Development and Testing of Solid-Bourne Sound Sensor for Bearing Faults Based on a Piezo-Electric Foil

Jurij Kern, Elaphe Propulsion Technologies Ltd.
Carsten Thun, Hella Fahrzeugkomponenten GmbH

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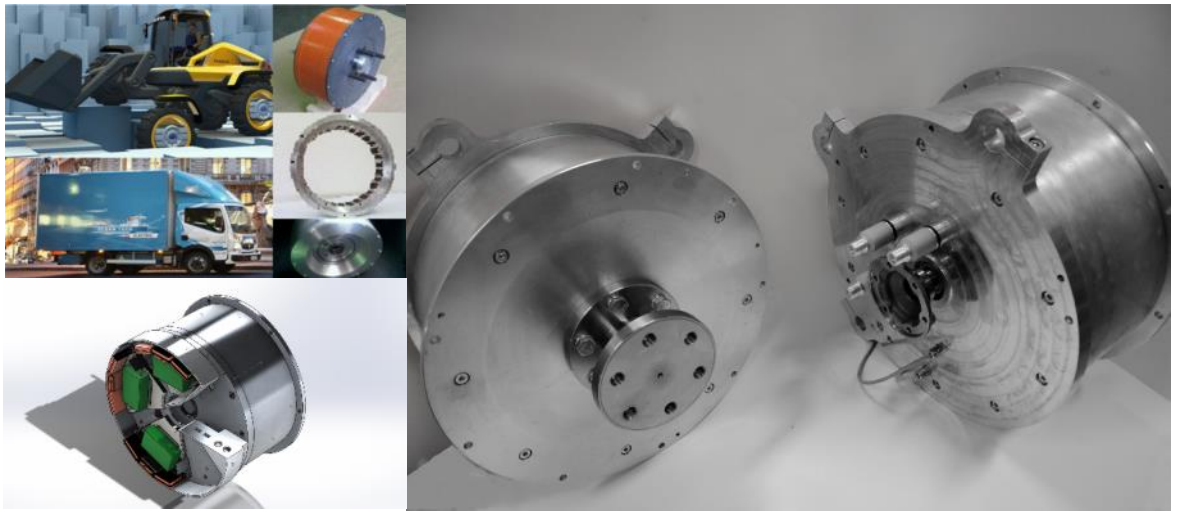
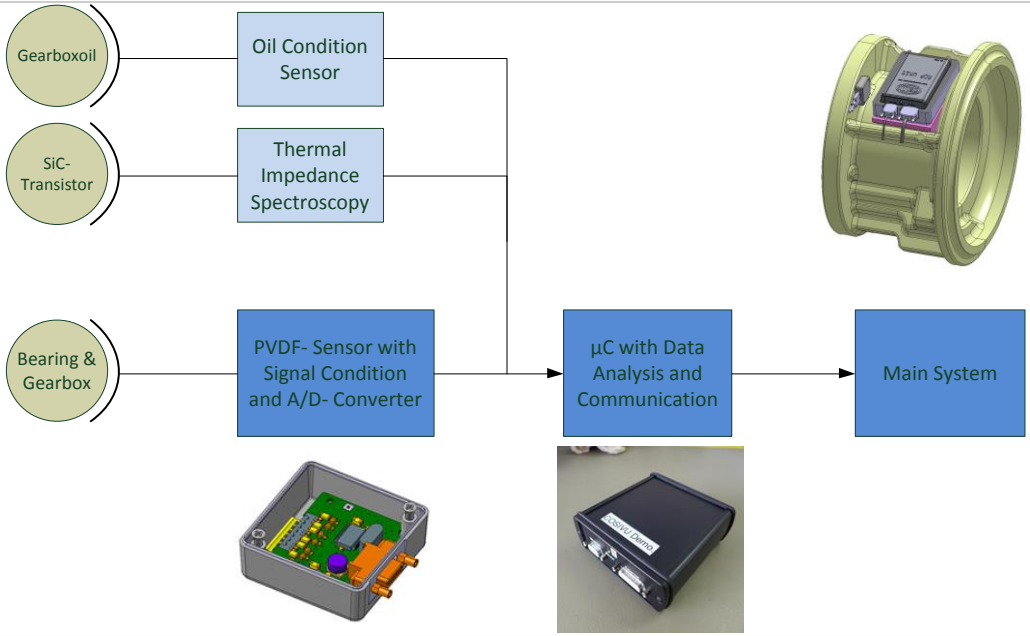
COSIVU project



