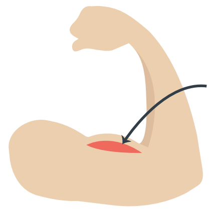
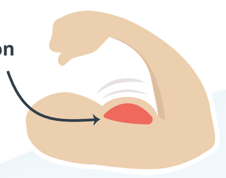
MYOWARE® 2.0

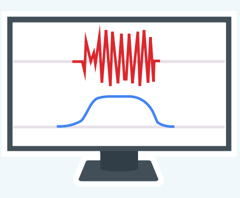
Advanced Guide

How MyoWare works

The MyoWare measures muscle activity through the electric potential of the muscle, commonly referred to as surface electromyography *(EMG or sEMG for short)*. When your brain tells your muscle to flex, it sends an electrical signal to your muscle to start recruiting motor units *(the bundles of muscle fibers that generate the force behind your muscles)*.



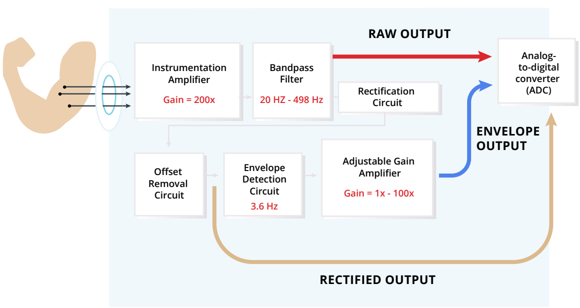




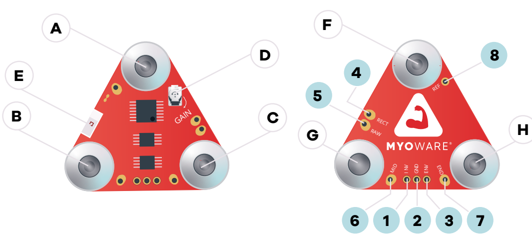
The harder you flex, the more motor units are recruited to generate greater muscle force.

The greater the number of motor units, the more the electrical activity of your muscle increases. The MyoWare will analyze this electrical activity and output an analog signal that represents how hard the muscle is being flexed. The harder you flex, the higher the MyoWare output voltage will go.

Circuit Workflow



Sensor Parts



A - Ground (GND) snap for shields
B - Envelope (ENV) output snap for shields
C - Input Voltage (VIN) snap for shields
D - Gain potentiometer (clockwise turn)
E - Reference electrode port (optional)
F - Reference electrode snap socket
G - Mid-muscle (MID) electrode snap socket
H - End-muscle (END) electrode snap socket

Primary Pins
1 - Input Voltage (VIN)
2 - Ground (GND)
3 - Envelope (ENV) output

Optional Pins
4 - Rectified (RECT) output
5 - Raw (RAW output
6 - Mid-muscle (MID) electrode
7 - End-muscle (END) electrode
8 - Reference (REF) electrode

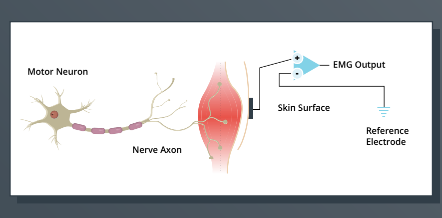
Why three electrodes?

Mono vs. Bipolar

EMG sensors can either have a two electrode (monopolar) or three electrode (bipolar) configuration.

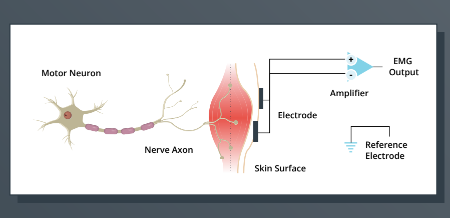
Monopolar Configuration

A single input electrode is placed over the body of the targeted muscle group. A reference electrode is placed in an adjacent electrically neutral location.



Bipolar Configuration

Two input electrodes (e.g. MID and END) are placed on the body of the targeted muscle group. The first electrode is placed near the middle of the muscle body and the second electrode is placed 1-3 cm from the first electrode. A reference electrode is placed in an adjacent electrically neutral location.



The difference in voltage between the two electrodes is amplified with respect to the reference electrode. The advantage of this configuration is the common noise between the two electrodes is removed due to the amplifier's common mode rejection ratio (CMRR).

A bipolar EMG sensor, like the MyoWare, produces a much cleaner EMG signal with a much greater signal-to-noise ratio (SNR).

