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Mechanical Improvement of Electrical Interharmonics Damping

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TEXAS A&M ENGINEERING EXPERIMENT STATION

Presenter/Author bios

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Vijay Anantham Ganesan is medium voltage drive system consultant at Siemens Industry Sector in Nuremberg, Germany. He received his M.Sc. degree in electrical power engineering from RWTH Aachen University, Aachen, Germany in 2005. From 2005 to 2010, he was a research assistant at Leibniz University Hannover, Germany.

Presentation content

Introduction

During operation of compressor trains by a variable speed drive system (VSDS) integer and non-integer harmonics are generated in the inverter. Via the electrical system of inverter and motor a torsional excitation is transferred across the air gap torque into the main mass of the motor. This excitation may cause torsional resonances.

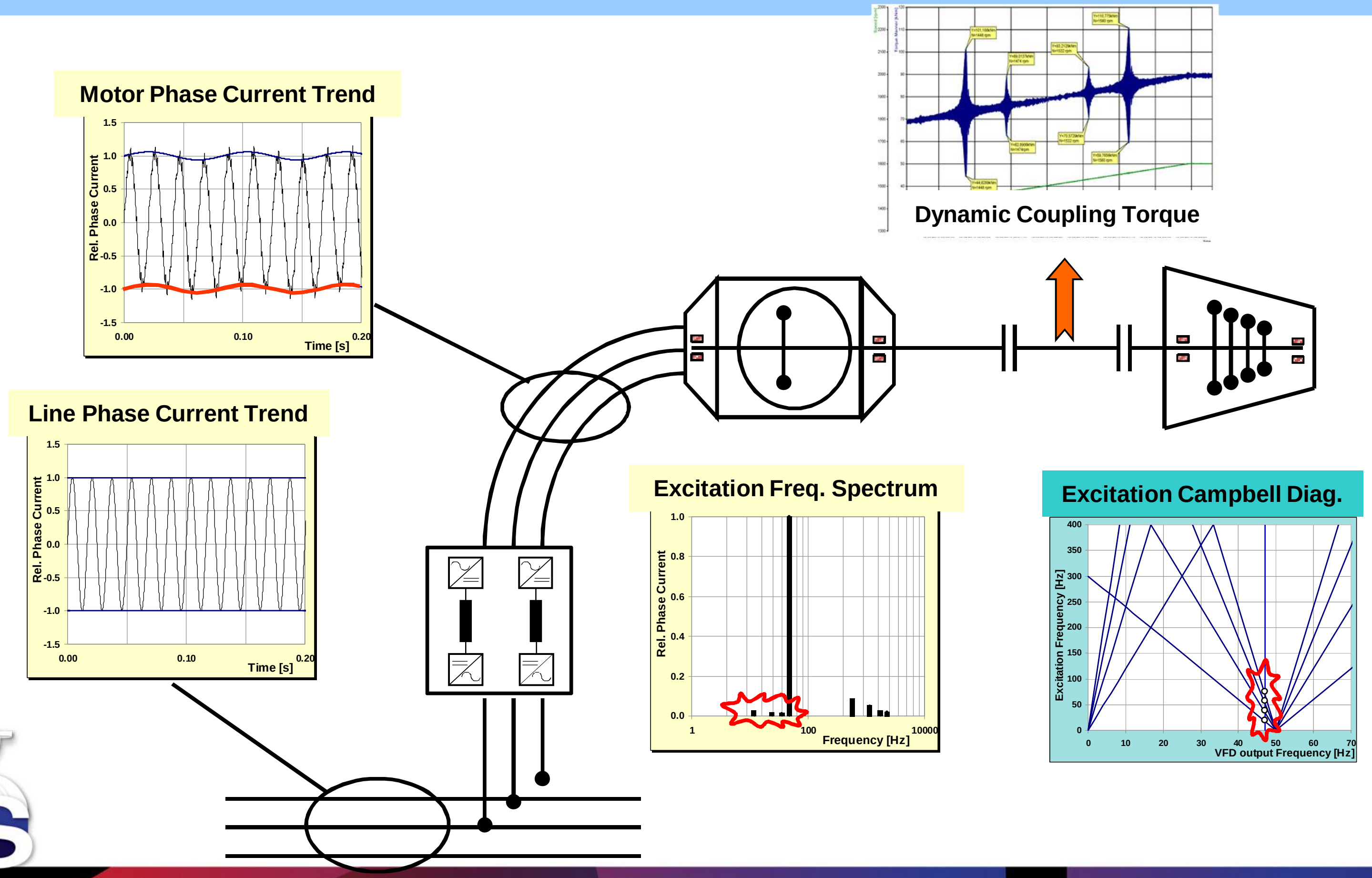
However, the main focus of this case study will be on the new electrical damping method to attenuate the torsional excitations induced by an Load Commutated Inverter (LCI) in a Variable Frequency Drive (VFD).

The effectiveness of the proposed electrical damping method will be demonstrated in 2 case studies:

Case Study 1: Blocked speed ranges eliminated
Case Study 2: High gear vibrations avoided

Mechanical Improvement of Electrical Interharmonics Damping

Introduction (Basics of LCI Drive Interharmonics)



