DESIGN, MODELLING AND CLOSED LOOP CONTROL OF BUCK BOOST CONVERTER

B.Tech -Mini Project Report

EPICS

BY

V.SAKETH REDDY	511987
TARUN PULI	511965
L.LOKESH	511946

Under the Guidance of

Dr.Sandeep

Department of Electrical Engineering

NATIONAL INISTITUTE OF TECHNOLOGY ANDHRA PRADESH

Abstract :-

This project describes the design of a buck boost conveter by using microcontroller as controller. First, this converter is introduced and its principles of operation of each element is described. The equations of capacitance and inductance of required specifications describing the converter circuit are reviewed by precalculating the respective critical values. Next, the modelling of the buck boost converter is found by averaging the state equations (derived from the turn on and turnoff conditions of a mosfet switch) and the transfer function derived from modelling and values of proportional constant and integral constant are found out for proper closed loop operation of buck boost converter. Buck boost controller, which is adaptive against input voltage and load disturbances (to provide line regulation and load regulation) is verified. Finally, several simulation results from simulink and experimental results from a prototype buck boost reported to verify the operation of the designed controller(using arduino).

CONTENTS: Page.no

LIST OF FIGURES:

Chapter 1

Introduction

1.1 Introduction:

Buck-Boost converter is a type of switched mode power supply that combines the principles of the buck converter and the boost converter in a single circuit. The buck converter described in power supplies produces a DC output in a range 0 V to just less than the input voltage. The boost converter will produce an output voltage ranging from the same voltage as the input, to a level much higher than the input. There are many applications however, such as battery-powered systems, where the input voltage can vary widely, starting at full charge and gradually decreasing as the battery charge is used up. At full charge, where the battery voltage may be higher than actually needed by the circuit being powered, a buck regulator would be ideal to keep the supply voltage steady. However, as the charge diminishes the input voltage falls below the level required by the circuit, and either the battery must be discarded or re-charged; at this point ideal alternative would be the boost regulator. By combining these two regulator designs it is possible to have a regulator circuit that can cope with a wide range of input voltages either higher or lower than the needed by the circuit. Fortunately both buck and boost converter use very similar components; they just need to be re-arranged, depending on the level of the input voltage. Such kind of advantages appears only in simple buck-boost converter. Hence buck-boost converter is chosen.

This converter is broadly used for energy management applications and the switching devices and passive components such as inductors and capacitors introduce nonlinearities in the converters. As a result, the linear control techniques cannot be straightly applied for analysis.

CHAPTER 2

Working, Modelling and Design

2.1 Working:

The schematic diagram of Buck-Boost converter is shown in Figure. The converter provides an output voltage that may be greater than or less than the input voltage. As the polarity of the output voltage is always opposite to that of the input voltage, it is also called as “Inverting converter”. E_0 is the output voltage and E_{dc} is the input voltage.

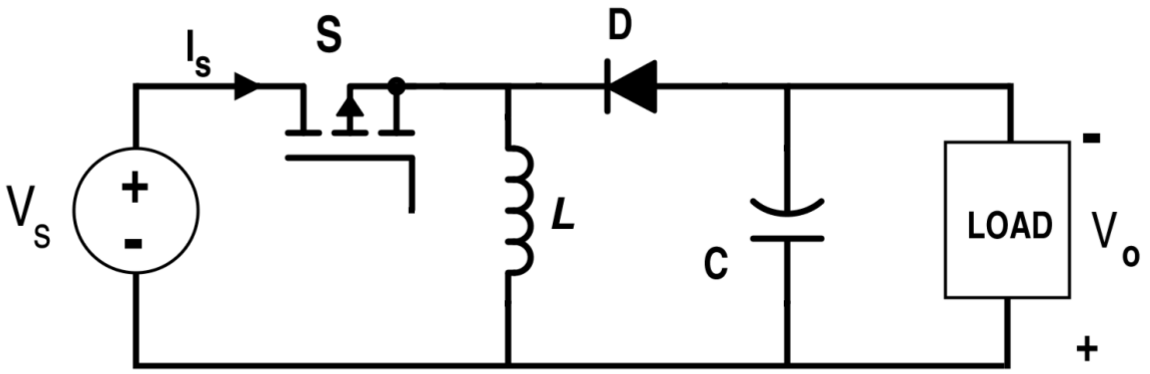


Fig 2.1 Basic circuit of buck boost converter

.

Assuming continuous conduction mode

I_2 ,I_1 are the maximum and minimum values of current through Inductor during charging or discharging

α is duty ratio

$V_S = L\left(\frac{I_2 - I_1}{T_{on}}\right) = L\frac{\Delta I}{T_{on}}$ when switch is ON

$V_o = -L\frac{\Delta I}{T_{off}}$ when switch is OFF

$\Delta I = \frac{V_S . T_{on}}{L} = \frac{-V_o \, . \, T_{off}}{L}$ from above equations

$$V_o = -V_S\frac{T_{on}}{T_{off}} = -V_S\frac{T_{on}/_T}{T_{off}/_T} = \frac{-V_S \, . \, \alpha}{(T - T_{on})/_T}$$

$$V_o = -V_S\frac{\alpha}{1-\alpha}$$

For a lossless system in steady state

$$\mathrm{V_S}.\ \mathrm{I_s} = -\mathrm{V_o}\mathrm{I_o}\ \text{ or } \mathrm{V_S}.\ \mathrm{I_s} = \mathrm{V_S}\frac{\alpha}{1-\alpha}\mathrm{I_o}$$

$$\mathrm{I_s} = \frac{\alpha}{1-\alpha}\mathrm{I_o}$$

$$\mathrm{T} = \frac{1}{\mathrm{f}} = \mathrm{T_{on}} + \mathrm{T_{off}}$$

Thus we get the critical value of inductance as given below

$$\mathrm{T} = \frac{\Delta \mathrm{I.L}}{\mathrm{V_S}} - \frac{\Delta \mathrm{I.L}}{\mathrm{V_o}} = \frac{\Delta \mathrm{I.L}(V_\mathrm{o} - \mathrm{V_S})}{\mathrm{V}_S\ .\ \mathrm{V_o}}$$

$$\Delta \mathrm{I} = \frac{\mathrm{V_S}\ .\ \ \mathrm{V_o}}{\mathrm{f\,L}(\mathrm{V_O} - \mathrm{V}_S)}$$

$$\Delta \mathrm{I} = \frac{\mathrm{V_S}\ .\ \alpha}{\mathrm{f\,L}}$$ which is peak to peak ripple current in inductor generally 20-30%

Peak to peak ripple voltage in a capacitor is given by,

$$\Delta V_C = \frac{1}{C}\int_0^{T_{on}} I_C dt = \frac{1}{C}\int_0^{T_{on}} I_o dt = \frac{I_o . T_{on}}{C}$$ generally, 1-5%

The above formula is used to find critical value of Capacitance.

2.2 Design of Buck boost converter:

Assuming all the elements are ideal we get Volt-Sec and Ampere-Sec balance equations from law of conservation of energy in inductor and capacitor

2.2.1 VOLT-SEC BALANCE:

V_O*(DT) +V_{OFF}*((1-D)*T) = 0.

V_{IN}*(DT) +V_O*((1-D)*T) = 0

V_O=-[D/(1-D)T]*V_{IN}

2.2.2 AMPERE-SEC BALANCE:

I_{CON}*(DT) + I_{COFF}*((1-D)*T) = 0

-I_O*(DT) + (-I_L-I_O)*((1-D)*T) = 0

I_O = - (1-D)*I_L

2.2.3 Duty cycle:

Duty Cycles are selected as D_{MIN}=0.3 and D_{MAX}=0.7 for satisfactory performance

2.2.4 Inductor selection and its design :

The higher the inductor value, the higher is the possible maximum output current because of the reduced ripple current. Normally, the lower the inductor value, the smaller is the solution size. Note that the inductor must always have a higher current rating than the largest value of current. This is because the peak current increases with decreasing inductance. So an inductor that satisfies both buck and boost mode conditions must be chosen.

Value of inductor is chosen as 1mH, load and frequency are adjusted according to it.

In ON mode V_{IN}=L*(di_L/DT)

By solving we get

L=[(1-D)*R/F*x]

R is ranging from 6 to 30 ohm and F=35kHz for buck mode with D=0.3

R is ranging from 25 to 45 ohm and F=35kHz for boost mode with D=0.7

Above values are designed by assuming current ripple is around 20% to 40%

Therefore x=0.2 to 0.4

Of output current and output is assumed to be less than 1A.

A good estimation for the inductor ripple current is 20% to 40% of the output current, or 0.2 < Iind < 0.4.

Design of Inductor:

Assuming k_w = 0.35 for round conductor
J = 3A/ sqr mm for copper conductor
Bw=0.2 T for ferrite core
The obtained product value is 27420 mm^4

The core E 65/32/27 is being used which has Ac = 535mm^2 and Aw = 537mm^2
The formula for calculating L is as given below

$$\frac{LI_{peak}\, I_{rms}}{K_w B_w J} = A_C A_W$$

The peak current through inductor = I_{peak}
The rms current through inductor = I(rms)
Thus we get the number of turns to make the required value of inductor

$$N=\frac{L\, I_{peak}}{B_m A_c}$$

2.2.5 Switch selection:

Value of switch current is assumed to be double the calculated maximum value.

As we know $I_{SW} = [V_O*(1-D)/2FL]+[V_O/R*(1-D)]$

By assuming V_{in}=14V

Maximum Current in buck mode=1.5A by assumingV_O=6V,F=35kHz,D=0.3

Maximum current in boost mode=1.5A by assuming V_O=21V,F=35kHz,D=0.6

So switch current is assumed to be 3A as minimum rating while selection of switch.

2.2.6 Capacitor selection:

As the value of capacitance increases the value of ripple in output voltage decreases. Capacitor, designed for buck mode is well suitable for boost mode too.

For the better output, ripple in voltage is assumed to be 2% to 5% of the output voltage.

$C*(dV_O/dt) =-I_O$

By solving we get

C = [D/ (F*y*R)]

As we know D=0.3,F=35kHz,y=0.02, R_{MIN}=6 ohms

On solving C=70uF

For better performance C=100uF is selected.

