# EMG Sensors

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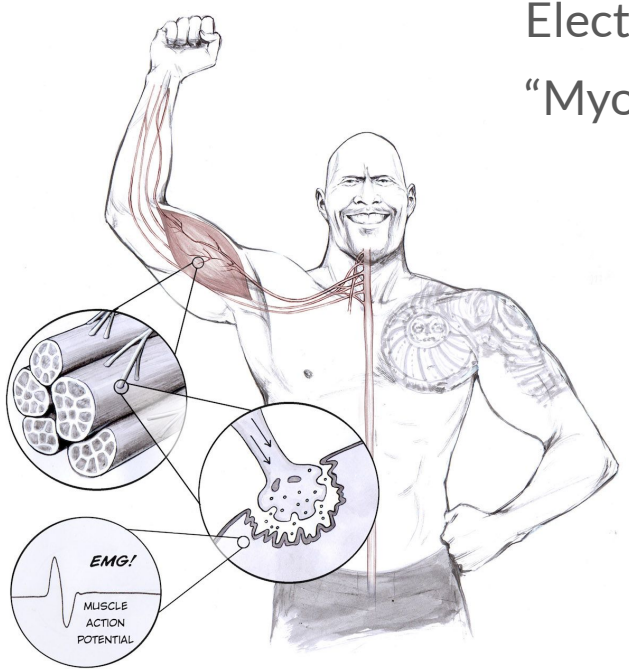
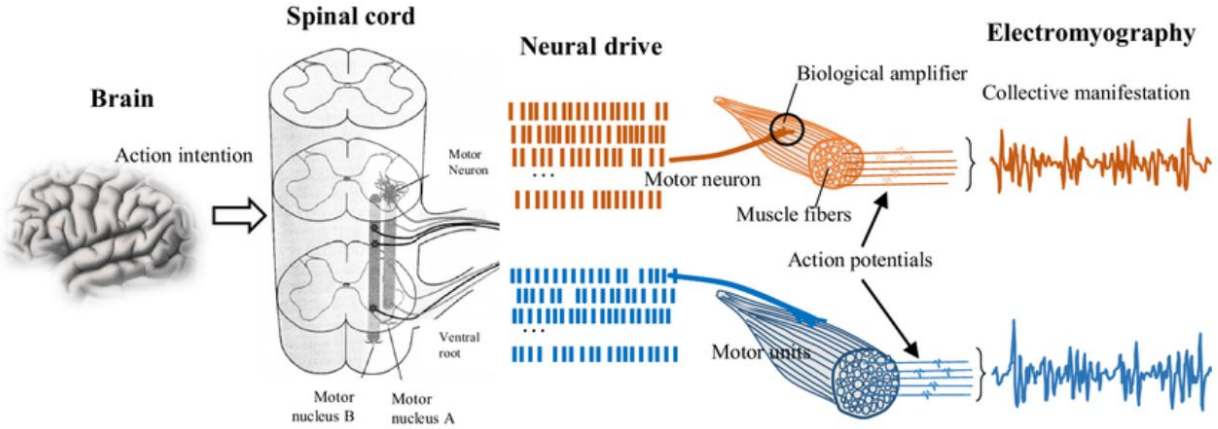
# EMG: Origin and Characteristics

# EMG Definition



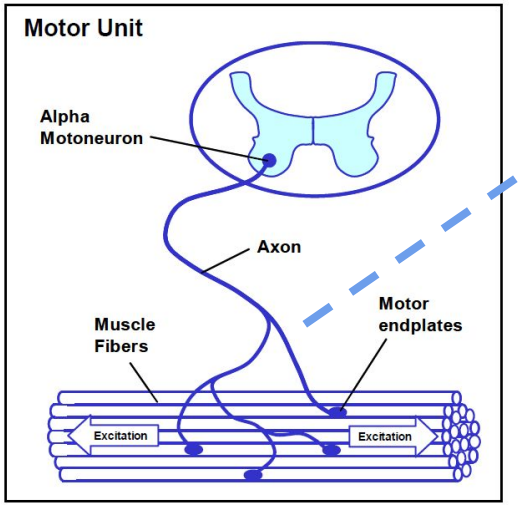

Electromyography (EMG): study of myoelectric signals.

