Automotive Engineering
Topics

- X-in-the-loop test and simulation techniques
- Assistance systems for optimized driving safety and energy efficiency
- longitudinal and transverse dynamics control for autonomous vehicles
- Integrated active suspension systems for multi-actuated and electric drive vehicles
- Reserarch and test center for non-exhaust-emissions

Contact:

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MASTER: Four-Roller Power Dynamometer

Modern vehicles are equipped with an increasing number of technical functions in order to enhance safety, comfort and performance. Despite the increasing complexity, manufacturers expect short development cycles with a constant price-performance ratio. Therefor the four-wheel power dynamometer was integrated as a MASTER node in a real-time test and development environment, which allows to test products from different development stages. This leads a faster and more effective development of automobiles.

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MASTER: Four-Roller Power Dynamometer

Technical Properties

- Test chamber (LxBxH)   12x7, 5x4,5 m
- Air conditioning   -20 bis 45 °C
- Max. power   4x230 kW
- Roller diameter   front 48", rear 75"
- Wheel and axle load operation possible

Corner Module

- Examination of longitudinal-, transverse- and vertical-dynamic tire characteristics
- Analysis of electric drives up to 250 kW
- Experimental analysis of spring, damper and suspension characteristics
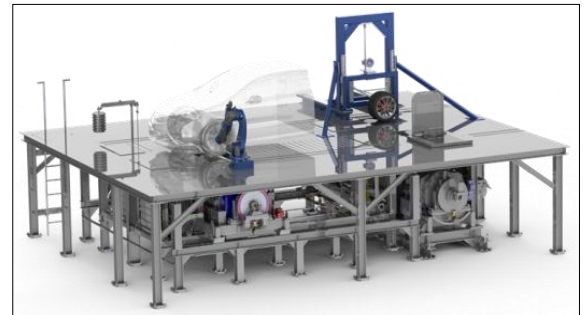

Environmental Analysis of Emissions

- Environmental analysis of exhaust and non exhaust particle emissions
- Automated measuring head positioning using an industrial robot
- Efficiency optimization / friction reduction on the subsystem level for reduced CO_2 emissions

Vehicle Properties

- Speed   up to 250 km / h
- Spreading width   0.8 to 2.3 m
- Wheelbase   2.1 to 4.4 m
- Max. Wheel load   1.25 t

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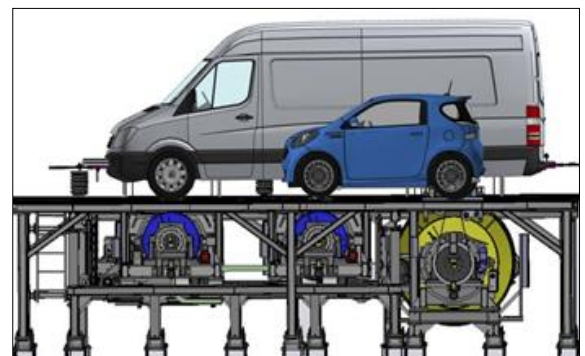
Testing Center for Suspension and Brake Systems

Testing center used for interdisciplinary research tasks with regard to driving safety, driving comfort and environmental protection.

- Simulation of heavy vehicles (transporters)
- High performance testing and comfort analysis (NVH)
- Investigations on braking systems, chassis components and complete axles

Specifications:

- Revs: n_{max} = 2500 min-1
- Speed: v_{max} = 310 km/h
- Momentum: M_{max} = 2300 Nm (up to 1100 min-1)
- Inertia: I_{max} = 191 kgm^2
- Air conditioning: Q_{max} = 4200 m^3/h
  -20 to +50 ℃; 15-85% air moisture

## Experimental Platform for Real-Time Coupling

Model Roller Dynamometer

- Demonstrator for real-time coupling of roller test stands and simulation platforms
- Scaled illustration of test scenarios for drive and suspension technology
- Real-time coupling enables a reproducible, true-to-life test
- Investigation of complex physical phenomena

Model Brake Dynamometer

- Demonstrator for real-time coupling of brake test stands and simulation platforms
- Scaled illustration of test scenarios for brake technology
- Real-time coupling enables a reproducible, true-to-life test
- Consideration of complex tribological properties

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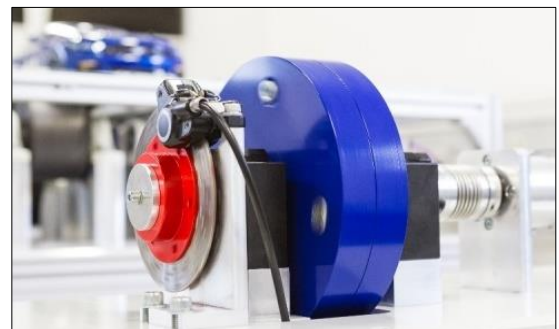
Friction Test System for Shock Absorbers

Galdabini Quasar 5

Machine for tensile and compression tests for the material characterization of elastomers, which has been specially developed for friction measurements in automotive shock absorbers.

Specifications:

- Standard measuring equipment: force sensor + extensometer

- Additional force, pressure and differential pressure sensors Additional attachments for introducing lateral forces into the damper

Quelle: Galdabini

Hardware-in-the-Loop Test Stand

Test stand for the investigation of algorithms developed for anti blocking systems (ABS), electronic stability programs (ESP) and other driving safety systems.

- Hardware: Main brake cylinder, four Wheel brakes, hydraulic control

- Hydraulic control unit (HCU) follows control strategies implemented in MATLAB / Simulink using a dSpace interface

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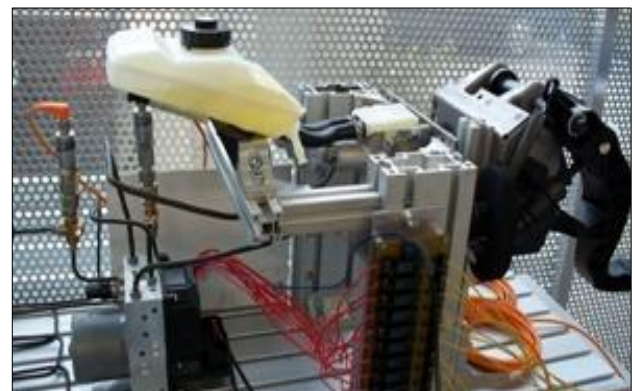
Dynamic driving simulator

Simulator mock-up

Mock-up for the investigation of user acceptance of different assistance systems and human-technology interactions (MTI or HMI).

