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Using Cepstrum and Historical Data to Detect Planetary Stage Fault

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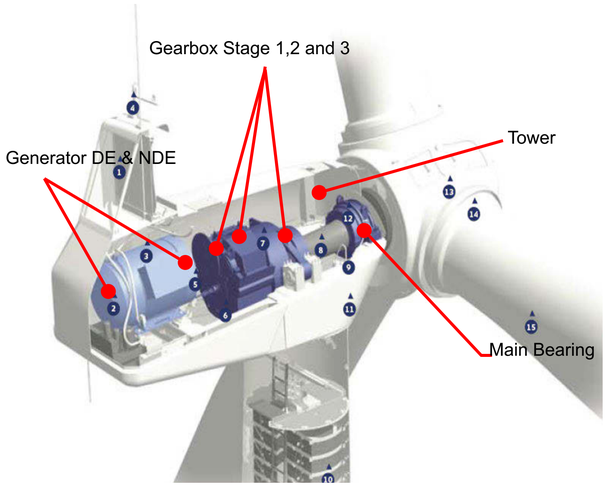
Abstract

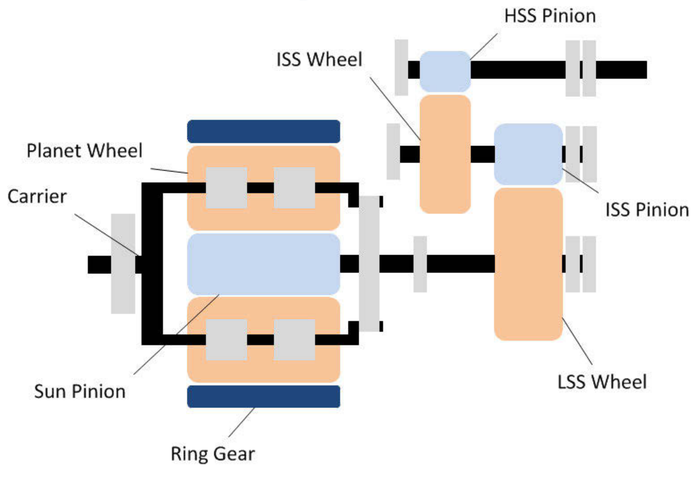
This work shows how cepstrum helps identify families of sidebands related to gear faults in the planetary stage of a wind turbine gearbox. Quefrency peaks (representation of those sidebands families) identified can be trended over time, and early stage fault detection can be achieved. Normally the kinematical data of a specific gearbox, such as gear mesh frequency and shaft rotational speed, must be known in order to trend the quefrency peaks. Compiling cepstrum signatures from hundreds of turbines with known and unknown faults shows that turbines with similar gearbox ratios can have common increasing quefrency peaks related to certain faults. Information regarding these quefrency ranges can then be used for trending. In this way, it is not necessary to know the details of gear counting for each turbine.

Detecting planetary stage fault with vibration based online condition monitoring system is challenging

Accelerometers at various locations



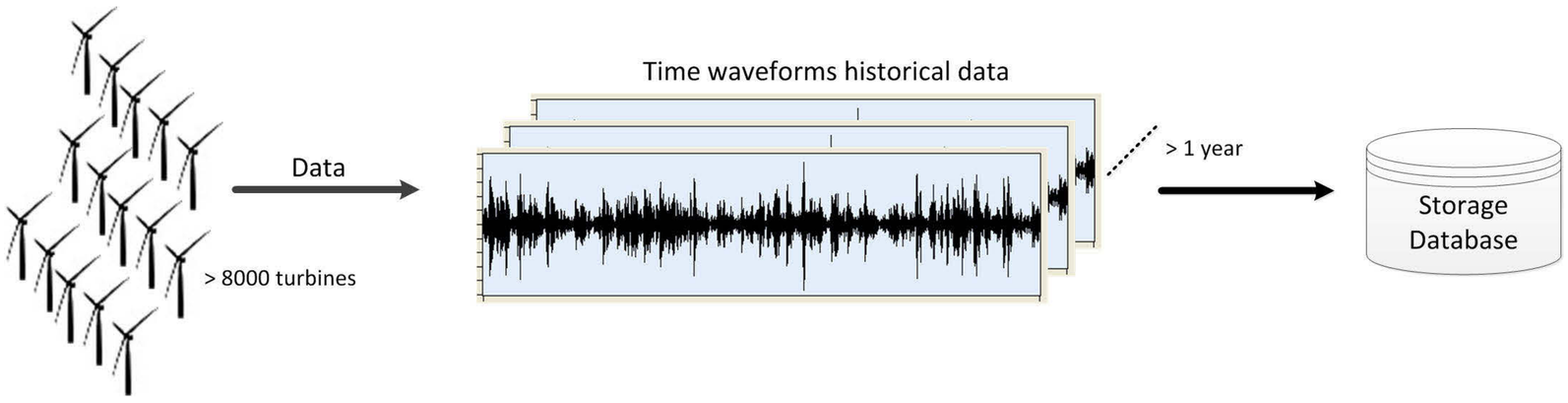
Schematic of gearbox with 1 planetary and 2 helical stages



