



Faculty of Engineering and Technology  
Electrical and Computer Engineering Department  
Simulation Lab (4104)  
Power Electronic Converters, Negative feedback, Modular design and sub-  
circuits using ORCAD

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Prepared by:

Name: Anas Tomaizeh

Number: 1152325

Instructor:

Teacher Assistance:

Eng. Ahmed W.Hamed

Dr: Jamal syam

Date:

4/4/2019

Section: #1

## Abstract:

The aim of these experiments is to become familiar with Orcad, verify the operation of different power electronic converters according to see the effect of changing the load, the filter size and duty cycle, to become familiar with modular design in Orcad, to make sub circuit and add it in the library and to show some properties about open, close multistage amplifier.

Results: The results obtain in these experiments are acceptable with theoretical theorems.

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## **1. Introduction:**

in these experiments the basic concepts about Orcad program learned, some of these basics is to how to simulate simple circuit used Orcad, simulate power electronics convertor which is Dc-Dc boost and buck- boost chopper circuit and show the effect of some parameter on the output voltage for instance, change duty cycle, and studied some properties about Dc-Dc convertor such as, effect of low pass filter at the spectrum of the output voltage, in addition, how to make modular design by added multistage at different schematics and connect it together and make sub circuit in Orcad and added it in the library to use it when the user need.

## **2. Theoretical background:**

### **2.1 Modular design:**

Orcad capture can offers a tool to employ hierarchal design “modular design” was a design approach that subdivides a system into smaller parts called modules and each of which can be represented by a block with input and output pins, and the blocks can be used it to build complicated system.[1]

### **2.2 Sub Circuit:**

Orcad used to generate circuit in one bored with input pin and output pin.

### **2.3 Multistage amplifiers:**

The multistage amplifiers used to maximize the gain, to increase the bandwidth, and to make a good frequency response of the amplifier.

### **2.4 Dc-Dc Chopper Circuit:**

#### **2.4.1 Dc-Dc Step Up Convertor (Boost Convertor):**

The boost convertor is a topology of a power electronics circuit used to step up the DC voltage from low level to high level dependent on the duty cycle according to Equation one in Appendix A.1.

#### **2.4.2: Dc-Dc step up, down convertor (Buck- Boost Convertor):**

The Buck- Boost convertor is a topology of power electronics circuit used to step up the DC voltage when the Duty cycle is more than 50%, and step down the DC voltage when the Duty cycle less than 50% the Equation 2 in appendix A.1 show the relation between input and output DC voltage function of duty cycle.

#### **2.4.3: Dc-Dc Step down convertor (Buck Convertor):**

The Buck convertor is a topology of power electronics circuit used to step down the Dc voltage from level to another low level it has deepened on the duty cycle according to Equation 3 in Appendix A.1

### 3. Methods and materials:

The Orcad Program used to solve the problem and achieve the aim of these experiments

#### 3.1: Modular design:

The Open-Loop multistage amplifier divided to two parts, low first and low second parts. The first part shown in the Figure 1, and second part shown in the Figure 2.

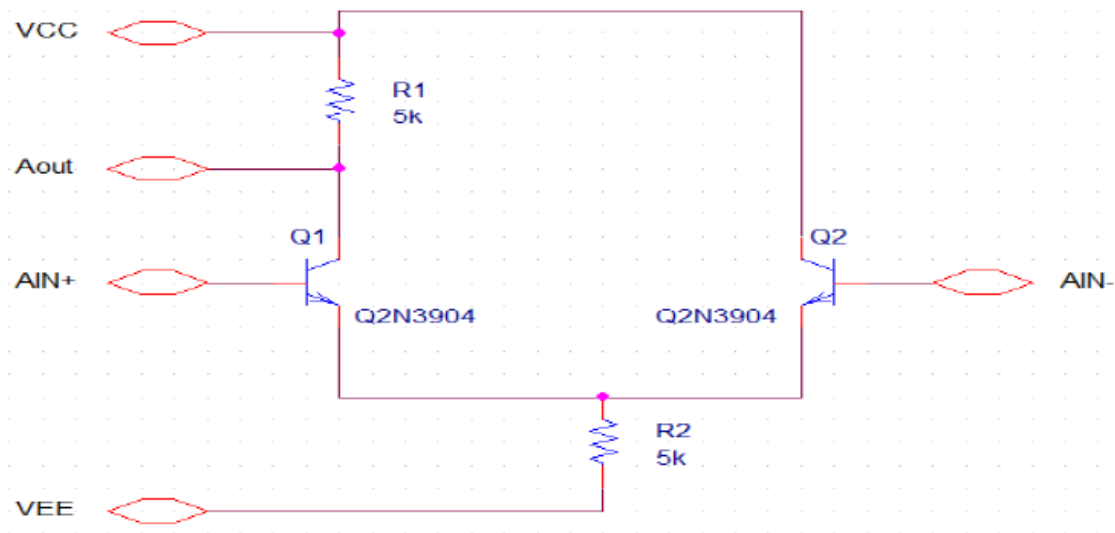


Figure 1: The low first schematic circuit, First Stage of open loop multistage amplifier

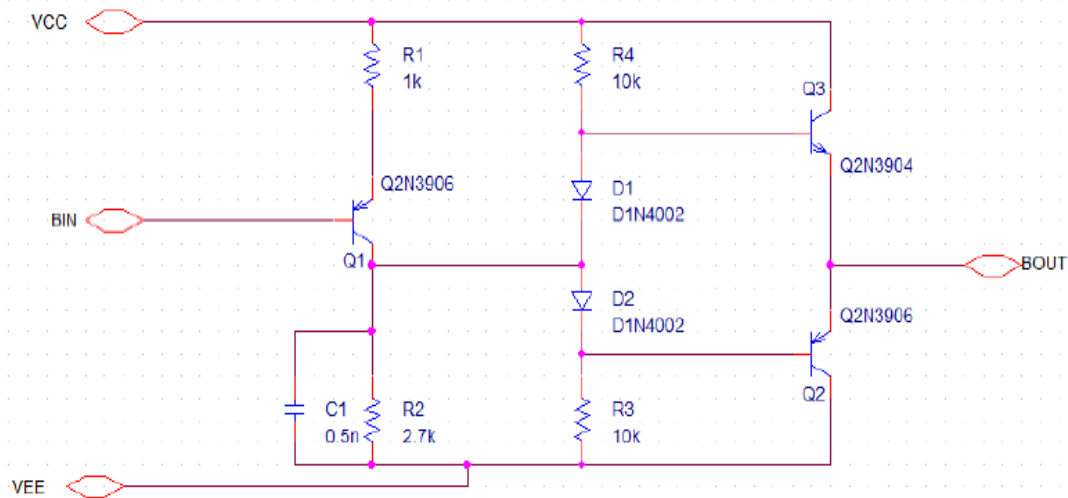


Figure 2: The Low second schematic circuit, second stage of open loop multistage amplifier

Another schematic inserted in project manager.

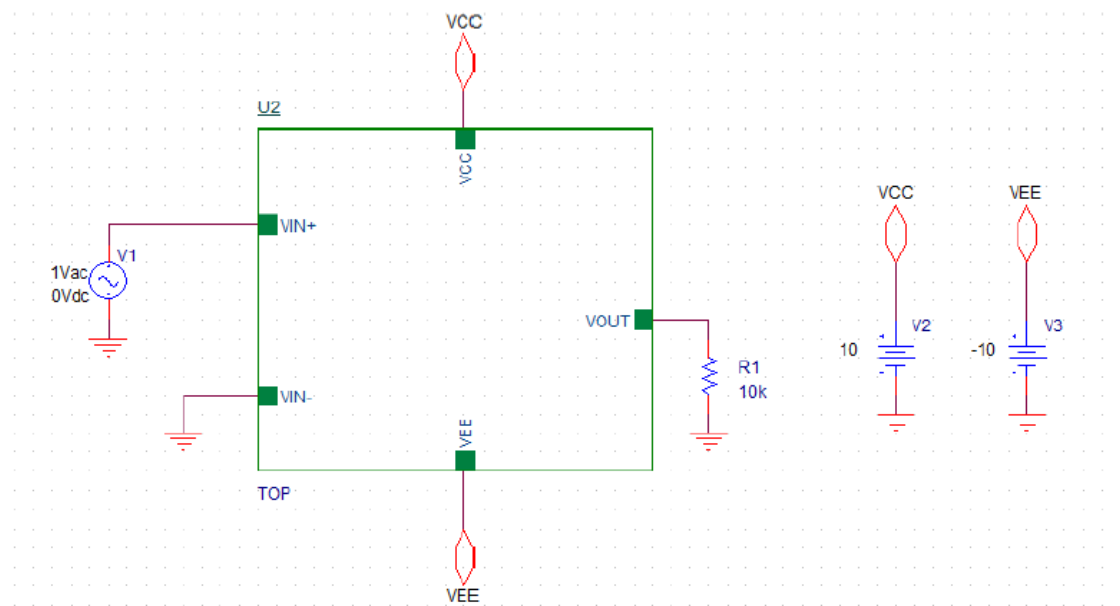


Figure 3: The open loop multistage amplifier, the Top schematic

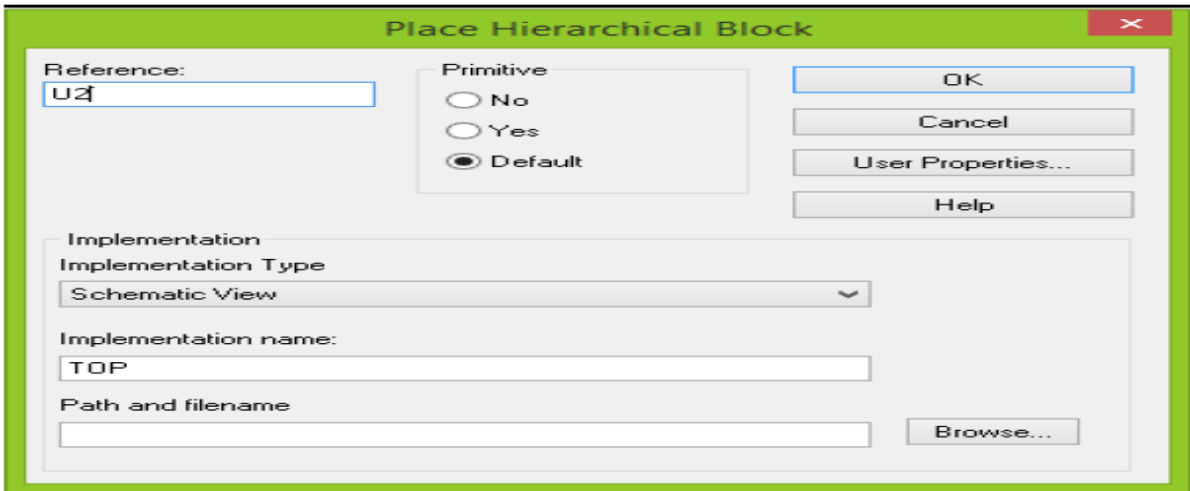


Figure 4: The Setting of the Hierarchical Block of open loop multistage amplifier

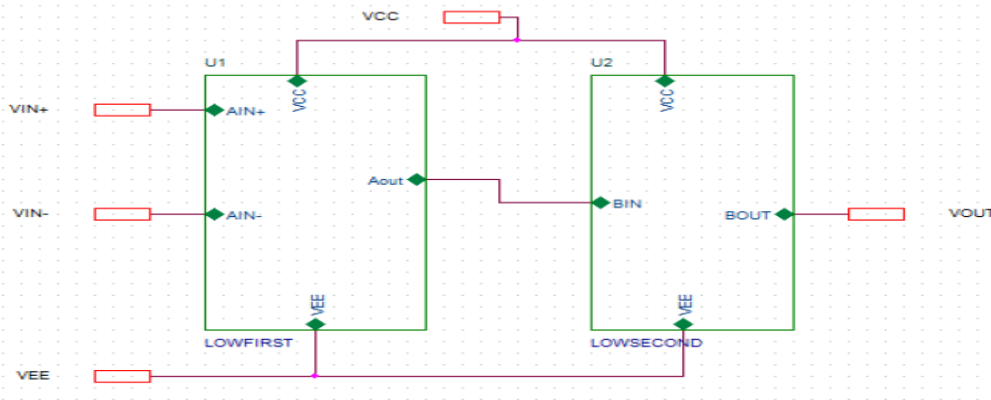


Figure 5: the First and second stage of multistage amplifier

### 3.2: Sub Circuit in Orcad:

The Circuit shown in the Figure 6 draw in new schematic to make it in sub Circuit:

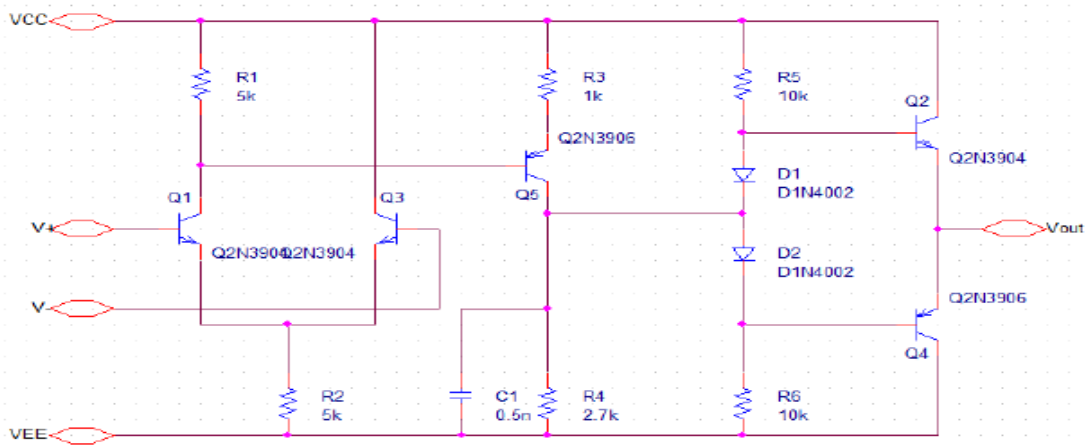


Figure 6: The open loop multistage Amplifier



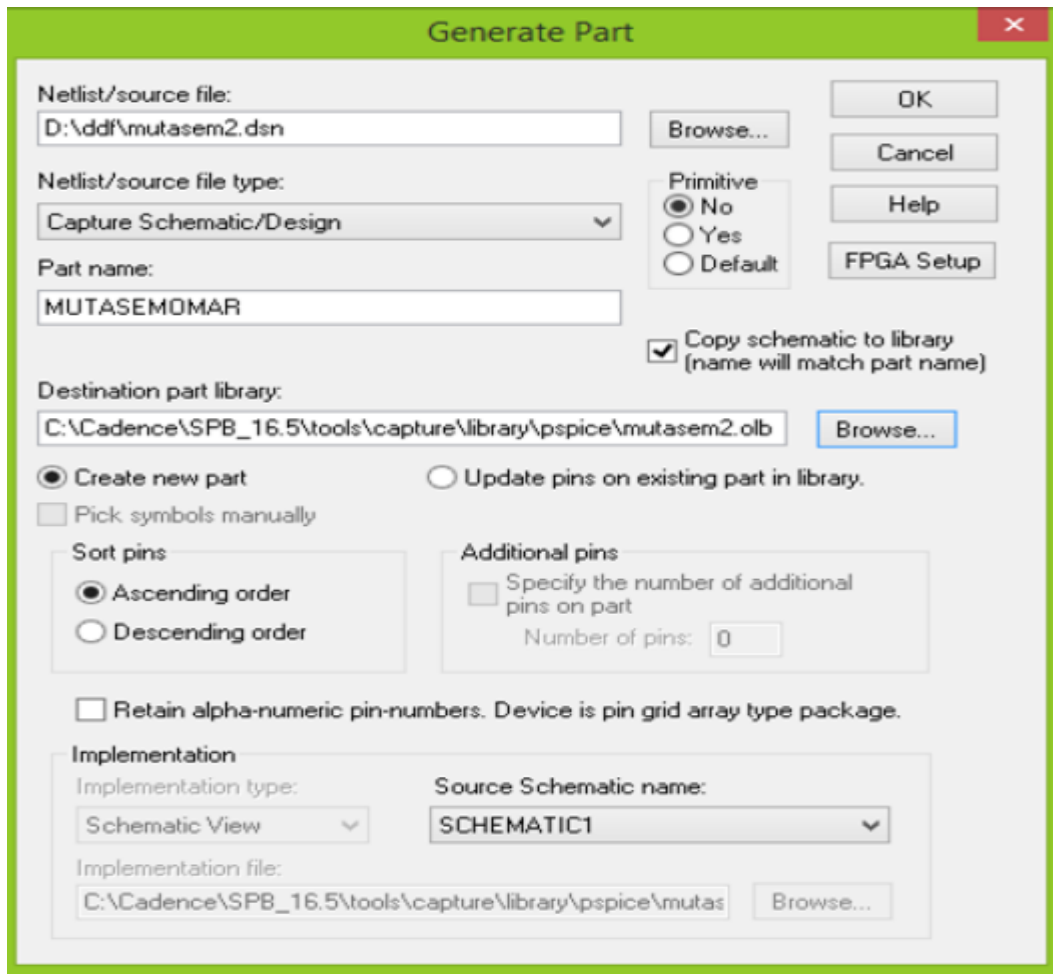


Figure 7: Generate part setting

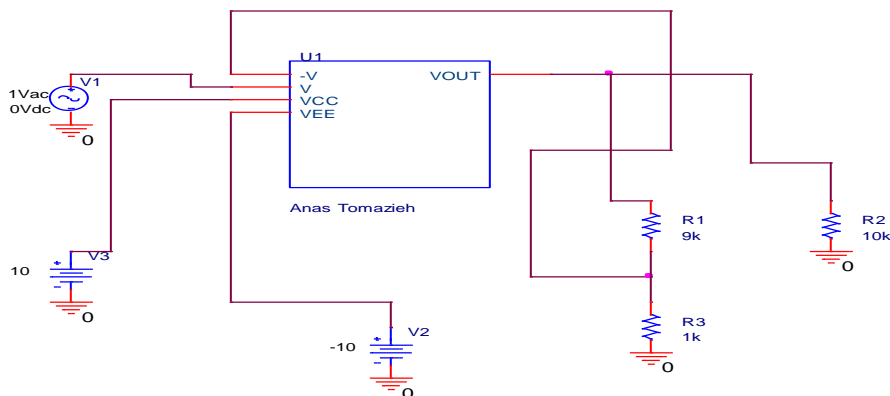


Figure 8: The Close loop multistage amplifier inserted in the library

### 3.3: Power Electronics Converter in Orcad:

The Circuit, which is a step down converter (Buck Converter), shown in the figure 9 was draw in Orcad:

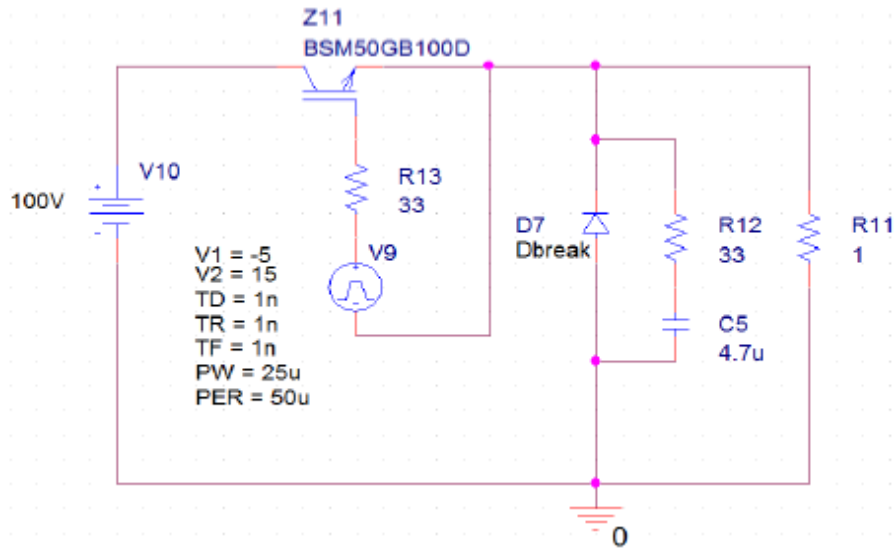


Figure 9: Dc-Dc step down convertor

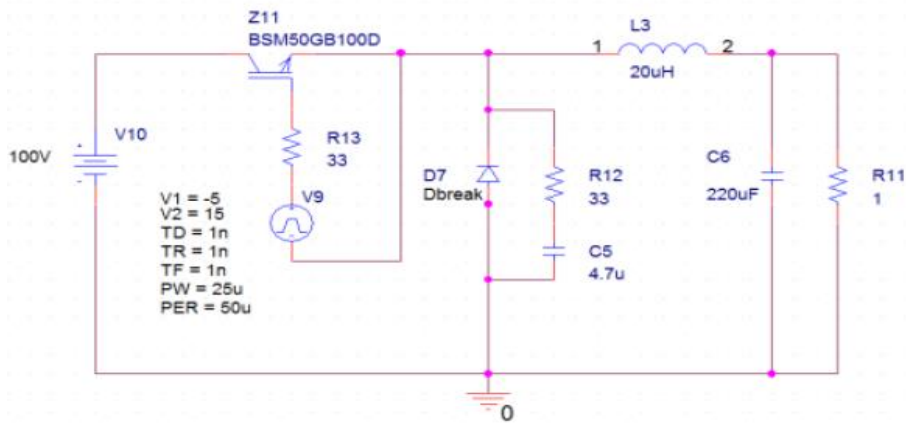


Figure 10: Buck Converter with Low Pass Filter

The Circuit, which is Step-up-step-down buck-boost converter shown in Figure 11 was draw in Orcad.

