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10 March 2017 LAB5 Checks functionality of FIR window design ... create a number realizable FIR filter

Part 1: Check filter design

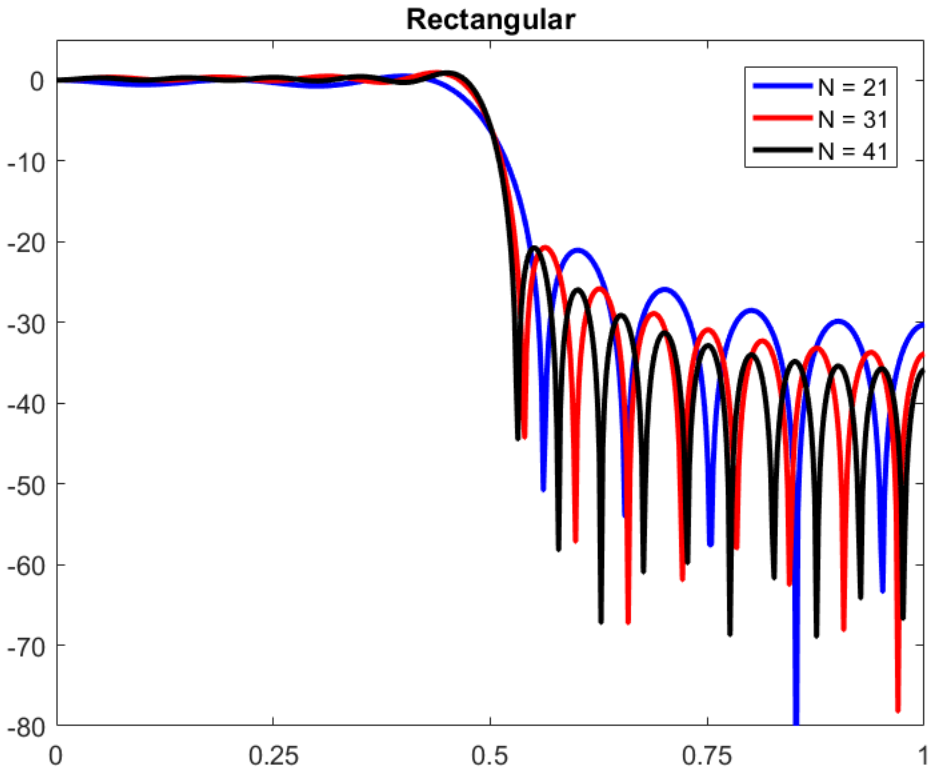
```
    test_lab5a
```

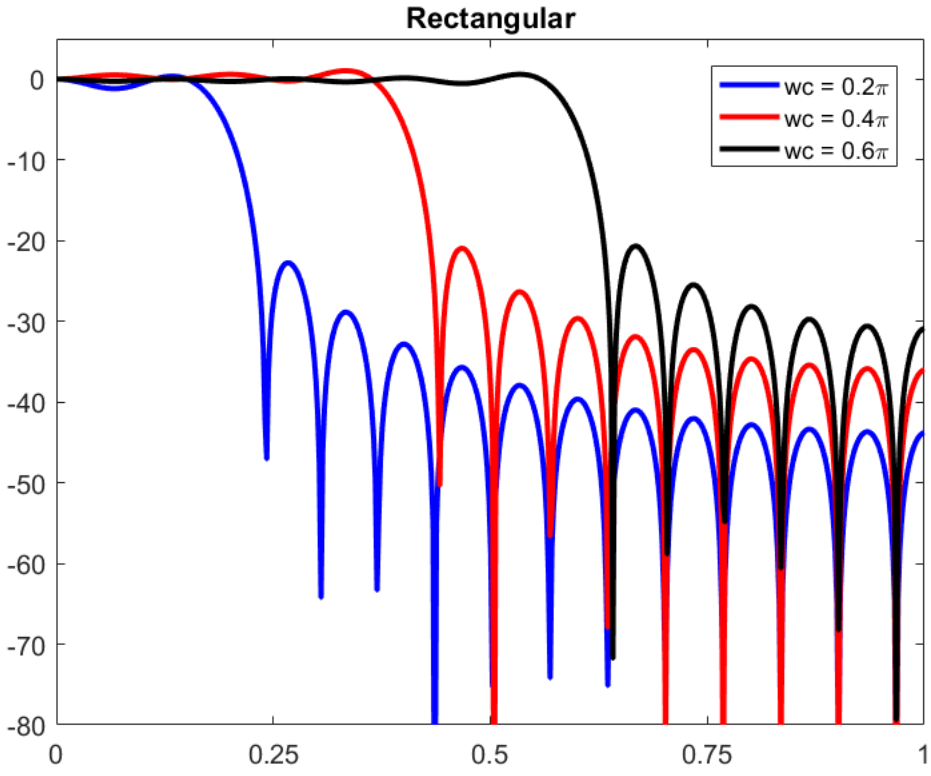
```
Testing 'rectfilt' with N=21 and wc=0.25: O.K.
Testing 'rectfilt' with N=31 and wc=0.25: O.K.
Testing 'rectfilt' with N=41 and wc=0.25: O.K.
Testing 'rectfilt' with N=21 and wc=0.50: O.K.
Testing 'rectfilt' with N=31 and wc=0.50: O.K.
Testing 'rectfilt' with N=41 and wc=0.50: O.K.
Testing 'rectfilt' with N=21 and wc=0.75: O.K.
Testing 'rectfilt' with N=31 and wc=0.75: O.K.
Testing 'rectfilt' with N=41 and wc=0.75: O.K.

Testing 'hammingfilt' with N=21 and wc=0.25: O.K.
Testing 'hammingfilt' with N=31 and wc=0.25: O.K.
Testing 'hammingfilt' with N=41 and wc=0.25: O.K.
Testing 'hammingfilt' with N=21 and wc=0.50: O.K.
Testing 'hammingfilt' with N=31 and wc=0.50: O.K.
Testing 'hammingfilt' with N=41 and wc=0.50: O.K.
Testing 'hammingfilt' with N=21 and wc=0.75: O.K.
Testing 'hammingfilt' with N=31 and wc=0.75: O.K.
Testing 'hammingfilt' with N=41 and wc=0.75: O.K.

Testing 'kaiserfilt' with deltaOmega=0.1, delta=0.01:
 N (45) is correct, beta (3.39532) is correct
 Checking wc=0.25: O.K.
 Checking wc=0.50: O.K.
 Checking wc=0.75: O.K.
Testing 'kaiserfilt' with deltaOmega=0.1, delta=0.00097:
 N (73) is correct, beta (5.68242) is correct
 Checking wc=0.25: O.K.
 Checking wc=0.50: O.K.
 Checking wc=0.75: O.K.
```

