Experiment - 2 **Date - 19/1/2024**

Aim :- Spectral Analysis of discrete-time signals and systems using DTFT

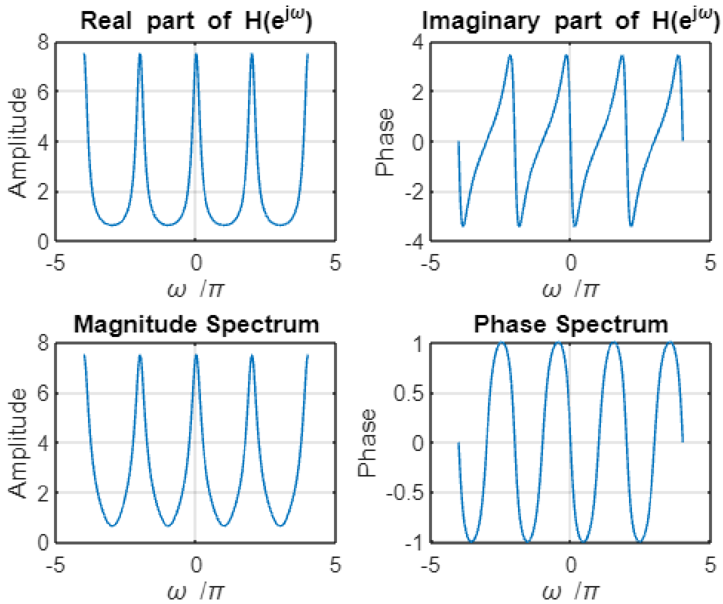
Laboratory Exercise

A) Modify program P3_1 to compute and plot the magnitude and phase spectra of a moving average filter of given Eq.

For three different values of length M and for 0 <= w <= 2pi . Justify the type of symmetries exhibited by the magnitude and phase spectra . What type of filter does it represent ?

```
% Program P3_1
% Evaluation of the DTFT
clc ; clear all ; close all ;
% Compute the frequency samples of the DTFT
w = -4*pi:8*pi/511:4*pi;
num = [2 1];den = [1 -0.6];
h = freqz(num, den, w);
% Plot the DTFT
subplot(2,2,1)
plot(w/pi,real(h));grid
title("Real part of H(e^{j\omega})")
xlabel("\omega /\pi");
ylabel("Amplitude");
subplot(2,2,2)
plot(w/pi,imag(h));grid
title("Imaginary part of H(e^{j\omega})")
xlabel("\omega /\pi");
ylabel("Phase");

%|H(e^jw)|
subplot(2,2,3)
plot(w/pi,abs(h));grid
title("Magnitude Spectrum")
xlabel("\omega /\pi");
ylabel("Amplitude");
subplot(2,2,4)
plot(w/pi,angle(h));grid
title("Phase Spectrum")
xlabel("\omega /\pi");
ylabel("Phase");
```

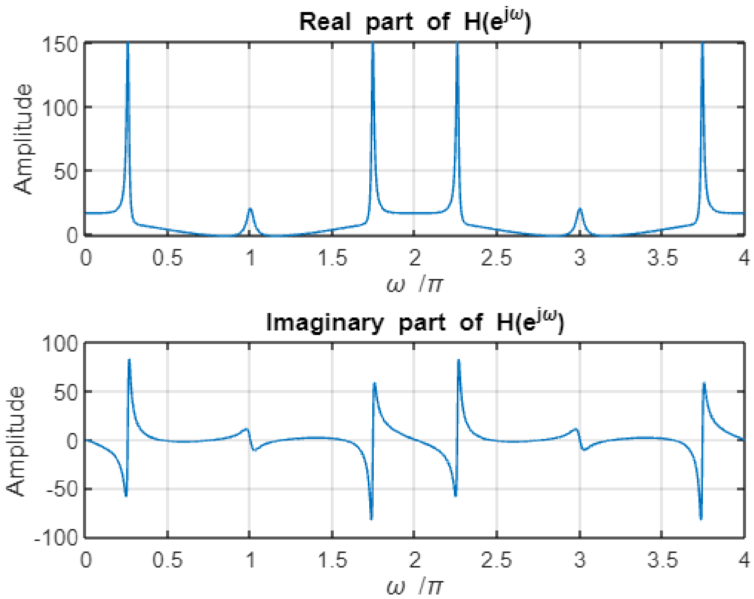



```
% Modification

% Evaluation of the DTFT
clc ; clear all ; close all ;
% Compute the frequency samples of the DTFT
% M = 5
w = 0 : pi/512 : 4*pi ; num = [2 1 3 5 7] ; den = [1 -0.6 -0.2  1 -0.1] ; h =
freqz(num , den , w) ;

% Plot the DTFT
subplot(2,1,1) ; plot(w/pi,real(h)) ; grid
title("Real part of H(e^{j\omega})") ; xlabel("\omega /\pi") ; ylabel("Amplitude") ;

subplot(2,1,2) ; plot(w/pi,imag(h)) ; grid
title("Imaginary part of H(e^{j\omega})") ; xlabel("\omega /\pi") ;
ylabel("Amplitude") ;
```

