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A STUDY OF SUBHARMONIC EXCITATION OF MECHANICALLY COUPLED MICROBEAMS FOR FILTRATION

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ABSTRACT

We study the feasibility of employing subharmonic resonance of order one-half to create a bandpass filter using two clamped-clamped microbeam resonators connected by a weak coupling beam. We discretize the distributed-parameter system using the Galerkin procedure to obtain a reduced-order model composed of two nonlinear coupled ODEs. It accounts for geometrical and electrical nonlinearities as well as the coupling between these two fields. Using the method of multiple scales, we determine four first-order nonlinear ODEs describing the amplitudes and phases of the modes. We use these equations to determine closed-form expressions for the static and dynamic deflections of the structure. The basis functions in the discretization are the linear undamped global mode shapes of the unactuated structure.

We found that we can not produce a single-valued response for small excitation amplitudes. So that, it is impractical to use a single structure made of two mechanically coupled beams excited subharmonically in filtration. But we can use a pair of structures to build a bandpass filter by operating one in the softening domain and the other in the hardening domain and, more importantly, implementing processing logic and hardware schemes. However, the complications brought about by mechanically coupling of two microbeams can be avoided by using a pair of uncoupled beams. This makes the fabrication and modeling processes much easier. Using subharmonic excitation with mechanically uncoupled microbeams to realize bandpass filters is the subject of the next work.

1 Introduction

The rising demand for efficient and effective filtration forces researchers to design filters with near-optimal specifications. There are many works whose primary interest is to optimize some specifications of filters through well-established design techniques. The optimal design for a bandpass filter, which is the subject of this paper, would pass the entire signal in the passband and completely suppress it outside the passband. Moreover, in an ideal filter the transition from stopband to passband would be an extremely sharp roll-off.

A great majority of micromechanical resonators rely on a direct external excitation at a resonant frequency. Unlike those works mentioned above, Rhoads *et al* [1] used parametric resonance to implement a filter made of a pair of micro-resonators and showed improved filtering, nearly ideal stopband rejection and an extremely sharp response roll-off. They achieved this effective bandpass filter by using tuning schemes and implementing hardware to overcome the complications introduced by the parametric excitation. Other filtering mechanisms based on 1:2 internal resonance were proposed in [2, 3]. For a micro T-beam structure excited electrostatically [2], the modal interaction between the internally resonant modes is activated when the actuation signal frequency is close to the second natural frequency of the system and results in transfer of energy to the first mode.