PHASE3 Technologies Ltd.

Intelligent Predictive Maintenance Solutions

Predictive Maintenance for electric motors and motor based machinery.

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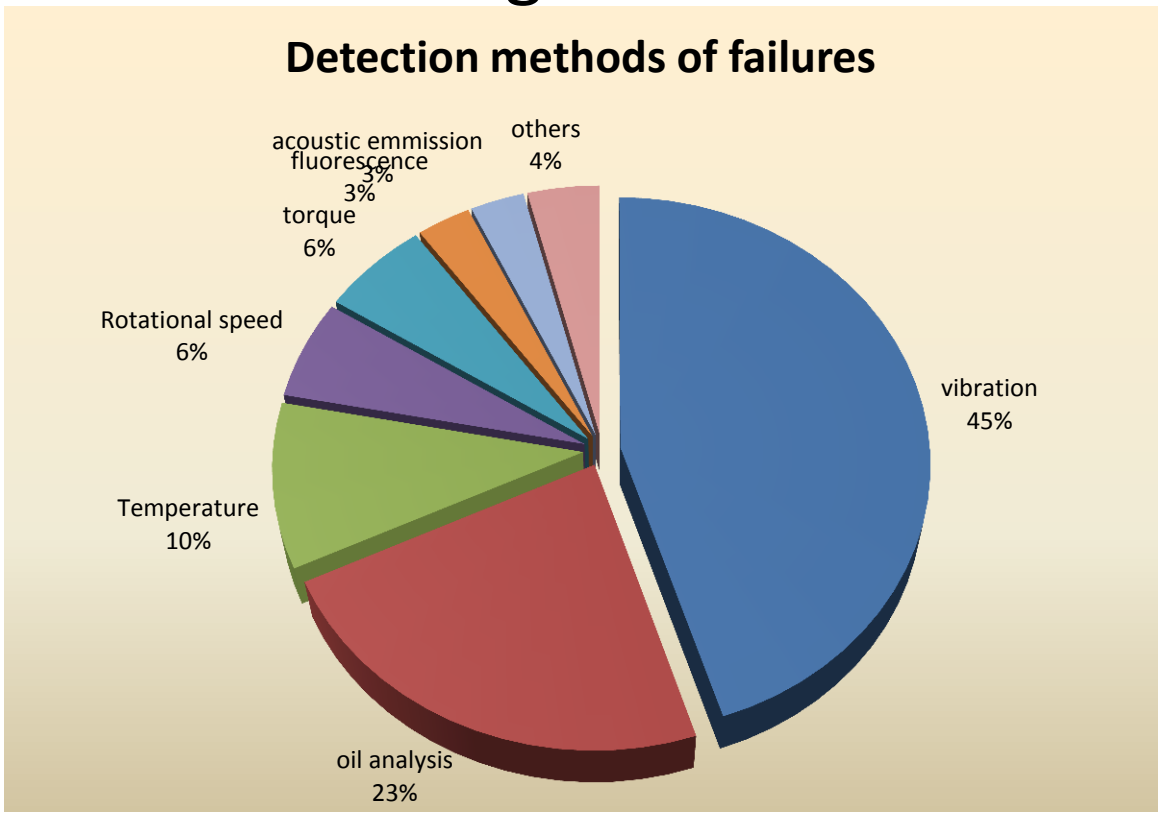
Introduction

The common solution to evaluate rotating and non-rotating machinery condition is predictive maintenance technologies base on vibration analysis.



Disadvantages of vibrations

- ✓ Physical installation
- ✓ Shut down
- ✓ Many cables
- ✓ Analysis per location
- ✓ Expensive

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PHASE3 Solution

- Continuous monitoring of performance and energy usage
- Eliminates the need for unplanned repair and maintenance
- Provides early warning of developing faults

What's wrong?

What do I have to do?

How soon I have to do it?

Save from the domino effect

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Equipment Covered

✓Equipment driven by three-phase electric motors: Pumps, fans, compressors, conveyors, …

✓Generators
✓Turbines

Description of the Process

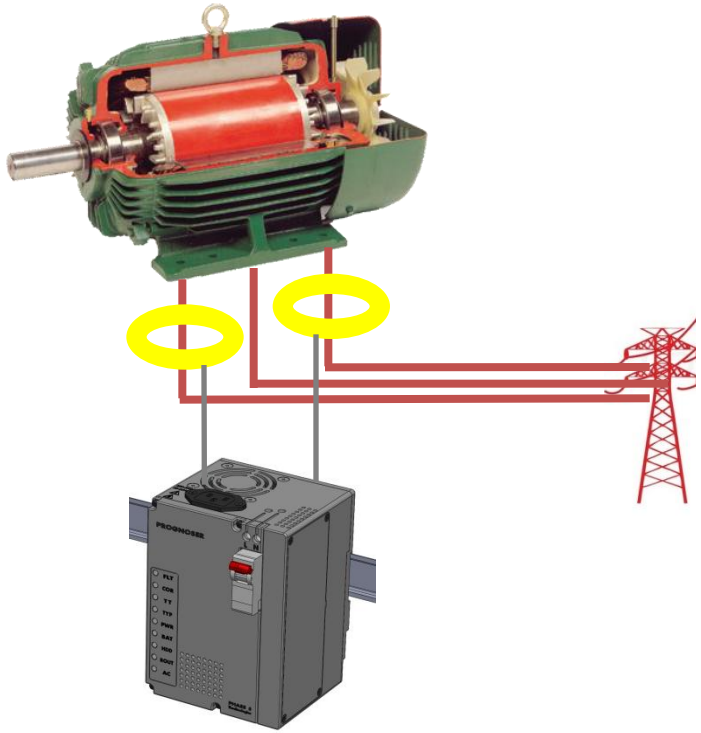
Motor / Generator / Turbine

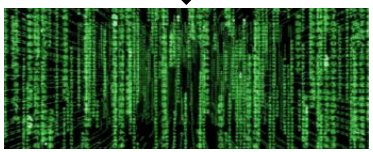
Current Transformers

Online MCM System

Algorithm

Alert





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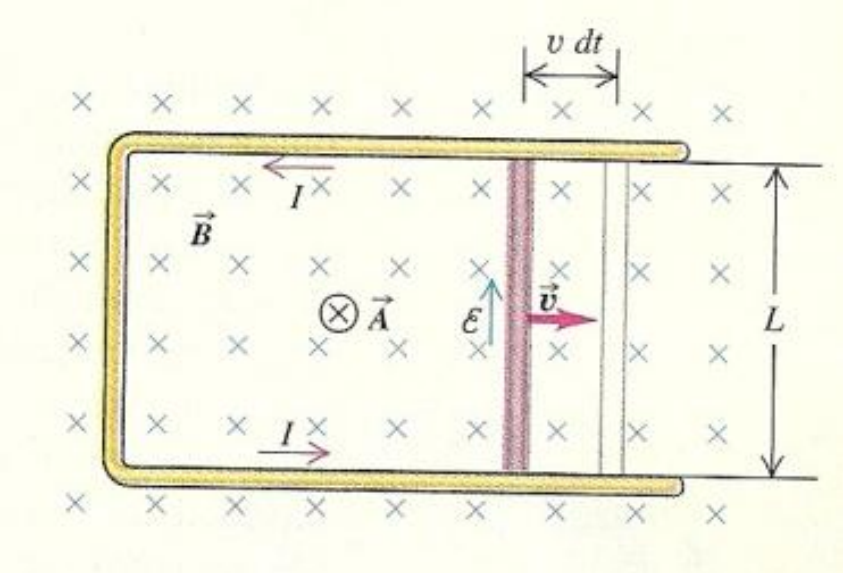
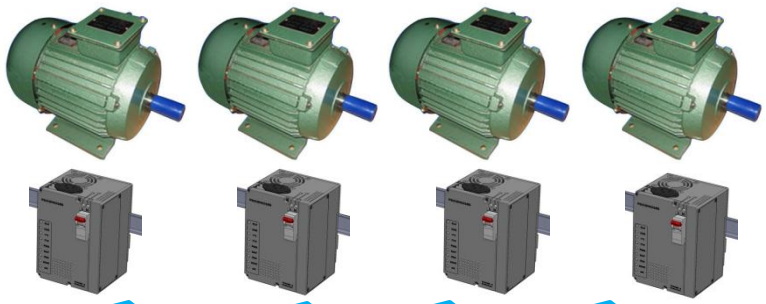
Induced EMF

- $\epsilon = \int_b^a (\bar{v} \times \bar{B}) \cdot \bar{dl}$



Fleet management

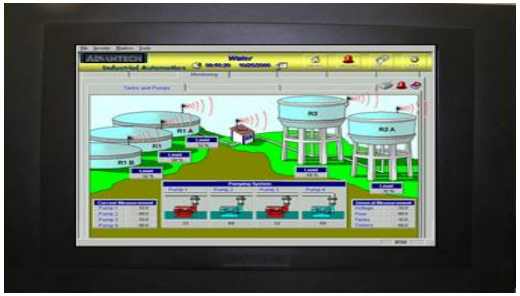


Wireless

Local control room

Internet

Global control center



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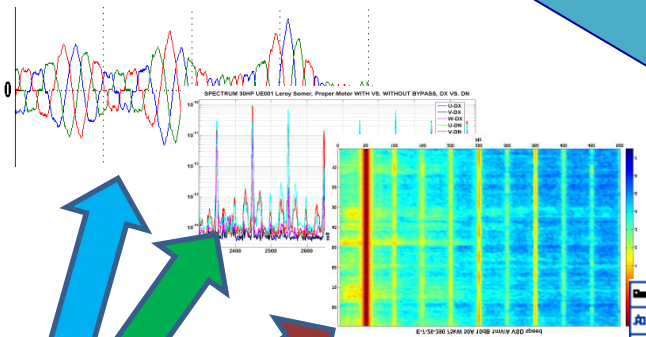
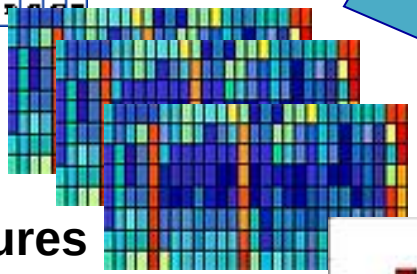
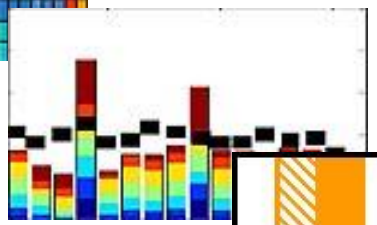
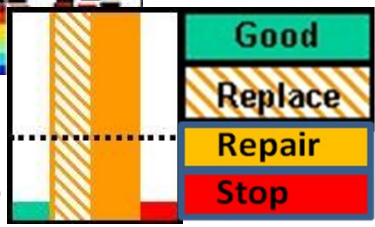
Diagnostic Process



