International Institute of Information Technology
Bangalore

SUBJECT : Signal Processing

COURSECODE : EC 304

# Lab Report 4

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# 1 INTRODUCTION

Electroencephalography is an efficient modality to acquire and study brain signals from different regions of the scalp. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain.
They are categorized into different categories based on their frequency.They are delta (0.5-4Hz), theta (4-8 Hz), alpha (8-14 Hz), beta (14-30Hz) and gamma (above 30Hz)

A data set was chosen from internet.It was of a alcoholic subject(person).The EEG data is taken with many electrodes.The data set used in this project is of one electrode.
The signal is separated into alpha ,beta and delta by use of a band pass filter made from scratch.The different categories of the signal obtained are compared with one obtained using in-built filter.For practical purposes,we will be processing only the data recorded from the C Channel of the EEG Data.

Matlab software was used to process the signal.The data set is of alcoholic person.The work begins wit

# 2 DATASET

EEG Database

The data set was taken from the above database.The data set being processed is that of a alcoholic subject.It contains measurements from 64 electrodes placed on subject's scalps which were sampled at 256 Hz (3.9-msec epoch) for 1 second.The data is taken for 10 times on every subject and averaged.The electrode positions were located at standard sites abiding Standard Electrode Position Nomenclature, American Electroencephalographic Association,1990.

There were two groups of people , control and alcoholic.The control subjects data were more stable than that of alcoholic .Each subject was exposed to either a single stimulus (S1) or to two stimuli (S1 and S2) .They were shown pictures of few objects chosen from the 1980 Snodgrass and Vanderwart picture set. When two stimuli were shown, they were presented in either a matched condition(S1 and S2 identical)or in a non-matched condition(S1 differed from S2).There were 122 subjects and each subject completed 120 trials where different stimuli were shown.The dataset chosen was a_co2a0000364 .

# 3 PROCEDURE

## 3.1 Preprocessing

The raw data set being used has noise in it.The process of manipulating and cleaning the data set is called preprocessing.The process includes removing noise from the data to get closer to the true neural signals.smoothdata() funtion was used to preprocess the data.
The preprocessed signal was plotted.[Figure 2]

code:

```
b = co2a0000364; % Data Set
a=smoothdata(b);
```

## 3.2 Working with the dataset

The data set obtained after preprocessing is converted to frequency domain.The frequency spectrum was observed and it was plotted along with the original signal(in time domain).
The in-built functions fft() and fft_shift() were used for obtaining frequency spectrum.[Figure 1]

Code:

```
clc
b = co2a0000364; % Data Set
a=smoothdata(b);
fft_a = fftshift(abs(fft(a))/length(a));
fft_t = linspace(-Fs/2,Fs/2,length(a));

figure(1);
subplot(211);
plot(a,'r');
axis([0 16000 -40 60])
ylabel("Voltage(mV)");
xlabel("t(s)")
title("Data Set in time domain");
legend("signal");
grid on;

subplot(212);
plot(fft_t,(fft_a).');
ylabel("Voltage(mV)");
xlabel("Frequency(hz)")
title('Frequency Domain of the Alocholic Signal');
legend("signal");
grid on;
```

