How to build an Elric module

Aaron Chen
Vittoria Santoro
Alexander Wilkinson

1. INTRODUCTION

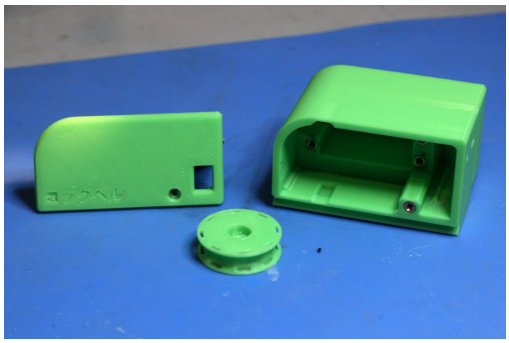
The Elric module is intended to be a low-cost, low-commitment myoelectric add-on for the popular open-source e-NABLE Phoenix hand. Its design allows it to easily snap on to the existing gauntlet and be a drop-in replacement for the rail-mounted box. The inexpensive MyoWare sensor can be attached to any muscle on the body for control. This guide will walk you through the entire process of assembling, flashing, and using an Elric module.

2. BUILDING

These instructions assume you have already built a Phoenix hand, for which files and instructions can be found at:

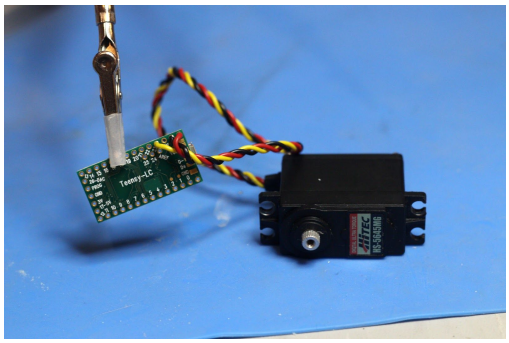
https://www.thingiverse.com/thing:1453190

If you do not plan on using the Phoenix hand as a wrist-actuated device, you do not need to print the gripper box, the device that sits in the rail on the gauntlet. The servo “backpack” will occupy this rail.

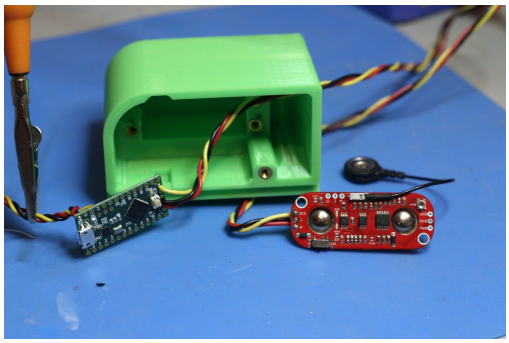


Parts list:

- enclosure.stl
- lid.stl
- spool.stl
- 4x M3x0.5 heat-set insert
- 4x M3x0.5x8mm socket head cap machine screws



