5. FIR FILTER (LP/HP) USING RECTANGULAR WINDOW TECHNIQUE

AIM:

To design a FIR filter using Rectangular windowing technique and verify its frequency response.

APPARATUS:

PC with MATLAB

THEORY:

FIR filter is described by the difference equation

$$y[n] = \sum_{l=0}^{M} b_l x[n-l]$$

and by the transfer function

$$H(e^{j\omega}) = \frac{Y(e^{j\omega})}{X(e^{j\omega})} = \sum_{l=0}^{M} b_l e^{-j\omega l}$$

The window design method does not produce filters that are optimal but the method is easy to understand and does produce filters that are reasonably good. Of all the hand-design methods, the window method is the most popular and effective. In brief, in the window method we develop a causal linear-phase FIR filter by multipying an ideal filter that has an infinite-duration impulse response (IIR) by a finite-duration window function:

$$h[n] = h_d[n]w[n]$$

where h[n] is the practical FIR filter,h_d[n] is the ideal IIR prototype filter, and w[n] is the finite-duration window function. An important consequence of this operation is that the DTFTs of h_d[n] and w[n]undergo circular convolution in frequency

$$H(e^{j\omega}) = \frac{1}{2\pi} \oint_{2\pi} H_d(e^{j\theta}) W(e^{j(\omega-\theta)}) d\theta$$

The transfer functions and corresponding impulse responses for the ideal Low pass and High pass filters are as follows:

Lowpass filters:

$$H_d(e^{j\omega}) = \begin{cases} Ge^{-j\omega n_d}, 0 \le |\omega| \le \omega_c \\ 0, \omega_c < |\omega| \le \pi \end{cases}$$

$$h_d[n] = G\frac{\sin(\omega_c(n-n_d))}{\pi(n-n_d)}$$

Highpass filters:

$$H_d(e^{j\omega}) = \begin{cases} Ge^{-j\omega n_d}, \omega_c \le |\omega| \le \pi \\ 0, |\omega| < \omega_c \end{cases}$$

$$h_d[n] = G\left(\delta[n-n_d] - \frac{\sin(\omega_c(n-n_d))}{\pi(n-n_d)}\right)$$

Rectangular window:

The rectangular window is simply obtained by segmenting a finite portion of the impulse response without any shaping in the time domain

$$w[n] = \begin{cases} 1, 0 \le n \le M \\ 0, \text{ otherwise} \end{cases}$$

and the DTFT of the window is given by

$$W(e^{j\omega}) = \frac{\sin\left(\frac{M\omega}{2}\right)}{\sin\left(\frac{\omega}{2}\right)} e^{-j\omega M/2}$$

PROCEDURE:-

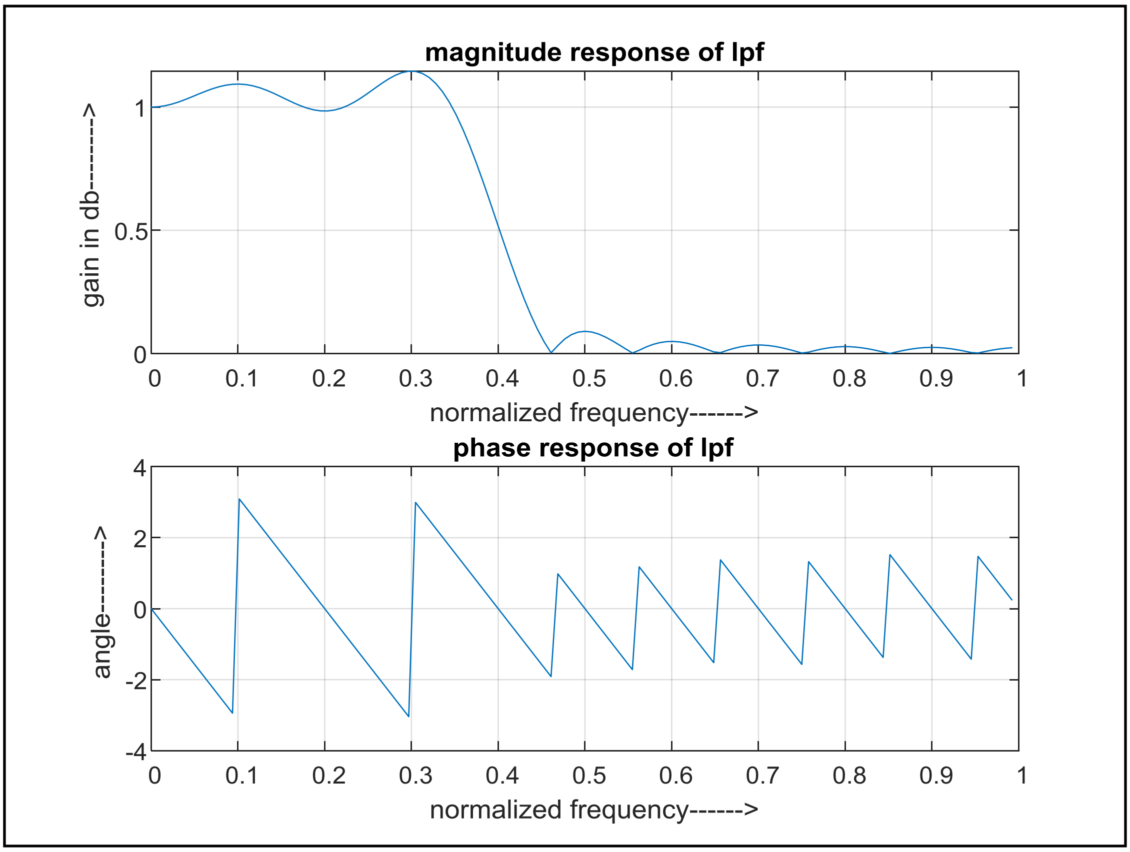
- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

