



Piezoelectric Patch Transducers: Can alternative sensors enhance bearing failure prediction?

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Who are we?



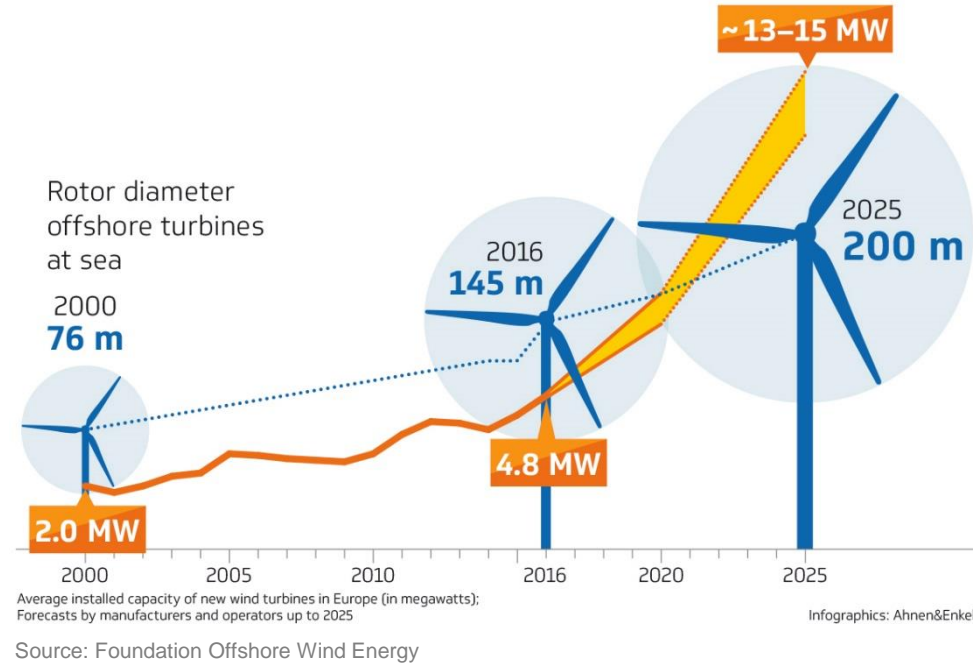
- University of Applied Sciences Hamburg
 - Competence Center for Renewable Energy and Energy Efficiency
 - 70 associates working in 30 different renewable energy projects
 - Topics:
 - Wind energy, energy storage, digitalization, sector coupling, acceptance and sustainability, and systems integration

cms@wind

- Condition monitoring company based in Hamburg
 - Development of condition monitoring hardware

Motivation for the project

A GROWTH IN CAPACITY



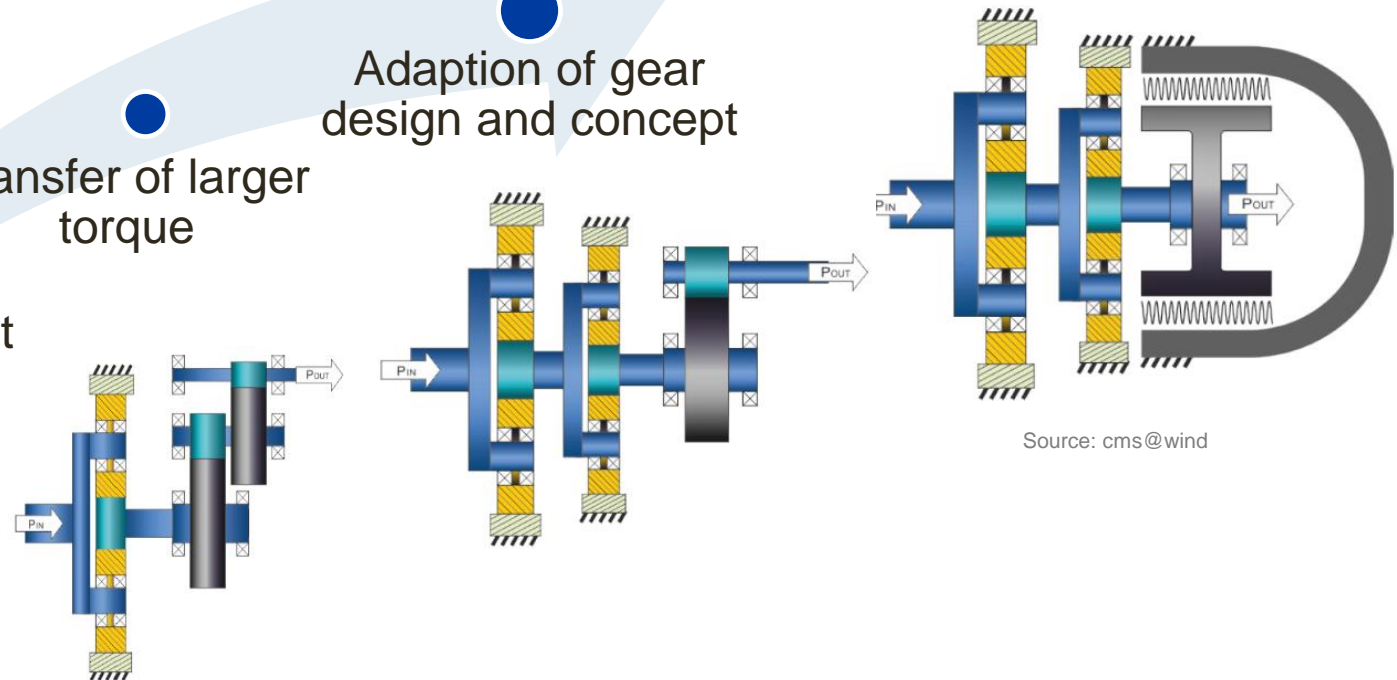
Correlation between turbine and gear growth

- ⇒ Increase of stiffness and damping
- ⇒ Incipient faults get more intricate to retrieve