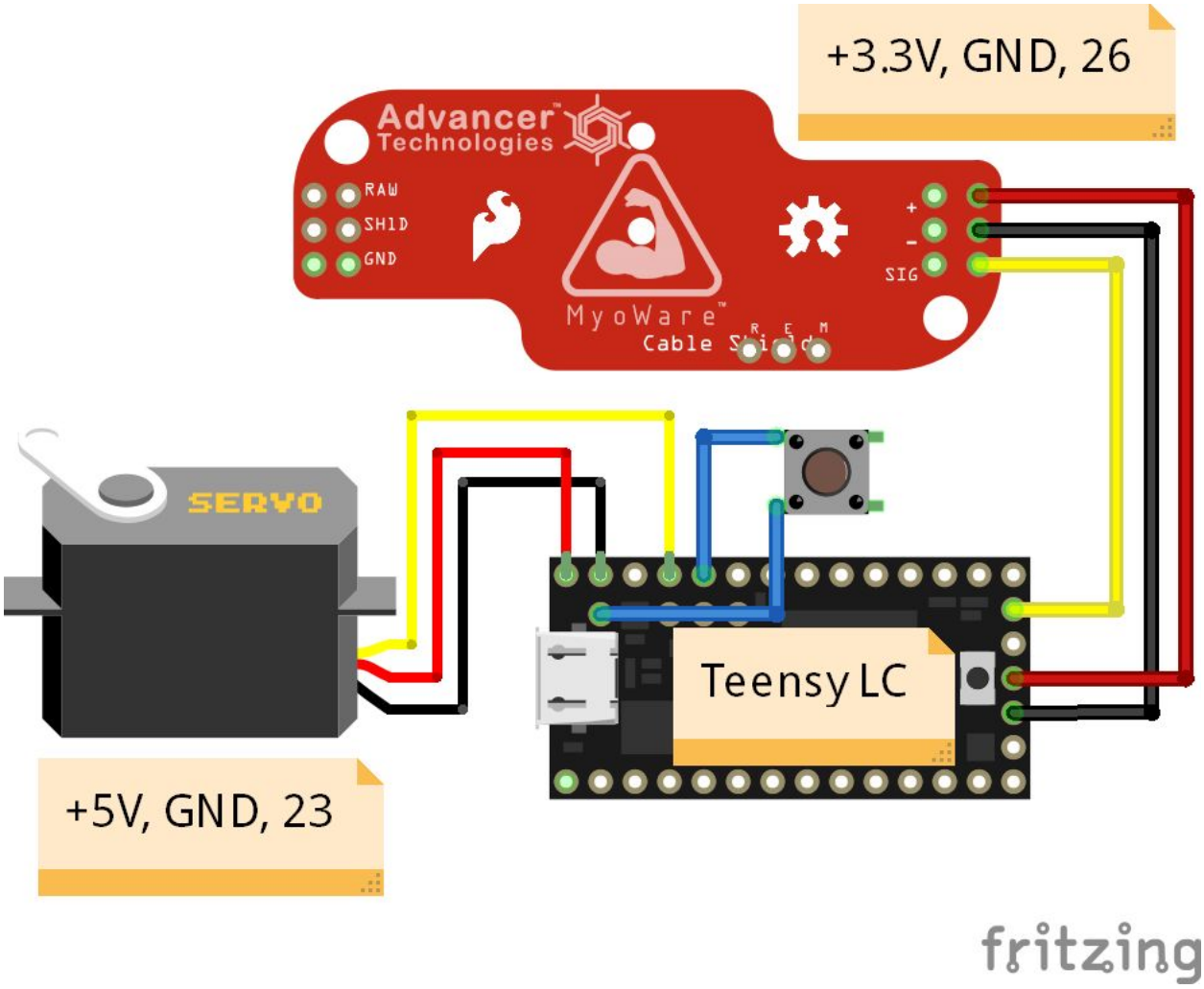
1. Place heat-set inserts into mounting holes for lid and servo. These can be pressed in with a soldering iron tip that you don’t care about.
2. Solder servo wire to Teensy pins. More info can be found in section 3 - wiring.
3. If you aren’t using a connector, route the MyoWare cable through the hole in the back. Then solder to both Teensy and MyoWare board.
4. Place Teensy board in slot, and screw servo into place.
5. Glue servo horn to spool.
6. Route finger lines to spool, adjust tension by rotating spool inside housing.
7. Screw horn to servo.

