Vertical Dynamic Test Rig for Integration in a Realtime Vehicle Simulation Model

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Short Overview.

University of applied sciences Landshut

- Near Munich Metropolitan Region
- Foundation in 1978
- Total: 5480 Students in WS15/16

- Faculties:
  - Business Administration
  - Computer Science
  - Electrical and industrial engineering
  - Mechanical Engineering
  - Interdisciplinary studies

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Why vertical dynamics will have a revival.

- The increasing automatisation of driving gives all the passengers the possibility to relax or work in the car

- Sensibility concerning primary and secondary ride comfort will increase

→ Vertical dynamics will even get more important

→ Thesis:

„For best benefit of fully autonomous driving controlled vertical dynamic systems will be necessary“
Overview of controlled vertical dynamic systems.

Functional Aspects

- Hight Control
- Body Movement
- Dynamic Tire Load

Comfort / Driving Safety / Energy Consumption

Comfort

Driving Safety
Overview of controlled vertical dynamic systems.

Functional Aspects
Systems

- **Hight Control Levelling Systems**
  - Comfort / Driving Safety / Energy Consumption

- **Body Movement Variable Damper, Full Active Systems**
  - Comfort

- **Dynamic Tire Load Variable Damper, Full Active Systems**
  - Driving Safety
Why is a HIL test bench for vertical dynamics needed?

Quarter car model

- **Body mass**
- **Unsprung mass**
- **Coil spring**
- **Stiffness of the top mount**
- **(Variable) damper or actuator**
- **Stiffness of the tire**
- **Damping of the tire**
- **P_{dyn}**
- **Z_r**
- **Z_a**
- **Z_b**

**Control strategy:**
Double skyhook damping

\[ F_{act} = k_{sky,b} \cdot \dot{z}_b - k_{sky,a} \cdot \dot{z}_a \]

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Why is a HIL test bench for vertical dynamics needed?

- Damper, spring and top mount have a significant influence on comfort.
- Accurate Modeling of these components is quite difficult.
- In durability tests with realtime road profiles the component behavior has a massive effect (‘feedback’).

→ Solution:
   Combination of realtime simulation model with vertical dynamic test rig.
HIL Test Rig: Concept.

RoadBox 4U ACDC
- F19P Core 2, Duo Single Board Computer
- M36N-01 - Analog Inputs
- M62N - Analog Outputs

Vertical Dynamic Test Rig
- Machine Frame Schenk PC400N
- Inova EU3000-RTC
- Hydropulse Cylinder 50 kN
- Cylinder Travel 250 mm
HIL Test Rig: Concept – Variants of test samples.

- Damper with rebound spring
- Damper with rebound, bound spring, spring coil or air spring including top mount
- Depending on concept: Airspring Stand Alone
Hydropulse Test Rig: Component Testing.

Component Testing

Soft Damper Characteristic

Middle Damper Characteristic

Hard Damper Characteristic

„VDA-Testing“
Hydropulse Test Rig: Component Testing.

- VDA Test
- Dynamic behavior

→ Validated Simulation Model (Matlab Simulink) for integration in CarMaker
Realtime Vehicle Simulation Model: Test Equipment.

Test car: BMW 730d

Additional sensors: Acceleration sensors, height sensors and sensor cluster in the center of gravity

Measurement System: dSpace micro autobox

Realtime Vehicle Simulation Model: Validation (1).

Measurement with real car

Comparision of relevant values

→ Good correlation.

Simulation with CarMaker
Realtime Vehicle Simulation Model: Validation (2).

Realtime Vehicle Simulation Model: Validation (3).

Realtime Vehicle Simulation Model: Validation (4).

Realtime Vehicle Simulation Model: Validation (5).

HIL Test Rig: Beam, single sided (right).
HIL Test Rig: Beam, single sided (right).
Vertical Dynamic Test Rig for Integration in a Realtime Vehicle Simulation Model.

Conclusion.

- (Advanced) Vertical Dynamics will get a revival.
- Realised Concept of a vertical dynamics test rig, suitable for HIL application and component measurement.
- Good accuracy of the HIL vehicle model and measurements with the real car concerning vertical dynamic (damper with fixed damping curve, obstacle beam).
- HIL can be used for functional development and endurance strength.