Heaven's Light is Our Guide

RAJSHAHI UNIVERSITY OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

LAB REPORT

Course No: EEE 4108

Course Name: Digital signal processing Sessional

Experiment No: 05

Experiment Name: Designing a digital filter (high pass/ low pass/ band pass/ band reject) using MATLAB code.

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Objectives: The following objectives of this experiment is-

- To learn about digital filter.
- To design a digital filter using MATLAB Code.

Theory:

A digital filter is a signal processing algorithm used to modify or extract specific frequency components from a digital signal. It operates on discrete-time samples of a signal and can be implemented using various methods.

The four main types of digital filters are:

1. Low-Pass Filter (LPF): A low-pass filter allows frequencies below a certain cutoff frequency to pass through while attenuating frequencies above the cutoff. It is commonly used to remove high-frequency noise or to smooth a signal. The cutoff frequency is the point at which the filter's response starts to attenuate the signal. Low-pass filters are essential for anti-aliasing in analog-to-digital conversion and for audio applications when you want to eliminate high-frequency noise or maintain bass frequencies.
2. High-Pass Filter (HPF): A high-pass filter allows frequencies above a specified cutoff frequency to pass through while attenuating frequencies below the cutoff. It is useful for removing low-frequency noise or DC offsets from a signal. High-pass filters are employed in various applications, including audio processing, image processing, and sensor signal conditioning.
3. Band-Pass Filter (BPF): A band-pass filter allows a specific range of frequencies to pass through while attenuating frequencies outside this range. It is used to extract or isolate signals within a particular frequency band. Band-pass filters are useful in applications like radio communication, biomedical signal processing, and audio equalization.
4. Band-Reject Filter (BRF) or Notch Filter: A band-reject filter, also known as a notch filter, attenuates a specific frequency band while allowing all other frequencies to pass through. It is often used to remove interference or unwanted noise at a specific frequency. Notch filters find applications in eliminating power line hum (50/60 Hz) in audio signals or canceling out specific frequency components from a signal.

Digital filters can be designed using various techniques, such as windowing, frequency sampling, bilinear transformation, and pole-zero placement methods. The choice of filter design method depends on the desired filter specifications and the trade-offs between various performance factors like sharpness of cutoff, filter order, passband ripple, stopband attenuation, and computational complexity.

The design process typically involves specifying parameters like the filter type (e.g., Butterworth, Chebyshev, elliptic), cutoff frequencies, passband ripple, stopband attenuation, and filter order.

Once designed, the filter can be implemented in software or hardware to process digital signals effectively.

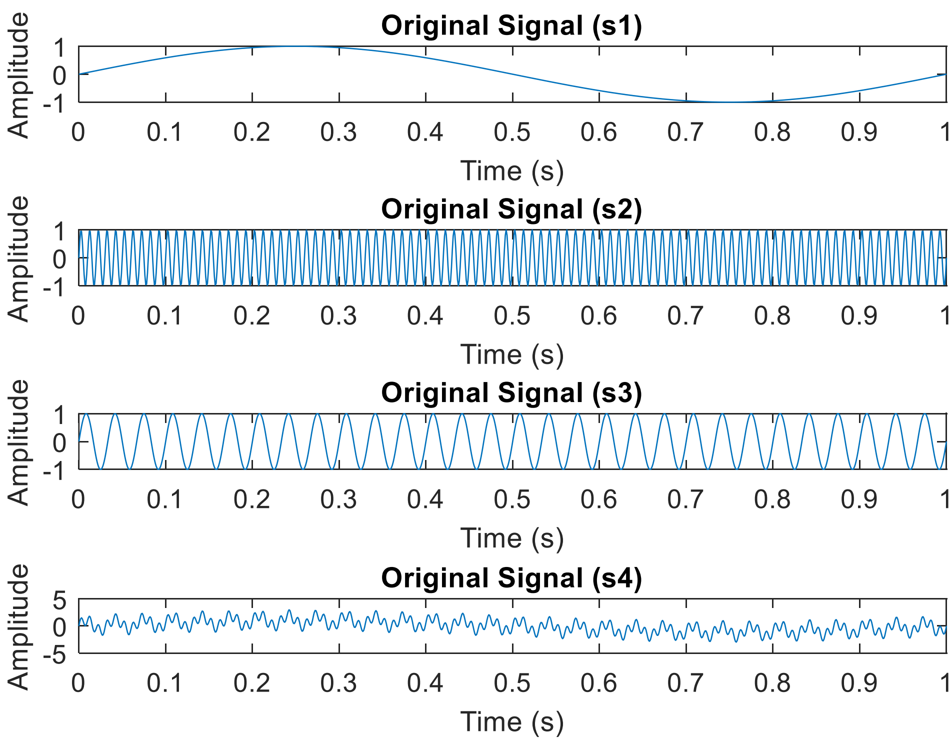
MATLAB Code:

