رابعة

Dept.of Electrical Engineering
Faculty of Engineering
Assiut University
2ndSemester– Final Exam.
2015/2016–Saturday, 21/5/ 2016.

Computers and Systems Program
Course: Digital Control"EC 426"
4th year – bylaw: 2004
Time: 3 Hours [9:12 AM]
Marks: 100

mportant remarks
- Number of Pages: 2 Number of Questions: 4
- The exam. Measures ILOs no. : A1, A2, B1, C1, C2, C3, D1, and D2.

Answer the Following Questions

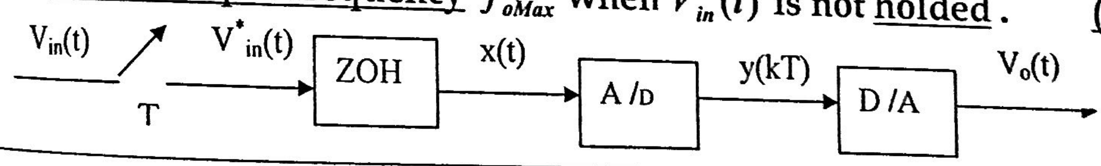
stion no. 1 (25 points).

plain the block diagrams of the following elements of a digital control ystem. How can you simplify them for the purpose of analysis and design of he system ? : Practical S/H - A/D - D/A. (10 pts.)

n input signal $V_{in}(t) = V_p \cos(2\pi f_o t)$ is sampled and holded (using ideal S/H) the input of a truncating A/D with sampling period $1/T = 8 f_o$ as shown low. Deduce an expression of $(SNR)_{db}$ in terms of the word length n. Plot $NR)_{db}$ vs. n . (4 pts.)

e signal and the truncating A/D and D/A have the following specifications : $V_p = 25V$, $f_o = 1\ Hz$, $1/T = 8 f_o$, $n = 12\ bits$, bipolar $-25/+25V$ and $T_c = 0.2\ \mu sec$.
rmine :

- The resolution in volts , and resolution % . (2 pts.)
- Compute and sketch the following signals for half cycle , $t = kT, k = 0,1,2,3,4,..$: $V_{in}(t)$, $V_{in}^*(t)$, $x(t)$, $y(kT)$ (in off set binary code) , $V_o(t)$ (in volts) , and the quantization error $e_q(t) = x(t) - V_o(t)$ (in volts). All analog and digital signals should be plotted on the same graph. (8 pts.)
- The maximum input frequency f_{oMax} when $V_{in}(t)$ is not holded . (1 pt.)



tion no. 2 (25 points).

plain the sampling theorem , and Anti-aliasing filter. (4 pts.)

e paramters of a unity-feedback digital control system are :
PI-controller : $G_D(z) = U(z)/E(z) = K(z+0.8)/(z-1)$, K = variable gain ,and
plant : $G_p(s) = Y(s)/U(s) = 1/[(s+\lambda)]$, $\lambda = 1$, and T =variable sampling period.
se Jury's stability test to determine the region of stability in the K vs. T in space. Find the critical values of $K = K_c$ when $T = 0.2$ sec. In these ses determine the critical closed-loop poles p_{c1}, p_{c2}, frequency of sustained cillations ω_d and the number of samples /cycle N_s. (21 pts.)

stion no. 3 (25 points).

ompare between ZOH and FOH regarding :

Transfer function - Frequency response. (4 pts.)

he paramters of a unity-feedback digital control system are :

PI-controller : $G_D(z) = U(z)/E(z) = K(z+0.8)/(z-1)$, K = variable gain ,and

plant : $G_n(s) = Y(s)/U(s) = 1/[(s+\lambda)]$, $\lambda = 2$, and $T = 0.25$ sec.

ot the root-locus of the characteristic equation of the system when $0 \le K \le \infty$, d indicate the important informations on the root-locus. Determine K to hieve $\zeta = 0.5$ for the dominant closed- loop poles $p_{1cl} = z_d$ and $\bar{p}_{1cl} = \bar{z}_d$. etermine also ω_n , t_s, N_s and e_{ss}^* for unit ramp input in this case . Can you duce e_{ss}^* by increasing K to 10 ? justify your answer. (21 pts.)

stion no. 4 (25 points).

xplain : (4 pts.)

Data acquisition systems - Data distribution systems.

he paramters of a unity-feedback digital control system are :

Lag-lead controller : $G_D(z) = \dfrac{U(z)}{E(z)} = K[\dfrac{z - z_{c1}}{z - p_{c1}}][\dfrac{z - z_{c2}}{z - p_{c2}}]$, $z_{c1} \succ p_{c1}$, $z_{c2} \prec p_{c2}$,

and K=variable gain of controller .

