



## **Simulation And Hardware Implementation Of Controlled DC Output Voltage For Compact Regulated Voltage Using Ardiuno Controller And Dead Band Converter**

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**Abstract** — Compact control DC system from a standard single phase 230V, 50Hz power supply is task in recent scenario. With the help of controlled switch like IGBT is suitable for control of output DC voltage. It is possible to vary the DC output with the help of change in switching frequency or change in duty cycle. From different simulation of controlled rectifier, switching frequency changing method is implemented here. Quality parameter of power and efficiency is improved from simulated result. Controlled signal is implemented with the help of Ardiuno micro controller at 5 KHz. Full bridge converter topology is implemented with FGA25N120ANTD IGBT also dead band circuit is implemented for reducing short circuit effect between two compliment switch. Prototype is implemented with different switching frequency from 1 KHz to 5 KHz. Battery chargers, speed control in DC motor, etc. is suitable for this topology.

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**Keywords-** IGBT, Ardiuno, Dead band, Isolation Circuit, High frequency.

### **I. INTRODUCTION**

SMPS is an electronic power supply unit that incorporates a switching regulator that is an internal control circuit that switches power transistor such as IGBT rapidly on and off in order to stabilize the output voltage or current. Switching regulators are used as replacements for the linear regulators when higher efficiency, smaller size and lighter weight are required. The efficiency of SMPS [1] is typically 80-90% as opposed to 30-40% for linear units. This greatly reduces the cooling requirements and allows a much higher power density. This topology will be analyzed with two types of secondary winding-techniques such as the Centre-tap configuration and full wave-bridge configuration. The switching topology used for the full-bridge converter is the bipolar voltage switching, where the transistors are switched in pairs.

### **II. BLOCK DIAGRAM**

Block diagram associated with control circuit, driver circuit, converter circuit, load circuit for simulation and hardware implementation of this concept. A switch mode power supply can be classified as either an AC to DC or DC to DC converter[2] in which the AC or DC input voltage is converted to the required DC output voltage.

