

Lab Documentation

in course

Autonomous Systems:   
Path Planning   
and   
Control

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# Vehicle Dynamics Simulation

## Low-Speed Controller: Signal-Time diagram of step response of vehicle speed 𝑣

## High-Speed Controller: Signal-Time diagram of step response of vehicle speed 𝑣

The figures in a) and b) result from giving a step signal into the vehicle dynamics system with a step time of one second. For the speed v the motor step signal *pedals* is set to 0.05 to trigger the Low-Speed Controller. For triggering the High-Speed Controller, *pedals* is set to 0.1. In the figure the switch from Low to High-Speed Controller is visible after approx. 1.6 seconds which leads to a very short sharp, jagged fluctuation. This arises because of the different equations used in the controller and therefore a sudden discontinuous change of *caroutputsext.*

## Signal-Time diagram of step response of yaw angle 𝜓

Giving a step signal of 0.7 in the steering angle *steering* results in the rising yaw angle 𝜓 which leads to the car driving in a sharp circular path (first diagram). In the second diagram the step signal is set to 0.2 which leads to a flatter rising curve and to a wider circular path

# Speed Control

## Mathematical expressions and values for values of 𝑇𝑖 and 𝑘𝑟

**𝑇𝑖:**

Open Loop Frequency Response:

General Open Loop Phase Response:

Phase Margin:

Solve with MatLab fzero() for 𝑇𝑖 with and

**𝑘𝑟:**

General Open Loop Magnitude Response:

with Magnitude Response at Crossover Frequency :

and therefore solved for :

## Bode diagram of including margins

Phase Margin: 62.56°  
Gain Margin: 4.76  
Phase Crossover Frequency: 3.56 rad/s

## Signal-Time diagram of step response

## Transfer function 𝐺𝑅∗(𝑧) of discrete-time PI controller

## Differences equations to compute I part 𝑢𝑖𝑘 = 𝑢𝑖(𝑘𝑇𝐴) and total manipulation signal 𝑢𝑘 =𝑢(𝑘𝑇𝐴) from control deviation 𝑒𝑘 = 𝑤𝑘 – 𝑦𝑘

Ich hab das nicht: Das hast du auf deinem Block gemacht Heiko. Glaub ich zumindest.

# Longitudinal Position Control

## Mathematical expressions for 𝑌𝑝(𝑠), 𝐸𝑝(𝑠), 𝑒𝑦, 𝑘𝑝

[dB] stimmt das? Siehe S. 55 lab exercises

## Signal-time-diagram of response 𝑦𝑝(𝑡) to 𝑤𝑝(𝑡) = 𝑣∗𝑡ℎ(𝑡)

## Root locus curves of control loop in dependence of 𝑘𝑝

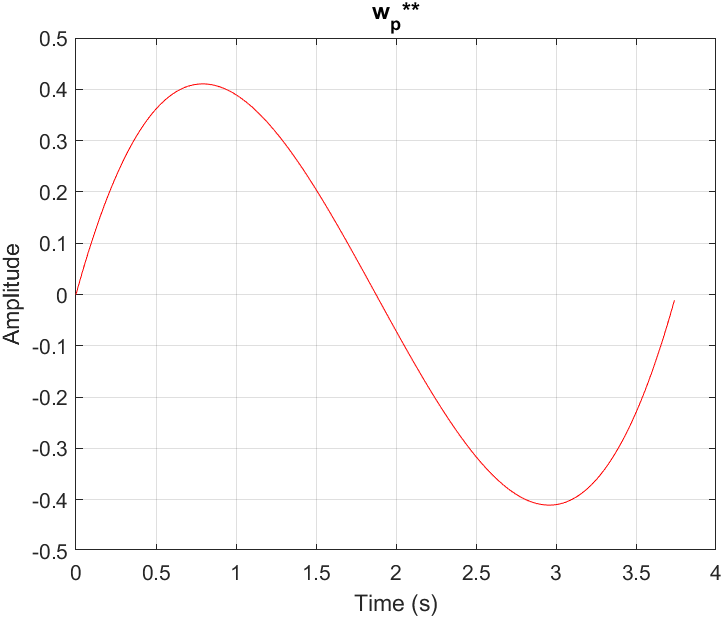
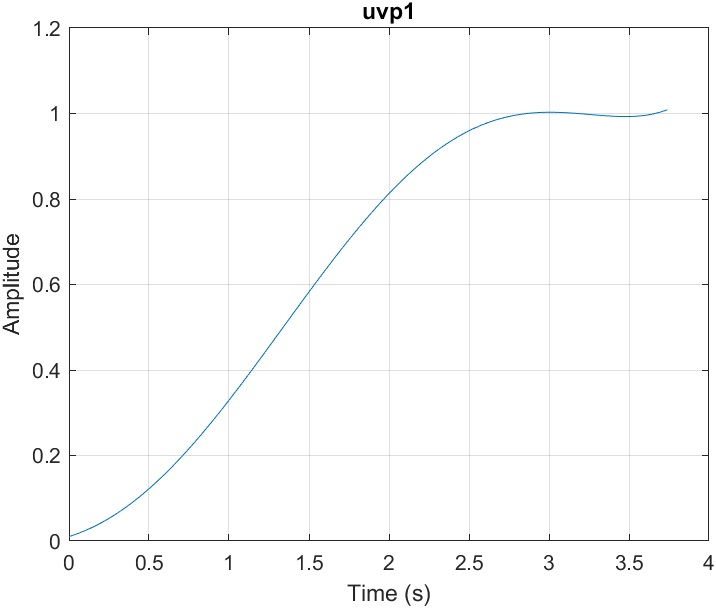
The first figure shows the root locus curve of the closed control loop as a function of kp=1. In this case, all poles are negative, indicating a stable control loop. In the second case, kp is set to 7.5, which makes the poles almost positive, and thus the control loop would be unstable.

