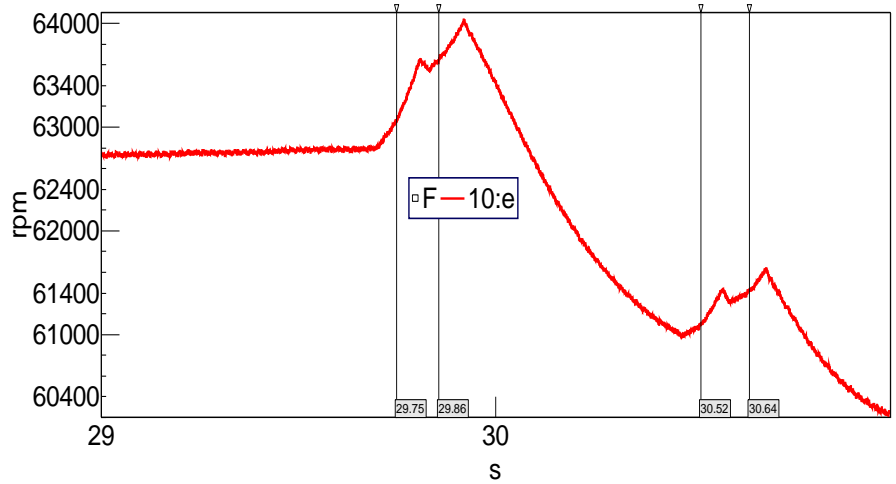# Incipient surge detection in large volume energy systems
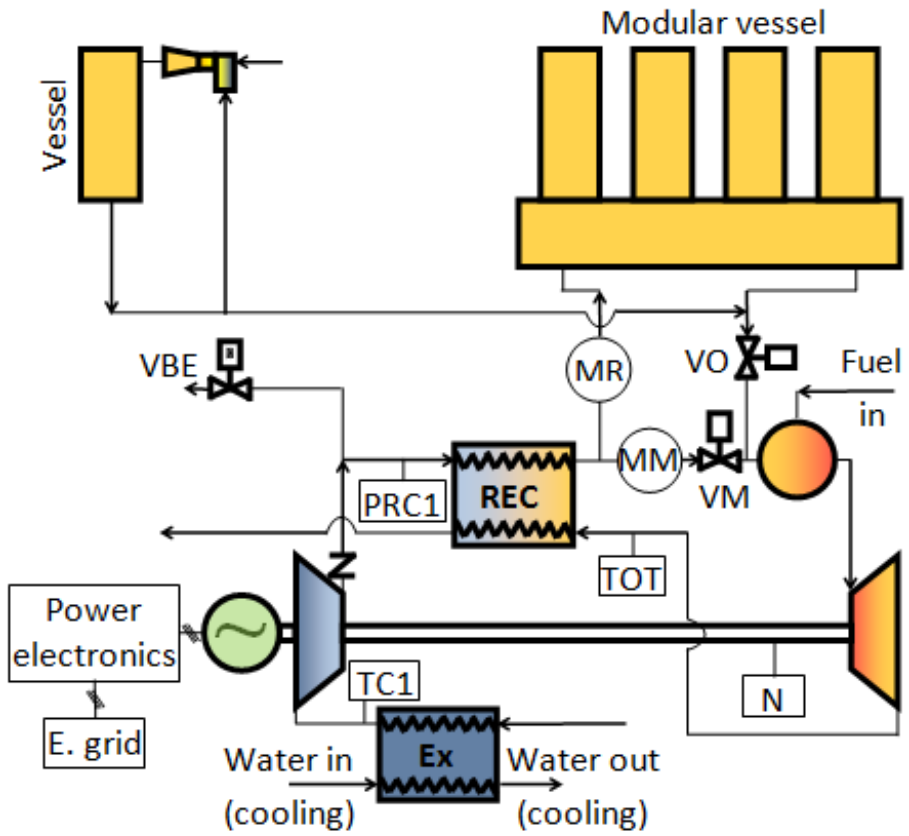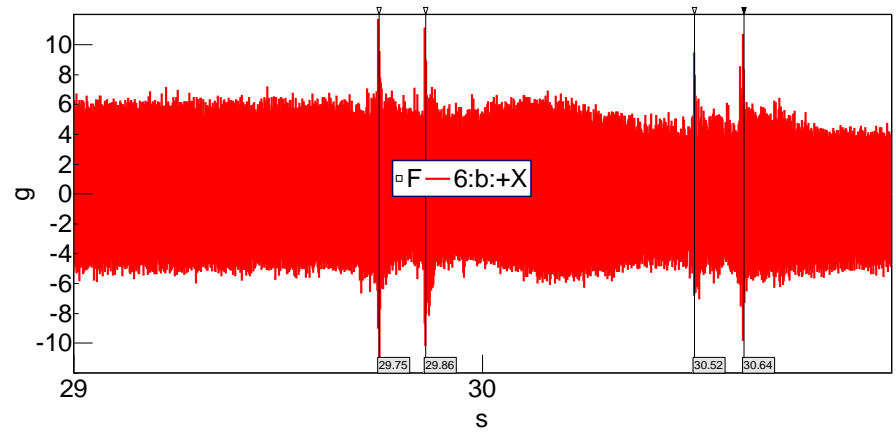
Table of Contents

