How to Control your Computer with your Brain!

A look at the OpenBCI board...

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Goal of this session

To provide an understanding of the OpenBCI hardware, firmware, and software such that you'll be able to modify the firmware and/or software in order to control your computer (or other device) with your brain.

How will we accomplish this?

- Provide an overview of the 8-bit OpenBCI hardware and firmware (Arduino IDE)
- Provide an overview of the OpenBCI GUI (PC-based) software (Processing IDE)

Agenda

- What is the OpenBCI board?
- OpenBCI board components
- System Block Diagram
- OpenBCI board firmware/software
- OpenBCI client software

What is OpenBCI?

OpenBCI

- OpenSource (hardware and software)
- Brain Computer Interface

More typical computer interfaces

- Command line / keyboard
- Mouse
- Joystick
- Track pad
- etc…

BCI is Hard

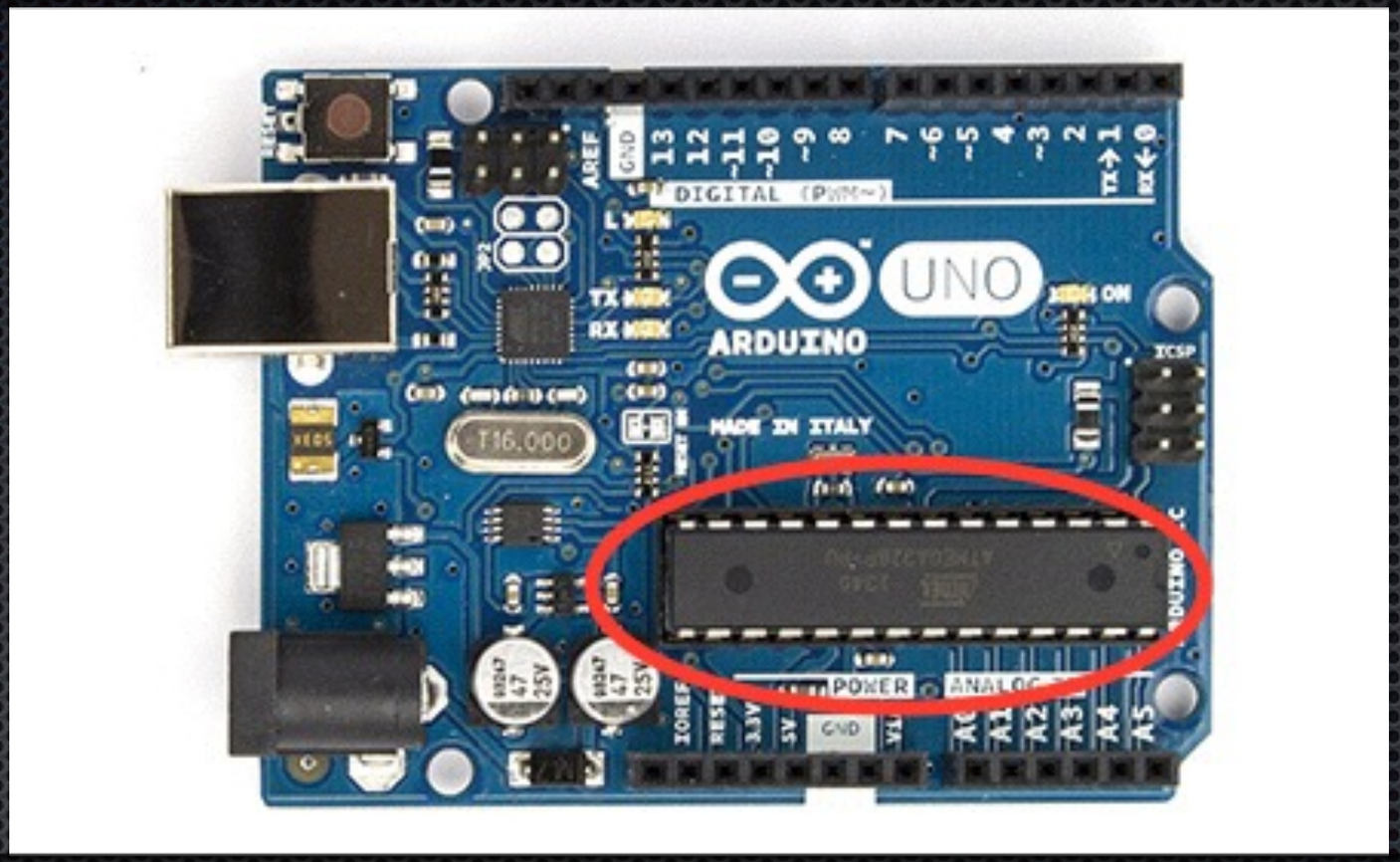
- Variability per person (calibration)
- Measuring very small signals, with large potential for noise interference (signal to noise ratio not good)
- Encompasses Signal Theory, Cognitive Science, Neuroscience