Key goals

- Consortium consists of: Swerea IVF AB, Volvo Technology AB, TranSiC AB/Fairchild, Hella FZG GmbH, Sensitec GmbH, Elaphe Ltd., Nanotest GmbH, Fraunhofer ENAS, Fraunhofer IISB, Technische Universität Chemnitz
- Reliable smart, compact and durable design of a drive unit with integrated SiC power electronics
- Novel control & Health monitoring module
- Increased reliability and performance achieved with integrated sensors and advanced fault assesment algorithms

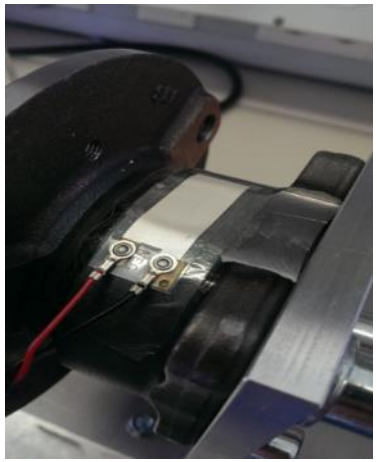
Condition monitoring

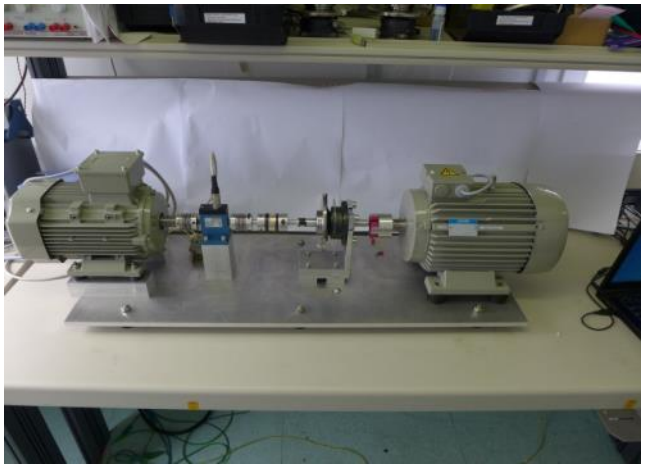


Features

- Powerful set of maintenance, control and parameter monitoring strategies to increase durability and availability of the system
- Includes noise&vibration, temperature, current, voltage, liquid flow, oil monitoring
- Provides early warnings of system faults and system breakdowns
- Maintenance costs are decrease, down time of the system is minimized, remaining useful time is prolonged

