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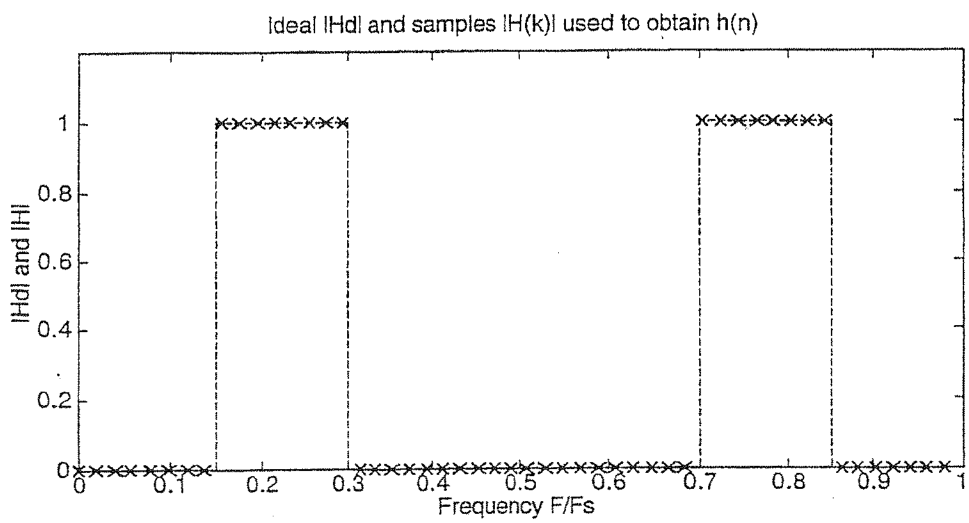
% EE253                                                    Prof. Essam Marouf
% DSP I                                                    Matlab Handout # 6
% ---------------------------------------------------------------------------
%
% FIR Design by the Frequency Sampling Method
% ----------------------------------------------
%
% Choose H(k), 0 <= k <= N-1, to be N equispaced samples of some (ideal)
% desired Hd(e^jw).  The finite impulse response h(n), 0 <= n <= N-1, follows
% as the inverse DFT of H(k).
%
% Desired Hd
% -----------
w1=0.3*pi;   w2=0.6*pi;
Hd=[0  0  1  1  0  0  1  1  0  0];
wd=[0  w1  w1  w2  w2  2*pi-w2  2*pi-w2  2*pi-w1  2*pi-w1 2*pi];
%
M=50  ;                              % Filter order is assumed to be M = 50
N=M+1;                               % transform size
k=[0:N-1];
w=2*pi*k/N;
index1=find(w <w1);               % indeces of samples satisfying stated condition
index2=find(w>=w1 & w<=w2);
index3=find(w>w2 & w < 2*pi-w2);
index4=find(w>=2*pi-w2 & w <= 2*pi -w1);
index5=find(w>2*pi-w1 & w<2*pi);
%
H_mag=[zeros(size(index1)) ones(size(index2)) zeros(size(index3)) ...
    ones(size(index4)) zeros(size(index5))];
H=H_mag .* exp(-j*w*M/2);               % Linear phase filter; h(n) is causal
%
plot(wd/(2*pi), Hd,'--b', w/(2*pi), abs(H),'xr')
axis([0 1 0 1.2]);
xlabel('Frequency F/Fs'), ylabel('|Hd| and |H|'),
title('Ideal |Hd| and samples |H(k)| used to obtain h(n)')
pause
```

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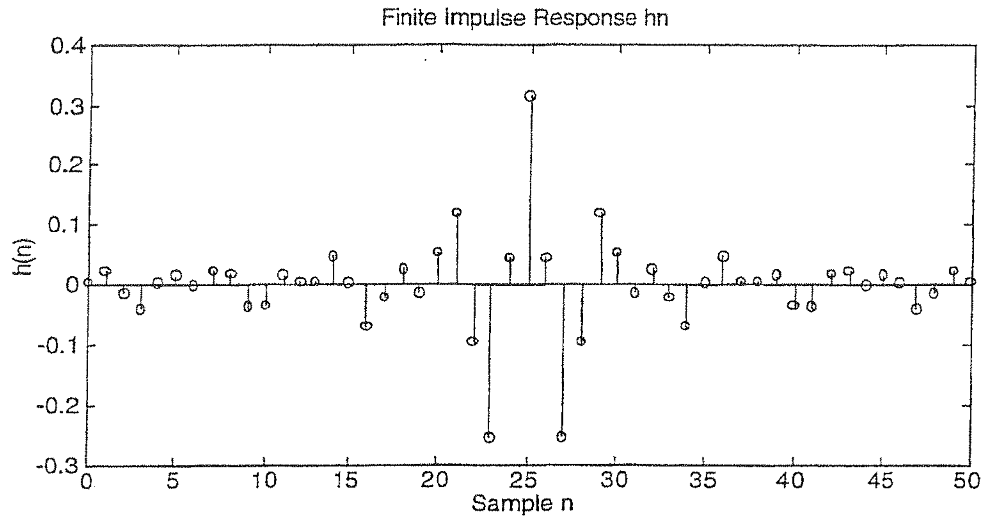
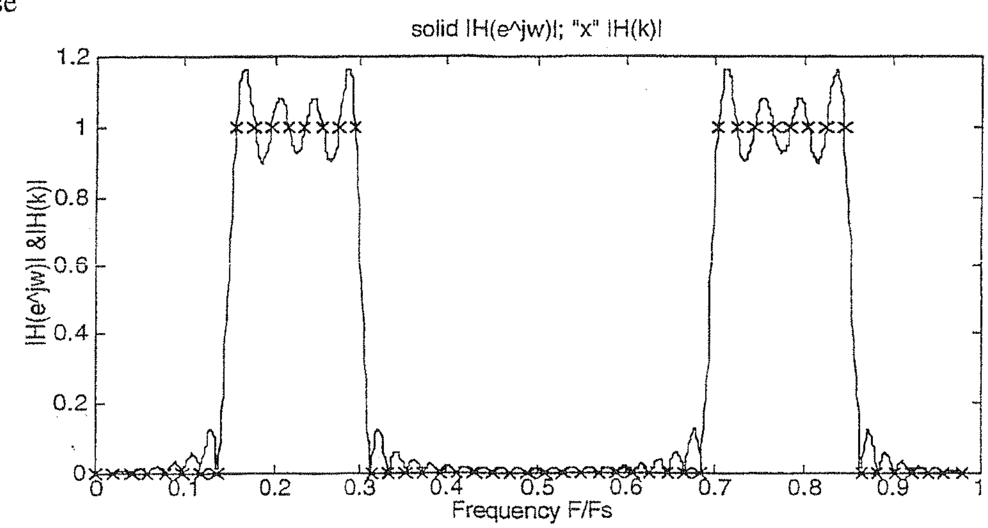
