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Benodigdhede vir hierdie vraestel/Requirements for this paper:			
Multikeusekaarte/ Multi-choice cards:		Nie-programmeerbare sakrekenaar/ Non-programmable calculator:	X
Grafiekpapier/ Graphic paper:		Draagbare Rekenaar/ Laptop:	

Oopboek-eksamen/ Open book examination?	NEE/ NO

EKSAMEN/TOETS EXAMINATION/TEST:	Eksamen (1e) / Examination (1st)	KWALIFIKASIE/ QUALIFICATION:	B Ing / B Eng
MODULEKODE/ MODULE CODE:	EERI 418	TYDSDUUR/ DURATION:	3 uur/hour
MODULEBESKRYWING/ MODULE DESCRIPTION:	Beheerteorie II	MAKS/ MAX:	100
EKSAMINATORE(E)/ EXAMINER(S):	PROF. G VAN SCHOOR DR. KR UREN	DATUM/ DATE:	17/06/2014
		TYD/TIME:	09h00
MODERATOR:	MR. J NAUDE		

VRAAG 1/ *QUESTION* 1

'n Stelsel word deur die volgende toestandsruimtevergelyking beskryf: /

A system can be described by the following state space equation:

$$\dot{\mathbf{X}} = \begin{bmatrix} -2 & 2 & 0 \\ 0 & -2 & 1 \\ 0 & 0 & -4 \end{bmatrix}\mathbf{X} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}u$$

Die toestandsveranderlikes x_1, x_2 & x_3 is almal meetbaar. x_1 is die uitset van die stelsel. Ontwerp 'n toestandveranderlike terugvoerbeheerder sodat die gekompenseerde stelsel krities gedemp is en 'n vestigingstyd van hoogstens 0.5 s het. Gebruik die ITAE optimum polinoom metode. /

The state variables x_1, x_2 & x_3 are all measurable. x_1 is the output of the system. Design a state variable feedback controller so that the compensated system is critically damped and has a settling time smaller than 0.5 s. Use the ITAE optimum polynomial method.

Addisionele inligting / *additional information:*

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

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

[10]

913

VRAAG 2 / *QUESTION 2*

2.1 'n Stelsel word deur die volgende verskilvergelyking gemodelleer: /

A system is modelled by the following difference equation:

$$x(k)+x(k-1)-x(k-2)=e(k-1)+2e(k)$$

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

Determine the transfer function of the system $(\frac{X(z)}{E(z)})$. (4)

2.2 Bepaal *x(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 *(x(3))* /

Determine x(k) for the system in 2.1 for a unit step input. Use the power series method and determine up to the fourth term (x(3)). All initial conditions can be taken as zero. (5)

2.3 Bepaal *x(k)* vir die stelsel in 2.1 in geslote vorm vir 'n eenheidstrapinset deur van parsiële breuk uitbreiding gebruik te maak. /

Determine x(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: /

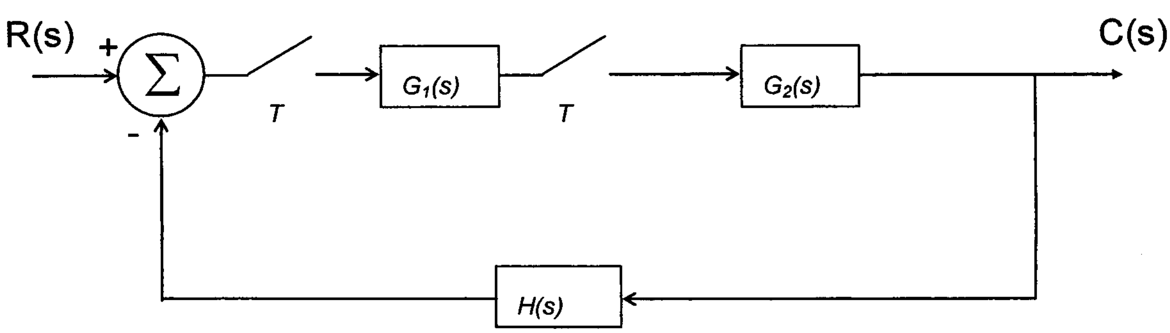
Determine the z-transform, in closed form, of the following signal:

$$E(s)=\frac{2(1-e^{-0.5s})e^{-1.1s}}{s(s+1)}, \quad T=0.5s$$

(6)

