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Experimental Characterization Of Grid Loss Event On Nacelle Test-rig Using Advanced Operational Modal Analysis

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Presentation Overview

- Introduction
- Goal
- Dynamic event description
- Test Object
- Resonance estimation
- HSS Toot Contact
- HSS Bending
- HSS Bearing Slip
- Conclusions
- Next steps

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Introduction

- **Main design load cases:**
  - Quasi static
  - Dynamic
  - IEC 61400-1
- **Electric excitation during grid events results in mechanical response:**
  - Grid loss
  - Low voltage ride through

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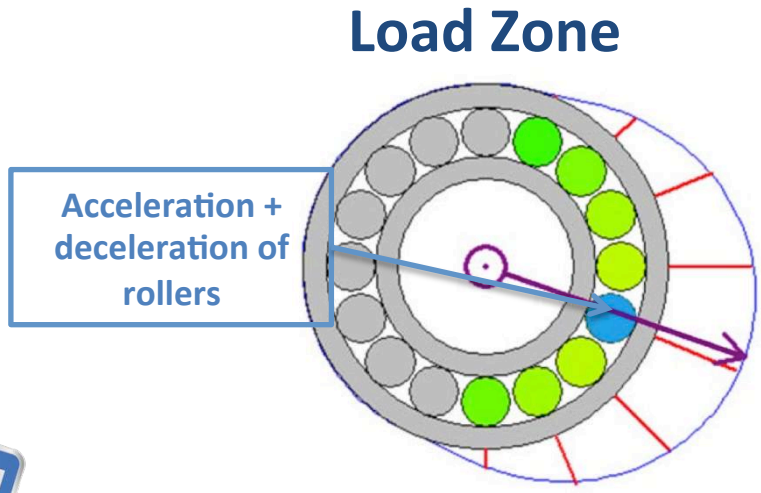
Introduction

- **Bearing slip:**
  - Roller slip
  - Cage slip
- **Widely believed to be playing important role in bearing failure**



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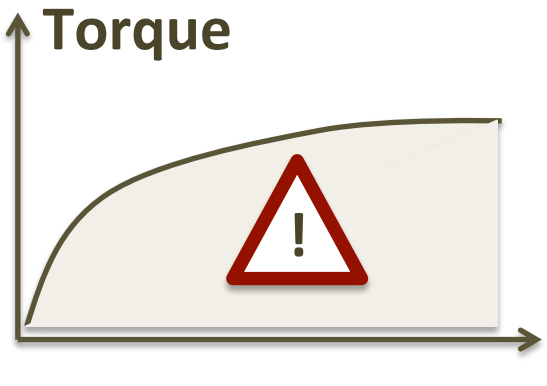

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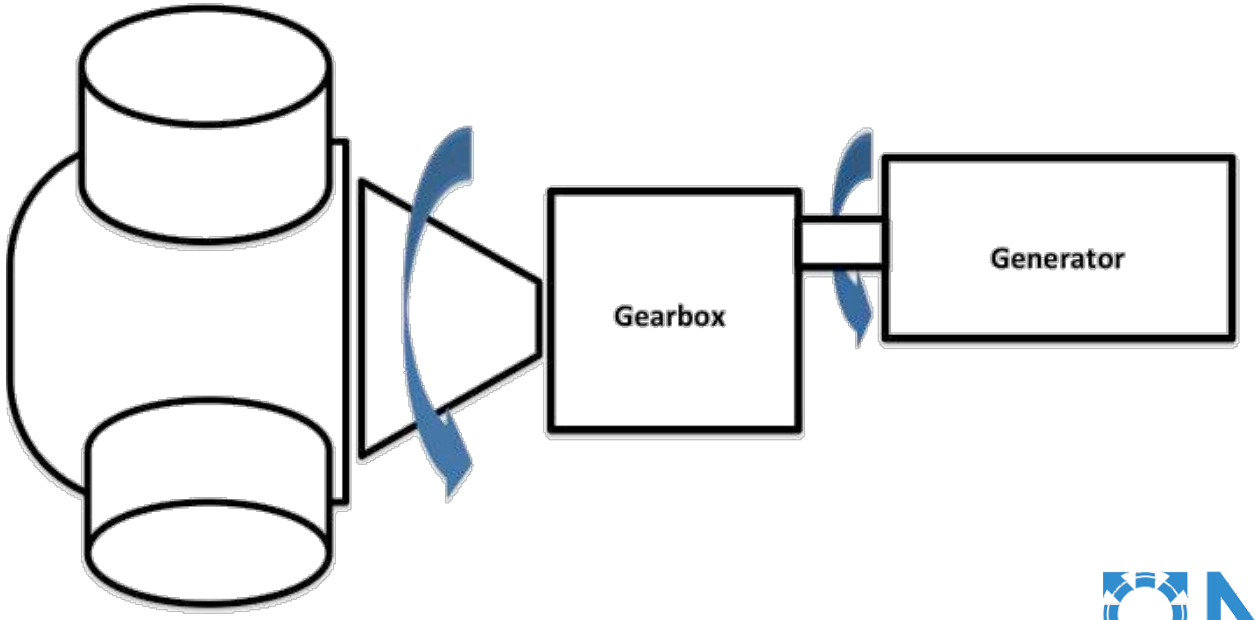
Introduction

- **First drivetrain torsional resonance:**
  - Counter clock wise motion of rotor and generator inertia
  - About drivetrain stiffness



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Research Goals

- Experimentally **perform** grid loss event on full-scale system
- **Identify** the first drivetrain torsional resonance
- Show leading role of this **resonance** in the event
- Show **gear backlashing** during event
- Experimentally show **bearing roller slip** during event

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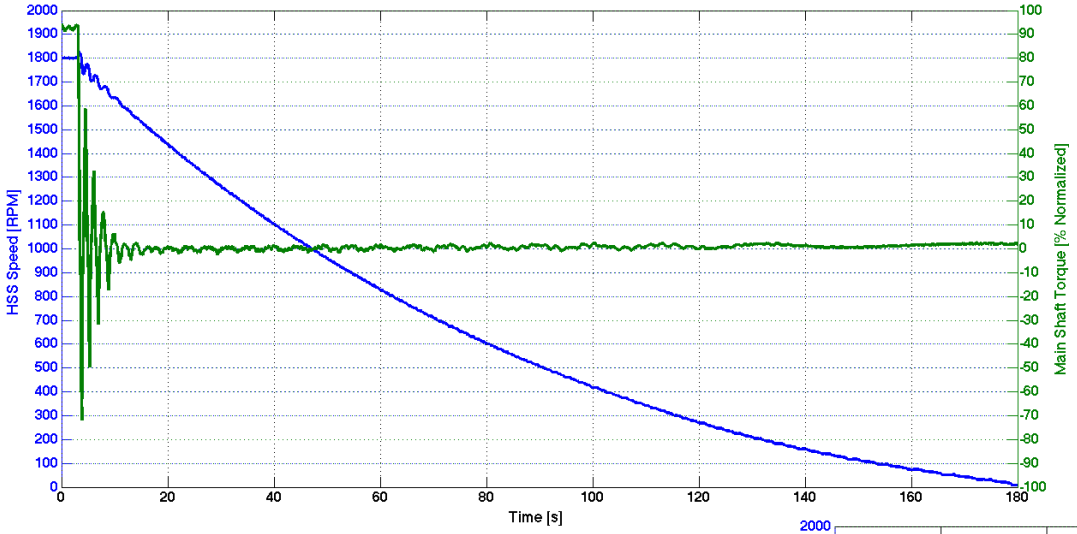
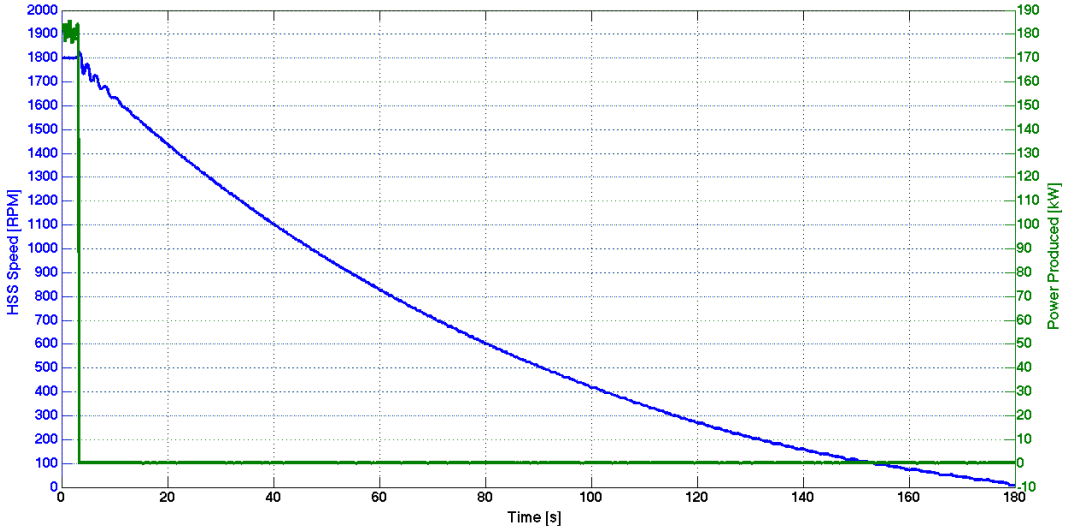
Load Case

