TÉCNICO LISBOA

Circuit Theory and Electronics Fundamentals

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RC circuit

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Contents

1 Introduction

The objective of this laboratory assignment is to build an AC/DC converter, with a transformer, envelope detector and voltage regulator. The AC voltage of 230V and frequency 50Hz will be transformed into a DC voltage of 12V.

In Section 2, a theoretical analysis of the circuit is presented. In Section 3, the circuit is analysed by simulation, and the results are compared to the theoretical results obtained in Section 2. The conclusions of this study are outlined in Section 4.

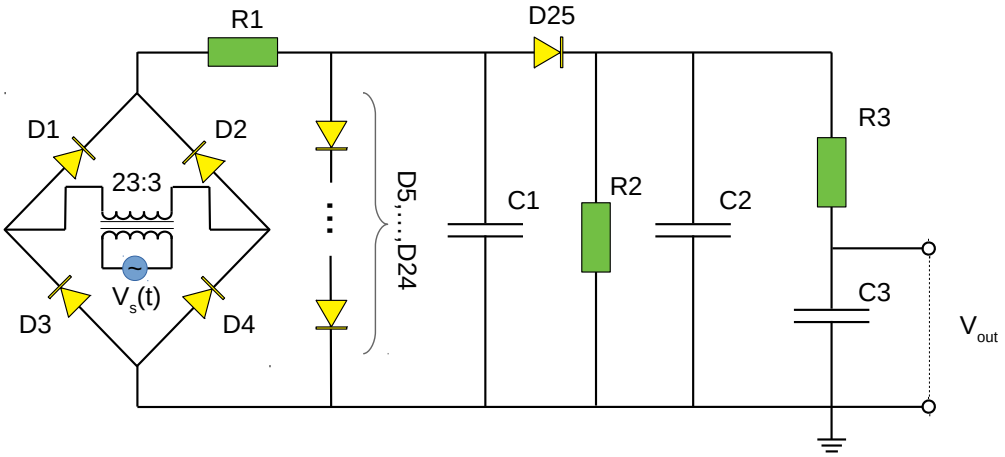


Figure 1: AC/DC Converter

2 Theoretical Analysis

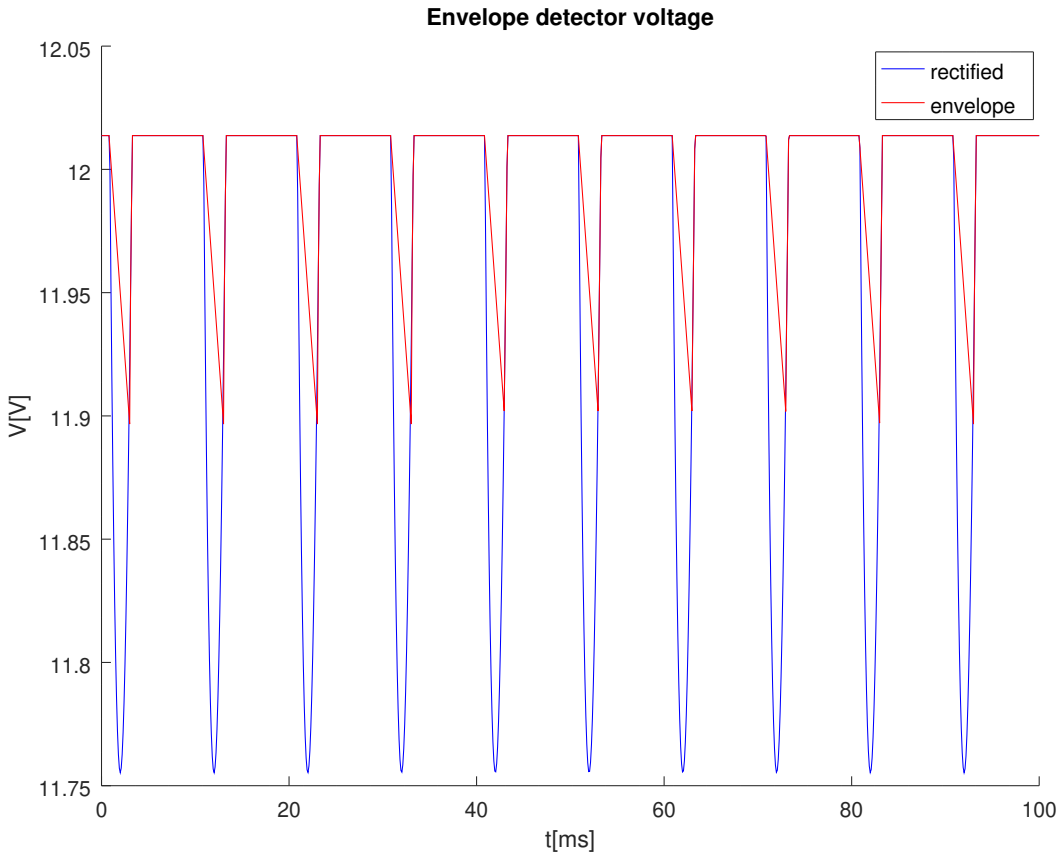
For the theoretical simulation, we used the ideal diode model for the full-wave bridge rectifier, obtaining the absolute value of the initial signal.