Solid bourne sound sensor- PVDF foil

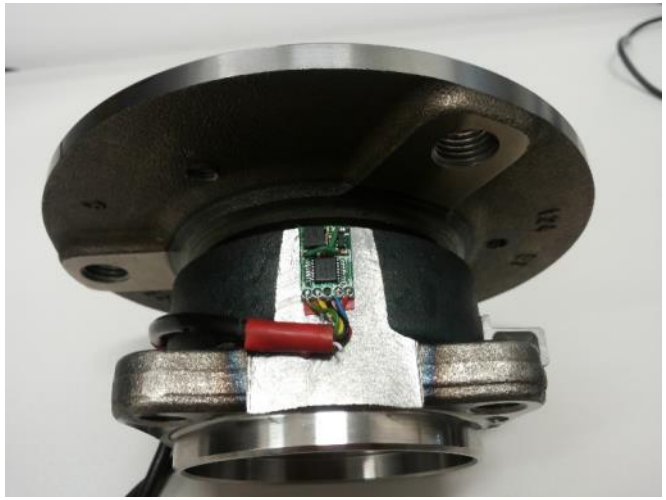


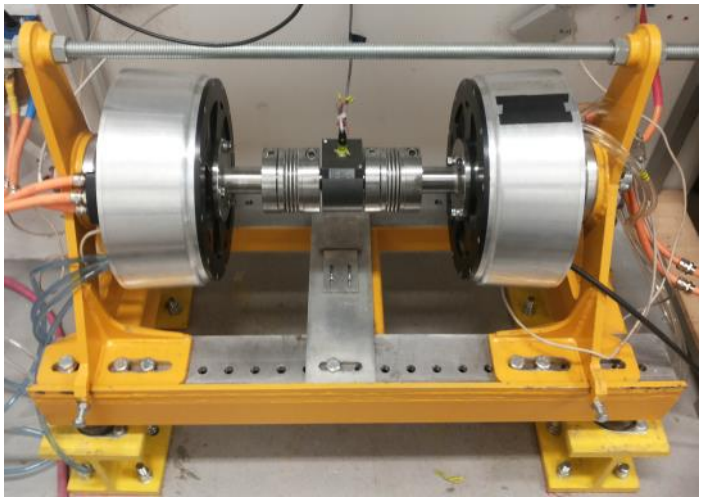


Features

- Piezo-electric foil can be attached to curved geometry
- Small size and low thickness
- Low-cost solution
- High voltage output
- High frequency response (0,01Hz-1GHz) which is beneficial for early fault detection
- Shielding is necesarry to improve signalo to noise ratio

Measurement set-up – reference sensor





- Motor - generator system-> test bearing mounted on the generator
- 2 in-wheel type motors with 550Nm peak torque, connected via couplings and torque sensor
- Low pass filter applied at 1kHz to prevent anti-aliasing
- NI USB-6212 DAQ card
- ADXL325 capacitive accelerometer – frequency response 1,6 kHz, which is not beneficial for early fault prognosis
- Easy to connect, negligent EMC noise
- 600 rpm, constant speed with minimal load

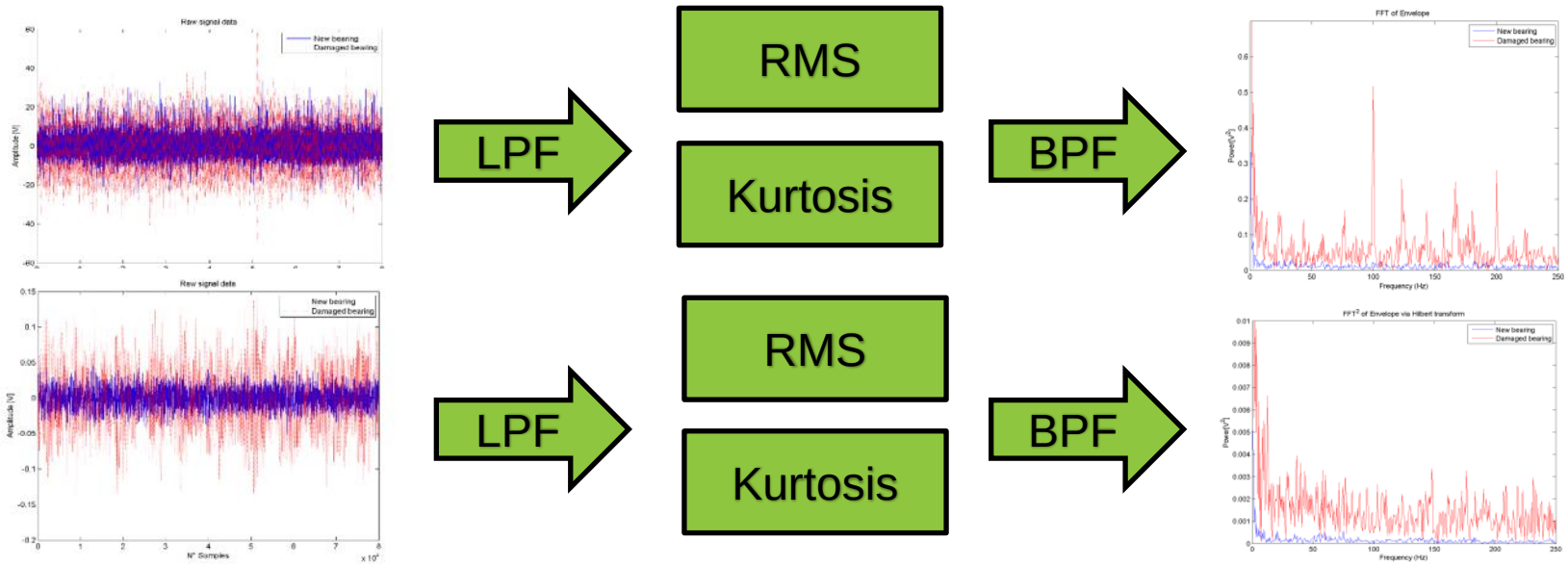
Bearing faults

Induced faults on the outer ring and balls

Common faults

- Account to almost 40% of all faults in PMSM motors
- Increased vibration and noise,
- Some bearing faults cause uneven airgap operation, which accelerate the fault progression
- Severe bearing faults can cause rotor/stator contact, which damages the permanent magnets
- Leakage currents to the ground cause sparking between the balls and the running surface
- Eccentricity induces additional load on the bearings
- Common bearing faults: Pitting, fretting, brinelling, flaking, wear, running surface cracks, fracture, contamination