OpenBCI board

- Affordable
- Versatile (hackable)
  - Analog-to-Digital converter that can be used to sample electrical brain activity (EEG), muscle activity (EMG), heart rate (ECG), and more.
  - Based on the Arduino Uno platform

OpenBCI manufactures and sells two boards

- 8 bit board (Arduino based - our focus)
- 32 bit board (PIC based)

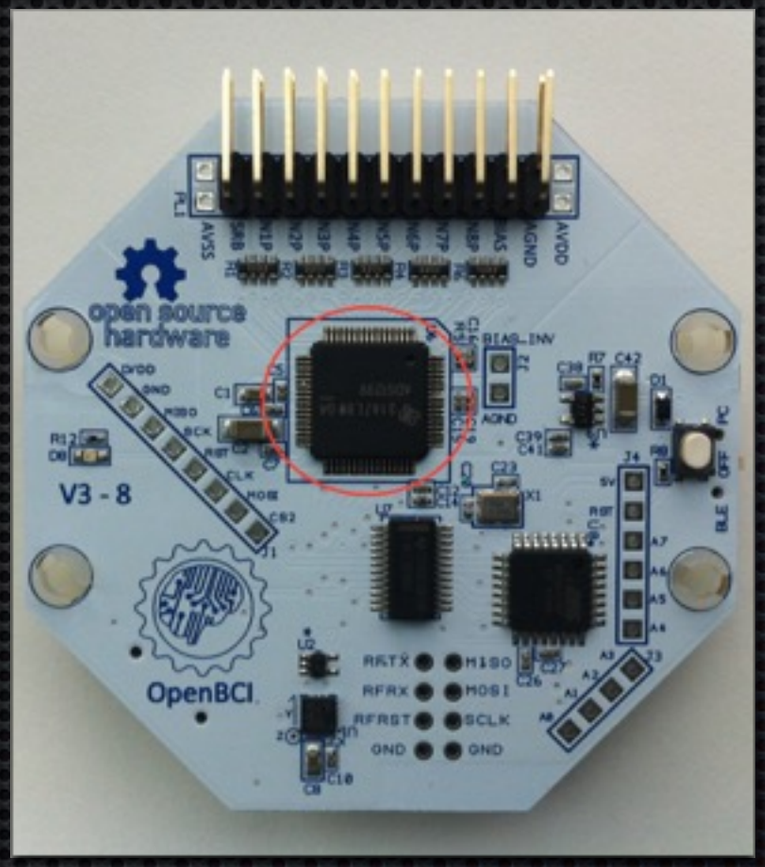


Arduino Uno

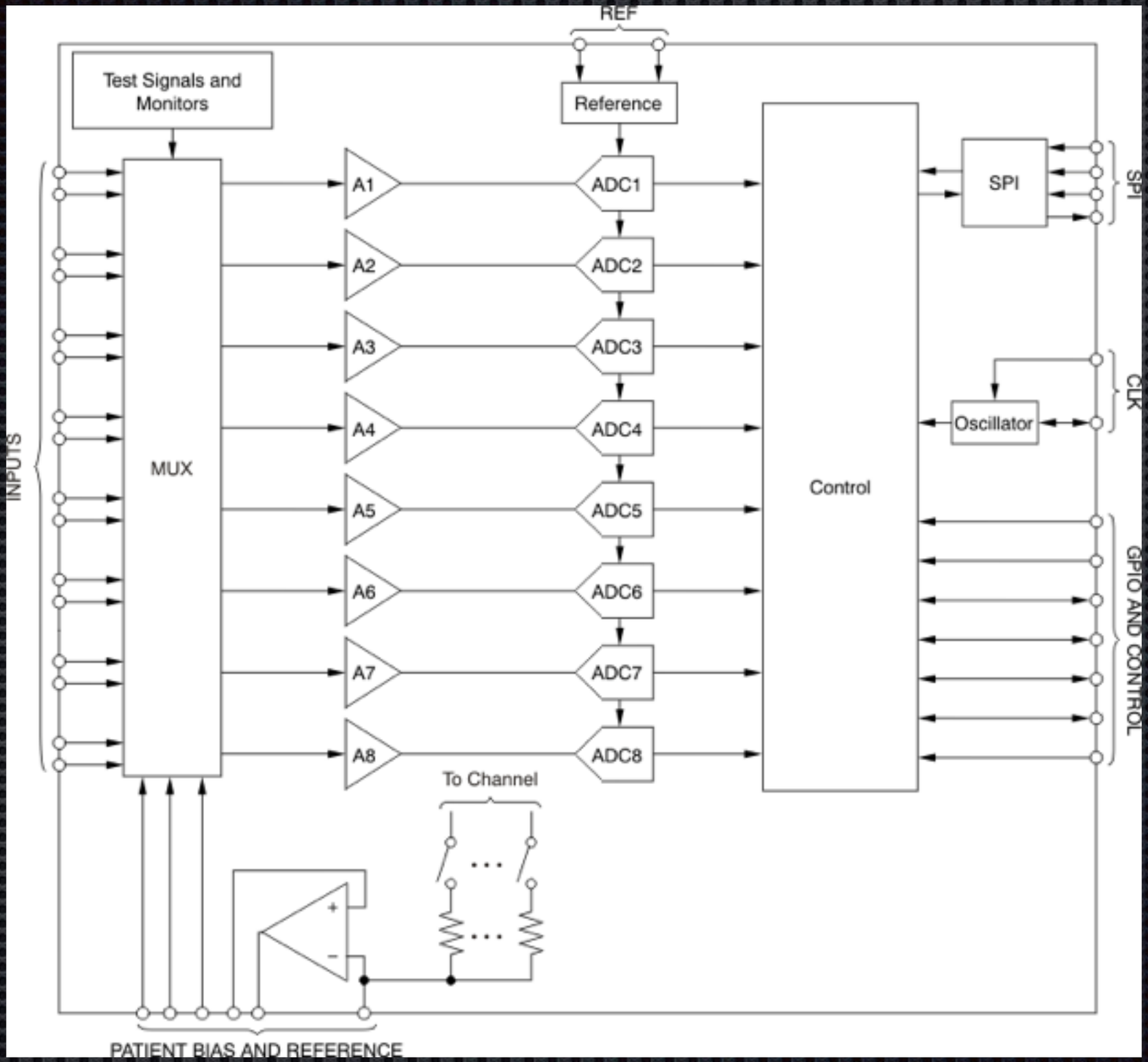
Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects.

8 bit board

- Texas Instrument ADS1299
- Low-noise, 8-channel, 24-bit analog front end for Biopotential measurements
- This chip is what makes this board possible

