



**Birzeit University**  
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**“Power Electronics Converters and Amplifiers”**

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# *Abstract*

**In this experiment OrCAD software was used in order to design and simulate several different circuits. We used to simulate power electronics circuits to study its characteristics and responses in different cases for different inputs. Its wide range library helped us in designing easily any digital or analog components and we used it as well to compare between closed loop and open loop amplifiers characteristics.**

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# Chapter 1

## Introduction

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The main purpose of this experiment was to get familiar with OrCAD software due to its major importance in electrical engineering applications. It will be used to study the Buck Boost converter for example and the effect of changing the load and the duty cycle for the converters and other several tools.



*Fig. 1.1: OrCAD Logo*

Capture was used to draw a circuit on the screen, known formally as schematic capture. It offers great flexibility compared with a traditional pencil and paper drawing, as design changes can be incorporated and errors corrected quickly and easily. While, Pspice simulates the captured circuit. We could analyze its behavior in many ways and confirm that it performs as specified.

The programs communicate using files called netlists but you should never need to look at them – everything happens transparently.[1]

# Chapter 2

## Procedure and Results

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To start the experiment a new project was created. In order to create a new project, these steps were followed, first from start menu Programs>> OrCAD >> Capture. Then the program starts, File >> New >> Project. Finally, a pop-up window will appear, Mixed A/D was chosen, and the name of the project to be filled then the directory where the project was chosen then OK.

### 2.1 Modular Design

Two different circuits were drawn in different schematics in order to design the amplifier. The modules in the next two figures were saved as “lowfirst.sch” and “lowsecond.sch” respectively.

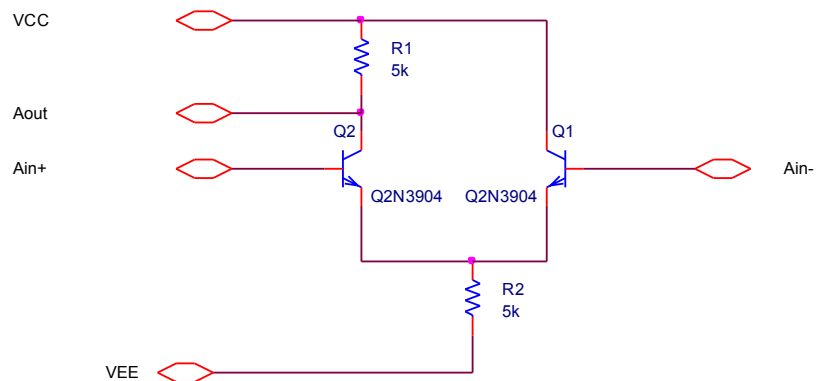


Fig. 2.1: Low First Schematic

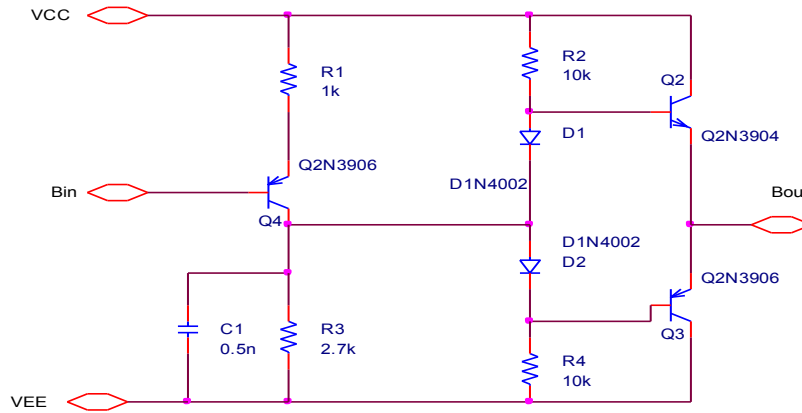


Fig. 2.2: Low Second Schematic

## 2.2 Open Loop Amplifier

In order to design a BJT amplifier, a new schematic was opened and named “top.sch”, then the following circuit was drawn:

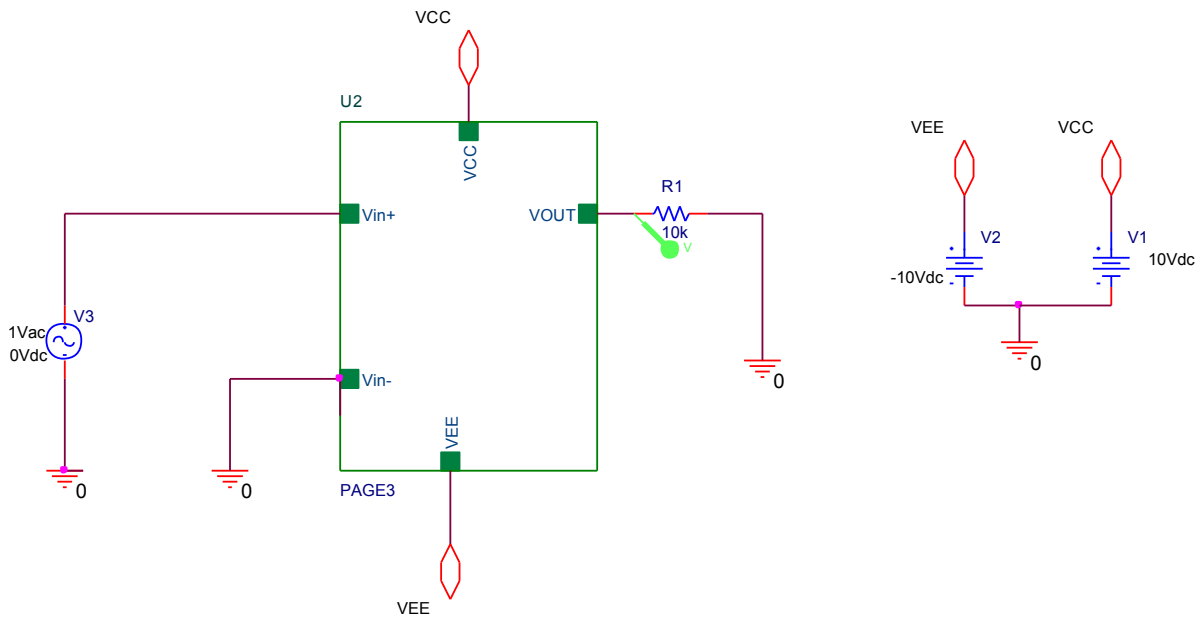


Fig. 2.3: BJT Amplifier Circuit

Then the “middle schematic” was drawn using two Hierarchical Blocks as in the following figure :



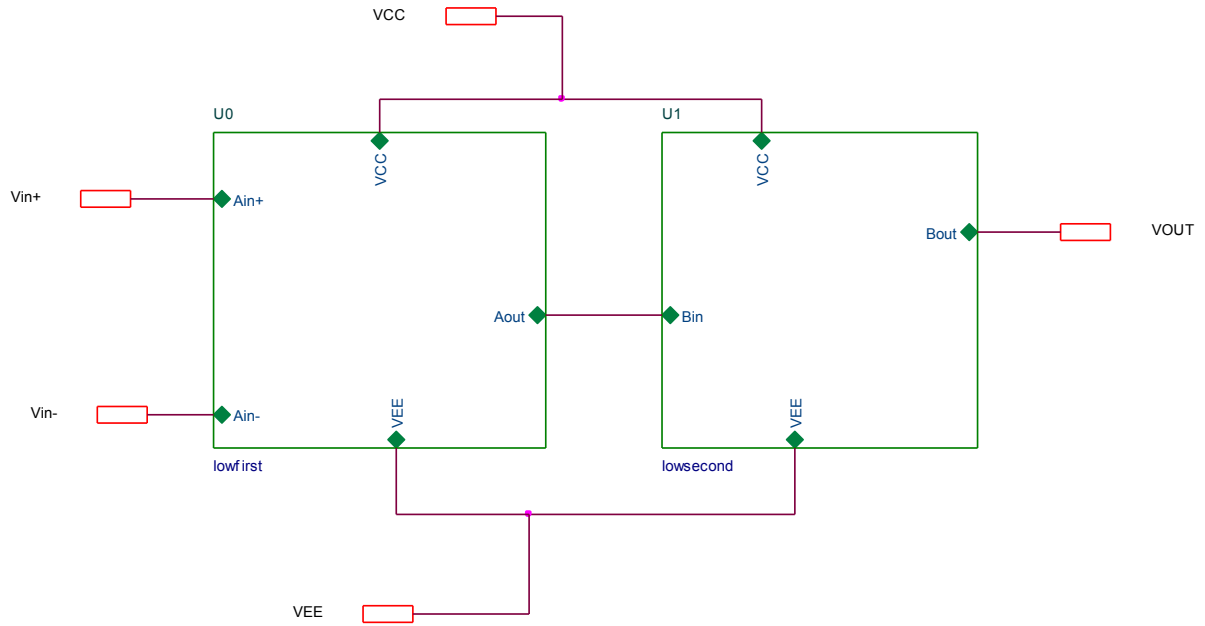


Fig. 2.4: Middle Schematic Circuit

Using AC Sweep , the response of the open loop amplifier when the input voltage =1 V and due to R1 were analysed as follows :

