

### SYSC 3203

## Project Title: EMG-Controlled Mouse Milestone #3B: EMG rectifier and integrator

Since an EMG signal is not rhythmic in nature, typical signal processing involves rectification and integration of the EMG signal once it is adequately filtered as was done in the previous lab. The output of the integrator represents the intensity of the muscle contraction. Lab #3B therefore consists in designing a precision rectifier followed by an integrator circuit.

**NOTE: You are free to choose EITHER option 1A (half wave rectifier) or 1B (full wave rectifier). Either implementation will satisfy the overall requirements of the project, although the final performance (in terms of sensitivity to smaller muscle movements) may be slightly better with the full wave option.**

### 1A. Half wave rectifier design

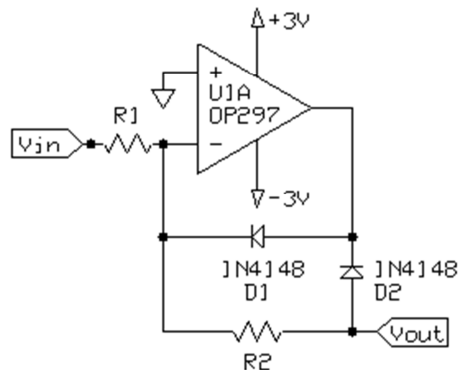


Figure 1: Half wave rectifier circuit

The circuit represented in Figure 2 realizes a half wave rectifier using one OP97 operational amplifier (or one half of an OP297 dual operational amplifier), two 1N4148 diodes and 2 resistors. While supposing the diodes are ideal, analyze the circuit when  $V_{in}$  is positive and when  $V_{in}$  is negative. Explain to the instructor whether each diode is conducting or not when  $V_{in}$  is positive and when  $V_{in}$  is negative and have him/her sign the instructor verification sheet. Calculate the values for  $R1$ ,  $R2$  for the circuit to act as a half-wave rectifier with a unit gain. Show your calculated  $R1$ ,  $R2$  values to the instructor and have him/her sign the instructor verification sheet.

## 1B. (OPTIONAL) Full wave rectifier design

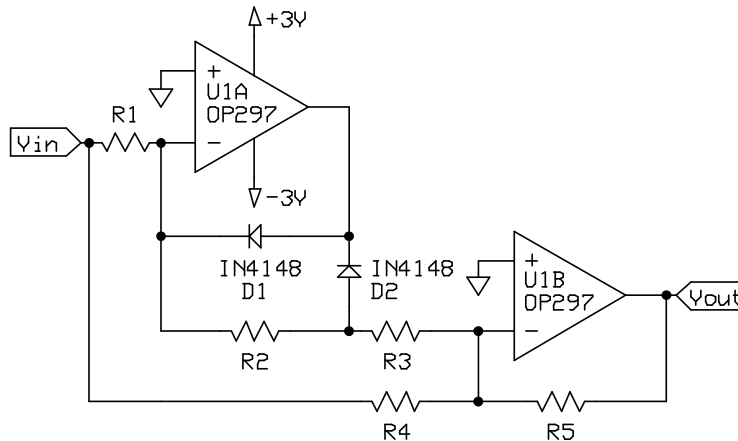


Figure 2. Full wave rectifier.

The circuit represented in Figure 2 realizes a full wave rectifier using one OP297 dual operational amplifier, two IN4148 diodes and 5 resistors. While supposing the diodes are ideal, analyze the circuit when  $V_{in}$  is positive and when  $V_{in}$  is negative. Explain to the instructor whether each diode is conducting or not when  $V_{in}$  is positive and when  $V_{in}$  is negative and have him/her sign the instructor verification sheet. Calculate the values for  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$  and  $R_5$  for the circuit to act as a full-wave rectifier with a unit gain. Show your calculated  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$  and  $R_5$  values to the instructor and have him/her sign the instructor verification sheet. Explain to the instructor two ways this circuit could be modified to act as a half-wave rectifier and have him/her sign the instructor verification sheet.

## 1C. Rectifier assembly and test

Assemble and test your full wave rectifier using a function generator and an oscilloscope. Test that it works correctly with DC and then find the frequency where you start to see some distortion and the frequency where distortions are too high to be acceptable for a wave rectifier. Validate your observed frequencies with the instructor. Have him/her sign the instructor verification sheet. Discuss with the instructor how these frequencies might impact the EMG signal for this project and have him/her sign the instructor verification sheet.

