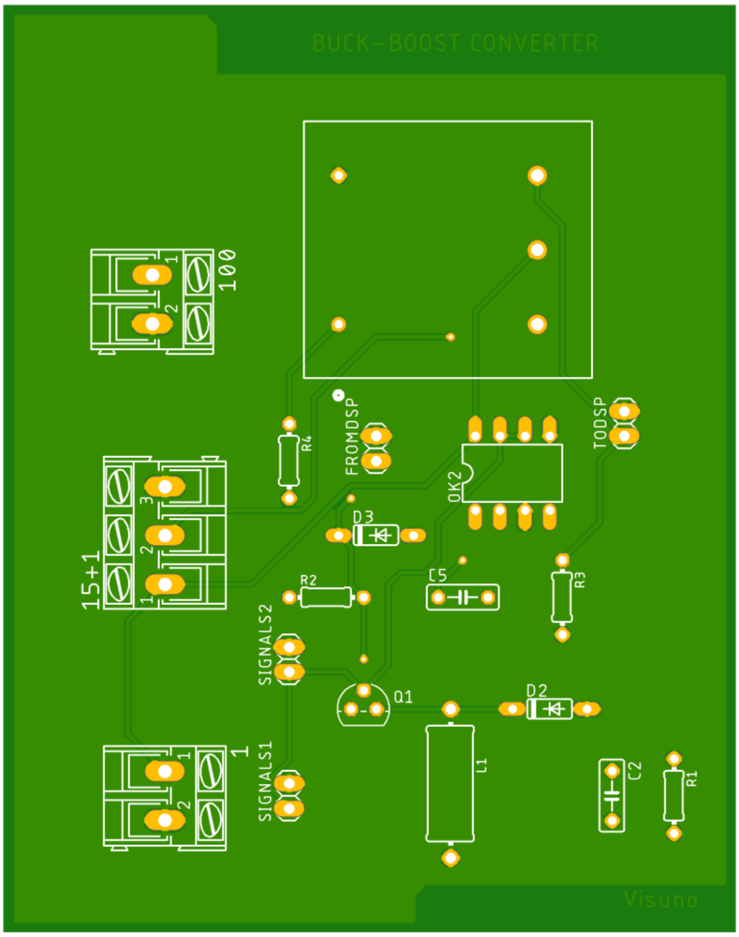


Fig.14: PCB of buck-boost close-loop.