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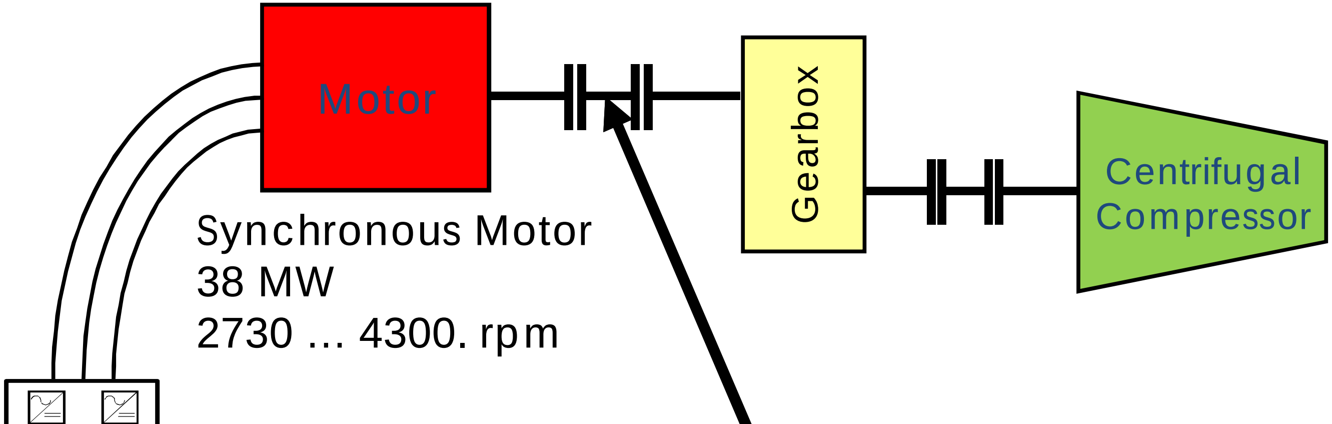
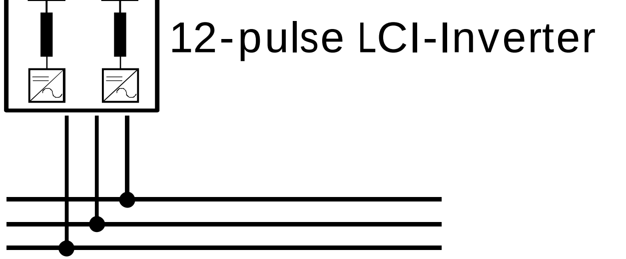
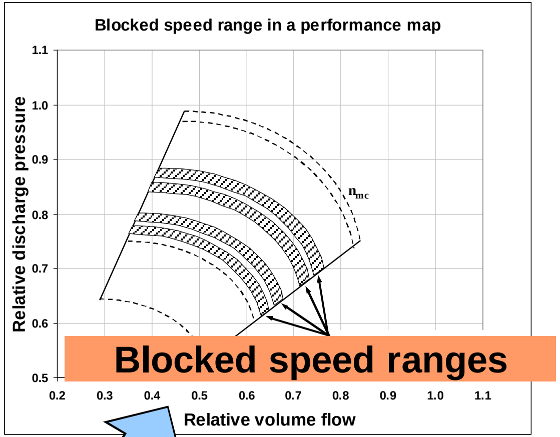
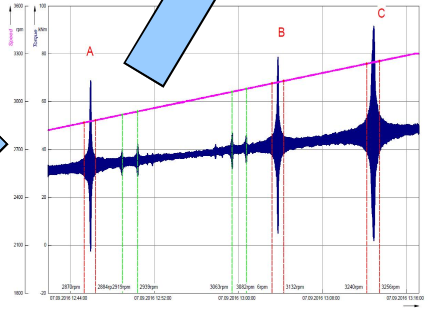
Case Study 1: Blocked speed range eliminated









Case Study 1: Blocked speed range eliminated

Principle: Interharmonic Suppression

- Additional control algorithm implemented as software feature

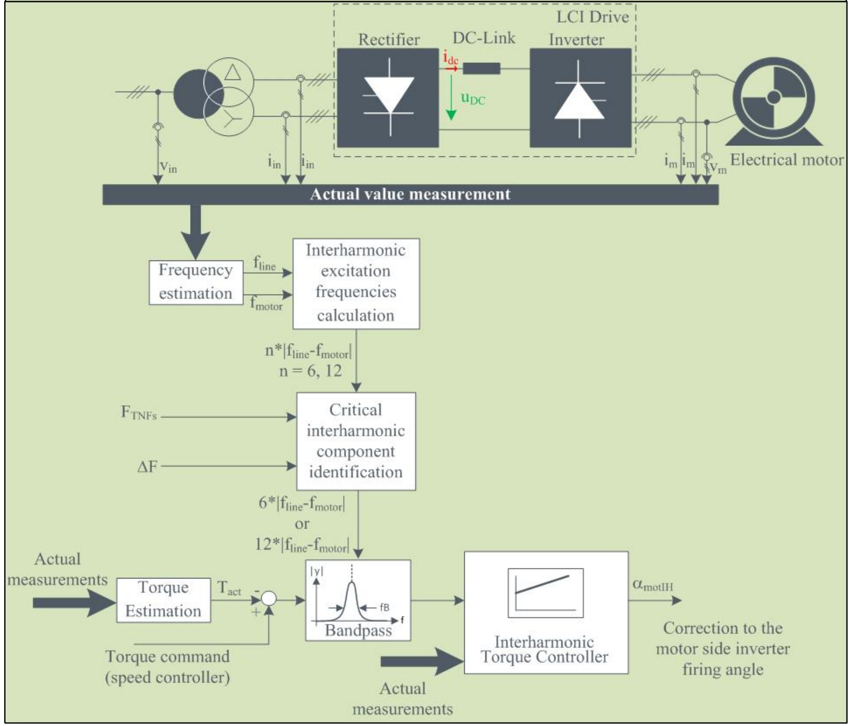
- Required input drive train data:
  - Critical TNF – currently up to 2 TNFs can be set
  - Frequency band DF – current limit +/- 5 Hz

- No additional hardware required

- Only acts on the critical interharmonic components 6*|f_{line} – f_{motor}| and 12*| f_{line} – f_{motor} | that is within the specified DF around TNF

- A dedicated controller will alter the motor side inverter firing angle within constraints to suppress the interharmonic component in the estimated air-gap torque.

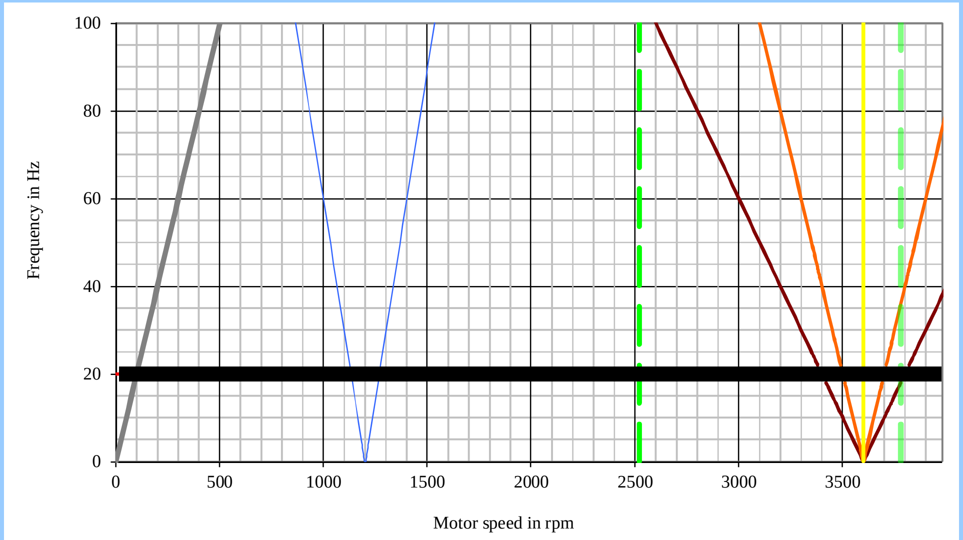
Active Damping Through Drive Control Software

