EXPERIMENT 1: BUCK, BOOST, BUCK-BOOST CONVERTER
Name: Mansi Uniyal
Roll number: 19EE10039

PART A: BOOST CONVERTER

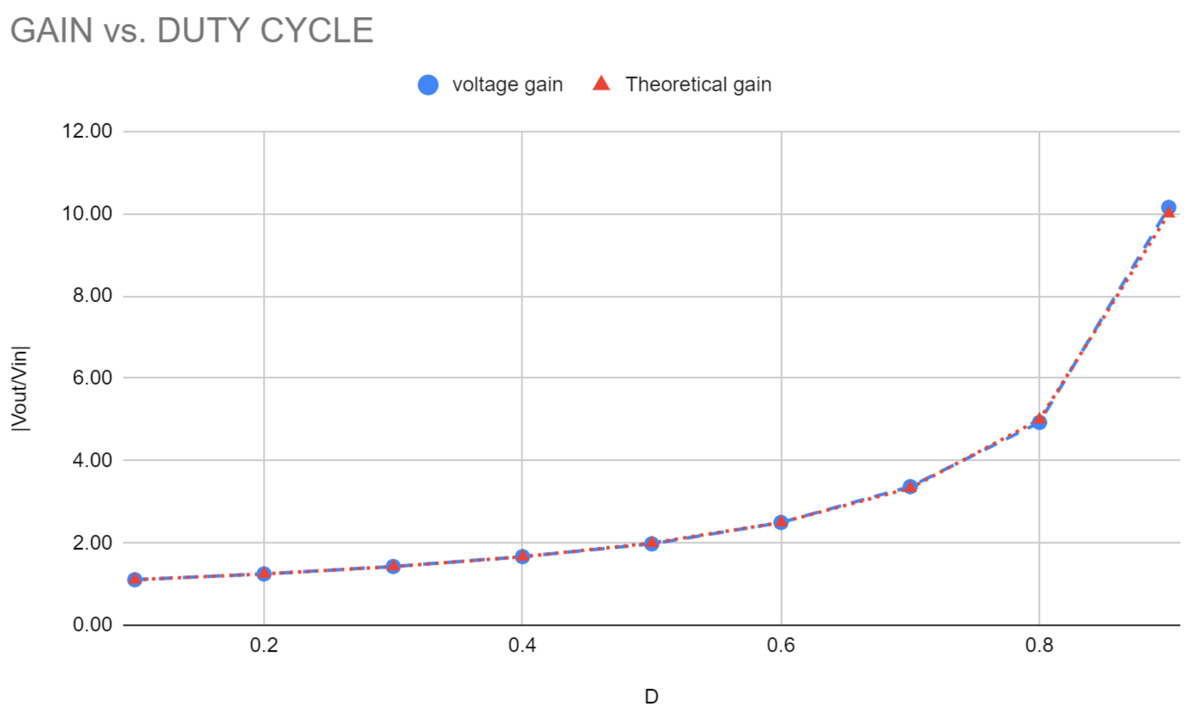
I)

- Vin=24V
- L = 115μH
- C = 54μF
- RL = 11.52Ω
- Switching Frequency(FS) = 50 kHz
- Duty Cycle (D) = 0.5
- MOSFET and diode resistance: 1μΩ
- Diode voltage drop as 0.
- Duty ratio is varied in range 0.1 to 0.9 in steps of 0.1

Case 1: Ideal Case

parasitic resistance of inductor rl = 0

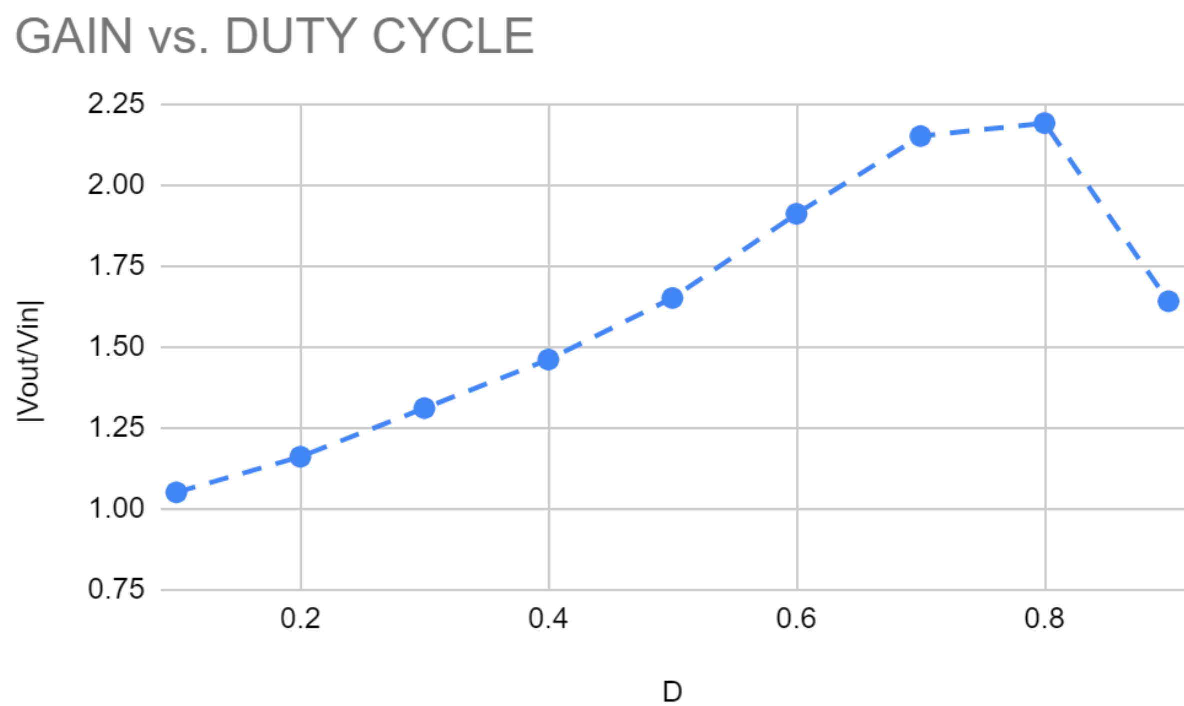
D	o/p voltage	voltage gain	Theoretical gain
0.1	26.71	1.11	1.11
0.2	30.02	1.25	1.25
0.3	34.00	1.43	1.43
0.4	40.22	1.67	1.67
0.5	47.56	1.98	2.00
0.6	60.04	2.50	2.50
0.7	80.89	3.37	3.33
0.8	118.41	4.93	5.00
0.9	243.50	10.15	10.00



The graph shows that the experimental and theoretical values follow the gain of the boost converter i.e. Gain = 1/(1-D). The curve is exponential and increases with the duty cycle ratio.