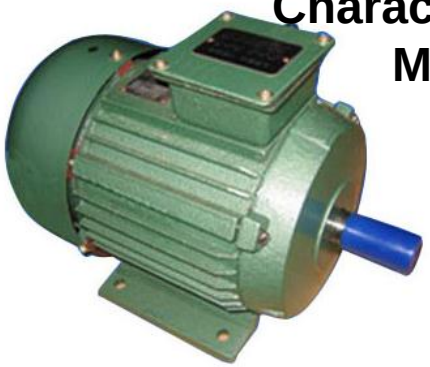






Signal Processing
Time domain
Frequency domain
T-F domain

Motor Characteristics Model



Features Analysis

Aggregation

Decision Process

Adaptive Algorithm

- Can work with:
- Soft Starters
- Variable Speed Drives (VSD)
- Generators

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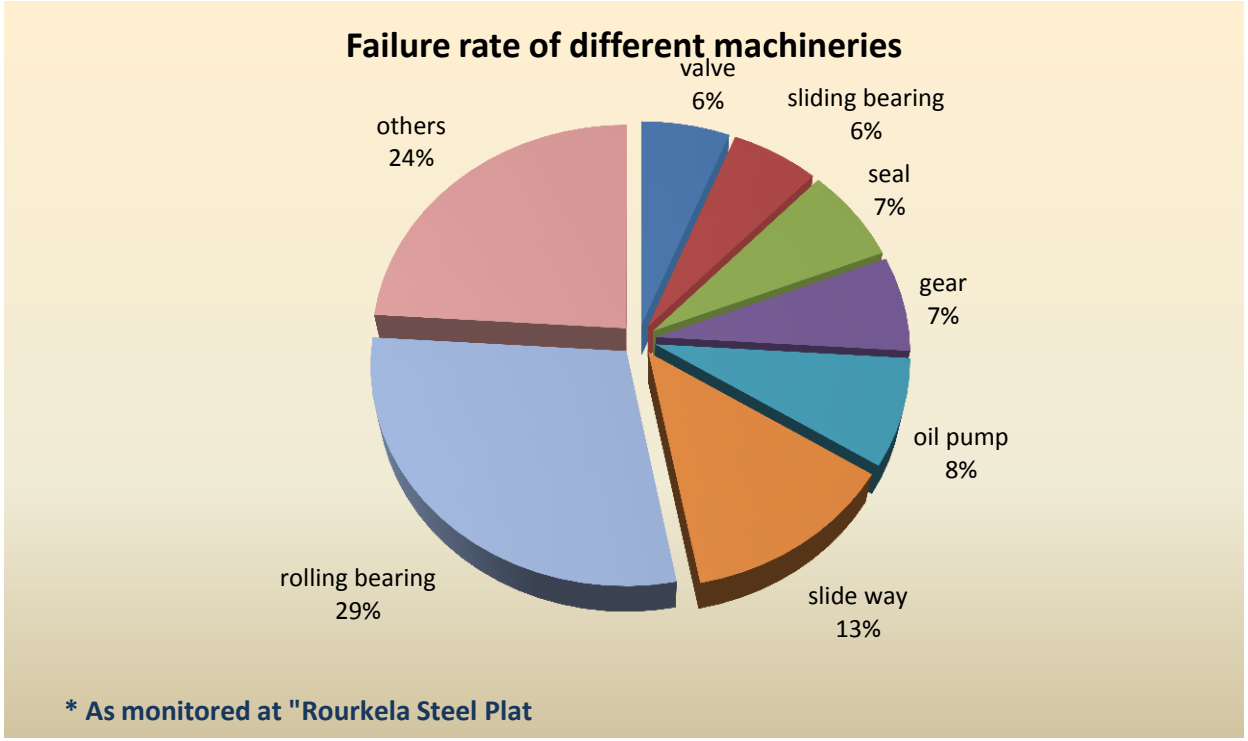
Faults

Mechanical faults

- Broken bar
- Cracks in rotor
- Imbalance
- Eccentricity
- Bearings
- FOD
- Looseness
- Chip



Electric faults

- Faults in VSD & voltage soft starters
- Electricity break down & shocks

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Phase3 pilot at Nesher Israel Cement

NESHER ISRAEL CEMENT ENTERPRISES LTD.

נשר מפעלי מלט ישראליים בע"מ

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The Algorithm

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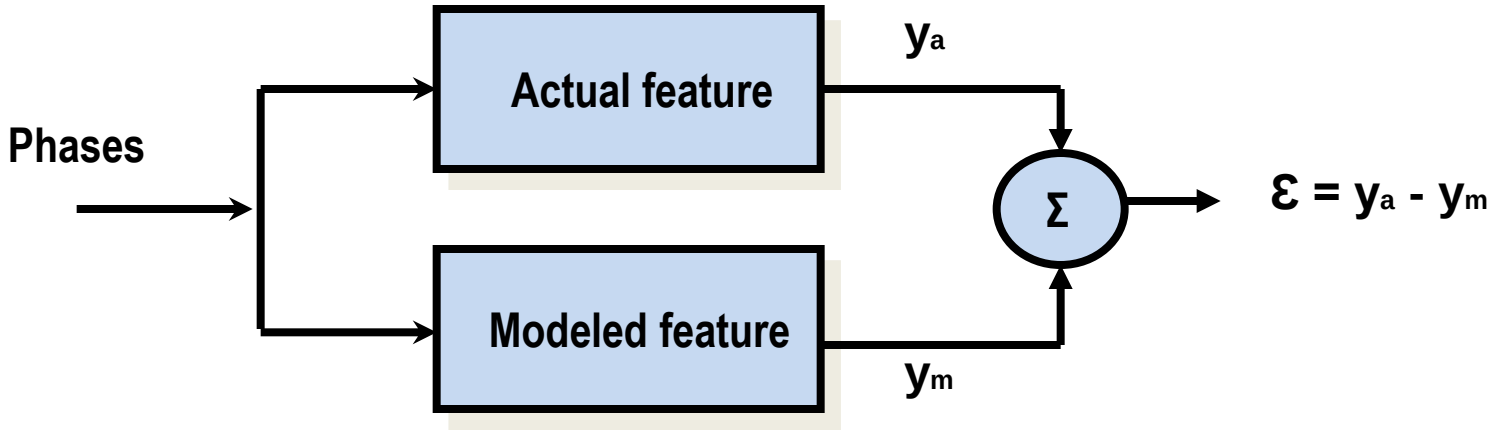
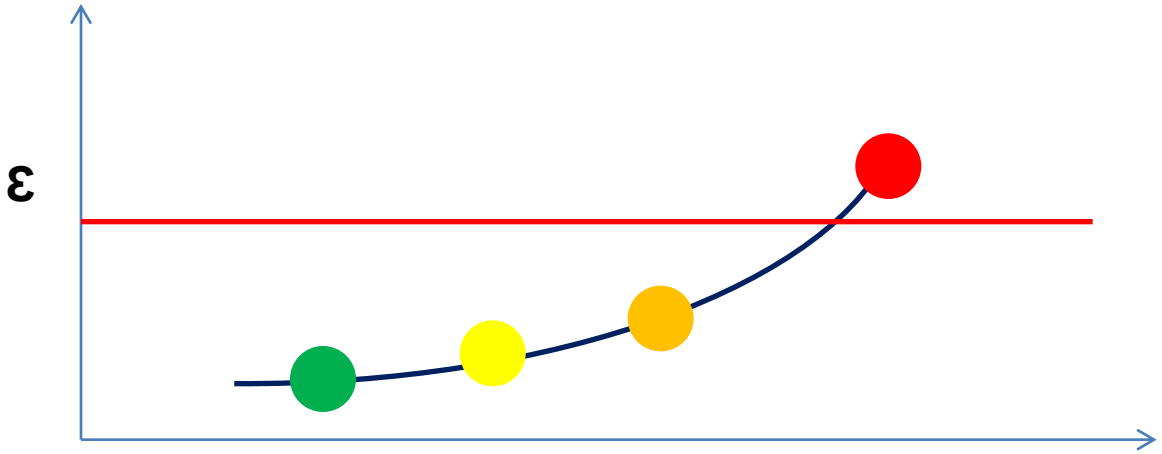
Model based fault detection





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The Model (Training)

- based on training measurements while the motor is still normal
- $y_m = a_0 + a_1 \cdot x + a_2 \cdot x^2$
- $y_m = y_{normal}$
- $\begin{Bmatrix} a_0 \\ a_1 \\ a_2 \end{Bmatrix} = X^{-1} * Y_{normal}$

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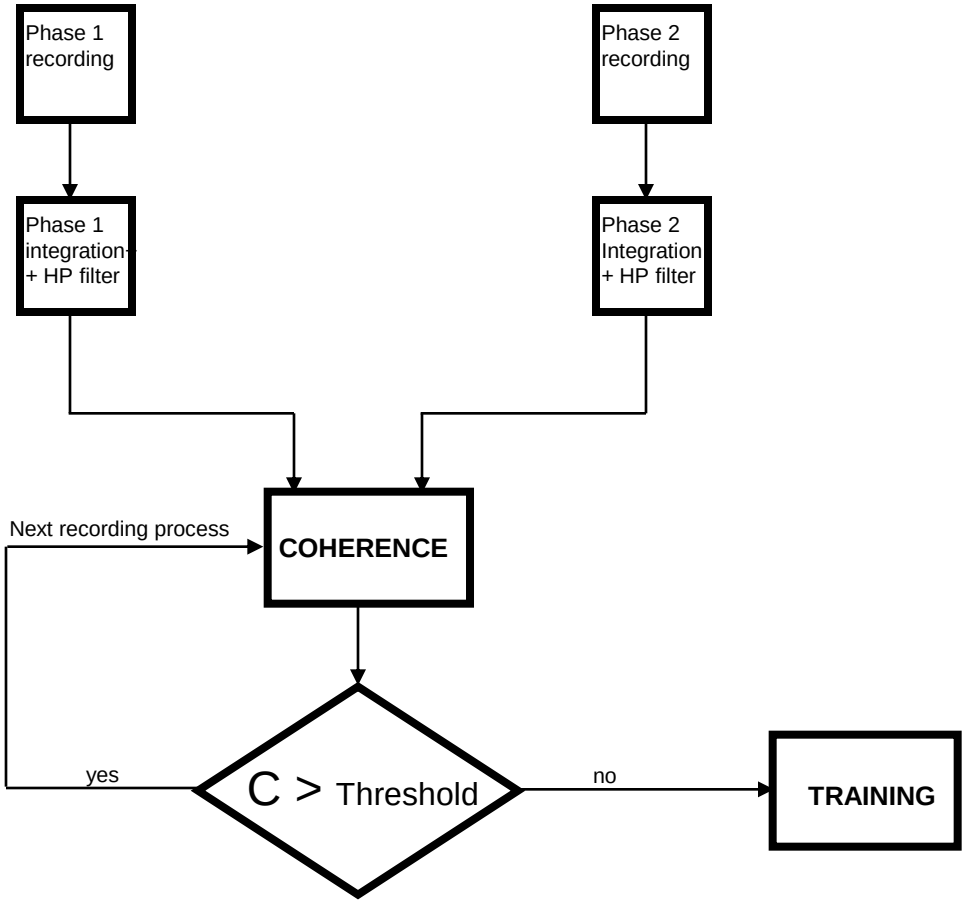
Innovation



