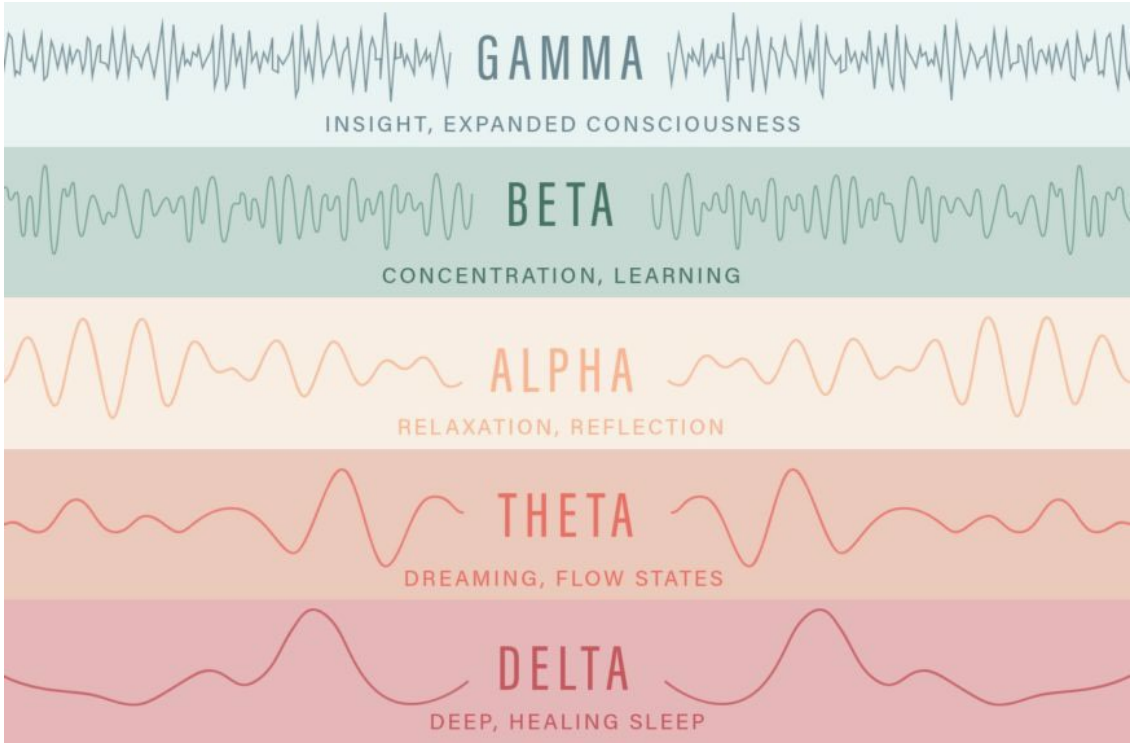
TeachEngineering

Analyze Brain Waves

Brain Wave Review



EEG, EKG, and EMG

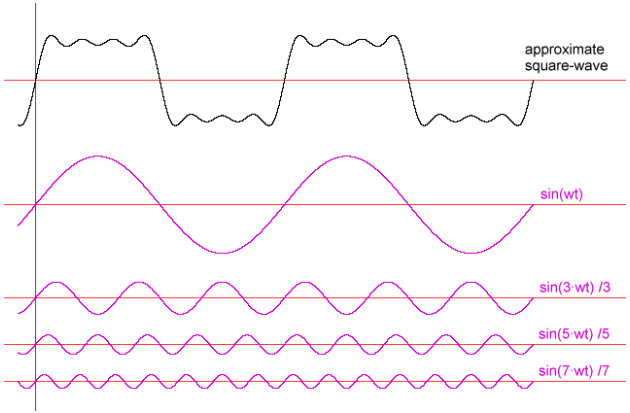
- **We can measure the electrical activity of our nervous system, heart, and muscles using EEG, EKG, and EMG, respectively**
    - **EEG stands for electroencephalogram, and it is used to measure brain waves**
    - **EKG (or ECG) stands for electrocardiogram, and it is used to measure electrical signals in the heart muscle**
    - **EMG stands for electromyogram, and it is used to measure electrical signals in the muscles**
- **In this lecture, we will focus on EEG, and how we can analyze the measured waves**