Set-up:

- Environmental visualization via 98" 4K screen
- active steering wheel (*Sensodrive*)
- Pedals (throttle, brake) / active pedals are planned

Function:

- Realization of a detailed vehicle simulation with different software tools (IPG CarMaker / PreScan / AMESim)
- CAN communication enables direct influence on steering wheel characteristics in the form of stiffness, damping and friction
- Hardware communication (dSpace / National Instruments): real-time transmission of steering angle and torque to the simulation environment
- feedback active adjustment of the steering wheel

Hexapod motion system

Extension of the simulator mock-up by an electrical hexapod motion system for realistic vehicle dynamics simulation dynamic feedback.

Field of research:

- Development of novel vehicle dynamics control and driver assistance systems
- Acceptance studies of new driving systems
- Complex and realistic mixed traffic simulations
- Cooperative driving with "human-in-the-loop"

Specification, motion system:

direction	amplitude		speed	acceleration
longitudinal	-0,499 m	+0,628 m	+/- 0,79 m/s	+/- 7,00 m/s²
lateral	-0,506 m	+0,506 m	+/- 0,81 m/s	+/- 7,00 m/s²
vertical	-0,383 m	+0,372 m	+/- 0,55 m/s	+/- 10,00 m/s²
roll	-24,01 deg	+24,01 deg	+/- 34,3 deg/s	+/- 250 deg/s²
pitch	-25,05 deg	+28,02 deg	+/- 37,4 deg/s	+/- 250 deg/s²
yaw	-27,25 deg	+27,25 deg	+/- 41,3 deg/s	+/- 500 deg/s²

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Vibration Testing System

TIRA TV 50350-120

Examination of component vibrations and durability

Specifications:

- Rated Power: Sine: 2700 N; Shock: 4000 N
- Swing path max. 25.4 mm
- Sample weight up to 25 kg

Climate Test Chamber

FEUTRON 3636/17

Climatic examination of components

Specifications:

- Chamber volume 600l
- (770x1020x745) mm
- Sample weight 3x30 kg
- Temperature range (-75 ... 180) ℃
- Humidity range (10 ... 95)%
- Change speed ± 5K

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Steering System Test Bed

Research
- Static and dynamic load scenarios for power steering an actuation systems
- Power and efficiency measurements

Technical Features
- Electro-mechanical actuators with max. 17,8 kN
- 300 mm of way at up to 267 mm/s
- Constructive realization of steering kinematic
- Max. incidence angle: ca. 30 deg
- Track widths and track lever lengths covering all classes of vehicles (small cars up to SUV)
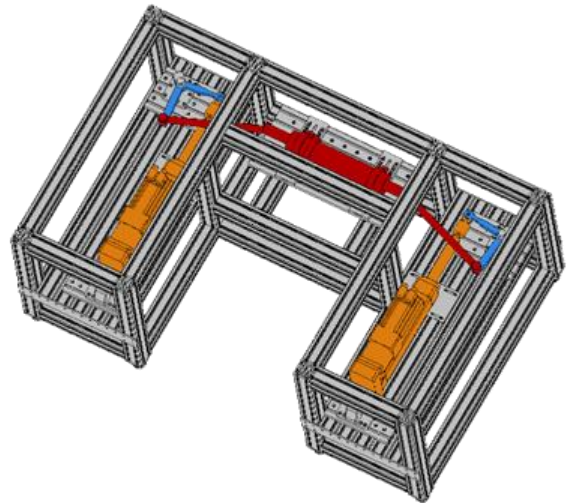
Windtunnel Test Bed

Research
- Validation of turbulence-, and particle models (CFD)
- Visualisation and measurement of particle dispersion (non exhaust emissions)
- Analysis of particle deposition mechanisms

Specification
- Max. volume flow: 7400 m3/h equalas 5 m/s inside the plenum
- Eclectic Engine: Pmax 135 kW / Mmax 1740 Nm / nmax 2600 1/min
- Solid and fluid seeding

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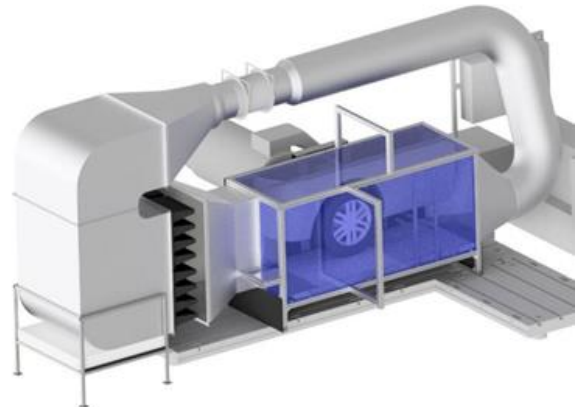
Particle Image Velocimetry (PIV)

2D/3D – Flow visualization for various vehicle technical applications

|	
Laser:	Double pulsed laser Nd:YAG200 mJ/Puls at 532 nm, 15 Hz
Camera:	2x 2048x2048 Pixel, 4 GB,14 Bit, 15.56 fps, 400 ns Interframing-time
Optic:	Movable mirror arm, divergent laser 35/50/85mm AF objectives
Equipment:	Particle Generator, 1 μm
	2x Tilt Adapter
	X-Z traverse
Computer:	Synchronisation unit, Workstation
Software:	VidPIV + Tecplot 360
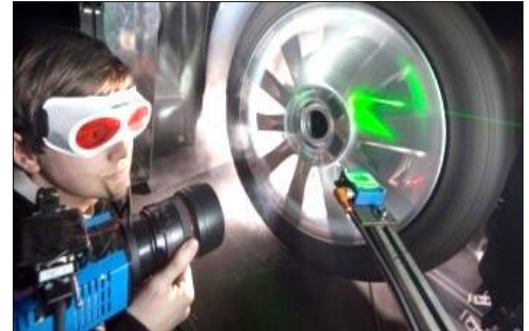
3D Laser Scanning Vibrometer