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Examples

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Pilot in Gershon Klein

Motors repair

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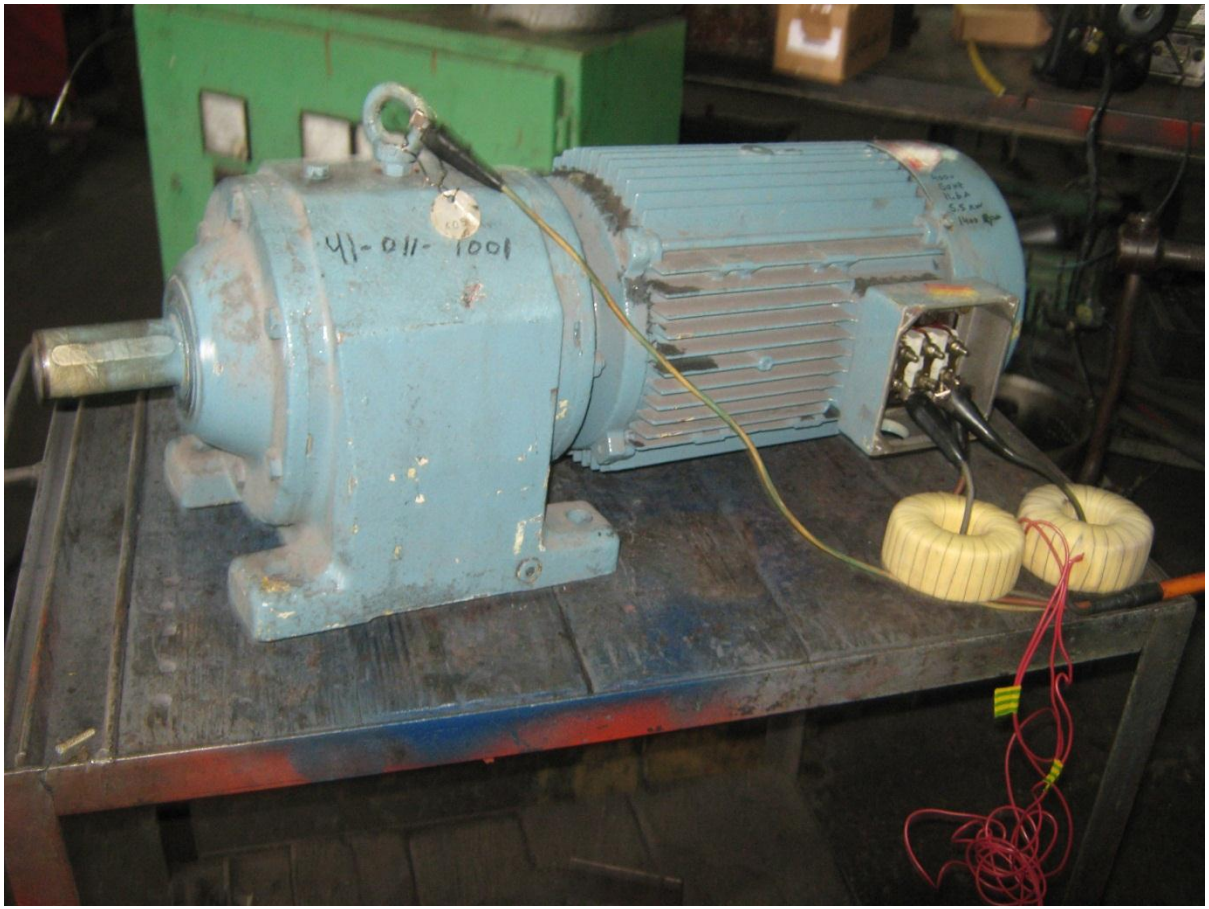
Gear motor 7.5HP 1400RPM



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Gear motor 7.5HP 1400RPM

Broken bearing

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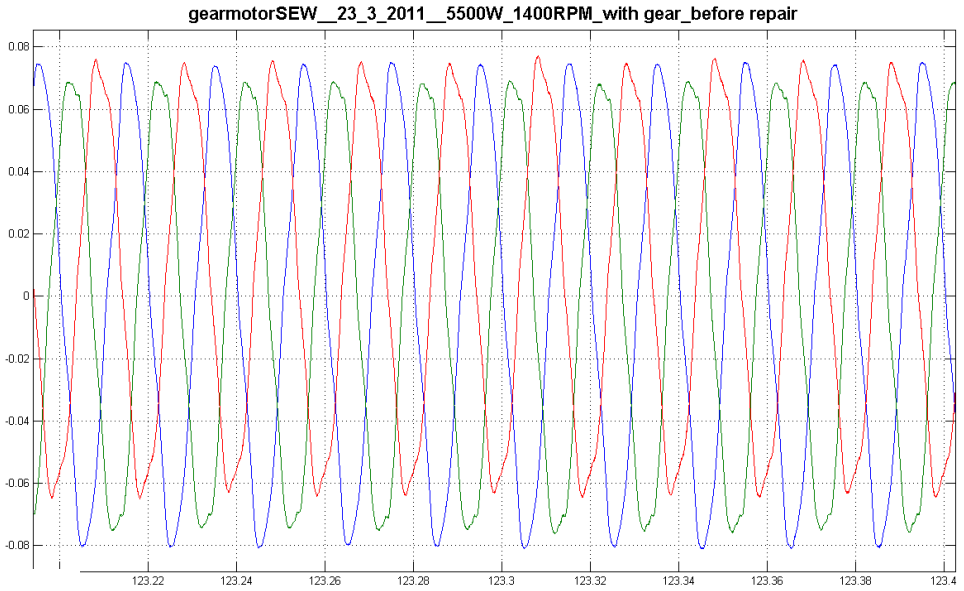
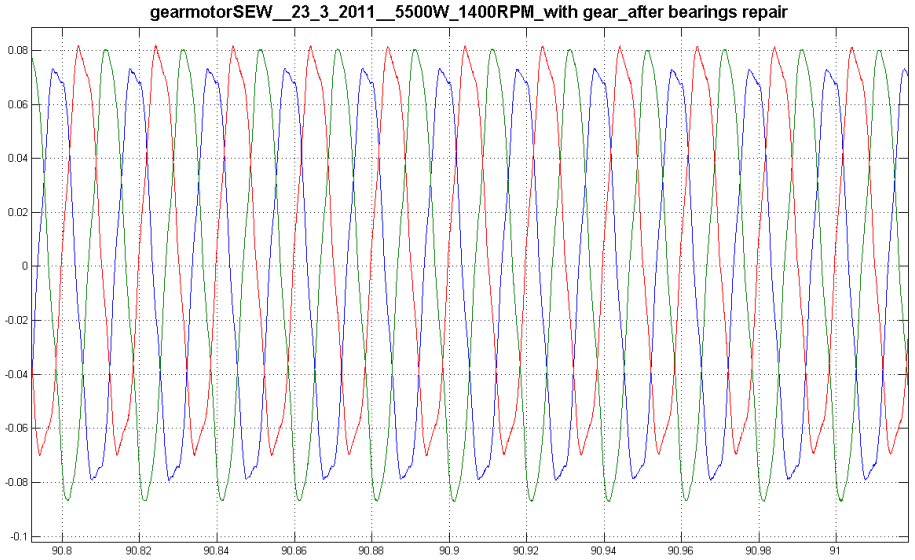
Gear motor 7.5HP Waveform