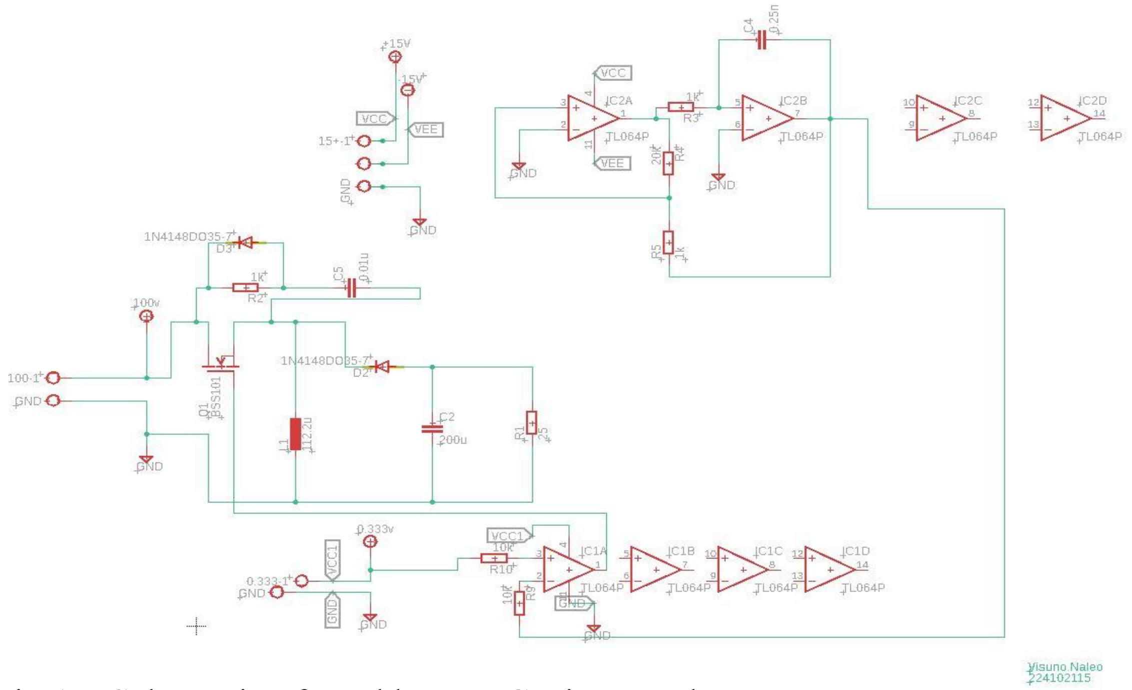


Fig.15: Schematic of Buckboost PCB in open-loop

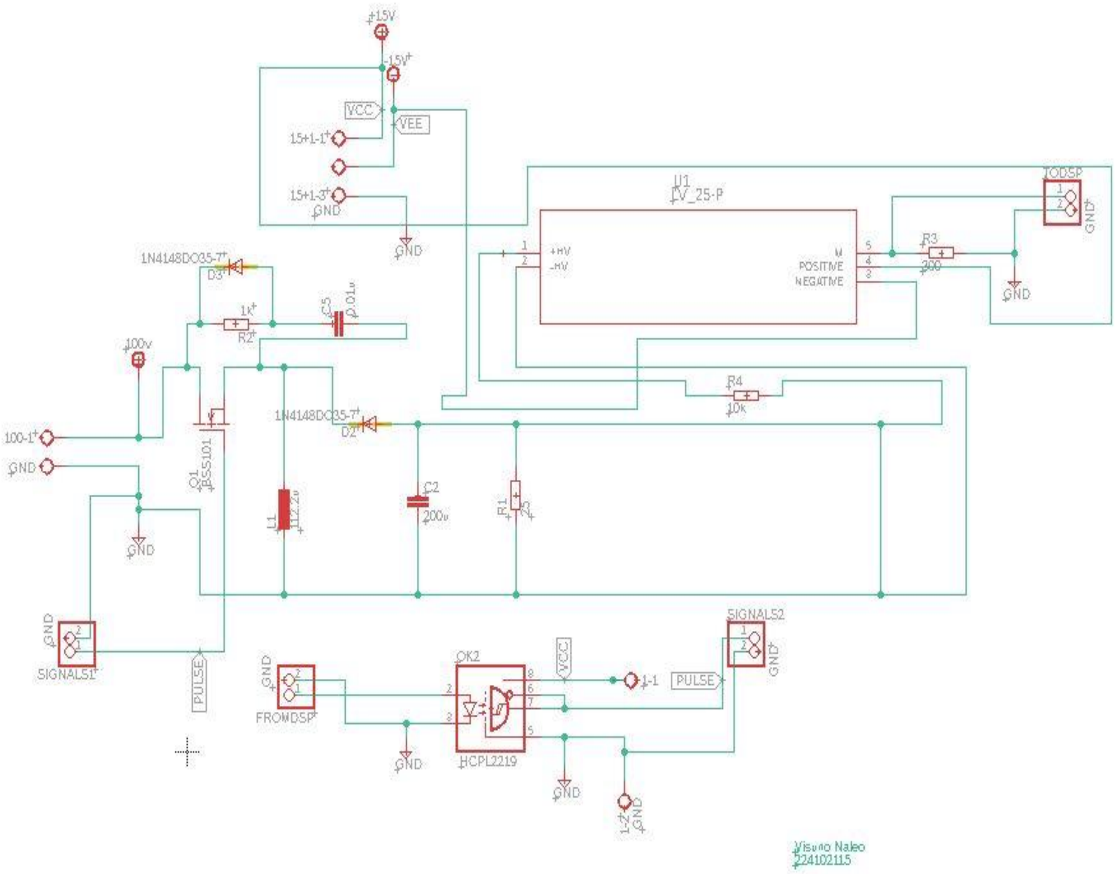


Fig.16: Schematic of Buckboost PCB in close-loop

5.1 PCB specification

Closedloop

i)TL064 quad op-amp is used for both triangle generation and for comparator.

ii)LEM LV 25P is used for sensor purpose.

iii) FOD3182 optocoupler is used for isolation purpose as well as for sending signals to the switch.

iv) Resistor(Ω)= 1k, 300, 10k, 25,

v) Capacitor(F)= 200u, 0.01u

vi) Inductor(H)=0.01m

Openloop

vii) Resistor(Ω) = 1k(3nos), 25, 10k(2nos), 20k.

viii)Capacitor(F) = 200u, 0.01u, o.25n

ix) Inductor(H) = 0.01mH