### 3.3 Categorizing into $\alpha$ , $\beta$ and $\delta$

The EEG signals are categorized into different categories based on the frequency. The alpha , beta and delta forms are obtained and plotted in this project.A band pass filter was used for the same purpose. A array of zeros was made.The length of the array is same as that of the signal.The array value was given one at required positions to make a band pass filter.The filter was converted to time domain using ifft() function.We have to multiply the band pass filter and the signal in frequency domain to get required category,based on the filter.Convolution in time domain is same as multiplying in frequency domain.Therefore,the time domain filter was convoluted with signal, giving the required category in time domain.The frequency domain filter was multiplied to signal in frequency domain to form the categories in frequency domain.Alpha ,beta and Delta signals were plotted in time domain [Figure 5]and frequency domain[Figure 6].[Figure 7]

```
code:
clc;
b = co2a0000364; % Data Set
a=smoothdata(b);
Fs=254; % Sampling Frequency.

fft_a = fftshift(abs(fft(a))/length(a));
fft_t = linspace(-Fs/2,Fs/2,length(a));
therefore the signal is

%The frequency spectrum is in form of an array from 1 to 16448
%it is from -fs/2 to fs/2
%therefore array index 8225 corresponds to zero freuqnecy
n=8225;
N=length(fft_a);
vec_d=zeros(N,1);
p=round(N/254);
%254 Hz is equal to 16448 indices.therefore ,1 hz equal p indices
pos=(n:n+4*p);
vec_d(pos)=1;
```

```
pos_=(n-4*p:n);
vec_d(pos_)=1;

n=8225;
N=length(fft_a);
vec_a=zeros(N,1);
pos=(n+8*p:n+14*p);
vec_a(pos)=1;
pos_=(n-14*p:n-8*p);
vec_a(pos_)=1;

n=8225;
N=length(fft_a);
vec_b=zeros(N,1);
pos=(n+14*p:n+30*p);
vec_b(pos)=1;
pos_=(n-30*p:n-14*p);
vec_b(pos_)=1;

vec_1=vec_d.*fft_a;
vec_2=vec_a.*fft_a;
vec_3=vec_b.*fft_a;

figure(1)

subplot(311)
plot(fft_t,(vec_1))
axis([-50 50 0 2.7]);
ylabel("Voltage(mV)");
xlabel("freq(Hz)")
title("Delta");
legend("signal");
grid on;

subplot(312)
plot(fft_t,(vec_2))
axis([-50 50 0 2.7]);
ylabel("Voltage(mV)");
xlabel("freq(Hz)")
title("Alpha");
legend("signal");
grid on;

subplot(313)
plot(fft_t,(vec_3))
axis([-50 50 0 2.7]);
ylabel("Voltage(mV)");
xlabel("freq(Hz)")
title("Beta");
legend("signal");
grid on;



vec_dd=ifft(vec_d);
cc1=conv(a,vec_dd,'same');
vec_aa=ifft(vec_a);
cc2=conv(a,vec_aa,'same');
```

```
vec_bb=ifft(vec_b);
cc3=conv(a,vec_bb,'same');

figure(2)
subplot(311)
plot(cc1,'b')
axis([1000 2000 -1.5 2])
ylabel("Voltage(mV)");
xlabel("t(s)")
title("Delta");
legend("signal");
grid on;

subplot(312)
plot(cc2,'r')
axis([1000 2000 -1.5 2])
ylabel("Voltage(mV)");
xlabel("t(s)")
title("Alpha");
legend("signal");
grid on;

subplot(313)
plot(cc3,'y')
axis([1000 2000 -1.5 2])
ylabel("Voltage(mV)");
xlabel("t(s)")
title("Beta");
legend("signal");
grid on;
```

### 3.4 Categorizing using in-built function

The fir1() function was used to make required band pass filters and it was convoluted with the original signal.The results were plotted.[Figure 3][Figure 4]

```
Code:
b = co2a0000364; % Data Set
a=smoothdata(b);
fs=254;

%delta 0.5 -4 Hz
b1 = fir1(51,[0.5/128 4/128]);
c1 = conv(a,b1,'same');

%alpha 8-14 Hz
b2=fir1(51,[8/128 14/128]);
c2=conv(a,b2,'same');

%beta  14-30 Hz
b3=fir1(51,[14/128 30/128]);
c3=conv(a,b3,'same');

figure(1)
subplot(311)
plot(c1,'b')
axis([0 1000 -20 20])
```

```
ylabel("Voltage(mV)");
xlabel("t(s)")
title("Delta");
legend("signal");
grid on;

subplot(312)
plot(c2,'r')
axis([0 1000 -20 20])
ylabel("Voltage(mV)");
xlabel("t(s)")
title("Alpha");
legend("signal");
grid on;

subplot(313)
plot(c3,'y')
axis([0 1000 -20 20])
ylabel("Voltage(mV)");
xlabel("t(s)")
title("Beta");
legend("signal");
grid on;

figure(2)
plot(c1,'b'); hold on;
plot(c2,'r');hold on;plot(c3,'y');
axis([0 1000 -20 20])
ylabel("Voltage(mV)");
xlabel("t(s)")
title("Comparing alpha beta and delta");
legend(["Delta","Alpha","Beta"]);
grid on;
```

# 4 THOERY

The electroencephalogram (EEG) is a recording of the electrical activity of the brain from the scalp. The recorded graphs reflect the cortical electrical activity.Since the electrical activity in the brain is quite weak,it is measured in microvolts.Typical EEG systems have single channel to as many as 256 channels. Electrode placement on the head is based on a standard called the 10/20 system.The brain consists of billions of cells, half of which are neurons, half of which help and facilitate the activity of neurons. These neurons are densely interconnected via synapses, which act as gateways of inhibitory or excitatory activity.Any synaptic activity generates a subtle electrical impulse referred to as a postsynaptic potential. Of course, the burst of a single neuron is difficult to reliably detect without direct contact with it. However, whenever thousands of neurons fire in sync, they generate an electrical field which is strong enough to spread through tissue, bone, and skull. Eventually, it can be measured on the head surface.