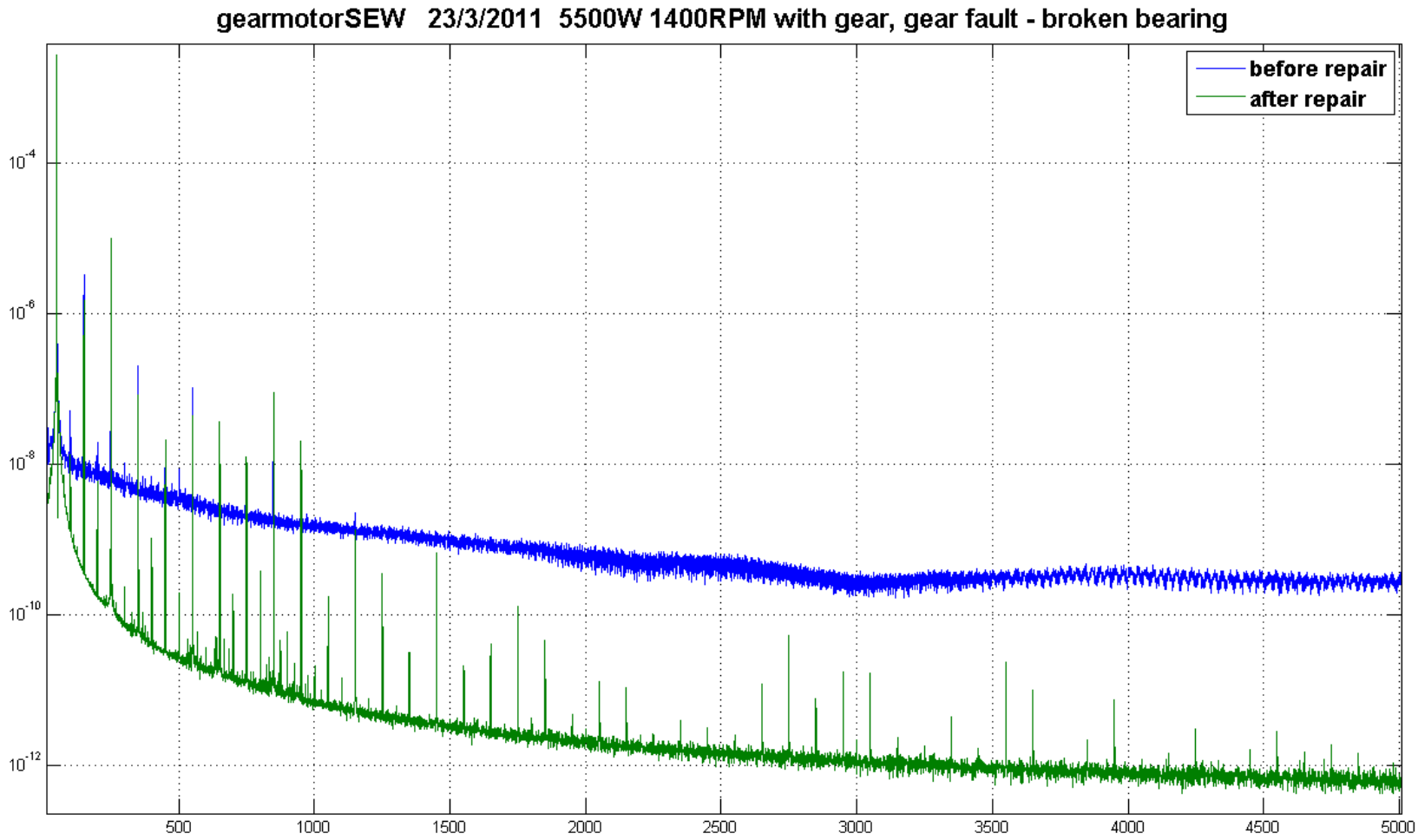
before repair





after repair

Gear motor 7.5HP Spectrum



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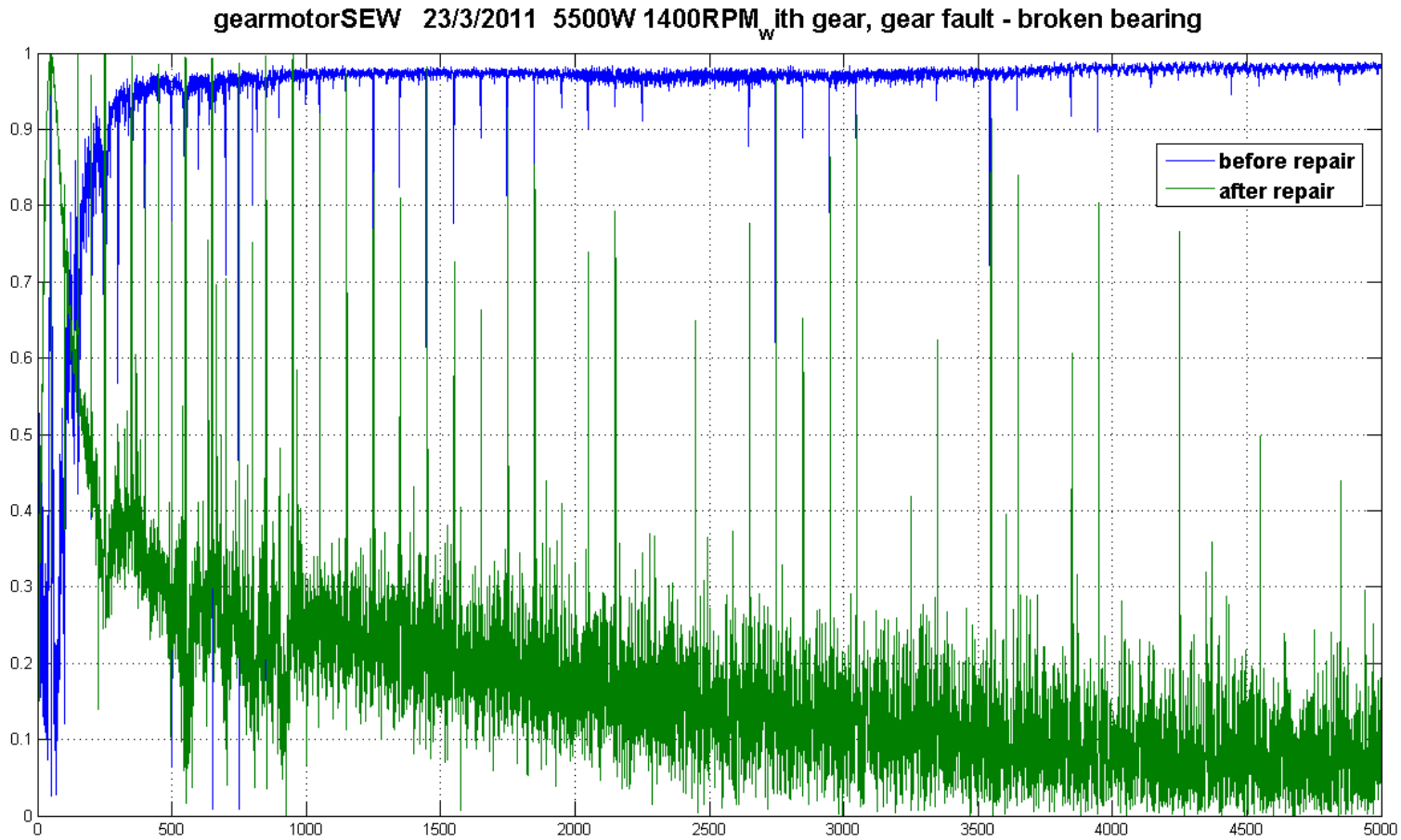
Gear motor 7.5HP Coherence



USHPIZ 40HP 980RPM

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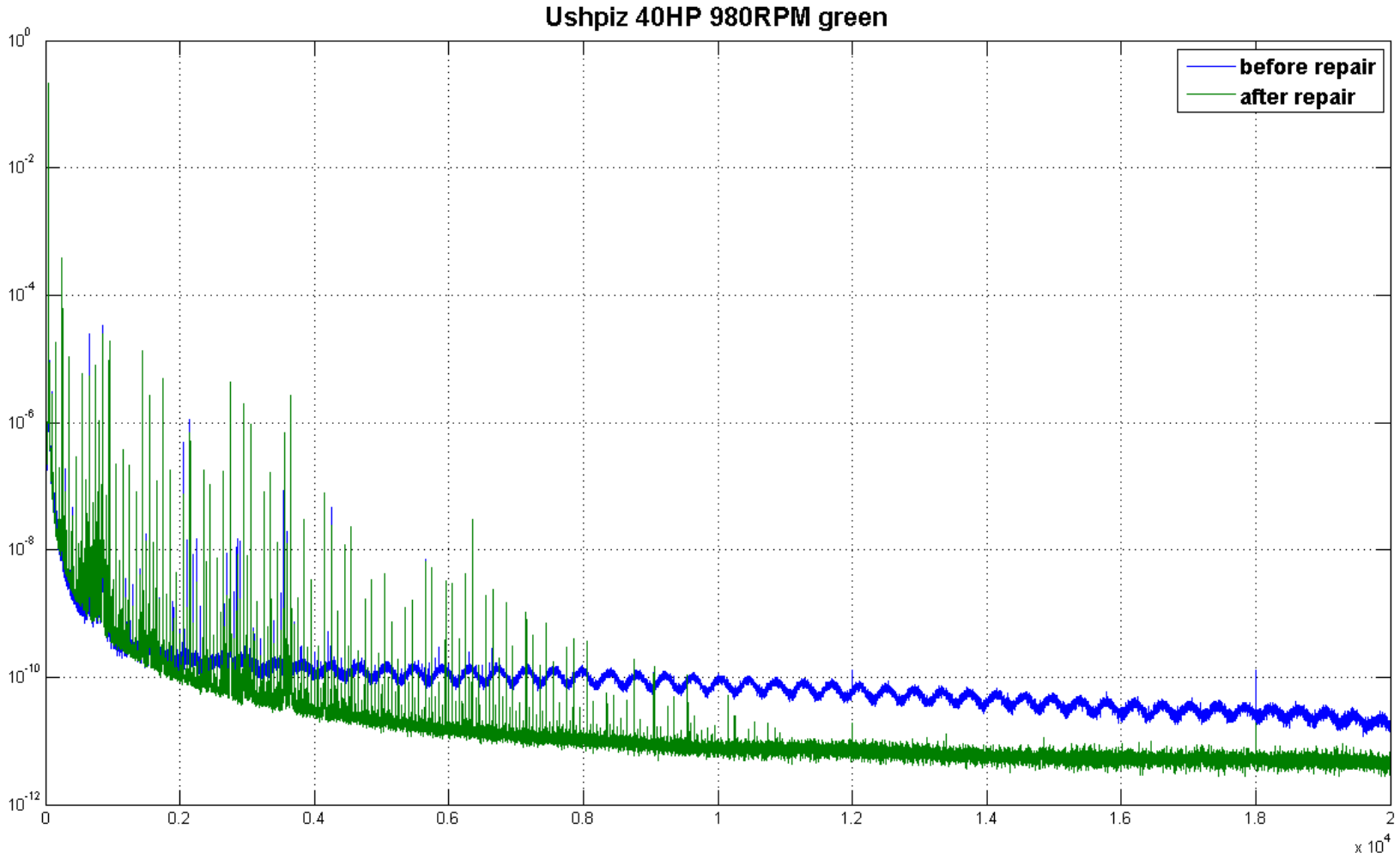
USHPIZ 40HP Spectrum



