Implantable Myoelectric Sensors for Intramuscular EMG Recording

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There are 18 extrinsic muscles in the forearm related to the control of the hand and wrist. Most of these are still present after a trans-radial amputation. The primary requirement of the IMES system is to be able to reliably obtain independent control signals from a relatively dense collection of small muscles. IMES have a sufficiently localized pickup field to be able to acquire EMG signal from the residual muscles of the forearm to provide estimates of the activation level for an internal model control approach. Also the IMES system is designed to be able to telemeter either raw EMG or integrated EMG out of the body depending on the control approach being used. Pattern recognition requires raw EMG while an internal model approach can use integrated EMG.

As opposed to multiple surface EMG sensors for control on the skin, the IMES system offers a potentially robust, repeatable, and reliable alternative to capturing EMG signals because the implants are permanently encapsulated in fibrous scar tissue within the muscle. This fibrous tissue does not impede signal transmission and prevents the implants from moving within the muscle. They operate in a constant environment with no skin impedance changes and no electrode liftoff issues.

Results suggest that for an implant placed along the fibers of the muscle, the pickup area for the sensor will be an ellipsoid about 5 mm in radius about the implant.

They are capable of measuring raw EMG at 8-bit resolution of up to 32 implants/sites at a sample rate of roughly 1000 samples/s/channel. Each implant is a bipolar differential instrumentation amplifier with an adjustable gain and adjustable high and low pass corner frequencies.

The IMES system consists of up to 32 IMESs, an external power coil and receiving antenna, and a telemetry controller. The telemetry controller passes data from the implants directly to the prostheseis controller or external recording device. The prostheses controller is where high-level decisions are made as to operation of the telemetry controller, where the reverse telemetery data are processed to determine user intent, and where the motor control signals originate to drive the appropriate components in the prosthesis. Implants are powered transcutaneously, via the external coil, with a 121 kHz magnetic field generated by an integrated high efficiency class E power oscillator. It's modulated to send control signals to the addressable implants. EMG signals generated by the residual muscles at each implant side are amplified and digitized by the implants. The telemetry controller within the prosthesis controls a time division multiplexing sequence to sent RF transmissions from each implant so that data from all implants may be sequentially collected by a receiver in the prosthesis. The telemetry controller demodulates the received signal and passes the multichannel EMG data to a prosthesis controller. The communications protocol and command set for this specific trial is defined around a system to support up to 32 active implants on each of two RF bands of operation 60kHz, and 6.8MHz.

Each implant is a single-chip integrated silicon device mounted on a ceramic substrate along with a surface-mount power supply filter capacitor. The electronics are encapsulated in a ceramic package that includes metal endcaps at either end between which serve as the differential recording electrodes.

The goal of the in vivo testing was to use the cross-extension reflex of a decerebrated cat preparation to elicit a natural EMG signal and to see how well the IMES system measured this signal. Cats were chosen because the calf muscles of the cat are similar in size and orientation to the small muscles of the human forearm. Three implants were implanted into the ankle extensor muscles of the cat, and bipolar fine wire electrodes were implanted into each of the muscles. The IMES system produced a response similar to that of an EMG system that is currently in clinical use, suggesting it is able to measure EMG accurately.

Currently they are monitoring the animals for signs of implant migration to provide data for the analysis of data over time. In conclusion, the IMES system is capable of measuring focal intramuscular EMG comparable in both the time and frequency domain to commercially available clinical EMG systems. As more powered components enter the field, the IMES systems will not be limited to upper limb prosthetics.

REFERENCES:

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