100 years 1912-2012 KOSTAL

WE CREATE FUTURE.

Multiphysics Simulations in Automotive Product Development: Concept and Beyond

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COMSOL CONFERENCE EUROPE 2012

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Excerpt from the Proceedings of the 2012 COMSOL Conference in Milan

„Operate the direction indicator at the steering wheel!“

„Push buttons: with 4 on-off switches - for interior, instrument or fog lighting, radio, wiper, head lamp, etc.“

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The KOSTAL Group

Company‘s data

1912: Foundation of parent company Leopold Kostal in Lüdenscheid

1973: Start of activities in first plant abroad (Mexico)

1978: Production of first automobile electronics

1983: Start of mechatronics (first sensor systems)

2011: Revenues: 1,623 bn €
Employees: 13.503 (73% abroad)
Subsidiaries in 17 countries
on 3 continents

Business areas

KOSTAL Automotive Electrical Systems

Mechatronic modules
Electronic control units
Switch panels/switches

KOSTAL Industries

Connectors
Industrial Electronics
SOMA Test Systems

The KOSTAL Group is acting globally as a family-owned company.

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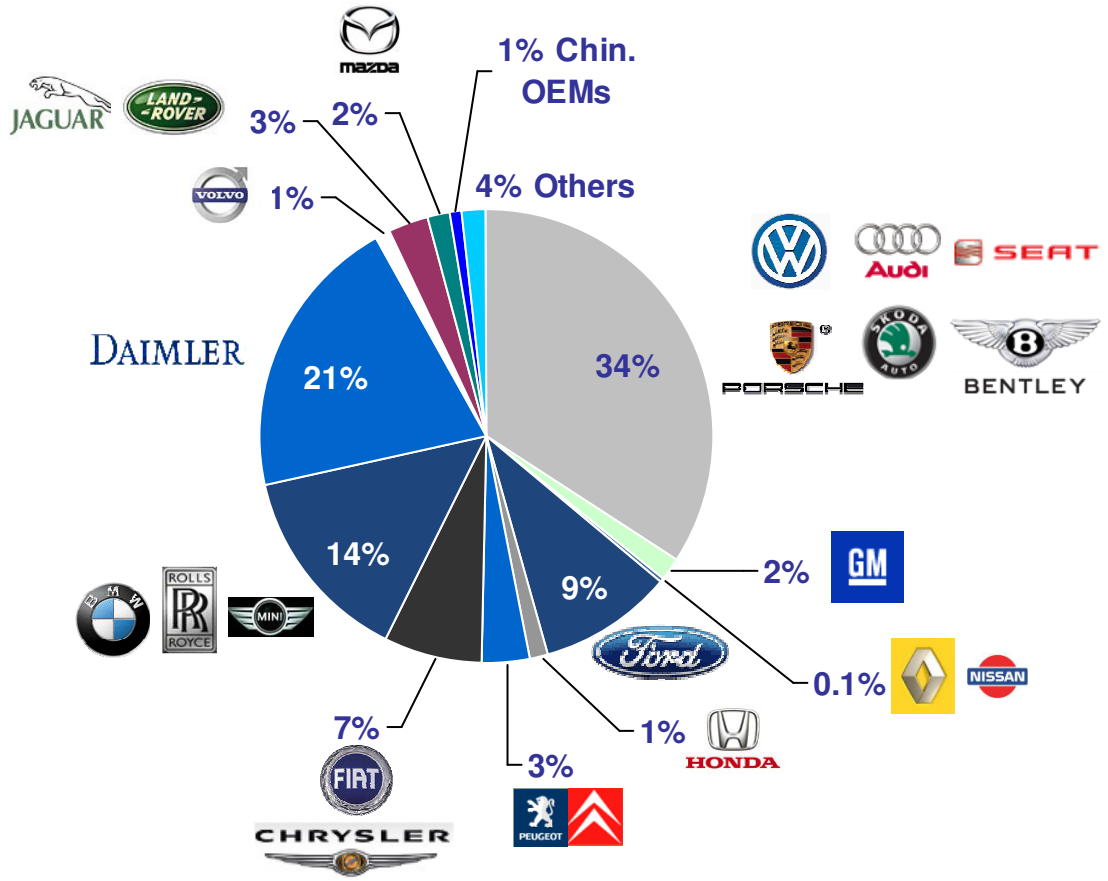
KOSTAL Automotive Electrical Systems: Customers and Turnover 2010

The total global goods turnover achieved in the Business Area Automotive Electrical Systems was 1,2 bn €.



Quellen: AVP, HC [Real 2010]

Our customers‘ success is the basis for KOSTAL‘s success !

