Department of Electrical Engineering

Indian Institute of Technology Hyderabad

Project Report - April 2024

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Electrical Circuits Lab (EE1200) - Professors

Siva Rama Krishna Vanjari

Thirumurugan

Members of Project

EE23BTECH11220 - Ryali Venkata Sai Sri Ram Varun

EE23BTECH11224 - Sri Krishna Prabhas Yadla

EE23BTECH11216 - Kalyan Pilli

EE23BTECH11215 - Penmetsa Srikar Varma

Programmable DC Voltage Regulator

Title of our project report

Aim of project

To build programmable voltage generator which gives desired output voltage (0-20V) which can be entered in a laptop

Electric components required for project

- arduino UNO R3 board
- IRF540 - nMOSFET
- voltage divider (1kΩ)
- 3 capacitors of rating 4.7μF
- 2 power inductors
- diode
- DC voltage source of 5V

Approach for project

To build this we used a SEPIC (single-ended primary-inductor converter) converter

SEPIC is basically a type of dc-to-dc converter which allows a range of dc voltage at its input side and gives a stable voltage at the output side

The output voltage can be varied by changing the duty cycle applied to the MOSFET (metal-oxide-semiconductor field-effect transistor)

this duty cycle is varied using a 'arduino UNO' - R3 board

Circuit diagram

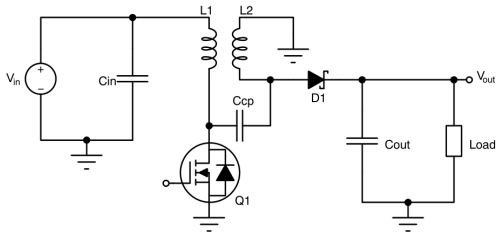


Figure 1. SEPIC Converter

SEPIC converter

Working

The SEPIC (Single-Ended Primary Inductance Converter) converter is a type of DC-DC converter that can step up or step down the input voltage

It is particularly useful when you need regulated output voltage that is either higher or lower than input voltage, especially battery-powered applications or when dealing with variable input sources

On and Off States

On State (Switch Closed) In the on state, the switch is closed, allowing current to flow through the inductor from the input source

This charges inductor, stores energy and diode across the inductor is reverse-biased during this phase to prevent current from flowing back into input source

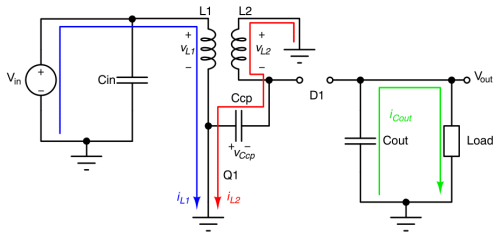


Figure 2. SEPIC Converter during ON State

SEPIC converter during On state

Off State (Switch Open): In off state, switch is open, causing inductor's magnetic field to collapse, releases the stored energy, which flows through diode into load and charges output capacitor

The diode is forward-biased in this phase, allowing current to flow in one direction only (from the inductor to the load)

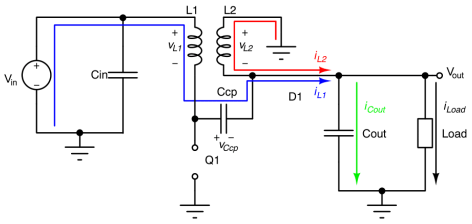


Figure 3. SEPIC Converter during OFF State

SEPIC converter during Off state

Duty Cycle

The duty cycle of a SEPIC converter refers to the ratio of time the switch is on (closed) compared to the total switching period and typically denoted by the symbol D and is expressed as a percentage

$$D = \frac{T_{on}}{T_{on} + T_{off}}$$

A higher duty cycle means the switch is on for a longer duration relative to the switching period, leading to a higher average output voltage. Conversely, a lower duty cycle results in a lower average output voltage

The duty cycle is crucial parameter in controlling the output voltage of SEPIC converter. It can be adjusted by varying timing of switch (using pulse width modulation, for example) to achieve desired output voltage regulation

The relationship between the input voltage (V_{in}), output voltage (V_{out}), and duty cycle (D) in a SEPIC converter can be given by,

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

A higher duty cycle results in higher average output voltage, while lower duty cycle leads to lower average output voltage

The duty cycle can be adjusted to regulate output voltage of SEPIC converter

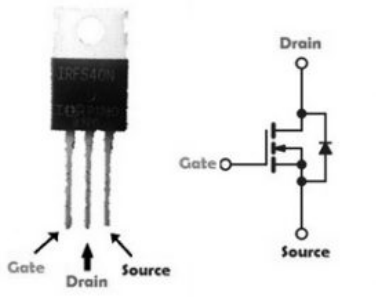
MOSFET

In this circuit MOSFET is used in switch mode

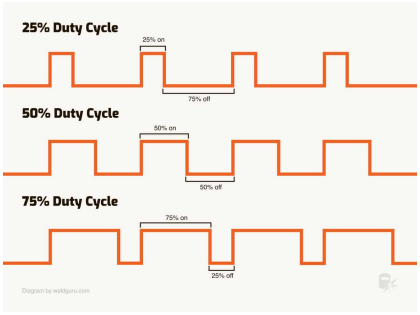
When a sufficient voltage is applied, the MOSFET turns "on" and conducts current between its Drain and Source terminals

This on/off control allows MOSFETs to function as efficient switches, rapidly transitioning between conducting and non-conducting states based on applied gate voltage

This gate voltage is supplied by arduino as a pulse in this project.



IRF540-nMOSFET



Duty Cycle

Arduino

Arduino is used to adjust duty cycle according to target voltage given by user, by changing the input pulse width given to gate terminal of MOSFET and this can be done by arduino by using this code

Arduino Code used for project

```
int feedback = A1;       //The feedback input is A1
int PWM = 3;             //Digital pin D3 por PWM signal
int pwm = 1;             //Initial value of PWM width

void setup() {
  Serial.begin(9600);
  pinMode(feedback, INPUT);
  pinMode(PWM, OUTPUT);
  TCCR2B = TCCR2B & B11111000 | B00000001;// pin 3 and 11 PWM frequency of 31372.55 Hz
}

void loop() {
  float voltage = (2.5/3.6)*(1023/5);//We read the value of the potentiometer, which is
  the desired value
  float output  = analogRead(feedback);//We read the feedback, which is the real value


//If the desired value is HIGHER than the real value, we increase PWM width
  if (voltage > output)
   {
// Serial.println("trying to increase output voltage. pwm: " + String(pwm));
    pwm = pwm+1;
    pwm = constrain(pwm, 1, 254);
    delay(90);
   }

//If the desired value is LOWER than the real value, we decreaase PWM width
  if (voltage < output)
   {
// Serial.println("trying to decrease output voltage. pwm: " + String(pwm));
    pwm = pwm-1;
    pwm = constrain(pwm, 1, 254);
    delay(90);
   }

   analogWrite(PWM,pwm);  //Finally, we create the PWM signal
}
```

Conclusion

In this project, SEPIC converter is used to obtain desired voltage from voltage source of 5V and this is done by varying duty cycle of switch using arduino

Thank You