- Experimental data from a T100 mGT centrifugal compressor with vaneless diffuser

- Transients from stable behavior to deep surge conditions

- Vibro-acoustic measurements

- Higher-Order Spectral Analysis (HOSA) and Wigner-Ville distribution (SPWVD)

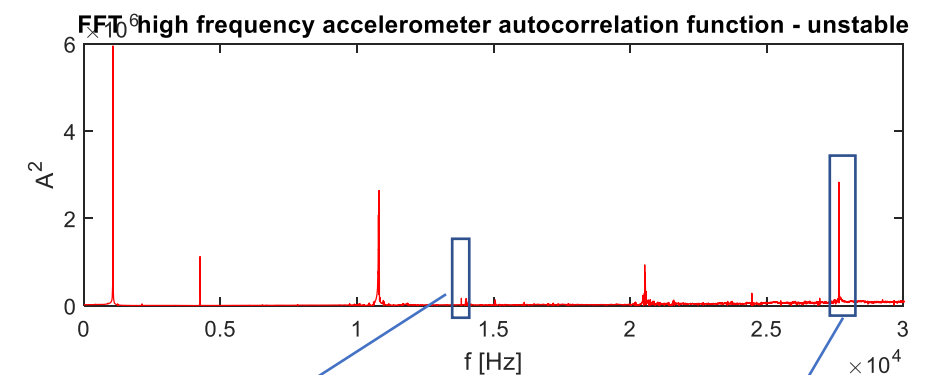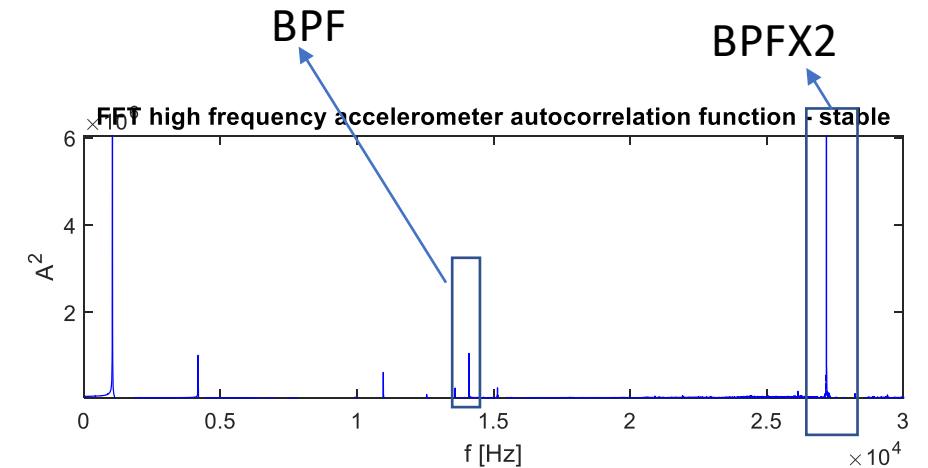- Definition of a diagnostic quantitative indicator

Comparison of results: power spectra (1/2)

