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Abstract
The objective of this study is to develop a set of low cost, high sensitivity, three-dimensional optical accelerometer. In the accelerometer structure, seismic mass is formed by a cross-form structure and four rectangular structures, the seismic mass is suspended from a symmetrical arrangement of thin steel strips. The dynamic response of the seismic mass was evaluated by performing a series of ANSYS finite element (FE) simulations. In constructing the model of the seismic mass and support mechanism, an assumption was made that the cross-form framework and rectangular masses were fabricated of 6061-T6 aluminum alloy, while the four strips supporting the seismic mass were fabricated of tool steel. The ANSYS FE simulations results revealed that the resonance frequencies of the seismic mass / suspension mechanism in the X, Y, and Z-axis directions were 132.99 Hz, 133.40 Hz and 132.49 Hz, respectively. Moreover, the simulations showed that the suspension mechanism limited the seismic mass to just three degrees of motional freedom, namely one translational motion in the vertical (Z-axis direction) and two rotational motions (about the X-axis and the Y-axis), respectively. Accordingly, cross-talk error between the different axes of the structure is reduced.
The seismic mass has only three degrees of motional freedom, one translation motion and two rotational motions. These translational and rotational displacements are measured using just two sensors, both based on a commercial DVD optical pick-up head. The first sensor measures the translational motion of the seismic mass. During the calibration procedure, the positions of the two pick-up heads are adjusted such that the laser beams reflected from the two mirrors on the cross-form structure of the seismic mass are incident at the centers of the four-quadrant photodectors in the two devices. Any subsequent translational or rotational displacement of the seismic mass causes these reflected light spots to deviate from their initial positions, and therefore produces a measurable change in the focus error signals produced by the two pick-up heads. The error signals are then processed in order to determine the acceleration acting on the base. The experimental results indicate that the resonance frequencies of the accelerometer in the X, Y and Z-axis directions are 130.63 Hz, 130.90 Hz and 130.51 Hz, respectively. These experimental results are lower than the corresponding ANSYS by 0.149%, 0.177% and 0.12%, respectively. Meanwhile, the sensitivities of the accelerometer in the X, Y and Z-axis directions are 21.28 V/g, 22.94 V/g and 22.75 V/g, respectively. Furthermore, the useful frequency range of the accelerometer is found to be approximately 20% of its resonant frequency. It can be seen that the acceleration results obtained using the optical accelerometer are in good agreement with those obtained from the reference

accelerometer at operating frequencies lower than 23 Hz. Furthermore, it is observed that a coupling of approximately 2.8%, 2.94% and 1.94% exists between the acceleration in the driven axis direction and that induced in the non-driven axial directions, respectively. In other words, no more than a minor cross-talk error exists between the different axes of the 3-D accelerometer.
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