Plant : $G_p(s) = Y(s)/U(s) = 1/[s(s+\lambda)]$, $\lambda = 1$, and $T = 1$ sec.

se the root-locus method to design a lag-lead controller $G_D(z)$ to achieve :

$\zeta = 0.5$, $t_s = 10$ sec., and $K_v^* = 5\,\text{sec}^{-1}$.

nplement the controller using hardware (standard programing) . Sketch the ot-locus and unit-step response of the designed system. (21 pts.)

END Of All Questions

Best wishes

Examiners: Dr. Mohamed M. M. Hassan + Committee .

Dept. of Electrical Engineering
Faculty of Engineering
Assiut University
2ndSemester– Final Exam.
2014/2015 –Sunday, May, 10, 2015.

Computers and Systems Program
Course: Digital Control"EC 426"
4th year - bylaw: 2004
Time: 3 Hours [9:12 AM]
Marks: 100

Important remarks
- Number of Pages: 2 Number of Questions: 5
- The exam. Measures ILOs no. : A1, A2, B1, C1, C2, C3, D1, and D2.

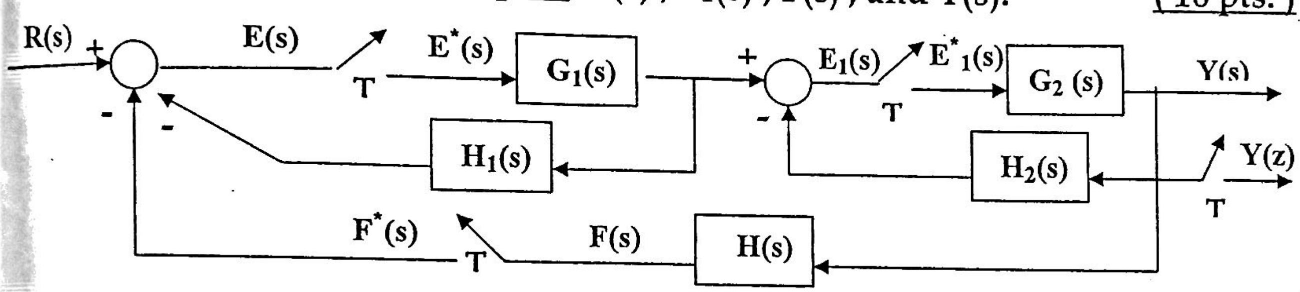
Answer the Following Questions

uestion no. 1 (20 points).

Explain the simplification of block diagrams of the following elements :

Practical S/H - A/D . (4 pts.)

.Consider the shown digital systems. Construct the original SFG , sampled SFG , and composite SFG . Determine the digital outputs E(z) , $E_1(z)$, F(z) , and Y(z) , and the analog outputs E(s) , $E_1(s)$, F(s) , and Y(s). (16 pts.)



uestion no. 2 (20 points).

. Explain the following errors :

Folding error – Aliasing error. (4 pts.)

. The shown digital control system has the following parameters :

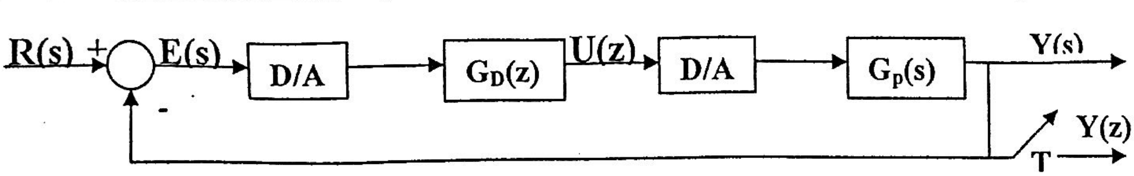
PI-controller : $G_D(z) = U(z)/E(z) = K_P + K_I[1/(1-z^{-1})]$, and

plant : $G_p(s) = Y(s)/U(s) = 1/[(s+\lambda)]$. Determine :

.The conditions of stability in terms of the variable parameters K_P, K_I, λ *and* T using Jury's stability test. (6 pts.)

.The region of stability in the K_P *vs.* K_I gain space using the conditions deduced in part (i) when $T = 0.2$ sec., *and* $\lambda = 2$. (5 pts.)