Sub-synchronous microphone auto-power spectrum

High-frequency accelerometer auto-power spectrum
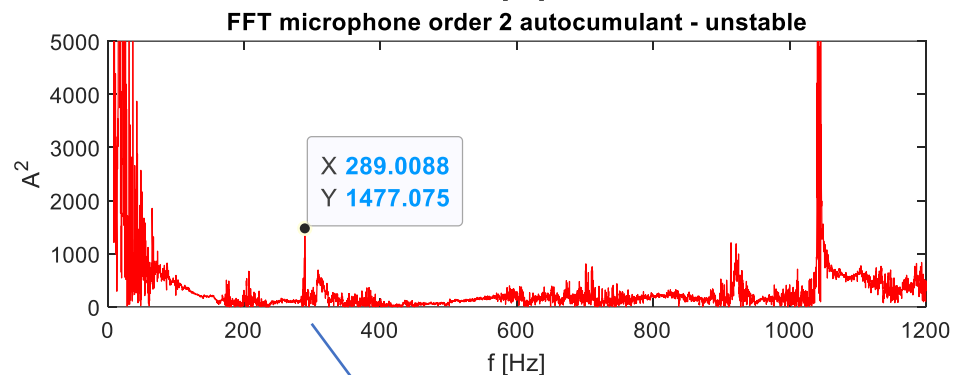