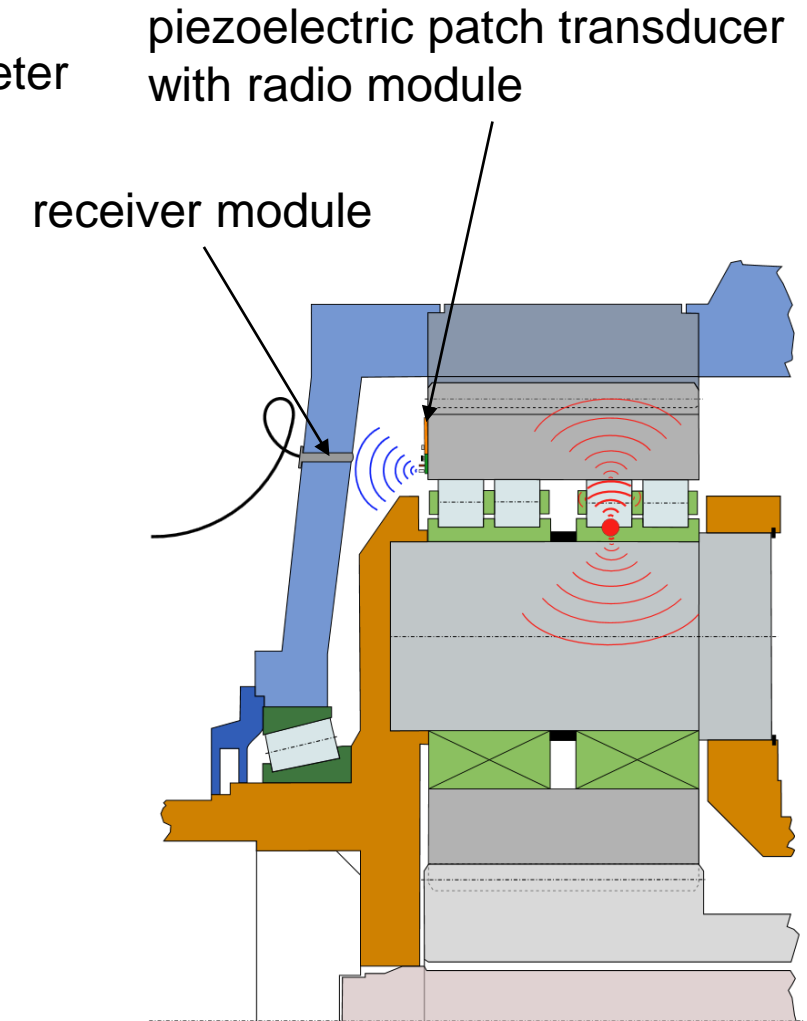
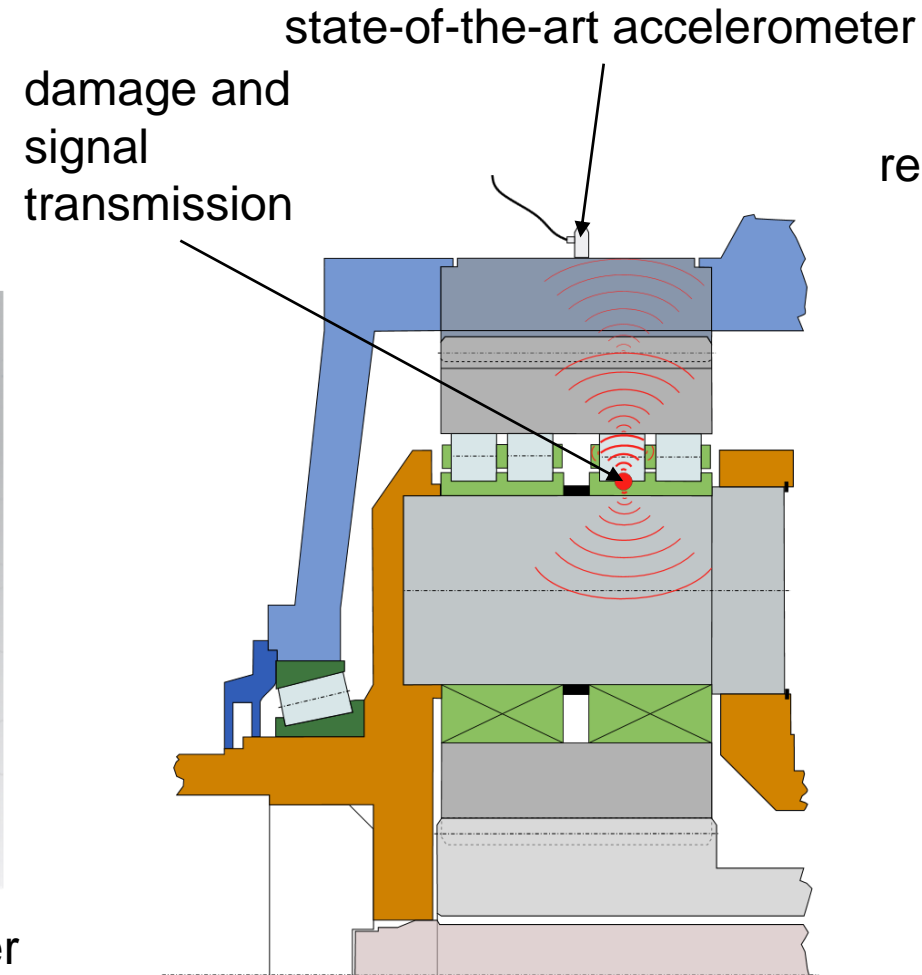
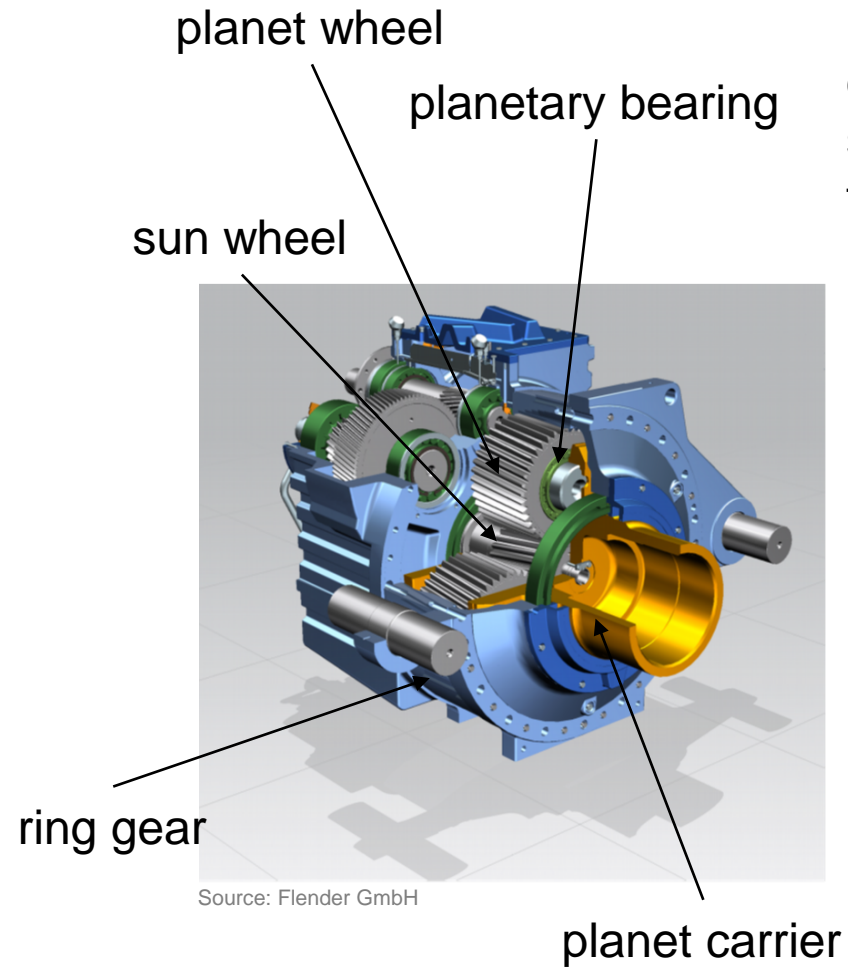
Growth of height and capacity