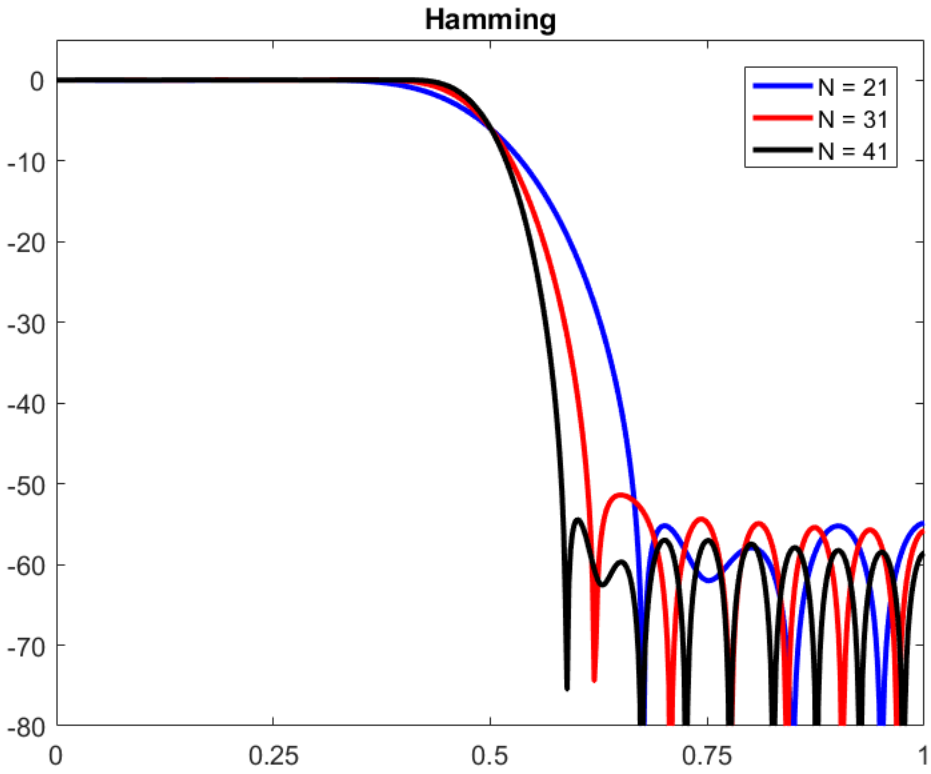
```
Testing 'kaiserfilt' with deltaOmega=0.1, delta=9.7e-05:
 N (101) is correct, beta (7.88642) is correct
 Checking wc=0.25: O.K.
 Checking wc=0.50: O.K.
 Checking wc=0.75: O.K.
Testing 'kaiserfilt' with deltaOmega=0.2, delta=0.01:
 N (23) is correct, beta (3.39532) is correct
 Checking wc=0.25: O.K.
 Checking wc=0.50: O.K.
 Checking wc=0.75: O.K.
Testing 'kaiserfilt' with deltaOmega=0.2, delta=0.00097:
 N (37) is correct, beta (5.68242) is correct
 Checking wc=0.25: O.K.
 Checking wc=0.50: O.K.
 Checking wc=0.75: O.K.
Testing 'kaiserfilt' with deltaOmega=0.2, delta=9.7e-05:
 N (51) is correct, beta (7.88642) is correct
 Checking wc=0.25: O.K.
 Checking wc=0.50: O.K.
 Checking wc=0.75: O.K.
```

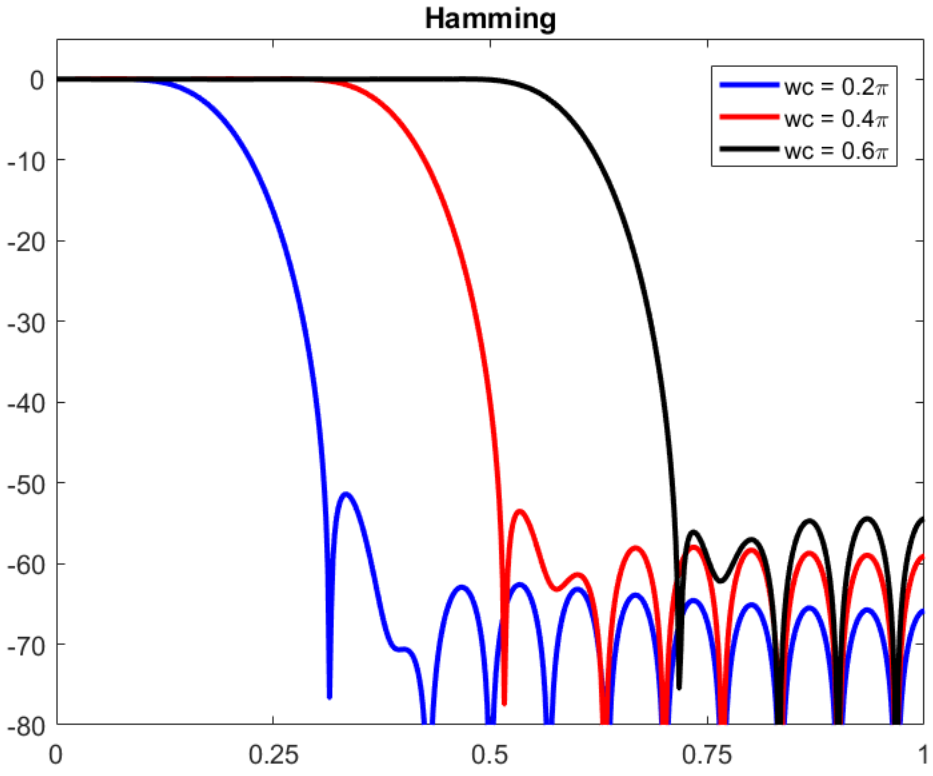
Part II: Comparative behavior of window filters

