EEE 316

Project Report| Single Phase Sine Wave Inverter

GROUP - 2

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1. Introduction

At present, the standards of electrical source are not uniform, so inverter power has broad ways. Inverter supplies can be used in car electrical device or boat device where it is very hard to find ac power. The uniform frequency of ac power in Chinese is 50Hz. Using inverter people can get fixed or variable frequency. The input of inverter can be cell or battery. It is very convenient and portable. The development of sine wave inverter power supply can bring considerable social and economic benefits. Under the investigation of current study, the uniform design of inverter always has Power MOSFET, control ship and Sinusoidal Pulse Width Modulation (SPWM) generator [1]. There are two ways to generate SPWM. First one is to use single ship and software to generate SPWM wave. Second one is to use hardware circuit to generate it. SPWM scheme functions by comparing a modulating sinusoidal signal at desired output frequency with a high frequency (in kHz range) triangular signal acting as a carrier. This wave is used to control turn-on and turn-off devices like. This project uses the second method to generate SPWM waves, because it will be easier than use software and there are many resources on the internet and chip to use. Using hardware can save the space of single ship, Central Processing Unit (CPU) can do other sophisticate work. When the inverter is connected to load, the output will be equal to ac power. Our circuit can invert dc voltage into ac voltage at fixed frequency of the given sine wave to generate the pulse. Peak voltage of sine wave is determined by the dc input.

2. System Design

The single-phase sine wave inverter accomplished in our project is efficient in low voltage usage where feedback is not necessary. The project is designed in Simulink. At first pulse signal of variable width was generated using sinusoidal pulse width modulation method. The pulses were then sent to the MOSFETs of the full bridge circuit. The input of the full bridge circuit was a constant DC voltage which in real life can be a battery or cell. The output of the full bridge circuit was an alternating square wave with an amplitude equal to the value of DC voltage. The square wave has the same variation the width as the pulse signal. Later, using a LC filter (low pass filter), the fundamental component (50 Hz) is extracted from the square wave and desired sinusoidal signal is generated.