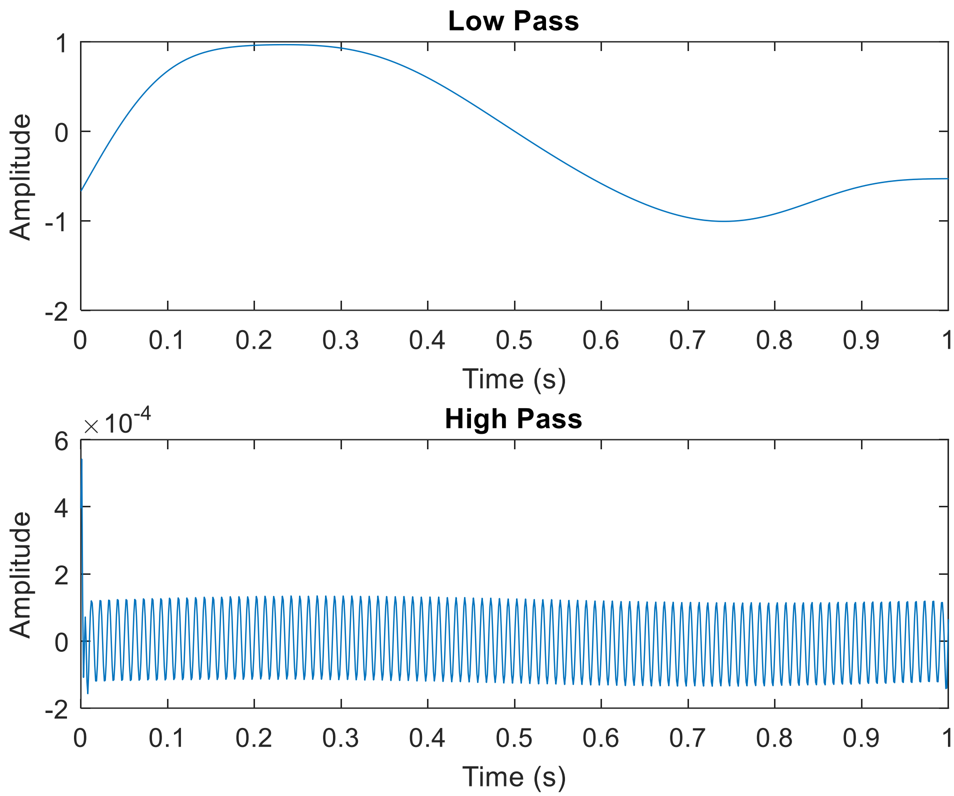
```
clc;
close all;
clear all;
fs = 1000;
duration = 1;
t = linspace(0, duration, fs * duration);

lowpass = sin(2 * pi * 1 * t);
highpass = sin(2 * pi * 100 * t);
mediumpass = sin(2 * pi * 30 * t);

s4 = lowpass + highpass + mediumpass;

figure
subplot(4, 1, 1)
plot(t, lowpass)
title('Original Signal (s1)')
xlabel('Time (s)')
ylabel('Amplitude')
subplot(4, 1, 2)
plot(t, highpass)
title('Original Signal (s2)')
xlabel('Time (s)')
ylabel('Amplitude')
subplot(4, 1, 3)
plot(t, mediumpass)
title('Original Signal (s3)')
xlabel('Time (s)')
ylabel('Amplitude')
subplot(4, 1, 4)
plot(t, s4)
title('Original Signal (s4)')
xlabel('Time (s)')
ylabel('Amplitude')
```