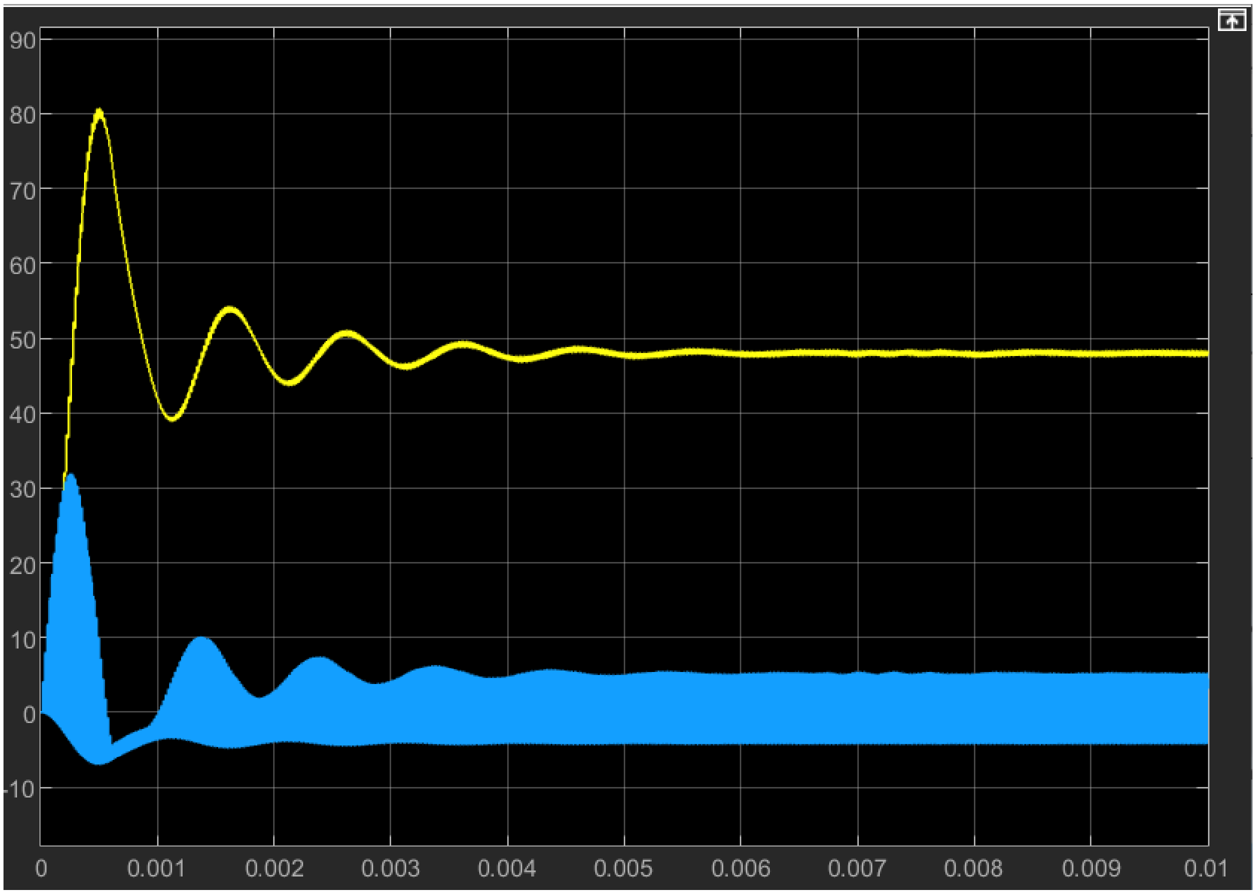
Case 2: Practical Case
parasitic resistance of inductor rl = 5% of RL

D	o/p voltage	voltage gain
0.1	25.14	1.05
0.2	27.88	1.16
0.3	31.21	1.31
0.4	35.16	1.46
0.5	39.6	1.65
0.6	45.62	1.91
0.7	51.54	2.15
0.8	52.51	2.19
0.9	39.33	1.64



There is power dissipation in practical cases because of parasitic inductance. Hence it's not exactly a rising exponential curve. For a very high value of duty ratio, gain decreases as more power gets dissipated.

II)
D=0.5;
RMS Capacitor Current: 4.34 amp

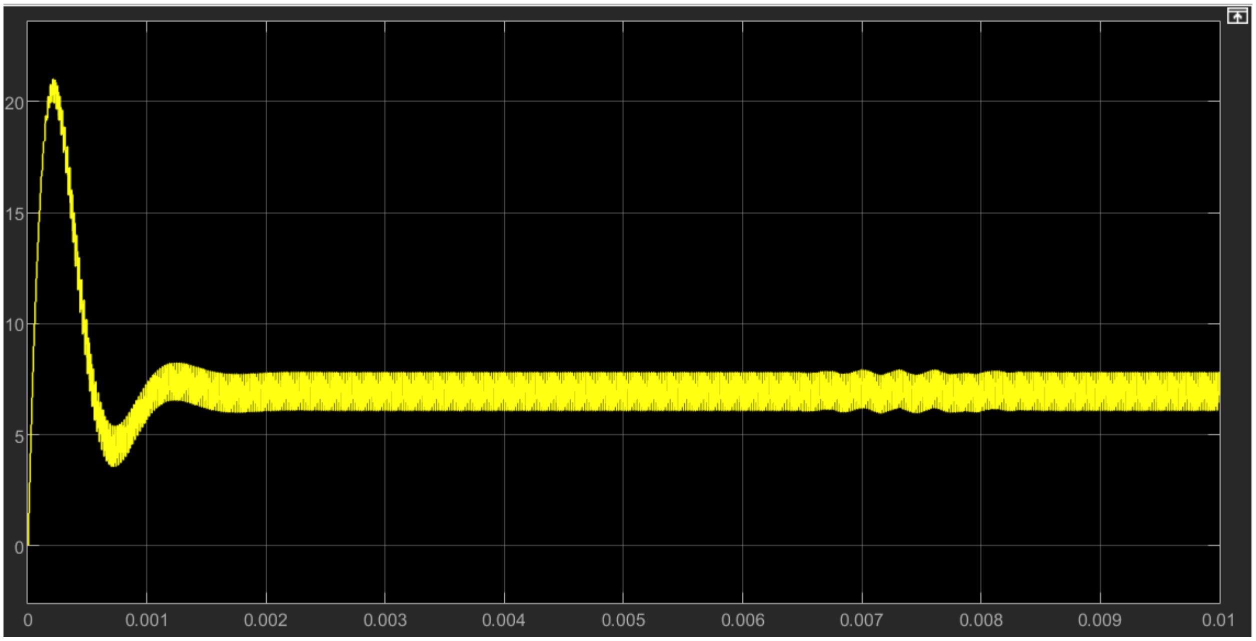


III)