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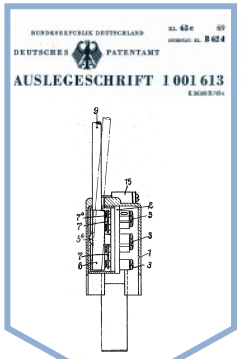
KOSTAL Automotive Electrical Systems: Innovations and Impetus

1954	1958	1986	1994	1998	2004	2007
KOSTAL patents for	KOSTAL patents for	KOSTAL patents for	KOSTAL patents for	KOSTAL patents for	KOSTAL patents for	KOSTAL patents for
Switch-panel	**Headlamp Flash Light**	**Anti-pinch protection**	**Rain sensors**	**Steering column modules**	**Shift-by-wire gear select switch**	**Front-end camera for driver assistance systems**
Invention Space-Savings & Safe Operation	Invention Use of Turnsignal Switch to Flash Headlamp	First market application Over 100 mio. applica-tions in the market	First market application Over 11,4 mio. applica-tions in the market	Market and integration leader Integration of five functional components	Market and integration leader Operating concept forms OEM brand identity	Innovative optomecha-tronics Integration of sensors adapted to windscreens
						

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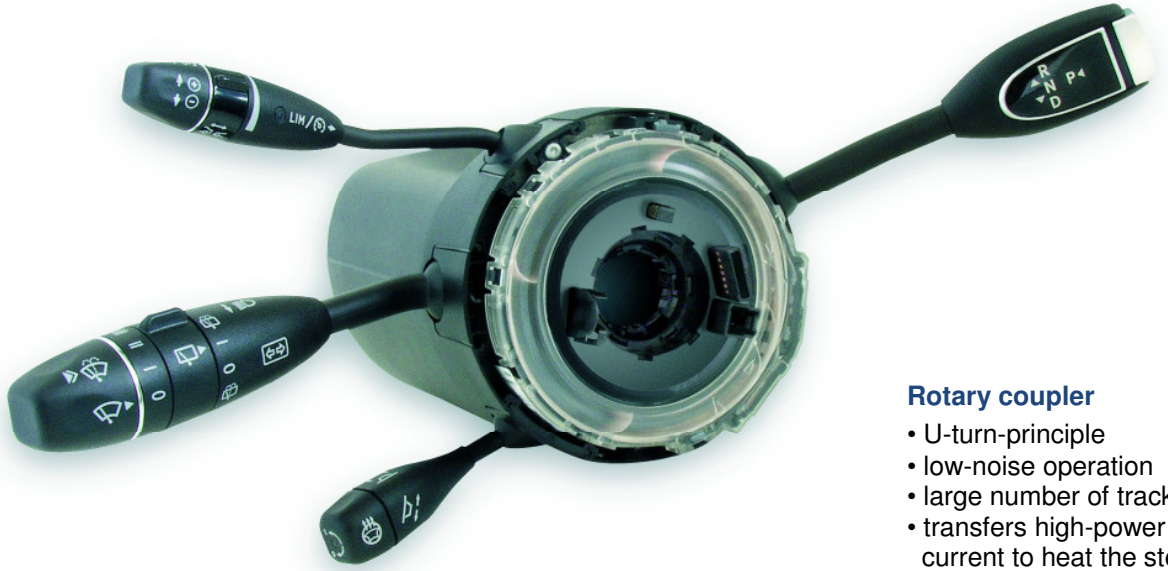
KOSTAL Core Product Area „Steering Column Modules“

CPU – central microchip
- 1µC resp. 2µC system
- OSEK
- ready for AUTOSAR
- 1/2-CAN/LIN; Flexray

Steering angle sensor
- non-contact, optic resp. magnetic
- absolute measurement
- resolution 0,1 °
- SIL3 to IEC 61508

Gear selector switch
- switching system contactless, magnetic
- suitable for higher operation and abuse force requirements
- SIL2 according to IEC 61508



Latching system
- optimised free play
- ergonomic latching forces on customer request

Rotary coupler
- U-turn-principle
- low-noise operation
- large number of tracks
- transfers high-power electrical current to heat the steering wheel

Optical Switching
- no mechanical wear
- no effect on tactile feedback
- simple structures ensure high quality

From steering column switches to complete, integrated modules

The KOSTAL product range extends from combined steering column switches for compact cars, through to „high-end“ steering column modules for premium class vehicles.
Scaled architectures provide platform functionalities across different vehicle ranges.

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KOSTAL Core Product Area „Roof Modules“

Switches / surface design
- integration of premium switch elements for control of sun roof, interior lights and emergency call activation

Electronics
- high performance electronics with special software for pinch protection control and anti-theft alarm

Light design
- innovative light design: optimal light distribution without direct or indirect glare
- modern tools for light simulation

Functional integration
- integrated anti-theft alarm sensorics
- passenger airbag off illumination
- integrated microphones for speech control and hands-off calling

Rain- / light- / fog - sensor
- ‚best in class‘- rain sensor functionality
- variable sensitivity selection
- integrated Light sensor
- integrated solar sensor
- integrated fog sensor

Driver assistance camera
- ‚smallest in class‘- foot print on wind shield
- maintenance-free, no-wind shield heating necessary
- integrated rain-/light sensor
- integrated solar sensor
- integrated fog sensor

Integrated functions in the vehicle roof

KOSTAL roof modules integrate various single components to a technical and logistical module. Design and production competencies in the fields of mechanics, electronics, software, lighting technology and simulation make KOSTAL a ideal partner for the development of such mechatronic modules.