# 5 RESULTS

## 5.1 Data

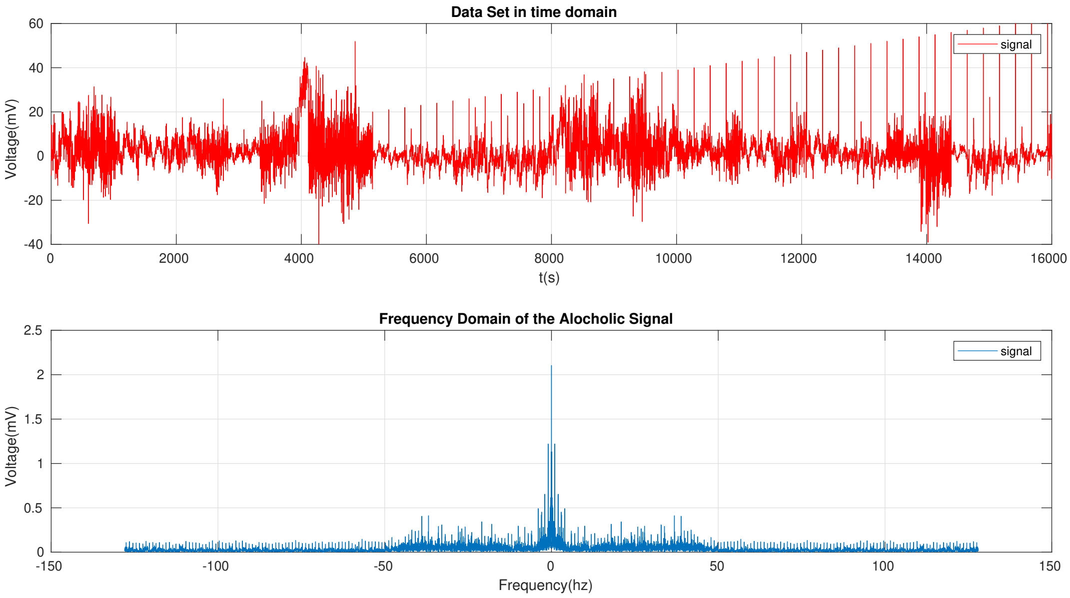


Figure 1 : Original Data set in time domain and frequency domain

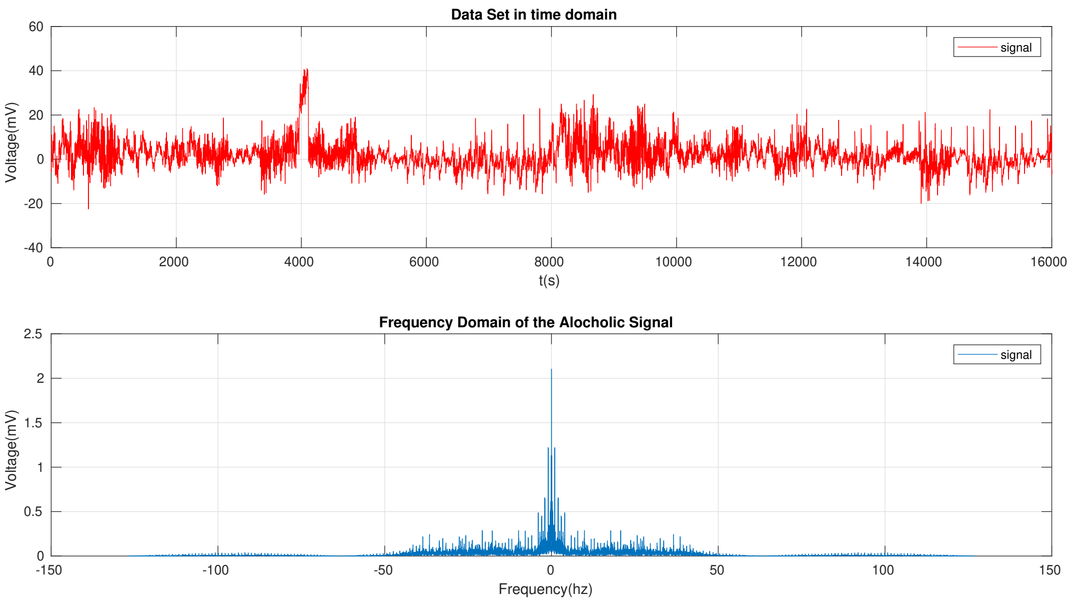


Figure 2 : Preprocessed Data set in