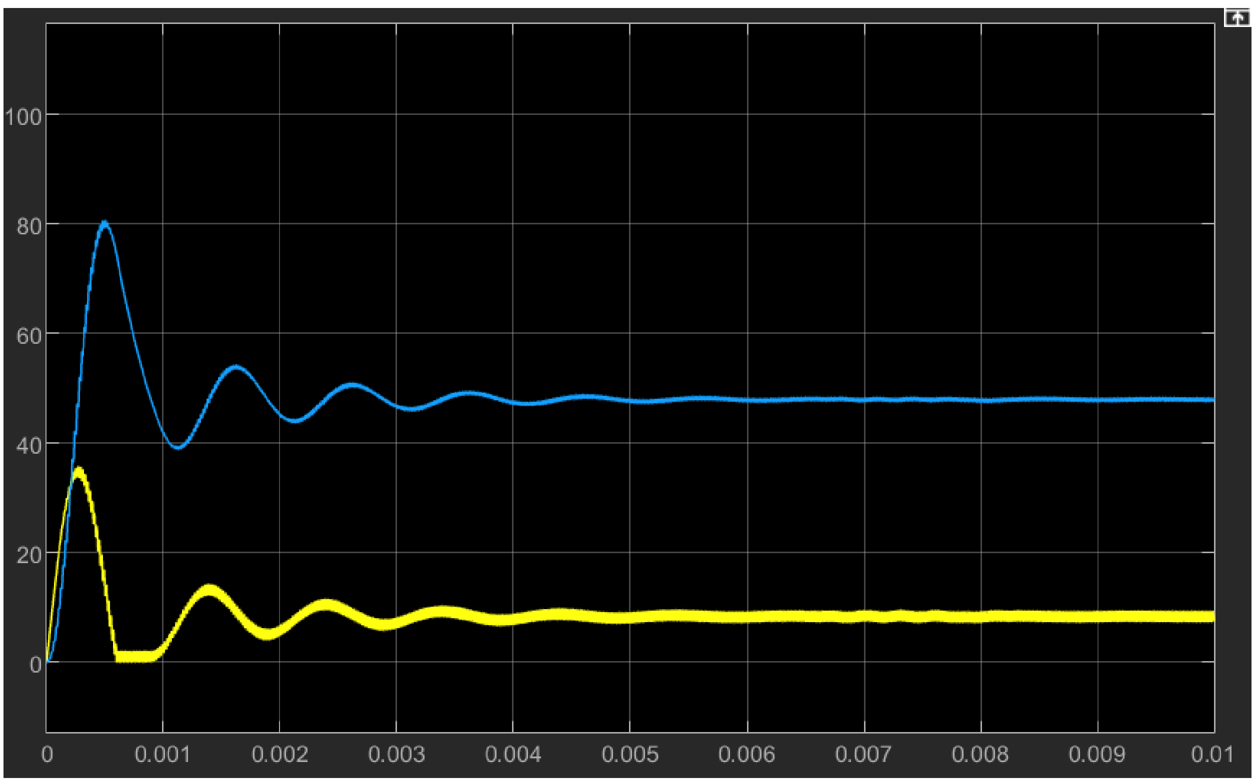
For practical case: When rl = 5% RL, the inductance for which converter falls under CCM mode.

D=0.5;

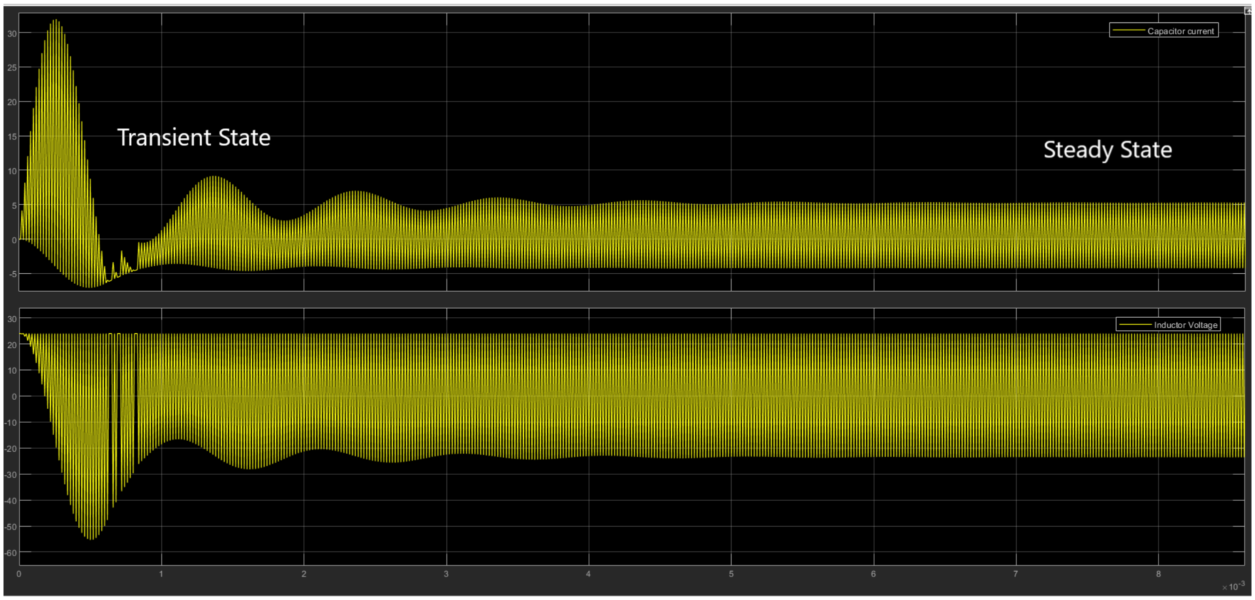
Inductance = 14.4 uF



IV)
For the ideal case with D=0.5, Initial output voltage = 0 V, Inductor current, and output voltage builds up from starting to steady-state.