Transfer of larger torque

Adaption of gear design and concept

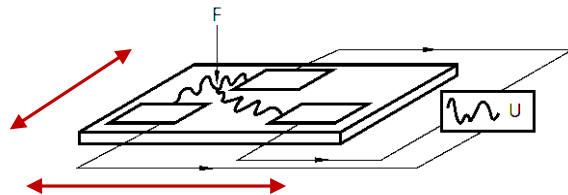
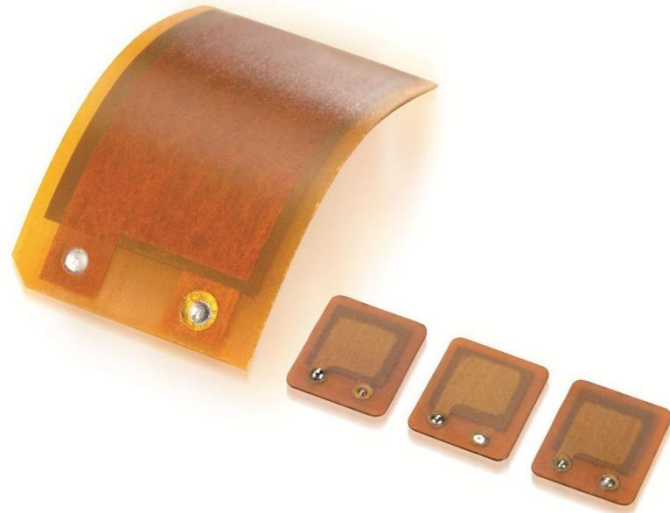


Fundamental idea – changing the measurement position for planetary bearings



Test object, competitor and matters of interest

Piezoelectric patch transducer



Sources: PI Ceramic GmbH

Questions concerning the applicability of patch transducers as condition monitoring sensors for the drive train:

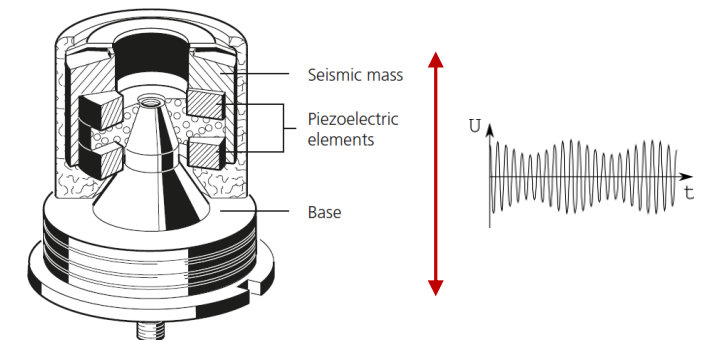
- Temperature stability?
- Sensitivity toward electromagnetic interference?
- Ability to detect bearing faults?