time domain and frequency domain

## 5.2 Using Inbuilt filter function

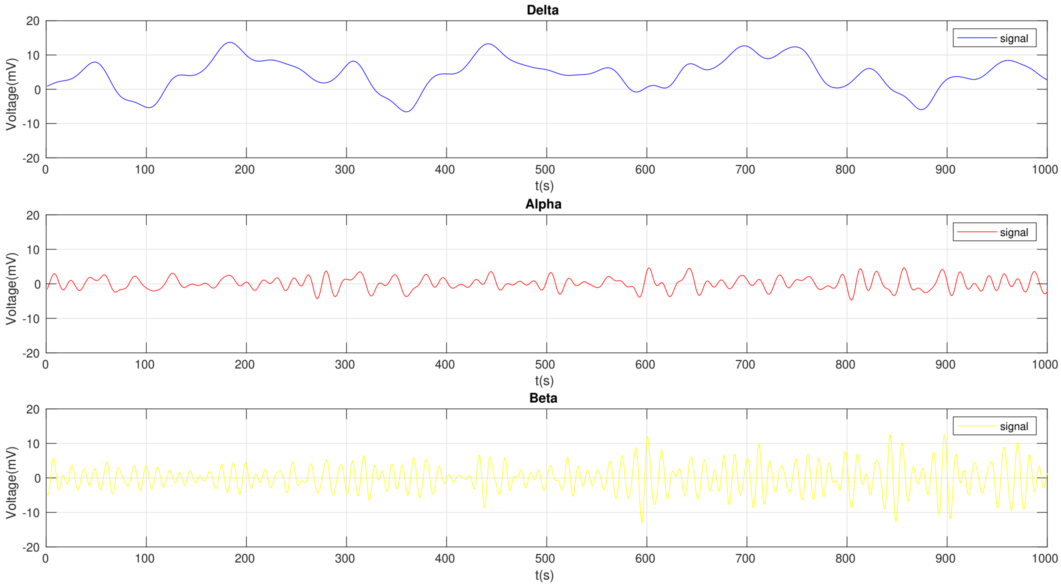


Figure 3 : Different categories of EEG signal obtained by in-built filter

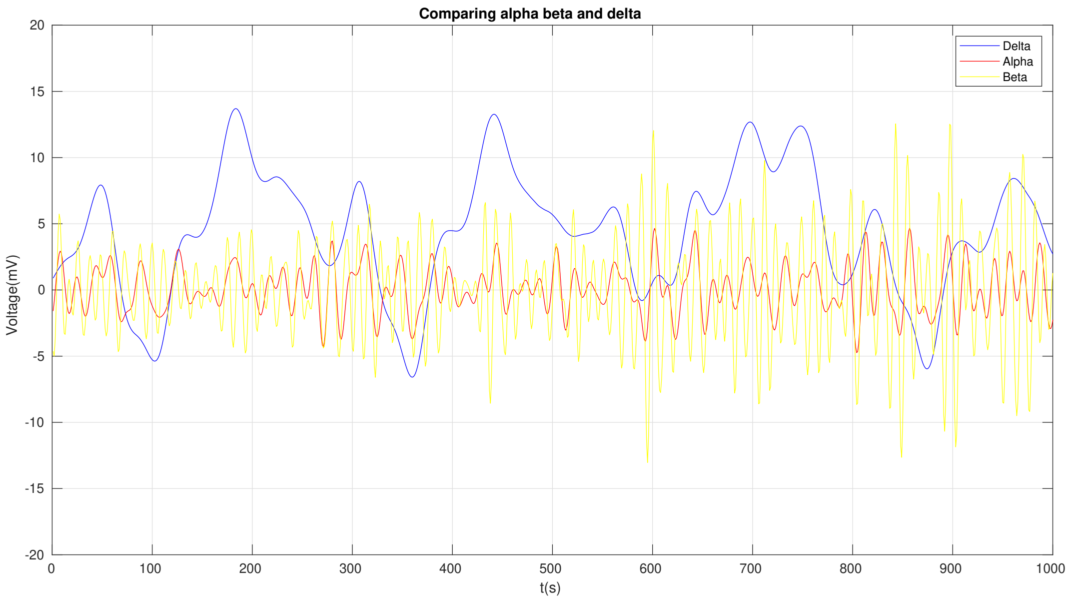


