

Optimum Design Strategies for Electromagnetic Vibration Transducers

A 3D visualization of an electromagnetic field, showing a central vertical axis with a rainbow-colored gradient from red at the top to blue at the bottom. Concentric, glowing rings of light surround the central axis, representing the field's distribution.

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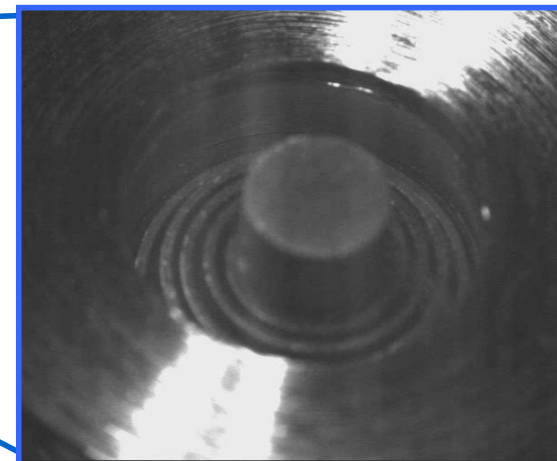
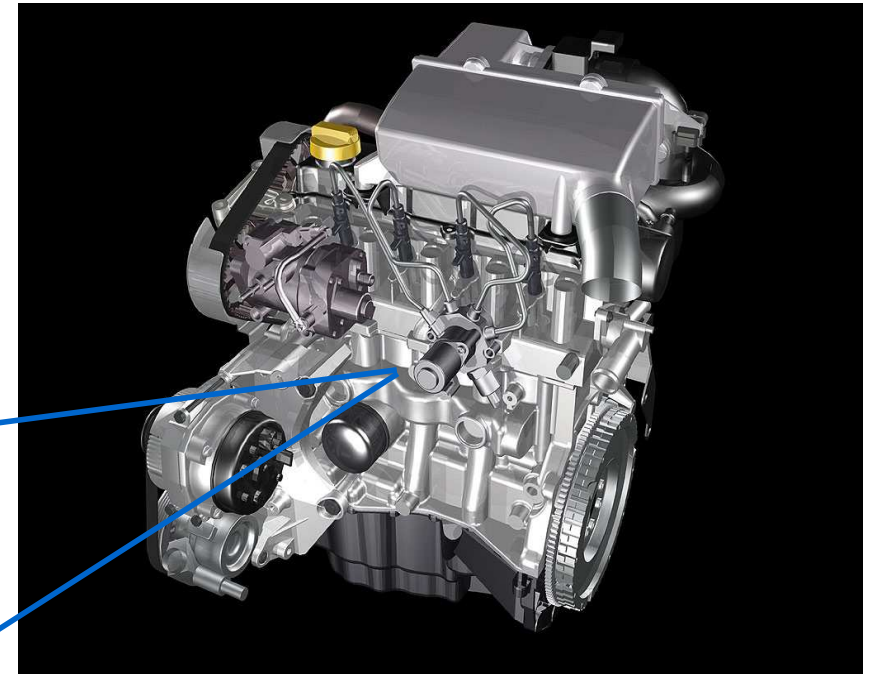
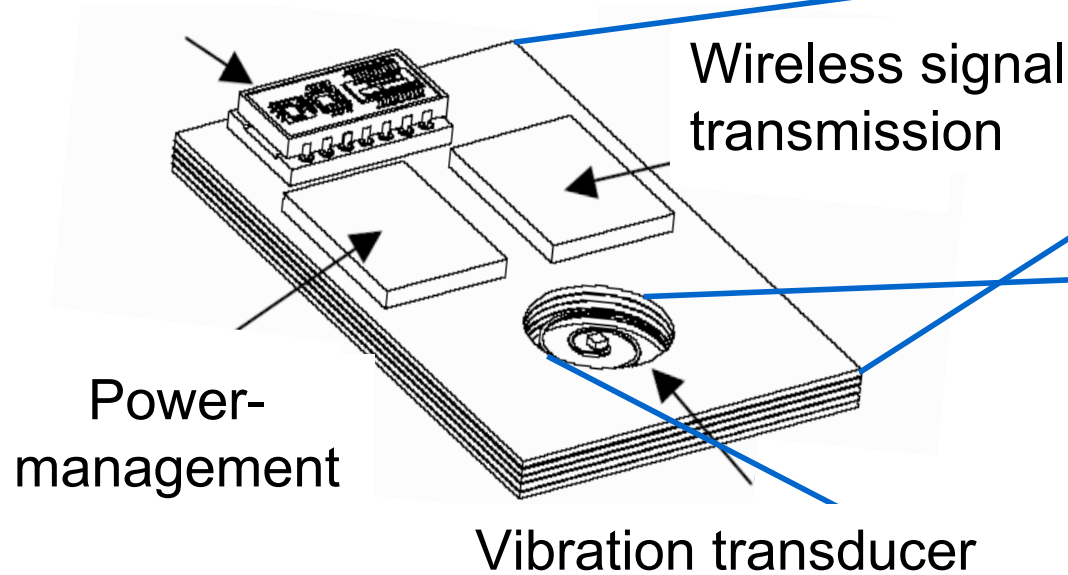
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- Background and idea of vibration energy harvesting
- Basic principle of resonant vibration transducers
- Optimized design of the electromagnetic coupling architecture
 - Performance limit and comparison of commonly applied architectures
 - Coil topology optimization
- Basic steps in the prototype development
- Conclusion

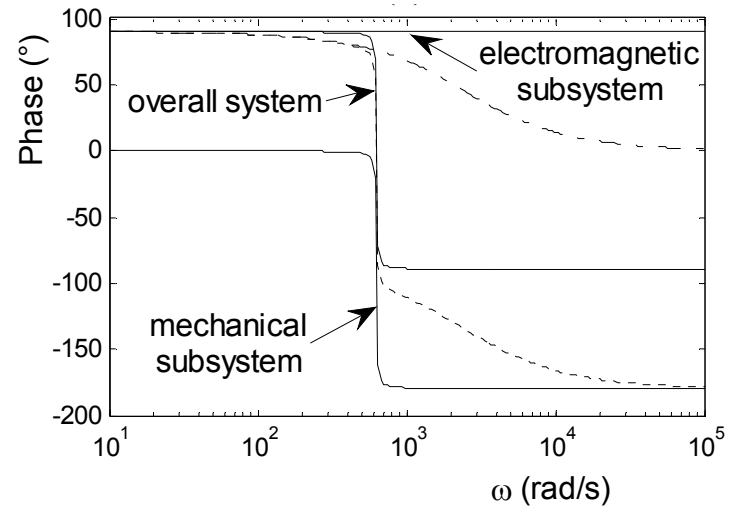
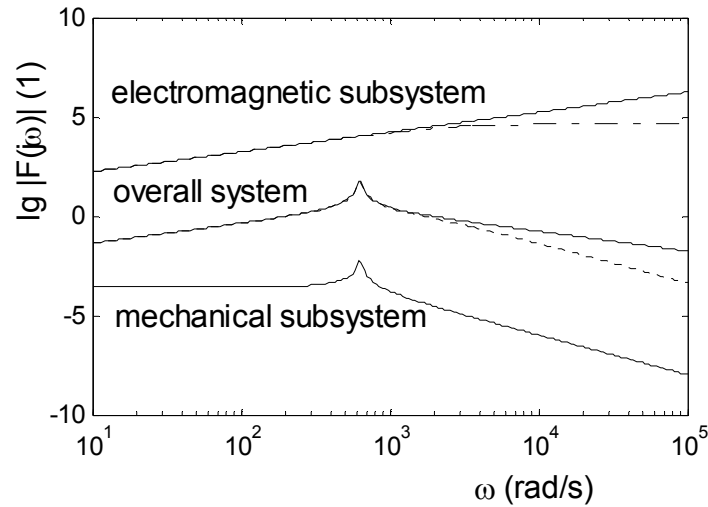
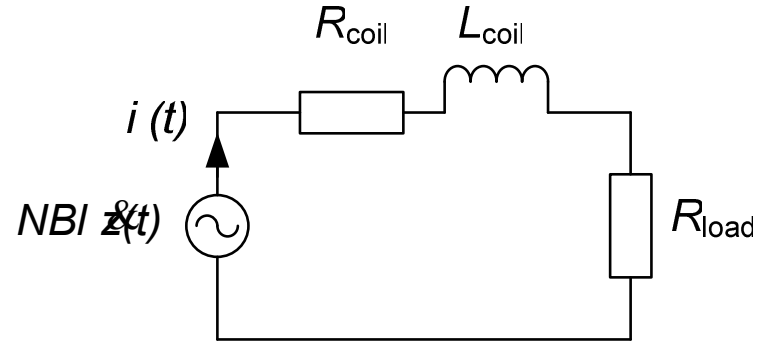
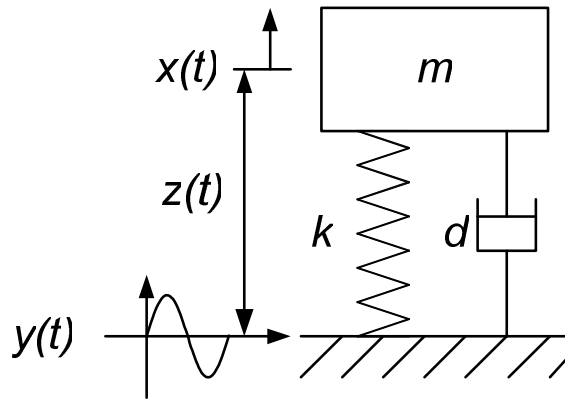
Goal of „vibration energy harvesting“?