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KOSTAL Core Product Area „Centre Console Modules“

Control elements / surfaces
- integration of high-level control elements to operate additional functions
- high level look and feel by leather- /ceramic- /metal surfaces

Function select / driver assistance
- drive position- and steptronic-mode
- end-stops/barriers can be configured according to the drive position
- actuator for automatic return from steptronic lane
- activation of sport mode

Position sensors
- non-contact Hall-Sensors
- SIL 2 to IEC 61508 (total system)

Installation in the vehicle
- assembly point in the centre console

Patented 3D latching system
- optimum play
- fully configurable to the user‘s requirements
- monostable or latching
- individual force-level display

Bus systems
- PT-CAN
- LIN
- redundant system in accordance with the required safety class

Shift-by-wire gear selector switches

The introduction of shift-by-wire gear selector switches in modern vehicles with automatic gearboxes is a trend which is now unstoppable. Their outstanding functionality and flexibility makes them superior to previous systems in in many respects. In addition this system gives the interior designer much greater scope in deciding the shape of the centre console.

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CADdoctor® MSC Software SIEMENS DASSAULT SYSTEMES MATLAB® &SIMULINK® SPEOS Autodesk Moldflow Insight Moldex3D MOLDING INNOVATION

COMSOL Multiphysics

- AC/DC
- Heat Transfer
- Optimization

Typical Use Cases

- Mechanical FEA
  - Use / Misuse Forces
  - Assembly Processes
  - (Flexible) Multi-Body-Simulations
- Injection Moulding Simulation
  - Filling
  - Pressure Distribution
  - Deformation
- Optical Simulation
  - Symbol Illumination
  - Light Guides
  - Reflectors
- System Modelling
  - Tolerance Analysis
- …

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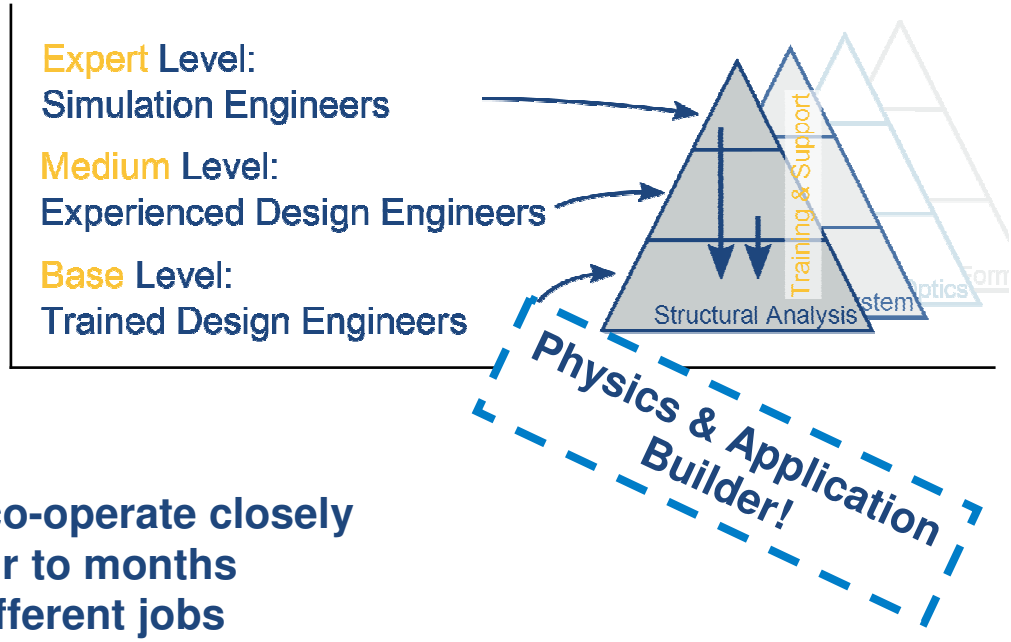
- „Pyramid“-Organization
  - 3 Levels of expertise
  - Have as much as possible done by the design engineer
  - Medium and Expert level to support Base level



- Simulation experts
  - In-house service suppliers
  - Not member of project team, co-operate closely
  - Lots of different jobs, one hour to months
  - Simultaneously working on different jobs

- Credo: ~~**Simulation**~~ ⇨ ***Special* Design Task**

- *Special*?
  - Needs numerical methods
  - Requires expert knowledge
  - Requires special software
  - Involves optimization, iterative procedures etc.