Why is electrode placement important? [2]

Proper electrode placement and orientation is essential to acquire consistent and quality signals with the MyoWare. For the best possible signal, place the electrodes on the belly of the target muscle between the nearest innervation zone and the myotendon junction where the muscle fibers are most dense. Orientation-wise, the electrodes should form a line longitudinally parallel to the muscle fibers. This ensures the detecting surfaces intersect the same muscle fibers creating a better superimposed signal.[1]

Raw EMG output

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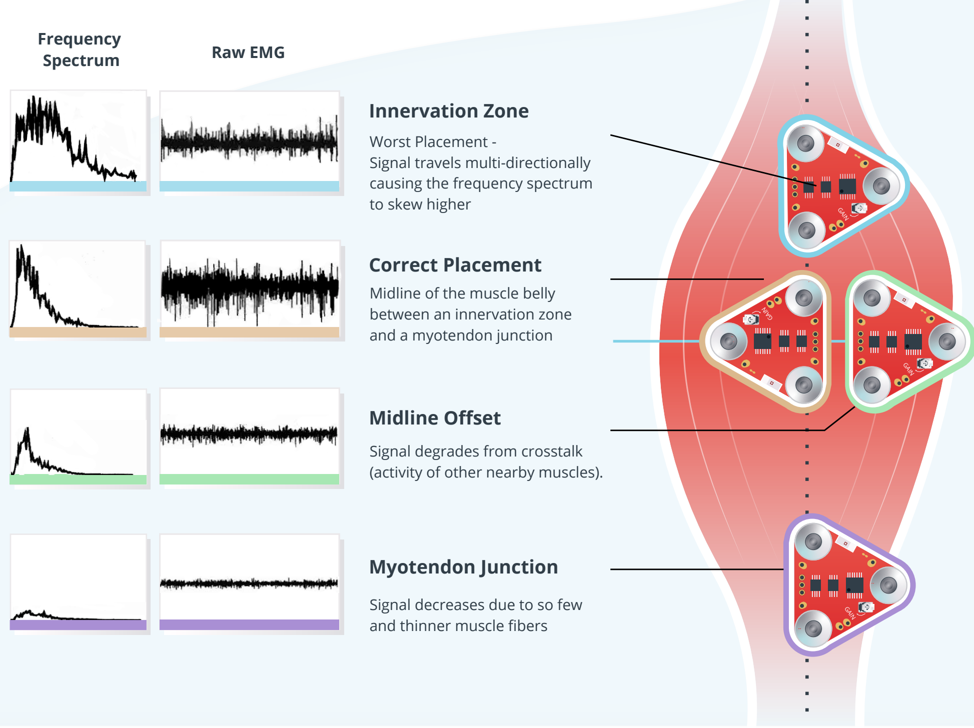


Innervation Zone
Worst Placement - Signal travels multi-directionally causing the frequency spectrum to skew higher

Correct Placement
Midline of the muscle belly between an innervation zone and a myotendon junction

Midline Offset
Signal degrades from crosstalk (activity of other nearby muscles).

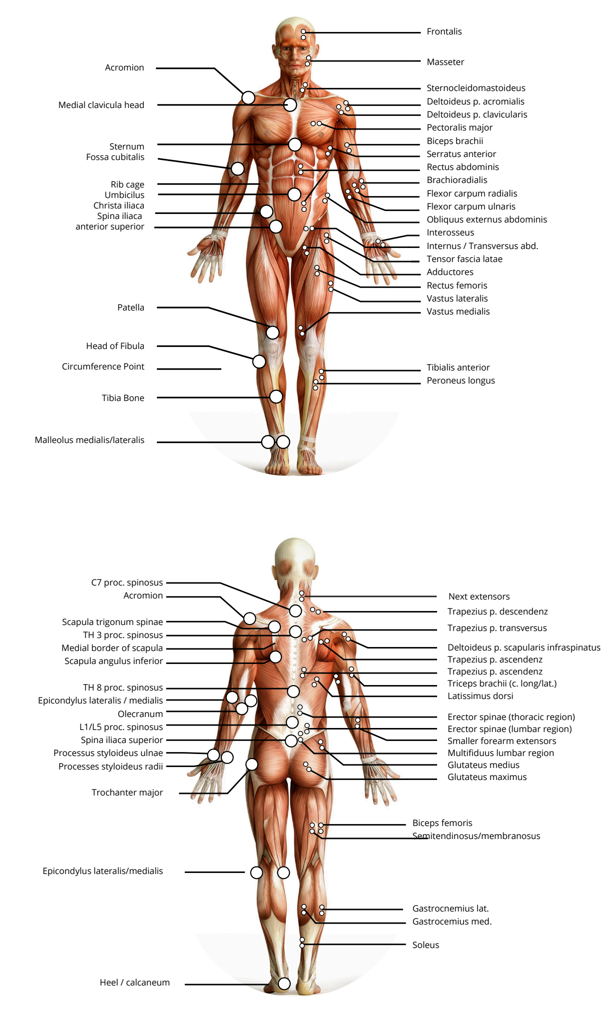
Myotendon Junction
Signal decreases due to so few and thinner muscle fibers