2.5 Bepaal die geslotelusoordragsfunksie $(\frac{C(z)}{R(z)})$ vir die stelsel in figuur 1. /

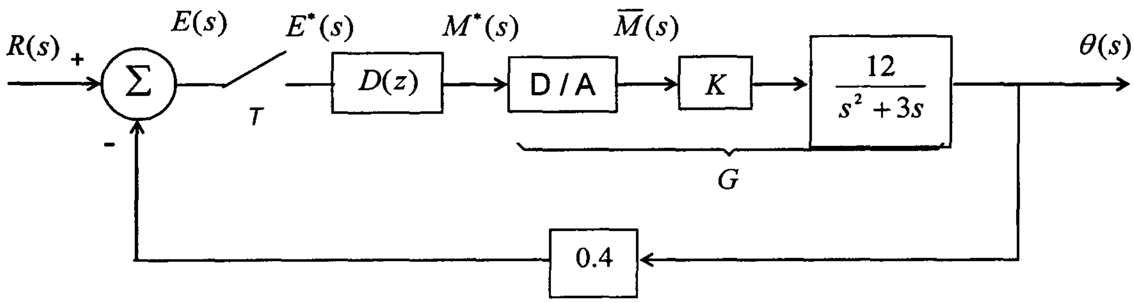
Determine the closed loop transfer function $(\frac{C(z)}{R(z)})$ *for the system in figure 1.*



Figuur / *Figure* 1 (8)

[30]

VRAAG 3 / *QUESTION* 3



Figuur / *Figure 2*

Beskou die antenna-beheerstelsel in figuur 2. Die eenheid vir die antennahoek *θ(t)* is grade. /
Consider the antenna control system shown in figure 2. The unit for the antenna angle θ(t) is degrees.

3.1 Bepaal die waardes van *r(t)* wat hoeke van ±20° vir *θ(t)* sal gee. /
Determine the values of r(t) that will give the angles of ±20° for θ(t). (1)

3.2 Bepaal die stelseloordragsfunksie $(\frac{\theta(z)}{R(z)})$ in terme van *G(z)* en *D(z)*. /
Determine the system transfer function $(\frac{\theta(z)}{R(z)})$ *in terms of G(z) and D(z).* (1)

3.3 Bepaal die oordragsfunksie vir *D(z)* = 1, *K* = 10 en *T* = 0.05 s. Wat is die tipe van die stelsel? /
Determine the transfer function for D(z) = 1, K = 10 and T = 0.05 s. Find the system type. (5)

3.4 Bepaal die bestendige toestand fout van die stelsel vir 'n eenheidshellingsinset. /
Determine the steady state error of the system for a unit ramp input. (5)

3.5 Bepaal die demping asook die natuurlike frekwensie van die diskrete stelsel. /
Determine the damping as well as the natural frequency of the discrete system. (4)

3.6 Die filter D(z) realiseer nou die volgende verskilvergelyking: /
The filter D(z) now realises the following difference equation:

$$m(k) = e(k) - 0.8e(k-1) + m(k-1)$$

Wat is die tipe van die stelsel nou? / *What is the system type now?* (3)

3.7 Met *D(z)* soos in 3.6, bepaal weer die bestendige toestand fout van die stelsel vir 'n eenheidshellingsinset. /
For D(z) as in 3.6, again determine the steady state error of the system for a unit ramp input. (1)

