Controller Design by SIMPACK/SIMAT/MATLAB: Disturbance Compensation by a Steer-by-Wire System in a MAN Truck

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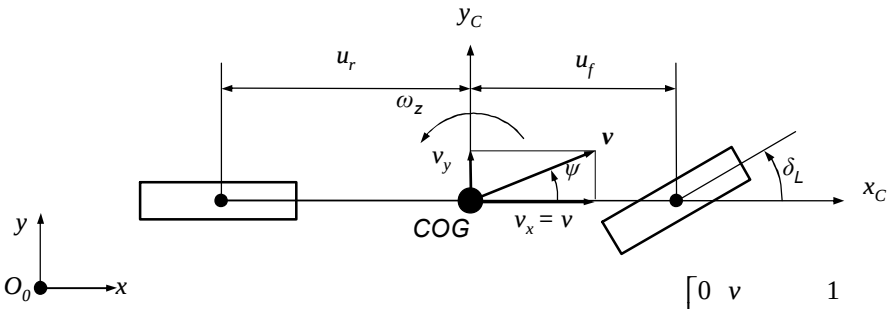
Contents

Model 2DOF



$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{B}u + \mathbf{G}\mathbf{w}$$

$$\mathbf{y} = \mathbf{C}^{\mathrm{T}}\mathbf{x} + \mathbf{D}u$$

- Implementation in Matlab/Simulink with 2 DOF
- Positions: y, ψ
- Velocities: v_y, ω_z
- Linear tyre model
- Disturbance: F_y, M_z
- Parameter v_x

$$\mathbf{A} = \begin{bmatrix} 0 & v & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & \dfrac{-c_{tf} - c_{tr}}{vm} & \dfrac{-c_{tf}u_f + c_{tr}u_r}{vm} - v \\ 0 & 0 & \dfrac{-c_{tf}u_f + c_{tr}u_r}{vI_z} & \dfrac{-c_{tf}u_f^2 - c_{tr}u_r^2}{vI_z} \end{bmatrix}$$

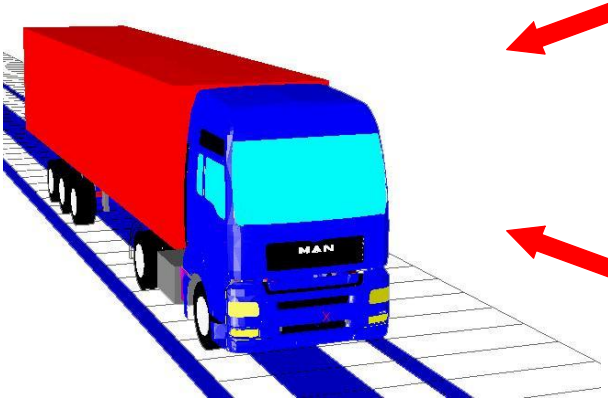
$$\mathbf{B} = \begin{bmatrix} 0 \\ 0 \\ \dfrac{c_{tf}}{m} \\ \dfrac{u_f c_{tf}}{I_z} \end{bmatrix} \qquad \mathbf{G} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ \dfrac{1}{m} & 0 \\ 0 & \dfrac{1}{I_z} \end{bmatrix} \qquad \mathbf{w} = \begin{bmatrix} F_y \\ M_z \end{bmatrix}$$

SIMPACK Model

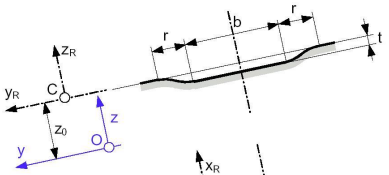
- MBS Model
- 155 degrees of freedom
- MAN TGA 460 tractor
- Gross vehicle weight 12t

