ELL720: Advanced Digital Signal Processing (Spring 202

Minor Exam # 2

Time allowed: 60 mins

$12\frac{1}{2}$ Sesher

Name: _

Entry No

<u>Answer in the space provided. Justify your answer clearly. Answers without justification will receive no credit.</u>

(10 points)

1. A linear-phase FIR system has a real impulse response $h[n]$ whose z-transform is given by:

$$H(z) = (1 - az^{-1})(1 - e^{\frac{j\pi}{2}}z^{-1})(1 - bz^{-1})(1 - 0.5z^{-1})(1 - cz^{-1})$$

It is also known that $H(e^{j\omega}) = 0$ for $\omega = 0$.

(a) Determine length of the impulse response.
(b) Is this a Type I/II/III/IV system?
(c) Determine group delay of the system in samples.
(d) Determine the values of a, b, and c.
(e) Determine the values of the impulse response and sketch it.

1) as we can see total degree of the Transfer function is odd which is 5
∴ length filter/ length of impulse response $= M+1 = 5+1 = \underline{6}$
where M is the order of the polynomial.

2) ~~The type of polynomial~~ It belong to polynomial of type IV as It have odd degree (N) and It have zero at $Z = +1$ and It also have Anti symmetric impulse length of filter is even and It also have response.

c) group delay $\Rightarrow \frac{\text{degree}}{2} = \frac{5}{2} = 2.5$ samples. {constant}

d) As we have Linear Phase FIR system, It should have reciprocal pairs at $Z = \pm 1$

one zero at 2 $\underline{a=2}$

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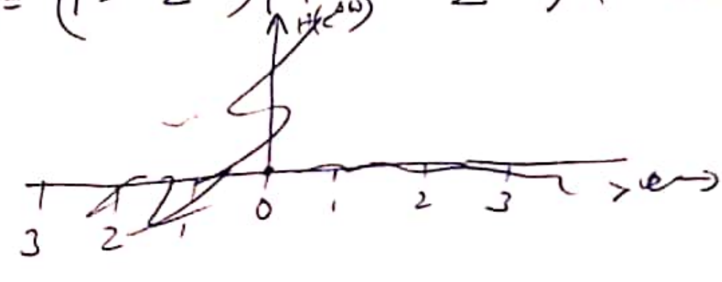
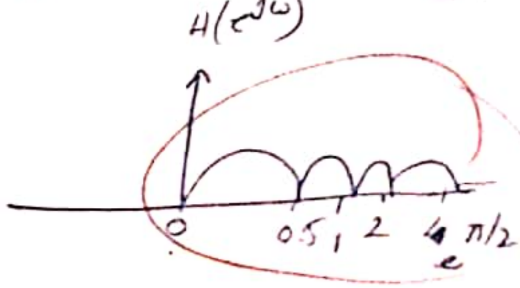
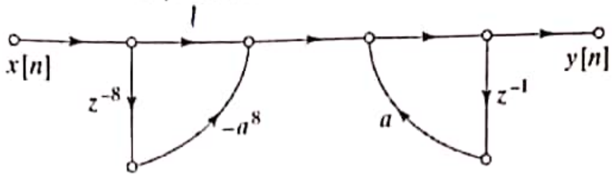
real impulse response $\Rightarrow$ complex zero in conjugate pairs; $b = e^{-j\pi/2}$
As there is one more zero It should be at $Z = \pm 1$ at unit circle
so $c=1$ (on the unit circle).

so $H(z) = (1 - z^{-1})(1 - e^{\frac{j\pi}{2}} z^{-1})(1 - 6z^{-1})(1 - 0.5z^{-1})(1 - z^{-1})$

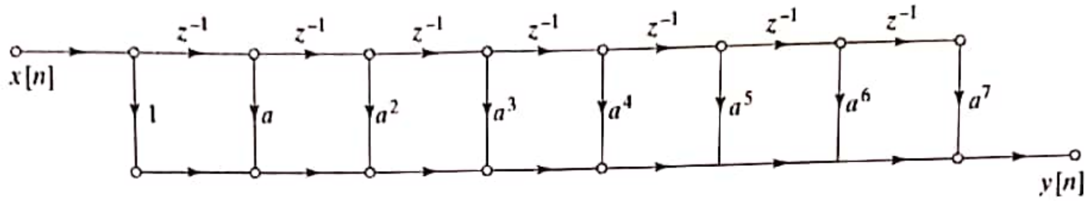




2. The signal flow graphs shown below have the same system function. Determine the range of values for $|a|$ such that Network 1 has lower output noise power than Network 2. (10 points)



