MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
**Department of Electronics System Engineering**
**SIGNALS & SYSTEMS**

# LAB # 15: OPEN ENDED LAB

| Name **Karan** | Roll # 20ES062 |
|---|---|
| Signature of Lab Tutor | Date |

## OBJECTIVE(S)

| # | *Topic* | # Of Lectures | CLO | Taxonomy level |
|---|---|---|---|---|
| 1 | To Perform Filters using MATLAB Functions | 3 | 4,5 | P3,A4 |

## OUTCOME(S)

| | |
|---|---|
| • An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. | **PLO5**:Modern Tool Usage |
| • An ability to communicate effectively (written/oral) | **PLO10**: Communication |

## LAB RUBRICS:

| Performance Metric | Good (5-4) | Average (3-2) | Poor (1-0) | Score |
|---|---|---|---|---|
| Use of modern engineering software [PLO5] | Demonstrates knowledge and application of modern engineering software through accurate development and interpretation of computer programs to solve problems. | Demonstrates awareness of modern engineering software through mostly correct development and interpretation of computer programs to solve problems, but may contain minor mistakes or syntax errors | Unable to use modern engineering software to develop or interpret computer programs to solve problems. | |
| Level of understanding of the learned skill [PLO5] | Demonstration of full knowledge of the handout with explanations and elaboration. | At ease with content and able to elaborate and explain to some degree. | No grasp of information. Clearly no knowledge of subject matter. No questions are answered. No interpretation made. | |
| Conducting simulation [PLO5] | Has an excellent simulations skill in the simulator. Always able to make the logical code for the given task. | Has a good simulation skill in the simulator. Always able to make the logical code for the given task. | Has poor simulation skill in the simulator. Unable to make the logical code for the given task. | |
| Responsiveness to Questions/ Accuracy [PLO10] | Responds well, quick and very accurate all the time. | Generally responsive and accurate most of the times. | Non-responsive at all or the candidate giving only one correct response of viva voce questions. | |
| Documentation: contents and organization [PLO10] | Report well organized, Appropriately sectioned, uses diagram/dscription when appropriate, important issues clearly stated. | Report reasonably well documented. May lack some minor aspects. | Report not well organized, lack key aspects. | |

| | |
|---|---|
| **Total** | |
| | |

## EQUIPMENT/SOFTWARE TOOL:

**MATLAB** - The Language of Technical Computing.

## DISCUSSION AND SETUP:

Introduction:

## Lab Tasks

Sinusoids using butterworth, chebyshev1, chebyshev2 and FIR filter. Please run them and generate plots. Youwill note that they all have unit amplitude