Accelerometer



Source: Voith Digital Solutions GmbH



Source: PRÜFTECHNIK Dieter Busch AG

Experimental setup – frame conditions



Temperature range -40 °C...+80 °C



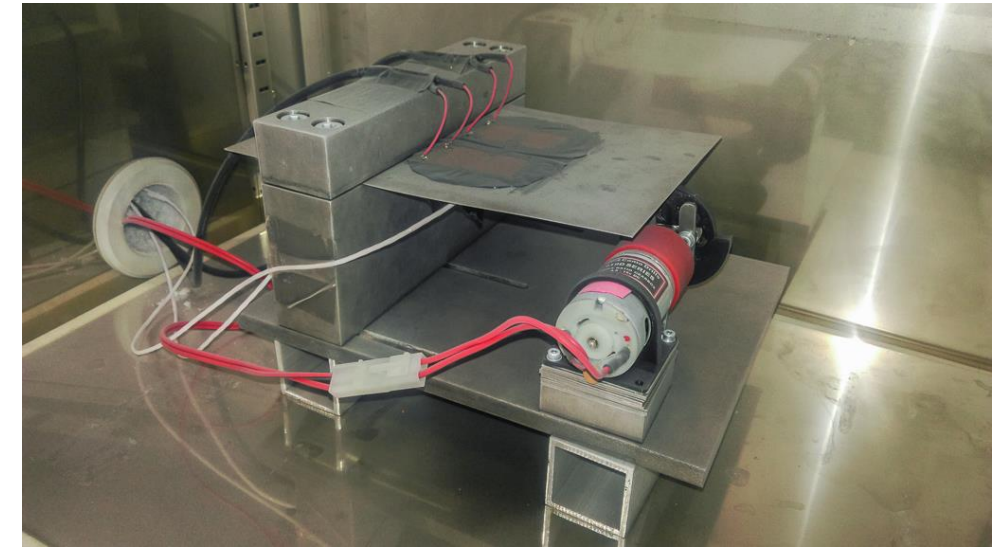
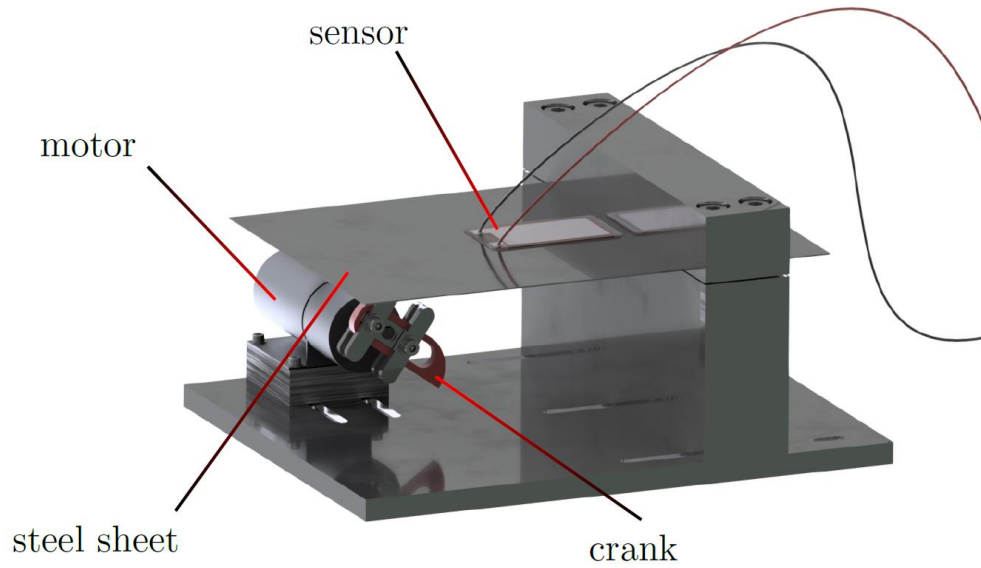
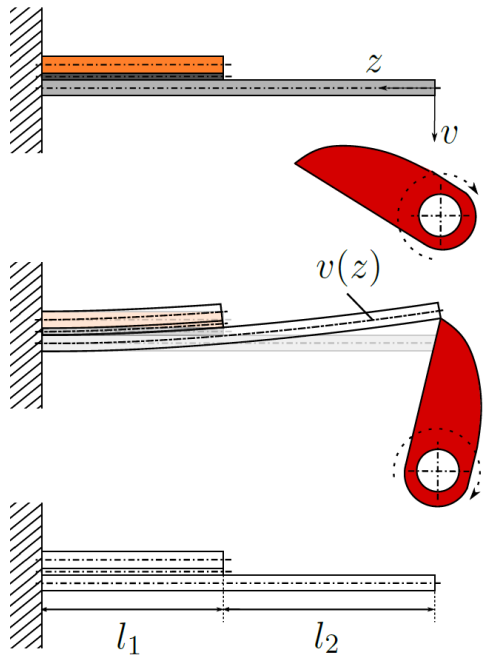
Frequencies < 12 kHz

Magnetic field strengths $0.1 \frac{\text{kA}}{\text{m}} \dots 6.0 \frac{\text{kA}}{\text{m}}$



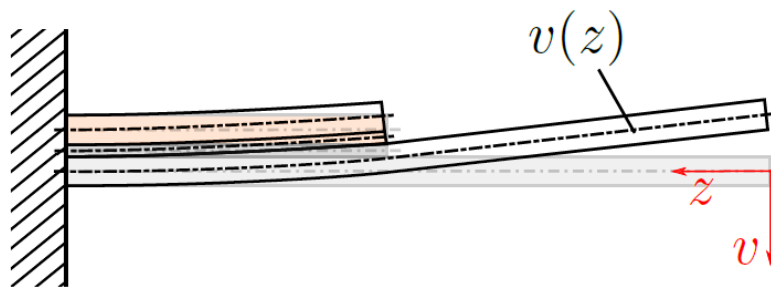
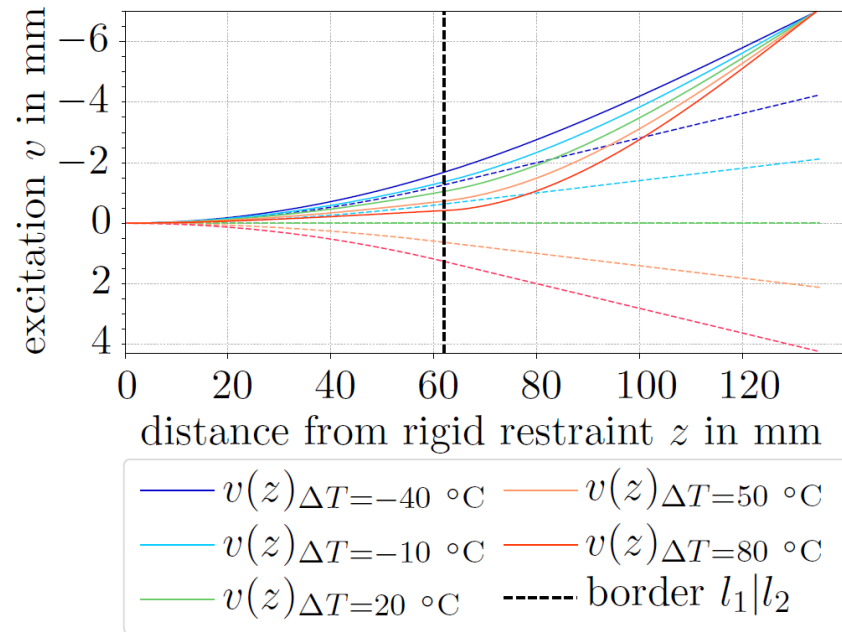
Rotational speeds 0 rpm...1500 rpm