dust– background noises during running

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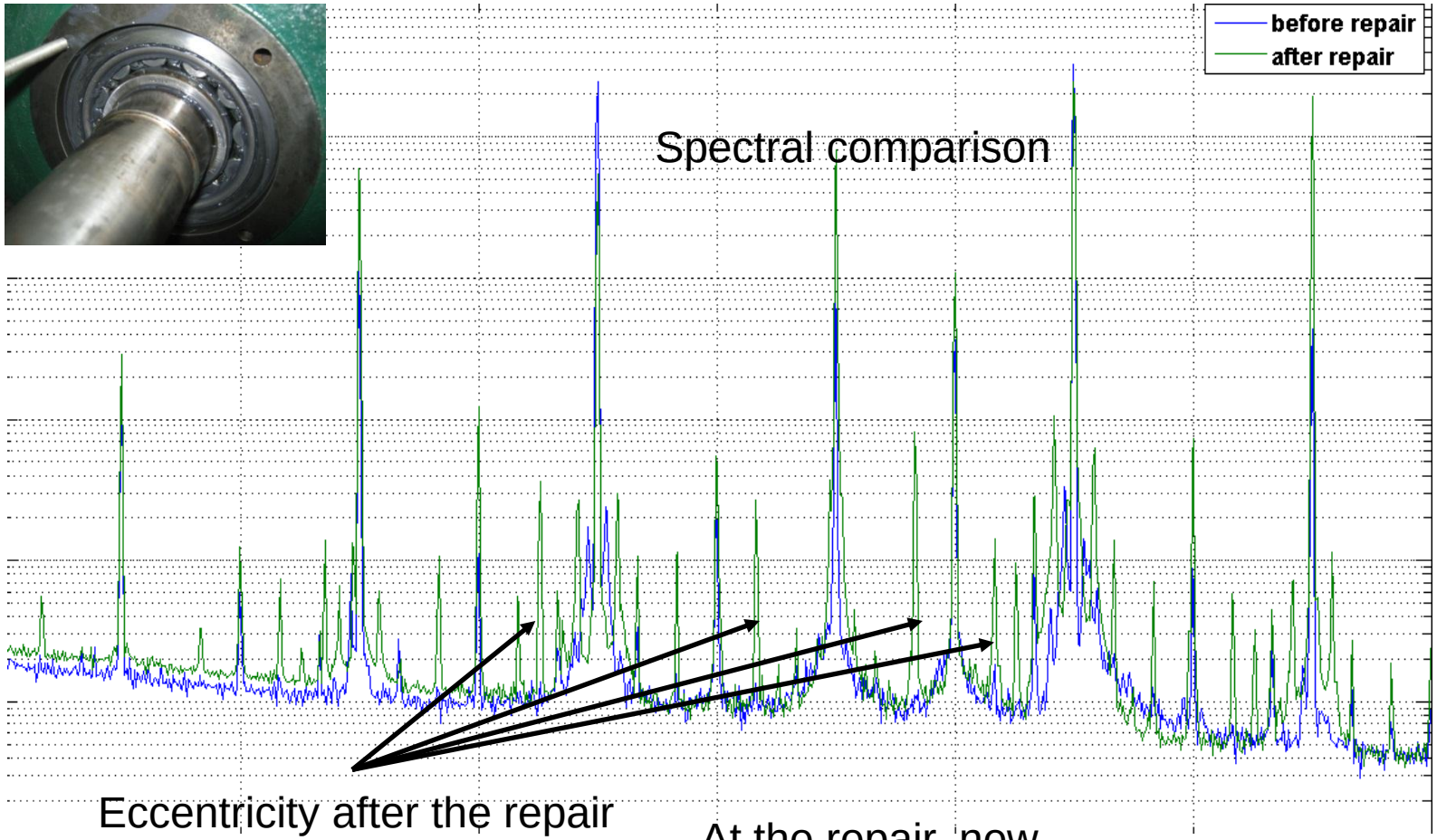
USHPIZ 40HP Spectrum



At the repair, new bearings where replaced but one of them was not assembled correctly.

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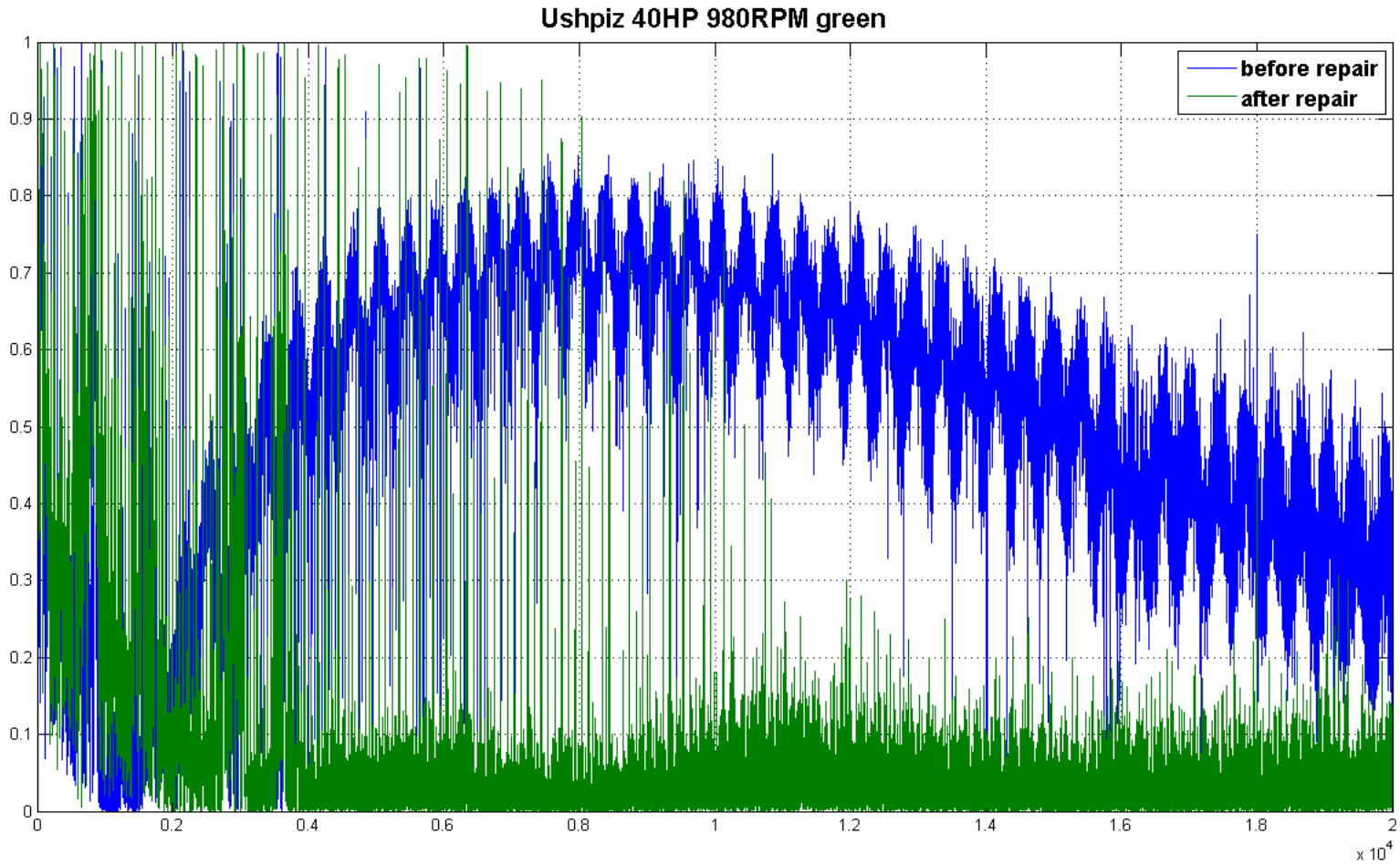
USHPIZ 40HP Coherence



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Pilot in Nesher Ramle

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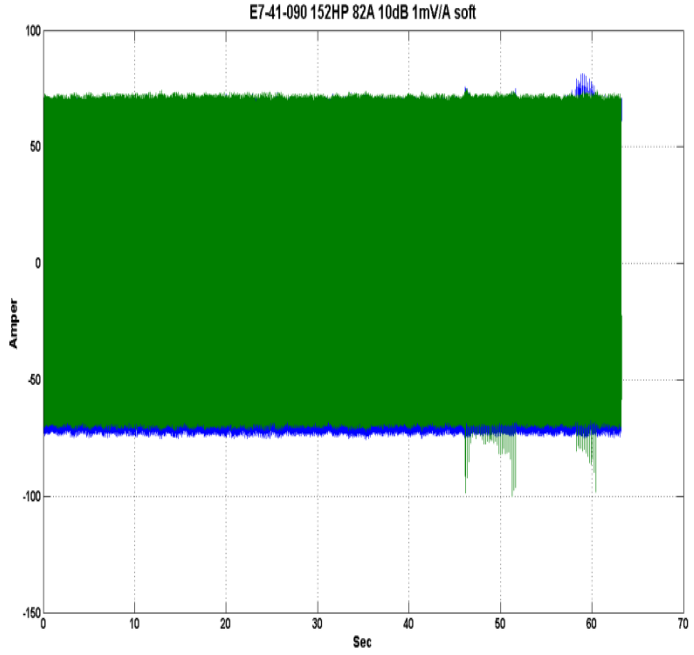
Results and comparison with a competitor based on vibrations

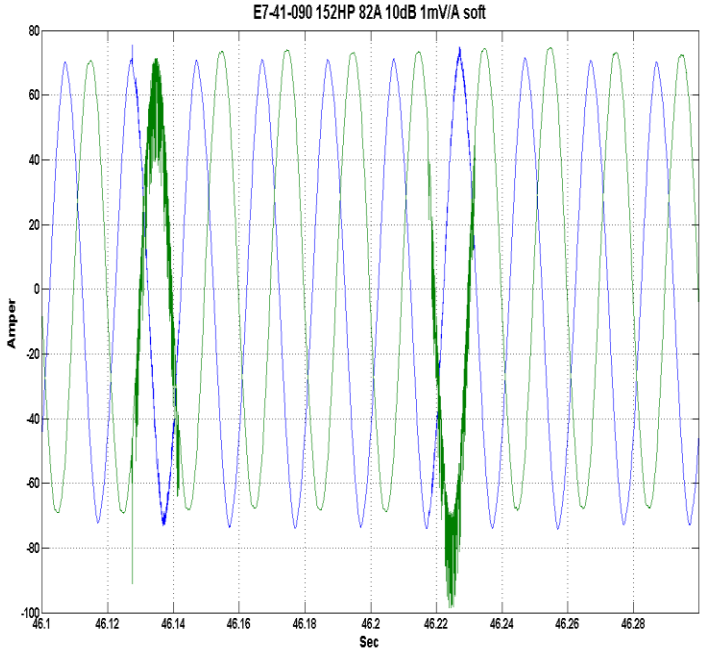
MOTOR S\N	Nominal Power	"PHASE3" diagnosis	"TISAR" diagnosis
7-43-165 DOL	25HP	Normal	Normal
7-76-635 DOL	30HP	Normal	Normal
7-41-090 SOFT	152HP	Load noises – Interrupted load operation	Load wear
7-44-750 SOFT	110kW	Normal	Normal
7-43-105 DOL	10HP	Load noises – Interrupted load operation	Load wear
7-41-133 DOL	40HP	Normal	Normal
7-44-880 SOFT	250HP	Normal	Normal
7-44-710 VSD	800HP	Normal	Normal
7-26-350 VSD	75kW	Normal	normal
7-26-390 VSD	75kW	Assembling fault	Normal
7-41-390 DOL	40HP	Normal	Motor looseness
7-41-740 DOL	40HP	Normal	Motor looseness