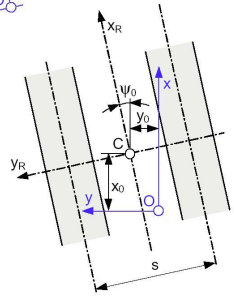
Road Models

Automotive+ Model in SIMPACK

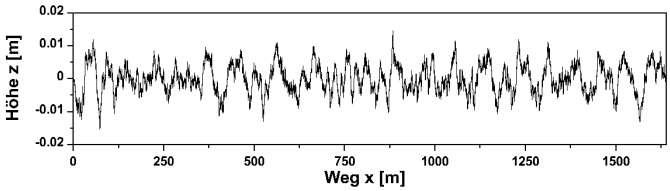


Track groove





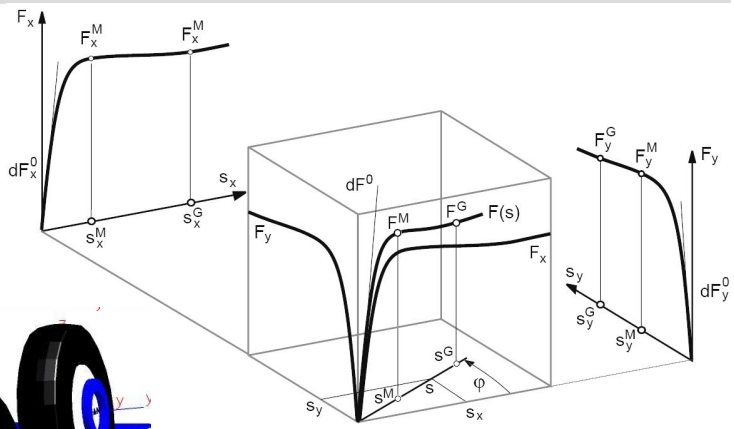
Uneveness

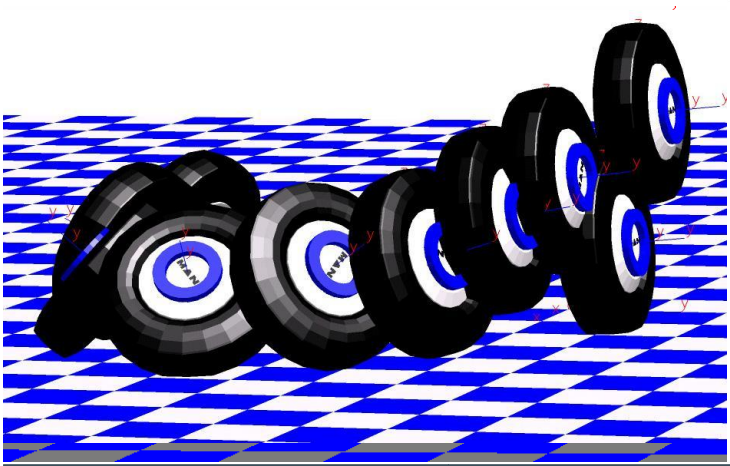


Tyre Model TMeasy

§ Vehicle Dynamics