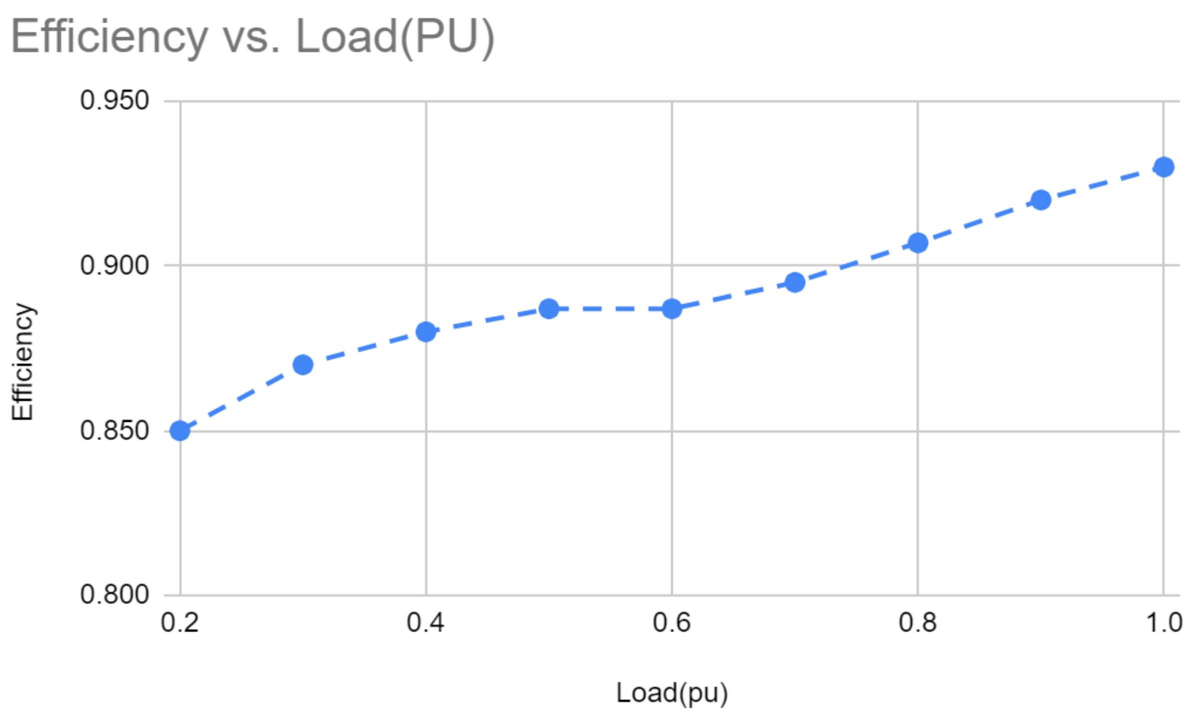


Capacitor Current, Inductor Voltage
Transient Current



V)

Load(PU)	Efficiency
0.2	0.850
0.3	0.870
0.4	0.880
0.5	0.887
0.6	0.887
0.7	0.895
0.8	0.907
0.9	0.920
1	0.930



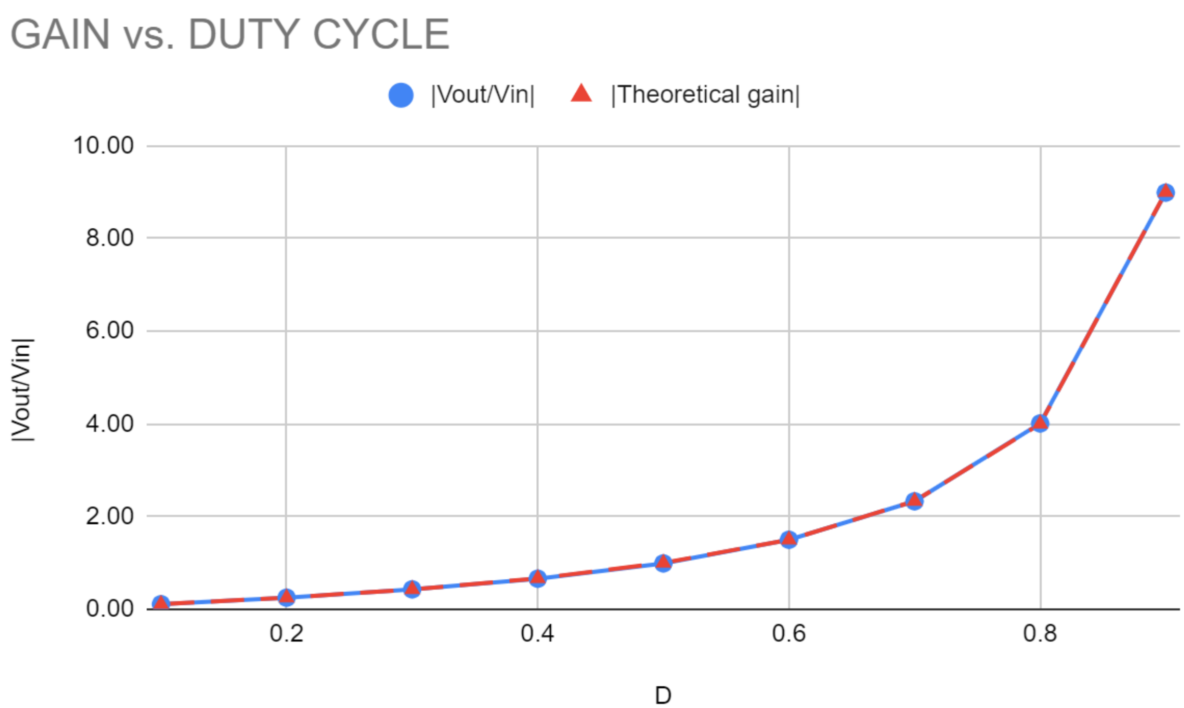
PART B: BUCK-BOOST CONVERTER

I)

- Vin=57V
- L = 226μH
- C = 54μF
- RL = 11.52Ω
- Switching Frequency(Fs) = 50 kHz
- Duty Cycle = 0.5
- MOSFET and diode resistance: 1μΩ
- Diode voltage drop: 0

