Experiment 04

Part 1: Synthesis of DTMF signal

Code:

```
function [x] = gen_dtmf(key, Fs)

t= 0:1/Fs:1;
switch key
    case '1'
      a = 697;
      b = 1209;
    case '2'
      a = 697;
      b = 1336;
    case '3'
      a = 697;
      b = 1477;
    case '4'
      a = 770;
      b = 1209;
    case '5'
      a = 770;
      b = 1336;
    case '6'
      a = 770;
      b = 1477;
    case '7'
      a = 852;
      b = 1209;
    case '8'
      a = 852;
      b = 1336;
    case '9'
      a = 852;
      b = 1477;
    case '*'
```

```
        a = 941;
        b = 1209;
    case '0'
        a = 941;
        b = 1336;
    case '#'
        a = 941;
        b = 1477;
    case 'A'
        a = 697;
        b = 1633;
    case 'B'
        a = 770;
        b = 1633;
    case 'C'
        a = 852;
        b = 1633;
    case 'D'
        a = 941;
        b = 1633;
end

x = cos(2*pi*a*t) + cos(2*pi*b*t);
end
```

Part 2 : DTMF decoder

Code:

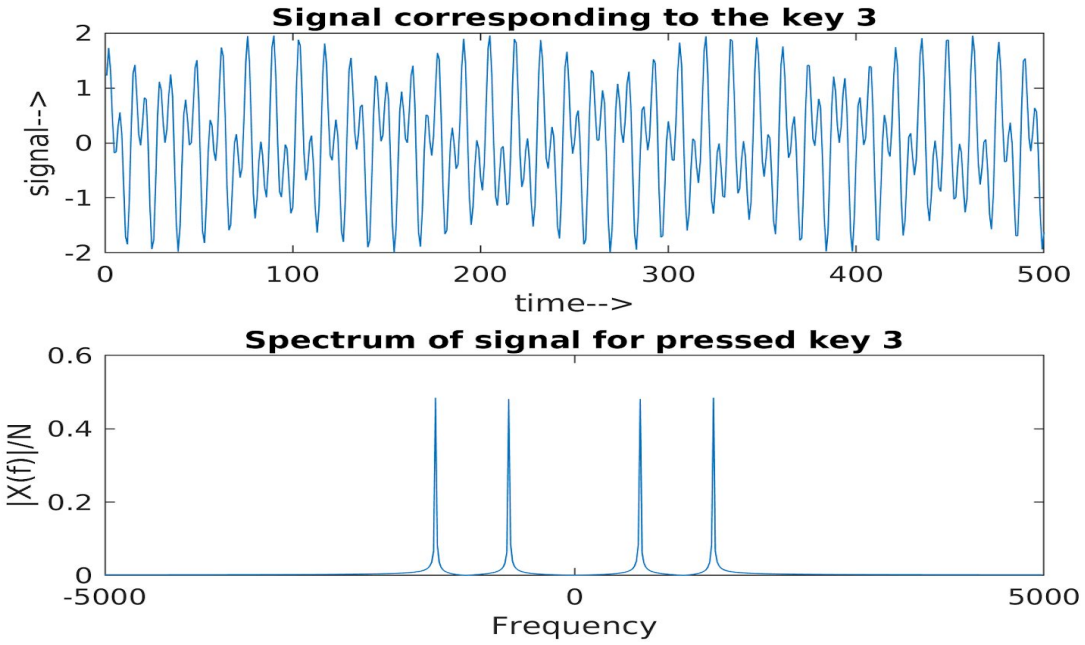
```
%%%%%%%%%%%%%%Exp04%%%%%%%%%%%%%%
clc
clear all
close all

key = 'B';
Fs = 3500;
nf = 1024;
```