Our Toolbox

- **Now that we know about the different types of brain waves, how do we take a brain wave dataset and determine which waves are present?**
    - **We can use the following mathematical processes to “break down” a raw EEG signal and analyze it:**
        - **Fast Fourier Transform (FFT)**
        - **Power Spectral Density (PSD)**
        - **Bandpass Filter**

Fast Fourier Transform (FFT)

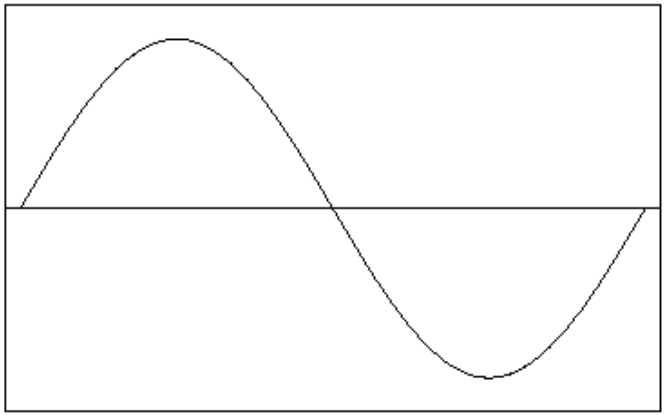
- **Sinusoids observed in the real world are not “perfect,” but they can be modeled using combinations of sinusoids**
    - **Example: The black signal below is modeled using a combination of the pink signals below it**



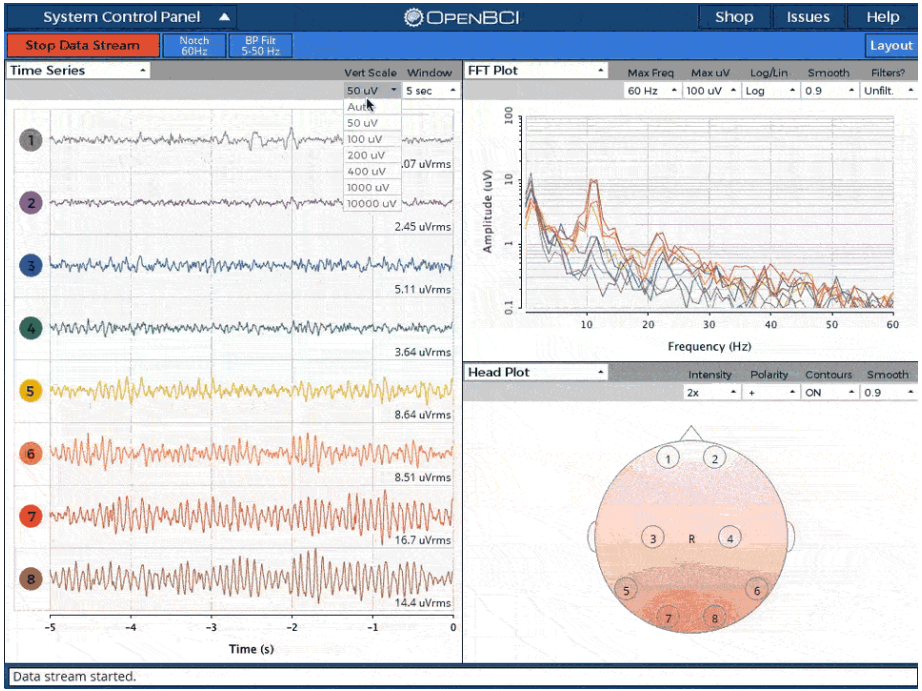
Fast Fourier Transform (FFT)

- **A Fast Fourier Transform (FFT) may be used to visualize the different frequencies of a signal's component sinusoids**
- **When we measure the raw EEG of a brain wave, we use the FFT to plot all the component frequencies observed in the wave**
    - **Using the FFT output, we can see which frequencies are "dominant" (appear the most) in the raw signal**
    - **If we notice that a frequency of ~ 1 Hz is dominant, we can conclude that the person is likely in a deep sleep since this frequency is representative of the delta wave**
- **We won't worry about the details of the FFT—just know what it's used for!**