. The critical values of $K_P = K_{Pc}$ when $K_I = 10.266$, $T = 0.2$ sec., *and* $\lambda = 2$. In these cases determine the closed- loop poles p_{c1} , p_{c2} , frequency of sustained oscillations ω_d and the number of samples /cycle N_s. (5 pts.)



Question no. 3 (20 points).

a . Compare between ZOH and FOH regarding : (4 pts.)

Transfer function - Frequency response.

b. Consider the system of problem (2) with parameters :

I-controller : $G_D(z) = U(z)/E(z) = K_I[1/(1-z^{-1})]$, $K_I = K =$ variable gain ,

plant : $G_p(s) = Y(s)/U(s) = 1/[(s+\lambda)]$, $\lambda = 2$, and $T = 0.2$ sec.

Plot the root-locus of the characteristic equation of the system when $0 \le K \le \infty$, and indicate the important informations on the root-locus. Determine K to achieve $\zeta = 0.5$ for the dominant closed- loop poles $p_{1cl} = z_d$ and $\bar{p}_{1cl} = \bar{z}_d$. Determine also ω_n , t_s, N_s and e_{ss}^* for unit ramp input in this case . Can you reduce e_{ss}^* by increasing K to 25 ? justify your answer. (16 pts.)

Question no. 4 (20 points).

a . Explain : (4 pts.)

Data acquisition systems - Data distribution systems.

b. Consider the system of problem (2) with parameters :

Lag-lead controller : $G_D(z) = \dfrac{U(z)}{E(z)} = K[\dfrac{z - z_{c1}}{z - p_{c1}}][\dfrac{z - z_{c2}}{z - p_{c2}}]$, $z_{c1} \succ p_{c1}$, $z_{c2} \prec p_{c2}$,

and K=variable gain of controller .

Plant : $G_p(s) = Y(s)/U(s) = 1/[s(s+\lambda)]$, $\lambda = 2$, and $T = 0.2$ sec.

Use the root-locus method to design a lag-lead controller $G_D(z)$ to achieve :

$$\zeta = 0.5, t_s = 2.5 \text{ sec.}, \text{ and } K_v^* = 10 \text{ sec}^{-1}.$$

Sketch the root-locus and unit-step response of the designed system. (16 pts.)

Question no. 5 (20 points).

a . Explain : Nyquist-Shanon sampling theorem - Quantization errors. (4 pts.)

b. Consider the system of problem (2) with parameters :

Lead-controller : $G_D(w) = \dfrac{U(w)}{E(w)} = \dfrac{1 + T_1 w}{1 + \alpha T_1 w}$, $\alpha \prec 1$, and $w = \dfrac{2}{T}(\dfrac{z-1}{z+1})$,

Plant : $G_p(s) = Y(s)/U(s) = K/[s(s+\lambda)]$, $\lambda = 2$, $T = 0.2$ sec. ,

and K=variable gain of the system.

Use the bilinear transformation $z = (1 + 0.5Tw)/(1 - 0.5Tw)$ and Bode diagram method to design a lead- controller $G_D(z)$ to achieve :

$$PM = 40 \pm 5^o \;, GM \ge 7 \text{ dB} \text{ and } K^*_v = 4 \text{ sec}^{-1} .$$

Implement the controller using standard programming and sketch the Bode - diagram of the designed system. (16 pts.)

END Of All Questions

Best wishes

Examiners: Dr. Mohamed M. M. Hassan + Committee .

Dept. of Electrical Engineering
Faculty of Engineering
Assiut University
2nd Semester– Final Exam.
2013/2014 – May, 8, 2014

Computers and Systems Program
Course: Digital Control "EC 426"
4th year – bylaw: 2004
Time: 3 Hours [9:12 AM]
Marks: 100

Important remarks	• Number of Pages: 2 Number of Questions: 4
	• ....

Answer the Following Questions

Question no. 1 (25 points).

