LAST NAME	
FIRST NAME	
MATRIKEL-NO.	

Problem 1

(each part 2 points)

a) Explain the difference between an open loop control and a closed loop control using a block diagram.

b) Which two methods to model a system do you know? Give for each method an example.

c) Give three different typical signal forms used in system dynamics and define their mathematical and graphical description.

d) What does the condition of linear transfer behavior of transfer functions include.

e) Using an input signal $u(t) = a \cdot \sin(\omega t)$ for a system yields to the output $y(t) = b \cdot \sin(3\omega - \varphi_0)$. Explain why it can be seen that the system is a nonlinear one?

Problem 2

(each part 2 points)

a) How can the output $y(t)$ be calculated using the impulse response $g(t)$, if the input $u(t)$ is given.

b) Calculate the Laplace transformed of the signal $f(t) = 2(t) - 1(t-1)$.

c) Is a system given by

$$G(s) = \frac{K(1 + T_1 s)}{s(1 + T_2 s)}$$

Lyapunov stable for $T_1, T_2 > 0$?

d) A controller has a PDT_2–transfer behavior. Define the describing differential equation and denote the the parameters.

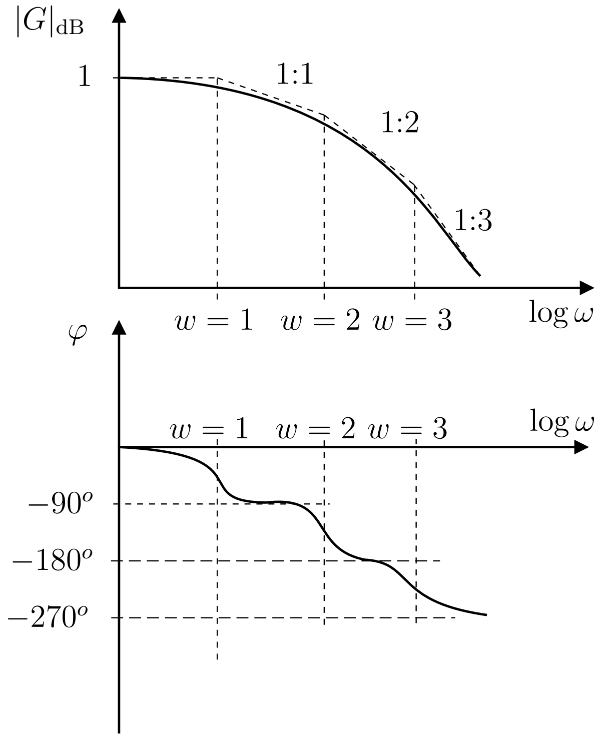
e) A system with I–transfer behavior should be controlled with negative feedback using an element with P–transfer behavior. What kind of transfer behavior (classification) has the resulting system.

Problem 3

(10 points)

a) The dynamical behavior of an open control loop $G_0(s)$ is known by measuring the Nyquist plot. Which method can be used to check the stability of the closed loop behavior and which statements can be given for which parameters.

b) The transfer behavior of a human–vehicle–system should be determined experimentally. For the transfer behavior between the steering wheel and the behavior of the vehicle the following Bode diagram is measured:



The behavior of the human driver is described by

$$G_{\text{human}} = \frac{K}{1 + T_1 s} \cdot e^{-T_t t}$$

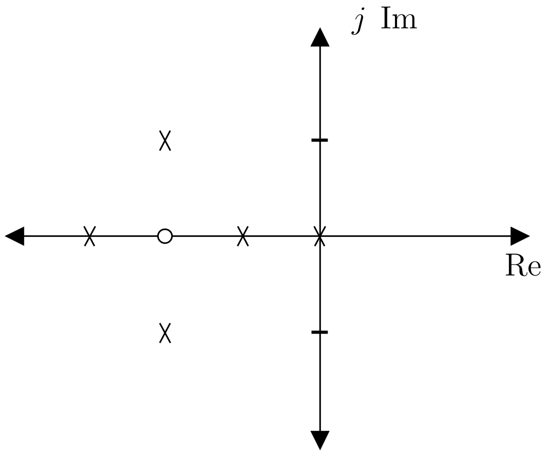
with $T_1 = 0.5$ sec, $T_t = 0.4$ sec. Draw the Bode plot qualitatively of the entire system.

