Brain Wave Music Synthesizer

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Abstract

Motivation:
Historically, real-time electroencephalograph (EEG) waveforms captured in clinical and research settings have been viewed using a monitor. Using sound to represent the underlying data is an intriguing idea with seemingly endless possibilities for the creation of music. The possibilities are not restricted to just the musical realm. Potential clinical applications include early warning systems for the onset of seizures in epilepsy patients, monitoring systems for surgeons in operation rooms, and positive feedback systems for comatose patients to name a few.

Problem Statement:
In order to produce music from the brain, the EEG signal had to be captured, amplified, and filtered, before finally being processed into a stream of music. The issue was in building a low-cost unit to accomplish this task.

Approach:
The input to the circuit consists of an active, reference, and ground electrodes. To obtain a detectable EEG signal, an amplifier was needed to boost the level of the signal. In addition, filters were needed to remove unwanted frequencies and prevent aliasing from occurring during signal processing. For this specific application, the EEG data frequencies of interest ranged from 2 Hz up to 60 Hz. A low pass, high pass, and notch filter were cascaded together to provide the necessary filtering. Two instrumentation amplifiers were used to achieve the necessary gain of 100 dB. After calculating the component values for the filters and the amplifiers, the circuit was simulated using AC analysis to verify its frequency response. Once the circuit was deemed correct, a prototype was constructed on a breadboard for testing. A function generator was used to sweep the frequencies of interest to confirm the simulation results. The output of this circuit was fed into an Arduino Due to be sampled. After performing several mappings, a real-time MIDI stream was generated to compose music.

Results:
A portable low cost device was successfully constructed, capable of amplifying an EEG signal and generating music. All of the design issues encountered along the development process were resolved with minor modifications. The low frequency signal drift issue was resolved by using passive RC high pass filters. This solution also resolved the insufficient gain issue in the first amplification stage. The final design produced unique and interesting music.

Conclusions:

This initial prototype confirmed the feasibility of generating music from EEG waveforms using simple mapping techniques. The use of more advanced mapping techniques in conjunction with spectral analysis using Fast Fourier Transform could lead to the addition of multiple instruments and more precise musical response to EEG waveforms.