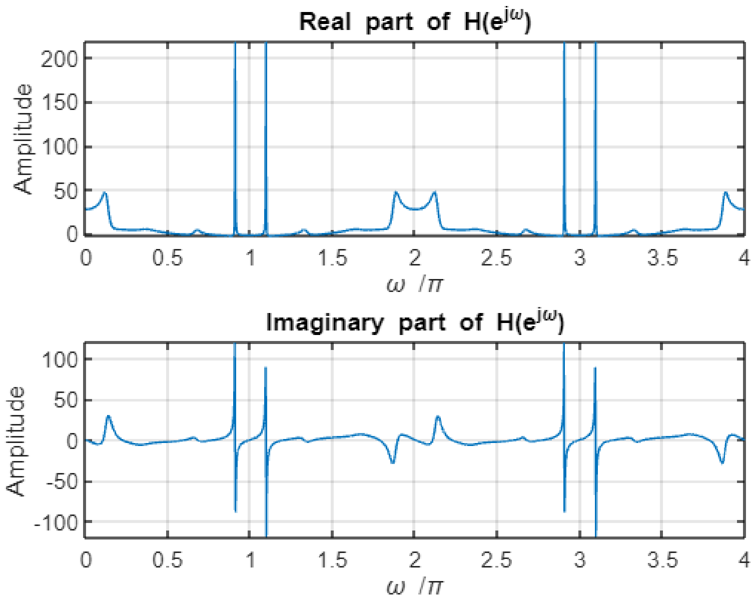


Here , for M = 5 , both the magnitude and phase spectra are symmetrical about w/pi = 1 .

```
% M = 10
w = 0 : pi/512 : 4*pi ; num = [2 1 3 5 7 4 2 6 9 10] ; den = [1 -0.6 -0.2  1 -0.1
-0.8 -0.2 1 1.2 -0.5] ; h = freqz(num , den , w) ;

% Plot the DTFT
subplot(2,1,1) ; plot(w/pi,real(h)) ; grid on ;
title("Real part of H(e^{j\omega})") ; xlabel("\omega /\pi") ; ylabel("Amplitude") ;

subplot(2,1,2) ; plot(w/pi,imag(h)) ; grid on ;
title("Imaginary part of H(e^{j\omega})") ; xlabel("\omega /\pi") ;
ylabel("Amplitude") ;
```

