EMG-Based Squat Form Indicator

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Motivation

Focus on proper form and full range of motion crucial for maximizing muscle growth and preventing injuries during strength training.

Study shows deeper squats lead to superior muscle growth compared to shallow squats.

High injury rates associated with squats highlight the importance of correct form.

Real-time feedback on muscle activity ensures consistent and safe squat technique.

Goal: Empower athletes to train smarter and effectively prioritize form and injury prevention.

Design Goals

Objective 1: Capture Electromyography (EMG) Signals during Squats

Objective 2: Refine Signal Quality by Eliminating Noise

Objective 3: Identify Initiation and Completion of Squat Repetitions

Objective 4: Provide Auditory Feedback for Incomplete Squat Repetitions

Assumptions

Threshold Crossing: Assumes a specific EMG threshold to determine if a squat has achieved a full repetition. This threshold may vary based on individual characteristics and exercise intensity.

EMG Sensor Placement: Assumes accurate placement of EMG electrodes on the target muscle(s) to capture reliable muscle activity signals during squats.

Repeatability: Assumes EMG threshold for a full squat doesn't change significantly with repeated reps.

EMG Signal Acquisition

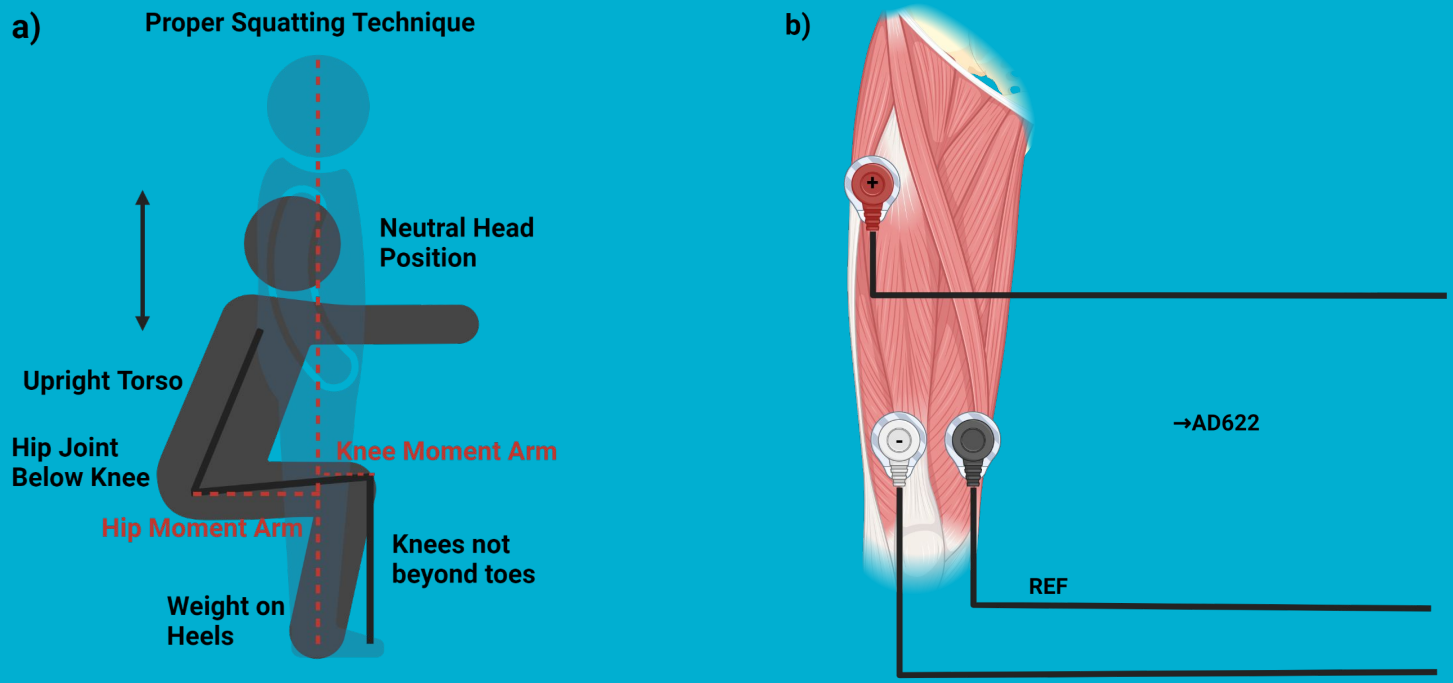
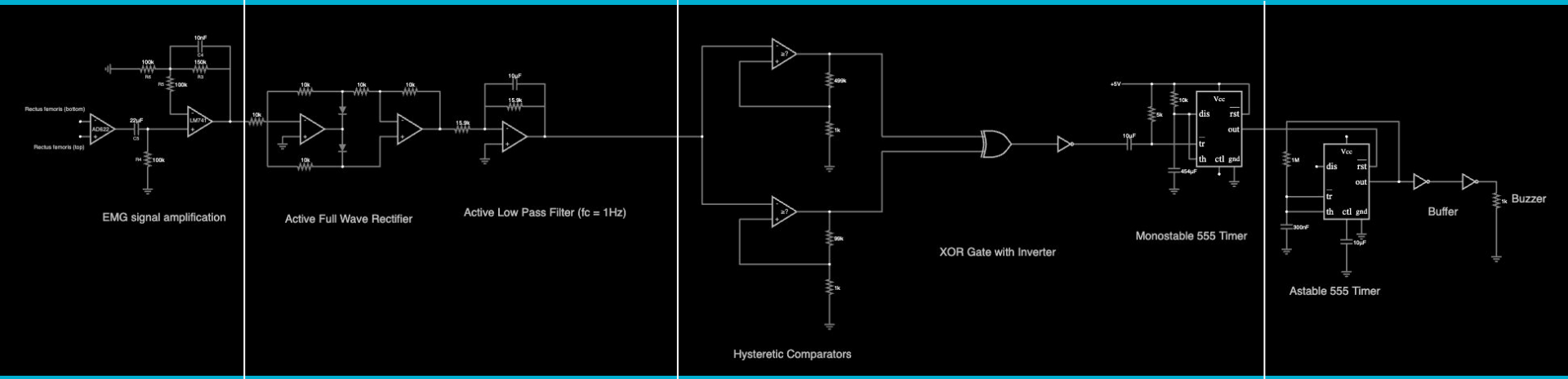


