Linear Network Analysis and Synthesis. Lab 1, April 2024

Session 2

FULL NAME: *insert your full name here*
DEGREE/GROUP: *insert here your degree and enrollment group*
DATE and TIME: *start date and time*
CLASSROOM: *classroom where the laboratory is carried out*

Insert the screenshots with each of the montages that you use in your measurements. Always reason the validity of the results obtained, and make the comments you consider pertinent.

NOTE: If the measurements taken in the laboratory do not correspond to the theoretical result obtained in the preparatory work or with previous lab results, you must either find the error in the theoretical approach, or find the error in the measurement, or try to explain the discrepancy.

1. Measurement of the voltage and current at the output of the microcontroller.
This link shows the simulation of a circuit where the relay that you have studied in the preparatory work is used to *activate/deactivate* a led. From this circuit diagram:

- Add an ammeter to measure the current flowing through the relay coil when the switch is activated. Comment what the ideal impedance of an ammeter would be taking into account that its objective is to measure current without disturbing the circuit.
- Add a voltmeter to measure the voltage at the output pin of the microcontroller (the connector one on the right of the switch, voltage vo(t) in the preparatory work). Comment what would be the ideal impedance of a voltmeter considering that its purpose is to measure voltage without disturbing the circuit.

[5%]

Insert a screenshot(s) here

Optionally insert the URL link to the circuit created in Falstad (this can be done in all sections)

2. Stationary current of the relay activated.
When the relay is activated, what value does the current flowing through the relay coil tend to after a long time? Relate the result with what was seen in the preparatory work. [2%]

Insert the screenshot(s) here and, optionally, the link(s).

Insert here the explanation of what is observed in the screenshot and the reasoning of your answer.

3. Stationary voltage at the output of the microcontroller.
When the relay is activated, to what value does the voltage at the output pin $v_O(t)$? Justify theoretically the result obtained. [3%]

Insert the screenshot(s) here and, optionally, the link(s).

Insert here the explanation of what is observed in the screenshot and the reasoning of your answer.

4. Relay activation time.
Use *oscilloscopes* (*scopes*) to measure the time it takes for the relay to activate from the time the switch is closed. That is, the time from the moment the relay is powered by the microcontroller until the LED turns on.
What is the current flowing through the coil at the moment when the relay switches? Does it coincide with the data given in the previous work?
NOTE: It is important to make a good selection of the time scale to take this measurement. [5%]

Insert the screenshot(s) here and, optionally, the link(s).

Insert here the explanation of what is observed in the screenshot and the reasoning of your answer.

5. Deactivation time of the relay.
Now we study the *deactivation* of the relay. Measure the time it takes for the LED to turn off (that is, for the relay to *deactivate*) from the moment the switch is opened.
What maximum voltage in absolute value is measured at the output of the microcontroller? Explain what you observed.
[5%]

Insert the screenshot(s) here and, optionally, the link(s).

Insert here the explanation of what is observed in the screenshot and the reasoning of your answer.

6. Effect of the capacitor in the deactivation of the relay.
Now place the capacitor C_p=200 μF in parallel with the relay coil. When the relay is turned off:

- What is now the maximum absolute value of voltage at the output of the microcontroller?
- How long does it now take for the relay to deactivate from the time the switch is opened (i.e., how long does it take for the LED to turn off)?
- What would happen if the relay only activated once more than 1% of the current flowed through it instead of 80%?

[5%]

Insert the screenshot(s) here and, optionally, the link(s).

Insert here the explanation of what is observed in the screenshot and the reasoning of your answer.

7. Effect of the capacitor on relay activation.
After placing the capacitor C_p, has the relay activation process also been affected? What is the time it now takes for the relay to *energize*?
[5%]

Insert the screenshot(s) here and, optionally, the link(s).

Insert here the explanation of what is observed in the screenshot and the reasoning of your answer.

8. Effect of capacitor capacity on relay activation/deactivation.
Investigate and justify (especially in the relay *deactivation* process) what happens when instead of choosing a value of 200 μF for the capacitor C_p the following values are chosen:

A. 20 μF
B. 800 μF

[5%]

Insert the screenshot(s) here and, optionally, the link(s).

Insert here the explanation of what is observed in the screenshot and the reasoning of your answer.

9. Alternatives.

There are other better solutions to discharge in a controlled way the relay coil.
Explore with the simulator the following alternatives:

A. Add a resistor in series with the capacitor C_p.
B. Replace the capacitor with a diode. The diode is a nonlinear element, but its behavior can be *linearized* modeling the diode as a short when forward biased, and as an open when reverse biased.

[EXTRA%]

Insert the screenshot(s) here and, optionally, the link(s).

Insert here the explanation of what is observed in the screenshot and the reasoning of your answer.