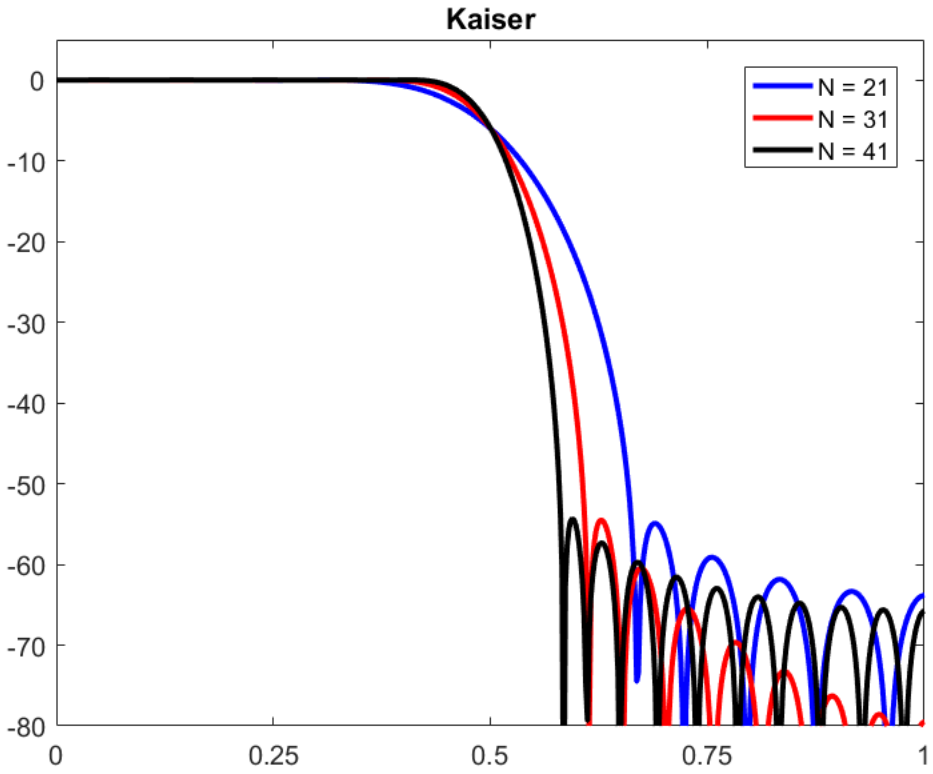
```
test_lab5b
```

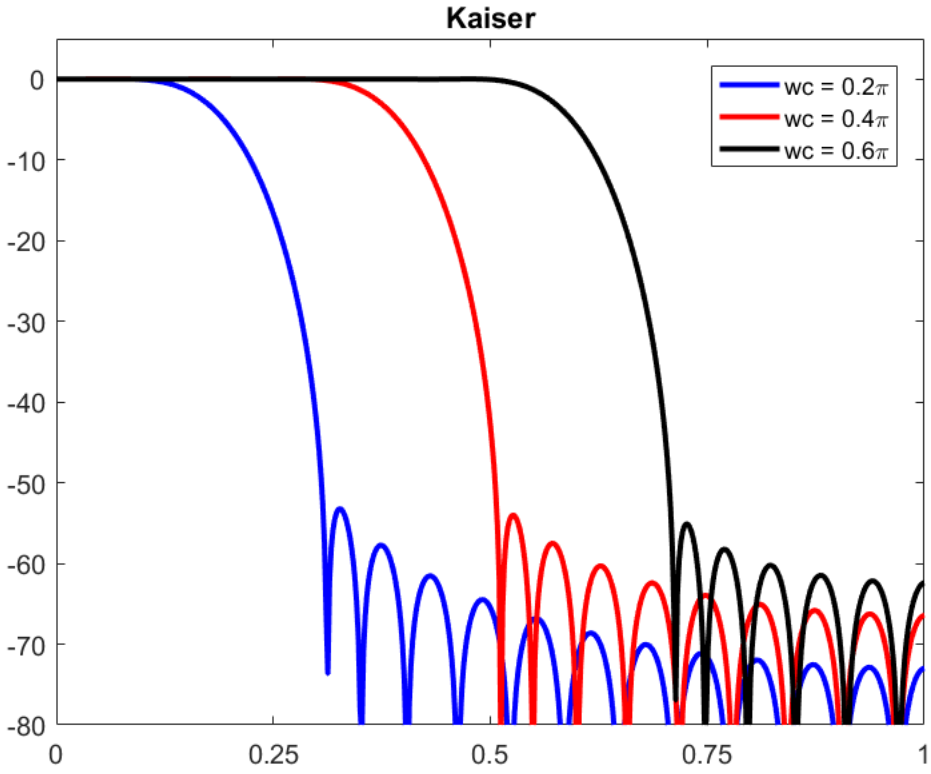


