Lab 3: AC/DC Converter

Circuit Theory and Electronics Fundamentals

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Contents

1 Introduction

The objective of this laboratory assignment is to build a AC/DC converter using a transformer, envelope detector and a voltage regulator. The circuit can be seen in Figure 1.

In Section 2, the circuit was built ,tested and adjusted to give the expected results. In Section 3, it was used the ideal model diode to study the envelope detector and the real model to solve the voltage regulator (using Newton Raphson's iterative method). The results are compared to the simulation results obtained in Section 2. The conclusions of this study are outlined in Section 6.

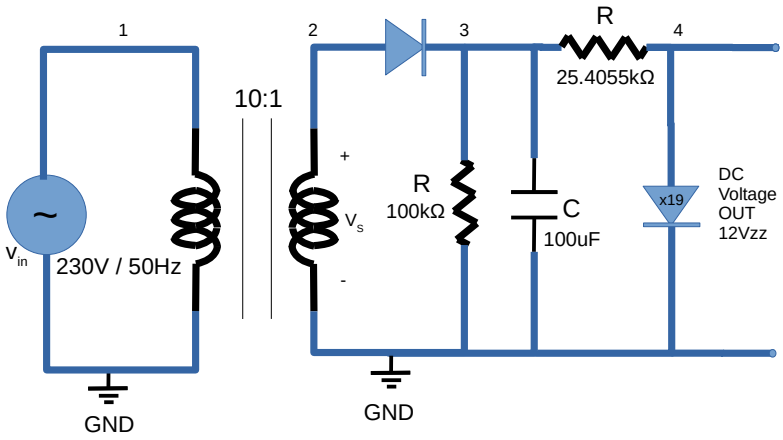

Figure 1: AC/DC Converter

2 Simulation Analysis

2.1 Transient Analysis

Figure 2 shows the simulated transient analysis results for the output voltage of the envelope detector(v3) and the voltage regulator(v4 - DC Output). The circuit was made so that the DC output voltage was 12V. In Figure 3 we see the ripple of the output around the average.

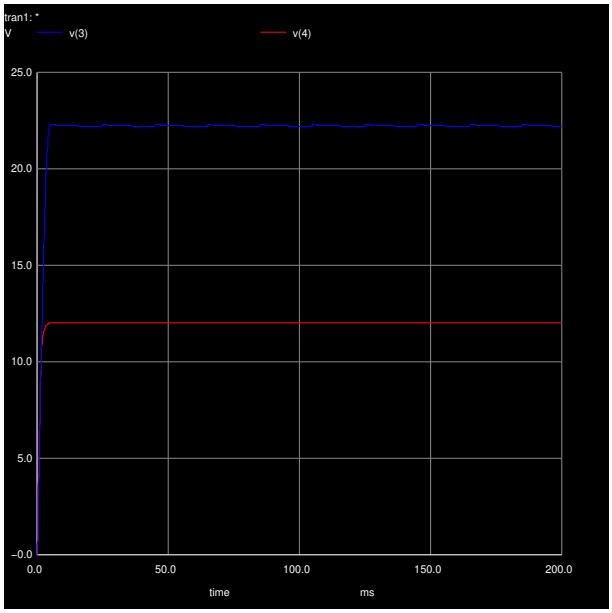

Figure 2: Output voltage of the envelope detector (v3) and the voltage regulator (v4 - DC Output)

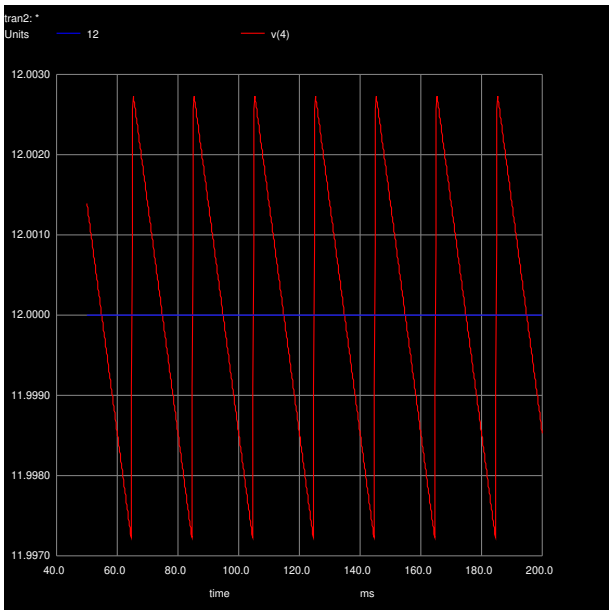

Figure 3: Ripple for the DC output

3 Theoretical Analysis

In this section, the eletrical device shown in Figure 1 is analysed theoretically to predict the output of the Envelope Detector and Voltage Regulator circuits.

