Project Title: Mode Localization of Weakly Electrically Coupled MEMS Structures

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Co-Supervisor(s): *(if already known)*

Sources of Fund: Deanship of Research Fund

Research Field(s): Dynamics, Vibrations, MEMS

Summary and Problem Statement:

Mode localization in micro/nanoelectromechanical systems (M/NEMS) has gathered significant attention over the past few years due to the potential to developing ultra-high sensitive sensors [1]. The phenomenon of mode localization [2, 3] is defined as the confinement of vibration energy to one of the modes of the coupled system in response to an external stimulus, i.e., mass/stiffness perturbations. Another phenomenon that is closely related in coupled systems exhibiting mode localization is the eigenvalue curve veering [2]. Veering occurs when frequencies of two linearly coupled modes approach each other and deviate away interchanging the path trajectories as an external control parameter is varied. In the veering zone the respective modeshapes of the two modes are affected by each other and get hybridized. Veering phenomenon has been demonstrated experimentally in the first two symmetric modes of an initially curved (arch) MEMS resonator via electrothermal tuning of the resonance frequencies [4, 5].

In this research proposal, the phenomenon of mode localization is to be possibly investigated theoretically and hopefully experimentally on coupled MEMS resonators, which can be electrically or mechanically coupled. Lumped parameter models will be used for the theoretical prediction of the dynamic response of the systems. The eigenvalue problems will be solved for both case studies under different stiffness perturbations and coupling strengths. The influence of the main electrode bias on the mode localization point will be also explored. The dynamics of the systems will then be studied and compared using their frequency response curves under different perturbation and damping scenarios.

Keywords: MEMS, Mode localization, sensitive sensors, eigenvalue curve veering.

Objectives:

There is a lack of a comprehensive theoretical and experimental study on the effect of mechanical and electrical couplings on the phenomenon of mode localization based on simple structures like MEMS based resonators. In this research, a theoretical investigation based on two case studies of two microbeam resonators under electrostatic actuation coupled (i) mechanically and (ii) electrostatically.

Tentative Methods of Approach:

For the theoretical analysis, lumped parameter models based on spring-mass-damper systems will be used. The eigenvalues of the two coupled systems will be analysed under different side electrode bias values. The effect of the side electrode bias on the veering zone is thoroughly will be demonstrated. The dynamic response of the two coupled systems will be investigated under different stiffness perturbations and coupling strengths, and compared against each other.

Required backgrounds and skills

Backgrounds:
Dynamics and Vibration…

Computing Skills: MATLAB/MATHEMATICA

Other requirements:

References:

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