LAST NAME	
FIRST NAME	
MATRIKEL-NO.	

Problem 1

(2 point per subtask)

a) Describe the difference between the time- and frequency domain concerning the usage of signals!

b) What is the assumption for linearity regarding dynamical systems?

c) Give the mathematical representations of three typical signals of system dynamics and their respective Laplace transforms.

d) What is a transfer function and in which way it is used for the graphical description of the transfer behavior?

e) A control system is described by two pure P transfer systems (gain factors K_R, K_S) with negative feedback. Describe the difference of the resulting reference - and disturbance transfer function regarding the stationary behavior!

Problem 2

(2 points per subtask)

a) The system dynamical representation of systems distinguishes three different kinds of transfer behaviors (proportional, differentiating, integrating). Denote the differences in a Bode diagram.

b) What is the stability of a transfer system? Give two methods for the analytical calculation, if the mathematical representation is given.

c) A given transfer system has a PIT_2T_t transfer behavior. Give the differential equation analytically, which describes the transfer behavior as well as the transfer function in form of its polar plot.

d) The spindle drive of a novel linear drive is approximately described by a PDT_1 transfer behavior (parameters K, T_D, T_1). For a closed-loop system a P-controller and a PI-controller are available. Sketch the principle behavior of both closed-loop systems with a root locus plot and describe the difference concerning the stability behavior.

e) In Figure 2.1 the Bode plot of a dynamic system is shown. Determine the transfer function of the system by the phase plot and the frequency response. Assume the location of the poles and zeros at $\omega_1 = 10$, $\omega_1 = 100$, and $\omega_1 = 1000$.

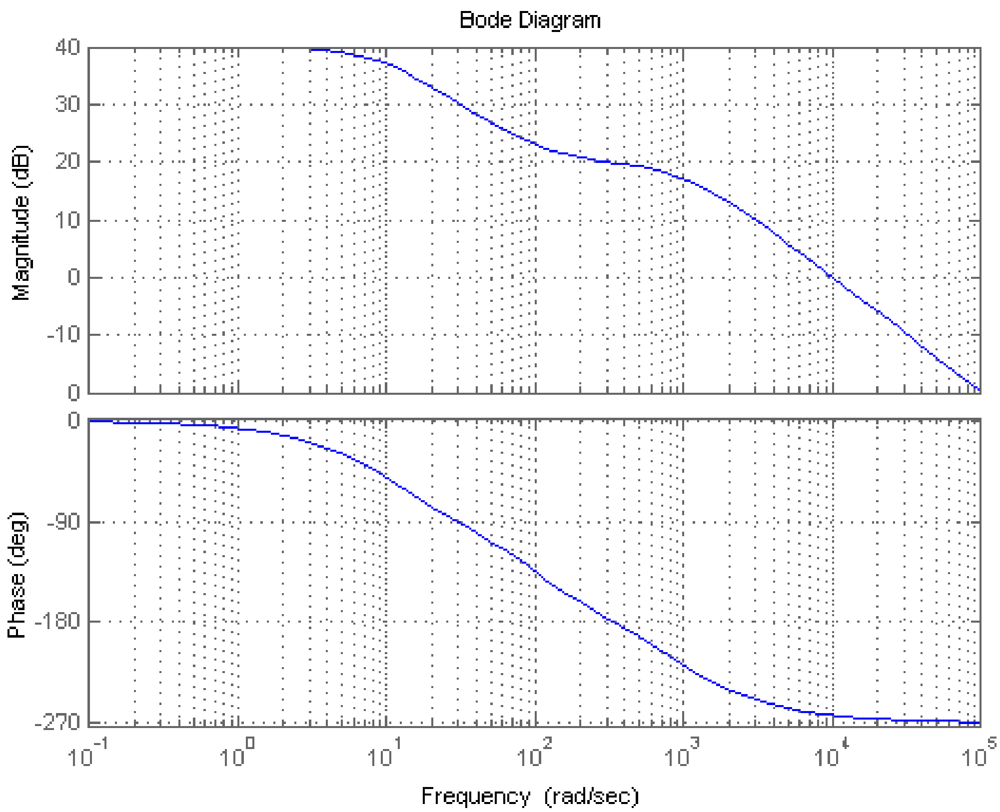

Figure 2.1: Bode plot of the dynamic system

Problem 3

(15 points)

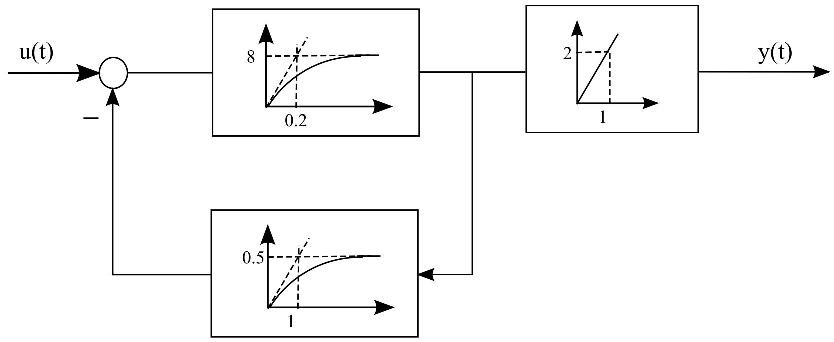

Figure 3.1: System block diagram

In Figure 4.1, the block diagram of a system of transfer elements is given.

