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A SUBHARMONIC RESONANCE - BASED MEMS FILTER

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ABSTRACT

We present a novel micromechanical filter exploiting the subharmonic resonance of order one-half to obtain a center frequency twice the fundamental frequency of the primary resonators, an ideal stopband, and a sharp roll-off. The filter is made up of two clamped-clamped microbeam resonators connected by a 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 filter. The basis functions in the discretization are the linear undamped global mode shapes of the unactuated filter.

The filtering mechanism is based on the exploitation of the interval where the trivial response to subharmonic excitations is unstable. We found criteria to tune the effective nonlinearities of the filter to realize a bandpass filter of an ideal stopband rejection and a sharp roll-off. When these criteria are not met, multivalued responses appear and distort the filter performance.

NOMENCLATURE

x	Position along each beam axis
ℓ	Length of the primary beams
c	Ratio of the length of the coupling beam to ℓ
h_{p}	Thickness of the primary beams
h_{c}	Thickness of the coupling beam
A_{p}	Area of the cross-sections of the primary beams
I_{p}	Moment of inertia of the cross-sections of primary beams
A_{c}	Area of the cross-section of the coupling beam
I_{c}	Moment of inertia of the cross-section of coupling beam
N_{p_k}	Applied tensile axial forces in the primary beams
N_{c}	Applied tensile axial forces in the coupling beam
b_{p}	Width of the primary beams
b_{c}	Width of the coupling beam
E	Young's modulus
ρ	Material density
d	Gap width
ϵ_{o}	Dielectric constant of the capacitor gap medium

1 Introduction

Wireless communication has revolutionized today's world. Cellular phones, pagers, televisions, wireless local area networks (WLANs), radio frequency identification tags, and global positioning systems (GPS) are just few examples of applications that range from indispensable tools to luxury items. However, due in large part to regulatory bodies, virtually all major communication systems are based to some extent on partitioning of the electromagnetic frequency spectrum. This demands that the enabling communication transceiver devices be capable of high-frequency selectivity; that is, capable of selecting a given fre-