A planet ring gear deformed and broken

Collecting historical data helps to identify signatures of faults

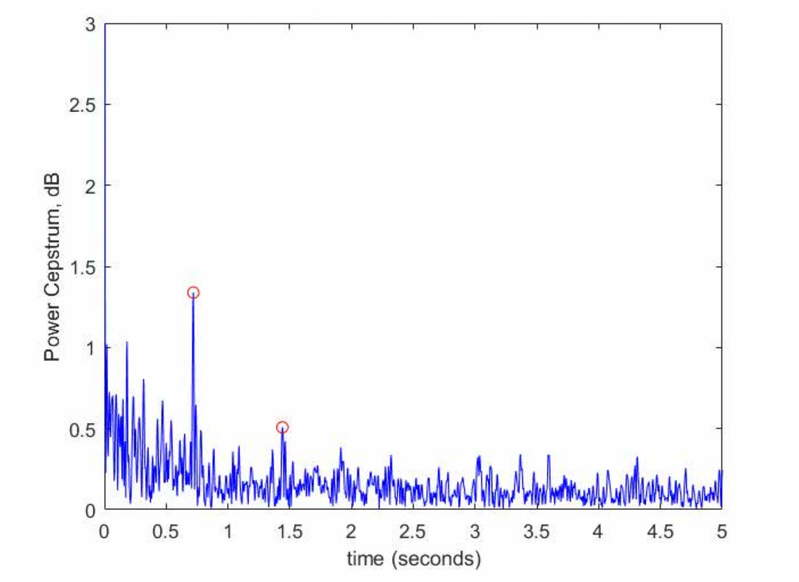
- Time waveforms are collected periodically from all sensors in the turbines
- All time waveforms recorded are stored
- Different kinds of analyses can be performed on the recorded time waveforms to identify fault signatures or features that can be trended over time.



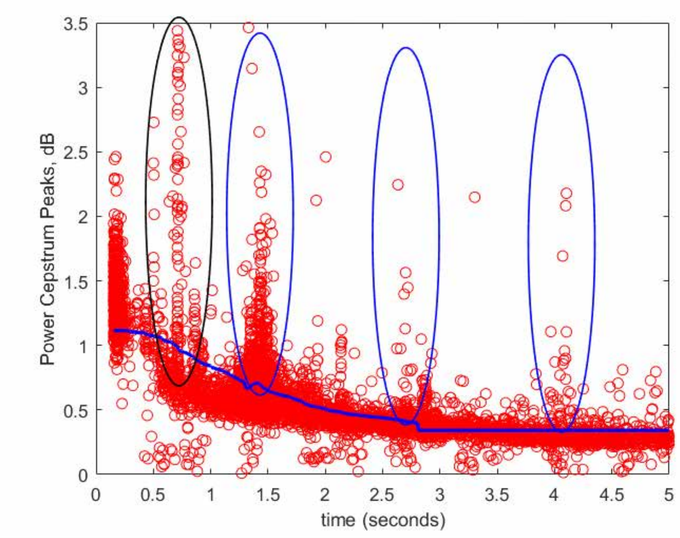
Fault detection is made based on cepstrum analyses of the planetary stage vibration

Cepstrum is a "spectrum of a logarithmic spectrum" expressed as $C(\tau) = F^{-1}\{log(S(f))\}$

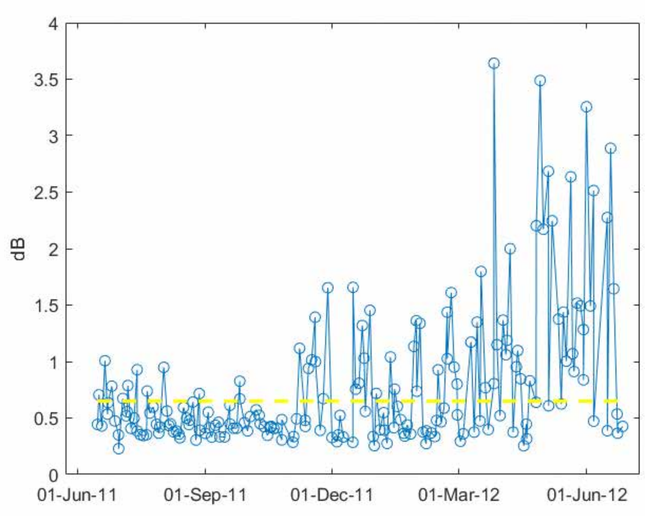
Cepstrum with identified quefrency peaks



Quefrency peaks collected from a group of turbines with similar gearbox ratio. Ellipses indicate quefrencies related to similar faults.



Magnitude of quefrency around 1.4 second is trended a year before repaired for a turbine with planetary stage gear fault. A fault development can be seen as the magnitude increases.



Conclusions

- Quefrencies related to particular faults from turbines with similar gearbox ratios can be grouped in very close ranges.
- Magnitudes of quefrencies in those ranges can be trended to detect the possible faults development without having to know the exact kinematical data of a turbine.
- This work also shows the benefits of analyzing many wind turbine data in order to identify common faults in similar turbines.

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