PSV 400 3D

Non-contact 3D vibration measurement technology, Applicable also at the customer site

Specifications:

Frequency range:	0 – 1 MHz
Data collection:	4 canals
Distance:	> 0,4 m
Object width:	≥ 1 mm^2
Velocity:	10 m/s (max.), 2,5 MHz (max.) 0,5 m/s (max.), 350 kHz (max.)
Signal generator	512 kHz (bandwidth) 0 – 10V, ± 5 mA
Measurement:	2x2 up to 512x512 measurement points
Resolution:	6400 FFT lines

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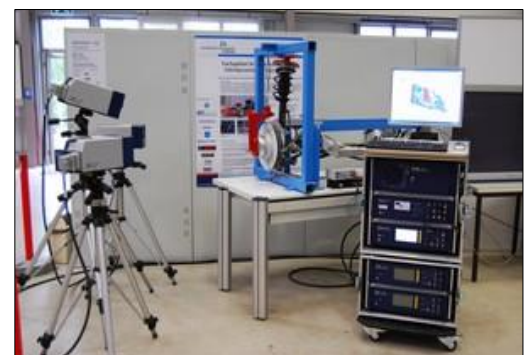
Real-Time Systems for Measurement and Control Tasks

PXI/Compact-PCI (Fa. National Instruments)

Autobox (Fa. dSpace):
- Prozessor-Board, DAQ-Board, HIL-Board
- 7 slots (AutoBox)
- Operation with 12V, 24V and 48V vehicle wiring

MicroLabBox (Pr. dSPACE):
- DS1202 Processor-Board
- A/D and D/A I/O Boards
- CAN Communication

Hardware-in-the-Loop Test Stand (Pr. dSPACE):
- DS1006 Processor-Board
- A/D und D/A I/O Boards
- CAN und FlexRay Communication
- Integrated control of Suspension systhems

Source: dSpace

Racelogic VB3i / Video VBOX Pro
- Detection of driving condition sizes, e.g. Speed, lateral and longitudinal acceleration as well as position in combination with a 4-channel camera system for driving documentation
- Additional equipment for highly dynamic vehicle data and vehicle dynamics measurement
- Measurement wheel - Correvit Datron

Specifications:
- 100 Hz DGPS
- 500 K Can-Bus-Anschluss
- Data logger
- 4xAI, 2xAO, 2xDI, 2xDO
- 4 cameras
- 2 Microphone
- Video-Overlay

Fahreranalyse

Quelle: Racelogic

Fahrzeuganalyse

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Bidirectional Telemetry System

System for bidirectional data transmission between the main station and a test vehicle, which is used for vehicle dynamics development and modeling (analysis of driving behavior).

- 3km range (omnidirectional)
- Sampling rate:
  48kSps (stand-alone mode)
  24kSps (modules coupled)
- Bandwidth per channel:
  20kHz (stand-alone mode)
  10kHz (modules coupled)
- 8x Analog, 4x Digital, 8x ICP, 4x Thermocouplex, 1x CAN

Vibration and Acoustics Measuring System

LMS SCADAS Mobile

- Mobile test hardware for noise, vibration and lifetime tests
- Compact size and light weight
- Robust design for extreme conditions and temperatures
- Very quiet, operation without fan
- Up to 204.8 kHz sampling rate per channel
- 24-bit ADC technology
- 150 dB dynamic range

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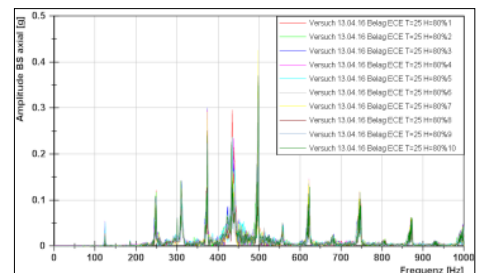
Fuel Consumption Measurement System

Gregory Flowtronic Sensor Series S8005

Accurate measurement of the fuel consumption of internal combustion engines with high accuracy

- Can be used on engines with petrol, diesel, alcohol and biofuels
- Accurate and highly dynamic measurement of minimum flow rates (idle) and high volume flows (full load)
- Can be used in mobile driving tests as well as on the test bench

Specifications:

- Measuring range: 0.1 to 250 l / h
- Measurement accuracy: +/- 0.5%
- Volume resolution: 0.004 ml

Source: Gregory

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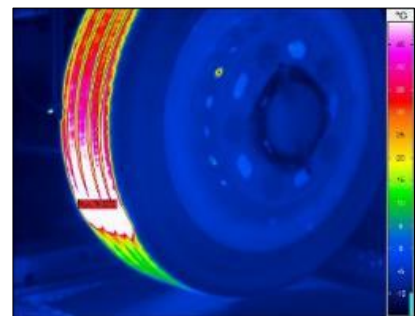**ILMENAU**

High- speed- Thermography

Thermography Camera InfraTec ImageIR 8300

Detector format: (640 x 512) Infrared-Pixel

Temperature resolution: 20 mK

Spectral range: MWIR, (2,0 … 5,7) μm

Frame rate: Full image: 355 Hz

                         Half image: 670 Hz

                         Quarter imager: 1.200 Hz

                         Split image-line-mode: 5.000 Hz
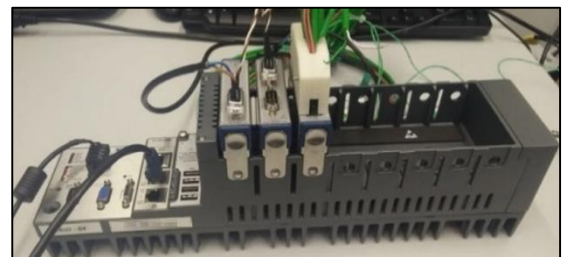
Measurement accuracy: +/- 1 K or +/- 1 %

