DSP Lab - Assignment 5

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QUESTION:

1. Design a linear phase, low-pass FIR digital filter whose
    a. passband frequency is 0.4π rad,
    b. stopband frequency is 0.6π rad, and
    c. The passband attenuation is −3 dB, while stopband attenuation is −60 dB.

    Use a Hamming window of appropriate length to obtain better characteristics over the rectangular window. You may start with a filter order determined using any of the standard available formulas (Hermann/Kaiser/ Bellander/etc...).

    Write a program in MATLAB to determine the transfer function H(z) of this filter. Plot the magnitude and phase responses of H(ei) using any of the standard available functions in the library. Does the magnitude response of your filter satisfy the desired specifications (including attenuation levels)? If not, with appropriate iterations, how much more do you need to increase the filter order? Is the phase response linear as desired? Justify with an appropriate plot of the phase response.

ANSWER:

Code:

```
clc; clear; close all;
wp = 0.4 * pi;
ws = 0.6 * pi;
A = -3;
As = 60;
wc = (wp + ws) / 2;
trans_bw = (ws - wp) / (2*pi);

N = ceil((As - 8) / (2.285 * (ws - wp)));
N = max(N, 1);
N = N + mod(N+1, 2);
Len = N;
n = 0:Len;
alpha = Len / 2;
hd = zeros(size(n));
for i = 1:length(n)
   if (n(i) == alpha)
       hd(i) = wc / pi;
```

```
    else
        hd(i) = sin(wc * (n(i) - alpha)) / (pi * (n(i) - alpha));
    end
end

hamm_window = zeros(size(n));
for i = 1:length(n)
    hamm_window(i) = 0.54 - 0.46 * cos(2 * pi * n(i) / Len);
end

h = hd .* hamm_window;
Nfft = 1024;
omega = linspace(0, pi, Nfft);
wp_index = round(0.4 * Nfft / pi);
Htemp = 0;
for m = 1:length(h)
    Htemp = Htemp + h(m) * exp(-1j * omega(wp_index) * (m - 1));
end

gain_at_wp = abs(Htemp);
desired_gain = 10^(A/20);
h = h * (desired_gain / gain_at_wp);
H = zeros(1, Nfft);
for k = 1:Nfft
    for m = 1:length(h)
        H(k) = H(k) + h(m) * exp(-1j * omega(k) * (m - 1));
    end
end
figure;
plot(omega/pi, 20*log10(abs(H)), 'LineWidth', 1.5);
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Magnitude (dB)');
title('Magnitude Response');
grid on;
ylim([-100 5]);
figure;
plot(omega/pi, unwrap(angle(H)), 'LineWidth', 1.5);
xlabel('Normalized Frequency (\times\pi rad/sample)');
ylabel('Phase (radians)');
title('Phase Response (Manual)');
grid on;
fprintf('Filter Order (N): %d\n', Len);
disp('Filter Coefficients h[n]:');
disp(h);
```

Output Plots:

Filter Order: 37