Case 1: Ideal Case
parasitic resistance of inductor rl = 0

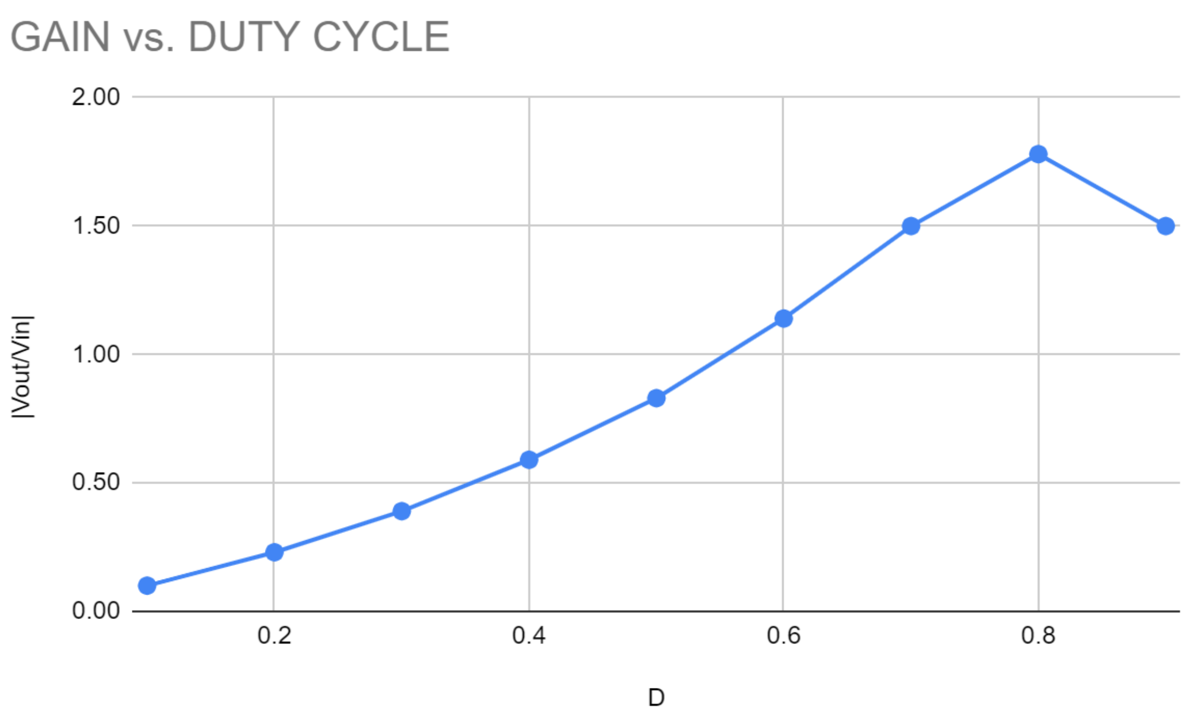
D	Vout	|Vout/Vin|
0.1	-6.33	0.11
0.2	-14.25	0.25
0.3	-24.52	0.43
0.4	-38.00	0.66
0.5	-56.88	0.99
0.6	-85.44	1.50
0.7	-133.00	2.33
0.8	-228.15	4.01
0.9	-513.01	8.99



For the ideal case, the graph is again exponentially increasing, and much similar to theoretical value according to the gain formula Gain = - D/(1-D), in CCM condition

Case 2:
parasitic resistance of inductor rl = 5% of RL

D	Vout	|Vout/Vin|
0.1	-5.96	0.10
0.2	-13.20	0.23
0.3	-22.15	0.39
0.4	-33.39	0.59
0.5	-47.48	0.83
0.6	-65.11	1.14
0.7	-85.48	1.50
0.8	-101.32	1.78
0.9	-85.55	1.50



For the practical cases where there is parasitic resistance with the inductor, hence there is power dissipation. With a high duty ratio, there is a greater power loss and gain decreases.

$$= \frac{D}{1-D+\frac{R}{R_{Load}(1-D)}}$$

Here,

II)
IDEAL CASE
D=0.457 Fsw for which system in CCM and DCM
Experimentally, Fs = 7.55 KHz

$$GAINccm = \frac{D}{1 - D}$$

$$GAINdcm = \frac{V_{in}D^2}{2LI_o f_{sw}}$$

In Limiting condition at both, the gains will be the same
So theoretically DCM to CCM transition happens at Fs=7.515KHz for no parasitic resistance
Negative values of IL signifies DCM and positive values as CCM.

Fs (kHz)	IL
5	-0.058
6	-0.054
7	-0.049
8	0.553
7.2	-0.042
7.4	-0.008
7.6	0.153

PRACTICAL CASE
D=0.457 Fsw for which system in CCM and DCM
Experimentally, Fsw = 7.95 KHz

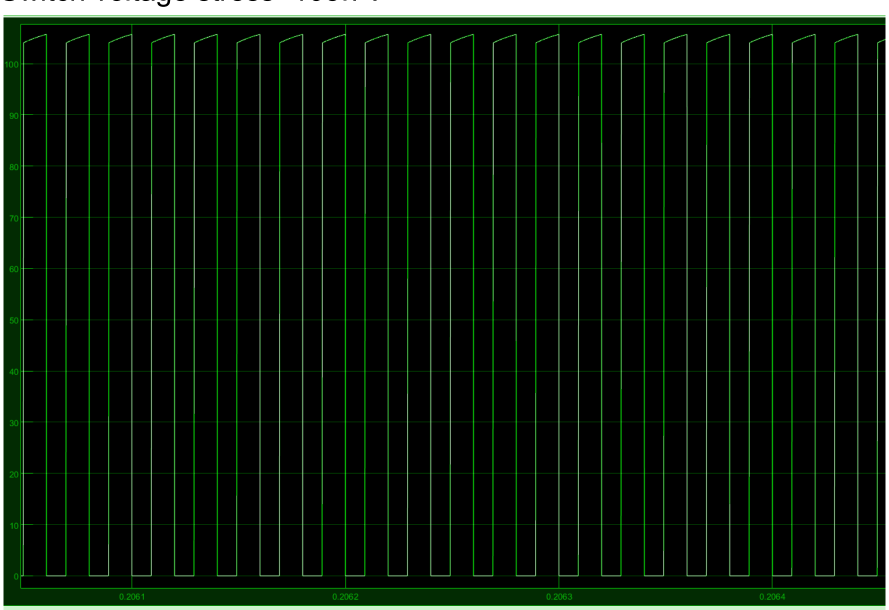
Fs (kHz)	IL
5	-0.037
6	-0.032
7	-0.031
8	-0.009
9	0.660
10	1.255
8.1	0.010
8.2	0.077

