FIR Filter Design

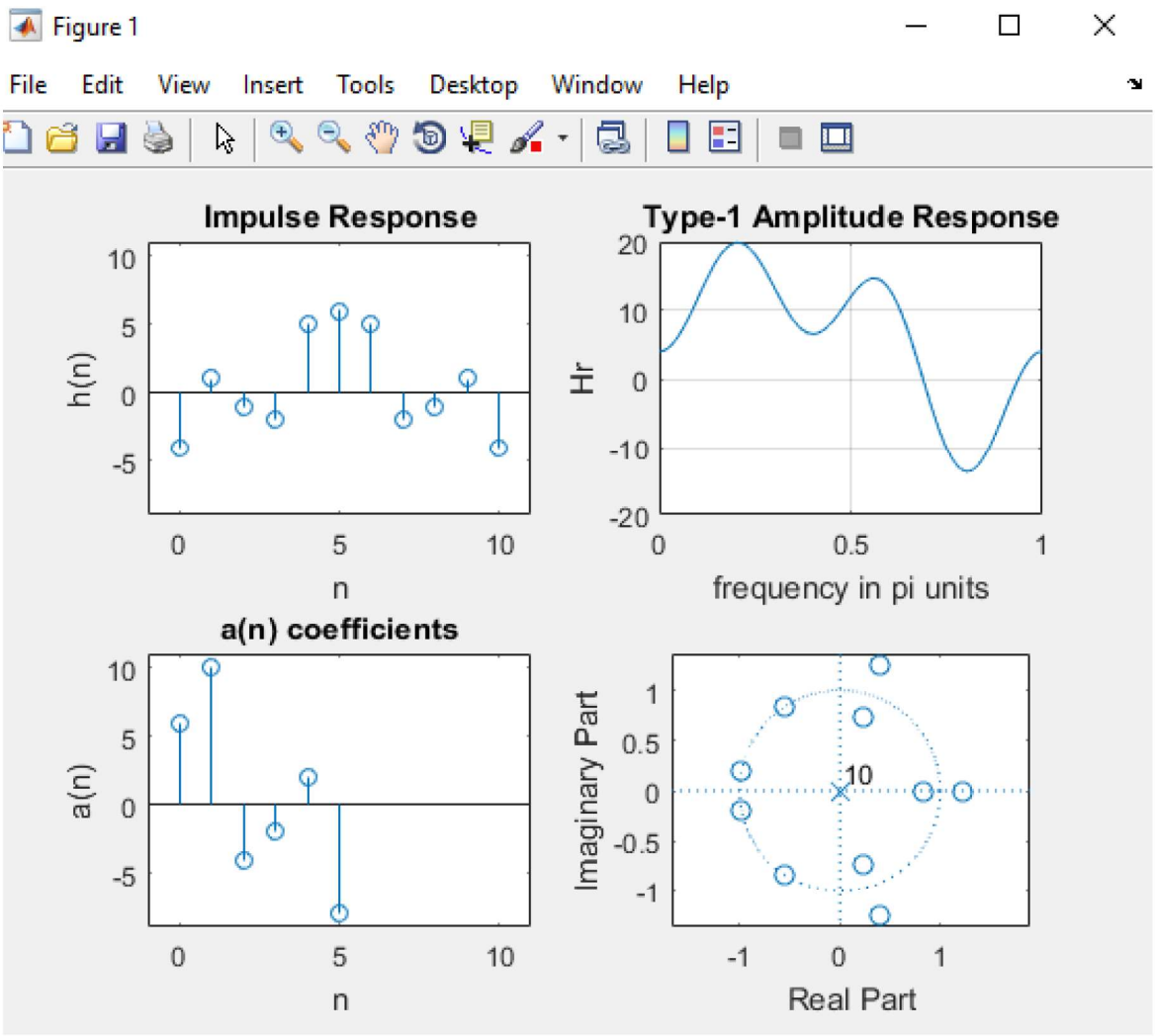
1. Let h(n) = {−4, 1,−1,−2, 5, 6, 5,−2,−1, 1,−4}. Write a MATLAB program to plot amplitude response Hr (ω) and the locations of the zeros of H (z).

```
function [Hr,w,a,L] = Hr_Type1(h)

M = length(h); L = (M-1)/2;
a = [h(L+1) 2*h(L:-1:1)]; % 1x(L+1) row vector
n = [0:1:L]; % (L+1)x1 column vector
w = [0:1:500]'*pi/500; Hr = cos(w*n)*a';
```

```
h = [-4,1,-1,-2,5,6,5,-2,-1,1,-4];
M = length(h); n = 0:M-1;
[Hr,w,a,L] = Hr_Type1(h);
a,L
%a = 6 10 -4 -2 2 -8
%L = 5
amax = max(a)+1; amin = min(a)-1;
subplot(2,2,1); stem(n,h); axis([-1 2*L+1 amin amax])
xlabel('n'); ylabel('h(n)'); title('Impulse Response')
subplot(2,2,3); stem(0:L,a); axis([-1 2*L+1 amin amax])
xlabel('n'); ylabel('a(n)'); title('a(n) coefficients')
subplot(2,2,2); plot(w/pi,Hr);grid
xlabel('frequency in pi units'); ylabel('Hr')
title('Type-1 Amplitude Response')
h=double(h);
subplot(2,2,4); zplane(h,1);
```