- **Worst case grid loss event**



- **25% of nominal load**
- **Nominal RPM**



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Nacelle Dynamometer

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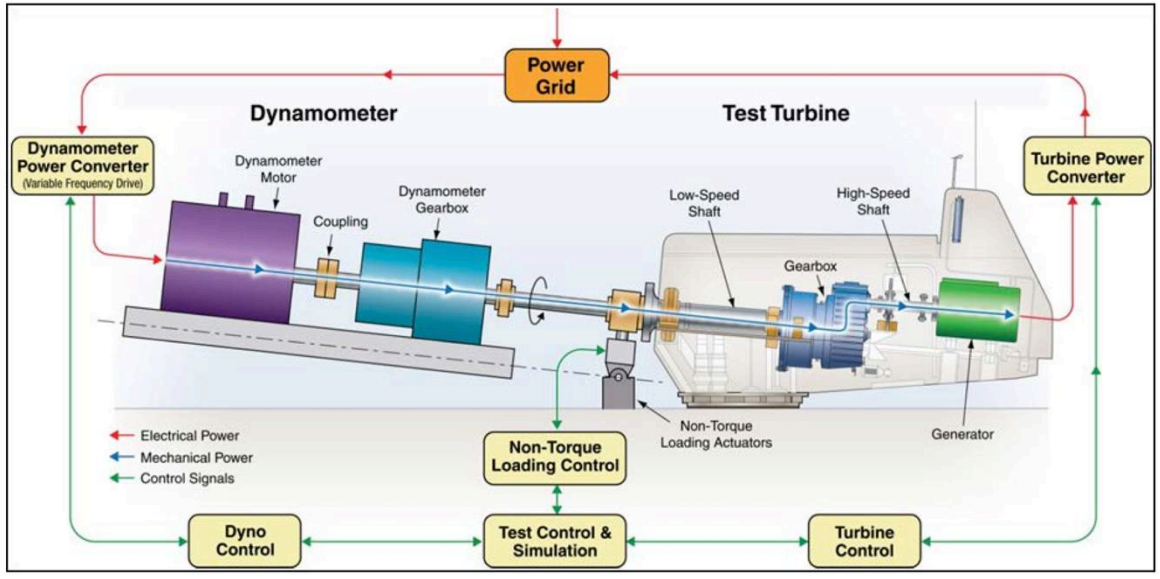

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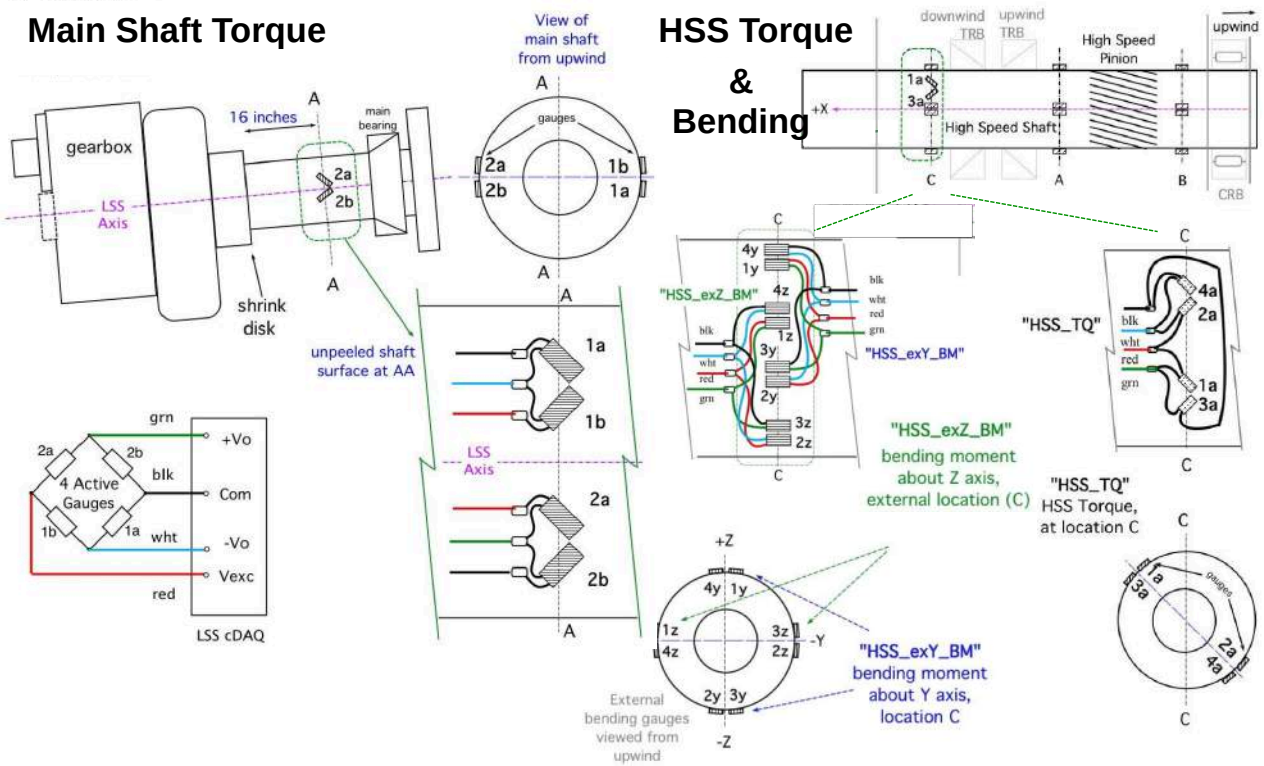
Instrumentation

