

# Minimax Optimal FIR Design Examples

# Minimax design of FIR filters

- linear phase

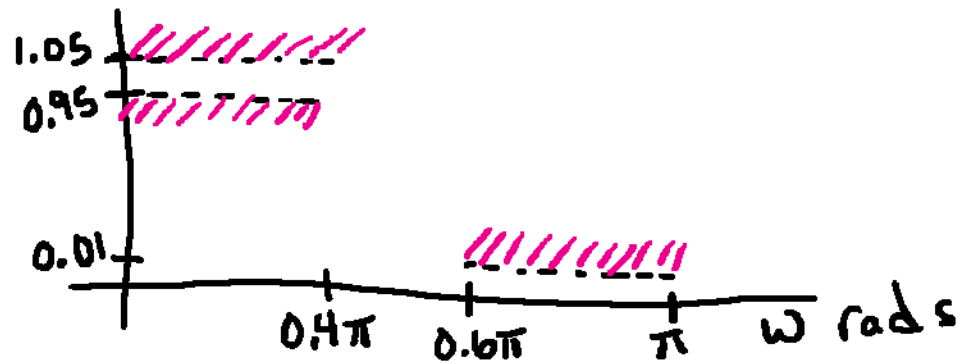
- design criterion

impulse response  $h[n]$ ,  $0 \leq n \leq M$

$$\min_{h[n]} \left\{ \max_{\omega \in F} |W(\omega) (H_d(\omega) - A(\omega))| \right\}$$

- equiripple weighted error

# Low Pass FIR Filter



Use MATLAB firpm

```
del_p = 0.05;  
del_s = 0.01;  
om_p = 0.4*pi;  
om_s = 0.6*pi;
```

```
M = ceil((-10*log10(del_p*del_s) - 13)/(2.324*(om_s-om_p)))
```

$M = 14$

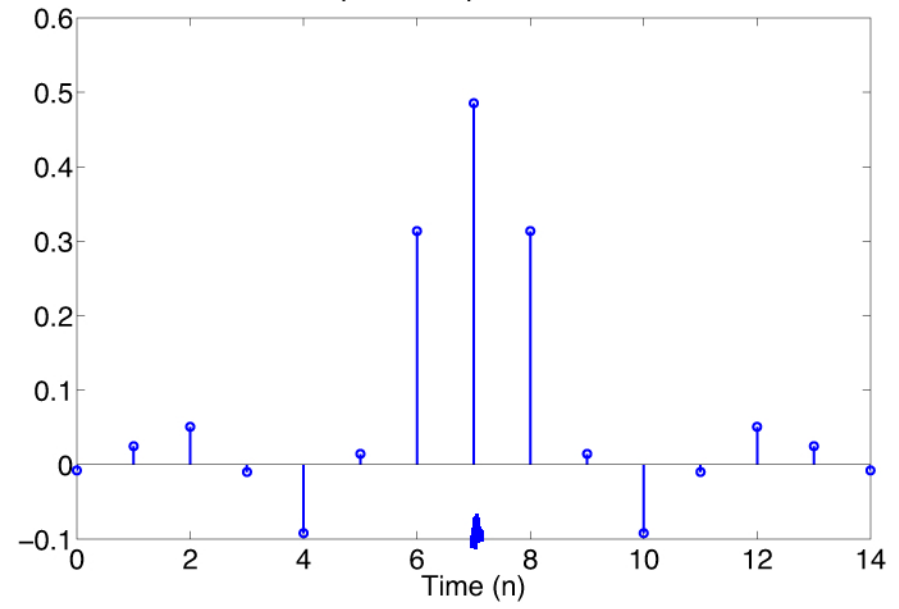
```
F = [0 om_p om_s pi]/pi;  
A = [1 1 0 0];  
W = [1 del_p/del_s];
```

$\frac{0.05}{0.01} = 5 \Rightarrow$  stopband error 5x as important as passband error