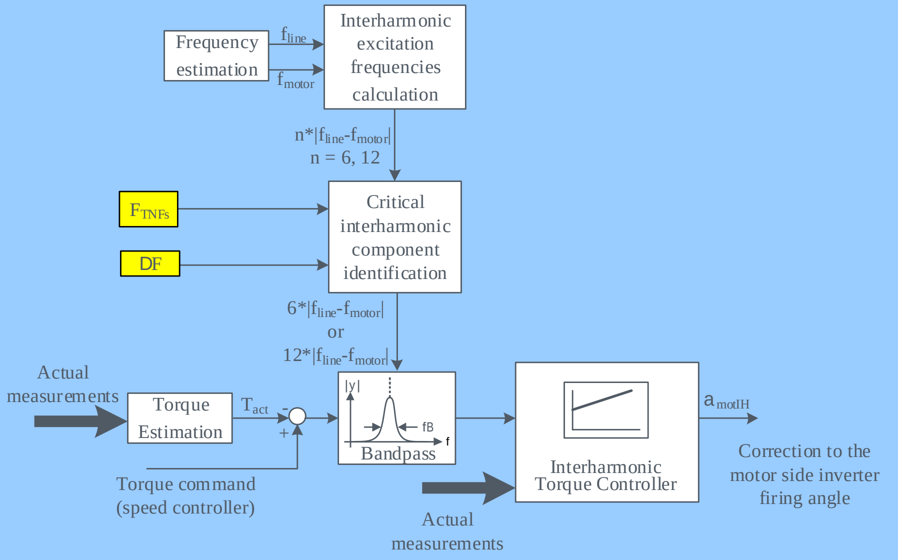


Case Study 1: Blocked speed range eliminated

Principle: Interharmonic Suppression

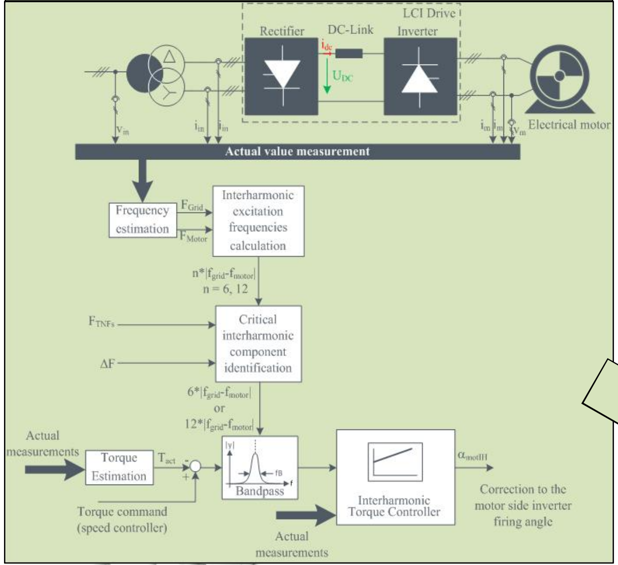
- The inter-harmonic excitations coming from the drive will be almost eliminated.
- The input for this control is the critical natural frequency of the drive train and the frequency band around this critical frequency.
- Within this band, the LCI injected inter-harmonics components, $6*|f_{line}-f_{motor}|$ and $12*|f_{line}-f_{motor}|$ will be almost eliminated.

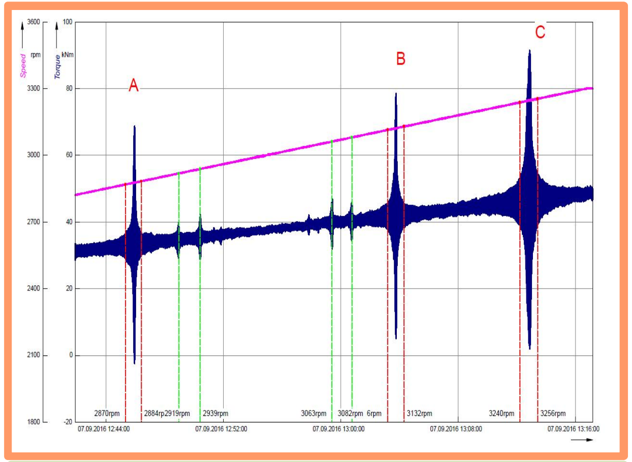




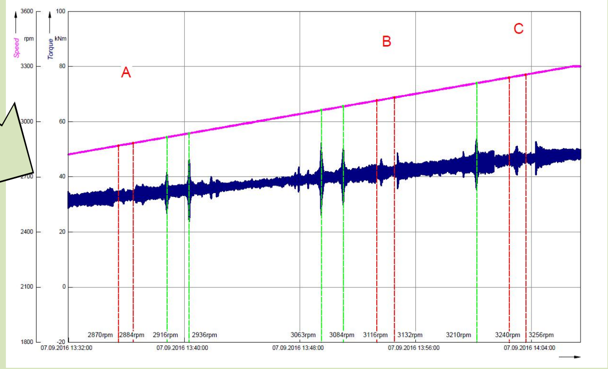
Case Study 1: Blocked speed range eliminated

