NAME	
FIRST NAME	
MATRICULATION NO.	

Problem 1

(each 2 points)

a) Describe the difference between feed-forward control and feed-back control using a block diagram.

b) For which purpose is experimental modeling of a technical system conducted?

c) Give a graphical representation of three typical test input signals as well as their names. Further on, give the Laplace transform of each signal.

d) What is a step response and how is it used graphically to denote systems?

e) Describe the purpose of the stability criteria and name three of them.

Problem 2

(each 2 points)

a) There are three basic types of transfer behavior: proportional, differential, and integral. Plot them in Bode-diagrams. In which way do they differ for low frequencies?

b) What can you tell from the stability of a transfer system? Describe a method for yielding the stability experimentally.

c) A transfer system has a PDT_2-behavior. Give the transfer function for an, initially energy-free system, and give the describing differential equation. Sketch the step response of the PDT_2 system.

d) A connection drive of a tool-machine is described as a PIT_1-transfer behavior (parameters K, T_I and T_1). For negative feedback control, a P-controller (parameter K_P) and a PI-controller (parameter K_{PR} and T_{IR}) are available.

Sketch the principal relationship of both control circuits by two root-locus and describe the differences.
(Parameters: $K = T_1 = T_{IR} = T_I = 1$).

e) A system to be controlled with a proportional transfer behavior is unknown. Detailed modeling is not possible. Give a short instruction of one possible strategy for how to implement and adjust a PID-controller and name the method.

Problem 3

(15 points)

The system described by the transfer function

$$G_\mathrm{S} = \frac{1}{1+T_1 s}$$

is controlled by the IT_1-controller

$$G_\mathrm{R} = \frac{K}{s(1+T_2 s)} \quad .$$

a) State the transfer function $G_0(s)$ of the open-loop system as well as its poles and zeros.

b) Which conditions have to be fulfilled by the amplification K, so that the closed-loop system (negative feedback) becomes stable? Use $T_1 = T_2 = 1$ for the necessary calculations.

c) State the equations of the magnitude plot $|G_0(j\omega)|$ and the phase plot $\phi_0(j\omega) = \arg G_0(j\omega)$.

d) Calculate the gain crossover frequency ω_s for $T_1 = T_2 = 1$ and $K = 5/8$. Is $\omega_\mathrm{s} = 0.5$ the solution? State reason!
Calculate the phase margin Φ_R.

e) Sketch the Bode plot qualitatively for the numerical values given in d). Draw in the gain margin A_R and phase margin Φ_R.

Problem 4

(15 points)

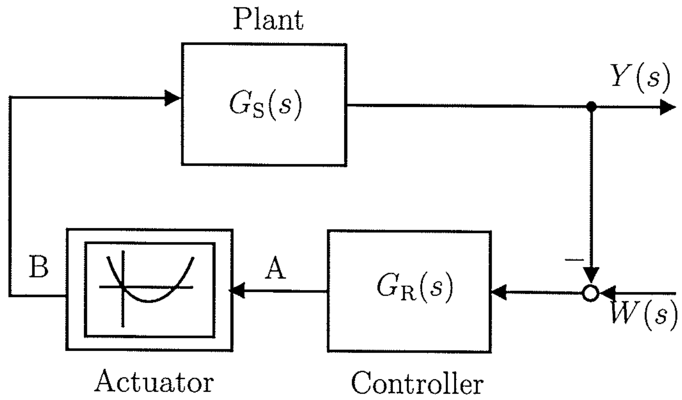

Figure 4.1: Closed-loop system

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

$$G_S(s) = \frac{s-1}{(s+5)(s+1)^2} \; .$$

For control a PDT_2-controller

$$G_R(s) = \frac{s+2}{(s+1)(0.25s+1)}$$

is used. The actuator is described by the nonlinear static characteristic curve

$$B = \frac{1}{3}A^2 - A \; .$$

a) Derive the linearized transfer function $G_0(s)$ of the open-loop system at the working point A_0.
State the associated static gain and label it K_{stat}.

b) Sketch the pole-zero map of $G_0(s)$.

c) Sketch the qualitative root-locus of the closed-loop in the hole range $-\infty < A_0 < \infty$.

d) Derive the state space representation of $G(s) = \frac{(s-1)(s+2)}{(s+5)(s+1)^3(s+4)}$.
Is the system stable? State reason!

Problem 5

(16 points)
A new approach for a controller of a new hybrid propulsion technology has to be analyzed. From the measured polar plot (see figure ??), a mathematical model of the system to be controlled has to be derived and analyzed.