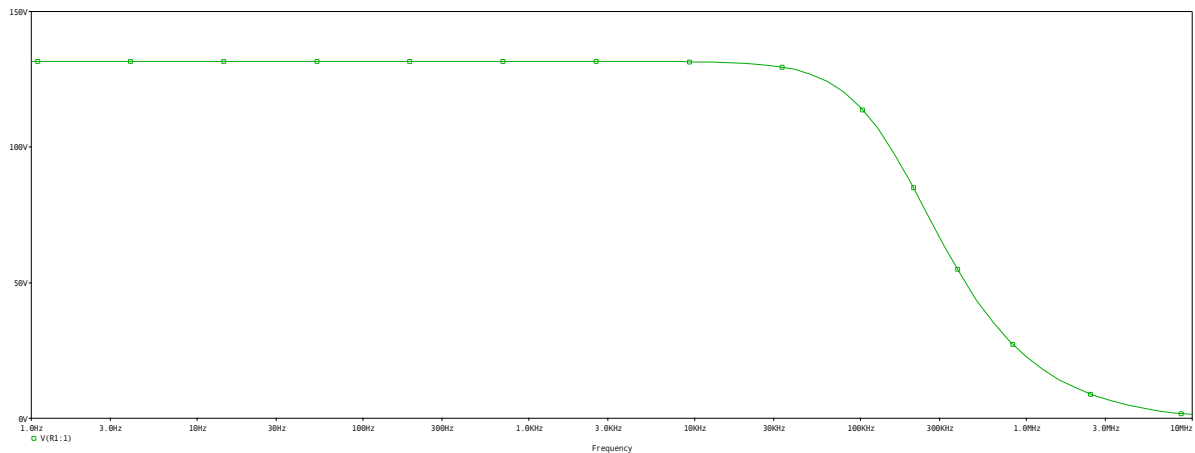


Fig. 2.5: Open Loop Amplifier Response

To find the corresponding frequency to the maximum gain, the bandwidth was found as follows:

$$\text{Bandwidth} = \text{Gain} \times 0.7$$

The Maximum gain is equal to 130, then the Bandwidth is equal to 91. The corresponding frequency is almost 180 kHz

The input Impedance of the Amplifier was found to be 9 kOhm. To find the output impedance, we replace the output of the amplifier by the input voltage and the input voltage is shorted, then the output voltage was found to be equal to almost 600 Ohm.

## 2.3 Negative Feed Back Amplifier

In order to design a negative feed back amplifier, a multistage amplifier circuit was drawn and built in a chematic window as follows :

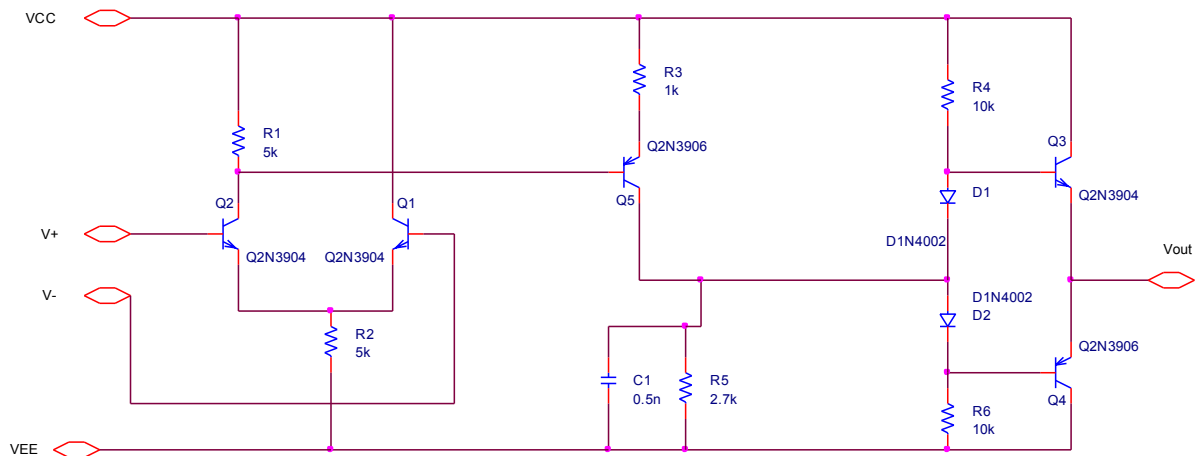


Fig. 2.6: Multi-Stage Amplifier Circuit

To add it to the OrCAD library and use it in any design we desire, a sub circuit was made, in order to do this, the schematic of the circuit was chosen then Tools → Generate part.

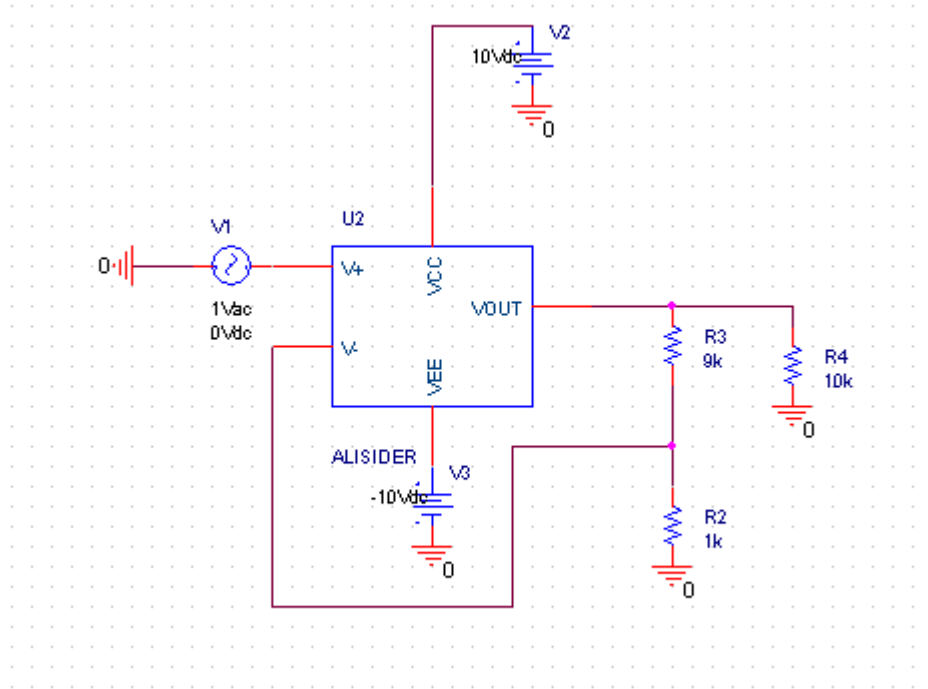


Fig. 2.7: Negative Feed Back Amplifier Circuit

The response of the negative feedback amplifier is show in the next figure:

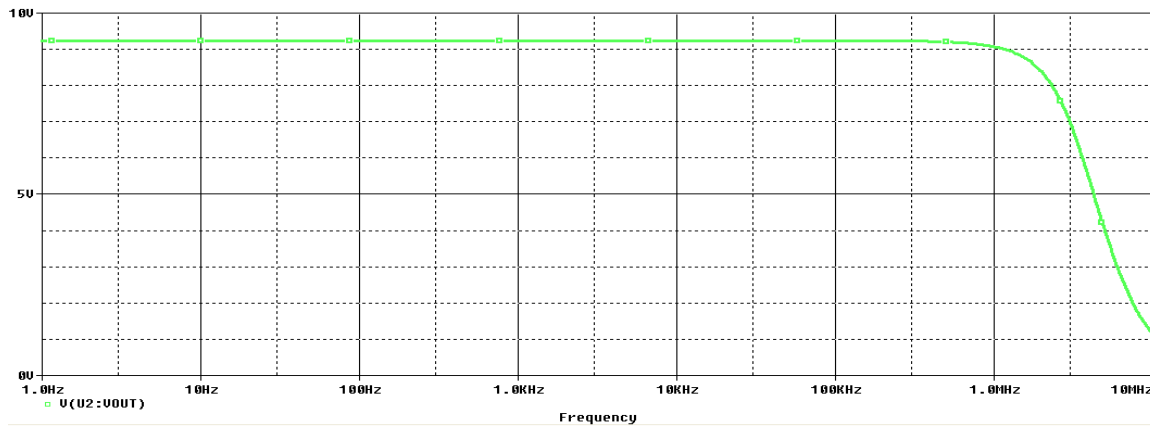


Fig. 2.8: Negative Feed Back Amplifier Response

To find the corresponding frequency to the maximum gain, the bandwidth was found as follows:

$$\text{Bandwidth} = \text{Gain} \times 0.7$$

The Maximum gain is equal to 9.25, then the Bandwidth is equal to 6.6 . The corresponding frequency is almost 3.2 MHz

The input Impedance of the Amplifier was found to be 5.6 kOhm. To find the output impedance, we replace the output of the amplifier by the input voltage and the input voltage is shorted, then the output voltage was found to be equal to almost 220 ohm .

We can notice that the gain decreases if the load impedance decreases and the input impedance decreases as well but in the negative feedback amplifier the gain is much smaller and the bandwidth remains constant.