For the limiter circuit associated with a first-order low-pass filter, we performed fourier analysis on the previously obtained signal, in order to use phasors to solve for the voltage on the capacitor. The vON diode model was used in this stage, such that any voltage above n*vON (n being the number of diodes in this part of the circuit) was limited.

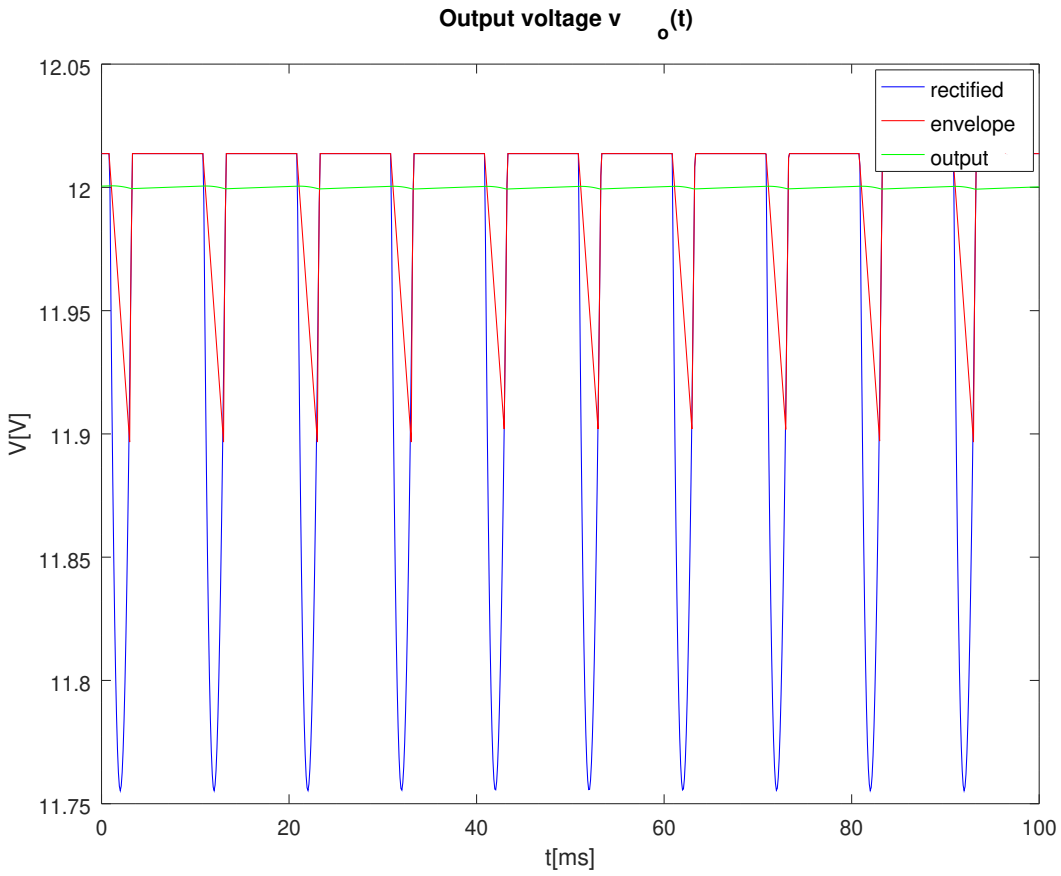
The envelope detector was analysed with the tOFF method, with its value being determined by the below equation:

$$\frac{dVs}{dt} = -\frac{Vs}{RC} \tag{1}$$

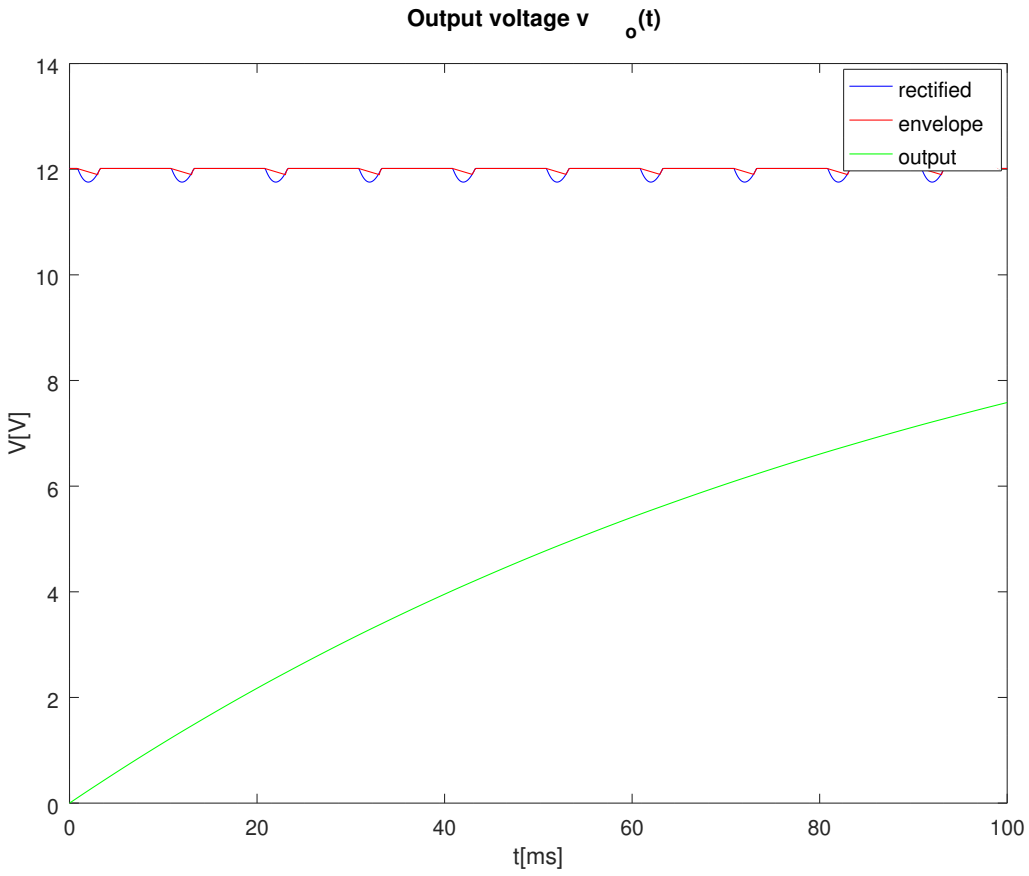
After time tOFF the output voltage of this part of the circuit was modeled using an exponecial, until it crossed the input voltage once more. We see the rectified and limited voltage, as well as the output of the envelope detector below:



For the low-pass filter at the end, we used the Euler method to solve the differencial equation for an RC circuit, thus obtaining the final output voltage:



We can also see the circuit stabilizing from time t=0:



3 Simulation Analysis

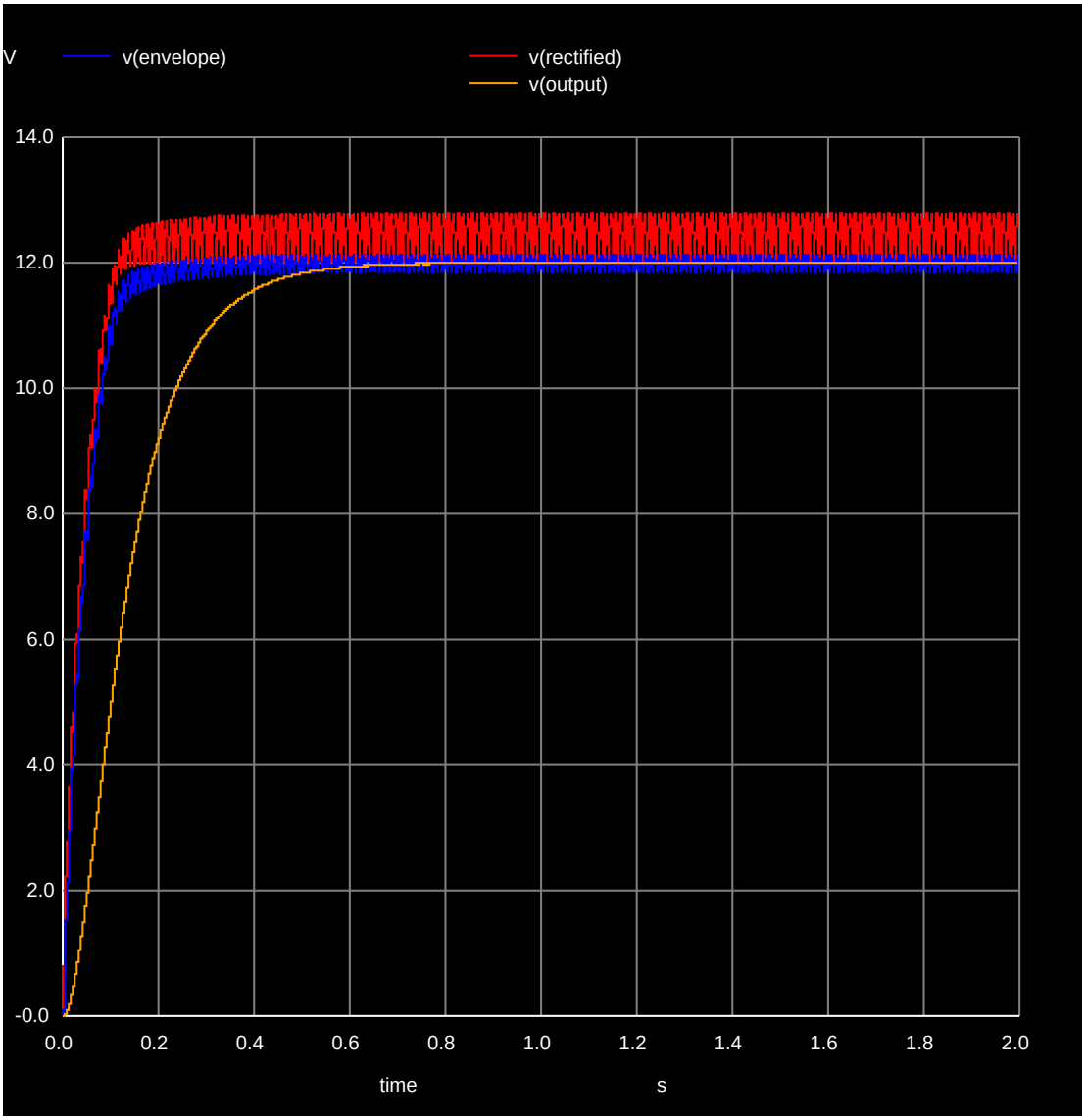
3.1 Transient analysis

We simulated the circuit using transient analysis, using a non ideal transformer and the following components:

Table 1: Values of capacitances and resistances for various circuit components

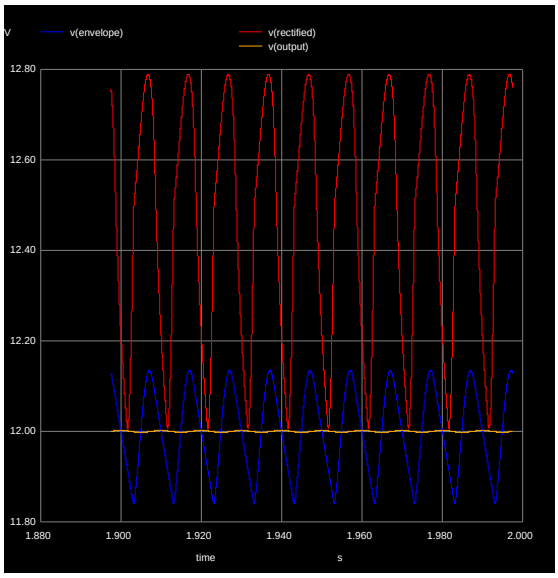
C1	$3.7224F$
R1	$3.7224k$
C2	$15F$
R2	$15k$
C3	$10F$
R3	$10k$