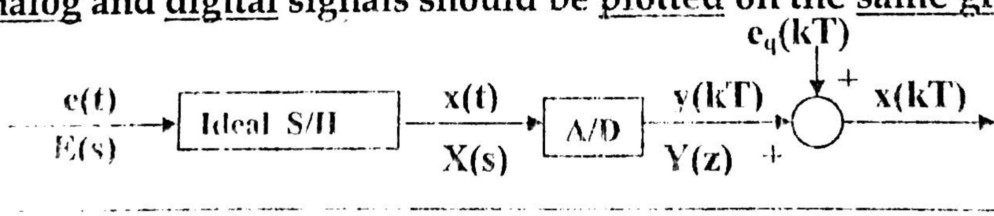
a. Explain the block diagrams of the following elements of a computer-controlled-system . How can you simplify them for the purpose of analysis and design of the system ? :

Practical S/H – A/D – D/A. (10 pts.)

b. Deduce the transfer function $G_{h1}(s) = Y(s)/X^*(s)$ of a first-order hold (foh) by assuming $x(t) = unit - impulse\ \delta(t)$. Write down the expressions for the frequency responses of the zero-order hold(zoh) and (foh). Plot these responses on the same graph and compare between them regarding :

Filter type – DC gain – Bandwidth . (7 pts.)

c. An error signal $e(t) = V_p \cos(2\pi\ f_o\ t)$ is sampled and holded (using ideal S/H) at the input of a rounding-off A/D with sampling period $T = 1/(12 f_o)$ as shown below. Let the signal and the rounding – off A/D has the following specifications : $V_p = 32\,V,\ f_o = 1\ Hz,\ T = 1/(12 f_o)$ sec., *and* $n = 10$ *bits*.
Plot half cycle of $e(t)$ *vs.* t and $x(t)$ *vs.* t. Also find and plot the output y(t)(in offset Binary code) and the quantization error $e_q(t) = x(t) - y(t)$ for half cycle at $t = kT, k = 0, 1, 2, 3, 4, 5, 6$. Note that $y(4T) = -y(2T)$ & $y(5T) = -y(T)$.
All analog and digital signals should be plotted on the same graph. (8 pts.)



Question no. 2 (25 points).

a . Explain : Folding error –Aliasing error –Anti-aliasing filter. (6 pts.)

b . A digital control algorithm is described by the following difference equation : $u(k+2) + a_1 u(k+1) + a_2 u(k) = b_0 e(k+2) + b_1 e(k+1) + b_2 e(k)$,

Where $a_1 = -0.7$, $a_2 = 0.1$, $b_0 = 1$, $b_1 = -0.7$, $b_2 = 0.12$, $u(k)$ = control signal ,

$e(k)$ = error signal= unit- step = 1 for $k \geq 0$,and $e(k) = 0$ *for* $k < 0$.

i . Compute the transfer function $G_D(z) = U(z)/E(z)$ and find its zeros z_{c1} , z_{c2} , and poles p_{c1} , p_{c2} . and plot them in the Z-plane . What are the type and features of this digital controller? Compute $U(z)$ and $u(k) = Z^{-1}[U(z)]$ using the partial fraction method. (10 pts.)

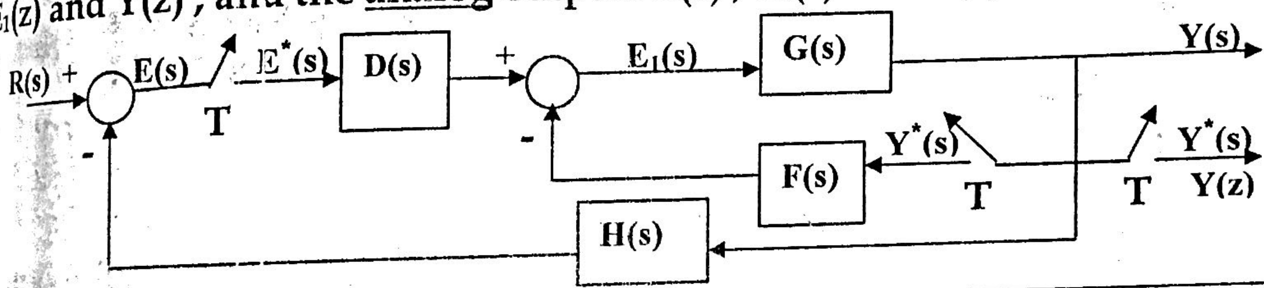
i. Implement the digital control algorithm using: Software (on-line, flow chart), and Hardware (standard programming). (4 pts.)

ii. Compute and plot $u(k)$, $k = 0, 1, 2, 3$, using recursive algorithm. Write down Matlab codes to implement this recursive algorithm. (5 pts.)

Question no. 3 (25 points).

Explain Nyquist-Shanon sampling theorem. If the condition of the sampling theorem is satisfied, $x(t)$ can be reconstructed completely from $x^*(t)$ by ideal low pass filter with gain T and bandwidth $= \omega_s / 2 = \pi / T$. Prove that this filter is not physically realizable. What can you do in practice to solve this problem? (5 pts.)