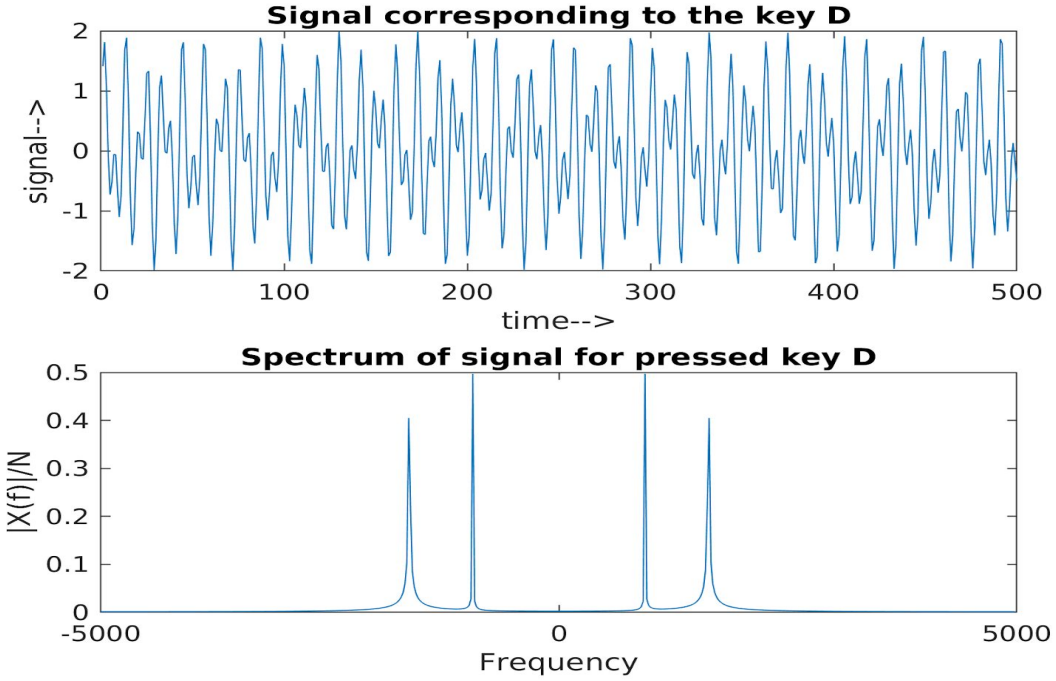
```
beta = 1;
L = Fs;

wc = [697 770 852 941 1209 1336 1477 1633];
x = gen_dtmf(key, Fs);
s = 0:1/Fs:0.1;

h1 = beta*cos(wc(1,1)*2*pi*s);
h2 = beta*cos(wc(1,2)*2*pi*s);
h3 = beta*cos(wc(1,3)*2*pi*s);
h4 = beta*cos(wc(1,4)*2*pi*s);
h5 = beta*cos(wc(1,5)*2*pi*s);
h6 = beta*cos(wc(1,6)*2*pi*s);
h7 = beta*cos(wc(1,7)*2*pi*s);
h8 = beta*cos(wc(1,8)*2*pi*s);

y1 = conv(x, h1);
y2 = conv(x, h2);
y3 = conv(x, h3);
y4 = conv(x, h4);
y5 = conv(x, h5);
y6 = conv(x, h6);
y7 = conv(x, h7);
y8 = conv(x, h8);

Y = zeros(1,8);
Y(1) = max(fftshift(abs(fft(y1,nf))));
Y(2) = max(fftshift(abs(fft(y2,nf))));
Y(3) = max(fftshift(abs(fft(y3,nf))));
Y(5) = max(fftshift(abs(fft(y5,nf))));
Y(6) = max(fftshift(abs(fft(y6,nf))));
Y(4) = max(fftshift(abs(fft(y4,nf))));
Y(7) = max(fftshift(abs(fft(y7,nf))));
Y(8) = max(fftshift(abs(fft(y8,nf))));

[M1,I1] = max(Y);
temp = Y(I1);
Y(I1) = -inf;
[M2, I2] = max(Y);
Y(I1) = temp;

Key = 100;                    %%%iniatlize key as a random value
```

```
if(l1 == 1 && l2 == 5 )
    Key = '1';
elseif(l2 == 1 && l1 == 5)
    Key = '1';
elseif(l1 == 1 && l2 == 6)
    Key = '2';
elseif(l2 == 1 && l1 == 6)
    Key = '2';
elseif (l1 == 1 && l2 == 7)
    Key = '3';
elseif(l2 == 1 && l1 == 7)
    Key = '3';
elseif(l1 == 2 && l2 == 5)
    Key = '4';
elseif(l2 == 2 && l1 == 5)
    Key = '4';
elseif(l1 == 2 && l2 == 6)
    Key = '5';
elseif(l2 == 2 && l1 == 6)
    Key = '5';
elseif(l1 == 2 && l2 == 7)
    Key = '6';
elseif(l2 == 2 && l1 == 7)
    Key = '6';
elseif(l1 == 3 && l2 == 5)
    Key = '7';
elseif(l2 == 3 && l1 == 5)
    Key = '7';
elseif(l1 == 3 && l2 == 6)
    Key = '8';
elseif(l2 == 3 && l1 == 6)
    Key = '8';
elseif(l1 == 3 && l2 == 7)
    Key = '9';
elseif(l2 == 3 && l1 == 7)
    Key = '9';
elseif(l1 == 4 && l2 == 6)
    Key = '0';
elseif(l2 == 4 && l1 == 6)
    Key = '0';
elseif(l1 == 4 && l2 == 5)
```