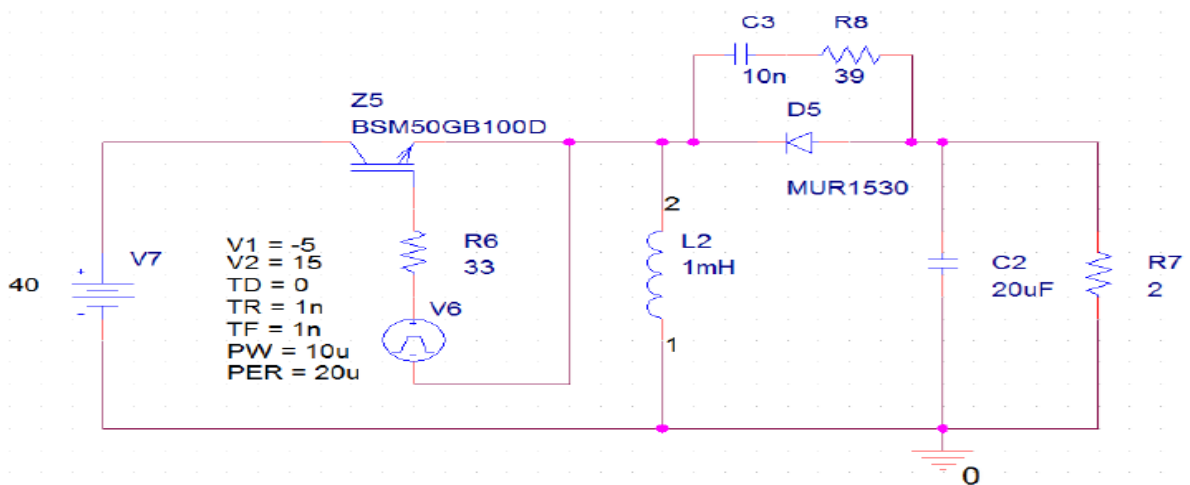


Figure 11: Dc-Dc Buck Boost convertor

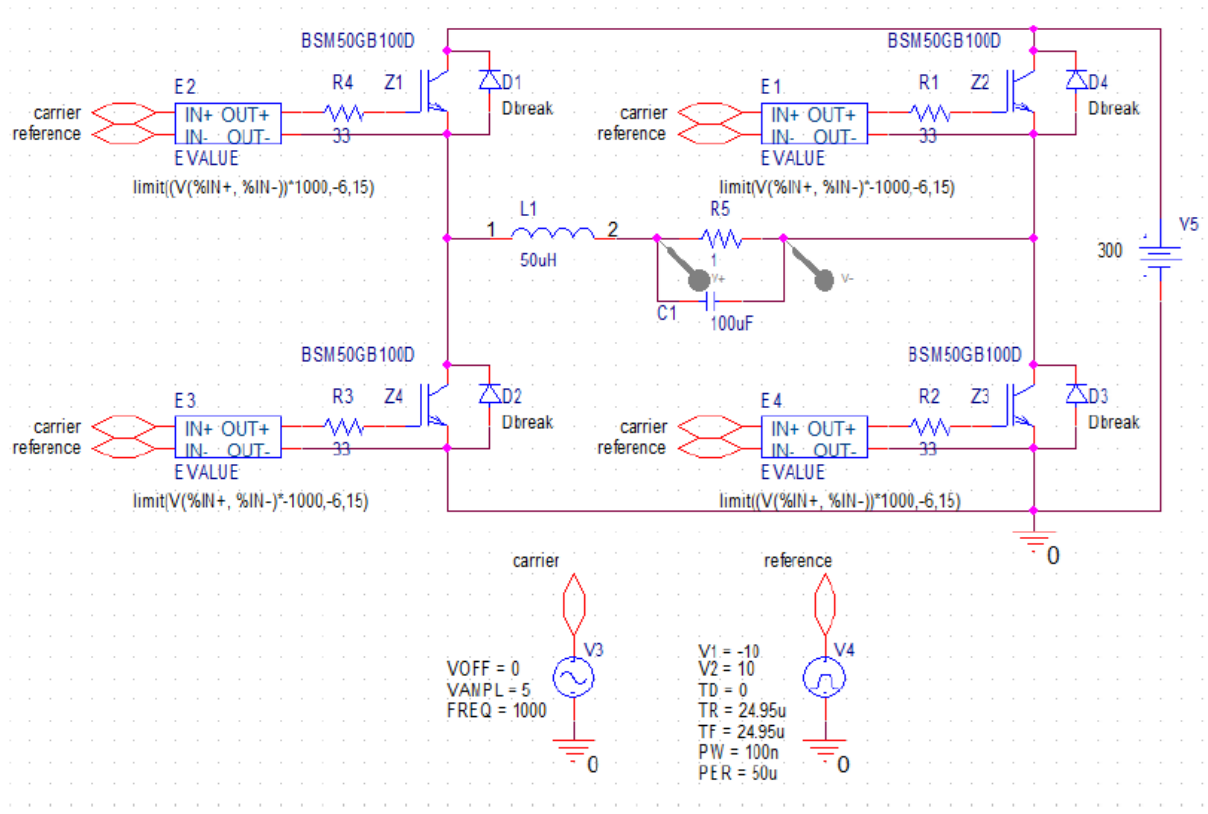


Figure 12: DC- Ac Bridge rectifier, power Electronics inverter

## 4. Procedure:

The two new schematics inserted in project in Orcad Program and its name Low first and low second respectively, in the new schematics the pages inserted and the Circuit shown in the Figure 1 and Figure 2 was draw in it.

The new schematic inserted in project manager and the Circuit shown in the Figure 3 was draw in it, the middle block name Hierarchical Block which give from the Place and the setting of it inserted as shown in the figure 4. Inside the middle block the circuit shown in the figure 5 was draw in it. The AC Sweep analysis was make at the Circuit shown in the figure 3, which is top schematic and the result shown in the figure 6 in results part.

The new schematic inserted in project manager and the open loop multistage amplifier shown in the figure 6 draw in it, after that the schematic Choosed and from tools the generate part Choosed, and the setting was inserted as shown in the figure 7, finally the sub circuit represent the multistage amplifier added in the library as shown in the figure , the AC sweep analysis was make for the close loop multistage amplifier and the results shown in the figure in result part.

The Circuit shown in the Figure 9 which is the buck converter was draw in Orcad, the output voltage at duty cycle 50%,20% and 70% were found, the Current at IGBT, Gate Current,  $V_{CE}$ , and FFT of the output Voltage at 70% duty cycle were found. After that, the LC Low Pass Filter added to the buck converter, as shown in Figure 10, the output voltage and IGBT current at duty cycle 20%, 50%, and 70% at  $1\Omega$  load resistor were found, and FFT for the output voltage at duty cycle 70% found, in addition the value of the capacitor changed and the output voltage found at duty cycle 70% and the output voltage found at  $20\Omega$  load resistor, all results shown in results part.

The Circuit shown in the Figure 11, which is the buck-Boost converter, was draw in Orcad, the output voltage, inductor current and IGBT current found at 20%, 50% and 70%. The FFT at duty cycle 70% found.

The Circuit shown in Figure 12, which is the Dc-Ac Invertor was draw in Orcad, the output voltage across the resistor and after the filter found, the voltages, Currents and Gate signals of Z1 and Z4 were found. After that, the frequency changed and the output voltage found.

## 5. Results:

### 6.1: Multistage amplifier in Orcad.

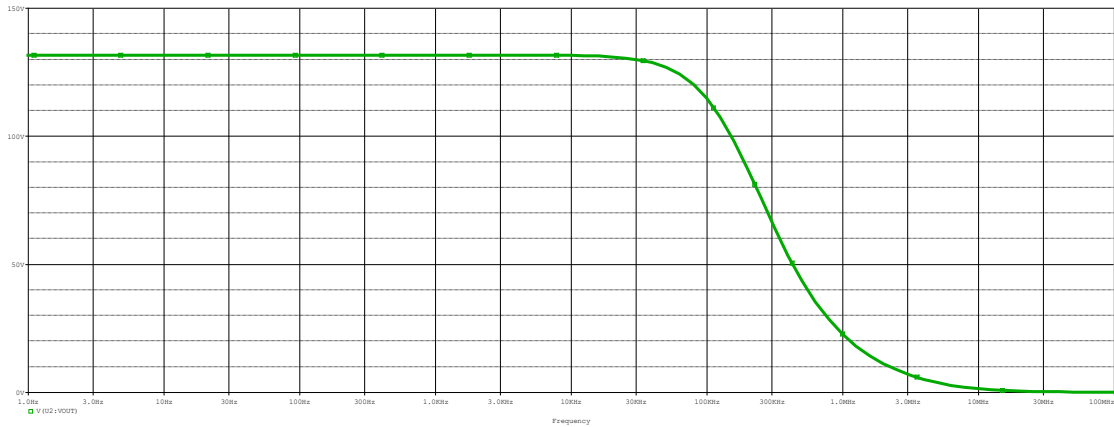


Figure 13: the Gain of open loop multistage amplifier

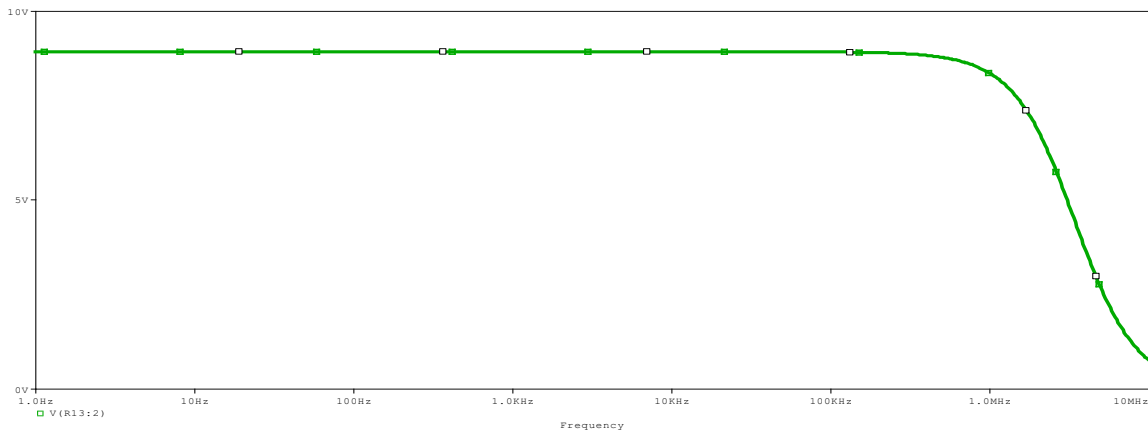


Figure 14: The Gain of Close loop multistage Amplifier

### 6.2 Power Electronics Convertor in Orcad:

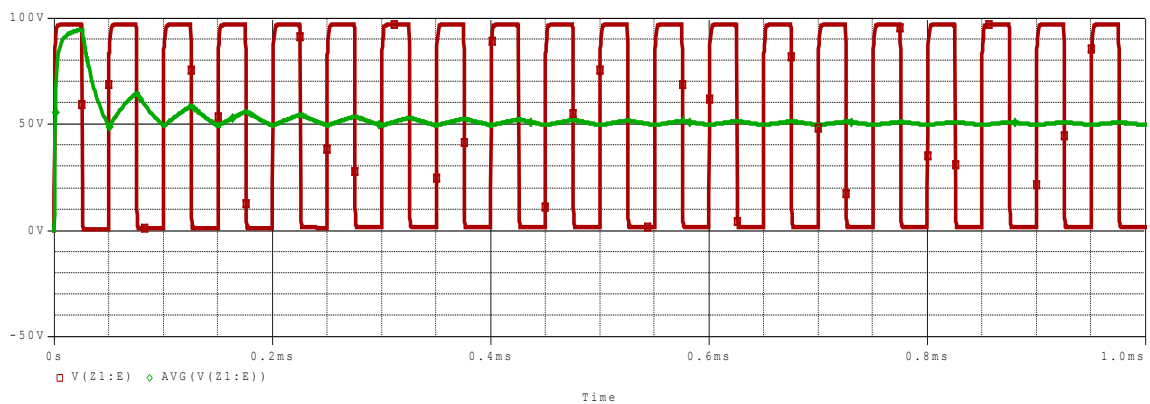
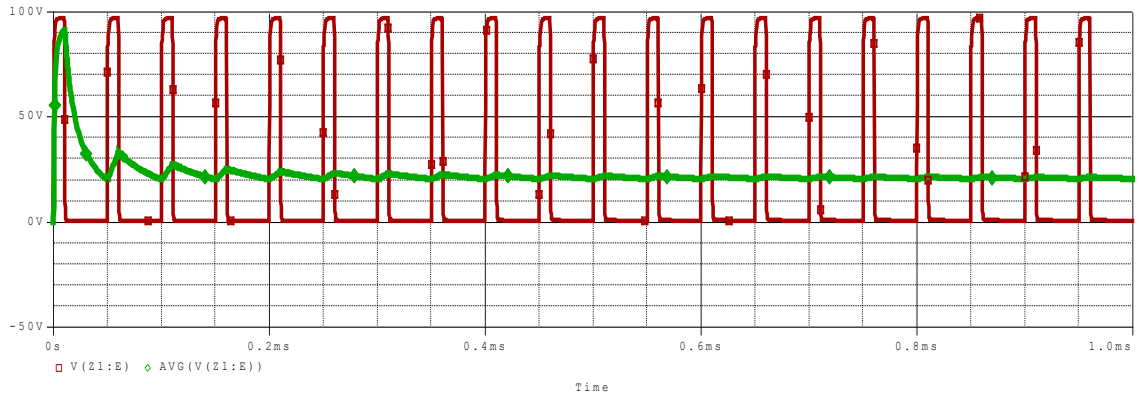
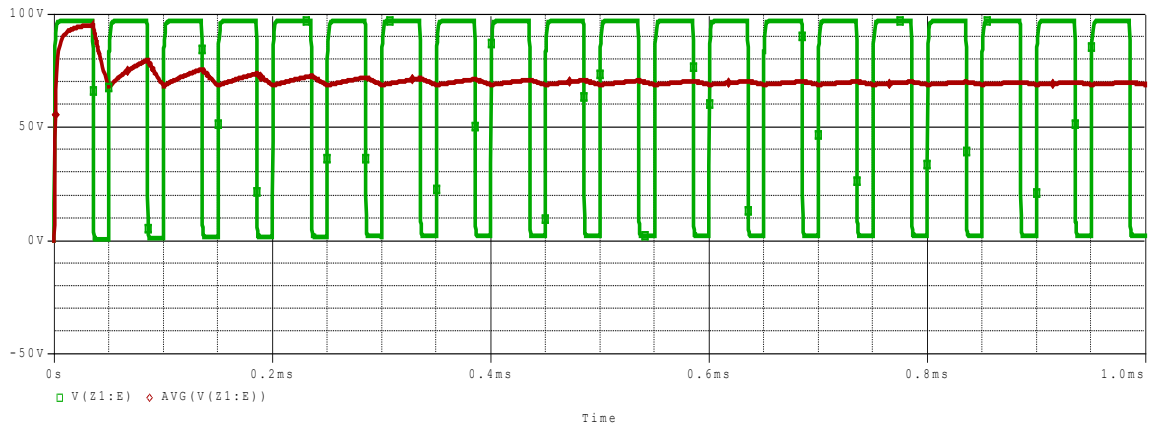


