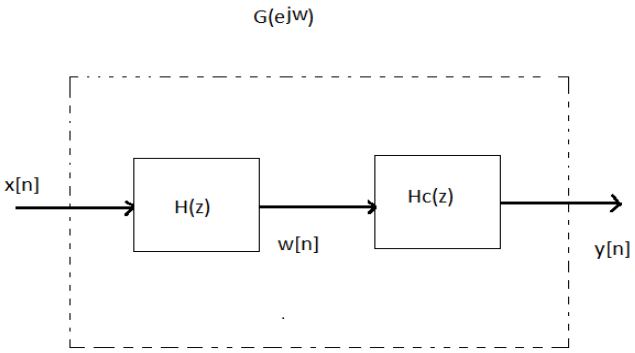
INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

AVD611 Modern Signal Processing

Tutorials 1

(to be submitted by September 10th 2025)

1.Suppose that a stable non minimum phase LTI descrete time system with a rational system function H(z) is cascaded with a compensating system H_c (z) as shown in figure



a) How should $H_c(z)$ be choosen so that it is stable and causal and so that the magnitude of the overall effective frequancy response is unity?
b) What are the corresponding system function $H_c(z)$ and G(z)?
c) Assume that
$H(z) = \left(1 - 0.8e^{j0.3\pi}z^{-1}\right)(1 - 0.8e^{-j0.3\pi}z^{-1})(1 - 1.2e^{j0.7\pi}z^{-1})( )(1 - 1.2e^{-j0.7\pi}z^{-1})$
Determine $H_{min}(z)$, $H_{ap}(z)$,$H_c(z)$ and G(z) for this case, and construct the pole-zero plots for each ωsystem function.

2. Determine whether the following statement is true or false, if it is true concisely state your resoning. If it false give a counter example?

Statement: if the system funtion H(z) has poles anywhere other than at the origin or inifinity, then the system cannot be a zero phase ora generalized linear- phase system.

3. Let S_1 be a causal and stable LTI System with impulse response $h_1(n)$ and frequency response $H_1(e^{j\omega})$

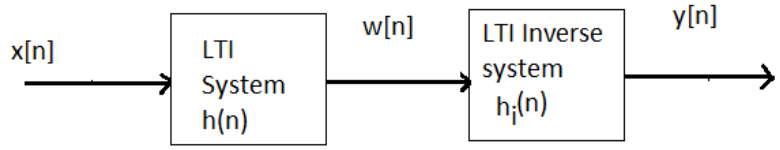
The input x(n) and output y(n) for S_1 are related by the difference equation

$$y(n) - y(n-1) + \frac{1}{4}y(n-2) = x(n)$$

If an LTI system S_2 has a frequency response given by $H_2(e^{j\omega}) = H_1(-e^{j\omega})$. Would you characterize S_2 as being a low pass filter , a band pass filter or a highpass filter. Justify your answer?

4. Consider a causal sequence x(n) with the Z- Transform $X(z) = \frac{\left(1-\frac{1}{2}z^{-1}\right)\left(1-\frac{1}{4}z^{-1}\right)\left(1-\frac{1}{5}z^{-1}\right)}{\left(1-\frac{1}{6}z^{-1}\right)}$ for what values of α is α^n x(n) a real, minimum- phase sequance ?

5. Consider the cascade of an LTI system with its inverse system shown in figure



The impulse response of the first system is h(n) =$\delta(n) + 2\delta[n-1]$

a) Determine the impulse response $h_i[n]$ of a stable inverse system for h[n] is the inverse system causal ?
b) Now consider the more general case where h[n] =$\delta n + \alpha\delta(n-1)$. Under what condiitions onα will there exist an inverse system that is both stable and causal?

6. A discrete time causal LTI system has the system function

$H(z) = \frac{1+0.2z^{-1})(1-9z^{-2})}{(1+0.81z^{-2})}$

a) Is the system stable?
b) Determine expressions for a minimum phase system and an all pass system $H_{ap}(z)$ such that
$H(z)=H_1(z)H_{ap}(z)$

7. Determine the group delay for $0< \omega < \pi$ for the following sequance $x(n)=\left(\frac{1}{2}\right)^{|n-1|} + \left(\frac{1}{2}\right)^{|n|}$.