Wireless Transmission System for Brain Controlled Lower Limb Prosthesis

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Overview

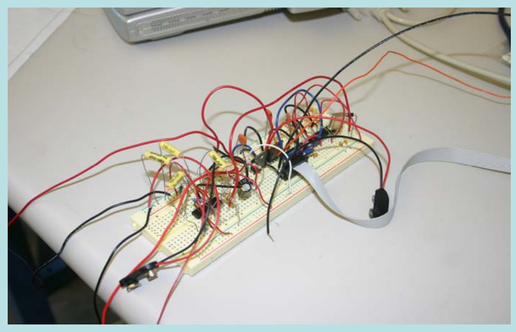
Functional electrical stimulation (FES) is a technique for restoring muscle control to people affected by spinal cord injuries. Promising research is going into pairing FES with a brain-machine interface. This would allow patients to mentally control the contraction of their muscles. Such a system would require gathering data from neurons in the brain and relaying it to a computer which would process it and control the electrical stimulation. A wireless network is the best way to do this because it reduces the inconvenience of the system.

This system serves as a prototype of the communications system. It transmits 100 channels for a total of 24Mbps. Most channels represent neurons simulated by Duke University's NEURON software, and one channel carries a digitized electrocardiogram signal to demonstrate real-time capabilities. These data channels are multiplexed and transmitted over an 802.11g wireless link by a low-power single-board computer running the Linux OS.

Hardware Components

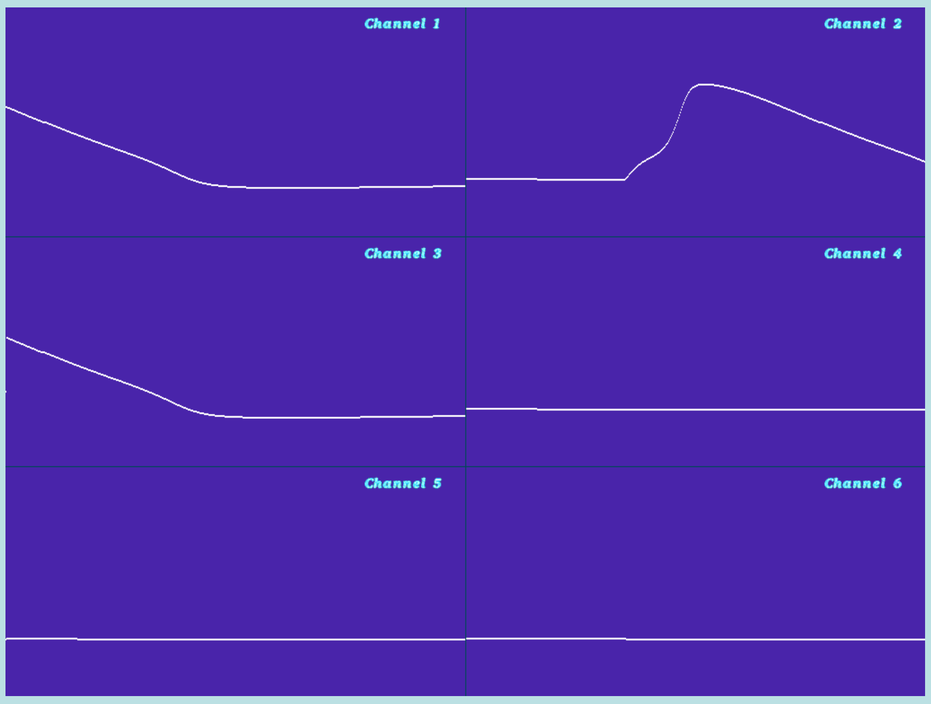
- **Soekris net4801 single-board computer**
  Processes, generates, and aggregates data before sending it over a wireless link. Uses Atheros 802.11g wireless hardware. Very low power.

- **ECG amplifier**
  Amplifies ECG signal by 1500 before digitization.
- **PIC microcontroller**
  Samples ECG signal and sends samples to Soekris board over RS232