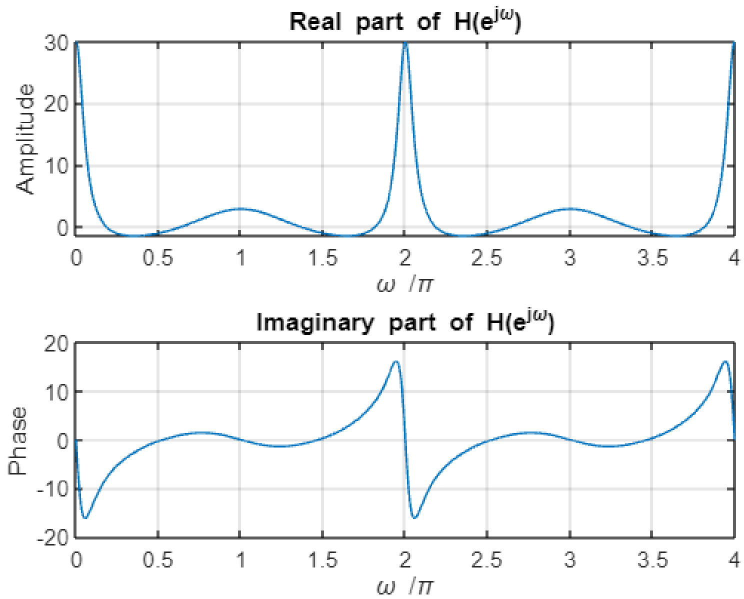


Here , for M = 10 , both the magnitude and phase spectra are symmetrical about w/pi = 1 .

```
% M = 3
w = 0 : pi/512 : 4*pi ; num = [2 1 3] ; den = [1 -0.6 -0.2] ; h = freqz(num , den ,
w) ;

% Plot the DTFT
subplot(2,1,1) ; plot(w/pi,real(h)) ; grid on ;
title("Real part of H(e^{j\omega})") ; xlabel("\omega /\pi") ; ylabel("Amplitude") ;

subplot(2,1,2) ; plot(w/pi,imag(h)) ; grid on ;
title("Imaginary part of H(e^{j\omega})") ; xlabel("\omega /\pi") ;
ylabel("Phase") ;
```



Here , for M = 3 , both the magnitude and phase spectra are symmetrical about w/pi = 1 .

Inference :- Here , all the signals are symmetric about w/pi = 1 and repeat after 2pi interval .

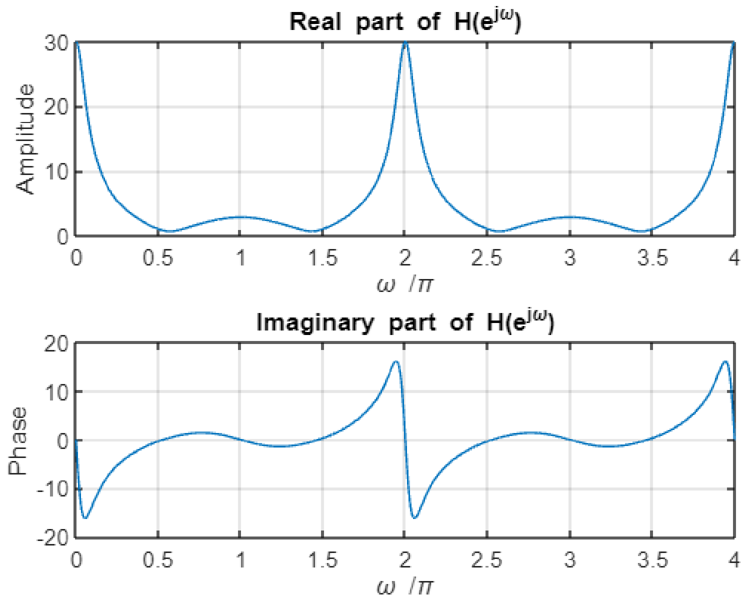
B) Write a function named as dtftuser() to compute DTFT for given time domain sequence .

```
clc ; clear all ; close all ;

%function [H] = dtftuser(num, den, w)
    %N = length(w);
    %H = zeros(size(w));
    %for k = 1:N
        %H(k) = sum(num .* exp(-1i * w(k) * (0:length(num)-1))) / sum(den .*
exp(-1i * w(k) * (0:length(den)-1)));
    %end
%end

w = 0 : pi/512 : 4 * pi ; num = [2 1 3] ; den = [1 -0.6 -0.2] ; b = num; a = den;
[H] = dtftuser(b, a, w);

subplot(2,1,1) ; plot(w/pi,abs(H)) ; grid on ;
title("Real part of H(e^{j\omega})") ; xlabel("\omega /\pi") ; ylabel("Amplitude") ;
subplot(2,1,2) ; plot(w/pi,imag(H)) ; grid on ;
title("Imaginary part of H(e^{j\omega})") ; xlabel("\omega /\pi") ;
ylabel("Phase") ;
```