§ Connection of Vehicle- and Road model

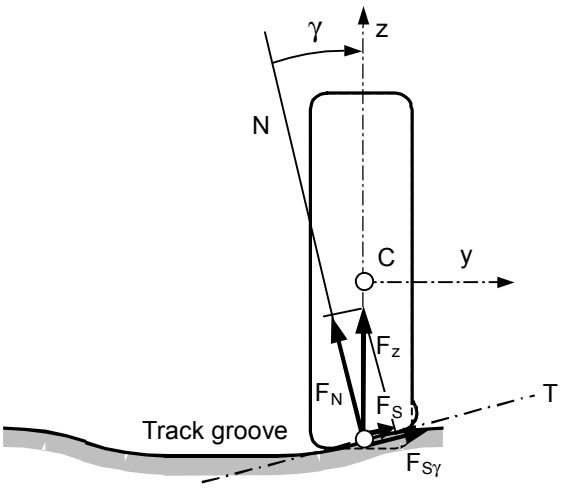


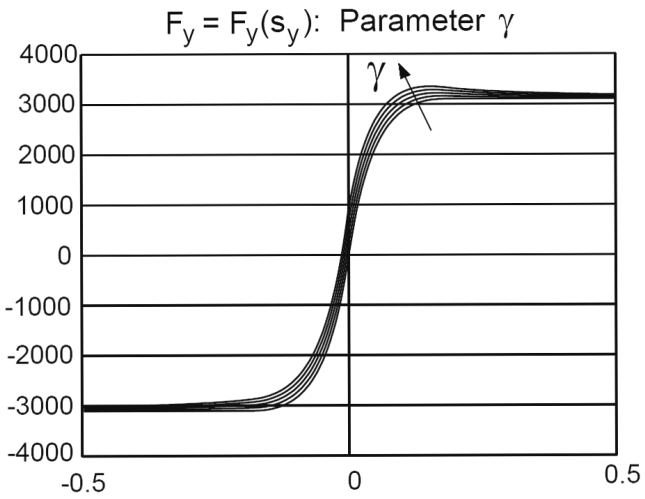


TMeasy

Track grooves

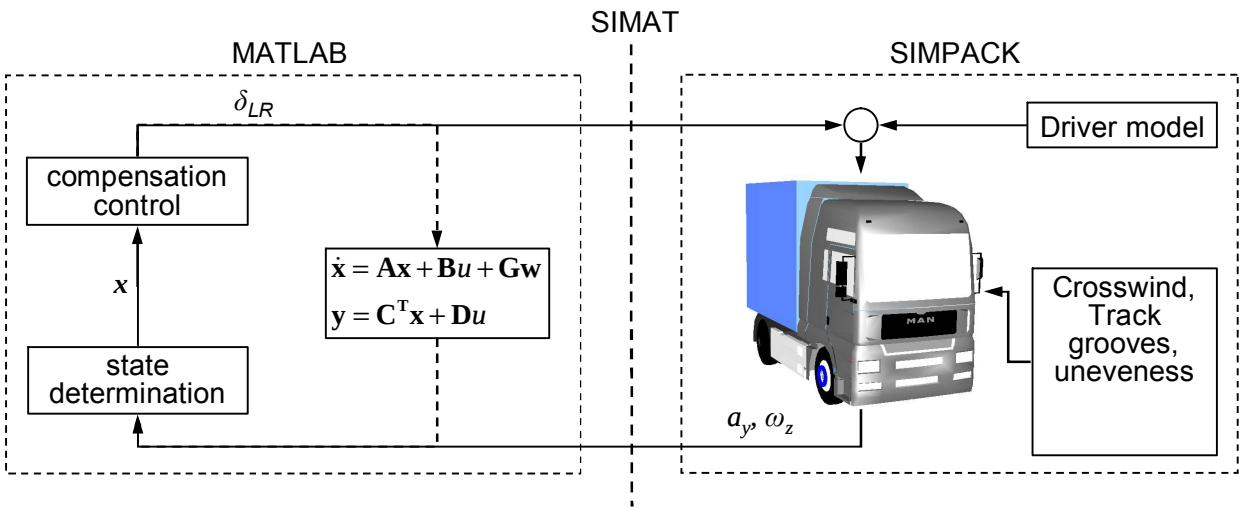
- Lateral force vs. camber
- Tyre is drawn out
- Depth up to 18mm
- High steering effort



