Problem 14 (filter design)

Determine the unit sample response h_i of a linear-phase FIR filter of length $L = 4$ for which the amplitude frequency response $H_0(\Omega)$ at $\Omega = 0$ and $\Omega = \pi/2$ is specified as

$$H_0(0) = 1, \qquad H_0(\pi/2) = 1/2.$$

Problem 15 (filter design)

An ideal discrete-time Hilbert transformer is a system that introduces $-\pi/2$ radians of phase shift for $0 < \Omega < \pi$ and $\pi/2$ radians of phase shift for $-\pi < \Omega < 0$. The amplitude frequency response of the Hilbert transformer is shown in figure 1. Such systems are called ideal $\pi/2$-radians phase-shifters.

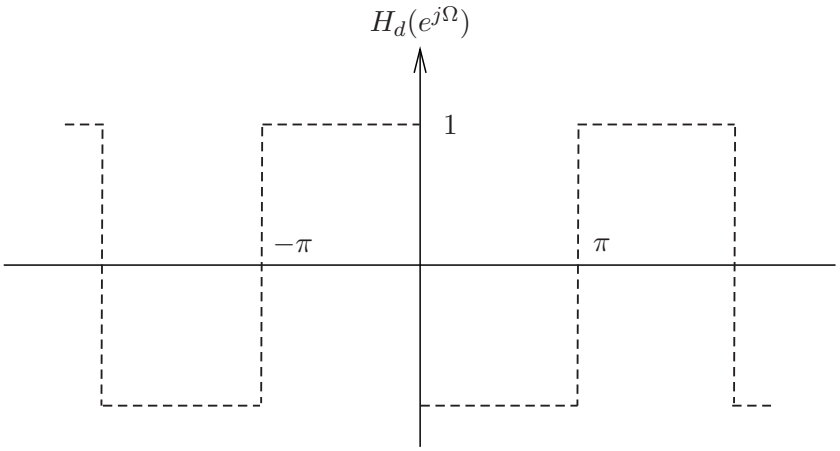

Figure 1: hilbert transformer

(a) Give a close-form equation (use the step function) for the ideal frequency response $H_d(e^{j\Omega})$ of an ideal discrete-time Hilbert transformer that also includes the constant (nonzero) group delay for $-\pi < \Omega < \pi$. Plot the phase response of this system for $-\pi < \Omega < \pi$.

(b) What type(s) of FIR linear-phase systems (I, II, III, IV) can be used to approximate the ideal Hilbert transformer in part a)?

(c) Suppose we want to use the window method with a rectangular window to design a linear-phase approximation to the ideal Hilbert-transformer. Use $H_d(e^{j\Omega})$ given

in part (a) to determine the ideal impulse response $h_{d,i}$ if the FIR system is to be such that $h_i = 0$ for $i < 0$ and $i > L - 1$.

(d) What is the delay of the system if $L = 21$? Sketch (use matlab) the magnitude of the frequency response of the FIR approximation for this case, assuming a rectangular window.

(e) What is the delay of the system if $L = 20$? Sketch (use matlab) the magnitude of the frequency response of the FIR approximation for this case, assuming a rectangular window.