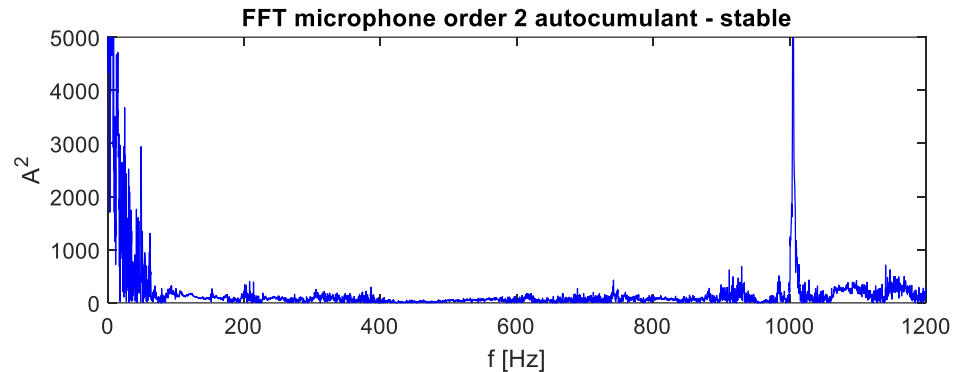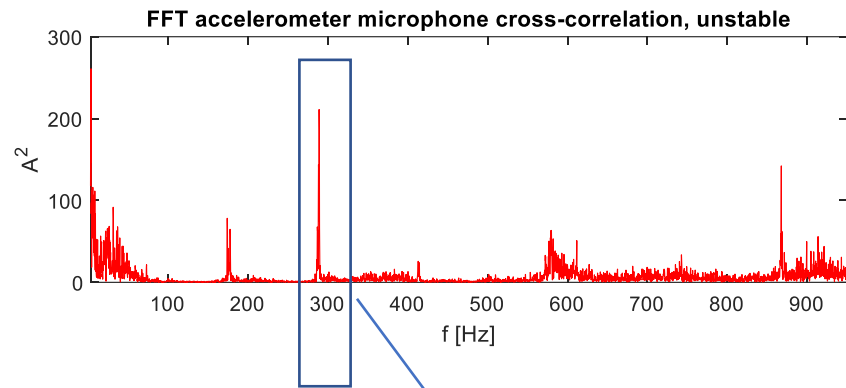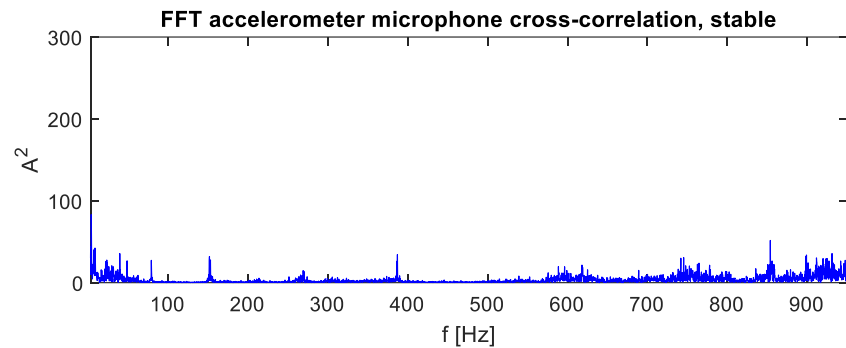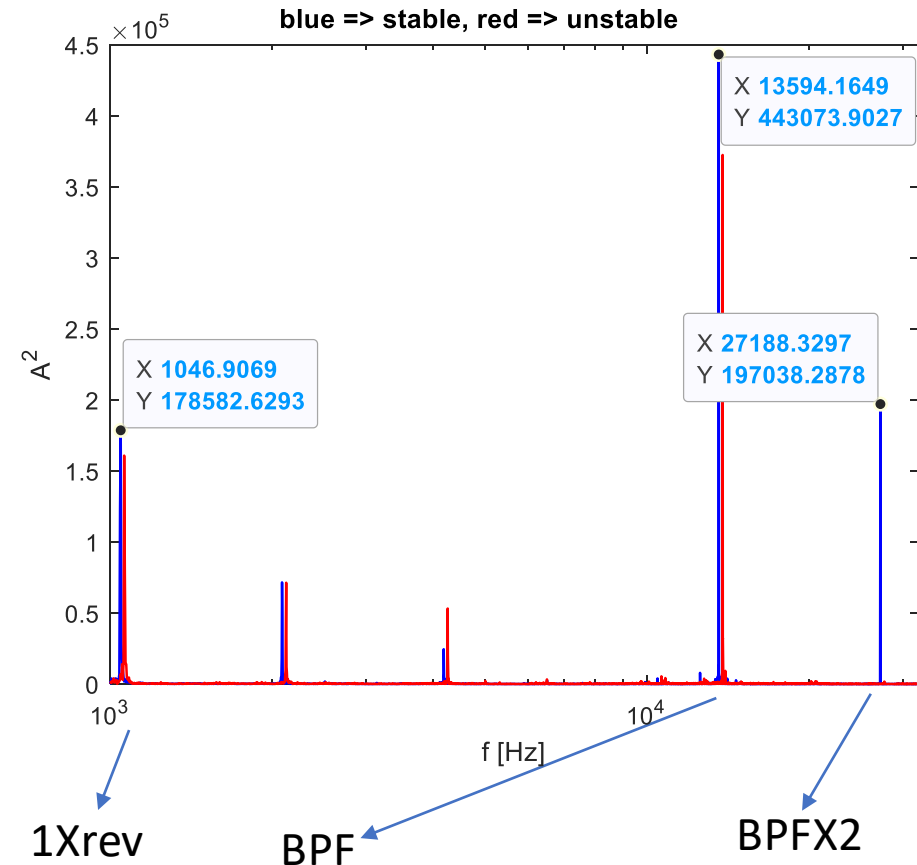