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Examples of COMSOL Applications

- **Thermal Optimization**
  - **Roof modules (high power LEDs)**
  - **High power electronics (high power density electronics)**
  - **Active heating eg. for sensor applications**

not shown, sorry!

- **Capacitive Sensors**

- **Coil Design and Optimization for Inductive Power Transfer**

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Interior Switches: Technology Transfer

Functions, User Interfaces and Operating Concepts are transferred from Smartphones to Cars

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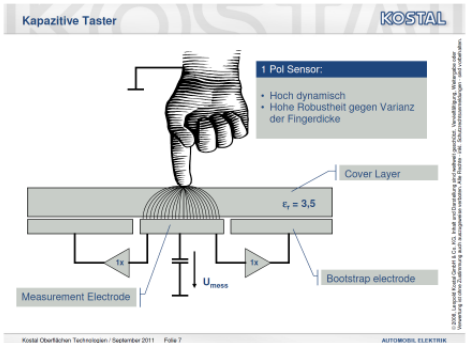
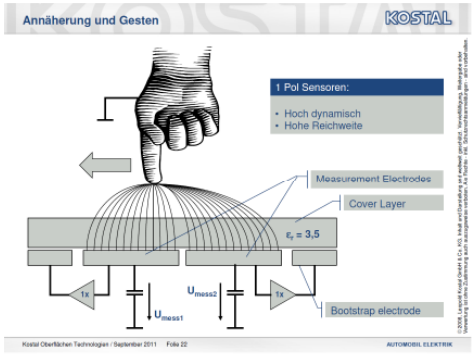
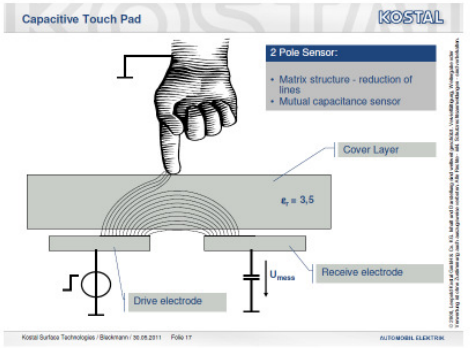
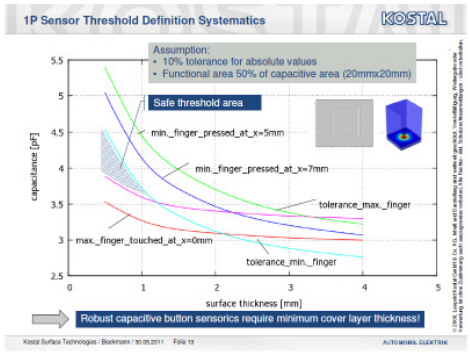
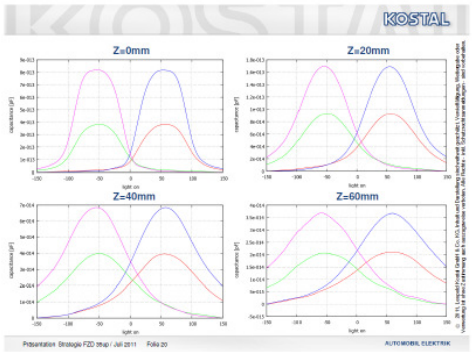
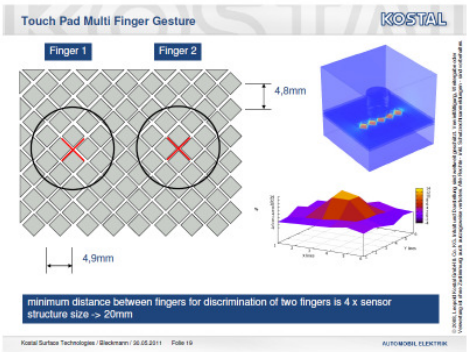
Capacitive Sensors: Applications & Basics