Bearing damages Inner ring, outer ring, rolling body, wear and combinations

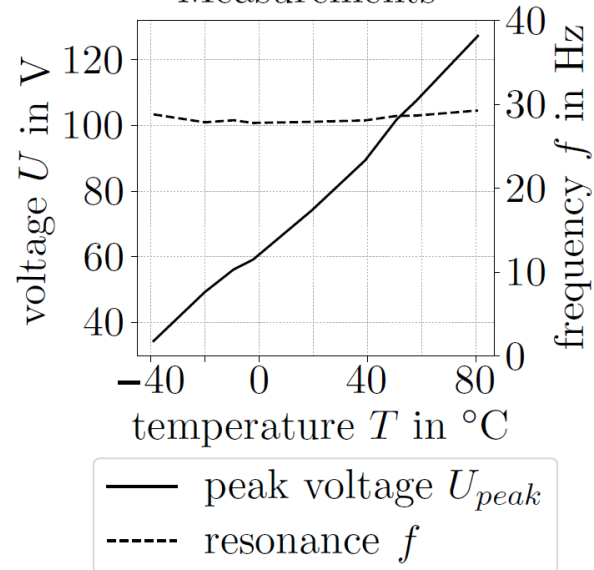




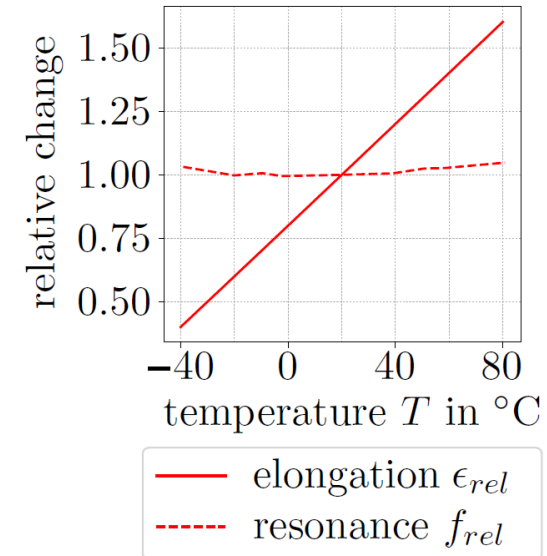
Bending lines



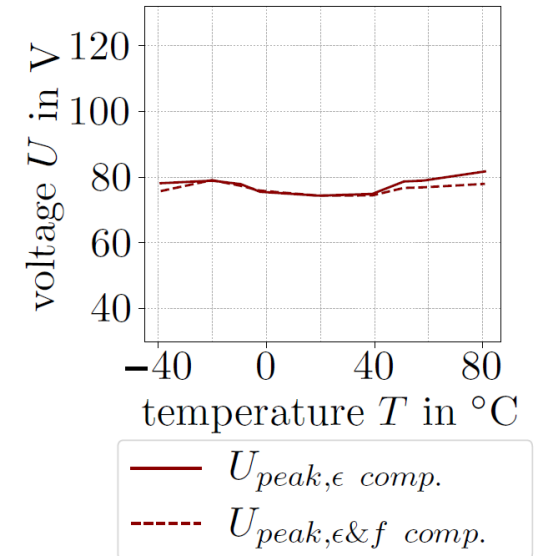
Measurements

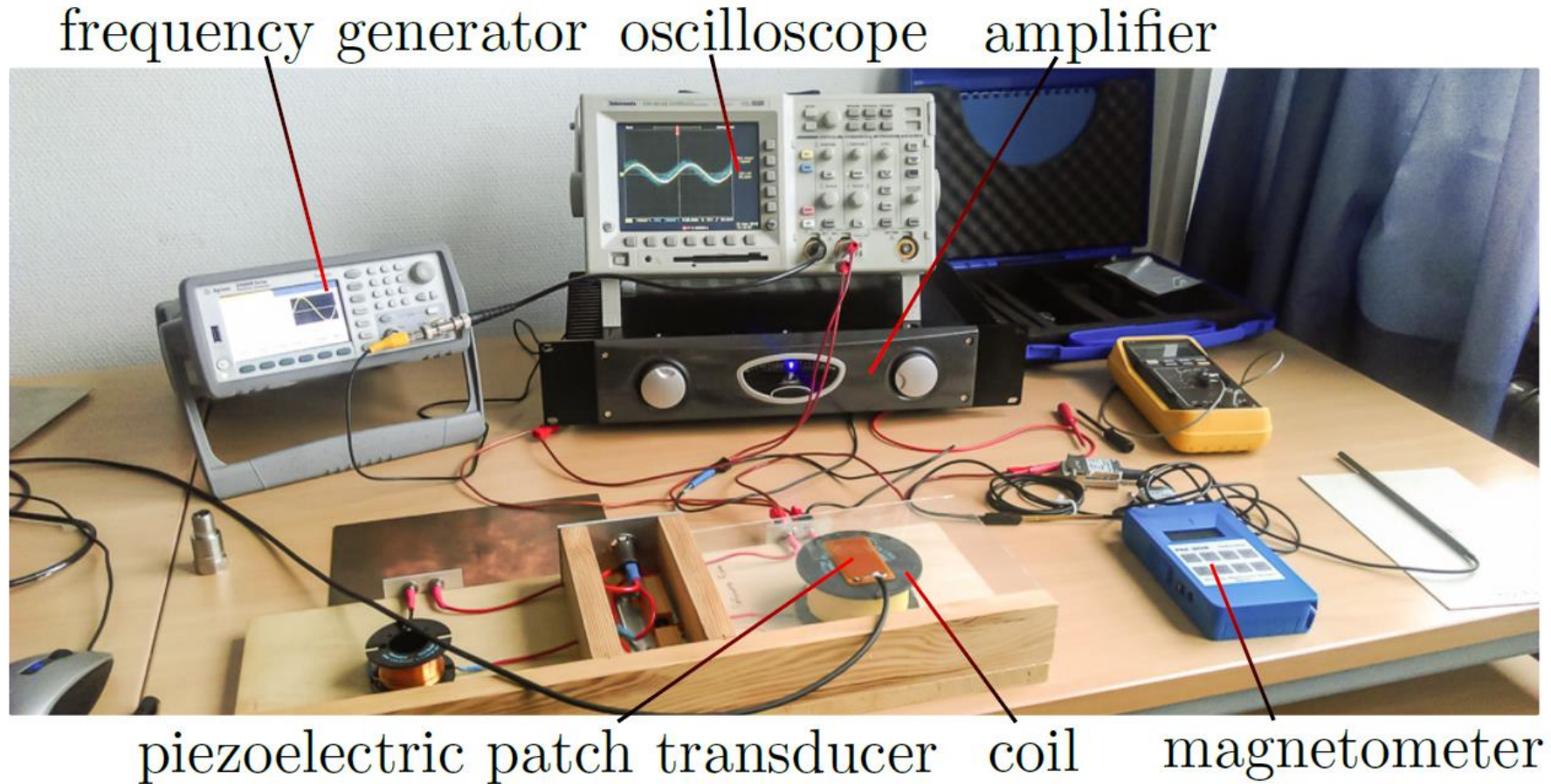