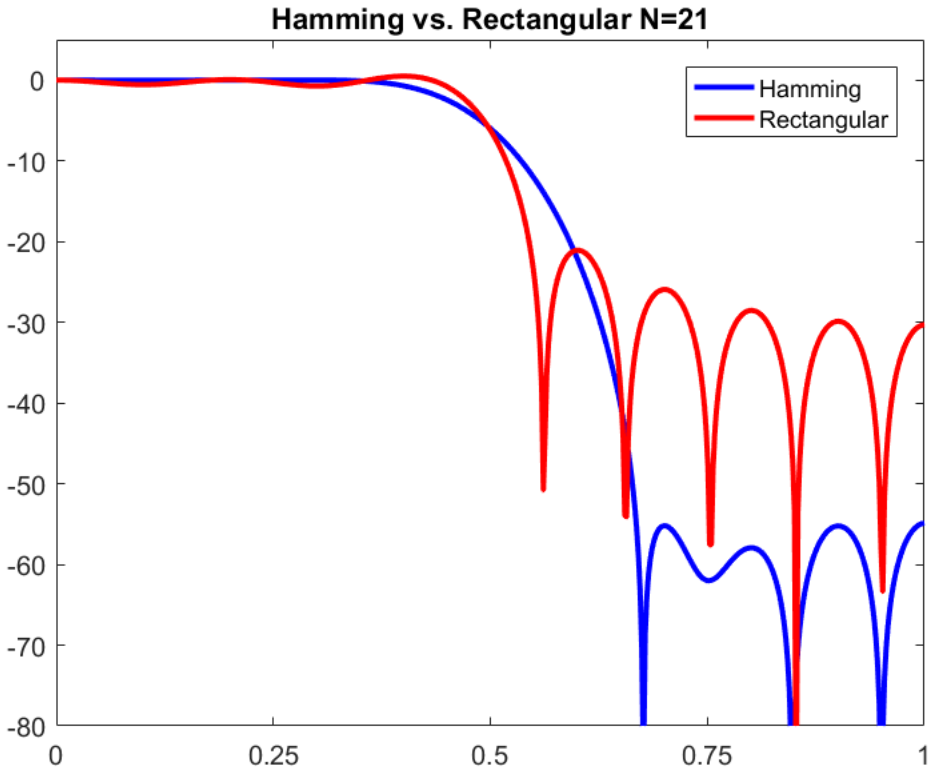

Rectangular
wc = 0.2π
wc = 0.4π
wc = 0.6π
0
-10
-20
-30
-40
-50
-60
-70
-80
0
0.25
0.5
0.75
1