Data analysis



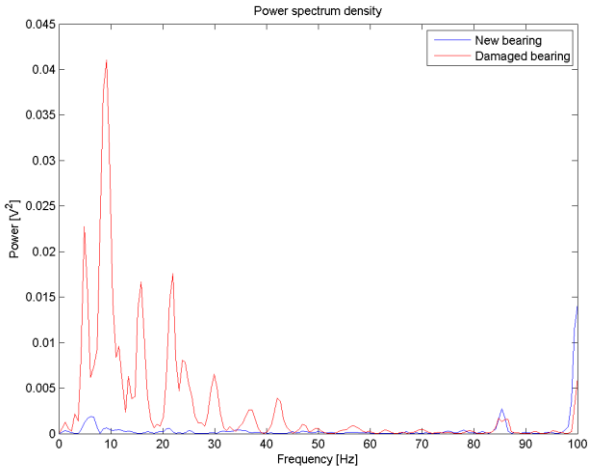
New bearing - blue

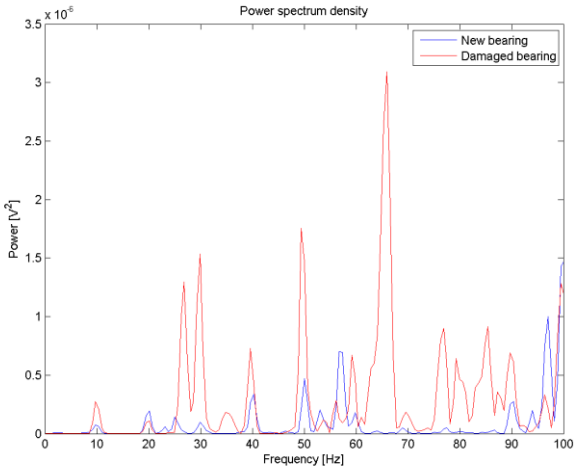
- Low amplitude vibrations
- Very few or no peaks in the signal
- Kurtosis has a value of 3, which is consistent for a healthy bearing
- Both sensors show similar results

Damaged bearing - red

- Peaks can be seen in the raw data
- Kurtosis is higher than 3 from both sensors
- PVDF foil shows a more clear picture of 2xBPFO and ball defect in envelope analysis
- Defects from ADXL325 data are difficult to identify, but BPFO can be seen