Consider the shown digital system. Construct the original signal flow graph SFG, sampled SFG, and Composite SFG. Determine the digital outputs E(z), $E_1(z)$ and Y(z), and the analog outputs E(s), $E_1(s)$ and Y(s). (20 pts.)



Question no. 4 (25 points).

Use trapezoidal numerical integration to deduce the equivalent digital PID controller transfer function $G_D(z) = U(z)/E(z)$ of analog PID controller transfer function $G_c(s) = U(s)/E(s) = K[1 + 1/(T_i s) + T_d s]$. (5 pts)

A unity-feedback digital control system has the following parameters: Second-order plant: $G_p(s) = Y(s)/U(s) = 1/[s(s + 2\zeta\omega_n)]$, Proportional digital controller: $G_D(z) = U(z)/E(z) = K$. Let $\zeta = 0.5$, $\omega_n = 2\ rad/s.$, T and K are variable parameters. Determine:

i. The region of stability in the K vs. T space using Jury's test. (14 pts.)

ii. The critical value of $K = K_c$ when $T = 0.2$ sec. (2 pts.)

iii. The closed-loop poles p_{c1}, p_{c2}, frequency of sustained oscillations ω_d and the number of samples/cycle N_s for the case in part (ii). (4 pts.)

END Of All Questions

Best wishes

Committee.

Dept. of Electrical Engineering
Faculty of Engineering
Assiut University
2nd Semester – Final Exam .
2012/2013 – May , 25 , 2013

Computers and Systems Program
Course: Digital Control"EC 426"
4th year – bylaw: 2004
Time: 3 Hours [9:12]
Marks: 100

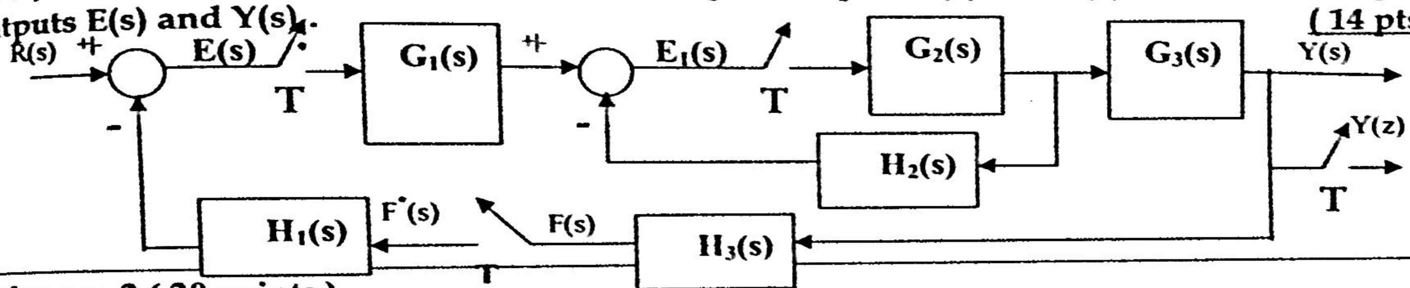
Important remarks
- Number of Pages: 2 Number of Questions: 5
- ....

Answer the Following Questions

Question no. 1 (20 points).

a. Explain the Timing and block diagrams of the following elements of a computer controlled system . How can you simplify these block diagrams ? : (6 pts.)
Practical S/H – Successive Approximation ADC .

b. Consider the shown digital system . Construct the original signal flow graph SFG , sampled SFG , and Composite SFG . Determine the digital outputs E(z) and Y(z) , and the analog outputs E(s) and Y(s) . (14 pts.)



Question no. 2 (20 points).

a. Explain Nyquist-Shanon sampling theorem . If the condition of the sampling theorem is satisfied , $x(t)$ can be reconstructed completely from $x^*(t)$ by ideal low-pass filter with gain T and bandwidth = $\omega_s/2 = \pi/T$. Prove that this filter is not physically realizable . What can you do in practice to solve this problem? (4 pts.)

b. The parameters of $\boxed{\text{the digital speed control system in your control Lab.}}$ are measured using time-domain techniques and found to be :

$$K_m = 6.02094\ rad/\sec./V\ ,\ K_t = 0.1528\ V/rad/\sec.\ ,\ \text{and}\ T_m = 0.225\ \sec.$$

Draw the block diagram of the system. Show that $\boxed{T = 0.08\ \sec.}$ is a suitable sampling period. Design a series PID-digital controller $G_D(z)$ to achieve :

$$\zeta = 0.707,\ t_s = 1\ \sec.,\ and\ K_v^* \geq 8\ \sec^{-1}.$$

Compute POS, $t_r(0.1-0.9)$, t_p ,and N_s. Sketch the root-locus and step-response of the designed system. Implement $G_D(z)$ using hardware (standard programming). (16 pts.)

