Indian Institute of Space Science and Technology,
Trivandrum
Department of Avionics

Modern Signal Processing (AVD611)

Mid Term Examination, Date: September 28, 2024

Time: 2.00 to 4.00 PM , (I Semester M.Tech: Digital Signal Processing/VLSI and Microsystems/ RF and Microwave engineering) Max mark: 30

1. (a) Consider a causal and stable system specified by the system function $H(z) = \frac{1+5z^{-1}}{1+1/2z^{-1}}$. Decompose into a all pass system and minimum phase system and draw the pole zero plots? **(3)**

   (b) Consider a causal LTI system $H(z) = \frac{(1-1.5z^{-1}-z^{-2})(1+0.9z^{-1})}{(1-z^{-1})(1+0.7jz^{-1})(1-0.7jz^{-1})}$
   i) Write the difference equation that is satisfied by the input and output of the system.
   ii) Plot the pole zero plot and indicate the ROC
   iii) Does the system have a stable and causal inverse **(3)**

   (c) A causal FIR transfer function is given by $H(z) = 1 - 2^{-1} + 3z^{-2} - 6^{-3} + 3z^{-4} + 2^{-5} - z^{-6}$, identify the Type of the system. Obtain the magnitude and phase response and calculate the group delay **(3)**

   (d) The system function of an LTI system is given by $H(z) = \frac{z-2}{z(z-1/3)}$. Decompose into a minimum phase system and linear phase system? **(3)**

   (e) A stable system with system function $H(z)$ has the pole-zero plot shown in Figure 1. It can be represented as the cascade of a stable minimum-phase system $H_{min}(z)$ and a stable all-pass system $H_{ap}(z)$. **(3)**

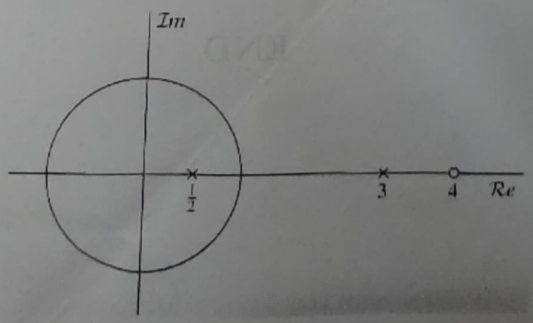

Figure 1:

2. (a) What would be the missing block in Figure 2 for the two systems to be identical? **(2)**

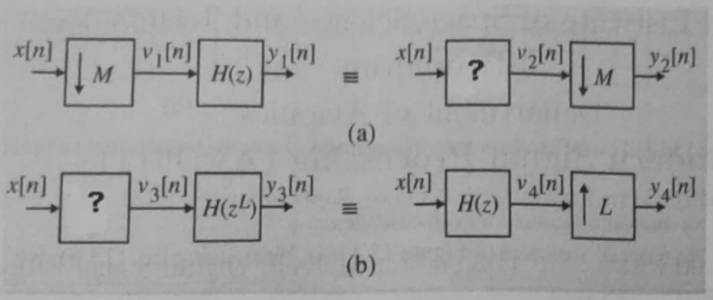

Figure 2:

(b) The prototype filter of a four channel uniform DFT filter bank is characterized by the transfer function $H_0(z) = 1 + z^{-1} + 3z^{-2} + 4z^{-3}$. Determine the transfer function of $H_1(z)$, $H_2(z)$ and $H_3(z)$ in the analysis section and synthesis section. [hint: use polyphase decomposition] **(3)**

(c) Suppose the analysis filters in a two channel QMF bank are given by $H_0(z) = 2 + 6z^{-1} + 5^{-3} + z^{-5}$ and $H_1(z) = H_0(-z)$. Find a set of stable synthesis filters that result in perfect reconstruction. **(4)**

(d) Design a two stage decimator for the following specification for $D = 100$:
Passband: $0 \leq F \leq 50$
Transition band: $0 \leq F \leq 50$
Input sampling rate :10,000Hz
$\delta_p = 10^{-1}; \delta_s = 10^{-3}$
Compare with the single stage decimator. [Choose D_1=50,$D_2 = 2$]. **(3)**

(e) What are the conditions for perfect reconstruction in two channel QMF? Explain in detail through derivations and mathematical expressions. **(3)**

END