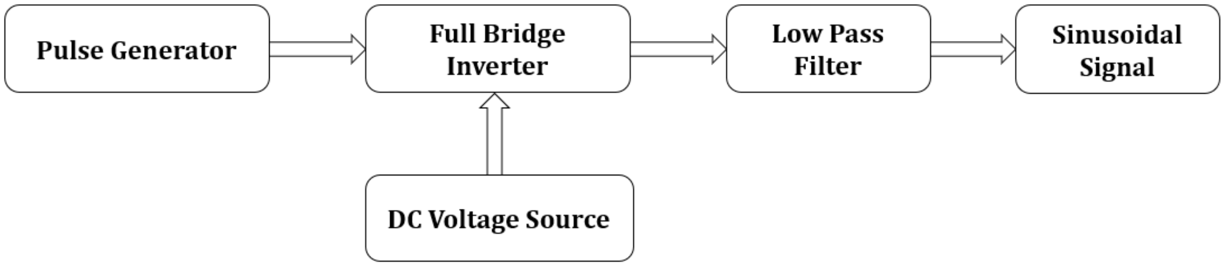

Figure: Design model of single-phase sine wave inverter

3. Components

We have designed our project in MATLAB Simulink. The components used are-

1. DC voltage source
2. MOSFET
3. Resistor
4. Capacitor
5. Inductor
6. Triangular and sinusoidal signals

4. Workflow

4.1 Generation of Pulse Signal

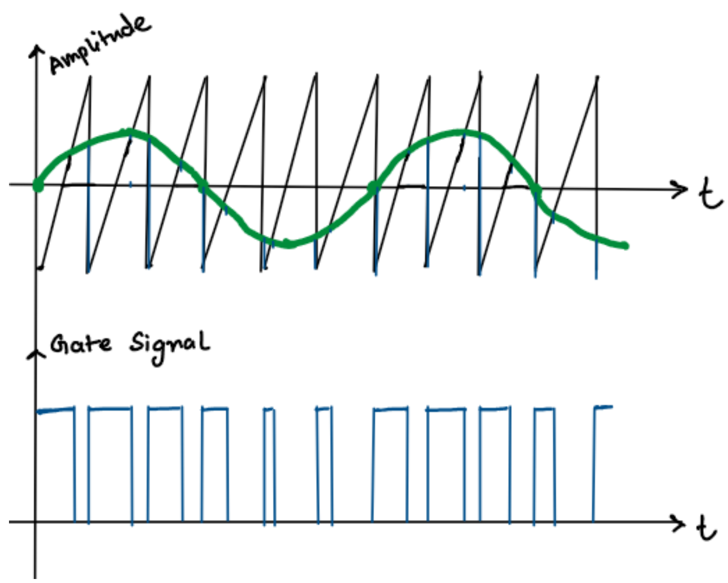

Figure: Generation of pulse signal using SPWM method

We have used SPWM method where a sinusoidal wave of desired frequency is compared with a saw-tooth signal. The frequency of the saw-tooth signal is much higher than the sinusoidal signal (in kHz range). Higher the frequency of the carrier signal is better the output sinusoidal signal will be.

Here, when the magnitude of the sine wave is higher than the saw-tooth wave, the dc output is high. And when the magnitude of the sine wave is lower than the saw-tooth wave, the output is low (zero). Therefore, the width of the pulses is variated according to the magnitude of the sinusoidal signal in the desired frequency. This method later enables us to filter the fundamental component using only passive filter.

4.2 Generation of AC square wave through full bridge circuit

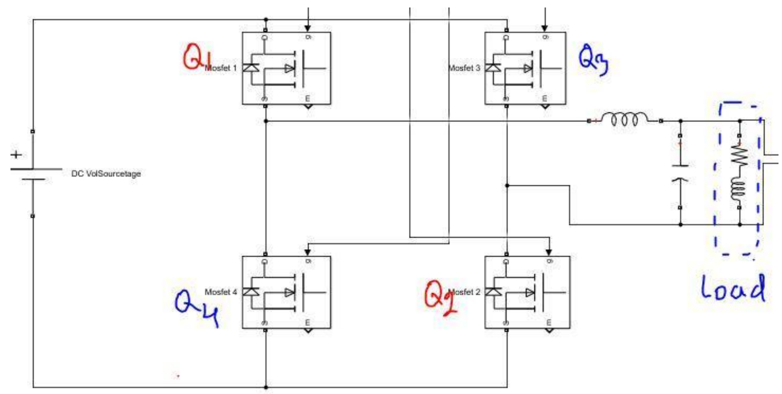

Figure: Full Bridge Circuit

The full bridge circuit consists of four power MOSFETs which have body diodes(that works as feedback path for current in case of inductive load when mosfet is in off state), DC input voltage supply, and load. Here an LC filter is added additionally in the Simulink diagram about which we will talk later.

The generated gate pulse is supplied to Q1 and Q2. Using a NOT gate this pulse signal is inverted and supplied to the other two MOSFETs, Q3 and Q4.

The process of generating ac square wave is quite simple. Due to the supplied pulse signal, whenever Q1 and Q2 are ON, Q3 and Q4 are OFF, and vice versa. So, during the operation of Q1 and Q2, the direction of the load current will be downward, as shown in the following diagram. Therefore, the $V_{out} = V_{dc}$.

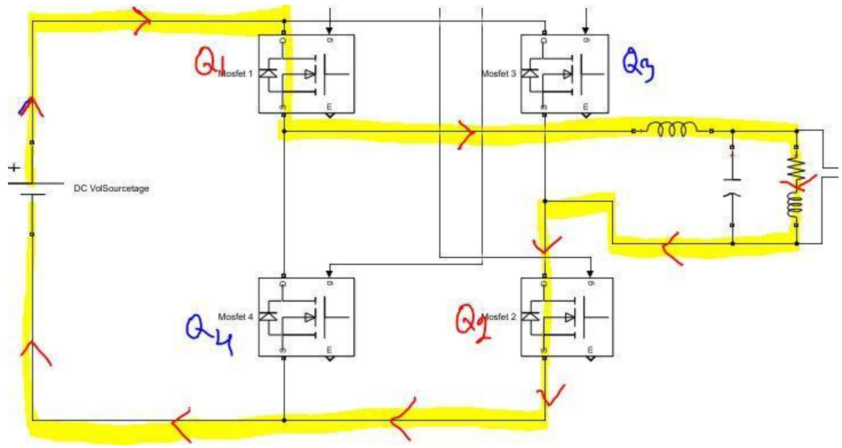

Figure: Operation Cycle of Q1 and Q2

On the other hand, during the operation of Q3 and Q4, the load current is upward. So, $V_{out} = -V_{dc}$.

