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Benodigdhede vir hierdie vraestel/Requirements for this paper:				Oopboek-eksamen/ Open book examination:	
Multikeusekaarte/ Multi choice cards:		Nie-programmeerbare sakrekenaar/ Non-programmable calculator:	X		
Grafiekpapier/ Graphic paper:		Draagbare rekenaar/ Laptop:			

EKSAMEN/ EXAMINATION:	Eerst Geleentheid	KWALIFIKASIE/ QUALIFICATION:	**B Ing**
MODULEKODE/ MODULE CODE:	**EERI 418**	DUUR/ DURATION:	3 ure 3 hours
MODULE BESKRYWING/ SUBJECT:	Beheerteorie II Control theory II	MAKS / MAX:	100
EKSAMINATOR(E)/ EXAMINER(S):	Proff. G van Schoor Mnr. KR Uren	DATUM / DATE: TYD / TIME:	**5 Junie 2009 5 June 2009 14h00**
MODERATOR:	Prof MA van Wyk		

TOTAAL: 100

VRAAG 1/ *QUESTION 1*

'n Terugvoerstelsel het die volgende aanlegoordragsfunksie: /

A feedback system has the following plant transfer function:

$$G(s) = \frac{K}{(s+5)(s+20)}$$

Dit word verlang dat die posisiefoutkonstante K_p groter as 20 moet wees en dat die verbyskiet vir 'n trapinset kleiner as 10 % moet wees. 'n Vestigingstyd kleiner as 0.1 s word ook verlang. Ontwerp 'n geskikte toestandsveranderlike terugvoerstelsel. /

It is desired to obtain a position error constant K_p greater than 20 and that the percentage overshoot be smaller than 10 %. A settling time smaller than 0.1 s is also desired. Design a suitable state variable feedback system.

Addisionele inligting / *additional information:*

$$PO = 100e^{-\zeta\Pi/\sqrt{1-\zeta^2}}$$

$$T_s = \frac{4}{\zeta\omega_n}$$

[10]

VRAAG 2 / QUESTION 2

2.1 'n Stelsel word deur die volgende verskilvergelyking gemodelleer: /
A system is modelled by the following difference equation:

$$m(k+2) = -4m(k+1) - 2m(k) + 0.5e(k+1) + 2e(k)$$

Bepaal die oordragsfunksie van die stelsel $(\frac{M(z)}{E(z)})$. /

Determine the transfer function of the system $(\frac{M(z)}{E(z)})$.

(4)

2.2 Bepaal *m(k)* vir die stelsel in 2.1 vir 'n eenheidstrapinset deur van magreeksuitbreiding gebruik te maak. Aanvaar alle begintoestande as nul en bereken tot die vierde term (*m(3)*) /

Determine m(k) for the system in 2.1 for a unit step input. Use the power series method and determine up to the fourth term (m(3)). All initial conditions can be taken as zero.

(5)

2.3 Bepaal *m(k)* vir die stelsel in 2.1 in geslote vorm vir 'n eenheidstrapinset deur van parsiële breuk uitbreiding gebruik te maak. /
Determine m(k) for the system in 2.1 in closed form for a unit step input using partial fraction expansion.

(7)

2.4 Bepaal die z-transform in geslote vorm van die volgende sein: /

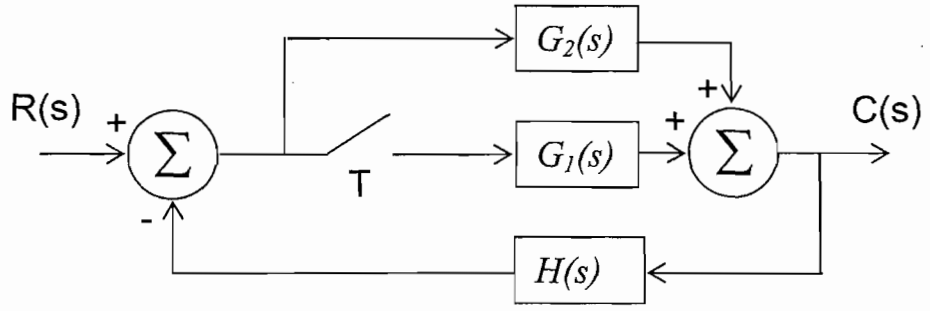
Determine the z-transform, in closed form, of the following signal:

$$E(s) = \frac{(1-e^{-s})e^{-0.1s}}{s^2(s+2)}, \quad T = 1s$$

(6)

2.5 Bepaal vir die stelsel in figuur 1 die uitset C(z) in terme van die inset en die oordragsfunksies. /

Determine for the system in figure 1 the output C(z) in terms of the input and the transfer functions.