- **Shaft torque and bending measurements**



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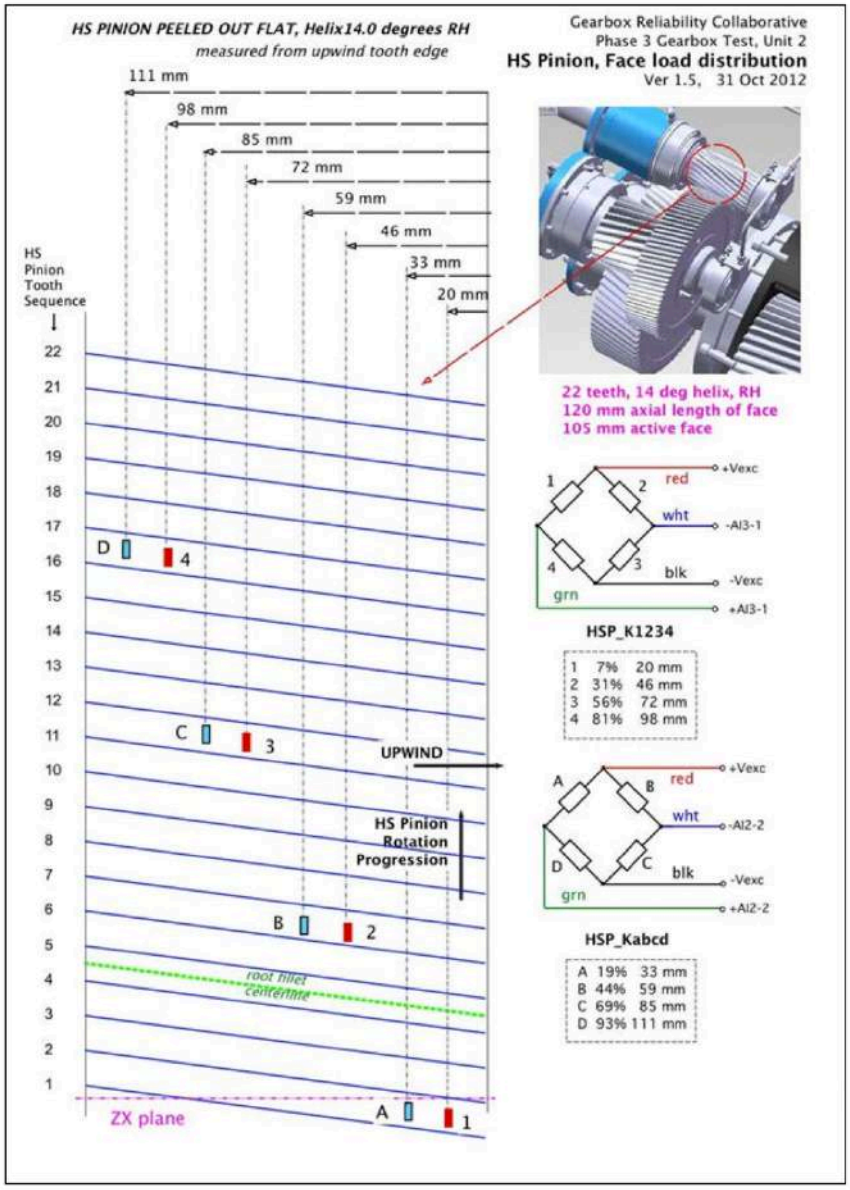
Instrumentation

- **Tooth strain measurements**



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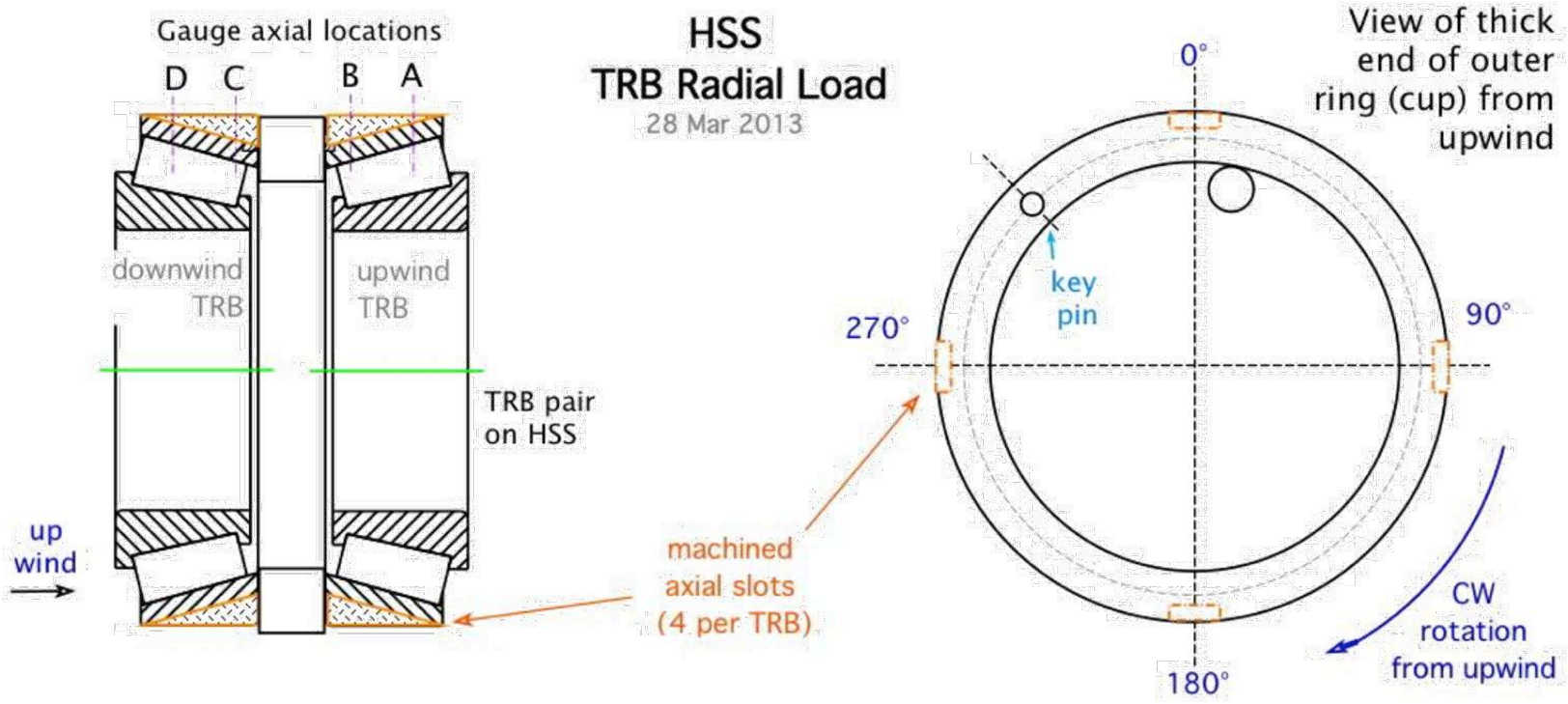
Instrumentation