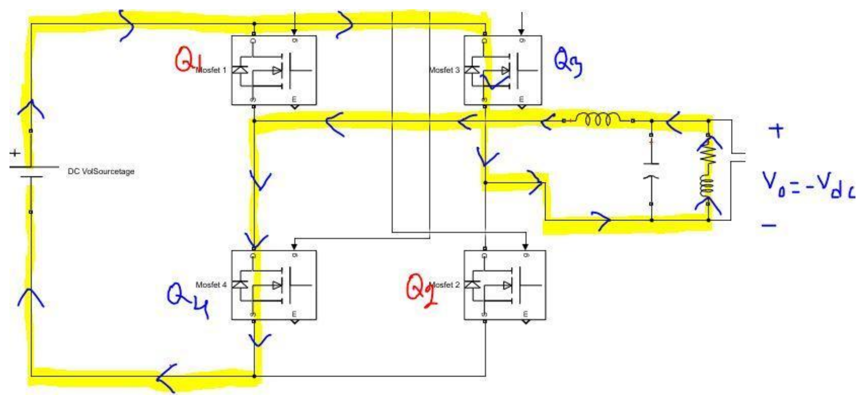

Figure: Operation cycle of Q3 and Q4.

In this way, the following output is achieved.

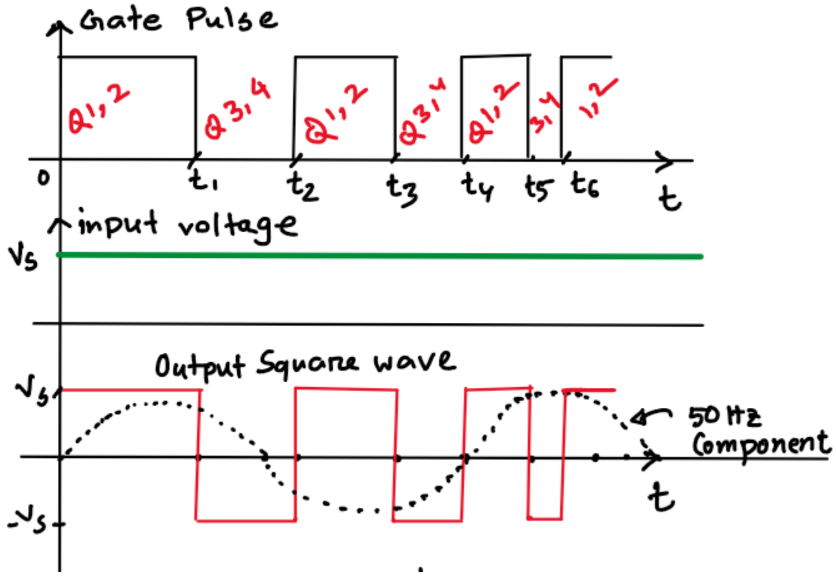

Figure: Input/Output Waveshapes

4.3 Generation of Sinusoidal Output

Now, as the pulse has the nature of sinusoidal wave latent in its width, most of the part of the harmonics is of the fundamental frequency or lowest frequency (50 Hz). Therefore, a low pass filter is used to filter it. The dashed line indicates the final output sinusoidal wave which has a peak value same as the dc input voltage. To get 220V rms output voltage, we must supply 311.127 V (220√2) dc input voltage.