7-41-090 Soft 152HP 82A Waveform

TIME



TIME Zoomin

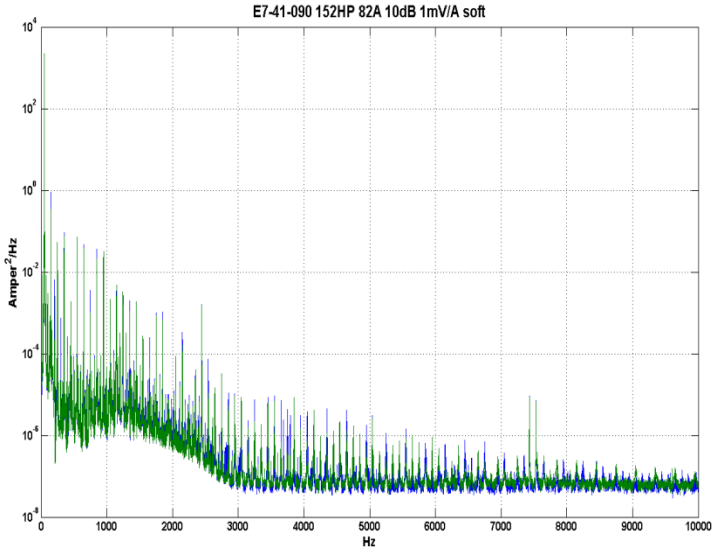


FAULT: Noises from Load

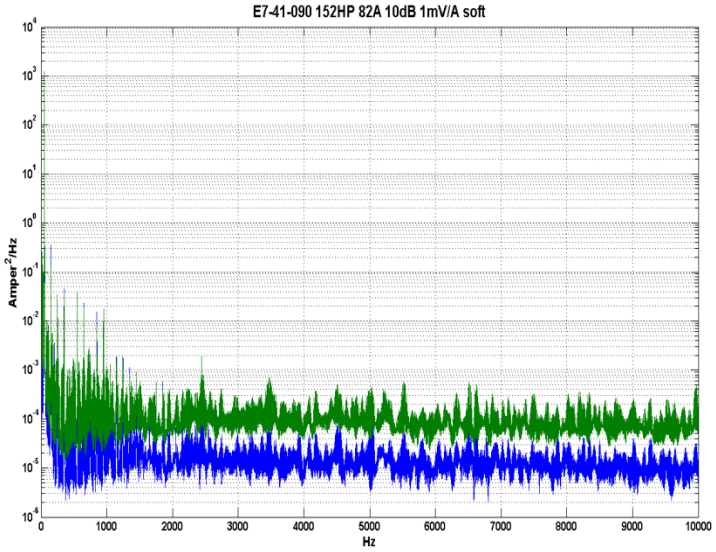
PHASE3 TECHNOLOGIES

7-41-090 Soft 152HP 82A Spectrum

no noises



with noises

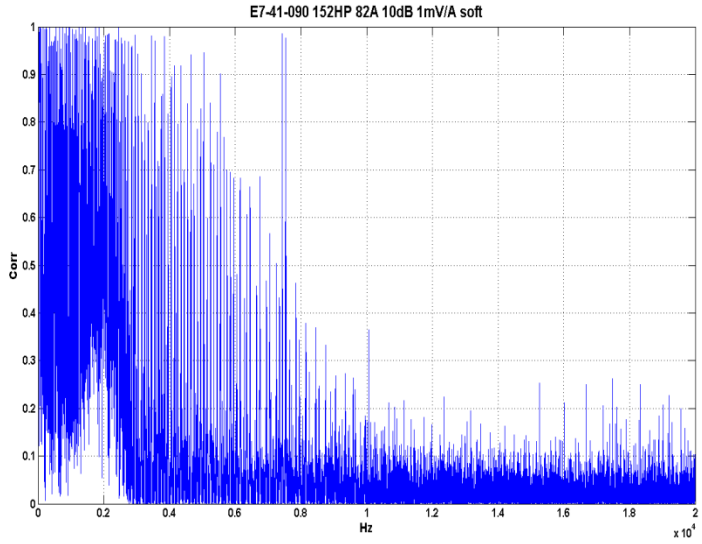


FAULT: Noises from Load

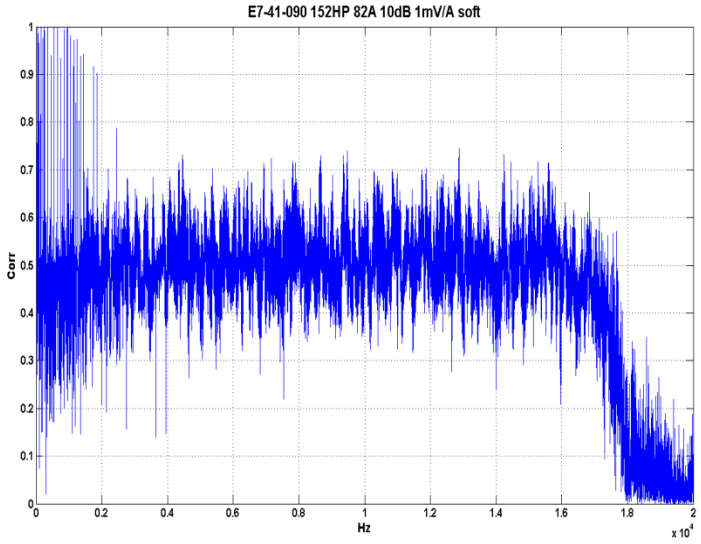
PHASE3 TECHNOLOGIES

7-41-090 Soft 152HP 82A Coherence

no noises



with noises



FAULT: Noises from Load

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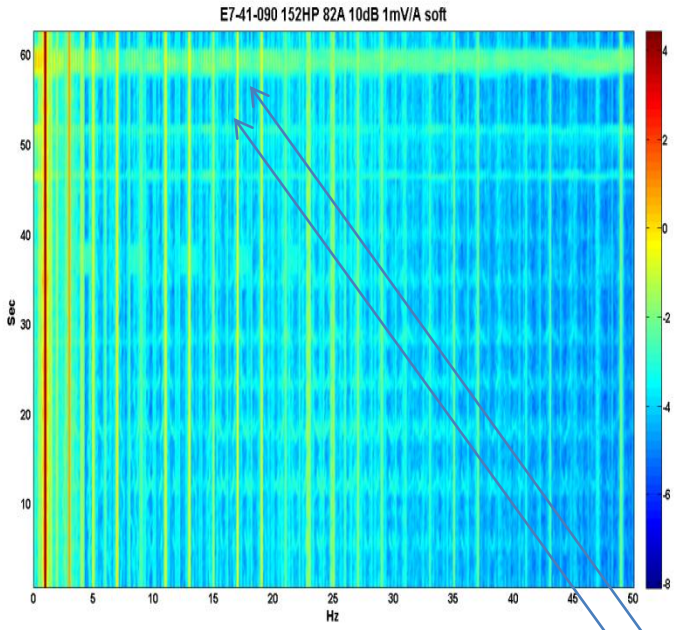
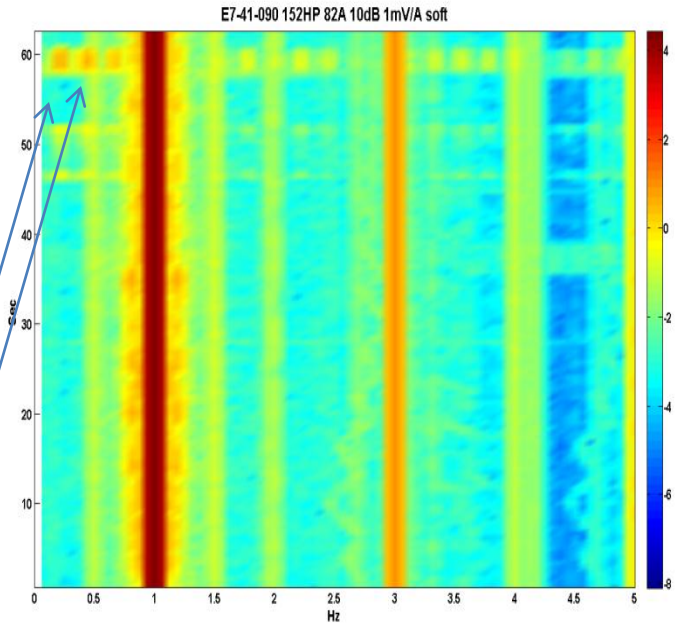
7-41-090 Soft 152HP 82A cont.