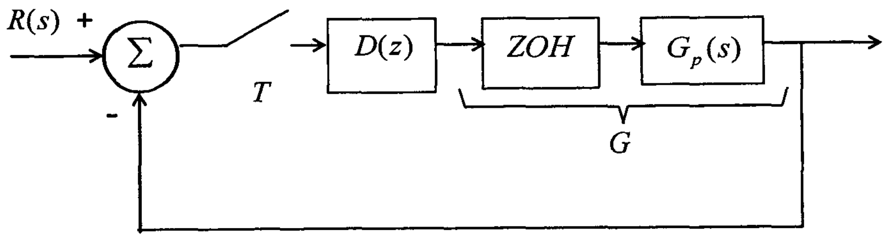
Addisionele inligting / *Additional information:*

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

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

$$G_p(s) = \frac{20K}{s(s+1)(s+4)}$$

Vir K = 1, is die diskrete oordragsfunksie van die stelsel soos volg: /

For K = 1, the discrete transfer function of the system is as follows:

$$G(z) = \frac{3.292\times10^{-6}z^2 + 1.3\times10^{-5}z + 3.211\times10^{-6}}{(z-1)(z-0.99)(z-0.9608)}, \qquad T = 0.01s$$

Figuur 4 toon die bodediagram van G(jω) vir K = 1. /

Figure 4 shows the bode diagram of G(jω) for K = 1.

Hou K = 1 en ontwerp 'n fasevoorloopnetwerk *D(z)* wat 'n fasegrens van 30° tot gevolg sal hê, maar nie die bestendige gedrag van die stelsel sal verander nie. /

Keep K = 1 and design a phase lead compensator D(z) that will give a phase margin of 30° for the system without changing the system's steady state performance.

Addisionele inligting / *Additional information:*

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

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

[15]

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

VRAAG 5 / *QUESTION 5*

Beskryf die ontwerpprosedure van 'n fase naloopkompensator m.b.v. die wortellokus en illustreer aan die hand van 'n voorbeeld. /

Describe the design procedure for a phase lag compensator using the root locus and illustrate it through an example.

[7]

VRAAG 6 / *QUESTION 6*

Sê of die volgende stellings **WAAR** of **VALS** is. **EEN** punt sal afgetrek word vir elke verkeerde antwoord. Moet dus nie raai nie; los liewer oop as jy nie weet nie. / *State whether the following statements are **TRUE** or **FALSE**, keeping in mind that **ONE** mark will be deducted for each wrong answer. Therefore do not guess; rather leave blank if you do not know the answer.*

6.1 Die effek van die nul-orde houbaan is om die tipe van die stelsel met een te verhoog. /

The effect of the zero order hold circuit is to increase the type of the system by 1. (2)

6.2 Die Jury-stabiliteitstoets stel ons in staat om direk in die z-vlak stelselstabiliteit te bepaal. /

The Jury stability test offers a technique for determining system stability directly in the z-plane. (2)

6.3 Met die fase-voorloopkompensator sal 'n klein variasie in die posisie van die pool 'n groot verandering in die kompensasierespons tot gevolg hê. /

With the phase lead compensator a small variation in the position of the pole will have a great impact on the compensation response. (2)

6.4 Die numeriese integrasietegniek het 'n direkte invloed op die grootte van die tydstap in 'n simulasie van 'n stelsel. Hoe hoër die orde van die numeriese integrasietegniek, hoe kleiner moet die tydstap wees om akkuraatheid te verseker. /

The numeric integration technique has a direct effect on the suitable time step in a simulation of a system. The higher the order of the integration technique, the smaller the time step should be to ensure accuracy of simulation. (2)

[8]

VRAAG 7 / *QUESTION 7*

Bespreek Kunsmatige Neurale Netwerke aan die hand van hul oorsprong, struktuur, funksionaliteit en opleiding. Klassifiseer ook die gebruik daarvan in terme van toepassings. /

Discuss Artificial Neural Networks in terms of their origin, structure, functionality and training. Classify their use in terms of applications.

[10]

TOTAAL/TOTAL: 100

917