5. Implementation in Simulink

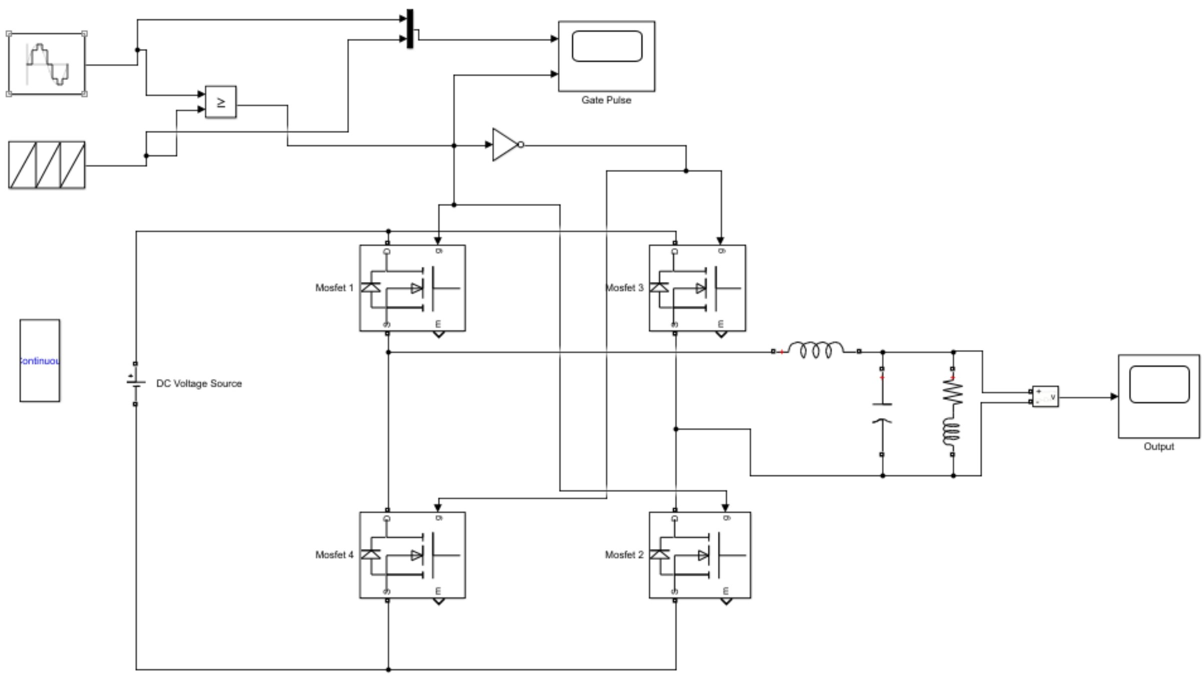

Figure: Simulink Diagram of Single-Phase Sine Wave Inverter

We have used a repeating sequence block to generate the triangular sequence of 10KHz. We have compared this sequence with a 50Hz sinusoidal signal of amplitude 1. In order to ensure a modulation index less than unity, the amplitude of the triangular sequence has been taken 1.13.