Data analysis





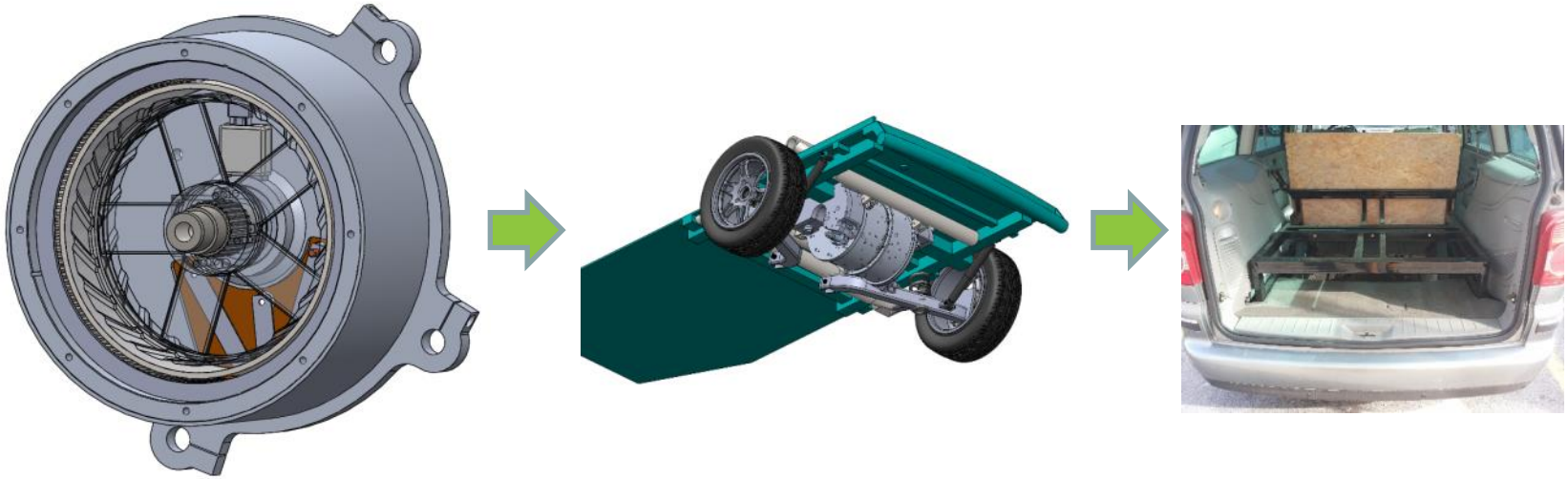
PSD- PVDF

- Rotating frequency visible
- Ball pass rolling frequency visible BPRF
- Low amplitude peaks, but can be differentiated from new bearing data

PSD-MEMS

- Rotating frequency visible
- BPRF visible – 26 Hz
- BPFO visible – 67Hz

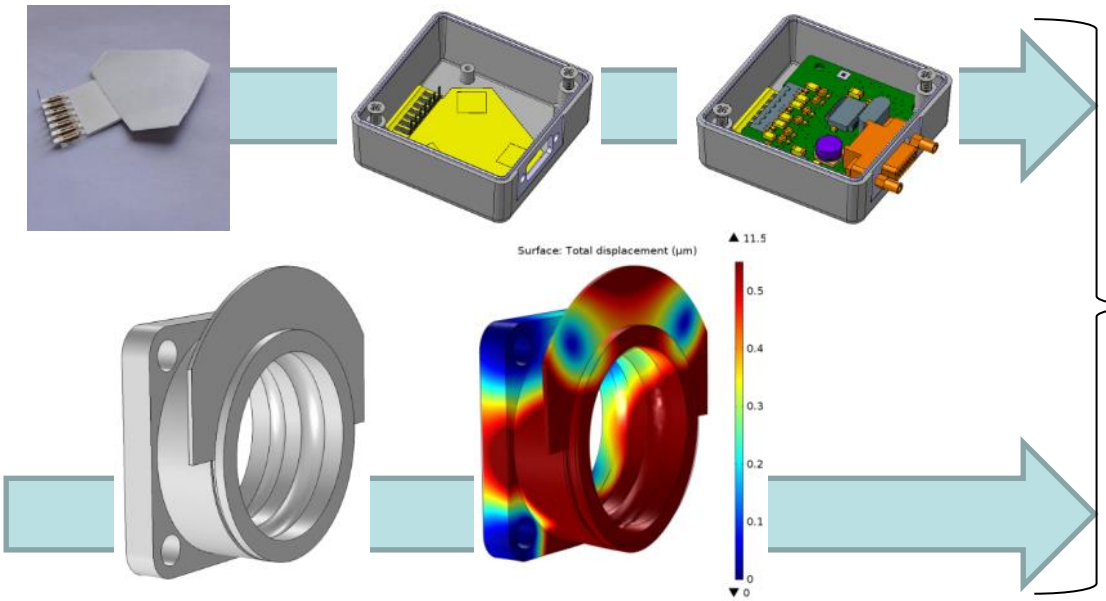
Sensor integration in the direct drive motor



Features

- Compact size
- Box is fitted above the bearing and enclosed inside the motor
- 2x Inverter ESB are integrated in the design of the near-wheel direct drive propulsion system
- 2x800Nm continuous torque, 1250 rpm
- Direct drive traction via original half axis

Next steps



Validation at Test rig

Reference with Laservibrometer and Accelerometer and MEMS

Features

- Integrate sensor with signal conditioning in a compact box
- Improve PVDF Foil enviroment through foil shielding and proper housing
- Improve sensing performance by mechanical amplification
- Improve fault identification with FEM modelling

Thank you for listening

Questions?