Final values:

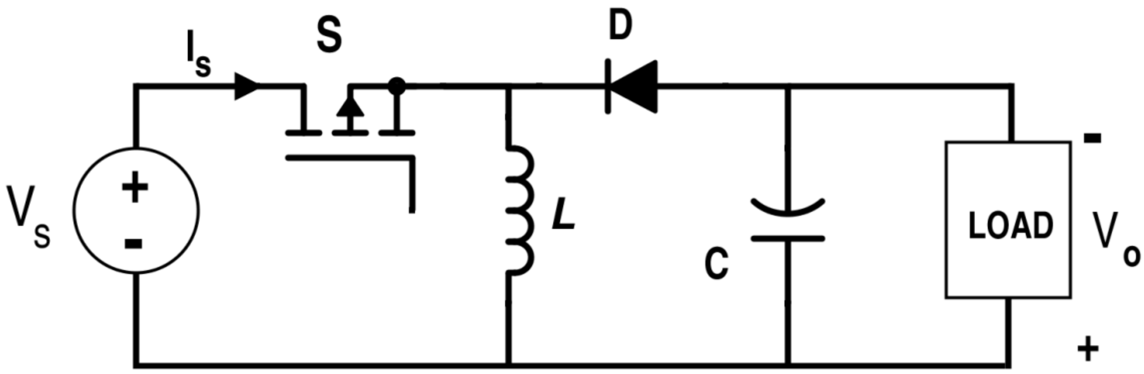
L=1mH(or more), C=100uF (or more)

R is ranging from 6 to 25 ohm in BUCK and BOOST mode

F=20khz(can be higher) .

2.3 MODELING OF BUCK-BOOST CONVERTER:

General configuration of the converter is as shown in the fig.



After designing of Buck-Boost converter, modeling is done using State-space averaging technique. The state vector for the Buck-Boost converter

$X'(t) = A_1X(t) + B_1V_S(t), S = 1$

$X'(t) = A_2X(t) + B_2V_S(t), S = 0$

Mode 1: When MOSFET switch S is ON, output voltage V_0 is negative hence diode D is OFF (reverse biased) and load is not connected to input. The equivalent circuit of Buck-Boost converter for mode 1 is shown in Figure . $i_C = i_R$ form a loop.

Applying Kirchoff's law to the mode 1 circuit is as follows:

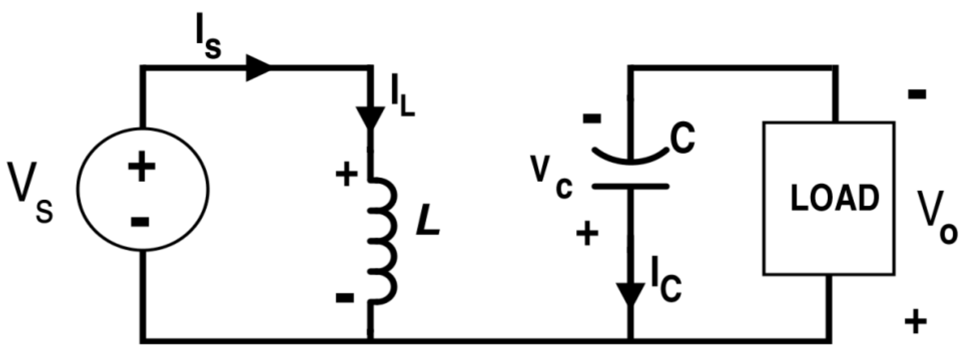


Fig 2.2 Equivalent circuit during switch ON state

SMALL SIGNAL MODEL:

Here $I = I_L$, $V = V_C$

$$\begin{bmatrix} dI/dt \\ dV/dt \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & -1/RC \end{bmatrix} \begin{bmatrix} I \\ V \end{bmatrix} + \begin{bmatrix} 1/L \\ 0 \end{bmatrix} V_S$$

$$V_O = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} I \\ V \end{bmatrix} + [0]V$$

That implies we get

$$\left.\begin{aligned} \frac{di_L}{dt} &= \frac{V_S}{L} \\ \frac{dV_C}{dt} &= \frac{-V_C}{RC} \end{aligned}\right\}$$

Here i_L and V_C are the state variables of x1 and x2 respectively, hence the coefficient matrices for mode 1 is defined as,

$x'(t) = A_1 x(t) + B_1 V_S(t)$

$$A_1 = \begin{bmatrix} 0 & 0 \\ 0 & \frac{-1}{RC} \end{bmatrix}$$

$$B_1 = \begin{bmatrix} \frac{1}{L} \\ 0 \end{bmatrix}$$

Mode 2: During mode 2 operation switch S is OFF as set by external control signal applied to switch S. Since $i_L = \int (V_I/L)dt$ no need to actively control the diode D with any control signals then it is automatically turned ON by i_L, when it flows to the left and turned OFF, when i_L flows to the right. The equivalent circuit of Buck-Boost converter during mode 2 operation is shown in Figure. Applying Kirchoff's voltage and current law to the mode 2 equivalent circuit

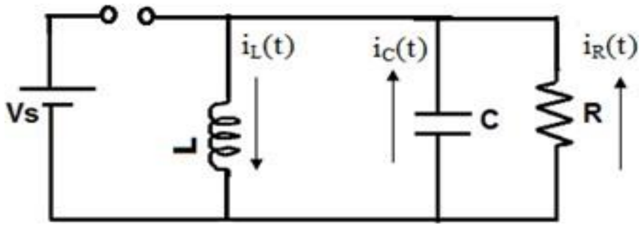


Fig 2.3 equivalent circuit during switch OFF state

SMALL SIGNAL MODEL:

Here $I=I_L$, $V=V_C$

$$\begin{bmatrix} dI/dt \\ dV/dt \end{bmatrix} = \begin{bmatrix} 0 & 1/L \\ -1/C & -1/RC \end{bmatrix} \begin{bmatrix} I \\ V \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \end{bmatrix} V_s$$

$$V_O = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} I \\ V \end{bmatrix} + [0] V_s$$

That implies we get

$$\left.\begin{aligned} \frac{di_L}{dt} &= \frac{-V_C}{L} \\ \frac{dV_C}{dt} &= \frac{i_L}{C} - \frac{V_C}{RC} \end{aligned}\right\}$$

$$\dot{x}(t) = A_2 x(t) + B_2 V_S(t)$$

$$A_2 = \begin{bmatrix} 0 & \frac{-1}{L} \\ \frac{1}{C} & \frac{-1}{RC} \end{bmatrix}$$

$$B_2 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

The A and B matrices are the weighted averages of actual matrices describing the switched system given by the following equations. By substituting the values of L and C in state equations, the state coefficient matrices for the Buck-Boost converter is obtained as follows,

$$A = \begin{bmatrix} 0 & \frac{d-1}{L} \\ \frac{1-d}{C} & \frac{-1}{RC} \end{bmatrix} \qquad B = \begin{bmatrix} \frac{d}{L} \\ 0 \end{bmatrix}$$

Finally we get,

$\hat{x}$ = A$\hat{x}$ + B$\hat{u}$ + [(A_1- A_2)X+(B_1-B_2)U]$\hat{d}$

$\hat{y}$ = C$\hat{x}$ + D$\hat{u}$ + [(C_1- C_2)X+(D_1-D_2)U]$\hat{d}$

$$\begin{bmatrix} d\hat{\imath}/dt \\ d\hat{v}/dt \end{bmatrix} = \begin{bmatrix} 0 & (1-D)/L \\ -(1-D)/C & -1/RC \end{bmatrix} \begin{bmatrix} I \\ V \end{bmatrix} + \begin{bmatrix} D/L & -V/L \\ 0 & I/C \end{bmatrix} \begin{bmatrix} \widehat{v_S} \\ \hat{d} \end{bmatrix}$$

$$\hat{v} = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{\imath} \\ \hat{v} \end{bmatrix} + \begin{bmatrix} 0 & 0 \end{bmatrix} \begin{bmatrix} \widehat{v_S} \\ \hat{d} \end{bmatrix}$$

By substituting all the values

$$\begin{bmatrix} d\hat{\imath}/dt \\ d\hat{v}/dt \end{bmatrix} = \begin{bmatrix} 0 & 700 \\ -7000 & -1000 \end{bmatrix} \begin{bmatrix} I \\ V \end{bmatrix} + \begin{bmatrix} 300 & -6000 \\ 0 & 857.142 \end{bmatrix} \begin{bmatrix} \widehat{v_S} \\ \hat{d} \end{bmatrix}$$ in buck mode

Resulting k_p= ,k_i=

$$\begin{bmatrix} d\hat{\imath}/dt \\ d\hat{v}/dt \end{bmatrix} = \begin{bmatrix} 0 & 400 \\ -4000 & -1000 \end{bmatrix} \begin{bmatrix} I \\ V \end{bmatrix} + \begin{bmatrix} 600 & -21000 \\ 0 & 52500 \end{bmatrix} \begin{bmatrix} \widehat{v_S} \\ \hat{d} \end{bmatrix}$$ in boost mode

2.4 Feedback loop:

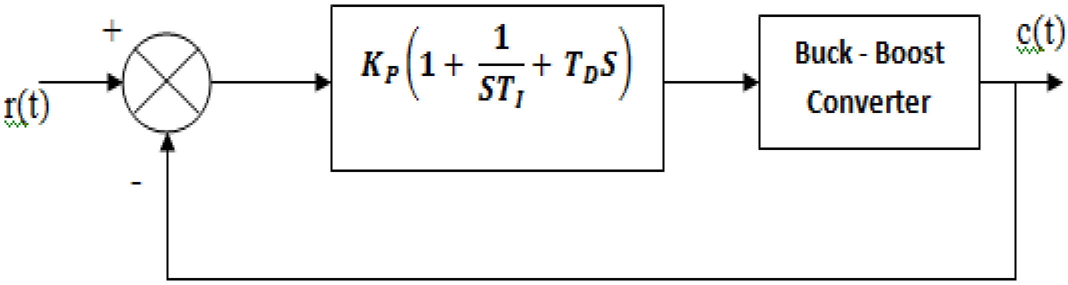


Fig 2.4 Block diagram of PI controller

The Analog PI control scheme has been employed successful in many industrial control systems. In a closed loop system, PID controller block provides the compensation in the feedback control of the Buck-Boost converter. The closed loop control with Analog PID control and Buck-Boost converter is illustrated in Figure

The continuous time PID controller can be expressed in Laplace transfer function as:

$$U(S) = K_P\left(1+\frac{1}{T_I S}+T_D s\right)E(S) = K_P + \frac{K_I}{S} + K_D S$$

where U(S) is the control output, and E(S) is the error (difference between reference voltage V_{ref} and output voltage V_0). The value of K_P, T_D and T_I are tuned depending on the present error, accumulation of past errors and prediction of future error respectively.

