

Power Converter Dual Functions Using Full Bridge Converter Controlled by Microcontroller Arduino

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Abstract: The power converter is one of the essential components in every aspect of our everyday lives. Power converter dual functions using full bridges converter controlled by Microcontroller Arduino project is proposed. The purpose of project is to design a multipurpose converter that produced AC output and DC output. Microcontroller Arduino Uno based gate pulse generation is used for firing the power electronic switching by using the power MOSFET IRF540 powered by 12 Volts DC Battery. Arduino transmits PWM signal to the gate of full bridge type of MOSFET. MOSFET driver IR2112 used for the switching of discrete power MOSFET ON and OFF state using low voltage input in high voltage applications. PWM operation of the full bridge converter will have the high sides and low sides of the switching circuit. This converter will generate AC output and DC output in of form forward motoring mode and DC output in form of forward regeneration braking mode.

Keywords: Power Converter, Dual Functions, MOSFET, Full Bridge, Arduino Uno, PWM Signal, Switching

1. Introduction

In this 21 century era, power converter is one of the important role in almost all parts of our daily life. The great advantage of power converter is that it's ability to optimize the specific load by changing the electric energy from one form into the desired form in electrical circuit. The important of DC-DC converter is takes the voltage from a DC source and converts the voltage of supply into another DC voltage level. DC to DC converter is commonly used especially by in all electronic, telecommunication, automation etc. The performance of these applications will be improved if a variable DC supply is used. It will help to improve controllability of the equipment. DC-DC converter topologies to increase the input source voltage[1]. In fact, to control the converter, there are two common approaches are used such as Hysteretic PWM control and one cycle control (OCC). Hence, these converters can also be applied to other methods such as conventional PWM and PI-controllers[2]. Next, inverter is widely

used in renewable energy such as Photovoltaic (PV) and wind power generation sources which is getting much more focus in an economical point of view due to the pollution increasingly extremely throughout the world caused from fossil fuels are draining and traditional power generation[3]. Inverter is used to convert DC voltage to AC voltage. Then, to fulfil market and consumer demands, converter with dual functions as DC-DC converter and inverter should be constructed for cost efficient use.

The project is convenient to implement in an electrical circuit by using four MOSFET arranged in full bridge type inverter circuit. Arduino which has programmed to send a PWM signal for the switching of MOSFET through the MOSFET drivers. The operation is based on the load type, for AC load type, the dual functions converter will convert DC input to AC output. For DC load type, the switch button need to push to trigger for Arduino to control the dual function converter to convert DC input to DC output of forward motoring and forward regeneration braking mode. This project causes convenient implementation for the power converter.

However, power converter which is converted from DC to AC voltage and use to convert from DC to DC voltage is not commonly used. Every time the load changed; the converter needs to change too. This operation may waste the time to install the new suitable converter based on the type of load used. After that, buying new converter every time the load changed is wasting the funds. These projects assemble to avoid that problem above because this converter as dual function can operate as DC-DC converter and inverter based to load.

The objective of the project is to generate switching algorithm using Arduino and to design and construct a dual functions power converter. Next, to develop a trainer kit for education purpose and to develop Fourth-Quadrant Chopper Drive that can be applied to electric vehicles.

2. Methodology

The main supply that has been used in this project is a 12 Volts battery. The 12 Volts battery generates DC voltage to the full bridge converter. Microcontroller Arduino connected with Push Button and connected to MOSFET drivers for amplifying the low power input and produce a high current drive input. Then the signal will transmit to each gate of fours transistor MOSFET in the full bridge converter. Figure 1 is shows the Full Bridge converter circuit.

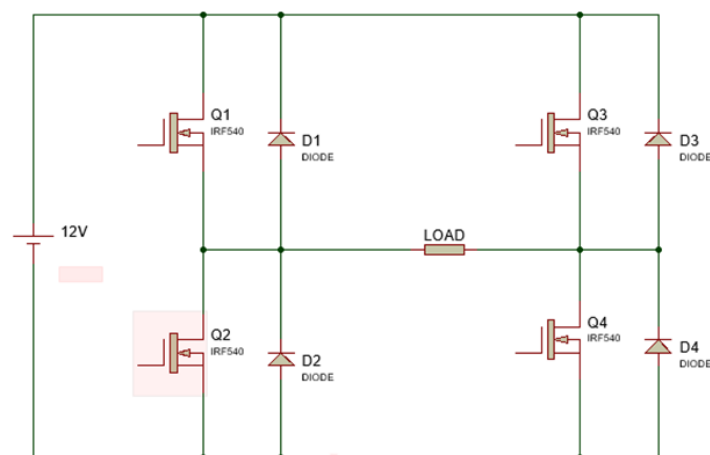


Figure 1: Full Bridge converter circuit

Microcontroller Arduino transmits PWM signal to the converter which is to the four MOSFET. IR2112 MOSFET driver used to amplifying the low power input and produces a high current drive input.