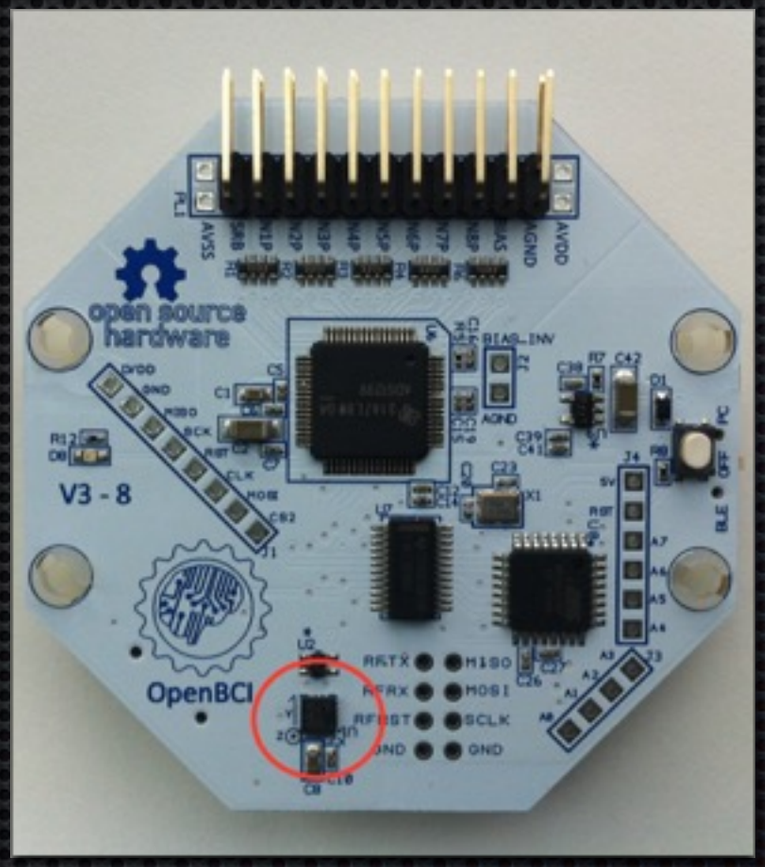


ADS1299 Function Block Diagram



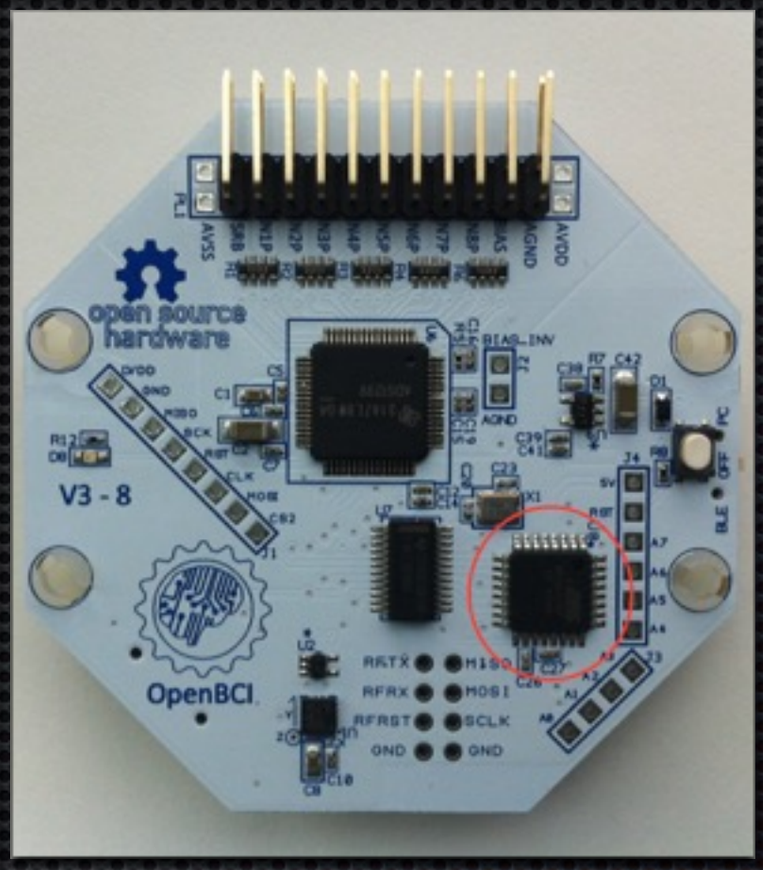
8 bit board cont.