Active Damping Through Drive Control Software



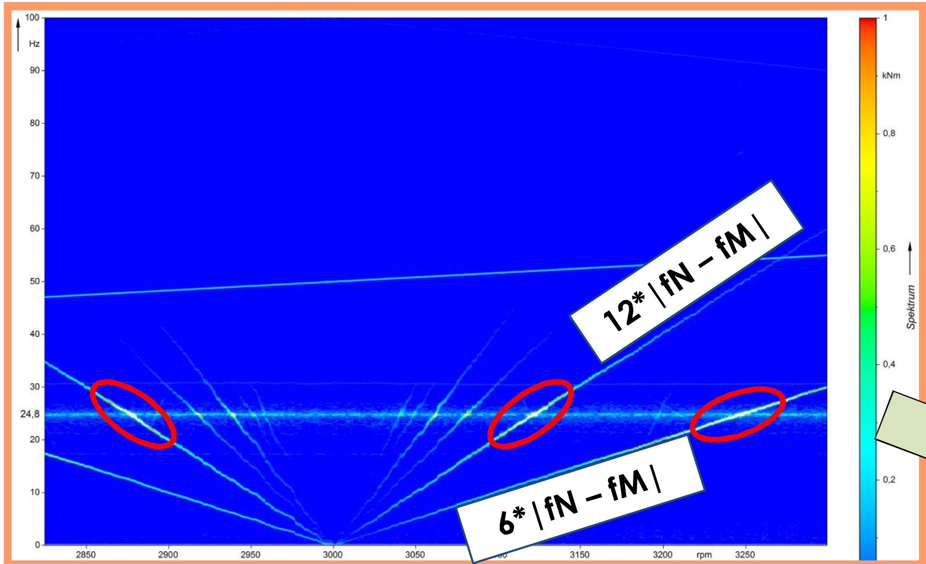


Without electrical interharmonics damping of an LCI



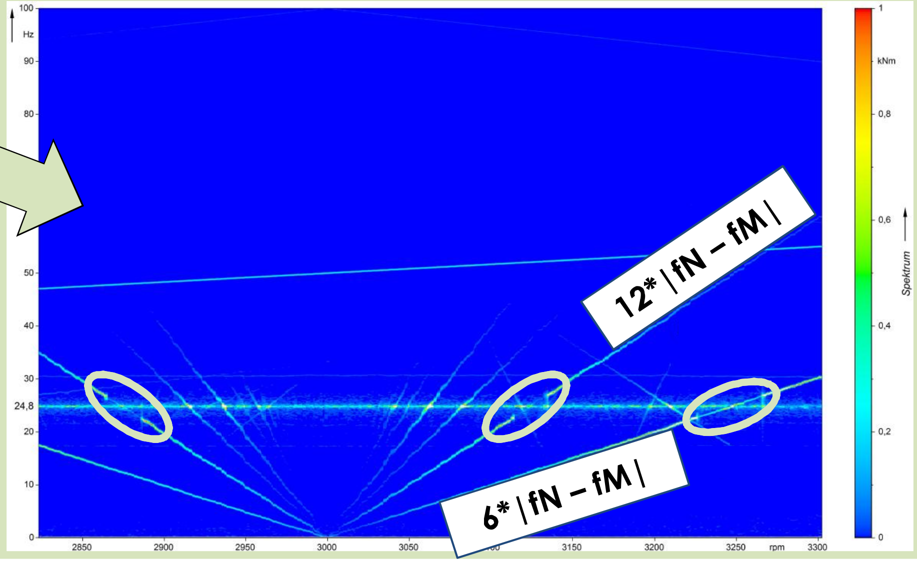
With activated improved electrical interharmonics damping of an LCI

Case Study 1: Blocked speed range eliminated



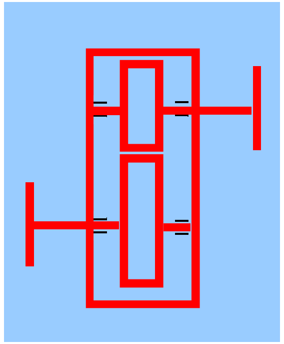
Without electrical interharmonics damping of an LCI

With activated improved electrical interharmonics damping of an LCI

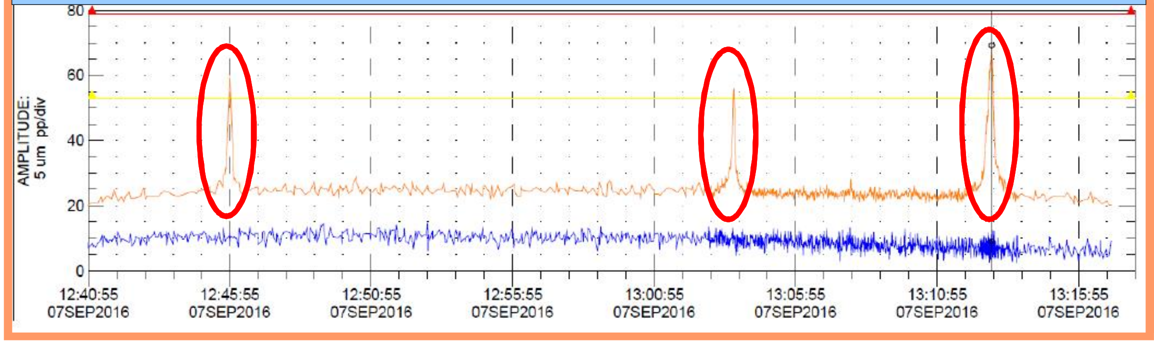


fN = electrical grid frequency
fM = electrical motor frequency

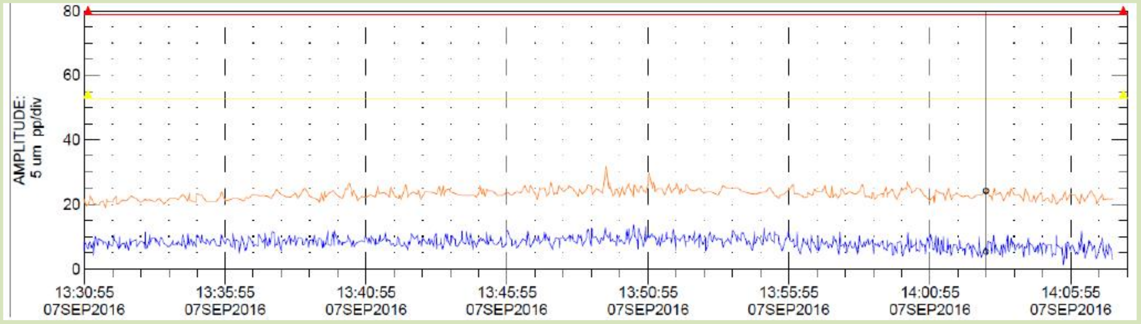
Case Study 1: Blocked speed range eliminated