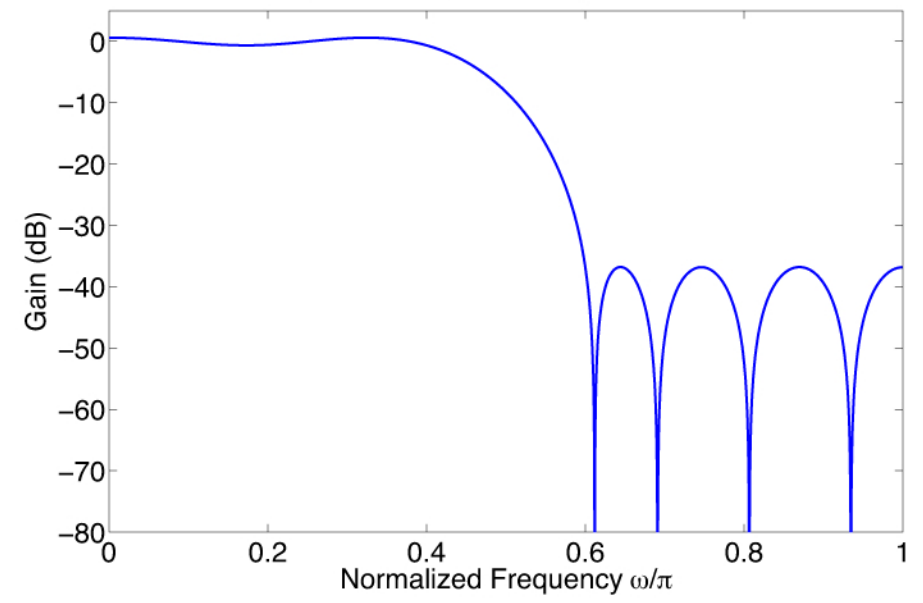
```
b = firpm(M, F, A, W);
```

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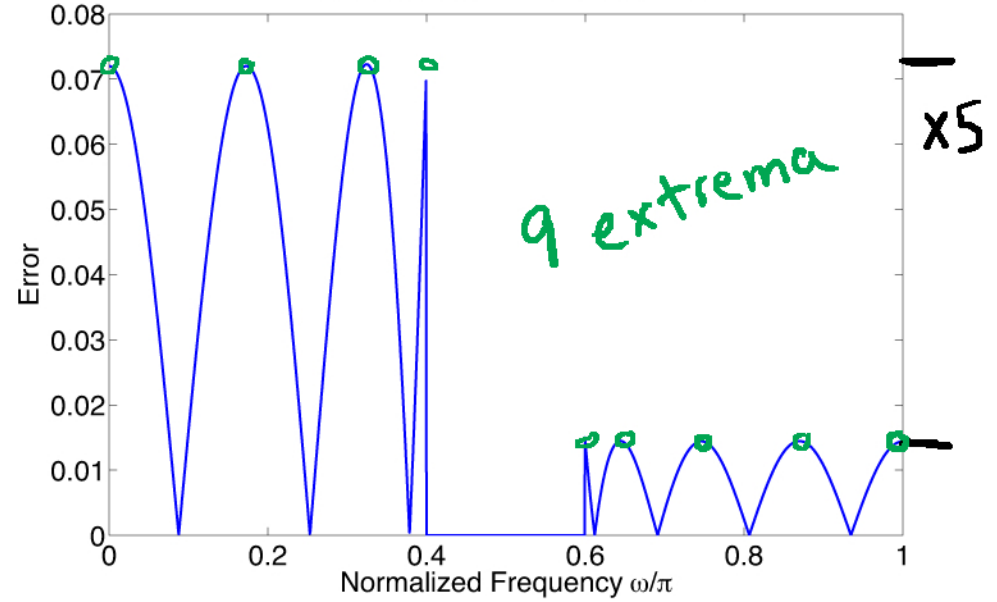
Impulse Response M = 14

