Modeling Inertial Sensors Using Nodal Analysis Methodology

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Abstract: The increasing integration of microelectromechanical systems (MEMS) has pushed the demand for computer aided design (CAD) tools to support fast design of systems including physical interactions among electrical, mechanical, thermal, fluidic, etc. At present, there are three methods of simulation used for MEMS: direct numerical simulation (e.g., finite element analysis), signal flow analysis, and nodal analysis.

Finite element analysis is both time consuming and computationally expensive for system design due to its low level of abstraction, lack of design hierarchy, and its inability to simulate multiple domains simultaneously. Signal flow analysis does not provide a one-to-one correspondence to layout due to its high level of abstraction. Working on higher level MEMS simulation with nodal analysis has focused on behavioral simulation of individual devices (e.g., micro resonators) with abstract models or with eigenmode decomposition. This approach is suitable for evaluation of existing devices, but inhibits a top-down design flow for new devices.

This paper focuses on modeling inertial sensors using SUGAR tool, which is nodal analysis software. SUGAR uses parameterized subnets for device components. These components are composed of physical modeling functions such as beams, electrostatic gaps, etc. User-definable model functions and subnets expand SUGAR's modeling capabilities and ease of design. This method allows large and complex systems to be created easily. Input parameters may be used to modify material property and geometry, such as Young's modulus, beam widths, number of comb arrays, number of holes in perforated beams, etc.

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