By proper choice of these tuning parameters a controller can be adapted for a specific converter to obtain a good behaviour of the controller system

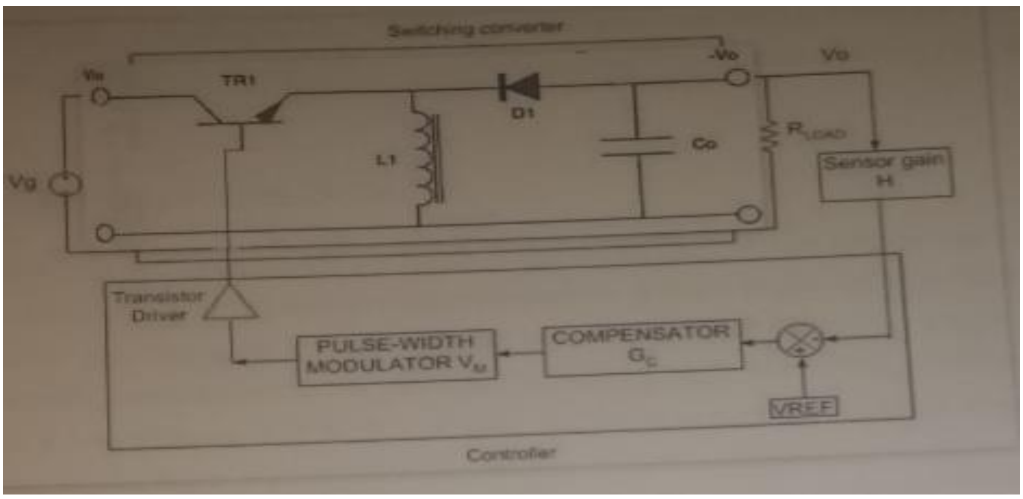


Fig 2.5 Block diagram of closed loop control

All regulators have a power transfer stage and a control circuitry to sense the output voltage and adjust to maintain the constant output voltage. Since a feedback loop is necessary to maintain regulation, some type of compensation is required to maintain loop stability.

Compensated system is expected to have the following characteristics:

(1)loop gain should be high at lower frequencies to minimise steady state error.

(2)the phase margin should be sufficient to ensure the system stability.

The duty cycle is varied in the feedback loop to compensate for variations. Sensor gain is used to scale down the output voltage to be equal to voltage reference .The error signal thus obtained is fed to the compensator. The PWM block compares the compensator output with another ramp signal to give the variation in duty cycle .A proportional-integral controller is a phase lag controller .It is used to increase the low frequency loop gain, thus reducing steady state error.

Chapter 3

Open loop Simuation and results

Circuit :-

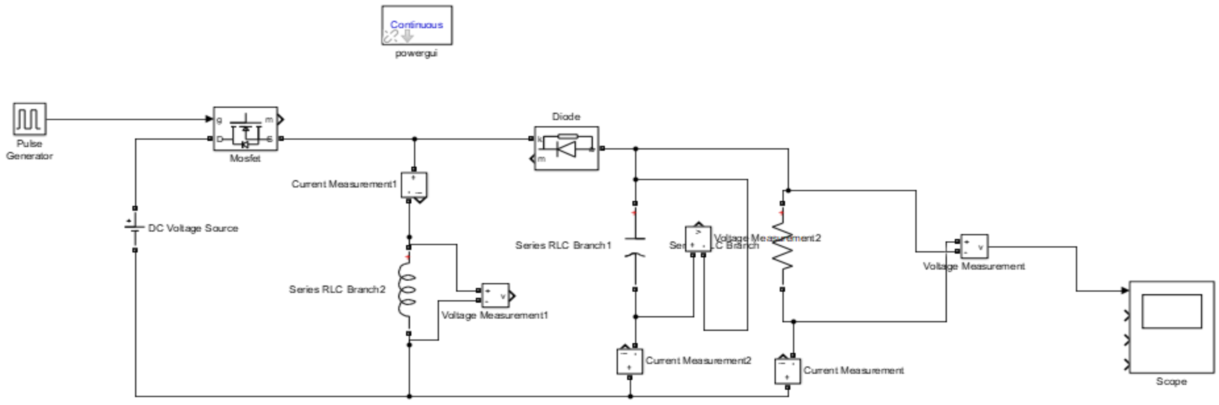


Fig 3.0 Open loop circuit

Values of design :-

Simulation outputs for open loop buck mode:

Duty ratio =0.3

Input voltage =14V

Output voltage =6V

Inductor =3mH

Capacitor =200uF

Resistor = 30ohm

Switching frequency =50kHz

current ripple = 10%

voltage ripple=2%

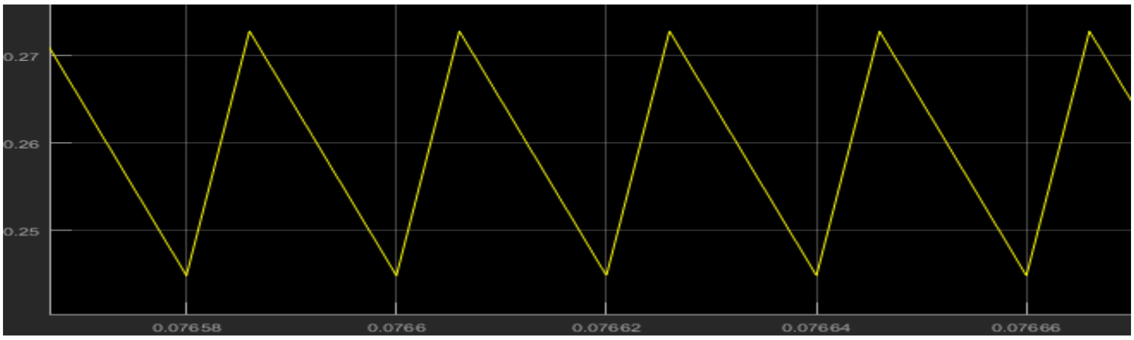


Fig 3.1 Current waveform across inductor in open loop buck mode

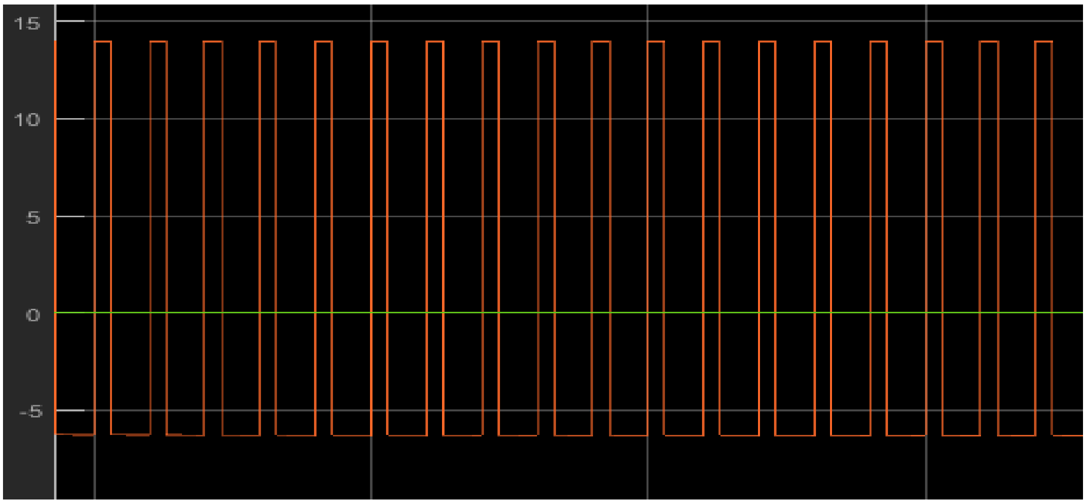


Fig 3.2 Voltage waveform across Inductor in open loop buck mode

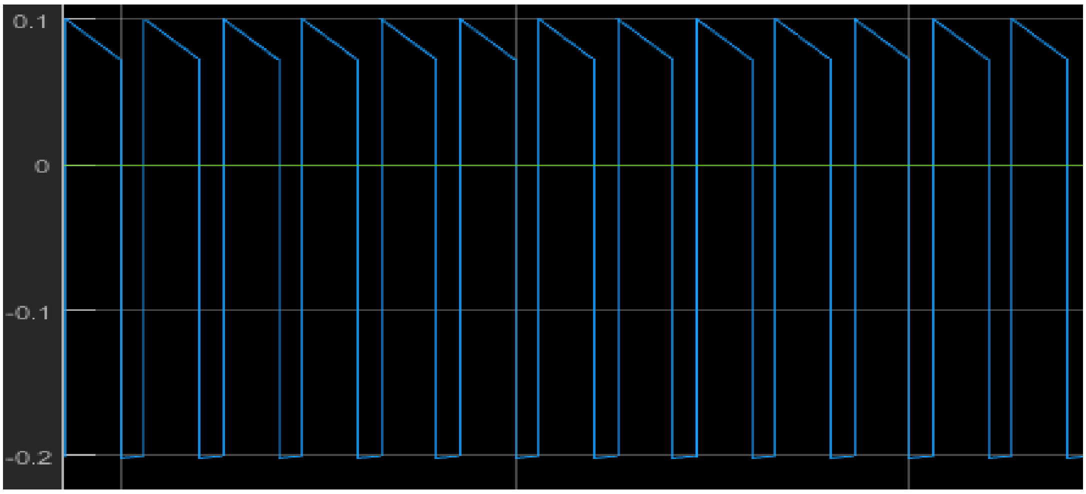


Fig 3.3 Current waveform across Capacitor in open loop buck mode

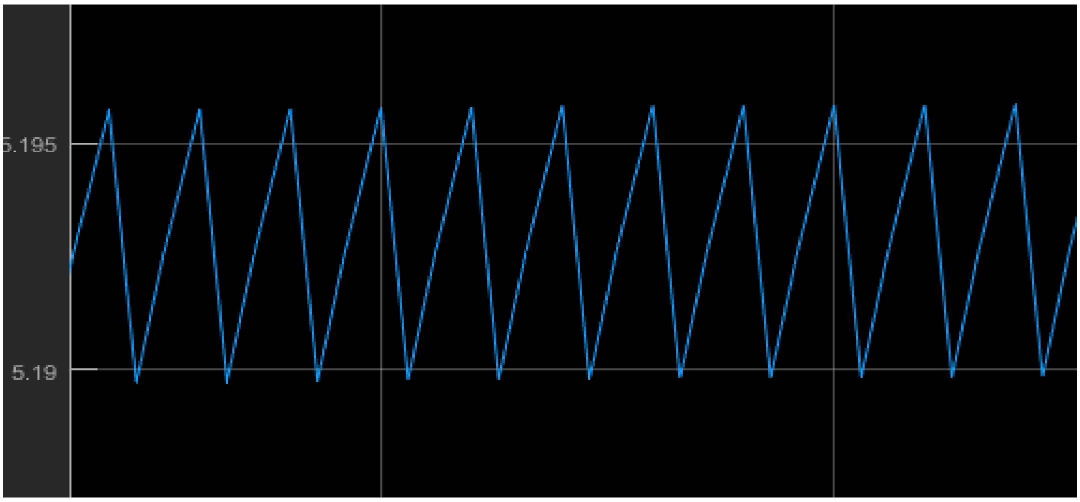


Fig 3.4 Voltage waveform across capacitor in open loop buck mode

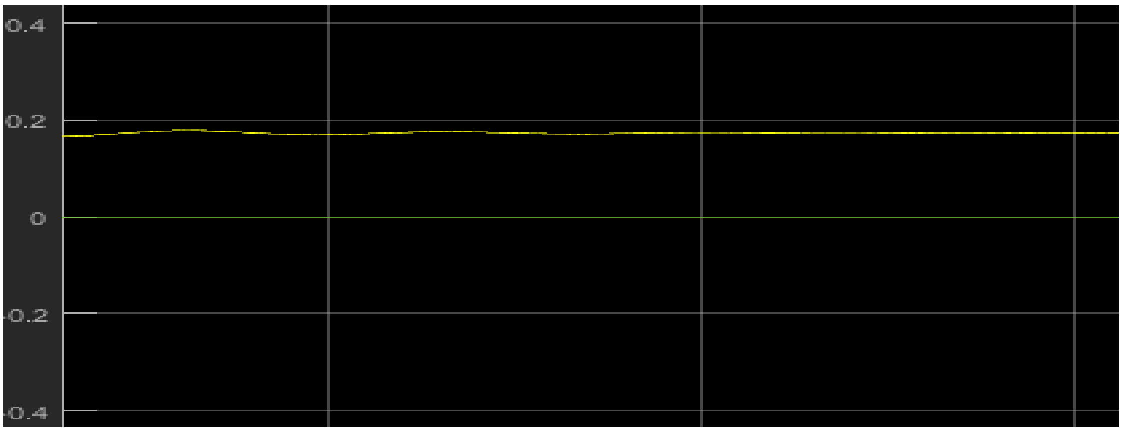


Fig 3.5 Current waveform across resistor(load) in open loop buck mode

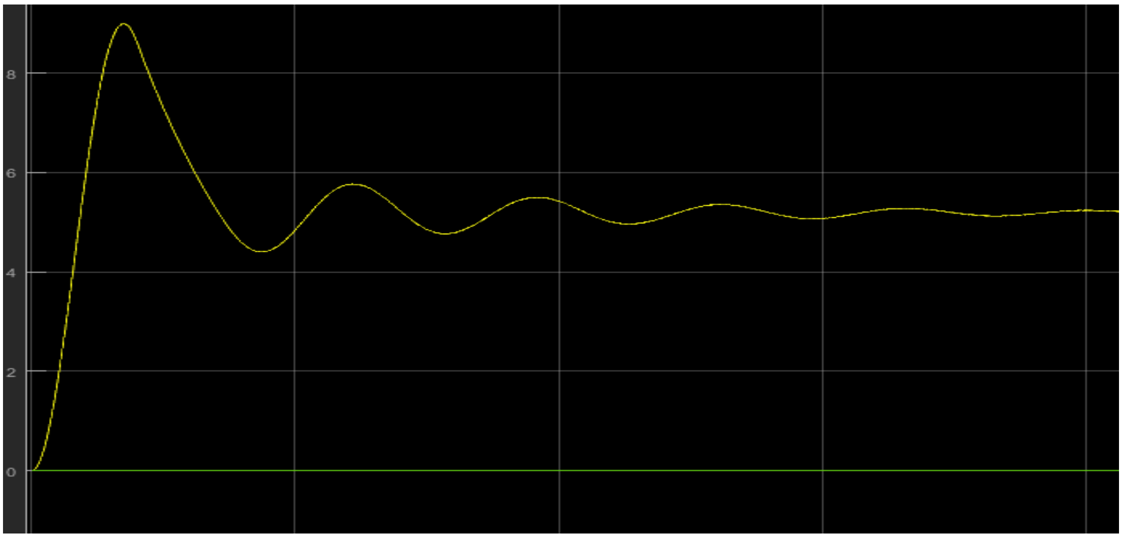


Fig 3.6 Voltage waveform across resistor(load) in open loop buck mode

Simulation outputs for open loop boost mode:

Duty ratio =0.6

Input voltage =14V

Output voltage =21V

Inductor =3mH

Capacitor =200uF

Resistor = 30ohm

Switching frequency =50kHz

current ripple = 10%

voltage ripple=2%

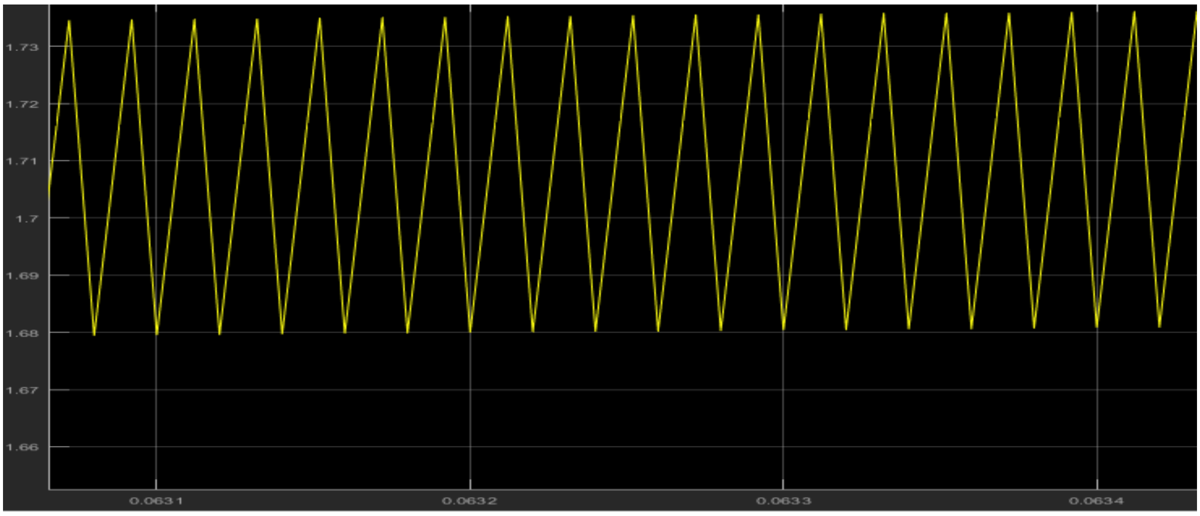


Fig 3.7 Current waveform across inductor in open loop boost mode

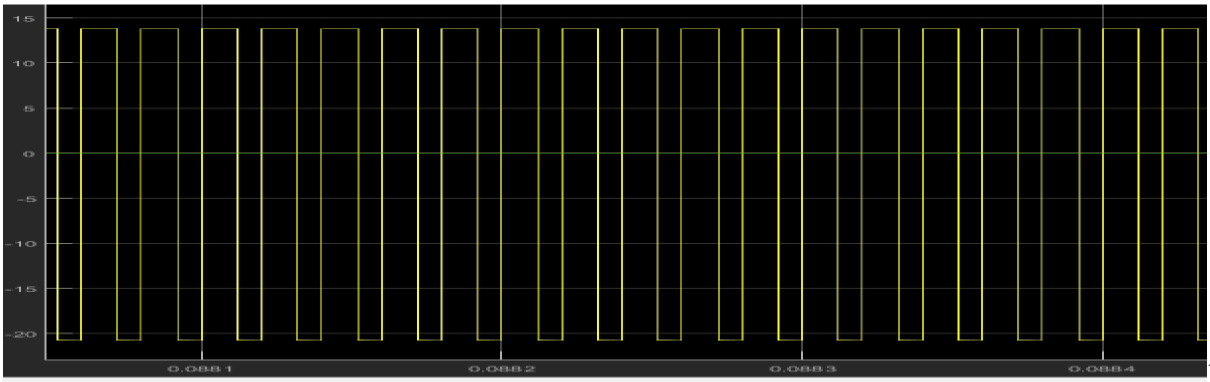


Fig 3.8 Voltage waveform across Inductor in open loop boost mode

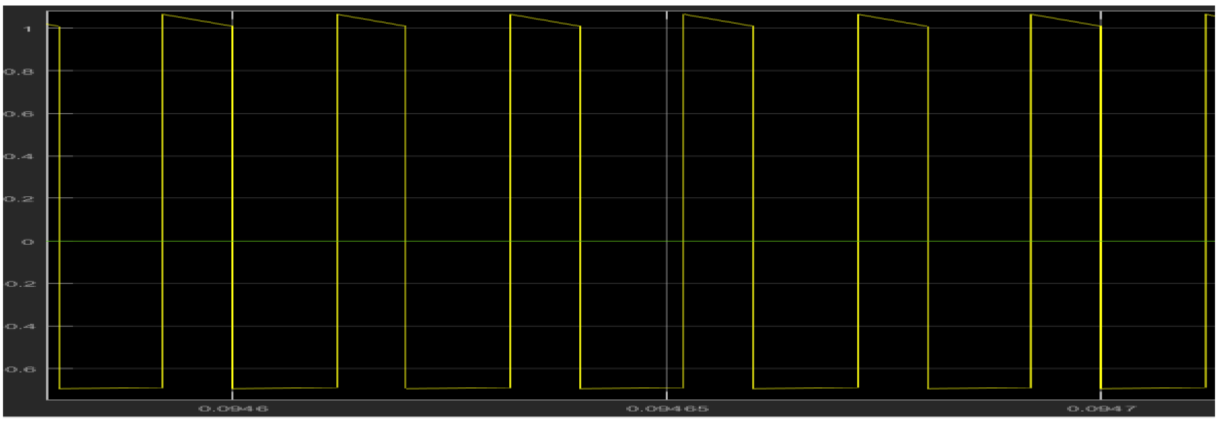


Fig 3.9 Current waveform across capacitor in open loop boost mode

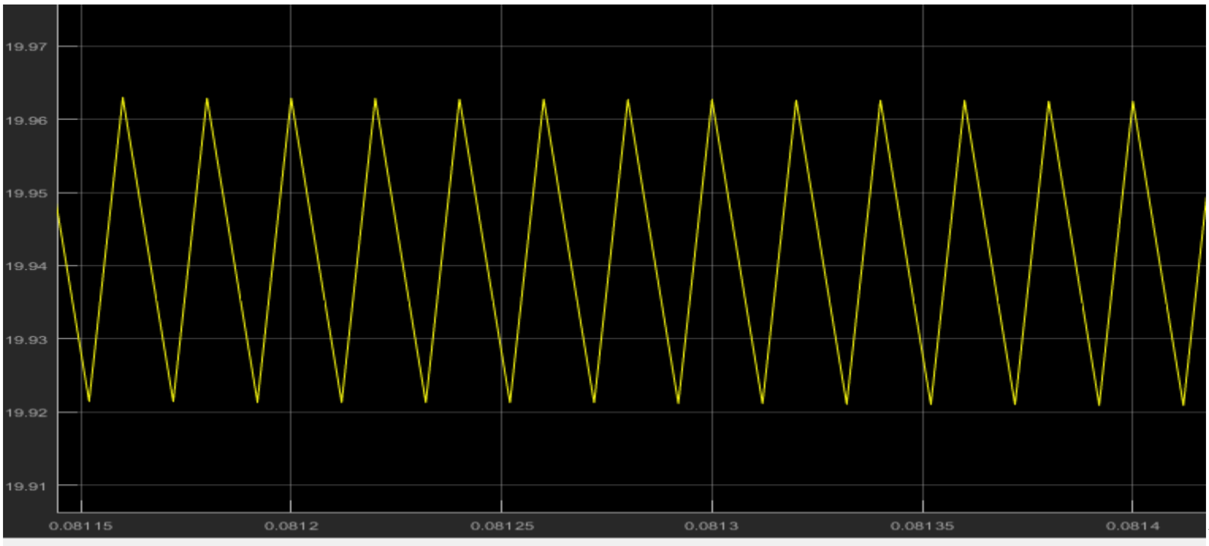


Fig 3.10 Voltage waveform across capacitor in open loop boost mode

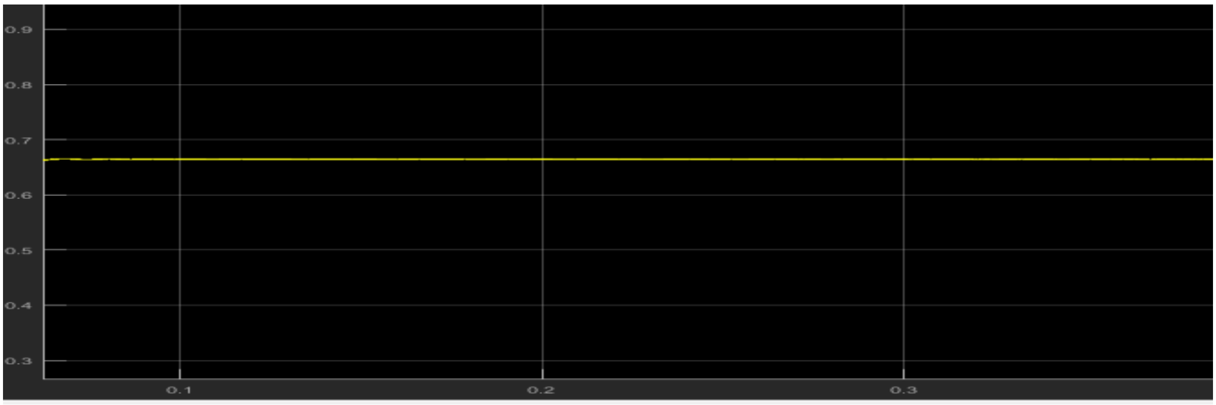


Fig 3.11 Current waveform across resistor(load) in open loop boost mode

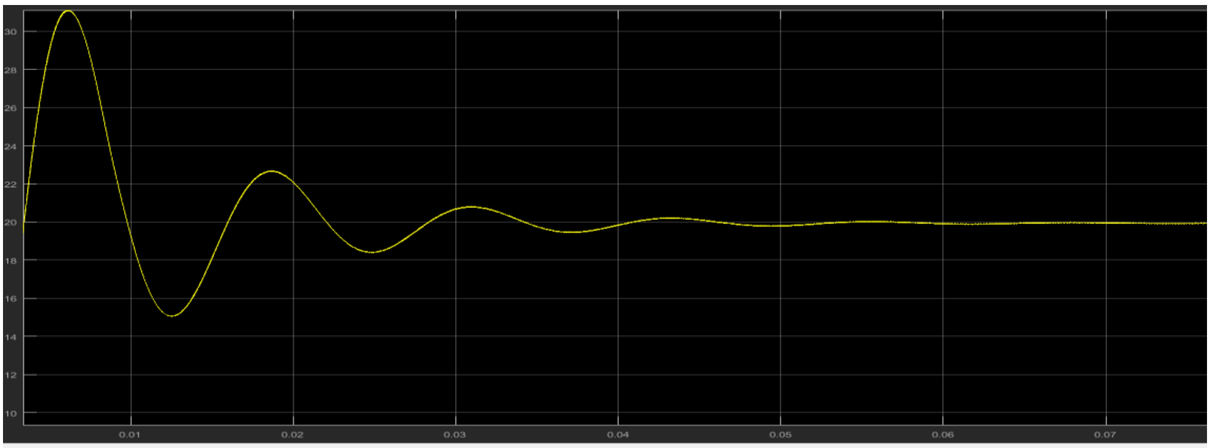