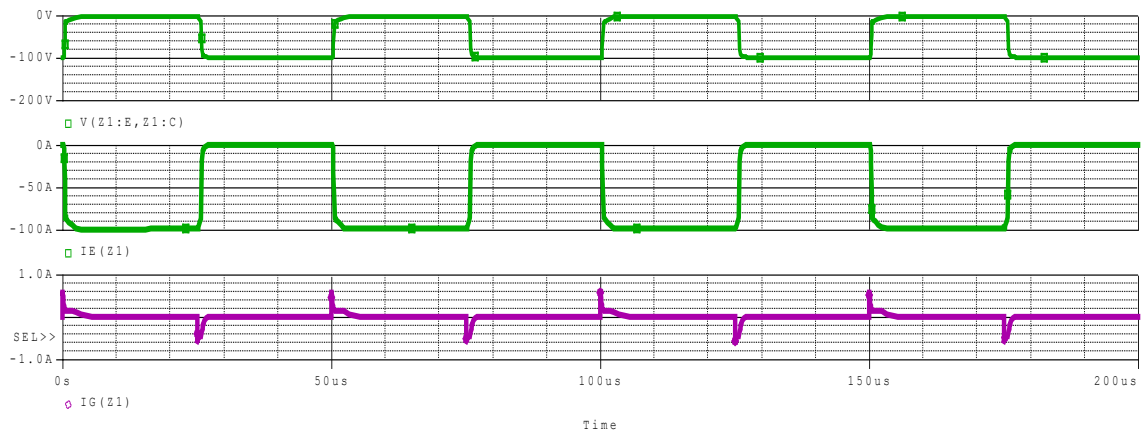
Figure 15: The output voltage from the DC- Dc Buck Convertor at duty cycle 50%



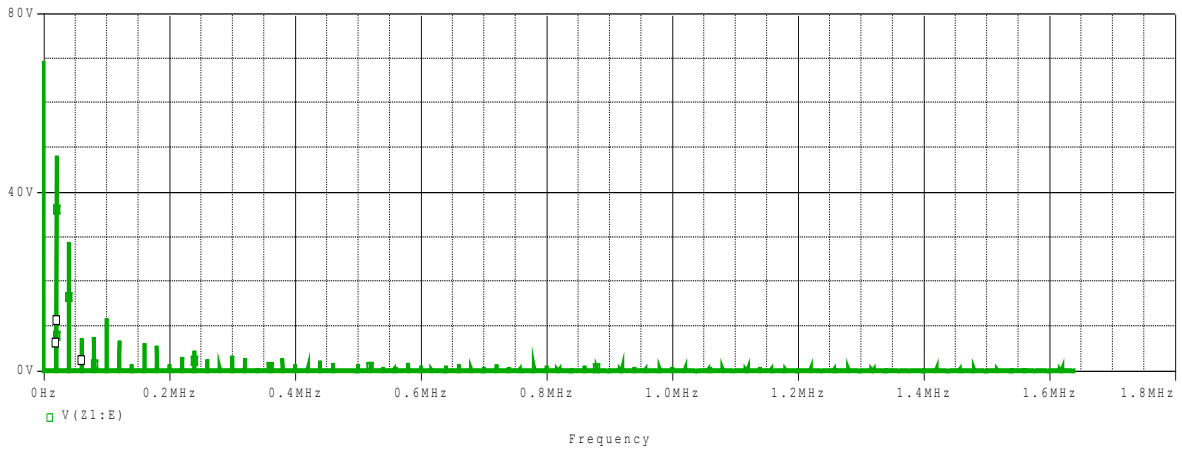
**Figure 16: the output voltage from DC –Dc Buck Converter at duty cycle 20%**



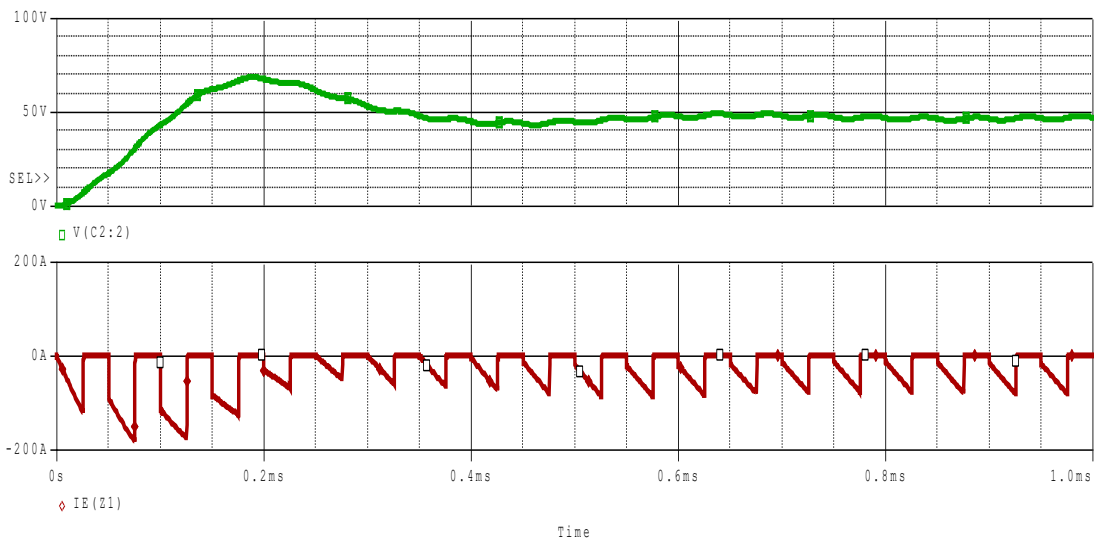
**Figure 17: The Output Voltage from DC- Dc Buck Converter at duty cycle 70%**



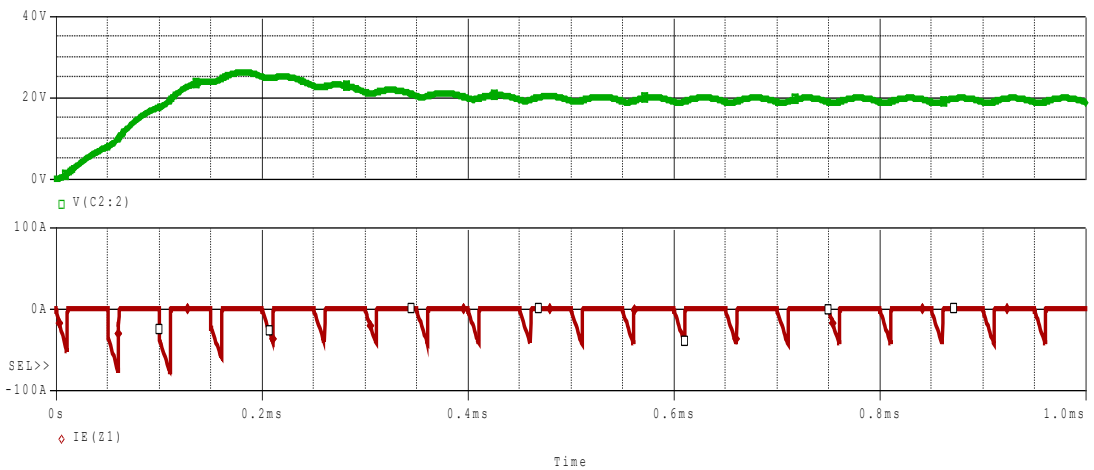
**Figure 18: The IGBT Current, Gate Current, and  $V_{CE}$  of DC-Dc Buck Converter**



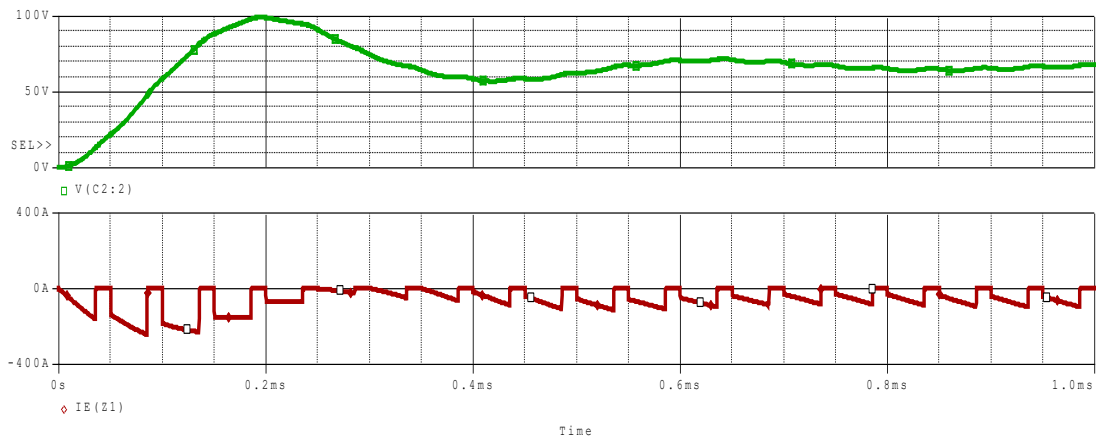
**Figure 19: FFT for the output voltage from the DC-DC Buck Converter at duty cycle 70%**



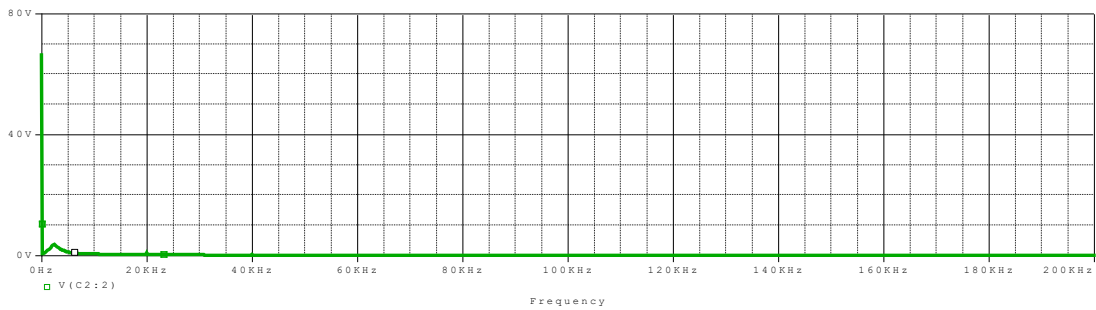
**Figure 20: The output voltage and IGBT current after LC low pass filter add at duty cycle 50%**



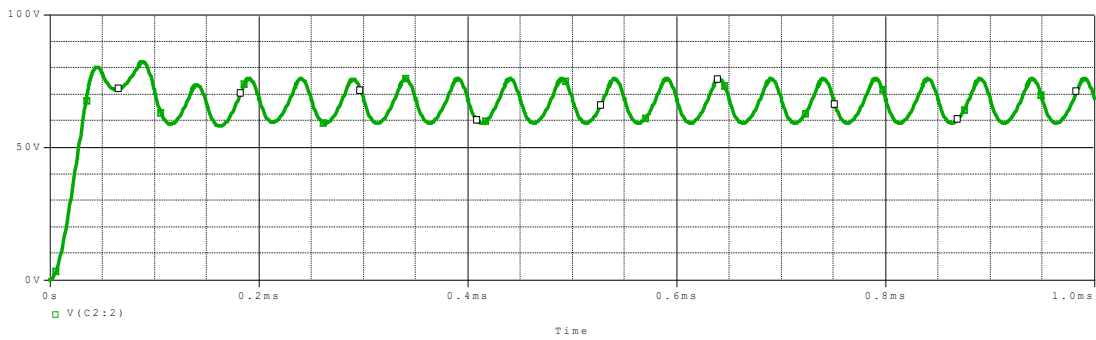
**Figure 21: The output voltage from DC-Dc buck Converter and IGBT current after LC low pass filter add at duty cycle 20%**



