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# Infinite Impulse Response Filter Design

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This code will prove to be classic example for proper use of the given functions for Butterworth filter, Chebyshev Type 1 filter and Chebyshev Type 2 Filter Design

## Inputs Provided

Passband Attenuation

$A_p = 3;$

Sampling Frequency

$F_s = 500;$

Stopband Attenuation

$A_s = 60;$

Passband Frequency

$\omega_p = 40;$

Dividing by Sampling Frequency

$\omega_p = \omega_p / F_s;$

Stopband Frequency

$\omega_s = 150;$

Dividing by Sampling Frequency

$$W_s = W_s / F_s;$$

## Derivation of order by butterord

$$[n, W_n] = \text{butterord}(W_p, W_s, A_p, A_s);$$

## Formula for Order n of Butterworth filter

$$n = \frac{\log \varepsilon}{\log \Omega_p - \log \Omega_s + \frac{1}{n} \log \sqrt{A^2 - 1}}$$

OR another simplified version will be

$$n = \frac{\log \left( \frac{\varepsilon}{\sqrt{A^2 - 1}} \right)}{\log \left( \frac{\Omega_p}{\Omega_s} \right)}$$

## Applying the Butterworth filter function

$$[b, a] = \text{butter}(n, W_n);$$

## Converting to frequency domain.

$$[h, w] = \text{freqz}(b, a);$$

Since the obtained input was in Normalized Form we get it back by multiplying with Sampling Frequency