c) The transfer behavior of a new actuator system is described by

$$G(s) = \frac{1 + s + 2s}{1 + 4s + K_1^2 s^2 + K_2 s} \ .$$

For which parameters K_1, K_2 is the system stable?

d) The poles and the zeros of an open control loop are given by:



Can the closed loop system be stabilized by tuning the control parameters? Explain your answer using an appropriate graphical description.

e) Define the state space representation of the system described by

$$m\ddot{x}(t) + (d_1 + d_2)\dot{x}(t) + (k + k_R)x(t) = u(t) \qquad \text{with} \qquad u(t) = u_0 \cdot \sin\omega_0 t\ ,$$

where $\dot{x}(t)$ is measured. Denote the matrices and give the general state space notation.

Problem 4

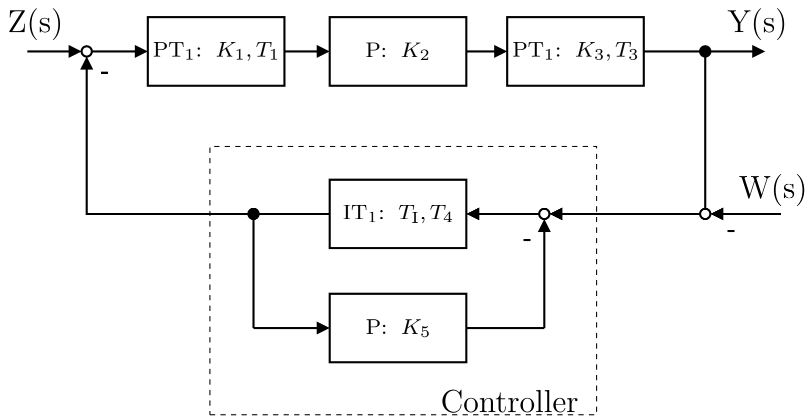
(15 points)

a) A system is given by:

$$G(s) = \frac{1}{1+Ts} \; .$$

Calculate the output $y(t=0)$ and $y(t=\infty)$ for the input signal $u(t) = 1(t)$ and define $Y(s)$!

b) A system is given by:



Define the transfer function $\frac{Y(s)}{W(s)}$.

c) The dynamical behavior of a test vehicle is approximated by a spring–mass–damper–system

$$m\ddot{x}(t) + d\dot{x}(t) + kx(t) = f(t) \; ,$$

with $x(t)$ as coordinate of the mass and $f(t)$ as the exciting force. The position of the mass $y(t) = x(t)$ is measured. The mass coordinate should be controlled using an electromechanical actuator. The transfer function of the actuator including the control is given by

$$G_R(s) = \frac{F(s)}{X(s)} = \frac{K_R}{(1+T_1 s)s} \; .$$

The characteristic of the actuator is the use of a worm gear to generate a linear motion. Determine for the energy free system (initial conditions = 0) the transfer function of the open loop system, determine the poles and zeros and draw them in a pole-/zero plot (case differentiation).

d) Draw the Bode plot for the given parameters $m = d = k = 1; K_{\mathrm{R}} = 1, T_1 \approx 0$. What are the stability criterions for the (special) Nyquist criterion in the Bode plot. Is the closed loop control stable?

e) The constructive design of the actuator is replaced using a new actor with a linear actuating characteristic. The new resulting open loop system is descibed by

$$G_0(s) = G_{\mathrm{R}}(s) \cdot G_{\mathrm{S}}(s) = \frac{K_{\mathrm{R}} s}{(ms^2 + ds + k)(1 + T_1 s)}$$

$$\text{with} \qquad K_{\mathrm{R}} = m = d = k = 1,\ T_1 \approx 0.$$

Draw the Bode plot qualitatively of the new system and describe the advantages of the resulting dynamic concerning the stability and the dynamic.

Problem 5

(15 Punkte)

The transfer function of a system is given by

$$G_{\mathrm{S}}(s) = \frac{1}{(s+1)(s+4)(s-1)} \; .$$

The system can be controlled using a controller described by

$$G_{\mathrm{R}_1}(s) = K_{\mathrm{R}_1}$$

or a controller described by

$$G_{\mathrm{R}_2}(s) = K_{\mathrm{R}_2}\frac{(s+1)^2}{s} \; .$$

a) What kind of transfer behavior (classification) have the controllers.

b) The system should be controlled with negative feedback using one of the controllers. Draw the root locus of the system for each controller type. Before drawing the root locus determine the

- the number of asymptotes,
- the root center,
- the angle of asymptotes.

c) Which controller would you choose to control the system. Explain your answer by the root locus plot.

d) How can the gain of the controller be calculated to get a stable closed loop system. Explain your answer using the root locus plot and give only the formula which can be used to calculate the gain.

