

E160 Lab 01

Spring 2018

1. Motherboard Assembly

There are seven sets of header pins that need to be soldered onto the motherboards. In Fig. 1(a) below, there are four 1x6 female header pin rows (left and right side of image). These must be soldered into the holes outlined in blue.

Also shown in Fig. 1(a) at the bottom is a long female header rows that must be CUT and soldered into the holes outlined in red.

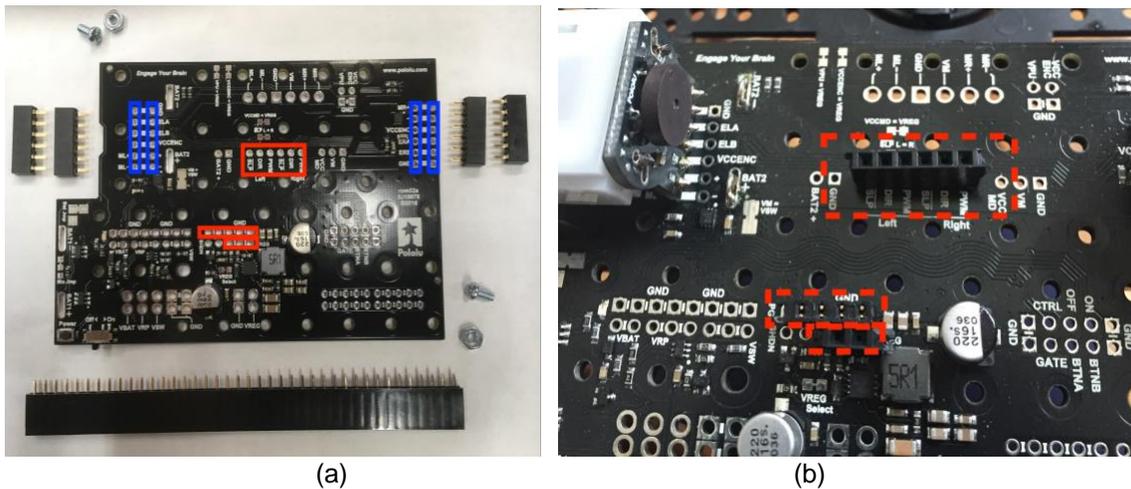
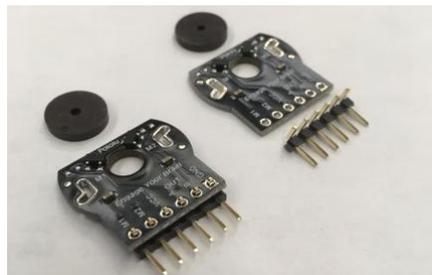


Figure 1: For the pins highlighted in **blue**, solder using the given 6 pin female headers. For the ones highlighted in **red**, use a wire cutter to cut the female headers (on the left) into their corresponding pin number and then solder it on.

2. Wheel Encoder Assembly

Wheel encoders are used to measure wheel rotations of the robot. They must first be built, then will be inserted between the motors and the Motherboard.

- Solder the 90 degrees 1x6 pin male headers on the encoder. Note the orientation of the header pins with respect to the encoder PCB.



- Note the orientation of header pins when attached to the encoder.
- Solder the two pins extruding from the back of the white motor gearbox to the encoder PCB. See locations indicated by red arrows in Fig. 3.

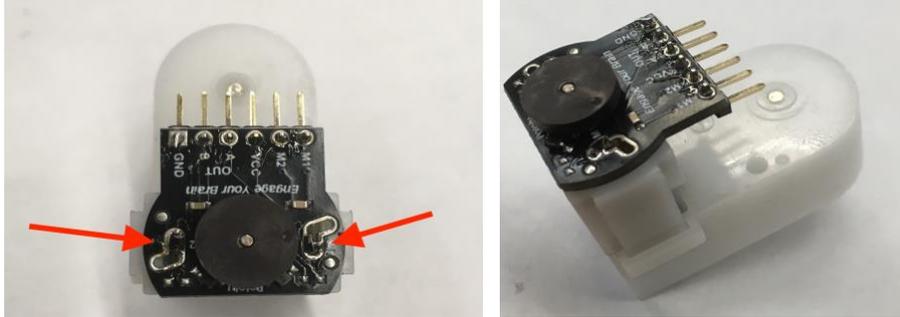


Figure 3: Soldering two pins of the motor gearbox onto the encoder PCB.