III)
IDEAL CASE:
Vin = 57V
C = 54μF

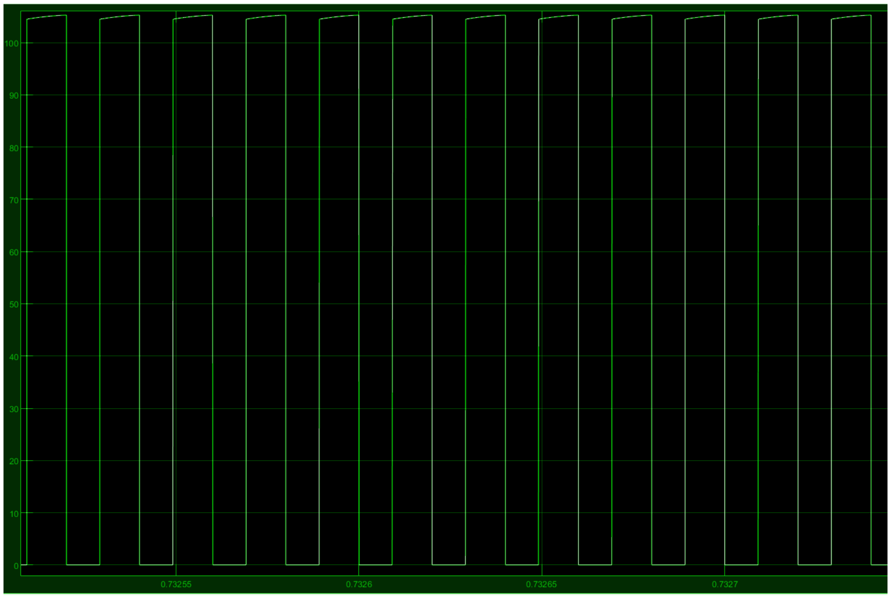
RL = 11.52Ω
Fs = 50kHz
L=226μH

D	i/p current	o/p current
0.1	0.15	-5.49
0.2	0.50	-1.24
0.3	0.91	-2.12
0.4	1.82	-3.30
0.5	2.48	-4.92
0.6	4.19	-7.36
0.7	8.57	-11.45
0.8	22.40	-19.62
0.9	107.78	-44.27

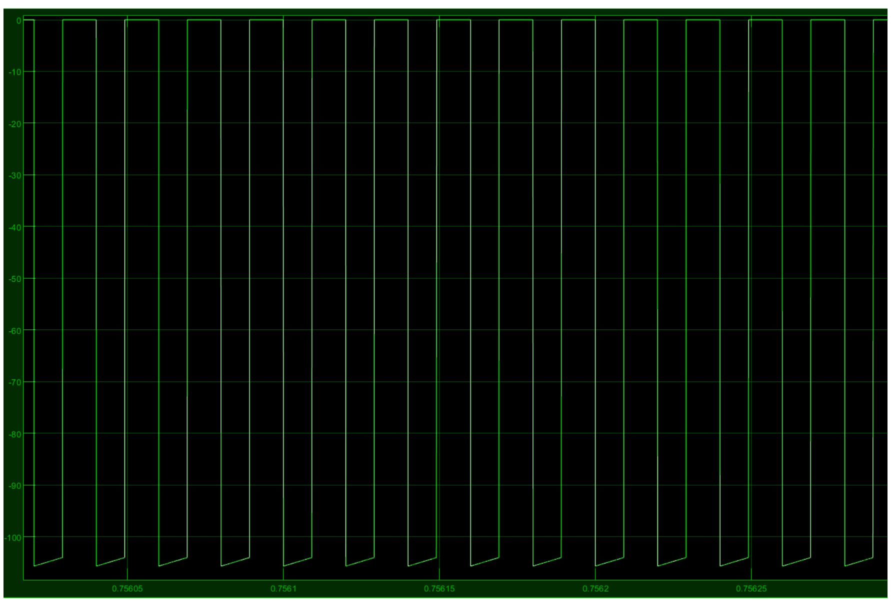
PART C:
(a): Voltage stress of Switch. Both are almost the same
Boost converter
Switch voltage stress=105.7V



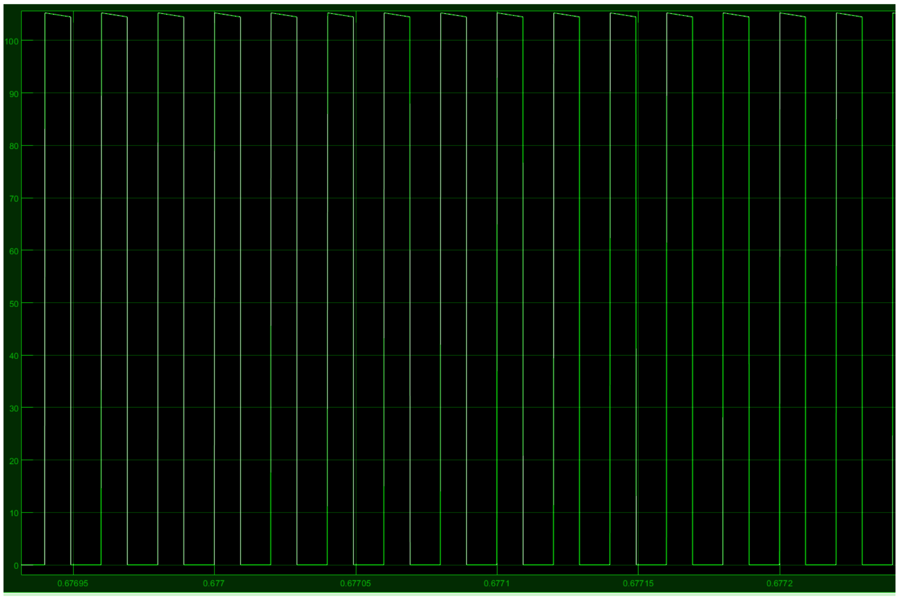
Buck-boost converter
Switch voltage stress=105.3V



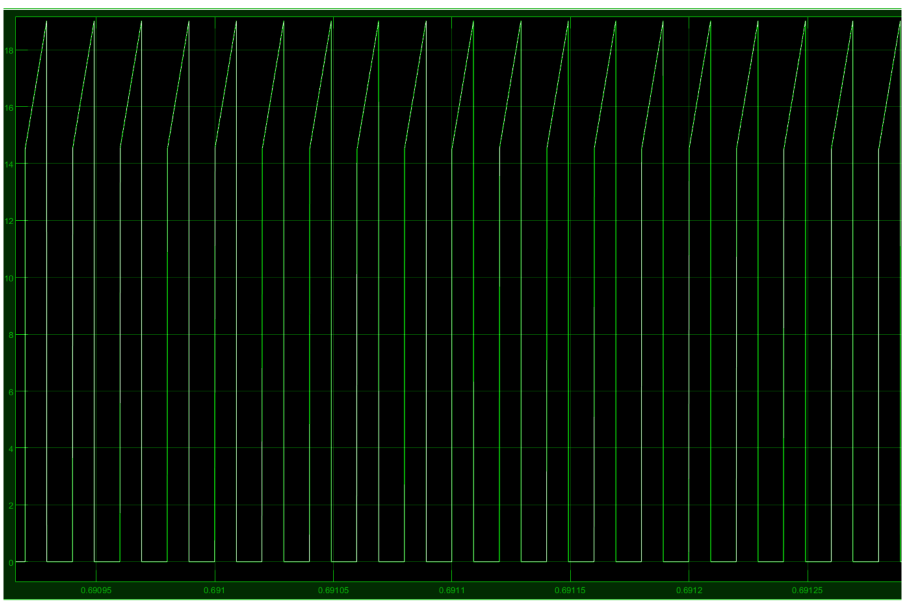
(b): Voltage stress of Diode. Both are almost the same
Boost converter
Diode voltage stress=105.7V



