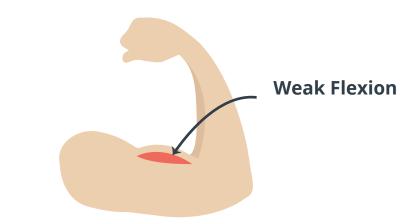
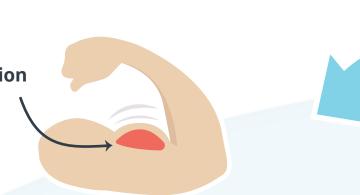
# Advanced Guide

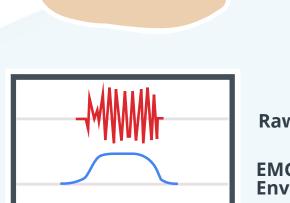
### **How MyoWare works**

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).









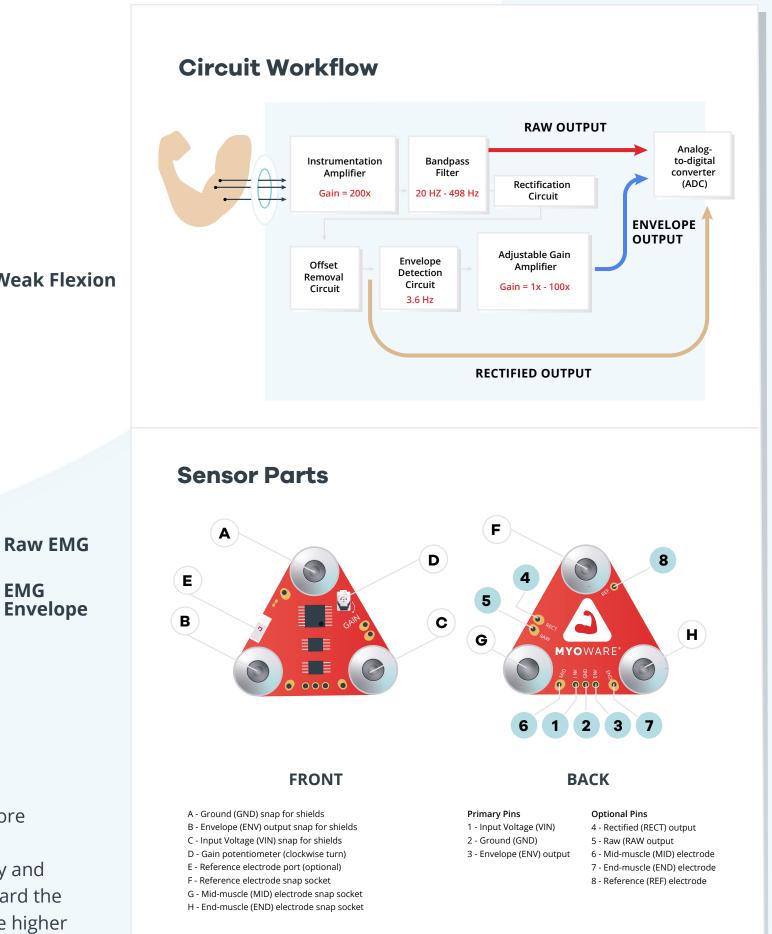
**Raw EMG EMG Envelope** 



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.



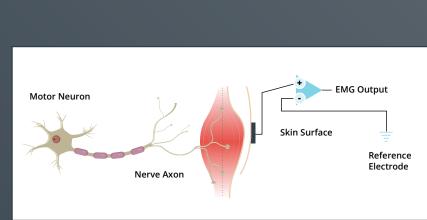
## Why three electrodes?

Mono vs. Bipolar

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

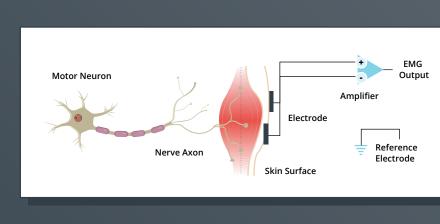
### **Monopolar Configuration**

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.



