Circuit Theory and Electronics Fundamentals

Lab 3 - AC/DC Converter

Aerospace Engineering

Laboratory Report

May 8, 2021

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Contents

1 Introduction

This report is being made for the subject of Circuit Theory and Electronics Fundamentals and is related to the third laboratory being its objective to develop an AC/DC converter circuit using a envelope detector and a voltage regulator. The display of this circuit can be seen in Figure 1. In Section 2 a theoretical analysis will be made. Secondly, in Section 3 it will be simulated the circuit using ngspice. Following with both results from Section 2 and Section 3 being compared and commented in Section **??**

The conclusions of this study are outlined in Section 4.

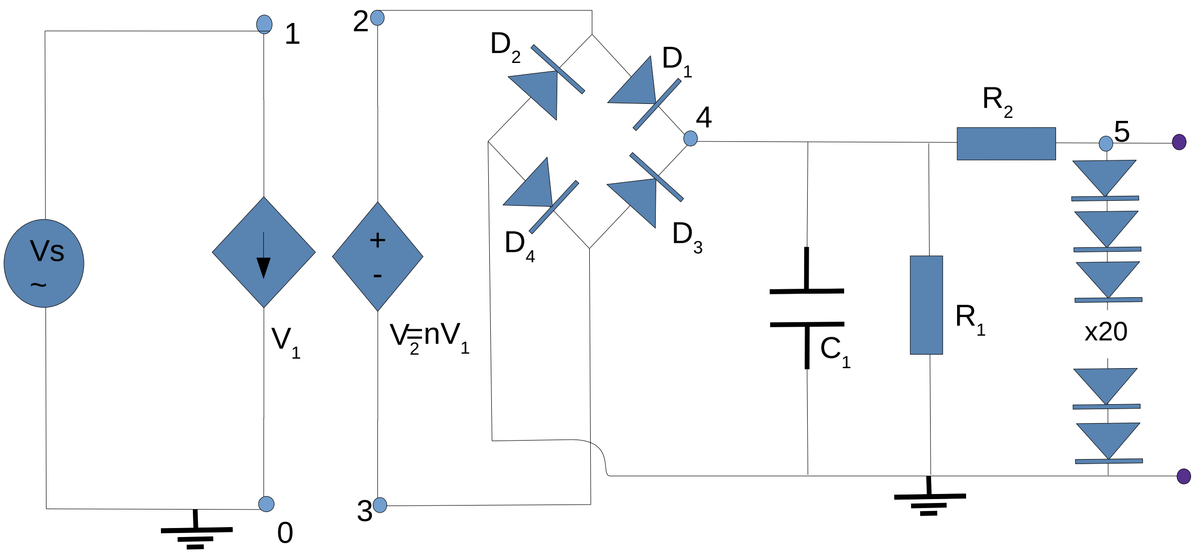

Figure 1: AC/DC converter circuit

2 Theoretical Analysis

In this section, the output voltage, voltage ripple and envelope detector output of the circuit shown in Figure 1 will be analysed theoretical.

As we were free to choose the circuit, these are the values that we decided to use for the resistances and the capacitor, as well as the voltage and frequency of the primary circuit in the transformer.

Name	**Value [V/Ohm/F]**
Frequency	5.000000e+01 Hz
Voltage	2.300000e+02 V
Resistance 1	8.000000e+03 Ohm
Resistance 2	6.284000e+04 Ohm
Capacitor	1.000000e-04 F

Table 1: Given and choosen variables of the circuit

By using a transformer with a proportion of 1:11, we were able to change the voltage from a value as high as 230V is in the primary circuit to a value which is much closer to the aim (12V) in the secondary circuit, with the voltage being shown in Figure 2. However, we also needed two essencial components in order to change the AC source to a DC voltage.