Sub-synchronous spectral content

BPF

BPFX2

Comparison of results: power spectra (2/2)

Accelerometer-microphone **cross-power spectrum: low frequency region**

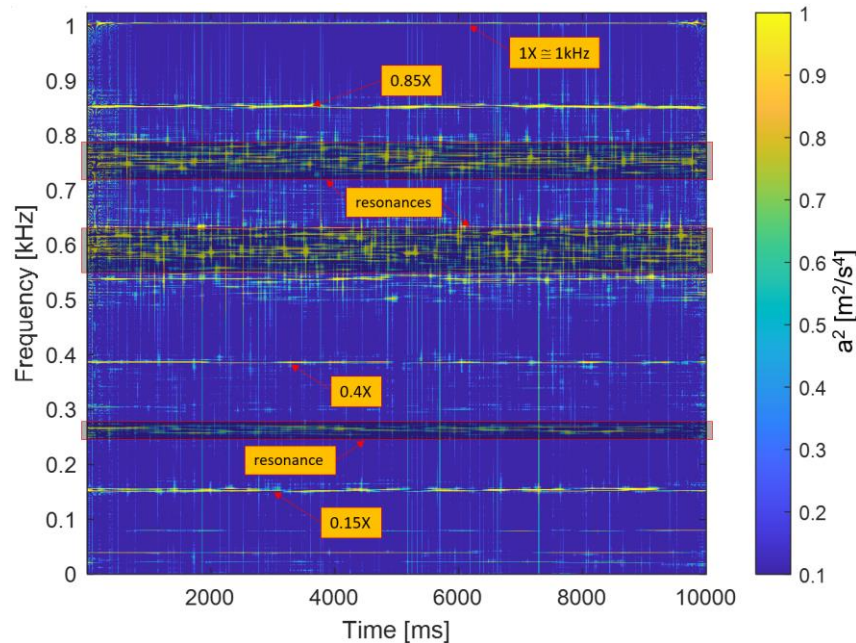Accelerometer-microphone **cross-power spectrum: high frequency region**