Calculated compensation

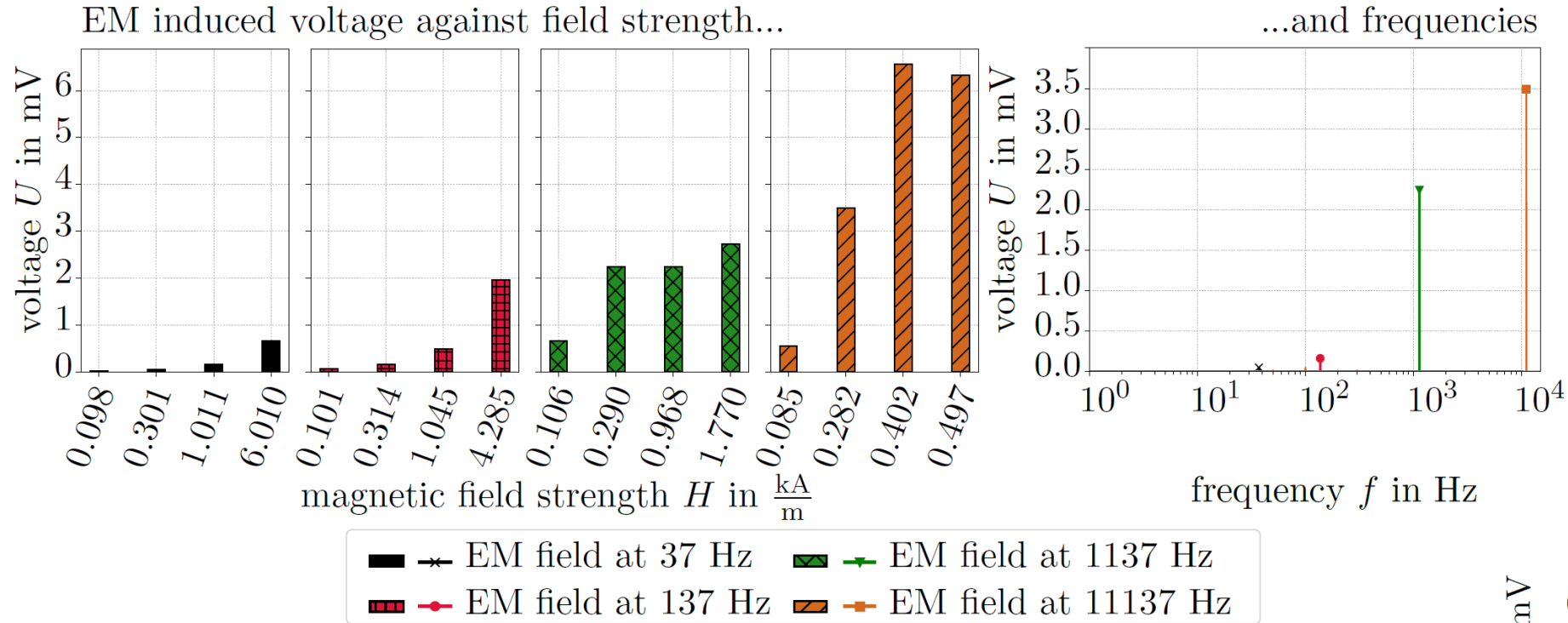


Compensated signal

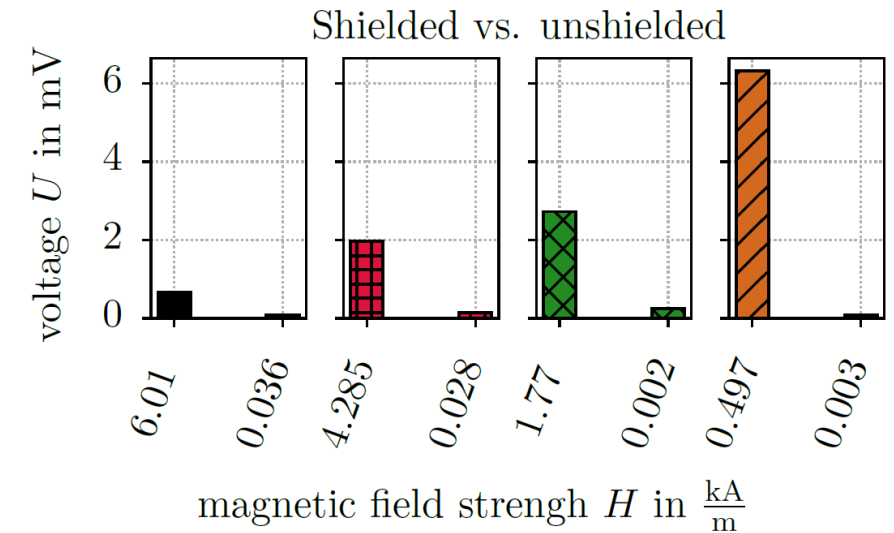




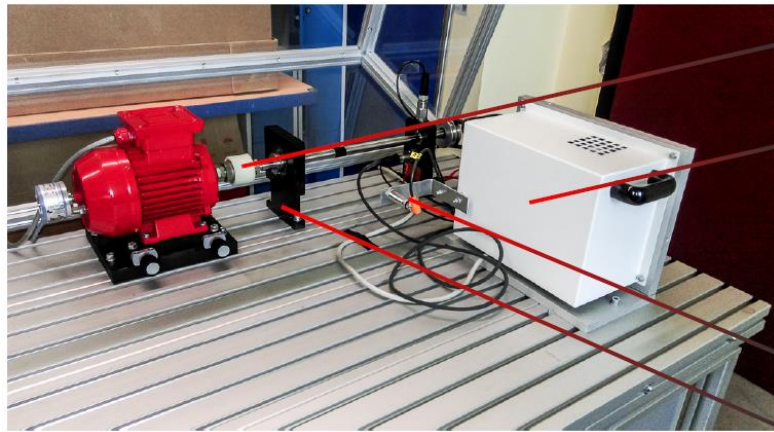
Electromagnetic interference test – results