Network 1



Network 2

We can make comparison by avg noise power of both the N/w

Avg noise power $\Rightarrow$ $\sigma^2 \cdot \sum_{k=-\infty}^{\infty} |h_{ef}[k]|^2$

0.5

σ = noise variance = $\frac{\Delta^2}{12} = \frac{2^{-2B}}{12}$

eq of N/w 1 b $\Rightarrow$ ~~y[n] =~~ $H(z_{N/w_1}) = \frac{1 - a^8 \cdot z^{-8}}{1 - a z^{-1}}$ {same like direct form I}

eq of N/w 2 = same like top delay line.

$y[n] = \sum_{k=0}^{7} (a)^n \cdot x[n-k]$

Avg noise power of N/w A < Avg noise of N/w B

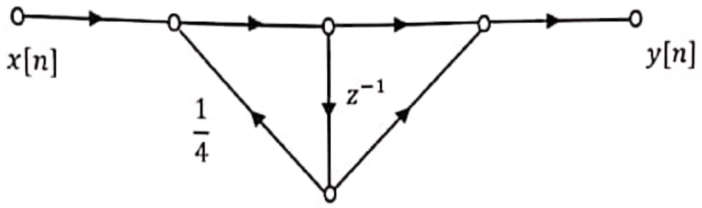
~~$\sigma^2 \cdot \sum_{k=-\infty}^{\infty} \left[\left| \frac{1 - a^8 z^{-8}}{1 - a z^{-1}} \right|^2 \right] < \sigma^2 \sum_{k=-7}$~~ $a z^{-8}$

~~so value of |a| sho~~

$$\sigma^2 \left[\sum_{k=-\infty}^{\infty} \left| \frac{1 - a^8 z^{-8}}{1 - a z^{-1}} \right|^2 \right] < \sigma^2 \left[1 + a z^{-1} + a^2 z^{-2} + \dots + a^7 z^{-7} \right]$$

so ~~value of a~~

. The signal flow graph of a first order system is shown below: (10 points)



(a) Assuming infinite-precision arithmetic, find the response of the system if $x[n] = \frac{1}{2}(-1)^n u[n]$. What is the response of the system for large n?

(b) If the system is implemented with a (4+1)-bit fixed-point arithmetic with the result of multiplications being truncated before additions occur. Compute the response of the quantized system to the input in part (a) and plot the responses of both the quantized and unquantized system for $0 \le n \le 5$. How do the responses compare for large n?

We say $x[n] = \frac{1}{2}(-1)^n u(n)$

we can find the ~~leg~~ difference eq ⇒/ system function as

$$H(Z) = \frac{b_0 + b_1 Z^{-1}}{1 - aZ^{-1}} \Rightarrow \frac{1 + 1/4\, Z^{-1}}{1 + Z^{-1}} \Leftarrow$$ frequency response of system.

$$H(Z) = \frac{1 + \frac{1}{4} Z^{-1}}{1 + Z^{-1}}$$

0

$$H(e^{j\omega}) = \frac{1 + \frac{1}{4} e^{-j\omega}}{1 + e^{-j\omega}} \Rightarrow \frac{1 + \frac{1}{4}\{\cos\omega - j\sin\omega\}}{1 + \{\cos\omega + j\sin\omega\}}$$

$$\Rightarrow \frac{\left(1 + \frac{\cos\omega}{4}\right) - j\cdot\left(\frac{\sin\omega}{4}\right)}{(1+\cos\omega) + j\sin\omega} \qquad \{e^{-j\omega} = \cos\omega - j\sin\omega\}$$

magnitude response = $$\sqrt{\frac{\left(1 + \frac{\cos\omega}{4}\right)^2 + \left(\frac{\sin\omega}{4}\right)^2}{(1+\cos\omega)^2 + (\sin(\omega))^2}}$$

?

