PROJECT DESCRIPTION

Title: *Wireless Neural Recording System and Software at Low Cost*

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Funding Source: NIH *Work Began: 09/01/2007*

Project Goals:

We are developing a stand-alone, wireless microsystem for recording and transmission of multichannel neural signals from unrestrained subjects. These wireless microsystems have a wide range of biomedical applications, and should be small, lightweight, and portable. Wired neural recording requires observation in restrained environments, which may limit the test subject's natural activities and social interactions. Wireless recording systems have found limited application however, in part because of the high cost and limited functionality. A successful system will have good range, small size compared to the test subject, moderate channel count and robust transmitter, and receiver hardware and software. Initially, the project's goal is to build and implement very small wireless units designed and built using off-the-shelf components. In the longer term (2–3 years), these systems will be designed using custom IC technologies to reduce size, weight, and power even further.

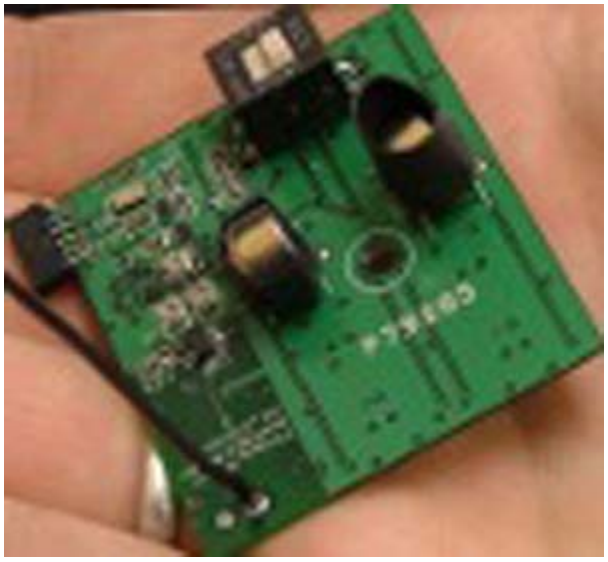

Figure 1: FM transmitter, version 2.

Approach and Methodology:

This project seeks to make optimum use of commercial components to reduce system cost and provide rapid progress. First, a basic transmitter prototype was developed to allow experimenting with different front ends. The initial architecture is a 15-channel analog front end and analog multiplexer feeding a VCO to allow time-domain, multiplexed frequency-modulated transmission of the neural signals to a base-station. A microcontroller is used to control channel selection and provide flexibility in channel count and sampling rate. A second, low-data-rate, low-power digital channel will be used for bidirectional communication and enable online programming and an interface for simultaneous stimulation and recording. For the base station, flexibility is important so that its capabilities can track the progress of the transmitter, while still providing a robust and user friendly interface to ease of collaboration. We are using a modular readout system consisting of a software-defined radio [2] and a powerful custom data acquisition GUI based on the open source GnuRadio [3] package.

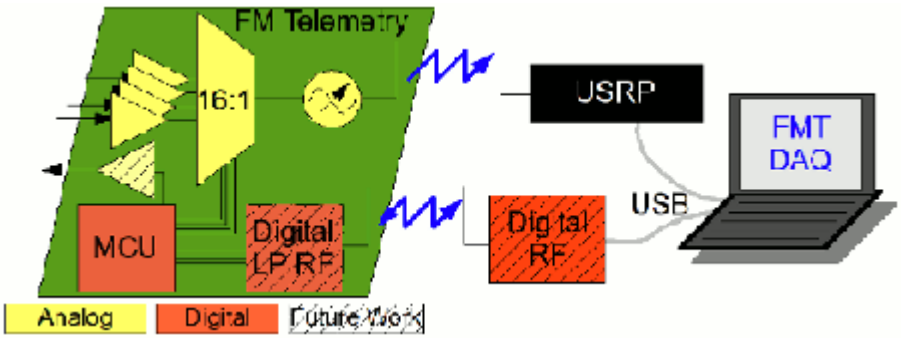

Figure 2: Block-level diagram of FM Telemetry device and data acquisition system.

