COMSOL Multiphysics® Software Simulation of a Dual-axis MEMS Accelerometer with T-Shaped Beams

C. Zheng[1], X. Xiong[1], J. Hu[2]

[1]Department of Electrical and Computer Engineering, University of Bridgeport, Bridgeport, CT, USA
[2]Department of Mechanical Engineering, University of Bridgeport, Bridgeport, CT, USA

Abstract

Introduction:

Inertial navigation requires acceleration measurement along all three degree-of-freedoms. Most accelerometers are designed to measure acceleration along a single sensitive direction. For complete inertial sensing, a move effective accelerometer which can sense acceleration along multiple axes is needed. In this research, a dual-axis MEMS (Microelectromechanical Systems) accelerometer with T-shape beams is proposed. Due to its unique T-shape beam structure, the beams can bend along both X and Y directions along the device plane. A movable central mass is connected to both T-shape beams. In case there is acceleration input along X and Y directions, the inertial force experienced by movable mass cause the T-shape beams to bend. Four sets of movable fingers extrude along the sidewalls of the movable mass, with fixed fingers next to them to form two set of differential capacitances. The displacement of the movable mass along X and Y directions due to inertial force can be measured by sensing the differential capacitance changes, hence the input acceleration along X and Y directions can be known.

A simulation created in the COMSOL Multiphysics® software is used to verify the vibrational modes and the displacement sensitivity of the accelerometer. Simulation results prove that the design accelerometer with T-shape beams can effectively measure accelerations along both X and Y directions. It can be used for inertial navigation system, gesture control and other applications.

Use of COMSOL Multiphysics:
COMSOL software is used to simulate the first five vibrational modes of the designed MEMS dual-axis accelerometer. Animation clearly shows how the sensing mass and the T-shape beams vibrate in its two working modes. A sensitivity simulation is also used to find out the sensitivity of the MEMS accelerometer in both X and Y directions.

Results:
COMSOL simulation is used to verify the effectiveness of the dual-axis MEMS accelerometer in its acceleration sensing. It helps understand the device working principle, and find the ways to reduce the cross-axis coupling of dual-axis accelerometer. The COMSOL results help guide the

device design optimization. Based on the results, a set of optimized design parameters of the MEMS accelerometer are achieved.

Conclusion:
In this research, the design and simulation of a dual-axis MEMS accelerometer with T-shape beam is reported. The proposed MEMS accelerometer can measure acceleration along both X and Y directions. The vibrational modes and the displacement sensitivities along both X and Y directions are simulated. The proposed dual-axis MEMS accelerometer can be used for inertial navigation system and other applications.

Figures used in the abstract

Figure 1

Figure 2

Figure 3

Figure 4