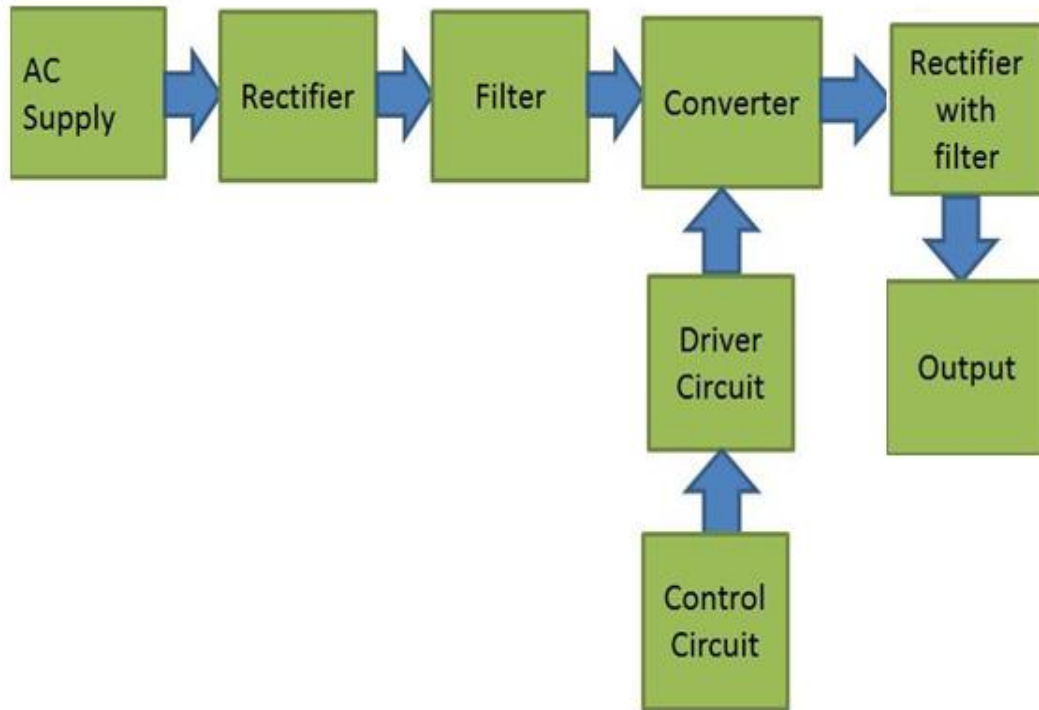


**Figure 1. Block Diagram of AC TO DC Converter**

Both converters operate in very similar ways except that the AC input voltage of the AC to DC converter has to be rectified to a DC voltage first. After which, the two converters function very much the same way. Figure: 1 shows the model diagram for simulation and hardware implementation of this concept. Rectifier designs have several topologies but they are common in the fact that a DC current is turned on and off producing a pulsed waveform through an inductor or transformer. The fundamental principle for the inductor topology is that current in an inductor cannot change instantaneously (based on Lenz's law). In most designs, the DC current passes through the primary side of the transformer when the switch is turned ON and the current has no path to continue when the switch is turned OFF. However, due to its inductive property the current cannot instantaneously, the energy that is previously built up in the transformer is transferred to the secondary side of the transformer [3]. By introducing the necessary circuitries (rectification, filters, DC to DC converter etc.) to the design, the converter can transform the input voltage from the mains to the desired output voltage on the secondary side of the transformer.

### III. SIMULATION AND RESULTS OF CONTROLLED DC

The given Figures show the exact simulation results from step to step conversion. Simulation is carried out using PSIM 6.0 Software tool. Each simulation is represented with its corresponding waveform. Entire simulation can be described in steps below.

#### A. Specifications:

- i. The AC input source is assumed to be ideal with nominal value,  $V_{in} = 230V_{rms}$ ;
  - ii. Line frequency,  $f = 50Hz$ ;
  - iii. Output power,  $P_{out} = 100\text{ W}$ ;
  - iv. Assuming an estimated efficiency of 80% for the SMPS,  $\eta_{est} = 80/100 = 0.8$
- Operating frequency of switching device,  $f_{sw} = 5\text{ KHz} - 10\text{ KHz}$