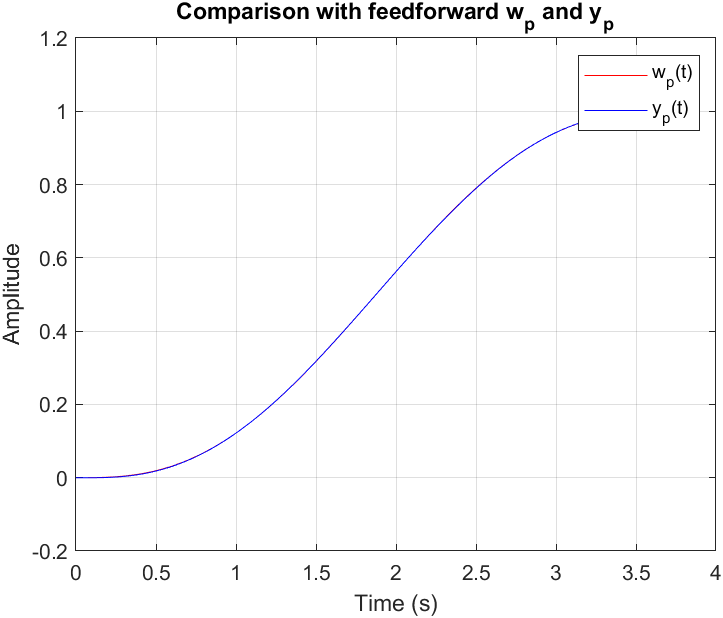
## MATLAB functions cd\_refpoly\_vmax and cd\_refpoly\_ff

The functions can be found in the corresponding files:

* cd\_refpoly\_vmax.m
* cd\_refpoly\_ff.m

## Signal-time-diagrams of 𝑤𝑝(𝑡), 𝑦𝑝(𝑡), 𝑤̇ 𝑝(𝑡), 𝑤̈ 𝑝(𝑡) and 𝑢𝑉𝑝1(𝑡)





From the different diagrams the computed polynomials and their derivatives. Applying the high-pass filter of the feed-forward controller leads to almost non-existing offset between and .

## Discrete-time transfer function of high-pass filter of feed-forward controller

## Differences equation of manipulation signal in dependence of

Hab ich nicht, du?

## Extended MATLAB script ex6\_1.m containing the solutions of the individual exercise and test the programmed MATLAB functions

File ex7\_1.m in *HS\_Path\_Planning\_and\_Control/*

Wir haben nur die Lösungen geplottet, keine Test für die programmierten Funktionen gemacht …

## Signal-time-diagrams of reference position 𝑤𝑝(𝑡) and actual position 𝑦𝑝(𝑡) = 𝑥(𝑡) from MiL and real drive tests

Ich glaube nicht dass das stimmt 🡪 sollten fast aufeinander sein…

# Extended Exercises - 20.4 Reference Path Following in Emergency Halts