% Obtain h(n) by computing the inverse DFT of H(k)
h=real(ifft(H,N));
%
stem(k,h), xlabel('Sample n'), ylabel('h(n)'),
title('Finite Impulse Response hn'), pause
%
```




```
% Note that DTFT{h(n)} = H(e^jw) should agree with Hd at the selected
% samples, but differs from Hd in between the samples. Below, we compute
% H(e^jw) using Matlab's "freqz" over a large number of points along the unit circle.
%
b=h; a=1 % FIR filter
nn=1024;
[HH,ww]=freqz(b,a,nn,'whole');
plot(ww/(2*pi), abs(HH), '-g', w/(2*pi), abs(H),'xr')
xlabel('Frequency F/Fs'), ylabel(' |H(e^jw)| &|H(k)|'),
title('solid |H(e^jw)|; "x" |H(k)|'),
pause
```

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%
% Note the apparent Gibb's phenomenon near the transition edges, a result
% of the sudden transitions of H(k) at the cutoff frequencies w1 and w2.
% To reduce the peak overshoot and the oscillations,
% we may choose to smooth the H(k) transitions. This
% can be accomplished by noting that the closest zeros to
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% the edges of H(k) occur at samples k = 7, 16, 35, and 44.
% We may force the magnitude of H(k) at these k's to be, for
% example, 0.5. An optimization process can be used to determine
% the transition value that yields, for example, the smallest maximum
% deviation from Hd
%
H_mag(8)= 0.5; H_mag(17)= 0.5; H_mag(36)= 0.5; H_mag(45)= 0.5;        % transition samples
H=H_mag .* exp(-j*w*M/2);
h=real(ifft(H,N));
%
b=h; a=1 ; nn=1024;
[HH,ww]=freqz(b,a,nn,'whole');
plot(ww/(2*pi), abs(HH), '-g', w/(2*pi), abs(H),'xr')
xlabel('Frequency F/Fs'), ylabel(' |H(e^jw)| &|H(k)|'),
title('solid |H(e^jw)|; "x" |H(k)|'), pause
```