**Design of Closed Loop Boost Converter**

**EE 561**

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# 1 Objective

To realize the closed loop control of boost converter using analogue PI controller

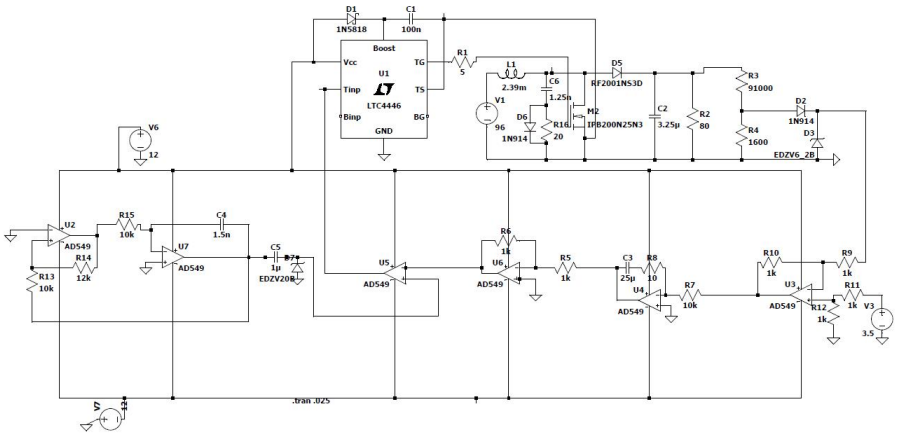
# 2 Software

LT Spice & Eagle PCB

# 3 Introduction

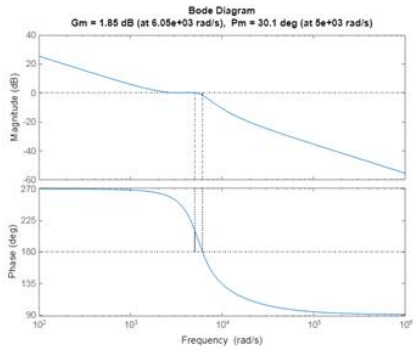
A DC-DC converter is a circuit which converts a constant dc supply to a variable dc supply. In closed loop control the output voltage is compared with the required voltage reference and the error signal is supplied to PI controller which is designed in analogue domain. Then the output of the PI controller is compared with the output of triangular wave generator designed in analogue domain . The error produced is provided to the MOSFET gate driver IC which produces required pulse waveform for the switch  rcd snubber is used to protect the gate terminal of the switch. In order to change the output voltage we need to change the reference so that new gate pulse will be generated as per our requirement.

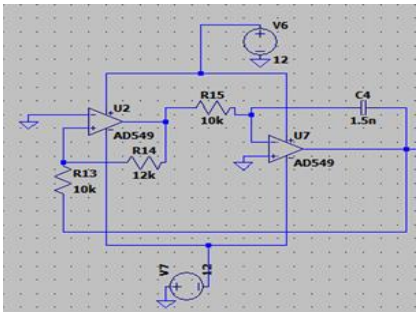
# 4 Circuit Diagram



# 5 Design

$P = 500w, V_{in} = 96v, V_o = 200v, f_s = 20kHz$
$percentage\nabla V_o = 10, percentage\nabla I_L = 20$
$R_0 = 200^2/500 = 80ohm, V_o/V_{in} = 1/(1-D), D = 0.52$
$\nabla I_L/I_o = D(1-D)^2R/Lf_s$ hence $L = 2.39mH$
$\nabla V_o/V_o = D/Rf_sC$ hence $C = 3.25 * 10^{-6}F$
$V_{ref} = 200(1.6/91 + 1.6) = 3.5v, I_o = 500/200 = 2.5A, I_{in} = 500/96 = 5.2A$
Open loop tf= $\frac{V_0R(1-D)^2 - V_oSL}{SL(1-D)+S^2LCR(1-D)+(1-D)^3R} = \frac{12.32*10^9(1-1.3*10^{-4}S}{S^2+3846.15S+29.58*10^6}$
Closed loop tf= $\frac{12.32*10^9(1-1.3*10^{-4}S}{S^2+3846.15S+29.58*10^6}(K_p + \frac{K_i}{S})$
Lets assume $W_{gc} = 5kHz$ and phase margin= $30^0$
$ThenK_p = 0.0010246andK_i = 4.356$
$(K_p + \frac{K_i}{S}) = (\frac{R_8}{R_7} + \frac{1}{SR_7C_3})$
If $R_7 = 10kohm$ then $R_8 = 10.246ohm$ and $C_3 = 25 * 10^{-6}F$
Peak voltage of triangular wave= $V_{sat}(R_{13}/R_{14}) = 10v$