Energy autonomous system in
e.g. difficult to assess environment

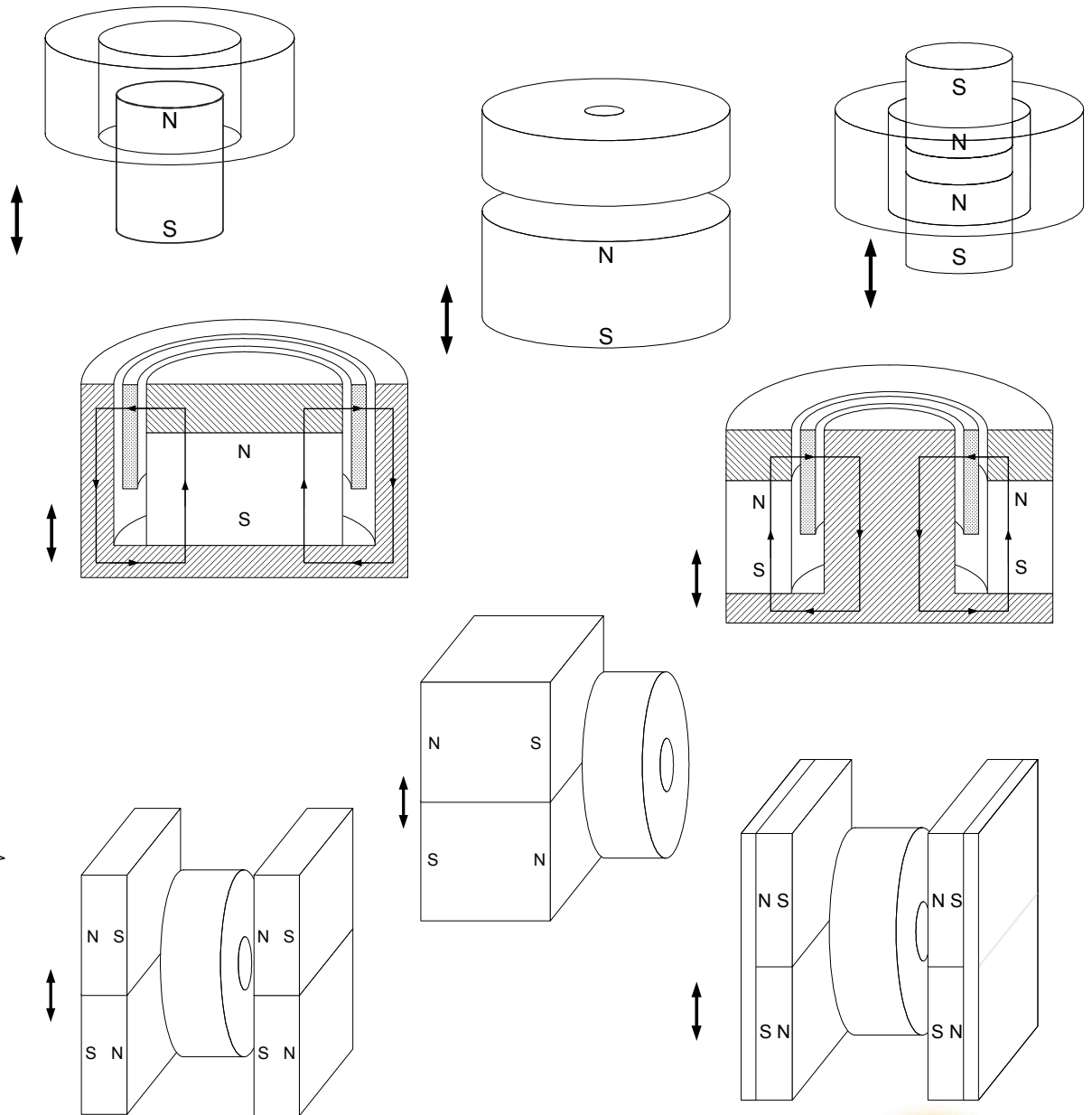
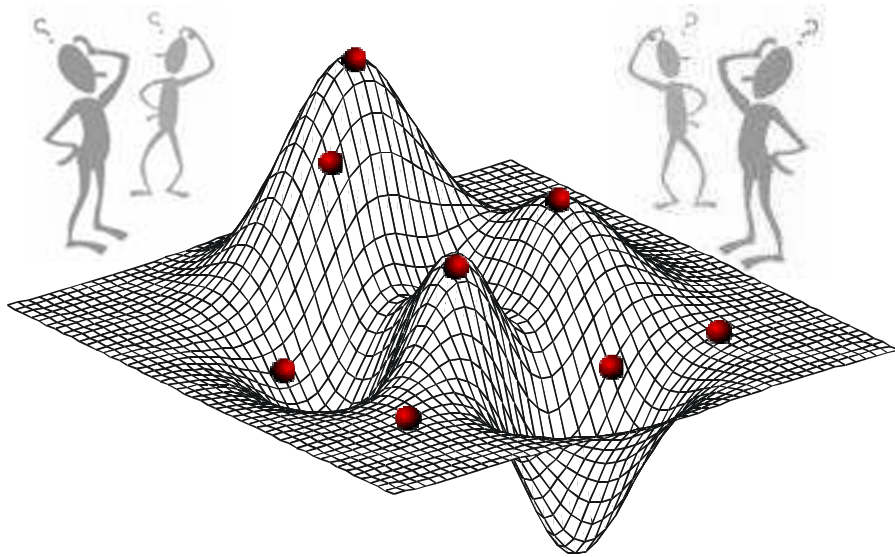
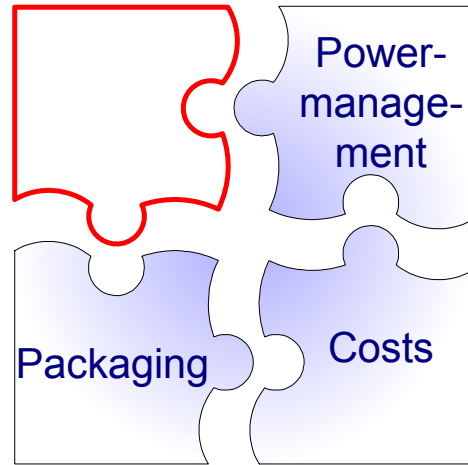
Application:
Sensor & Signal processing



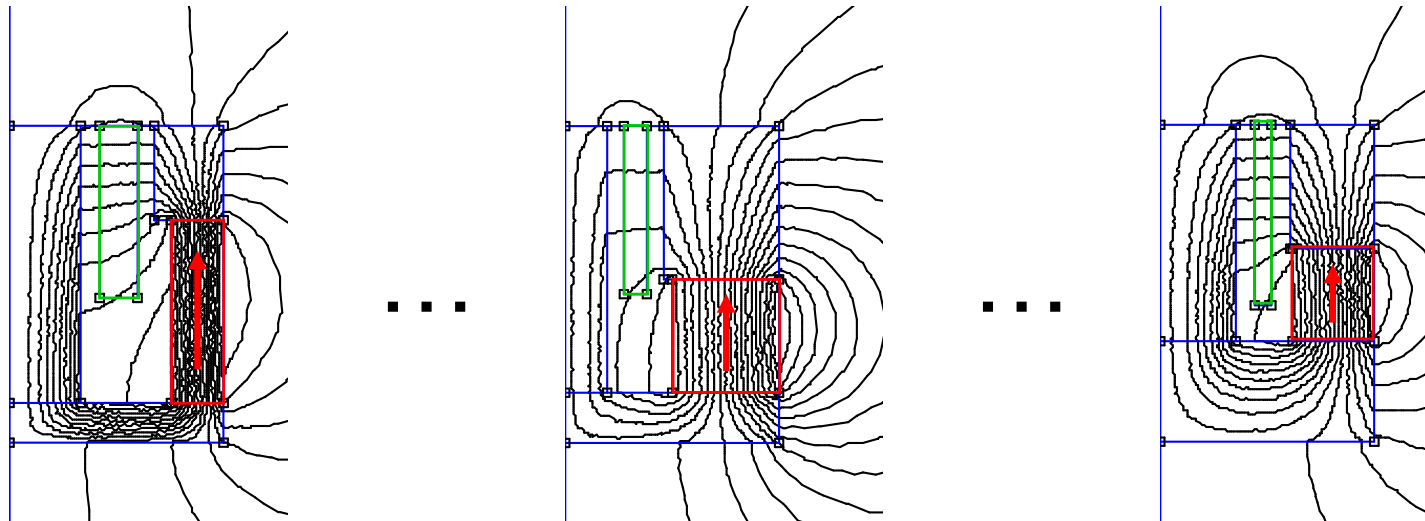
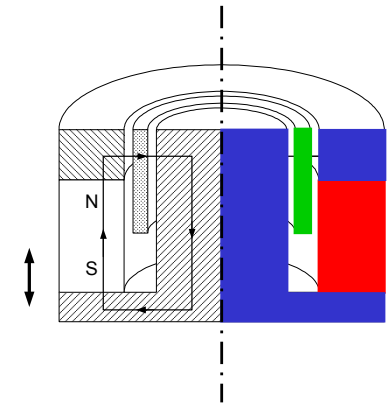
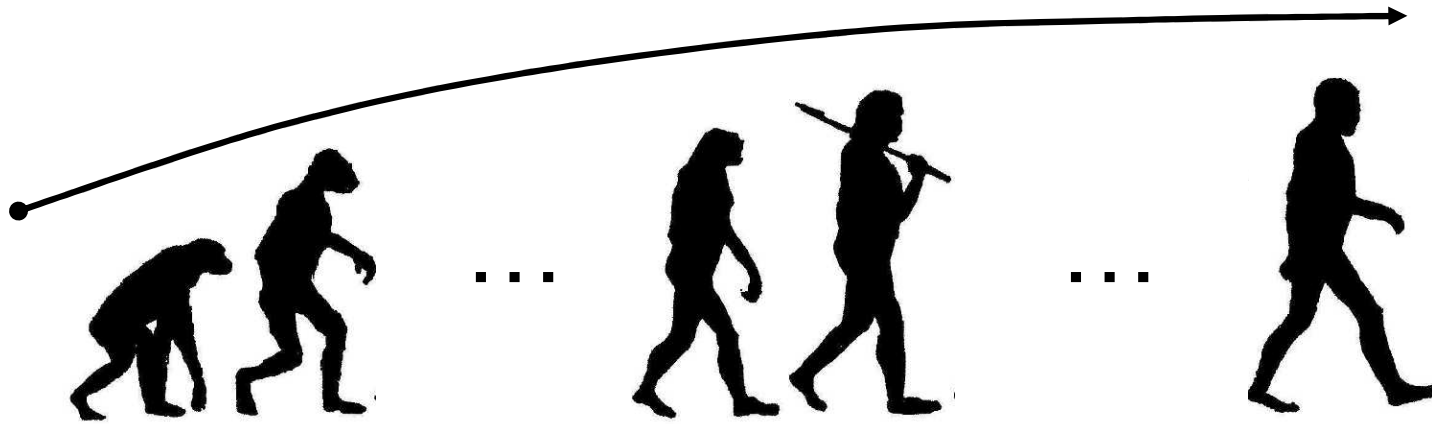
Basic principle of vibration transducers