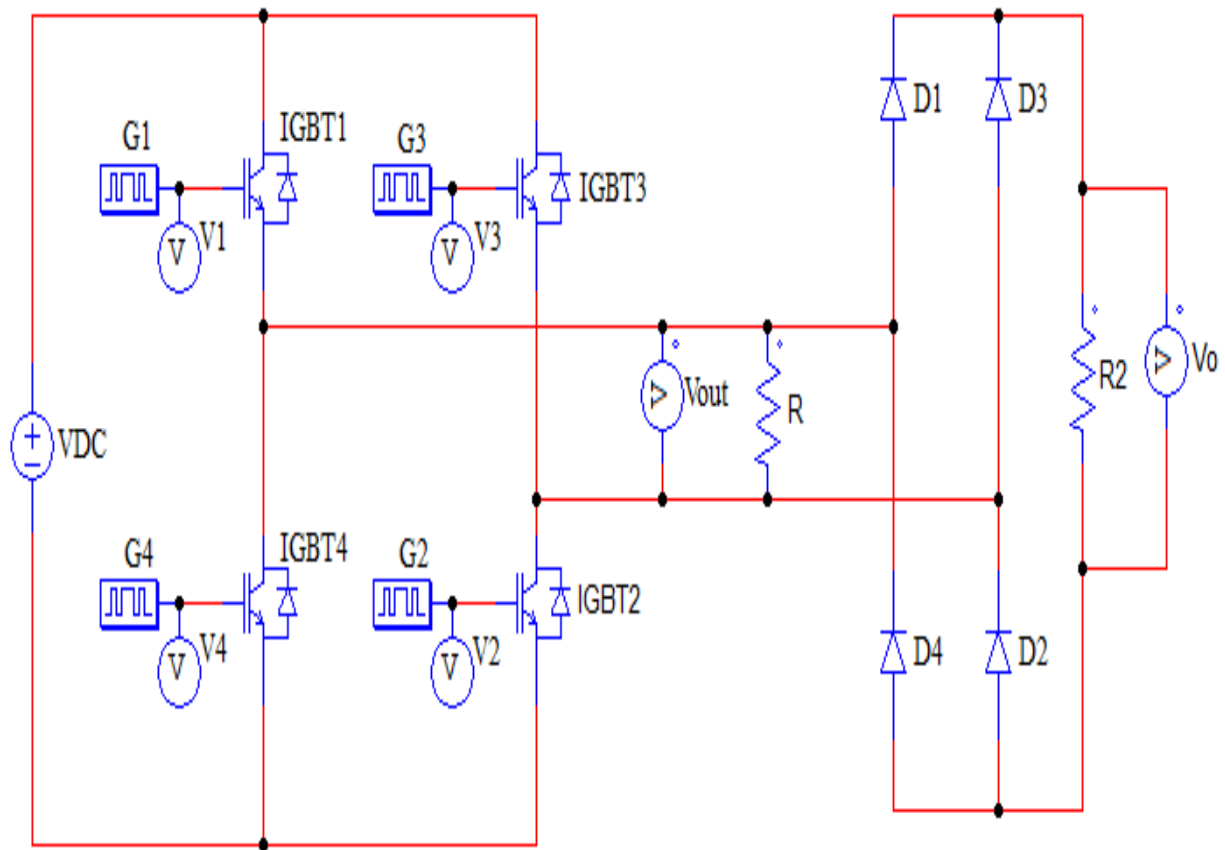


**Figure 3(a). Simulated circuit diagram of Full Bridge converter Circuit**

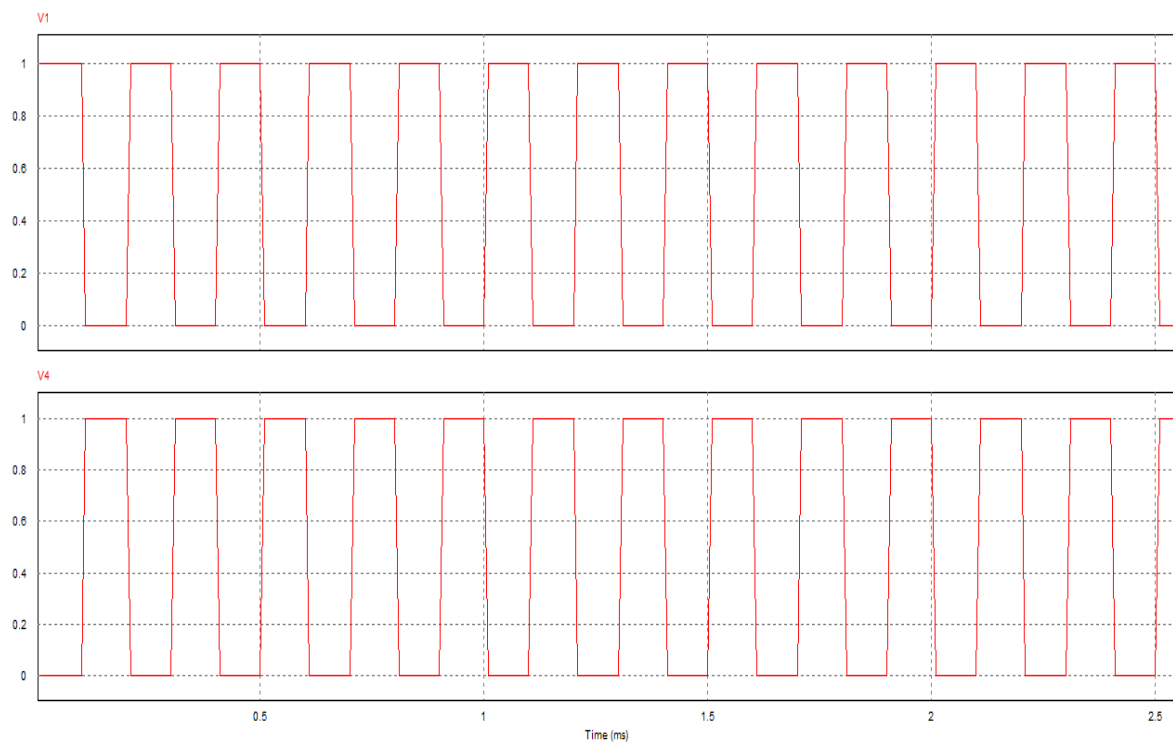


**Figure 3(b). Output result of Gate Signal at 5 KHz**

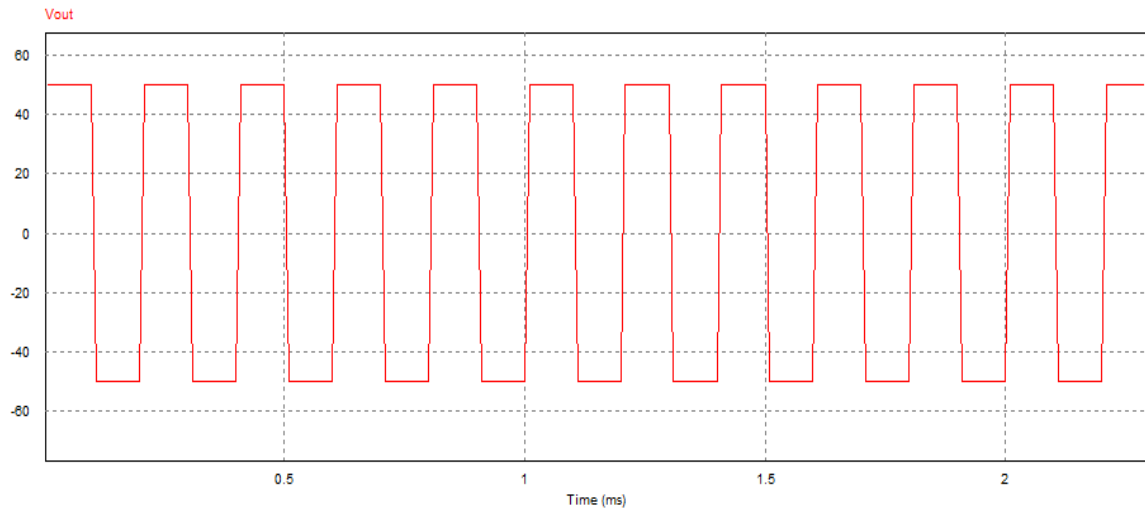


**Figure 3(c). Output result of High Frequency Inverter at 5 KHz**

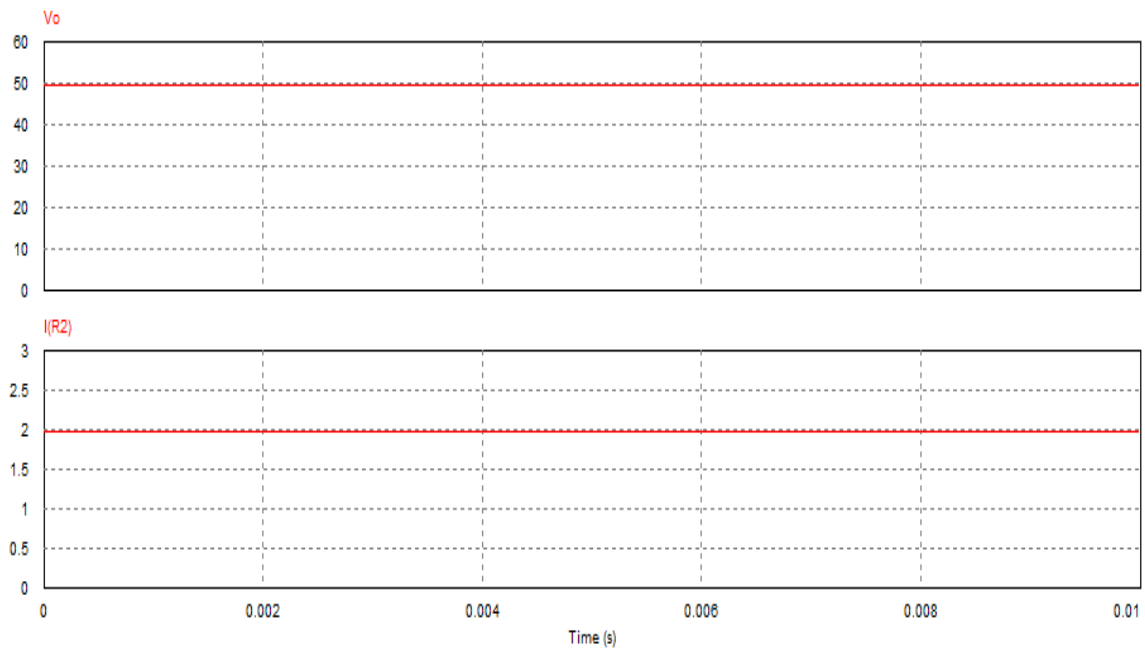


**Figure 3(d). Output result of high frequency rectifier o/p  $V_{out}$  &  $I_{out}$  at 5 KHz**

From different simulated result like gate pulse, inverter output