A Novel MEMS RF Filter

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ABSTRACT

We present an analytical model describing the response of a novel MEMS RF filter. The filter is made up of two identical capacitive resonators connected by a weak spring (microbeam). It employs a nonlinear resonance excitation, namely the subharmonic resonance of order-half, to act on an input signal. The model is obtained by discretizing the distributed-parameter system using a Galerkin procedure to produce a reduced-order model (ROM). It is composed of two nonlinearly coupled ordinary-differential equations. Using the method of multiple scales, we determine four first-order nonlinear ordinary-differential equations describing the amplitudes and phases of the global modes.

The filtering mechanism is based on the exploitation of the interval where the trivial solution is unstable. We found that when the effective nonlinearities are minimal, a bandpass filter of ideal stopband rejection (no leakage) and sharp rolloff (low shape factor) is realized for certain input signals.

Nomenclature

c	Ratio of the length of the coupling beam to the primary beams
ℓ	Length of the primary beams
b_{p}	Width of the primary beams
h_{p}	Thickness of the primary beams
b_{c}	Width of the coupling beam
h_{c}	Thickness of the coupling beam
d	Capacitor Gap
A_{p}	Area of the cross section of the primary beams
I_{p}	Moment of inertia of the cross section of the primary beams
A_{c}	Area of the cross section of the coupling beam
I_{c}	Moment of inertia of the cross section of the coupling beam
N_{p_k}	Applied tensile axial forces in the primary beams
N_{c}	Applied tensile axial forces in the coupling beam
E	Young's modulus of Polysilicon beams
ρ	Density of Polysilicon beams
ϵ_{o}	Dielectric constant of the capacitor gap medium
Q	Quality factor of the filter
μ_i	Linear modal damping coefficient

1 Introduction

Wireless communication has revolutionized today's world. Cellular phones, wireless local area networks, and global positioning systems are just few examples of applications that range from indispensable tools to luxury items. The wireless industry is greatly interested in the development of effective and efficient signal filtering. Most of the previous work in filtering focused on conventional electric filters and their mechanical counterparts. Recently, the advent of MEMS has opened promising new frontiers in the development of filters. This is based on the conspicuous advantages that MEMS filters hold over conventional designs.

The successful implementation of high-Q micromechanical resonators in many on-chip systems suggests a method for miniaturizing and integrating highly selective mechanical filters alongside other IC components.