Output:



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2. Let h(n) = {−4, 1,−1,−2, 5, 6,6, 5,−2,−1, 1,−4}. Write a MATLAB program to plot amplitude response Hr (ω) and the locations of the zeros of H (z).

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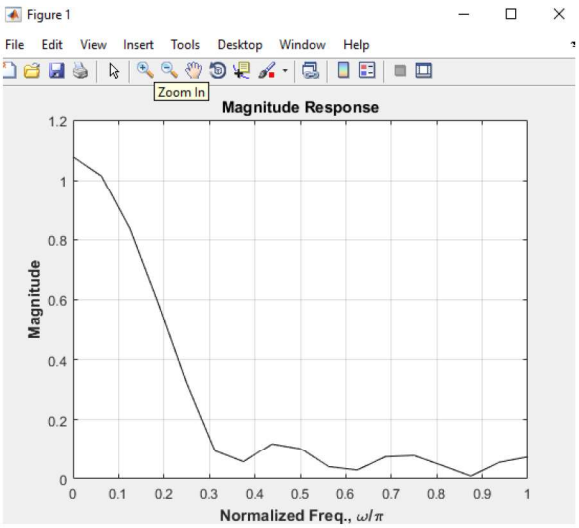
3. Write a MATLAB program to determine the impulse response of FIR lowpass Filter using rectangular window (taking 7 samples of window sequence and with a cutoff frequency, w c = 0.2pi rad/sample) and hence plot the frequency response.

```
wc=0.2*pi
N = 7 ;
hd = zeros (1, N);
a=(N-1)/2;
hna=wc/pi;
%% rect window
k = 1:1:((N-1)/2);
n = k-1-((N -1)/2) ;
hd( k ) = (sin(wc*n))./(pi*n) ;
hn(k) = hd(k) ;
hn = [hn hna];
%%
a = ( N - 1 ) / 2 ;
w= 0 :pi/16 : pi;
Hw1 = hna * exp (-j*w*a) ;
Hw2 = 0 ;
for m=1:1:a
Hw3= hn(m)*((exp(j*w*(1-m)))+ (exp(-j*w*(1-m+2*a))));
Hw2=Hw2+Hw3;
end
Hw = Hw2 + Hw1
H_mag = abs( Hw )
plot ( w/pi,H_mag, 'k' ); grid ;
title ( 'Magnitude Response', 'fontweight' , 'b') ;
xlabel ( ' Normalized Freq., \omega/\pi', 'fontweight' , 'b') ;
ylabel ( 'Magnitude' , 'fontweight' , 'b') ;
```

Output:



4. Write a MATLAB program to determine the impulse response of FIR lowpass Filter using hamming window (taking 7 samples of window sequence and with a cutoff frequency, w c = 0.2pi rad/sample) and hence plot the frequency response.

```
%% hamming
k = 1:1:((N-1)/2);
n = k-1-((N-1)/2) ;
w_ham(k)= .54 - .46*cos(2*pi*(k-1)/(N-1)) ;
hd( k ) = (sin(wc*n))./(pi*n) ;

for s = 1:length(k)
hn(s) = hd(s)*w_ham(s);
end

hn = [hn hna];
```

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