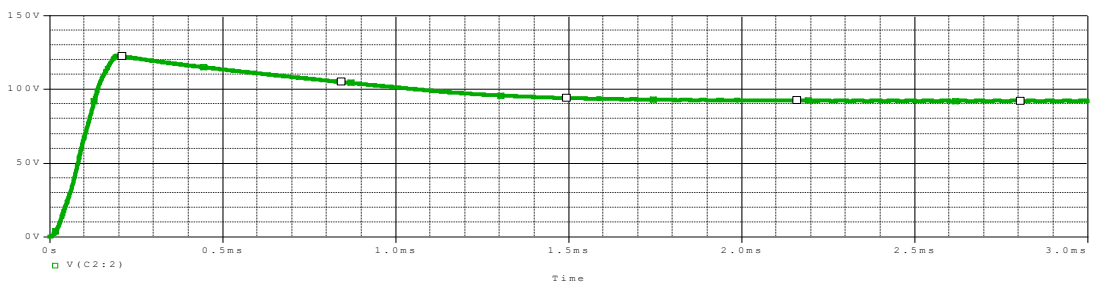
**Figure 22: The output voltage from DC-Dc Buck Converter and IGBT current after LC low pass filter add at duty cycle 70%**



**Figure 23: The FFT of output voltage from DC-Dc buck convertor at duty cycle 70%**

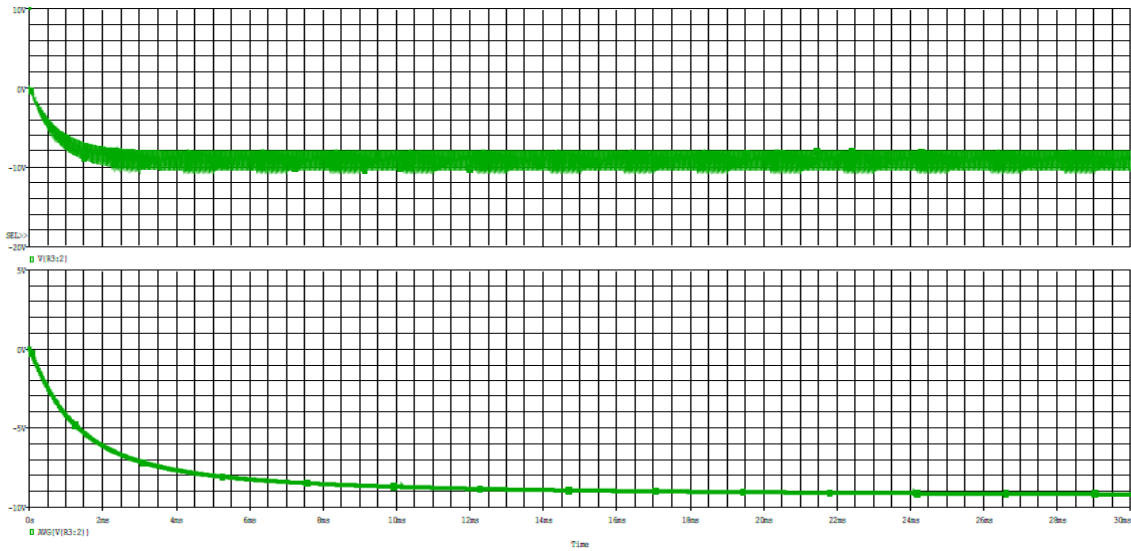


**Figure 24: The output voltage from DC-DC buck convertor at 70% duty cycle and 22uF capacitor**

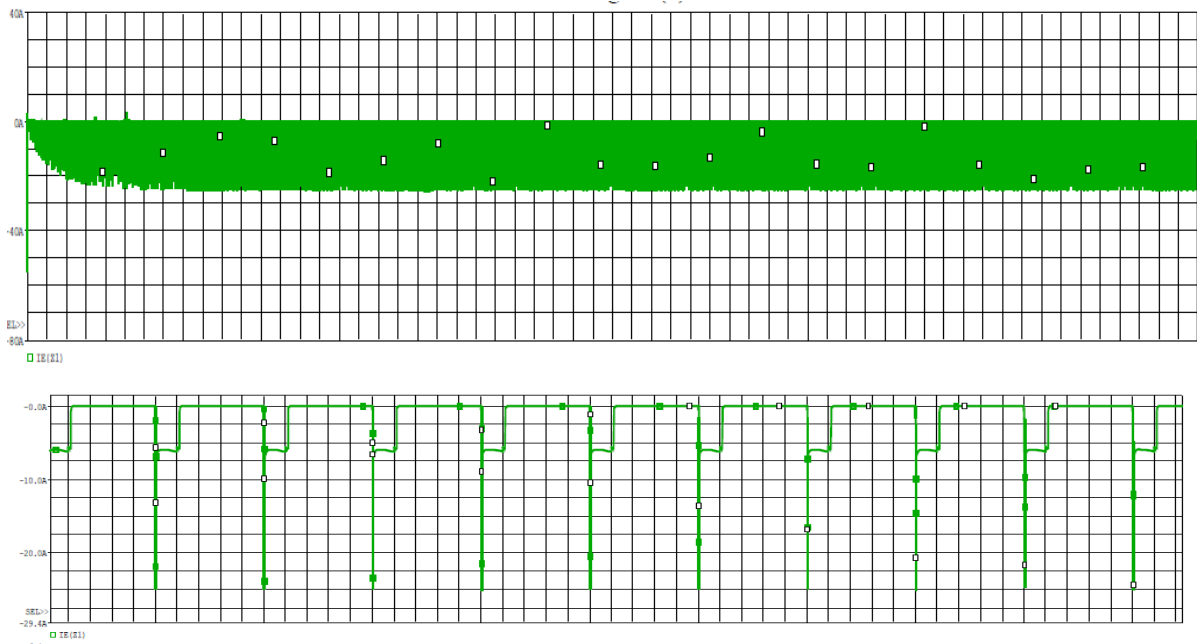


**Figure 25: The output voltage from DC-DC buck convertor at 20-Ω load resistor**

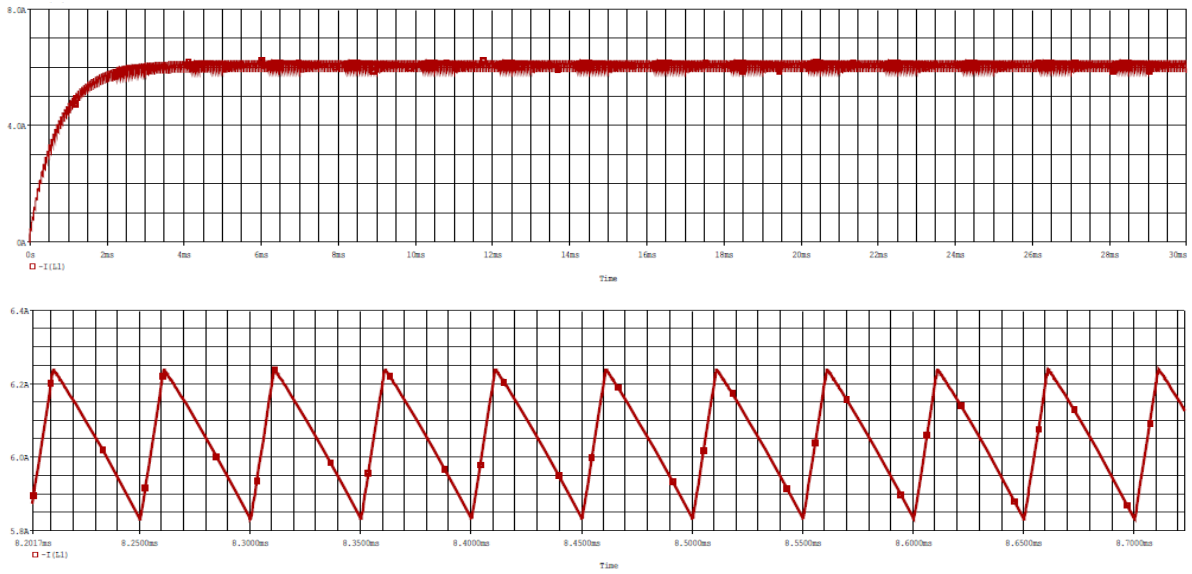




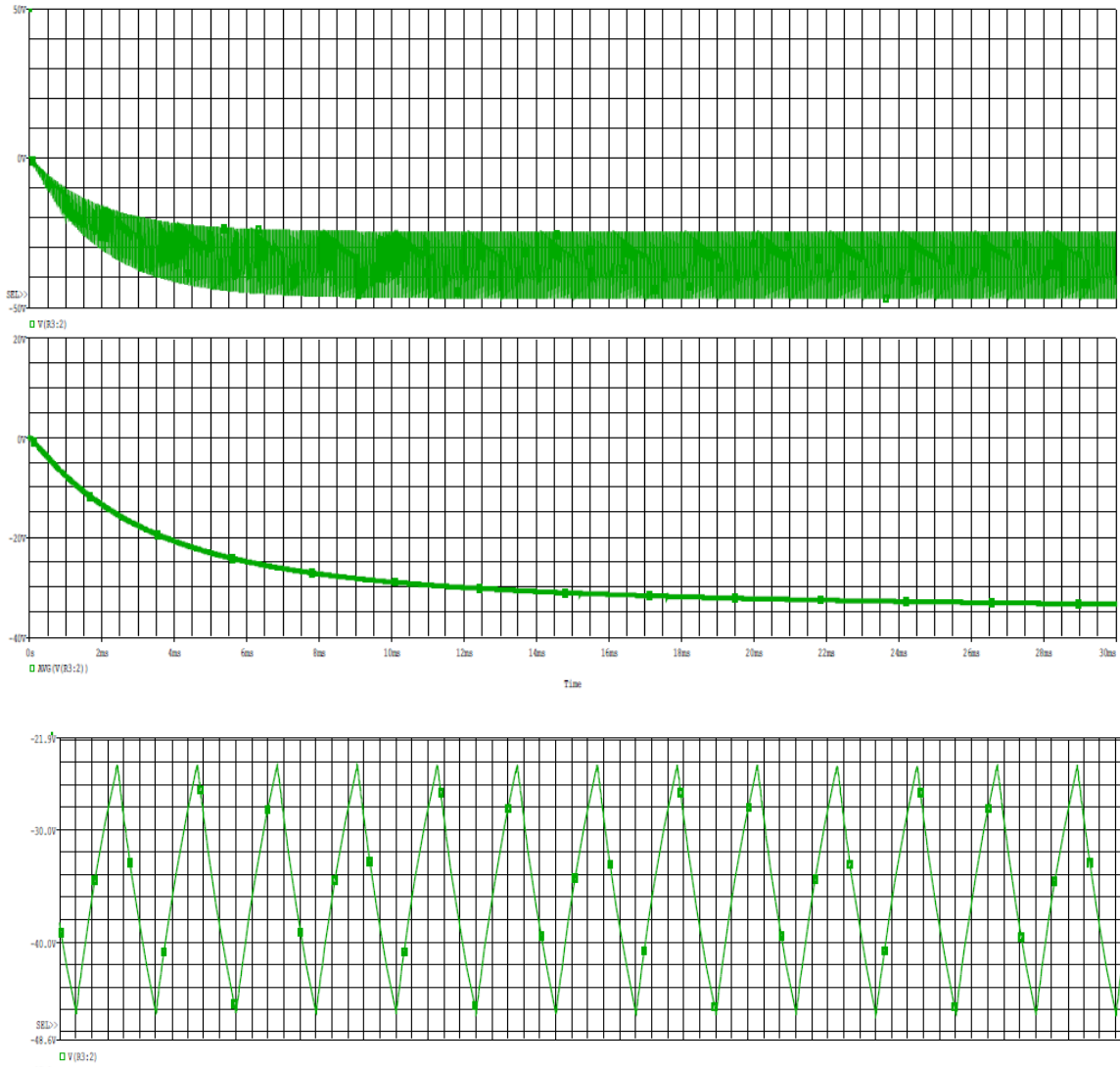
**Figure 26: The output voltage, its average and Ripple from Dc-Dc Buck-boost convertor at duty cycle 20%**