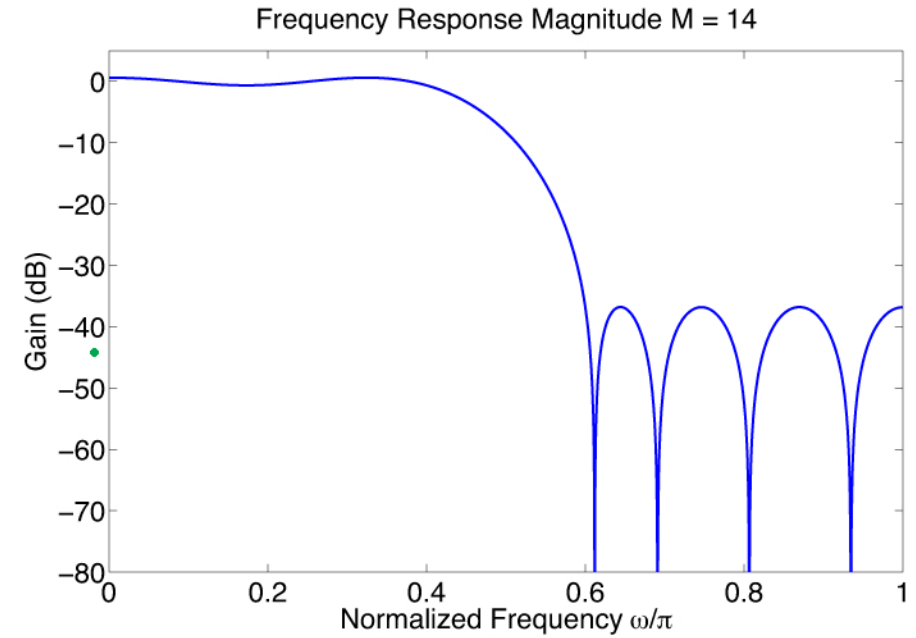
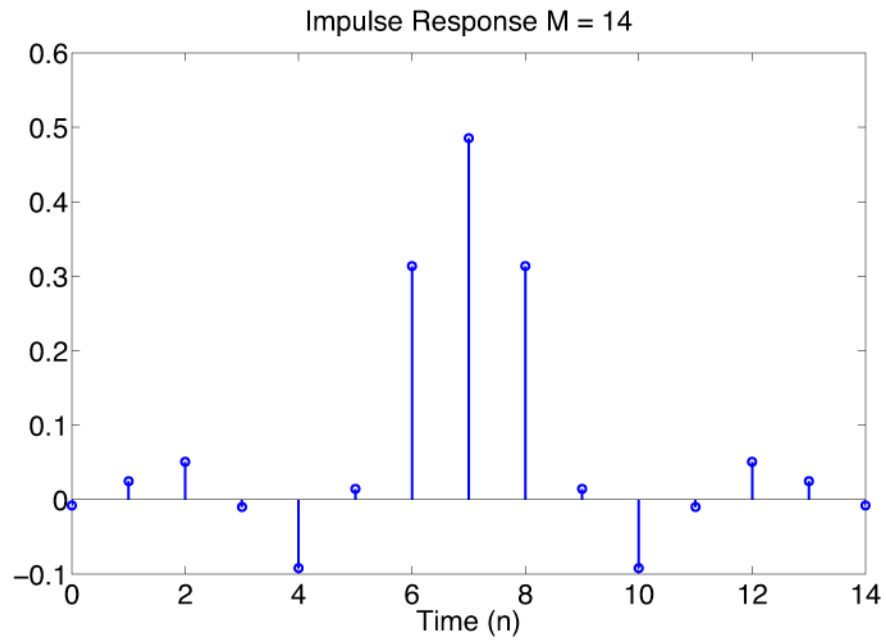