To generate AC output, Q1 and Q4 receive PWM signal and they are in ON state. Current will pass through from Q1 to the load then to the Q4 and to the ground. Next Q2 and Q3 receive PWM signal and they are ON state. Current will pass through from Q3 to the load then to the Q2 and to the ground. The ON/OFF state Q1 and Q4 vice versa with Q2 and Q4.

In fact, to generate DC output in form of forward motoring, push button 1 is pushed then Q1 and Q4 receive PWM signal and they are in ON state. Current will pass through from Q1 to the load then to the Q4 and to the ground. Output voltage and the output current both are positive. The DC output of forward motoring will generate.

In order to generate DC output of forward regeneration braking the push button 2 is pushed, Q2 receive PWM signal and in ON state while Q1, Q3, Q4 is in OFF state and generate current and torque in negative direction. The energy flow will return back to supply through D1, D4. Figure 2 illustrate overview of block diagram.

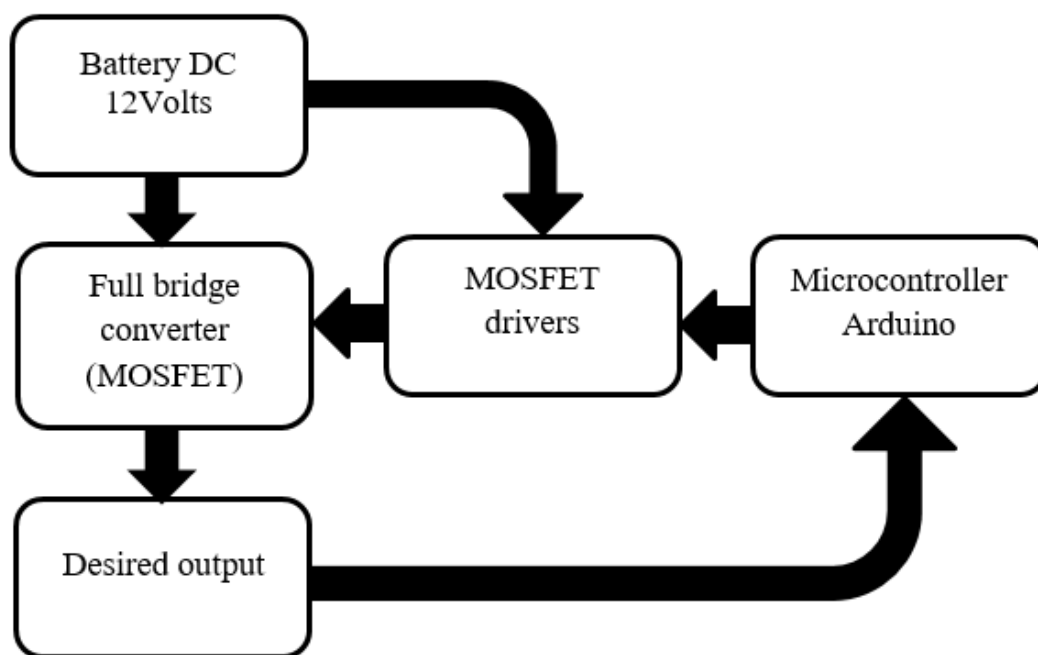


Figure 2: Project block diagram

2.1 Flow Chart

Designing a flow chart is really needed to make sure the project is done properly and following the procedure. This project using a full bridge MOSFET as the main component for switching process. This full bridge MOSFET received PWM signal from Arduino to each gate of MOSFET through the MOSFET drivers. Then, from the switching process, the desired output will generate such as DC output and AC output. Figure 3 illustrate the flow chart of the project.

