SYSC 3203
Project Title: EMG-Controlled Mouse
Laboratory: Deliverable #1A: Isolated Mouse Interface

Introduction

The project for the *SYSC 3203 bioelectronics* course is to modify a computer mouse so that its left button is operated by the electromyographic (EMG) signal produced by the forearm. When the EMG electrodes are connected on the left forearm, such a mouse could be moved on the computer screen using the right hand while left-clicks would be produced by closing the left hand. To verify the proper operation of this EMG-controlled mouse, a friendly competition of a widely-known video game, *Flappy Bird*, will be held at the end of the last lab.

A senior electronics engineer has drawn a block diagram (Figure 1) showing what the design for the whole EMG-controlled mouse will look like. Starting from the top left, three electrode leads will be connected from the **forearm muscles** to an **instrumentation amplifier** incorporating a circuit for common-mode rejection. The signal will then be **band-pass filtered** in accordance with the EMG signal bandwidth. Since the EMG signal is not rhythmic in nature, typical signal processing usually consists in **rectification** and **integration**. A **comparator with hysteresis** will then compare the integrator output to a threshold before triggering a **monostable** circuit that will send a pulse through an **optoisolator** to a **relay** that will activate the **mouse** left button while playing a game of **Flappy Bird**.
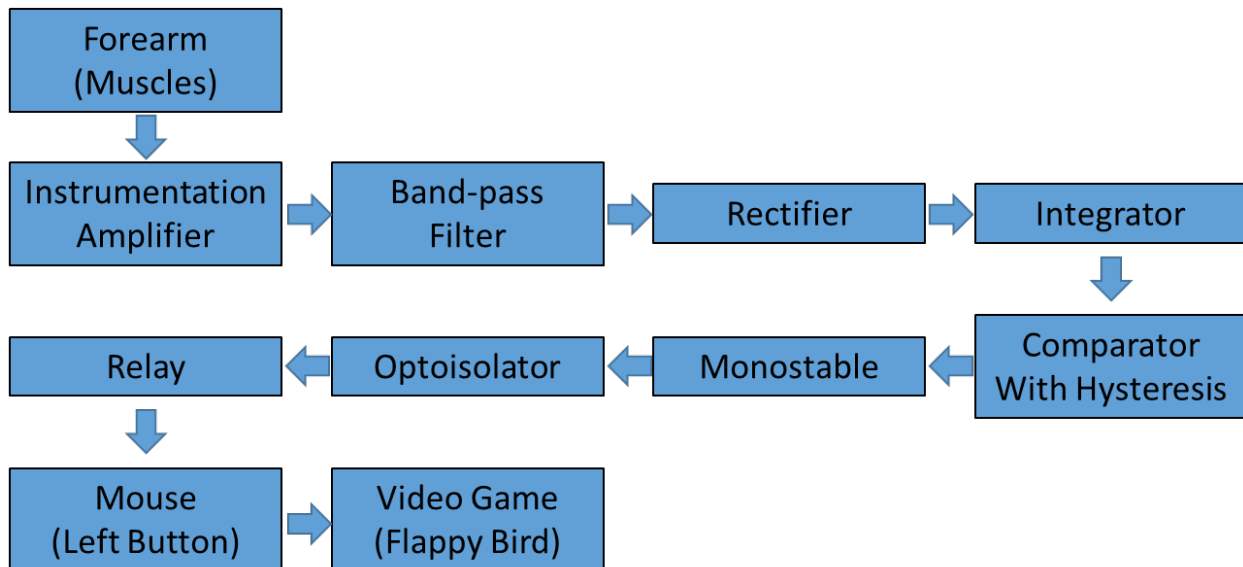

Figure 1: Block diagram for the whole EMG-controlled mouse project.

The whole project is divided in six parts, corresponding to six deliverables, as shown in Figure 2. The first will consist in implementing the isolated mouse interface. The second will focus on designing the instrumentation amplifier and connect it to the forearm muscles. The third will consist in designing a band-pass filter adapted to the EMG signal bandwidth. The forth will require designing and assembling the rectifier and integrator circuits. The fifth will focus on the comparator with hysteresis and the