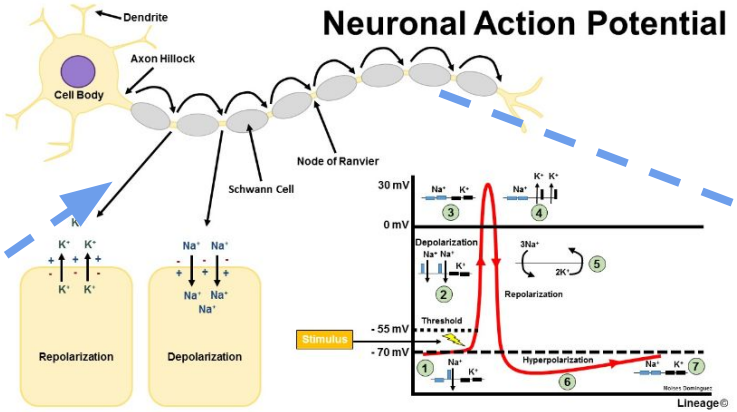
“Myo-”: Muscle

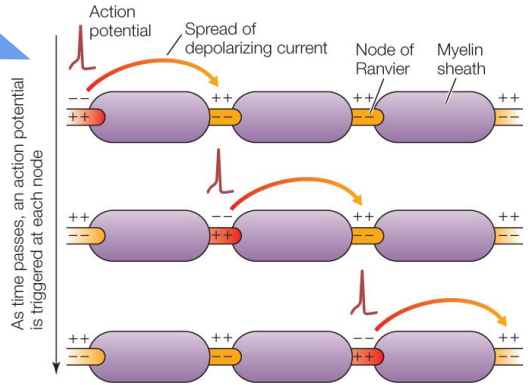


# Generation of EMG

When the **membrane potential** is **depolarized** beyond **threshold**, **action potential** is generated, and travels along the axon. Similar action potential also travels along the muscle fiber



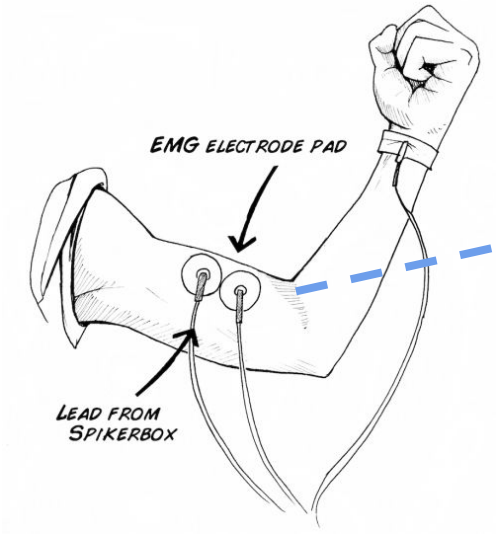



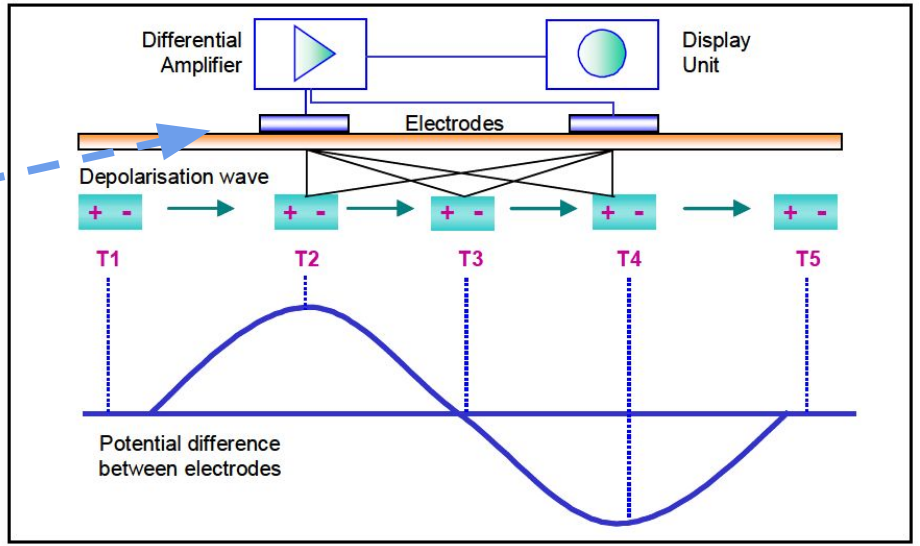



# Detect EMG with differential amplifier

Cannot probe individual neuron activity

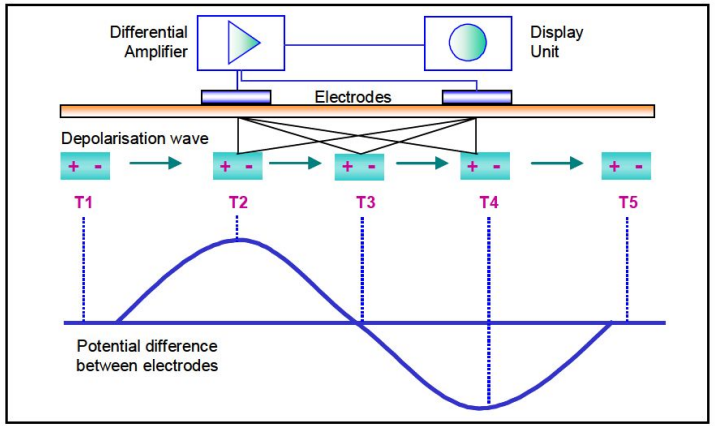
⇒ Surface EMG: stick electrodes to the skin, amplifies the difference