3. Robot Chassis Assembly

The robot chassis can be assembled by following steps in the [video](#). Use the instructions below to help, which have additional steps:

- On the bottom of the chassis base plate (the side on which the batteries are inserted), insert the three plastic rollers as seen in the video. Then, insert the ball and the retaining clip such that the clip makes a clicking noise.
- Insert the two of the battery contacts in the slots, as seen in the video. The nuts on the bottom of the chassis are not necessary for this project, but you can add them for extra securement.
- Flip the base plate over. Insert the two other battery contacts as seen in the video, leaving the tabs sticking out of the top so they can be soldered to the MD/PD board later.
- Place the Motherboard on the robot and screw it down with the pair of nuts and bolts provided.
- Press the motor clips into the sides of the base plate as seen in the video until you hear a click.
- Snap the motors (with wheel encoders attached) into the motor clips. Be sure that the male header pins from the encoder go into the female header pins on the motherboard.

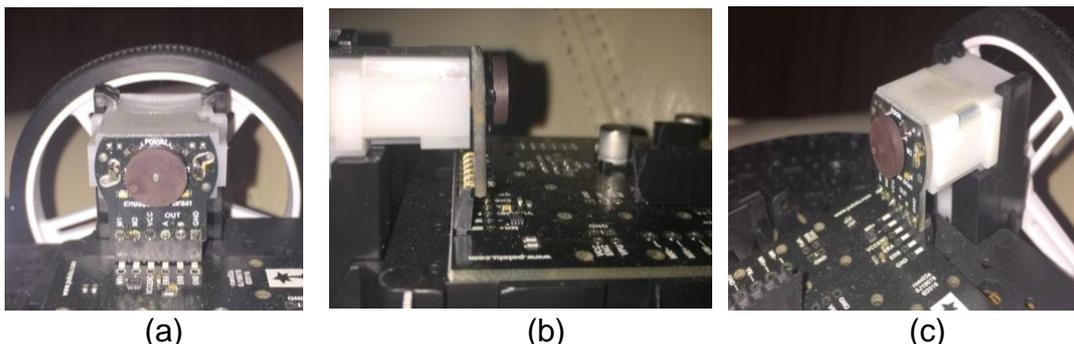
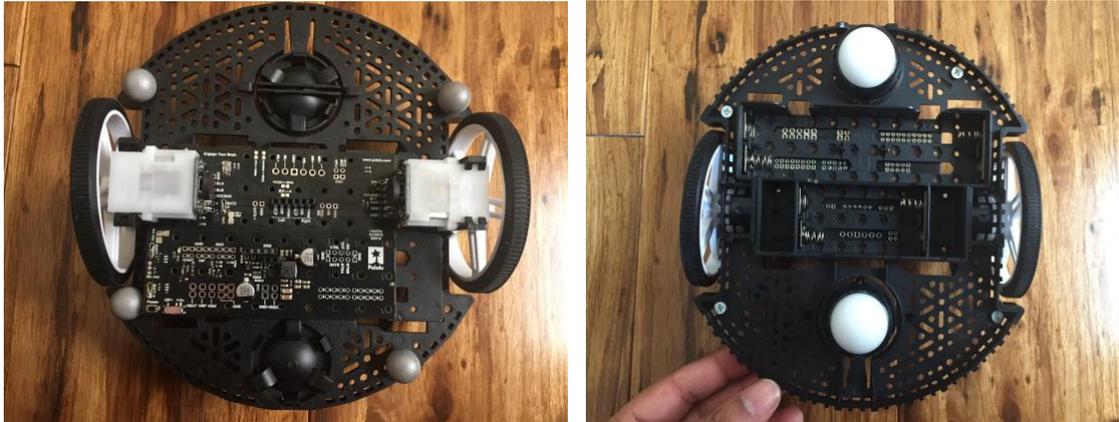


Figure 4: Side view of wheel encoder, assembled and soldered to the robot. Note that the motor is attached to the encoder via the **soldered prongs** on either side of the black disc.

- Put the rubber grips on the outside of the wheels. Push the wheels onto the axle of the motors.

- h) Check your assembled vehicle looks like the one in Fig. 5. Ignore the silver beads attached to the top of the robot.