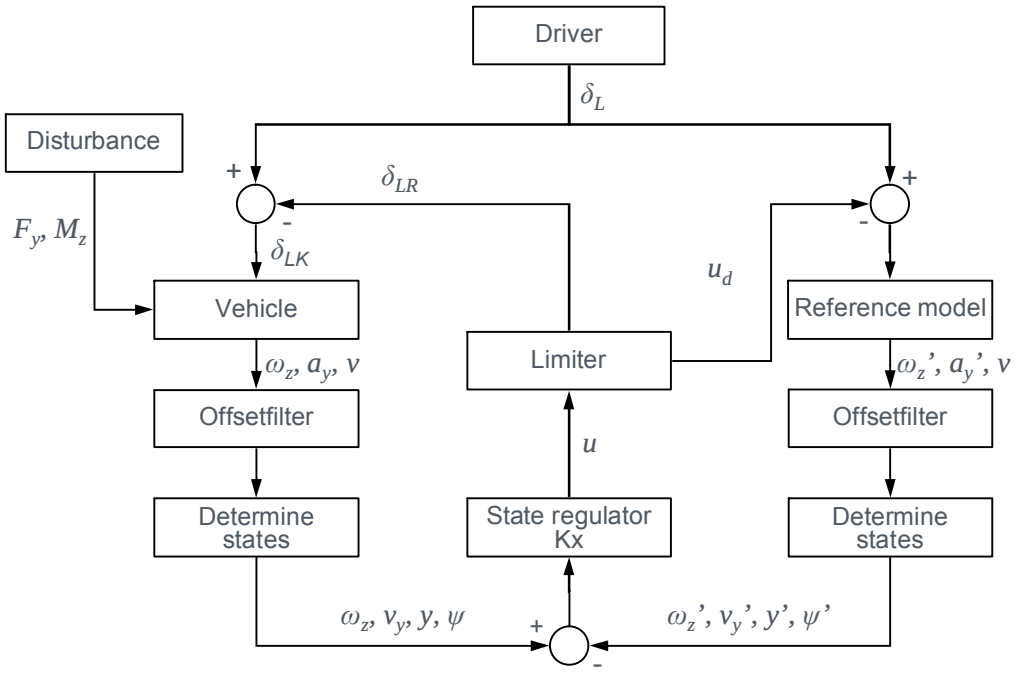


Simulation environment

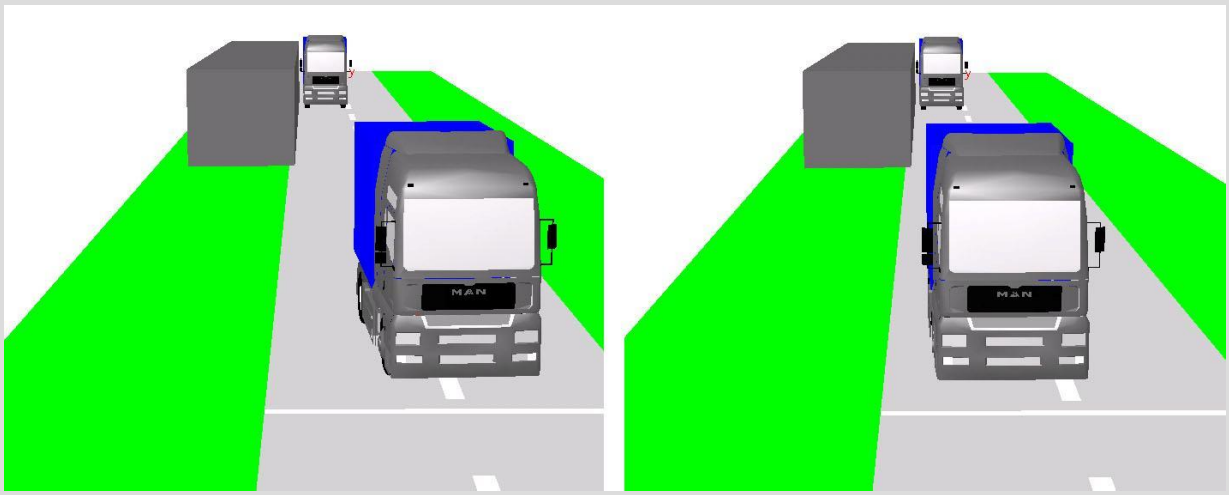
- MATLAB: 2DOF model and controller
- SIMAT: interface
- SIMPACK: Simulation 155DOF model
- State exchange at discrete time-steps