Figure 1: a) The proper squatting technique to be deemed a full repetition. b) The electrode locations on the rectus femoris muscle. Created with Biorender.com

Bioinstrument Design



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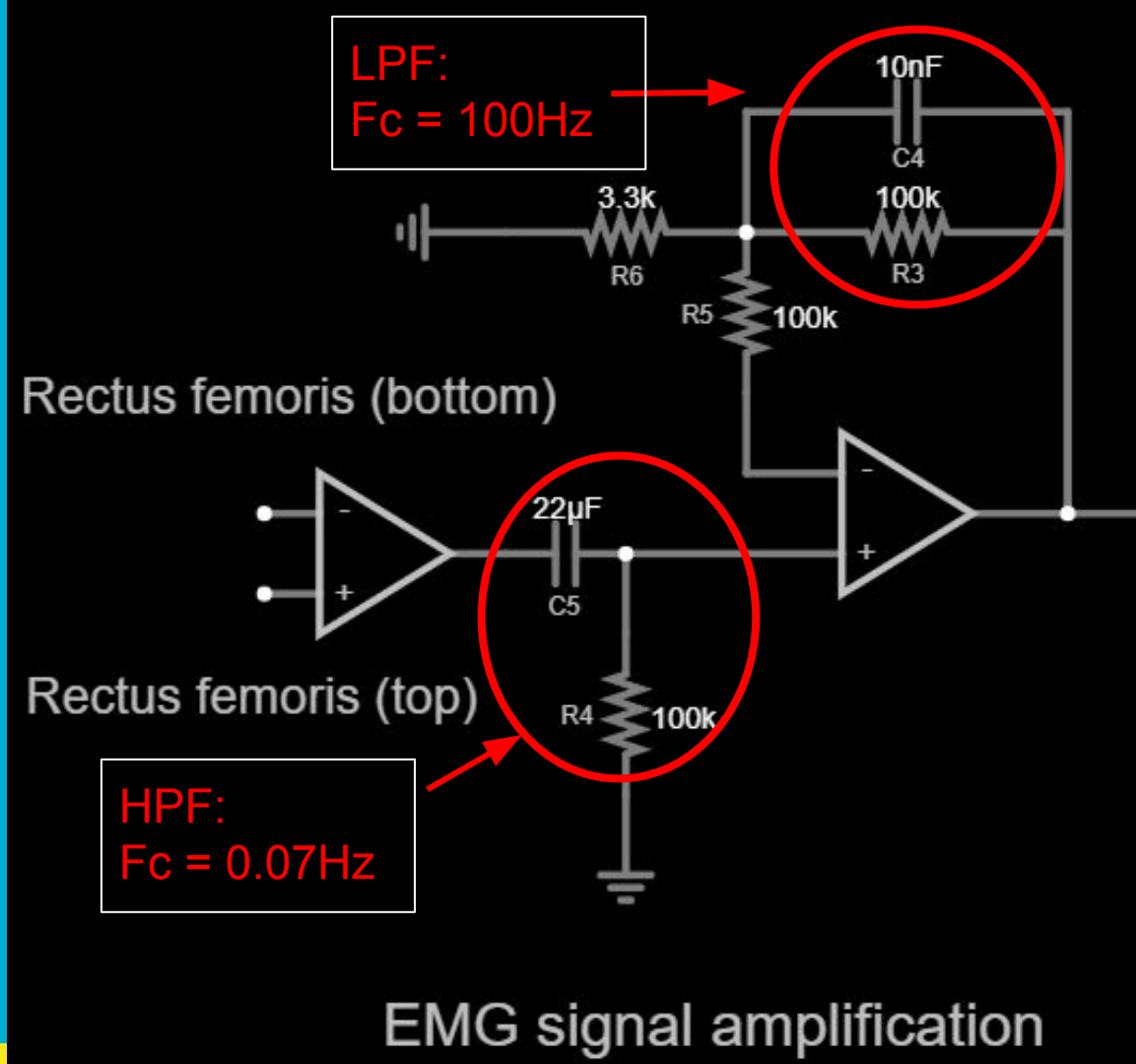
Signal Collection