Fig 3.12 Voltage waveform across resistor in open loop boost mode

Chapter 4

Closed loop simulation and results

Circuit :-

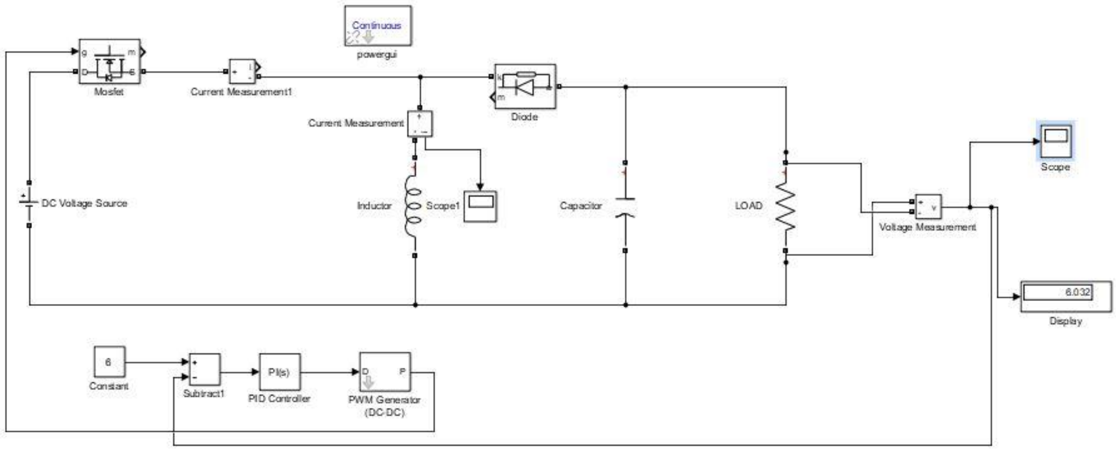


Fig 4.0 Closed loop circuit

Here L=1mH,C=100uF ,k_p=0.002 ,k_i =5

Simulation results :-

BUCKMODE

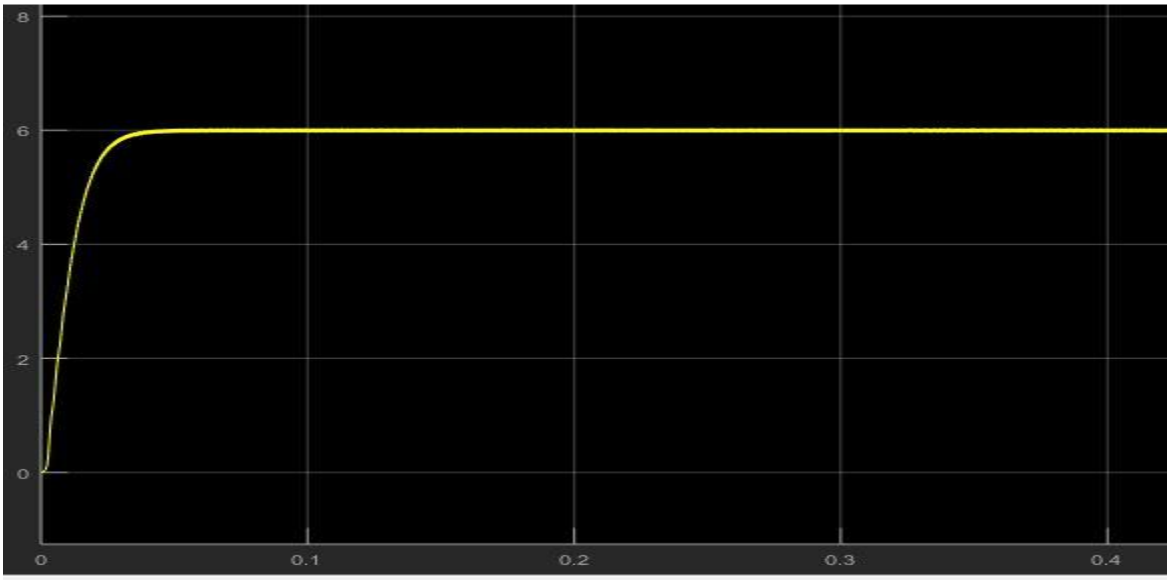


Fig 4.1 Output Waveform with V_{in} =14V,V_{ref}=6V,R=10Ω

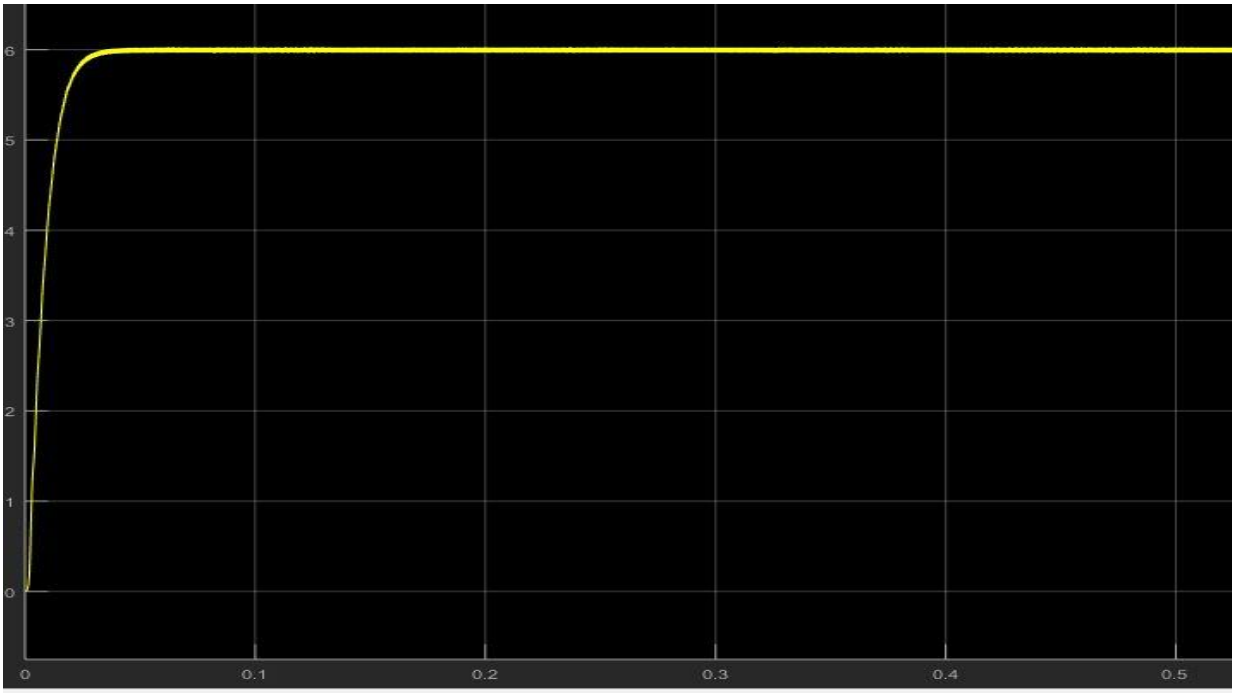


Fig 4.2 Output Waveform with V_{in} =20V,V_{ref}=6V,R=10Ω(change of V_{in})

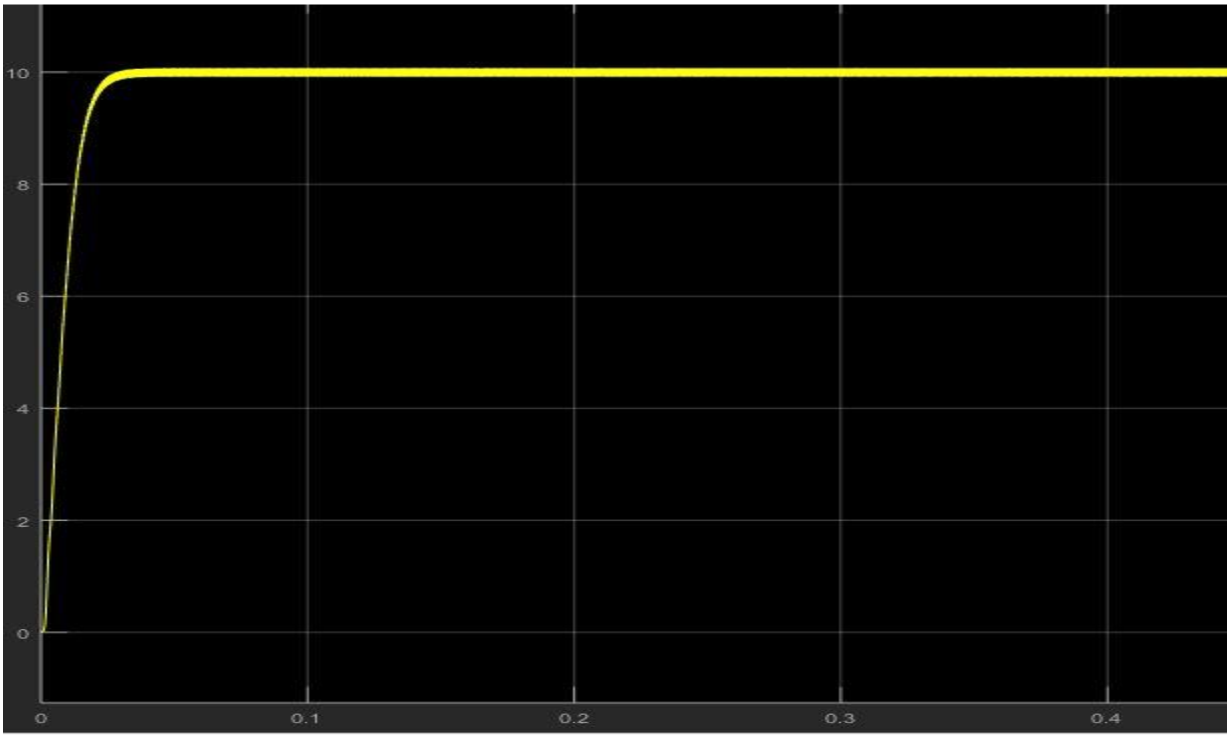


Fig 4.3 Output Waveform with V_{in} =14V,V_{ref} =10V,R=10Ω (change of V_{ref})

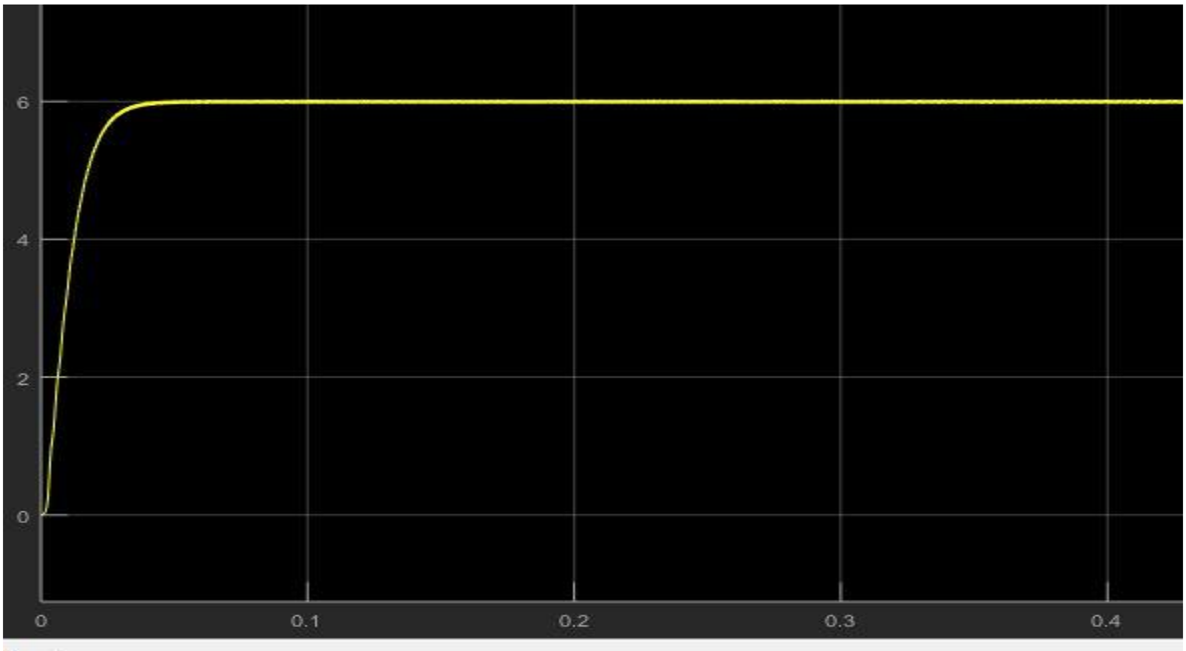


Fig 4.4 Output Waveform with V_{in} =14V,V_o=6V,R=20Ω (change of load)

BOOSTMODE:-

Voltage waveform across resistor(load):

