**WNR (Wireless Neural Recorder)**

Rice University

Weekly Progress Report 5

10/2/2015 - 10/8/2015

**Agenda for meetings**

Meeting I:

1. Analog front-end requirements and solutions with discrete components
2. Wireless transmission: delayed transmission scheme

Meeting II:

1. Power Consumption

Mentor Meeting:

1. Report in results from power consumption study
2. Discuss progress with CC2650 BLE development

**Activities this week**

1. Looked into power consumption of the entire device (analog front-end, BLE, batteries, compression)
2. Begun development of transmission scheme on CC2650

**Problems encountered**

1. BLE platform provided by TI is not trivial, so we will push the first prototype deadline to end of fall break (10/15/2015)

**Time devoted to project this week**

|  |  |  |
| --- | --- | --- |
| **Name** | **Tasks Accomplished** | **Hours Spent** |
| Stephen Xia | * Research power consumption of CC2650 and BLE transmission scheme * Begin transmission development | 14 |
| Tingkai Liu | * Research power constraints of Intan Chip * Begin development on CC2650 | 13 |
| Xin Huang | * Looked into battery technologies and alternative sources of power * Begin development on CC2650 | 6 |
| Yuan Gao | * CC2650 development environment setup * Research compression algorithms and their effects on power consumption * Begin server side development | 11 |
|  | **Team Total** | 44 |

**Meetings Minutes**

Meeting I – 10/2/2015, 1:30 - 2:30 PM

Attendees: Stephen Xia, Tingkai Liu, Gary Woods

Completed objectives:

1. Analog front-end
   1. Op-amp connected with 16 fan-out, one for each channel.
   2. Can attach another op-amp after the first one in which we can create a system with the desired transfer function and do ac coupling.
   3. Can model a neural signal as a voltage source in series with a resistance.
      1. Must find out the typical resistance.
      2. Must find out what the typical action potential is. We think it can go up to 500 microvolts, but is generally in the 10s of microvolt range.
   4. Discussed Intan chip: It pretty much has everything we need
   5. For next time:
      1. Look at how to build the circuit using discrete components
      2. Look into Intan chip, and set up a meeting with people from the company to discuss more about the product
      3. Look into obtaining Intan chip and development board
2. Transmission Scheme
   1. Data is saved onto flash memory instead of being transmitted
      1. Already done by Deuteron
   2. Data is transmitted continuously, but over bursts of maybe 10 seconds
      1. Find out if Dr. Tandon is fine with this
      2. Could save a lot of battery power

Meeting II – 10/5/2015, 4:00 PM - 5:00 PM

Attendees: Stephen Xia, Tingkai Liu, Xin Huang, Yuan Gao, Gary Woods

Completed objectives:

1. Power Consumption
   1. Intan RHD series: 3.5 mW
      1. 1.2mA at 3V
      2. To run for 24 hours requires 50 mAh
   2. CC2650: Not known at this moment
   3. Batteries:
      1. Alkaline is better than Lithium in terms of power density
      2. Nickel Metal Hydride is rechargeable
      3. Lithium rechargeable energy density = 4.32 MJ/L
         1. 0.28 Wh/cc = 1 MJ/L
         2. 400 mAh/cc is the best we can do assuming we use 1 cc
            1. May be doable since front end uses 50 mAh
         3. If battery is out of question look into other sources of power like wireless charging.
2. Considerations for next time
   1. Look deeper into available batteries
   2. Look into power consumption of wireless/BLE transmission
   3. Look into compression and see what kind of power consumption effect it has
   4. Look into alternative energy sources

Mentor Meeting – 10/8/2015, 12:30PM - 1:30 PM

Attendees: Stephen Xia, Tingkai Liu, Xin Huang, Yuan Gao, Hamed Rahmani, Aydin Babakhani, Gary Woods

Completed objectives:

1. Intan Chip:
   1. 2.2 kSamples/second for 35 channels
      1. 1.3mA \* 3.3 V turned on
      2. ADC: 510 uA + 150 uA to power ADC
   2. Based on power specs, it looks very promising, since it draws less than 10 mA. Should look to buy some, especially the 64-channel chips
2. Wireless/BLE
   1. Broadcom: A4WP wireless charging, which only works over a few cm and depends on geometry and angle
   2. Intan Chip:
      1. Transmit at 5 dBm: 9.1 mA
         1. To transmit for 24 hours requires 9.1 \* 24 = 220 mAh
      2. Transmit at 0 dBm: 6.1 mA
         1. To transmit for 24 hours requires 6.1 \* 24 = 150 mAh
      3. Based on these power specs, a 300 mAh battery should suffice for one electrode
   3. Aggregate Bandwidth: Not quite sure
      1. Must determine if there is enough bandwidth to support 16 channels. We seem to be able to support one channel.
3. Batteries
   1. Zinc air battery:
      1. 300 mAh at 1.4 V
      2. 7.9 x 5.6 mm (diameter x height)
      3. May satisfy needs if we place some in series
4. Compression
   1. Huffman Encoding saves 40.9% space, which is only a factor of 2. This compression is probably not enough.
5. For Next time:
   1. As CMC lab for Bluetooth test equipment when necessary
   2. Verify if we have enough bandwidth to transmit 16 channels with BLE

**Expenditures**

N/A

**Action items list**

|  |  |  |  |
| --- | --- | --- | --- |
| **Action item** | **Owner** | **Due date** | **Status** |
| Research Wireless/BLE technologies | Xin Huang | 10/15/2015 | 40% |
| Development environment setup | Yuan Gao | 10/13/2015 | 100% |
| Survey analog front-end chips for neural recording | Tingkai Liu | 10/15/2015 | 70% |
| Research analog front-end circuits for high SNR amplification | Stephen Xia | 10/15/2015 | 70% |
| Battery module research/survey | Xin Huang | 10/15/2015 | 99% |
| Intan Chip/Analog front-end power consumption research | Tingkai Liu | 10/15/2015 | 50% |
| Wireless transmission power consumption research | Stephen Xia | 10/15/2015 | 50% |
| Research compression algorithms | Yuan Gao | 10/15/2015 | 30% |
| CC2650/CC2640 BLE Development | Xin Huang | 10/15/2015 | 2% |

**Additional Comments/Questions for Mentors**