Objective 1: Capture Electromyography (EMG) Signals during Squats

Electrodes attached to the top & bottom of the rectus femoris

Ref electrode placed at the vastus lateralis (inner thigh)

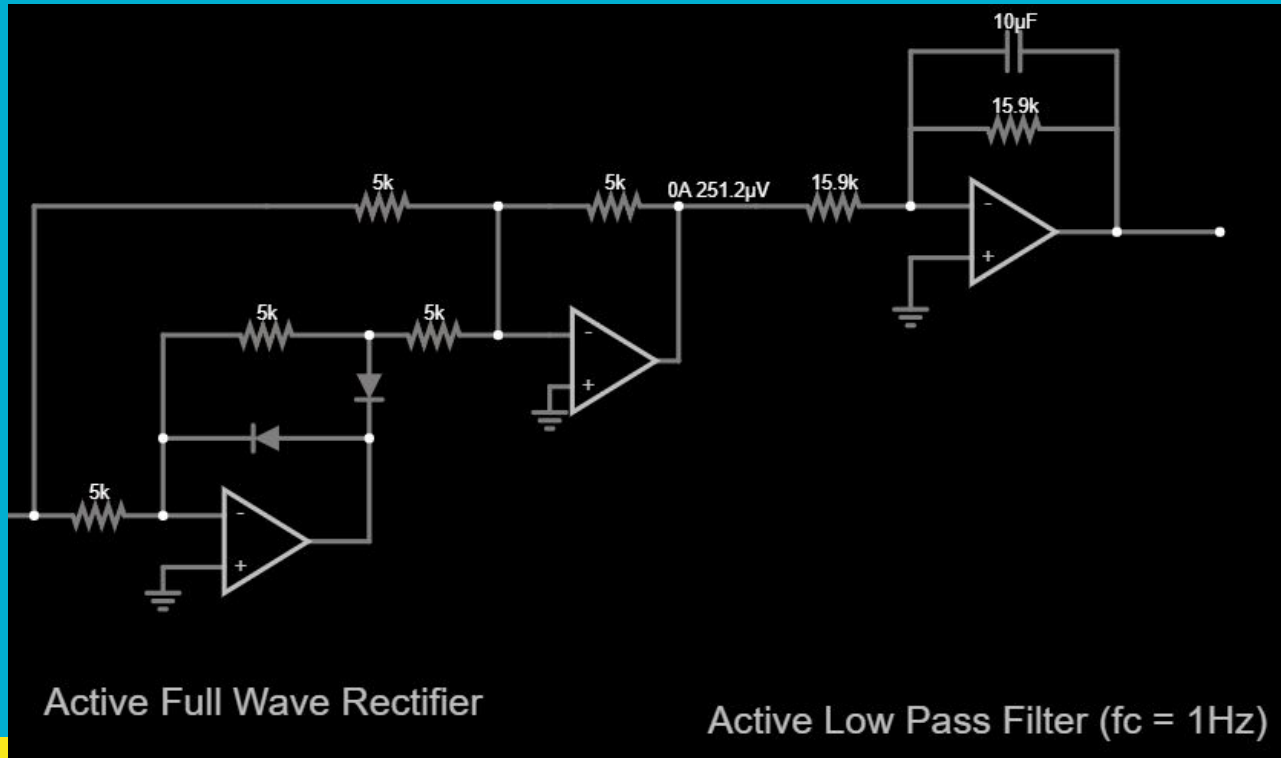


Rectifier + Low Pass Filter

Objective 2: Refine Signal Quality by Eliminating Noise

Implementation of an active-full wave rectifier converts all negative input signals positive, simplifying the visualization of muscle activity.

The signal is filtered once again for potential noise via LPF.



Hysteretic Comparators + Inverted XOR Gate

Objective 3: Compare EMG Signal to Threshold

Hysteretic comparators output signal if EMG signal is over thresholds for reps. Inverted XOR gate outputs signal if it receives high signals from both comparators. Monostable timer outputs signal if no there is no input for 2 seconds.

