**EEEE 281 Experiment 5:**

**RC Circuits**

**From:** Your Name (edit) [Department (edit)]

**To:**  Section X (edit) TA: [edit]

**Date:**  Performed: (edit) Due: (edit)

**Subject:**  Lab 4-Operational Amplifiers

**Lab Partner(s):**  (edit)

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Percentage of Grade | Score | Comment |
| Report Formatting | 20 |  |  |
| Hand Calculation: Step Response | 5 |  |  |
| Hand Calculation: Rise Time Derivation | 5 |  |  |
| Hand Calculation: /Rise Time | 5 |  |  |
| PSPICE: Setup Conditions | 5 |  |  |
| PSPICE: Data and Figures | 10 |  |  |
| PSPICE: Discussion of Simulation | 15 |  |  |
| Hardware: Experimental Setup | 10 |  |  |
| Hardware: Experimental Data and Tables | 10 |  |  |
| Hardware: Discussion of Results | 20 |  |  |
| **Total Score:** |  |  |  |
| **Graded By:** |  |  |  |

## Abstract

The abstract section should contain a summary of what was performed in the lab and should be between 100-200 words. This should succinctly rephrase the purpose slide (slide 2 and lab packet). It should also refer to the data collected. How many circuit topologies were investigated (3 in this lab)? What theory/data is observed for each circuit (Hand calculation of rise time, PSPICE simulation extraction of rise time, Oscilloscope trace extraction of rise time). In the last circuit, a ‘rolling’ capture is performed.

## 1 Introduction and Theory

Include 1-2 paragraphs that explains the scope of the experiment. Briefly introduce the concept of RC Circuits. What was the primary purpose of the experiment? What are the standard current and voltage made for Op-Amps? If the data collection has deviated in any way from the rest of your section (for example you had to come back to collect more data), explain this in a second paragraph. In particular, be sure to note if your data was acquired from a different lab than your classmates/using different equipment.

### 1.1 Hand Calculations

In this section,

1. Derive the equation for the step response, vc(t), in the series RC circuit.
2. Define the time constant in equation form.
3. **(From Prelab)** Calculate the time constant for the five resistors listed in the lab handout. Include the information in a Table (See Table 1 below)

Table 1 Hand calculation of time constant, pulse width, period and frequency for each series circuit in the lab.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Resistance () | Capacitance (F) |  (s) | Pulse Width(s) | Period (s) | Frequency  (Hz) |
| 1K | 0.01 |  |  |  |  |
| 10K | 0.01 |  |  |  |  |
| 100K | 0.01 |  |  |  |  |
| 1M | 0.01 |  |  |  |  |

1. Derive an expression for the rise time (t 10% to t 90%). Calculate the theoretical rise time for each RC combination. EDIT Table 2 below

Table 2 Rise time calculated based on theoretical calculations.

|  |  |  |
| --- | --- | --- |
| Resistance () | Capacitance (F) | Rise Time (s) |
| 1K | 0.01 |  |
| 10K | 0.01 |  |
| 100K | 0.01 |  |
| 1M | 0.01 |  |

### 1.3 Theory: PSPICE Simulation Summary

Begin by providing a 1 paragraph description of the PSPICE setup. Was a DC simulation used, transient simulation, etc.? Which **libraries** and **PSPICE elements** were used in the simulation? You can borrow from the text of your first tech memo here. If you do so, please be sure to cite the tech memo. Note the libraries used. You can find the information when you look at the properties of each element. There will be a reference to a “.olb” file. This is the library name.

Include a description of the Vpulse supply that was added to the circuit. Specifically idenitify the values that were adjusted (tr, tf, etc.). Explain the settings used for the transient simulation. What was the **Run to Time** value chosen to be? Why? How was the Monte Carlo extraction of rise time performed (iterations, analysis function, etc.)?

#### 1.3.1 PSPICE Circuit 1

In this section, **which is to be done as a part of the prelab. Use the section heading above (1.2 PSPICE Simulation of RC Circuit), BUT DO NOT write the rest of the section as an outline.**

1. Show the schematic diagram from PSPICE of the simulated circuit (Figure)
2. Show the transient simulation and rise time extraction for each of the four circuits.
   1. Make sure that the picture from PSPICE mirrors the figure on Slide 12 of the lab presentation. You should thicken the line, and label the rise time on the figure (font should be legible).
   2. Caption should indicate the resistance and capacitance, as well as the extracted rise time.
3. Summarize the Rise Time from simulation in Table 3.

Table 3 Rise time based on PSPICE simulations.

|  |  |  |
| --- | --- | --- |
| Resistance () | Capacitance (F) | Rise Time (s) |
| 1K | 0.01 |  |
| 10K | 0.01 |  |
| 100K | 0.01 |  |
| 1M | 0.01 |  |

#### 1.3.2 PSPICE Circuit 1 Monte Carlo

Include the Monte Carlo Analysis for the 10 k resistor. A figure should be included showing the histogram output and the 100 iterations. Provide a short explanation of the variation in rise time.