- LIS3DH 3 axis Accelerometer



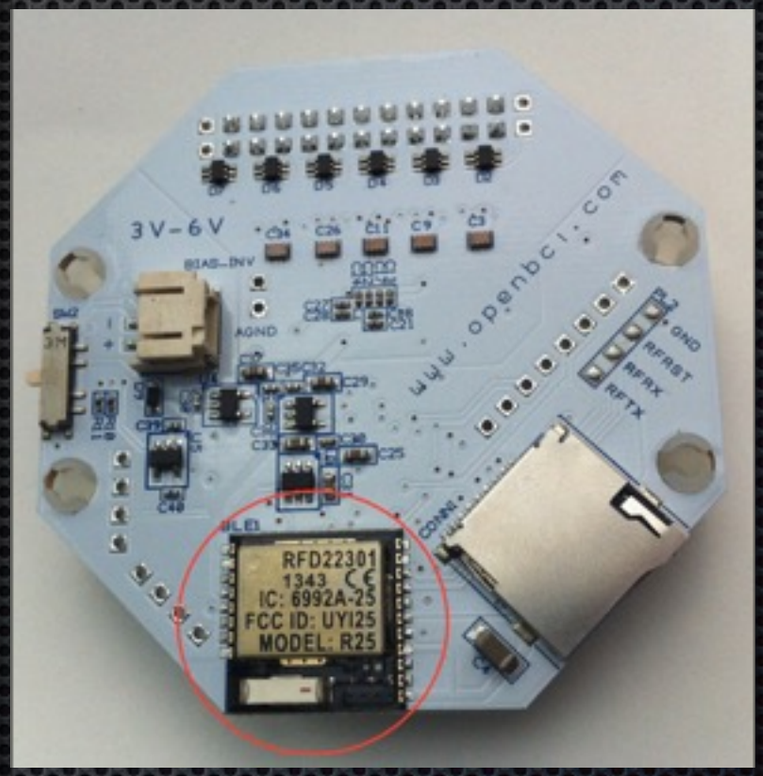
8 bit board cont.

- ATmega328P Microcontroller with Arduino Uno bootloader
- Arduino compatible



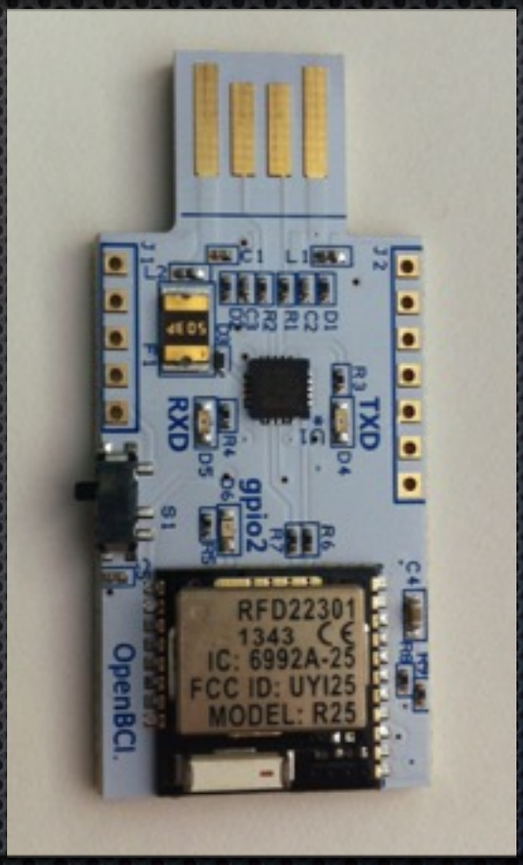
8 bit board cont.

- RFduino Bluetooth 4.0 Low Energy BLE RF Module



OBCI USB Dongle

- RFduino Bluetooth Low Energy radio module
- Used for communication between the 8-bit OpenBCI board and PC
- Requires FTDI VCP (virtual comm port) driver {windows, linux, mac}



