Beth Israel Deaconess Medical Center

A teaching hospital of Harvard Medical School

Workshop
Sleep EEG Analysis

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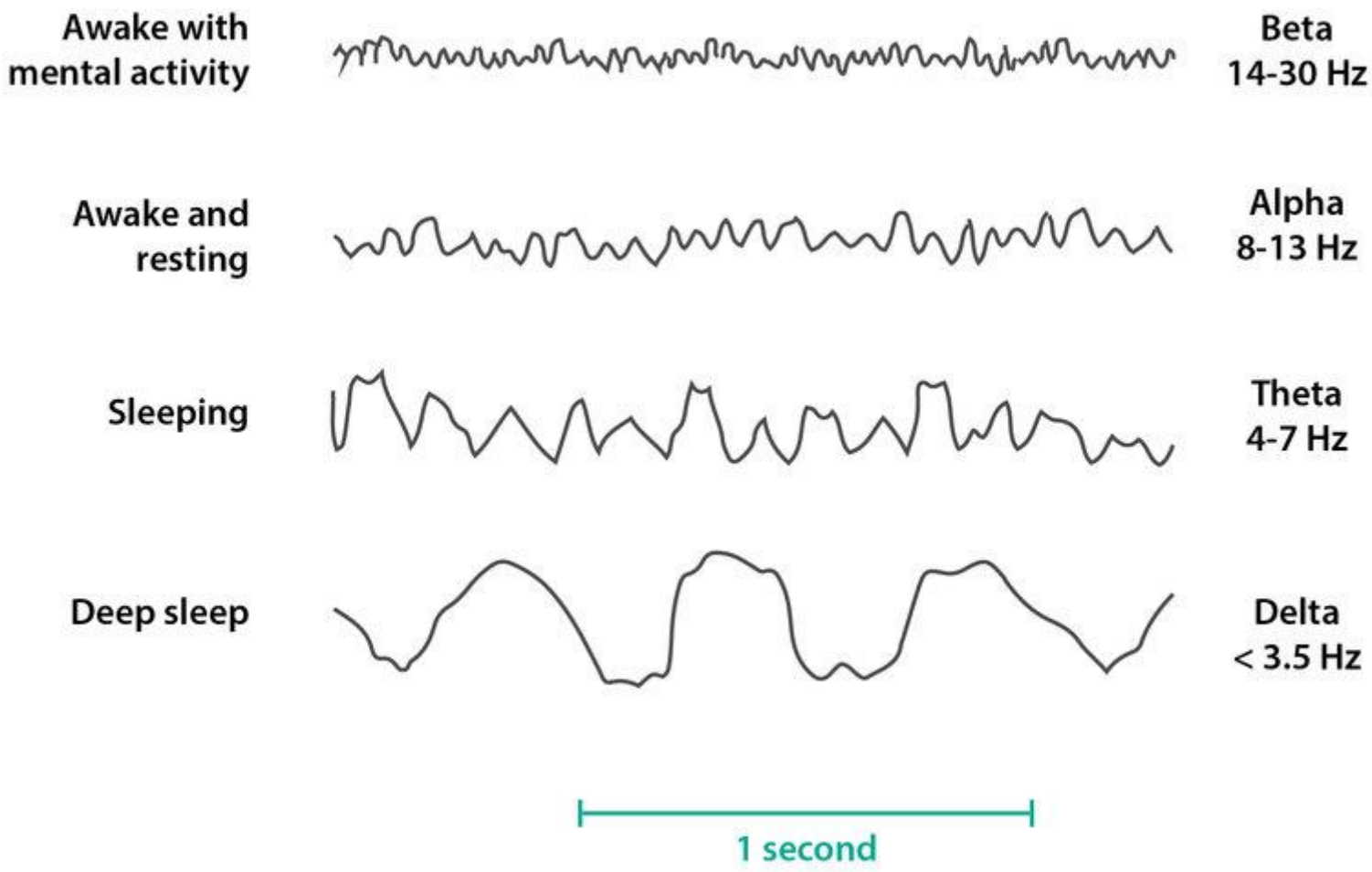
History

1929: Hans Berger developed electroencephalography, the graphic representation of the difference in voltage between two different cerebral locations plotted over time

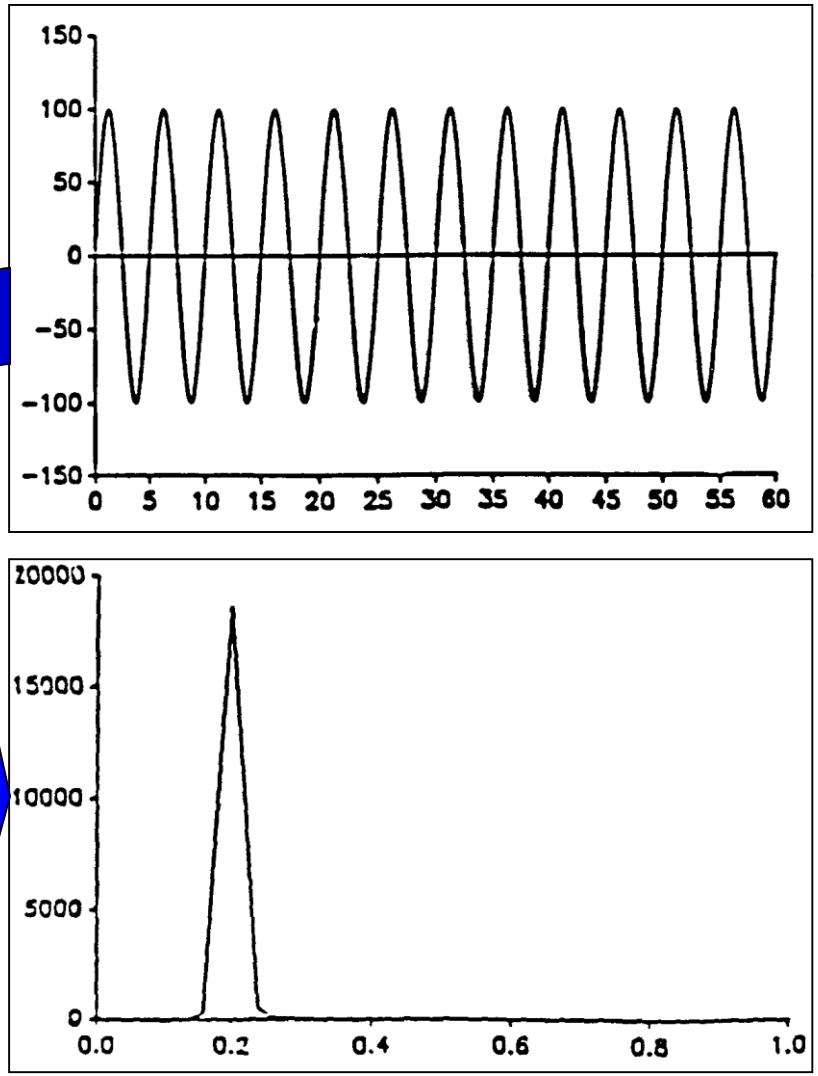
He described the human alpha and beta rhythms