Input A	Input B	XOR Output	NOT Output
0	0	0	1
0	1	1	0
1	0	1	0
1	1	0	1

Rep Attempt Comparator:

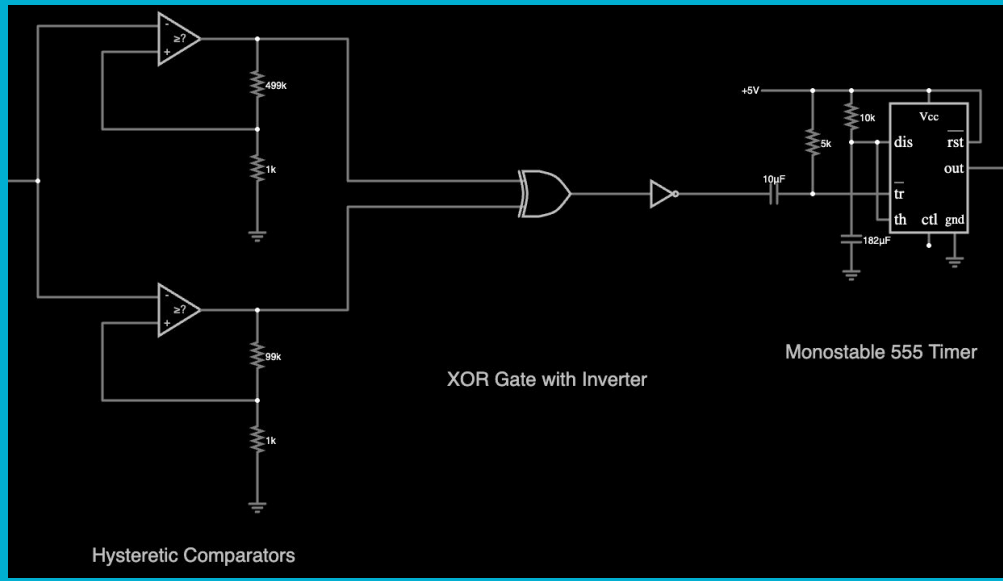
$$V_{hyst} = \frac{R_1}{R_1+R_2} * V_{cc}$$
$$\Rightarrow V_{hyst} = 10\ mV$$
$$\Rightarrow V_{cc} = 5\ V$$
$$\Rightarrow R_1 = 1\ \Omega$$
$$\Rightarrow R_2 = 499\ k\Omega$$

Full Rep Comparator:

$$V_{hyst} = \frac{R_1}{R_1+R_2} * V_{cc}$$
$$\Rightarrow V_{hyst} = 50\ mV$$
$$\Rightarrow V_{cc} = 5\ V$$
$$\Rightarrow R_1 = 1\ k\Omega$$
$$\Rightarrow R_2 = 99\ k\Omega$$

555 Timer:

$$T = 1.1RC$$
$$\Rightarrow T = 2\ sec$$
$$\Rightarrow R = 10\ k\Omega$$
$$\Rightarrow C = 182\ \mu F$$



Alarm Buzzer with 555 Timer + Buffer

Objective 4: Trigger Buzzer Sound for Incomplete Reps

555 timer sends signal to sound buzzer. Buffer isolates buzzer from the 555 timer. Buzzer sounds at frequency of 1000 Hz.