Frequency Response Magnitude M = 14

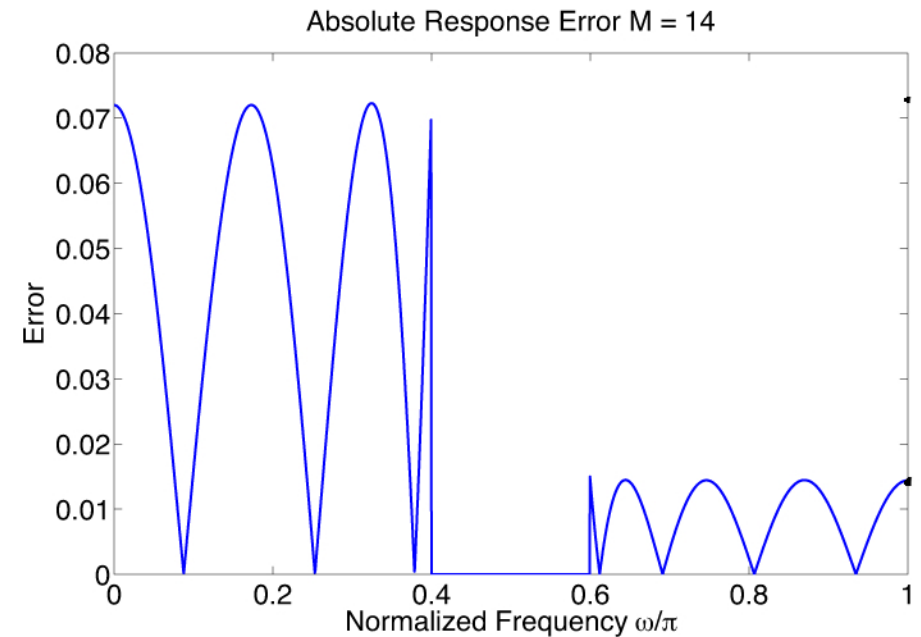


Absolute Response Error M = 14



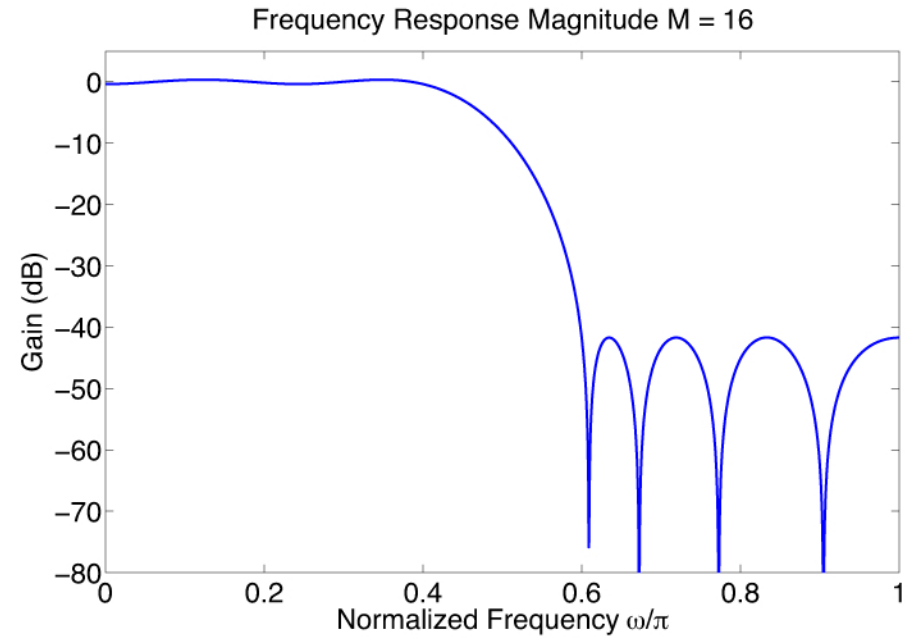
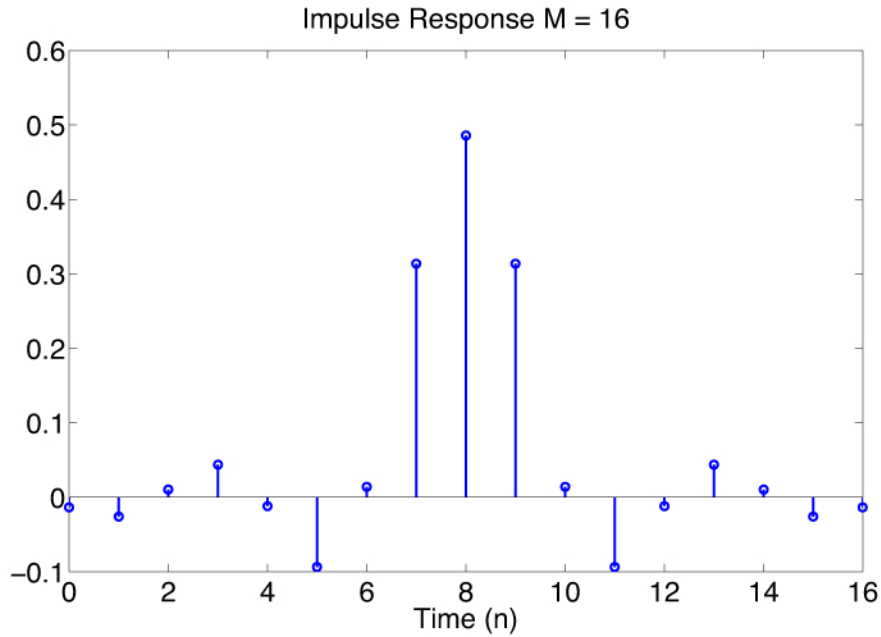