EEG Rhythm Nomenclature



What are the Underlying Rhythms?

Fourier Transform



One rhythm

5 seconds/cycle
or
12 times/minute

Frequency =

(1/5) cycle/second

=0.2 Hz

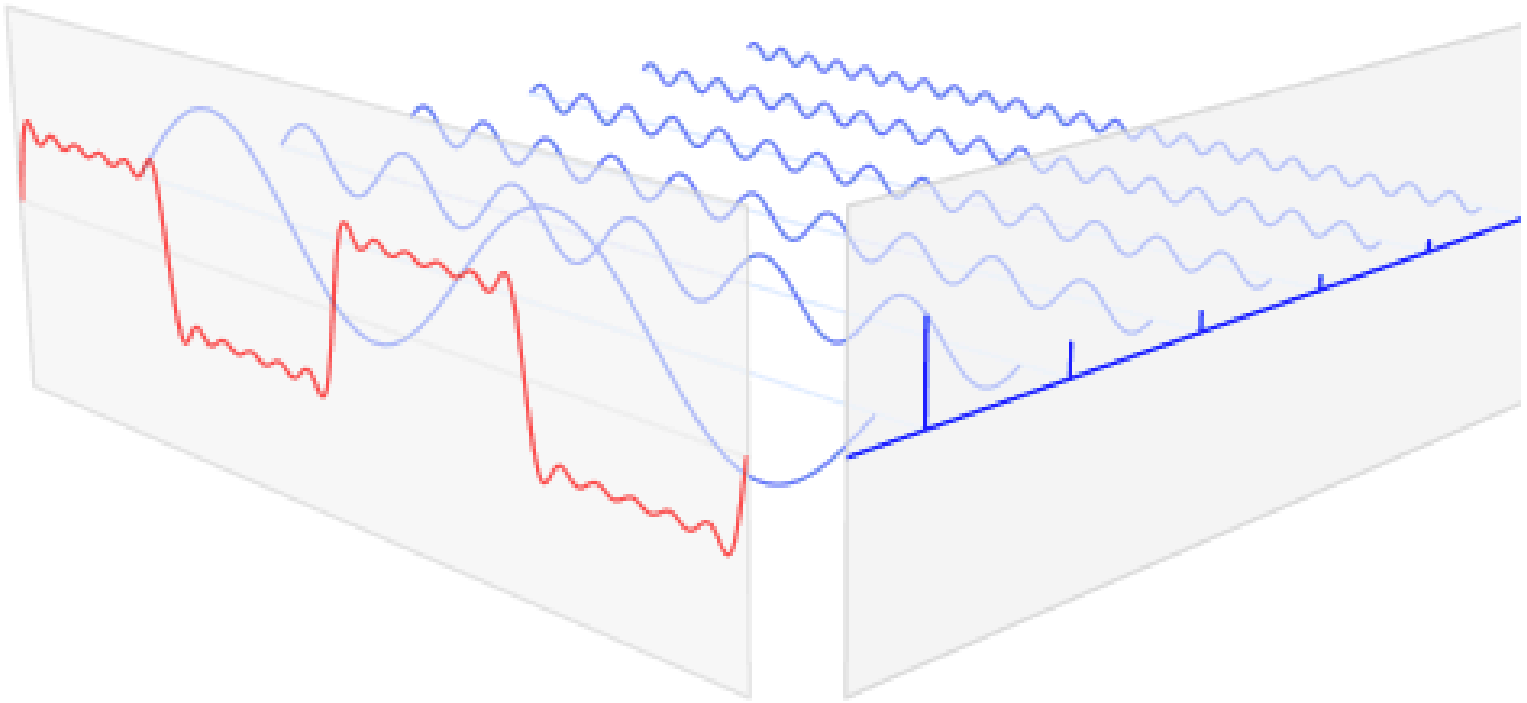
Jean Baptiste Joseph Fourier (1768-1830)

- Had crazy idea (1807):
- **Any** periodic function can be rewritten as a weighted sum of Sines and Cosines of different frequencies.
- Don't believe it?
  - Neither did Lagrange, Laplace, Poisson and other big wigs
  - Not translated into English until 1878!
- But it's true!
  - called Fourier Series
  - Possibly the greatest tool used in Engineering

A Sum of Sinusoids

- building block:

$$A\sin(\omega x + \phi)$$



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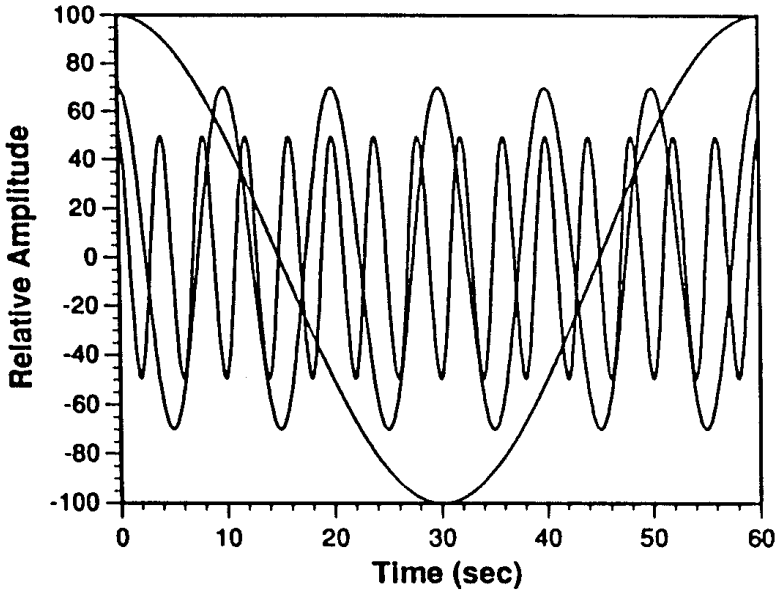

