Design and implementation of a bionic prosthetic hand

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Introduction
The idea behind this project is to further the development of affordable bionic prosthetic limbs. The bionic hand is controlled by user’s forearm muscles. Reading of the muscle contractions is done by electrode sensors on the skin and utilizing electromyography (EMG) technology. The design is comprised of 3-D printed parts and a pulley system using servos to actuate the fingers and wrist.

Engineering specifications
- Hand gestures: 1
- Freedom of movement (Finger Joints): 90 Degrees
- Signal Delay: 0.5 seconds
- Cost Range: $200-$300
- Weight: Under 2 lbs
- Grip strength: 1 lbs
- Battery Life: 3 Days
- 4 AA Batteries
- MCU: TI MSP Ultra-Low-Power

Block diagram
- Electodes
- Wireless transmitter
- Wireless receiver
- 1st stage amplification
- High pass filter
- Low pass filter
- MCU ADC
- Low pass filter
- 2nd stage amplification
- Motor shield
- Servo motor

EMG signal processing circuit
We've designed our own circuit for signal processing with an emphasis on noise treatment. It uses an instrumentation amplifier to get initial reading from the muscle. Then the signal is filtered by a second order bandpass filters with bandwidth of 50-700 Hz, which is the dominating range of frequencies in human muscles. In the final stage the signal is rectified and with the help of the peak detector it is integrated and can be processed.

Simulation
Simulation results for a 10mV input at 250 Hz frequency show the output voltage clipped at 3V as per the design specification.

Final prototype
The following is the current version of the project. The EMG sensor reads and amplifies the voltage from the muscle contraction. The MCU then determines whether the servo motors should move to an open or closed position depending on the threshold voltage (1V). There are 4 servo motors driving 5 fingers (One for thumb, index and middle fingers; one for ring and pinky).

Glossary
- EMG - electromyography; MCU - microcontroller unit; PCB - printed circuit board; mV - millivolt, a unit of measurement; Hz - hertz, unit of measurement.

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