Sub-synchronous common spectral content

1Xrev   BPF   BPFX2

Early surge detection in mGT based plants with large volume based on W.-V. distribution (1/3)

Time-frequency analysis based on structural signals: whole sub-synchronous range

Stable functioning – sub-synchronous range

Surge transient – sub-synchronous range

Signal processing (SPWVD) of surge transient performed on the whole *sub-synchronous frequency range* evaluated for the minimum interposed volume (0.3 m³) compared with stable functioning to look for *surge precursors*
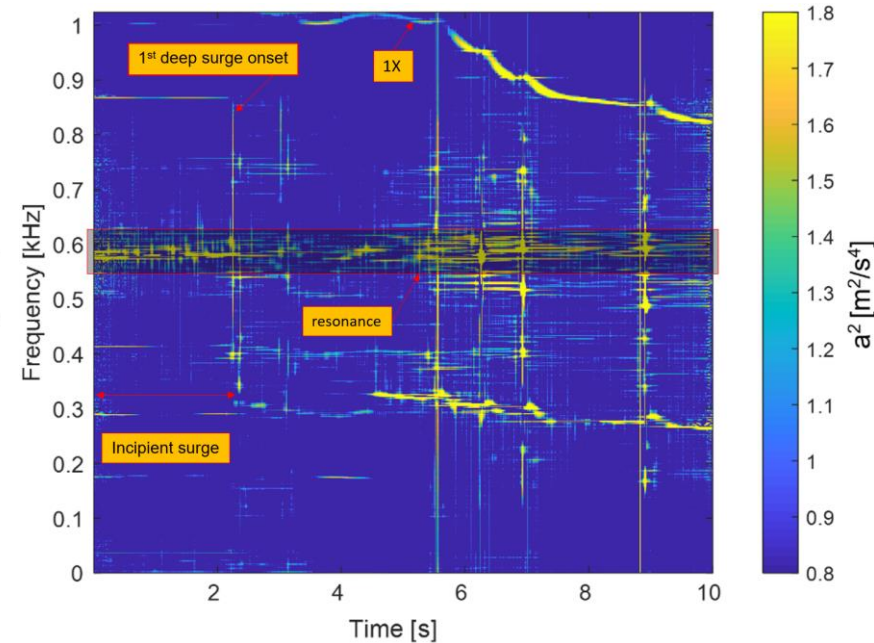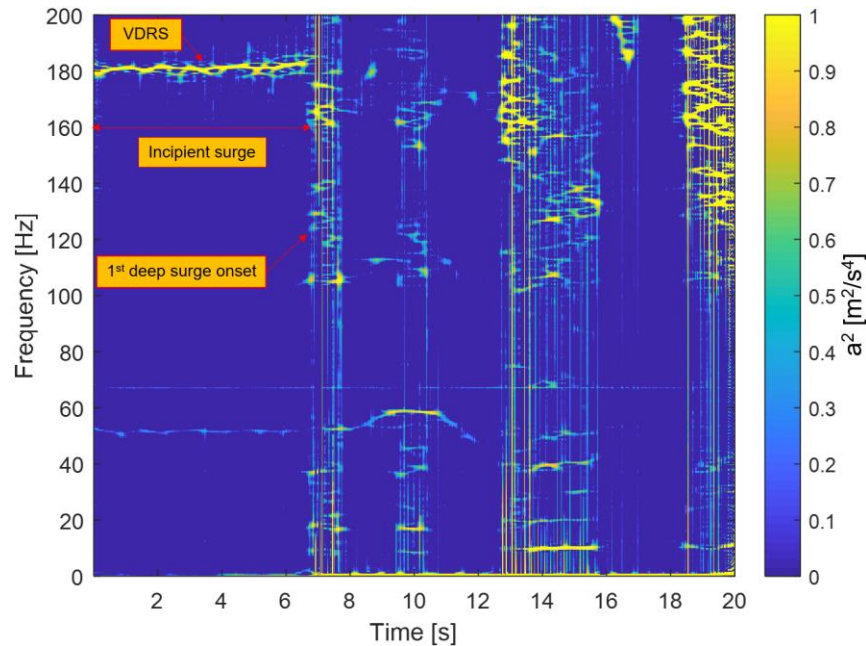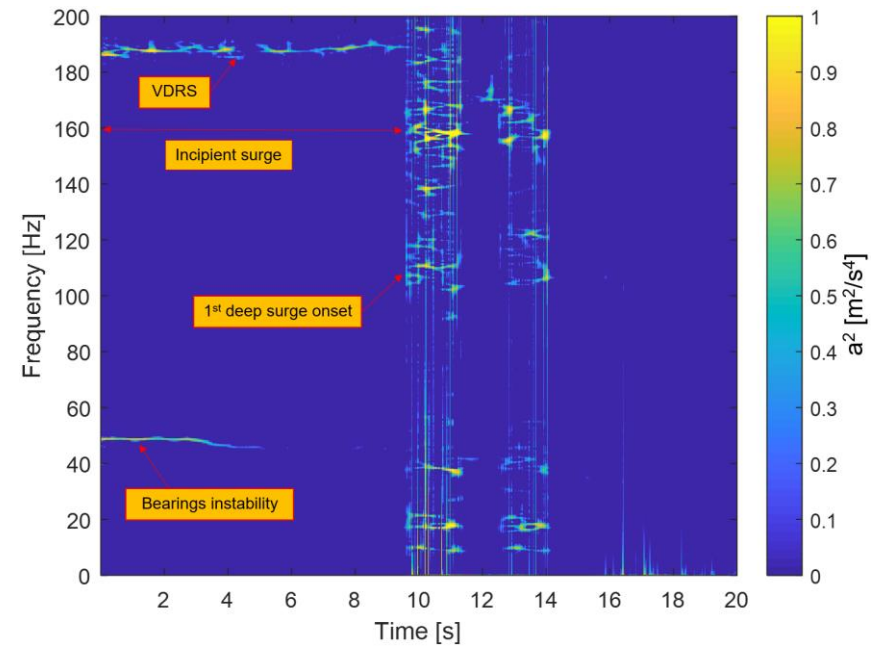
Early surge detection in mGT based plants with large volume based on W.-V. distribution (2/3)

