**Experiment Name:**

**Design and Simulator of different types of Infinite Impulse Response (IIR) Filters.**

**Filter Design Functions:**

|  |  |
| --- | --- |
| Filter Type | Design Function |
| Butterworth | [b,a]=butter(n,Wn,options) |
| Chebyshev Type I | [b,a]=cheby1(n,Rp,Wn,options) |
| Elliptic | [b,a]=ellip(n,Rp,Rs,Wn,options) |

#### Butterworth Filter:

#### The Butterworth filter is a type of signal processing filter designed to have as flat frequency response as possible (no ripples) in the pass-band and zero roll off response in the stop-band. Butterworth filters are one of the most commonly used digital filters in motion analysis and in audio circuits.

#### The Butterworth filter provides the best Taylor series approximation to the ideal lowpass filter response at analog frequencies Ω  = 0 and Ω = ∞; for any order N, the magnitude squared response has 2N – 1 zero derivatives at these locations. Response is monotonic overall, decreasing smoothly from Ω = 0 to Ω = ∞.

**Source Code:**

% Design a 10th order bandpass butterworth filter with a passband from 100 to 200 Hz and plot both impulse response and frequency response.

% Plot the impulse response and frequency response.

Fs = 1000 ; % sampling frequency

n = 10 ; % order of the filter

Wn = [ 100 200 ] / 500 ; % Normalized by Fs / 2

[ b , a ] = butter ( n , Wn ) ;

figure ( 1 )

[ y , t ] = impz ( b , a , 101 ) % 101 samples of impulse response

plot ( t , y )

title ( ' Impulse Response ' )

grid on

freqz ( b , a , 512 , Fs )

title ( ' Frequecy Response ' )

**Figure:**



#### Chebyshev Type I Filter:

#### The Chebyshev Type I filter minimizes the absolute difference between the ideal and actual frequency response over the entire passband by incorporating an equal ripple of Rp dB in the passband. Stopband response is maximally flat. The transition from passband to stopband is more rapid than for the Butterworth filter.

**Source Code:**

% Design a 10th order bandpass butterworth filter with a passband from 100

% to 200 Hz and plot both impulse response and frequency response.

% Consider 25 dB ripple in passband and 20 dB attenuation in stopband.

% Plot the impulse response and frequency response.

Fs = 1000 ;

n = 10 ;

Rp = 25 ; % Ripple parameter

Wn = [ 100 200 ] / ( Fs / 2 ) ;

[ b , a ] = cheby1 ( n , Rp, Wn ) ;

[ y , t ] = impz ( b , a , 101 )

figure ( 1 )

plot ( t , y )

grid on

title ( ' Impulse Response ' )

figure ( 2 )

freqz ( b , a , 512 , Fs )

title ( ' Frequecy Response ' )

Figure:01



Figur:02



#### Elliptic Filter:

Elliptic filters are equiripple in both the passband and stopband. They generally meet filter requirements with the lowest order of any supported filter type. Given a filter order n, passband ripple Rp in decibels, and stopband ripple Rs in decibels, elliptic filters minimize transition width.

Source Code:

% Design a 10th order bandpass butterworth filter with a passband from 100 to 200 Hz and plot both impulse response and frequency response.

% Consider 25 dB ripple in passband and 20 dB attenuation in stopband.

% Plot the impulse response and frequency response.

Fs = 1000 ; % sampling frequency

n = 10 ;

Rp = 5 ;

Rs = 20 ;

Wn = [ 100 200 ] / ( Fs / 2 ) ;

[ b , a ] = ellip( n , Rp, Rs, Wn ) ;

figure ( 1 )

freqz ( b , a , 512 , Fs ) % 512 samples

title ( ' Frequecy Response ' )

figure ( 2 )

[ y , t ] = impz ( b , a , 500 )

plot ( t , y )

grid on

title ( ' Impulse Response of Elliptic filter' )

Figure:01



Figure:02



**Comparison Original and Filtered Signal**

**Source Code:**

t = 0 : 0.01 : 1 ;

Fs = 1000 ;

y = sin ( 8 \* pi \* t ) % Orignal signal

yn = y + 0.5 \* rand ( 1 , length ( t ) ) % Signal with noise

subplot ( 2 , 2 , 1 )

plot ( t , y , 'k' )

title ( ' Orignal signal ' )

subplot ( 2 , 2 , 2 )

plot ( t , yn , 'r' )

title ( ' Noisy Signal ' )

[ b , a ] = butter ( 2 , 200 / Fs ) ;

z = filter ( b , a , yn )

subplot ( 2 , 2 , 3 )

plot ( t , z , 'b' )

title ( ' Filtered Signal ' )

subplot ( 2 , 2 , 4 )

plot ( t , y , 'm' , t , z , 'k' )

title ( ' Comparison Original and Filtered Signal ' )

Figure:



**Conclusion:**

**One main disadvantage of the Butterworth filter is that it achieves this pass band flatness at the expense of a wide transition band as the filter changes from the pass band to the stop band. It also has poor phase characteristics as well. The ideal frequency response, referred to as a “brick wall” filter, and the standard Butterworth approximations, for different filter orders are given below.**