	Touch	Proximity / Gesture	Touchpad
Principle			
Simulation			
Verification			

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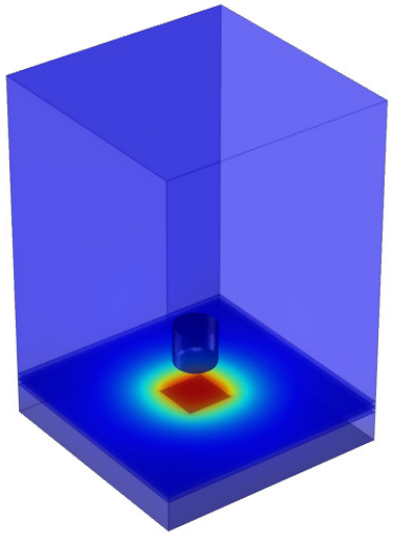
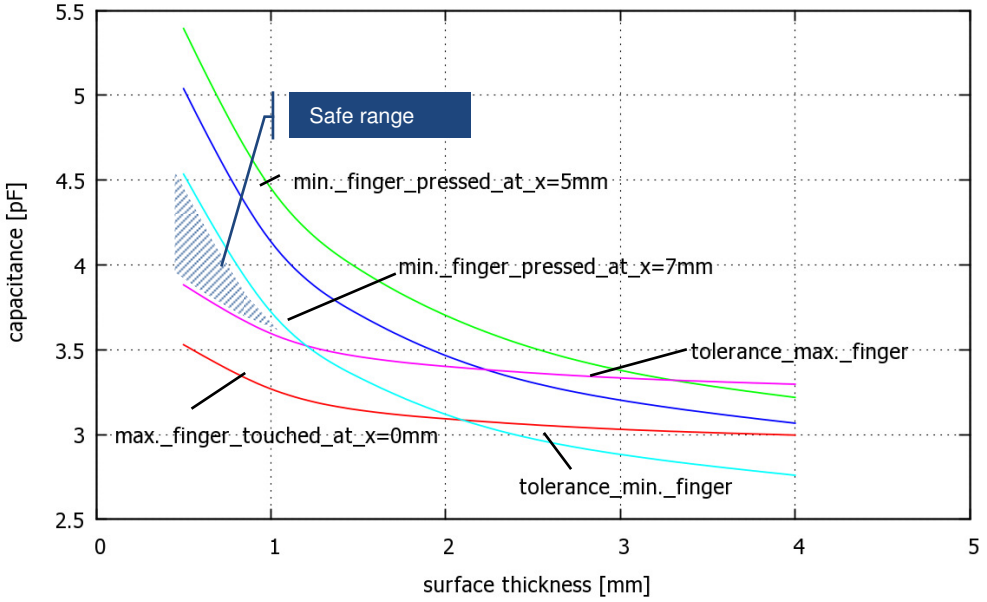
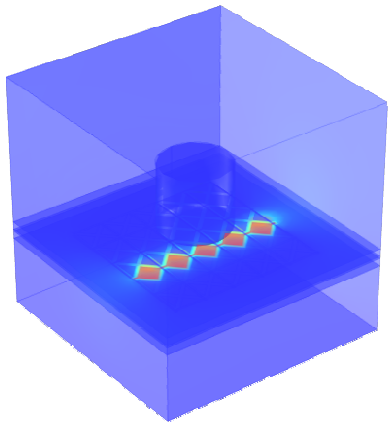
Capacitive Sensors: Modelling

