ECE 310 **University of Illinois at Urbana-Champaign** **Fall 2015**

Profs. Bresler & Radhakrishnan **Homework 9** **Due: Friday, Nov 6**

Reading: Chapter 11

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1. Consider the following LSI system with the following transfer function:

$$H(z) = \frac{z^3 - \frac{2}{3}z^2}{z^3 - \frac{21}{20}z^2 + \frac{1}{8}z + \frac{3}{40}}.$$

Draw the flter structures for the implementations of the system in each of the following forms:

(a) Direct Form I.

(b) Direct Form II.

(c) Cascade using first- and second-order direct form II sections.

(d) Parallel using first- and second-order direct form II sections.

2. The frequency response of a GLP filter can be expressed as $H_d(\omega) = R(\omega)e^{j(\alpha - M\omega)}$ where $R(\omega)$ is a real function. For each of the following filters, determine whether it is a GLP filter. If it is, state the Type, find $R(\omega)$, M, and α, and indicate whether it is also a linear phase filter.

(a) $\{h_n\}_{n=0}^{2} = \{2, 1, 1\}$

(b) $\{h_n\}_{n=0}^{2} = \{1, 2, 3\}$

(c) $\{h_n\}_{n=0}^{2} = \{-1, 3, 1\}$

(d) $\{h_n\}_{n=0}^{4} = \{1, 1, 1, -1, -1\}$

(e) $\{h_n\}_{n=0}^{2} = \{1, 0, -1\}$

(f) $\{h_n\}_{n=0}^{3} = \{2, 1, 1, 2\}$

In each case, the remaining terms of the unit pulse response of the filter are zero.

3. Consider the following systems,

(i) $y[n] = \frac{2}{5}x[n] - x[n-1] + x[n-2] - \frac{2}{5}x[n-3]$

(ii) $y[n] = \frac{1}{3}x[n] + x[n-1] - x[n-2] - \frac{1}{3}x[n-3]$

(iii) $y[n] = x[n] + x[n-2] + x[n-4]$

(iv) $y[n] = -x[n] + x[n-1] + \frac{1}{3}x[n-2]$

(v) $y[n] = x[n] - 0.76y[n-1]$

For each of the systems,

(a) Determine whether the system is FIR or IIR? If the system is FIR, sketch its $h[n]$.

(b) If the system is FIR, determine whether $h[n]$ is of even or odd length.

(c) If the system is FIR, determine whether $h[n]$ has even or odd symmetry, or neither.

(d) Determine whether its $H_d(\omega)$ has linear phase. If it does not, determine whether it has generalized linear phase (GLP).

(e) The frequency response of a GLP filter can be expressed as $H_d(\omega) = R_d(\omega)\, e^{j(\alpha - M\omega)}$, where $R_d(\omega)$ is a real function. For systems that have a GLP or linear phase, find $R_d(\omega)$, M, and α.

4. Determine the coefficients of a linear-phase FIR filter

$$y[n] = h_0 x[n] + h_1 x[n-1] + h_2 x[n-2]$$

such that (i) it rejects any frequency component at $\omega_0 = 5\pi/6$, and (ii) its frequency response is normalized so that $H_d(0) = 1$.