Calibration: 10 up to 850 ° C

Source: InfraTec

Free-Sense HAT cRIO-9082

- Intel Core i7, 2GB RAM, 32 GB
- LabView Real-Time
- Maximum number of measuring cards: 8

Temperature Measuring Cards

NI 9213 high speed module:
- 16 channels
- Maximum sample rate 75 S/s
- Supports standard thermo-sensor types (J, K, S…)

NI 9214 precision module:
- 16 channels
- Measurement accuracy up to 0,45 °C
- Supports standard thermo-sensor types (J, K, S…)

Source: National Instrumensts

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Computer-Tomograph for Component Analysis (µm-Range)

Ray Scan 200

- 2D and 3D material and structure analyzes
- Microstructure analysis
- Defect analysis
- Measuring tasks

Specifications:

- X-ray source: Micro focus 10-250 kV
- Burning spot: 3-250µm
- Object dimensions Ø / H: 1-600 mm / 1-1500 mm
- Max. Object weight: 80 kg
- Active area detector: 410 x 410 mm^2
- Detector Pixels: 1024 x 1024 (2048 x 2048 optional)
- Digitization: 16 bit
- Measurement time incl. Reconstruction: 2 - 30 min.
- Detectability: 1µm
- Contrast: <1%
- Operating modes: 3D-CT and radioscopy
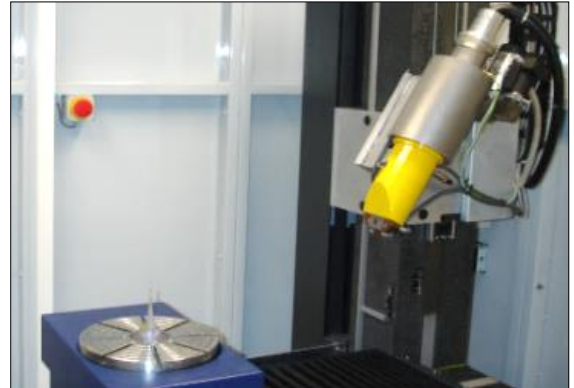
Scanning Electron Microscope with Element Analysis

JEOL JSM-6610 + EDX

Analysis of physically and chemically properties of components in nm-range

Specifications:

- Resolution of 3 nm at 30 kV
- Large sample chamber (350x340x230) mm with fully motorized sample table and a max. sample weight of 5kg
- Samples with a diameter of up to 208mm can be approached at any surface point
- Low-pressure operation with BSD allows high resolution
- Integrated element analysis (from boron to americium)
- 30 mm2 active detector area
- Gold / Carbon sputter system

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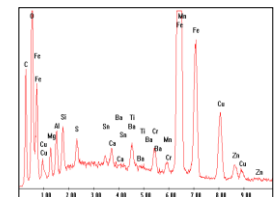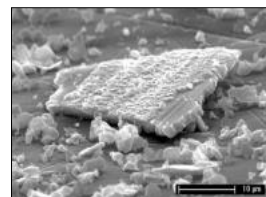
Laser Scanning Microscope

Keyence VK-X 3D-Laser Scanning Colour Microscope

Surface analysis of tribologically stressed surfaces, roughness and ripple determination, 3D analysis of seals or friction linings and particle size determination

Specifications:
- Red semiconductor laser with a wavelength of 658 nm
- More than 3 million measurement points in each level
- 16 bit PMT, color CCD image sensor (3072 x 2304)
- 5 nm high resolution
- 8x optical zoom (laser mode)
- Scanning speed up to 120Hz
- XY image composition module with software and travel table (motorized 100x100mm)
- Comprehensive evaluation and analysis software
- Large number of different lenses

Source: Keyence
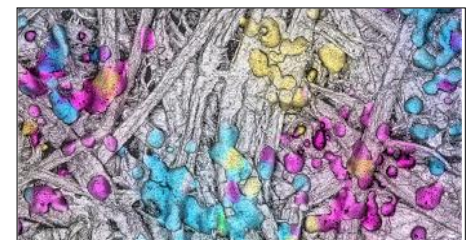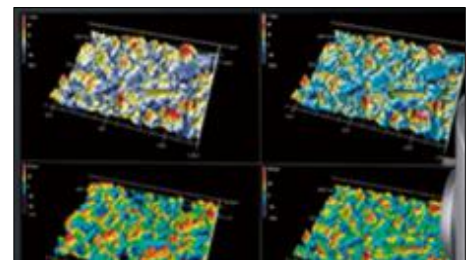
High Speed Digital Microscope
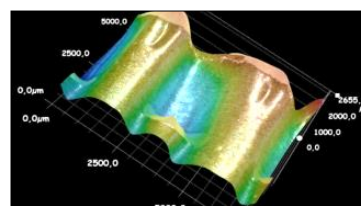
Keyence VW 9000
- Analysis of highly dynamic processes in the micrometer range
- 3D measurement of surfaces

Specifications:
- 4000 fps at 640x480 pixels
- Max. 230000 fps
- Microscope up to 1920x1440 pixels
- Magnification up to 200 times
- Macro zoom lens for long distance

Source: Keyence

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Measuring Arm with Probe and Laser Scanner

FARO Fusion + Laser Line Probe

- 3D measurement of components, interior and body
- 3D modeling and reverse engineering
- Positioning and calibrating in the room
- anthropometry

Construction: 2,4m / 7 axes
Accuracy tactile: 51μm
Accuracy optical: 35μm

3D Midrange Laser Scanner

FARO Focus 3D X 330

- Surveying and verification of industrial plants and installations
- Testing of large moldings and components
- Architecture and terrain surveying

Range: 0.6m - 330m
Systematic error: +/- 2mm
Special features: - Integrated GPS-receiver
                        - Scanning in direct sun light