## 2.4 Step Down Converter

The Circuit of the step down converter was built as shown in the next figure:

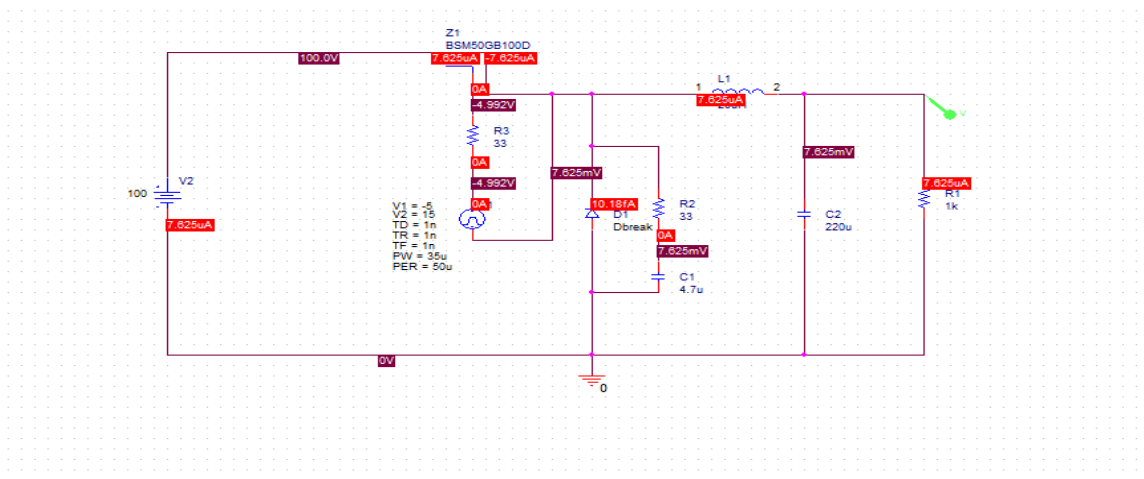


Fig. 2.9: step down converter

At duty cycle equal to 50%, the PW was set to be equal to 25u and the output voltage and its average, the IGBT Current, The Gate current, and V<sub>CE</sub> are shown in the next figures respectively:

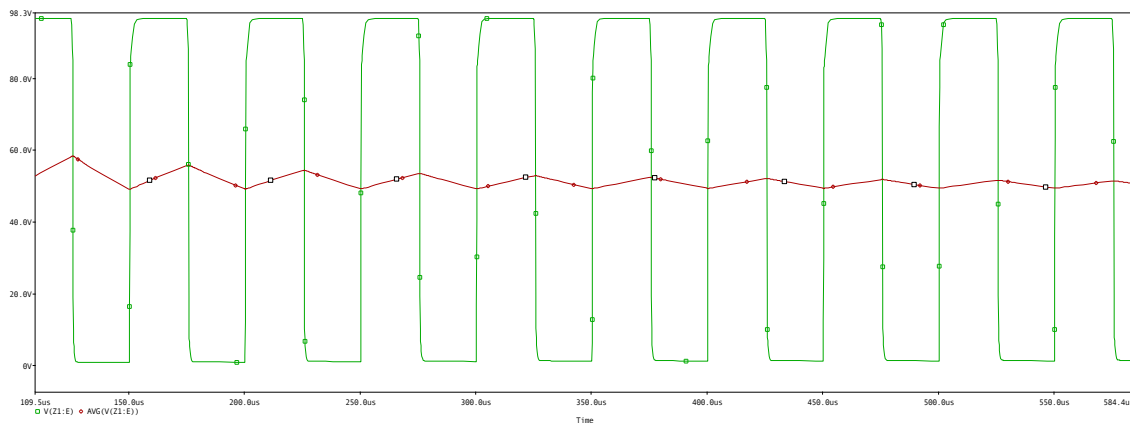


Fig. 2.10: output Voltage and its average for 50% duty cycle.

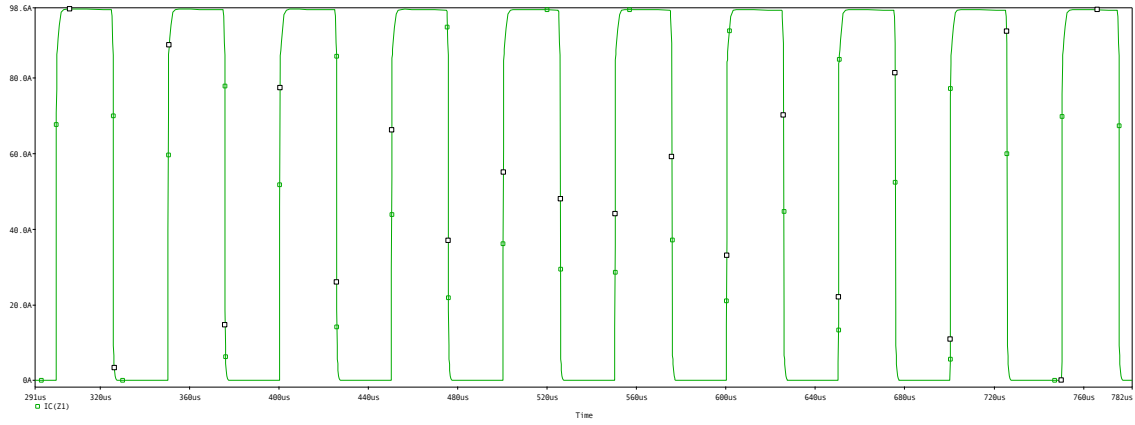


Fig. 2.11: IGBT Current for 50% duty cycle.

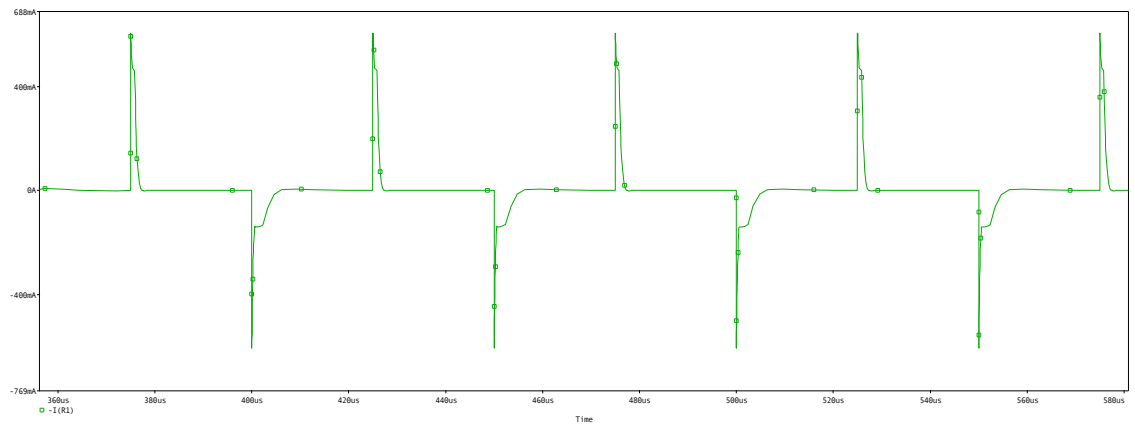


Fig. 2.12: Gate Current for 50% duty cycle.

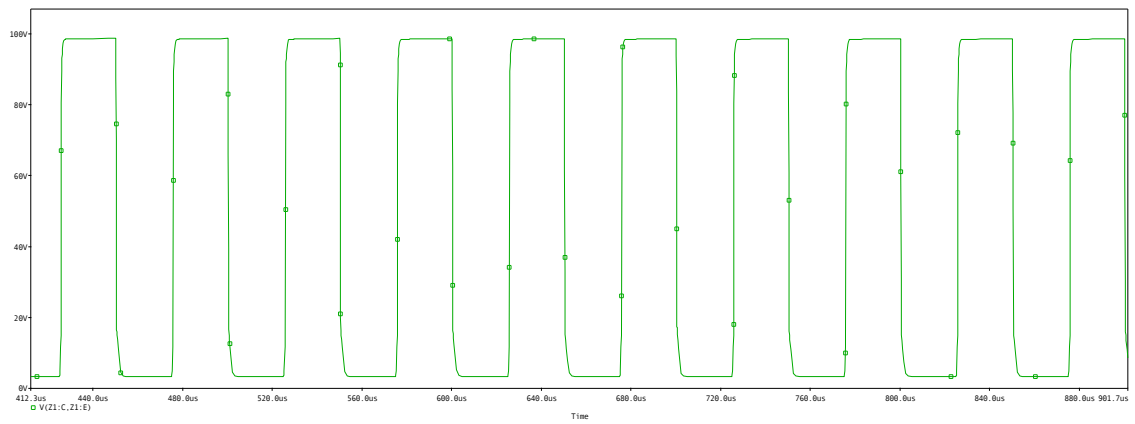


Fig. 2.13: VCE 50% duty cycle.

For duty cycle equal to 20% :

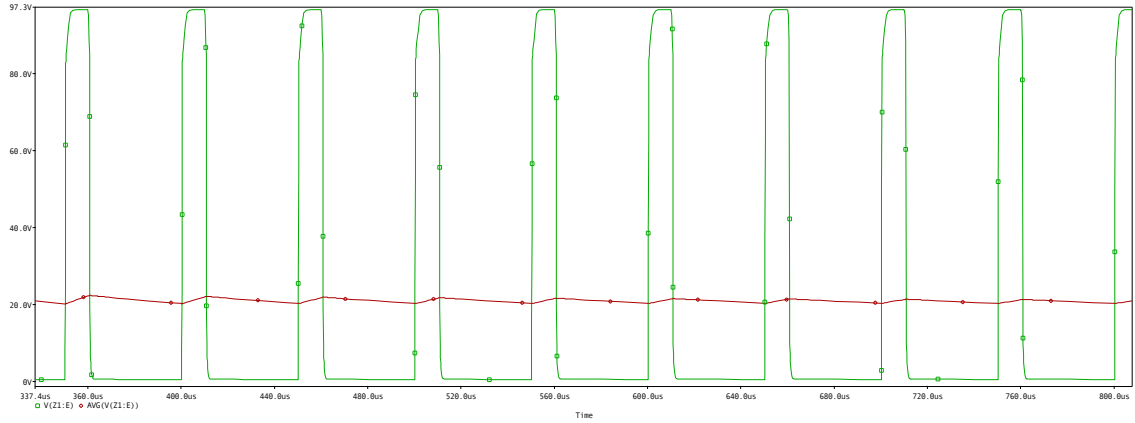


Fig. 2.14: output Voltage and its average for 20% duty cycle.