voltage waveform and controlled DC voltage and current waveform of prototype is as above. Resulted output is possible to implement in hardware.

#### **IV. HARDWARE AND RESULTS OF CONTROLLED DC**

In prototype module tested at 60V and 5 KHz switching frequency. From this test satisfactory output result is achieved in control signal, dead band circuit and full bridge IGBT topology. High frequency rectifier result will be achieved successfully.

##### **A. Implementation of Control Circuits and result:-**

With the help of Arduino, the control circuit output signal is generated at 5 KHz. The Arduino used is ATMEGA328P. The output waveform of control circuit is shown below:

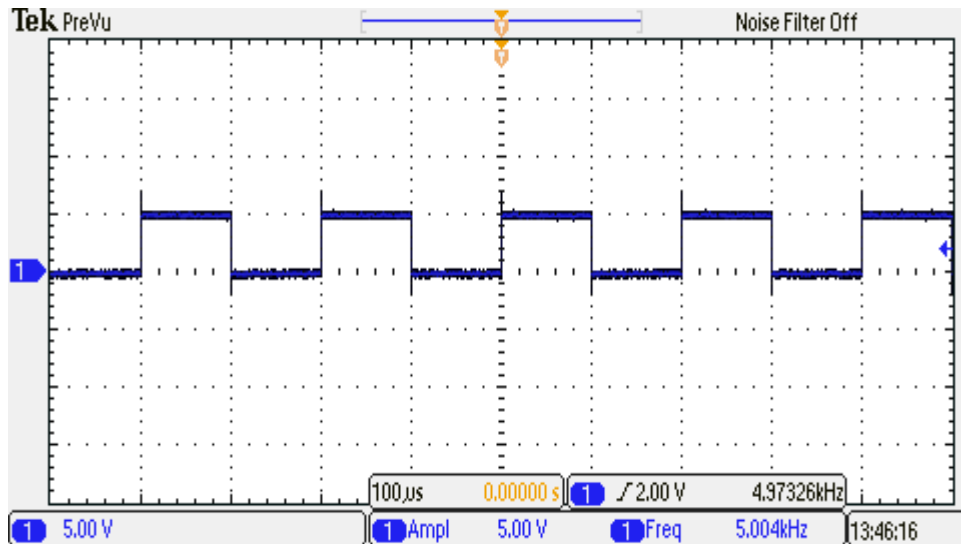


**Figure 4(a). Output result of control circuit at 5 KHz**

#### B. Implementation of Dead Band Circuit:-

Dead time generator is required to provide a delay of few microseconds in rising time of switching pulses. Logic for Dead time generator and schematic diagram of dead time generator circuit, which has been used, is shown in Figure: 4().