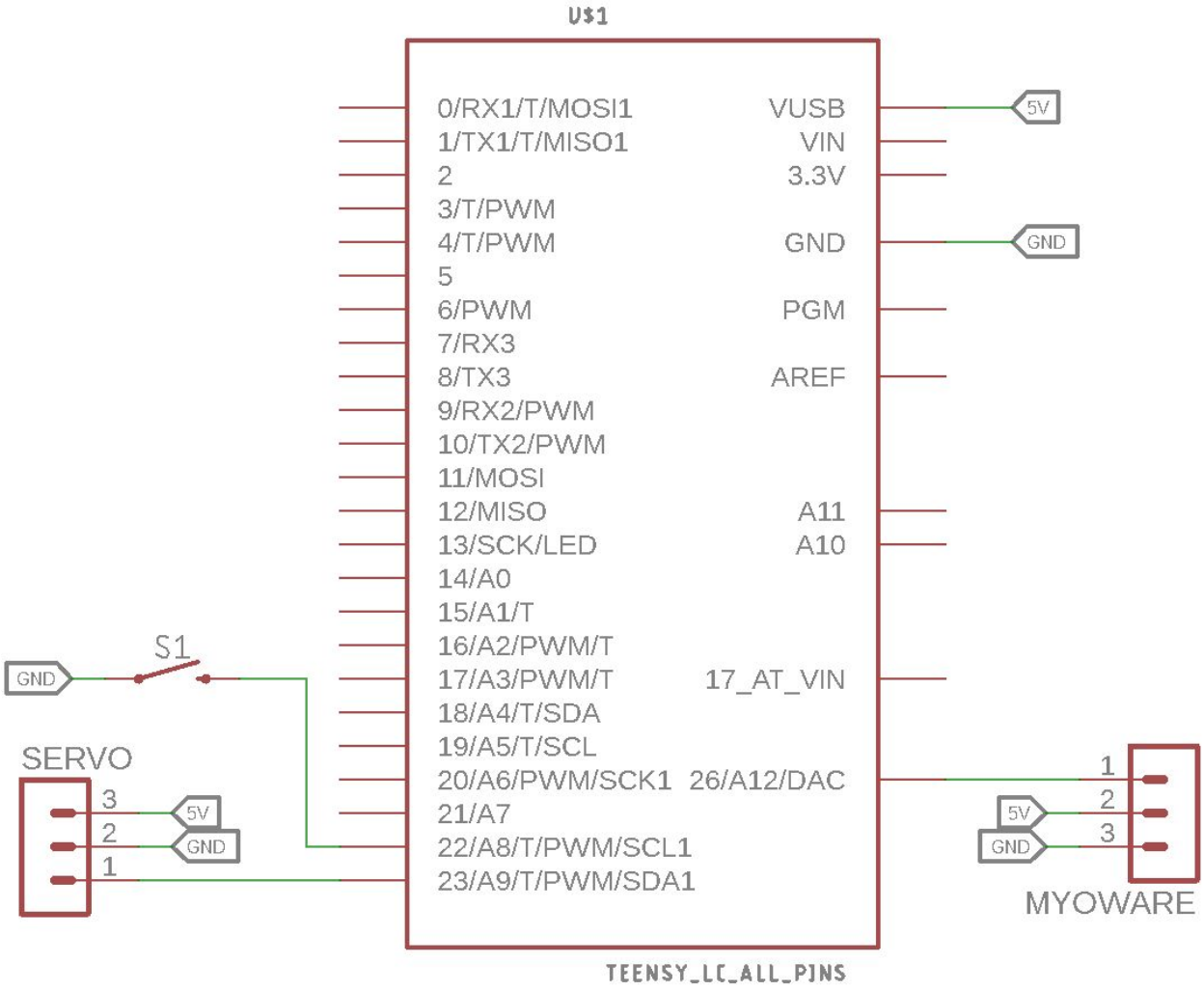


3. WIRING

PARTS LIST

PART	LINK	Price
Servo	https://www.amazon.com/Hitec-35645S-HS-5645MG-Digital-Torque/dp/B0006O3XLS	$41.98
Teensy LC	https://www.sparkfun.com/products/13305	$12.95
MyoWare Sensor	https://www.sparkfun.com/products/13723	$37.95
6MM SMD Button	https://www.sparkfun.com/products/12992	$0.50
		Total: $93.38


+3.3V, GND, 26
Advancer Technologies
RAW
SHLD
GND
+
-
SIG
MyoWare
Cable Shield
SERVO
Teensy LC
+5V, GND, 23
fritzing


U$1
0/RX1/T/MOSI1
1/TX1/T/MISO1
2
3/T/PWM
4/T/PWM
5
6/PWM
7/RX3
8/TX3
9/RX2/PWM
10/TX2/PWM
11/MOSI
12/MISO
13/SCK/LED
14/A0
15/A1/T
16/A2/PWM/T
17/A3/PWM/T
18/A4/T/SDA
19/A5/T/SCL
20/A6/PWM/SCK1
21/A7
22/A8/T/PWM/SCL1
23/A9/T/PWM/SDA1
VUSB
VIN
3.3V
GND
PGM
AREF
A11
A10
17_AT_VIN
26/A12/DAC
5V
GND
S1
GND
SERVO
3
2
1
5V
GND
1
2
3
5V
GND
MYOWARE
TEENSY_LC_ALL_PINS

4. FLASHING

Now that the circuit is complete, it is time to flash the software onto the Teensy. First, install the necessary software on your computer. We will be installing the Arduino IDE and the Teensyduino add-on. Be sure to follow all installation instructions on each page.

Arduino IDE:
https://www.arduino.cc/en/Main/Software

Teensyduino:
https://www.pjrc.com/teensy/td_download.html

Next, download a copy of the code, or copy and paste it into your Arduino IDE.

Libraries:
Install the following library by cloning or downloading/unzipping in the Arduino/libraries directory:
https://github.com/JonHub/Filters

Elric module code:
https://github.com/sashaiw/elric/blob/master/elric.ino

There are several parameters that you can modify in this code, in case you wish to modify these in the future. Most can be found as variables under the `// Tunable parameters` comment.

