Problem 12 (FIR Filter Design)

Digital filter specifications are often given in terms of the loss function, $H_l(\Omega) = -20log_{10}(|H(e^{j\Omega})|)$, in dB. In this problem the peak passband ripple δ_p and the minimum stopband attenuation δ_s are given in dB, i.e., the loss specifications of the digital filter are given by

$$\begin{aligned} \delta_p &= -20log_{10}(1-\delta_1)dB, \\ \delta_d &= -20log_{10}(\delta_2)dB. \end{aligned}$$

(a) Estimate the order of an optimal equiripple linear-phase lowpass FIR filter with the following specifications: passband edge $F_p = 1.8kHz$, stopband edge $F_s = 2kHz$, $\delta_p = 0.1dB$, $\delta_s = 35dB$, and sampling frequency $F_T = 12kHz$.

The estimation formula can also be used to estimate the length of highpass, bandpass, and bandstop optimal equiripple FIR filters. Then the width of the smallest transition band is used to estimate the filter order.

(b) Estimate the order of an optimal equiripple linear-phase bandpass FIR filter with the following specifications: passband edges $F_{p1} = 0.35kHz$ and $F_{p2} = 1kHz$, stopband edges $F_{s1} = 0.3kHz$ and $F_{s2} = 1.1kHz$, passband ripple $\delta_1 = 0.002$, stopband ripple $\delta_2 = 0.001$, and sampling frequency $F_T = 10kHz$.