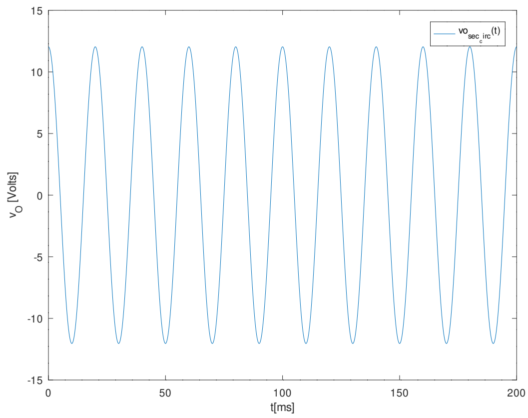

Figure 2: Output voltage of the secundary circuit

The first thing that the circuit does is transforming the voltage coming from the transformer ($v_(out)$) to its absolute value ($vOhr$). This happens due to the 45 degree 4 diode circuit which is a full wave rectifier. (Note: tha diodes are considered to the ideal for the theoretical calculations).

Then, the voltage enters in the envelope detector, where the voltage passing the capacitor starts to have behavior closer to a DC voltage. The result can be seen in the Figue **??**, where we can see that the amplitude clearly decreased. We calculated the times when the diodes were ON and OFF. 1 gives us the expression that we needed to compute the values of $t_(OFF)$.

$$t_(OFF) = 1/w * atan(1/(w * R1 * C)) \tag{1}$$

While t¡t_OFF

$$vOenv(t) = vOhr(t) \tag{2}$$

And for t¿t_OFF

$$vOenv(t) = abs(v_(out) * cos(w * t_(OFF)) * e^(- (t - t_(OFF))/(R * C) \tag{3}$$

With vOenv being the value of the voltage in the envelope detector.

The voltage ripple (the difference between the maximum and minimum value of the voltage) and the average value for the envelope detector are given in the following table.

Name	**Value [V]**
Ripple of the Envelope	1.421989e-01
Averageof the Envelope	1.197192e+01

Table 2: Voltage Ripple and Average Voltage for the Envelope Detector

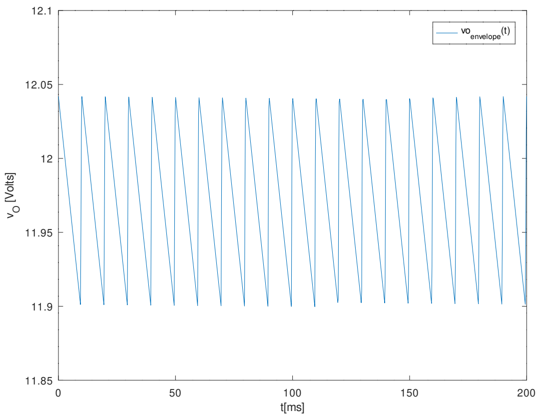

Figure 3: Output voltage of the envelope

For the last segment of the circuit, the voltage regulator, we have 20 diodes in series make almost a perfect DC, by reducing the majority of the noise produced. For the computation of the values, we decided to divide the DC component (dc_vOreg) from the AC one (ac_vOreg). For the DC component, we analysed the voltage of the 20 diodes and, if it was superior to the average value of the vOenv, then

$$dc_(vOreg) = VOn * n_(diode) \tag{4}$$

If not

$$dc_(vOreg) = vOenv_(medium) \tag{5}$$

This happens in order to understand if the vOenv is a voltage with a bigger value than the maximum value the diodes can handle. For the AC component, we start by calculating the value of r_D, which is the resistance value of each diode

$$r_D = eta * v_t/(I_s * e^(VOn/(eta * v_t))) \tag{6}$$

With the value of r_D, we now are able to calculate the value of the AC component.

$$ac_vOreg = (n_(diode) * r_D)/((n_(diode) * r_D) + R2) * (vOenv - dc_vOreg) \tag{7}$$

To calculate the final value of the voltage leaving the regulator (vOreg), we simply add the AC and DC component, which gives us a value extremely close to 12V, as it can be seen in the Figure 4 (final value) and 5 (difference to 12V).