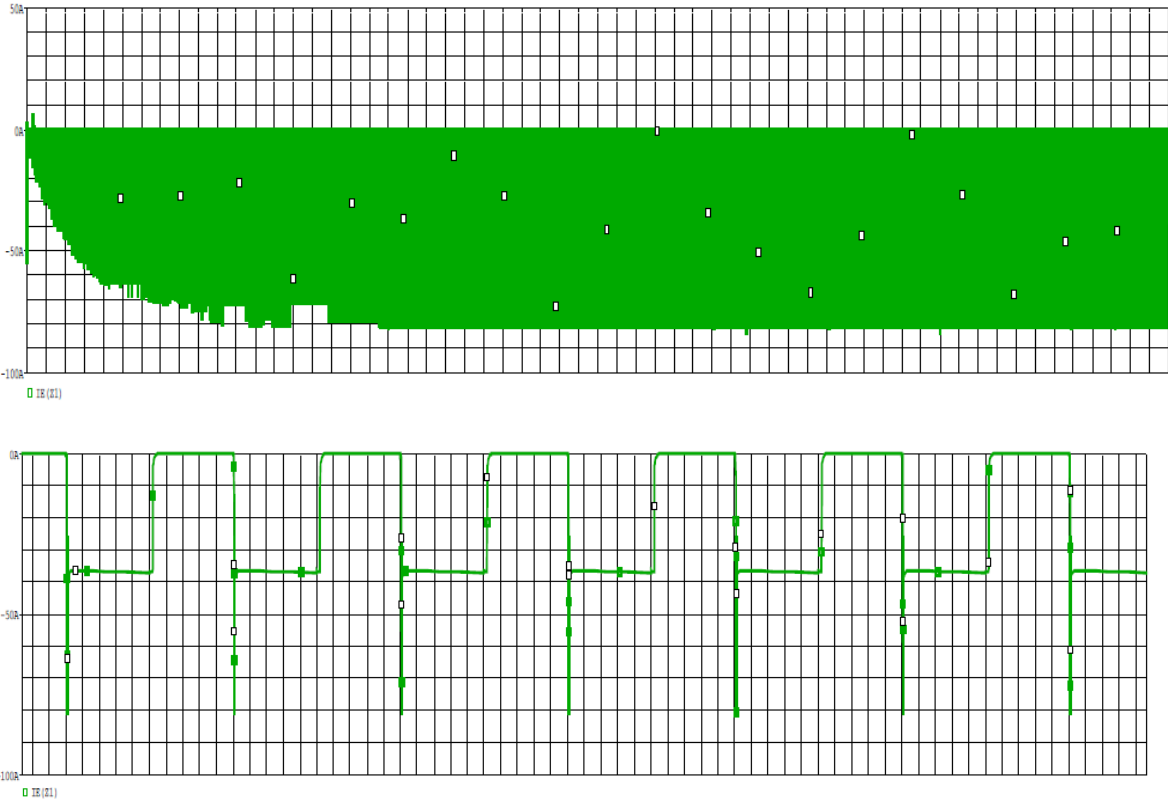
**Figure 27: The Current in IGBT of Dc-Dc buck boost convertor at duty cycle 20%**



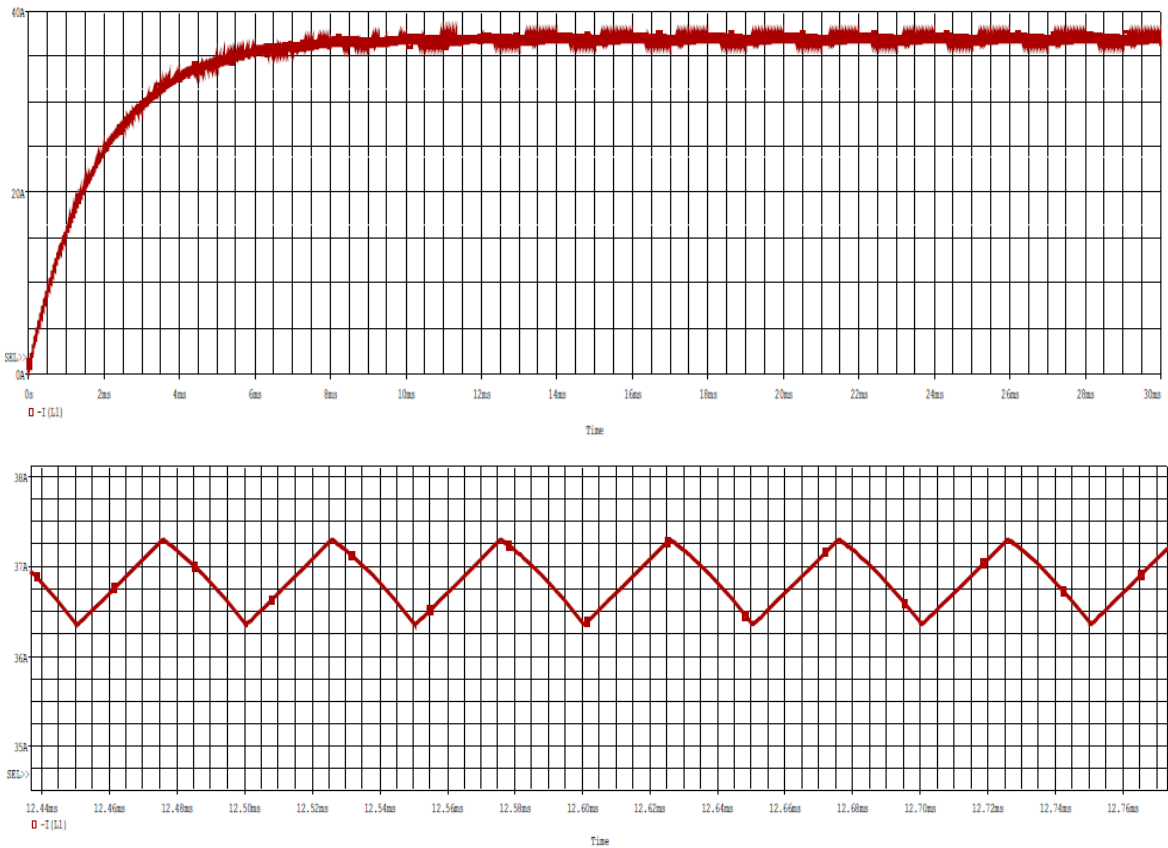
**Figure 28: The Inductor Current in Dc-Dc buck-Boost convertor at 20% duty cycle**



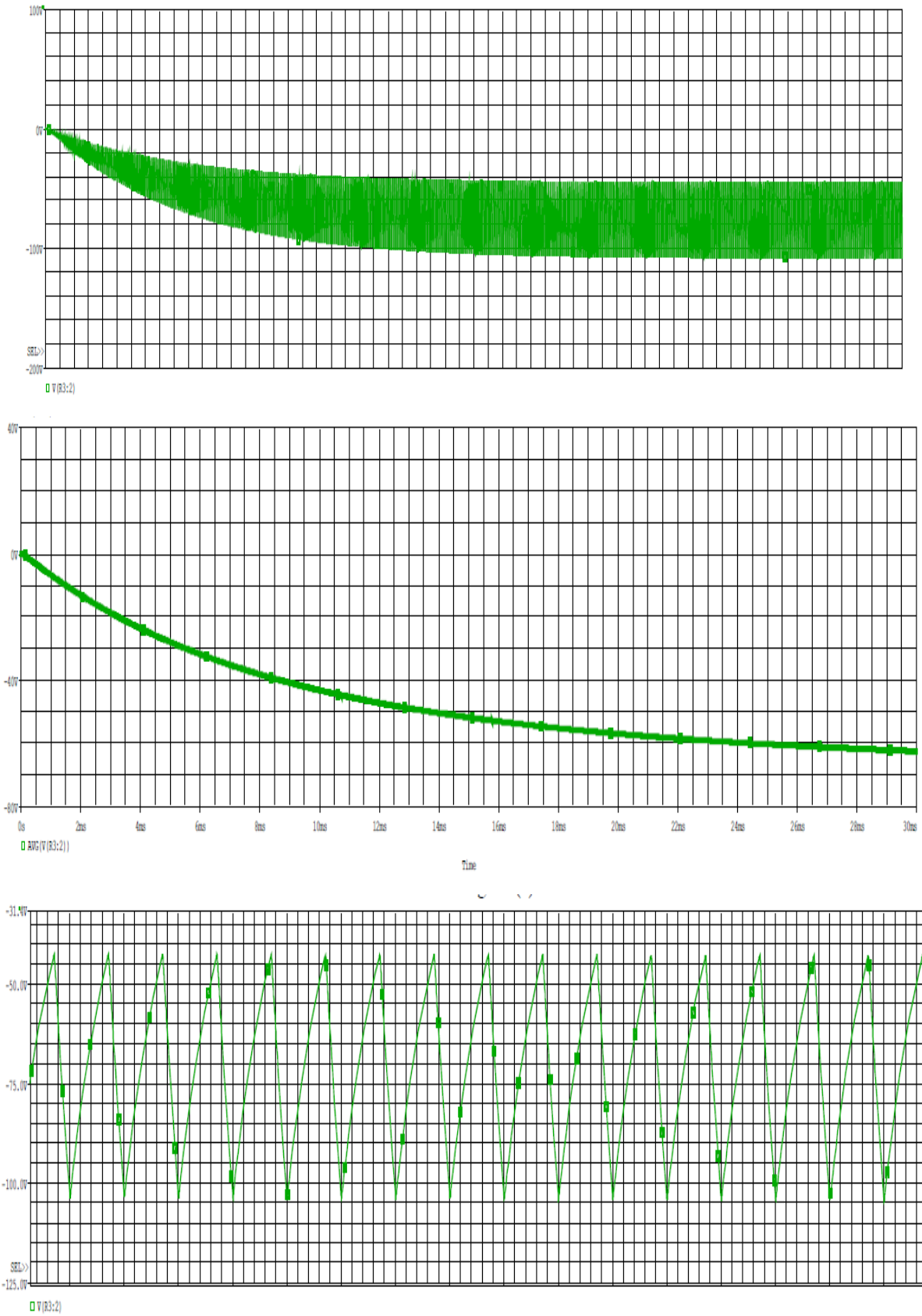
**Figure 29: The output voltage, its average and ripple from Dc-Dc buck boost convertor at 50% duty cycle**



