Int. J. Dynam. Control (2015) 3:121
DOI 10.1007/s40435-015-0170-5

Preface: Special issue on applications of nonlinear resonances to microscale and nanoscale systems

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Published online: 28 April 2015

Resonators are very important mechanical parts in sensors to detect mass, force, acceleration, angular rate and viscosity, in mechanical filters, energy harvesters, so on. The enhancement for their performances has been carried out mainly by modifications of the fabrication methods with material design. However, it appears that such improvements approach their limit. In such a situation, it is valuable to consider the breakthroughs from the viewpoint of dynamics. In most MEMS and NEMS resonators, the resonances under linear external or forced excitations have been applied to date.

Recently, in order to advance the sensitivity and feasibility much more, it is received much attention to utilize resonances other than the above conventional resonance phenomena, for example, parametric resonance, self-excited oscillation, nonlinear resonance as subharmonic and superharmonic resonances, and so on. Such resonances can easily emerge the variety of dynamics through bifurcation phenomena, because the number and the stability of the equilibrium points and periodic orbits are changed depending on the variation of system parameters. Such variations of dynamics are attributed to the enhancement of the performance of Microscale and Nanoscale systems.

The special issue focuses on the analysis and utilization of various resonances other than the conventional ones in linear dynamic systems and nonlinear phenomena including mode localization. Warminski investigates nonlinear phenomena in MEMS devices modelled as van-der Pol–Mathieu–Duffing oscillator. It has recently known that the dynamics of resonators with atomic scale cannot be described by linear damping but nonlinear one of van der Pol type. Kovacic deals with oscillator models expressed by power-form as Duffing, van der Pol, and Reyleigh types, and for the case when the coefficients is not small, a novel analytical approach is described to obtain an amplitude–frequency equation and approximations to motion. Micro scanners have the combined structure with segments of beams and a plate. Okada et al. theoretically and experimentally indicate the nonlinear or chaotic response of the system which reduces the quality of scanning. Such beam structures are often utilized in various resonators as their fundamental elements. For improvement for the design or fabrication of microbeam subjected to an electric actuation, it is important to understand the effect of thermoselastic damping. Belardinelli et al. theoretically clarify the effect of thermoelastic damping on the nonlinear dynamics in a microbeam. The higher mode oscillation in the microbeams is used for the enhancement of the sensitivity of mass sensor. Masri and Younis propose a method exciting with higher mode the beam using partial electrodes and theoretically analyze the nonlinear dynamics of a clamped–clamped resonator. The nonlinear localized motion in a micro-cantilever array has been attractive very much not only from physical pint of view but also for the practical applications to mass sensing, energy harvesting, and so on. Balachandran et al. investigate in free oscillations and force oscillations the interplay between noise and cubic coupling nonlinearities. Kubota et al. propose the energy harvesting from a muti-frequency force using a coupled Duffing oscillators and clarify the condition to increase the energy absorption.

The guest editor would like to thank all authors and coauthors for their high-quality contributions to this special issue, and also acknowledge the encouragement of Professor Jian-Qiao Sun, the Editor of IJDC.

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