- **Internal bearing strain**



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Resonance Identification

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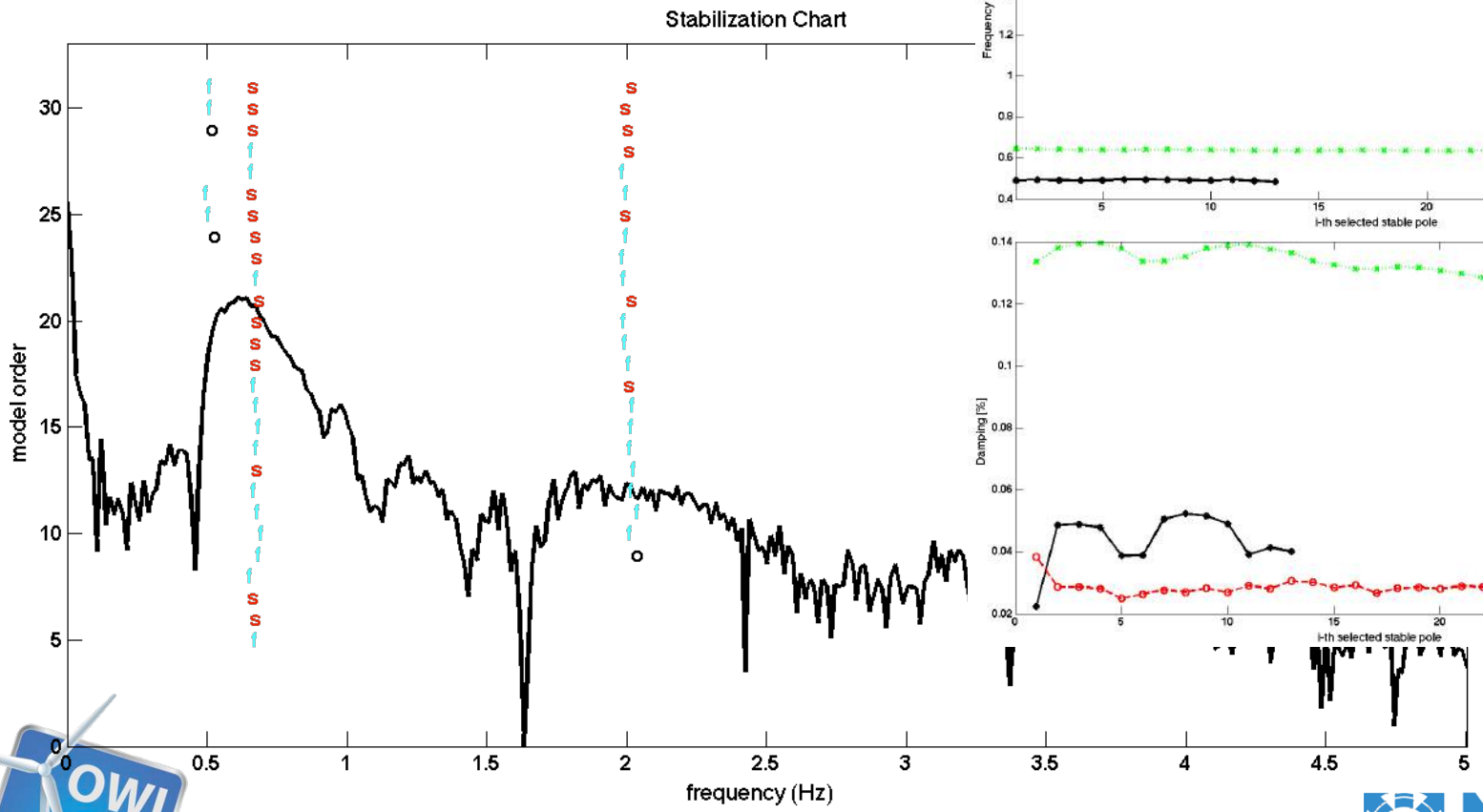
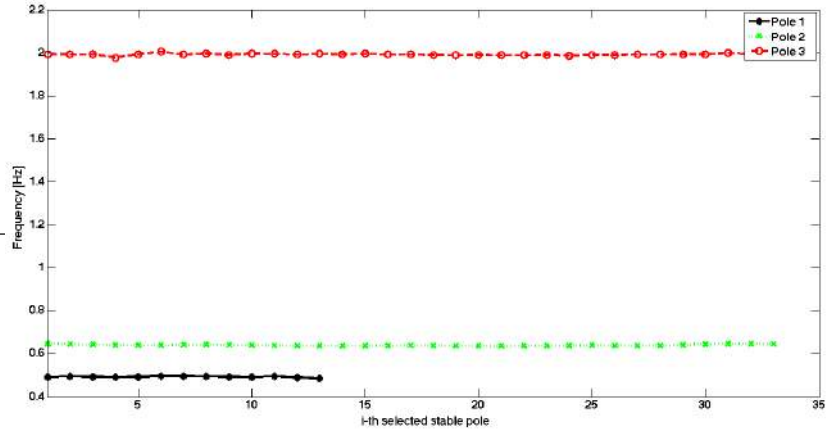
- **p-LSCE OMA estimator:**





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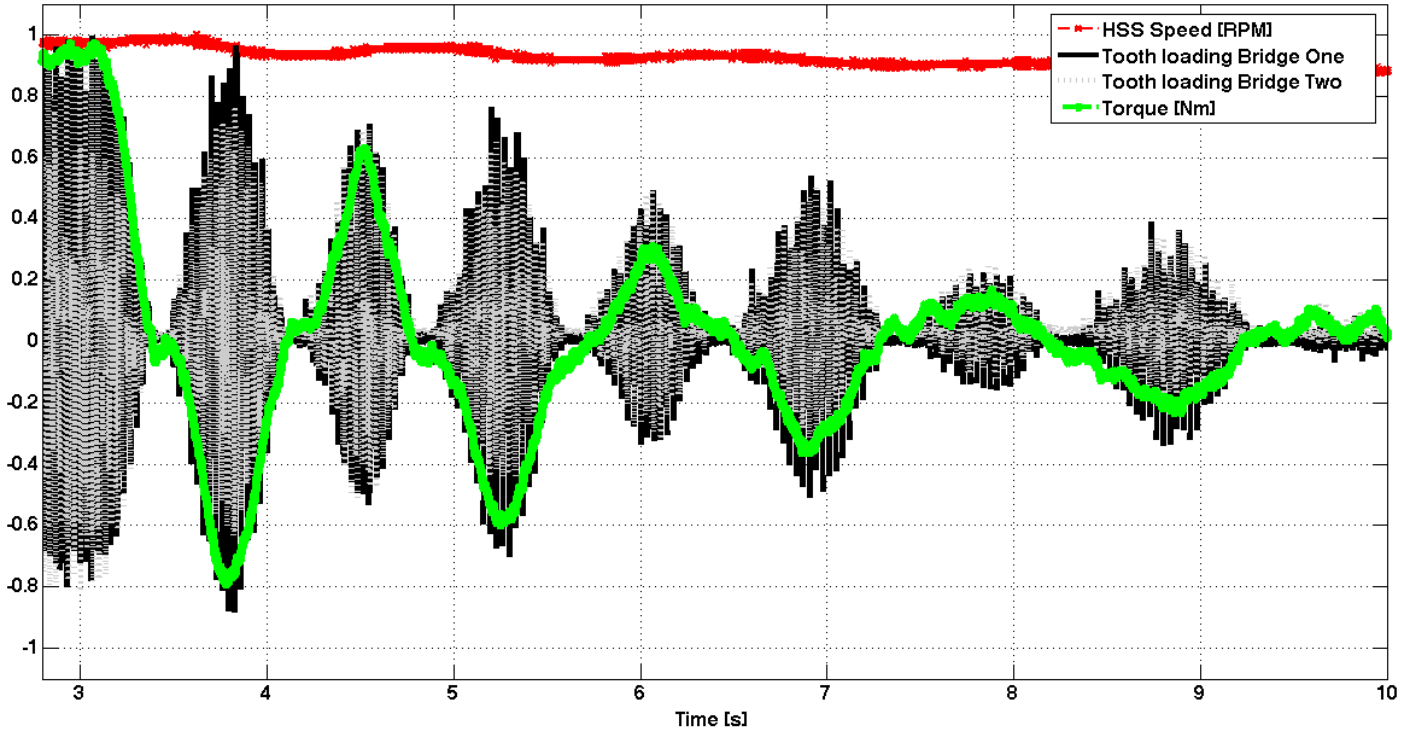
HSS gear mesh