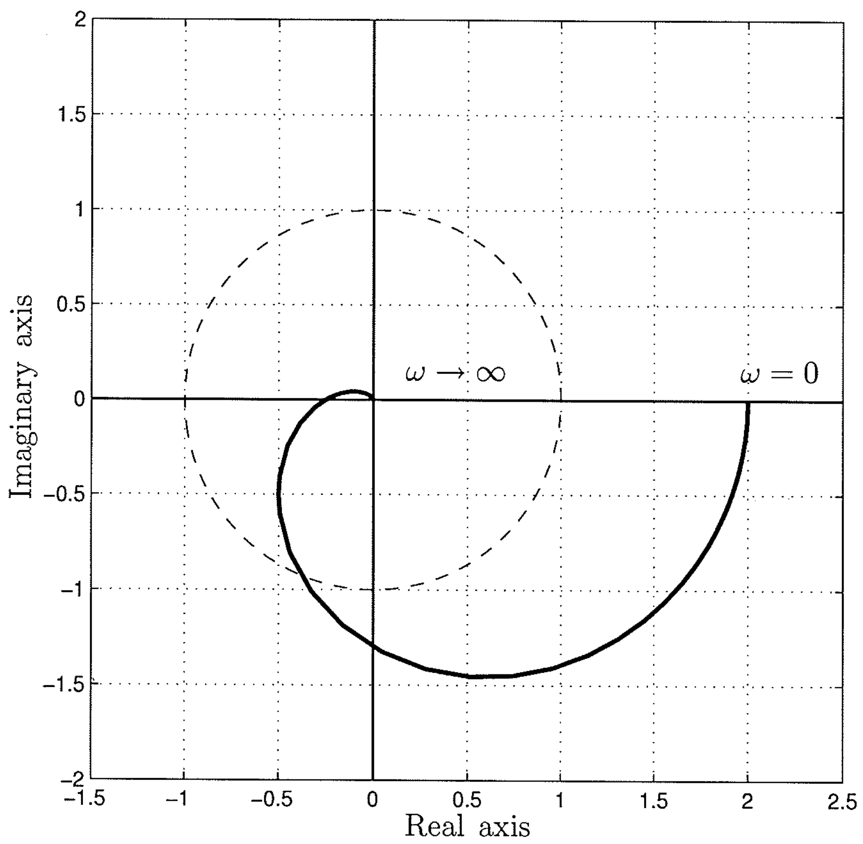

Figure 5.1: Polar plot

a) Which system behavior can be concluded (state reasons) from the polar plot (see figure ??)?

b) Mark the gain margin A_R and phase margin φ_R in figure ?? and state both values.

c) Is the system stable (state reason)?

d) For closed-loop control a proportional controller with negative feed-back is used. Calculate the critical amplification K_P for this controller.
Use the simplifying assumption that all time constants of the measured system are identical.

Below (see figure **??**) the pole-zero allocation for an open-loop system including a proportional controller ($K_P = 1$) is given.

e) Sketch the root locus plot.

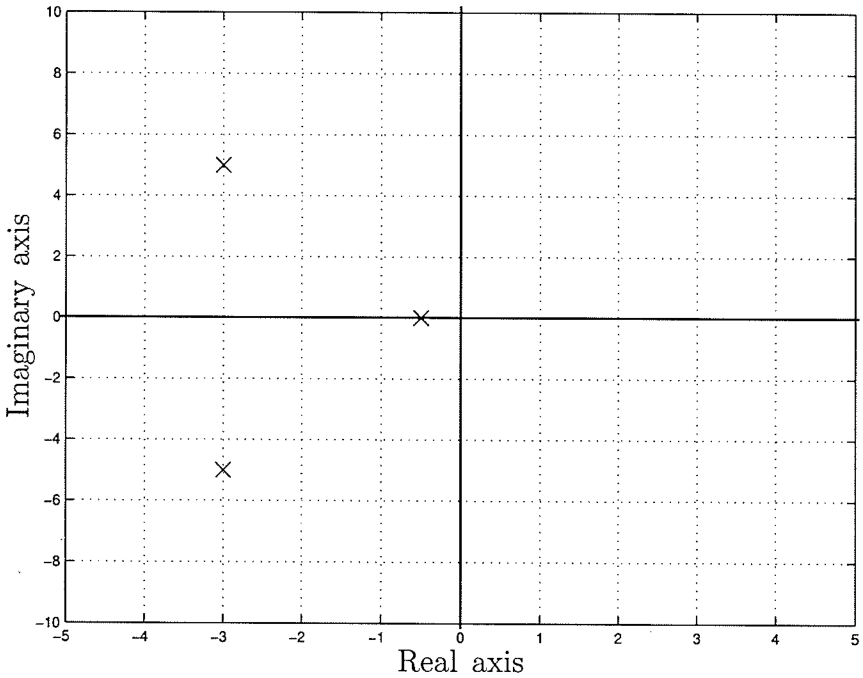

Figure 5.2: Root locus plot

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