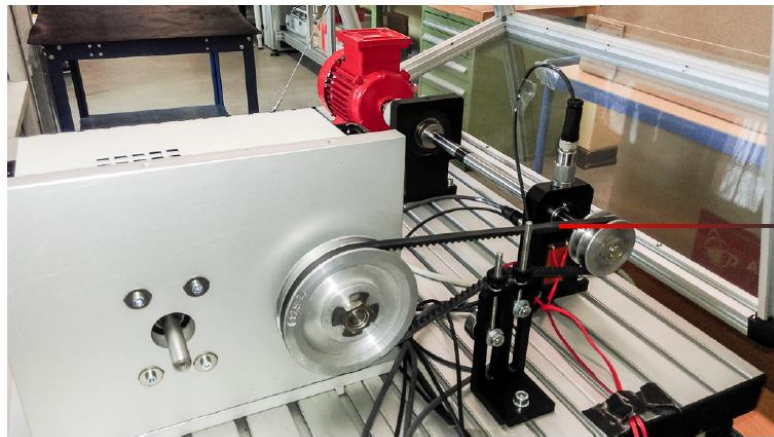
Shielding with a 1 mm mu-metal sheet:



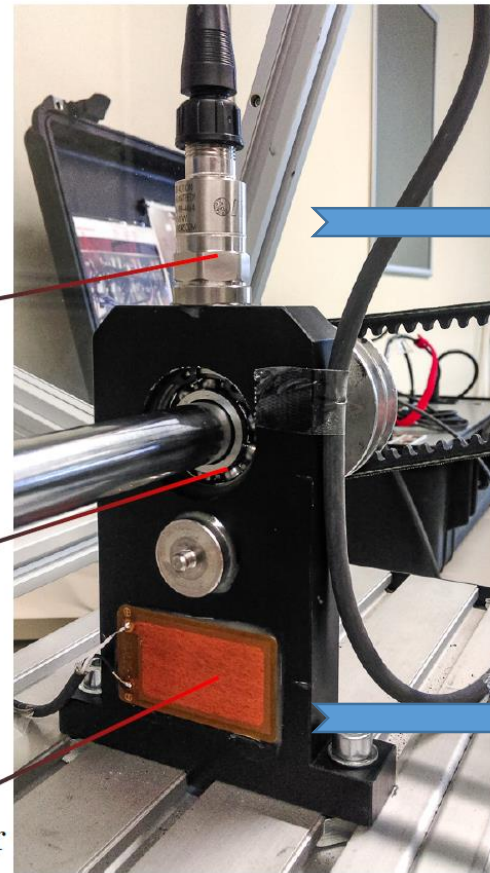
Damage detection – experimental setup and run-up plot



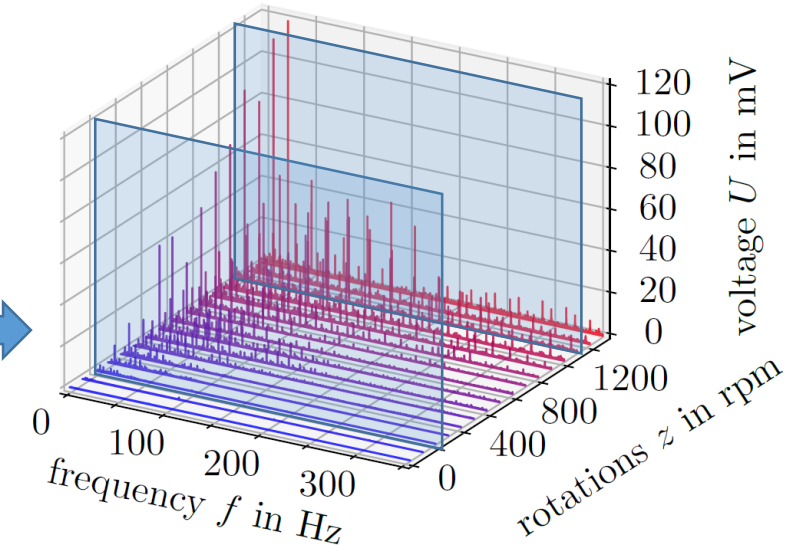
curved tooth
coupling
electromagnetic
powder brake