- Teeth through backlash and re-engage at other flank



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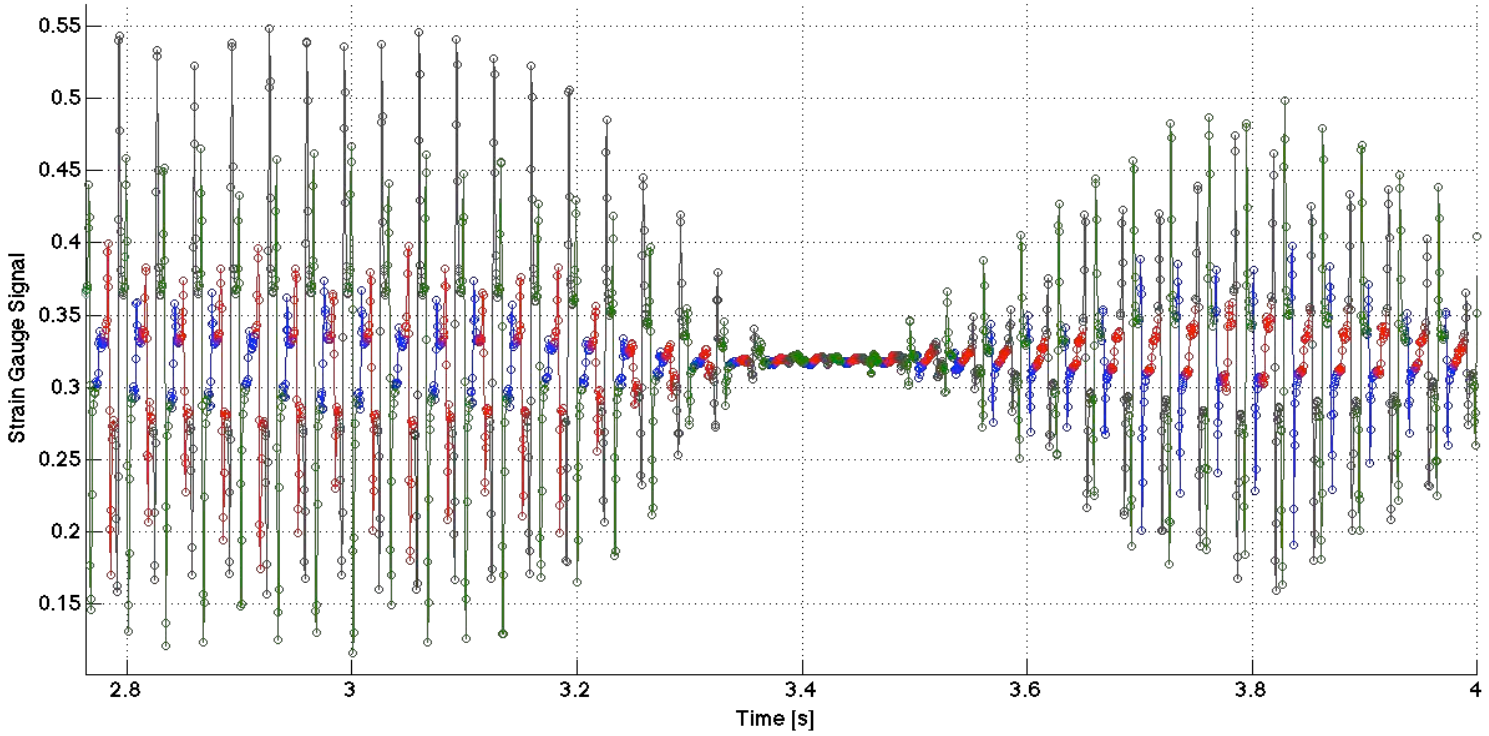
HSS gear mesh

- **Teeth through backlash and re-engage at other flank**



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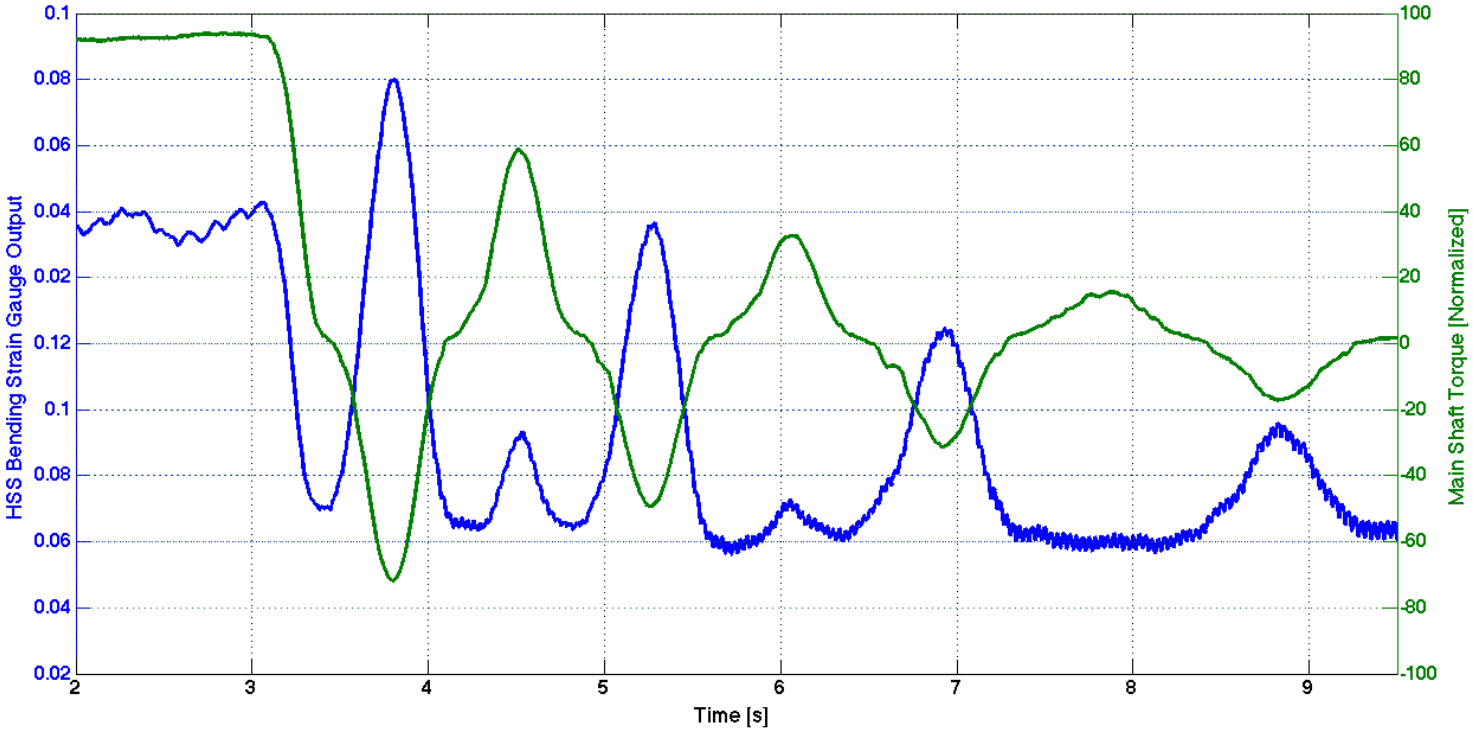
HSS bending

- **Significant bending during negative torque periods**



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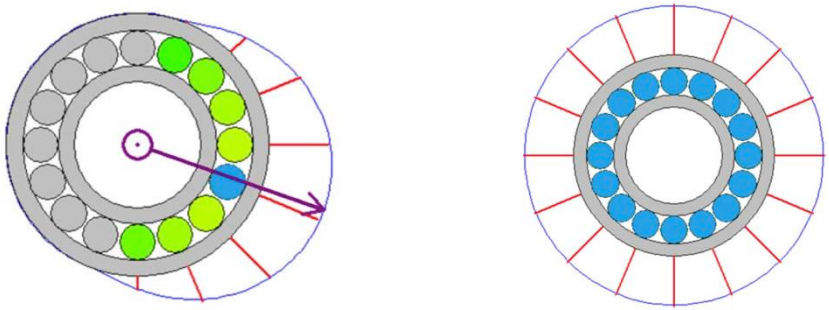
HSS Bearing Slip