Source: FARO

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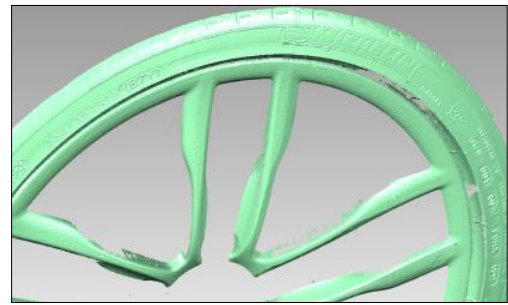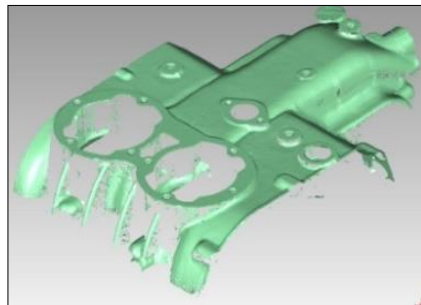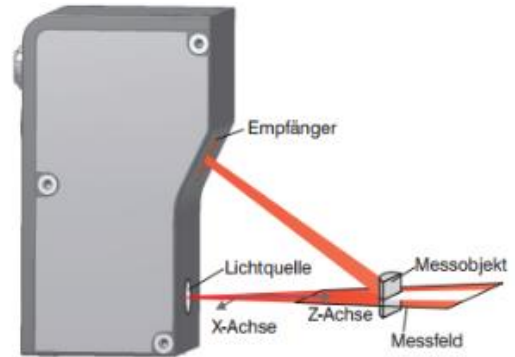
Laser Line Scanner for Geometry Detection

Micro Epsilon ScanControl 2750 – 100

- Max. Profile sampling rate (test surface depended): 4000 Hz
- Typical profile sampling rate: 500Hz
- Component vibrations can be detected
- Measuring distance: approx. 500 mm
- Profile width: approx. 100mm

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Wheel Alignment System

Beissbarth ML 8 R easy +Hydraulic Ramp Nussbaum UNI-Lift 3500 NT Plus

- Extensive database with setpoints of vehicles
- Measurement of individual wheel position variables
- Runout compensation
- Wheel sizes up to 24 "
- 4 measuring heads with 2 infrared cameras each
- Load capacity: max. = 4000 kg (wheel free lift 3500 kg)
- Wheelbase: max. = 4050 mm
- Width: max = 2120 mm

Robotic Handling Systems

Precision Positioning Robot

- Precision positioning robot
- Max. Payload: 34 kg
- Robotic weight: 248 Kg
- Brakes: in all axles
- Max. Speed in the center of gravity: 10.3 m/s
- Operating distance: 710 mm
- Degrees of freedom: 6
- Repeatability (typical): ± 0.01mm
- Repeatability (ISO 9283): ± 0.05mm
- Programming language robot control: VAL3
- Self-developed Labview interface

Source: Stäubli

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Actuation Robots

Pedal Actuator

- Reproducible pedal operations with high dynamics and precision
- Static and dynamic measurement of the pedaling properties and associated vehicle reactions

Principle: Servo-hydraulic

Limits: $F = 0...1500$ N
$v = 0...1000$ mm/s

Modes: Force controlled,
Length controlled,
Ramped actuation,
Oscillated actuation,
Measurement while driving possible

Data collection:

Pedal force, actuation path,
Hydraulic pressure,
BKV-pressure,
Vehicle velocity,
Vehicle deceleration

Steering Robot

Vehico CS-60B

- Performance of lateral test manoeuvers under reproducible conditions
- Highly automated driving

Technical Features
- Max. 60 Nm steering torque at 1200°/s angular speed
- Applicable steering wheel diameters from 250 mm to 440 mm
- Operation modes: open-loop (pure actuator), closed-loop (GPS)
- Conservation of manual steering and airbag function

Source: VEHICO GmbH

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Pressure Measuring Mat

Tekscan TVR8404

- Analysis of pressure distribution of car tires in wheel-to-ground contact

- 36.608 piezo-resistive sensors on a surface of 268 mm x 317 mm allow the recording of the surface pressure distribution in the tire

- Recording frequencies of up to 106 Hz allow the measurement of dynamic processes during rolling

- Extensive analysis software

Highly Dynamic Force and Vibration Measurement System

Kistler Vibration Measurement System

- Determination of the dynamic force at the vehicle chassis connecting points

- Recording of oscillating forces and moments with up to 16 sensors

Specifications:

- Range: $\pm100 \ldots 1\,000\,000$ pC
- Frequency range: $0 - 45$ kHz
- Drift: max. 0,2 pC/s
- Measurement uncertainty: <1%
- Measurement signal: 0-10V
- Storage of the measuring signals by direct reading of the measuring amplifiers (via Ethernet)

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Wheel Load Sensor

Kistler RoaDyn S635

- Highly dynamic detection of wheel forces and moments
- 6-component wheel force sensor allows the measurement of multi-axis loads
- Complete assembly of the measuring wheel on the vehicle (as replacement for the standard wheel)
- Mounting on the tire trailer for the analysis of the behavior of the tire / road contact
- Mounting at the corner-module test stand for the analysis of the behavior under laboratory conditions

Measurement Range:

Fx	–35 … 35 kN
Fy	–20 … 20 kN
Fz	–35 … 35 kN
Mx/y/z	–5 … 5 kNm

Emission Analysis Systems

HORIBA MEXA – 2100 SPCS and SMPS

- Solid Particle Counting System (CPC) + Scanning Mobility Particle Sizer (SMPS)
- Enlargement of the surface of the particles by heterogeneous condensation makes optical detection possible (the particles are passed through saturated alcohol / n-butanol)
- Counting by means of optical scattered light detection

Specifications:

- Particle count range: 10 - 2500nm (CPC - modified)
- Dilution Factors: 150: 1 - 3,000: 1 (two dilution steps)
- Size distribution by SMPS: 2.5 - 150nm and 10 - 1000nm over 167 channels