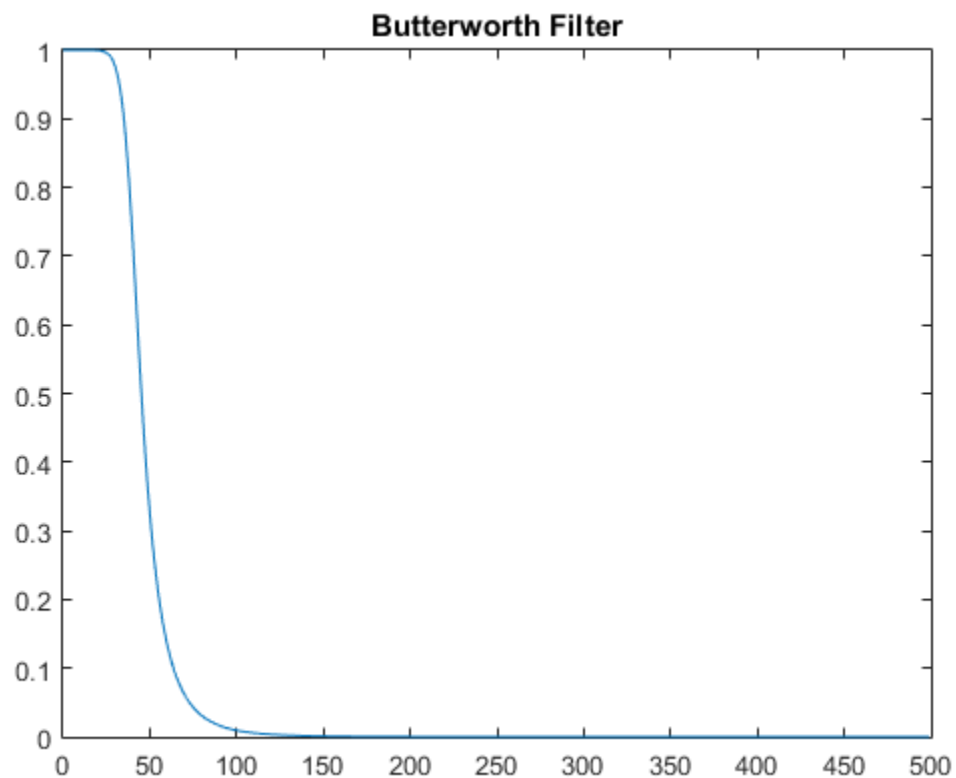
```
W = w*Fs/pi;
```

To remove the negative values of h we take absolute

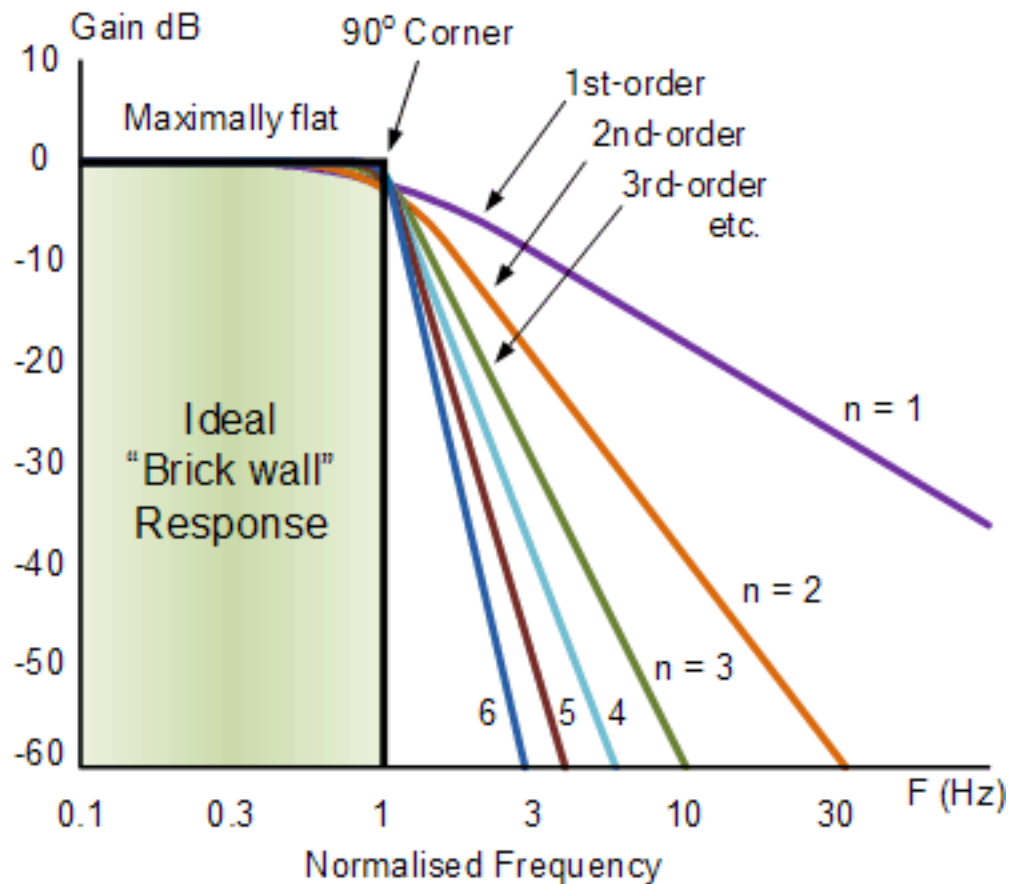
```
h = abs(h);
```

## The PLOT for Butterworth Filter

```
figure();  
plot(W,h);  
title('Butterworth Filter')
```



## Butterworth Filter Characteristics



## Derivation of order

```
[n,Wp] = cheblord(Wp,Ws,Ap,As);
```

## Applying the Chebyshev Type I filter function

```
[b,a] = cheby1(n,Ap,Wp);
```

## Converting to frequency domain.

```
[h,w] = freqz(b,a);
```

Again since the obtained input was in Normalized Form we get it back by multiplying with Sampling Frequency

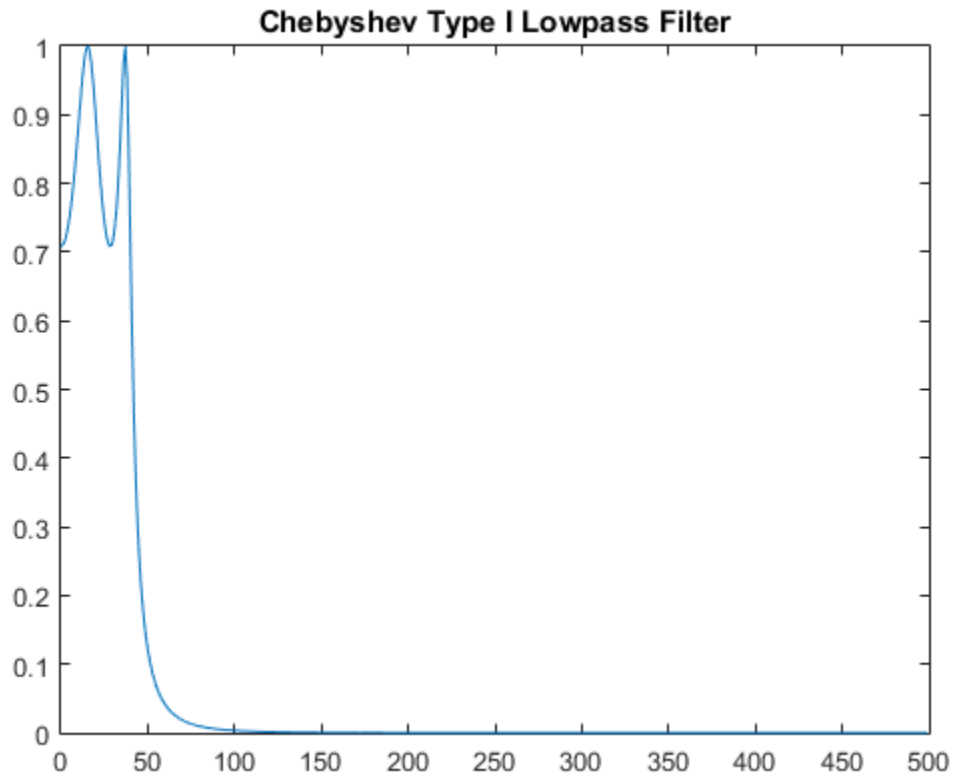
```
W = w*Fs/pi;
```

Again to remove the negative values of h we take absolute

```
h = abs(h);
```

## The PLOT for Chebyshev Type I Filter

```
figure();  
plot(W,h);  
title('Chebyshev Type I Lowpass Filter')
```



## Derivation of order

```
[n,Wp] = cheb2ord(Wp,Ws,Ap,As);
```

## Applying the Chebyshev Type II filter function

```
[b,a] = cheby2(n,Ap,Wp);
```

## Converting to frequency domain.

```
[h,w] = freqz(b,a);
```

Again since the obtained input was in Normalized Form we get it back by multiplying with Sampling Frequency