- **TRB roller slip:**
  - Preload needs to be overcome



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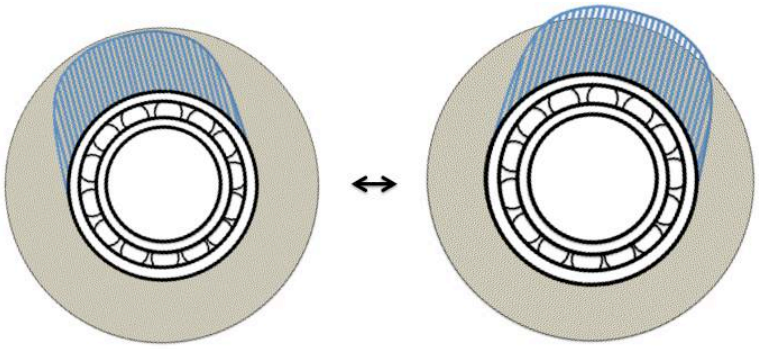

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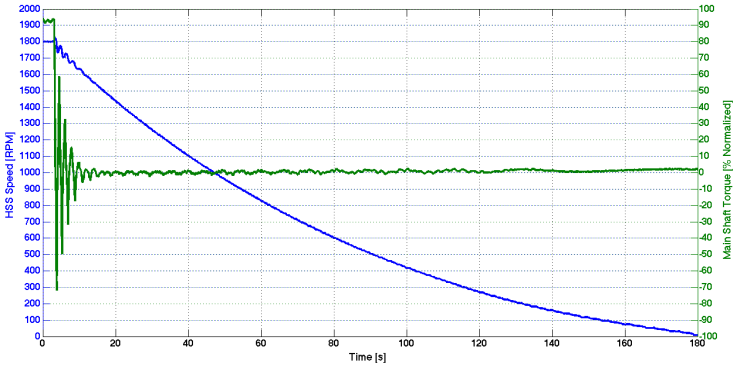
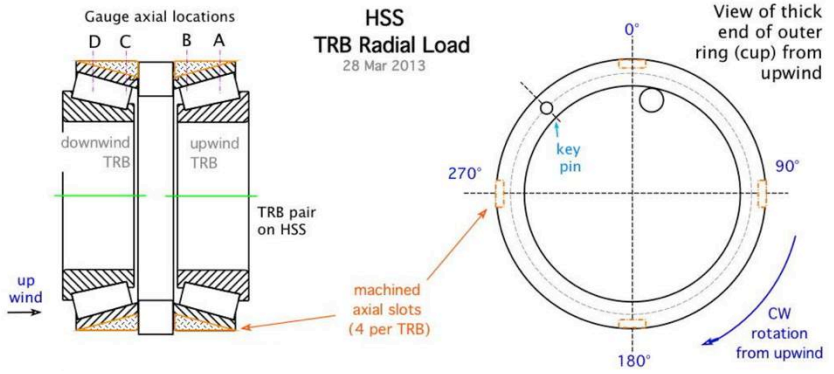
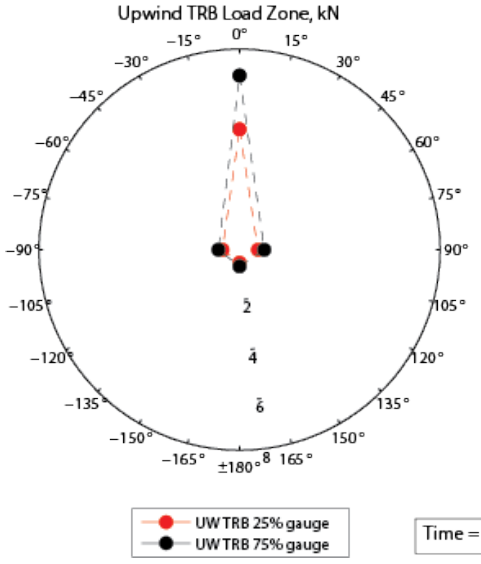
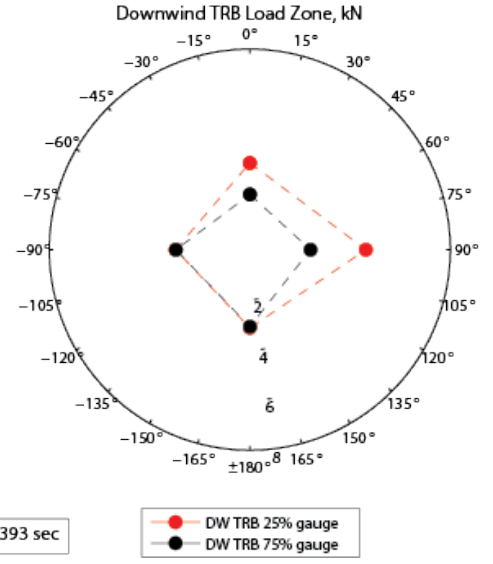
HSS Bearing Slip

- **Bearing load distribution during event → Positive torque**









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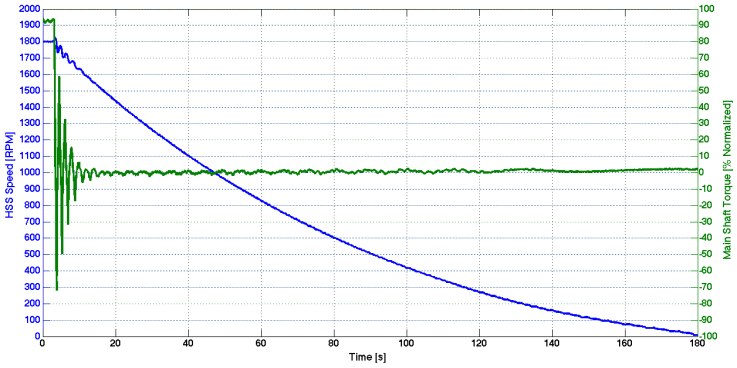
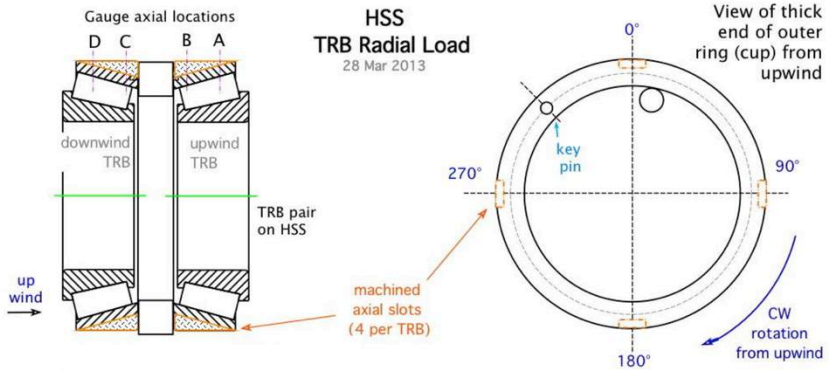
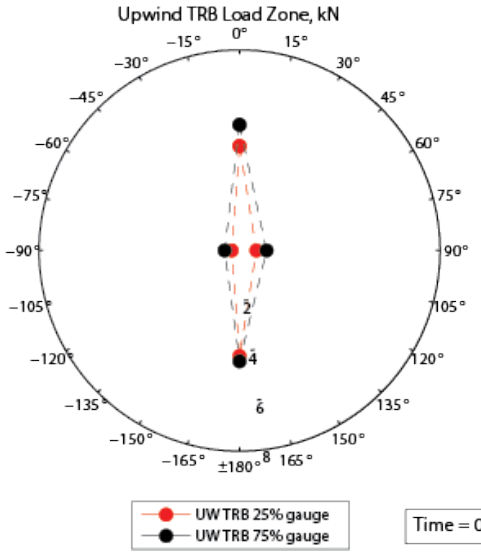
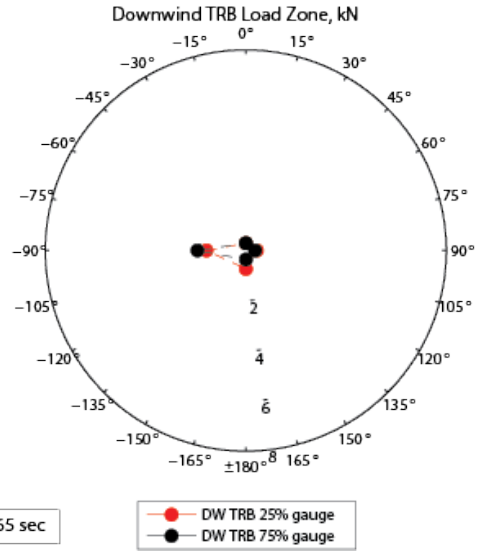
HSS Bearing Slip