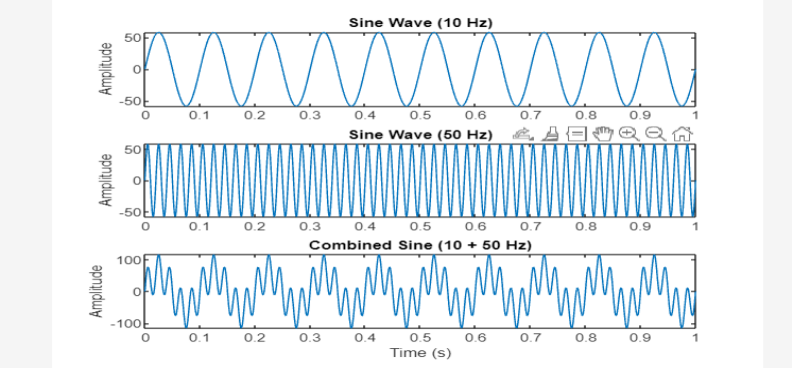
**BUTTERWORTH FILTER:**

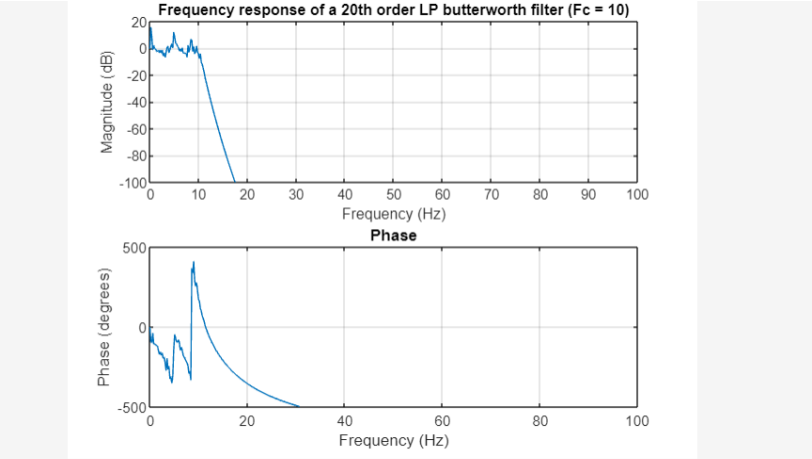
### Code:

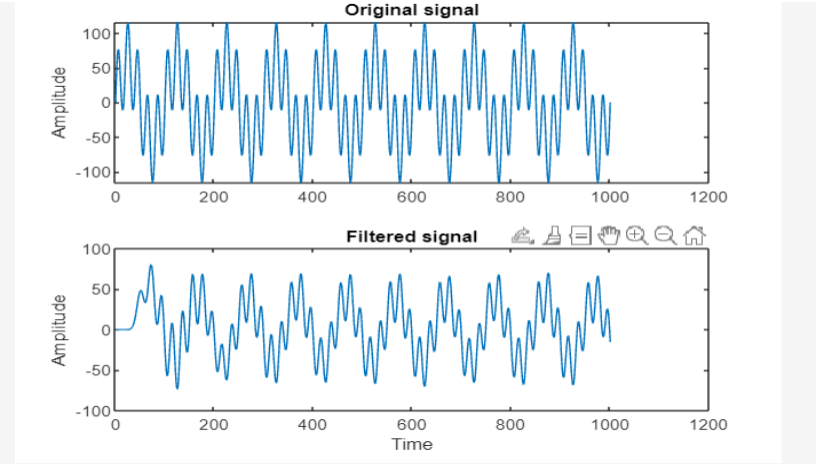
```
%Filtering using a butterworth filter
clear;
%Generate a sine wave
% Define the parameters
freq1 = 10;      % Frequency of the sine wave (in Hz)
freq2 = 50;      % Frequency of the sine wave (in Hz)
amp =62;        % Amplitude of the sine wave
time = 0:0.001:1; % Time vector (from 0 to 1 second with 0.001 sec step)


% Generate the sine wave1
sine_wave1 = amp*sin(2*pi*freq1*time);
sine_wave2 = amp*sin(2*pi*freq2*time);

combined_sine = sine_wave1 + sine_wave2;

%Plot the sine waves
figure;
subplot(311)
plot(time, sine_wave1);
title("Sine Wave (10 Hz)")
ylabel('Amplitude');


subplot(312)
plot(time, sine_wave2);
title("Sine Wave (50 Hz)")
ylabel('Amplitude');



subplot(313)
plot(time, combined_sine);
title("Combined Sine (10 + 50 Hz)")


xlabel('Time (s)');
```

```
ylabel('Amplitude');


% Create a butterworth filter to remove the 50 Hz sine wave,what kind of
% filter do we need

%Cutoff frequency we need to use
fc = 10;

%Set sampling frequency of signal
fs = 200;

%Construct the butterworth filter
[b,a] = butter(20,fc/(fs/2));

%Plot the response
figure;
freqz(b,a,[],fs)
subplot(2,1,1)
title("Frequency response of a 20th order LP butterworth filter (Fc = 10)")
ylim([-100 20])


%Filter the combined signal
filtered_combined_sine = filter(b,a,combined_sine);
figure;
subplot(211)
plot(combined_sine)
ylabel("Amplitude")
title('Original signal')

subplot(212)
plot(filtered_combined_sine)
title('Filtered signal')
ylabel("Amplitude")
xlabel("Time")
%%
dataIn = randn(1000,1);
dataOut = filter(b,a,dataIn);
```

## Simulation:


Sine Wave (10 Hz)
Amplitude
Sine Wave (50 Hz)
Amplitude
Combined Sine (10 + 50 Hz)
Amplitude
Time (s)


