11.9 End of Chapter Problems

EOCP 11.1

Consider the following difference equations

1. $y(n) = x(n) + x(n-1) + x(n-2) + x(n-3) + x(n-4)$
2. $y(n) = \frac{1}{2}x(n) + x(n-1) + x(n-2) + x(n-3) + \frac{1}{2}x(n-4)$
3. $y(n) = x(n) + x(n-1) + x(n-2) + \frac{1}{2}x(n-3) + \frac{1}{2}x(n-4)$
4. $y(n) = x(n) + 2x(n-1) + 3x(n-2)$
5. $y(n) = x(n) + x(n-1) + x(n-2) + 2x(n-3) + x(n-4)$

Find the impulse response $h(n)$ for all the filters above and plot their frequency responses using the function `freqz` and the `fft`. Compare the results.

EOCP 11.2

Consider the following continuous signals

1. $x(t) = 2 + \cos(10t) + \sin(100t)$
2. $x(t) = \cos(10t)$
3. $x(t) = \cos(100t) + \sin(1000t)$

Design a lowpass digital filter to filter out the sinusoidal term with the highest frequency in each input signal above. Use different windows in the design. Comment on your answers and the resulting plots. Do not use MATLAB filter design functions.

EOCP 11.3

Consider the analogue signals

1. $x(t) = \cos(100t) + \sin(1000t) + \sin(500t)$
2. $x(t) = 10 + \cos(150t) + \sin(1050t)$
3. $x(t) = \cos(t) + \sin(10000t) + \sin(400t)$

We are interested in passing the highest frequency in the input signals given. Design a filter that can do that. Use different windows and compare results. Do not use MATLAB filter design functions.

EOCP 11.4

Consider the following analogue signals

1. $x(t) = \cos(5/2t) + \sin(10/3t) + \sin(5/4t)$
2. $x(t) = 10 + \cos(150t) + \sin(700t)$
3. $x(t) = \cos(200t) + \sin(1020t) + \sin(400t)$

Design a filter that will suppress the intermediate frequency and pass the other two in the input signals above. Again, use different windows and you may increase the order of the filter in some cases to eliminate some frequencies if they are very close. Do not use MATLAB filter design functions.

EOCP 11.5

Consider the following analogue signals

1. $x(t) = \cos(5/7t) + \sin(1/3t) + \sin(5/4t)$
2. $x(t) = 1 + \cos(140t) + \sin(70t)$
3. $x(t) = \cos(200t) + \sin(3\pi/4\ t) + \sin(400t)$

Design a filter that will suppress the highest and the lowest frequencies and pass the one in between in the input signals above. Again, use different windows and you may increase the order of the filter in some cases to eliminate some frequencies if they are very close. Do not use MATLAB filter design functions.

EOCP 11.6

Repeat EOCP 11.2 by using the MATLAB filter design functions.

EOCP 11.7

Repeat EOCP 11.3 by using the MATLAB filter design functions.

EOCP 11.8

Repeat EOCP 11.4 by using the MATLAB filter design functions.

EOCP 11.9

Repeat EOCP 11.5 by using the MATLAB filter design functions.

EOCP 11.10

We are interested in removing the unwanted frequencies 50 Hz, 100 Hz and 150 Hz from the continuous signal $x(t)$.

1. Design a digital filter that will eliminate these frequencies. Assume that the highest frequency in $x(t)$ is 1000 Hz.
2. Demonstrate by using a sample input that the filter is working.

EOCP 11.11

Consider the following IIR digital filters

1. $H(z) = \dfrac{z-1}{z^2 - \dfrac{1}{8}}$
2. $H(z) = \dfrac{1}{z^2 - \dfrac{3}{4}z + \dfrac{1}{8}}$
3. $H(z) = \dfrac{z^2}{z^2 - 5z + 2}$
4. $H(z) = \dfrac{z^2 - z + 1}{z^2 - \dfrac{3}{4}z + \dfrac{1}{8}}$
5. $H(z) = \dfrac{z^2 - 1}{z^3 + \dfrac{1}{8}}$

Derive an FIR digital filter to approximate the digital IIR filter. Comment on the results.

EOCP 11.12

Consider the following digital filter magnitude responses shown in Figure 11.31 through Figure 11.35. Use the frequency sampling method to design an FIR lowpass filter to approximation the magnitude response of these IIR filters.

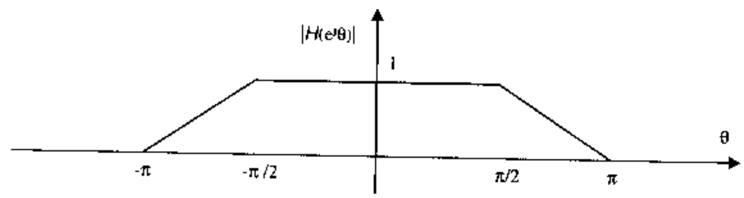

FIGURE 11.31 Filter for EOCP 11.12.