monostable circuit designs. The final will consist in assembling all modules together and optimizing the performance of the whole design for playing a game of *Flappy Bird*.
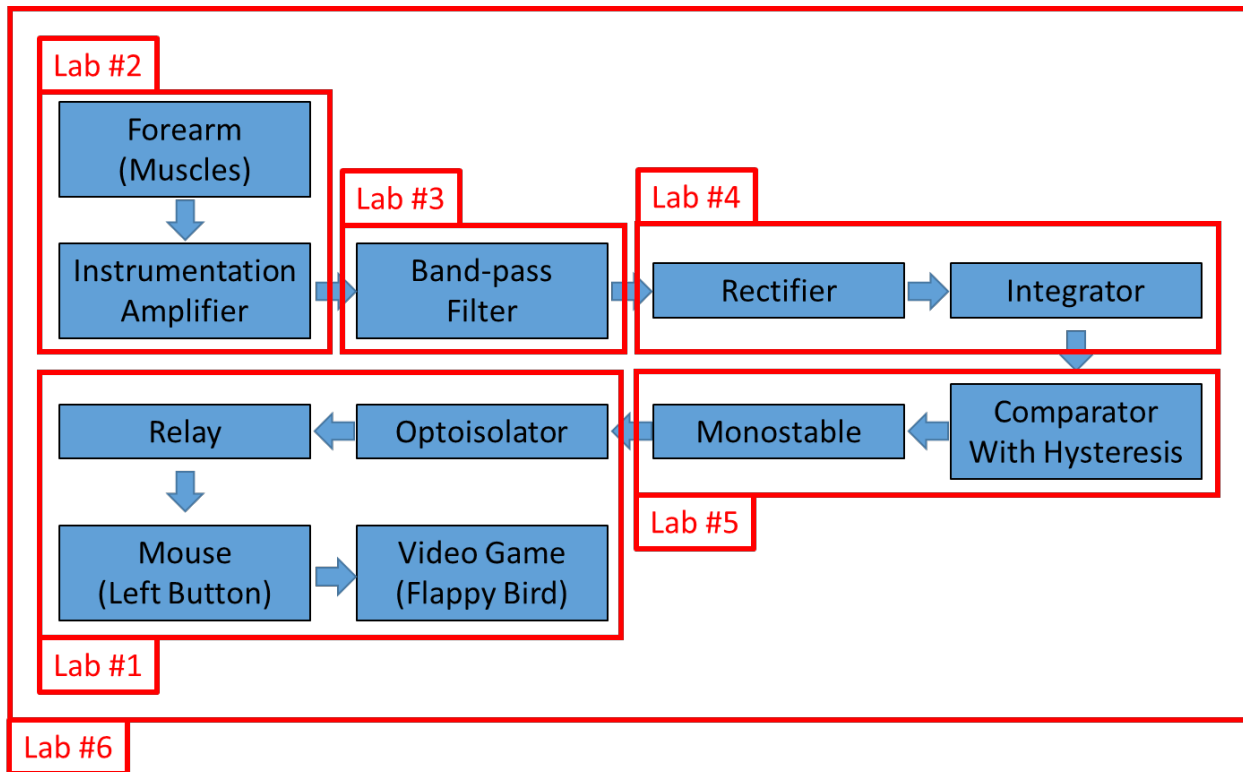

Figure 2: Division of the project in six parts corresponding to the six labs.

General Guidelines for the project

The whole project will be battery-powered using three sets of two AA batteries. Two battery sets will be used to generate +3V and -3V for all circuits connected to the human subject. The third battery set will be used to generate a voltage we will call +5V_mouse and its corresponding ground, Gnd_mouse. +3V_mouse and Gnd_mouse will be used to power any circuits located on the mouse side of the optoisolator. This safety precaution is necessary and very important to make sure that circuits that are electrically connected to the forearm of the human subject are electrically isolated from anything else including the mouse that is electrically-connected to the PC and the sector through its USB port. The use of an optoisolator completes the isolation barrier between the human subject and the mouse/PC/sector. Therefore, if anything electrical goes wrong on the mouse/PC/sector side, it will not affect the human subject connected on the other side of the isolation barrier.

For each lab, the senior electronics engineer will provide you with some specifications for the part of the circuit, some hints on how to implement the circuit and a few things that should be tested. You will not have to provide a lab report but rather show the instructor some accomplishments or answer some questions as specified in the lab instructions. The instructor will sign an instruction verification sheet each time an accomplishment is verified or a question is answered correctly.

For all six labs, the senior electronics engineer encourages you to use sufficient decoupling (tantalum and ceramic) capacitors for all power signals and for all integrated circuits.

Lab #1A instructions

Lab #1 consists in designing the isolated mouse interface represented in Figure 3. At the end of this lab, you will be able to press an electrically-isolated pushbutton to generate a left mouse click. The block diagram in Figure 3 is extracted from the block diagram from Figure 2. The rest of the circuit has been replaced by a pushbutton that will be used to generate a signal that will eventually come from a monostable circuit. There are four parts to this lab that will be covered in the following four sections.
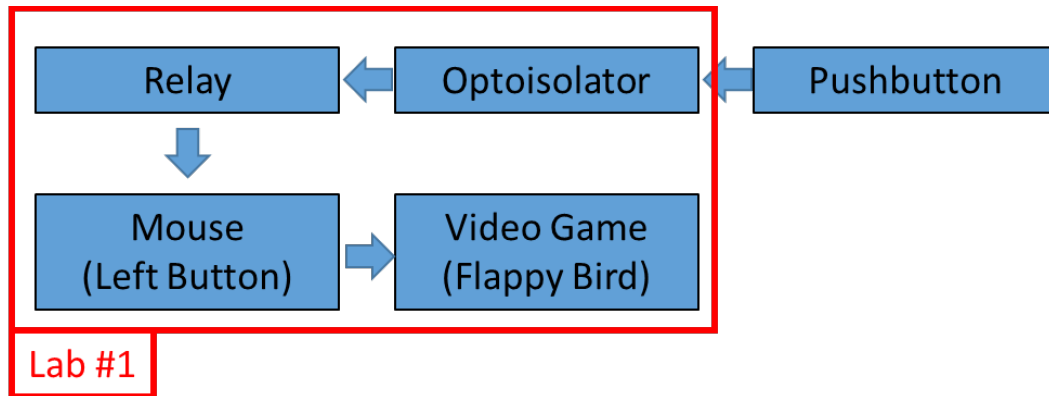

Figure 3: Block diagram for lab #1.