Relative Shaft Vibrations of HS-shaft

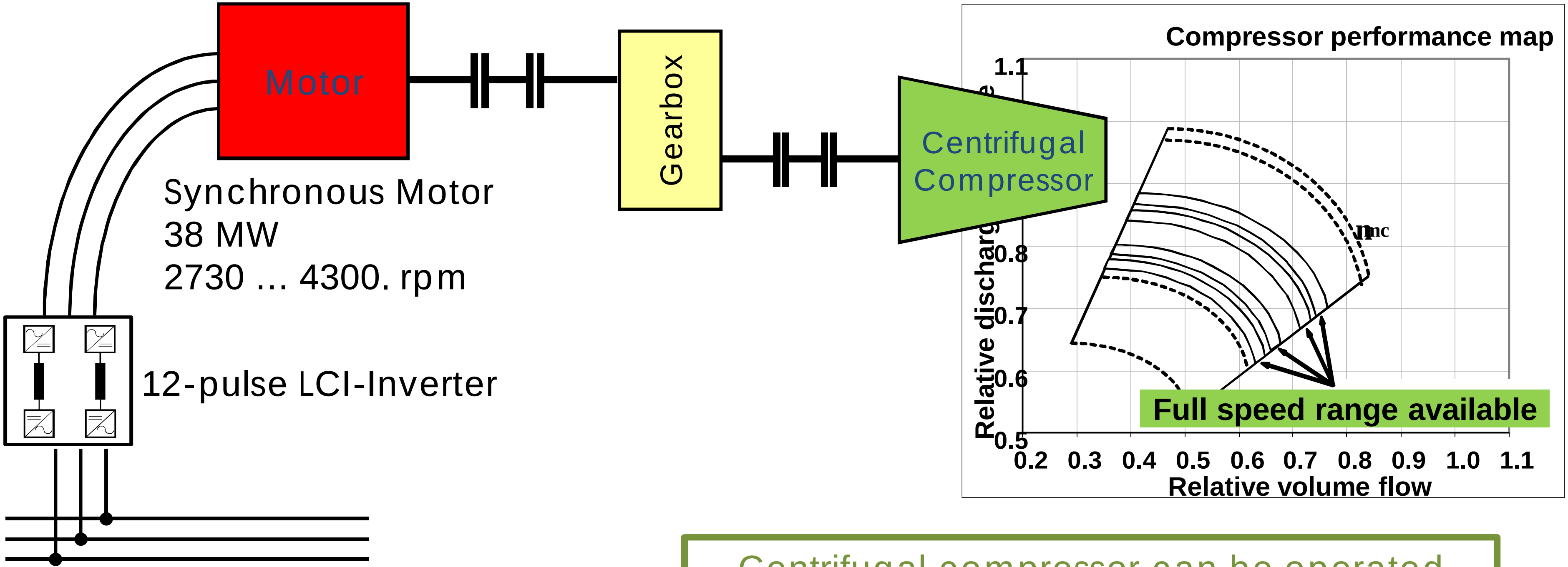


Without electrical interharmonics damping of an LCI



With activated improved electrical interharmonics damping of an LCI

Case Study 1: Blocked speed range eliminated



Centrifugal compressor can be operated within the full performance map without any restrictions.

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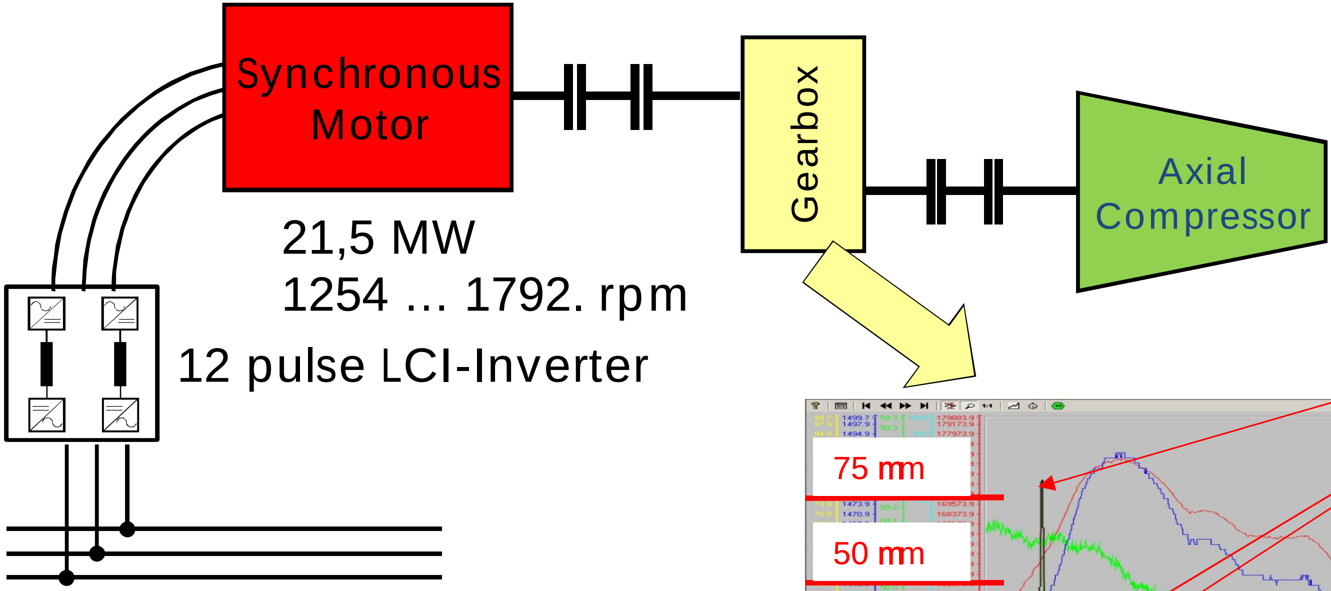
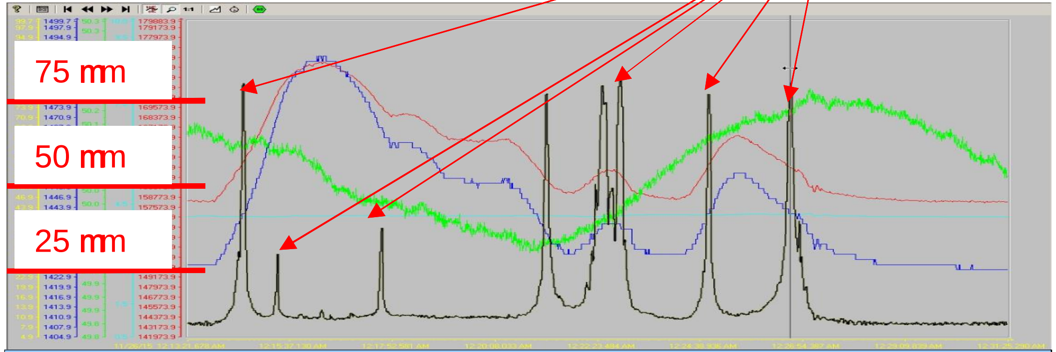
Case Study 2: High gear vibrations avoided

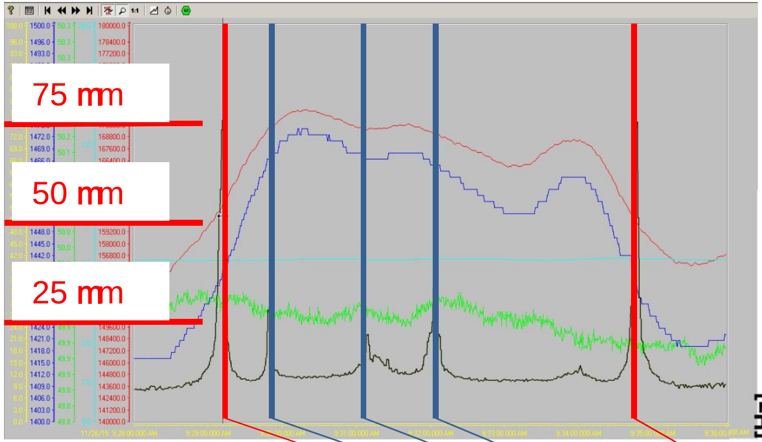


High relative shaft vibration of gear pinion observed. Vibration frequency corresponds with 1st torsional natural frequency.