Figure 4 : All three categories above in same plot

### 5.3 Using self made filter

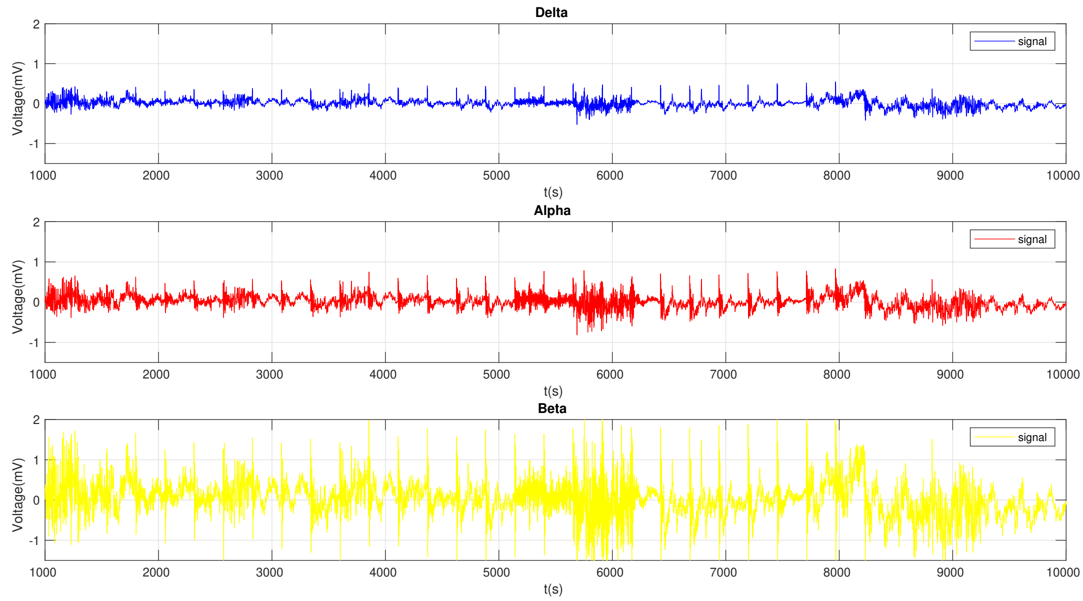


Figure 5 : Different categories of EEG signal obtained in time domain.