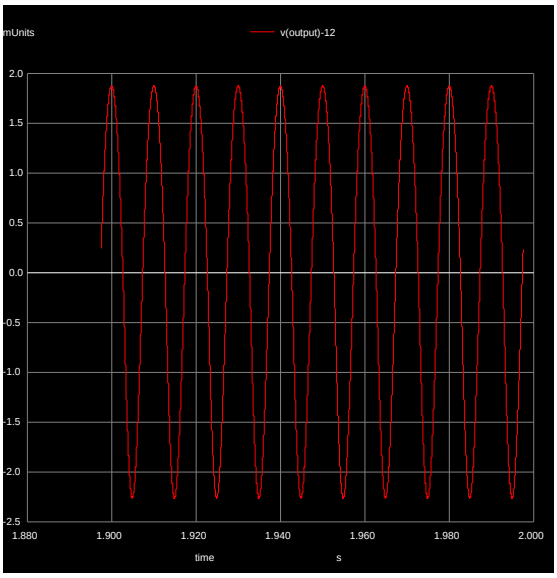
Firstly we simulate the initialization of the circuit, and only once it has stabelized do we take the average and ripple of V_{out}. Ploting the potential of the rectifier circuit, the envelope detector circuit and V_{out} for the first 2 seconds.



As we can observe, the stabilization time for V_{out} is approximatly 0.6 seconds, but the start-up sequence always has a lower voltage than the desired output, so it doesn't pose a threat to damage the circuit connected to the output.

By choosing a 10 period section in which the circuit has already stabelized, we can better study it.



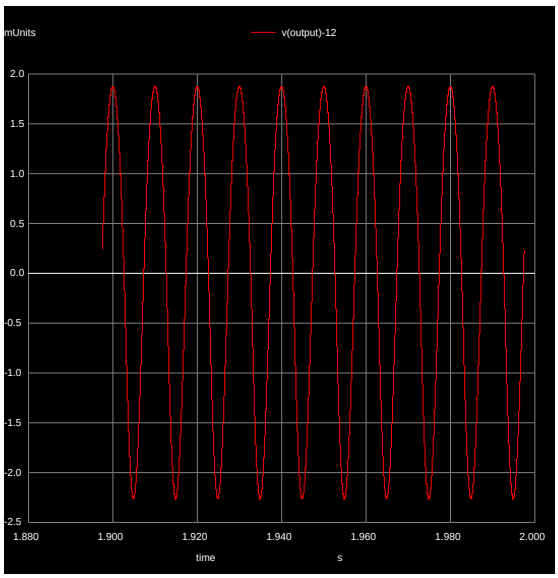


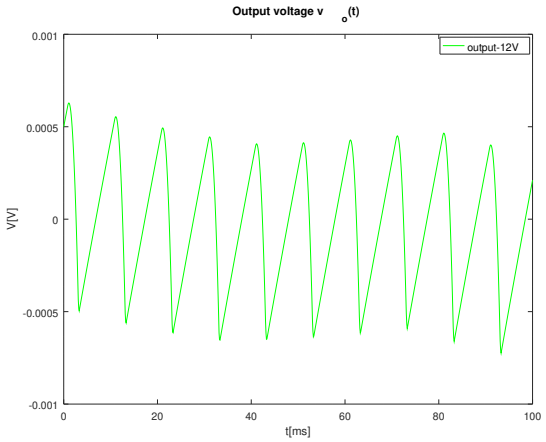
The average of V_{out} in equilibrium is 12.000000V and the ripple is 4.13 mV. The circuit costs 59.9448 monetary units, and the calculated merit is 4.038251.

4 Conclusion

In this laboratory assignment the objective of building an AC/DC converter circuit by using a tranformer, envelope detetcor and a low-pass filter was achieved. The ripple has a value of $4.13 * 10^{-3}V$. The stabilization time was of around 1 second. The cost of the circuit was of $59.9448MU$. The merit is therefore equal to 4.03825

The results from both the theoretical analysis using octave and the circuit simulation using ngspice appear to match as can be seen in the below comparison:


mUnits
v(output)-12
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1.880
1.900
1.920
1.940
1.960
1.980
2.000
time
s


Output voltage v o(t)
output-12V
0.001
0.0005
0
-0.0005
-0.001
V[V]
0
20
40
60
80
100
t[ms]