Commonly applied coupling architectures

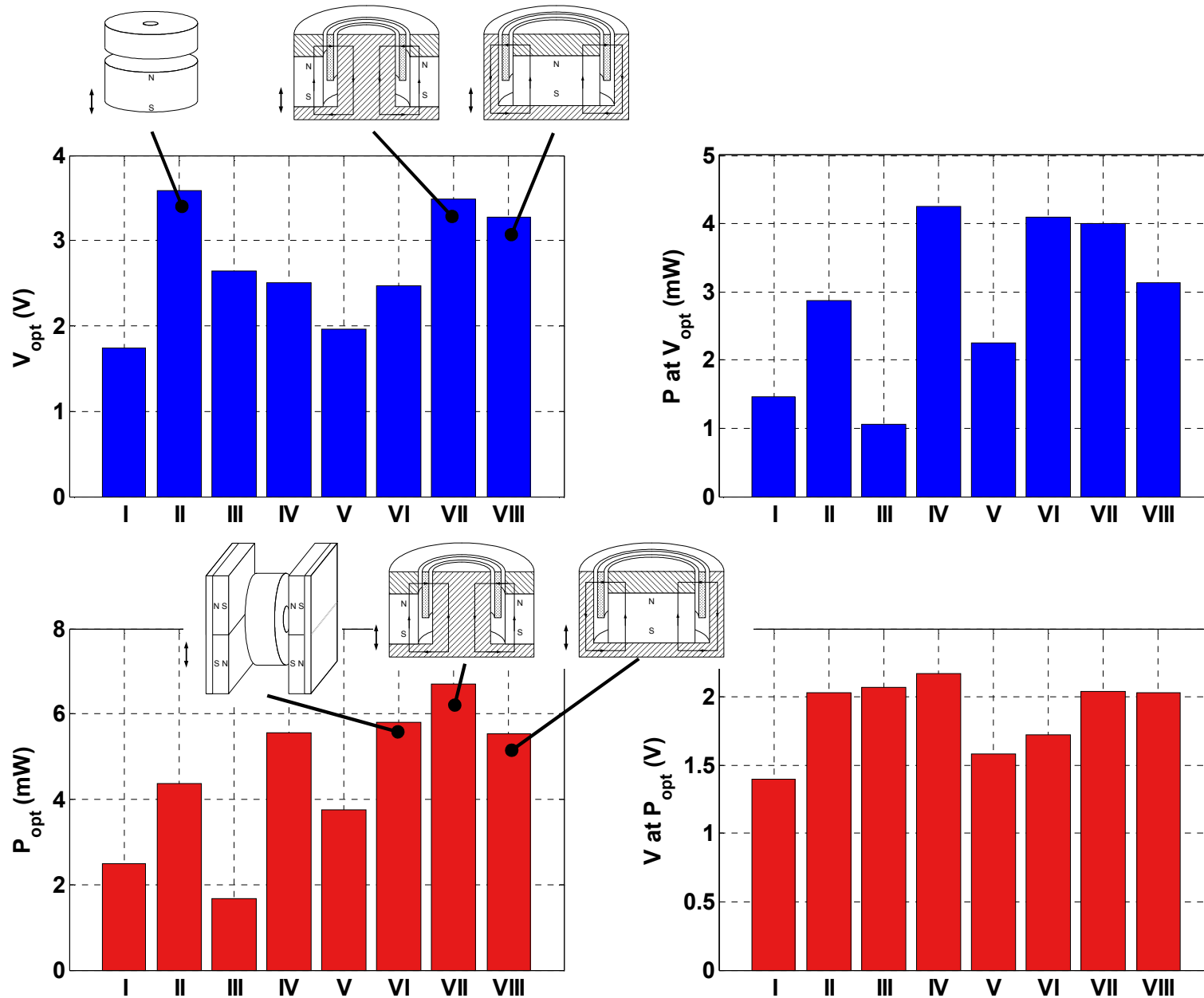


Evolution strategy optimization

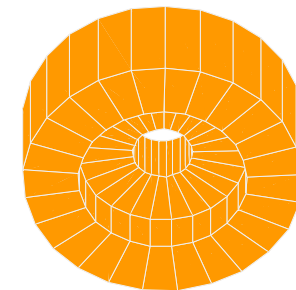
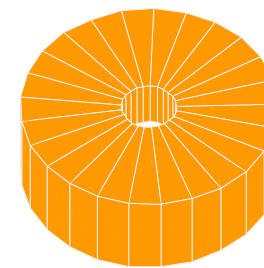
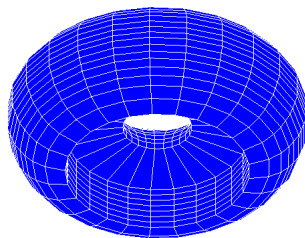
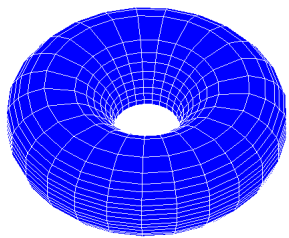
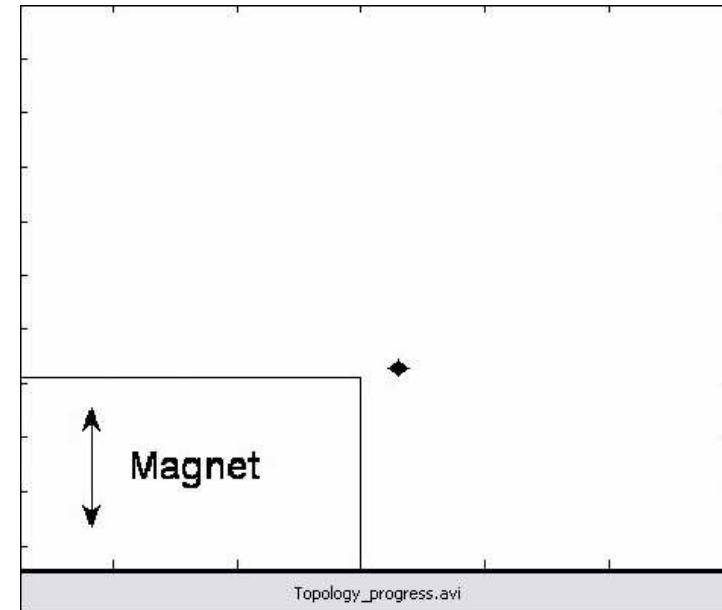
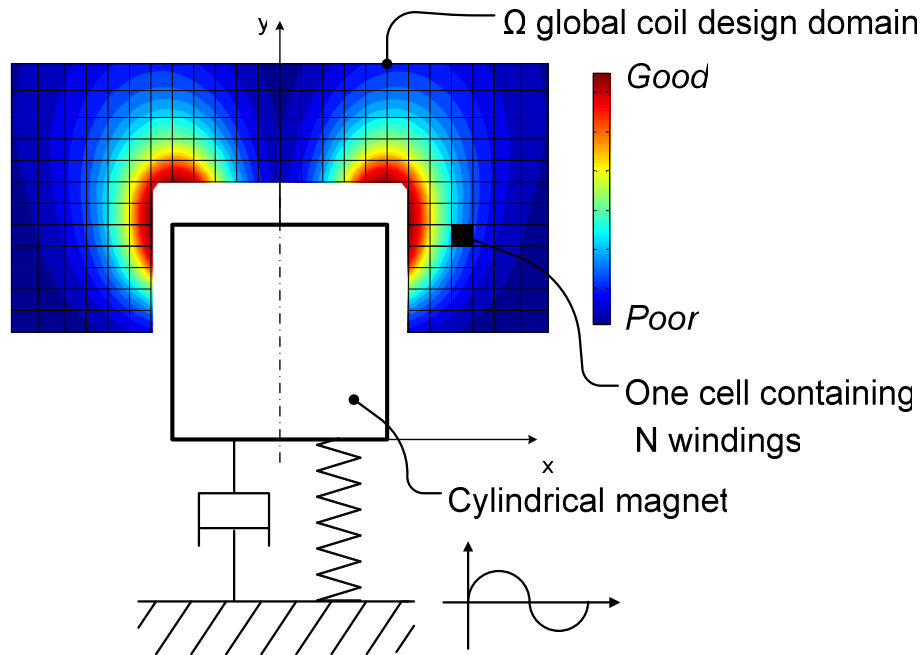


-  Magnet
-  Coil
-  Back-iron

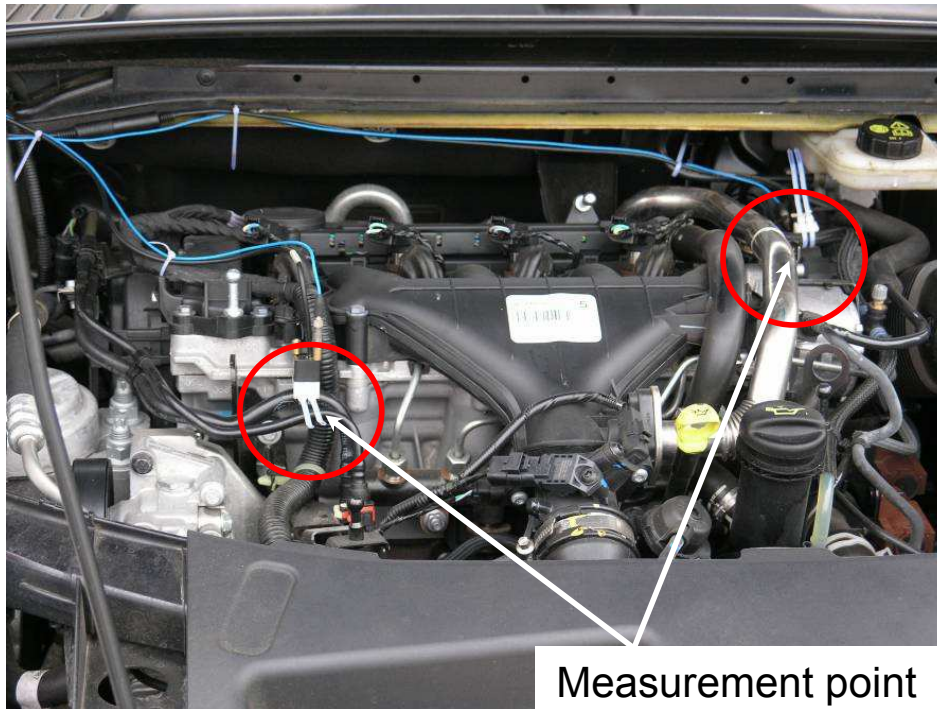
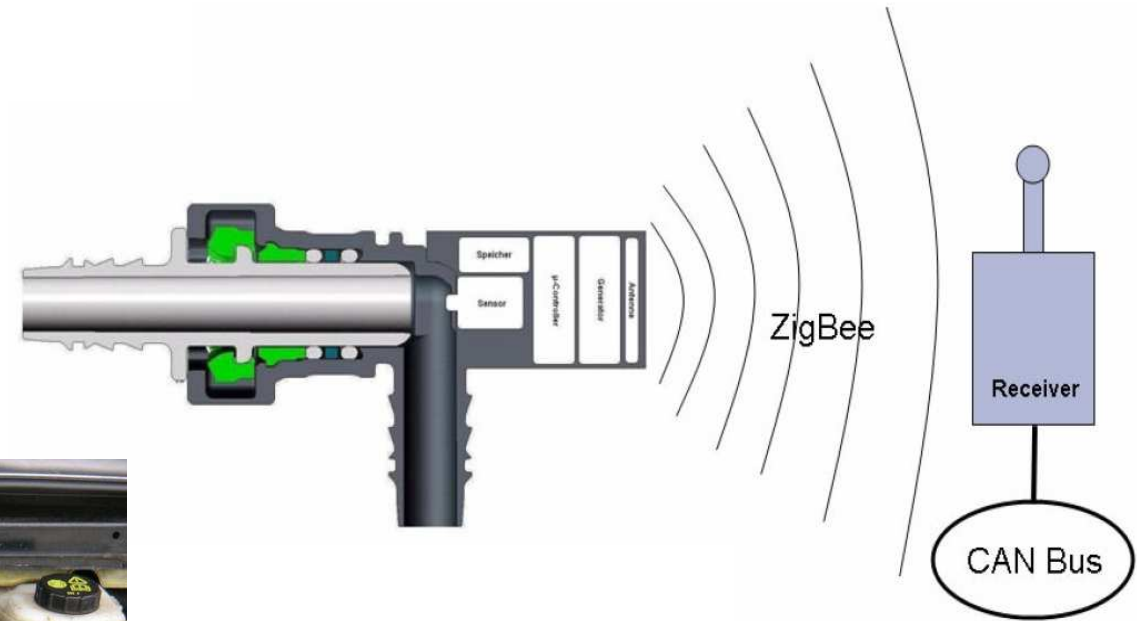
Performance limits of the coupling architectures



