POWER ELECTRONICS PROJECT (PE-4)

GROUP-29

Admission number	Name
20je0972	Sparsh Lal
20je0993	Supriya
20je1017	Tanishq Mittal
20je1022	Tarun Srivastava

TITLE:

20W, 12 V to 24V Boost converter, 10% inductor current ripple, 2% output voltage ripple.

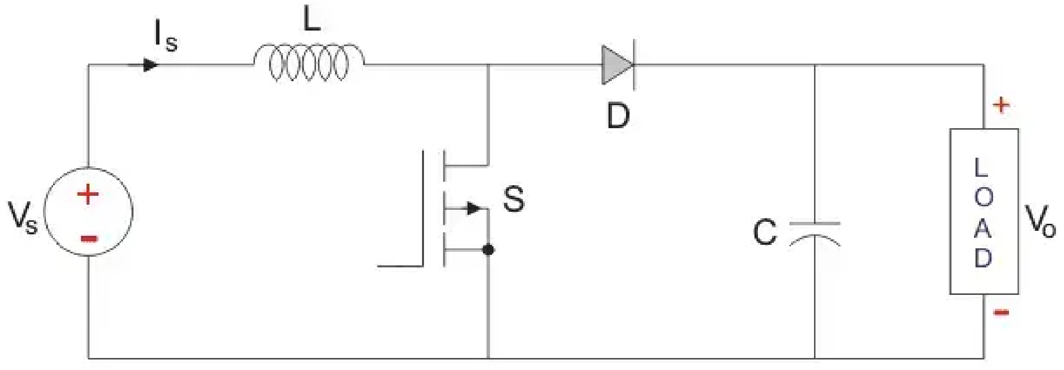
OBJECTIVE :

To study the operation of a boost converter.

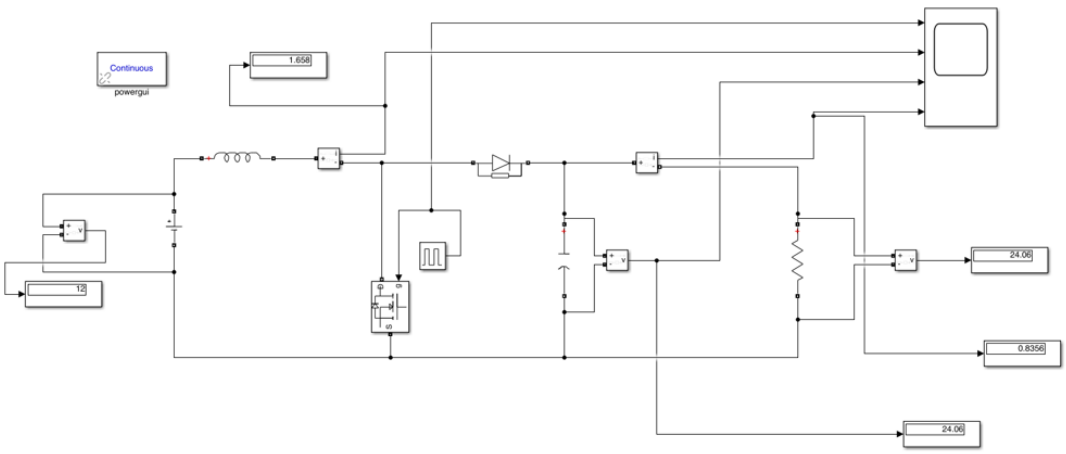
MATERIALS REQUIRED

Serial number	Item	Rating	Quantity
1	Capacitor	8.784 μF, 60V, 5A	1
2	Inductor	729.176 μH, 1A DC, 1.4A saturation current	1
3	MOSFET (IRF840)	40V, 1A	1
4	Diode	60V, 2A	1
5	Resistance	28.8 Ω	1
6	Voltage Source	12 V	1
7	PCB	-	1
8	Multimeter	-	1
9	Connecting wires	-	-
10	Gate trigger circuit	15V/0V output	1
11	Two pin terminal block	-	2

CIRCUIT DIAGRAM:

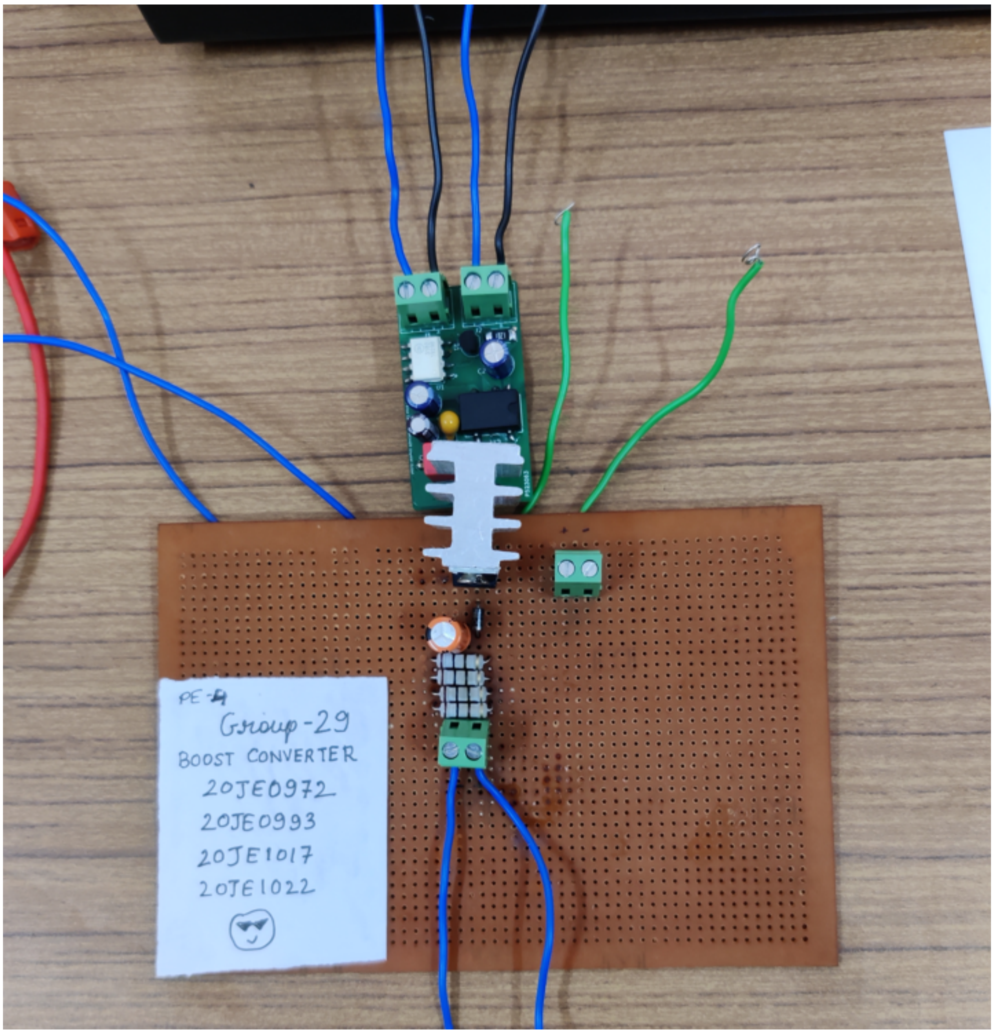


BLOCK DIAGRAM:



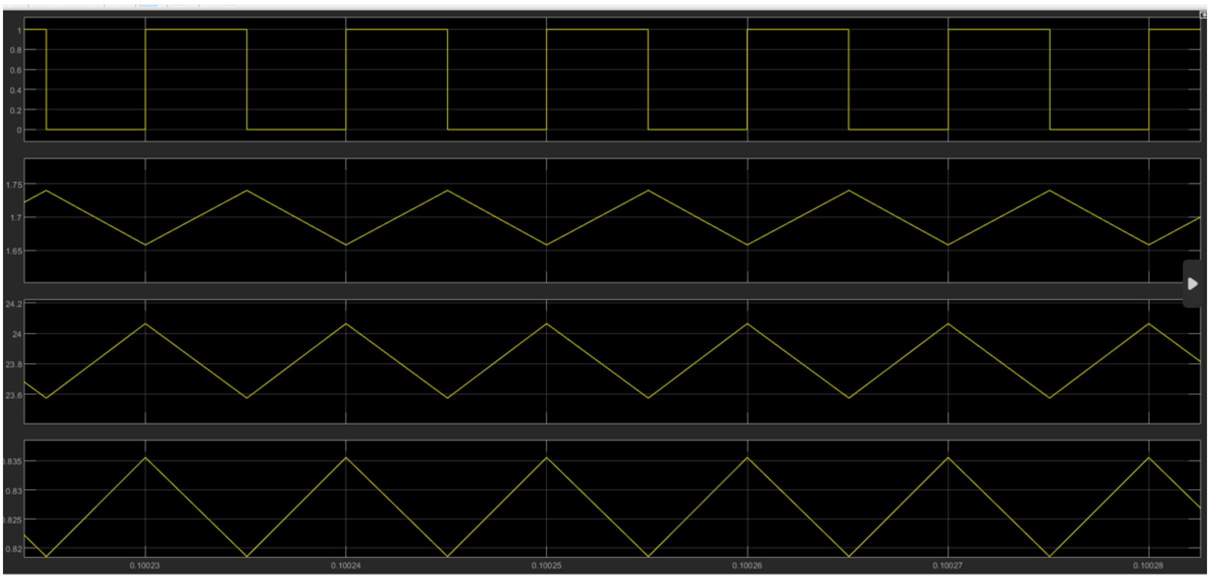
Block diagram of the booster circuit with theoretical values in MATLAB

HARDWARE CIRCUIT:



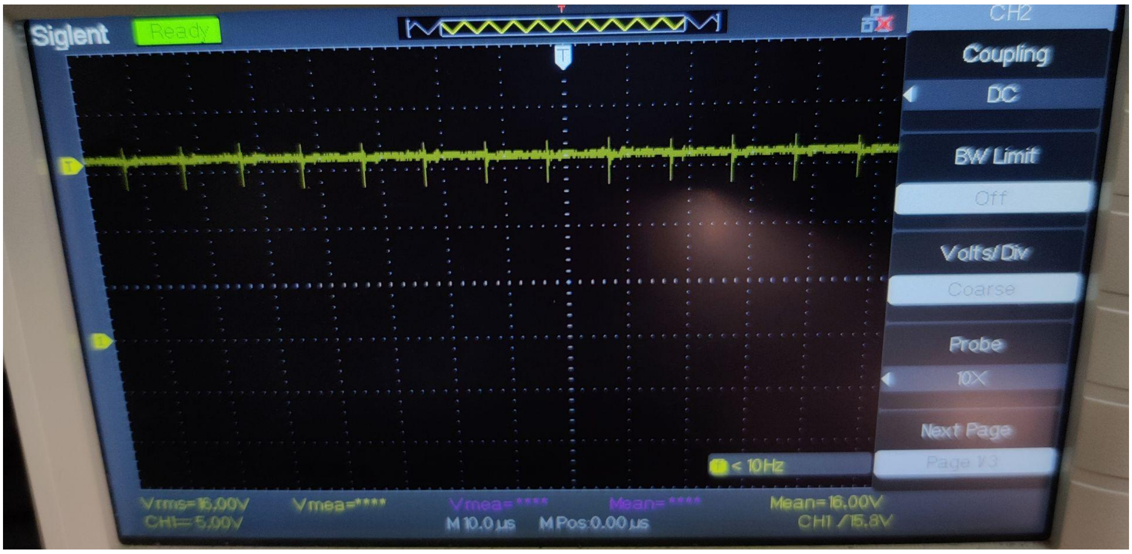
The circuit made using the components from the lab

SIMULATION RESULTS:

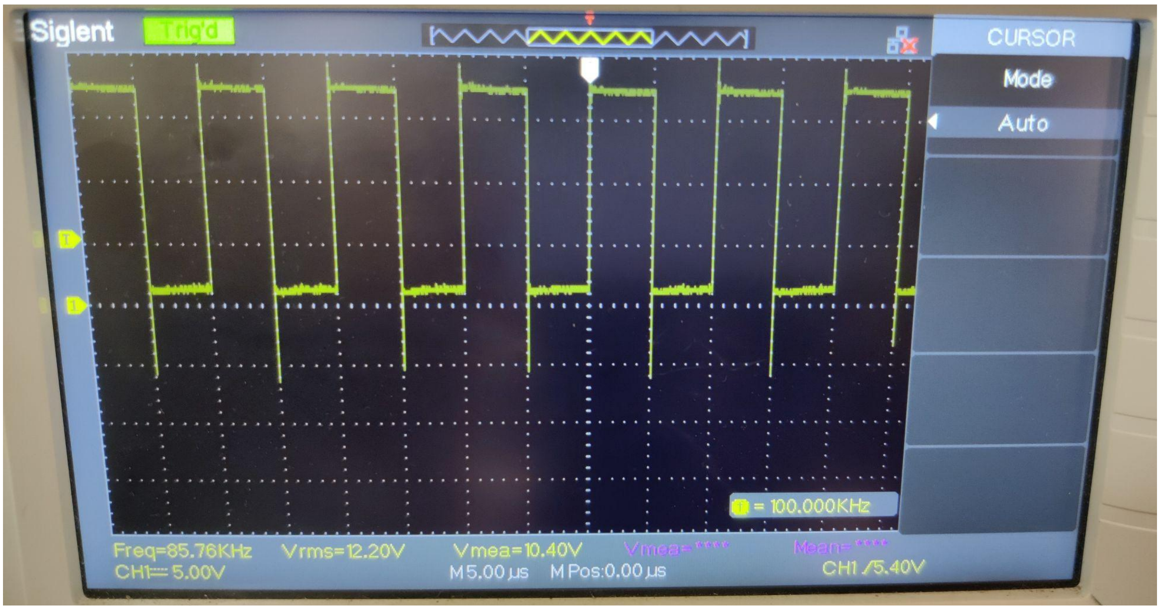


The output waveforms obtained after running the block diagram in MATLAB

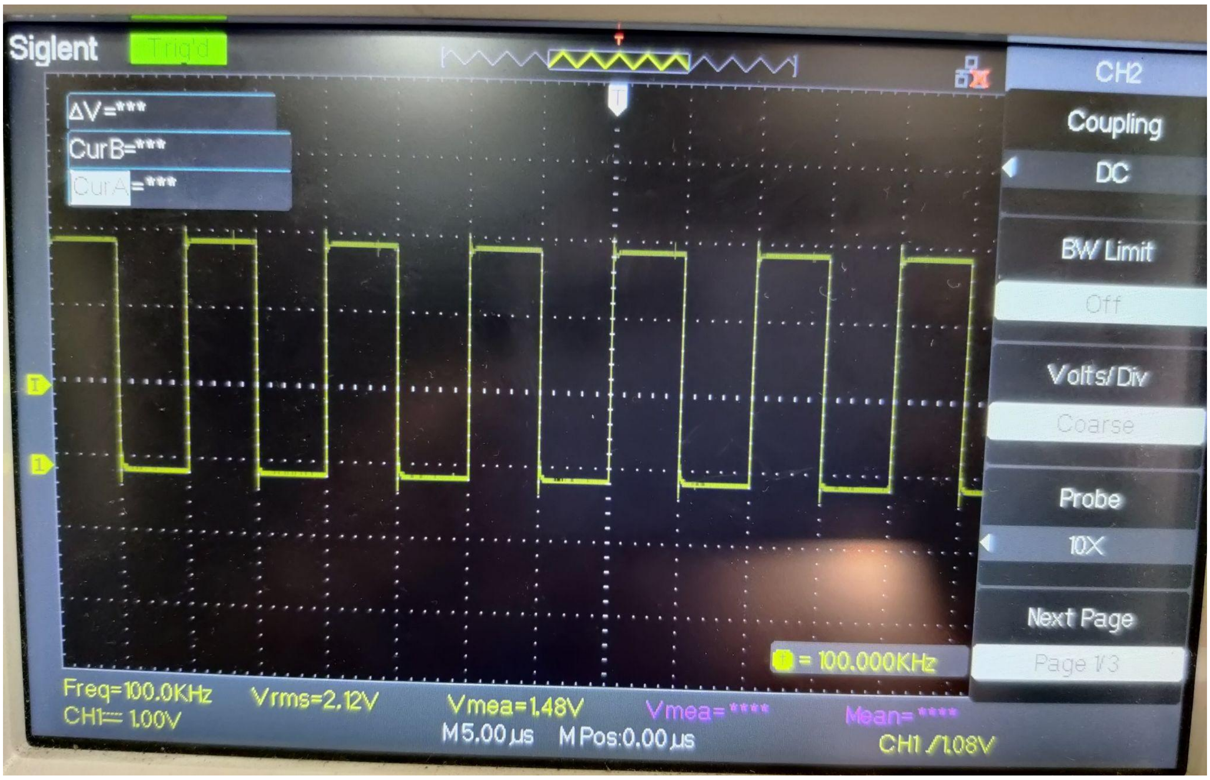
CIRCUIT RESULTS:



