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Simultaneous measurement of multiple fluid characteristics

Keywords

Vibration control, Multi-frequency control, Multi-mode oscillator, Phase-locked loop, Multiple-output sensor, Viscometry, Rheology, Density Measurement, Mass flow meter, Process instrument

Summary

The technology enables the simultaneous measurement of multiple fluid characteristics such as mass flow, density, viscosity, elasticity etc. with a single resonant sensor. The method is based on the phase-controlled excitation of the oscillator at multiple frequencies.

Background

The resonance frequency of an oscillator shifts when it is immersed in a fluid. For certain oscillators, such as the rheometer in Fig. 1, the frequency shift of a bending vibration gives primarily information about the density of the fluid, the torsional oscillation yields convoluted information on density and viscosity. In practice, measurements at several different eigenfrequencies are desired to improve accuracy and robustness of



Fig. 1: Prototype of a process rheometer

the result. Ideally multiple frequencies are measured simultaneously with the same resonator and detector.

Invention

To improve and extend resonance sensor principles, multiple frequencies are superimposed and tracked at the same time. This is achieved by using a parallel arrangement of multiple phase-locked loops (PLL) that are each responsible for one frequency component of the excitation signal. Based on the phase shift between excitation and response each PLL constantly adjusts its excitation frequency (Fig. 2).

Each PLL provides an efficient frequency separation, hence one sensor/actuator pair only is sufficient. Therefore, the method can be applied to existing PLL-based sensor principles as an algorithmic-only update.

Multiple frequencies increase accuracy, allow damping measurements without phase switching, provide the simultaneous measurement of different parameters like viscosity, density, temperature etc. or reveal frequency dependent properties.

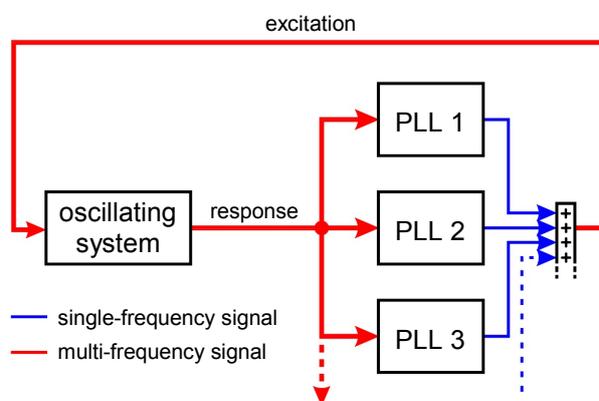


Fig. 2: Multi-frequency control loop: Each PLL subsystem is designed to track one single resonance frequency.

Patent Status

- Patent pending, PCT/EP2015/056859

Features & Benefits

- Simultaneous tracking of multiple resonance frequencies of an oscillator
- No additional transducers required
- Continuous output of multiple measurement parameters
- Easy implementation with low computational costs and minimal adjustments of the physical sensor

Field of Application

- Resonance sensors in general, especially viscometry, rheometry, density meters, mass flow meters, process instruments
- Fatigue detection
- Ultrasound

References & Institute

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