Experiment 8: Linear Phase F. I. R. Filter Design using Windowing Method

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Experiment No.	8

Code:

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% Linear Phase FIR Filter Design using Windowing Method
clc;
clear;
close all;

disp("Step 1: Accept user input specifications");

disp('Enter filter type (LPF, HPF, BPF, BSF): ');
filter_type = input('Enter filter type (LPF, HPF, BPF, BSF): ', 's');
Fs = input('Enter the sampling frequency (Hz): ');

if strcmpi(filter_type, 'LPF') || strcmpi(filter_type, 'HPF')
    Fp = input('Enter passband frequency (Hz): ');
    Fs_stop = input('Enter stopband frequency (Hz): ');
else
    Fp1 = input('Enter lower passband frequency (Hz): ');
    Fp2 = input('Enter upper passband frequency (Hz): ');
    Fs_stop1 = input('Enter lower stopband frequency (Hz): ');
    Fs_stop2 = input('Enter upper stopband frequency (Hz): ');
end

Ap = input('Enter passband attenuation (dB): ');
As = input('Enter stopband attenuation (dB): ');
N = input('Enter the filter order (N): ');
if mod(N, 2) == 0
    warning('Filter order should be odd for linear phase. Incrementing N by 1.');
    N = N + 1;
end

disp("step 2: Select appropriate window function");
if As <= 21
    window_type = 'rectwin';
elseif As <= 44
    window_type = 'hann';
elseif As <= 53
    window_type = 'hamming';
else
    window_type = 'blackman';
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end

fprintf('Selected window: %s\n', window_type);

disp("Step 3: Normalize frequencies");
if strcmpi(filter_type, 'LPF') || strcmpi(filter_type, 'HPF')
    Wp = Fp / (Fs / 2)
    Ws = Fs_stop / (Fs / 2)
    Wn = [Wp];
else
    Wp1 = Fp1 / (Fs / 2);
    Wp2 = Fp2 / (Fs / 2);
    Ws1 = Fs_stop1 / (Fs / 2);
    Ws2 = Fs_stop2 / (Fs / 2);
    Wn = [Wp1 Wp2];
end

disp("Step 4: Design the filter using the selected window")
switch lower(filter_type)
    case 'lpf'
        b = fir1(N-1, Wn, 'low', window(window_type, N))
    case 'hpf'
        b = fir1(N-1, Wn, 'high', window(window_type, N))
    case 'bpf'
        b = fir1(N-1, Wn, 'bandpass', window(window_type, N))
    case 'bsf'
        b = fir1(N-1, Wn, 'stop', window(window_type, N))
    otherwise
        error('Invalid filter type.');
end

disp("Step 5: Frequency response");
[H, f] = freqz(b, 1, 1024, Fs);

figure;
subplot(2, 1, 1);
plot(f, 20*log10(abs(H)));
grid on;
xlabel('Frequency (Hz)');
ylabel('Magnitude (dB)');
title('Magnitude Spectrum');
xlim([0 500]);
ylim([-70, 5]);
hold on;
yline(-Ap, 'r--', 'Passband Attenuation (Ap)');
yline(-As, 'g--', 'Stopband Attenuation (As)');
hold off;

subplot(2, 1, 2);
plot(f, angle(H));
grid on;
xlabel('Frequency (Hz)');
ylabel('Phase (radians)');
```

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title('Phase Spectrum');

disp("Step 7: Impulse response");
figure;
stem(b, 'filled');
grid on;
xlabel('Samples');
ylabel('Amplitude');
title('Impulse Response of FIR Filter');
disp('Observe the phase spectrum for linearity. Linear phase indicates symmetry in the impulse response.');
```