Assessment of wind turbine condition using a time frequency signal processing method

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Background

OPTIMUS is a 36-month EU funded FP7 project with 12 partners participating from six countries across Europe. The project follows on from the recently completed NIMO FP7 project. The project objectives include:

1. To improve reliability within the wind power generation industry by delivering prognostic technology.
2. Improvement in the efficiency of maintenance procedures and operational reliability of wind turbines.
3. To support implementation of the European Wind Initiative of the SET-Plan.

To efficiently capture wind energy, most large modern wind turbines operate at variable speed due to the intermittent nature of wind. As a result, the signals collected from the wind turbine condition monitoring systems are characterised by their non-linear and non-stationary features. It is believed that in order to achieve a reliable condition monitoring and diagnostic based on these signals, advanced signal processing techniques should be implemented to interpret more efficiently the condition monitoring signals collected from the turbines. This poster addresses the capability of a signal processing method, namely the spline kernelled chirplet transform (SCT), in analysing wind turbine condition monitoring data and providing a reliable diagnostic of potential anomalies.

Introduction

To investigate how the improvement of condition monitoring systems can be carried out using advanced signals processing techniques, the effectiveness of the SCT method is demonstrated. This follows up a previous work investigating the use of signal processing methods to enhance the diagnostic of wind turbines' condition monitoring systems[1]. The SCT transform is based on time frequency analyses rather than the conventional spectral analyses. It has been used and proved to be efficient in the field of machine fault detection and also in telecommunications where it is considered to be very effective for non-stationary signals [2, 3, 4]. The work proposed in this poster summarises the capability of an improved SCT to detect both the instantaneous amplitude and frequency of lengthy non-linear and non-stationary (NNS) signals.

Methodology

The SCT method is widely used and documented and its mathematical formulation can be found in [1, 2].

The proposed use of algorithm processed data collected from a WT power train test rig (Figure 1) illustrates one future wind turbine application for the SCT method. In experiments to date, various simulated wind speed inputs have been applied to a smaller test rig via its DC motor. During the study, the generator electrical imbalance was emulated on the test rig. The relevant CM signals were collected from the generator terminals and its input-side shaft.

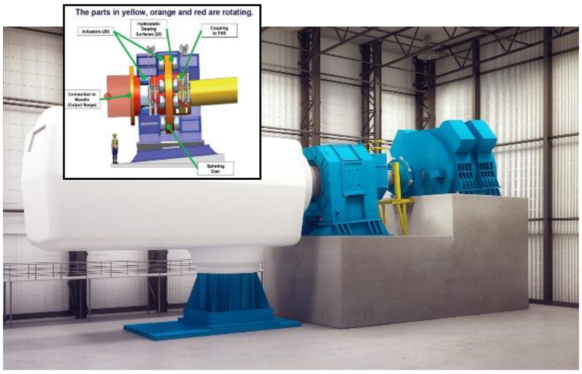

Figure 1: ORE Catapult's 15MW wind turbine drive train

Results

To extract the characteristic of the induced faults, the improved SCT was applied to the power signal. The results found are presented in Figure 2.

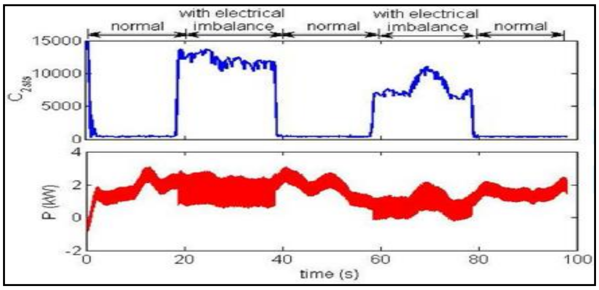

Figure 2: Diagnostic of electrical imbalance using the SCT[1]

Based on the results of Figure 2, it can be seen that the improved SCT have successfully predicted the presence of the fault.

To further verify the effectiveness of the proposed algorithm in detecting incipient fault, two different levels of rotor asymmetries were induced as faults. Figure 3 presents the results obtained by the SCT. The results also show that that both the incipient and the early developed electrical imbalance faults have been detected successfully by the improved SCT

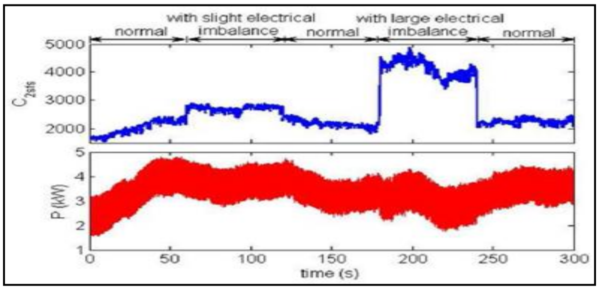

Figure 3: Diagnostic of electrical imbalance using the SCT for different severity levels of rotor imbalance [1]

Conclusion

To improve the ability of WT condition monitoring systems to analyse lengthy non-linear & non-stationary signals, an improved SCT algorithm was proposed. The improved SCT algorithm was successful in extracting potential electrical faults of non-linear and non-stationary multi-component signals at the fault frequencies of interest on a test rig.

References

[1] W. Yang, P. Tavner, W. Tian, "Wind Turbine Condition Monitoring Based on an Improved Spline-Kernelled Chirplet Transform," IEEE Transactions on Industrial Electronics, vol. 62, no. 10, pp. 6565-6574, 2015.

[2] Y. Yang, Z. Peng, G. Meng and W. Zhang, "Spline-Kernelled Chirplet Transform for the Analysis of Signals With Time-Varying Frequency and Its Application," IEEE Transactions on Industrial Electronics, vol. 59, no. 3, pp. 1612-1621, 2012.

[3] J. Zhang, A. Papandreou-Suppappola, B. Gottin and C. Ioana, "Time-Frequency Characterization and Receiver Waveform Design for Shallow Water Environments," *IEEE Transactions on Signal Processing,* vol. 57, no. 8, pp. 2973-2985, 2009.

[4] D. Marelli, M. Aramaki, R. Kronland-Martinet and C. Verron, "An Efficient Time-Frequency Method for Synthesizing Noisy Sounds With Short Transients and Narrow Spectral Components," IEEE Transactions on Audio, Speech, and Language Processing, vol. 20, no. 4, pp. 1400-1408, 2012

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