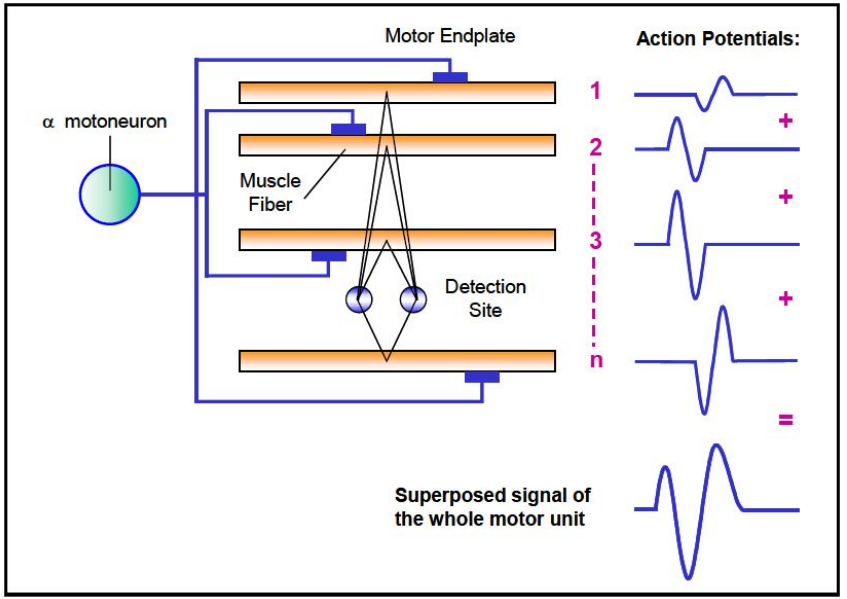


# Detect EMG with differential amplifier

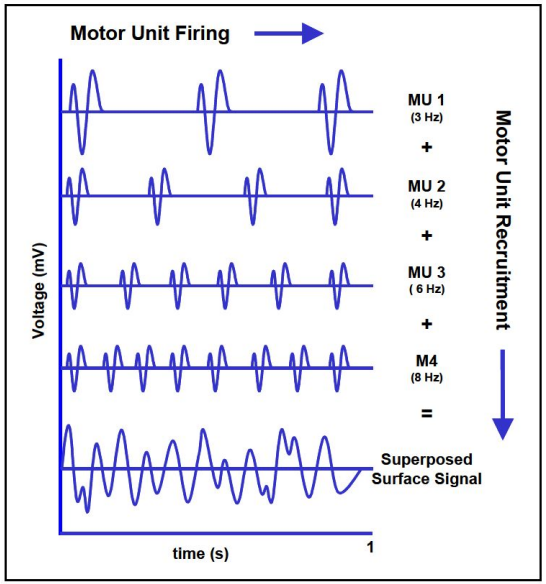
Unipolar action potential signal becomes bipolar signal after differential amplifier.
Signals  from multiple muscle fibres superpose together

