**Experiment :- 14**

**Aim:-** Design of FIR lowpass and highpass filter using Rectangular Window.

**Software Used**:- Matlab 2019a

**Program**:-

rp = input('Enter passband ripple = ');        %taking passband ripple from user

rs = input('Enter stopband ripple = ');        %taking stopband ripple from user

fp = input('Enter passband frequency = ');        %taking passband frequency from user

fs = input('Enter stopband frequency = ');        %taking stopband frequency from user

f = input('Enter sampling frequency = ');        %taking sampling frequency from user

wp = 2\*fp/f;                    %calculating the omega

num = -20\*log10(sqrt(rp\*rs))-13;            %converting to decibel

den = 14.6\*(fs-fp)/f;

n = ceil(num/den);                %forming the n vector

n1 = n+1;

if(rem(n,2)~=0)

    n1 = n;

    n = n-1;

end

y = boxcar(n1);                    %using boxcar window

b = fir1(n,wp,y);                    %designing the filter

[h,o] = freqz(b,1,256);                %finding its frequency response

m = 20\*log10(abs(h));                %finding its decibel form

figure(1)

subplot(2,1,1)                    %plottin the LPF filter

plot(o/pi,m)

title('Boxcar (LPF) -Rishabh')

ylabel('Gain(dB)');

xlabel('Normalized freq');

b = fir1(n,wp,'high',y);                %designing the HPF filter

[h,o] = freqz(b,1,256);                %finding its frequency response

m = 20\*log10(abs(h));                %its decibel form

subplot(2,1,2)

plot(o/pi,m)

title('Boxcar (HPF) -Rishabh')            %plotting the output

ylabel('Gain(dB)');

xlabel('Normalized freq');

y = hanning(n1);                    %repeating the above step for hanning window filter

b = fir1(n,wp,y);

[h,o] = freqz(b,1,256);

m = 20\*log10(abs(h));

figure(2)

subplot(2,1,1)

plot(o/pi,m)

title('Hanning (LPF) -Rishabh')

ylabel('Gain(dB)');

xlabel('Normalized freq');

b = fir1(n,wp,'high',y);

[h,o] = freqz(b,1,256);

m = 20\*log10(abs(h));

subplot(2,1,2)

plot(o/pi,m)

title('Hanning (HPF) -Rishabh')

ylabel('Gain(dB)');

xlabel('Normalized freq');

y = bartlett(n1);                   %repeating the above step for bartlett window filter

b = fir1(n,wp,y);

[h,o] = freqz(b,1,256);

m = 20\*log10(abs(h));

figure(4)

subplot(2,1,1)

plot(o/pi,m)

title('Bartlett (LPF) -Rishabh')

ylabel('Gain(dB)');

xlabel('Normalized freq');

b = fir1(n,wp,'high',y);

[h,o] = freqz(b,1,256);

m = 20\*log10(abs(h));

subplot(2,1,2)

plot(o/pi,m)

title('Bartlett (HPF) -Rishabh')

ylabel('Gain(dB)');

xlabel('Normalized freq');

y = blackman(n1);                %repeating the above step for blackman window filter

b = fir1(n,wp,y);

[h,o] = freqz(b,1,256);

m = 20\*log10(abs(h));

figure(5)

subplot(2,1,1)

plot(o/pi,m)

title('Blackman (LPF) -Rishabh')

ylabel('Gain(dB)');

xlabel('Normalized freq');

b = fir1(n,wp,'high',y);

[h,o] = freqz(b,1,256);

m = 20\*log10(abs(h));

subplot(2,1,2)

plot(o/pi,m)

title('Blackman (HPF) -Rishabh')

ylabel('Gain(dB)');

xlabel('Normalized freq');

y = hamming(n1);                %repeating the above step for hamming window filter

b = fir1(n,wp,y);

[h,o] = freqz(b,1,256);

m = 20\*log10(abs(h));

figure(3)

subplot(2,1,1)

plot(o/pi,m)

title('Hamming (LPF) -Rishabh')

ylabel('Gain(dB)');

xlabel('Normalized freq');

b = fir1(n,wp,'high',y);

[h,o] = freqz(b,1,256);

m = 20\*log10(abs(h));

subplot(2,1,2)

plot(o/pi,m)

title('Hamming (HPF) -Rishabh')

ylabel('Gain(dB)');

xlabel('Normalized freq');

**Result:-** FIR lowpass and highpass filter were designed and it was verified by the following output.