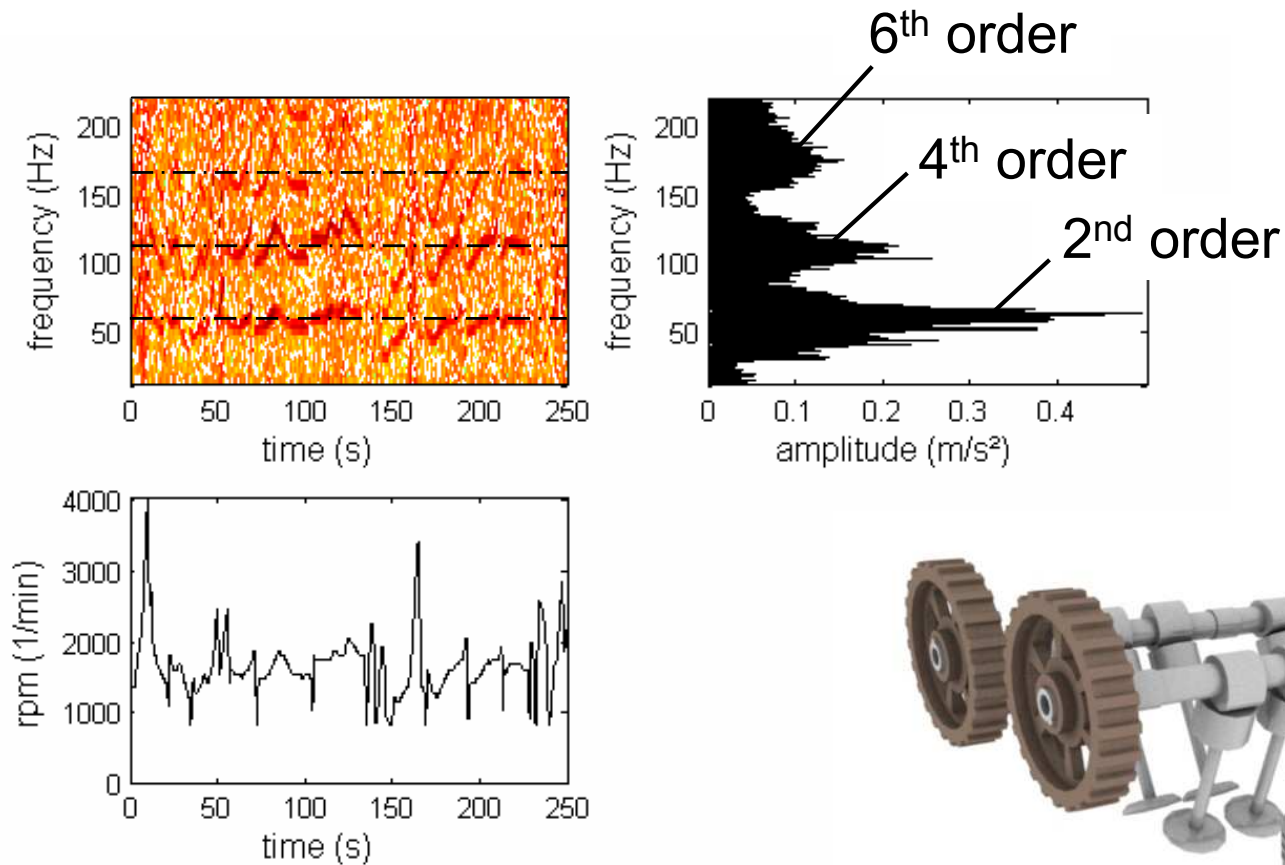
Coil topology optimization



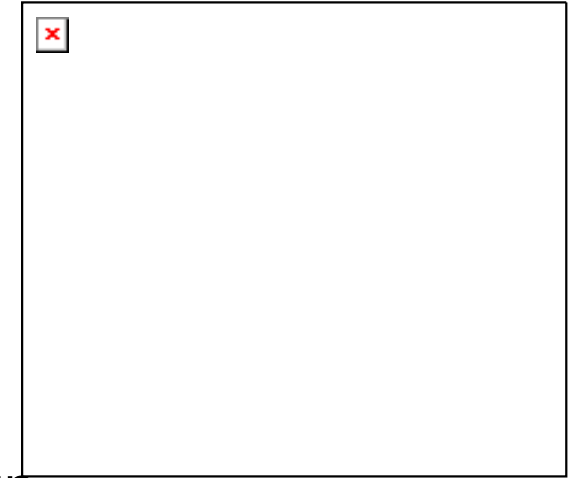
Transducer for intelligent fluid quick connector



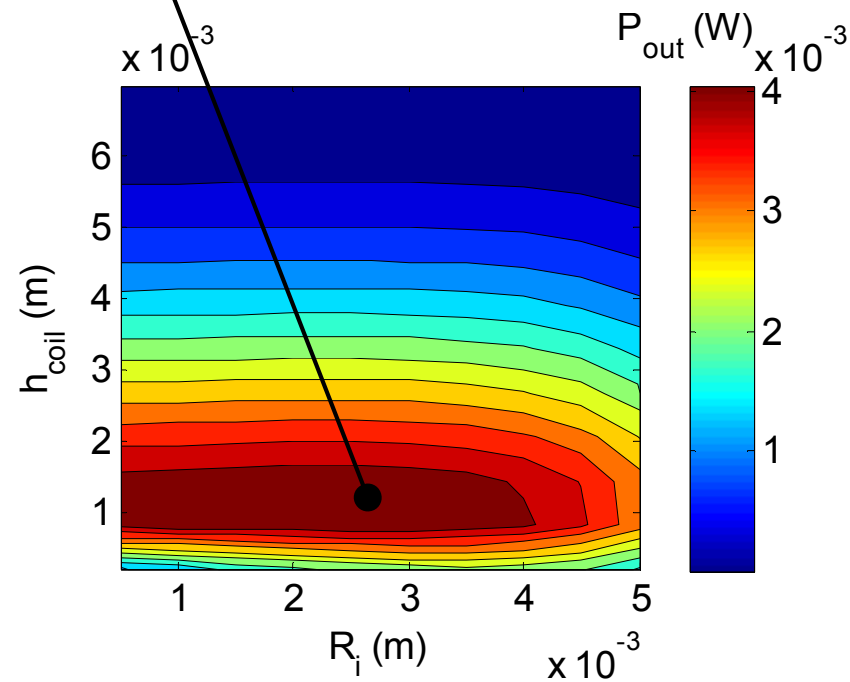
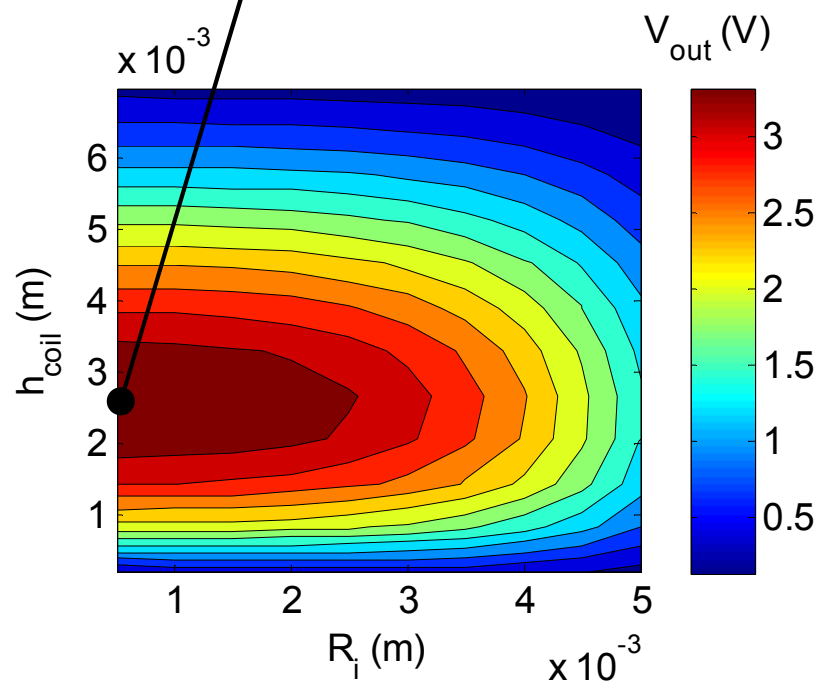
Define the most energetic resonance frequency



