Lab session 2. Simulation

Simulation of electronic circuits.

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In this lab session, we will gain proficiency in the use of an electronic circuit simulation tool.

> ATTENTION: Remember that paragraphs like this indicate work you must carry out as a preliminary study, individually. Also remember that, in order to access the laboratory and perform the practical session, it is essential to have submitted the preliminary report to Atenea before 0:00 on the day of the lab.
> This practical session will be done using a computer. It is not necessary to bring laboratory equipment.

1 The circuit to be studied

In this practical session, we will study the circuit shown in Figure 1. This is a circuit known as a boost converter, which is capable of generating a higher constant voltage from a lower voltage source.

> *Previous Work* 1. If the circuit is initially at rest (all dynamic elements have zero initial conditions) and the switch is closed at time $t = 0$, calculate and sketch the inductor current $i_L(t)$. What is its final value? (Note that you can ignore the right-hand side of the circuit, which is isolated.)

Let us consider that the switch opens at a certain instant, at which a current called I_m is flowing through the inductor. If the rest of the circuit did not exist, the inductor current would have to change instantaneously from I_m to zero, which would mean that an infinite voltage would appear across its terminals for an infinitesimal instant: what we call an *impulse* or Dirac *delta* function.

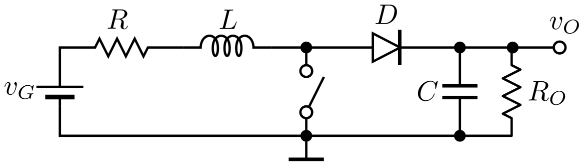

Figura 1: The boost converter.

Previous Work 2. Would the voltage impulse that would appear across the switch terminals be positive or negative? And what would its "amplitude" (more precisely, its area) be? Compute this voltage.

The rest of the circuit, however, allows continuity in the inductor current: the current I_m that was flowing through the switch when it was closed can flow through the diode and will help charge the capacitor.

If the resistance R_O were infinite, the capacitor would never discharge, because the diode does not allow a current $i_D < 0$, and it would reach a certain voltage that depends on all the circuit element values: we can argue that (part of) the energy stored in the inductor is transferred to the capacitor, from which it cannot return due to the presence of the diode.

If we now close the switch again until the inductor current reaches a value I_m and then open the switch, the capacitor will charge a little more. In this way, values of V_O much higher than V_G can be achieved.

Previous Work 3. A *hydraulic ram* (Bomba d'Ariet in Catalan) operates in a similar way. Search for information about this device, describe how it works, and establish the similarities with the proposed circuit.

2 Qucs

As you may know (you can find information on Atenea), Qucs is an electronic circuit simulator. To simulate what our circuit does when we open the switch for the first time, after the inductor current has stabilized, we can use the simulation schematic described in Figure 2.

In the figure we can see several circuit elements that we can easily recognize and that do

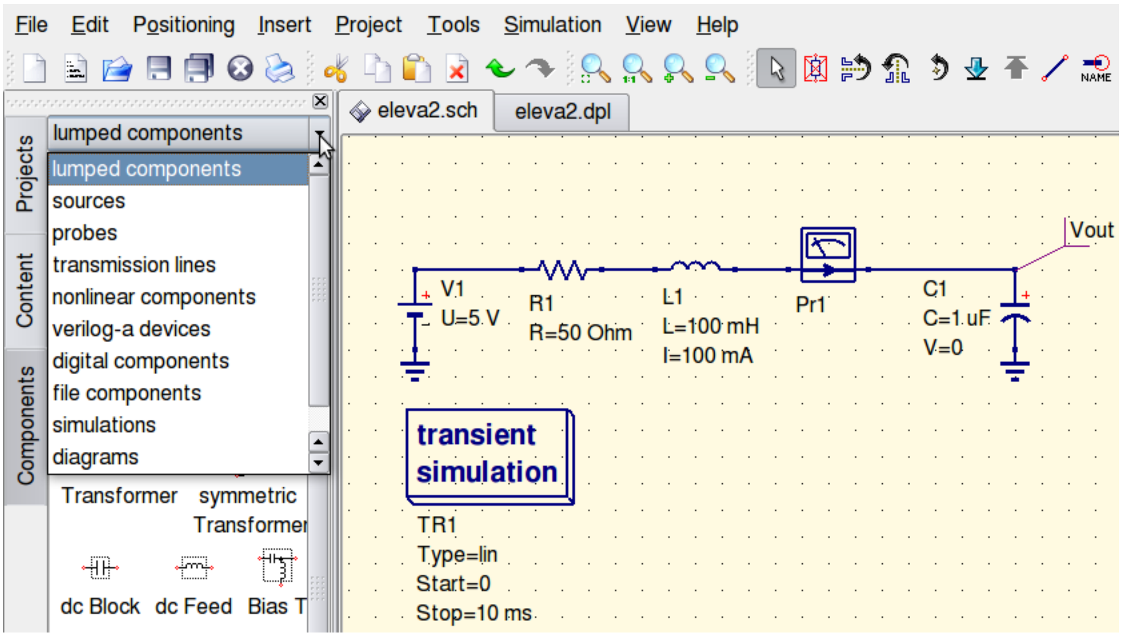

Figura 2: The boost converter when the switch is opened.