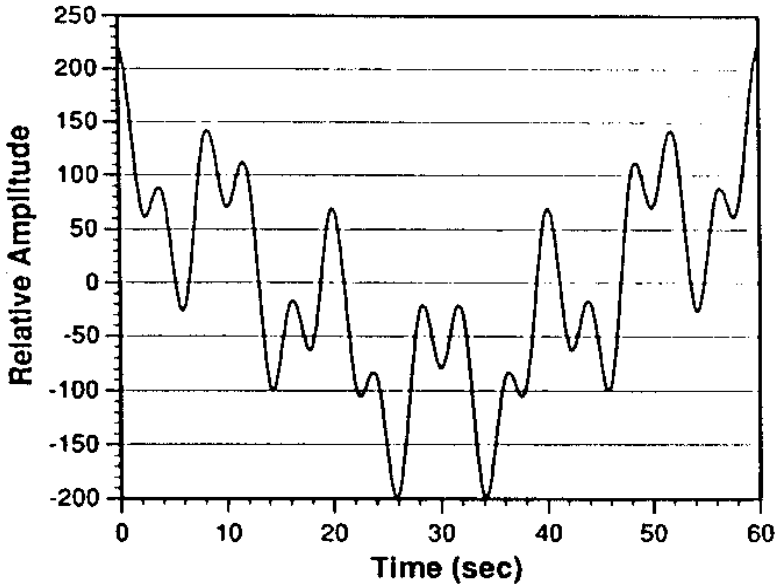

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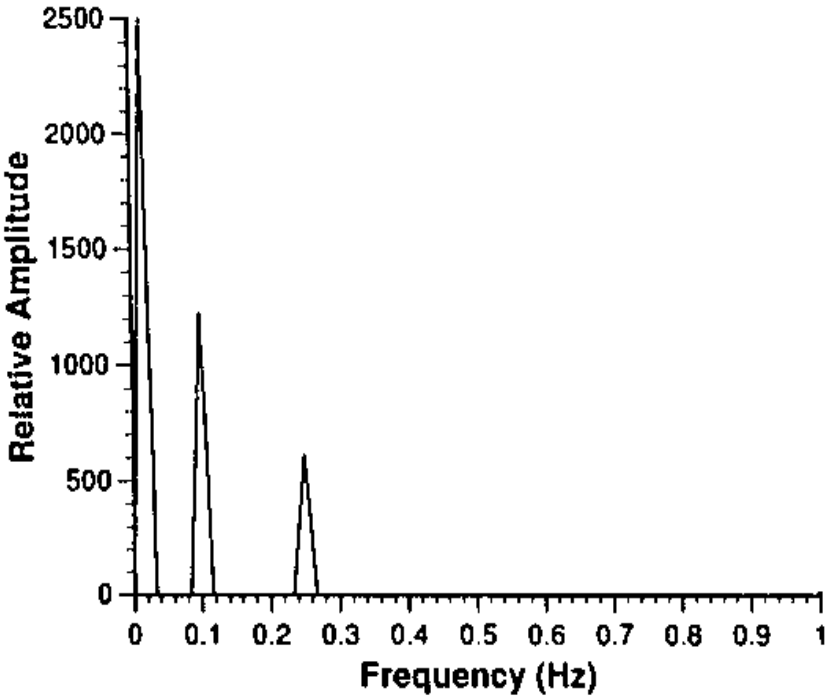


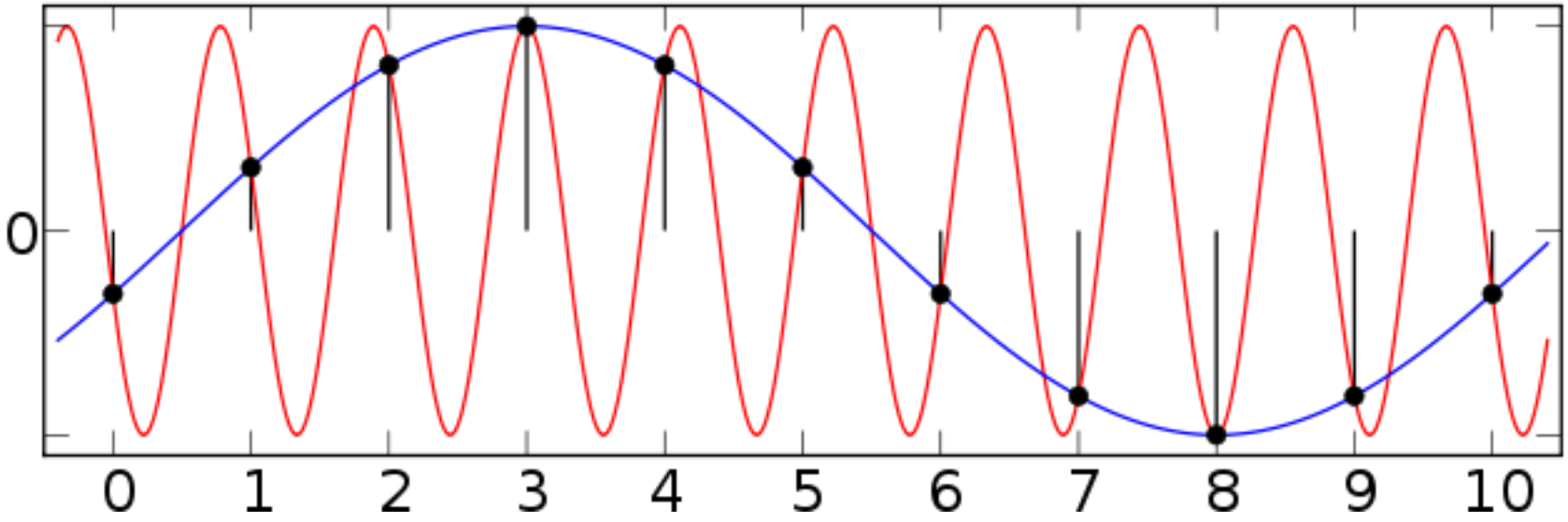
Three Different Rhythms

High Frequency = 0.25 Hz
(15 cycles/min)

