SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
ACADEMIC YEAR 2019-2020 SEMESTER 1
DIGITAL SIGNAL PROCESSING
TUTORIAL 13

1. Develop the transposed form structure of a length-8 Type IV linear phase FIR filter making use of the coefficient symmetry.

2. Analyze the digital structure of Figure 1, and determine its transfer function $H(z) = \frac{Y(z)}{X(z)}$.

(a) Is this a canonic structure?
(b) What should be the value of the multiplier coefficient K so that $H(z)$ has a unity gain at $\omega = 0$?
(c) What should be the value of the multiplier coefficient K so that $H(z)$ has a unity gain at $\omega = \pi$?
(d) Is there a difference between these two values of K ? If not, why not?

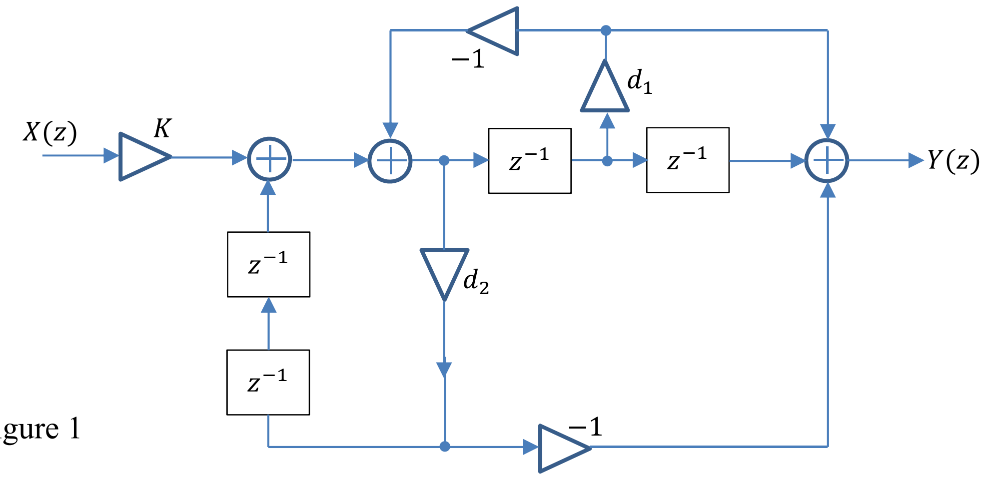

Figure 1

3. Develop a canonic direct-form realization of the transfer function

$$H(z) = \frac{3 + 4.5z^{-2} - 2.9z^{-3}}{1 + 2.2z^{-1} - 0.81z^{-3} + 5.1z^{-4}},$$

and then determine its transposed configuration.

4. Derive the impulse response coefficients $h_{HP}[n]$ of the ideal highpass digital filter with the zero-phase frequency response

$$H_{HP}(e^{j\omega}) = \begin{cases} 0, & |\omega| < \omega_c \\ 1, & \omega_c \leq |\omega| \leq \pi. \end{cases}$$

5. (a) Determine the peak ripple values δ_p and δ_s for the peak passband ripple $\alpha_p = 0.24\text{dB}$ and minimum stopband attenuation $\alpha_s = 49\text{dB}$.
(b) Determine the peak passband ripple α_p and minimum stopband attenuation α_s in dB for the peak ripple value $\delta_p = 0.015$, and $\delta_s = 0.04$.

6. Let $G(z)$ be the transfer function of a lowpass digital filter with a passband edge at ω_p, stopband edge at ω_s, passband ripple of δ_p, and stopband ripple of δ_s, as indicated in figure on Slide 3 of Lecture Notes 10. Consider a cascade of two identical filters with a transfer function $G(z)$. What

are the passband and stopband ripples of the cascade at passband and stopband, respectively? Generalize the results for a cascade of M identical sections.

7. The causal IIR digital transfer function

$$G_a(z) = \frac{4(z^2 + z - 2)}{10z^2 + 4z + 6}$$

was designed using bilinear transformation with k=5. Determine its prototype causal analog transfer function.

8. A first-order analog Butterworth highpass filter has an s-Transform transfer function $H_a(s) = \frac{s}{s+10}$.

(a) Determine the 3-dB cutoff frequency of the analog filter.

(b) Use bilinear transformation to transform the analog filter into a highpass digital filter transfer function with 250 Hz sampling frequency and 80 Hz 3-dB cutoff frequency.

9. Another bilinear transformation that can be used to design digital filters from an analog filter is given by

$$s = k\left(\frac{1 + z^{-1}}{1 - z^{-1}}\right)$$

(a) Develop the mapping of a point $s = \sigma_0 + j\Omega_0$ in the s-plane to a point z in the z-plane.

(b) Does this mapping have all the desirable properties indicated on Slide 14 of lecture notes 10?

(c) What is the relation of the above linear transformation to the bilinear transformation given on slide 16 of the lecture notes 10?

(d) Express the normalized digital angular frequency ω as a function of the normalized analog angular frequency Ω.

(e) If $H_a(s)$ is a causal analog lowpass transfer function, what is the type of the digital transfer function $G(z)$ that is obtained by the above bilinear transformation?