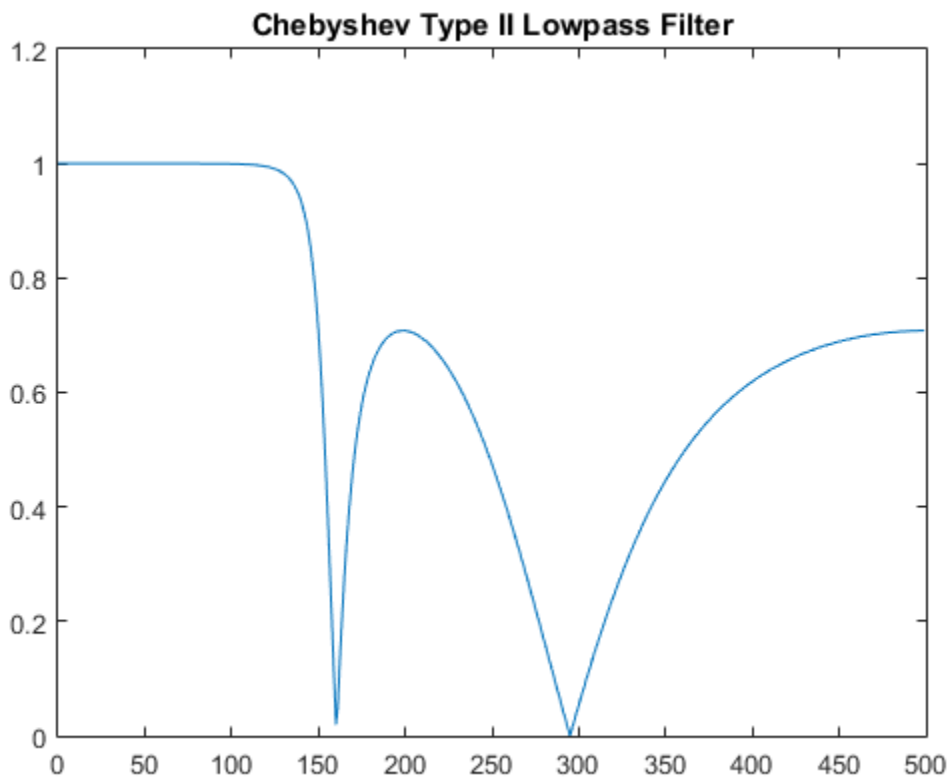
```
W = w*Fs/pi;
```

Again to remove the negative values of h we take absolute

```
h = abs(h);
```

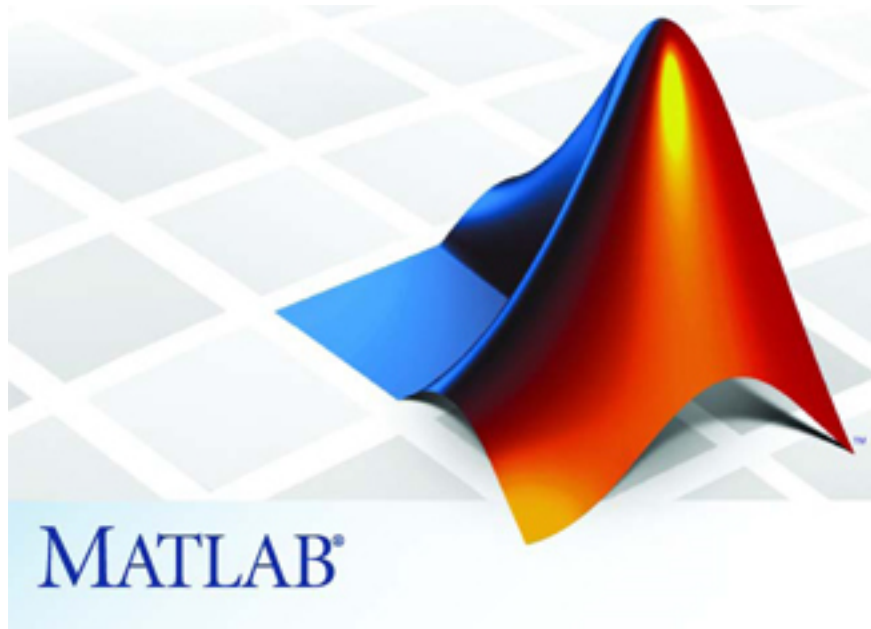
## The PLOT for Chebyshev Type II Filter

```
figure();  
plot(W,h);  
title('Chebyshev Type II Lowpass Filter')
```



**Author: Kaustubh Shivdikar**

MATLAB Lab experiment of Linear to circular convolution.



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