Low Frequency = 0.1 Hz
(6 cycles/min)

Very Low Frequency = 0.016 Hz
(1 cycle/min)

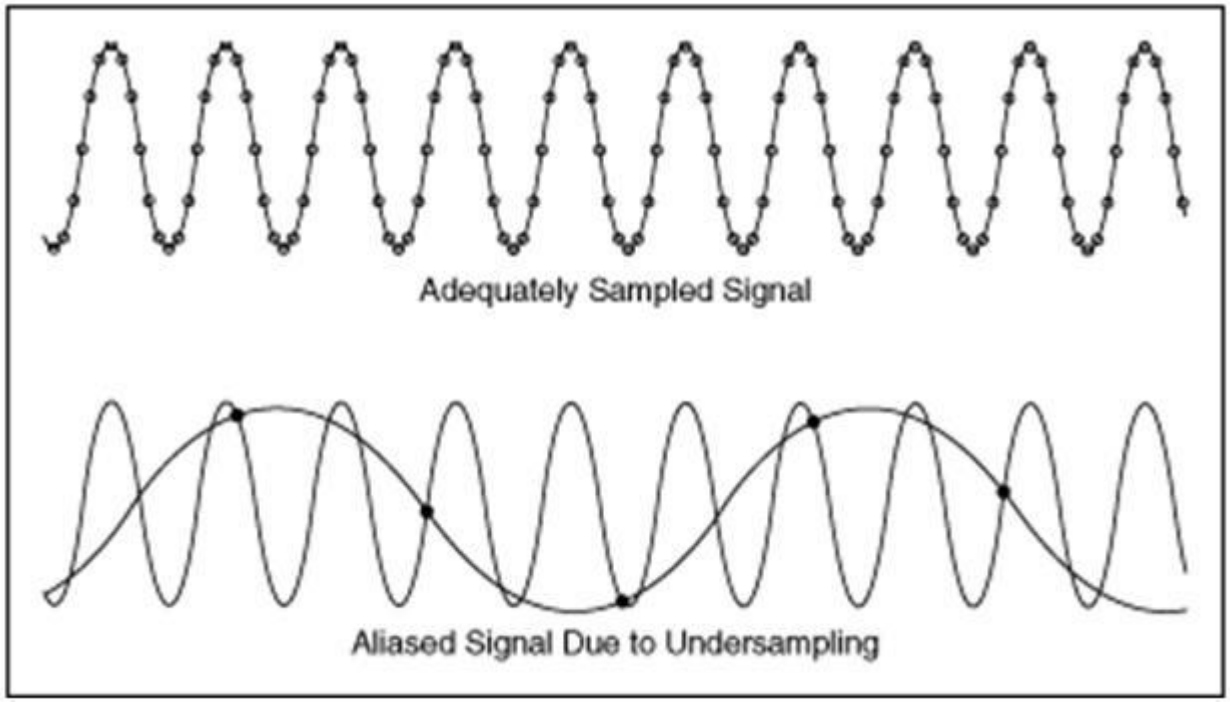
Signal Sampling



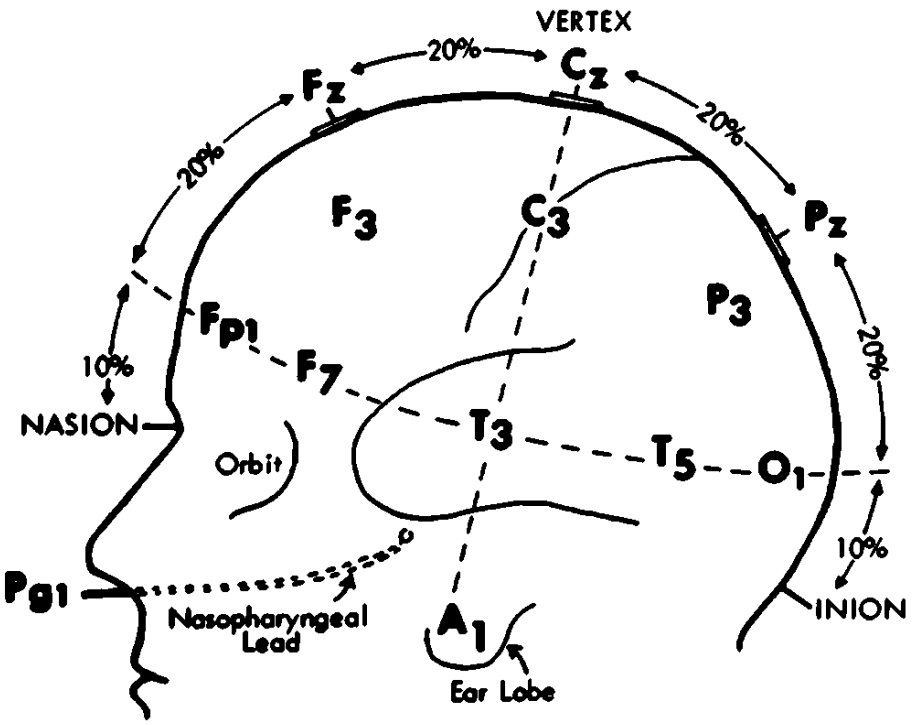
Aliasing Effect