Frequency response of a 20th order LP butterworth filter (Fc = 10)
Magnitude (dB)
Frequency (Hz)
Phase
Phase (degrees)
Frequency (Hz)


Original signal
Amplitude
Filtered signal
Amplitude
Time

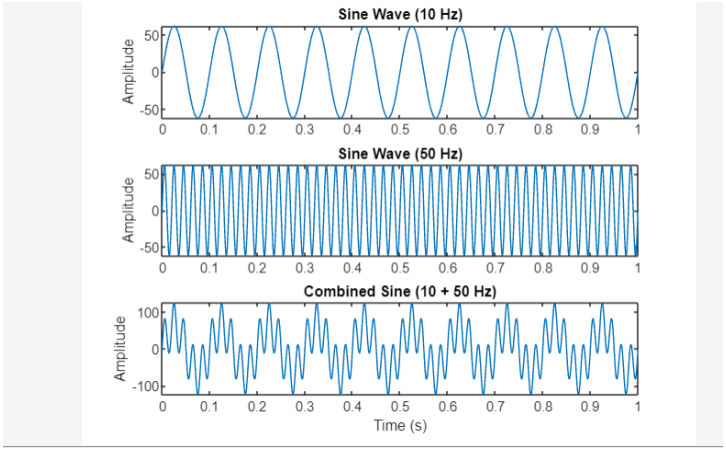
**CHEBYSHEV1 FILTER:**

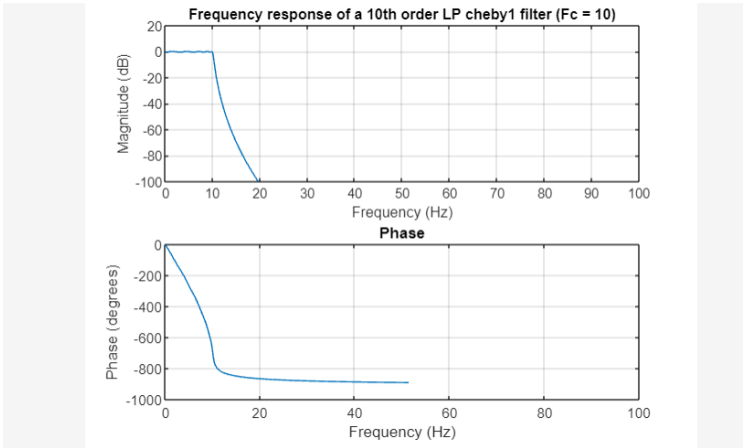
**Code:**

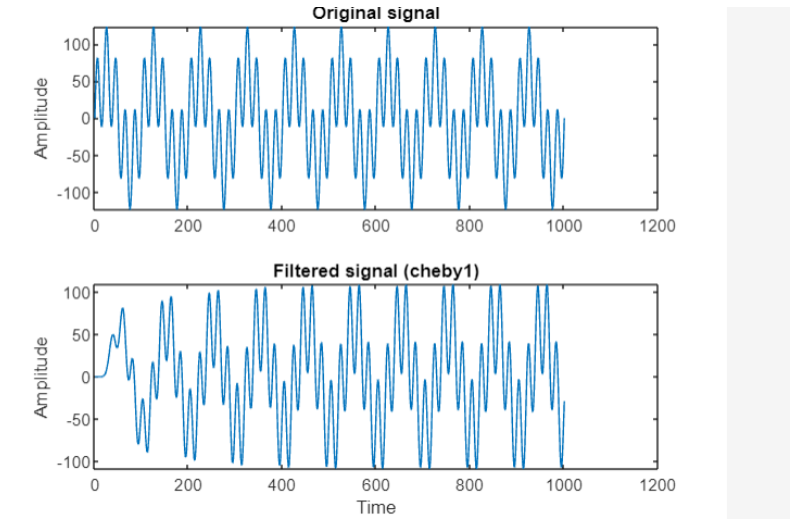
```
clear;
% Generate a sine wave
% Define the parameters
freq1 = 10;      % Frequency of the sine wave (in Hz)
freq2 = 50;      % Frequency of the sine wave (in Hz)
amp = 62;        % Amplitude of the sine wave
time = 0:0.001:1; % Time vector (from 0 to 1 second with 0.001 sec
step)

% Generate the sine wave1
sine_wave1 = amp*sin(2*pi*freq1*time);
sine_wave2 = amp*sin(2*pi*freq2*time);
combined_sine = sine_wave1 + sine_wave2;

% Plot the sine waves
figure;
subplot(311)
plot(time, sine_wave1);
title("Sine Wave (10 Hz)")
ylabel('Amplitude');

subplot(312)
plot(time, sine_wave2);
title("Sine Wave (50 Hz)")
ylabel('Amplitude');

subplot(313)
plot(time, combined_sine);
title("Combined Sine (10 + 50 Hz)")
xlabel('Time (s)');
ylabel('Amplitude');

% Create a chebyshev1 filter to remove the 50 Hz sine wave
fc = 10; % Cutoff frequency we need to use
fs = 200; % Set sampling frequency of signal
[b,a] = cheby1(10,0.5, fc/(fs/2)); % Construct the cheby1 filter

% Plot the filter response
figure;
freqz(b,a,[],fs)
subplot(2,1,1)
title("Frequency response of a 10th order LP cheby1 filter (Fc = 10)")
```

```
ylim([-100 20])

% Filter the combined signal
filtered_combined_sine = filter(b,a,combined_sine);
figure;
subplot(211)
plot(combined_sine)
ylabel("Amplitude")
title('Original signal')

subplot(212)
plot(filtered_combined_sine)
title('Filtered signal (cheby1)')
ylabel("Amplitude")
xlabel("Time")
```