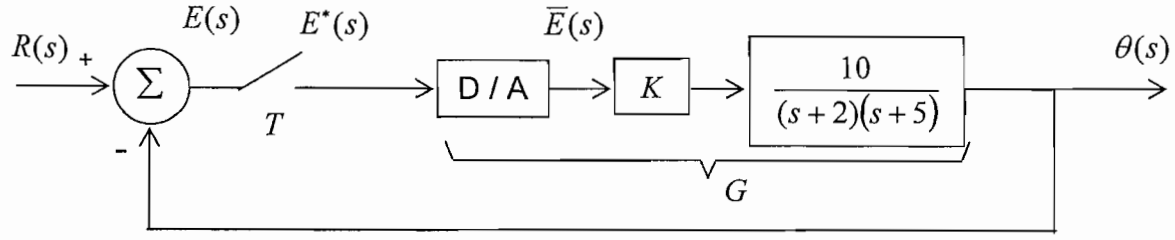


Figuur / *Figure* 1

(8)

[30]

Vraag 3 / *Question 3*



Figuur / *Figure 2*

Beskou die stelsel in figuur 2. / *Consider the system in figure 2.*

3.1 Bepaal die stelseloordragsfunksie $(\frac{\theta(z)}{R(z)})$ in terme van *G(z)*. /

Determine the system transfer function $(\frac{\theta(z)}{R(z)})$ *in terms of G(z).* (1)

3.2 Bepaal die oordragsfunksie vir $K = 20$ en $T = 0.03$ s. Wat is die tipe van die stelsel? /
Determine the transfer function for $K = 20$ and $T = 0.03$ s. Find the system type. (5)

3.3 Bepaal die bestendige toestand fout van die diskrete stelsel vir 'n eenheidstrapsinset. /
Determine the steady state error of the discrete system for a unit step input. (4)

3.4 Bepaal die natuurlike frekwensie en die tydkonstante van die diskrete stelsel. /
Determine the natural frequency and the time constant of the discrete system. (5)

3.5 Spreek jou uit oor die sinvollheid van die keuse van die monstertempo. Wat sal die effek van 'n hoër monstertempo op die respons van die stelsel wes. Maak 'n aanbeveling oor die monstertempo wat die diskretiseringsfout sal minimeer, maar nie die modelleringstyd onnodig sal verleng nie. /
Discuss the meaningfulness of the choice of the sampling rate. What will the effect of a higher sampling rate be on the response of the system. Make a recommendation on the sampling rate that would minimise the discretisation error without unnecessarily increasing the modelling time.
(5)

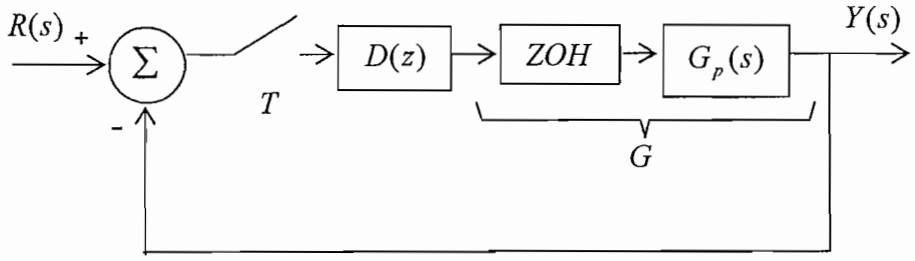
Addisionele inligting / *Additional information:*

$$\zeta = \frac{-\ln r}{\sqrt{\ln^2 r + \theta^2}}$$

$$\omega_n = \frac{1}{T}\sqrt{\ln^2 r + \theta^2} \qquad [20]$$

$$\tau = \frac{1}{\zeta\omega_n}$$

VRAAG 4 / *QUESTION* 4



Figuur / *Figure* 3

Die stelsel in figuur 3 het die volgende oordragsfunksie: /
The system in figure 3 *has the following transfer function:*

$$G_p(s) = \frac{10K}{s(s+4)}$$

Die diskrete oordragsfunksie van die stelsel soos volg: /
The discrete transfer function of the system is as follows:

$$G(z) = \frac{K(0.06658z + 0.05638)}{z^2 - 1.607z + 0.6065}, \qquad T = 0.125\,s$$

4.1 Konstrueer die benaderde wortellokus in die z-vlak met *D(z)* = 1. /
Construct the approximate root locus in the z-plane with *D(z)* = 1.

Bepaal die waardes van *K* waarvoor die stelsel stabiel sal wees. /
Determine the values of K for which the system will be stable. (10)

4.2 Figuur 4 toon die bodediagram van G(jω) vir *K* = 1. /
Figure 4 shows the bode diagram of G(jω) for K = 1.

Om die bestendige toestand fout te verminder word *K* verhoog na 3. /
To reduce steady state errors the gain K is increased to 3.

Gebruik die gegewe bodediagram om 'n eenheidswins fasevoorloopnetwerk *D(z)* te ontwerp wat 'n fasegrens van 40° tot gevolg sal hê. /
Use the given bode diagram to design a unity gain phase lead compensator D(z) that will give a phase margin of 40° *for the system.* (10)

Addisionele inligting / *Additional information:*

$$D(w) = a_0\left[\frac{1 + w/(a_0/a_1)}{1 + w/(1/b_1)}\right]$$

$$a_1 = \frac{1 - a_0|G(j\omega_{w1})|\cos\theta}{\omega_{w1}|G(j\omega_{w1})|\sin\theta},\ b_1 = \frac{\cos\theta - a_0|G(j\omega_{w1})|}{\omega_{w1}\sin\theta} \qquad [20]$$

$$K_d = a_0\left[\frac{\omega_{wp}(\omega_{w0} + 2/T)}{\omega_{w0}(\omega_{wp} + 2/T)}\right],\ z_0 = \left[\frac{2/T - \omega_{w0}}{2/T + \omega_{w0}}\right],\ z_p = \left[\frac{2/T - \omega_{wp}}{2/T + \omega_{wp}}\right]$$