Benodigdhede vir hierdie vraestel/Requirements for this paper:				Oopboek-eksamen/ Open book examination?	NEE/ NO
Multikeusekaarte/ Multi-choice cards:		Nie-programmeerbare sakrekenaar/ Non-programmable calculator:	X		
Grafiekpapier/ Graphic paper:		Draagbare Rekenaar/ Laptop:			

EKSAMEN/TOETS EXAMINATION/TEST:	Eksamen (1e) / Examination (1st)	KWALIFIKASIE/ QUALIFICATION:	B Ing / B Eng
MODULEKODE/ MODULE CODE:	EERI 418 / EERI 618	TYDSDUUR/ DURATION:	3 uur/hour
MODULEBESKRYWING/ MODULE DESCRIPTION:	Beheerteorie II	MAKS/ MAX:	100
EKSAMINATORE(E)/ EXAMINER(S):	PROF. G VAN SCHOOR	DATUM/ DATE:	14/06/2011
		TYD/TIME:	09h00
MODERATOR:	PROF. MA VAN WYK		

TOTAAL/TOTAL: 100

VRAAG 1/ *QUESTION* 1

'n Stelsel word deur die volgende toestandsruimtevergelyking beskryf word: /

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

$$\dot{\mathbf{X}} = \begin{bmatrix} 0 & 1 & 1 \\ 0 & 0 & 1 \\ -2 & -6 & -4 \end{bmatrix}\mathbf{X} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}u$$

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 se verbyskiet vir 'n trapinset nie 10 % oorskry nie en die vestigingstyd minder as 2 s is. /

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 overshoot for a step input does not exeed 10 % and the settling time is less than 2 s.

Benader die stelsel as tweede orde deur die derde wortel 'n orde hoër in frekwensie te kies as die dominante wortels. /

Approximate the system as a second order system by choosing the position of the third root an order in frequency higher than the dominant poles.

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:

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

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: /

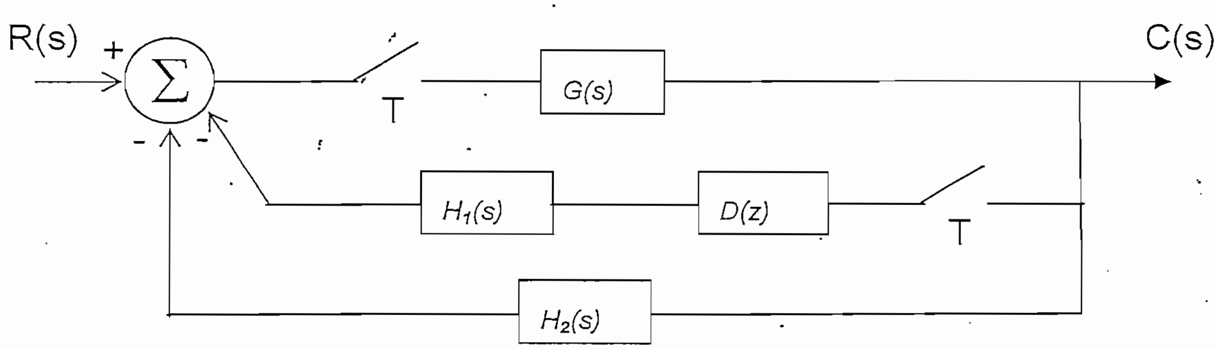
Determine the z-transform, in closed form, of the following signal:

$$E(s)=\frac{(1-e^{-0.5s})e^{-0.75s}}{s(s+2)^2}, \quad T=0.5\,s$$

(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.*

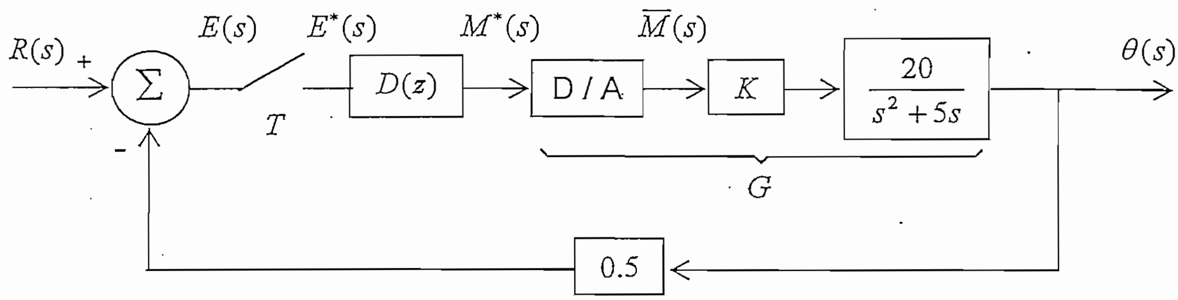


Figuur / *Figure* 1

(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:

$$m(k) = e(k) - 0.9e(k-1) + m(k-1)$$

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

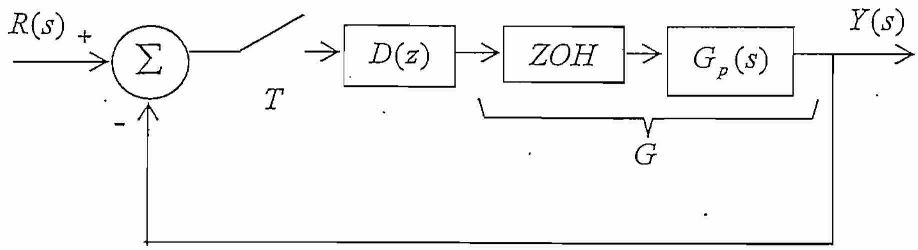
Addisionele inligting / additional information:

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

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

$$G(z) = \frac{3.292\cdot 10^{-6} z^2 + 1.3\cdot 10^{-5} z + 3.211\cdot 10^{-6})}{(z-1)(z-0.99)(z-0.9608)}, \qquad T = 0.01s$$

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:*

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

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

[10]

$$K_d = a_0\left[\frac{\omega_{wp}\left(\omega_{w0}' + 2/T\right)}{\omega_{w0}\left(\omega_{wp} + 2/T\right)}\right],\ z_0 = \left[\frac{2/T - \omega_{w0}}{2/T + \omega_{w0}}\right],\ z_p = \left[\frac{2/T - \omega_{wp}}{2/T + \omega_{wp}}\right]$$

VRAAG 5 / *QUESTION 5*

Gestel die stelsel in figuur 3 het die volgende oordragsfunksie: /

The system in figure 3 now has the following transfer function:

$$G_p(s) = \frac{10K}{(s+1)(s+4)}$$

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

$$G(z) = \frac{K(0.06379z + 0.0518)}{(z^2 - 1.489z + 0.5353)}, \qquad T = 0.125\,s$$

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]

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 As die inset na 'n diskrete tyd stelsel nie gemonster word voordat dit op 'n analoë deel van die stelsel inwerk nie, kan daar nie 'n oordragsfunksie vir die stelsel bepaal word nie. /

If the input to a discrete time system is not sampled before being applied to an analog part of the system, no transfer function can be derived. / (2)

6.3 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)

6.4 Met die gebruik van die fase voorloopkompensator het die fasevoorloop 'n stabiliserende effek. /

The phase lead of the phase lead compensator has a stabilising effect. (2)

6.5 Die tydkonstantes van die dominante pole in die stelsel kan as maatstaf gebruik word om die geskikte monsterfrekwensie vir die stelsel te bepaal. 'n Goeie reel is om hoogstens teen vyf keer die hoogste dominante poolfrelwensie te monster. /

The time constants of the dominant poles in the system can be used as a measure to determine a suitable sampling frequency for the system. A good rule is to sample at the highest at five times the biggest dominant pole frequencies in the system. (2)

[10]

VRAAG 7 / *QUESTION 7*

Bespreek Wasige Logiese Stelsels aan die hand van hul oorsprong, struktuur, funksionaliteit en opleiding. Klassifiseer ook die gebruik daarvan in terme van toepassings. /

Discuss Fuzzy Logic Systems in terms of their origin, structure, functionality and training. Classify their use in terms of applications.

[10]