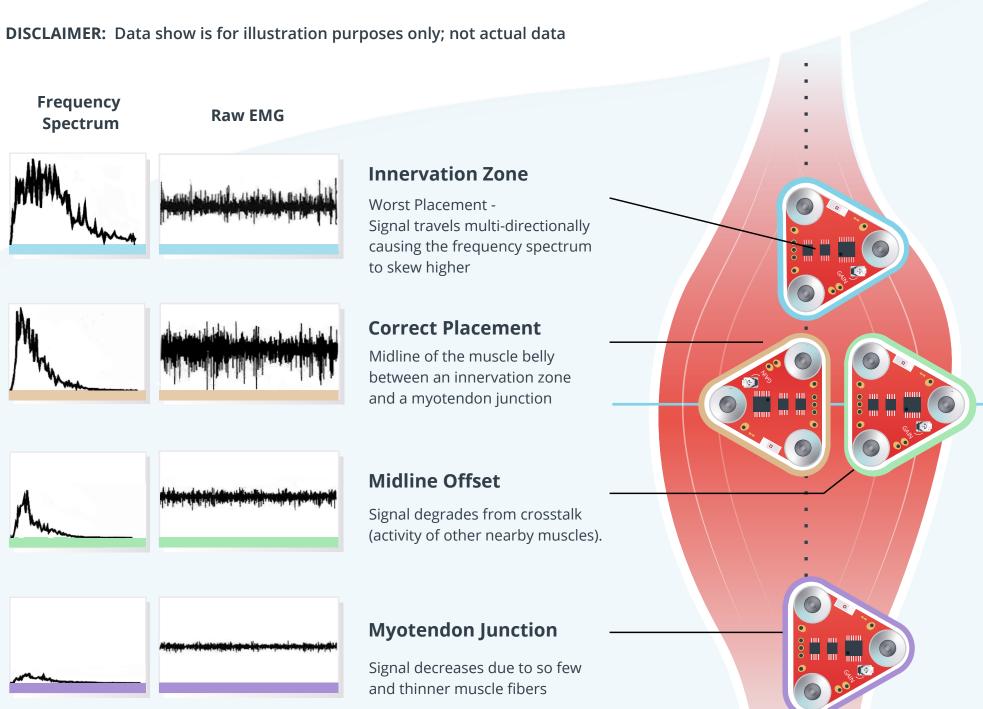
The difference in voltage between the two electrodes is amplified with respect to the reference electrode. The advantage of this configuration is the common noise between the two electrodes is removed due to the amplifier's common mode rejection ratio (CMRR).

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?<sup>2</sup>

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**

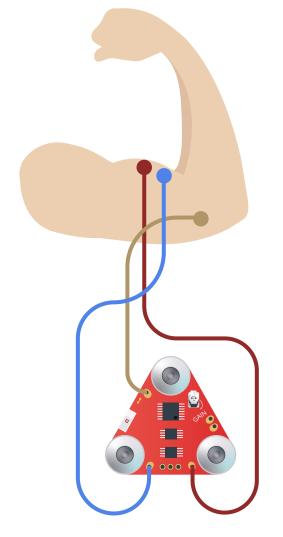


Muscle Group Sensor Placement<sup>2</sup> **Reference Electrode Positions sEMG Electrode Positions** NOTE: The positions in this image are approximate Deltoideus p. acromialis Medial clavicula head Deltoideus p. clavicularis Pectoralis maior Biceps brachii Serratus anterior Rectus abdominis Brachioradialis Rib cage Flexor carpum radialis Umbicilus Christa iliaca Flexor carpum ulnaris Spina iliaca Obliquus externus abdominis anterior superior Internus / Transversus abd. Tensor fascia latae Adductores Vastus lateralis Vastus medialis Head of Fibula Circumference Point Tibialis anterior Peroneus longus Malleolus medialis/lateralis C7 proc. spinosus Frapezius p. descendenz Scapula trigonum spinae rapezius p. transversus TH 3 proc. spinosus Deltoideus p. scapularis infraspinatus Medial border of scapula Scapula angulus inferior Trapezius p. ascendenz Trapezius p. ascendenz Triceps brachii (c. long/lat.) TH 8 proc. spinosus Latissimus dorsi Epicondylus lateralis / medialis Olecranun L1/L5 proc. spinosus Erector spinae (lumbar region) Spina iliaca superior Smaller forearm extensors Processus styloideus ulna Multifiduus lumbar region Glutateus medius Processes styloideus radii Biceps femoris Semitendinosus/membranosus Epicondylus lateralis/medialis Gastrocnemius lat.

### **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.



electrode towards the end of the muscle body Middle

Connect this to the cable leading to an

electrode placed adjacent to the middle

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

Ref

End

placed on an separate section of the body, such as the bony portion of the elbow or a nonadjacent muscle

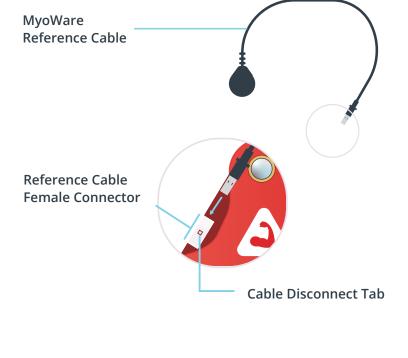
Connect this to the reference electrode.