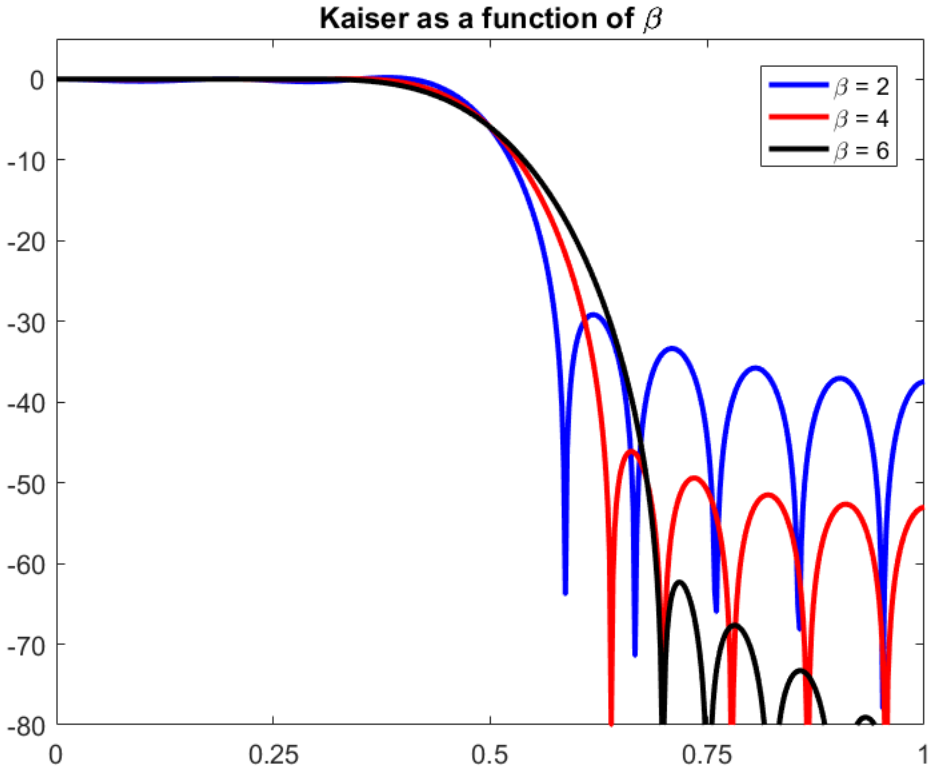

Hamming
N = 21
N = 31
N = 41
0
-10
-20
-30
-40
-50
-60
-70
-80
0
0.25
0.5
0.75
1

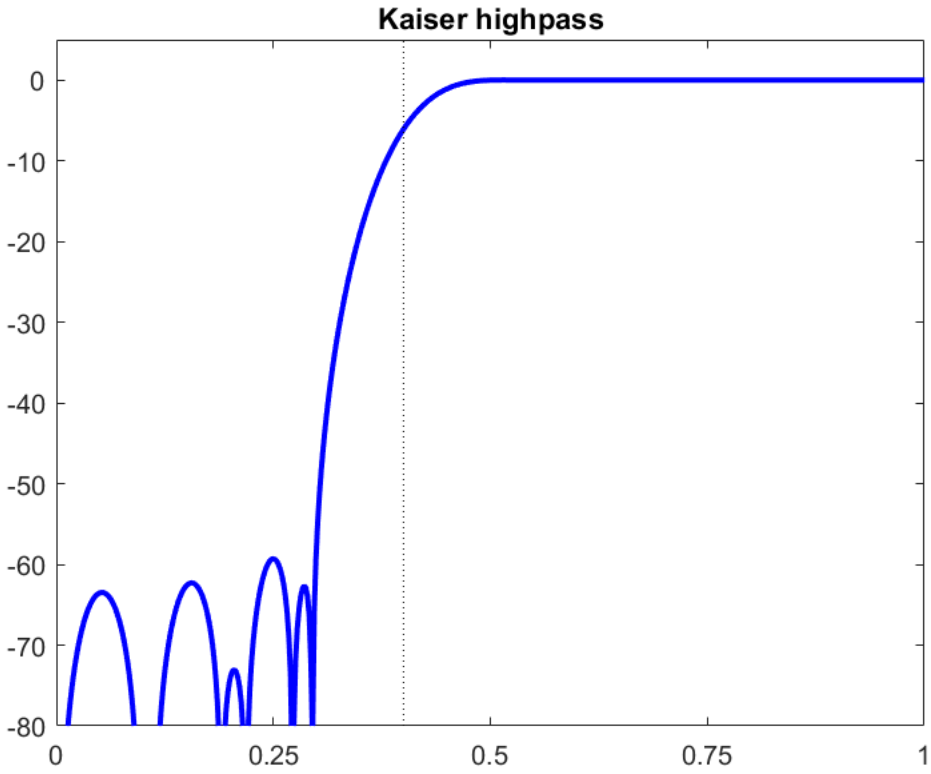

Hamming
wc = 0.2π
wc = 0.4π
wc = 0.6π
0
-10
-20
-30
-40
-50
-60
-70
-80
0
0.25
0.5
0.75
1