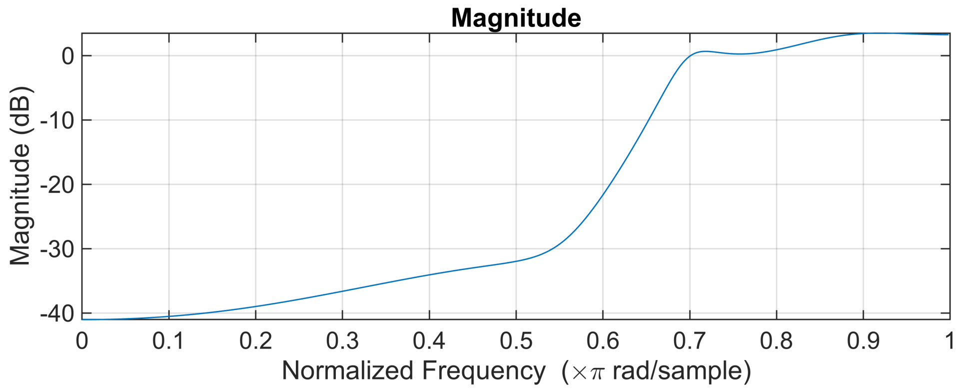
Inference :- Here , we learnt to implement a **Matlab Function dtftuser() similar to freqz()** and observing the output we can say that the output is similar to what output was reflected by freqz() funnction in the first case .

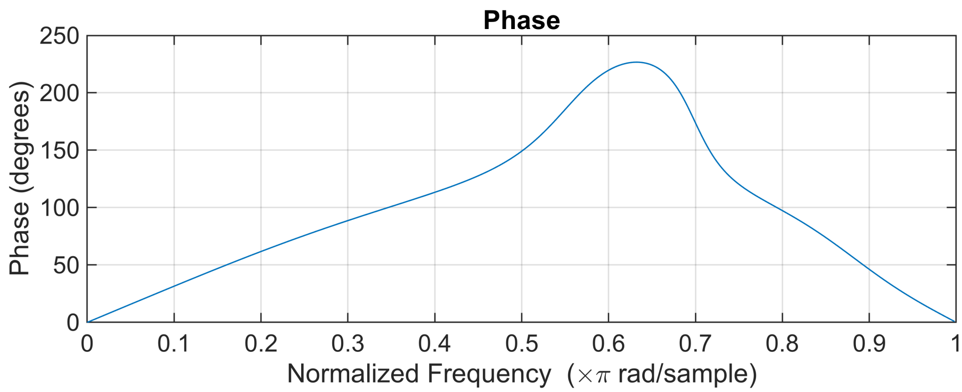
C) Compute and plot the frequency response of the following system . Based on your plots , comment on what kind of system this is (lowpass , highpass , etc.).

$y[n] + 2.37y[n - 1] + 2.7y[n - 2] + 1.6y[n - 3] + 0.41y[n - 4] =$

$0.08x[n] - 0.033x[n - 1] + 0.05x[n - 2] - 0.033x[n - 3] + 0.008x[n - 4]$

```
a = [1 2.37 2.7 1.6 0.41] ; b = [0.08 -0.033 0.05 -0.033 0.008] ;
freqz(b,a)
```





Comment :- By observation of magnitude spectrum , we ca say that it is **high pass system** as it allows higher frequencies to pass thorugh it .

Conclusion : - In this experiment , we learnt to plot the frequency response of discrete - time signals and systems . We also learnt to replicate inbuilt functions by user defined functions and learnt to determine the type of the system (lowpass , highpass , etc.) by visualizing the graphs .