0

$$\Rightarrow \frac{1}{4}\sqrt{\frac{\cancel{2}\; 16 + 1 + 2\cos\omega}{2 + 2\cos\omega}} \Rightarrow \left(\sqrt{\frac{17 + 2\cos\omega}{\cancel{4}\; 2 + 2\cos\omega}}\right)\frac{1}{4}$$

if we have 5 bit fixed point

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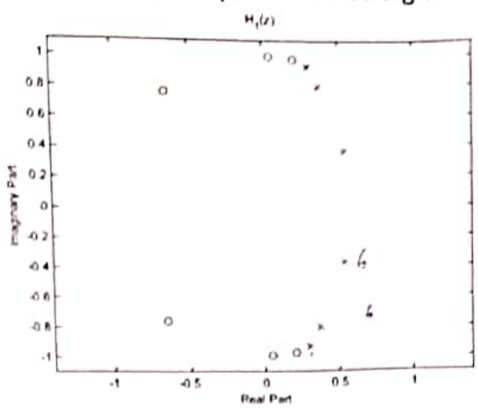
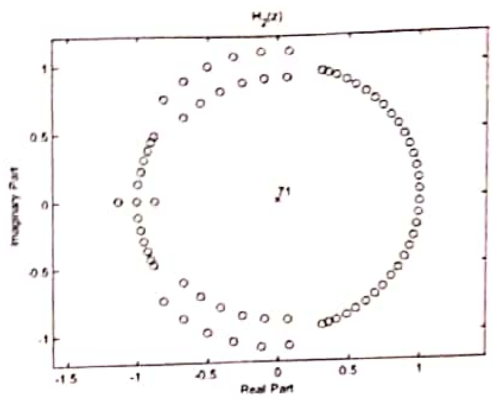
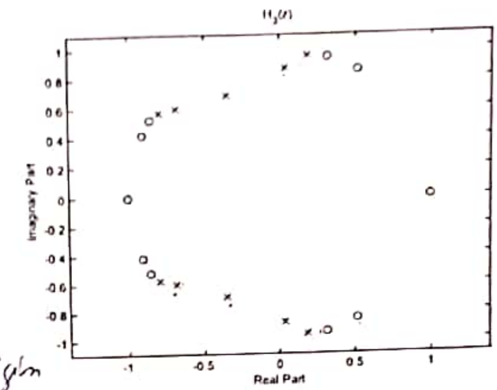
Consider the following pole-zero plots of three digital filters: (10 points)







all poles at origin

For each of the three filters, determine the following: (Brief explanation is required for full credit)

(a) Filter is FIR or IIR, (b) Filter type, (c) Filter order,

(d) Filter is low-pass (LP), high-pass (HP), band-pass (BP), or band-stop (BS), and

(e) Approximate cutoff or edge frequencies for each filter.

1) $H_1(Z)$ = IIR Filter (as no pole is at origin)(X)

$H_2(Z)$ = FIR (as all poles at origin) and Zero are otherwise

$H_3(Z)$ = IIR Filter (as no pole is at origin.

IIR = it have poles inside the unit circle at nonzero location.

(b) $H_1(Z)$ = ~~Type~~ IIR Filter

$H_2(Z)$ = Type 3 filter as have Zero at both $Z = +1$ & $Z = -1$, Zero at both ends (FIR Filter)