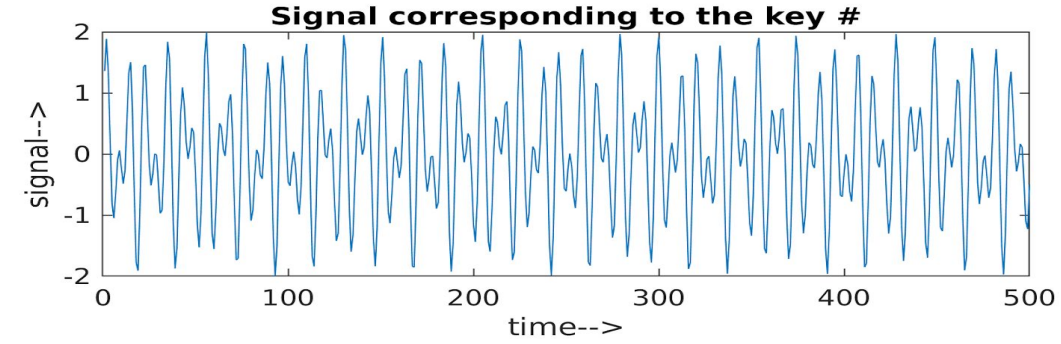
```
    Key = '*';
elseif(l2 == 4 && l1 == 5)
    Key = '*';
elseif(l1 == 4 && l2 == 7)
    Key = '#';
elseif(l2 == 4 && l1 == 7)
    Key = '#';
elseif(l1 == 1 && l2 == 8)
    Key = 'A';
elseif(l2 == 1 && l1 == 8)
    Key = 'A';
elseif(l1 == 2 && l2 == 8)
    Key = 'B';
elseif(l2 == 2 && l1 == 8)
    Key = 'B';
elseif(l1 == 3 && l2 == 8)
    Key = 'C';
elseif(l2 == 3 && l1 == 8)
    Key = 'C';
elseif(l1 == 4 && l2 == 8)
    Key = 'D';
elseif(l2 == 4 && l1 == 8)
    Key = 'D';
End
```