Problem 6

(40 Punkte)

a) The block diagram of a system is given by:

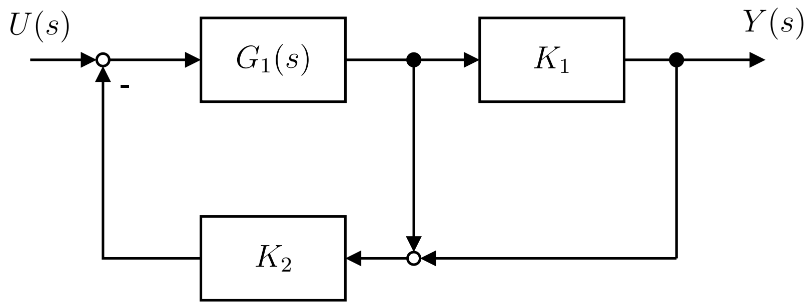


Abbildung 6.1: Block diagram

Define the transfer function of the system. Then, replace the transfer function with $G_1(s) = \frac{1}{s(1+s)}, K_1 = 1, K_2 = 2$ (should be taken for the following considerations) and determine (classify) the transfer behavior.

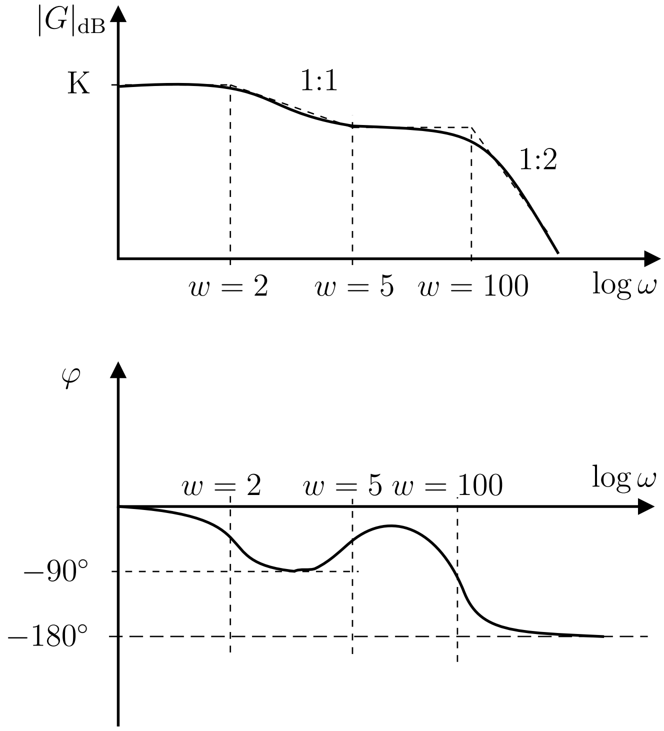
b) The system given in a) should be controlled with negative feedback by a transfer element which is described by the differential equation

$$x_a(t) = K(x_e(t) + T_1\dot{x}_e(t) + T_2 \int x_e(\tau)\, d\tau) \ ,$$

where $x_a(t)$ is the output and $x_e(t)$ the input of the controller. What kind of controller (classify) results? Calculate the poles and the zeros of the open control loop and give the block diagram of the closed loop control.

c) For the controller given in b) the parameters $K = 1, T_1 > 0, T_2 > 0$ are given. Determine for which parameters of the controller the system given in a) is stable using a negative feedback control. Use the Hurwitz criterion and draw the area in the T_1, T_2–parameter plane for which ones the closed control loop is stable.

d) The following Bode plot of a system is measured:



Give the transfer function which describes the system and draw the Nyquist plot qualitatively.

e) The system should be controlled with negative feedback by a P–transfer element. For which parameters of the P–transfer element is the closed loop system stable.

Maximum achievable points:	**100**
Minimum points for the grade 1,0:	**95**
Minimum points for the grade 4,0:	**50**