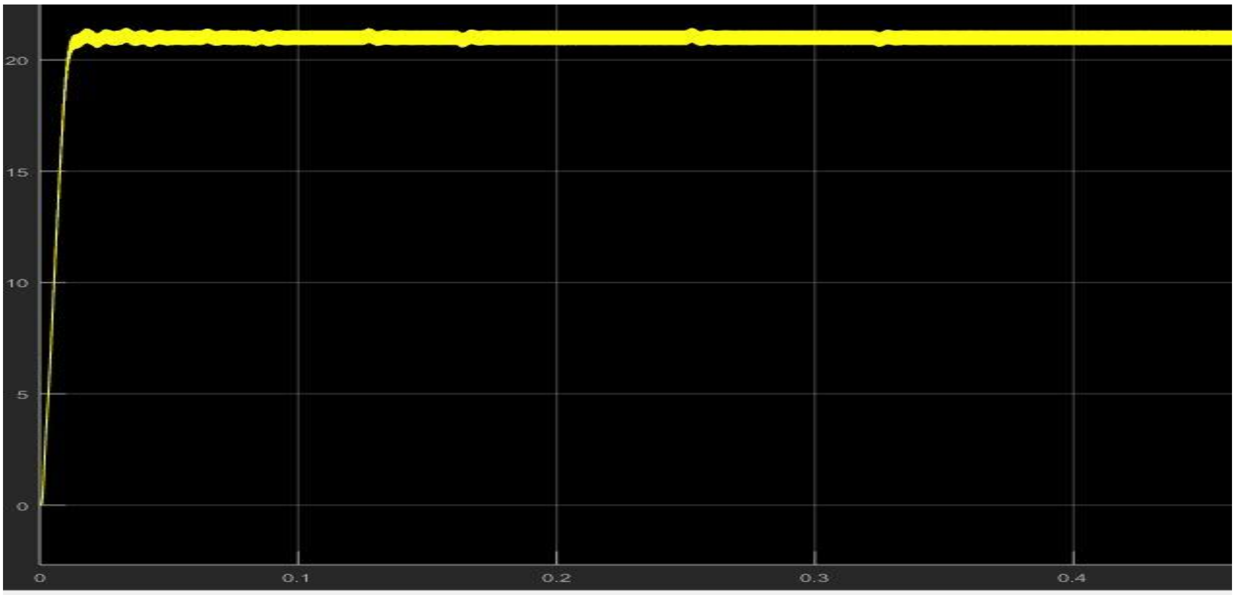


Fig 4.5 Output Waveform with V_{in} =14V,V_{ref}=21V,R=10Ω

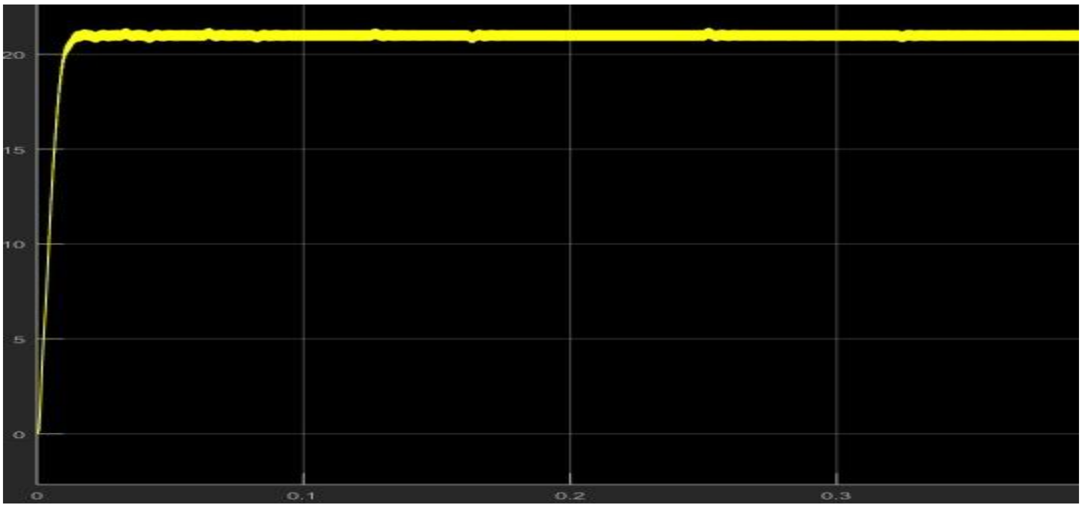


Fig 4.6 Output Waveform with V_{in} =20V,V_{ref}=21V,R=10Ω (change in V_{in})

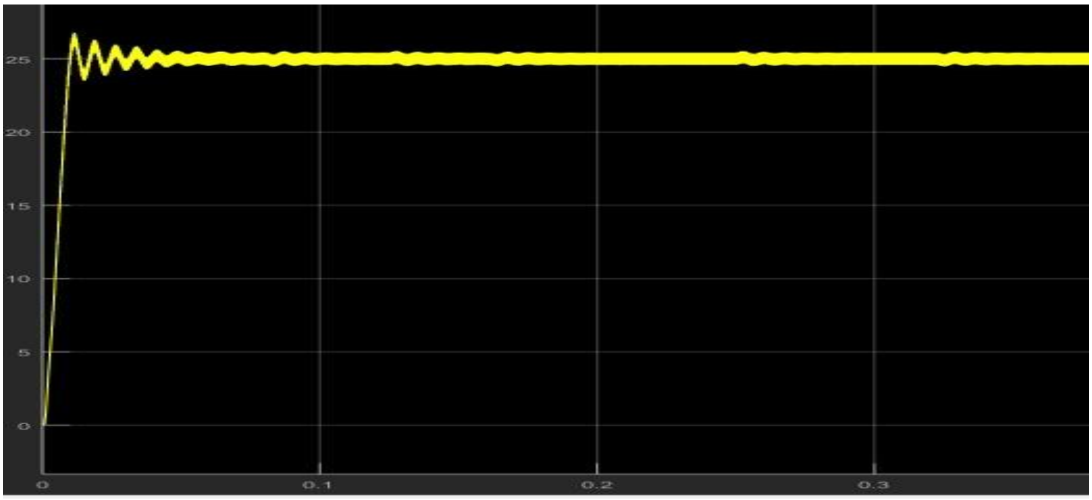


Fig 4.7 Output Waveform with V_{in} =14V,V_{ref}=25V,R=10Ω (change of V_{ref})

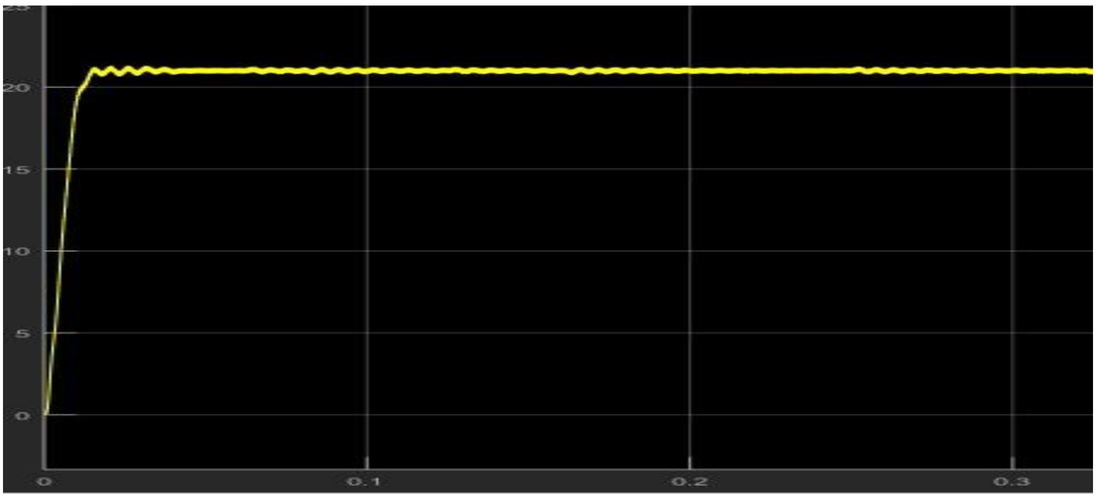


Fig 4.8 Output Waveform with V_{in} =14V,V_{ref}=21V,R=20Ω(change of load)

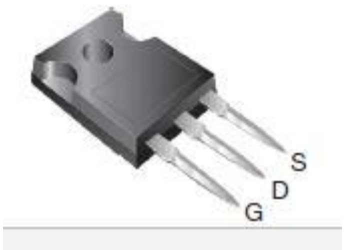
CHAPTER 5

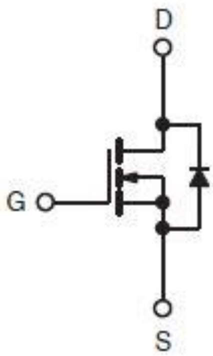
Hardware Implementation

COMPONENTS:

1. DC voltage source
2. MOSFET(IRFP250)
3. Fast recovery diode(MUR460)
4. Inductor
5. Capacitor
6. Resistive load
7. Operational Amplifier (LM 741 IC)
8. Arduino Uno
9. Gate driver IC (TLP 250)

5.1 MOSFET :- IRFP250





Mosfet is a three terminal device and can be triggered by applying a gate pulse .It is a voltage controlled current device and the drain current depends on the gate source voltage .

The primary advantage over other power electronic devices is the superior switching speed and the ability to interrupt the current without reversal of the device voltage. mosfet advantages (i) high switching speed because it is a majority carrier device and there is no secondary break down

(ii) relatively low control power requirement which complicates the control circuit design. Besides, bipolar devices can be paralleled easily. mosfet has positive temperature coefficient resistance which means with increase in temperature resistance increases current falls and power loss i2Rdecreases and can be paralleled easily.

The new device promised extremely low input power levels and no inherent limitation to the switching speed. Thus, it opened up the possibility of increasing the operating frequency in power electronic systems resulting in reduction in size and weight. Need to design the gate drive circuit to account for the pulse currents required to charge and discharge the high input capacitance of these devices. At high frequency of operation the required gate drive power becomes substantial. MOSFETs also have comparatively higher on state resistance per unit area of the device cross section which increases with the blocking voltage rating of the device. The use of MOSFET has been restricted to low voltage (less than about 500 volts) applications where the ON state resistance reaches acceptable values. It can be used over 100 khz

Specifications :-

V_{DS} (V)	200	
$R_{DS(on)}$ (Ω)	V_{GS} = 10 V	0.085
Q_g (Max.) (nC)	140	
Q_{gs} (nC)	28	
Q_{gd} (nC)	74	
Configuration	Single	

V_{DS} =200V,I_d=33A

■ Typical R_{DS}(on) = 0.085Ω

■ Extremely high dv/dt Capability

5.2 Fast recovery Schottkey diode(MUR 460)

The Ultrafast Rectifier is designed for use in switching power supplies, inverters and as free wheeling diodes.

F(AV)= 4.0 A ,V_{RRM} =400 V- 600 V, I_{FSM} =150 A, t_{rr}= 50 ns, Forward Voltage drop=1.05 V

• Ultrafast 50 nanosecond Recovery Time

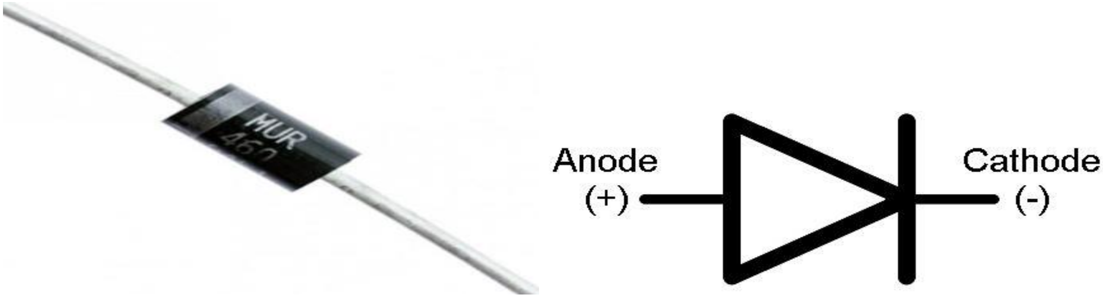
• 175°C Operating Junction Temperature

• Low Forward Voltage

• Low Leakage Current

• High Temperature Glass Passivated Junction

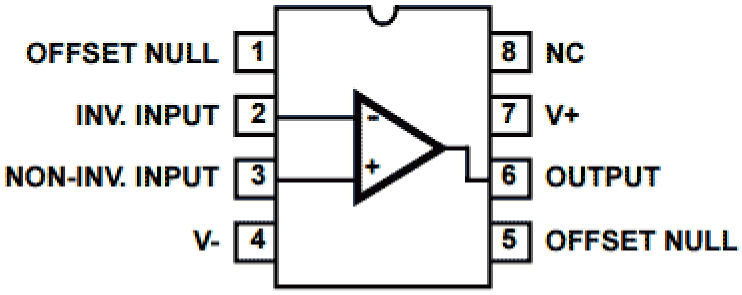
• Reverse Voltage upto 600 Volts



5.3 Operational Amplifier (LM741 IC):

The short form of the operational amplifier is op-amp, is a one kind of solid state IC. It is the basic building block of analog electronic circuits that accomplish a different types of analog signal processing tasks. These ICs uses an exterior feedback to regulate its functions and these components are used as a multipurpose device in various electronic instruments. It consists of two inputs and two outputs, namely inverting and non inverting terminals. This 741 IC is most commonly used in various electrical and electronic circuits. The main intention of this 741 op amp is to strengthen AC & DC signals and for mathematical operations. The applications of operational amplifier mainly involve in filters, comparators, pulse generators, oscillators, etc.