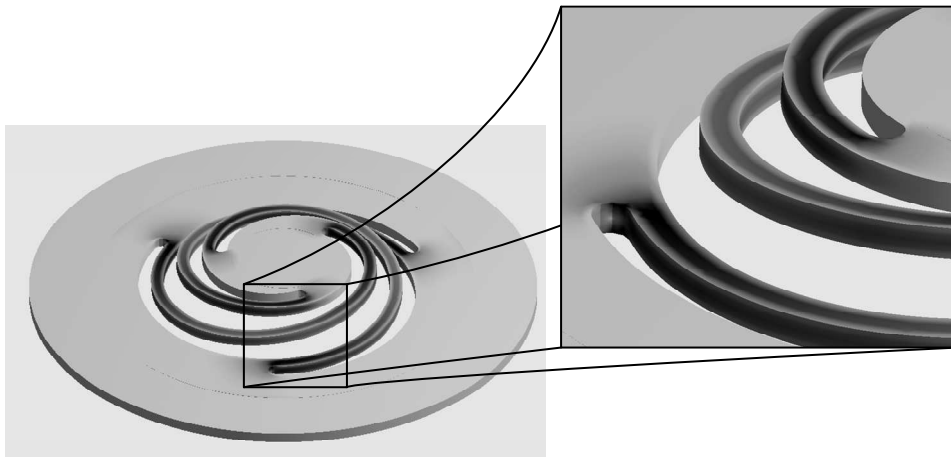
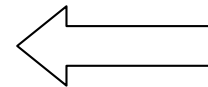
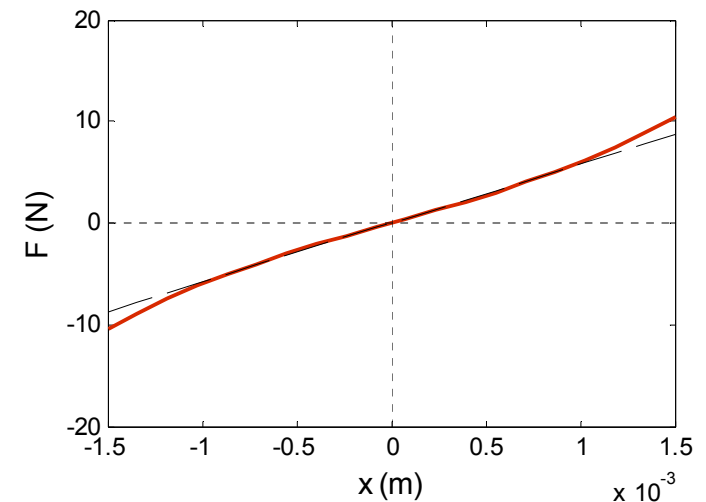
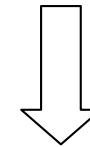
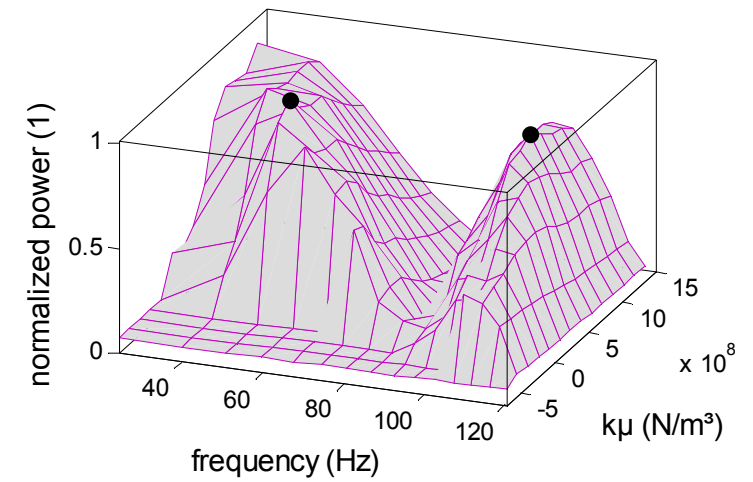
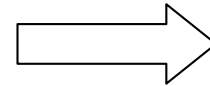
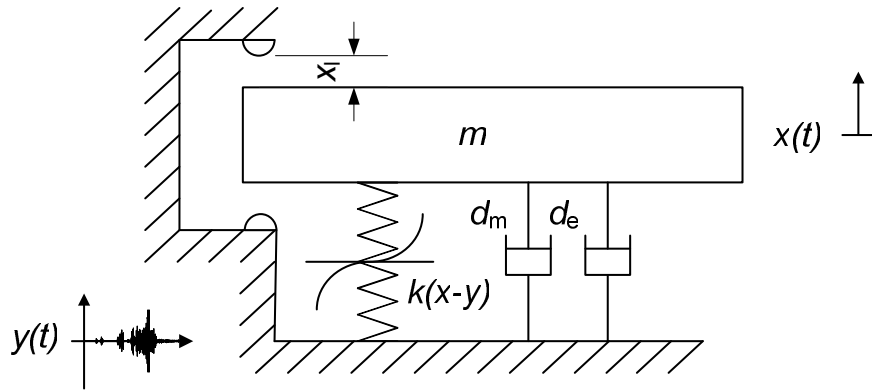
Optimal dimensioning of the magnet and the coil



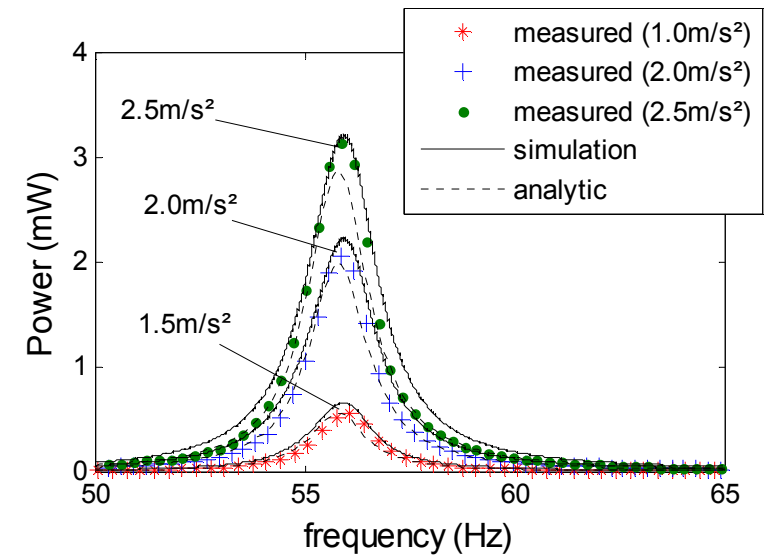
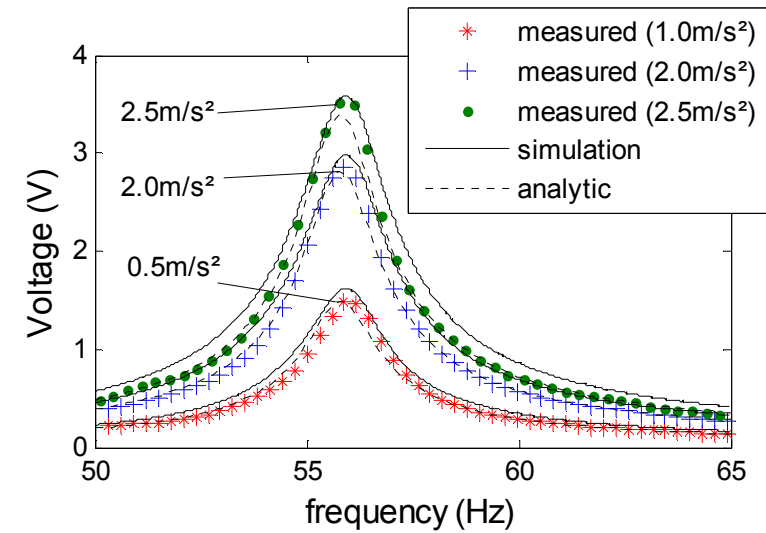
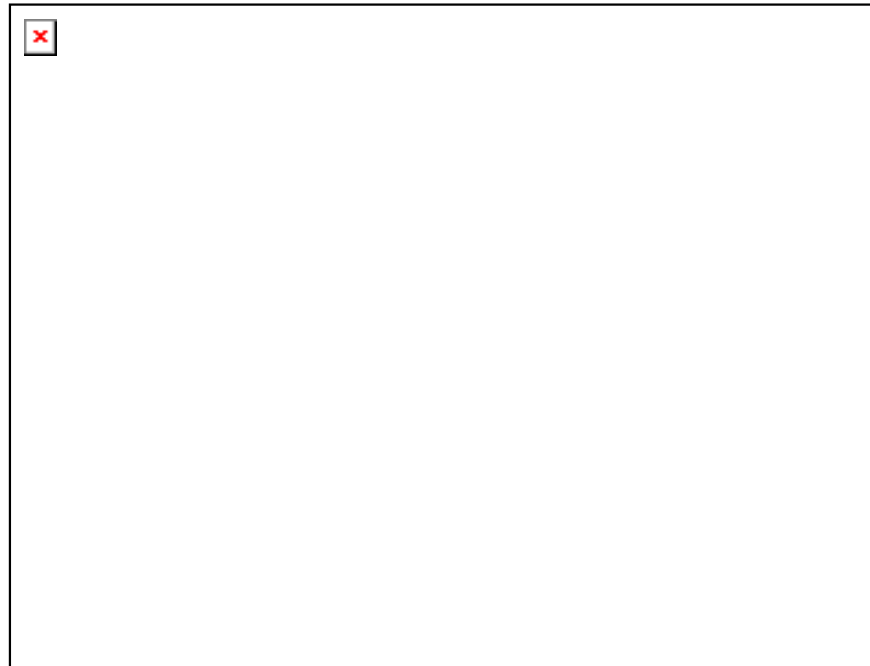
Voltage optimized design \neq Power optimized design