Nyquist Criterion

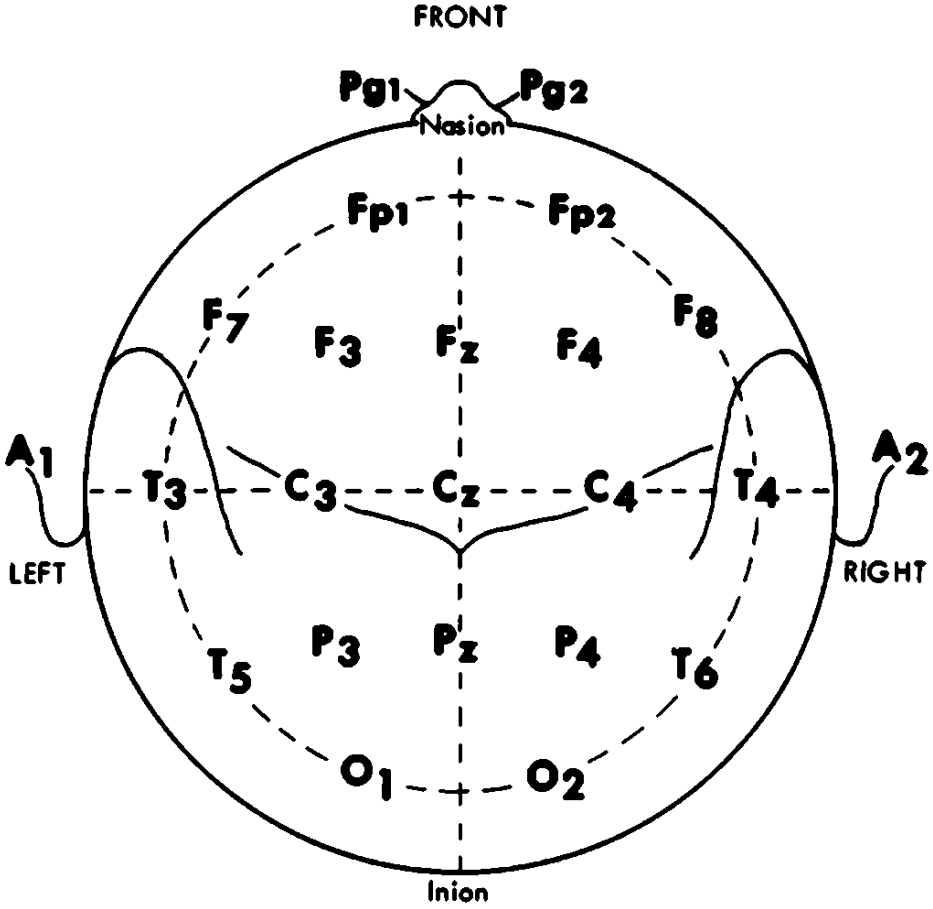
The sampling rate (frequency) has to be at least twice of the highest frequency component in a given signal to capture such frequency band.