Passband error  $> 0.05$   
 Stopband error  $> 0.01$   
 $\Downarrow$   
 increase  $M$

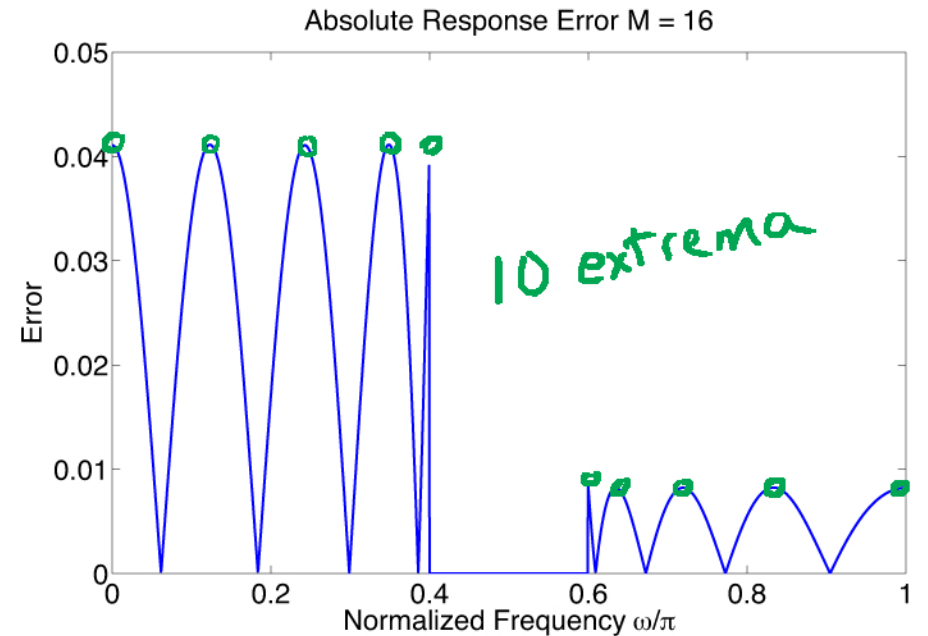


Try  $M = 16$

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Passband ripple  $< 0.05$   
Stopband ripple  $< 0.01$