TIME-FREQUENCY



TIME-FREQUENCY Zoomin



MOMENTARY NOISES FROM LOAD

Spectrograms, T-F domain

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Pilot in MILU-OF

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The System – CMG Motor no. 14 + Compressor, broken bar fault

- **Features:**
  Max Power 400kW
  Nominal Speed 3000 RPM

- **Complains:**
  Strong Vibrations
  High Temperatures on Coils
  A Crack on Ground under the Motor

long and wide crack

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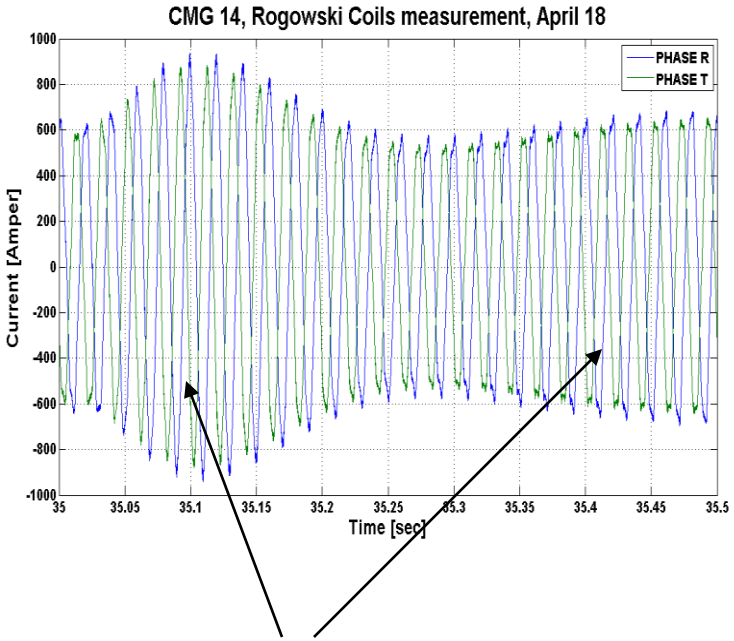
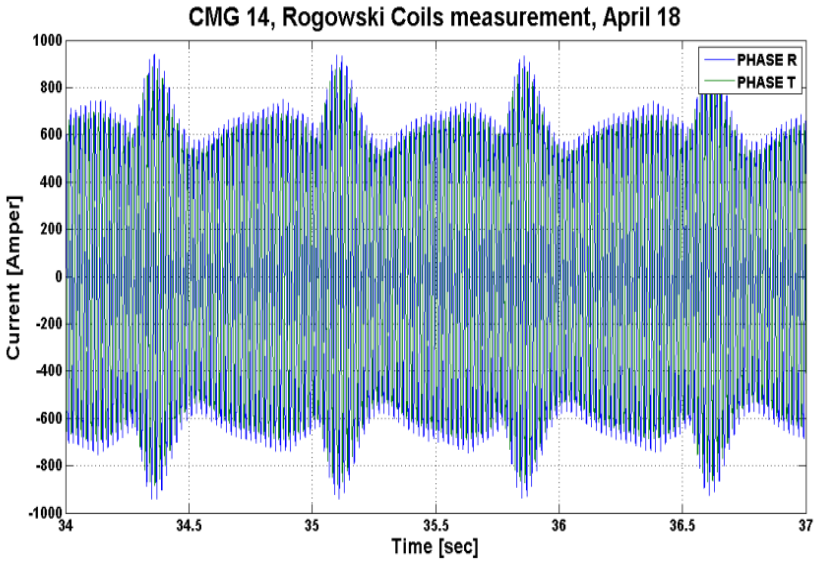
Current waveforms

Data of the 2 phases R and S in Time Domain

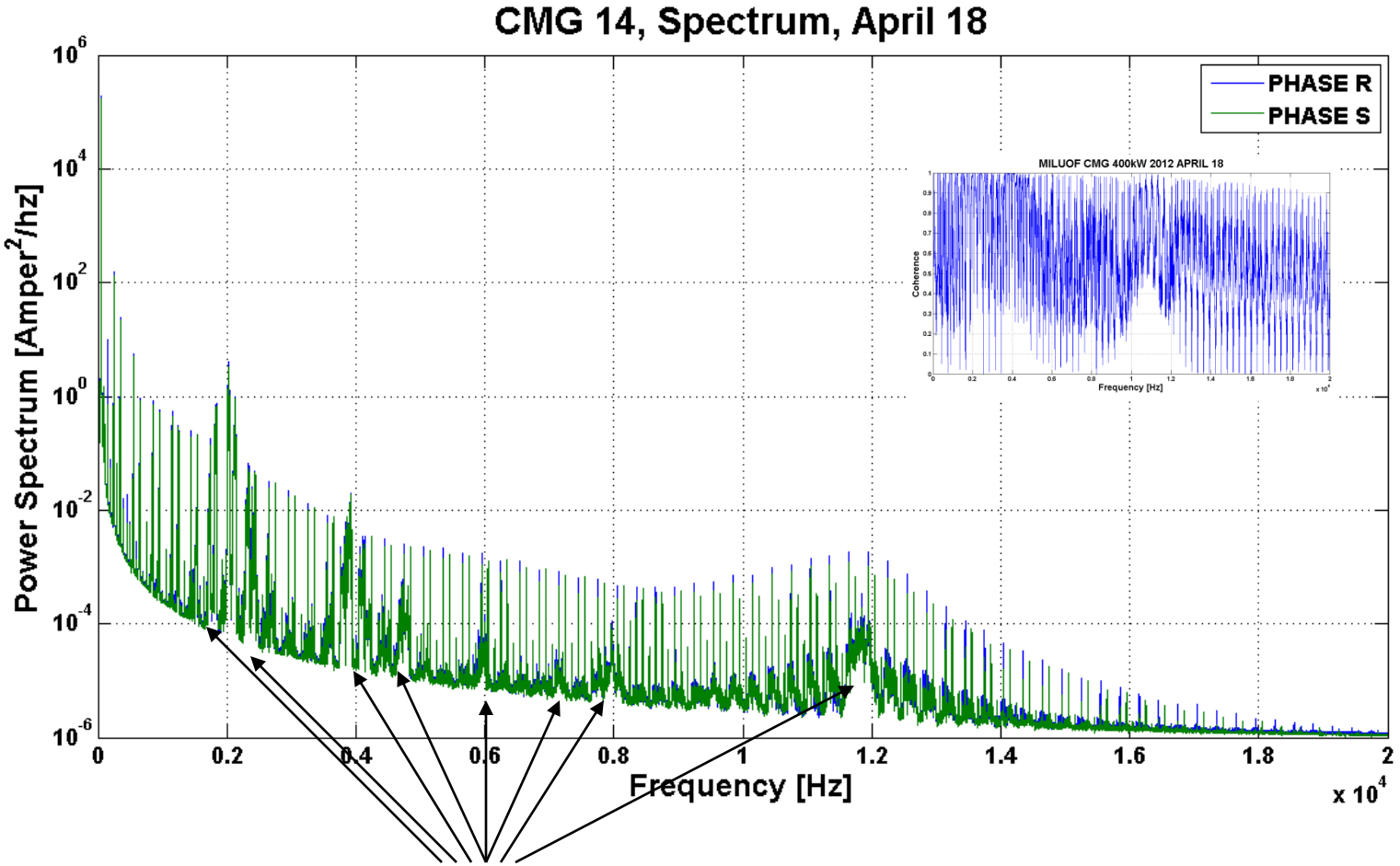


Changes in RMS

Zoom in 1



Spectrum



Anomalies – indications of a mechanical fault in Motor

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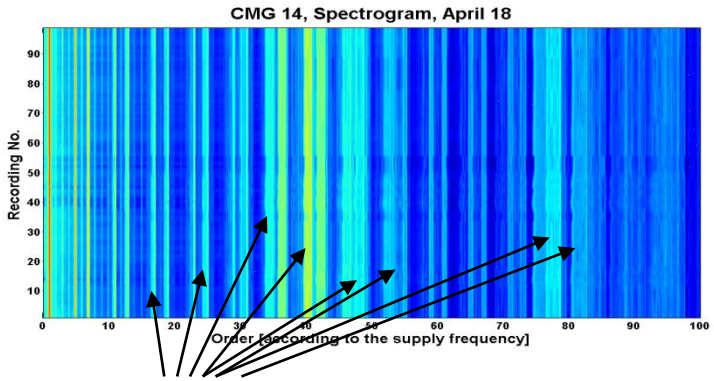
Order Spectrogram

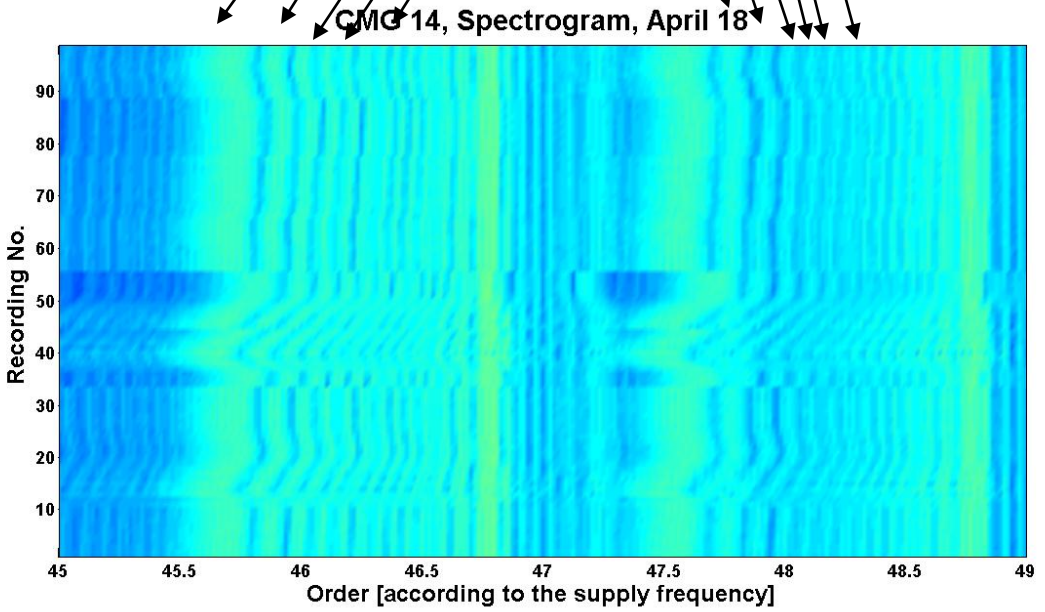
Synchronized spectrogram to the supply frequency (~50hz)
Order 1 → means 50hz



Sidebands of the rotor speed higher harmony
The rotor speed is also unstable!