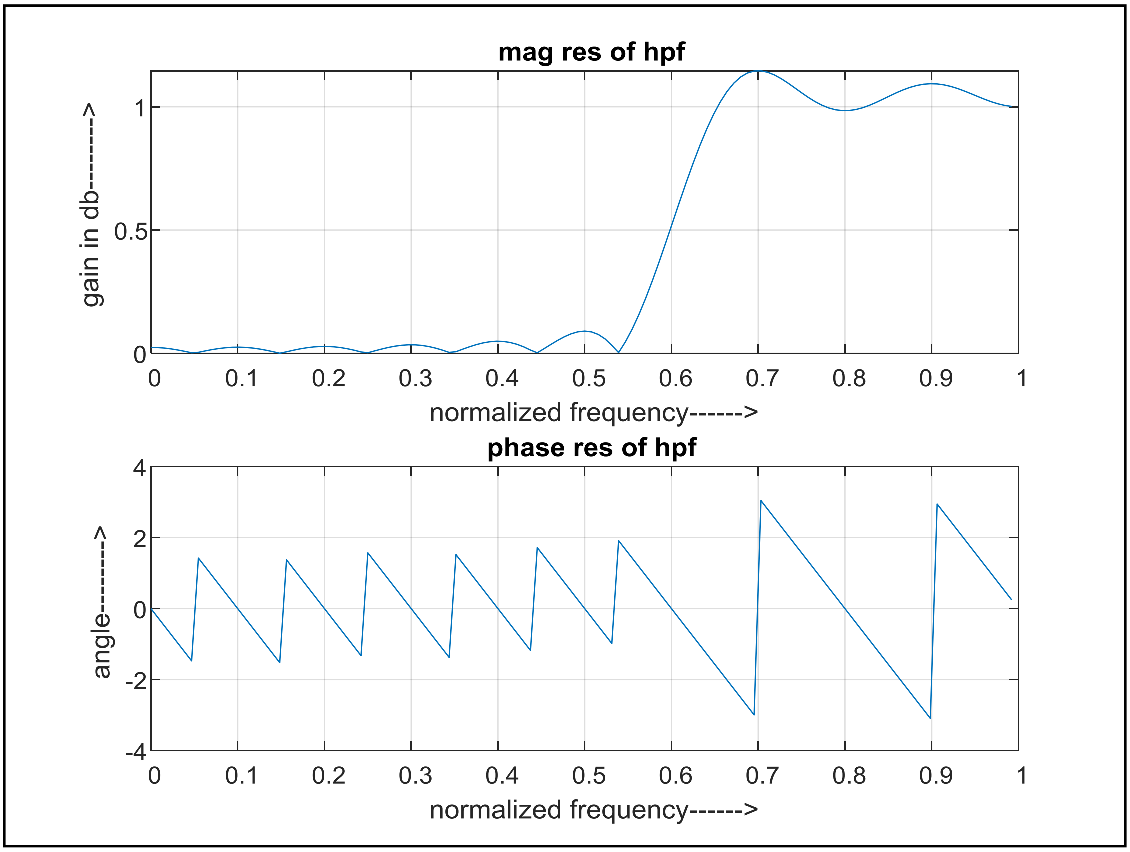
PROGRAM:

```
% To design of FIR filters using rectangular window
techniques.

clc;
clear all;
close all;

% Low Pass Filter
n=20;
fp=200;
fq=300;
fs=1000;
fn=2*fp/fs;
% window=boxcar(n+1);
window=rectwin(n+1);
b=fir1(n,fn,window);
[H W]=freqz(b,1,128);
subplot(2,1,1);
plot(W/pi,abs(H));
title('magnitude response of lpf');
ylabel('gain in db-------->');
xlabel('normalized frequency------>');
grid on
subplot(2,1,2);
```

```
plot(W/pi,angle(H));
title('phase response of lpf');
ylabel('angle-------->');
xlabel('normalized frequency------>');
grid on
% Highpass Filter
n=20;
fp=300;
fq=200;
fs=1000;
fn=2*fp/fs;
% window=boxcar(n+1);
window=rectwin(n+1);
b=fir1(n,fn,'high',window);
[H W]=freqz(b,1,128);
figure(2)
subplot(2,1,1);
plot(W/pi,abs(H));
title('mag res of hpf');
ylabel('gain in db-------->');
xlabel('normalized frequency------>');
grid on
subplot(2,1,2);
plot(W/pi,angle(H));
title('phase res of hpf');
ylabel('angle-------->');
xlabel('normalized frequency------>');
grid on
```

OUTPUT:





RESULT:

Thus, the MATLAB program for FIR LP/HP using rectangular window Techniques was executed and its frequency response is also verified.