Towards a self-evaluation of the reconstruction of the instantaneous phase of a vibration signal

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Abstract

The cyclo-stationary nature of rotating machine signals is an essential lever for most diagnostic strategies. For this lever to be operated, the signal must be analysed with a detailed knowledge of the machine's instantaneous frequency. In a context where many monitoring systems do not have access to an adequate angular sensor, the extraction of the instantaneous frequency of the machine from the vibration signal alone has been the object of particular attention from the community. Thus, multiple tools have been developed in different contexts/environments, often with reduced efficiency as soon as the study case moves away from the one for which the tool was created.
This work focuses on the proposal of a key performance index (KPI) evaluating the quality of the reconstructed instantaneous quantity. Such a tool can be useful for determining the most suitable instantaneous frequency extraction method for the case under study, for assisting the expert in the possible parameterisation of the method chosen, or simply for discriminating between the signals from which it is relevant to perform a cyclostationary diagnosis. The KPI is only based on the analysis of the estimation of the instantaneous phase of the signal. While the instantaneous phase is traditionally used to diagnose balancing problems, this quantity also has the advantage of being able to superpose (spacially synchronize) signals obtained at different stages of the system's life. While the adaptation of instantaneous frequency extraction tools to estimate the instantaneous phase does not pose any major difficulty, the construction of the KPI is subject to a number of cautions.
Several KPI proposals will be presented in this paper, and successively tested on a simulated and then real measurement campaign. The signals studied are those transmitted by inductive sensors observing the shaft orbit of several power plant turbines. The effectiveness of the KPIs will be assessed by tachometers installed on these machines. The indicators will then be compared with another campaign using the signal emitted by an accelerometric sensor installed on a mechanical transmission involving an epicyclic gear train.

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