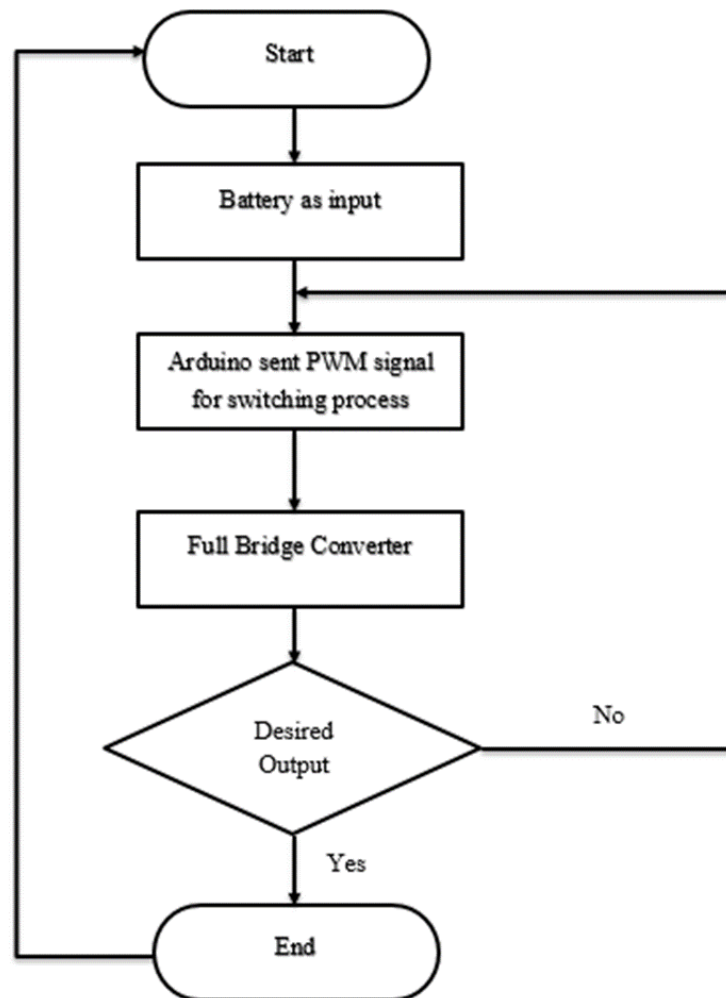


Figure 3: Flowchart diagram of project

2.2 Project Design

The development formed for Arduino IDE and Proteus are to make sure the system can cooperate as desired. The desired coding created using Arduino IDE while the circuit wiring designed using Proteus software.

2.2.1 Arduino IDE

The coding for power converter dual functions created using Arduino IDE. The coding then uploads and verify to the Arduino Kit. Besides, before proceeding to hardware, the coding of this Arduino uploads at the Arduino in Proteus software. Figure 4 show the software of Arduino IDE.

```

void setup()
{
  pinMode(10,OUTPUT); // set pin 10 as output
  pinMode(9, OUTPUT); // set pin 9 as output

  pinMode(6,OUTPUT); // set pin 6 as output
  pinMode(5, OUTPUT); // set pin 5 as output
}

void loop()
{
  int bt1 = digitalRead(A0); // set pin A0 as input (Button switch)
  int bt2 = digitalRead(A1); // set pin A1 as input (Button Regen braking)

  if(bt1 == HIGH) // if push button pushed set for DC output
  {
    //positive cycle
    digitalWrite(10,HIGH);
    digitalWrite(6,HIGH);
  }
}

```

Figure 4: Coding created using Arduino IDE

2.2.2 Proteus Software

The circuit of the project is designed in Proteus software in order to analyze the result of the dual functions converter. Figure 5 show the Proteus software.