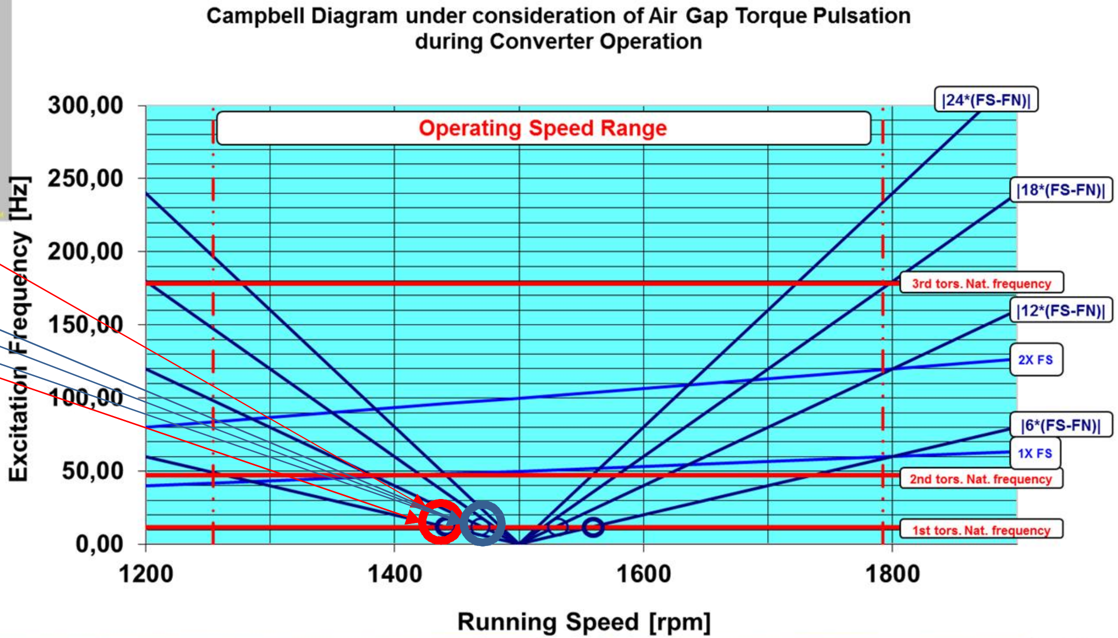


High Relative Shaft Vibrations of HS-shaft

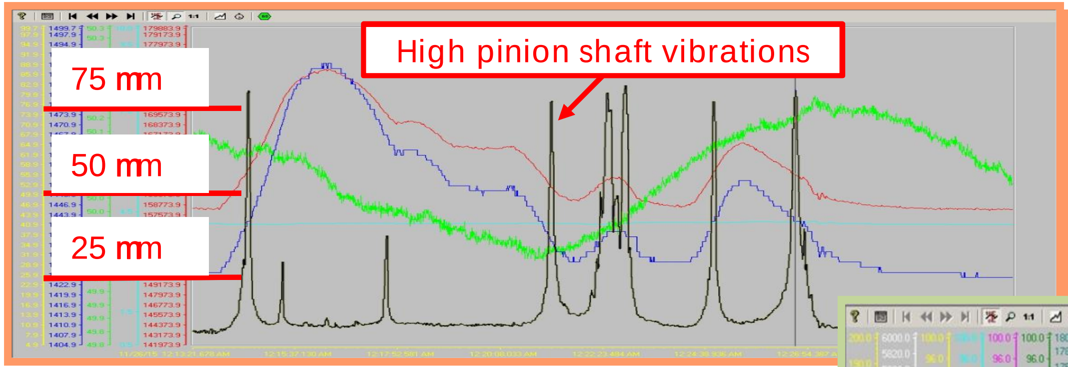
Case Study 2: High gear vibrations avoided



Shaft vibration frequency corresponds with 1st torsional natural frequency and correlates with interharmonic excitation of LCI-inverter