Role in Supporting the Strategic Plan and Testbeds:

Techniques developed in this project can be directly applied to the neural interface projects, especially any advances in the transmitter and computer-based receiver. In addition, the front end may be replaced to adopt the system for a wide range of applications requiring continuous or intermittent wireless telemetry.

Results and Accomplishments:

We have successfully recorded data with 15 active channels from both Marmoset monkeys and Long Evan's rats. Figure 3 shows five of the 15 channels from a Marmoset monkey recorded with tungsten wire electrodes; the inset is a magnified spike from channel 7. Performance *in vivo* of the two prototype versions is summarized in Table 1. The signal-to-noise ratio of the transmitter is dominated by the neural probes and the front-end design, which will be improved in future versions. The radio does not currently add significant noise, even at a range of 3m.

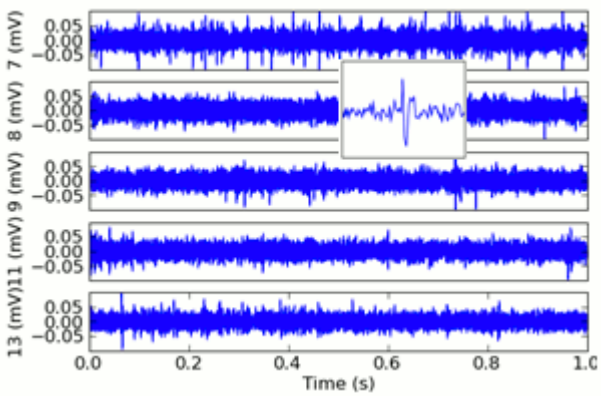

Figure 3: Data recorded wireless from Marmoset monkey using FMTv2.

Relevance to Other Work:

The software and radio used for the base station are suitable for use by other neural recording projects at U-M and other locations. Experience gained from the FMT prototypes is being used to guide the development of more highly integrated projects.

	Number of Chan.	Range (4" ant)	Tx Power	Power	Battery Lifetime	Amp Gain	Sample Rate
FMT Versions	15 Size (cm)	>3m Weight	<20µW DC Block	10mW Channel Bandpass	>24Hrs Battery	51x Center Freq	22kS/s Noise Floor
FMTv1	2.9x3.1	10.4g	No	100-6kHz	1x3V	423MHz	20µVRMS
FMTv2	3.6x4.0	6.3g	Yes	100-7kHz	2x1.4V	396MHz3	25µVRMS

Table 1: FM Telemetry (FMT) prototypes.

Plans for the Coming Year:

Digital versus analog communication will be re-evaluated for this application at a theoretical level and work will be done on a digital front end and transmitter chip to complement the analog approach of other projects. In order to further increase the options for scientific experiments using the FMT, auxiliary inputs and features are under development.

Expected Milestones and Dates:

- Develop analog signal path test boards *(Completed)*
- 16 channel *in vivo* testing with restrained animals *(Completed)*
- Integrated front end (11/30/2009)
- *In vivo* testing and characterization (01/30/2010)

Expected Contributions, Deliverables, and Company Benefits:

- Modular and robust wireless recording system suitable for general use
- Low-power, low-noise, small-area, telemetry devices

References and Recent Publications:

1. P. Mohseni, K. Najafi, S. J. Eliades, and X. Wang, "Wireless Multichannel Biopotential Recording Using an Integrated FM Telemetry Circuit," *IEEE Trans. on Neural Systems and Rehabilitation Engineering*, (see also *IEEE Trans. on Rehabilitation Engineering)*, vol. 13, issue 3, pp. 263–271, September 2005.
2. GnuRadio Community, "USRP FAQ," February 2009; http://www.gnuradio.org/trac/wiki/UsrpFAQ.
3. GnuRadio Community, "GnuRadio – Trac," February 2009; http://www.gnuradio.org/trac.
4. J. Gregory, A. Borna, S. Roy, X. Wang, B. Lewandowski, M. Schmidt, and K. Najafi, "Low-Cost Wireless Neural Recording System and Software," *Proc. of IEEE EMBS*, September 2009.