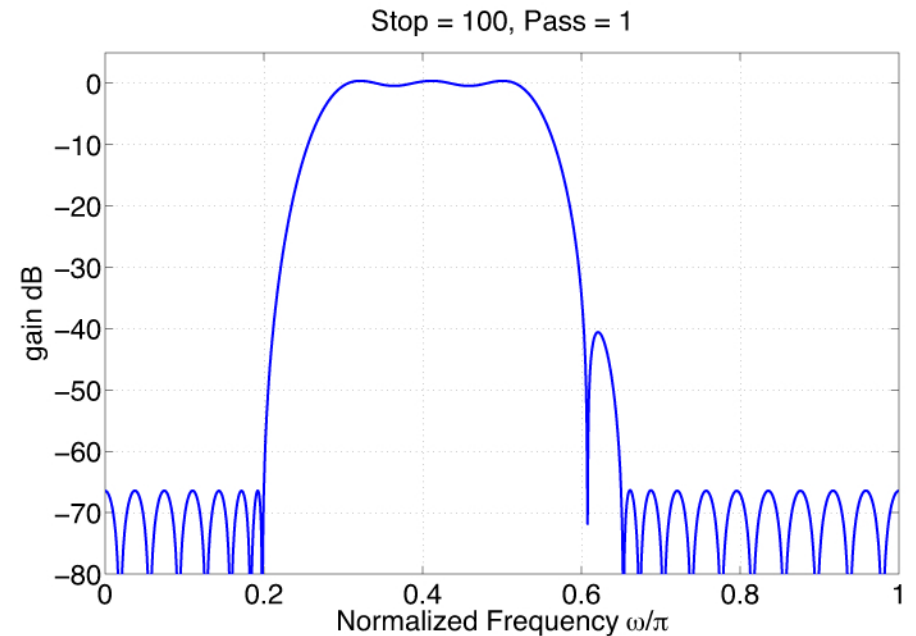
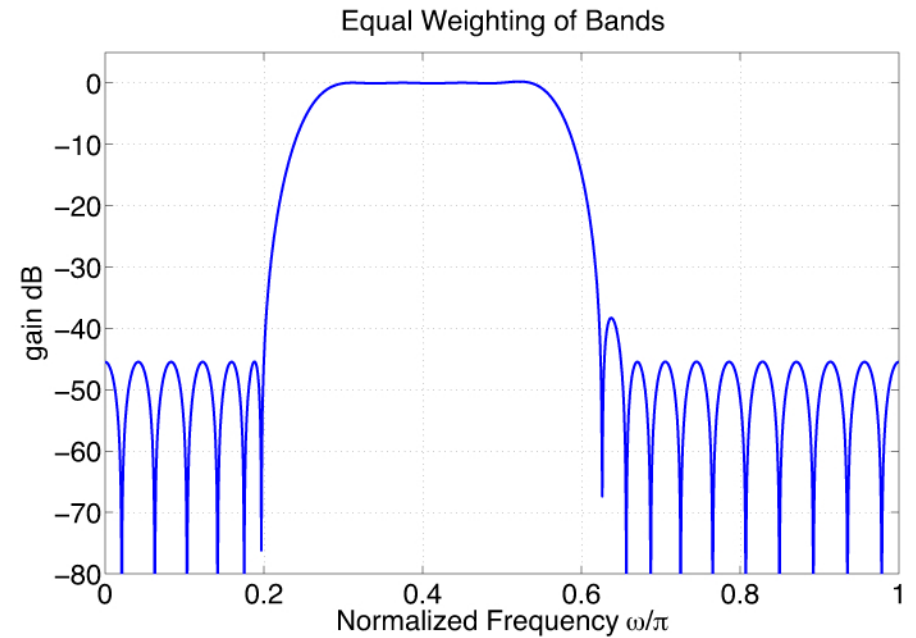
# Band pass FIR Filter - different weightings

```
order = 46;
```

```
freqbands = [0 0.2*pi 0.3*pi 0.5*pi 0.65*pi pi]/pi;  
bandgains = [0 0 1 1 0 0];
```

```
bandwghts1 = [1 1 1];  
Bf1 = firpm(order,freqbands,bandgains,bandwghts1);
```

```
bandwghts2 = [100 1 100];  
Bf2 = firpm(order,freqbands,bandgains,bandwghts2);
```