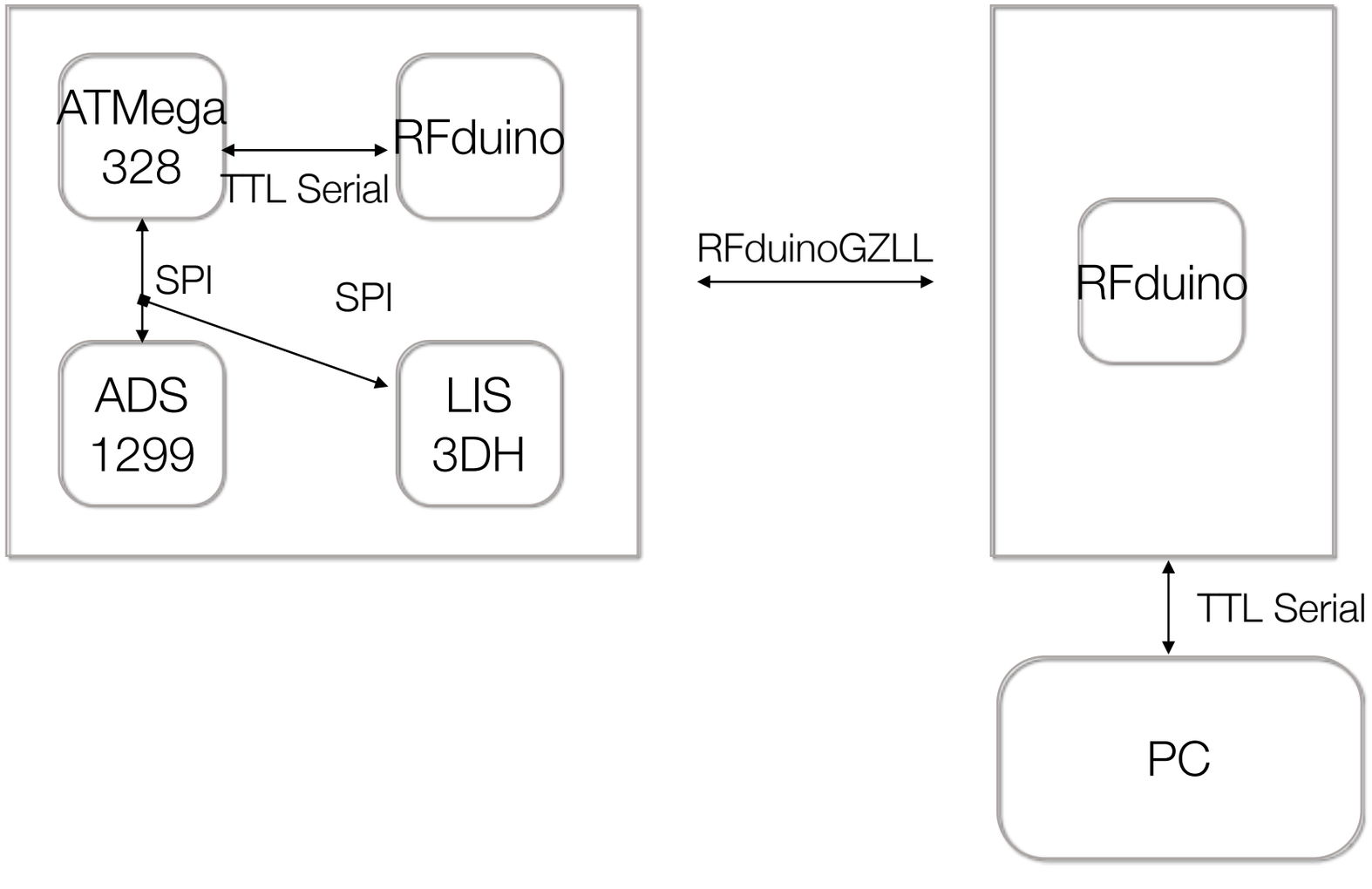
RFduino

- Based on Nordic nRF51822 SOC
- 32-bit ARM® Cortex™ M0 CPU with 256kB/128kB flash + 32kB/16kB RAM
- Arduino derivative

System Block Diagram

8-bit board

OBCI Dongle



ADS1299 to ATmega328 data transfer

- Let's take a look and see how data (i.e. EEG data) is transferred from the ADS1299 to the ATmega328 (Arduino)

Header

- Byte 1: 0xA0
- Byte 2: Sample Number

EEG Data

Note: values are 24-bit signed, MSB first

- Bytes 3-5: Data value for EEG channel 1
- Bytes 6-8: Data value for EEG channel 2
- Bytes 9-11: Data value for EEG channel 3
- Bytes 12-14: Data value for EEG channel 4

EEG Data cont.

- Bytes 15-17: Data value for EEG channel 5
- Bytes 18-20: Data value for EEG channel 6
- Bytes 21-23: Data value for EEG channel 7
- Bytes 24-26: Data value for EEG channel 8

Accelerometer Data

Note: values are 16-bit signed, MSB first

- Bytes 27-28: Data value for accelerometer channel X
- Bytes 29-30: Data value for accelerometer channel Y
- Bytes 31-32: Data value for accelerometer channel Z

