%PART 4.1

fs = 1/(0.3e-3);

ww = -pi:(pi/1000):pi;

%FILTER #1

F = [679 770];

A = [1 0];

DEV = [0.02 0.01];

[N, Fo, Ao, W] = firpmord(F, A, DEV, fs);

%order is 64, but needs to be increased to meet specs

B1 = firpm(N+2, Fo, Ao, W);

% figure

% H1 = freqz(B1, 1, ww);

% plot(ww, abs(H1)), grid on

% xlabel('Normalized Radian Frequency')

% title('Filter #1')

%Filter #2

F = [679 764 776 852];

A = [0 1 0];

DEV = [0.01 0.02 0.01];

[N, Fo, Ao, W] = firpmord(F, A, DEV, fs);

%order is N = 76, but can be smaller

B2 = firpm(N-10, Fo, Ao, W);

% figure

% H2 = freqz(B2, 1, ww);

% plot(ww, abs(H2)), grid on

% xlabel('Normalized Radian Frequency')

% title('Filter #2')

%Filter #3

F = [770 852-6 852+6 941];

A = [0 1 0];

DEV = [0.01 0.02 0.01];

[N, Fo, Ao, W] = firpmord(F, A, DEV, fs);

B3 = firpm(N-10, Fo, Ao, W);

% figure

% H3 = freqz(B3, 1, ww);

% plot(ww, abs(H3)), grid on

% xlabel('Normalized Radian Frequency')

% title('Filter #3')

%Filter #4

F = [852 941-6 941+6 941+(941-852)];

A = [0 1 0];

DEV = [0.01 0.02 0.01];

[N, Fo, Ao, W] = firpmord(F, A, DEV, fs);

%N is 70, but can be lower

B4 = firpm(N-6, Fo, Ao, W);

% figure

% H4 = freqz(B4, 1, ww);

% plot(ww, abs(H4)), grid on

% xlabel('Normalized Radian Frequency')

% title('Filter #4')

%Filter #5

F = [1082 1203 1215 1336];

A = [0 1 0];

DEV = [0.01 0.02 0.01];

[N, Fo, Ao, W] = firpmord(F, A, DEV, fs);

%order is N = 48, but can be smaller

B5 = firpm(N-4, Fo, Ao, W);

% figure

% H5 = freqz(B5, 1, ww);

% plot(ww, abs(H5)), grid on

% xlabel('Normalized Radian Frequency')

% title('Filter #5')

%Filter #6

F = [1209 1336-6 1336+6 1477];

A = [0 1 0];

DEV = [0.01 0.02 0.01];

[N, Fo, Ao, W] = firpmord(F, A, DEV, fs);

%N = 48, but can be lower

B6 = firpm(N-6, Fo, Ao, W);

% figure

% H6 = freqz(B6, 1, ww);

% plot(ww, abs(H6)), grid on

% xlabel('Normalized Radian Frequency')

% title('Filter #6')

%Filter #7

F = [1336 1477-6 1477+6 1633];

A = [0 1 0];

DEV = [0.01 0.02 0.01];

[N, Fo, Ao, W] = firpmord(F, A, DEV, fs);

%N is 43, but must be even and can be lower

B7 = firpm(N-3, Fo, Ao, W);

% figure

% H7 = freqz(B7, 1, ww);

% plot(ww, abs(H7)), grid on

% xlabel('Normalized Radian Frequency')

% title('Filter #7')

%Filter #8

F = [1477 1633];

A = [0 1];

DEV = [0.01 0.02];

[N, Fo, Ao, W] = firpmord(F, A, DEV, fs);

%order is 38, but needs to be increased to fit specs

B8 = firpm(N+6, Fo, Ao, W);

% figure

% H8 = freqz(B8, 1, ww);

% plot(ww, abs(H8)), grid on

% xlabel('Normalized Radian Frequency')

% title('Filter #8')

%Fixing Delay

delay4 = [0 1];

B4 = conv(B4, delay4);

delay5 = [zeros(1,10) 1];

B5 = conv(B5, delay5);

delay6 = [zeros(1,11) 1];

