Foundations of Audio Signal Processing
Assignment 11

Giulia Baldini, Luis Fernandes, Agustin Vargas Toro

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Exercise 11.1

a.

Exercise 11.2

a. Let us consider

$$h(n) = \begin{cases} 0.5 & \text{if } n \in \{0, 1\}, \\ 0 & \text{otherwise.} \end{cases}$$

$$g(n) = \begin{cases} 0.5 & \text{if } n = 0, \\ -0.5 & \text{if } n = 1, \\ 0 & \text{otherwise.} \end{cases}$$

and

$$\sum_{N-1}^{n=0} q^n = \frac{1 - q^N}{1 - q}$$

and the fact that $N = 2$ because we are considering a Haar lowpass-filter, then the frequency response H^2 can be written as:

$$\begin{aligned} H^2(\omega) &= \sum_{N-1}^{n=0} \frac{1}{N} \cdot e^{-2\pi i \omega n} \\ &= \frac{1 - e^{-2\pi i \omega N}}{1 - e^{-2\pi i \omega n}} \\ &= \frac{1}{N} \cdot \frac{e^{\frac{2\pi i \omega N}{2}} - e^{\frac{-2\pi i \omega N}{2}}}{e^{\frac{2\pi i \omega}{2}} - e^{\frac{-2\pi i \omega}{2}}} \cdot \frac{e^{\frac{-2\pi i \omega N}{2}}}{e^{\frac{-2\pi i \omega}{2}}} \\ &= \frac{1}{N} \cdot \frac{\sin(\pi \omega N)}{\sin(\pi \omega)} \cdot e^{\frac{2\pi i \omega (N-1)}{2}} \\ &= \frac{1}{2} \cdot \frac{\sin(2\pi \omega)}{\sin(\pi \omega)} \cdot e^{\frac{2\pi i \omega}{2}} \\ &= \frac{1}{2} \cdot \frac{0}{\sin(\pi \omega)} \cdot e^{\frac{2\pi i \omega}{2}} & = 0 \end{aligned}$$