**Simulation:**





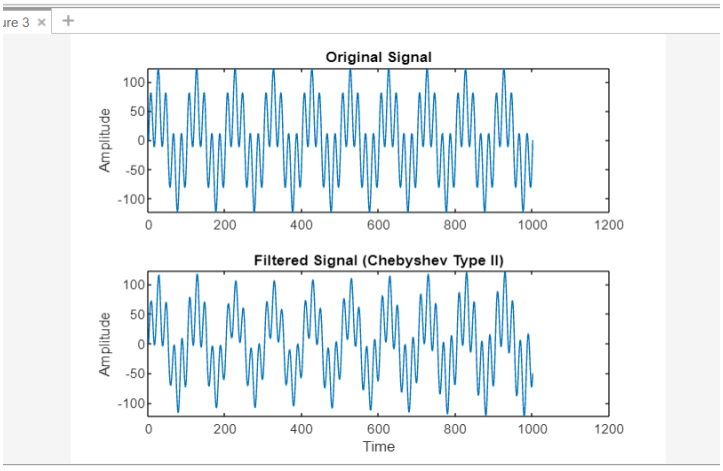

- **CHEBYSHEV2 FILTER:**

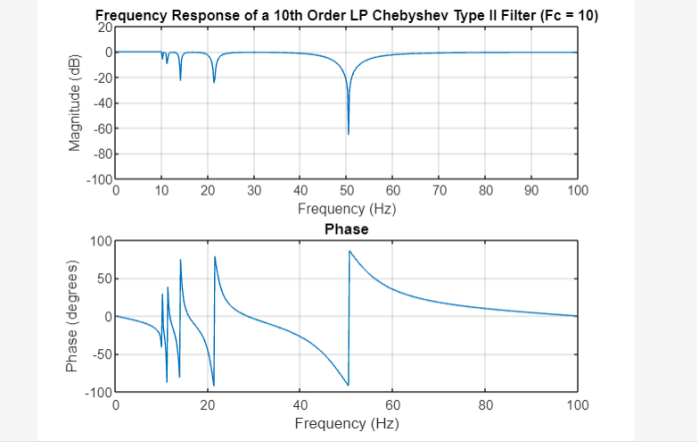
**Source Code:**

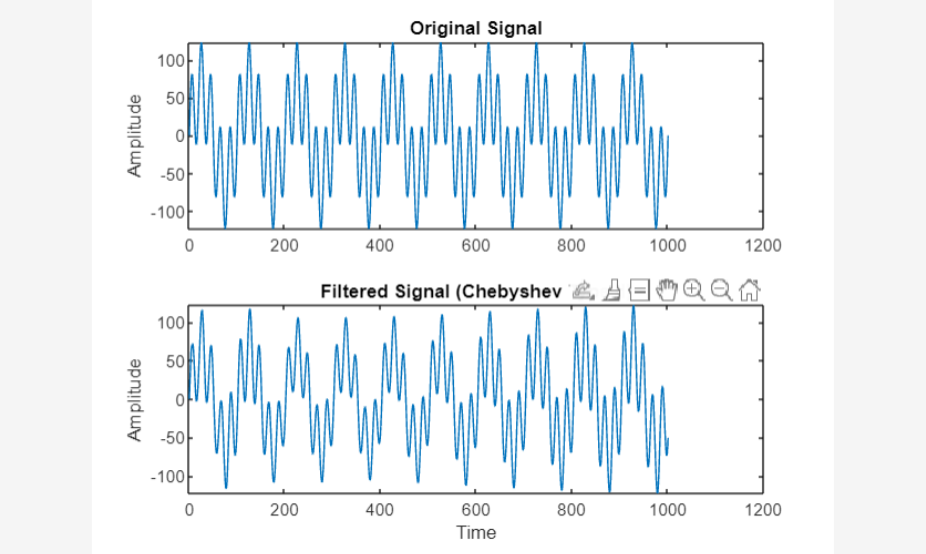
```
clear;

% Define the parameters
freq1 = 10;      % Frequency of the first sine wave (in Hz)
freq2 = 50;      % Frequency of the second sine wave (in Hz)
amp = 62;        % Amplitude of the sine waves
time = 0:0.001:1; % Time vector (from 0 to 1 second with 0.001 sec step)

% Generate the sine waves
sine_wave1 = amp*sin(2*pi*freq1*time);
sine_wave2 = amp*sin(2*pi*freq2*time);

% Combine the sine waves
combined_sine = sine_wave1 + sine_wave2;

% Plot the sine waves
figure;
subplot(311)
plot(time, sine_wave1);
title("Sine Wave (10 Hz)")
ylabel('Amplitude');

subplot(312)
plot(time, sine_wave2);
title("Sine Wave (50 Hz)")
ylabel('Amplitude');
subplot(313)
plot(time, combined_sine);
```

```
 title("Combined Sine (10 + 50 Hz)")
 xlabel('Time (s)');
 ylabel('Amplitude');
 % Create a Chebyshev Type II filter to remove the 50 Hz sine wave
 fc = 10;          % Cutoff frequency
 fs = 200;         % Sampling frequency
 [b,a] = cheby2(10,0.5, fc/(fs/2));  % Construct the filter
 % Plot the filter response
 figure;
 freqz(b,a,[],fs)