Optimal spring element design



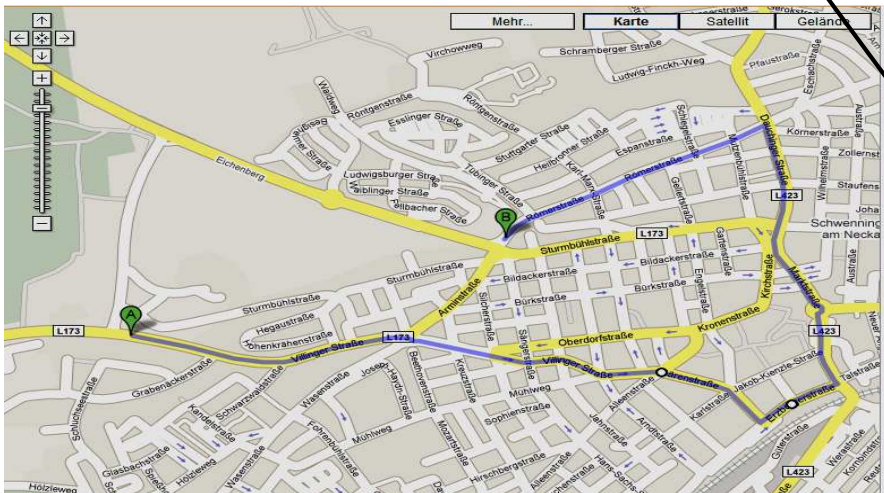
Prototype development



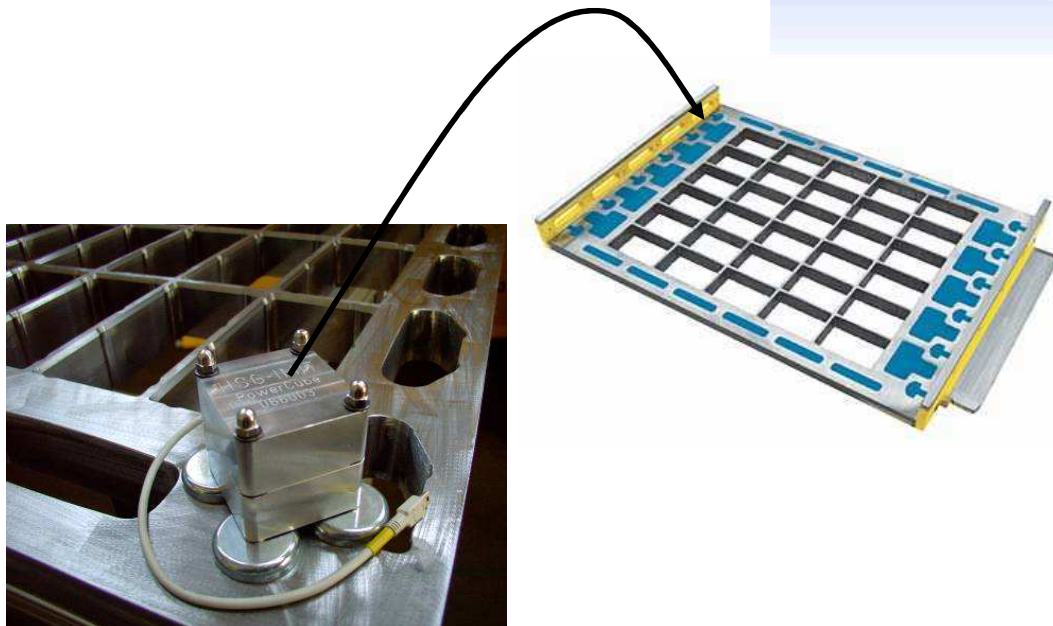
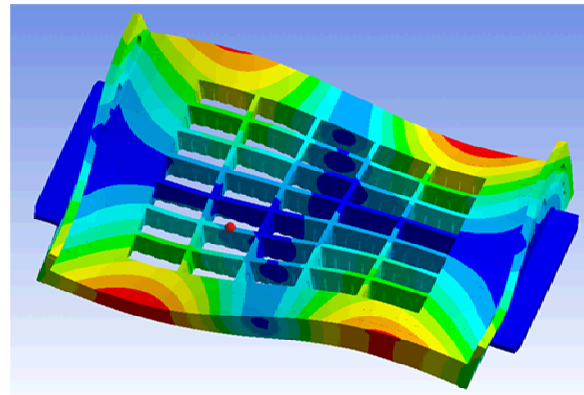
Prototype performance in operational environment



	City driving route	Country driving route	Highway driving route
Threshold voltage	Mean Power	Mean Power	Mean Power
300mV	290 μ W	473 μ W	275 μ W
700mV	270 μ W	464 μ W	264 μ W
1000mV	266 μ W	451 μ W	248 μ W



Transducer for concrete products mould

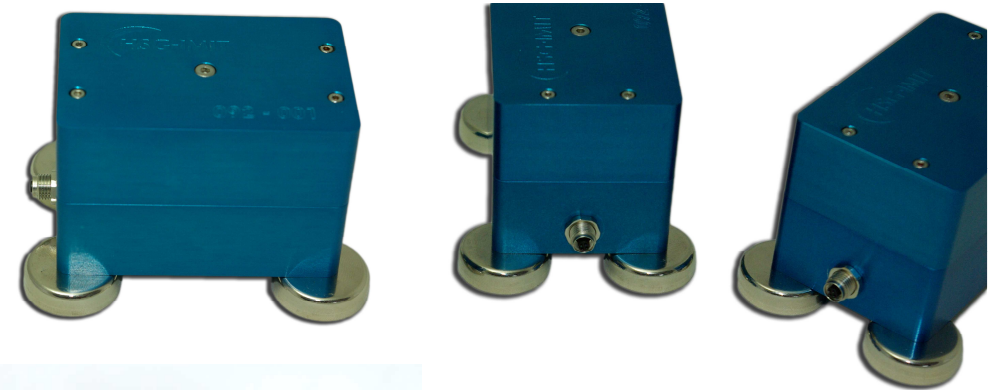


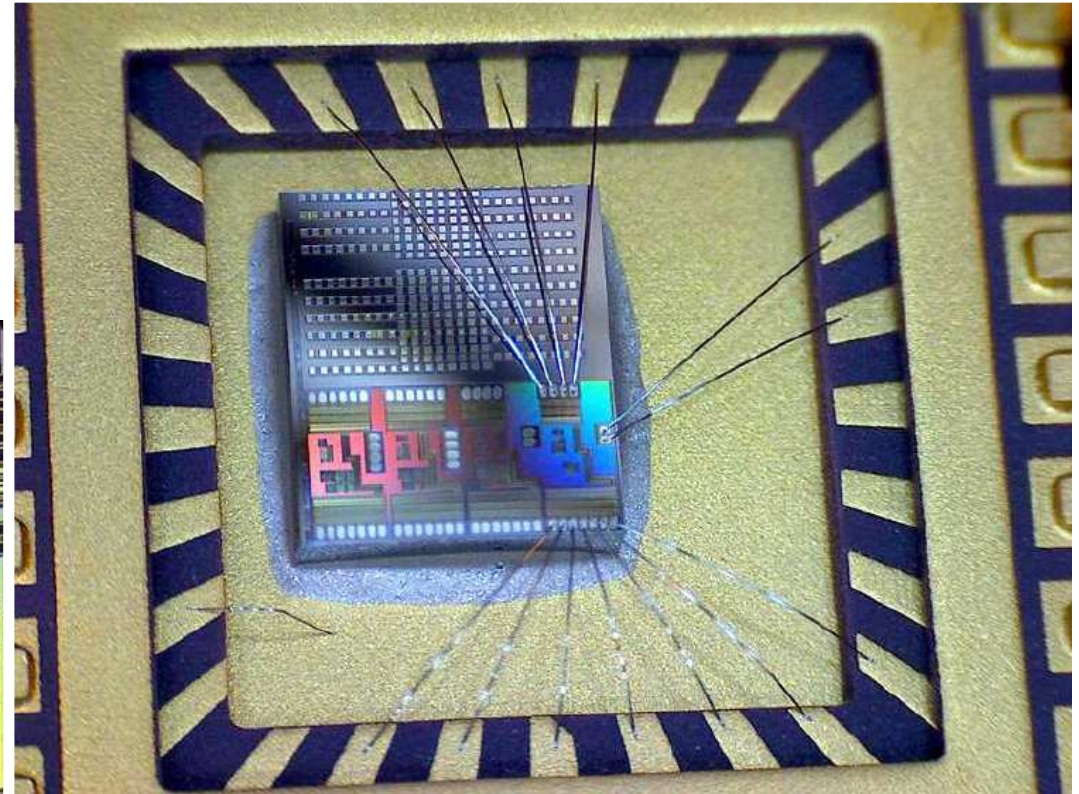
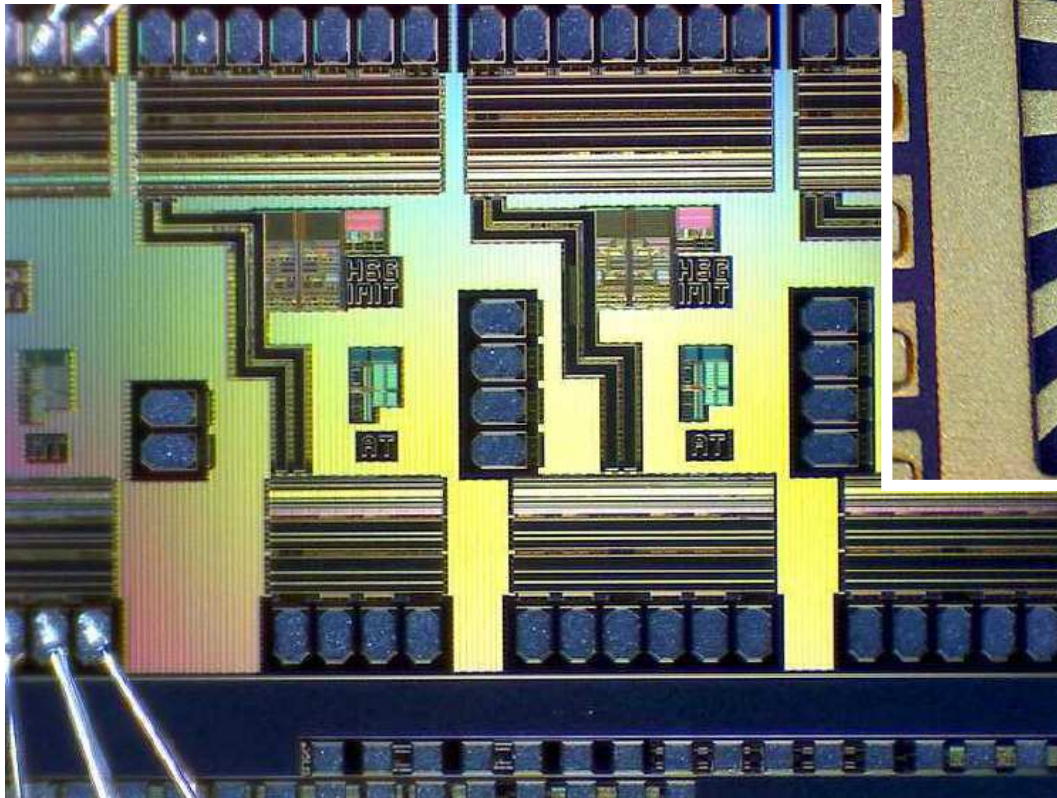
Energy harvesting in railroad application