Question no. 3 (20 points).

a. Draw the regions in the S-plane , and Z-plane corresponding to the following time-domain specification (Assume that $\boxed{T = 0.04\ \sec.}$) : (4 pts.)

$$M_p \leq 0.1\ \text{and}\ t_s \leq 1\ \sec.$$

b. Consider $\boxed{\text{the same digital speed control system in problem(2-b)}}$. Assume that $\boxed{T = 0.04\ \sec.}$ For this case , a series PI-digital controller $G_D(z)$ is used to achieve $e_{ss}^* = 0$ due to step input . Assume that the gains K_P and K_I are variable parameters, determine the region of stability in the K_P vs. K_I space using Jury's test . Detrmine also the critical values of $K_P = K_{Pc}$ when $K_I = 4.5$. For this case, find the frequency of sustained oscillations ω_c and N_s = the number of samples /cycle. (16 pts.)

Question no. 4 (20 points).

a . Explain the following terms :

Quantization error - folding error - Alaising error - Anti aliasing filter. (4 pts.)

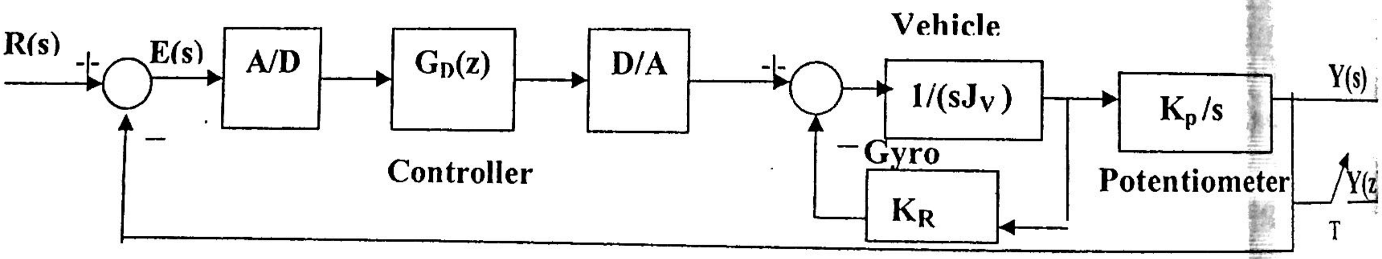
b. Consider $\boxed{\text{the same digital speed control system in problem (2-b)}}$.Assume that $\boxed{T = 0.02 \text{ sec}}$. Use the Tustin's bilinear transformation to design a series PI-digital controller $G_D(z)$ to achieve : $PM = 50^o$ and $\omega_{gc} = 10\ rad/\sec$.

Sketch the Bode - diagram of designed system in the W-domain and determine the gain margin GM , v_{pc} and the corresponding ω_{pc} . Determine K_v^* , the closed-loop poles $z_d, \bar{z}_d$ and the corresponding ζ and ω_n and relate these values to PM and ω_{gc}. (16 pts.)

Question no. 5 (20 points).

a . Write down the extrapolation equation of a first-order hold (FOH) and use it to deduce the transfer function $G_{h1}(s)$ assuming unit impulse input. Plot the frequency response $G_{h1}(j\omega)$. (4 pts.)

b . Consider the shown space vehicle system with velocity feedback .



i . If $\boxed{T = 0.1 \text{ sec.}}$, $G_D(z) = K$, $J_v = 41822$, $K_P = 1.65 \times 10^6$, and $K_R = 3.71 \times 10^5$,

prove that : $G_D(z)G(z) = \dfrac{Y(z)}{E(z)} = \dfrac{0.15K(z + 0.7453)}{(z-1)(z-0.4119)}$ (4 pts.)

ii . Plot the root-locus of the characteristic equation of the system when $0 \le K \le \infty$. Indicate the important informations on the root-locus . Determine K to achieve $\zeta = 0.5$, the corresponding closed-loop poles z_d , $\bar{z}_d$, ω_n , t_s and e_{ss}^* due to unit ramp input . Can you reduce this e_{ss}^* by increasing K to 20 ? Why ? (12 pts.)

END Of All Questions

Best wishes

Examiners: Dr. Mohamed M. M. Hassan + Committee .