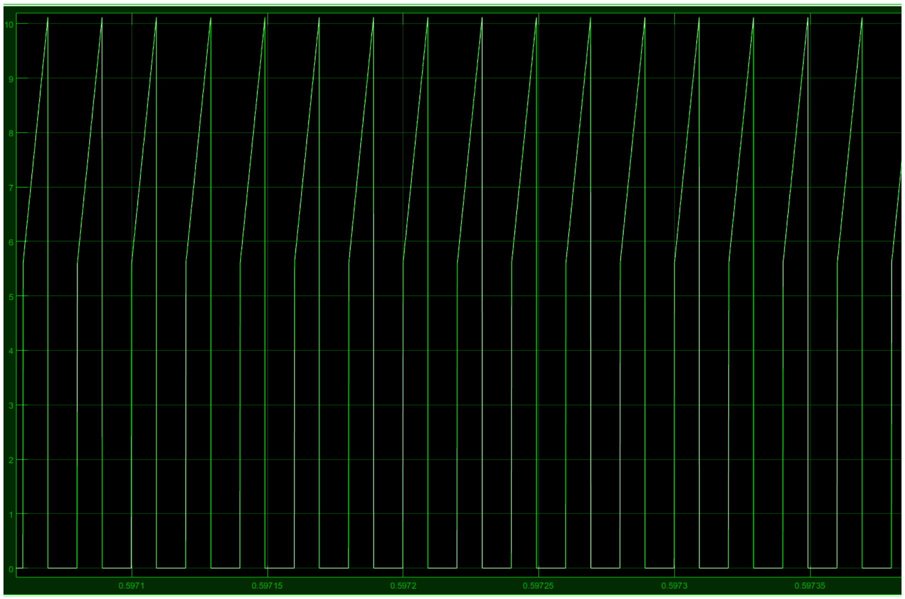
Buck-boost converter
Diode voltage stress=105.3V



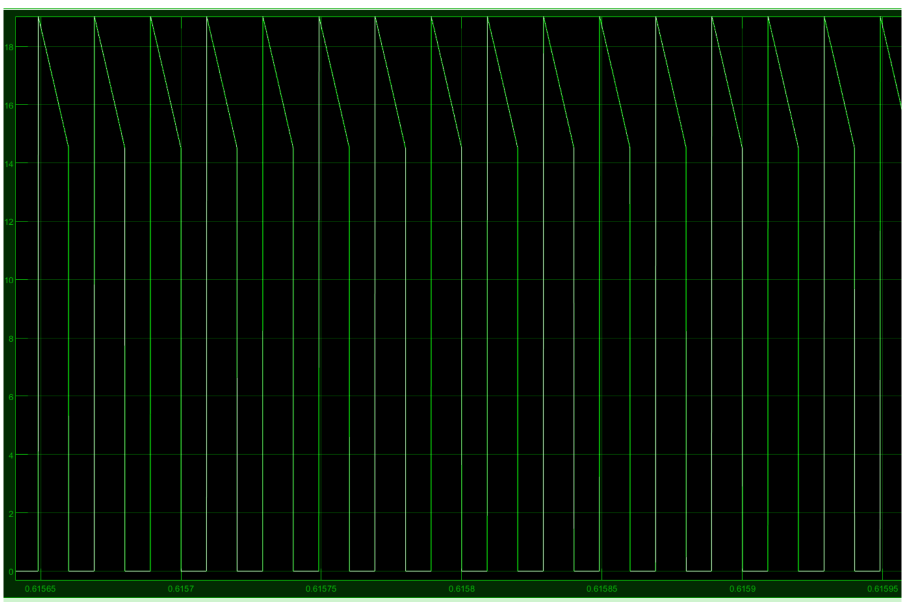
(c): Current stress of Switch. Boost has higher switch current stress.
Boost converter
Switch current stress=19.02A



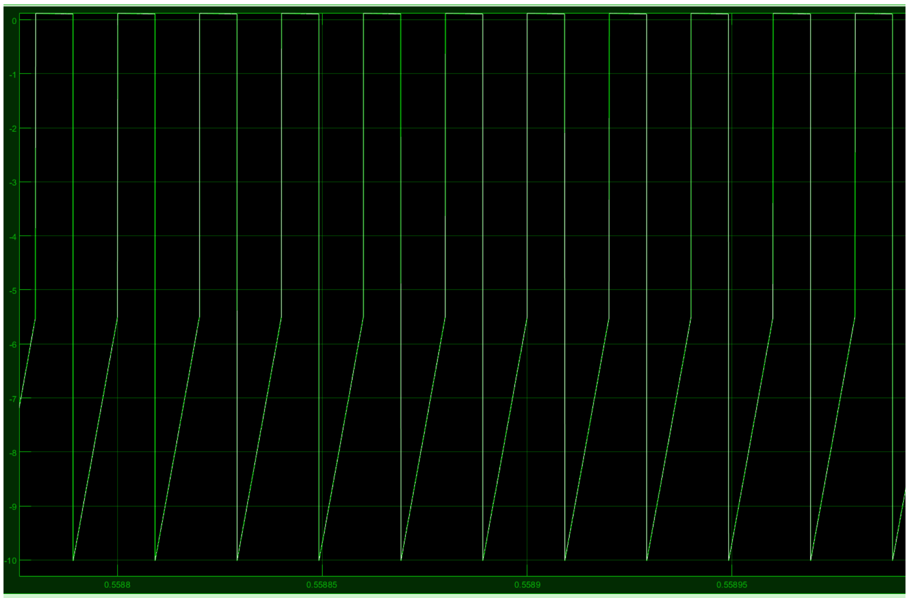
Buck-boost converter
Switch current stress=10.12A