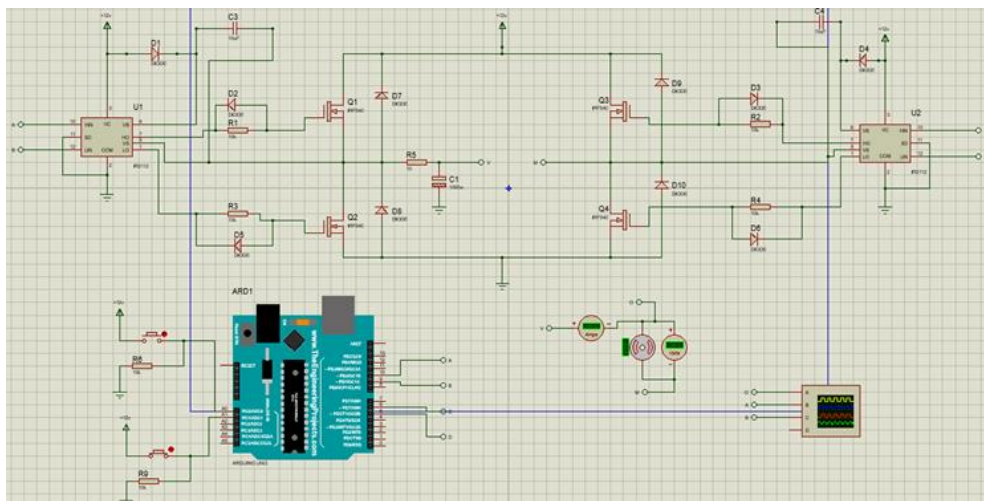


Figure 5: Overall circuit diagram for Power Converter Dual functions using full bridge MOSFET controlled by Microcontroller Arduino

3. Results and Discussion

This chapter provides the explanations of the result of this project and discussion which included the combination software of Arduino IDE and Proteus Software and the prototype used in this project. The coding of the process for dual converter has to be successful transmit the data to the Arduino Uno.

3.1 Coding uploads in Arduino IDE

The full Coding of Power converter dual functions programming is applied and burned to the simulation of Proteus Software and the Prototype of the project.

3.2 Simulation Result

The result is based on the simulation of the project using Proteus software to analyze the result.

3.2.1 Simulation Results of AC output

Assume that the load is AC load type. The aim of this simulation is the dual converter will convert DC input to AC output waveform and function as an inverter. Figure 6 show the result of current output and voltage output while Figure 7 shows the result of AC output waveform from the simulation of the circuit.

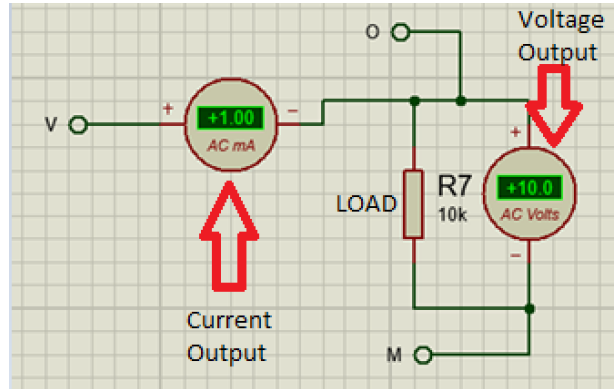


Figure 6: Voltmeter and ammeter show AC output

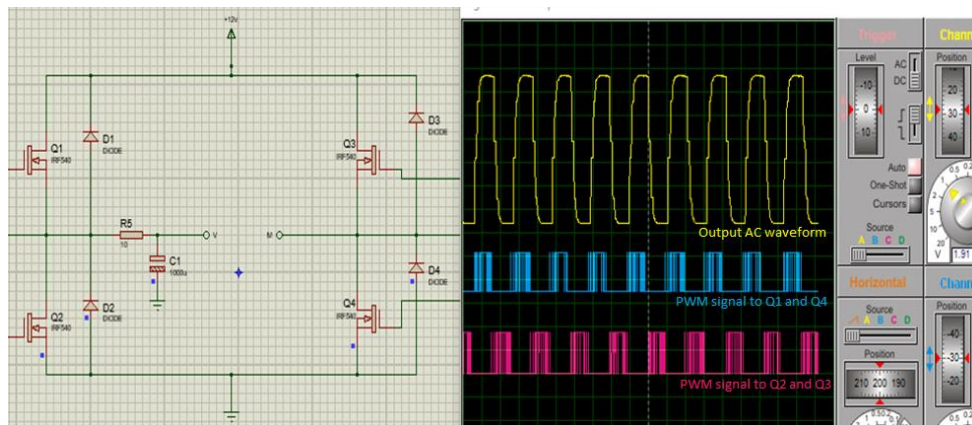


Figure 7: Waveform of AC output

The observation from the simulation, the data of Voltage output and percentage of the duty cycle is collected for the analysis. Figure 8 and Table 1 shows that how the percentage of duty cycle of PWM signal from Microcontroller Arduino Uno affecting the voltage output of AC. The percent of duty cycle is set from 10 % until 100 % is for generating a sinewave. By implementing that, the curve of a waveform can be achieved by adding of resistor and capacitor for filtering the square waveform.