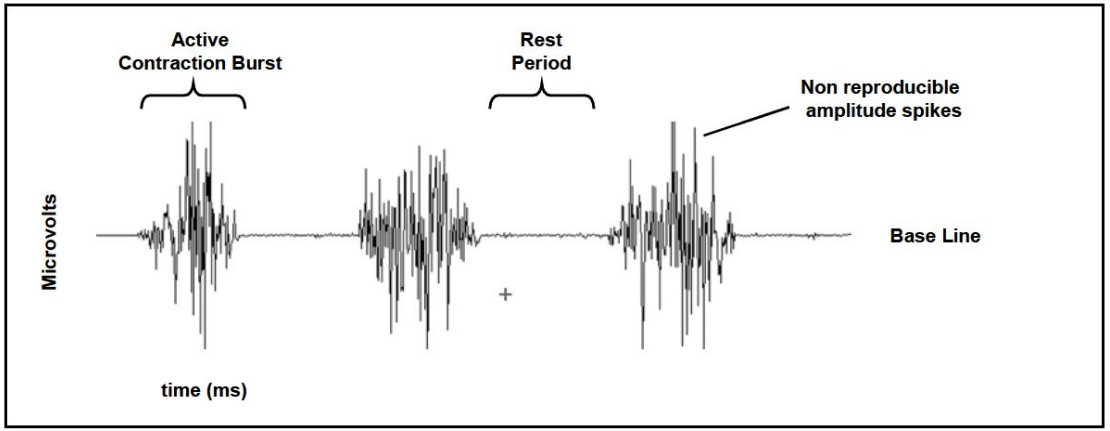


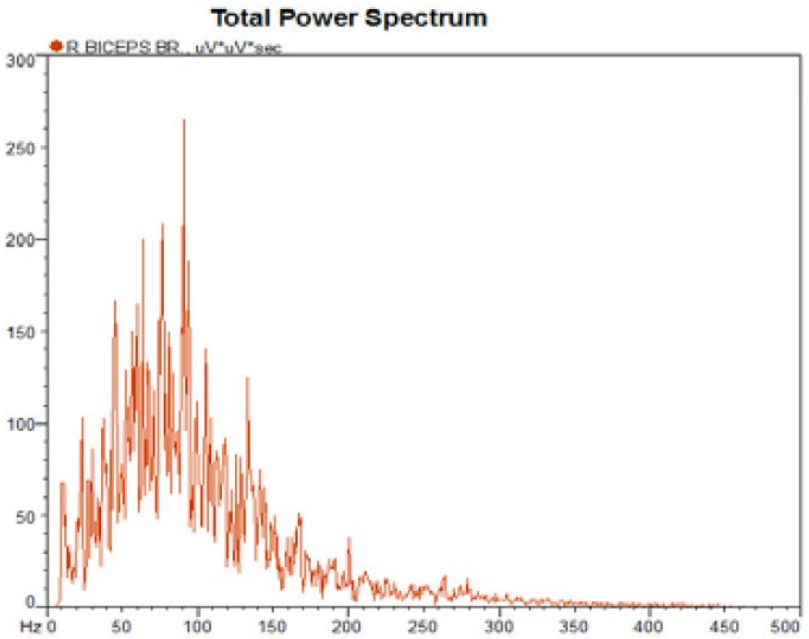
# Superposition and EMG Characteristics

Recorded EMG signals waveforms are **random** and **non-reproducible**,
But the difference between active and rest are significant.



# Magnitude and Spectrum of EMG




Raw surface EMG:

+/- 5000 μV (athletes)

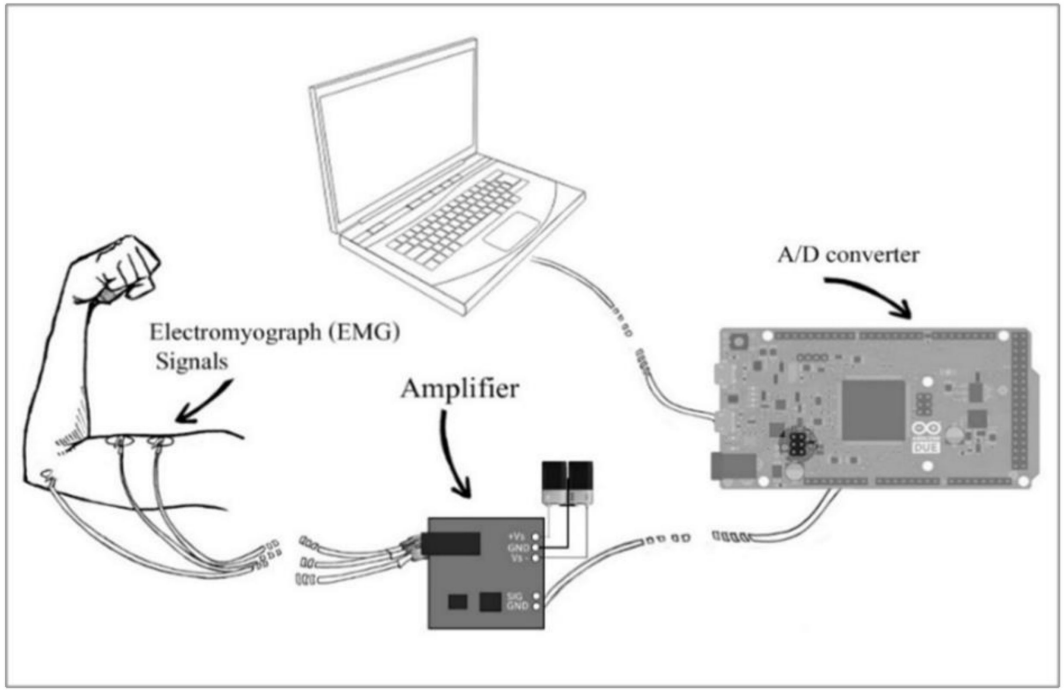
Frequency:

6~500Hz,

majority of power in:

20~150Hz

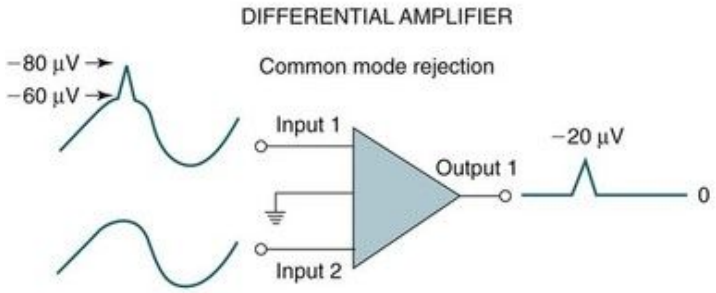
# Setup to work with EMG signals



# Inside EMG Sensor:
## Amplification and signal processing

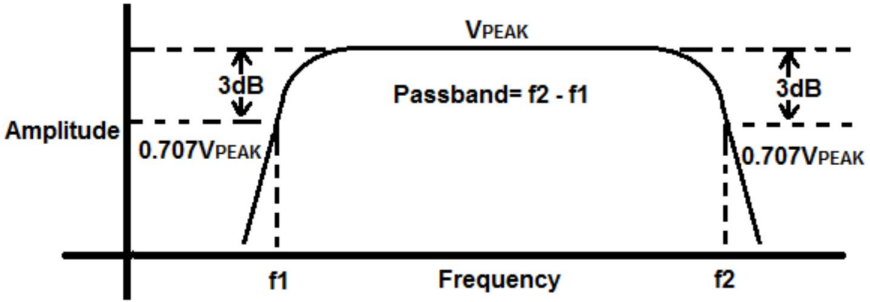
# EMG-Amplification

- Electrodes attached to EMG-amplifier
- Acts as differential amplifier
  - Detects differences between electrodes
- Cancel external noise at both electrodes
  - “Common mode” signals
  - E.g. 60Hz power noise
- Preamp near electrodes to buffer original signal



# Bandpass filter

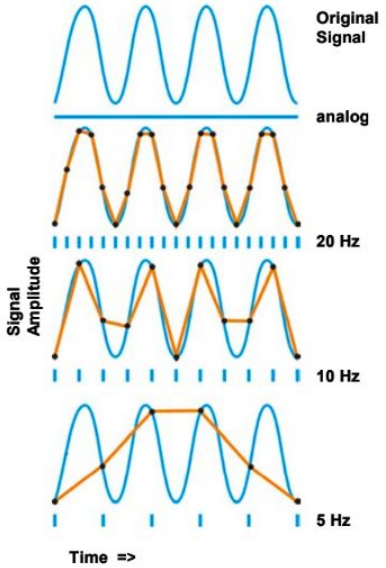
- EMG signal generally between 20 Hz and 250 Hz
- Frequency range should start from 10 Hz highpass to 500 Hz lowpass



# A/D Conversion

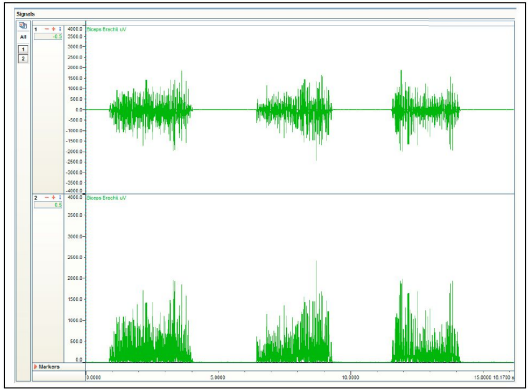
- Signal must be converted from analog to digital
- Sampling rate: 1000Hz
  - Nyquist Theorem
- Signal after filter: 10~500Hz

Sampling frequency

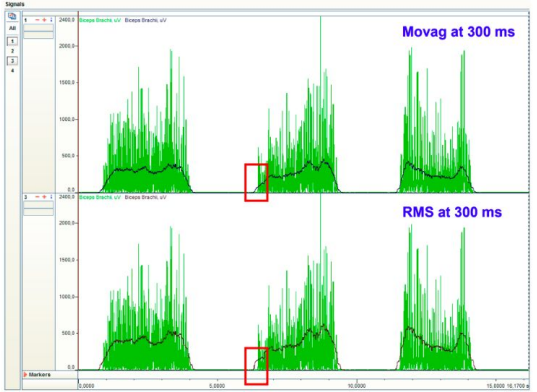


# Signal Processing

- Full wave rectification
  - Allows for average, max, and area measurements
- Smoothing
  - Moving average vs. Root Mean Square
- Digital filtering
  - Generally not needed with newer tech
- Amplitude Normalization
  - Use of MVC-normalization (Maximum Voluntary Contraction) is most common