Time-frequency analysis based on structural signals: detail of sub-synchronous range for different volumes

Surge transient – intermediate volume (2.3 m³)

Surge transient – maximum volume (4.3 m³)

Signal processing (SPWVD) of surge transients focused on a portion of _sub-synchronous frequency range_ for different interposed volumes to identify possible *surge precursors*: Vaneless Diffuser Rotating Stall (VDRS) and bearings instability spectral contents increase their energy with respect to *stable functioning*

Early surge detection in mGT based plants with large volume based on W.-V. distribution (3/3)

Time-frequency analysis based on structural signals: high frequency range
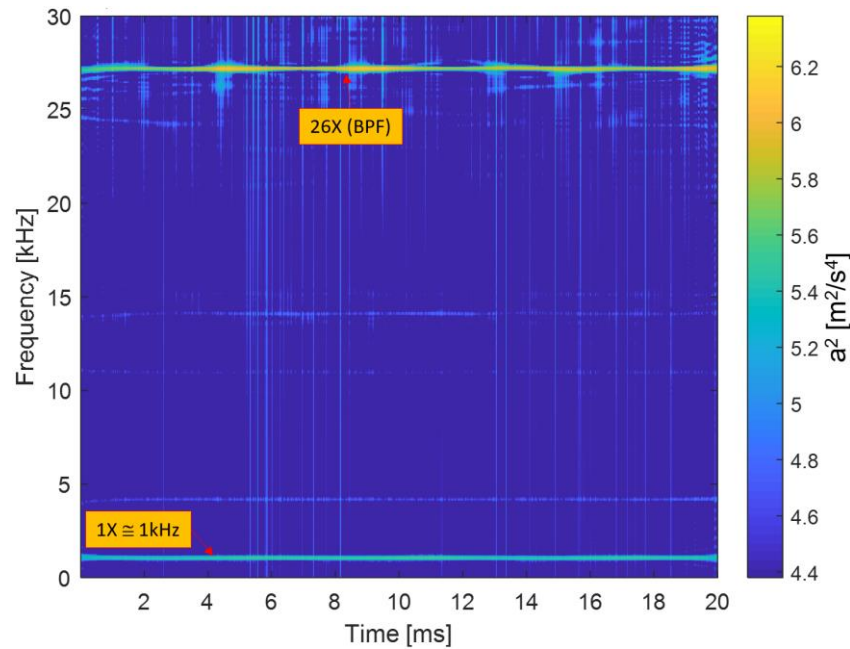
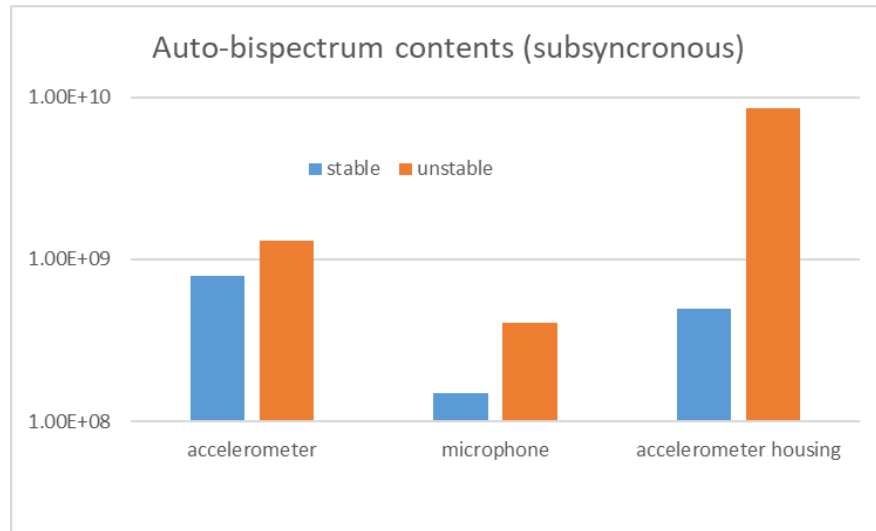Stable functioning – BPF frequency range
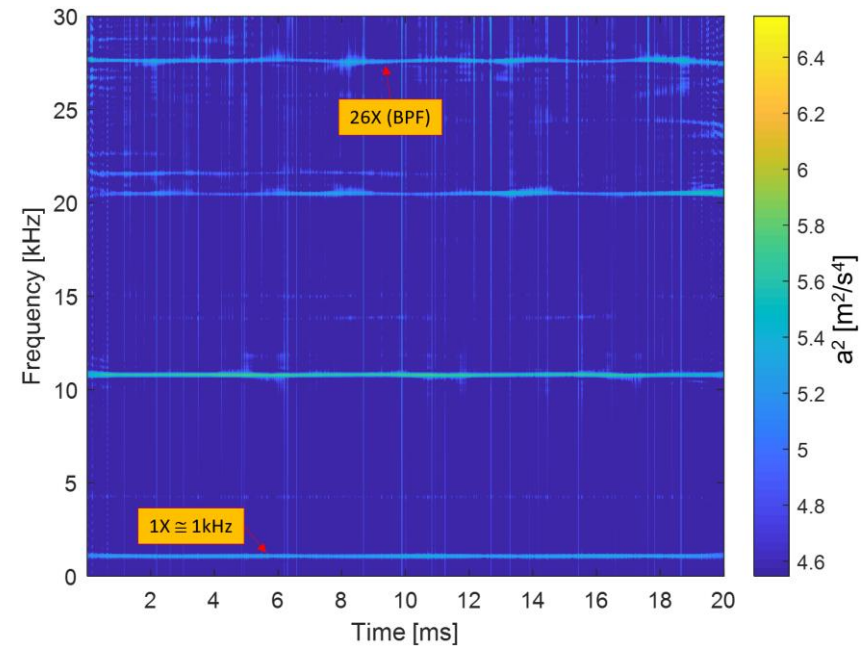
Surge transient – BPF frequency range

Signal processing (SPWVD) of surge transient performed in the _blade pass frequency (BPF)_ range to obtain robust _surge precursors:_ in the high frequency range _BPF_ spectral content changes its energy in surge transient with respect to _stable functioning_

Quantitative indicator for early surge detection
Sum of all auto-bispectrum spectral contents modulus in the whole sub-synchronous frequency range

Auto-bispectrum contents (subsyncronous)

- Addressed sum of such contents in this range as it is the most suitable frequency interval for surge onset detection
- Comparison between stable and unstable (surge transient) functioning
- For all the employed probes it is tested, and it always works => robust diagnostic tool
- Accelerometer placed on compressor housing is the most sensitive to instability onset