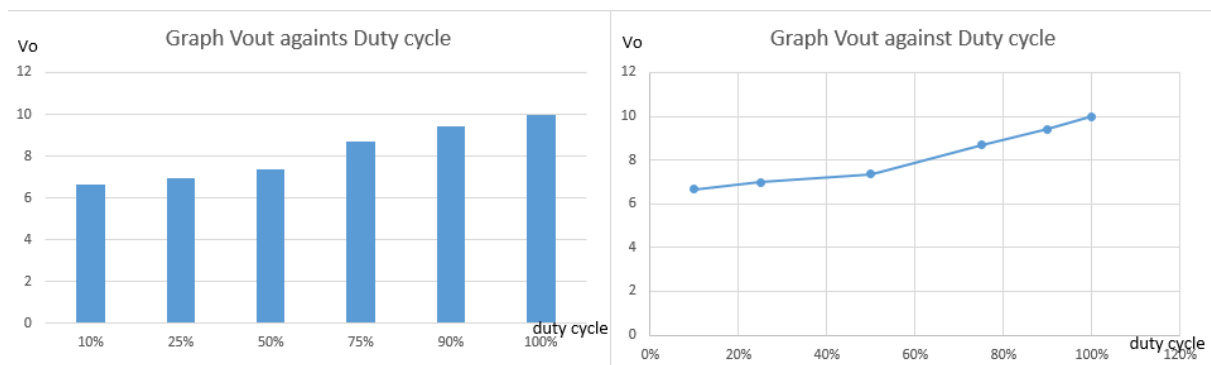


Figure 8: Voltage output against duty cycle

Table 1: Duty cycle and Voltage output

Duty cycle, %	Voltage output, V
10	6.67
25	6.97
50	7.37
75	8.70
90	9.40
100	10.00

3.2.2 Simulation Results of DC output in form of Forward Motoring mode

Assume the load is changed to DC load type, the load is DC motor. The aim of the simulation is the dual converter function as DC Chopper to convert DC to DC output in form of forward motoring mode. Figure 9 shows the result current output and voltage output while Figure 10 shows the result of DC output waveform of Forward Motoring mode from the simulation of the circuit.