For duty cycle equal to 70% :

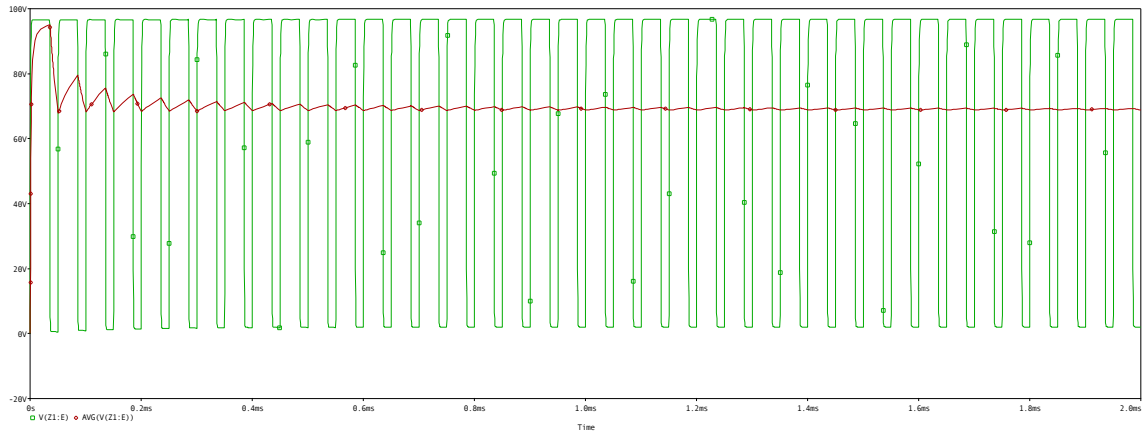


Fig. 2.15: output Voltage and its average for 70% duty cycle.

The FFT analysis was found for the output voltage at 70% duty cycle as follows :

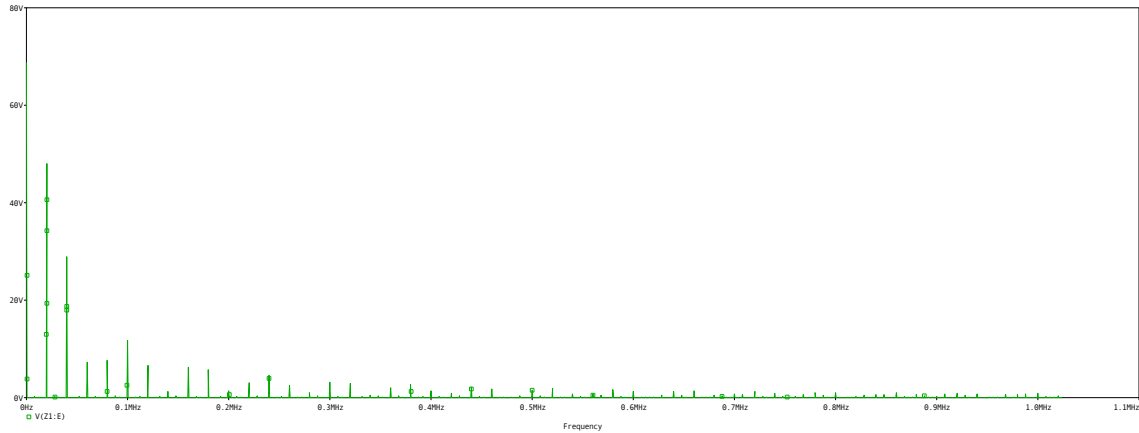


Fig. 2.16: FFT for the output Voltage at 70% duty cycle.

An LC low pass filter was added to the step down converter and following responses were achieved :

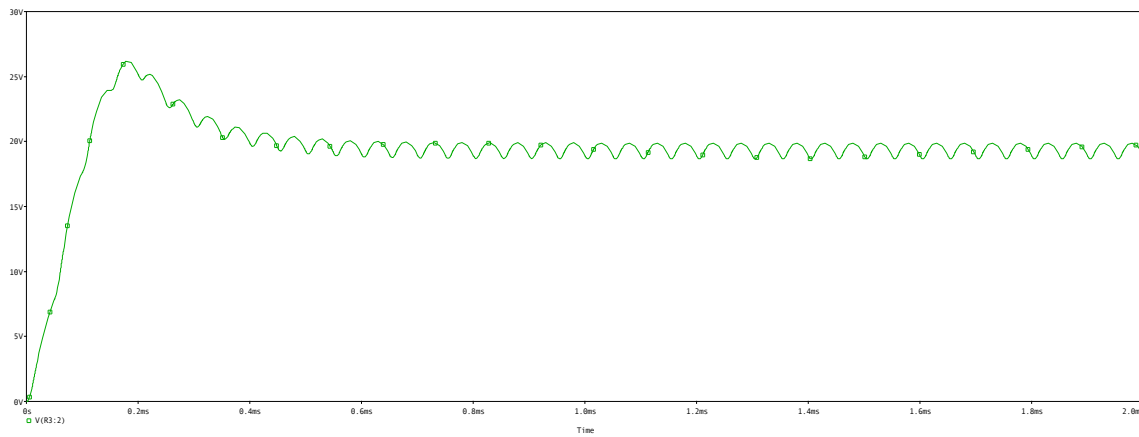


Fig. 2.17: output Voltage and its average for 20% duty cycle with LC Filter

We can easily notice the ripple at the output voltage .

The IGBT current was found to be :

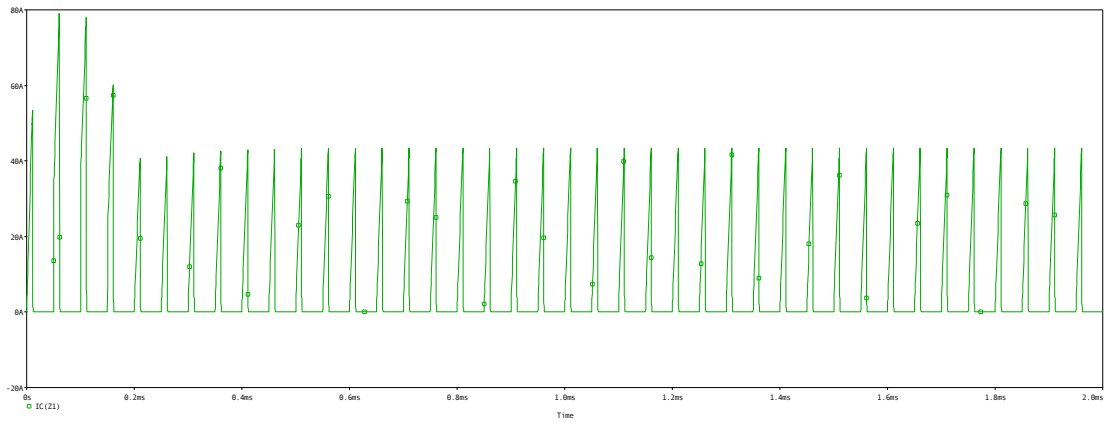


Fig. 2.18: IGBT Current for 20% duty cycle with LC Filter

For duty Cycle equal to 50% :

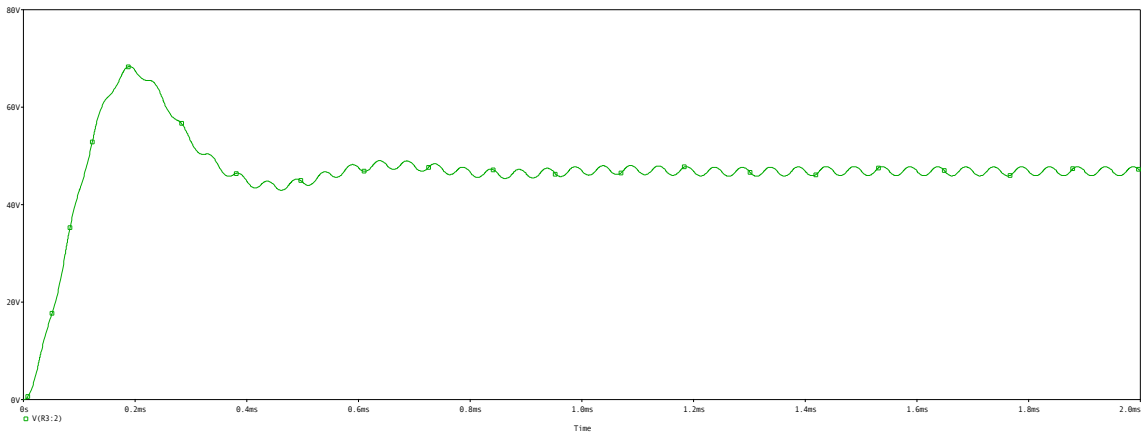


Fig. 2.19: output Voltage for 50% duty cycle with LC Filter

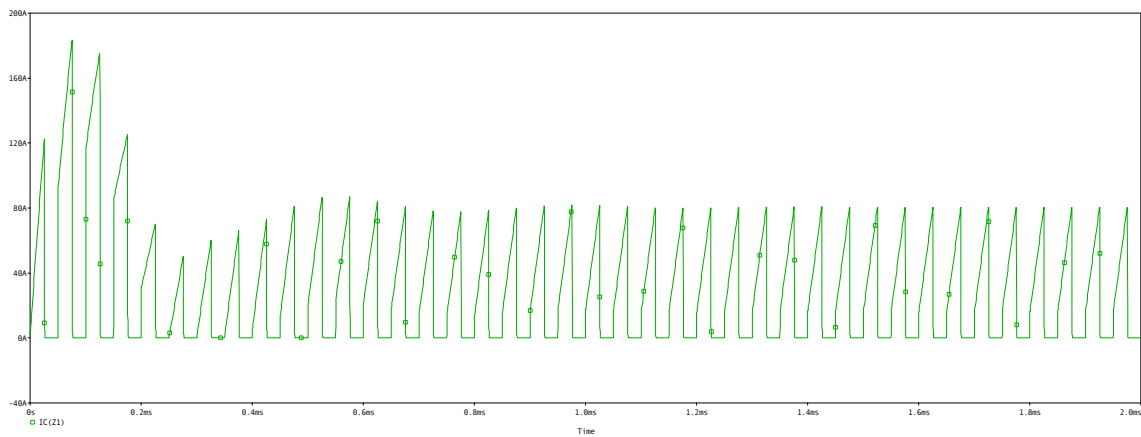


Fig. 2.20: IGBT Current for 50% duty cycle with LC Filter



After that, the filter capacitance was changed to  $22\mu\text{F}$  instead of  $220\mu\text{F}$  and the result was as follows:

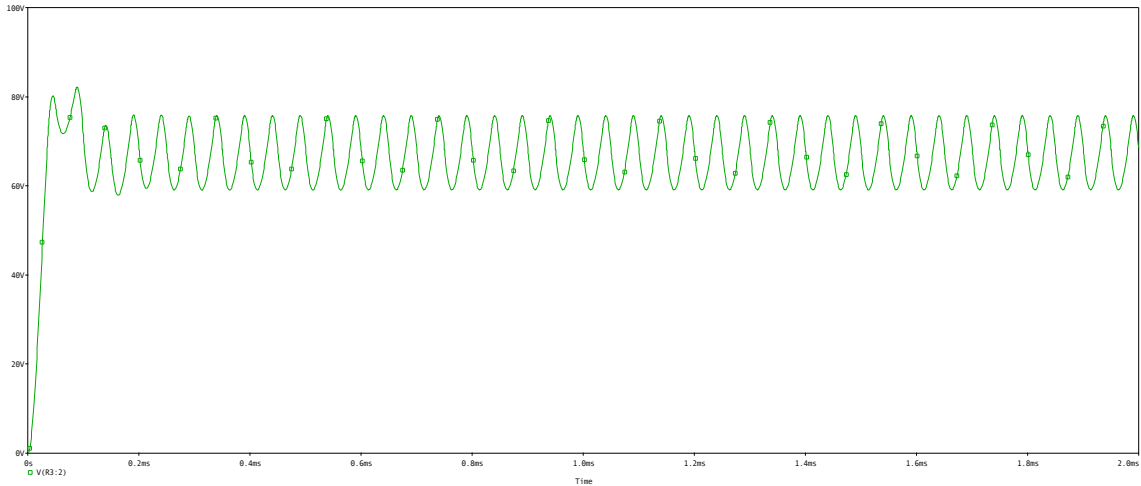


Fig. 2.21: output Voltage for with LC Filter whe  $c = 22\mu\text{f}$

We can notice that the ripple increased so much, so the value of the new capacitor is not suitable for the converter.

then the resistive load value was changed to  $20\Omega$  instead of  $1\Omega$ . The output voltage for a duty cycle of 70% is shown in the next figure :

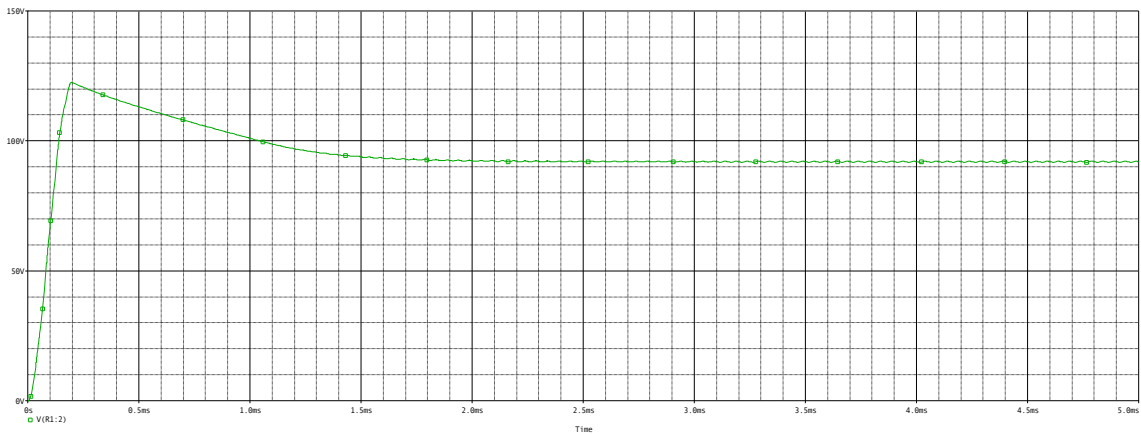


Fig. 2.22: output Voltage for with LC Filter where  $r = 20\ \text{ohm}$

# 2.5 Buck Boost Converter

The circuit shown in the next figure was drawn in order to simulate the converter .

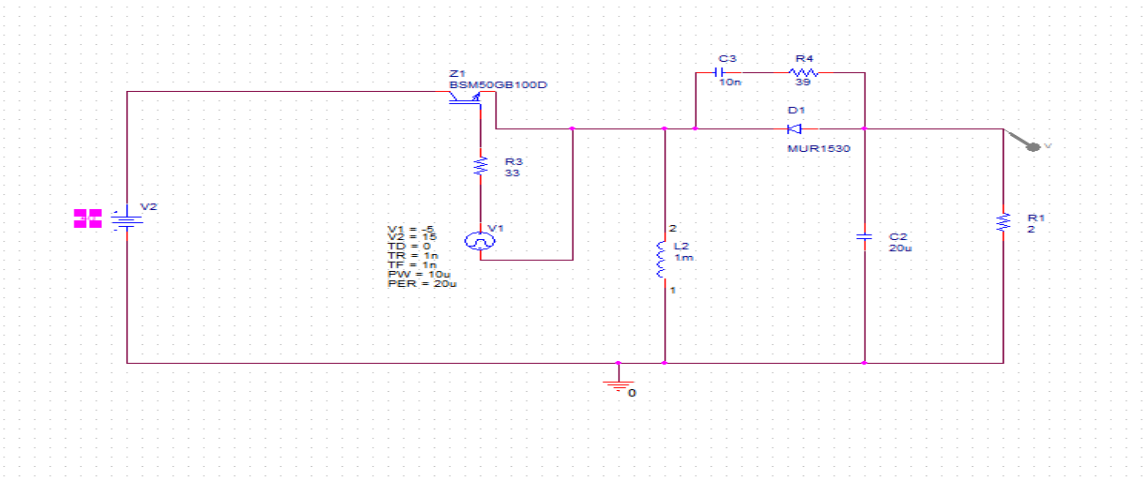


Fig. 2.23: Buck Boost Converter Circuit

After simulating the circuit as required in the manual , The following results were obtained :

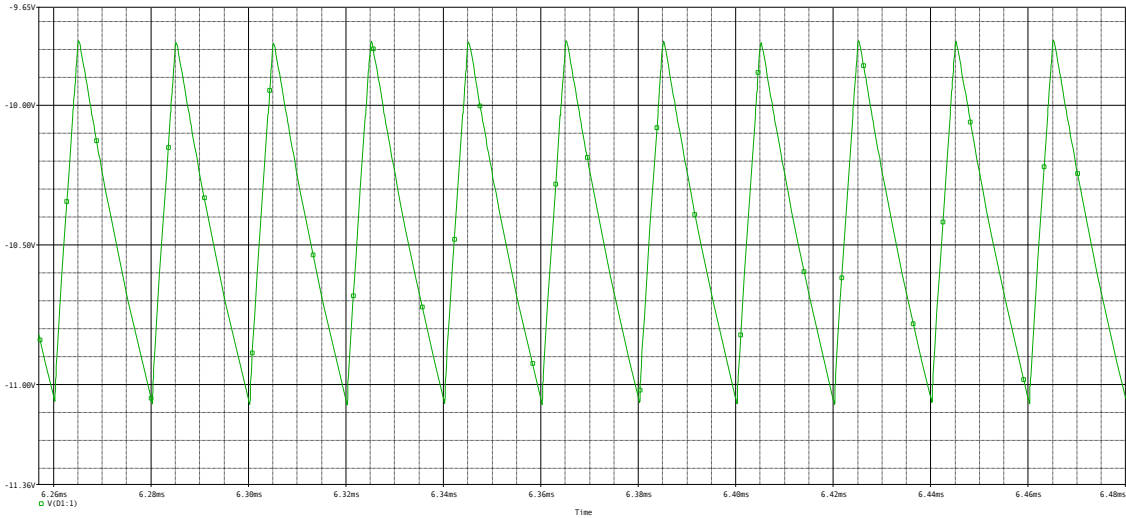


Fig. 2.24: output Voltage for 20% duty cycle.

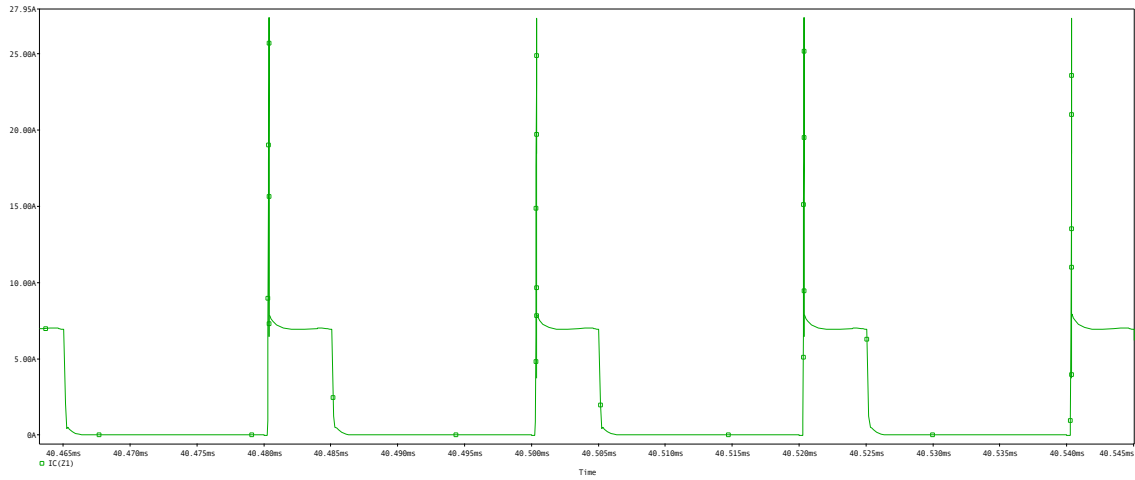


Fig. 2.25: IGBT Current 20% duty cycle.