$H_3(Z)$ = ~~Type~~. IIR Filter

c) order of filter. => $H_1(Z) = 6$

$H_2(Z) = 71$

$H_3(Z) = 5$

d) $H_1(Z)$ = ~~AA~~ as it is IIR filter with infinite impulse response

$H_2(Z)$ = only for bandpass filter

$H_3(Z)$ = IIR filter with ∞ impulse response

e) $H_1(Z) \Rightarrow \omega_c = 1$ {look at Zero's}

$H_2(Z) \Rightarrow \omega_c$ = approx 0.9

$H_3(Z) \Rightarrow \omega_c = 1$

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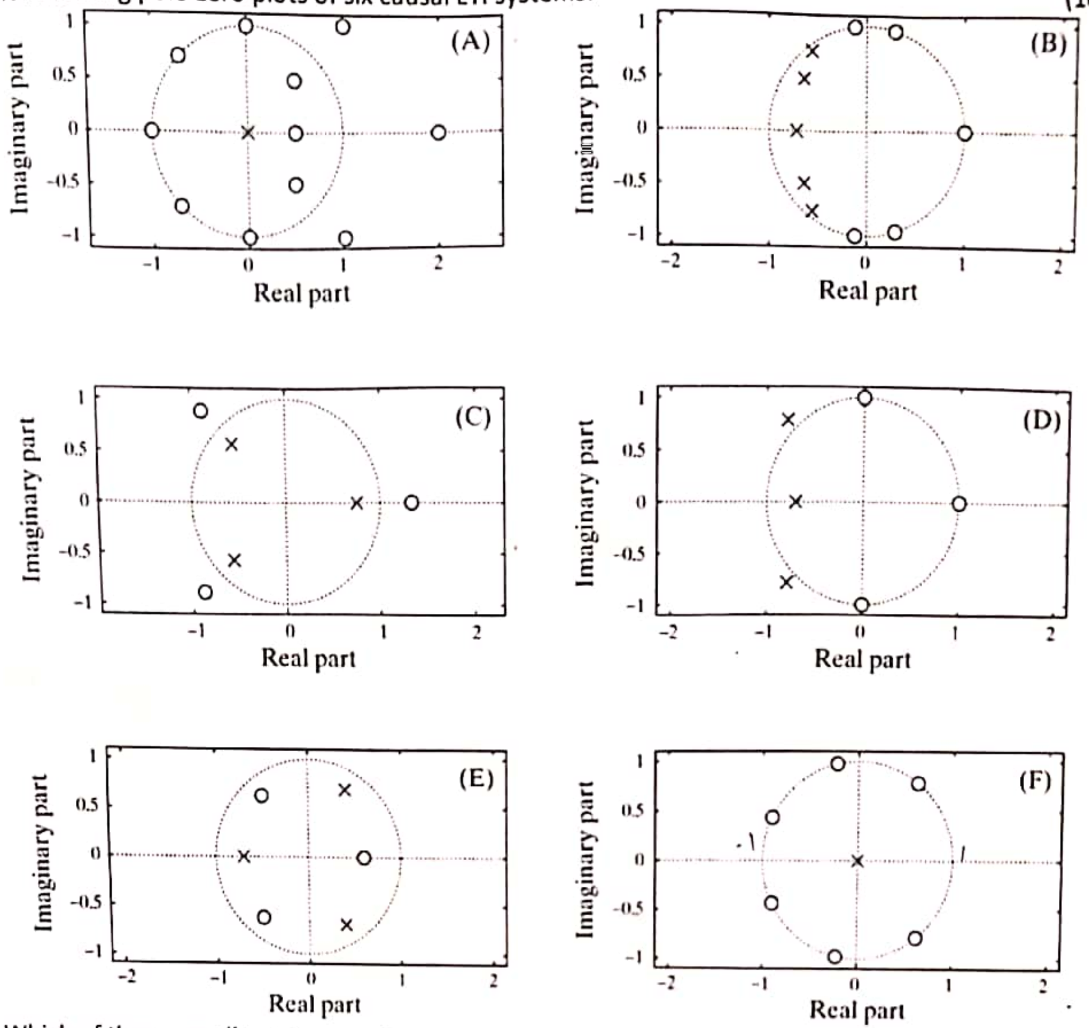
Consider the following pole-zero plots of six causal LTI systems: (10 points)



(a) Which of these are all-pass systems?

(b) Which systems have low-pass frequency response?

(c) Which systems are generalized linear-phase systems?

(d) Which systems have causal and stable inverse systems?

Brief explanation is required for full credit.

a) to look at all pass system we see the zero which is outside the unit circle and to its reciprocal location I put a pole.

∴ System ~~B~~ C is the all pass system.

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b) ~~low~~ high pass frequency response is made by system A at z = ∞ as we have zero at z = −1 & ω = π which is high frequency end. we can design low pass filter

~~low pass frequency~~

c) generalized linear phase ⇒ system A ~~B~~ & C {poles and zero must occur at reciprocal pair

d) causal & stable inverse are ⇒ A ~~system & AT~~ system A & F as it have all poles at origin. and ~~we also~~ if we have zero at z_0 I also have zero at z_0^{-1}.

~~zero outside uni~~