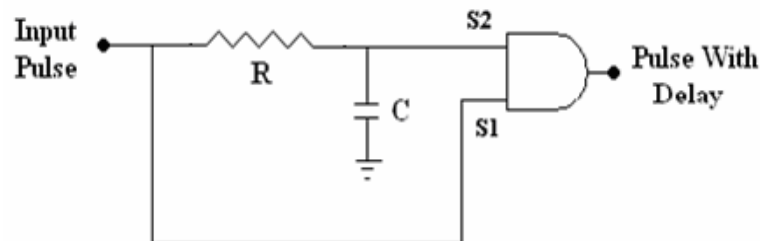


**Figure4(b). Dead time generator circuit**

In Figureure4 (1) input side square pulse S1 is applied. During on time of input pulse capacitor C will charge through the resistor R. In off condition capacitor C will discharge through the resistor [5]. So that discharging time will be reduce. By AND Gate signal S1 and S2 delay in rising time of pulse will generates shown in Figureure2 (f). Calculation for dead time is simply multiplication of R and C.

$$\text{Time Delay} = R \times C = 5K \times 470P = 2 \mu \text{ Sec}$$

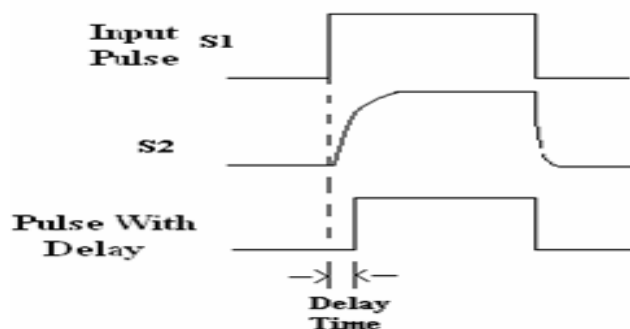


**Figure 4(c). Output result of Dead Time Generator**

With the help of NAND gate dead band is prepared between two compliment pulses, and through that dead band circuit of 2 microsecond dead band is set between rising and falling edge between two compliment pulses. Circuit diagram of dead band circuit