Output voltage



Pulse gate output voltage(1)



Gate pulse output (2)

THEORY:

A boost converter is a type of DC-DC converter that steps up the input voltage to a higher output voltage. It operates based on the principle of inductor energy storage and transfer.

Boost converters are widely used in various applications such as battery charging, LED drivers, and power supplies. The basic operation of a boost converter involves two main stages: the on-time (charging) and the off-time (discharging) of the inductor.

The key components in a boost converter are the inductor (L), the switch (typically a MOSFET), the diode (D), and the capacitor (C).

During the on-time, the switch is closed, and the input voltage is applied across the inductor, causing the current through the inductor to increase linearly. The inductor stores energy in its magnetic field. The diode is reverse-biased and prevents the output voltage from being applied across the inductor.

During the off-time, the switch is open, and the inductor discharges its stored energy to the output load through the diode, as well as charges the output capacitor. The output voltage is higher than the input voltage due to the energy stored in the inductor.

It is already established that the net change in current in inductor over the entire cycle is zero:

$$\therefore (\Delta i_L)_{closed} + (\Delta i_L)_{open} = 0$$

$$\left(\frac{V_{in} - V_o}{L}\right)(1-D)T + \left(\frac{-V_o}{L}\right)DT = 0$$

$$\frac{V_o}{V_{in}} = \frac{1}{1-D}$$

<u>CALCULATIONS:</u>

Using the voltage second balance method we can find the duty cycle for obtaining circuit of these specifications:

Volt-sec balance
stored= released

(Vs x D x T) + (Vs - (Vo + Vd))(1 - D)T=0

Using this we obtain

D = (Vo + Vd - Vs)/(Vo + Vd)

D= (24+0.3-12)/(24+0.3)

D=0.50617 or 50.6017%

<u>1) Determine the output power</u>
The output power of the converter is given as 20W.

<u>2) Determine the output current</u>
The output current of the converter can be calculated by dividing the output power by the output voltage:
Output current = Output power / Output voltage
Output current = 20W / 24V
Output current = 0.833A

<u>3) Determine the switching frequency</u>
The switching frequency can be chosen based on the desired trade-off between efficiency and size/cost of components. A higher switching frequency results in smaller and cheaper components, but lower efficiency due to switching losses. A lower switching frequency results in higher efficiency but larger and more expensive components.

Assuming a switching frequency of 100 kHz.
f=100 x 10^3 Hz

<u>4) Determine the inductor value</u>
The inductor value can be calculated using the following formula:
L = (Vin x D) / (f x ΔIL)

where Vin_min is the minimum input voltage, D is the duty cycle, f is the switching frequency, and ΔIL is the inductor current ripple.