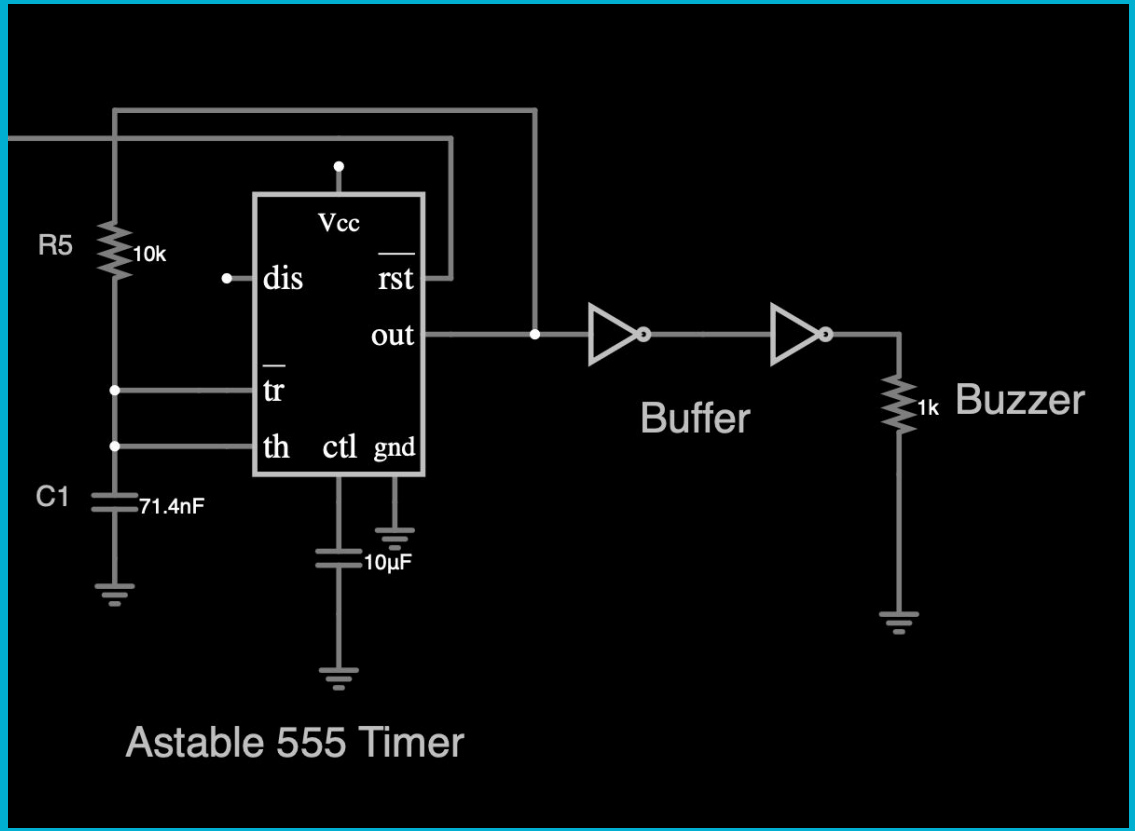
Buzzer:

$$f_{buzz} = \frac{1}{1.4RC}$$

$$\Rightarrow f_{buzz} = 1\ kHz$$

$$\Rightarrow R = 10\ k\Omega$$

$$\Rightarrow C = 71.4\ nF$$



Advantages and Limitations

Advantages

- Real-time feedback aids immediate form adjustment.
- Reduces injury risk by promoting consistent, safe technique.

Disadvantages:

- Accuracy may be affected by fatigue, electrode placement, and signal interference.
- Limited feedback for specific muscle groups.
- Focuses on muscle activation only and may overlook aspects of proper form and technique

Future Applications

Expanded Exercise Monitoring: Device adaptable for various exercises, enhancing workout feedback.

Physical Rehabilitation: Supports injury recovery and mobility improvement in rehab programs.

Personalized Training: Integrates data for tailored training programs, reducing injury risks.

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