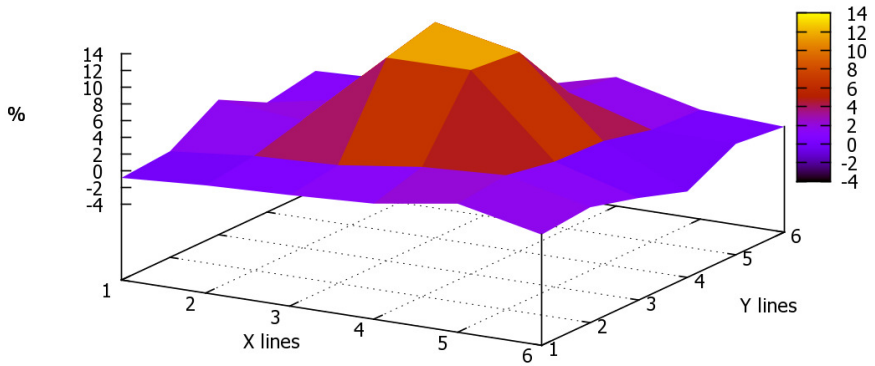
Touch





Touchpad





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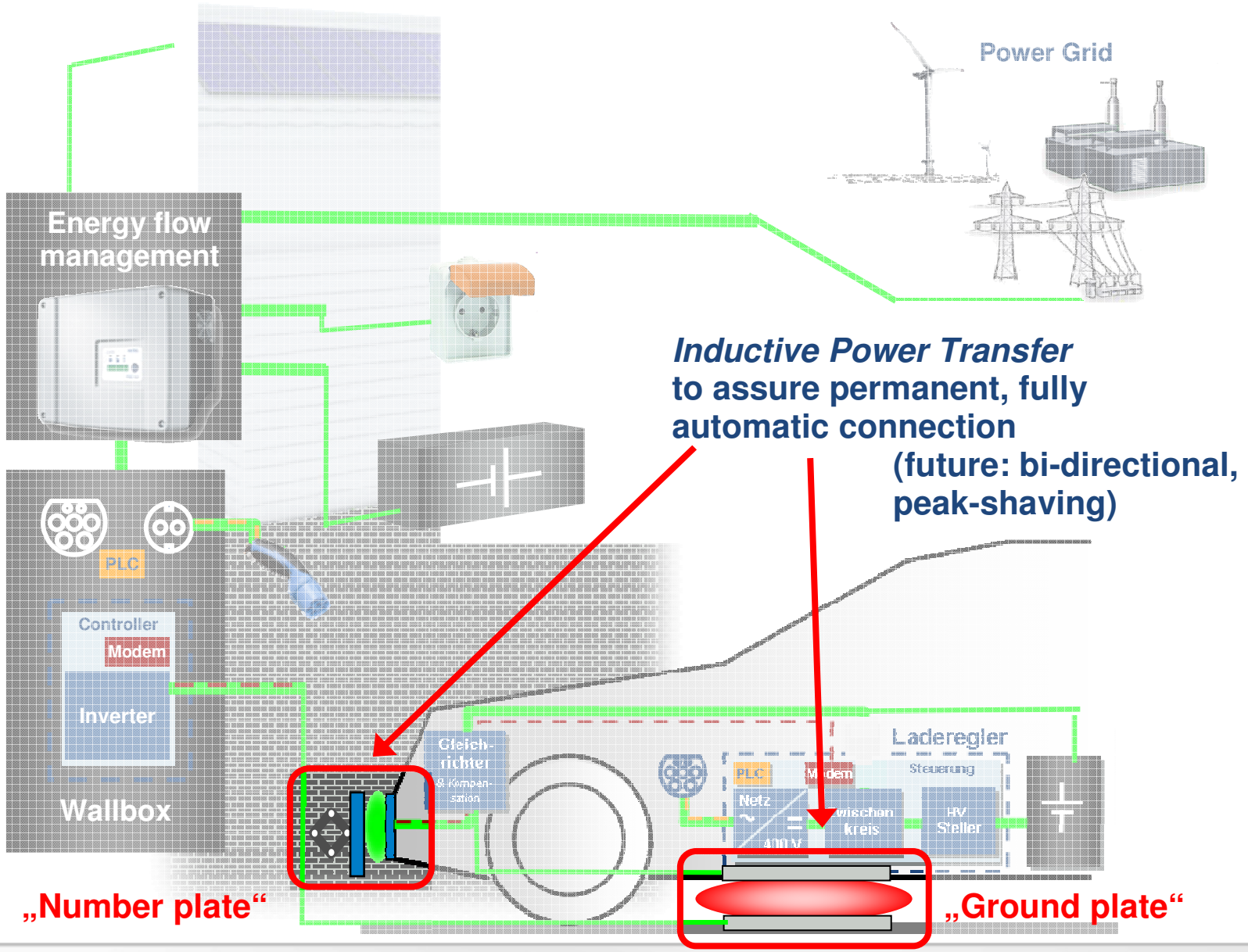
EVs in a Decentralized Infrastructure



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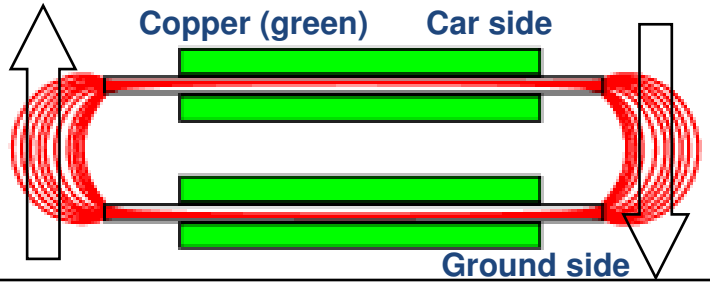
Inductive Power Transfer: Basics

- Requirements:
  - 3.5 kW (7 kW, 21 kW?)
  - Safe & Reliable
  - Efficiency > 92%
  - Large positioning tolerances
  - Minimum mass
  - Low cost
- Coil System
  - Transformer with air gap
  - Low coupling
  - High stray field ⇨ high reactive power
  - 40 … 150 kHz
- Electronics
  - Primary side: 230V AC + rectifier + inverter
  - Secondary side: rectifier + 400V DC
  - Digitally controlled
  - No real-time communication between primary + secondary side!
- Effiency determined by losses:
  - DC resistance, Skin and Proximity effects
  - Magnetization
  - Eddy currents in shielding and environment
  - Electronics (semiconductors)

Typical „Ground plate“ specifications:

- ca. 30 x 30 cm car side coil
- ca. 80 x 80 cm ground coil
- 10-15 cm air gap
- +/- 15 cm lateral tolerances
- 30° yaw angle

Typical „Ground plate“ design: magnetic quadrupol



Field Energy

$$W_i = \frac{1}{2}\int \vec{H}_i \cdot \vec{B}_i \, dV, \qquad i \in [1;2;12]$$

Inductance

$$L_i = \frac{2W_i}{I_i^2}, \qquad i \in [1;2]$$

Mutual Inductance

$$M = \frac{W_{12}}{I_1 I_2} - \frac{1}{2}\left(\frac{I_1}{I_2}L_1 + \frac{I_2}{I_1}L_2\right) \overset{(I_1=I_2=I)}{=} \frac{W_{12}}{I^2} - \frac{L_1+L_2}{2}$$

