Contactless inductive transmission systems for high power applications

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KONTENDA GmbH – The company

- Formation on April, 24th 2007 in Magdeburg
- Continuation of the network activity
- Share holders – active members of the KONTENDA - network
- Development, production, and distribution of products and solutions of the contactless power- and data transmission and involving services
- First products in 2008

Company's founder of the KONTENDA GmbH in front of the Hundertwasser Building
1. Introduction – Benefits of contactless energy transmission

- Contactless technology prevents:
  - Conductor rails
  - Sliding contacts
  - Trailing cables
  - Slip rings
  - Plug connectors

- Increasing reliability / Reducing maintenance:
  - No wear and tear on electrical contacts
  - No cable breaks
  - No contact resistance

- Increasing safety:
  - No spark formation
  - Electrical isolation

- Simplified assembling
1. Introduction – Magnetic arrangements

Energy transmission on movable devices (linear)
Example: E / ELP-cores

Energy transmission on rotating devices
Example: Pot cores with additional data coil (PCB) in aluminium housing

Energy transmission on rotating devices (with higher positioning tolerance)
Example: Flat ferrite elements with additional data coil (PCB)

10 .. 100 mm

50 .. 150 mm

100 .. 210 mm
2. Dimension inductive systems with air gap – Determining the coil parameters

- Transformer principle
- Description by T-equivalent circuit
- Determining the T-parameters by FEA

main inductance

\[ L_h = N_1^2 \cdot \frac{\Phi_2}{i_1} \]

primary leakage inductance

\[ L_{1\sigma} = N_1^2 \cdot \frac{\Phi_1 - \Phi_2}{i_1} \]

secondary leakage inductance

\[ L_{2\sigma} = N_2^2 \cdot \frac{\Phi_2 - \Phi_1}{i_2} \]
2. Dimension inductive systems with air gap

- Important characteristics:
  - Transferable electric power, efficiency (power loss)
  - Number of consumers
  - Positioning tolerance
  - Magnetic field emission
  - Size, weight, costs

- Aim
  - Output power $\uparrow$
  - Efficiency $\uparrow$
  - Power loss $\downarrow$

- Reached by
  - Using higher transmission frequencies
  - Using of ferrite materials
  - Resonant switching operation ZCS
  - Optimisation of the coil design
3. EMC - Subdivisions and device classification

- **EMC**
  - Emission
    - Radiation
      - (f=30 MHz..1 GHz, power electronics on primary side)
    - Conducted disturbance
      - (f<30 MHz, power electronics on primary side)
  - Noise immunity
  - Measurement methods and equipment
    - Magnetic field
      - (f<30 MHz, secondary side)
3. EMC – Emission measurements

- Measurements at flat ferrite systems (P=1 kW, magnetic field probe)
- Limit values* are kept at a distance of 10 cm (x-dir) to the transmission system (15 cm at displacement)

*reference limit values of the BGV B11 and the ICNIRP guidelines for full-time exposition
4. Power electronics – Modular power electronic components

Enables the simulation of the whole circuit:

- Filter dimensioning
- Static behaviour (conduction losses)
- Dynamic behaviour (estimate voltage peaks and switching losses)
- Control techniques of the inverter topologies
- Controlling the output voltage
4. Power electronics – Developed inverter prototypes

- Half-bridge inverter for single phase connection, 1 kW
- Full-bridge inverter for single phase connection, 2 kW
- Full-bridge inverter for automotive (12V), 400 W
5. Combined energy- and data transmission

Apart from conventional wireless techniques:
-> Inductive data transmission (magnetic near field coupling)

- Geometrical and frequency bandwidth isolation
- Applications
  - Data transmission (bidirectional) for control processes
  - Consumer identification (copy protection, similar RFID-technology)
  - Position detection of the secondary device
6. Applications – Stranding machines

**Technical data**

- **Coil configuration:** axis-symmetric
- **Input:** AC 230 V, 50 Hz
- **Output power:** 2 kW
- **Air gap:** 28 mm
- **Efficiency:** > 90 %
- **Data transmission:** inductive
  - 115 kBaud

Sensors / actors on the secondary side:
- 4 Initiators
- 1 Ultrasonic sensor
- 2 Three-phase drives
6. Applications – Power supply on rotating devices for sensor- and actor-modules

**Technical data**

- **Coil configuration:** axis-symmetric
- **Output power:** 60 W
- **Air gap:** 5 mm
- **Horizontal tolerance:** 1 mm
- **Transmission frequency:** 100 kHz
- **Total efficiency:** >85 %
- **Data transmission:** 115 kBaud, half duplex
- **Safety class:** IP 64

**Distributor:**

*KONTENDA GmbH*
7. Summary

- Complex system / new demands on …
  - Magnetic transmission system
  - Power electronics
  - Control technique
  - Combined energy and data transmission

- Design of the entire system by means of …
  - Field simulation (EM FEA)
  - SPICE
  - Analytical expressions (transfer function)
  - Experimental setup (laboratory)
  - Norm conditions / regulation (safety, EMC)