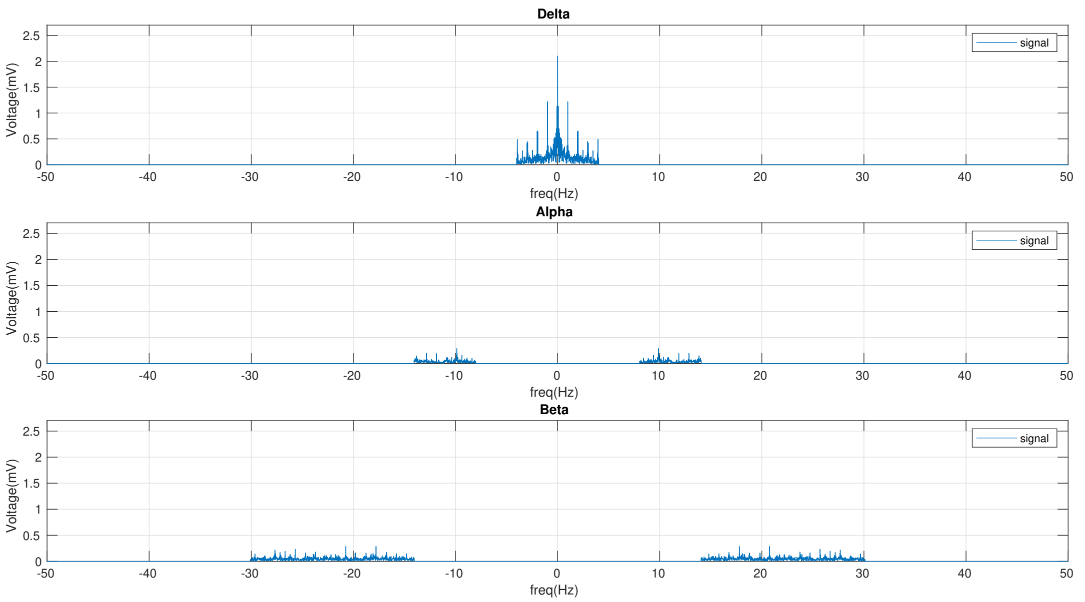


Figure 6 : Different categories of EEG signal obtained in frequency domain.

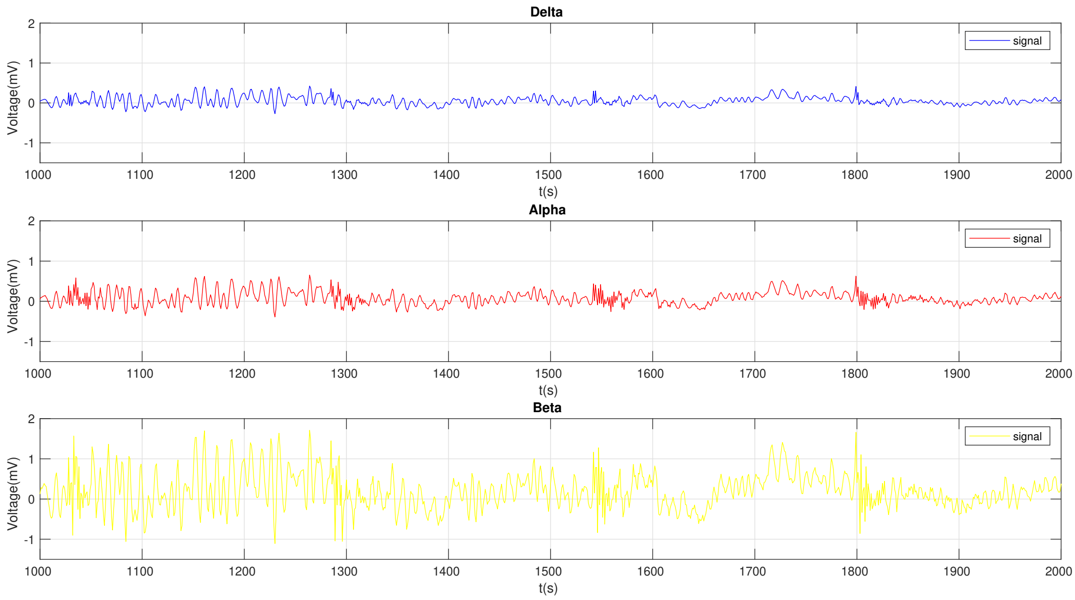


Figure 7 : Delta , Alpha , Beta

# 6 FUTURE WORK

The project deals with categorizing the original data set based on the frequencies of the comprising categories,alpha,delta and beta.This project can be extended to compute lot of characteristics like mean,minimum,maximum,average,standard deviation,variance,energy and power of the filtered signal.We can find the intensities of the sub bands of the signal and compare them between different subjects.

Since EEG signals are good indicators of global brain state,we can exploit this property and use them for truth identification.We can come up with a system to work with the frequency of the EEG wave.When the subject is calm,the signal is calm as well,but as the subject gets excited the signal's frequency increases.The beta part dominated more than the delta part. (delta<alpha<beta).We can find if the person lies if alpha category's contribution decreases and that of beta increases.Only three categories were used in describing the system ,as the project works only on those three.

The process can be done at least in one other way.In this project,the band pass filter was made in the frequency domain,inverse Fourier transformed to time domain and convoluted with the original signal which is already in time domain.Instead of this,the filter can be multiplied with the signal in the frequency domain and the output can be inverse Fourier transformed.

# 7 REFERENCES


- EEG Waves
- dataset-Henri Begleiter, Neurodynamics Laboratory,State University of New York Health Center,Brooklyn.
- Information about Experiment
- Working with data set
- Preprocessing
- q1 and q2 related theory