SIEMENS

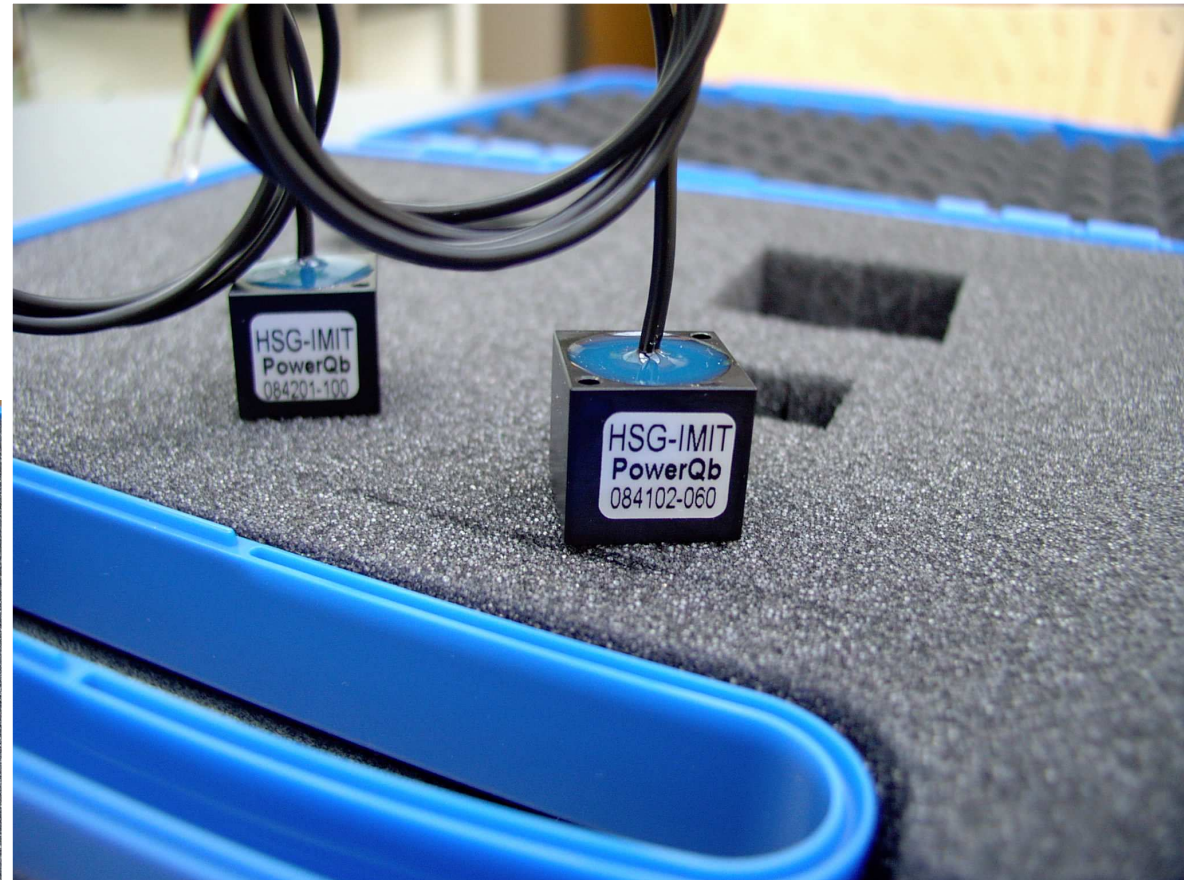
BASF

The Chemical Company





HSG-IMIT Evaluation kit



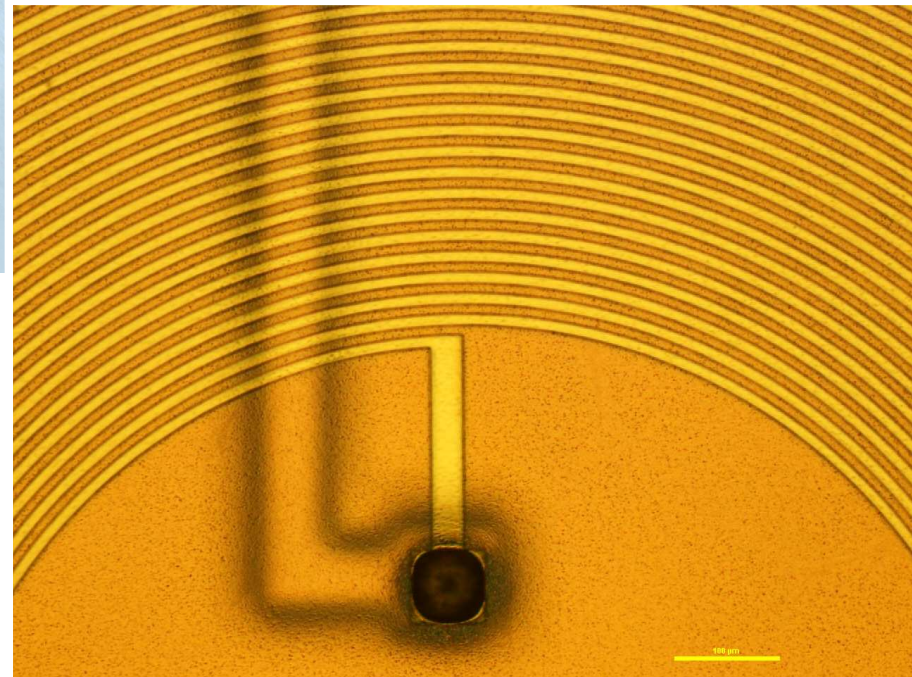
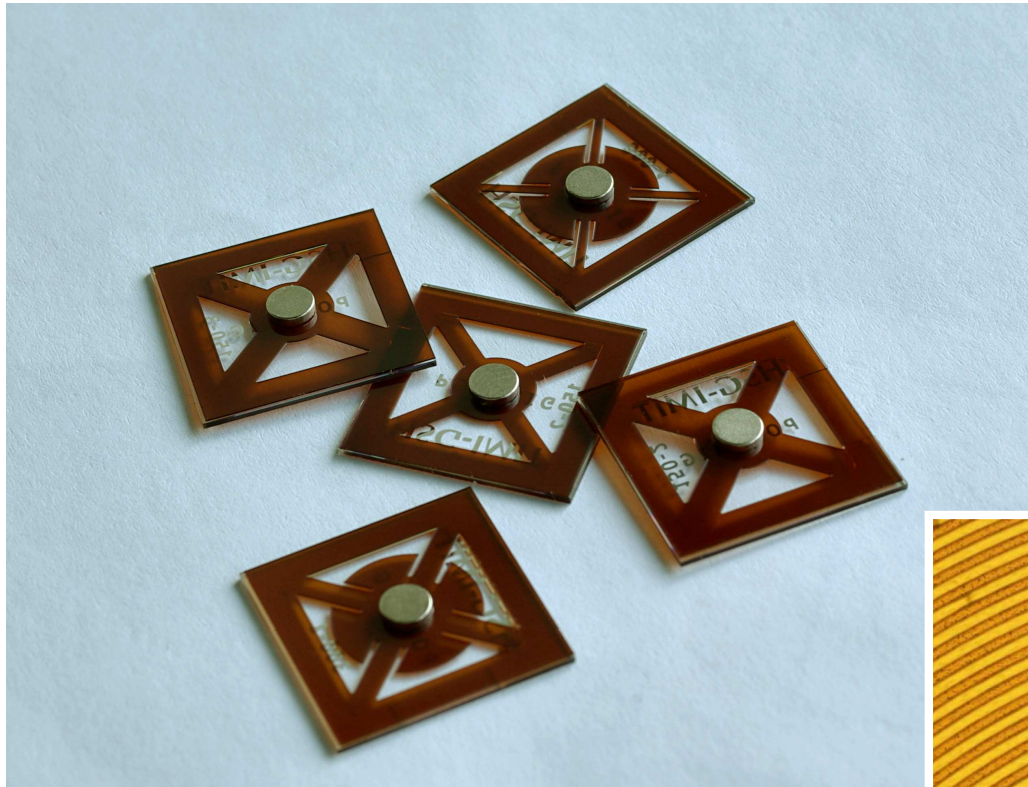
Dirk Spreemann