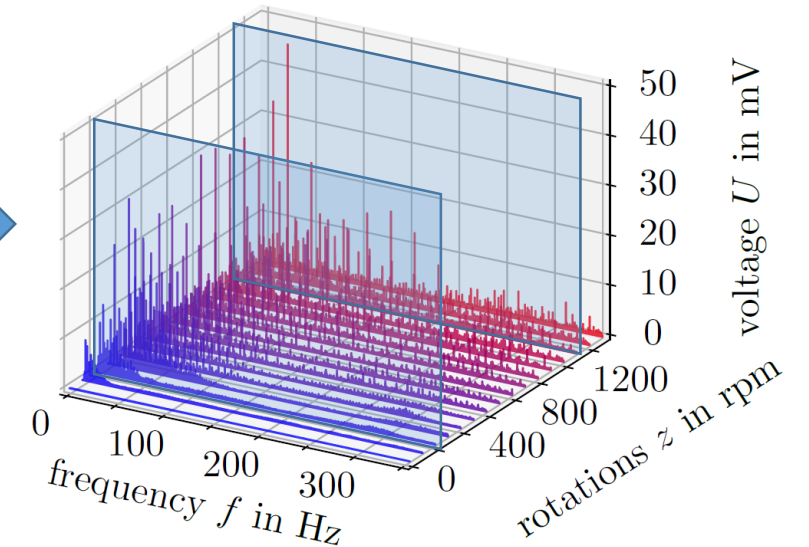
accelerometer
light barrier
fixed bearing
support
replaceable
bearing
V-belt
piezoelectric
patch transducer

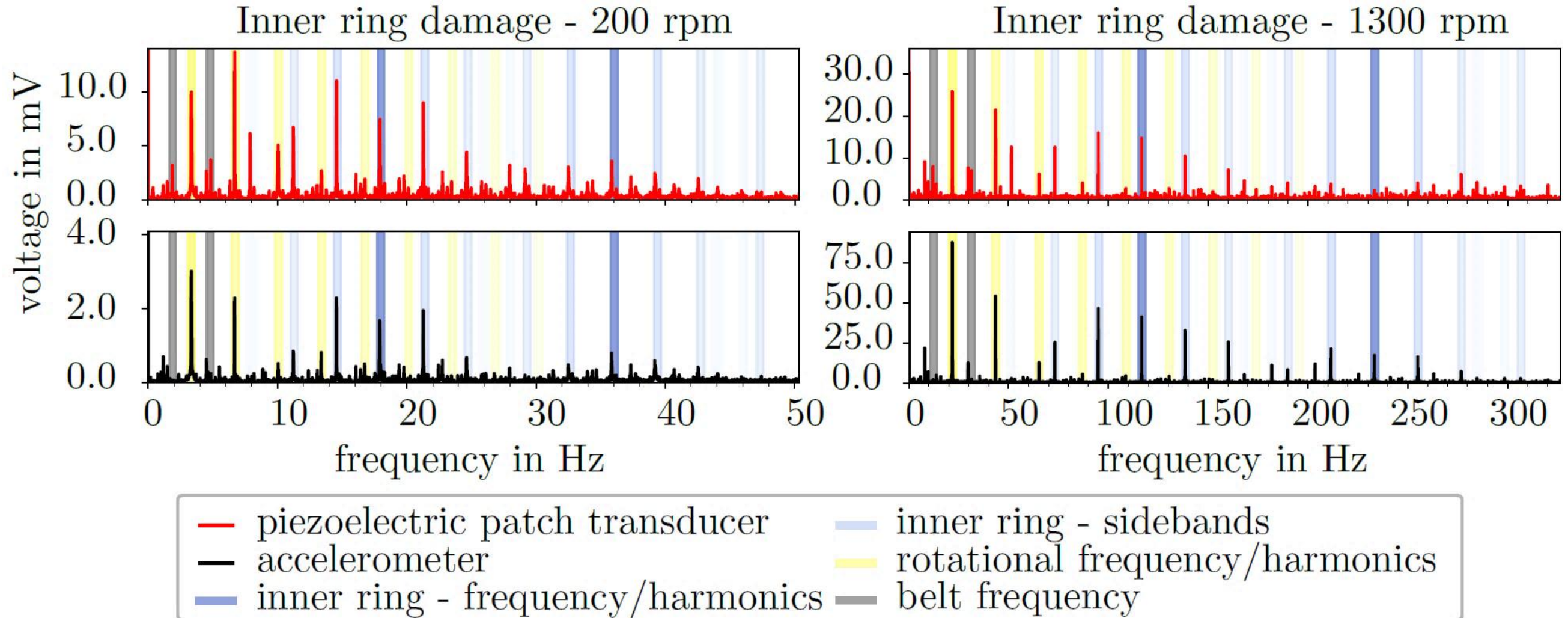


Inner ring damage - accelerometer



Inner ring damage - PPT





Summary



Temperature stability is given in the tested range of -40 °C to +80 °C



Sensor produces similar signals at all tested temperatures



Sensitivity toward electromagnetic interference is present, though the induced signal voltage is small compared to the damage frequency peaks



Shielding is yet recommended to fully eliminate any unwanted interference



Damages can be identified in the piezoelectric patch transducer's signal



The sensor shows strong signals at low rotational speed, but is exceeded by the accelerometer's signal voltage and depth at high rotational speed



Application of the piezoelectric patch transducer for a wind turbine's drive train is possible and might be a welcome alternative to accelerometers in the future



➔ Further optimization of the sensor is necessary to make it competitive

➔ Integration into the gear may improve its competitiveness, due to the reduced signal path from damage to sensor

This research was funded by

Thank you for your attention!

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