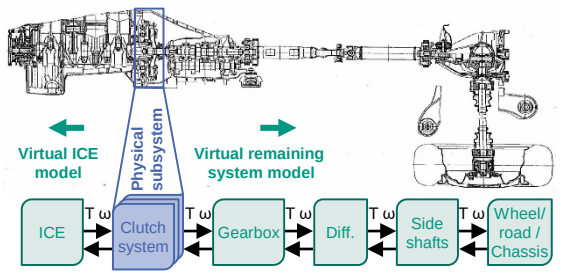
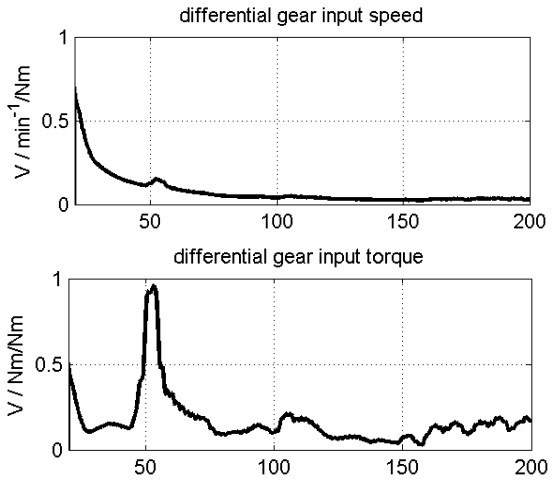
Detailed Application Example

Analyze of the dynamic powertrain behavior

- Integration of physical clutch systems in a real-time environment:
  - Virtual Internal Combustion Engine model on primary side
  - Virtual remaining powertrain model on secondary side (gearbox, …)
- Determining dynamic validity limits of current and new types of damper systems





Result of one application example
Amplitude response by 1000 rpm, 300 Nm, 1. gear

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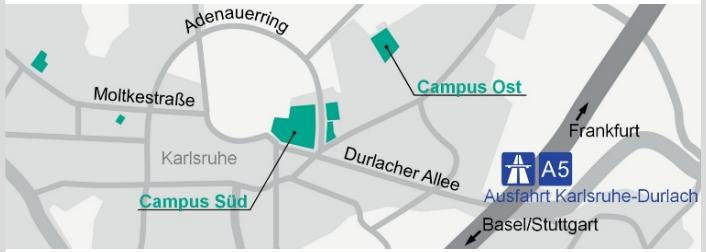

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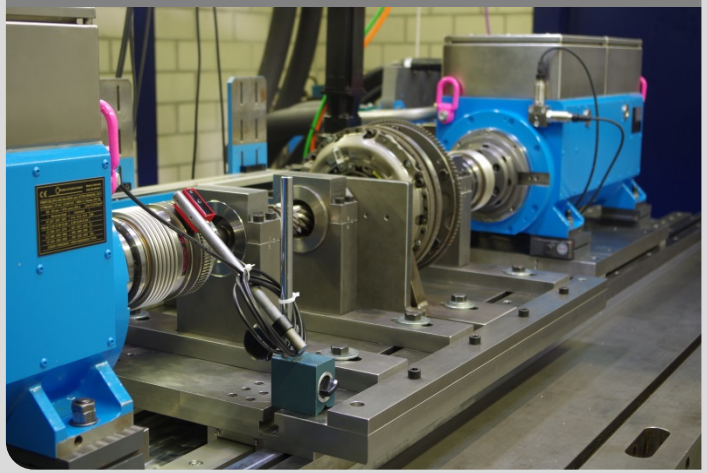
PPP

Power Pack Test Bench

IPEK ▪ Institute of Product Engineering



Technical specifications

High Dynamic Motors (2x)