Coupling

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

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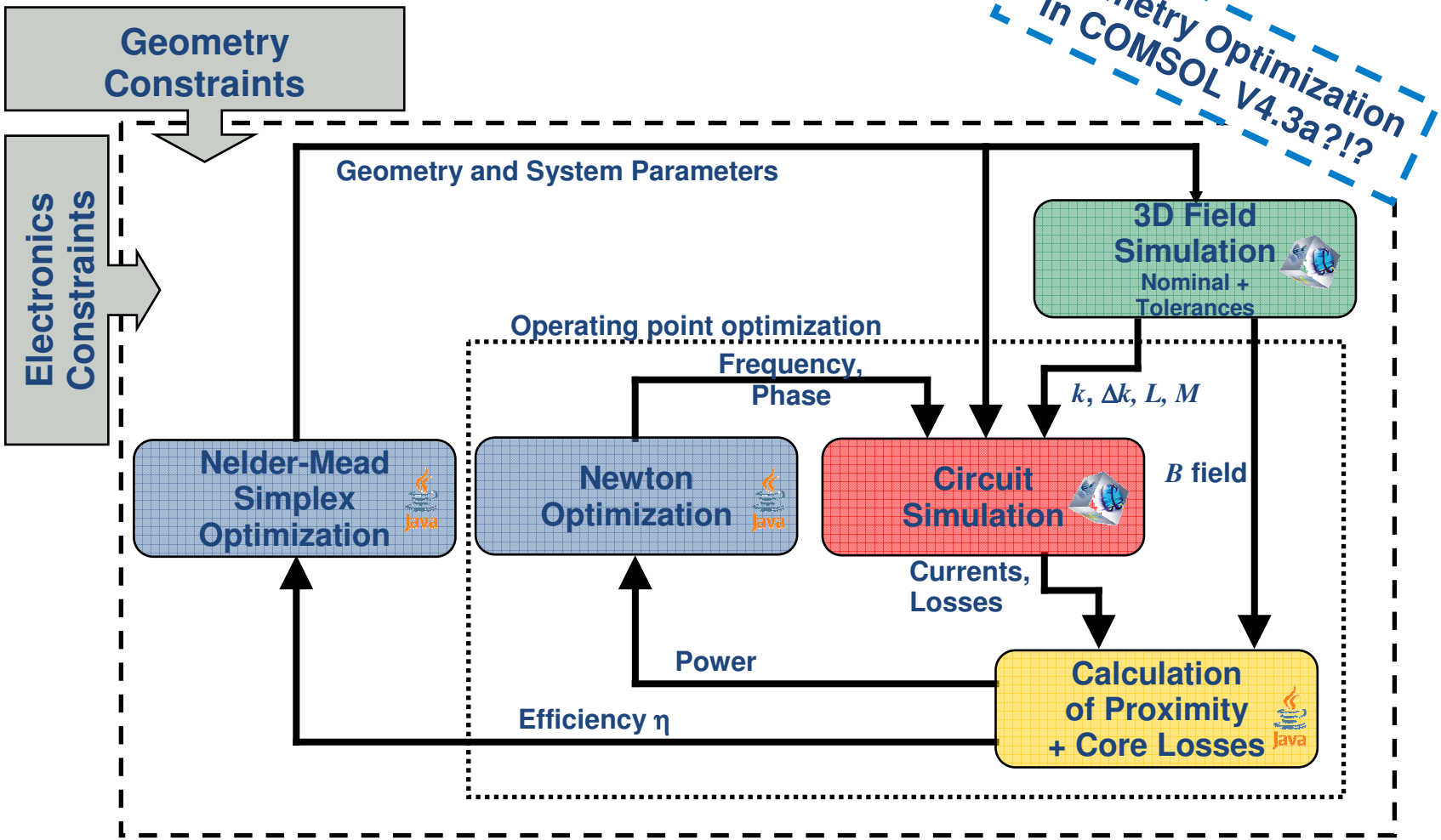
Inductive Power Transfer: Numerical Optimization

- Fully automatical numerical optimization of system efficiency
- Implemented using JAVA API



