Detection and characterization of oscillations in control loops using multivariate empirical mode decomposition: An Overview

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Oscillations are one of the major performance issues in industrial control systems. The presence of oscillation can lead to equipment wear and product variability, thereby effecting the profitability of the plant. Moreover, oscillations originating in one of the loops can propagate to different parts due to underlying interactions and process flows, giving rise to plant-wide oscillations. In order to reduce the adverse impacts of the oscillatory control loops a robust oscillation detection and diagnosis mechanism is required to reduce the shut down and maintenance time.

The increased level of complexity and automation in industry necessitates the provision of adaptive and data driven tools for the diagnosis and detection of oscillations. The data driven approaches are preferred over the traditional model based analysis as the accurate physical mathematical models are not easily available. Multivariate empirical mode decomposition (MEMD) has the ability to process multivariate data and to sift out different oscillatory components from the data without any model and any assumption about the underlying process itself. The MEMD is applicable to both non-stationary and non-linear time series data and is quite helpful in detection and diagnosis of the oscillations in control loops.

MEMD owing to its peculiar dyadic filter bank and mode alignment property can be applied to the variety of issues ranging from oscillations in individual loops to the plant wide oscillations. The method not only detects the oscillation in the loops but also checks for the presence of the harmonics to ascertain the existence of non-linearity as the source of oscillations in an automated manner. Presence of multiple sources of oscillations can also be handled accordingly. Moreover, the MEMD can be used for the case of plant wide oscillation detection where the loops oscillating with common cause and hence common frequency are grouped for further analysis.

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The effectiveness of the MEMD based methods both for the detection of oscillations in individual control loops and plant-wide oscillations are demonstrated using simulation and industrial case studies.