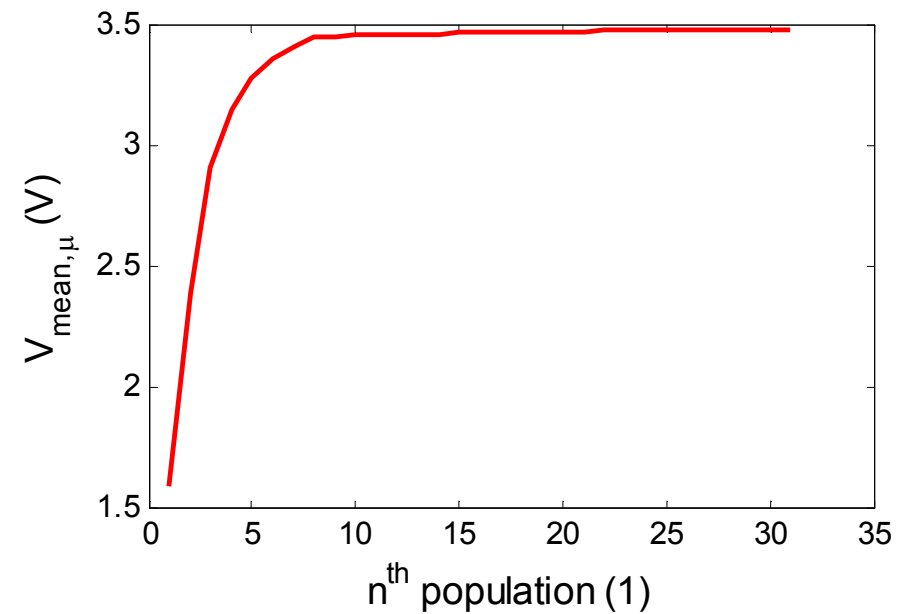
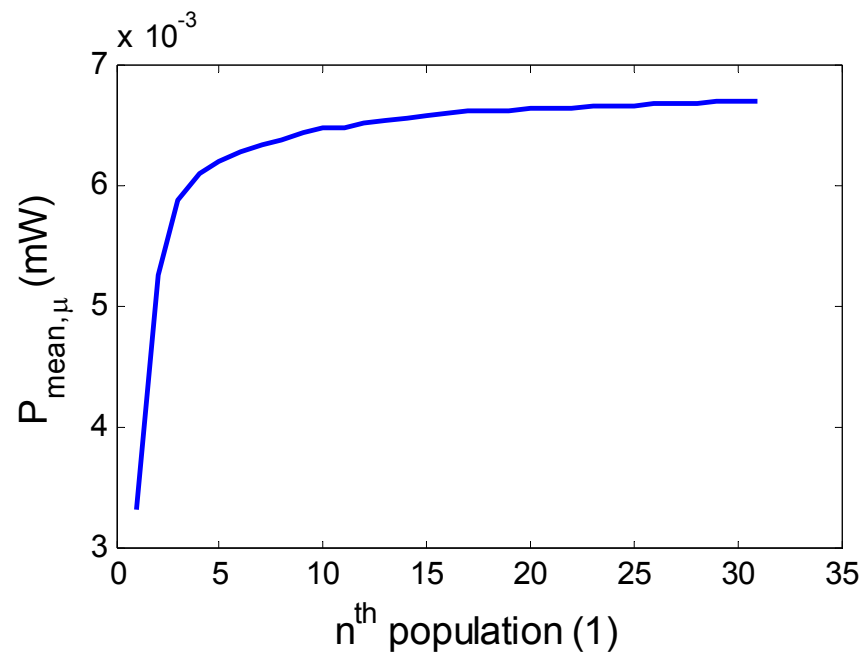
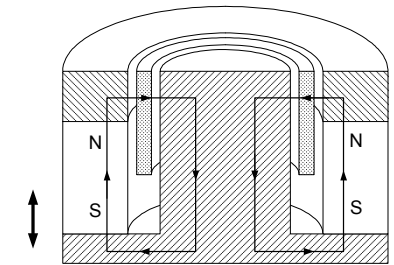
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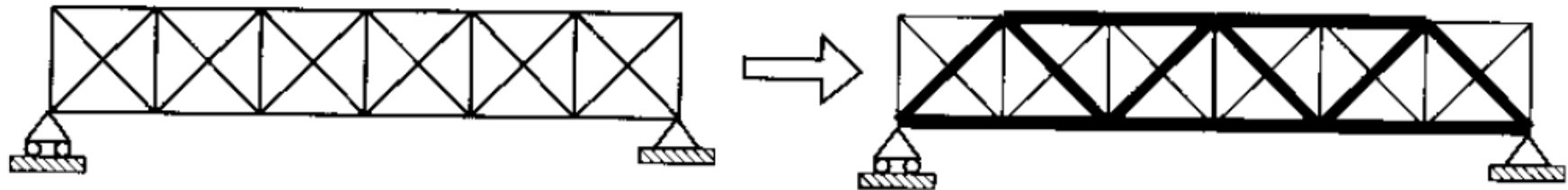
- BPI - Bekleidungsphysiologisches Institut Hohenstein e.V.
- fem - Forschungsinstitut Edelmetalle & Metallchemie
- FPL - Forschungsinstitut für Pigmente und Lacke e.V.
- FZI - Forschungszentrum Informatik an der Universität Karlsruhe
- HSG-IMAT - Institut für Mikroaufbautechnik
- HSG-IMIT - Institut für Mikro- und Informationstechnik
- ILM - Institut für Lasertechnologien in der Medizin und Meßtechnik, Ulm
- IMS - Institut für Mikroelektronik Stuttgart
- ITCF - Institut für Textilchemie und Chemiefasern, Denkendorf (DITF)
- ITV - Institut für Textil- und Verfahrenstechnik der DITF
- DITF/MR - Zentrum für Management Research der DITF
- LGR - Lederinstitut Gerberschule Reutlingen e.V.
- NMI - Naturwissenschaftliches und Medizinisches Institut, Tübingen
- ZSW - Zentrum für Sonnenenergie- und Wasserstoff-Forschung



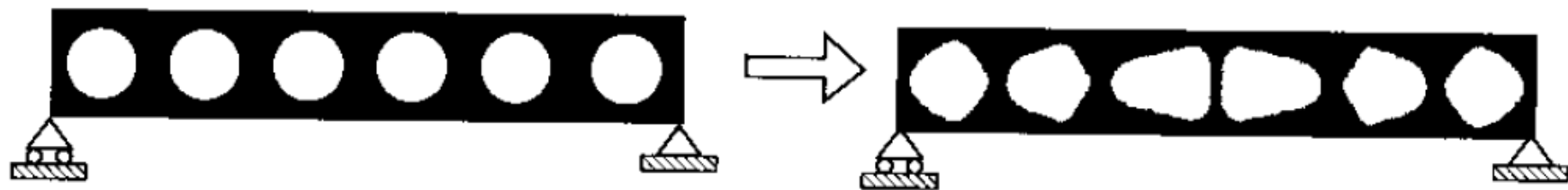


What is a topology optimization

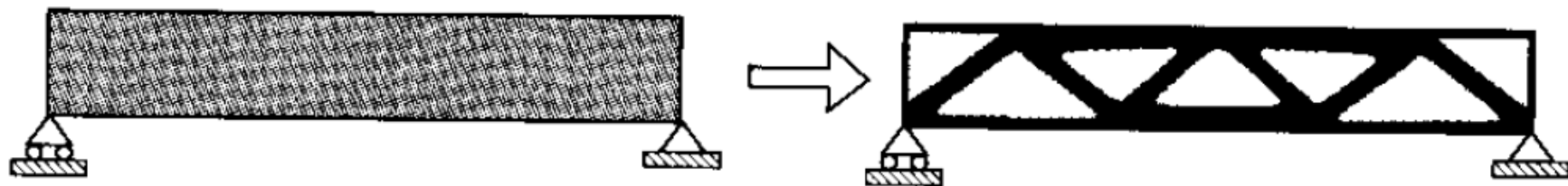
- Sizing optimization



- Shape optimization

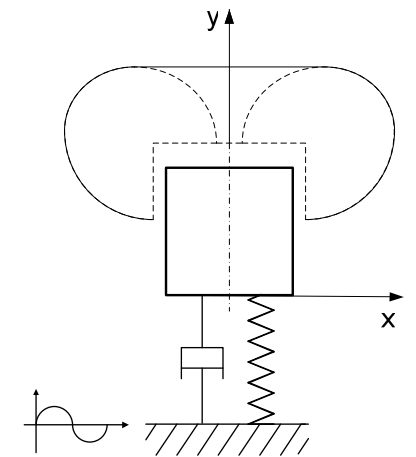
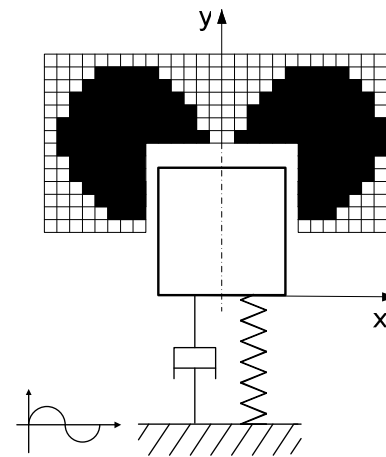
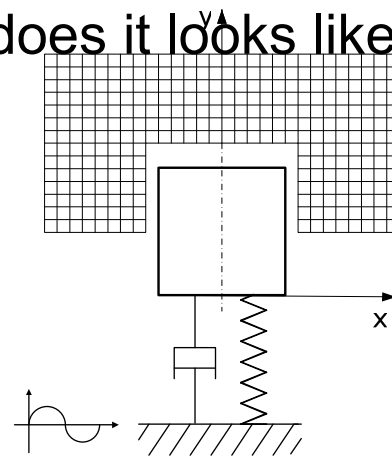
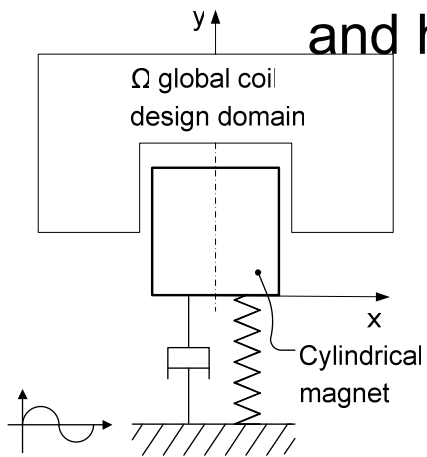


- Topology optimization

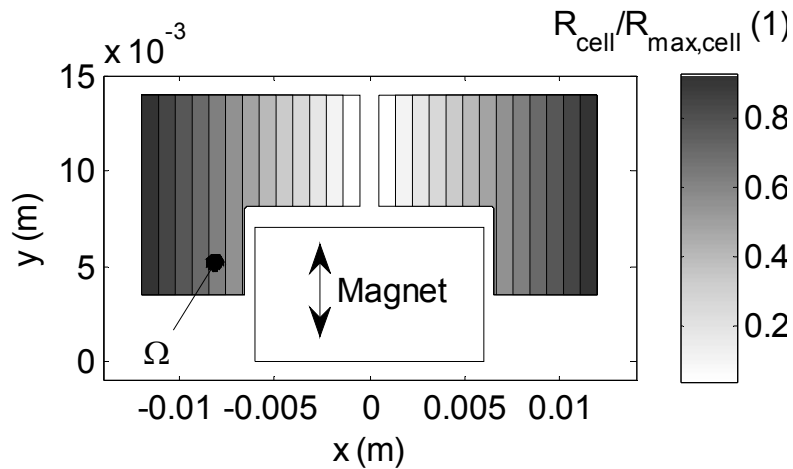


* Script 'Topology Optimization Topologische Strukturoptimierung', Prof. Nicolas Gauger, HUMBOLDT-UNIVERSITÄT ZU BERLIN

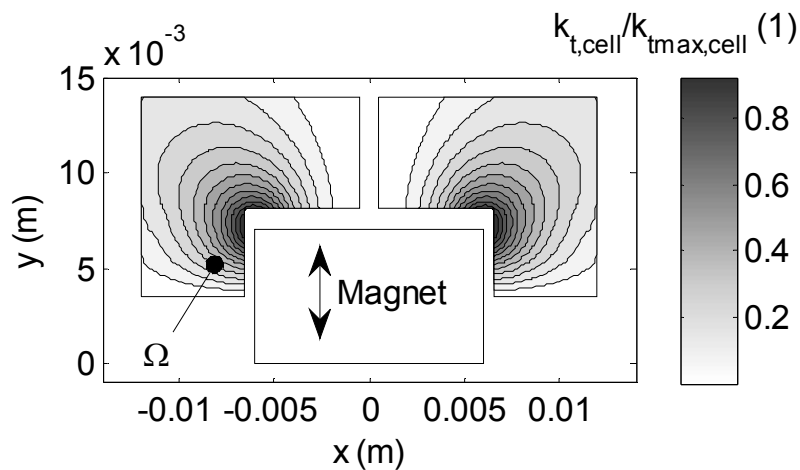
1. Defining global design domain • So far the coils are (predefined) cylindrical
2. Discretizing • But is there a coil topology for an arbitrary cylindrical magnet, which yields a higher output power than the cylindrical coil, and how does it look like?
3. Finding optimal topology
4. Interpreting final topology



Resistance



Transduction factor



$$P_{cell} \propto \frac{k_{t,cell}^2}{(k_{t,cell}^2 + R_{cell})} = \Gamma_P$$

Output power proportionality