- **Bearing load distribution during event → Negative torque**









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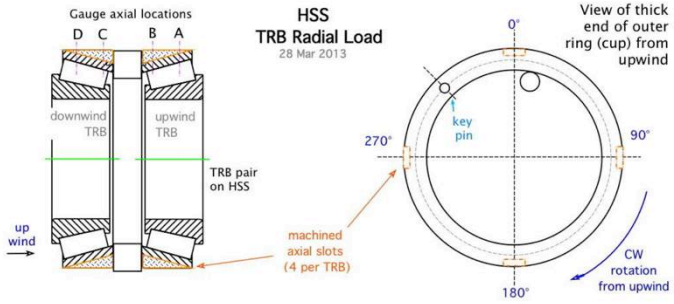
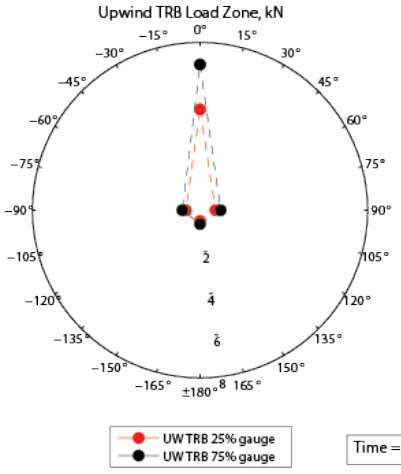
HSS Bearing Slip

- **Bearing load distribution during event**



Positive torque



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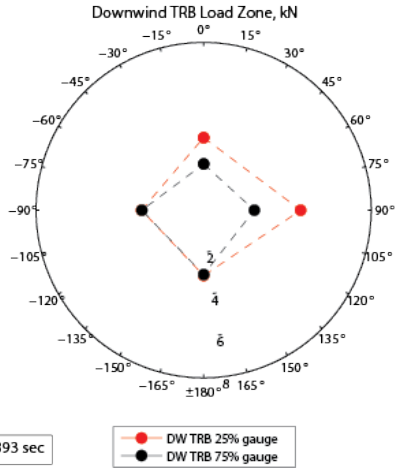
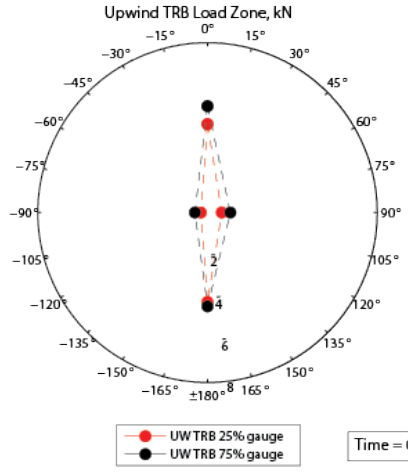


Negative torque



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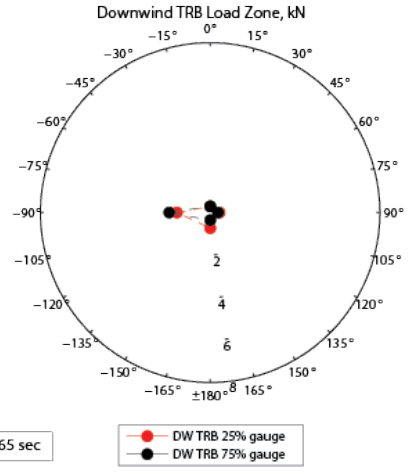

Clear unloading on upwind side A position

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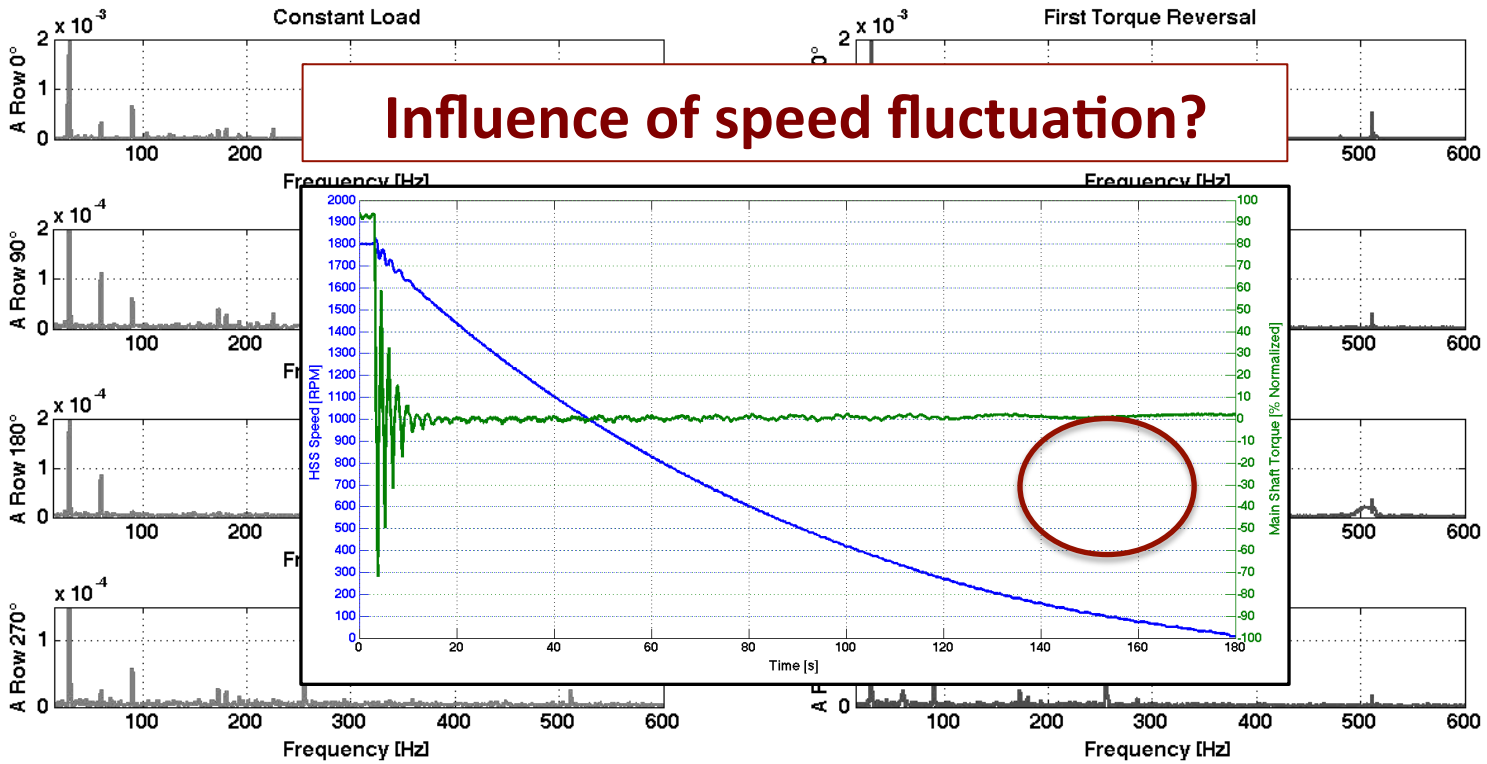
- **Frequency domain analysis**