EEG Channels Nomenclature
10/20 System

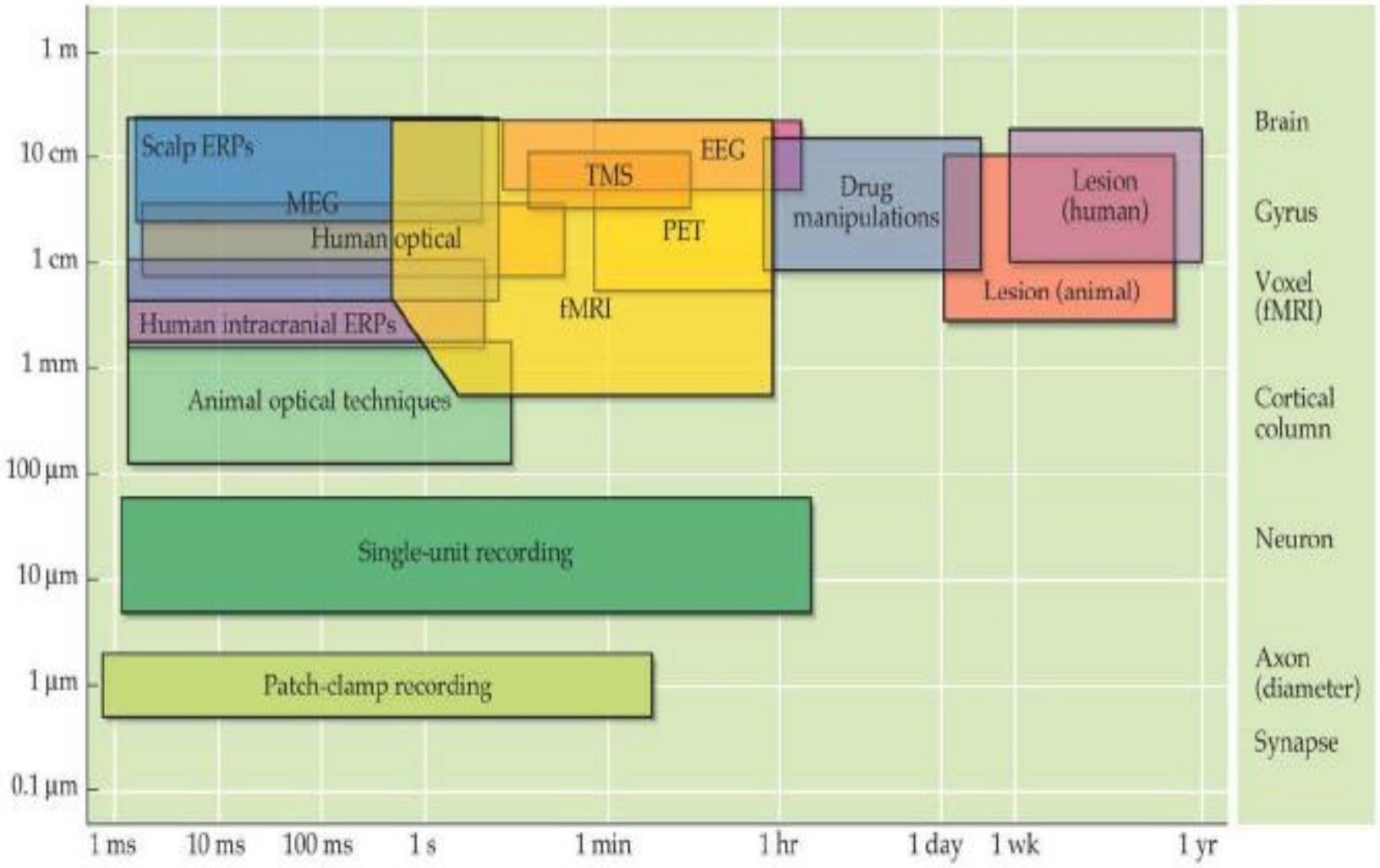


LEFT SIDE OF HEAD

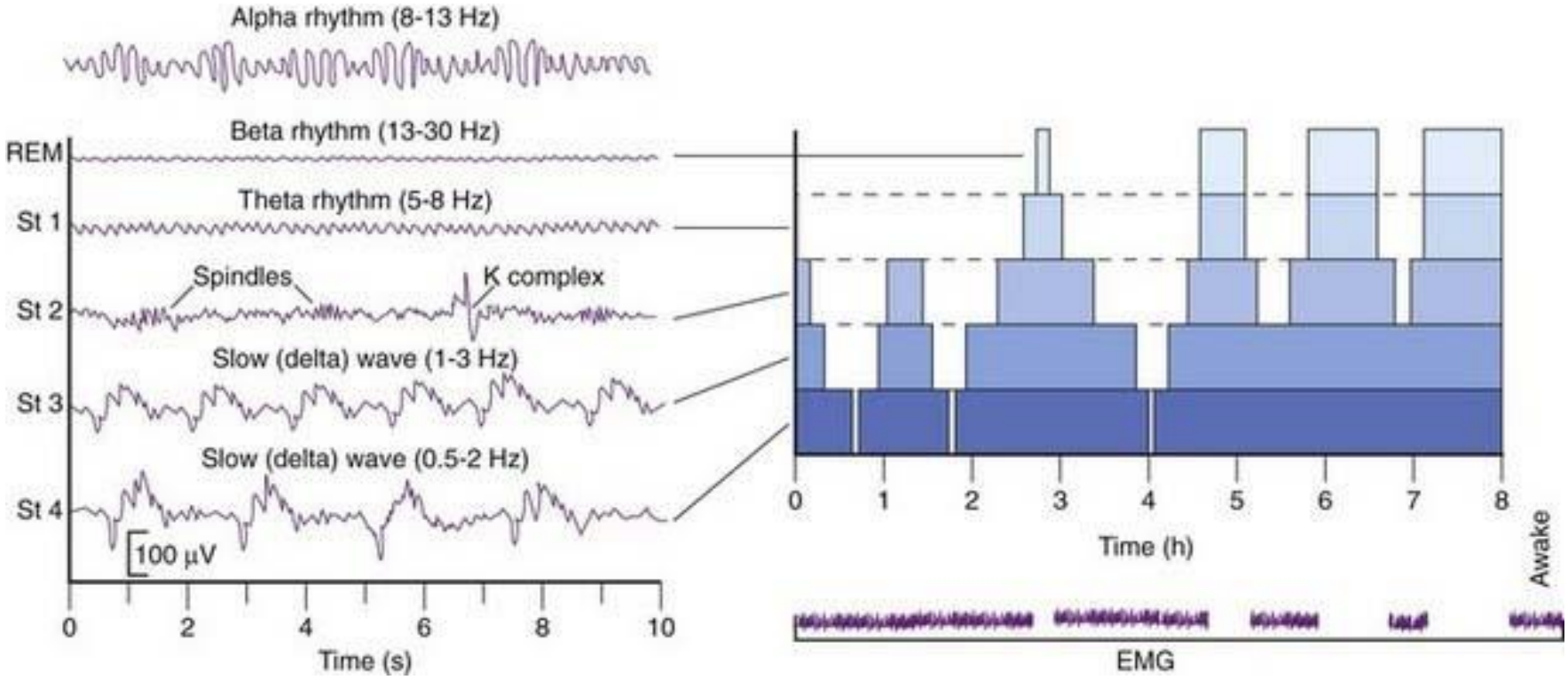


TOP OF HEAD

Techniques to Measure Brain Activity



Sleep EEG Patterns

