

# Chapter 4: Problem Solutions

## Digital Filters

### Problems on Non Ideal Filters

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#### ■ Problem 4.1

We want to design a Discrete Time Low Pass Filter for a voice signal. The specifications are:

Passband  $F_p = 4 \text{ kHz}$ , with  $0.8 \text{ dB}$  ripple;

Stopband  $F_s = 4.5 \text{ kHz}$ , with  $50\text{dB}$  attenuation;

Sampling Frequency  $F_s = 22 \text{ kHz}$ .

Determine a) the discrete time Passband and Stopband frequencies, b) the maximum and minimum values of  $|H(\omega)|$  in the Passband and the Stopband, where  $H(\omega)$  is the filter frequency response.

#### Solution

a) Recall the mapping from analog to digital frequency  $\omega = 2\pi F / F_s$ , with  $F_s$  the sampling frequency. Then the passband and stopband frequencies become  $\omega_p = 2\pi 4 / 22 \text{ rad} = 0.36\pi \text{ rad}$ ,  $\omega_s = 2\pi 4.5 / 22 \text{ rad} = 0.41\pi \text{ rad}$ ;

b) A  $0.8 \text{ dB}$  ripple means that the frequency response in the passband is within the interval  $1 \pm \delta$  where  $\delta$  is such that  $20 \log_{10} (1 + \delta) = 0.8$ . This yields  $\delta = 10^{0.04} - 1 = 0.096$ . Therefore the frequency response within the passband is within the interval  $0.9035 \leq |H(\omega)| < 1.096$ . Similarly in the stopband the maximum value is  $|H(\omega)| < 10^{-50/20} = 0.0031$ .

#### ■ Problem 4.2

A Digital Filter has frequency response  $H(\omega)$  such that

$$\begin{aligned} 0.95 \leq |H(\omega)| \leq 1.05 & \quad \text{for } 0 \leq \omega \leq 0.3\pi \\ 0 \leq |H(\omega)| \leq 0.005 & \quad \text{for } 0.4\pi \leq \omega \leq \pi \end{aligned}$$

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**JL Elias**



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