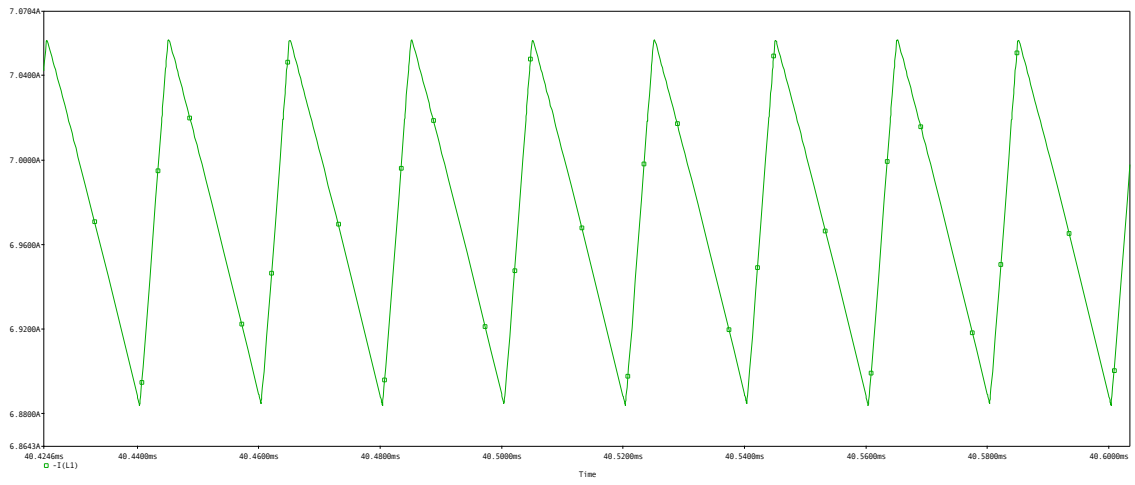


Fig. 2.26: Inductor Current 20% duty cycle.

For duty cycle = 50%

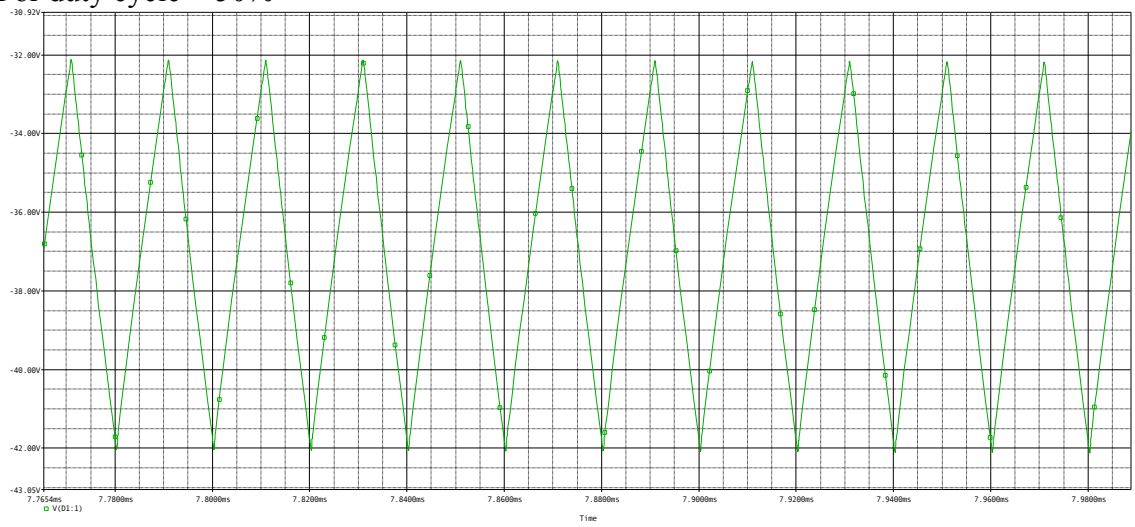


Fig. 2.27: output Voltage and its average for 50% duty cycle.

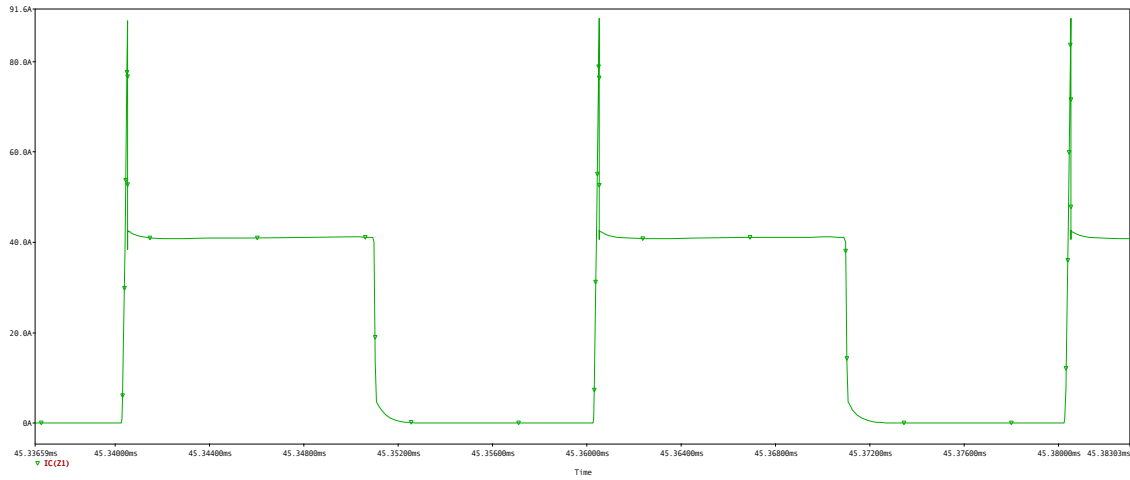


Fig. 2.28: IGBT Current.

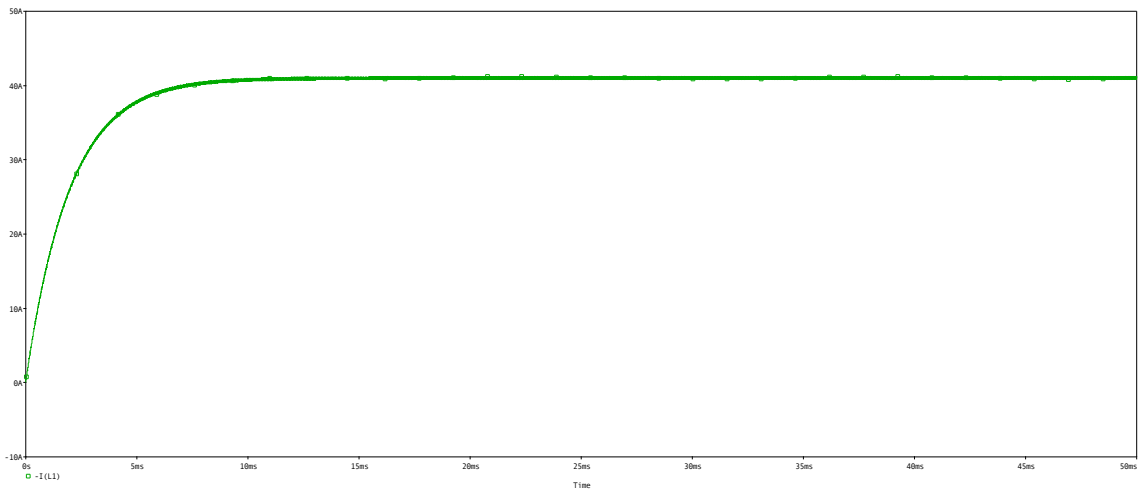


Fig. 2.29: Inductor Current.

We notice that changing the duty cycle affects the average output voltage,.

## 2.1 Full Bridge Converter

In this part, the circuit shown in the next figure was drawn in order to build the converter :

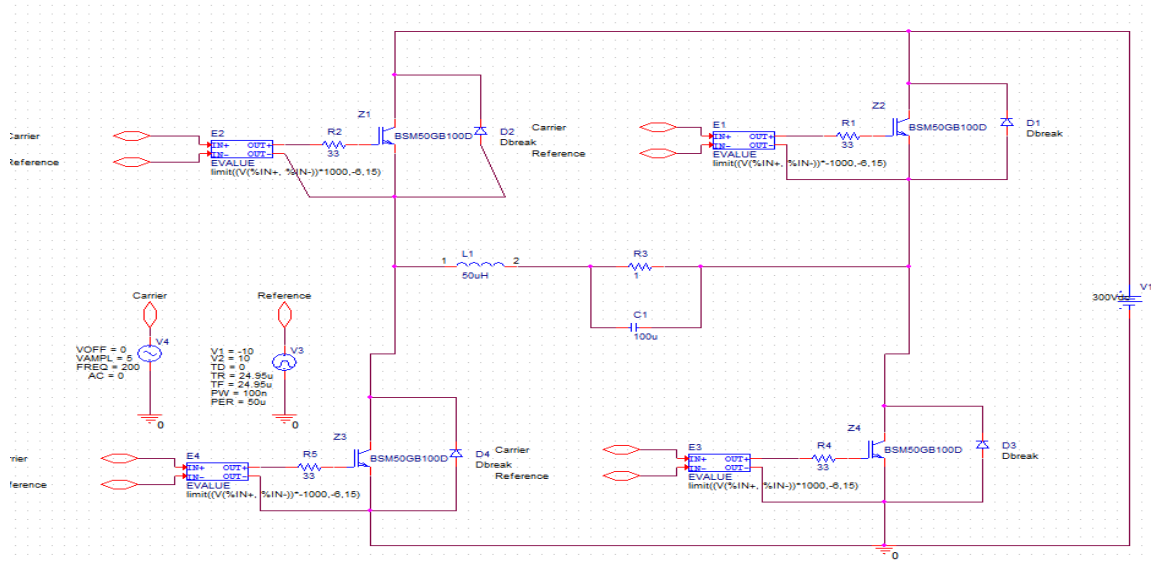


Fig. 2.30: Full Bridge Converter Circuit

A reference and carrier signals were used in this part .

