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Entitled

DESIGN AND MODELLING OF FEM BASED MEMS CAPACITIVE ACCELEROMETER AND GYROSCOPE FOR THE QUADCOPTER/UAV APPLICATIONS

by

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Abstract

This study presents the design, simulation, and analysis of Micro Electromechanical Systems (MEMS) sensors, constituting the principal components of MEMS-based Inertial Measurement Units (IMUs). The main objective of the study is to design, simulate and analyze 3-axis capacitive accelerometer and 3-axis gyroscope. The MEMS-based capacitive accelerometers and gyroscope are analyzed using Ansys Workbench. Modal, Static Structural and harmonic analysis are used to obtain resonant frequencies, deformation/stress and profile of amplitude over a wide range of frequencies. Mechanical sensitivity analysis of the designed accelerometer and gyroscope is performed using the Finite Element Method (FEM). Analytical equations are developed to calculate mechanical sensitivity and capacitance sensitivity and a comparison is performed between the FEM analysis and the analytical calculations. A simulation study is performed in MATLAB/Simulink for the designed MEMS accelerometer and gyroscope to analyze the performance of the designed accelerometer and gyroscope sensors. Kalman filter is employed in the Simulink model to investigate the effects of measurement noise. The main findings of the study demonstrated that under typical loads of 10 g accelerations and 34.9 rad/s angular rate, the structures of the two sensors can withstand such loading and exhibit little deformations. The IMU sensor can be used in various applications in unmanned aerial vehicles (UAVs) and drones.

Keywords: Capacitive Accelerometer, Gyroscope, IMU, Finite Element Method (FEM), Kalman filter, mechanical sensitivity analysis.