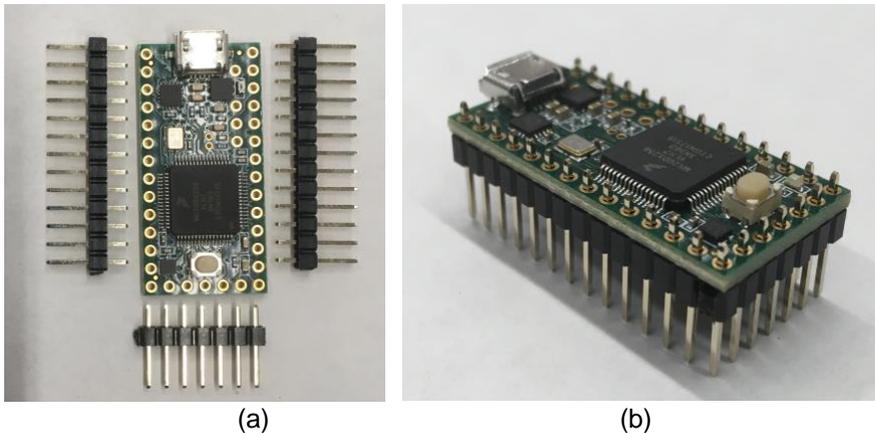


(a) (b)
Figure 5: Top view of robot chassis fully assembled (with MD/PD board, without adapter board and distance sensors.) Ignore silver OptiTrak balls). In (b), a bottom view of fully assembled robot (without batteries)

4. Teensy board

The microcontroller used to wirelessly connect the motherboard to a laptop computer can be found is a Teensy 3.2. A schematic of the board can be found [here](#).

- a) Solder the male header pins (with the black plastic buffer under the Teensy) to the Teensy. Break the male header pins into the chunks as shown below in Fig. 6.



(a) (b)
Figure 6: The Teensy and male header pin rows (a) that must be soldered to the Teensy as shown in (b).

- b) Break the female header pins and solder them onto the Xbee breakout board. Yellow is for the attaching Teensy, blue are for the wires connecting to the MotherBoard.

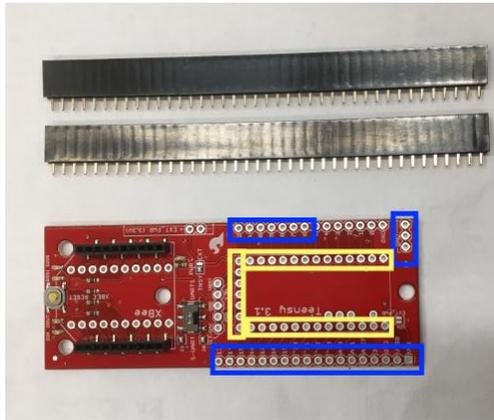


Figure 6: Teensy / Xbee breakout board and female header pin rows.

- c) Note the following wiring guide from the teensy to the MotherBoard.
 - a. Teensy Pin 11 → MotherBoard RDIR
 - b. Teensy Pin 10 → MotherBoard RPWM
 - c. Teensy Pin 18 → MotherBoard board LDIR
 - d. Teensy Pin 20 → MotherBoard board LPWM
 - e. Teensy Pin 6 → MotherBoard ERA
 - f. Teensy Pin 7 → MotherBoard ERB
 - g. Teensy Pin 8 → MotherBoard ELA
 - h. Teensy Pin 9 → MotherBoard ELB
 - i. Teensy GND → MotherBoard board GND
 - j. Teensy VIN → MotherBoard board VREG
- d) If you don't have Arduino and Teensy programming software, download and install it on your computer. Follow this [link](#) for some pointers.
- e) Download the code *Robot.ino* and upload it onto the teensy.
- f) Connect the Teensy and Xbee boards to the red Teensy/Xbee breakout board as shown in Fig. 7.



Figure 7: Side view of the Teensy with male header pins soldered to it, connected to female header pins soldered to the Teensy/xbee breakout board (a). In (b), a top view of adapter board with female header pins, Xbee, and Teensy attached

5. Range Sensor Installation

Sensors and the JET connectors are in the lab next to the batteries on the main table.

- a) First take 3 male pins and solder them to the JET connectors as shown in Fig. 8(a).