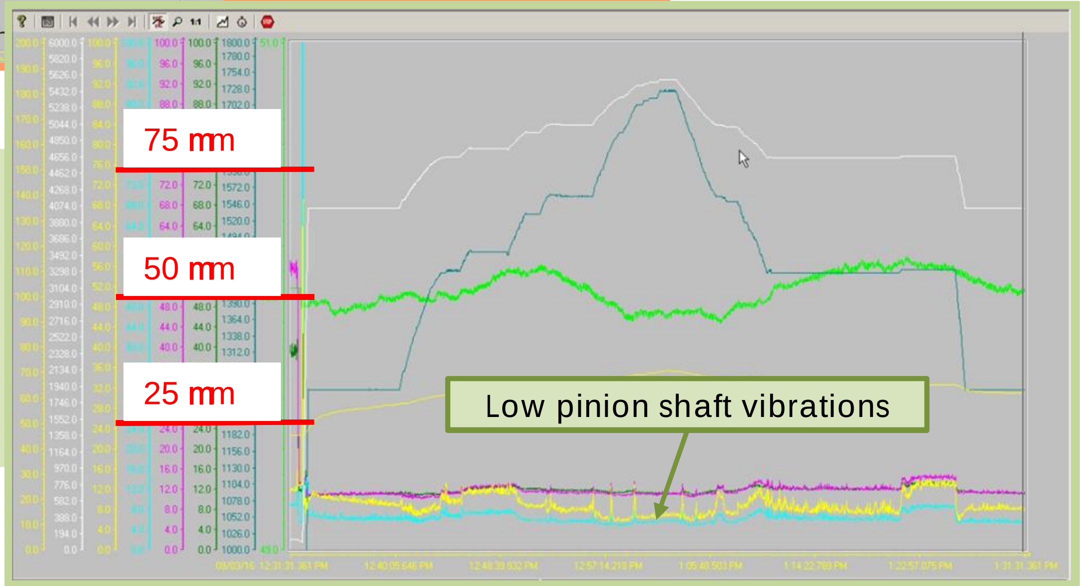


Case Study 2: High gear vibrations avoided

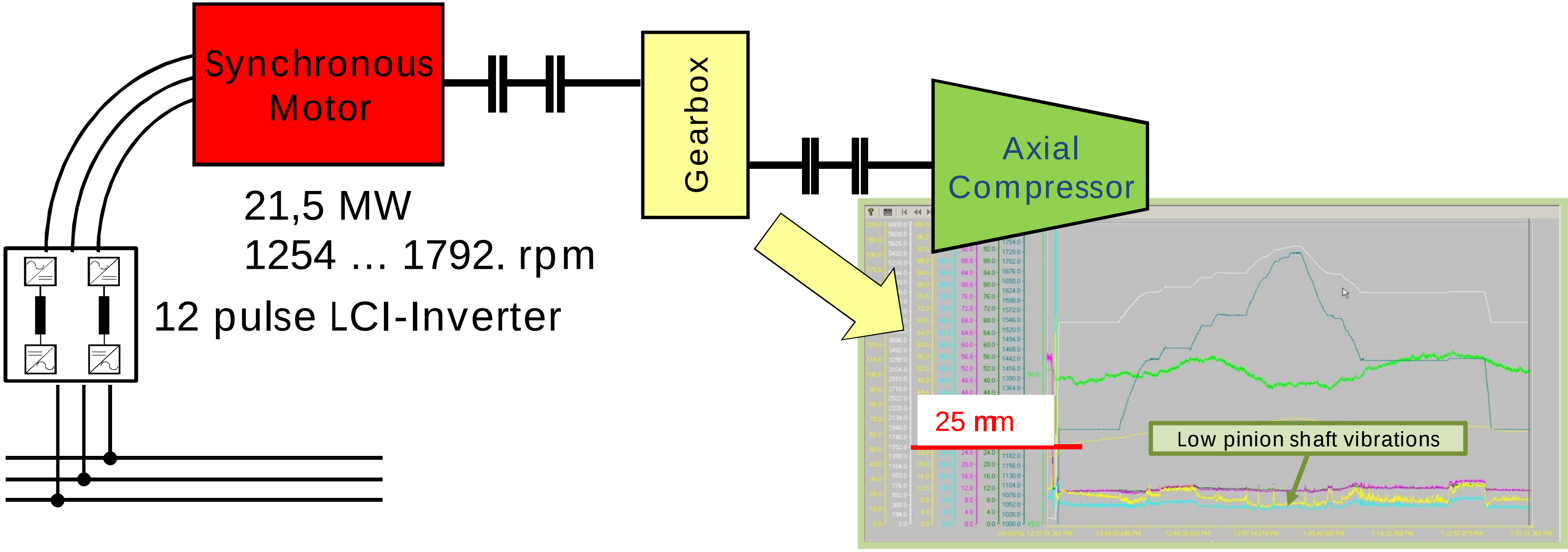


Without electrical interharmonics damping of an LCI

With activated improved electrical interharmonics damping of an LCI



Case Study 2: High gear vibrations avoided



Train can be operated within the full performance map without torsional resonances.

Presentation content

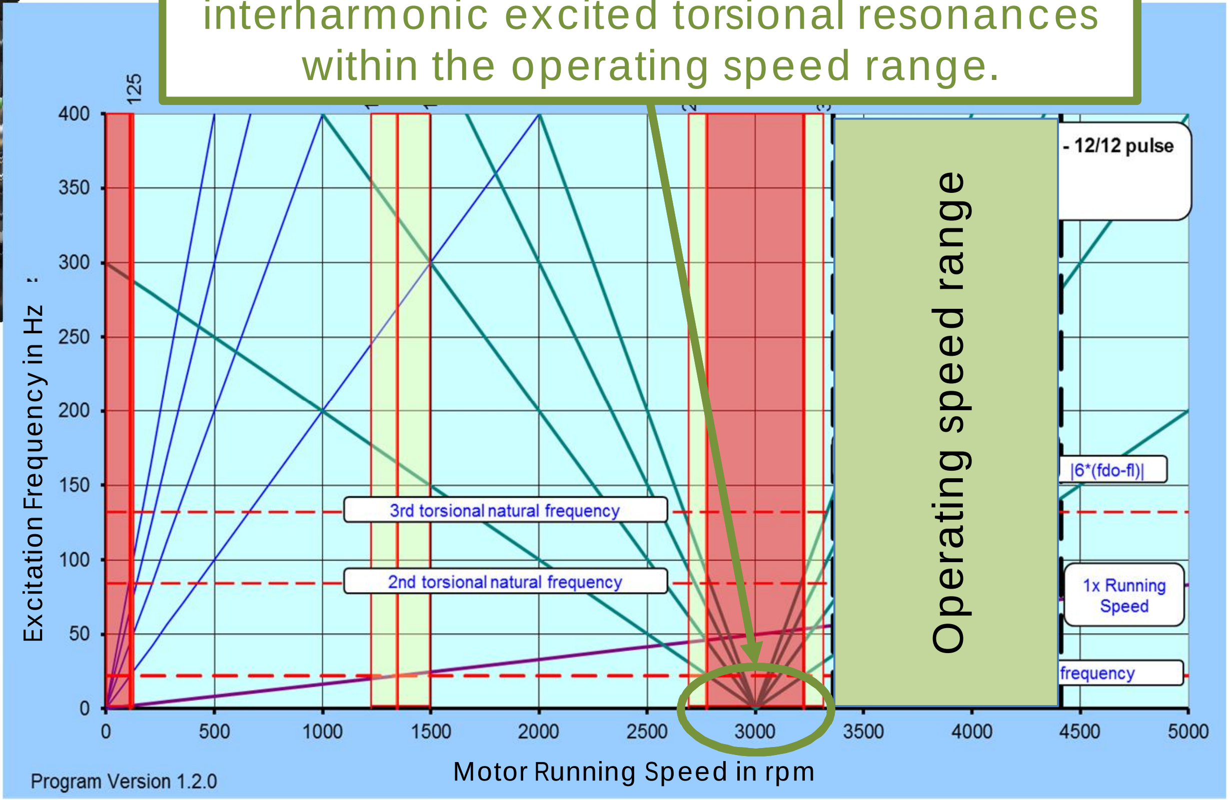
Summary and Conclusion

- Interharmonic pulsating torque are inherently injected by LCI drive system
- LCI drive systems are still the best fit for very high power applications
- The proposed Active Damping technique suppresses the critical interharmonic excitations within the specified frequency range
- This does not have any impact on the normal operation of the drive
- Field measurements within Case Study 1 and 2 show the effectiveness of the implemented active LCI interharmonics damping

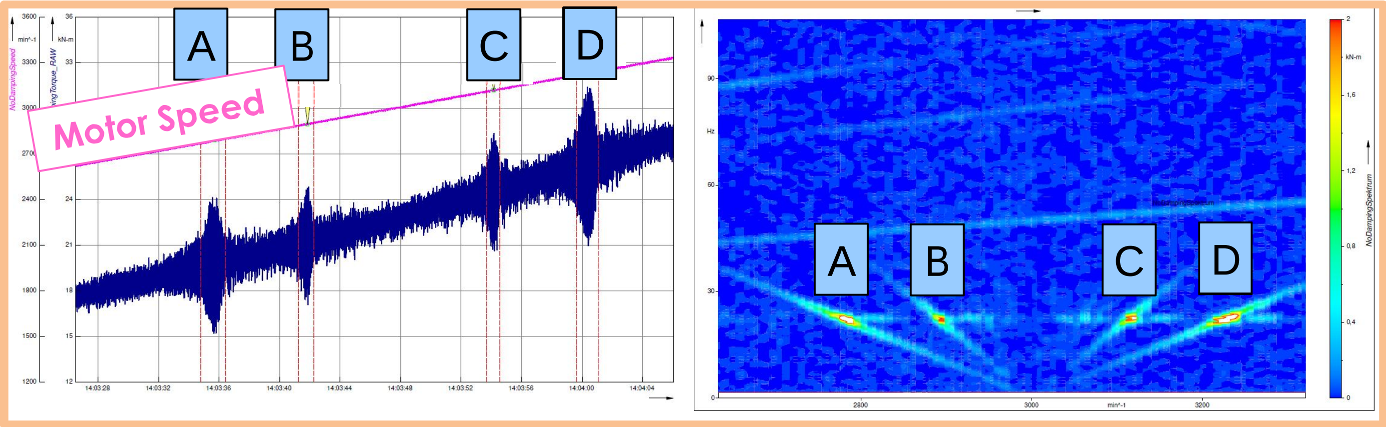
Presentation content

Outlook for new LCI drive train application

Train designed in order to avoid interharmonic excited torsional resonances within the operating speed range.