Source: HORIBA

Mobile Exhaust Measurement Systems

AVL M.O.V.E

- **GAS PEMS iS:** The AVL GAS PEMS iS is a compact, portable exhaust-gas analyzer developed for the determination of NO / NO2, CO / CO2 and O2 concentrations in the exhaust gas of diesel and gasoline engines

- **PN PEMS IS:** The PN PEMS iS has been developed for continuous measurement of particulate matter emissions [# / cm^3] of solids particles under real driving conditions (RDE)

Specifications:

- Sensor principle: Advanced Diffusion Charger
- Sample preparation: Catalytic Stripper
- Max. Sampling rate: 10Hz
- Dilution rate 10: 1

Source: AVL

Differential mobility analyser (DMA)

CAMBUSTION DMS500

Function:

- Particles are charged by an unipolar corona charger with relation to the particle surface
- In a classifying unit the electrically charged particles are exposed to a static electric field, witch leads to deflection in direction of 22 ring electrodes
- The trajectory (impact location on a ring electrode) depends on the electrical mobility of the particles, based of witch the aerodynamic diameter is estimated

Specifications:

- Range: 5 – 1.000nm (optional: 5 – 2.500nm)
- Max. sampling rate: 10Hz
- 38 size fractions

Source: CAMBUSTION

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Electrical Low Pressure cascade Impactor (ELPI)

DEKATI ELPI+

The ELPI + provides real-time measurement of particle size distribution and particle number concentration within a size range of 6 - 10,000 nm. In addition the measuring system is suitable for measuring the particle charge distribution and for gravimetric impact measurements.

Function:

• Particles are charged by unipolar corona charger

• Size-selective fractionation of the particles in a cascade impactor with 14 electrically isolated isolation stages (5 separation stages in the range of PM0.1)

• Collection of the particles with the possibility of a subsequent gravimetric, chemical-analytical or electron microscopic (e.g., SEM) analysis

• Electrical determination with electrometers

Specifications ELPI +:

• Measuring range: 6 - 10,000nm

• Max. Sampling rate: 10Hz

• 14 size fractions / impactor stages

Source: DEKATI

DEKATI Thermodenuder

Application for the removal of volatile and semi-volatile substances in aerosol streams, witch can eliminate unwanted transformation effects in the sample.

Specifications ELPI+:

• 10 – 20 l/min sample rate

• Heating up to 300 °C

Source: DEKATI

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Particle- Measurement station

EN 16450-certified fine dust aerosol spectrometer

- Suitability tested and certified according to the latest EU requirements
- Applicable for environmental monitoring, immission measurement campaigns and long-term studies
- Continuous and simultaneous real-time measurement of multiple PM values (PM1, PM2.5, PM4, PM10)
- Measurement of particle number concentration and size distribution

Specifications:

- Measuring range (size): 0.18 - 100 µm
- Measuring principle: Optical light scattering
- Measuring range: 0 - 20.000 #/cm³ (number) and 0 - 10.000 µg/m³ (mass)
- Time resolution: 1 s to 24 h

Source: Palas

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Condensation Particle Counter

Ultrafine Ultrafine Condensation Particle Counter (CPC) for the detection of a particle number concentration of highly dynamic processes

- Reference instrument without pre-separation, pre-dilution or thermal preconditioning
- Detection of single particles in a wide concentration range

Specifications:

- Measuring range (size): 2.5 nm (D50) - > 3 μm
- Measuring principle: Optical light scattering
- Measuring range (number): 0 - 300.000 #/cm³
- Response time: T10-90 up to < 2 s
- Sampling rate: up to 50 Hz

Souce: TSI

Palas PMP-CPC 100

This condensation particle counter (CPC) is suitable for PMP applications of the EU standard ILCE

- PMP-compliant measuring system for particle count measurement
- Detection of single particles in a wide concentration range

Specifications:

- Measuring range (size): 23 nm (D50) - 10 μm
- Measuring principle: Optical light scattering
- Particle number oncentration range: 0 - 1E+05 #/cm³ in single count mode and up to 1E07 #/cm³ in nephelometer mode
- Response time: T10-90 up to 2 s
- Sampling rate: 1 Hz

Source: Palas

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Dekati eFilter

The Dekati® eFilter™ combines a gravimetric filter holder with real-time particle measurement technology and provides an online signal on particle mass concentration

- Applicable for environmental monitoring and exhaust gas measurements in the automotive industry
- Combination of gravimetric particle measurement (U.S. EPA) and automated real-time measurement

Specifications:

- Max. particle diameter (real time): 3 µm
- Sensitivity: approx. 1 µg/m³ or 1000 #/cm³ for 70 nm particles
- Measuring principle: diffusion charger
- Sampling rate: up to 1 Hz

Source: Dekati

3-stage cascade impactor with ITES

3-stage cascade impactor according to ISO 23210 for the detection of the concentration in flowing gases in the fractions > PM10, PM10 and PM2.5. In addition, the ITES serves as a control and regulation unit for the isokinetic partial flow extraction

- Emission measurement/sampling according to EN, ISO and VDI standards (ISO 23210 and VDI 2066)
- Automated measuring system - applicable for environmental monitoring and exhaust gas measurements

Specifications:

- Max. mass concentrations: 200 mg/m³
- Max. temperature range: 400 °C
- orifice measuring section: 0.5 - 4 m³/h

Source: Paul Gothe

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Particle Generator

Generation of test aerosols from powders, pollen and spores

- Highest short-term and long-term dosing constancy and possibility for impulse operation
- Dispersion of almost all non-cohesive dusts

Specifications:

- volume flow: 0,5 - 5,0 m³/h
- maximum particle number concentration: approx. 1E+07 #/cm³
- Mass flow rate (particles): 0.04 - 430 g/h (at assumed plug density of 1 g/cm³)
- Particle size range: 0.1 - 100 µm
- dispersing gas: any possible (usually air)

Source: Palas

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Flow measurement and Visualization

High Speed PIV

- Highly dynamic visualizations of velocity and acceleration fields at a sampling frequency of up to 10.000 Hz
- Automated traversing of illumination and image capture device

Specifications:

- camera sensor: 2048x2048 pixels
- Pixel size: max. 10x10 μm
- Frame rate: up to 20,000 Hz
- Recording time at 100 fps: 13.3 s (full frame)
- Recording time at 100,000 fps: 6.86 s (red. resolution)
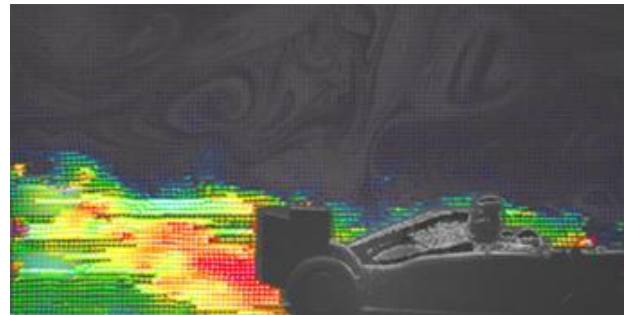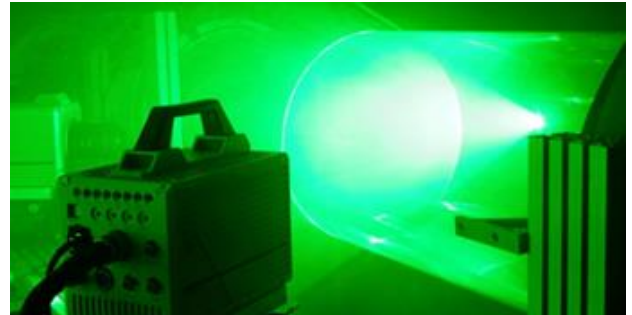
Source: ILA5150

Omiprobe

- Measurement of flow vectors up to 160 °
- For measurement tasks with unknown flow directions or when backflow is expected

Specifications:

- Number of wholes: 14
- Temperature: 600° C
- Flow angle: ± 160°
- Velocities: 3 m/s bis Mach 0,95
- Veloctiy accuracy: < ± 1 m/s
- 1 m/s

Source: Vectoflow

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Precision Balance

Mettler-Toledo Balance XSR225DU
### (analytical balance for small loads)

- Maximum weighing Capacity: 220 g/121 g
- readability: 0,1 mg; 0,01 mg
- Repeatability (typical): 0,02 mg (10 g)
- Minimum sample weight: 20 mg
- DAkkS Certificate
- usage: weighing of unloaded and loaded filters

Source: Mettler Toledo

Sartorius Cubis manual mass
comparator MCM40K3

- Maximum weighing Capacity: 41 kg
- readability: 0,1 mg
- Repeatability (test weight): 2 mg
- DAkkS Certificate
- usage: precise mass loss determination of brake discs and tires

Source: Sartorius

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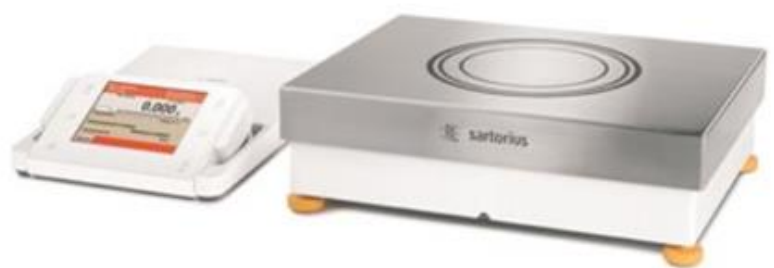
Opel Ampera

Vehicle with Range Extender for the
Examination of drive concepts

- Maximum power: 111 kW / 150 hp
- Max. Torque: 370 Nm
- Vmax: 161 km / h
- 0-100 km / h: <10 sec
- Empty weight: 1732 kg
- Electric drive: 54 kW generator
- 16 kWh battery
- 40-80 km range

Range Extender: 4 cylinder Otto engine, 1398 cm³
    63 kW/86 hp at 4800 rpm
    >400 km range

Mitsubishi i-MiEV

- Vehicle with electric drive
- Investigation of drive concepts
- Investigation of HMI

Power:	49 kW/67 PS	Capacity:	16 kWh
0-100 km/h:	15,9 s	Range:	150 km
Vmax.:	130 km/h	Empty weight:	1110 kg

Land Rover Range Rover Evoque

- Vehicle with dynamic tire pressure control, semi-active suspension and decoupled braking system with continuous wheel-slip control
- Examination of driving dynamics

Power:	110 kW/150 PS
Inertia:	380nm
Vmax.:	182 km/h
Empty weight:	2275 kg
Tire size:	235/55 R19

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Audi A5 Sportback

- Man-machine interaction
  (e.g., pedal feel characteristics)

- Brake-by-Wire

Model series B8

- Otto engine, displacement: 1984 cm^3
- Power: 155 kW / 210 PS
- Max. Inertia: 350 Nm
- Acceleration: 0-100 km/h: 6,4-7,9 s
- Empty wieght: 1590 kg
- Vmax: 241 km/h

Audi e-tron 55 quattro S-Line

Research
- Demonstrator for innovative propulsion technologies
- Development and validation of integrated chassis control systems for fully electric Sport Utility Vehicles (SUVs)
- Automated Driving

Tire Measurement Trailer

- Developed by division of automotive engineering
- Analysis of the adhesion behavior of tires on dry and wet roads
- Electro-servo-hydraulic brake system for the realization of brake slip
- Measurement and control of the braking system using LabVIEW Realtime (Real-Time System CompactRIO)
- Highly dynamic force and torque recording
- Defined adjustment of wheel position variables
- Great variation of wheel loads
- Highly dynamic tire inflation pressure system

