

MINIPROJECT 1 (OF 2) - THE HAPTIC JOYSTICK

AARON HOOVER & BRAD MINCH

JANUARY 30, 2020

1 *Overview*

The goal of the first two miniprojects in this course is to build and program a one degree of freedom haptic joystick. A haptic device is a physical interface that provides information to the user via touch. In this class, the haptic joystick will provide a reaction force (torque) felt by the user according to some control law that you will implement on the PIC microcontroller.

Common applications in which you might encounter haptic feedback are simulation systems like surgical simulation, teleoperated master/slave systems like robotic manipulation, everyday devices like touchpads on laptops, and, of course, video game controllers.

2 *Introduction*

For this first miniproject, you will build the physical joystick system and drive it using open loop control (ie. without feedback from any sensors). To do this, you will need to fabricate and assemble the mechanical joystick (with drive motor), assemble and test a motor driver circuit board, and write some code to control the motor using the microcontroller.

The objectives for this first miniproject are:

1. Fabricate and assemble the mechanical joystick system.
2. Assemble and test a motor driver circuit board.
3. Drive the motor for the joystick with a pulse width modulation (PWM) signal from the microcontroller.
4. Electrically and mechanically integrate a magnetic rotary encoder.
5. Sense and record the motor shaft position.

3 *Materials*

- [Motor driver circuit board](#)
- [Magnetic encoder board](#)
- [AS5048A magnetic encoder datasheet](#)

- [MAX14870 motor driver datasheet](#)
- Motor driver circuit components
- Commercial, off the shelf (COTS) mechanical components
- [Maxon DC Max 22mm brushed DC motor](#)

4 *Mechanical System Fabrication and Assembly*

Your mechanical system input is required to be a single rotational degree of freedom (DOF) (eg. a car steering wheel, a mouse click wheel, etc.). You must also integrate a brushed DC motor in order to actuate that rotational degree of freedom. You may drive it directly or through a mechanical transmission such as a gear train, a belt drive, or simple friction drive. Finally, your system must integrate a magnetic encoder to enable you to track the position of the motor in realtime for all appropriate motor speeds.

We encourage you to develop your own design, but it might be helpful to check out a variety of other “haptic paddle” designs that have been created at a number of different educational institutions. Here is a list of other designs you might consider referencing or learning from. In cases where design files exist, you are permitted to directly use them in your own design.

- [The Rice Haptic Paddle](#)
- [The Stanford Hapkit](#)
- [Vanderbilt haptic paddle](#)
- [More papers on haptic paddles](#)

5 *Motor Driver Circuit Assembly and Integration*

We have designed a circuit and fabricated a printed circuit board for driving the DC motor included as part of your kit of parts. You will need to assemble all of the components on the board and verify that you can integrate it with the microcontroller to provide the driving signal to your motor. A basic schematic and board footprint with component values can be found in the [Elecanisms motor shield schematic](#).

We will learn how to use the surface mount soldering tools in AC329 during class. You will also have time during class to complete the assembly of your boards.

6 *Motor Shaft Angle Sensing*

In order to write a controller for your haptic joystick, you'll need to be able to sense the shaft angle of your motor and compute the output angle of the joystick. To do this, we have provided you with a magnetic encoder, the [AS5048A chip](#). This particular chip interfaces with a microcontroller using a protocol called serial peripheral interface (SPI).

To test that your sensor is working as expected you should first calibrate it. Using some reference for measuring angles, verify that you can map the output from the sensor to an angle measurement reliably. After that, attach a mass to your motor's output shaft and run the motor at full speed. Then, remove the driving signal and sample your sensor as the motor slows down to a full stop. You'll need to record and visualize the output from this "spin-down" test.

7 *Deliverable*

By the start of class on **February 13, 2020**, each group should email a short report in pdf format to both instructors. Your report should describe the process of building and integrating your electromechanical system. Please include:

1. A written summary of your design with justifications for your design decisions
2. A photo of your integrated system (mechanical paddle, motor, and electronics)
3. A labeled plot of the calibration curve for your angle sensor
4. A labeled plot of your "spin-down" data
5. A link to your repository with source code