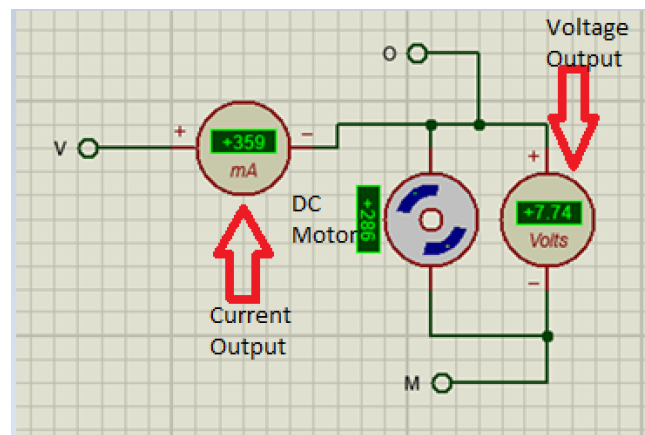


Figure 9: Voltmeter and ammeter show DC output in form of Forward Motoring mode

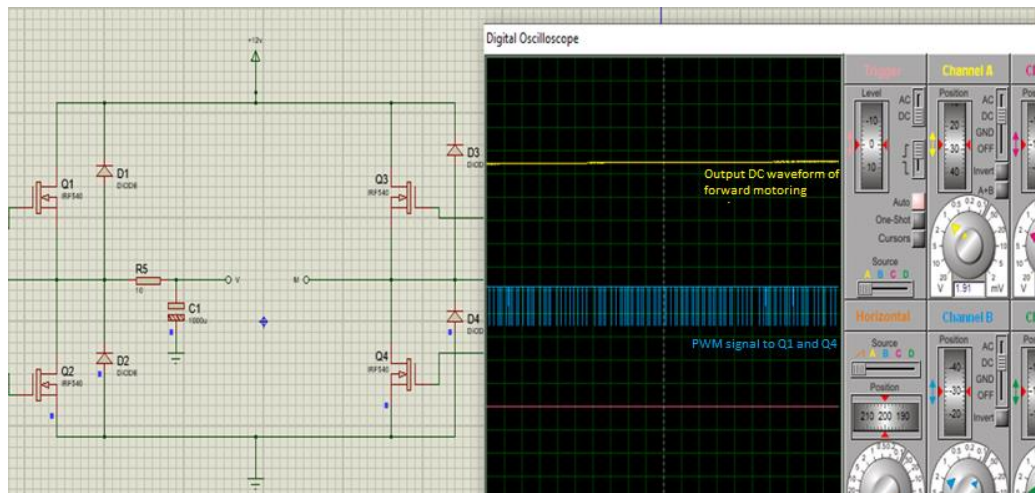


Figure 10: Waveform of DC output in form of Forward Motoring mode

From observation from the simulation, the data of Voltage output and the Current output is collected for the analysis. Figure 11 and Table 2 shows that how the voltage output affecting to the current output of forward motoring mode. The current output will decrease when the voltage output increase to rotating of DC motor.

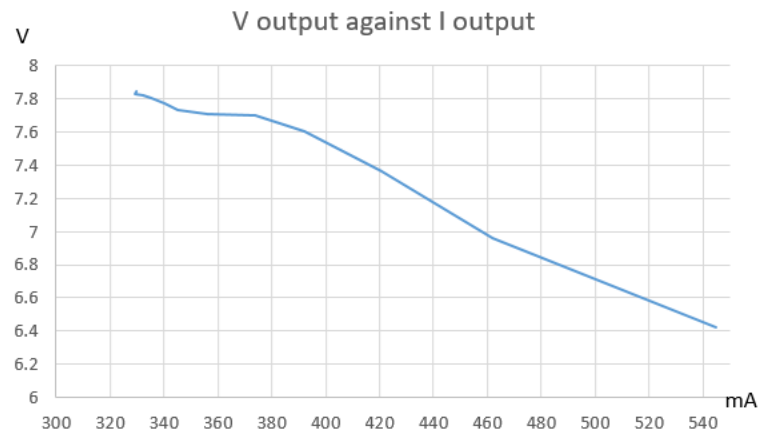


Figure 11: Graph of Voltage output against Current output

Table 2: Current output and voltage output

Voltage output, V	Current output, mA
6.42	545
6.96	462
7.36	421
7.6	392
7.7	374
7.71	356
7.73	345
7.77	340
7.8	335
7.82	332
7.83	329
7.84	330

3.2.3 Simulation Results of DC output in form of Forward Regeneration Braking mode

From the forward motoring mode, in order to brake or stop the motor, the aim for the simulation is dual converter function as DC Chopper of forward regeneration braking mode. Figure 12 shows the result of regenerative current and the voltage output while Figure 13 is the result of DC output waveform of Forward Regeneration Braking mode.

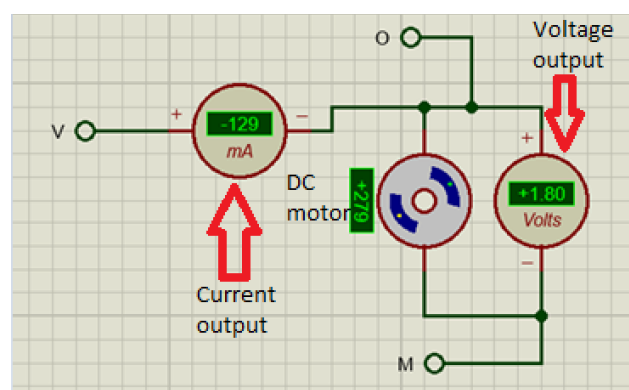


Figure 12: Voltmeter and ammeter show DC output in form of Forward Regeneration Braking mode

