Ausio is a neurofeedback system that is used as an alternative/compliment to traditional methods of therapy. Traditional neurofeedback therapy allows the user to view their own brain wave activity through the use of an EEG that usually displays the brainwaves on a visual display format like an FFT. Different types of brainwaves are associated with different states of consciousness: Alpha waves with relaxation, focus, memory, and learning; Beta waves with stress, anxiety, but also alertness, logic, and critical reasoning. What sets our product apart from other neurofeedback systems is that we feed back neurological data via audio rather than video. Our device allows you to “hear” your brain waves.

Neurofeedback in a medical application can help to reduce the dependence on drugs for ADHD treatment. Ausio can assist in attaining a meditative state that reduces anxiety and ADHD symptoms. Non-Medical applications are also possible for consumers who wish to improve cognitive function, by stimulating concentration and alertness. Meditation has been shown to improve brain performance.

Since most brain wave frequencies are below the range of human hearing, our product utilized a microprocessor to carry out Digital Signal Processing techniques that allow for the EEG signals frequencies to be scaled to coincide with the range of human hearing. Thereby allowing the use to hear a composite sound that represents their brain waves chaning states in real time.

### Theory

- The frequency we wanted our device to detect was around 8-12 Hz which is associated with a alpha wave activity. In order to achieve the desired frequency response, a series of filters were implemented to attenuate high frequency noise and EML.

  ADC and DAC are used to interface the EEG sensors and the audio system with the microcontroller.

  Microcontroller used SPI communication and DMA to implement circular buffer for continuous real time processing.

  Pitch shifting of EEG signal accomplished by write pointer writing audio samples into ring buffer, while read pointer reads samples out of the ring buffer at a faster rate than the write pointer.

  A pitch shift factor of 10 allows Alpha, Beta, and Gamma brain waves to fall well into the range of human hearing.

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**Introduction**

**Ausio: Neurofeedback System**

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**Equipment & Software**

- Tektronix P5200
- Agilent 33210A
- Agilent DSO6034A
- Keil μVision
- Altium Designer
- LTSpice
- Keil μVision
- Altium Designer

**Approach/Design**

**Stage 1: Gain Stage**  
Stage 2: Notch  
Stage 3: High Pass  
Stage 4: Low Pass  
Stage 5: Gain Stage  
Stage 6: Notch

**AD620 by Analog Devices**

- Low-noise instrumentation amplifier
- Wide power supply range (±2V to ±18V)
- High gain (up to 10,000)
- Perfect for precision data acquisition
- Set gain with 1 resistor!

Gain = 1+ (49.4kΩ/RG)

**Figure 1: Theoretical Bode Plot**  
**Figure 2: AD620 Pinout**

**Figure 3: Circuit Schematic via Altium Designer**

**Figure 4: Block diagram for ADC to DAC translation**

**Figure 5: Diagram of the ring buffer. Pitch shifting is carried out by the difference in speed of the read pointers relative to the write pointer.**

**Figure 6: Ausio EEG MAIN PCA, Rev. 1**

**Figure 7: Ausio EEG MAIN PCA, Rev. 1**

**Results**

With the code that we have, we were able to receive a sound while changing the frequency pitch, which is needed to be able to hear the sound of the brainwaves. This shows that the transfers of data from ADC to DAC works successfully and that the method of changing the frequency was valid as well. However, there are some issues with the wiring connections that causes the audio output to disappear sometimes. In addition, our lab equipments were having technical issues and other materials were difficult to obtain due to supply chain shocks.

**Conclusion**

The intention with Ausio was to create non-invasive treatment for psychological issues or assist in meditation skill building for anyone in need. This device will be accessible and affordable to anyone which allows the replacement of the expensive EEG equipment provided in clinical sites. After being able to capture the target frequency of the simulated brainwave, transferring data from analog signals to digital signals, and shifting pitch frequencies of the signal, we were able to create a foundation to completing Ausio. We are hoping to refine this device when condition allows.

**Key References**

- Serial Peripheral Interface (SPI), leam.sparkfun.com/tutorials/serial-peripheral-interface-spi/all.

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