1. Video Game (Floppy Bird)

Verify that the *Floppy Bird* game can be played in a browser of your computer. Several versions are available; the one provided for the course is: sysc3203/labs/floppybird.

2. Mouse (Left Button)

The mouse has to be modified in order to control the left-click button. On most mice, left-clicking is performed by a pushbutton located on a PCB inside the mouse. You will therefore have to disassemble the mouse. Be careful while disassembling the mouse not to break anything. Locate any screws on the mouse. They are usually located on the bottom of the mouse. If you do not see any screws, they may be located underneath the sliding pads of the mouse that are usually self-adhesive decals that should be carefully removed as you will have to stick them back on the mouse afterward. Once the screws are located, carefully open the mouse casing. Inside some mice, the PCB and optional wheel might require removing a few more screws.

> **2.1. Sketch the layout of components on the electronics PCB in the mouse. Identify what each is and its value (look them up if required).**

Locate the left pushbutton and identify the right connecting points on the PCB. An ohmmeter might be useful to locate the proper connecting points. Once you see where the left pushbutton connecting points are, this is where you will have to solder one lead for each connecting point of the pushbutton. If the job is done cleanly, the physical left button on the mouse should still work in parallel with the leads you just added. Also, plan a way to cleanly route the leads outside the mouse with a clean exit point through the mouse casing. The wires should be long enough for proper mouse operation and the lead endpoints should be easy to insert into the breadboard holes.

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2.2. **Write down your planned circuit modification, with a sketch of the mouse and the new wiring. Show it to the instructor. Ask the instructor to verify your plan and sign your lab book.**

Once the instructor agrees with your plan, proceed soldering the leads and modifying the mouse casing for a clean exit. Reassemble the whole mouse and test that the mouse is still working as originally designed. Test that the mouse left-clicks whenever you short the two lead endpoints together.

2.3. **Show the instructor the mouse is operating properly after your modifications and have him/her sign your lab book.**

■ Relay

For this project, the senior electronics engineer picked a SIL03-1A72-71D reed relay whose datasheet can be found online. Notice that this reed relay includes an internal protection diode. Make sure you understand the role of this protection diode before using the relay. A relay without a protection diode is available from the instructor if you want to experiment to figure out how the protection diode works.

2.1. **In your lab notebook, explain how the protection diode works. Sketch the turn-off voltage across a relay coil with and without a protection diode.**

As explained in the *general guidelines for the project* section, remember that the relay is directly connected to the mouse and should therefore be powered using the +3V_mouse and Gnd_mouse obtained from a AA battery set which is independent from the two other sets that will later be used to power other circuits.

A series resistor is typically used to limit the current passing through the coil to a safe value that will not damage the coil wiring. Compute the value for this resistor using the information from the datasheet.

2.2. **Show your calculation to the instructor and have him/her sign off the value.**

Test the relay using a pushbutton connected in series with the relay coil and series resistor and verify that the mouse left button is correctly operated when its leads are connected to the relay switch connections.

2.3. **Write down three reasons to the instructor why the SIL03-1A72-71D is an appropriate choice for this project. (You can find a datasheet on Digikey or other websites).**

■ Optoisolator

The senior electronics engineer picked a PC1231xNSZ0F as an optoisolator for this project. The datasheet is available online. An optoisolator has an IRED (infrared emitting diode) side and a phototransistor side. As its name implies, the optoisolator is the part that implements the electrical isolation barrier since the information flows optically and not electrically from one side to the other. Remember that, anything on the phototransistor side should be powered by +3V_mouse and Gnd_mouse while everything on the photodiode side should be powered by +3V, -3V and Gnd provided by different battery sets. While assembling all circuits on your breadboard, make sure that the isolation barrier is physically well defined by keeping parts on both sides clearly separated on the breadboard.

2.4. Looking at the datasheet, write down the rated isolation voltage for this optoisolator. Describe one scenario in which patient safety might be compromised, and discuss whether rated the isolation voltage is suitable (2-3 lines).

2.5. **Write down at least one additional reason why the PC1231xNSZ0F is an appropriate choice for this project (i.e. why is this relay a good choice while some others may not be).**

The phototransistor part should be connected in series with the relay coil. A series resistor should be connected with the photodiode in order to limit the current to a safe and efficient value in accordance with the optoisolator datasheet.

2.6. Calculate an appropriate value for this resistor. Have your instructor verify and sign off your value in your lab book.

Using a pushbutton connected in series with the resistor and the photodiode part of the optoisolator, test that the mouse left button is activated whenever you press the pushbutton while playing a game of *Floppy Bird*.

2.7. Show the instructor the complete isolated mouse interface is operating properly and have him/her sign off the completed milestone.