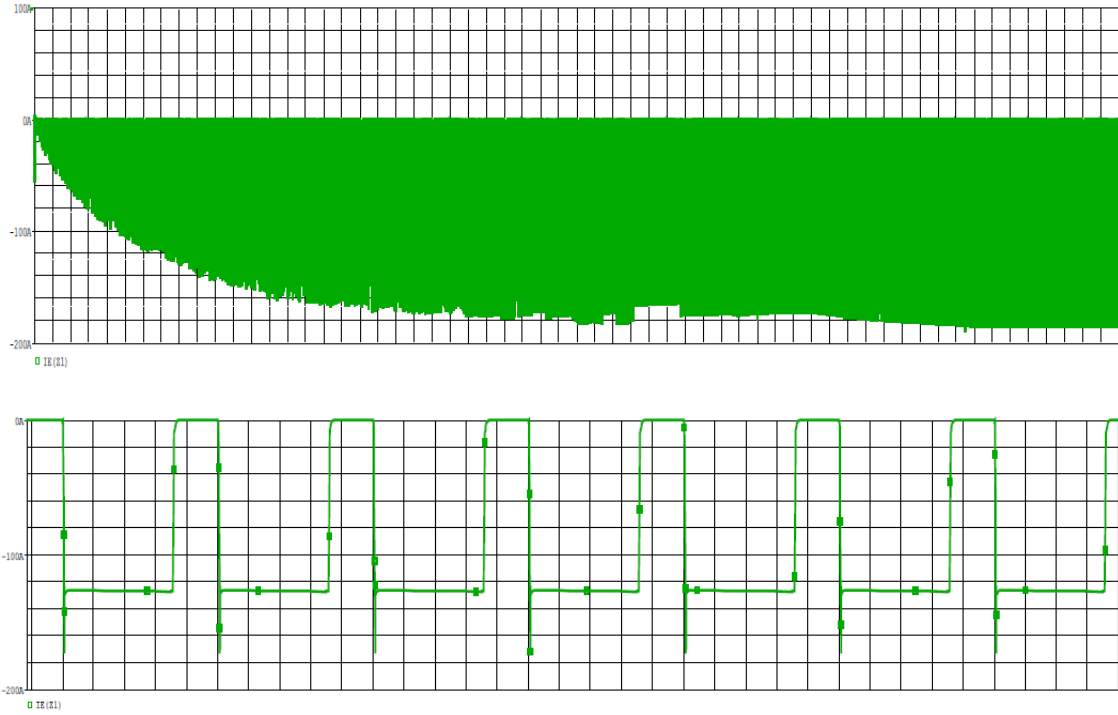
**Figure 30: The IGBT Current of Dc-DC buck-Boost convertor at 50% duty cycle**



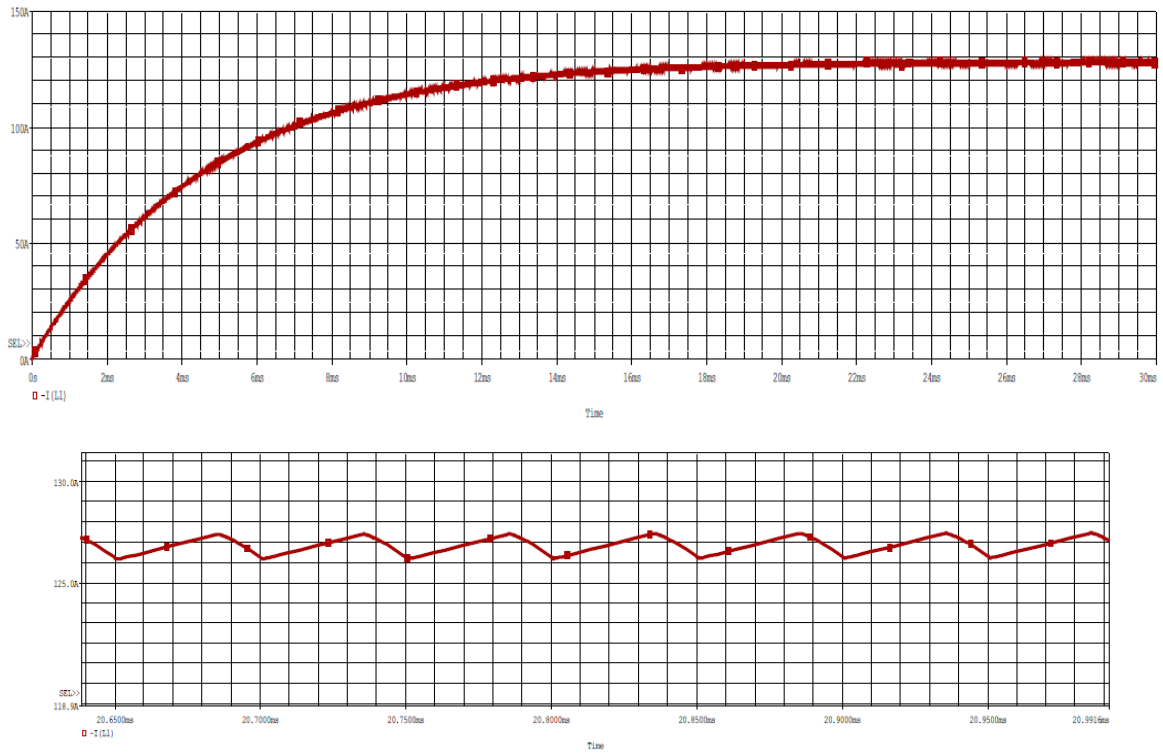
**Figure 31: The inductor current of Dc-DC buck- boost convertor t duty cycle 50%**



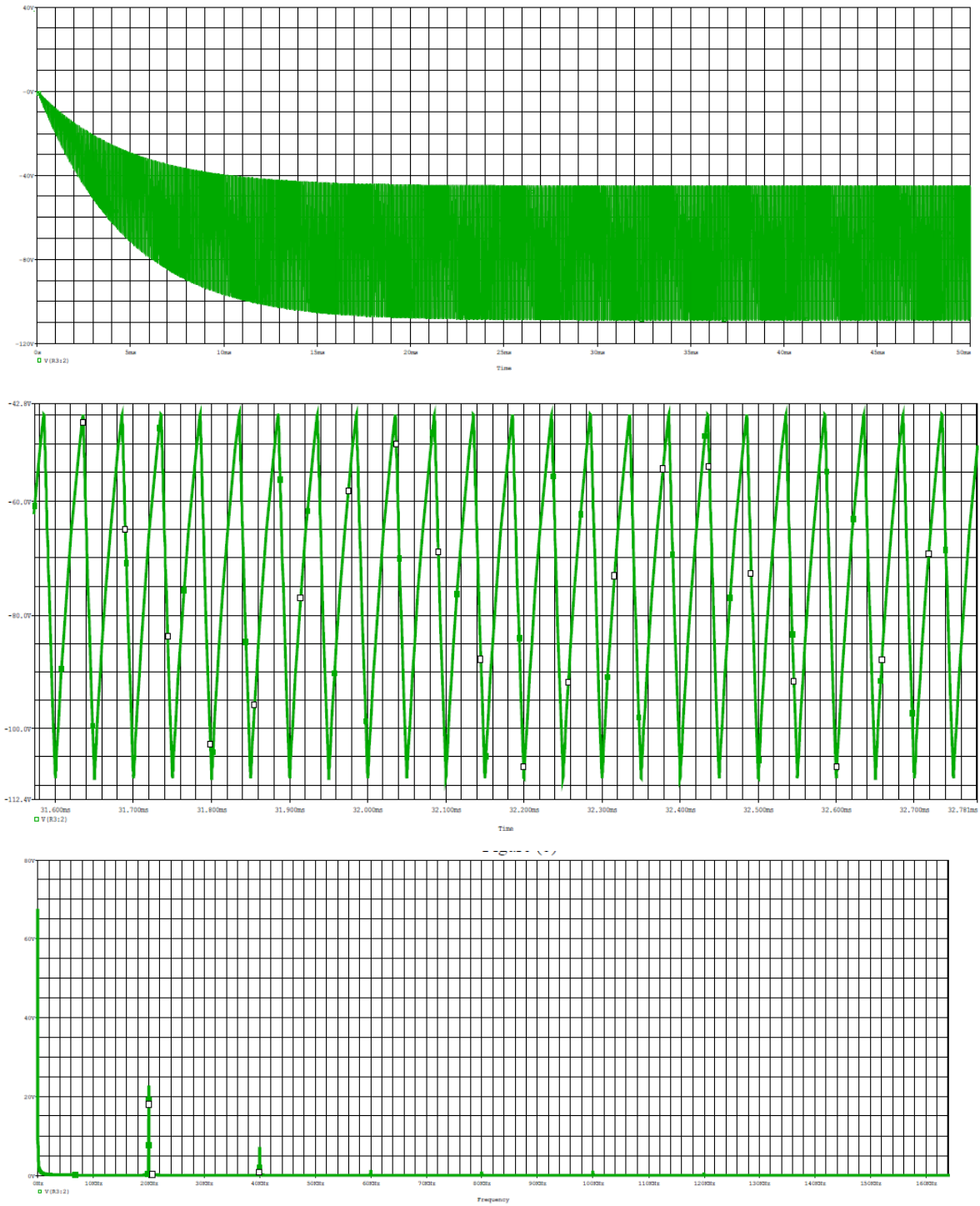
**Figure 32: The output voltage, it average and ripple of Dc-Dc buck boost converter at duty cycle 70%**



**Figure 33: The IGBT current in Dc-Dc buck-boost convertor at duty cycle 70%**



**Figure 34: The inductor current in Dc-Dc buck-boost convertor at duty cycle 70%**



**Figure 35: The output voltage, its ripple and FFT of the output voltage from Dc-Dc buck boost converter at duty cycle 70% and 20uF capacitor**



**Figure 36: The output voltage, its ripple and FFT of the output voltage from Dc-Dc buck boost convertor at duty cycle 70% and 1uF capacitor**

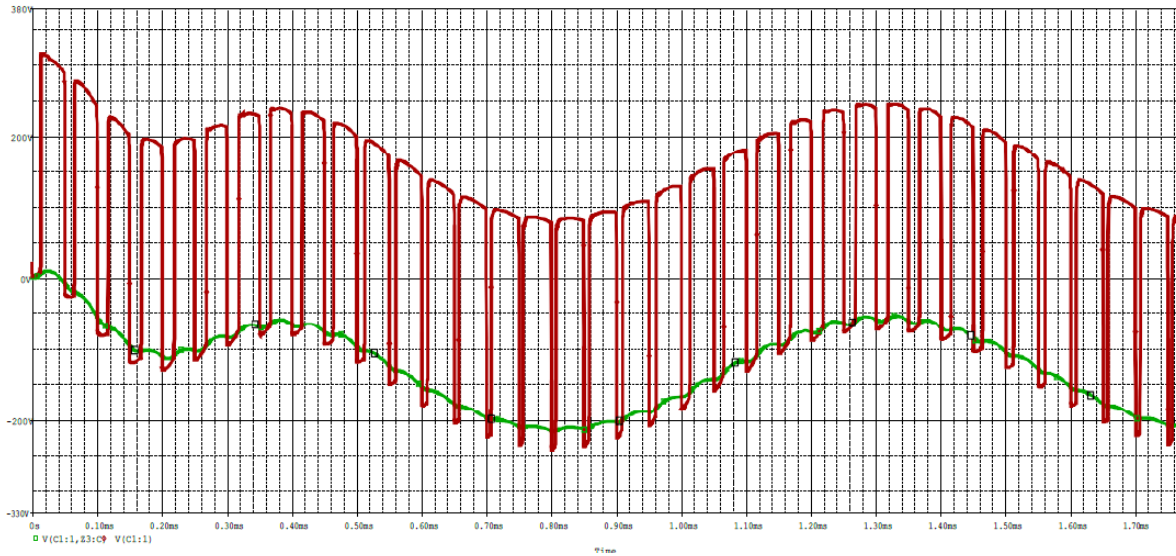


Figure 37: Output voltage over the load resistor and the output voltage before the filter of Dc-Ac Bridge