Muscle Group Sensor Placement[2]

LEFT SIDE
Reference Electrode Positions

RIGHT SIDE
sEMG Electrode Positions

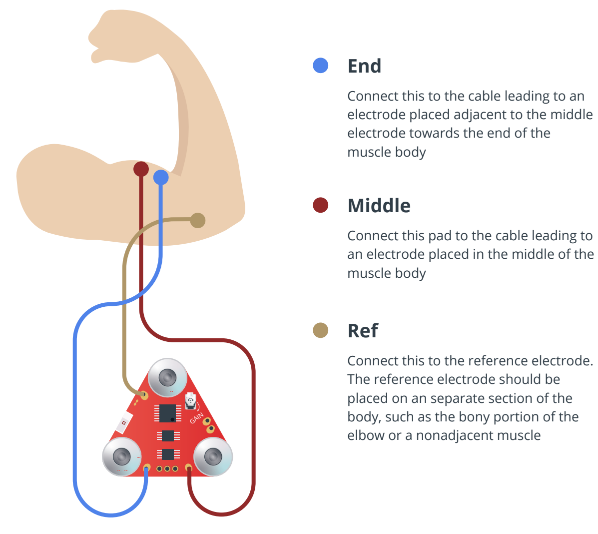
NOTE: The positions in this image are approximate



Connecting Optional External Cables

The MyoWare has embedded electrode snaps right on the sensor board itself, replacing the need for a cable. However, if the on board snaps do not fit a user's specific application, an external cable can be connected to the board through three through hole pads shown above.

PLEASE NOTE: MyoWare 2.0 Cable Shield is recommended.



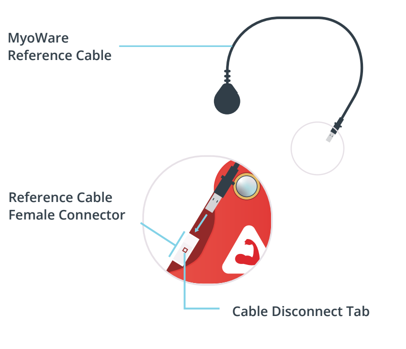
End
Connect this to the cable leading to an electrode placed adjacent to the middle electrode towards the end of the muscle body

Middle
Connect this pad to the cable leading to an electrode placed in the middle of the muscle body

Ref
Connect this to the reference electrode. The reference electrode should be placed on an separate section of the body, such as the bony portion of the elbow or a nonadjacent muscle

Connecting Optional Reference Cable

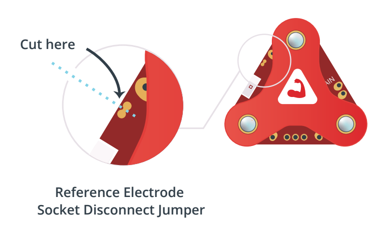
For certain applications where the reference electrode snap socket is poorly positioned, the v2.0 can still accept a MyoWare Reference Cable.



Insert the MyoWare Reference Cable into the female connector located on the left side of the sensor.

Remove the cable by pressing down on the tab on top.

The reference electrode socket remains active even with the cable inserted. Disable the socket by cutting the jumper trace on the top side of the sensor. Re-enable the socket by shorting the jumper pads with solder.



Overview

The MyoWare is designed to be used directly with a microcontroller. It's primary output is not the raw EMG signal but rather the envelope of the amplified and rectified signal that is ideal to work with a microcontroller's analog-to-digital converter (ADC). However, MyoWare 2.0 also provides the raw and rectified signals.