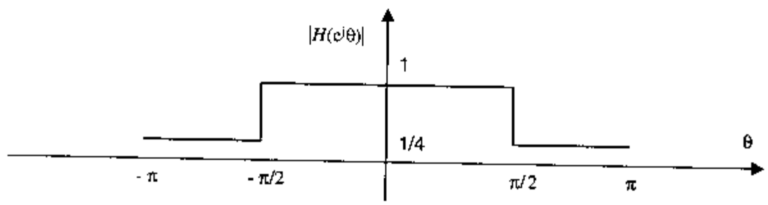

FIGURE 11.32 Filter for EOCP 11.12.

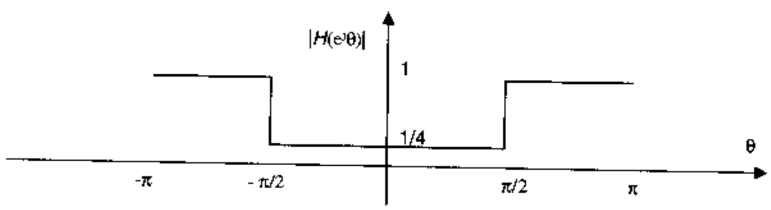

FIGURE 11.33 Filter for EOCP 11.12.

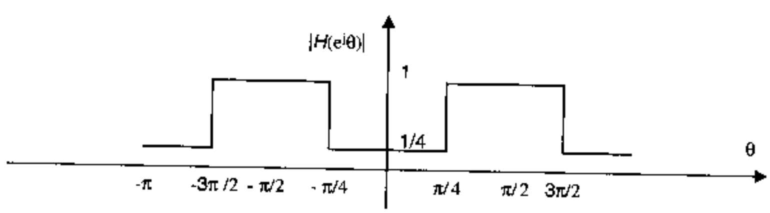

FIGURE 11.34 Filter for EOCP 11.12.

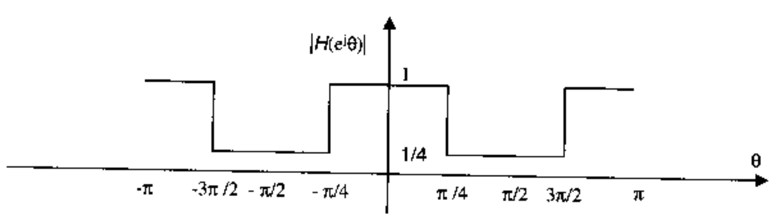

FIGURE 11.35 Filter for EOCP 11.12.

EOCP 11.13

We are interested in removing the frequencies that are higher than 115 kHz from the analogue signal $x(t)$. Design a digital filter to accomplish that. Use a sampling frequency of 500 kHz. Plot the results and use different windows.

EOCP 11.14

We wish to pass the range of frequency $40\,\text{kHz} \le f \le 80\,\text{kHz}$ in the analogue signal $x(t)$. Suppose that the highest frequency is $x(t)$ in 100 kHz. Design a bandpass digital filter to do just that. Use different windows and plot results.

EOCP 11.15

Use MATLAB to design a lowpass filter of order 32 that will pass frequencies from 0 to 1 kHz with unity magnitude. We expect zero magnitude for other frequencies. Assume that the highest frequency coming to this filter is 10 kHz. Use the functions `fir1`, `firls` and `remez` for the design. Use the Blackman and the Hanning windows. Plot the results.

EOCP 11.16

We are interested in designing a bandstop FIR filter with edge frequencies at 0.1π and 0.3π. The gain in the passbands is three and in the stopband is zero. Use the functions `fir1`, `firls` and `remez` for the design. Use the Hamming and rectangular windows and plot the results.

EOCP 11.17

Design an ideal differentiator using the `remez` function from MATLAB. Compare it with the formula derived in the chapter. Plot the magnitude responses.

EOCP 11.18

1. Use MATLAB to plot the highpass filter magnitude response with $\theta_c = 0.2\pi$ derived from the lowpass IIR filter.
2. Use MATLAB to plot the stopband filter magnitude response derived from the lowpass FIR filter. The stop edges are at $\theta_l = 0.2\pi$ and $\theta_u = 0.6\pi$.
3. Use MATLAB to plot the bandpass filter frequency response derived from the lowpass FIR filter. The pass edges are at $\theta_l = 0.2\pi$ and $\theta_u = 0.8\pi$.
4. Use MATLAB to plot the lowpass filter frequency response derived from the highpass FIR filter. Use a cutoff frequency of $\theta_c = 0.5\pi$.
5. Use MATLAB to plot the highpass filter frequency response derived from the lowpass FIR filter. Use a cutoff frequency of $\theta_c = 0.5\pi$.