Make sure that there is at least 1 paragraph to explain this section.

#### 1.3.3 PSPICE Circuit 2

1. Show the schematic diagram from PSPICE of the simulated circuit (Figure)
2. Show the transient simulation and rise time extraction for each of the four circuits.
3. Have a brief explanation of the simulation

#### 1.3.4 PSPICE Circuit 3

You are NOT required to simulate Circuit 3.

## 2 Hardware Experiment: Results and Discussion

This section of the report should present what was done in hardware. A reader should be able to recreate an experiment from the detail present. One section discusses the equipment used in the experiment. The remaining sections discuss the results for each circuit.

### 2.1 Equipment Used in the Laboratory

Write a short paragraph to detail the equipment used in the laboratory, and specific model numbers. Ideally, you should create a table of the equipment which should be referred to in text (See Table as an example). The room location where the experiment was performed should be included. Note that this should be a part of all Tech Memos, as it is an essential piece for other users to replicate your experiment. **As you will be likely using the same equipment throughout the term, once the text/tables are established, you may reuse the information with the permission of your instructor/TA. Again, cite your first lab report as a reference.**

Table 3: Equipment/Software required for Lab 2.

|  |  |  |
| --- | --- | --- |
| Item | Tool | Room |
| Simulation | OrCAD Capture CIS | All Open EE Labs |
| DC Power Supply | Agilent E3630A | 09-3170 |
| DC Power Supply | Agilent E3631A | 09-3200 |
| Multimeter | Agilent E34401A | 09-3170, 09-3200 |
| Waveform Generator | Agilent 33120A | 09-3170, 09-3200 |
| Oscilloscope | Textronix TDS2012C | 09-3200 |
| Oscilloscope | Agilent DSO 3102A | 09-3170 |

### 2.2 Hardware Results: Circuit 1

1. Show the Oscilloscope trace for the 10k/0.01F resistor combination. Have the rise time clearly labeled. Note that the lab pack ONLY calls for this trace. Make sure that the plot clearly shows the date that the picture was taken.
2. Summarize the results for all four circuits in Table 4.
3. Include a 1 paragraph discussion of the results.

Table 4 Rise time based on Hardware Measurements

|  |  |  |
| --- | --- | --- |
| Resistance () | Capacitance (F) | Rise Time (s) |
| 1K | 0.01 |  |
| 10K | 0.01 |  |
| 100K | 0.01 |  |
| 1M | 0.01 |  |

### 2.2 Hardware Results: Circuit 2

1. Show a schematic diagram of the circuit here (it is not discussed in the Theory section as we did not do theoretical calculations for the circuit.
2. Show the Oscilloscope trace for the circuit. Have the rise time clearly labeled. Summarize the results for circuit 2 in Table 5.

Table 5 Rise time Extraction for Resistor Voltage, Circuit 2

|  |  |  |
| --- | --- | --- |
| Resistance () | Capacitance (F) | Rise Time (s) |
| 10K | 0.01 |  |

### 2.3 Hardware Results: Circuit 3

1. Briefly explain how the measurement was performed.
2. Include an oscilloscope plot of the rolling capture of RISE TIME and FALL TIME as a figure. Have the rise time clearly labeled in the figure. Include the data in Table 6.
3. Discuss the results and how they compare to theoretical values of the time constants when the switch is opened and closed.

Table 6 Rise time Extraction for Resistor Voltage, Circuit 3

|  |  |  |
| --- | --- | --- |
| Resistance () | Capacitance (F) | Rise Time (s) |
| 10k | 1 |  |

## 3 Conclusion

Provide a 1 paragraph summary of the laboratory experiment. What were the major conclusions for each part of the experiment? Also did the theory agree with the experiment? The conclusion is a revised version of the abstract. Some specific verbiage from the lab documentation lists the following points:

• Include a concise statement of conclusions commenting on differences, if any, between the ideal and simulated performance of the circuit and theory.

• Does the data agree with the hand calculations and PSPICE simulations?

## 4 Acknowledgments

Acknowledge **any** source of help received in the experiment/writing the report. This should certainly include your lab partner/teaching assistant/instructor. It may also include other classmates/study partners. State briefly what the nature of the help was.

**Your report should include references to appropriate pages in the text, as well as any other sources, websites/etc. consulted in the preparation of the report.**

References

[1] C.K. Alexander, and M.K.O. Sadiku, *Fundamentals of Electric Circuits, 4th Edition*, McGraw Hill, pp. xx-yy(EDIT), 2009.

[2] A. Student, *EEEE 281 Lab 1 Tech Memo*, page xx-yy, submitted Month, Day, 2015.

[3] S. Rommel, *EEEE 281 Lab 1 Lecture notes*, slides xx-yy, Spring 2015.