Disturbance compensation



Simulation Crosswind

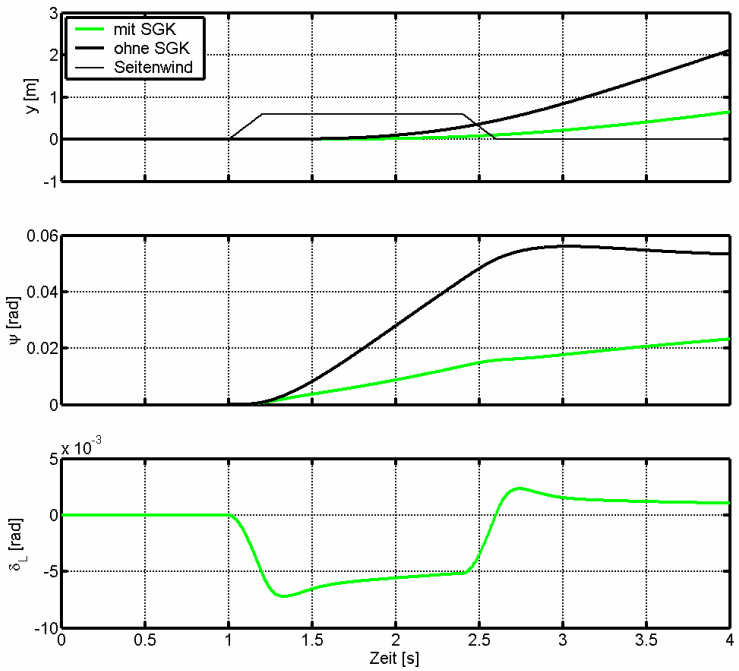


Without Compensation

Compensation active

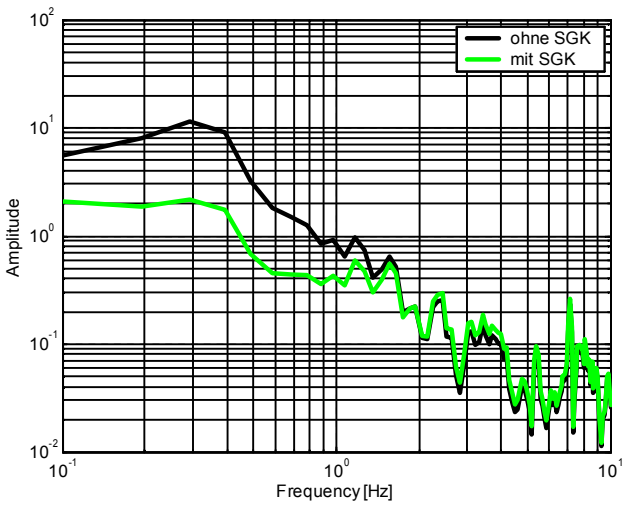
Simulation Crosswind

- Crosswind 1.5sec, 80km/h
- Explicit reduction of the deviation
- Used steering angle: 0.4°