Pin diagram :-



Pin-1 is Offset null.

Pin-2 is Inverting (-) i/p terminal.

Pin-3 is a non-inverting (+) i/p terminal.

Pin-4 is -Ve voltage supply (VCC)

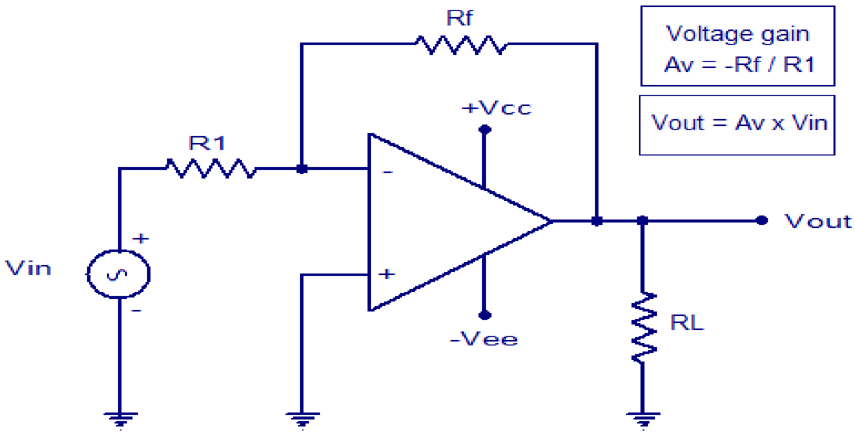
Pin-5 is offset null.

Pin-6 is the o/p voltage.

Pin-7 is +ve voltage supply (+VCC)

Pin-8 is not connected.

Inverting amplifier:-



opamp inverting amplifier

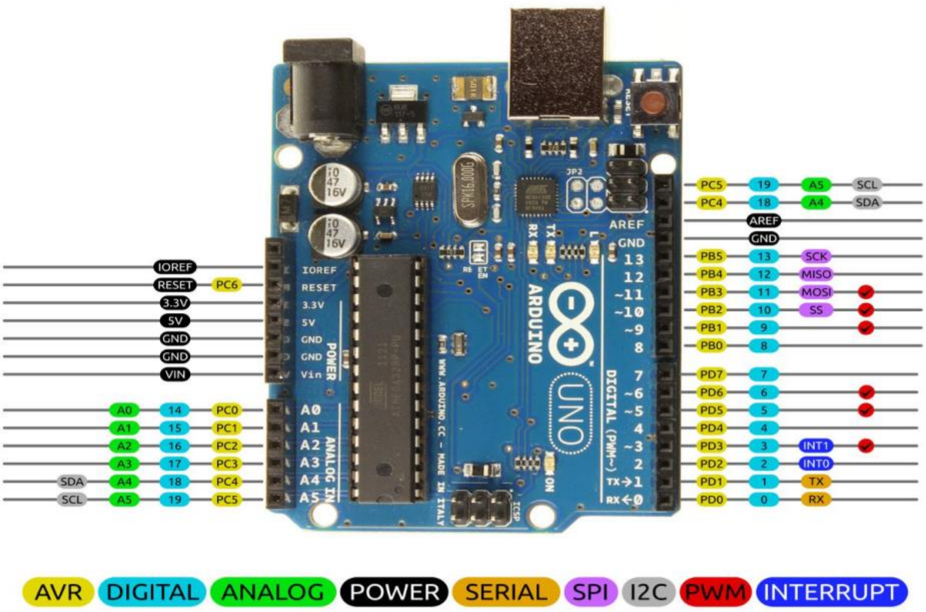
We used R_1 =3.3k =R_f

The output waveform of operational amplifier obtained is inversion of input waveform.

5.4 ARDUINO UNO

Arduino is an open source computer hardware and software company, project, and user community that designs that manufactures single board microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical and digital world. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards or Breadboards (*shields*) and other circuits.

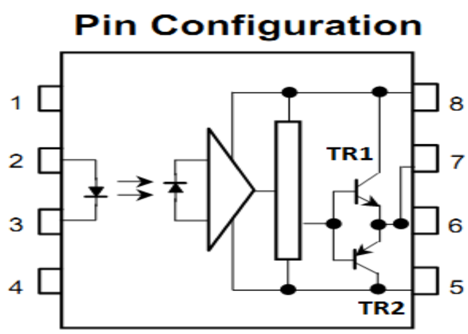
The Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.



TECHNICAL SPECIFICATIONS:

Microcontroller used	ATmega328
Operating Voltage of microcontroller	5V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (of which 0.5 KB used by boot loader)
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

5.5 Gate driver circuit:



1 : N.C.
2 : Anode
3 : Cathode
4 : N.C.
5 : GND
6 : V_O (Output)
7 : V_O
8 : V_{CC}

The gate driver is required to control the switching of the switch used. Here we are using TLP250 which is suitable for gate driving circuit of IGBT or Power MOSFET

Input threshold current: IF=10mA(max.); Supply current (ICC): 11mA(max.);Supply voltage (VCC): 10−35V ; Output current (IO): ±1.5A (max.) ; Switching time (tp_{LH}/tp_{HL}): 1.5μs(max.) ; Isolation voltage: 2500Vrms(min.)

Tlp250 circuit as a gate driver :-

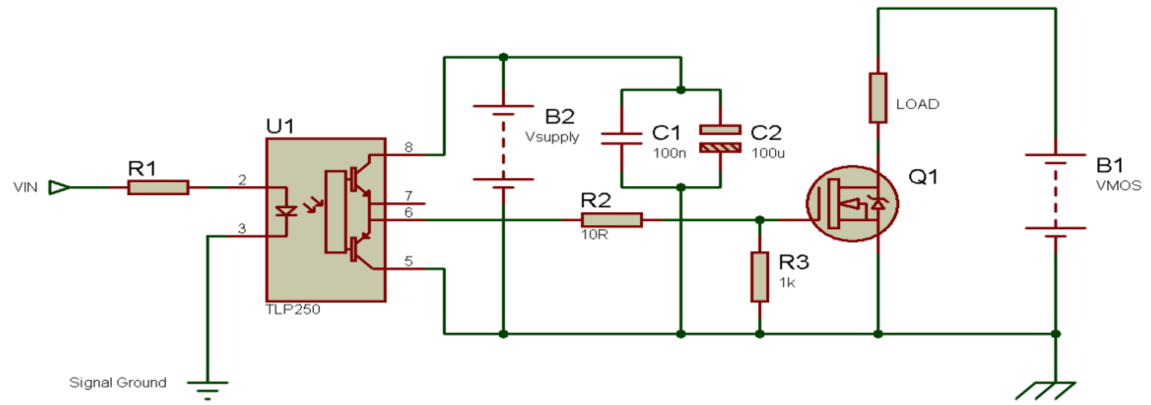


Fig 5.1 Gate driver circuit using TLP 250

Design :-

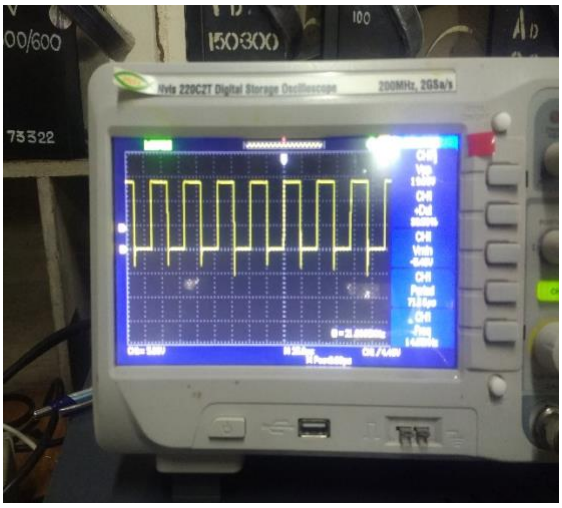
The forward current for photo diode between pin 2 and 3 is 10mA (max value used) . TLP250 is being driven from a arduino and the amplitude for the signal is 5V. the forward voltage drop for the LED would typically be between 1.6V and 1.8V – I'll take it to be 1.8V for this example.

So, V = (5.0 – 1.8)V = 3.2V

V = IR

R = V/I = 3.2V/(0.01A) = 320Ω

R3 is the gate resistor and the value is 3.3k and R2 upto 1k



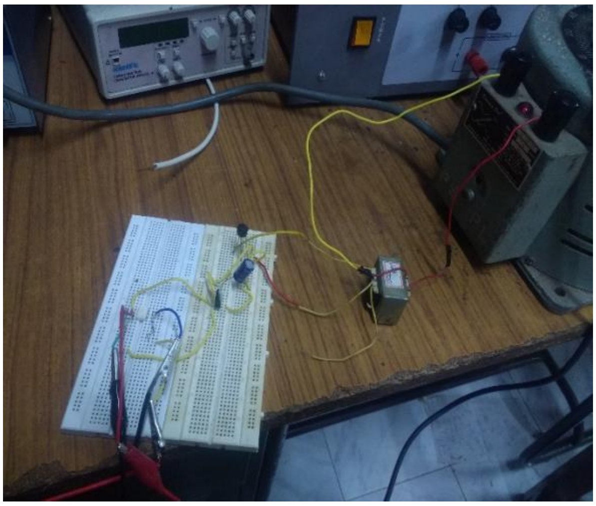


Fig 5.2 Output waveform for gate driver circuit and its circuit