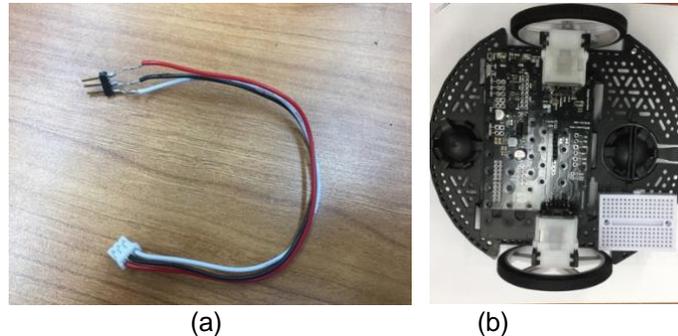


Figure 8: Range finder cable (a) and breadboard attached to the chassis (b).

- b) Plug the white connector into the rangefinder.
- c) Take out your mini breadboard, and peel off the backside attached to the chassis as shown in Fig. 8(b).
- d) Plug the other end of the 3 male header pins into the mini breadboard
- e) Connect three jumper wires to each respective pins, with the other ends connected to destination as shown below.

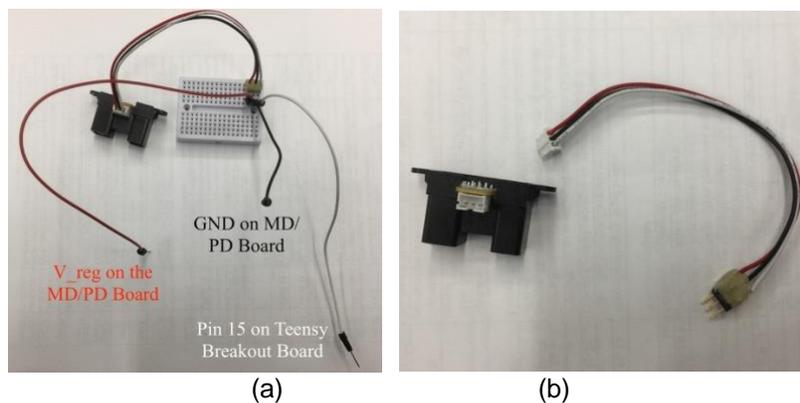


Figure 9: Range finder wiring.

- f. Attached the sensor to the robot. Use a small screw and attached it to the robot chassis using the tiny screws and bolts. See Fig. 10.



Figure 10: Possible range sensor mounting strategies.

5. Xbee Configuration

Define the *Computer XBee* as the XBee that will be connected to the computer and used to send commands from the computer to the robot(s). Define the *Robot XBee* as the XBee that will be on a robot adapter board with a Teensy and used to receive commands from the Computer XBee

- a) Download and install XCTU: <https://www.digi.com/products/xbee-rf-solutions/xctu-software/xctu>
- b) Plug the XBee into your computer using the XBee breakout board. Open XCTU and click “Add Devices” in the top left corner.

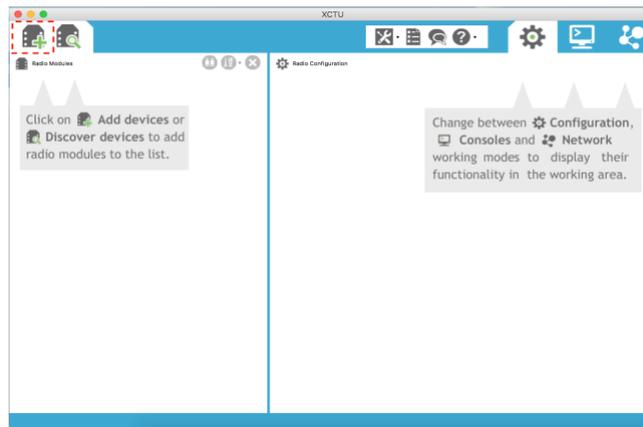


Figure 11: XCTU software upon opening.

- c) Select the XBee from the list of serial ports that appear. It will probably be named similarly to the device shown below. Use the same Baud Rate, Data Bits, etc. shown below. Then click “Finish”.

