Pràctica 4. Circuit Dynamics

Some different responses of linear circuits.

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In this lab session we are going to investigate the dynamic behavior of linear circuits. Specifically, we will investigate an active second order circuit that exhibits different responses depending on a circuit parameter.

> ATTENTION: Paragraphs like this one indicate work that must be completed as individual preliminary work. You may discuss it with classmates, but everyone must fully understand the preliminary work.
> AI tools may not be used to solve the exercises. They may only be used for specific queries, occasional calculations, or to check results. In these cases, the corresponding screenshot must be attached.
> The solution of the exercises must include:
>
> - The circuits redrawn at each step, clearly showing any transformations carried out, where applicable.
> - Explicit indication of voltage polarities and current directions.
> - An orderly and justified solution so that the reasoning can be followed.
>
> Remember that, in order to enter the laboratory and carry out the session, the preliminary report must have been submitted on Atenea before the session. At the beginning of the laboratory session, **you will be asked to orally justify your preliminary work**, and this will be taken into account in its assessment. Finally, remember to bring the required laboratory equipment and make sure that it is in good condition.

1 Circuit dynamics

In this laboratory session we will investigate the circuit depicted below.

> *Previous Work* 1. Find the transfer function $H(s) = V_O(s)/V_G(s)$ of the circuit. Indicate which values of α make the circuit stable, marginally stable and unstable.

> *Previous Work* 2. Indicate which values of α give real, complex and purely imaginary poles of $H(s)$. Relate these results with the stability of the circuit

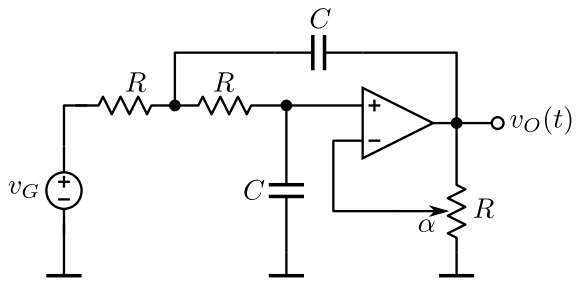

Figure 1: The circuit.

Previous Work 3. Find the step response, i.e. find $v_o(t)$ for $v_G(t) = u(t)$, when $\alpha = 1/2$. Make a sketch of the $v_o(t)$ indicating the most significant features of the waveform. Find as many ways as possible to validate the results. In particular, compute the steady-state response to a constant input in as many ways as possible.

Previous Work 4. Demonstrate that the time constant τ of an exponential waveform such as $Ae^{-t/\tau} + B$ may be found from two points of the waveform (t_1, v_1) and (t_2, v_2) and from the final value v_∞ by the expression

$$\tau = \frac{t_2 - t_1}{\ln \dfrac{v_1 - v_\infty}{v_2 - v_\infty}} \tag{1}$$

2 Laboratory work

Task 1. Build the circuit on your prototyping board with $R = 10$ kΩ and $C = 10$ nF. The input signal should be a square wave between 0 and 1 V and half-period greater than 5τ.

Task 2. Use the oscilloscope to view simultaneously the input and the output signal with different values of α that make the circuit stable. Consider specifically the case you worked out in your *previous work*.

Task 3. Find out what happens when you lower the input frequency. Does the output signal still resemble a square wave? What happens when you change the input signal to triangular or sinusoidal?

Task 4. Make $v_i = 0$ and observe $v_o(t)$ for values of α that make the circuit unstable. Measure the oscillation frequency when α gives purely imaginary poles. Investigate what happens when you further decrease α.