The figure above provides an illustration about the position of the final device in relation to the brain after it is implanted. Before we look into our proposed system for a wireless neural recording device, we will provide an overview of the components of the more common wired equivalent. The general system diagram flow of wired neural recording machines is shown below.



figure x: System block diagram of wired neural recorder.

Data from the electrodes (fig. xa) is digitized by the analog front end (fig. xb) and can be sent directly to the server (fig xc). Generally, the server will be running continuously from a inexhaustive power supply, and thus, will not have any power constraints. Since transmission is not through an intermediary medium, like air or water, that separates the where the data obtained and where the data needs to be transmitted, the data can be sent directly to the server for storage and analysis, without any need for preprocessing or any additional overhead.

However since the goal of our design is to provide a wireless solution to neural recording and data storage, our system design becomes more complicated.



figure y: System block diagram of wireless neural recorder

The figure above shows the proposed design of our entire system. The front-end remains relatively the same. Electrode data is sampled by the analog front-end, which accounts for low-noise signal amplification and DC offset rejection that arises from the nature of brain signals and the electric potential difference that forms at the contact point between the electrode and the brain [1]. Once the data is digitized, it is passed into a CPU or microprocessor (fig. yc) where the data is preprocessed for transmission. When the data has been processed for transmission, it is passed to the wireless transmitter (fig. yd) and transmitted across the air medium (fig. ye) to a server (fig. yf), which can be a module near or on the patient’s body. In the server, the data can be stored, viewed, and analyzed for deviations from standard brain activities.

Raw pulses observed from electrodes are generally in the microvolt range and require amplification to be accurately digitized [7]. Multiple problems arise because of this. Before sending the signal to be digitized in the analog to digital converter (ADC), we must send the signal through a circuit that amplifies the signal, while keeping a good signal-to-noise-ratio [7]. Proposed solutions exist in academia and in the market [1][5][6][7], so it is a matter of choosing the implementation that best suits our system’s needs. Additionally, when electrodes come in contact with the brain, an electric potential difference or DC offset is created that can be as great as a few volts [7]. Recording the signal without removing the DC offset will generally yield poor results because the DC offset is orders of magnitudes greater than the actual brain pulse [1]. Therefore, the analog circuit we create for the front end of our system must also reject as much DC offset as possible.

Beginning from the microprocessor preprocessing section of the system block diagram (fig. yc), there are deviations from the wired neural recorder system (fig. x). At this stage, the data will be processed based on the precision of the sampled data points as well as the limitations of the wireless transmission protocol we decide to use. For instance, one viable transmission protocol that we are considering is Bluetooth Low Energy. Bluetooth Low energy has a maximum data transfer rate of 260 kb/s [8]. If we decide to sample each contact point with a precision of eight bits, then the channel can support a data point transfer rate of 32,500 data points per second. This means if we have more than 32 channels or contact points sampled at 1 kHz, all collecting and transferring data to the same server, then the channel capacity for bluetooth low energy will be incapable of supporting the entire offered load from the electrodes, and the system will incur data loss. Then in order for the transmission rate to keep up with the sampling rate from all nodes in the array, the data coming in for transmission has to be downsampled or compressed in some other way in order to reduce the amount of bits transmitted across the channel.