 subplot(2,1,1)
 title("Frequency Response of a 10th Order LP Chebyshev Type II Filter (Fc =
10)")
 ylim([-100 20])

 % Filter the combined signal
 filtered_combined_sine = filter(b,a,combined_sine);

 % Plot the original and filtered signals
 figure;
 subplot(211)
 plot(combined_sine)
 ylabel("Amplitude")
 title('Original Signal')
 subplot(212)
 plot(filtered_combined_sine)
 title('Filtered Signal (Chebyshev Type II)')
 ylabel("Amplitude")
 xlabel("Time")
```

**Simulation:**






- **FIR FILTER:**

**Code:**

```
% Define the filter specifications
passband_freq = 20; % Hz
stopband_freq = 40; % Hz
Fs = 200; % Hz

% Determine the filter order
f_norm = passband_freq / (Fs/2);
filter_order = 4 / f_norm;

% Design the filter using FIR1
b = fir1(filter_order, f_norm, 'low');
```

```
% Generate a test signal with a 50 Hz component
t = 0:1/Fs:1;
x = 62*sin(2*pi*50*t) + sin(2*pi*10*t); % 62 is my roll number

% Apply the filter to the signal
y = filter(b, 1, x);

% Plot the original and filtered signals
figure;
subplot(2,1,1);
plot(t, x);
xlabel('Time (s)');
ylabel('Amplitude');
title('Original Signal');
subplot(2,1,2);
plot(t, y);
xlabel('Time (s)');
ylabel('Amplitude');
title('Filtered Signal');
```

**Simulation:**