Solution of ECE 316 Test #11 S04

1.   Which of the digital filter design techniques can create an unstable DT system from a stable CT system?   Difference equation method or finite difference method

Some students said the bilinear method, apparently thinking the bilinear method comprises both $s \to \dfrac{1 - z^{-1}}{T_s}$ which is the two-term approximation to the exponential and $s \to \dfrac{2}{T_s}\dfrac{z-1}{z+1}$ which is the modification putting a two-term approximation in both the numerator and denominator.   Only $s \to \dfrac{2}{T_s}\dfrac{z-1}{z+1}$ is the bilinear method.

If the design is unstable, what can be done to make it stable while still using the same design technique? Increase the sampling rate

Some students said change from $s \to \dfrac{1 - z^{-1}}{T_s}$ to $s \to \dfrac{2}{T_s}\dfrac{z-1}{z+1}$ in the bilinear method. But, since the first substitution is not the bilinear method this answer is wrong. One student said to change the sampling rate but did not say in which direction. Only increasing the sampling rate will help.

2.   What is the transition from s to z that is used in the difference-equation design technique to approximate a backward difference? $s \to \dfrac{1 - z^{-1}}{T_s}$

A few students said $s \to \dfrac{1 - z^{-1}}{T_s}X(s)$ for reasons I do not understand. Substituting $\dfrac{1 - z^{-1}}{T_s}X(s)$ for s will not yield a difference equation design so I cannot accept this answer, even though the $\dfrac{1 - z^{-1}}{T_s}$ part is right.

3.   Which two of the digital filter design techniques map the entire left half of the s plane into the interior of the unit circle in the z plane?   Matched z transform, Direct Substitution and Bilinear z transform

Actually there are three if Matched z Transform and Direct Substitution (which are very similar) are counted as two methods. I accepted any two of these three.

4.   What is the reason the bilinear z transform approximation method has that name?
In the transformation, $s \to \dfrac{2}{T_s}\dfrac{z-1}{z+1}$ both the numerator and denominator are linear functions of z.

5.   What is the transformation from s to z that is used in the bilinear method?

$$s \to \frac{2}{T_s} \frac{z-1}{z+1}$$

6.   Which digital filter design method maps the entire left half of the s plane into the entire interior of the z plane and for which there is a unique s domain point for each z domain point and vice versa?
Bilinear z transform

7.   What does the term, IIR, stand for?
Infinite-duration impulse response. I (reluctantly) accepted Infinite Impulse Response also.

Some of the more creative answers on the question were Interior Imaging Relation, Ideal Impulse Response, Invariant Impulse Response, Initial Instability Region, Infinite Iteration Rate, Initial Intermediate Response, Impulse Invariant Response and Infinite Invariant Response.

8.   (3 pts) A digital filter has a transfer function, $H_1(z) = \dfrac{z^2}{z^2 + az + b}$. If it is excited by a unit sequence, the first three values of its response, $y_1[n]$, are $y_1[0] = 3$, $y_1[1] = -4$, $y_1[2] = 2$. If a digital filter with a transfer function, $H_2(z) = \dfrac{z}{z^2 + az + b}$, is excited by a unit sequence, what are the first three numerical values of its response, $y_2[n]$? $y_2[0] = 0$, $y_2[1] = 3$, $y_2[2] = -4$

$$H_2(z) = z^{-1} H_1(z) \Rightarrow h_2[n] = h_1[n-1]$$