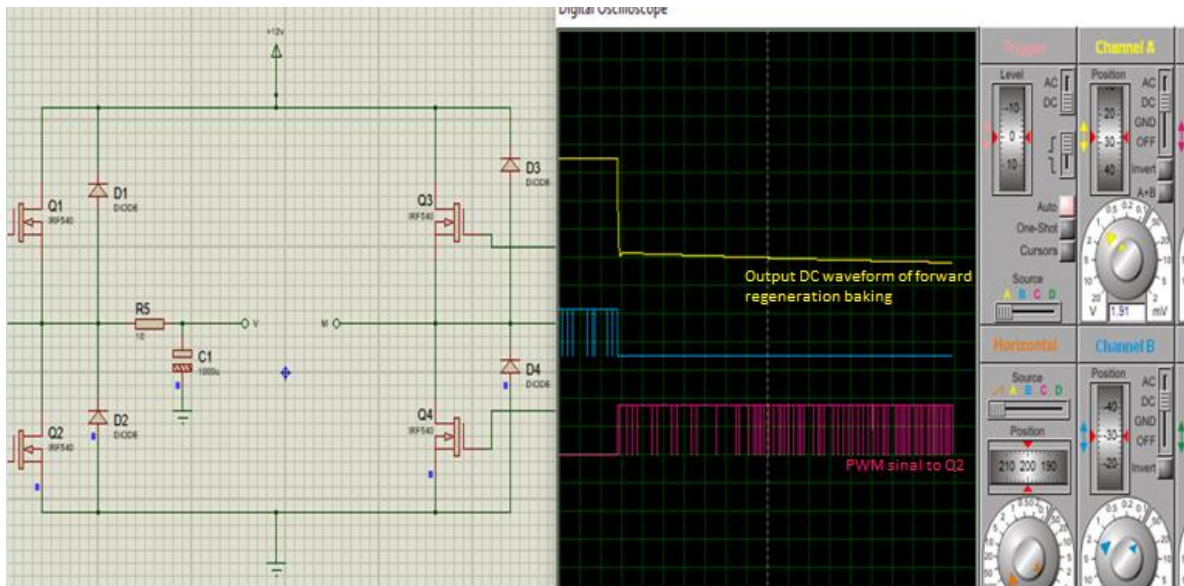


Figure 13: Waveform of DC output in form of Forward Regeneration Braking mode

From observation from the simulation, the data of Voltage output and the Regenerative current is collected for the analysis. Figure 14 and Table 3 show the regenerative current generate by motor that control by voltage output. The current will supply back to the main source. Regenerative current decrease when the voltage output decrease then DC motor will stop.

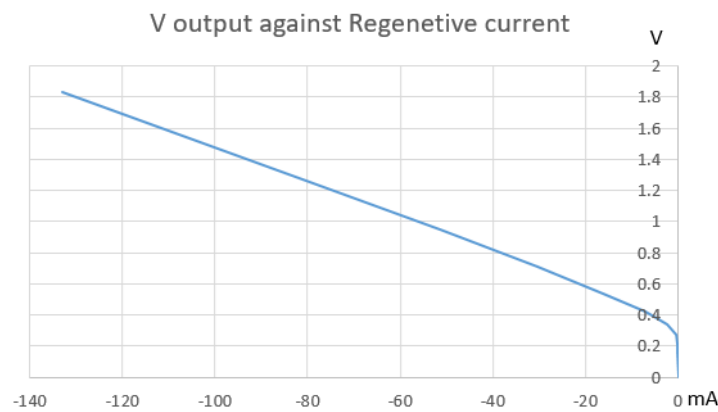


Figure 14: Graph of Voltage output against Regenitive current

Table 3: Regenerative current and Voltage output

Voltage output, V	Regenerative current, mA
1.83	-133
1.27	-81.1
0.95	-51.4
0.71	-30.4
0.54	-16.2
0.42	-7.02
0.34	-2.23
0.27	-0.29
0.2	-0.03
0.15	-0.01
0	0

3.3 Prototype of the Project

The prototype is developed by using bread board to connect the connection of circuit. Figure 15 and Figure 16 show the prototype of the project.