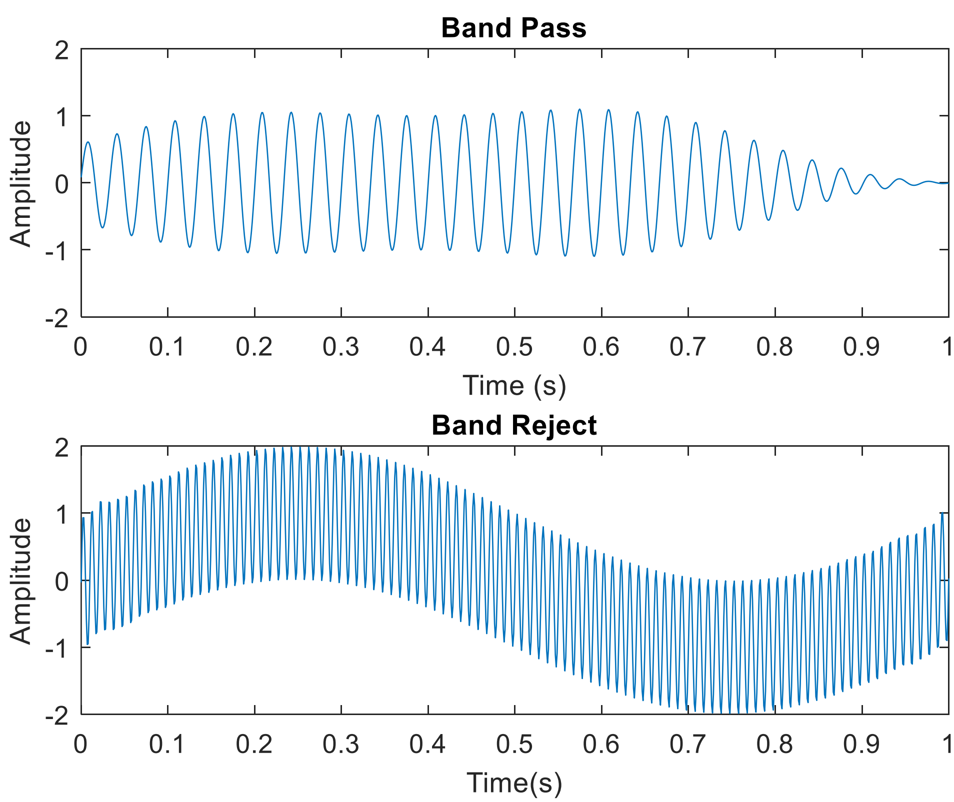
```
%  low-pass filter
fc = 10; % Cutoff frequency (Hz)
order = 4; % Filter order
[b, a] = cheby2(order, 50, fc / (fs / 2), 'low');

% Apply the filter to the combined signal
filtered_signal = filtfilt(b, a, s4);

figure
subplot(2, 1, 1)
plot(t, filtered_signal)
title('Low Pass')
xlabel('Time (s)')
ylabel('Amplitude')


fc = 90; % Cutoff frequency (Hz)
order = 4; % Filter order
[b, a] = cheby2(order, 50, fc / (fs / 2), 'high');

filtered_signal = filtfilt(b, a, s4);

subplot(2, 1, 2)
plot(t, filtered_signal)
title('High Pass')
xlabel('Time (s)')
ylabel('Amplitude')

fc_low = 25; % Lower cutoff frequency (Hz)
fc_high = 35; % Upper cutoff frequency (Hz)
order = 4; % Filter order
[b, a] = cheby2(order, 50, [fc_low / (fs / 2), fc_high / (fs / 2)], 'bandpass');

filtered_signal = filtfilt(b, a, s4);

figure
subplot(2, 1, 1)
plot(t, filtered_signal)
title('Band Pass')
xlabel('Time (s)')
```

```
ylabel('Amplitude')

fc_low = 25; % Lower cutoff frequency (Hz)
fc_high = 35; % Upper cutoff frequency (Hz)
order = 4; % Filter order
[b, a] = cheby2(order, 50, [fc_low/(fs/2), fc_high/(fs/2)], 'stop');

filtered_signal = filtfilt(b, a, s4);

subplot(2,1,2);
plot(t,filtered_signal);
title('Band Reject');
xlabel('Time(s)');
ylabel('Amplitude');
```

Output:




Low Pass
Amplitude
Time (s)
High Pass
×10^-4
Amplitude
Time (s)


Band Pass
Amplitude
Time (s)
Band Reject
Amplitude
Time(s)

Discussion & Conclusion:

In this experiment, we have designed a digital filter which is works as all the low-pass, high-pass, band-reject and band-pass filters. Three sinusoidal signals of low(1Hz), medium(30Hz) and high(100Hz) frequencies are mixed to generate a multi-frequency signal. Then the signal is filtrated and extract the signal of frequency of 1 Hz, 100Hz, 30Hz as well as mixture of 1Hz and 100Hz which have shown in figure-02 and figure-03 respectively.