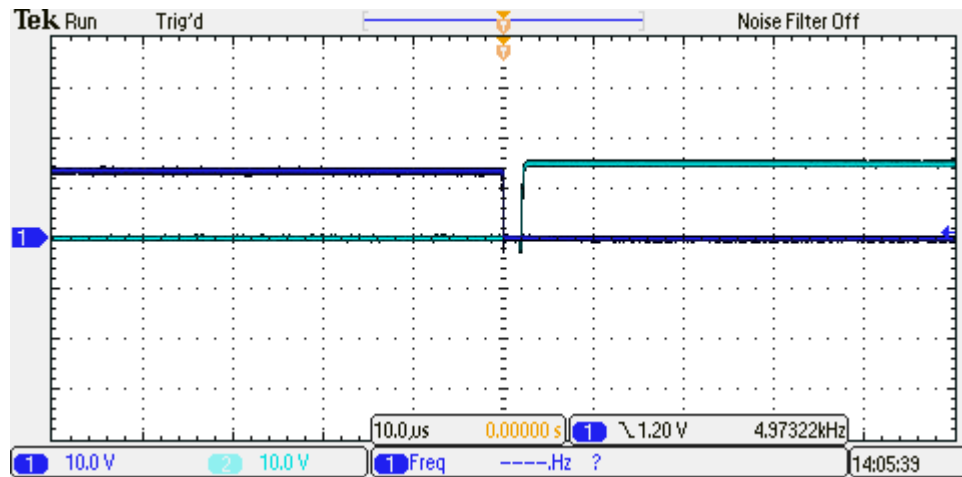


**Figure 4(d). Output result of dead band circuit at 5 KHz at raising edge**

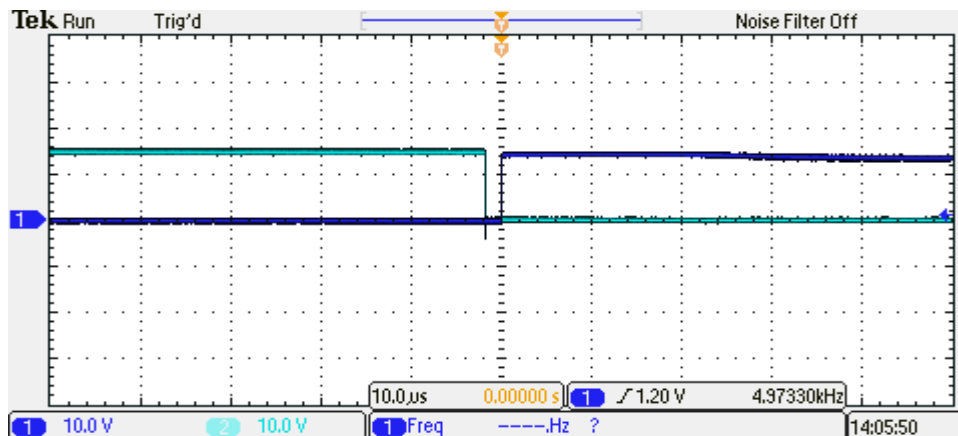


**Figure 4(e). Output result of dead band circuit at 5 KHz at falling edge**

#### C. Implementation of Driver Circuit:-

Isolation is required between control circuit and power circuit using 6N137 output isolated IC 2N2222 transistor driver circuit is prepared. Individual isolation is provided to each IGBT trough individual power supply. From driver circuit output is amplified to a signal at 15 V that is more than is enough to drive IGBT.

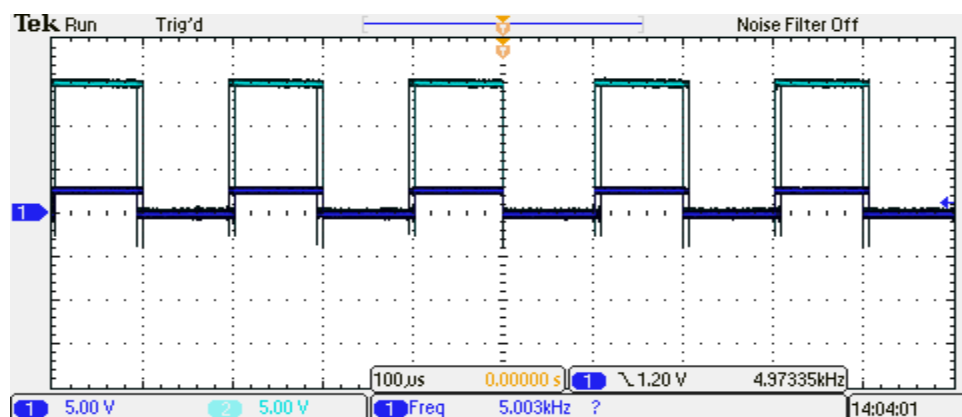


**Figure 4(f). Input and Output result of driver circuit at 5 KHz**

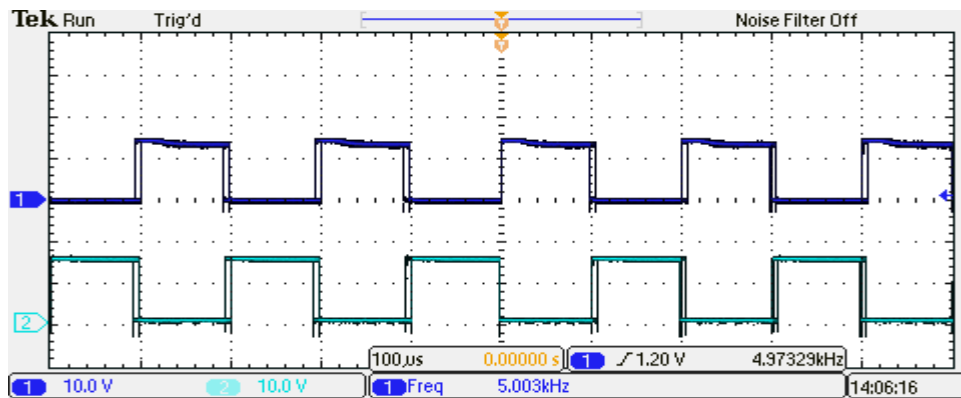


**Figure 4(g). Compliment Output result of driver circuit at 5 KHz**

**D. Implementation of Full wave Bridge Circuit:-**

This entire circuit is built on IGBT which is used in our circuit namely FGA25N120ANTD. The output wave form for the full wave bridge circuit is shown as below:

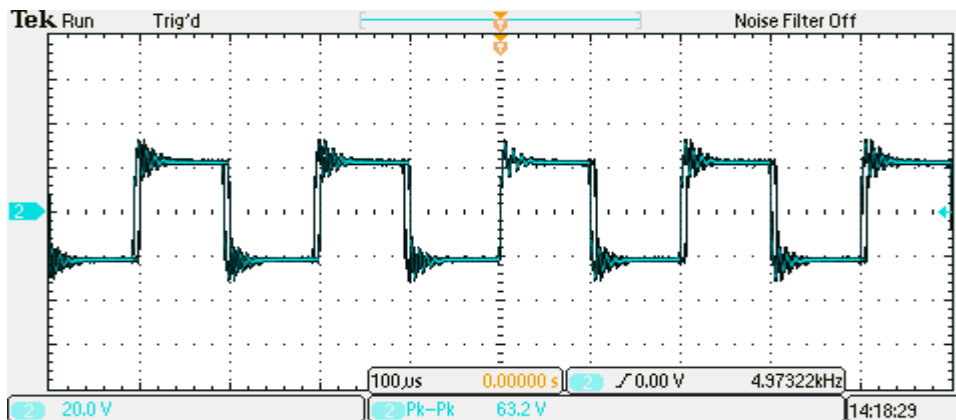


**Figure 4(h). Output result of Full Wave Inverter at 5 KHz**

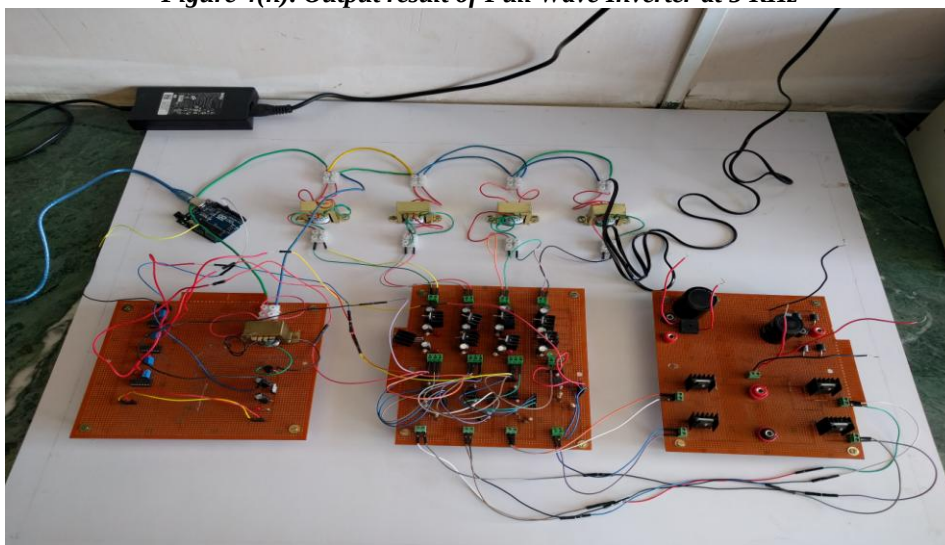


**Figure 4(i). Pictorial view of prototype**

## **V. CONCLUSION**

The background regarding various aspects of controlled DC was studied. The carrier based project was simulated on PSIM. Hardware contains of converter circuits and its control. As a reference of simulated results and its implementation is quite much similar. From various trouble shooting done during hardware implementation of this concept like ringing effect, dead band effect, change in switching frequency, etc. Arduino is more suitable to generate this type of varying frequency signal. Also, output voltage varies while changing different frequency, but during at high frequency level it doesn't suit our prototype. It is also possible to implement this concept at higher rating with compact system. Hence, for speed control of motor and SMPS concept is recommended.

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