User-tunable parameters

`DEFAULT_MIN_INPUT`	The default minimum sensor value, or the value the sensor reports when the muscle is relaxed
`DEFAULT_MAX_INPUT`	The default maximum sensor value, or the value the sensor reports when the muscle is flexed
`RANGE_DELTA`	The buffering given to the calibrated range to clamp it between a smaller range
`CURVE_STEEPNESS`	The value of *s* in the equation for the output curve as defined by $f(x) = \frac{1}{2} + \frac{1}{2}tanh(s * (x - \frac{1}{2}))$ This curve is used to bias the gripper between fully open/closed to make it easier to use.
`FILTER_FREQUENCY`	Frequency of a low-pass filter applied to the sensor output

Under the `//pins` comment are several variables that represent the pins used on the Teensy. These can be changed, but the defaults will work for the circuit defined in the previous section.

If you don't feel like modifying the code, don't worry about it. The defaults will work.

To flash the Teensy, simply connect the board to your computer using a MicroUSB cable and press the *Upload* button designated by a checkmark in your Arduino IDE. If this is the first time you are uploading Arduino code to your Teensy, press the small button located on your Teensy immediately prior to flashing the code.

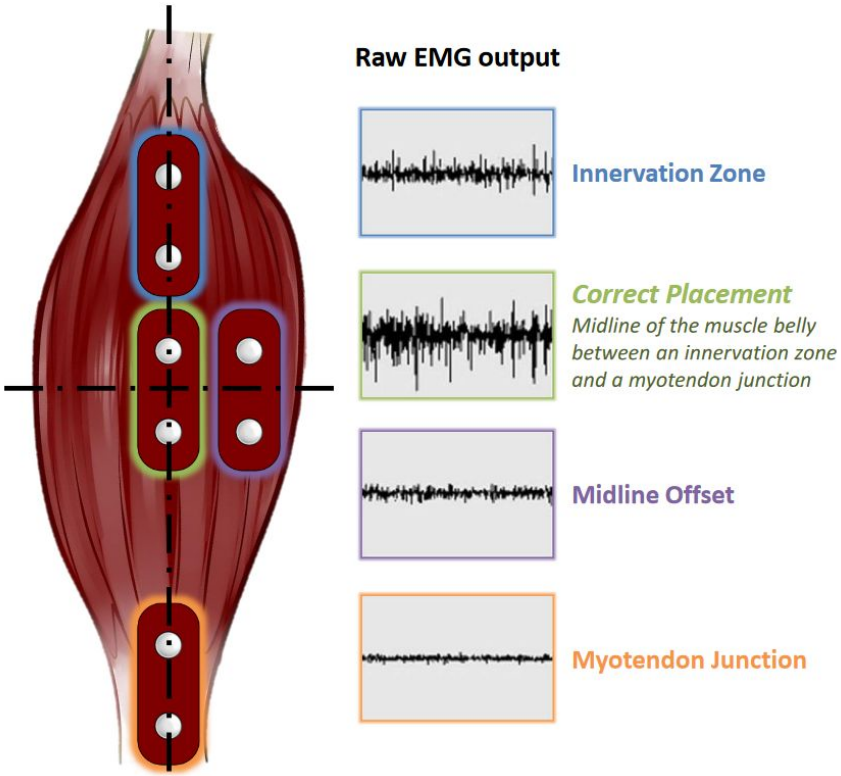
5. USING THE ELRIC MODULE

Sensor placement

Correct placement of the MyoWare sensor is essential for good performance. The official documentation for the sensor, which can be found here, recommends the following steps:

1. Thoroughly clean the intended area
2. Snap electrodes to sensor's snap connectors
3. Place the sensor on the desired muscle
    a. Place the sensor so one of the connected electrodes is in the middle of the muscle body. The other electrode should line up in the direction of muscle length.
    b. Peel off backing on electrodes to expose the adhesive and apply them to the skin
    c. Place the reference electrode on a bony or nonadjacent muscular part of the body near the targeted muscle

The following image, stolen shamelessly from the MyoWare sensor documentation, illustrates correct sensor placement:



Calibration

Whenever the sensor is moved or placed on a different person, the device will need to be re-calibrated to set the upper and lower ranges of values being reported by the sensor. The procedure for performing a recalibration is as such:

1. With the device and the sensor connected and powered on, hold the calibration button for 2 seconds. The device should deactivate and the servo should stop moving, indicating that the device is now in calibration mode.
2. With the user's target muscle relaxed, press the calibration button once. The device will sample the sensor for the next 5 seconds. Afterwards, the device will quickly contract and extend, indicating that this part of the calibration is finished.
3. Press the button again with the user's muscle fully flexed. The device will sample the sensor again for 5 seconds. When it is finished, it will resume operation.

If you wish to manually change the default calibration, you may edit the code and re-flash the Teensy. See the section about the code for details. It is possible to graph the sensor input and motor output against the minimum and maximum range to be able to set it manually if you enable the serial plotter with the Teensy connected.