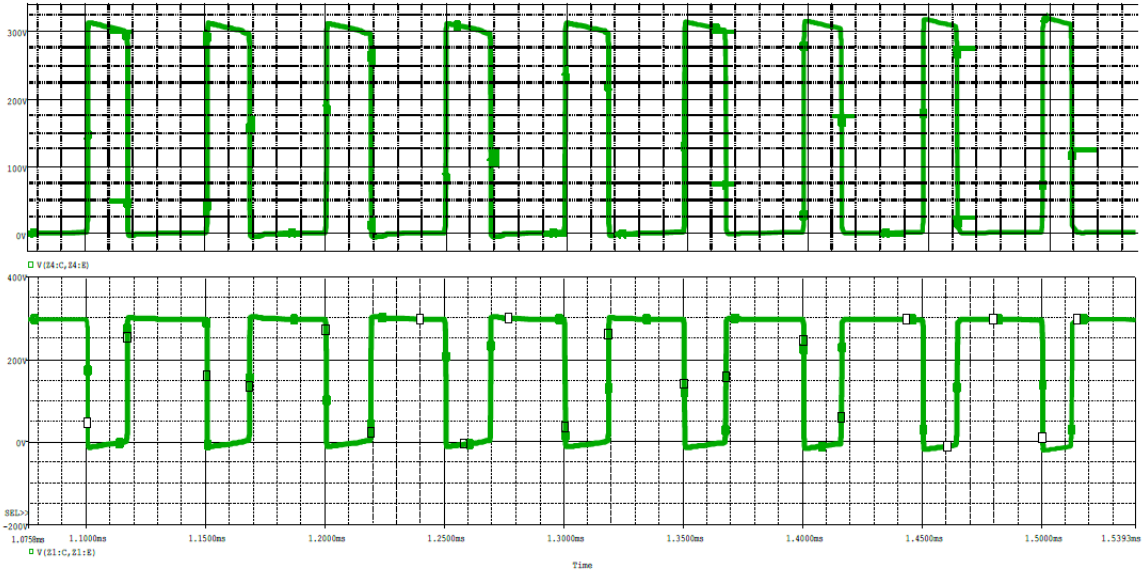


Figure 38: The voltage across Z1 and Z4 in Dc-Ac Bridge convertor

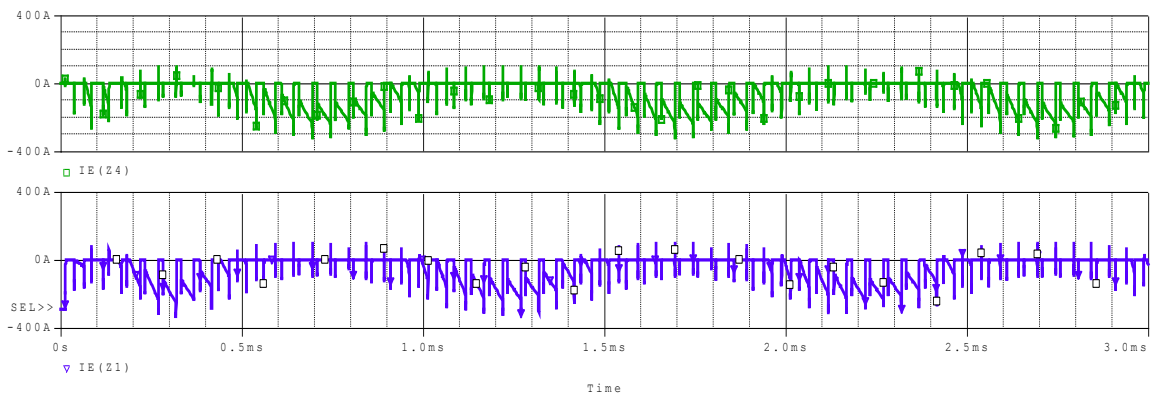
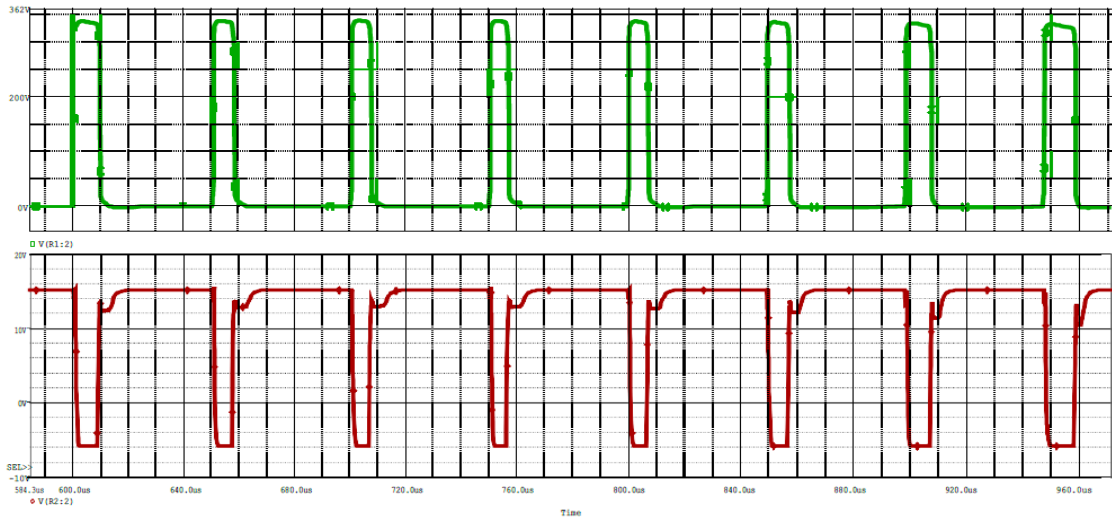
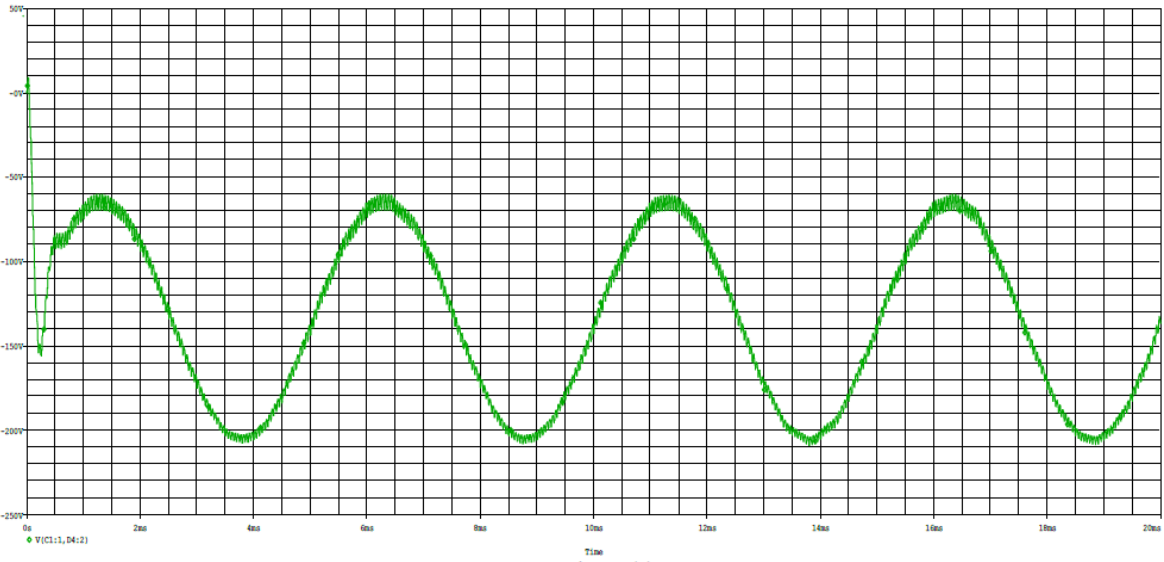


Figure 39: The Current in Z1, Z4 in Dc-Ac Bridge convertor





**Figure 40: The Gate Signal to Z1 and Z4 in Dc-Ac Bridge convertor**



**Figure 41: The output voltage from the Dc-Ac Bridge Converter at frequency 200 Hz**

## **6. Discussion of the results:**

### **6.1 Multistage amplifier:**

From the Figure 13, which is the characteristics of the gain of open-Loop multistage amplifier shown in the Figure 5, note that the maximum gain achieved at zero frequency which is 131.66 and when the frequency increases the gain stile constant, at 30 kHz the gain of open-loop multistage amplifier began decreases, in addition, from the Figure 14 which is the characteristics of the close-Loop multistage amplifier shown in Figure 8, note that the maximum gain obtained at zero frequency which is 9.241, and when the frequency increase the gain stile constant, but at 500 kHz the gain began decreases.

### **6.2 Power Electronics convertor in Orcad:**

#### **6.2.1: Buck Convertor:**

From the Figures 13, 14 and 15, which are the average, output voltage from the buck convertor shown in the Figure 9, the input voltage at the system 100V but the output voltages less than 100V, when the duty cycle increases the output voltage from the system increase, from the Figure 19 which is the frequency spectrum density of the output voltage from the buck convertor shown in the Figure 9, note that the fundamental component of voltage at zero frequency and some harmonic at different frequencies these type of analysis help to design the filter, Figure 23 shown the frequency spectrum density of the same convertor and same duty cycle but with low pass filter, from this figure note that the only the fundamental component was take and other harmonic was rejection.

From the Figure 18, which is contain three plots which are the  $V_{CE}$ ,  $I_G$  and IGBT current, note that when the gate current set to zero, the VCE set to zero and the IGBT current -100 A, in other hand, when the gate current set to 1, the voltage  $V_{CE}$  set to -100 V and IGBT current set to zero, this is operation of switching.

From the Figure 20, 21 and 22, which are the output voltage from the Dc-Dc buck convertor shown in the Figure 10 after added low, pass filter, note that the output voltage is the same voltage at the capacitor so the output voltage contain transient and steady state response, and the output voltage contain a ripple due to charge and discharge, in addition, when the output voltage in transient the current through IGBT is grater but when the output voltage reach to steady state the current in IGBT reach to constant value.

From Figure 24, which is the output voltage from the Dc-Dc buck convertor shown in Figure 10 after added low pass filter, note that, the ripple in output voltage increase when the value of filter capacitor decreases, and from Figure 25 note that the ripple in output voltage decreases when the load resistor increase.

#### **6.2.2: Buck-Boost Convertor:**

From Figure 26, which is the output voltage from buck-boost convertor shown in Figure 11; note that, since the duty cycle 20% the system work as a step down convertor and the output voltage less than input voltage.

From Figure 29, which contains the output voltage, its average and ripple at 50% duty cycle from the buck-boost convertor shown in Figure 11, from these figures notes that, the output voltage almost same input voltage.

From Figure 32, which is the output voltage from the buck- boost convertor at 70% duty cycle, note that, the output voltage is greater than input voltage, so the system in this case work as a step up convertor.

From Figure 27, 30 and 33, which are the current through IGBT in buck-boost convertor shown in figure 11 at 20%, 50% and 70% duty cycle respectively, from these Figures notes that, the value of current increase when the duty cycle increases.

From Figures 28, 31 and 34, which are the current in the inductor and its ripple, in buck-boost convertor shown in figure 11, at 20%,50% and 70% duty cycle respectively, notes that, the current increases when the duty cycle increases and the ripple in current decrease when the duty cycle increase.

From Figures 35, which are the output voltage, its ripple and frequency spectrum density at 70% duty cycle and 20uF capacitor in buck-boost convertor shown in figure 11, note that, the output voltage contain small quantity of ripple, however from figure 36, which are the output voltage, its ripple and frequency spectrum density at 70% duty cycle and 1uF capacitor, notes that the ripple in output voltage high, so when the value of capacitor is increases the ripple decreases.

### **6.2.3: Bridge rectifier:**

From Figure 37 which is the output voltage from Dc-Ac Bridge convertor shown the Figure 12, the input voltage in bridge 300V DC, and the output is almost AC voltage.

From Figure 38, 39 and 40 which are the voltage and current in Z1, Z4, from these figures notes that, when the switch Z1 on the switch Z4 off.

## 7. Conclusion:

At the first time in these experiments, the Orcad used to make modular design of multistage amplifier and studied some properties about each types such as gain, input impedance and output impedance , in addition, the Orcad used to make sub circuit of multistage amplifier and add it in the library, this functionality of the Orcad help the designer to get good results at small time and size, in other hand, in these experiments the Different Dc-Dc chopper circuit implemented and simulated in Orcad and some properties of these circuit studied such as the output voltage, currents in inductor and switch. Finally, these experiments benefits to become familiar with Orcad program, which is the important tools, in Electrical Engineering world.

## 8. References:

[1] <https://en.wikipedia.org/wiki/OrCAD.>, 3.04 AM, April 7,2019

[2] Simulation LAB manual, 2019-second semester editions April 7, 2019 4.38 AM.

## 9. Appendix A.1:

$$V_{out} = -\frac{V_{in}}{1-\rho} \quad , \quad 0 < \rho < 1$$

**Equation... (1)**

$$V_{out} = -\frac{\rho V_{in}}{1-\rho} \quad , \quad 0 < \rho < 1$$

**Equation ... (2)**

$$V_{out} = \rho V_{in} \quad , \quad 0 < \rho < 1$$

**Equation ... (3)**