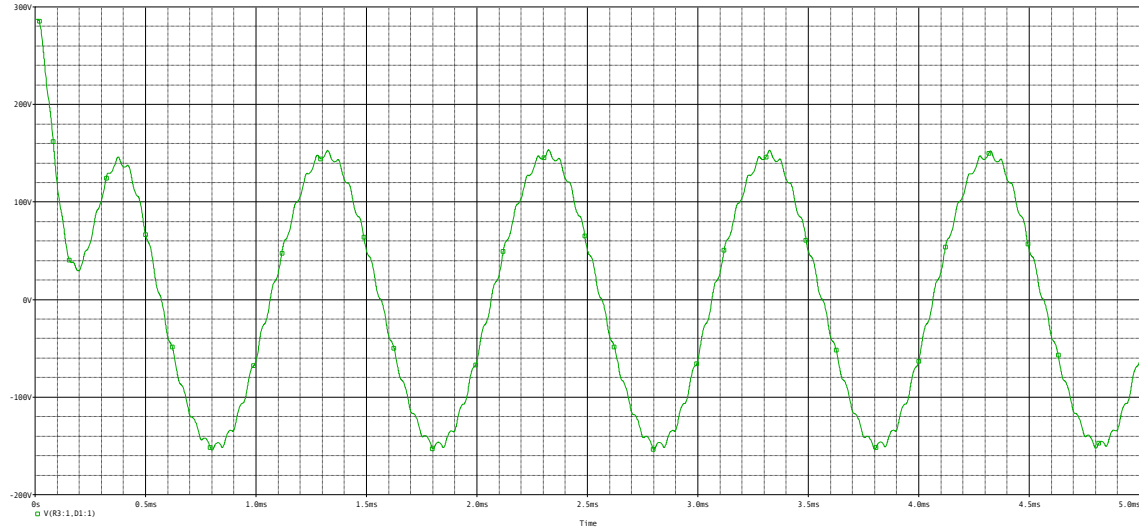


Fig. 2.31: The Output Voltage

We can notice that it works as an inverter.

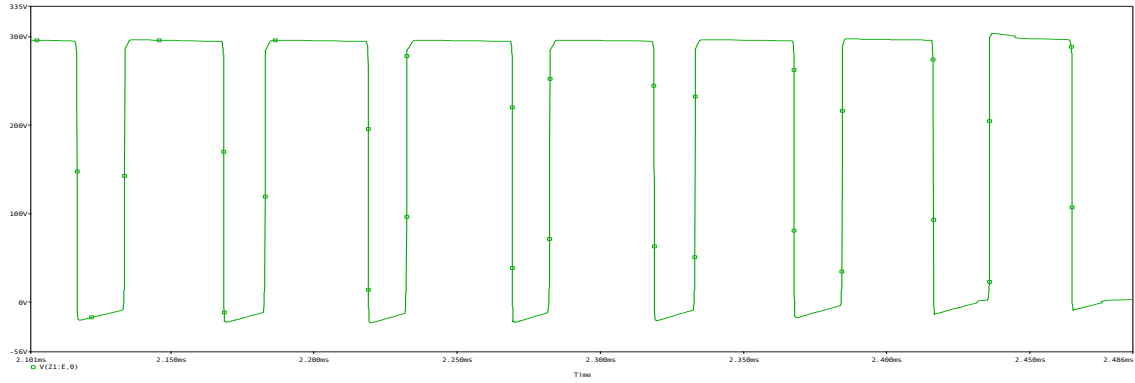


Fig. 2.32: The Output Voltage across Z4

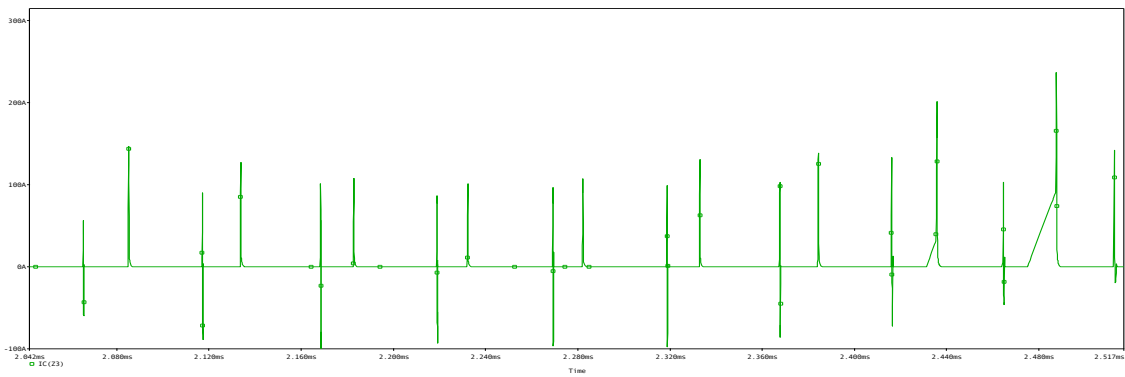


Fig. 2.33: The Current through Z4

At frequency = 200 Hz

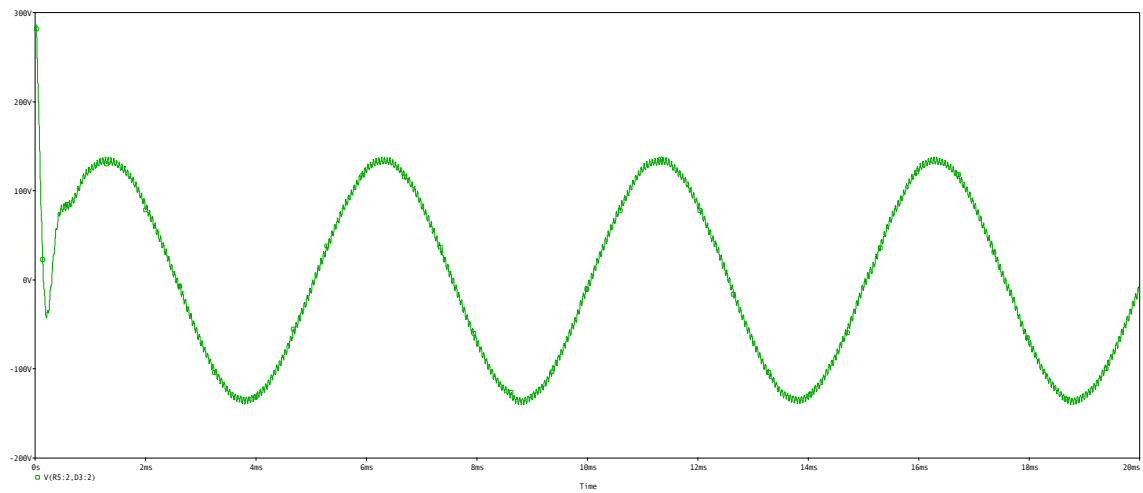


Fig. 2.34: The Output Voltage at  $f=200\text{Hz}$

For modulation index 0.2

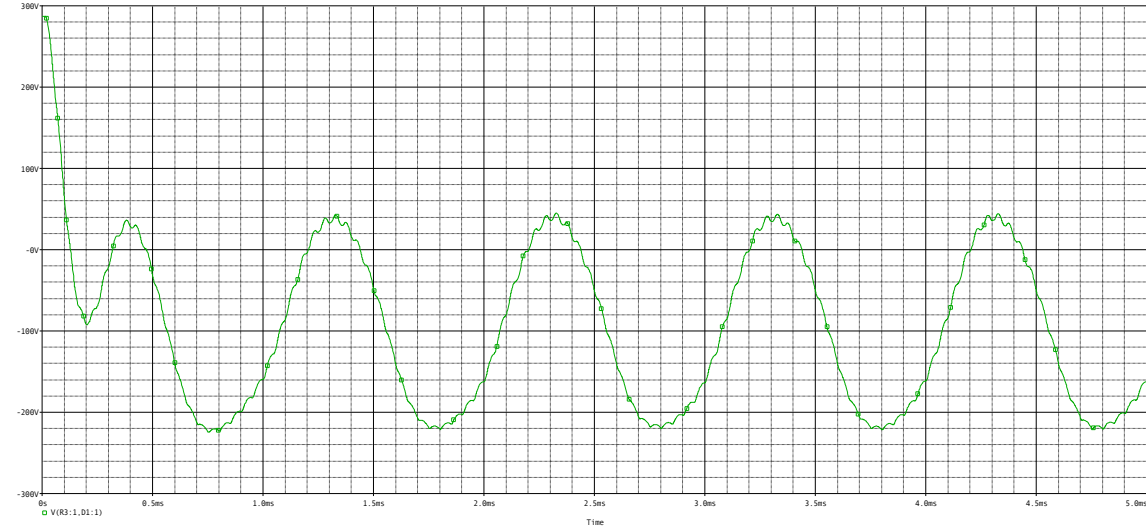


Fig. 2.35: The Output Voltage for modulation index = 0.2

For modulation index 0.8

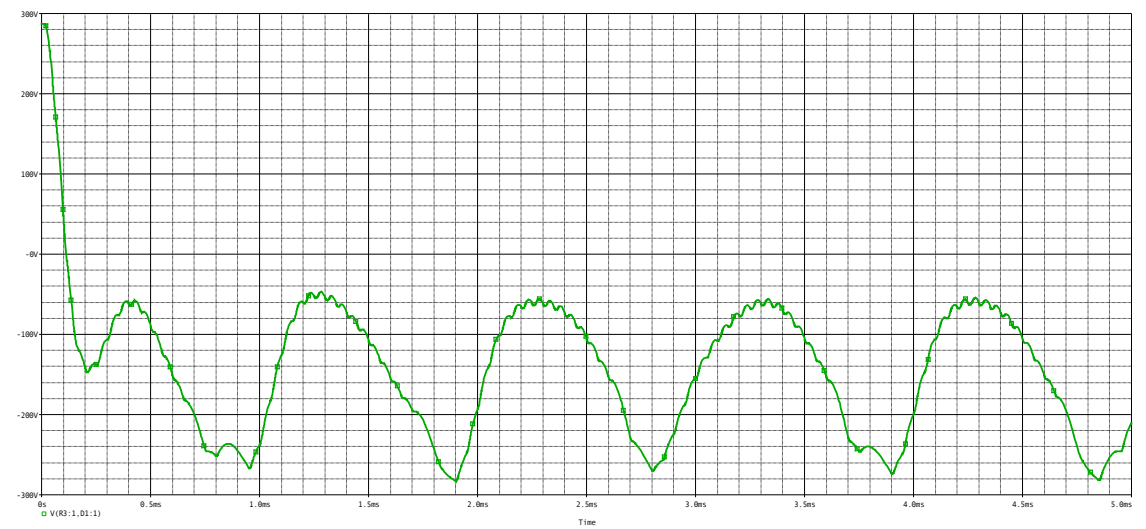


Fig. 2.36: The Output Voltage for modulation index = 0.8

Now we change the voltage to 0Vdc :