Footer

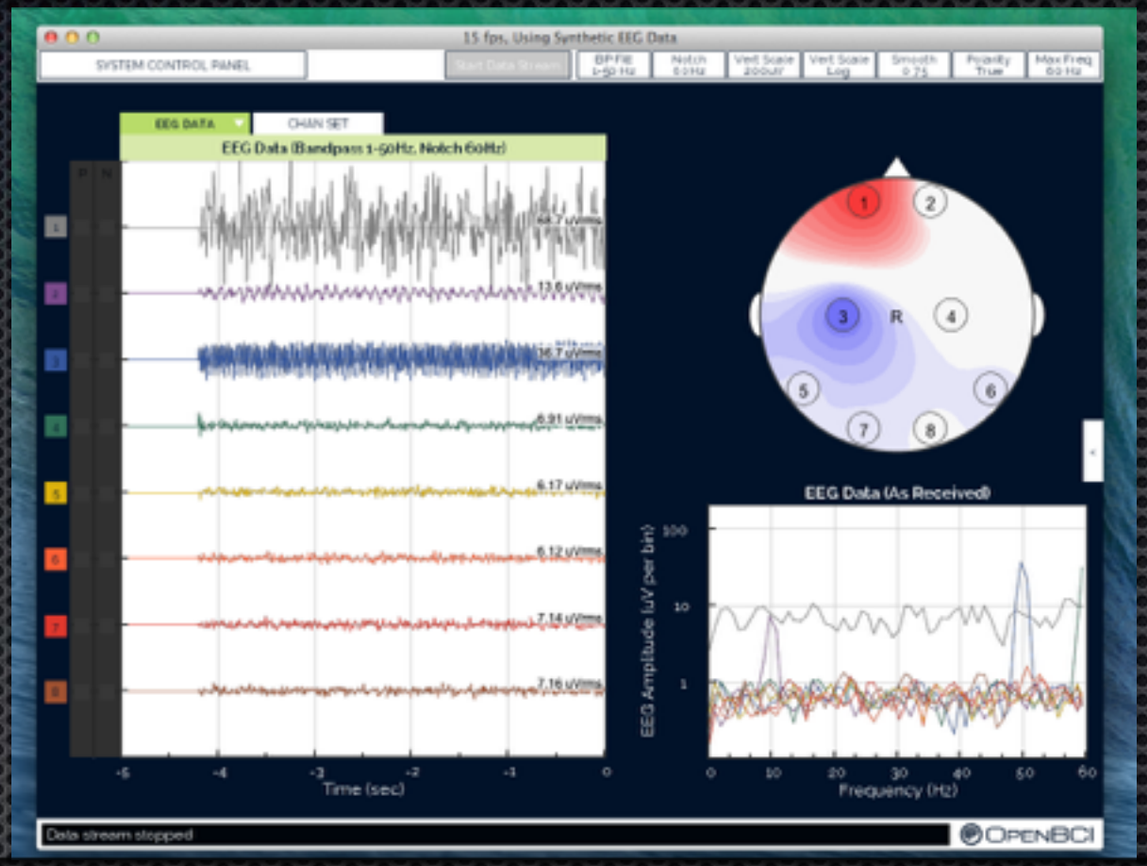
- Byte 33: 0xC0

Arduino Software Platform

- Let’s look at the Arduino Software Platform and a simple example…

OpenBCI Software

- OpenBCI 8-bit board software
- RFduino device and host software
- Let’s take a look…



OpenBCI Client Software

This is also open source and built on a popular hacking platform

Processing

Processing is a simple programming environment that was created to make it easier to develop visually oriented applications with an emphasis on animation and providing users with instant feedback through interaction.

OpenBCI Client EEG Data

- Sample Rate = 250.0 Hz
- First Column = SampleIndex
- Columns 2 - 9: EEG data in microvolts
- Columns 10 - 13: Accel Data (in G)

- You'll need to modify Arduino code if you want to intercept and control things at the board level
- You'll need to modify the client code if you want to gather data sent/received via RFduino. (Doesn't have to be done in Processing).
- Future - You can directly send the data via BLE to any other BLE device (iPhone/iPad, Android device, etc)

Additional Resources

- OpenBCI http://www.openbci.com
- Arduino http://www.arduino.cc
- Processing http://www.processing.org
- RFduino http://www.rfduino.com
- TI ADS1299 http://www.ti.com/product/ADS1299/description
- Intro BCI http://sccn.ucsd.edu/wiki/Introduction_To_Modern_Brain-Computer_Interface_Design
- FTDI http://www.ftdichip.com