Kaiser
N = 21
N = 31
N = 41
0
-10
-20
-30
-40
-50
-60
-70
-80
0
0.25
0.5
0.75
1


Kaiser
wc = 0.2π
wc = 0.4π
wc = 0.6π
0
-10
-20
-30
-40
-50
-60
-70
-80
0
0.25
0.5
0.75
1


Hamming vs. Rectangular N=21
Hamming
Rectangular
0
-10
-20
-30
-40
-50
-60
-70
-80
0
0.25
0.5
0.75
1


Kaiser as a function of β
β = 2
β = 4
β = 6
0
-10
-20
-30
-40
-50
-60
-70
-80
0
0.25
0.5
0.75
1


Kaiser highpass
0
-10
-20
-30
-40
-50
-60
-70
-80
0
0.25
0.5
0.75
1

Part III: Phone tones

```
    test_lab5c
```

```
Signal to noise ratio of row tones: 53.6423
Signal to noise ratio of column tones: 7.0686
```

Part IV: Program .m scripts

```
disp('************* rectfilt.m  *************')
type('rectfilt')
disp('************* hammingfilt.m  *************')
type('hammingfilt')
disp('************* kaiserparams.m  *************')
type('kaiserparams')
disp('************* kaiserfilt.m  *************')
type('kaiserfilt')
disp('************* magdb.m  *************')
type('magdb')
disp('************* separate.m  *************')
type('separate')
```

```
************* rectfilt.m  *************

function h = rectfilt(N,w)

n = -((N-1)*(.5)) : ((N-1)*(.5));
N = ceil(N)+1-rem(ceil(N),2);
        % Ceil--> round to positive infinity

% Impulse Response
h = (w/pi) * sinc(w*n);
h = h/sum(h);
  % Returns the sum of the elements of A along the first array
 dimension
end
************* hammingfilt.m  *************

function h = hammingfilt(N,w)

N = ceil(N) + 1 - rem(ceil(N),2);
% Ceil--> round to positive infinity
% r = rem(a,b) returns the remainder after division of a by b
n = -((N-1)*(.5)) : ((N-1)*(.5));

W=0.54+0.46*cos((2*pi*n)/(N-1));
 % Equation for Hamming Window
h=(w/pi)*sinc(w*n).*W;
h=h/sum(h);

end
************* kaiserparams.m  *************
```

```
function [N, B] = kaiserparams(deltaOmega, delta)
% Kaiserparams   Returns Kaiser design parameters N and beta.
A = -mag2db(delta); % Convert magnitude to decibels
% procedure to compute Beta and N ...
if A>50
    B = 0.1102 * (A-8.7);
elseif 21 <= A <= 50
    B = 0.5842 * (A-21)^0.4 + 0.07886 * (A-21);
else
    B = 0;
end

N = ceil((A-8)/(2.285*deltaOmega*pi));
end
************* kaiserfilt.m  *************

function h = kaiserfilt(N,w,beta)

n = -((N-1)*(.5)) : ((N-1)*(.5));

W = (besseli(0,(beta*(1-((2*n)/(N-1)).^(2)).^(1/2)))./
(besseli(0,beta));
 % computes the modified Bessel function of the first kind for the
 above
h = (w/pi)*sinc(w*n).*W;
h = h / sum(h);

end
************* magdb.m  *************

function ph = magdb(h)
    % Convert magnitude to decibels
w = linspace(0,2,1024);
H = fft(h,1024);
ph = plot(w,20 * log10(abs(H)));
xlim([0,1]);

end
************* separate.m  *************

function [sr, sc] =separate(s, fs)
% Separate row and column tone for a DTMF tone

 [N , beta] = kaiserparams(0.05, 0.005);
 N = N + 1 - mod(N,2);
 Hlp = kaiserfilt(N, 2 * 1050/fs, beta);
 hhp = -Hlp; % flip the low-pass filter

 hhp(ceil(end/2)+1) = 1 + hhp(ceil(end/2)+1);

 sr = conv(s,Hlp);
 sc = conv(s,hhp);
end
```

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