not require much explanation. The meter named `Pr1` will later allow us to display the current flowing through the inductor. On the other hand, the output node has been labeled as `Vout`.

The block called `transient simulation` contains the main simulation parameters: it starts at $t = 0$ and ends at $t = 10$ ms.

You will notice that, in the figure, the dynamic elements include information about their initial values: the current in the inductor and the voltage in the capacitor at the start of the analysis.

The simulation results can be viewed in a separate window, where we can place the plots that are useful for our simulation. Figure 3 shows the output voltage at the top and the inductor current at the bottom.

We observe that the response is a damped sinusoid, which is only possible due to the presence of two dynamic elements.

Previous Work 4. Justify why, and under which conditions, the simulation in Figure 2 can correspond to the circuit in Figure 1. Considering that the circuit we are simulating is not exactly the original circuit, up to what point will the simulation results be valid? What would be the subsequent evolution of the signals shown?

Previous Work 5. After some time, we begin a second period: we close the switch again and then open it. To determine the evolution of the signals in this second period, what changes should we make to the schematic in Figure 2?

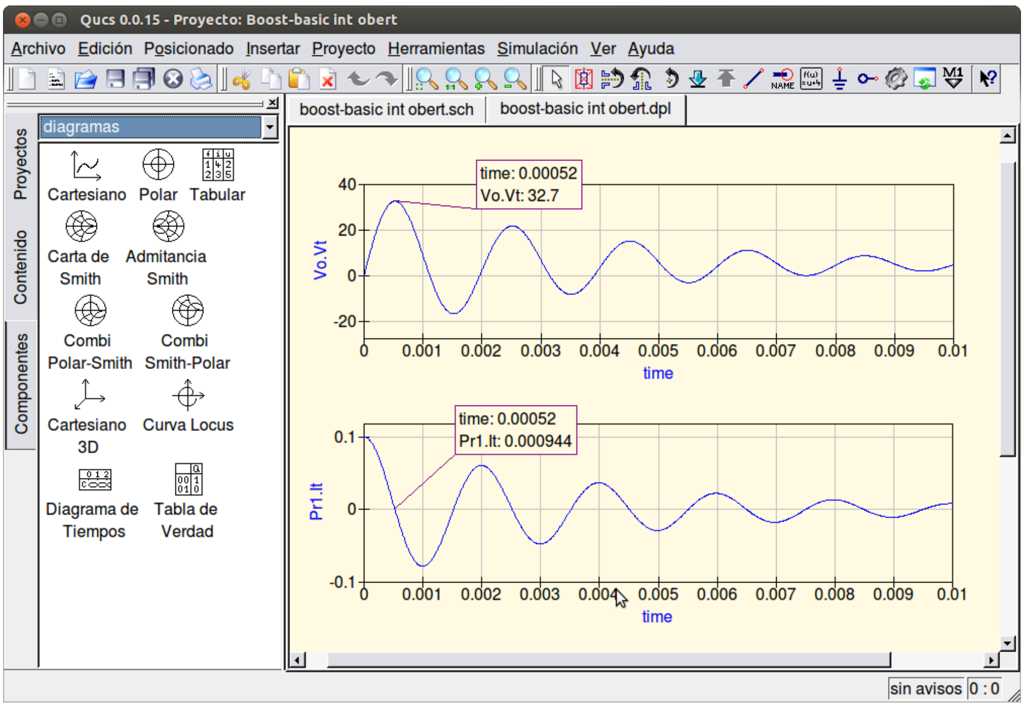

Figura 3: The boost converter when the switch is opened.

Previous Work 6. Without simulating it, estimate the waveform of the two signals from the beginning of the first period to the end of the second.

Task 1. Simulate the operation of the circuit in the laboratory during the first time interval. This means: determine what happens when the switch is closed for the first time and what happens when the switch opens.

Task 2. What value is reached at the end of the second, third, fourth, etc. period?

Task 3. Following the instructor's instructions, you may simulate the complete circuit.