SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
ACADEMIC YEAR 2019-2020 SEMESTER 1
DIGITAL SIGNAL PROCESSING
TUTORIAL 11

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1. The z-transform $X(z) = \frac{7}{1+0.3z^{-1}-0.1z^{-2}}$ has three non-empty ROCs. Evaluate their respective inverse z-transforms corresponding to each ROC.

2. Use power series expansion to determine the inverse z-transform of $X(z) = \frac{1}{1-z^{-3}}, |z| > 1$.

3. Consider the digital filter structure of Figure 1, where $H_1(z) = 2.1 + 3.3z^{-1} + 0.7z^{-2}$, $H_2(z) = 1.4 - 5.2z^{-1} + 0.8z^{-2}$, $H_3(z) = 3.2 + 4.5z^{-1} + 0.9z^{-2}$. Determine the transfer function $H(z)$ of the composite filter.

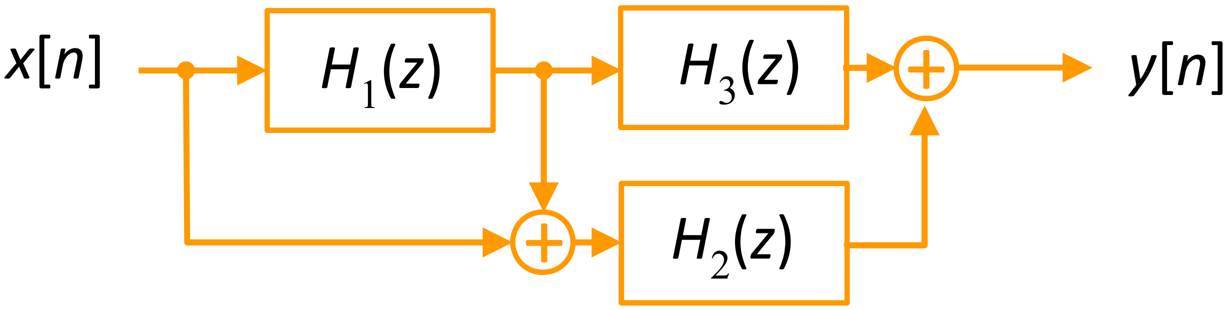

Figure 1

4. Let $H_{LP}(z)$ denote the transfer function of a real coefficient lowpass filter with a passband edge at ω_p, stopband edge at ω_s, passband ripple of δ_p, and stopband ripple of δ_s. Sketch the magnitude response of $G_1(z) = H_{LP}(-z)$, for $-\pi \le \omega \le \pi$. What type of filter is $G_1(z)$? Determine its impulse response $g_1[n]$ in terms of the impulse response $h_{LP}[n]$ of $H_{LP}(z)$. Determine the bandedge and ripple of $G_1(z)$ in terms of that of $H_{LP}(z)$.

5. Let $H_{LP}(z)$ denote the transfer function of an ideal real-coefficient lowpass filter having a cutoff frequency of ω_p, with $\omega_p < \frac{\pi}{2}$. Consider the complex coefficient transfer function $H_{LP}(e^{j\omega_0}z)$, where $\omega_p < \omega_0 < \pi - \omega_p$. Sketch its magnitude response for $-\pi \le \omega \le \pi$. What type of filter does it represent? Now consider the transfer function $G(z) = H_{LP}(e^{j\omega_0}z) + H_{LP}(e^{-j\omega_0}z)$. Sketch its magnitude response for $-\pi \le \omega \le \pi$. Show that $G(z)$ is a real-coefficient bandpass filter with a passband centered at ω_0. Determine the width of its passband in terms of ω_p and its impulse response $g[n]$ in terms of the impulse response of $h_{LP}[n]$ of the parent lowpass filter.

6. Consider the discrete-time system of Figure 2. For $H_0(z) = 1 + \alpha z^{-1}$, find a suitable $F_0(z)$ so that the output $y[n]$ is a delayed and scaled replica of the input.

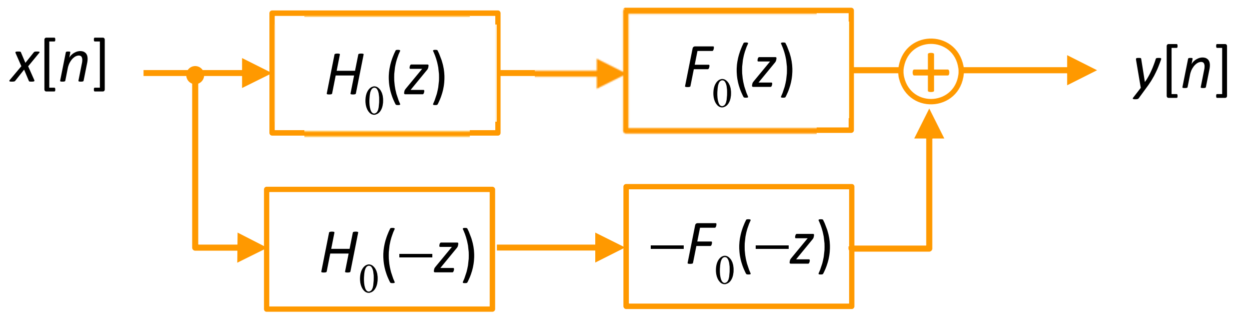

Figure 2

7. A causal FIR LTI discrete-time system is described by the difference equation

$$y[n] = a_1 x[n+k+1] + a_2 x[n+k] + a_3[n+k-1] + a_2[n+k-2] + a_1 x[n+k-3]$$

where $y[n]$ and $x[n]$ denote, respectively, the output and the input sequence. Determine the expression for its frequency response $H(e^{j\omega})$. For what value of the constant k will the system have a frequency response $H(e^{j\omega})$ that is real function of ω.

8. A Type 3 real-coefficient FIR with a transfer function $H(z)$ has the following zeros: $z_1 = 0.1 - j0.599$, $z_2 = -0.3 + j0.4$, $z_3 = 2$.

(a) Determine the location of the remaining zeros of $H(z)$ having the lowest order.

(b) Determine the transfer function $H(z)$ of the filter.