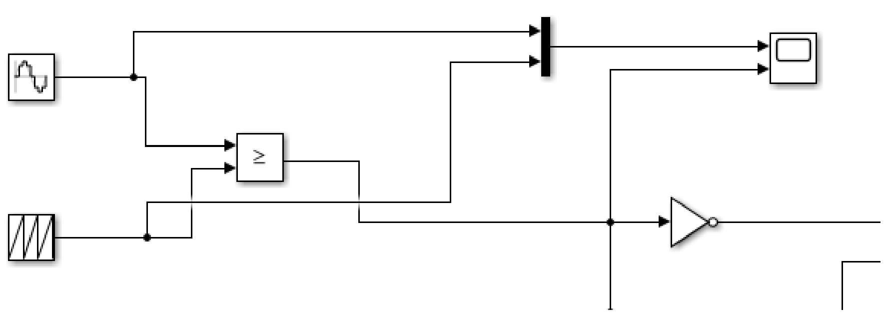

Figure: Pulse Generation Part

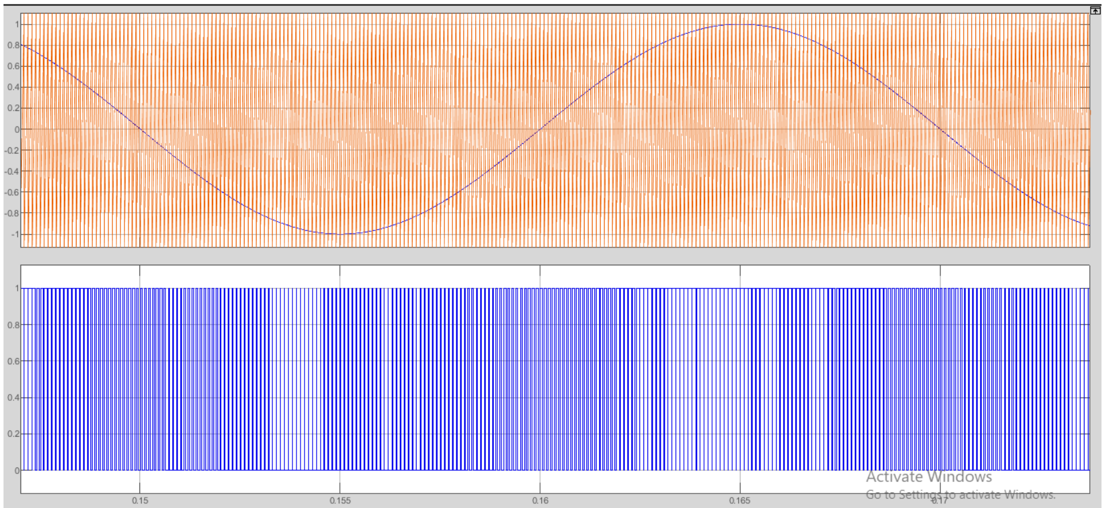

Figure: Generated Pulse

As we have discussed earlier, the pulse width is not constant, rather it follows the magnitude of a sine wave. There the LC filter (low pass) is used to extract the 50Hz components, higher order ripples get reomved in the output signal.

The final output for an inductive load is shown below.

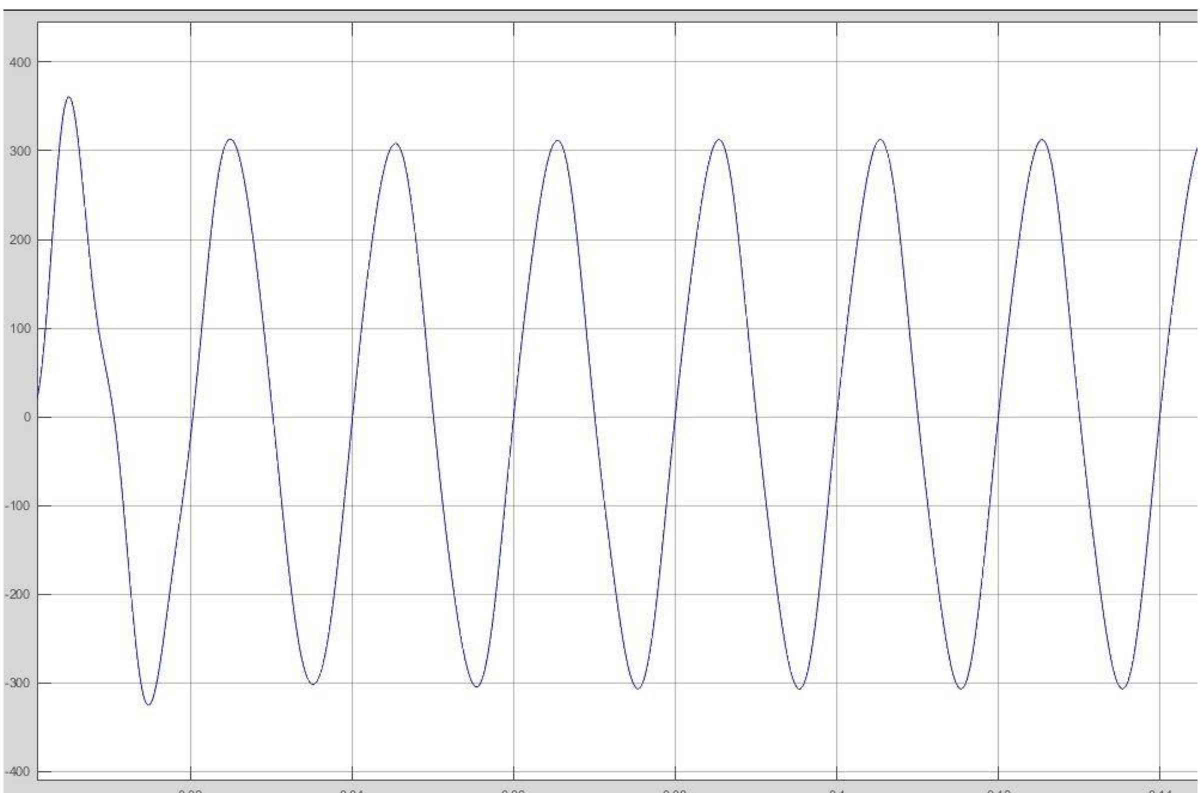

Figure: Output Signal for Inductive Load.

We can, the amplitude of the sine wave is almost equal to 311 V which is the inpu dc voltage. The frequency of the output signal is 1/T =1/0.02 = 50 Hz. And there is no noticeable ripples in the output signal.