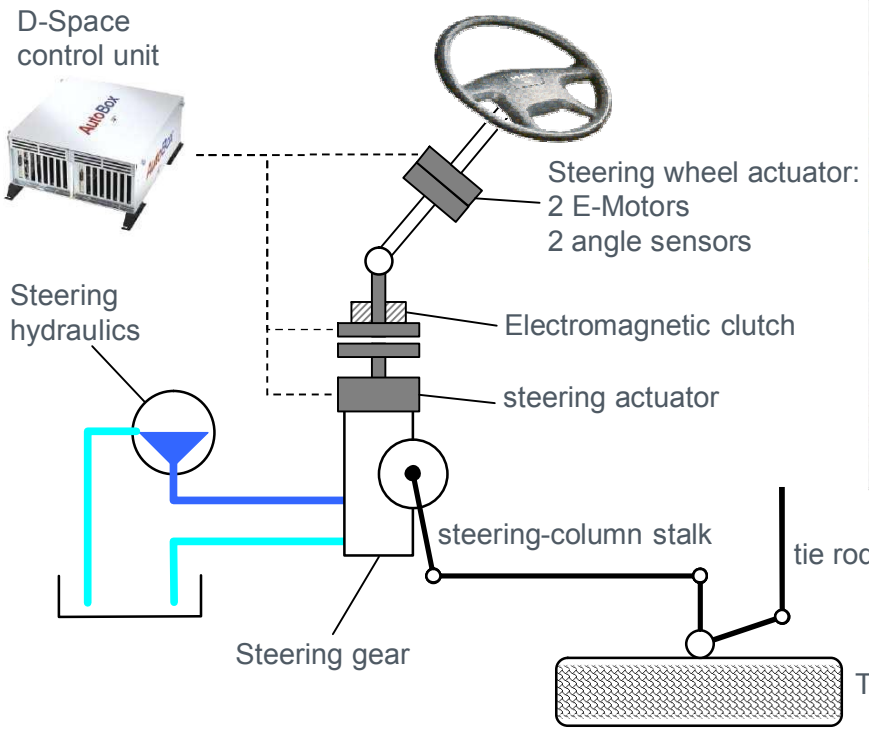


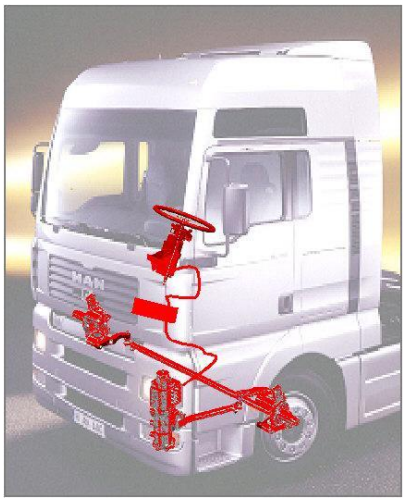
Simulation track grooves

- Simulation:
  MBS model with 155 degrees of freedom
- Yaw rate:
  evaluation in the frequency domain
- Clear disturbance reduction
- Compensation limit at 1.5Hz



ZF Steer by Wire - Implementation





Test: Crosswind

- Straight track
- Clear compensation of the crosswind

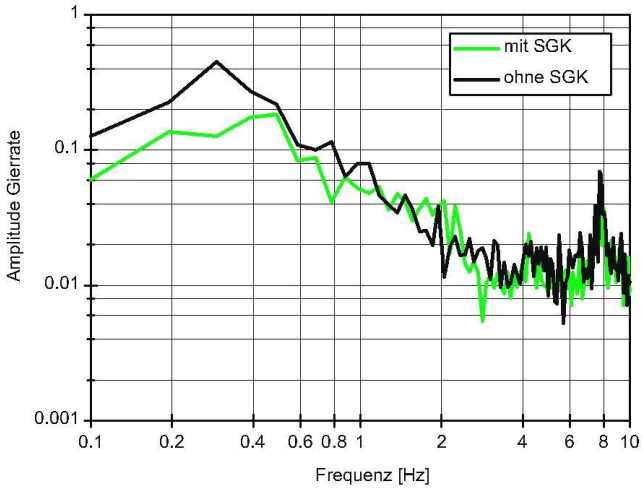
Without Compensation

Compensation active

Testing track grooves

§ Evaluation of Yaw rate
§ Drivers comment

§ Good correlation to Simulation results



Summary

§ Good results in simulation und testing

§ Simulation –minimize danger

§ Increasing comfort und safety

§ Investigation of further disturbances

§ Test course: BMW Aschheim