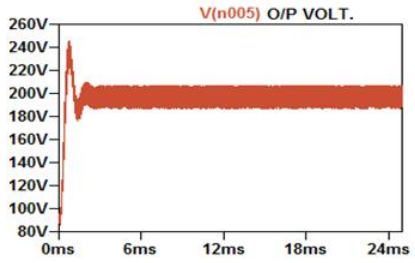



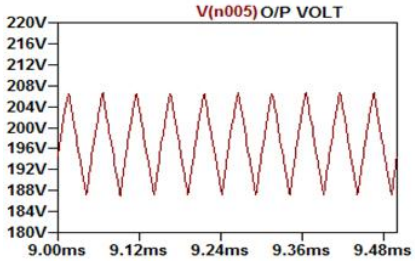

Peak voltage of triangular wave(after level shift)= $20v$
Frequency= $R_{14}/4R_{13}C_4R_{15} = 12k/(4 * 10k * 10k * 1.5n) = 20kHz$
In snubber circuit $R = V_{sw}/I_{max} = 200/10 = 20$ and $C = 1/(v^2f) = 1.25nF$

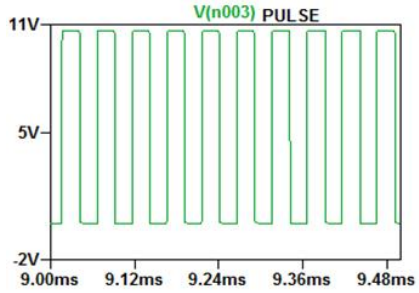
# 6 Components

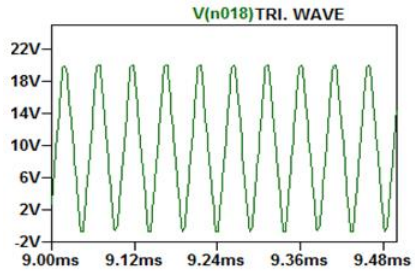
1.Voltage sources:96v(input),12v(opamp),3.5v(reference)
2.Opamp:AD549(LTSpice)/LM324AN-NOPB(Eagle)
3.Mosfet:max. voltage=200v,volt. rating=1.5*200=300v
max. current=5.2+5.2*0.1=5.72A
Model:IPB200N25N3(LTSpice)/IRF644(Eagle)
4.Diode:max. voltage=200-96v=104,volt. rating=1.5*104=156v
max currrent=2.5+2.5*0.1=2.75A
Model:RF2001NS3D(LTSpice)/BY550(Eagle)
5.Scaling circuit diode:EDZV6-2B(LTSpice)/1N5333(Eagle)
6.Gate driver:LTC4446
7.Snubber circuit diode:1N914(LTSpice)/BY550(Eagle)
8.Tri. wave generator diode:EDZV20B(LTSpice)/1N4004(Eagle)

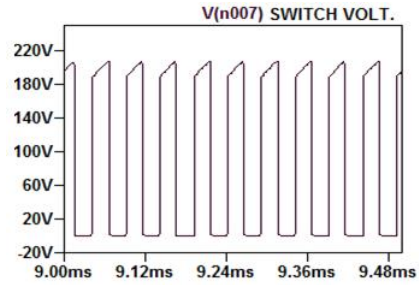
# 7 Waveforms

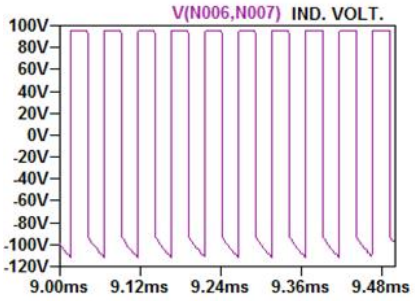

V(n005) O/P VOLT.
260V
240V
220V
200V
180V
160V
140V
120V
100V
80V
0ms
6ms
12ms
18ms
24ms

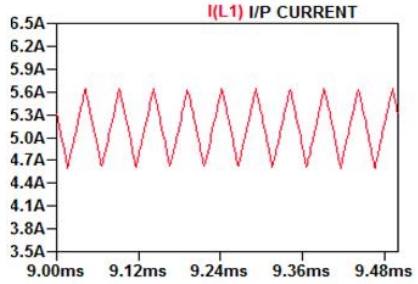

V(n005) O/P VOLT
220V
216V
212V
208V
204V
200V
196V
192V
188V
184V
180V
9.00ms
9.12ms
9.24ms
9.36ms
9.48ms