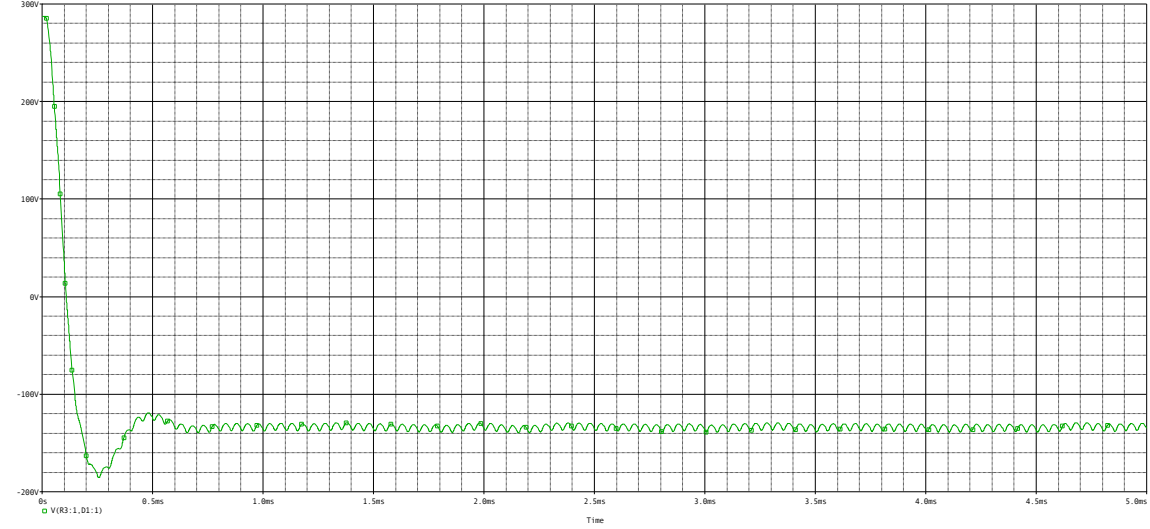


Fig. 2.37: The Output Voltage for vdc =0

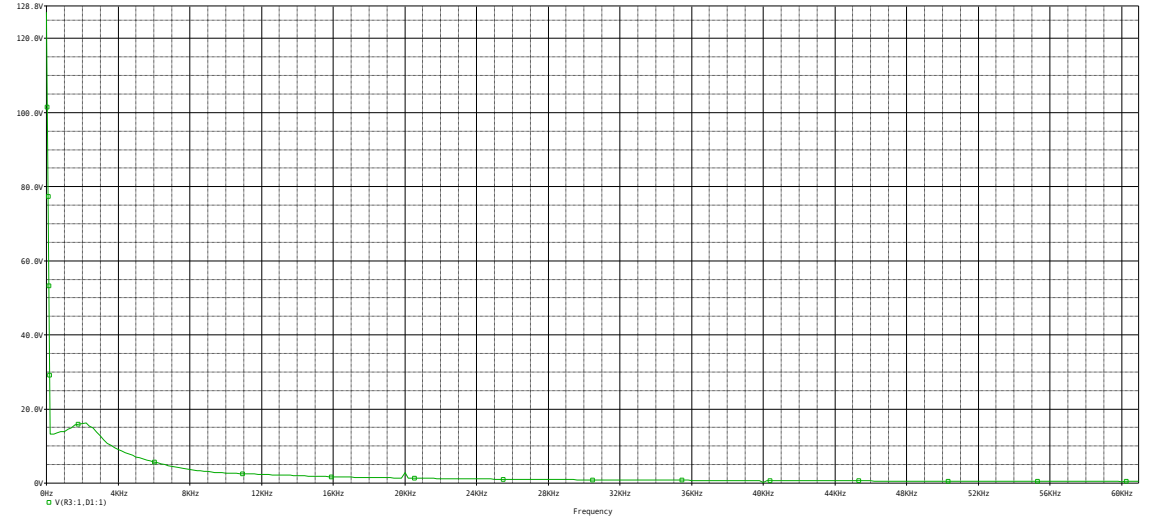


Fig. 2.38: The Output Voltage spectrum for vdc =0



Now we change the voltage to 4Vdc :

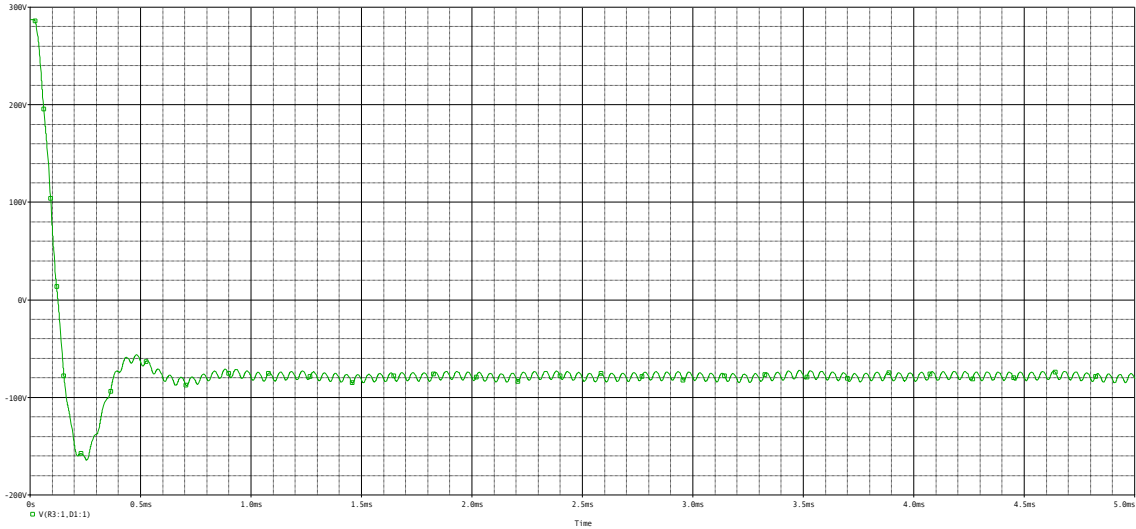


Fig. 2.39: The Output Voltage for vdc =0

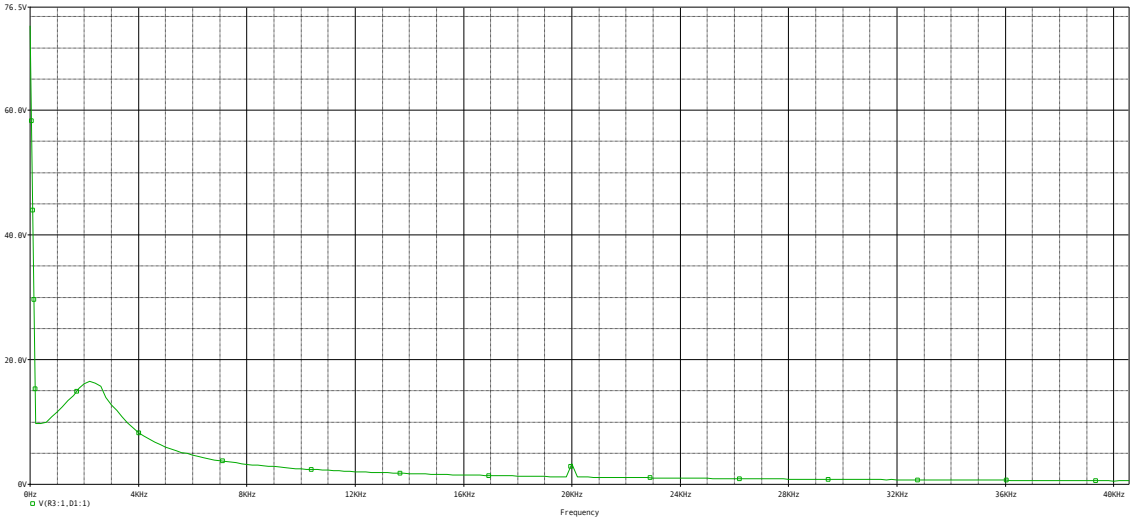


Fig. 2.40: The Output Voltage spectrum for vdc =4

# Conclusion

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A multistage closed loop and open loop amplifiers were simulated in this experiment, additional to three types of power electronic converters which are the step down converter and Buck-Boost Converter, and the Full bridge converter. We studied the characteristics of the circuits and its response for several changes such as filters and load effects. It was concluded that OrCAD is very helpful and easy way that makes studying the circuits much easier for research or study purposes and we learned how to use the most common, basic features of Capture and PSpice

# Refernces

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[1] [www.orcad.com/about](http://www.orcad.com/about)

[2] Lab Manual