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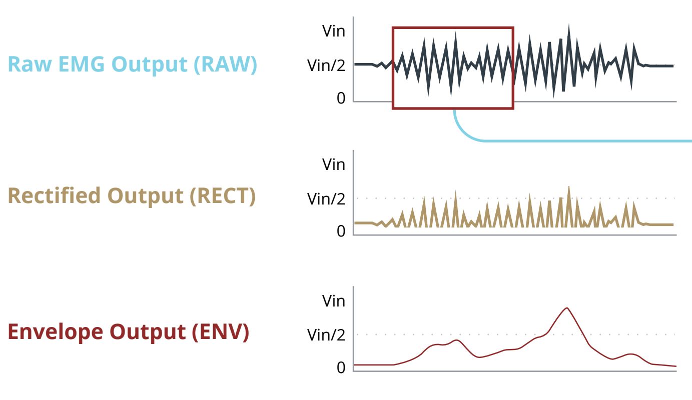

Power Spectrum

Surface EMG signals typically have an amplitude of 0 - 10 mV (peak to peak) and a frequency band of 10 - 500 Hz. MyoWare has a first-order passband of 20 - 500 Hz which is ideal for capturing the bulk of the power spectrum while removing unwanted signal sources such as motion artifacts.[2]

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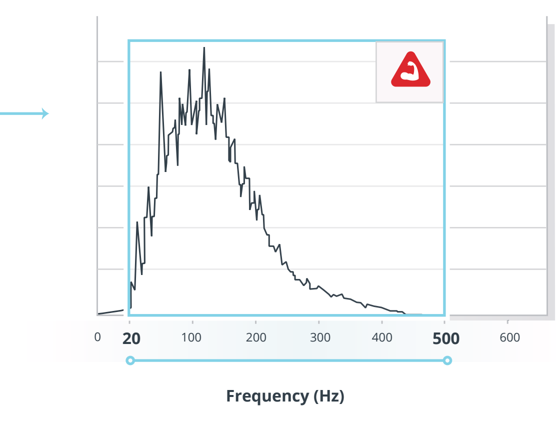
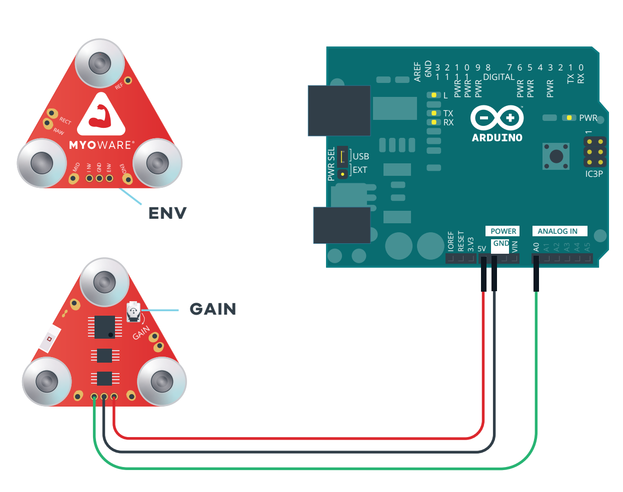


Setting up Envelope (ENV) Output

To output the ENV signal, simply connect the ENV pin to one of your measuring device's analog input. Unlike the other two outputs, the ENV output has an additional gain stage that is adjustable via the gain potentiometer.

To adjust the gain, locate the gain potentiometer in the upper left corner of the sensor (marked as "GAIN"). Using a Phillips screwdriver, turn the potentiometer clockwise to increase the output gain; turn the potentiometer counterclockwise to reduce the gain.

QUICK TIP
We recommend for users to get their sensor setup working reliably prior to adjusting the gain. The default gain setting should be appropriate for most applications.



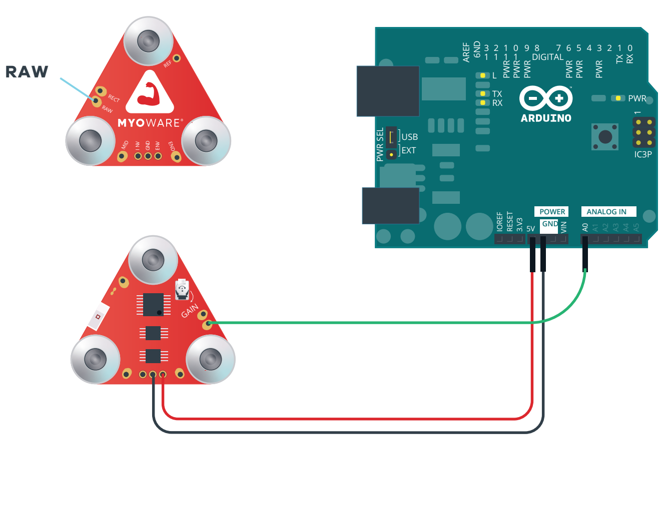
Setting up Raw (RAW) Output

Like the previous version, MyoWare 2.0 has the ability to output an amplified raw EMG signal.