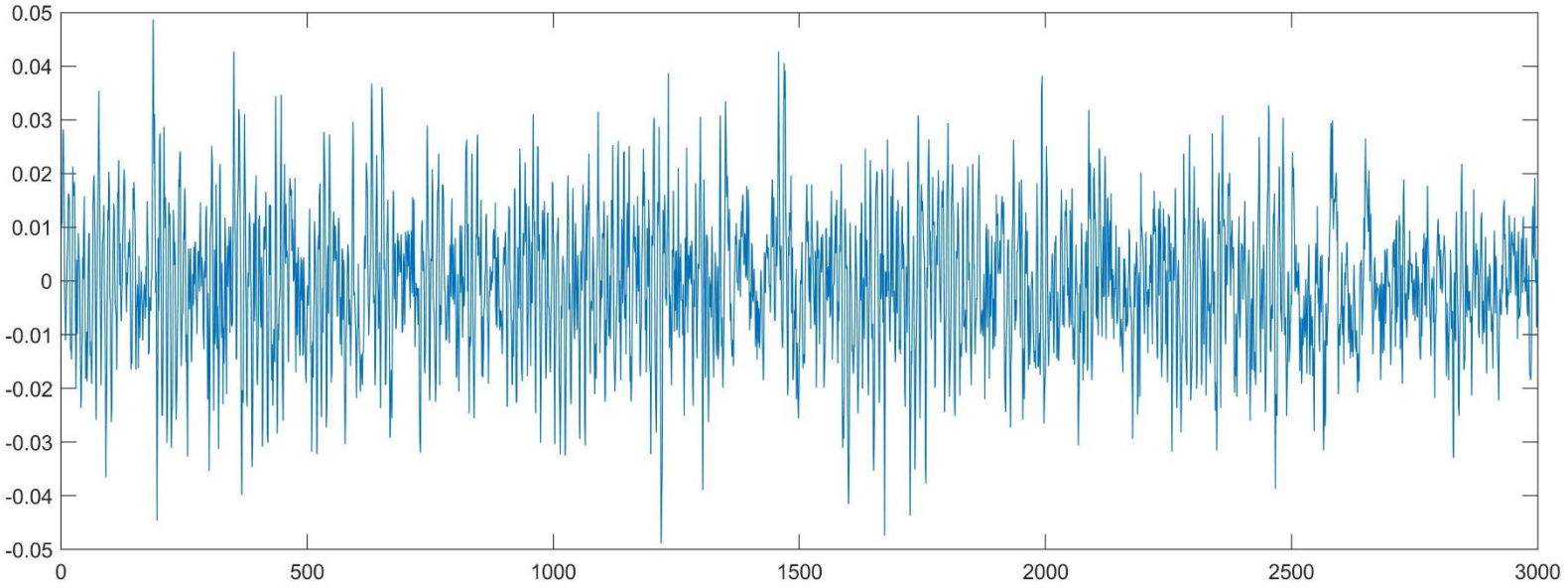


Objective

- Calculate power spectrum of EEG alpha wave in Matlab

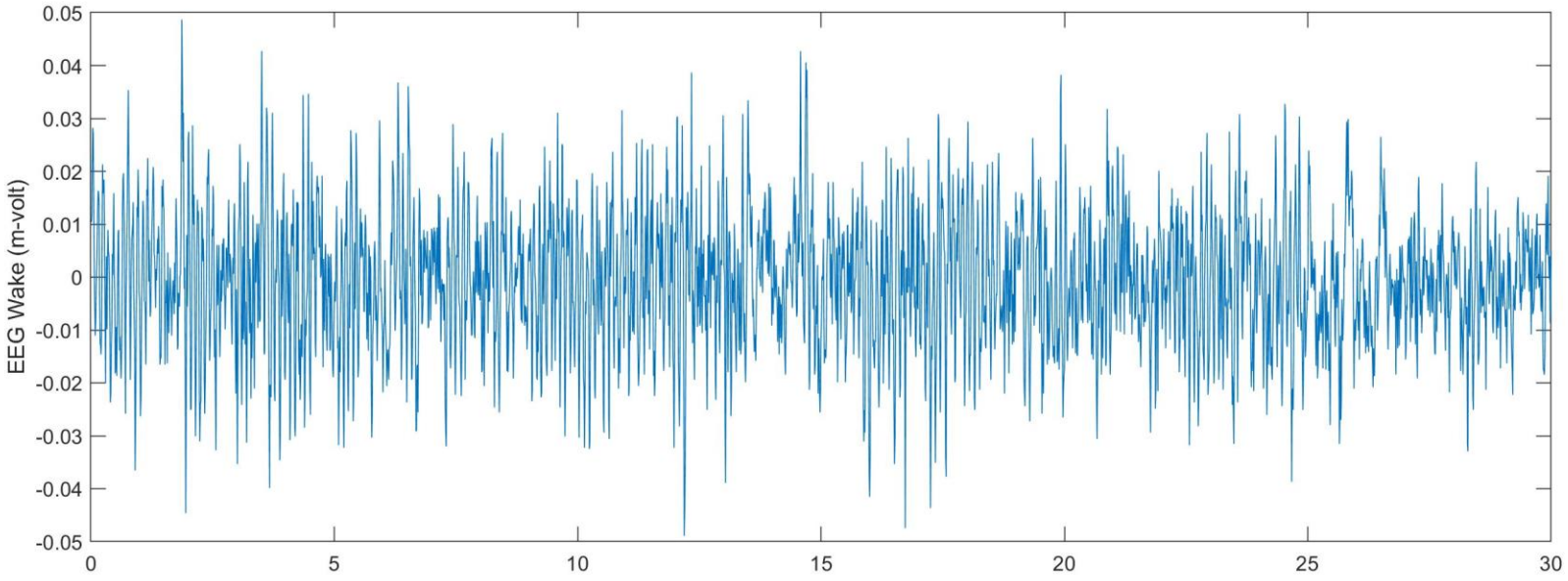
Load EEG Time Series

- eeg_wake = load('EEG_Wake.txt');
- plot(eeg_wake);