Fast Fourier Transform (FFT) Example



Example of a Real-Time EEG with FFT

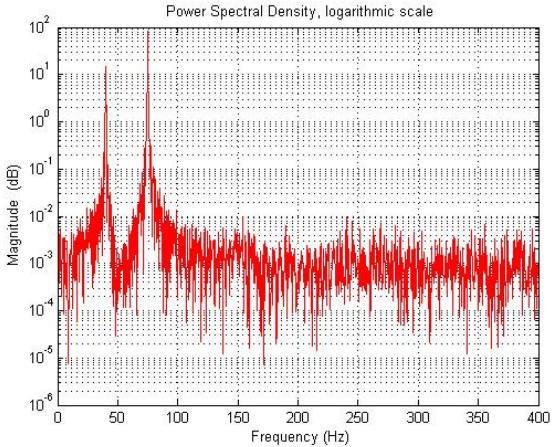


Power Spectral Density (PSD)

- The **power spectral density (PSD)** is the distribution of the signal's power over the frequency
- When we want to analyze which types of brain waves are dominant in a raw EEG signal, we can calculate and plot the PSD of the signal to visualize which waves "occur" most often in the signal

Power Spectral Density (PSD) Example

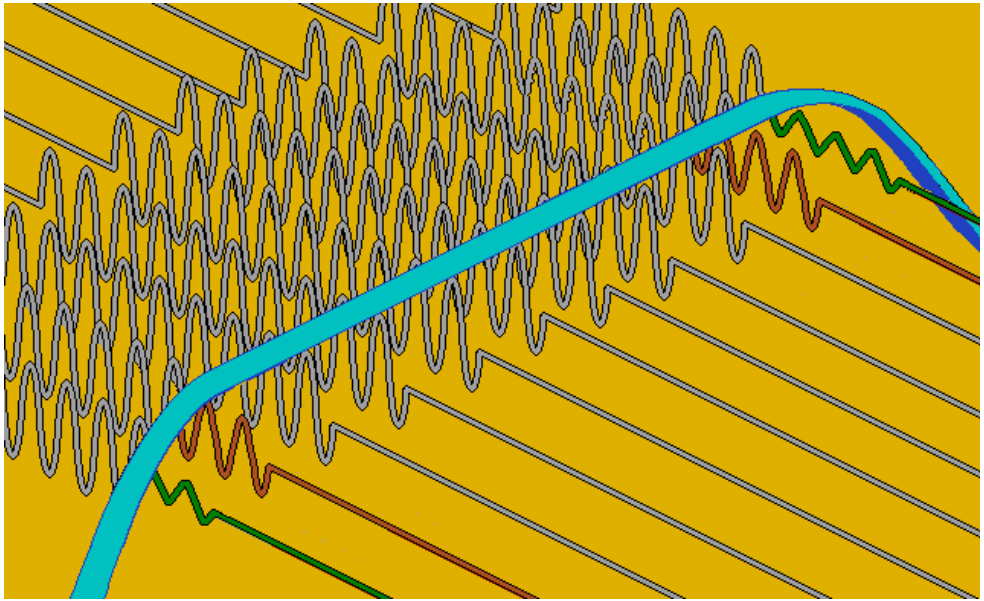
- **In the example below, there are two peaks at f = 40 Hz and f = 75 Hz**
  - **These peaks show us that most of the original signal's power comes from waveforms with frequency 40 Hz and 75 Hz**



Bandpass Filter

- **A bandpass filter may be used to “filter out” parts of the original signal that are not within a range (or band) of specified frequencies**
- **When we are analyzing an EEG signal, we can choose to only view wave components that are within the frequency range of a specific type of brain wave**
    - **Example: We can choose the band 9 Hz – 13 Hz if we wish to view the alpha wave components**

Bandpass Filter



Compare EEG Results