Same anomalies
as seen in spectrum

Zoom in 1 for example →



*Colors indicates the current power spectrum (jet scale)

Conclusions

1. An online MCM system can identify faults
2. Coherence between phases can obtain immediate identification whether the motor is normal or faulty
3. To discover all types of faults still need an expert in the loop

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Draft

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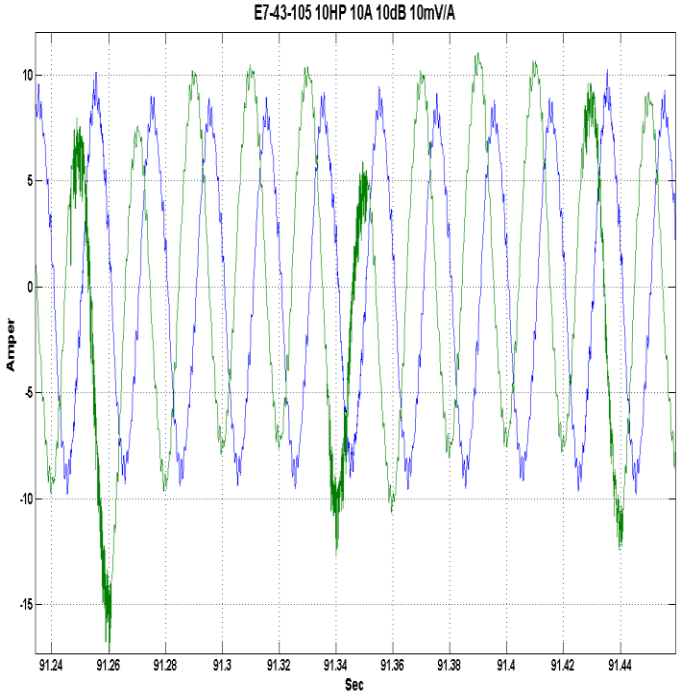
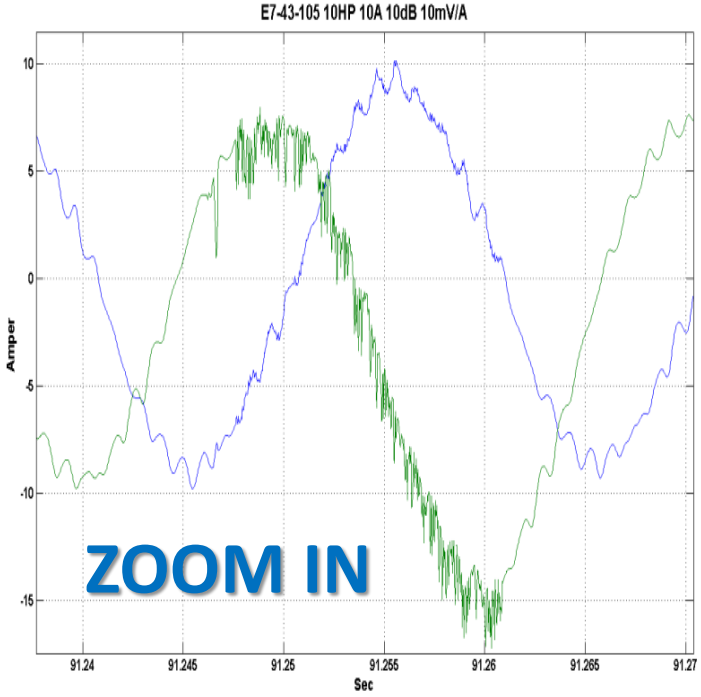
7-43-105 10HP 10A

TIME DOMAIN



TIME DOMAIN



FAULT: Noises from Load

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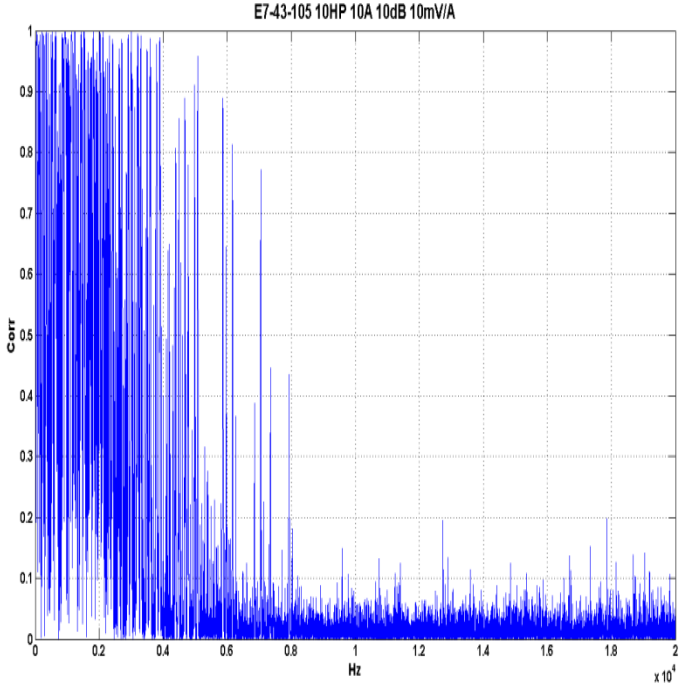
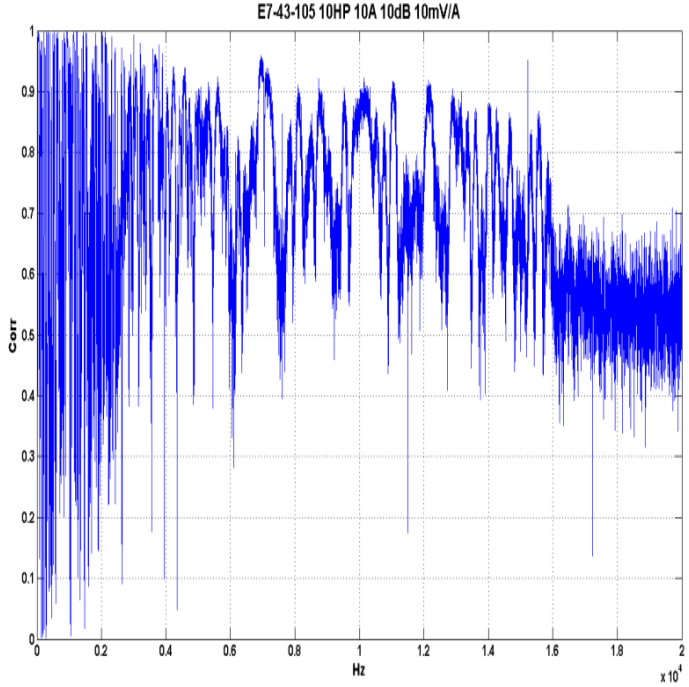
7-43-105 10HP 10A cont.

COHERENCE SPECTRUM
NORMAL OPERATION



COHERENCE SPECTRUM
ABNORMAL OPERATION



Correlation between phases
in normal state and abnormal state

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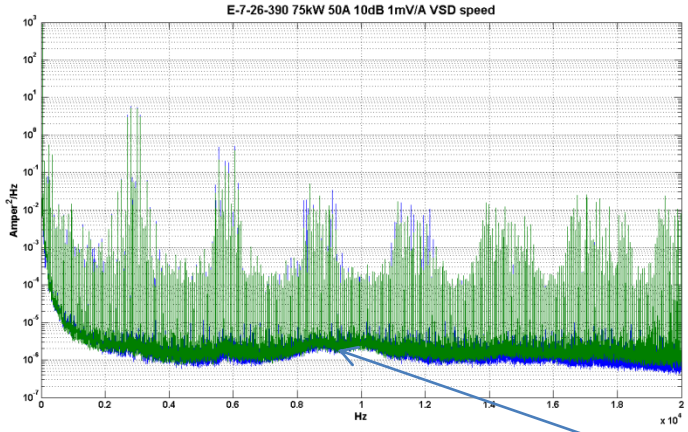
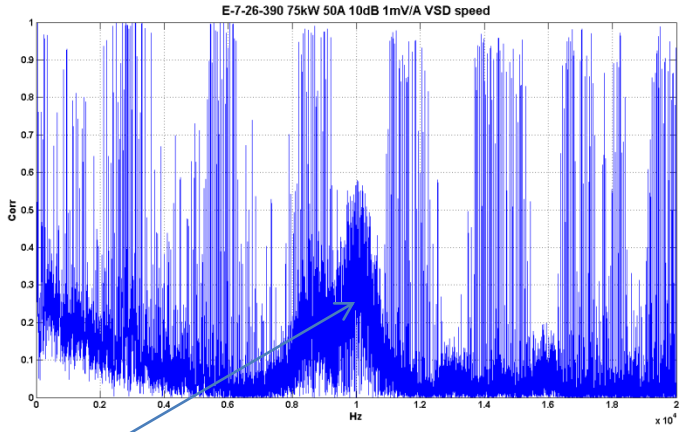
7-26-390 75kW 50A VSD cont.

SPECTRUM



COHERENCE



Mechanical Assembly problem

Spectrum and Correlation, Malfunction

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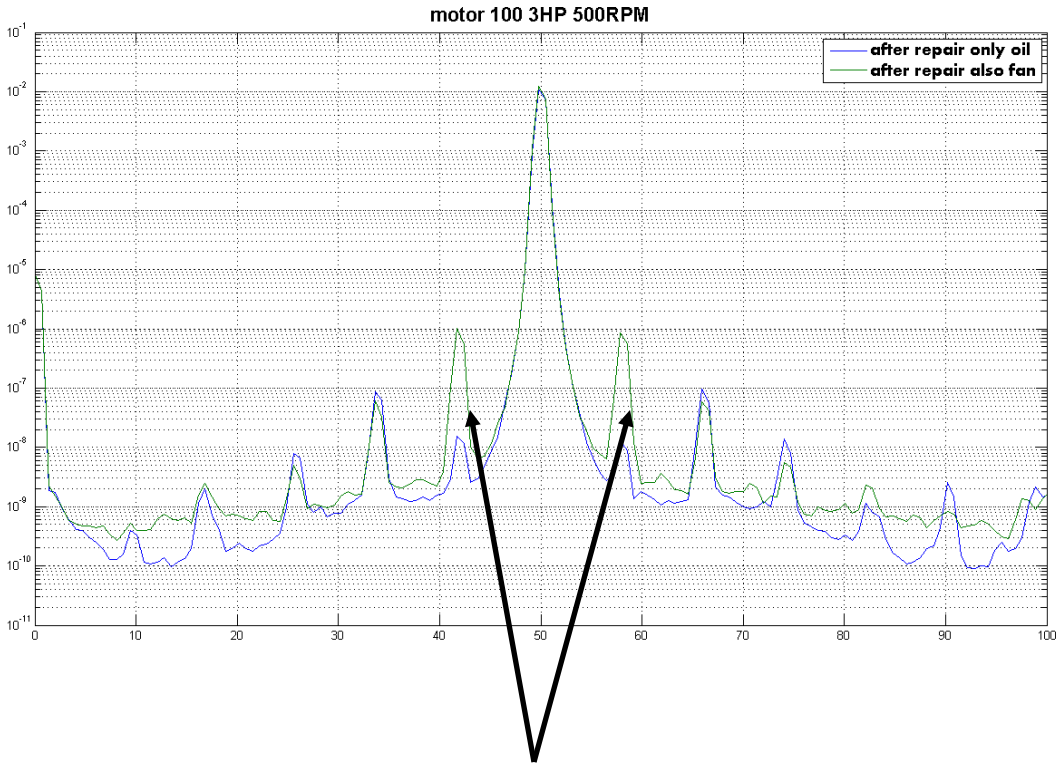
Motor 3HP



The motor didn't repaired well but with a small eccentricity

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