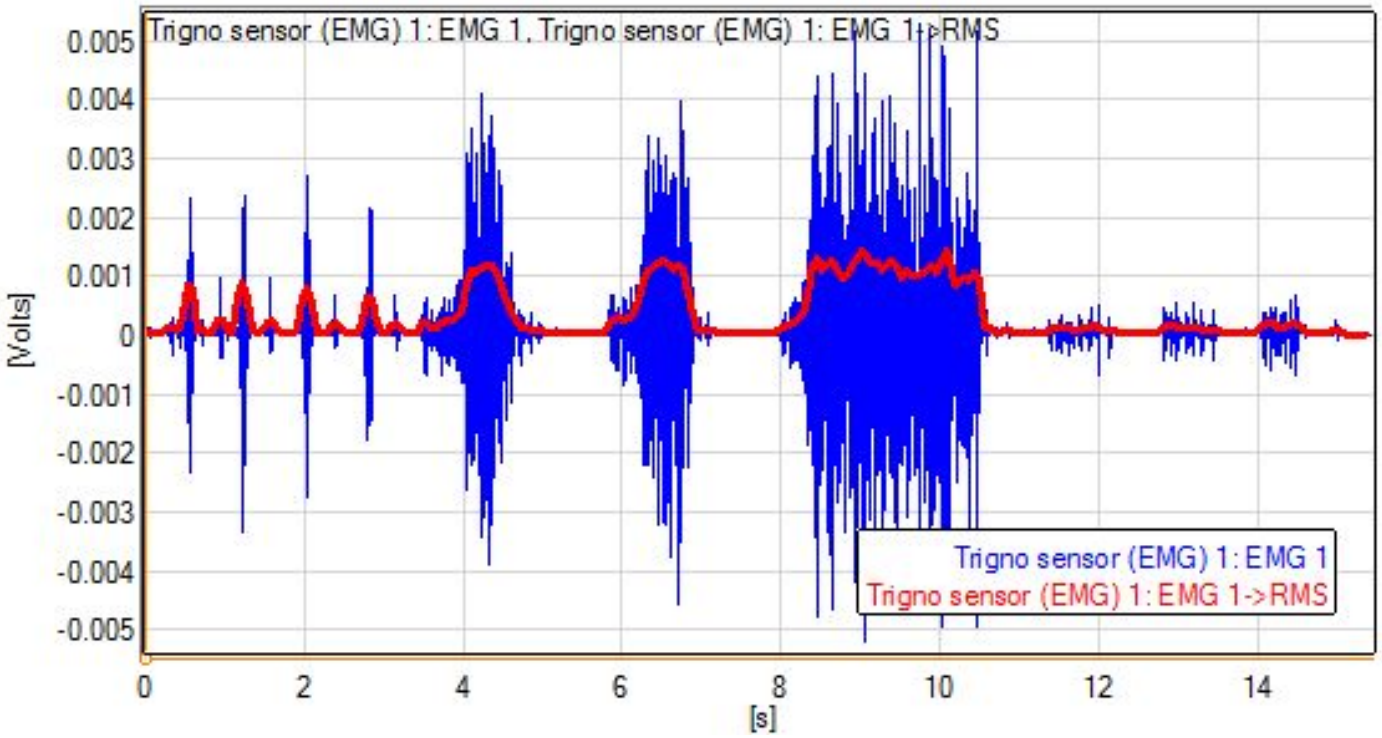


Rectification




Smoothing

# Signal Processing




Blue:

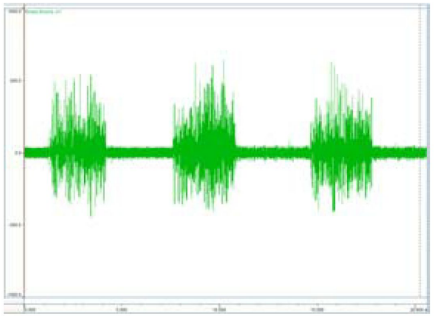
Raw EMG

Red:

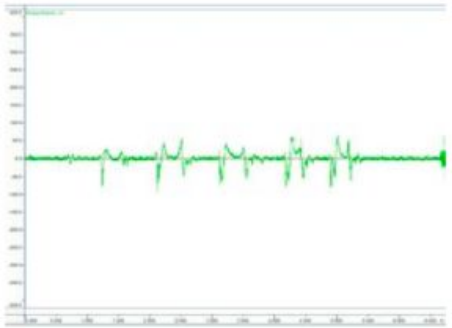
Processed Signal

# Signal Baseline Quality Inspection

- Power hum
  - Make sure ground is connected and clean
- Baseline offset
  - Offset correction/calibration required shortly before recording of data
- Baseline shift
  - Proper electrode/cable fixation
  - Good skin preparation