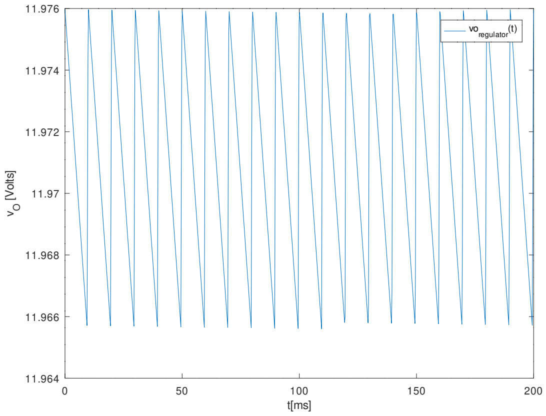

Figure 4: Output voltage of the regulator

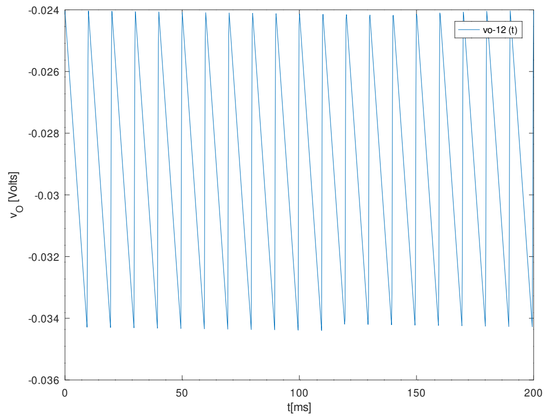

Figure 5: Deviation from the wanted DC voltage

The voltage ripple (the difference between the maximum and minimum value of the voltage) and the average value for the envelope detector are given in the following table.

Name	**Value [V]**
RippleRegulator	1.036599e-02
AverageRegulator	1.197087e+01

Table 3: Voltage Ripple and Average Voltage for the Voltage Regulator

The total cost of the circuit and the merit value is given in the following table.

Name	**Value**
Total cost of the components	1.732400e+02
Merit	1.461056e-01

Table 4: Cost and Merit

3 Simulation Analysis

This section covers the circuit simulation using the Ngspice tool, where the AC/DC converter was simulated for 10 periods using the default diode model.

Firstly, the transformer was replaced by an ideal model using an dependent current source and an dependent voltage source. Then, by trial and error the values of the resistors, capacitor and n parameter were adjusted reaching a good accuracy. The goal was to reach the closest value to 12V in the output voltage.

As asked in the lab assignment, the input voltage of the the secondary circuit, the output voltage of the envelope detector, the output voltage of the voltage regulator and (v(5)-12) were computed and ploted.

Later in this report, we will compare this results with the theoretical ones but for now we will just show them.

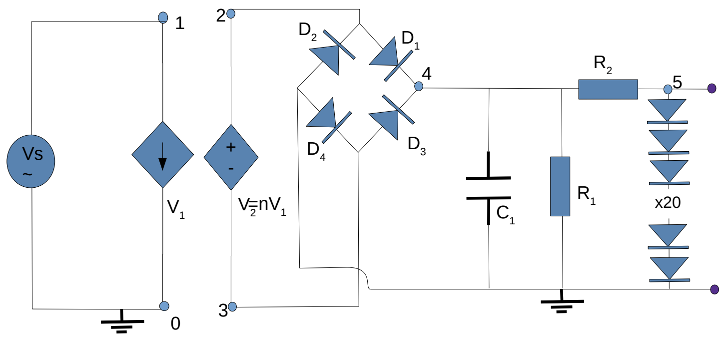

Figure 6: AC/DC converter circuit

The Table 5 shows the output voltages results for the circuit described in Figure 6.

Name	Value [A or V]
maximum(v(4))-minimum(v(4))	7.243825e-01
mean(v(4))	1.256325e+01
maximum(v(5))-minimum(v(5))	3.427691e-01
mean(v(5))	1.196956e+01

Table 5: Outpu voltages results in Volts

The Table 6 show the merit value obtained by the group.