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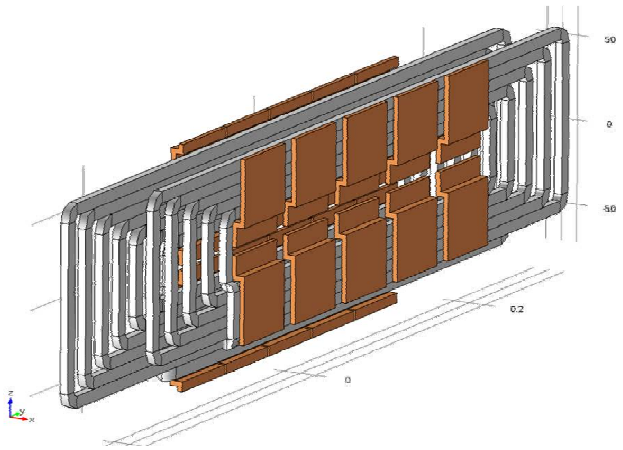
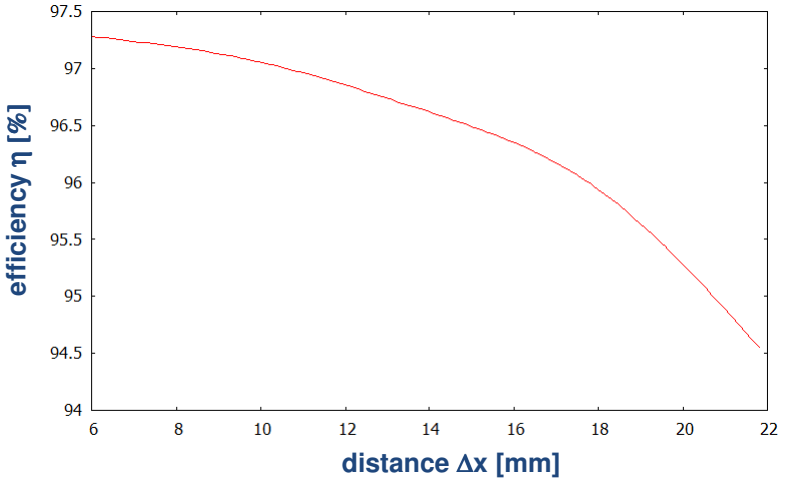
Inductive Power Transfer: Result

Efficiency η: ca. 96,9 % in nominal position („DC-DC“ efficiency!)

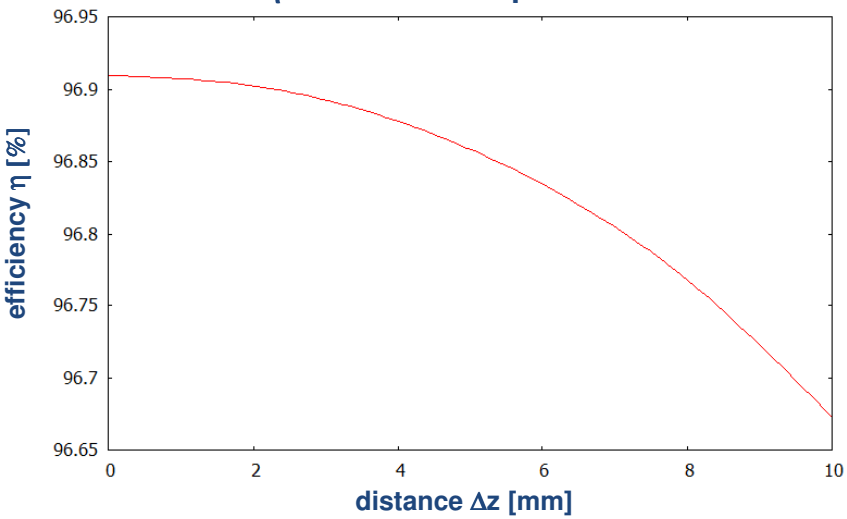
Design



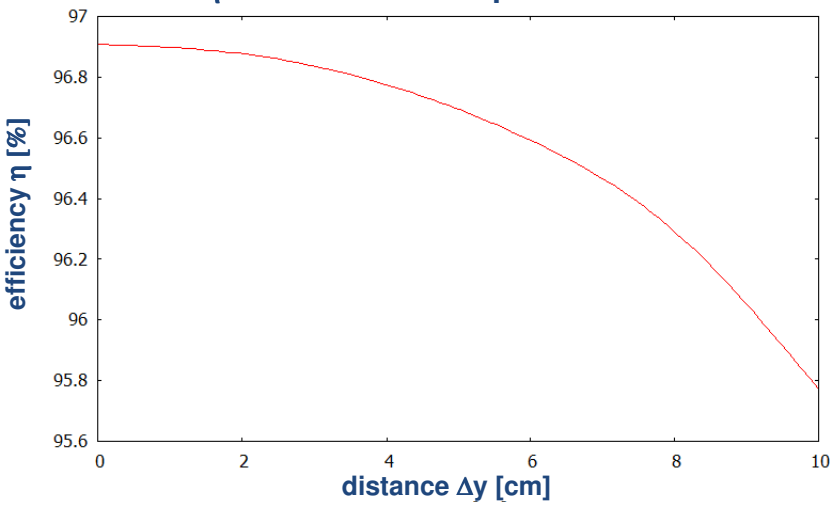
η vs. horizontal distance



η vs. vertical displacement



η vs. horizontal displacement



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Thank you for your attention!

Credits: M. Bleckmann, D. Klagges, C. Lexow, Dr. I. Münster, Dr. S. Steinke, F. Wendland, et. al.

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