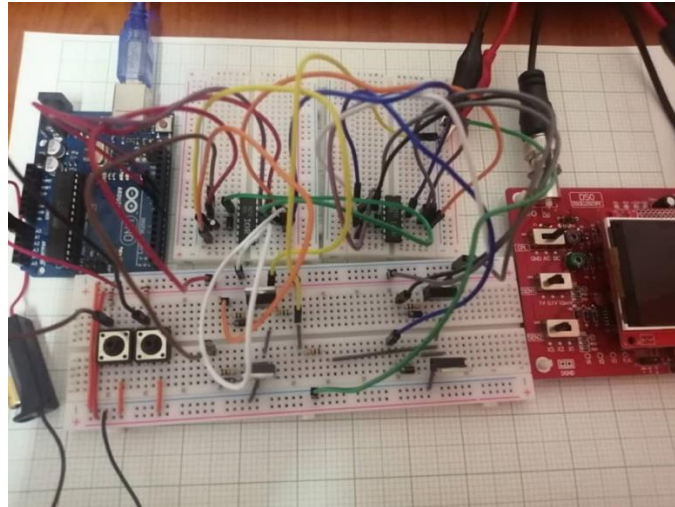


Figure 15: The top of the prototype

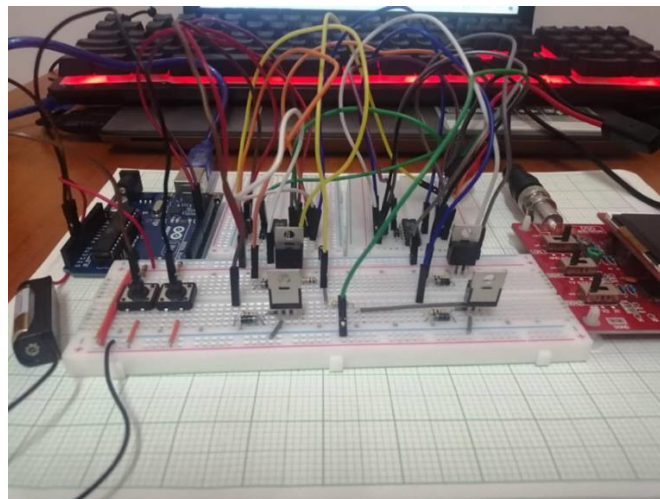


Figure 16: The front of the prototype

3.3.1 Result from the Prototype of the Project

The objective to analyzed result from the prototype as an expected result from the simulation of the circuit to achieve waveforms from these dual functions converter using full bridge converter is not obtained because there is a technical problem that occurs. The problem is the mini digital oscilloscope model DSO brand of OEM is not function well. It is because the oscilloscope doesn't show the display and only displays a "white screen" when supplied with a 9 Volt battery. Figure 17 show the display from mini digital oscilloscope.

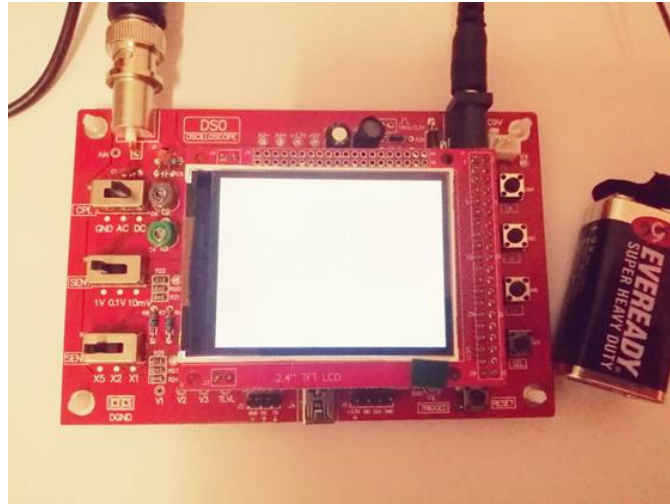


Figure 17: “White screen” display from the mini digital oscilloscope

4. Conclusion

In conclusion, power converter dual functions using full bridge converter controlled by Microcontroller Arduino have presented. The dual functions converter is relevant to design because it can give a big contribution to electrical systems. This project has good features such as, convenient to implement in an electrical circuit. The Arduino is able to provide PWM signal for generate switching algorithm. This project is able to construct and designed a dual functions power converter. Trainer kits for education purposes and for electric vehicles such as for electric cars and electric motorcycles can be done with this converter. Overall, the design implementations proved that dual functions converter can converted AC and DC output from DC supply such as 12 Volts Battery. The objective of the project had been achieved but the aim to analyze result from the prototype as an expected result from the simulation has not been obtained because there is a technical problem that occurs.

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