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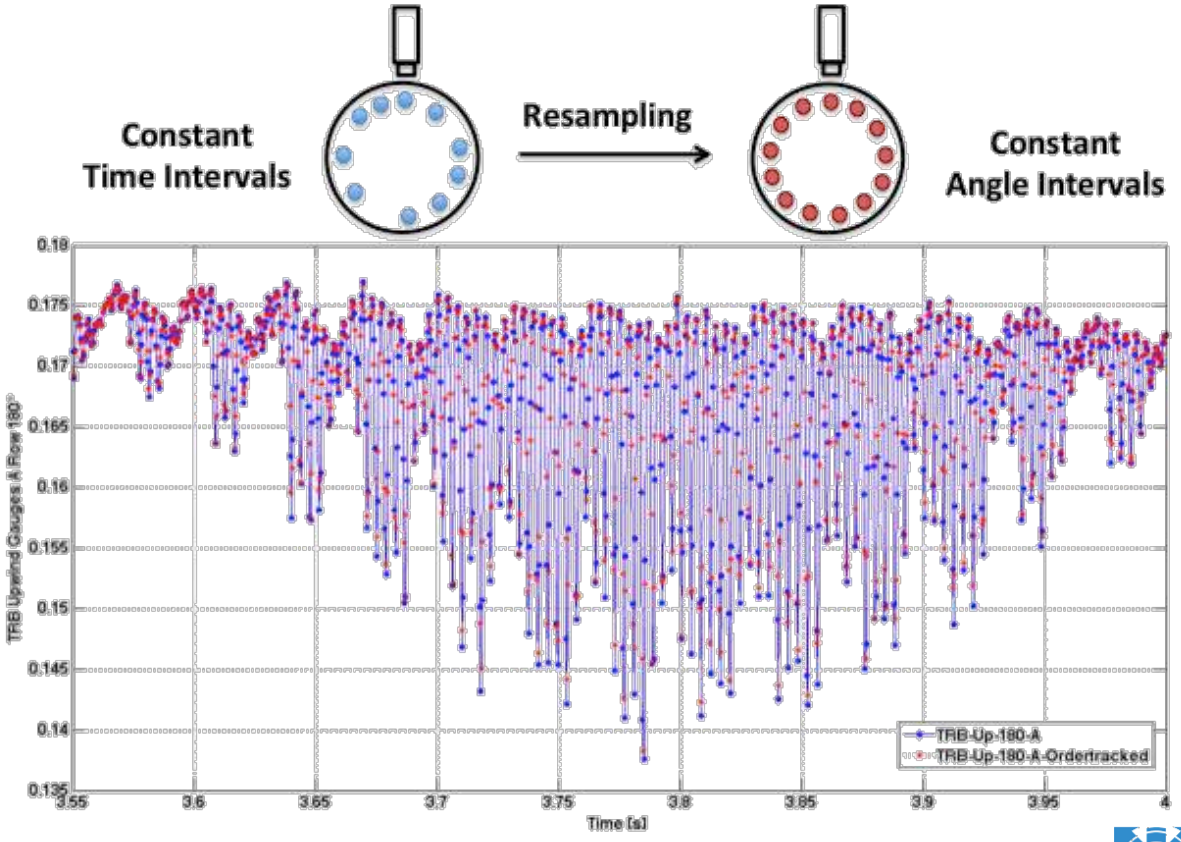
HSS Bearing Slip

- **Frequency domain analysis combined with ordertracking**



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HSS Bearing Slip

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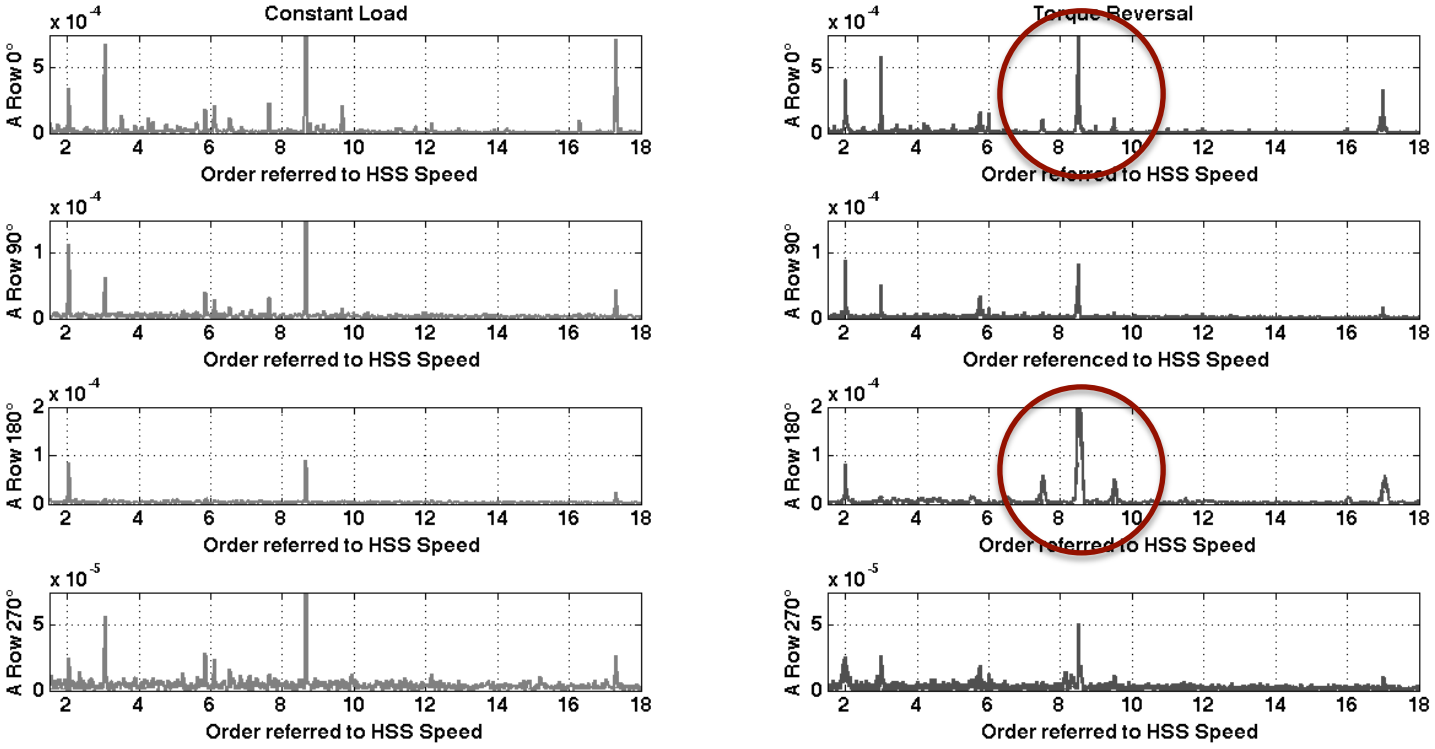

Bearing roller slip induced by grid induced event

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Conclusions

- A worst case grid loss was investigated experimentally
- The driving resonance identified at 0.64 Hz
- HSS mesh disengaging and re-engaging due to torque changes
- Dynamically changing HSS Bending
- HSS TRB roller slip due to changed loading due to grid loss experimentally shown

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Next steps

- **Linking these events to failure:**
  - Monitoring on wind farm level:
    - SCADA data
    - CMS data
    - Additional measurements
  - Structured storage in Big-Data database
  - Event detection + link to maintenance records

  → **Statistically show influence of these events on failure**

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