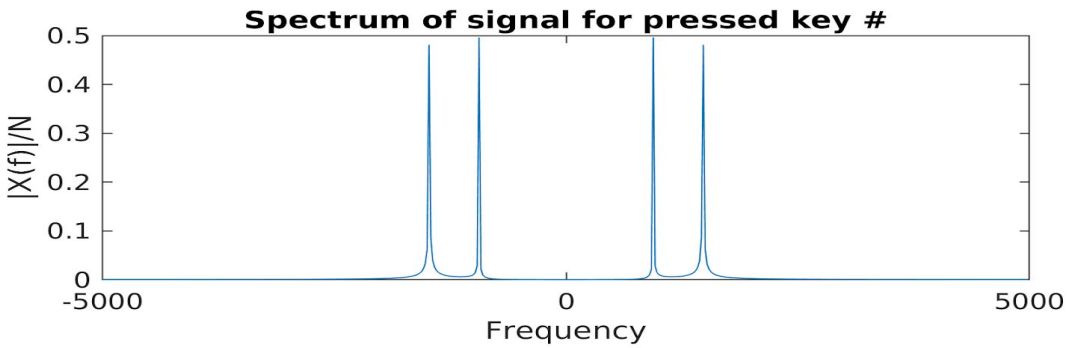
Key

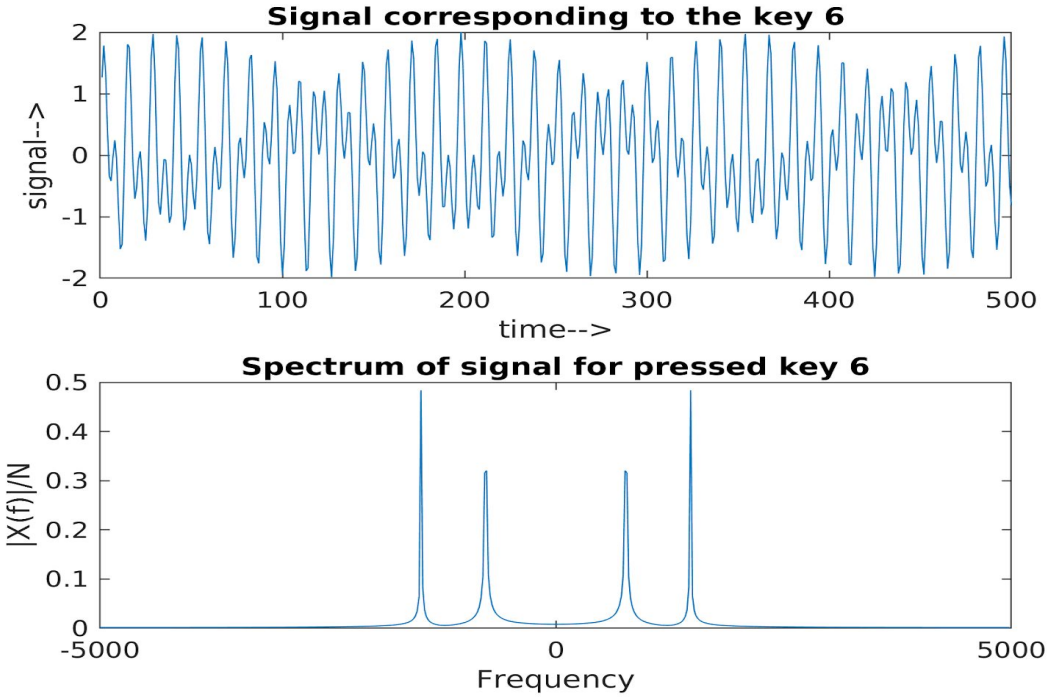



Signal corresponding to the key D
signal-->
time-->

Spectrum of signal for pressed key D
|X(f)|/N
Frequency


Signal corresponding to the key #
signal-->
time-->


Spectrum of signal for pressed key #
|X(f)|/N
Frequency



- A DTMF tone representing a single key selected consists of two summed frequencies that have been chosen such that no harmonics occurs .
- The sampling frequency used is much more than the maximum frequency component listed,so there will not arise a case of aliasing which reduces the probability of wrong detection of key .
- No frequency is an integer multiple of one another so that no overlap occurs at the receiver side.
- Difference or sum of any two frequencies does not equal any of the defined frequencies.
- To decode a DTMF signal,8 band pass filters each centered at one of the DTMF frequencies implemented by a L point FIR BPF.
- Larger the value of L,narrower is the bandwidth of the bandpass filter as the width of he mainlobe is inversely proportional to the length of the filter(L).
- The maximum of them among row frequencies(magnitude of FFT) and column frequencies are determined to detect the key selected from the signal received.