a) Set up the transfer function of the system with the given constants. Determine the poles and zeros of the system. Is the system asymptotically stable? State reason!

b) Derive the differential equations of the system from the transfer function and classify the transfer character. Transform the differential equations into a state space representation.

c) The state space model of a system is given by

$$\begin{aligned} \dot{\boldsymbol{x}}(t) &= \begin{bmatrix} -0.5 & 0 \\ 1 & -1 \end{bmatrix} \boldsymbol{x}(t) + \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} u(t), \qquad \boldsymbol{x}(0) = \begin{bmatrix} x_{01} \\ x_{02} \end{bmatrix}, \\ y(t) &= \begin{bmatrix} 1 & -1 \end{bmatrix} \boldsymbol{x}(t). \end{aligned}$$

Calculate the eigenvalues and eigenvectors of the system matrix.

d) Transform the given state space model in c) into a diagonal canonical form.

e) Set up the equation of motion for the transformed state space model in d) and put the matrices into the equation. Indicate the eigenmotion (free motion) and the excited motion.

Problem 4

(15 points)

The system $G_S(s)$ is described by the transfer function

$$G_S(s) = \frac{s-2}{(s+3)(s^2+2s+1)} \;.$$

a) Illustrate its amplitude and phase shift behavior qualitatively in a Bode-diagram.

b) Is the system I/O-stable (BIBO-stable)? State reason!

c) A P-element with gain K_1 is taken as the controller. Please determine the transfer function of the closed loop system with negative feedback according to the reference value. Please draw schematically the standard control loop. For which value of control gain K_1 is the control loop stable (use the Hurwitz-criterion)?

d) Determine the remaining control deviation (control error) of the control loop for $K_1 = 1$ if the reference input is a step function, $w(t) = 1(t)$.

e) A PI-element $G_{c2}(s) = K_2 + \frac{K_3}{s}$ is taken as a new controller. Please determine the new remaining control deviation with a step function as the reference value. Please compare the result with d). Why the control loop has such a remaining control deviation with a PI-controller? State reason!

Problem 5

(16 points)

A novel approach to a new electrical drive has to be analyzed. For the plant to be controlled, a mathematical model should be derived.

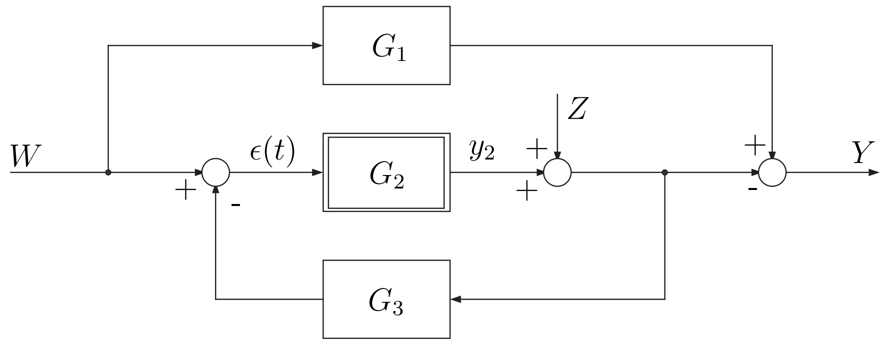

Figure 5.1: Block diagram

a) Derive the reference transfer function $G_{\mathrm{W}}(s) = \frac{Y(s)}{W(s)}$ and the disturbance transfer function $G_{\mathrm{Z}}(s) = \frac{Y(s)}{Z(s)}$ for the shown block diagram in figure 5.1. Please use the given signal names.

b) The transfer elements are now described by:

$$\begin{aligned} G_1 &= K\ , \\ G_2 &: \ y_2 = \log(\epsilon(t)+1) - 2\epsilon(t) \text{ and} \\ G_3 &= \frac{1}{s+T_3}\ . \end{aligned}$$

Linearize[1] the transfer behavior G_2 at the working point $\epsilon_0 = 0$ and state the total transfer function $G(s) = f(G_{\mathrm{W}}(s), G_{\mathrm{Z}}(s))$.

c) Consider the following system transfer function:

$$G(s) = \frac{(K-1)(s+T)}{s+T+1}W(s) - \frac{s+T}{s+T+1}Z(s)\ .$$

[1] Hint: Taylor series: $f(x) = f(x_0) + \frac{\partial f}{\partial x}|_{x_0}(x - x_0)$

Which final values reach the system with the following input signals?

i) w(t) = 1(t), z(t) = 0

ii) w(t) = 0, z(t) = 1(t)

iii) w(t) = z(t) = 1(t)

d) For which values of K has the system a direct feedthrough $D \neq 0$ ($Z(s) = 0, W(s) = \frac{1}{s}$; output reacts without delay on input; calculate and state reason!)?

Maximum achievable points:	**66**
Minimum points for the grade 1,0:	**95 %**
Minimum points for the grade 4,0:	**50 %**