Name	Value [A or V]
1/((maximum(v(5))-minimum(v(5)))*(mean(v(5)))+10e-6)	2.437356e-01

Table 6: Merit values

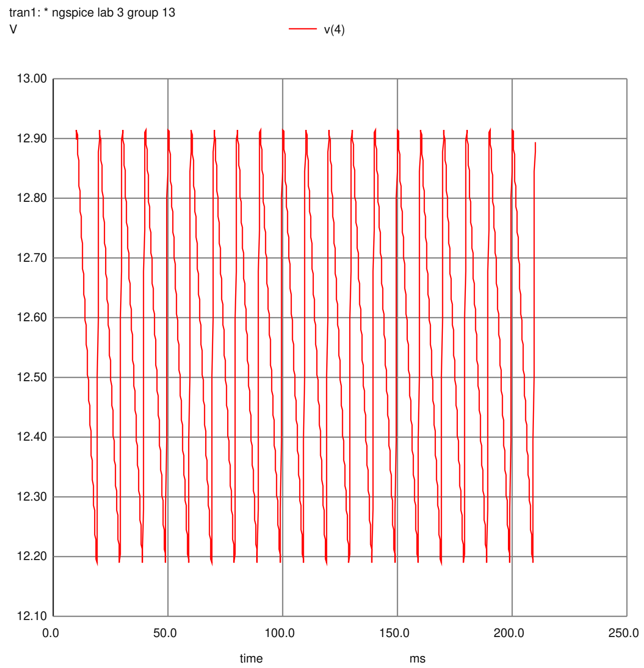

Figure 7: Output Voltage of the envelope detector v(4)

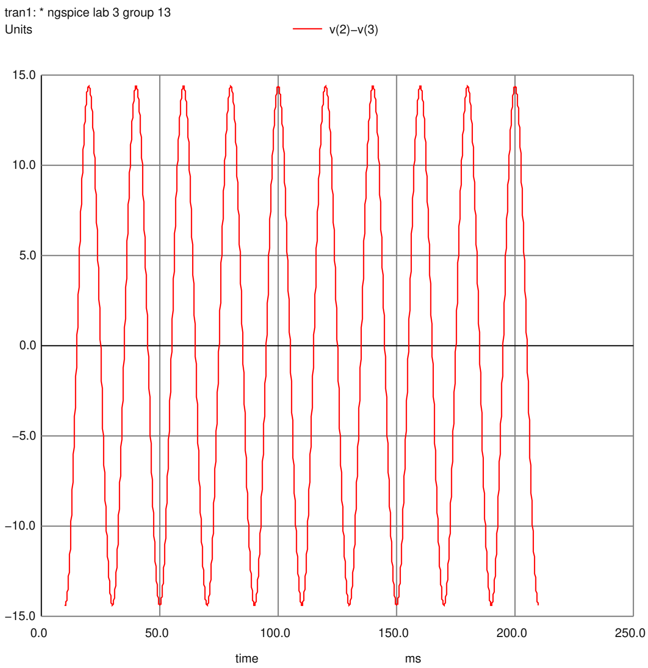

Figure 8: Input Voltage of the secondary circuit (v(2)-v(3))