Assuming a minimum input voltage of 12V and a duty cycle of 50%, the inductor value can be calculated as follows:
L = (12V x 0.50617) / (10e5x 0.1*0.833)
L = 0.6 / (f10e5x 0.1*0.833)
L = 729.176 uH

5) Determine the output capacitor value
The output capacitor value can be calculated using the following formula:
C = (IL x D) / (f x ΔV)
where IL is the inductor current, D is the duty cycle, f is the switching frequency, and ΔV is the output voltage ripple.

Assuming a 10% inductor current ripple and a 2% output voltage ripple, the output capacitor value can be calculated as follows:
C = (0.833A x 0.50617) / (100 kHz x 0.02 x 24)
C = 8.784 μF

6)Calculations for Input power calculation
Input Power (W) = Input Voltage (V) x Input Current (A)

7)Calculations for Output power calculation
Output Power (W) = (Experimental Output Voltage (V))^2 / Load resistance (Ohms)

*Here the load resistance for the experimental setup is 99.1 Ohms

8)Calculation of efficiency
Efficiency (%) = (Output Power (W) / Input Power (W)) x 100

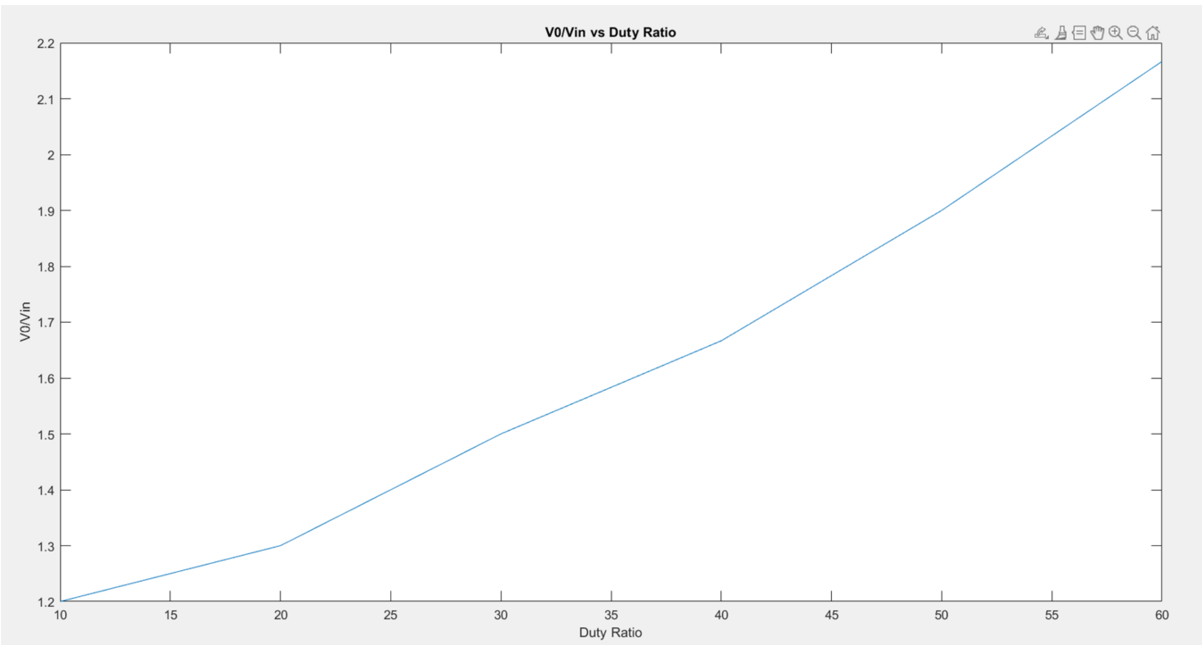
9)Peak to peak ripple obtained on the experiment day with the input voltage as 5V