B6 = conv(B6, delay6);

delay7 = [zeros(1,12) 1];

B7 = conv(B7, delay7);

delay8 = [zeros(1,10) 1];

B8 = conv(B8, delay8);

%filters who did not have delay adjusted have length 67

add4 = length(B1) - length(B4);

B4 = [B4 zeros(1, add4)];

add5 = length(B1) - length(B5);

B5 = [B5 zeros(1, add5)];

add6 = length(B1) - length(B6);

B6 = [B6 zeros(1, add6)];

add7 = length(B1) - length(B7);

B7 = [B7 zeros(1, add7)];

add8 = length(B1) - length(B8);

B8 = [B8 zeros(1, add8)];

%Now all filters have the same delay and length.

%PART 4.2

%(a)

xx = DTMFdial('159D\*86A', fs);

figure

subplot(211)

plotspec(xx,fs);

subplot(212)

yy1 = firfilt(B1, xx);

plotspec(yy1,fs);

title('Filter #1')

figure

subplot(211)

plotspec(xx,fs);

subplot(212)

yy2 = firfilt(B2, xx);

plotspec(yy2,fs);

title('Filter #2')

figure

subplot(211)

plotspec(xx,fs);

subplot(212)

yy3 = firfilt(B3, xx);

plotspec(yy3,fs);

title('Filter #3')

figure

subplot(211)

plotspec(xx,fs);

subplot(212)

yy4 = firfilt(B4, xx);

plotspec(yy4,fs);

title('Filter #4')

figure

subplot(211)

plotspec(xx,fs);

subplot(212)

yy5 = firfilt(B5, xx);

plotspec(yy5,fs);

title('Filter #5')

figure

subplot(211)

plotspec(xx,fs);

subplot(212)

yy6 = firfilt(B6, xx);

plotspec(yy6,fs);

title('Filter #6')

figure

subplot(211)

plotspec(xx,fs);

subplot(212)

yy7 = firfilt(B7, xx);

plotspec(yy7,fs);

title('Filter #7')

figure

subplot(211)

plotspec(xx,fs);

subplot(212)

yy8 = firfilt(B8, xx);

plotspec(yy8,fs);

title('Filter #8')

%(b)

Bh = hamming(99);

R = round(99/4);

avgpower1 = firfilt(Bh, yy1.^2);

pDownSampled1 = avgpower1(1:R:end);

figure

strips(pDownSampled1);

title('Downsampled Filter #1')

avgpower2 = firfilt(Bh, yy2.^2);

pDownSampled2 = avgpower2(1:R:end);

figure

strips(pDownSampled2);

title('Downsampled Filter #2')

avgpower3 = firfilt(Bh, yy3.^2);

pDownSampled3 = avgpower3(1:R:end);

figure

strips(pDownSampled3);

title('Downsampled Filter #3')

avgpower4 = firfilt(Bh, yy4.^2);

pDownSampled4 = avgpower4(1:R:end);

figure

strips(pDownSampled4);

title('Downsampled Filter #4')

avgpower5 = firfilt(Bh, yy5.^2);

pDownSampled5 = avgpower5(1:R:end);

figure

strips(pDownSampled5);

title('Downsampled Filter #5')

avgpower6 = firfilt(Bh, yy6.^2);

pDownSampled6 = avgpower6(1:R:end);

figure

strips(pDownSampled6);

title('Downsampled Filter #6')

avgpower7 = firfilt(Bh, yy7.^2);

pDownSampled7 = avgpower7(1:R:end);

figure

strips(pDownSampled7);

title('Downsampled Filter #7')

avgpower8 = firfilt(Bh, yy8.^2);

pDownSampled8 = avgpower8(1:R:end);

figure

strips(pDownSampled8);

title('Downsampled Filter #8')

%(c)

matrix = horzcat(pDownSampled1(:),pDownSampled2(:),pDownSampled3(:), pDownSampled4(:),... pDownSampled5(:), pDownSampled6(:), pDownSampled7(:), pDownSampled8(:));

phoneNumber = decodeDTMF(matrix, fs, R);