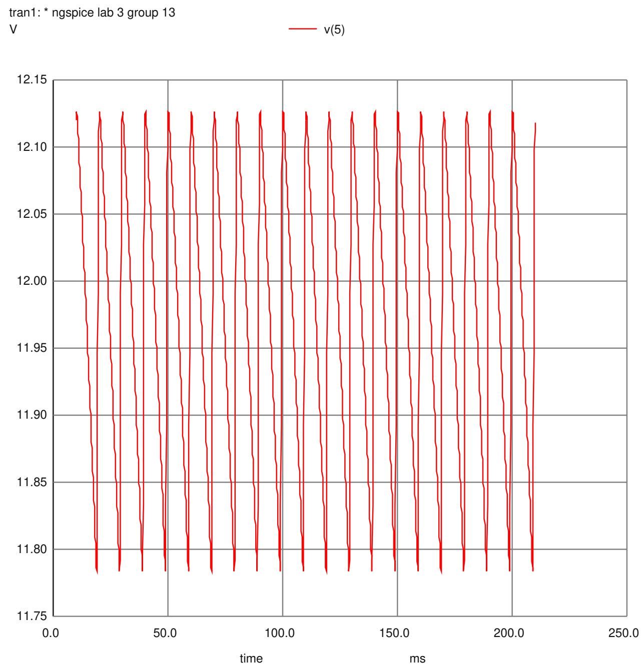

Figure 9: Output Voltage of the voltage regulator v(5)

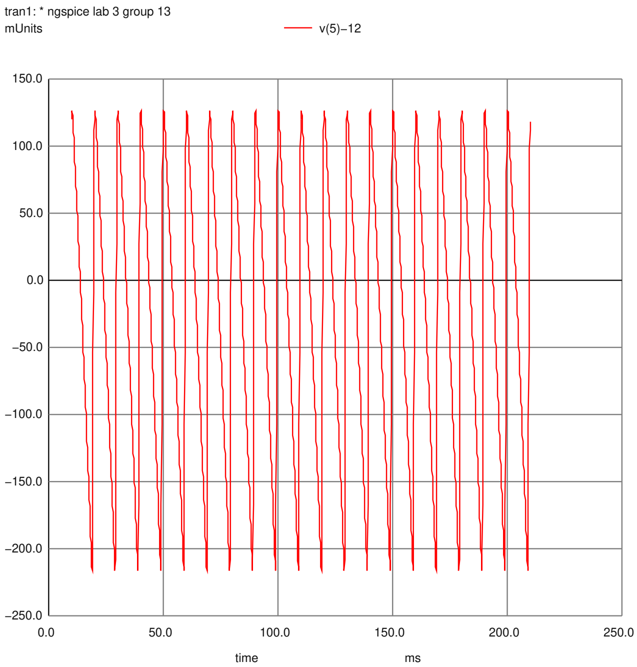

Figure 10: SImulated voltage output error (v(5)-12)

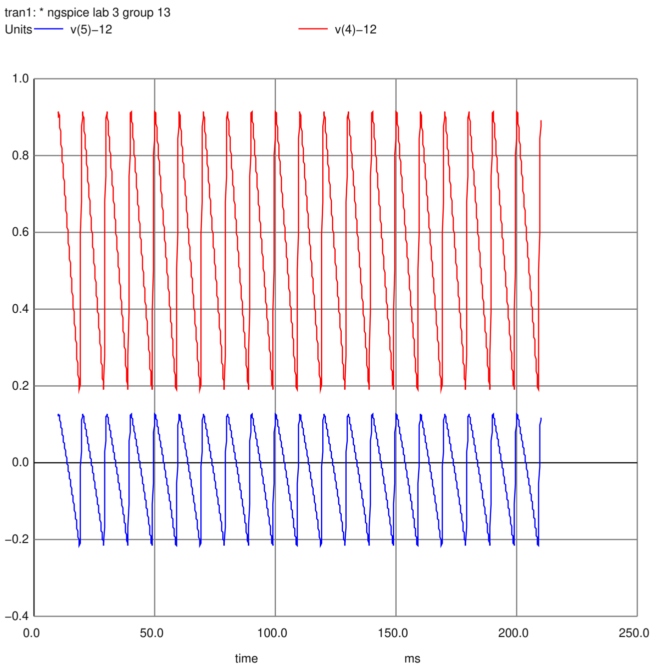

Figure 11: Total Response of V_6 and V_s

4 Conclusion

The objective of this laboratory assignment was to develop an AC/DC converter circuit and that goal was achieved. The error was The merit was So we can conclude that the circuit created was...