Ipp = 566 mA

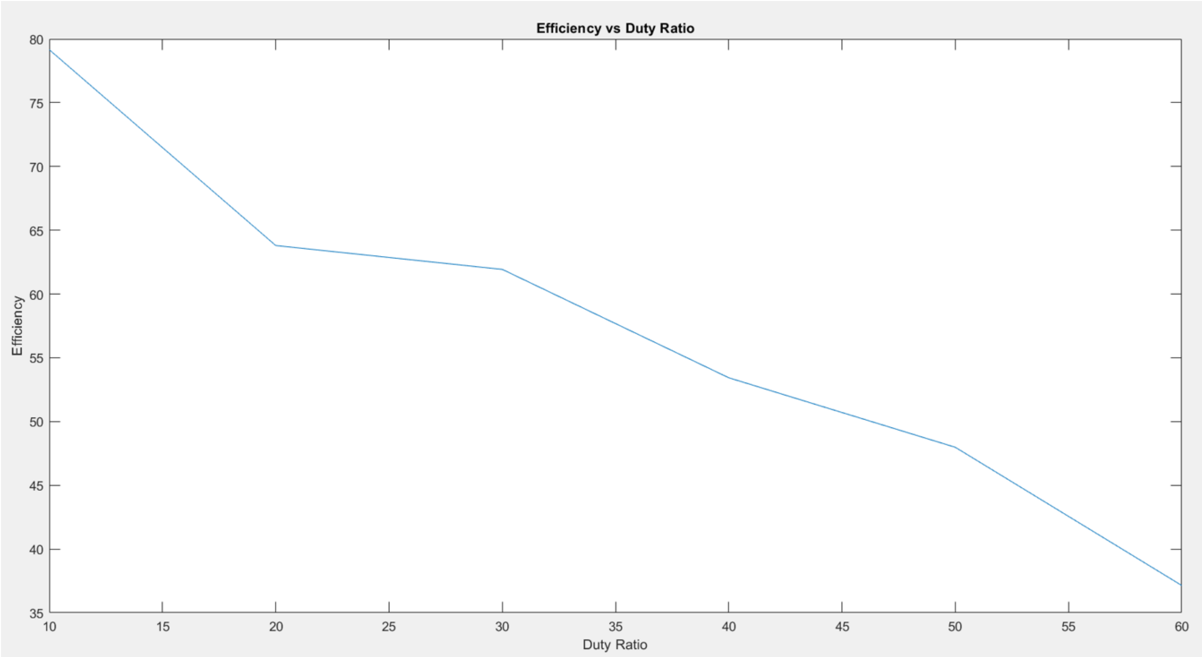
OBSERVATION TABLE:

Duty (%)	Input Voltage (Volts)	Experimental output Voltage (Volts)	Calculated output voltage (Volts)	Input Current (Amperes)	Input Power (Watts)	Output Power (Watts)	Efficiency (%)
10	12	14.4	13.33	0.22	2.64	2.09	79.16
20	12	15.6	15.00	0.32	3.84	2.45	63.80
30	12	18	17.14	0.44	5.28	3.27	61.93
40	12	20	20.00	0.63	7.56	4.04	53.43
50	12	22.8	24.00	0.91	10.92	5.24	47.98
60	12	26	30.00	1.53	18.36	6.82	37.14

GRAPHS:



Vo/Vin - Duty Ratio



Efficiency- Duty Ratio

Analysis and Discussions:

Here in this circuit we supplied a 12 V input voltage through which we tried to obtain a 24 V output voltage by using a Boost converter circuit. Here to obtain the Output through the calculations we found the Duty ratio to be 0.50617 which we then applied through pulses to the input waveform in order to get the desired output voltage of 24V.
We also through the data saw that the smaller the duty cycle (D) the more is the efficiency of the power obtained.

Conclusions:

All of the specifications stated previously have been met by this boost converter design. MATLAB simulation using calculated parameters were performed and corresponding waveforms were obtained. The output voltage across the output capacitor is nearly 24V with a maximum output ripple of 2%. Hardware design of BOOST CONVERTER was done. It is observed, by varying duty cycle output voltage also changes.

References:

- *Basic Calculation of a Boost Converter's Power Stage (Rev. D)a*
- *Boost Converter | Step Up Chopper | Electrical4U*