EECE5610, Fall 2018, Sample First Exam, 1 Hour 50 minutes

Name:______________________________ Signature: ______________________________

Instructions:

1. This is a closed–book test but **one** $8\frac{1}{2} \times 11$ single–sided cheat–sheet is allowed.
2. Work as many problems as you can. Try not to spend too much time working on a single problem. If you get stuck, try working on a different question.
3. Show all your work, but try to be as concise as possible.
4. • **DO NOT LOOK** at the problems until told to do so.
5. • **STOP** working after the "time's up" announcement.
6. • **GOOD LUCK !**

Problem 1: (50 points)

1.1- (10 pts) The (continuous–time) transfer function of a *first hold* is given by:

$$G_{foh}(s) = \frac{1+Ts}{T}\left[\frac{1-e^{-Ts}}{s}\right]^2 \tag{1}$$

Find an analytic expression (in the time domain) for its impulse response and sketch it.

1.2- (20 pts) Consider the block diagram shown in Figure 1 Show that this diagram is equivalent to a first order hold. Hint: put an appropriate input, sketch the corresponding output $c(t)$ and compare it with the output of a first order hold.

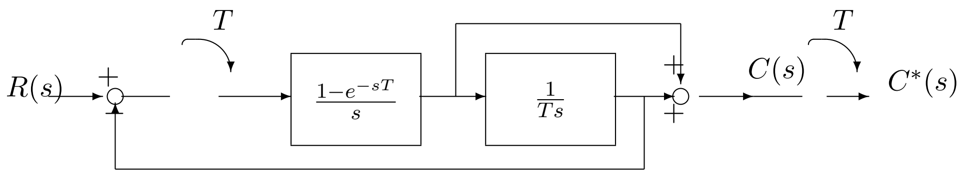

Figure 1: Block Diagram for Problem 1

1.3- (20 pts)

(a) Show that for frequencies $\frac{\omega}{\omega_s} \ll 1$ the phase characteristic of the first order hold (equation (1) is given by

$$\text{angle}\{G_{foh}(j\omega)\} \simeq -\frac{2\pi\omega}{\omega_s} \tag{2}$$

where $\omega_s = \frac{2\pi}{T}$ is the sampling frequency in radians per second.

(b) Assume that this hold will be used in a closed–loop system where the plant has bandwith 10 Hz and can tolerate up to $\frac{\pi}{6}$ radians of phase lag. Find the minimum sampling interval so that this condition is satisfied. For this part you may use the approximation (2).

Problem 2: (50 points)

2.1- (20 pts) Consider the model of a first order hold shown in Figure 1 (**previous page**).

(a) Find the discrete transfer function $E(z)/R(z)$.

(b) Find the discrete transfer function $C(z)/R(z)$. Does your result make sense (recall that this block diagram is supposed to implement a first order hold)

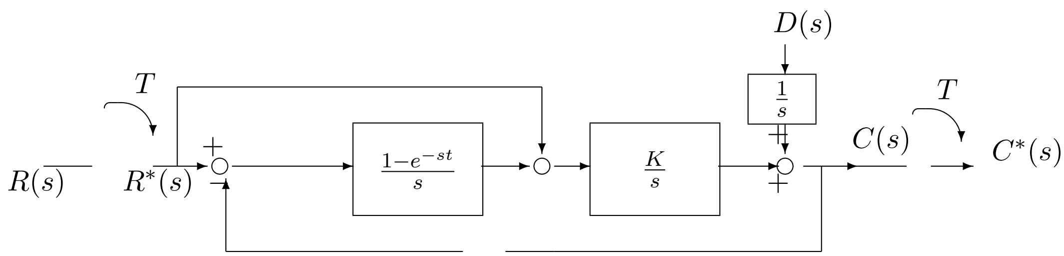

Figure 2: Block Diagram for Parts 2.2 and 2.3

2.2- (15 pts) Consider the block diagram shown in Figure 2 above. Assume that $R = 0$. Does the discrete transfer function from D to C exist? If so, find it. If not, fully justify your answer and find $C(z)$ for the case where $D(s) = 1$ (i.e. $d(t) = \delta(t)$).

2.3- (15 pts) Find a pair of values for K and T such that, when $R = 0$ and $D(s) = 1$, the steady state value of $c_{ss} = \lim_{k\to\infty} c_k$ satisfies $|c_{ss}| < 0.1$. Compare the answer with the one that you would have gotten in the case of a continuous time system (ie same loop without sampling and holding action). Explain both similarities and differences.