Outlook for new LCI drive train application



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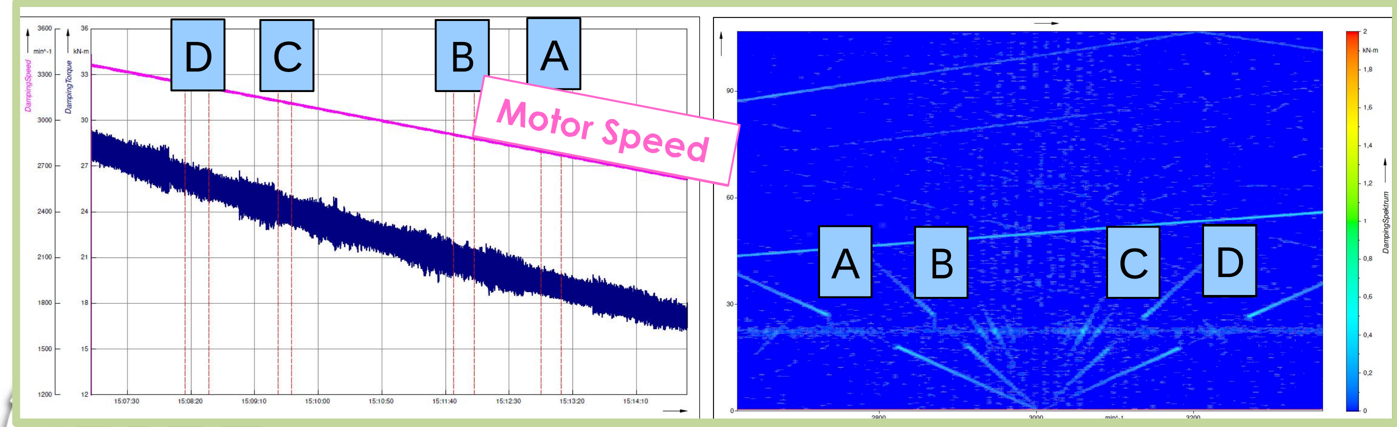
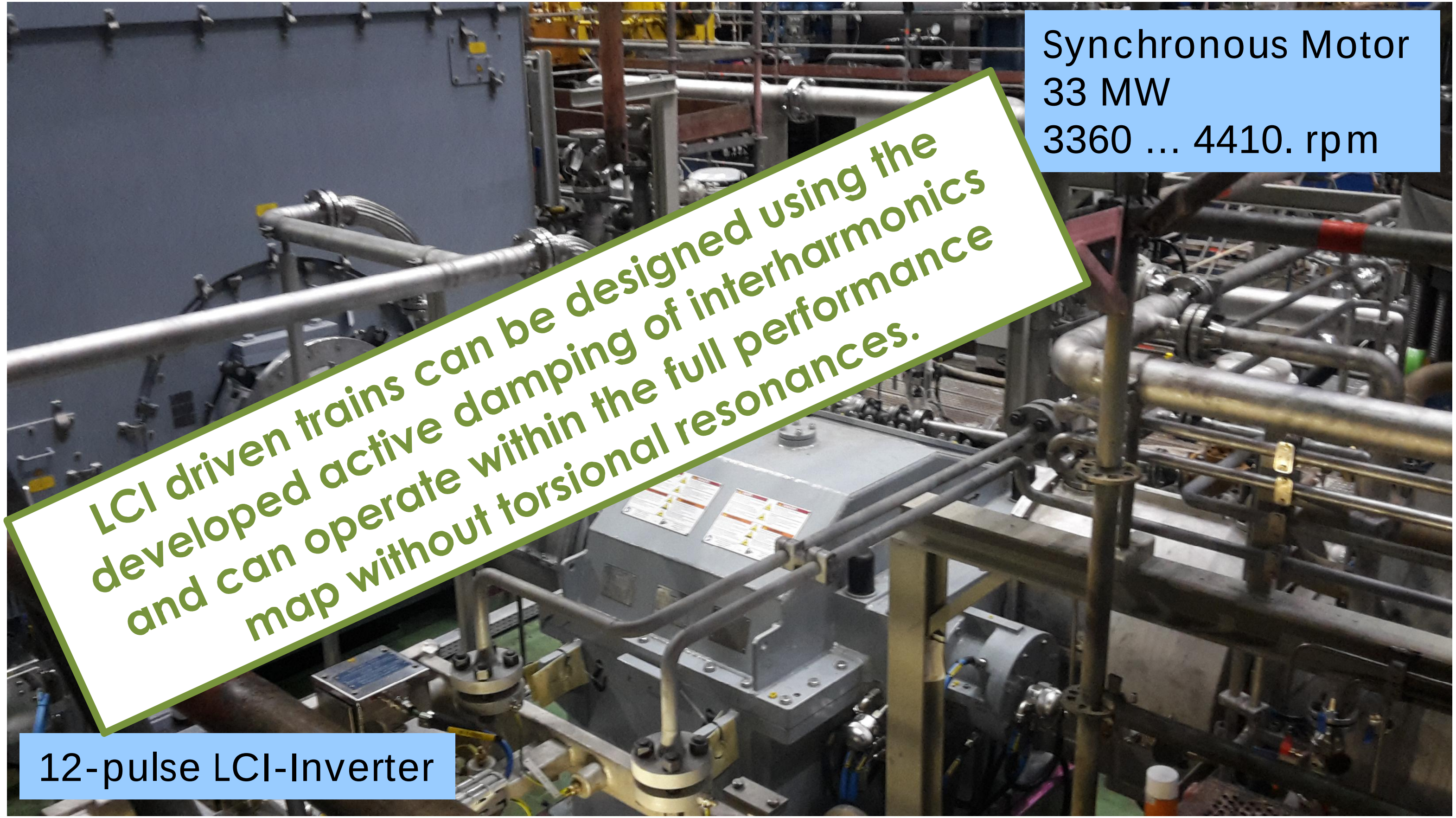


With activated improved electrical interharmonics damping of an LCI

Outlook for new LCI drive train application



Thank you for your attention

References:

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