To output the raw EMG signal, simply connect the RAW pin to your measuring device instead of the ENV pin.

QUICK TIP
The RAW output is centered about an offset violtage of +Vs/2, see above. It is important to ensure +Vs is the max voltage of the MCU's analog to digital converter. This will assure that you completely see both positive and negative portions of the waveform.

The amplification for the RAW output is not adjustable via the GAIN potentiometer.

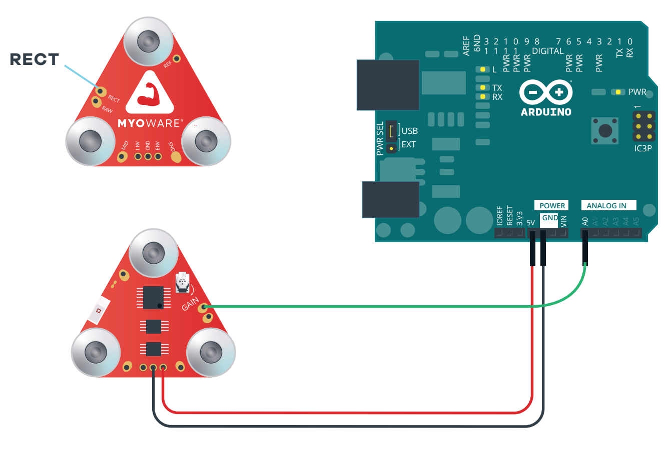


Setting up Rectified (RECT) Output

MyoWare 2.0 now has the ability to output the amplified and full-wave rectified signal.

To output the rectified signal, simply connect the RECT pin to your measuring device instead of the ENV pin.

QUICK TIP
The amplification for the RECT output is not adjustable via the GAIN potentiometer.



Technical Specifications

Supply Voltage:
min. = 2.27V,
typ. = +3.3V or +5V,
max. = +5.47V

Input Bias Current:
250 pA, max 1 nA

Input Impedance:
800

Common Mode Rejection Ratio (CMMR):
140 dB

Ideal Gain Equation:
Raw (RAW): G = 200
Rectified (RECT): G= 200
Envelope (ENV): G = 200 * R / 1 kOhm
R is the resistance of the gain potentiometer in kOhm

Filters:
High-pass Filter: Active 1st order, fc = 20.8 Hz,[2] -20dB

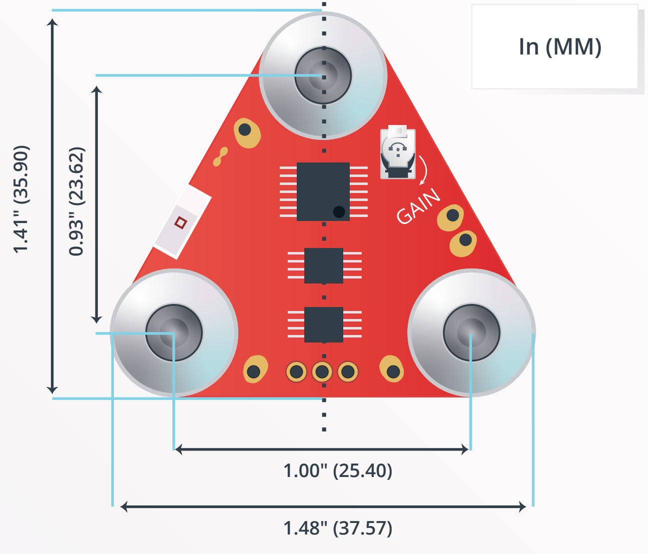
Low-pass Filter: Active 1st order, fc = 498.4 Hz,[2] -20dB

Envelope Detection:
Linear, Passive 1st order, fc = 3.6 Hz,[3] -20 dB

Rectification Method:
Full-wave

Sample Rate:
Not applicable - MyoWare Sensor is analog. See measuring device specifications.

Dimensions



References

[1] De Luca, C. J. (1997). The use of surface electromyography in Biomechanics. Journal of Applied Biomechanics, 13(2), 135–163. https://doi.org/10.1123/jab.13.2.135

[2] Hermens, H. J., Freriks, B., Merletti, R., Stegeman, D., Blok, J., Rau, G., Disselhorst-Klug, C., Hägg, G. (1999). *SENIAM 8: European Recommendations for Surface ElectroMyoGraphy* (2nd ed.). Roessingh Research and Development b.v., ISBN 90-75452-15-2.

[3] Winter, D. A. (2009). *Biomechanics and motor control of human movement* (4th ed.). Wiley. ISBN 978-0-470-39818-0.