The reference electrode should be

### **Connecting Optional Reference Cable**

Heel / calcaneum

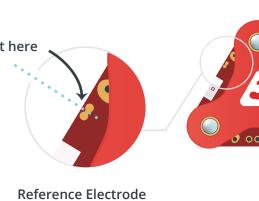
For certain applications where the reference electrode snap socket is poorly positioned, the v2.0 can still accept a MyoWare Reference Cable.



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.



Socket Disconnect Jumper

# **Overview**

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. **DISCLAIMER:** Data show is for illustration purposes only; not actual data

The MyoWare is designed to be used directly with a microcontroller.

**Raw EMG Output (RAW)** 

Vin

Vin/2

Vin

Vin/2

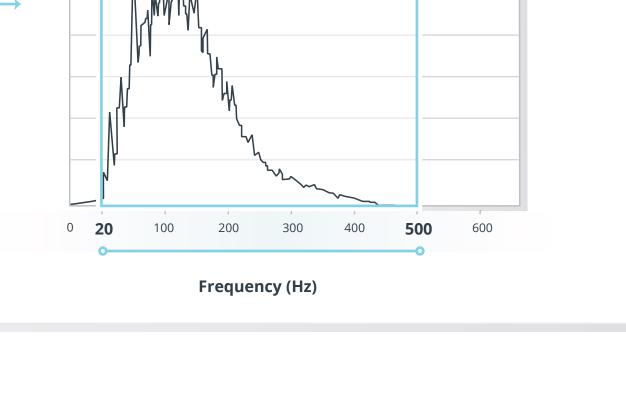
**Rectified Output (RECT)** 

**Envelope Output (ENV)** 

# Surface EMG signals typically have an amplitude of 0 - 10 mV

**Power Spectrum** 

(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.<sup>2</sup> **DISCLAIMER:** Data show is for illustration purposes only; not actual data



#### 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.

**Setting up Envelope (ENV) Output** 

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.

# **ENV GAIN**

### an amplified raw EMG signal. To output the raw EMG signal, simply connect the RAW pin

**QUICK TIP** 

**Setting up Raw (RAW) Output** 

to your measuring device instead of the ENV pin.

Like the previous version, MyoWare 2.0 has the ability to output

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.

# **RECT**

# rectified signal.

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

**Setting up Rectified (RECT) Output** 

device instead of the ENV pin.

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

# To output the rectified signal, simply connect the RECT pin to your measuring **QUICK TIP**

**RAW** 

### **Supply Voltage: Ideal Gain Equation:** Raw (RAW): G = 200

**Technical Specifications** 

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

References

Ratio (CMMR):

140 dB

potentiometer in kOhm Filters: High-pass Filter: Active 1st order,  $fc = 20.8 \text{ Hz},^2 - 20 \text{dB}$ 

Rectified (RECT): G= 200

Envelope (ENV): G = 200 \* R / 1 kOhm

R is the resistance of the gain

Low-pass Filter: Active 1st order,  $fc = 498.4 \text{ Hz},^2 - 20dB$ **Envelope Detection:** 

Linear, Passive 1st order,  $fc = 3.6 \text{ Hz},^3 - 20 \text{ dB}$ 

# **Rectification Method:**

specifications.

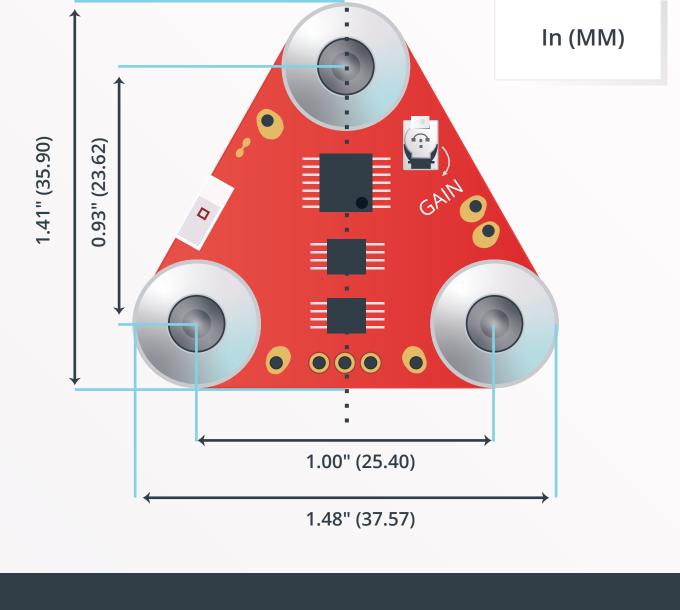
Not applicable - MyoWare Sensor is

analog. See measuring device

Full-wave

Sample Rate:

# **Dimensions**



[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.

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