Another output wave shape is given for a pure resistive load.

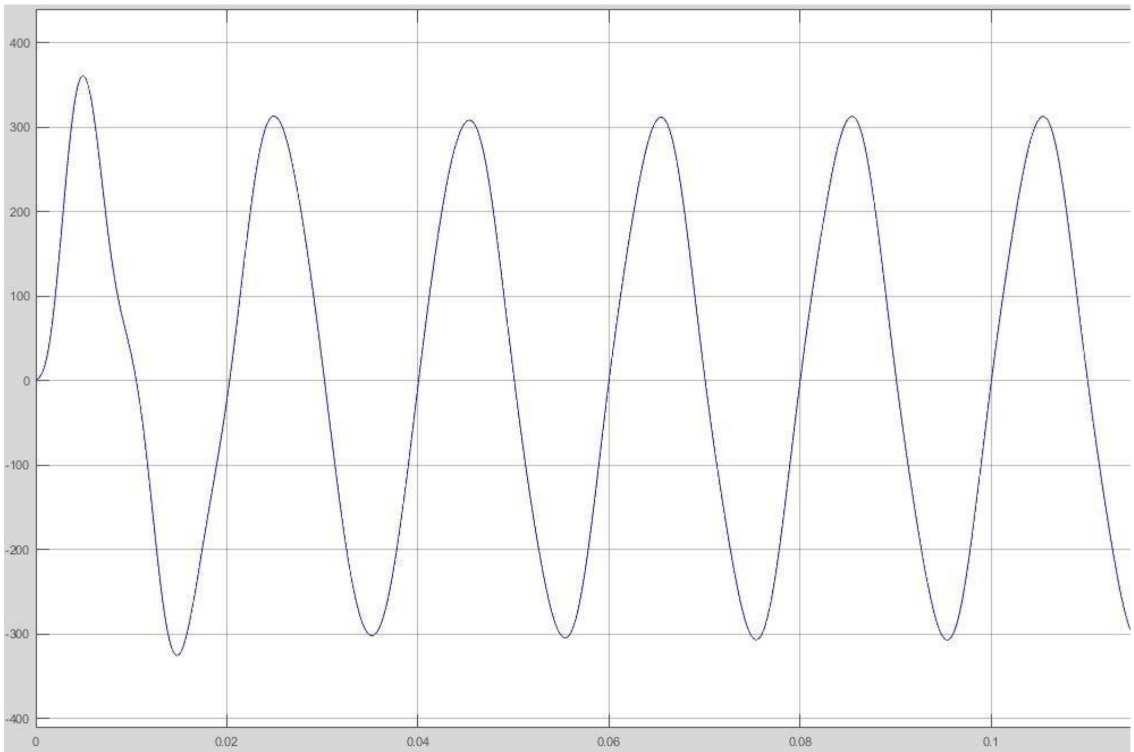

Figure: Output Waveform for Pure Resistive Load.

We can see, the output is a pure sinusoid as previous. Therefore, we can claim that, our circuit can generate sinusoidal signal from pure dc signal irrespective of the type of loads.

6. Discussion

In this sessional course EEE316 we were assigned to implement a single-phase sine wave inverter for project. So, far we have given a short brief, the basic workflow, circuit, and operations, and showed the output from our sine wave inverter. We were supposed to implement this on hardware, but due to covid situation we had to settle in a software project, we implemented the project in Simulink. Our inverter gave us the desired output, the output was purely sinusoidal with a frequency 50Hz, although setting the frequency was completely on the SPWM circuit since it generated the frequency. Amplitude of the sine wave voltage was equal to the given DC input, as such we set the dc value at 311.17V and in output we got 220V rms. value, more precisely amplitude was 311.17V. At first cycle we got a bit higher value because of transient response of active elements of LC filter. But it was in as minimized condition as possible. Other input voltages also showed proper result. Moreover, our circuit was an appropriate fit for both inductive, capacitive, and purely resistive load. For generating pulse although there were other techniques, we chose SPWM because it has an advantage of constant switching frequency. A constant switching frequency makes it possible to calculate the losses of switching devices. So, the thermal design for them becomes easier. Also, this SPWM technique has high power handling capacity and can utilize high frequency. To sum up, our project ended successfully, and it has a future scope to use a transformer at the output end, so we can get desired higher output voltage from different lesser DC inputs.