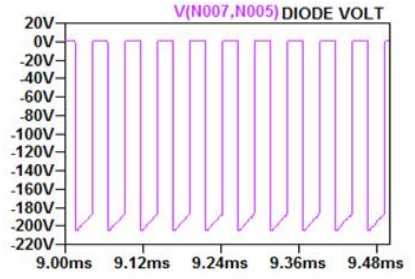

V(n003) PULSE
11V
5V
-2V
9.00ms
9.12ms
9.24ms
9.36ms
9.48ms


V(n018) TRI. WAVE
22V
18V
14V
10V
6V
2V
-2V
9.00ms
9.12ms
9.24ms
9.36ms
9.48ms

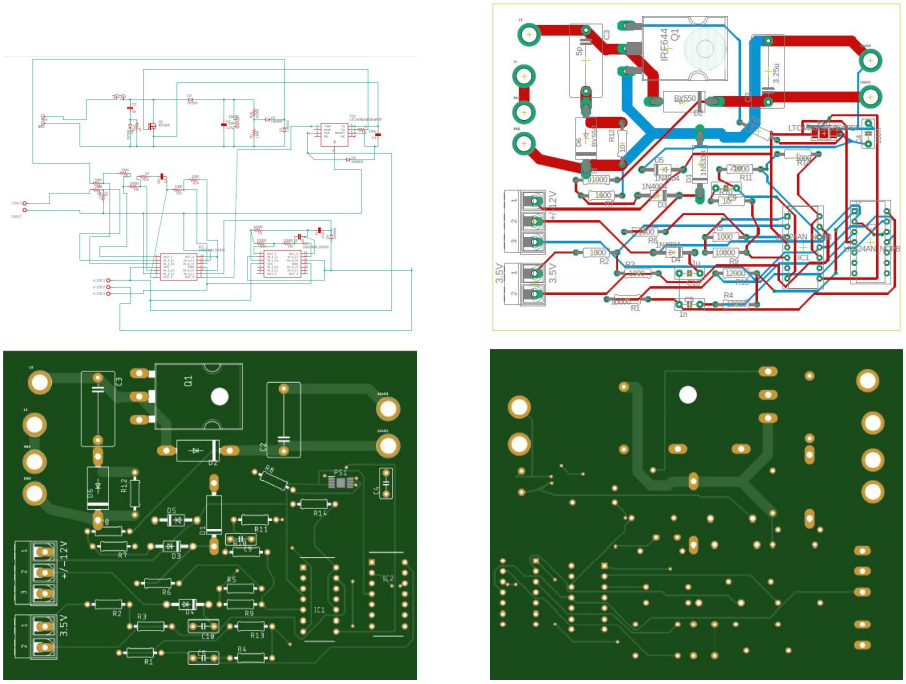

V(n007) SWITCH VOLT.
220V
180V
140V
100V
60V
20V
-20V
9.00ms
9.12ms
9.24ms
9.36ms
9.48ms


V(N006,N007) IND. VOLT.
100V
80V
60V
40V
20V
0V
-20V
-40V
-60V
-80V
-100V
-120V
9.00ms
9.12ms
9.24ms
9.36ms
9.48ms


I(L1) I/P CURRENT
6.5A
6.2A
5.9A
5.6A
5.3A
5.0A
4.7A
4.4A
4.1A
3.8A
3.5A
9.00ms
9.12ms
9.24ms
9.36ms
9.48ms


V(N007,N005) DIODE VOLT
20V
0V
-20V
-40V
-60V
-80V
-100V
-120V
-140V
-160V
-180V
-200V
-220V
9.00ms
9.12ms
9.24ms
9.36ms
9.48ms

# 8 Eagle Schematic and PCB Layout



# 9 Conclusion

In this project we observed the closed loop control of boost converter using analog PI controller.From LT Spice simulation the average output voltage is found to be 196v.The ripple in output voltage is 18v .The average inductor/input current is 5.2A and the ripple in inductor current is 1A.The average load current is found to be 2.45A.The converter is working in continuously conduction mode.And the PCB board is designed in EAGLE PCB with choosing appropriate ratings both in LTSpice and Eagle PCB.