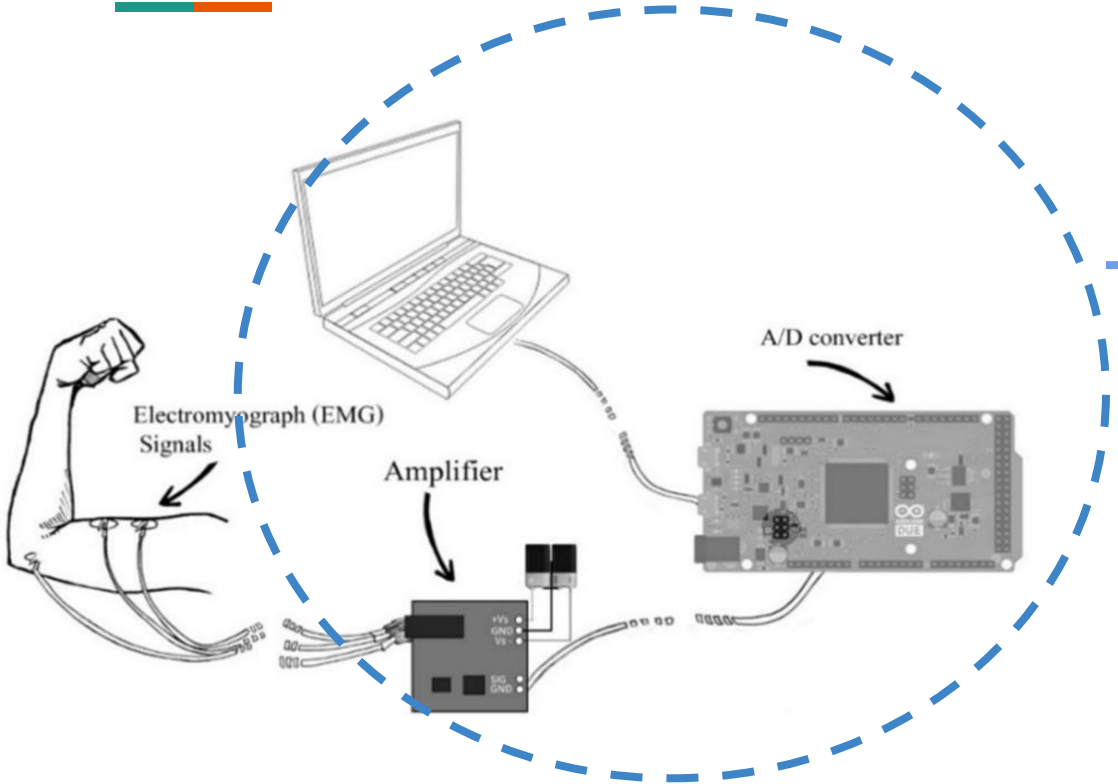
Power hum



Baseline shift

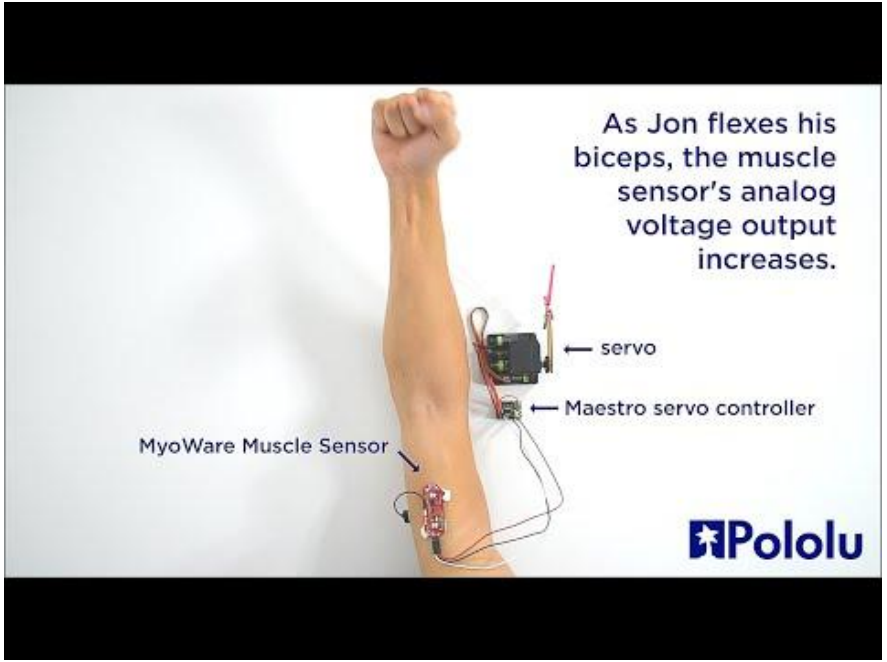
# Work with EMG Sensor: MyoWare

# MyoWare: Built-in signal processing




Signal processing done on sensor,
Analog output for activity level

# Demo Video

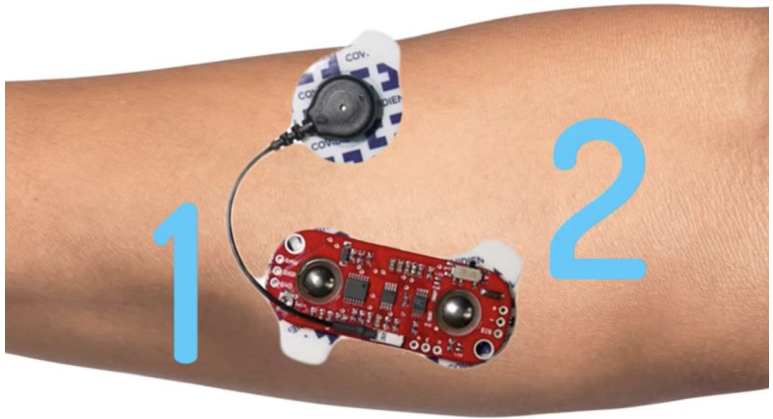

As Jon flexes his biceps, the muscle sensor's analog voltage output increases.
servo
Maestro servo controller
MyoWare Muscle Sensor
Pololu

# MyoWare EMG Sensor

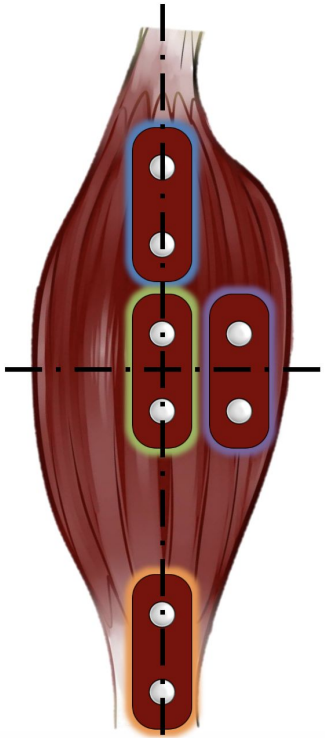

| Parameter | Min | TYP | Max |
|---|---|---|---|
| Supply Voltage | +2.9V | +3.3V or +5V | +5.7V |
| Adjustable Gain Potentiometer | 0.01 Ω | 50 kΩ | 100 kΩ |
| Output Signal Voltage<br>EMG Envelope<br>Raw EMG (centered about +Vs/2) | <br>0V<br>0V | <br>--<br>-- | <br>+Vs<br>+Vs |
| Input Impedance | -- | 110 GΩ | -- |
| Supply Current | -- | 9 mA | 14 mA |
| Common Mode Rejection Ratio (CMRR) | -- | 110 | -- |
| Input Bias | -- | 1 pA | -- |