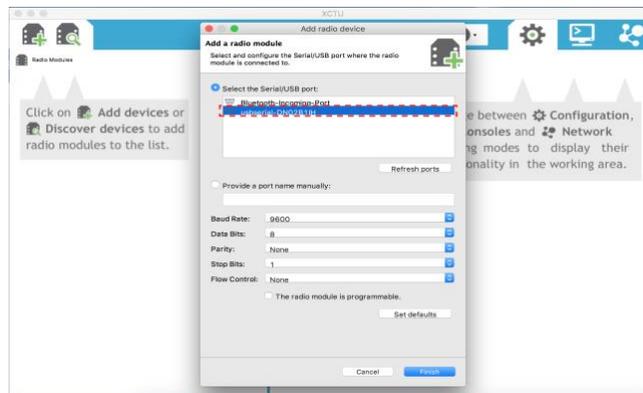


Figure 12: XCTU software – selecting the device.

- d) The device should now appear under “Radio Modules” on the left side of the screen. Double click on it to open its settings.

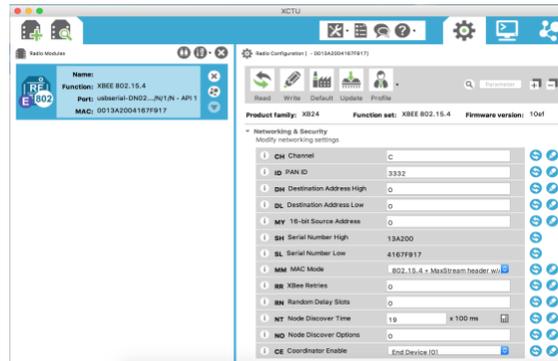


Figure 13: XCTU software – device settings.

- e) Configure both Xbees. To configure them, one at a time plug them into your computer with the small red USB/Xbee board.
1. Set “Channel” to ‘C’ for both Xbee.
 2. Set “PAN ID” to your group number for both Xbee.
 3. For both XBee, “Destination Address High” and “Destination Address Low” should both be 0. It does not matter for the Computer XBee.
 4. For the Robot XBee, “MY 16-bit Source Address” should be “C”. For the Computer XBee, it should be zero.
 5. Under “Serial Interfacing” for the “AP” setting, the Computer XBee should be set to “API enabled [1]” (second option). The Robot XBee should be set to “API disabled [0]” (first option).
 6. The Robot XBee’s “Coordinator Enable” setting should be set to “End Device [0]”. The Computer XBee’s “Coordinator Enable” setting should be set to “Coordinator [1]”.
- f) Once the Xbees are configured, the Computer XBee will live on the small red USB/XBee breakout connected to the computer. The Robot XBee will live on the larger red Teensy/XBee breakout board.

6. Running the E160 Software

- a) If you haven’t already: Install Python and Pip on your laptop
- b) Download Python packages *serial* and *xbee* using pip:
 - a. For Mac, type in your terminal
 - i. `pip install pyserial`
 - ii. `pip install xbee`
 - b. Windows, type in your command prompt
 - i. `python -m pip install pyserial`
 - ii. `python -m pip install xbee`
- c) Once both libraries are installed, download the source code from the E160 website.
- d) Explore the code structure, noting what is inside each file.

- e) Connect the Computer Xbee to your laptop, check using XCTU which serial port is using. Copy the information.
- f) Go to file *E160_environment.py*, find the line:
 - a. `self.serial_port = serial.Serial('/dev/tty.usbserial-DN02BDUM', 9600)`
 - b. Replace the first argument with the port number of your computer Xbee. Note in Windows system the name of your port will be "COM" + the number of the port.
- g) Turn on your robot, THEN run *E160_gui.py*, and you're ready to go! NOTE: Your robot will only run the hardware, NOT the simulator. YOU will add the code to do this next week.
- h) Play with the slider controls on the bottom. Drive your robot around. Use Stop to stop the robot from moving. Use quit to exit the program.

7. Deliverables

- a) Your fully functional robot.
- b) Demonstration and Data - Before **Sunday, January 28th at 4pm**, program the robot such that it autonomously drives to (or away from) a position 30cm from a wall and then stop. Log the sensor data and save it to a file.
- c) Report: Write a 1-2 page report documenting your closed-loop control design. Be sure to include the following sections: abstract, introduction, problem definition, control design, results, conclusion. Be sure that your results section includes plots of distance to the wall as a function of time.
 - a. Note, all lab documents in this class will follow the IEEE Conference template found [here](#).
 - b. Please email a pdf of your lab 1 report by **4pm, Sunday, February 4th** to clark@hmc.edu.