4 Envelope Detector

The circuit consists of a diode(that receives a sinusoidal signal) and a resistance in parallel with a capacitor. The voltage source $v_S(t)$ drives its input, and the output voltage $v_3(t)$ is taken from the capacitor terminals. Using the diode ideal model and the solution for the RC circuit, at $t = 0$ the diode is on (its a short circuit) and $v_3(t) = v_S(t)$. When $t = tOFF$ the diode goes off (its an open circuit) and $v_3(t) = -R * i_C$. Noticing that at $tOFF$ $i_R = -i_C$ then $tOFF = \frac{1}{w} \times \arctan 1 * w * R * C$ and for $t > tOFF$ $v_3(t) = A \times \sin(w \times tOFF) \times \exp -\frac{t-tOFF}{RC}$. The time tON is given by the first intersection between the solution for $t > tON$ and $v_S(t)$.

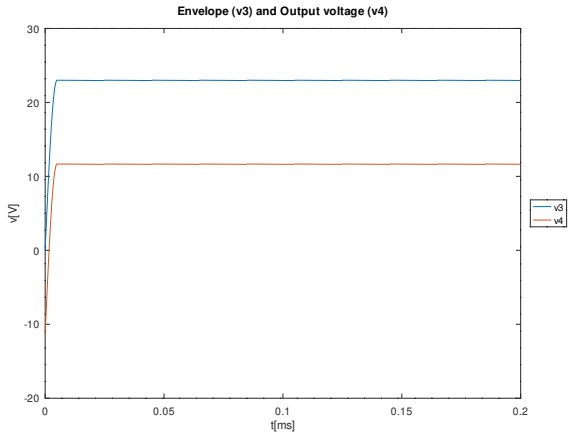

Figure 4: Output voltage of the envelope detector(v3) and the voltage regulator(v4 - DC Output)

5 Voltage Regulator

Using the real diode model and applying the Kirchhoff Voltage Law (KVL), a single equation for the single loop in the circuit can be written as

$$v_4 + R \times I_s \times \exp \frac{v_4}{19\eta \times v_T} - 1 - v_3 = 0 \tag{1}$$

Solving the equation with the Newton Raphson's iterative method, we got the DC output (v4). And in the image below, we see the oscillation around the average. Noticing that it is a little bit different from the simulation result, as was expected.

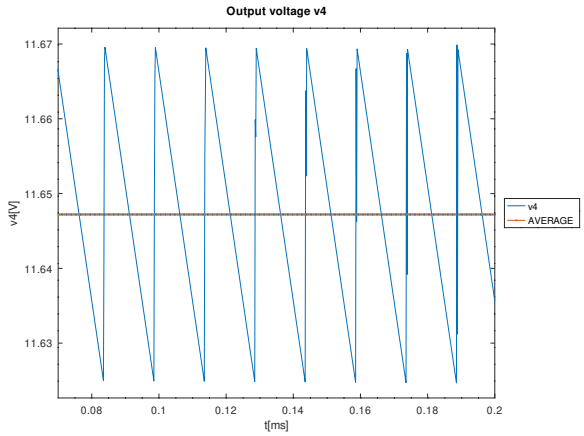

Figure 5: Ripple for the DC output

6 Conclusion

In this laboratory assignment the objective of building an AC/DC converter has been achieved. The output analyses has been performed both theoretically using the Octave maths tool and by circuit simulation using the Ngspice tool. The simulation results differed from the theoretical results by an error of $2,94\%$ on the output average, as was expected because of the non-linear components used. The final merit was of 0.8008433839 with a cost of 227.4055 MU, for he simulation the average and ripple were of $12.00000V$ and $0.00549V$, respectively, and for the theoretical analyses the average and ripple were of $11.647198V$ and $0.04545V$, respectively.