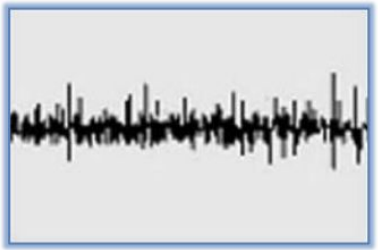
# MyoWare Electrodes

- Middle Electrode (1):
  - Placed in the belly of the muscle
- End Electrode (2):
  - Placed such that the length of the device is parallel to muscle fibers
- Reference Ground (wire):
  - Placed away from middle and end electrodes
  - Often placed on boney area near the muscle



# MyoWare Placement

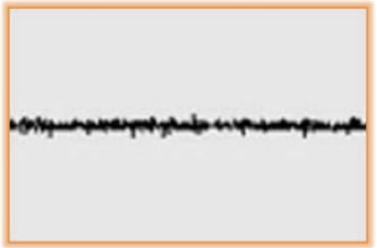




Innervation Zone

Correct Placement

Midline Offset



Myotendon Junction

# Myoware Output: Rectified EMG Envelope

- Signal Processing done on board
- Output is an ADC friendly signal

# Myoware Output: Raw EMG Waveform

- New Myoware offers Raw EMG output (already amplified) from the board
- Enable user to do different signal processing techniques

RAW EMG Signal

# Reference:

“The ABC of EMG: A Practical Introduction to Kinesiological Electromyography”
By Peter Konrad, Noraxon INC (2005).

“MyoWare™ Muscle Sensor (AT-04-001) DATASHEET”

# Thanks

# Q & A