Implantable Myoelectric Sensors (IMESs) for Intramuscular Myogram Recordings and Prosthetic Function

Kyle Waterman
Biomedical Engineering
University of Rhode Island

In today's world of medical science and standards, individuals with recently amputated hands expect to receive a prosthetic hand that functions like a normal hand. Most of these prosthetics only offer a single degree of freedom, which translates to the simple opening and closing of the hand. To reach a design that is more closely functional to that of a physiologically sound hand the prosthetic must be able to operate in multiple degrees of freedom. Currently, devices that offer this are slow operating because they require a series of signal processes and mechanical functions for locking and switching into each type of movement. The major restricting factor is the efficiency in the control sources that dictate the physiological movements.

A possible solution to this is the implantable myoelectric sensor system. The system uses a transcutaneous magnetic link that is capable of recording myoelectric signal generated by the excitement of muscles in the amputated arm. The system can manage up to 32 implantable sensors, each implanted into a separate muscle. This creates various control sources responsible for generating an electromyogram (EMG) signal that is unique for each muscle. These signals are detected and amplified using several electrode and amplifier systems. The resulting signal is then sent through the telemetry coil, that encircles the implants exteriorly around the limb, to the telemetry controller. The telemetry controller takes data from the implants and passes it to the prosthetic controller or if the USB interface is used the data is passed to an external recording device. The prosthetic controller is responsible for high-level processing and decision- making. The prosthetic controller operates the telemetry controller, determines the user intent of the data received by the telemetry controller, and determines the locations of the motor controls signals in order to evaluate the type of motion requested and control the components necessary to drive the prosthesis for this particular motion.

The implants themselves are powered transcutaneously by the external coil, through a 121-kHz magnetic field, which is driven by a integrated high efficiency power oscillator. The implants are a single-chip integrated silicon device mounted on a ceramic substrate combined with a power supply filter capacitor. This is placed in between two parts of a cylindrical magnetic core. A 121-kHz power coil and the radiofrequency coil are wound over the core. Then the electronics are put into the ceramic package with metal cap on either end to serve as the recording electrodes. A tissue protection circuit is placed within the metal caps to prevent current from damaging the surrounding tissue. Next amplifier gain stages are used to amplify the signals and are converted using an analogue to digital converter making them ready to be sent and received by the telemetry controller. Lastly, a programmable 8-bit address is used to decipher between implants while in operation such that specific commands from certain implants will determine the movement of the prosthetic.

The system is capable of measuring intramuscular EMGs in both the time and frequency domain. Testing has shown that the system is fully capable of generating EMGs in cats even 9 months after implementation. Future research includes the testing of the IMES system with multifunction prosthetics.

References:

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