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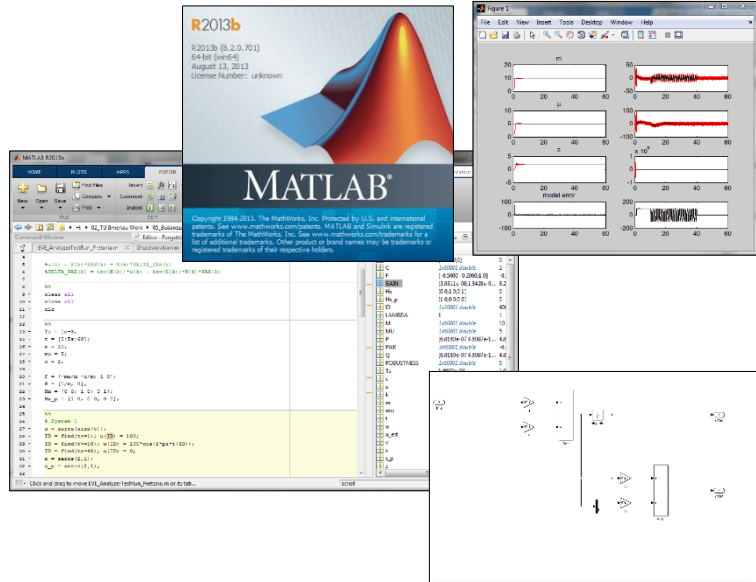
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MATLAB/Simulink

Computer-algebraic solver for differential equations

Application:

- Data collection and data analysis
- Rapid Control prototyping and optimization
- Prototypical software development
- Statistics, signal and image processing
- (Co) Simulation

InMotion

Mobile real-time simulation platform with multivalent interfaces:

- Interfaces to MATLAB / Simulink, C-Code
- Communication interfaces: UDP / IP, TCP / IP, CAN, FlexRay, USB
- Application: Complete vehicle simulation (IPG CarMaker) for the representation of complex test scenarios through real-time networking
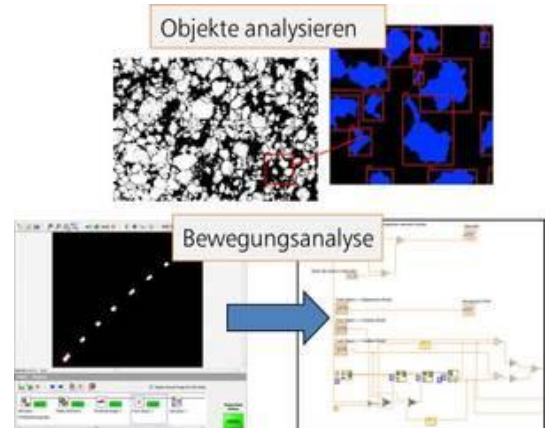
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IMAQ

- PC-based image processing
- Online and offline image analysis
- Automated image analysis using sequences
- Automatic testing of dimensional and positional deviations
- Interface to LabVIEW

IPG CarMaker

- Virtual vehicle testing in the pre-development stage
- Possibility to implement driver and vehicle models (or even individual subsystems) and related regulations
- Application: Simulations for preliminary investigation of new concepts and newly developed control systems

Diadem

- Creation of applications for measurement data recording
- Automated data analysis with DIAdem script
- Application: data acquisition, data evaluation

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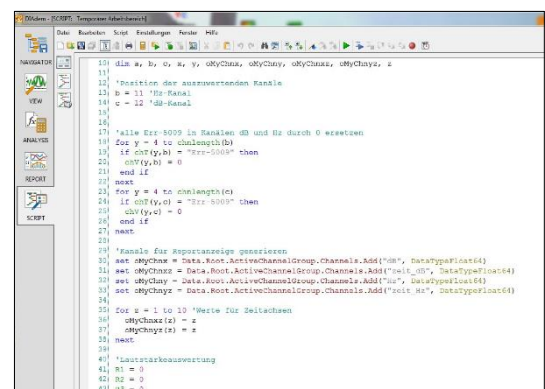
ANSYS

- FEM software for linear and non-linear problems in the fields of structural mechanics, structural dynamics, fluid mechanics, thermodynamics, piezoelectricity, electromagnetism and combined approaches
- Application: NVH analysis / analysis of aerosol flows (fine dust emissions) / friction simulation in automotive vibration dampers
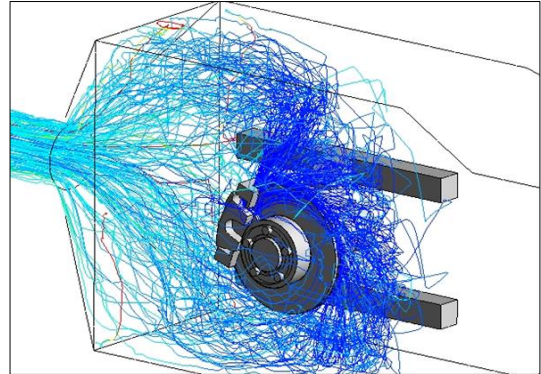
AME Sim

- Simulation of hydraulic and pneumatic systems, signal processing, fluid and heat transfer coupling
- Application: Unsteady system simulation of electrohydraulic braking systems
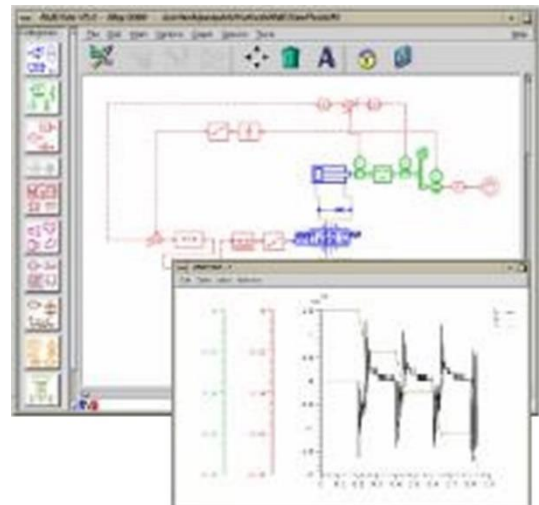
LabView

- Software for system development used in measurement, test, control and regulation applications
- Fast hardware access with fast insight into data
- Creation of real-time applications for measurement data and controlling processes
- Creation of executable programs in customer order (stand alone applications)
- Application: Data acquisition and control of automated systems

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