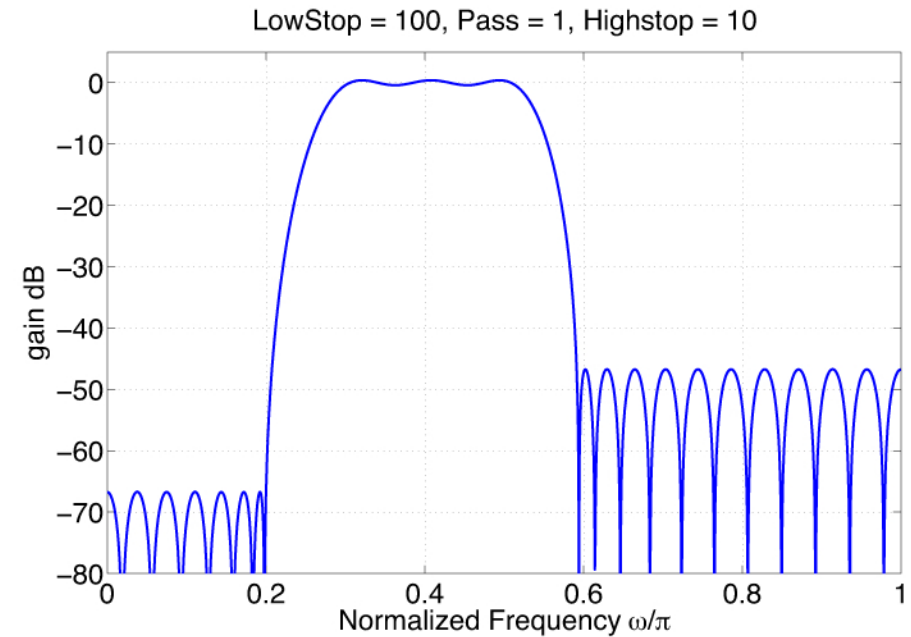
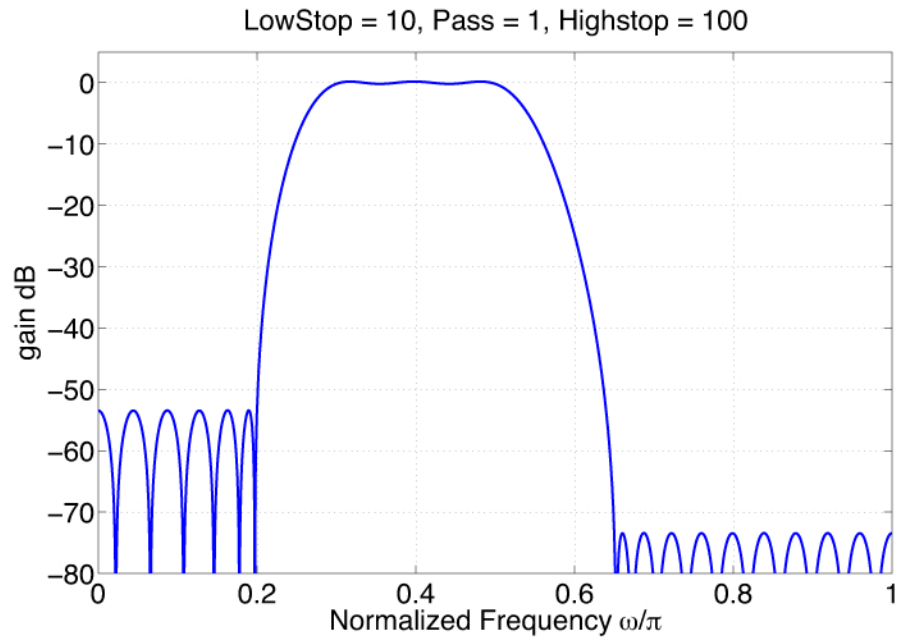
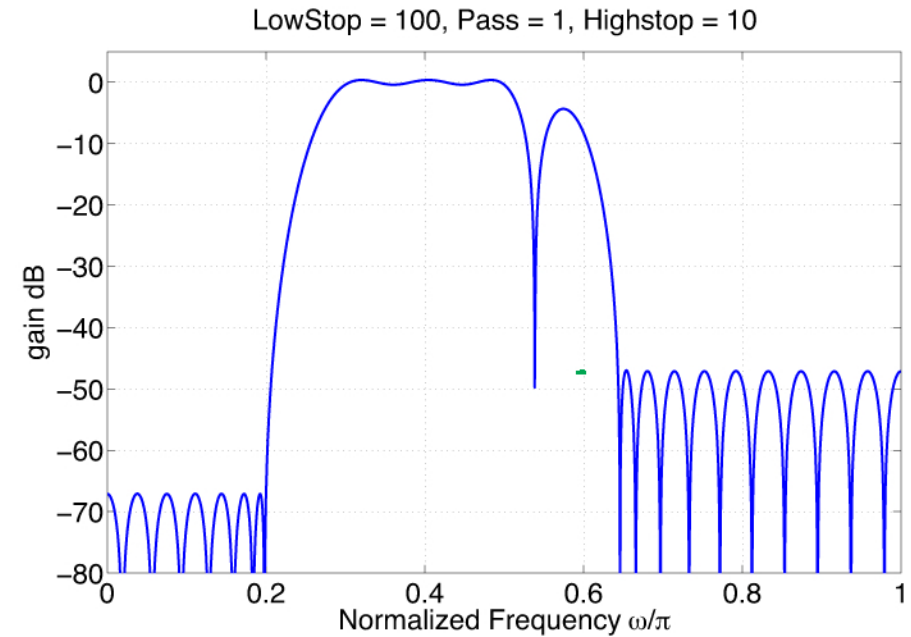


```
bandwghts3 = [10 1 100];  
Bf3 = firpm(order,freqbands,bandgains,bandwghts3);
```

```
bandwghts4 = [100 1 10];  
Bf4 = firpm(order,freqbands,bandgains,bandwghts4);
```

```
freqbands = [0 0.2*pi 0.3*pi 0.5*pi 0.6*pi pi]/pi;  
Bf5 = firpm(order,freqbands,bandgains,bandwghts4);
```

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