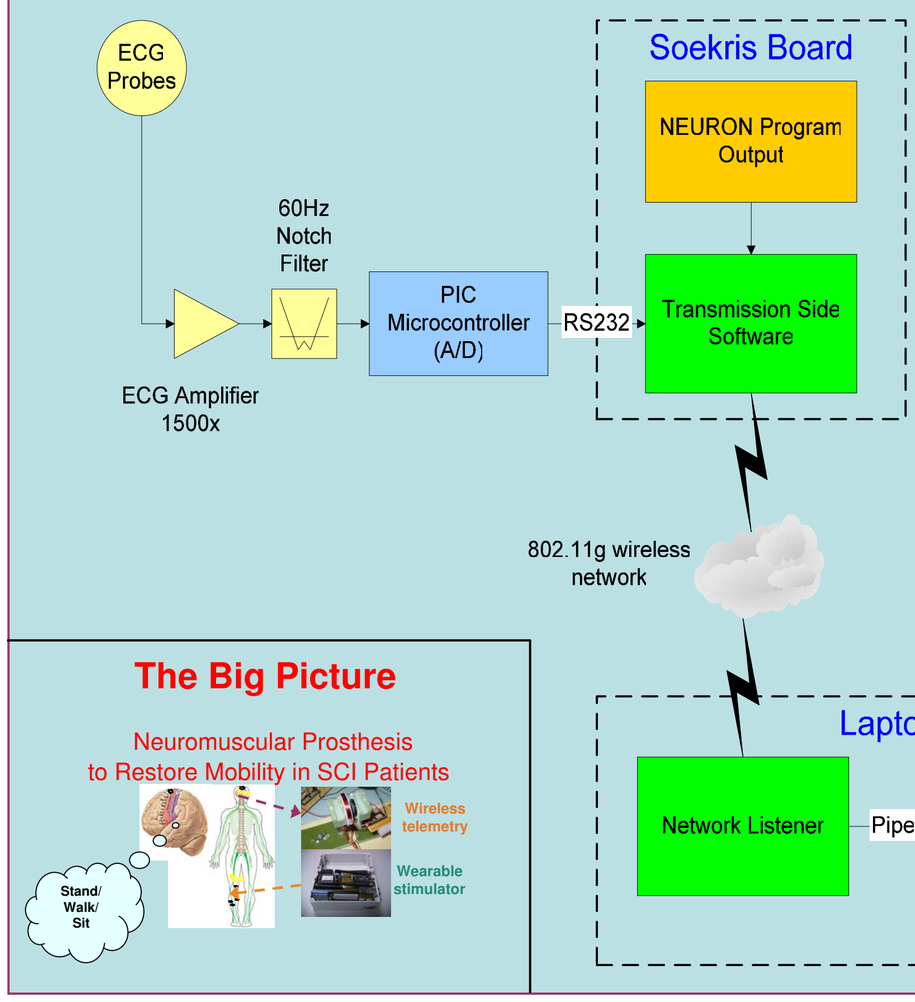
Software Components

- **Transmission Side Software**
  Runs on Soekris board. Aggregates data and transmits it over the wireless network.
- **Data Plotting Software**
  Runs on a laptop and receives data. Allows the user to select which of the 100 channels are visible.



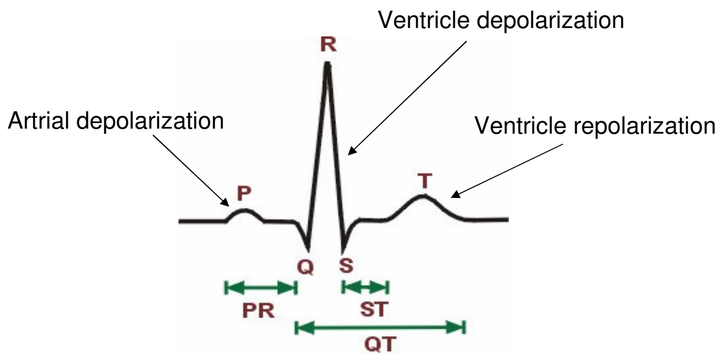
- **NEURON**
  Duke University's NEURON program was scripted to provide example neuron data streams.
- **PIC firmware**
  Simple assembly code on the microcontroller samples the ECG signal using the internal A/D converter and transmits the samples with the internal UART.

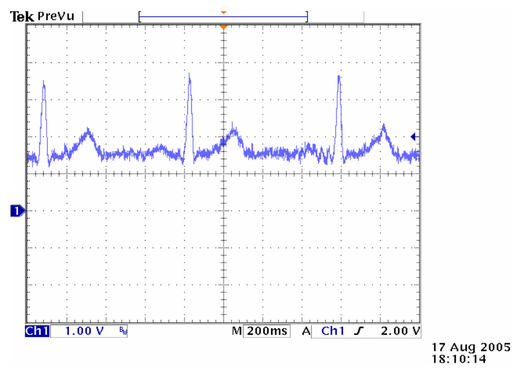
System Architecture



The Big Picture

Neuromuscular Prosthesis to Restore Mobility in SCI Patients





Electrocardiogram waveform

Results / Future Work

I found that the setup was capable of achieving the desired data rate, even with the very limited processor speed on the Soekris board. In order to be suitable for actual electrical stimulation applications, this communications system will need to accommodate input from 100 analog channels. A data acquisition system may be connected to the PCI bus of the Soekris board, or another embedded system with more expansion capabilities may replace it.

Thanks

Linh Hoang assisted me with programming NEURON, making design decisions, and fixing problems. This project was supported by the University of California Santa Cruz Summer Undergraduate Research Fellowship in Information Technology (SURF-IT).

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