## 2. Integrator

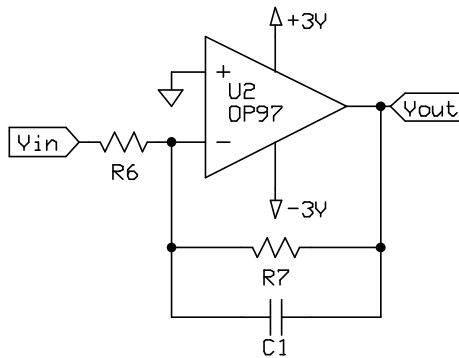
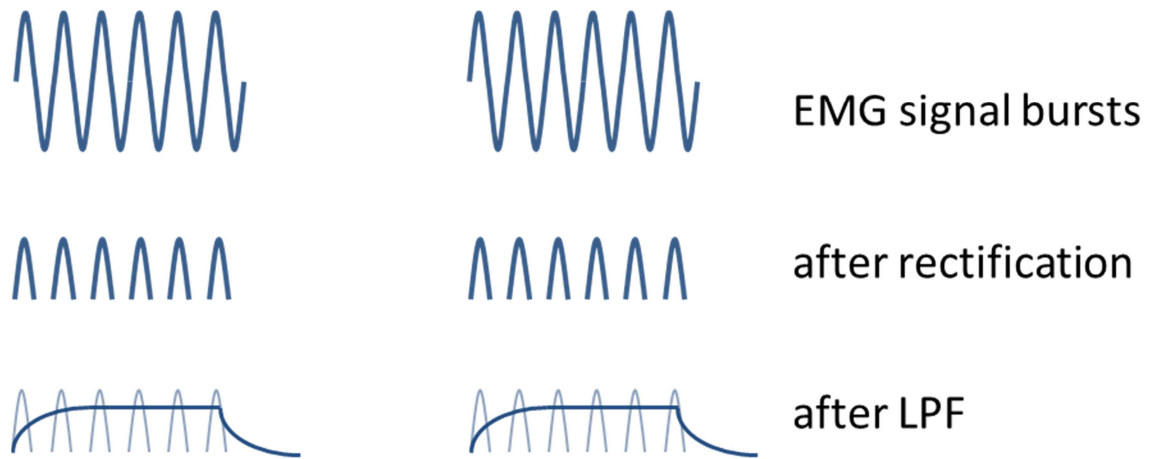


Figure 3: “Lossy” or practical integrator.

Figure 2 presents an integrator circuit that is called a “lossy” integrator or a practical integrator. Analyze the circuit and explain to the instructor why this circuit is called a “lossy” or practical integrator and how it compares to an ideal integrator. Have him/her sign the instructor verification sheet. How would an ideal integrator behave for the current project? Validate your answer with the instructor and have him/her sign the instructor verification sheet.

Select an adequate cut-off frequency for our particular application and calculate adequate values for R6, R7 and C1 for a gain of 10. Explain to the instructor why you selected this cut-off frequency and explain your calculations for R6, R7 and C1. Have him/her sign the instructor verification sheet.

Test your circuit with a function generator and an oscilloscope and verify that the gain and cut-off frequency are as designed. Show your experimental results to the instructor and have him/her sign the instructor verification sheet.



*Figure 4: schematic representation of the half-wave rectifier / peak detector*

**Milestone #3B**  
**SYSC 3203**  
**Fall 2016**  
**Instructor Verification Sheet**

Submit this page to the lab instructor.

Name: \_\_\_\_\_ Student ID: \_\_\_\_\_

Name: \_\_\_\_\_ Student ID: \_\_\_\_\_

1.1: Explain whether each diode is conducting or not when  $V_{in}$  is positive and when  $V_{in}$  is negative.

Verified: \_\_\_\_\_ Date/Time: \_\_\_\_\_

1.2: Show your calculated  $R_1$ ,  $R_2$ , ( $R_3$ ,  $R_4$  and  $R_5$  if applicable) values.

Verified: \_\_\_\_\_ Date/Time: \_\_\_\_\_

1.3: Discuss how the frequency response of the rectifier might impact the EMG signal for this project.

Verified: \_\_\_\_\_ Date/Time: \_\_\_\_\_

2.1: Analyze the integrator circuit and explain why this circuit is called a “lossy” or practical integrator and how it compares to an ideal integrator.

Verified: \_\_\_\_\_ Date/Time: \_\_\_\_\_

2.2: How would an ideal integrator behave for the current project?

Verified: \_\_\_\_\_ Date/Time: \_\_\_\_\_

2.3: Explain why you selected this cut-off frequency and explain your calculations for  $R_6$ ,  $R_7$  and  $C_1$ .

Verified: \_\_\_\_\_ Date/Time: \_\_\_\_\_

2.4: Show your experimental results.

Verified: \_\_\_\_\_ Date/Time: \_\_\_\_\_