

INTRODUCTION

The **electroencephalogram (EEG)** was invented in 1924 by psychiatrist Hans Berge in Germany. The EEG is a noninvasive tool for measuring the amplitude and frequency of the electrical waves being emitted by the brain. Brainwaves as measured on the scalp have an amplitude between 1 – 2 mV and a frequency range between 1 – 50 Hz. The frequency range is divided into four levels: beta, alpha, theta and delta waves. Alpha waves, associated with relaxation, range from 8-13 Hz, and Beta waves, associated with concentration, range from 13-30 Hz.

As a class project in Circuit Analysis II (EET 300L) taught by Dr. Steven Cox at Northern New Mexico College we built an EEG as a collaboration with artist Shel Neymark. The intention was to utilize the binary difference between alpha and beta waves to turn water pumps on and off with the brain alone. These water pumps will drip water into an illuminated still pool that was designed by Shel and fabricated by Phillip Ginn. The water droplets will create ripples in the pool that are intended to mimic brainwaves.

This circuit incorporated all of the concepts that the class was designated to teach. Operational amplifiers are the building blocks of modern electronics, because accompanied by resistors and capacitors, nearly any circuit can be created.

Using the instructions provided by Christian Henry on his DIY EEG Instructables.com page as a template, we were able to build the EEG for less than \$20 using one instrumentation amplifier, a few operational amplifiers, resistors and capacitors. For educational and troubleshooting purposes, we built, tested and plotted each stage of the larger circuit individually before building the circuit in its entirety.

First we amplified the signal because the amplitude of the brainwaves are so small. Next we removed noise created by the interference of grid power with two 60 Hz notch filters. We also included a low-pass, a high-pass filter and a variable amplifier in order to extract just the frequencies of alpha and beta waves.

Once all of the filters and amplifiers were working as expected, we tied all of the stages of the circuit together. However, there was still some noise, so we applied the Fourier Transform to isolate the specific frequencies that dominate at any given time.

Finally, we integrated electrodes into a bicycle helmet with the EEG affixed to the top. Using two 9-V batteries, we will transmit the results from the EEG wirelessly to an Arduino, which will turn on low-flow water pumps when alpha waves are detected.