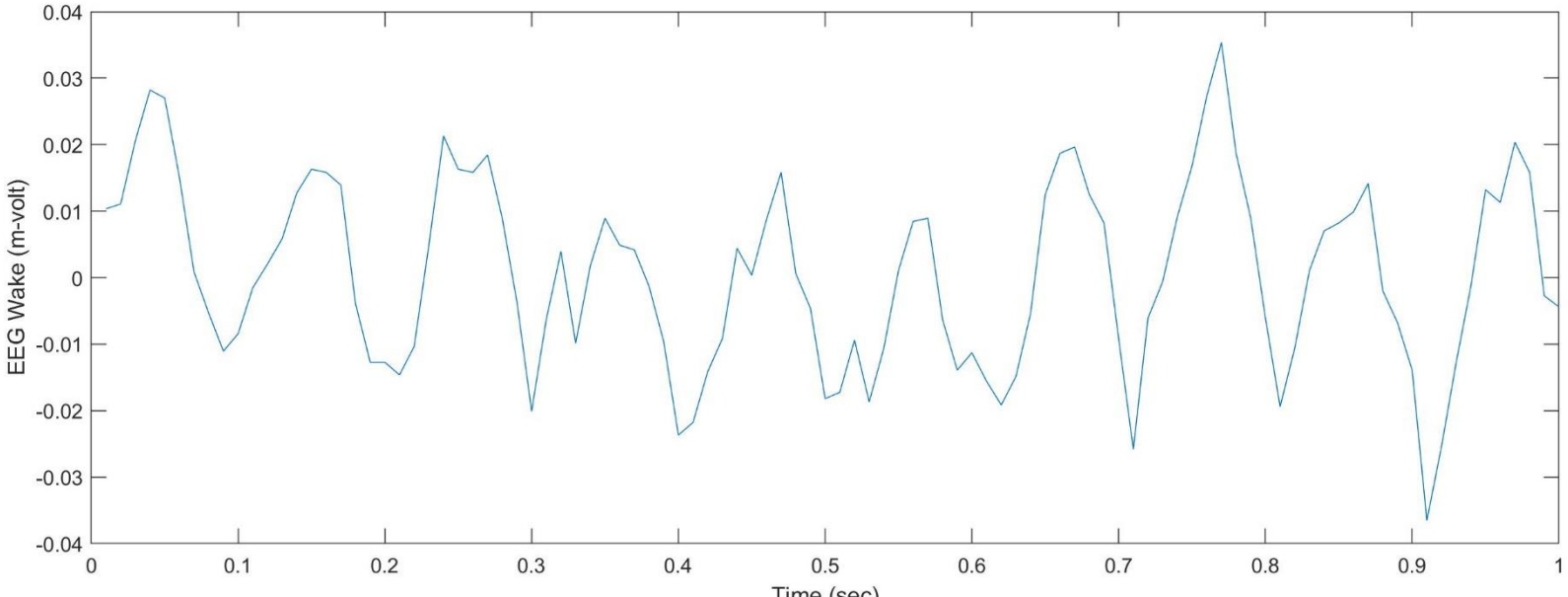
Plot EEG Time Series

- t=1/100:1/100:30;
- plot(t,eeg_wake);
- xlabel('Time (sec)’);
- ylabel(‘EEG Wake (m-volt)');



Zoom into the Time Series

- t=1/100:1/100:1;
- plot(t,eeg_wake(1:100));
- xlabel('Time (sec)');
- ylabel('EEG Wake (m-volt)');



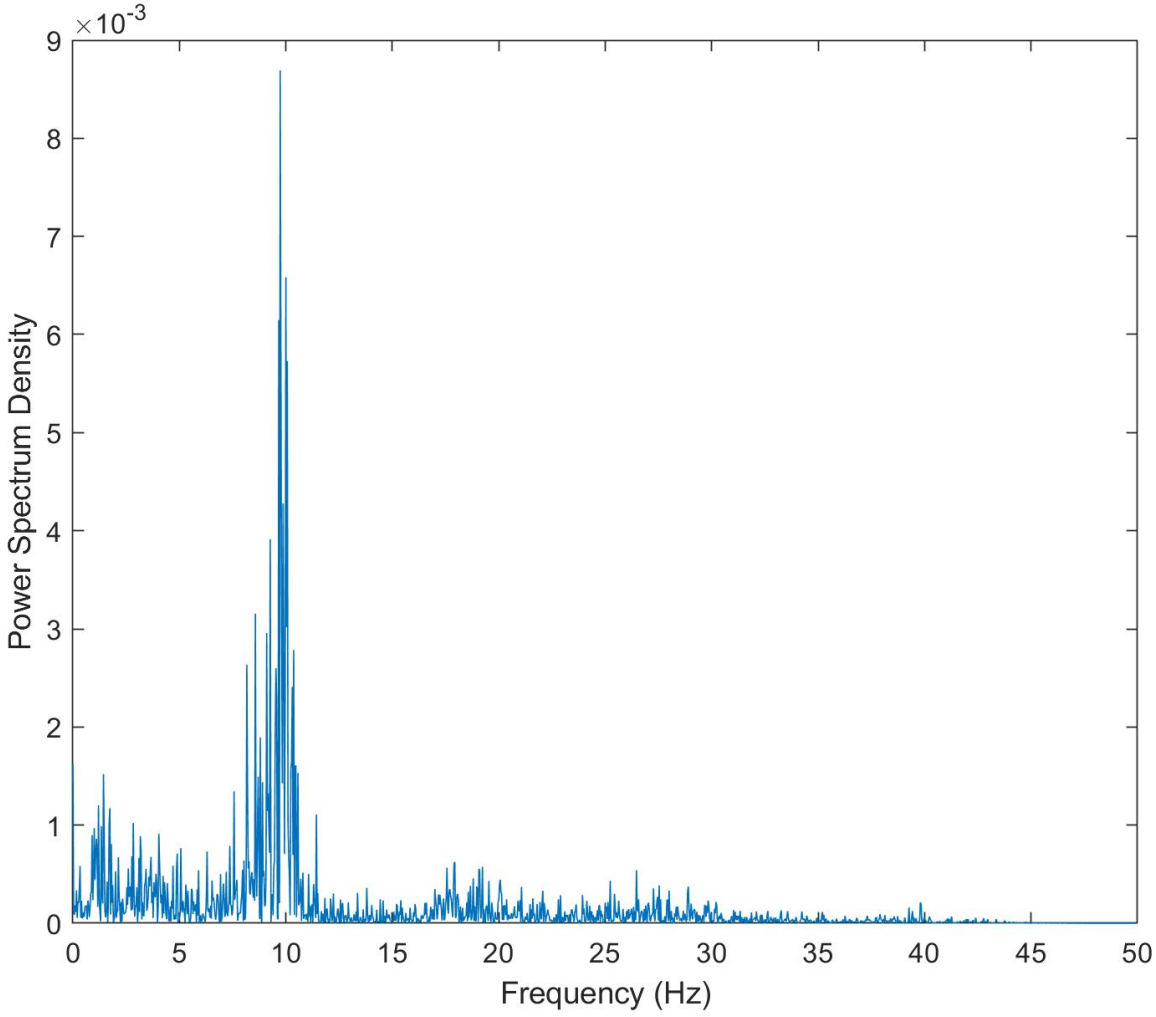
Fast Fourier Transform (FFT)

- Y = fft(eeg_wake,3000);

Determine Spectral Power

- Pyy = Y.*conj(Y)/3000;
- f = 100/3000*(0:1499);
- plot(f,Pyy(1:1500))
- title('Power spectral density')
- xlabel('Frequency (Hz)')

Result of Power Spectral Density



Additional Material

- pwelch function

- [pyy,f]=pwelch(eeg_wake,hanning(3000),0,3000,100);
- plot(f,pyy)
- xlabel('Frequency (Hz)')
- ylabel('Power Spectrum Density');

Homework

- Calculate power spectrum of EEG signal from different sleep stages