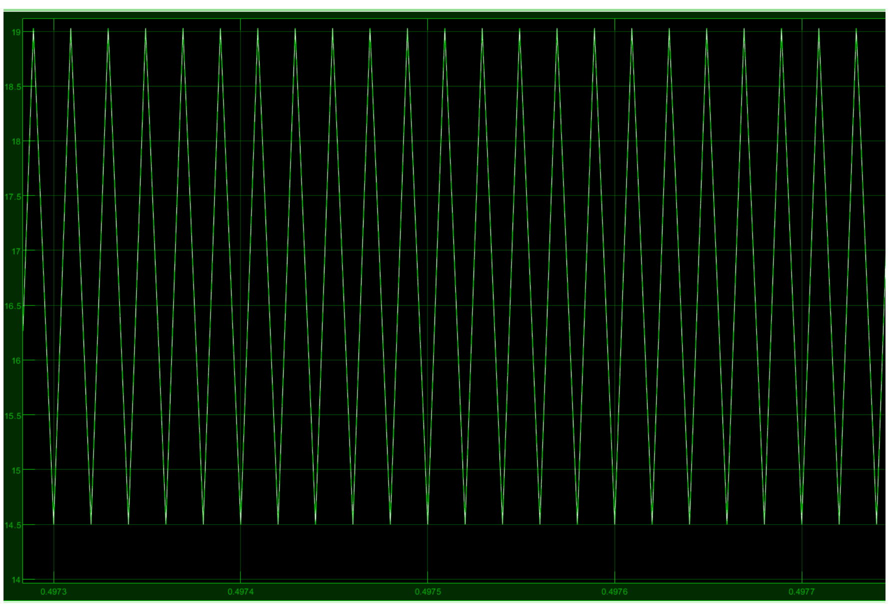
(d): Current stress of Diode. The boost converter has higher diode current stress in a given working condition.
Boost converter
Diode current stress=19.03A



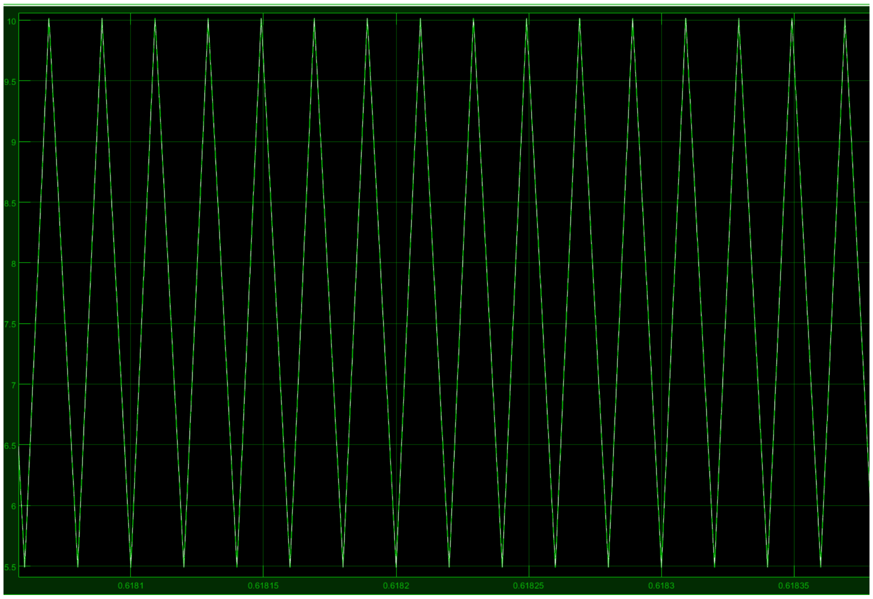
Buck-boost converter
Diode current stress=10.14A



(e): Inductor current ripple. Both are almost the same.
Boost converter
Inductor current ripple=4.53A

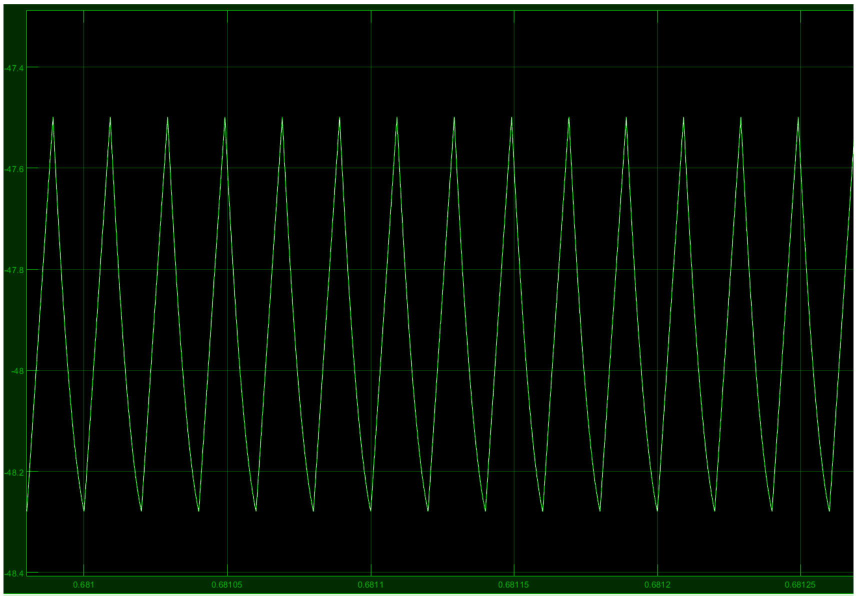


Buck-boost converter
Inductor current ripple=4.53A



(f): Output voltage ripple. Ripple is more in Boost converter.
Boost converter
Output voltage ripple=1.66A

Buck-boost converter
Output voltage ripple=0.78A



DISCUSSION QUESTIONS :

1. Comment on the comparison of overall (both core and copper loss) loss of the inductor when the inductance is changed from specified value in CCM to critical inductance value. Assume inductor resistance has not changed.

Experiment shows that when the inductance is changed from a specified value in CCM to a critical inductance value, core loss increases but the copper loss remains constant. Finally, when a critical state is achieved then, overall loss increases even more.

2. Assuming ideal boost converter, compare the theoretical and simulated value of Vout for duty ratio=1, and write down your observations.

In theory, the output voltage of the ideal boost converter should go to infinity. But in the experiment at a duty ratio of 0.1, the output appears 0.

3. For a given duty ratio and load, voltage gain is higher in DCM or CCM? Why? (Consider ideal Boost Converter)

For an ideal boost converter, it is observed that the voltage gain under DCM is greater than the CCM condition. In CCM mode the inductor current is always positive. In DCM mode the inductor current goes to negative in one switching cycle. The gain in CCM mode is independent of load resistance. In CCM it does not reach 0 so at the end of every switching cycle, there is some energy left. In DCM, all the energy each cycle is used up, and the capacitor stores the extra energy giving higher output voltage.