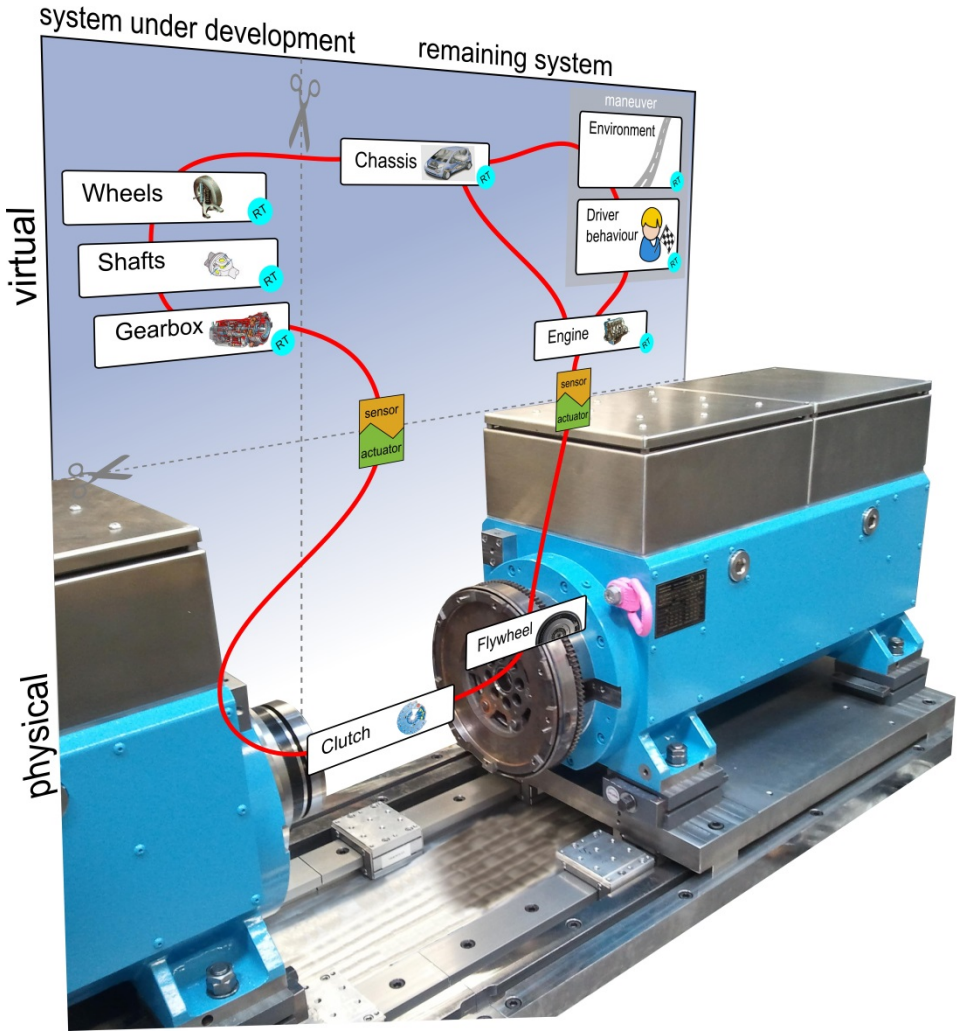
- Power: ea. 209 kW
- max. speed: 9000 rpm
- max. torque: 500 Nm
- torque excitation up to 500 Hz
- Rotor inertia: 0.037 kgm²

EtherCAT® Fieldbus

- Real-time Ethernet
- Cycle time: 1/4000 s
- Flexible EtherCAT® topology
- Wide range of I/O components
- EtherLab® Master

Real-Time Enviroment

- Jäger ADwin-Pro II:
  Powertrain simulation,
  digital signal processing
  up to 20 kHz
- Test bench control using flexible MATLAB®/Simulink®-Models
- Automatic mode, e.g. endurance run
- Analog und digital I/O interfaces
- FPGA programming



XiL-Approach with transition between virtual and physical subsystems

Flexible Rail System

- Short setup-time and exact positioning of the both motors
- Large number of possible test bench setups (back-to-back, e.g. in line)

Investigation examples

Clutch-in-the-Loop

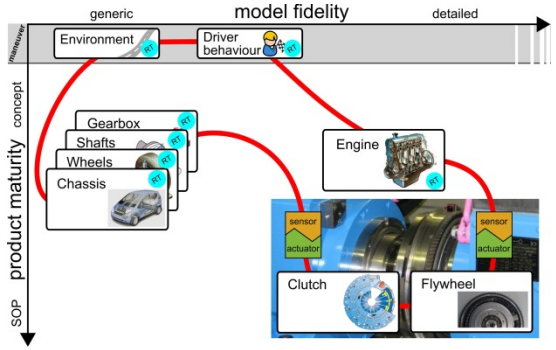
Investigation of clutch systems under similar operation conditions using electrical modelling of internal combustion engine excitation

Gearbox-in-the-Loop

Analyzing and application of the main powertrain dynamic behavior using both virtual (e.g. gear box) and physical subsystems (e.g. clutch system and flywheel) to determine judder and shuffle sensitivity (see left figure)

DMF-in-the-Loop

Investigation of powertrain components, e.g. flywheels, damper systems and clutch systems using virtual combustion engine models (see figure below) and electrical excitation motors.



Validation approach to combine different product maturities and accuracies of the subsystems using the Power Pack Test Bench