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INTRODUCING NOVEL MEMS LORENTZ FORCE MAGNETOMETER DESIGNS

Abstract

A couple of decades ago, micro-electromechanical systems (MEMS) technology was introduced, gaining wide popularity due to its many advantages such as low cost, low power consumption and most importantly, miniaturized size. In space navigation, diverse sensors are utilized to determine a vehicle's altitude and orientation and a magnetometer is one of those sensors. It employs the surrounding magnetic field and its direction to estimate the position of the vehicle. Traditional commonly used devices are SQUID and fluxgate magnetometers. However, they are bulky, expensive and complex. Hence, MEMS magnetometers came into the picture. In this work, three different MEMS magnetometer designs that employ Lorentz force principle are presented. The designs are made of current-carrying elements that along with a magnetic field will drive their structure. Additionally, the design capacitive sensing is used as the sensing technology, which measures the capacitance change during the gap change occurring between the stator and rotor combs. The first design (M1) exhibits a translation single axis (X) motion, whereas the second design (M2) is a torsional single axis magnetometer. The third proposed design (M3) has a torsional motion around two axes, X and Y. All of the designs were modeled through Coventor MEMS+ software and later fabricated using MEMSCAP SOIMUMPS standard process with 25 m Silicon layer. Furthermore, DC and modal analyses were conducted on the 3D models of the designs in order to determine the static capacitance and resonant frequency. The simulation results showed that the devices resonant at 43.15 kHz and 82.27 kHz for M1 and M2, respectively and 355.81 kHz and 582.01 kHz for M3. These devices are intended for space application; however, based on the sensitivity test it may change to Earth-based application. Static capacitance measurements and scanning electron microscope (SEM) characterization are used to evaluate the devices at the first step, the results confirm that the capacitance and gap distance are very close to the design values, device-level tests such as resonance frequency and sensitivity are planned to be conducted in the near future upon the development of a driving and detection circuit.

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