전자기력 엑츄에이터를 이용한 2 자유도 스캐닝 미러
-D Scanning Mirror Using Electromagnetic Actuators

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1. Introduction

Laser beam scanners are widely used in commercial and industrial fields. A few types of 2-D scanning mirror systems using electromagnetic actuators have been introduced [1, 2]. They cause a large angular deflection and high dynamic performance, but complex structures and bulky size are drawbacks. Some 2-D mirror scanner are also investigated using MEMS based actuators. The thermal actuated method [3, 4], PZT actuated method [5], electromagnetically actuated method [6, 7, 8] and electrostatic actuated method [9] are proposed to actuate 2-D scanning mirrors. The MEMS based 2-D mirror scanners have high dynamic performance at resonance frequency but rather small angular deflection and high manufacturing cost. In this paper, we present a compact two dimensional scanning mirror system to swing the direction of laser beams, using electromagnetic actuators. The new compact design of 2-D scanning mirror scanner uses coils and magnet to produce large angular deflection and moderate bandwidth.

2. Actuator design

The proposed 2-D mirror actuator has a novel structure to combine electromagnetic actuators of both the moving coil type and the moving magnet one. In order to rotate the mirror along the x-axis, the coil is attached to the back side of the mirror placed inside of the moving frame, acting as the moving coil type. To swing the frame along y-axis, the magnet is attached on the moving frame over the coil placed on the base frame, acting as the moving magnet type. The prototype of the proposed mirror scanner is shown in figure 1. The size of mirror is 8 mm x 8 mm and the overall size is 22 mm (W) x 20 mm (D) x 15 mm (H).

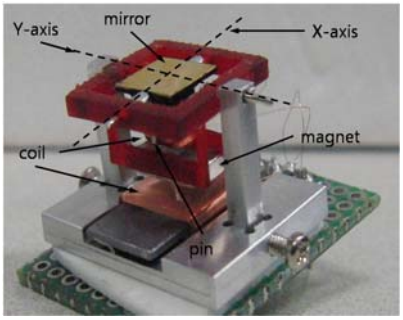

Fig. 1 Prototype of the 2-D mirror actuator

3. Experimental results

To measure dynamic performances of the 2-D mirror scanning system, the experiments using the prototype are implemented. The open loop control circuit using power Op-Amps is used and the input signals come from a function generator. The laser displacement sensor Keyence LB 1101 is used to measure the displacement of the mirror. The rotational angle is calculated by converting the displacement measurement of the mirror.

Firstly, we measure and calculate the static property such as the rotational angle as a function of the input voltage. In the case of the moving-coil-type actuator on x-axis, the rotational angle is 23 deg at 5V. The current applied to the mirror coil is 100mA. In the case of the y-axis actuator acting as the moving magnet type, the rotational angle is 13 deg at 10V.

The current applied to the base coil is 100mA. Both the rotational angles of the x and y axes are larger than those of the mirror scanning system using MEMS. The dependence of the rotational angle on the input voltage proves to be linear. Therefore, the proposed 2-D actuators can be utilized as the mirror-rotating mechanism of a laser pointing device.

Furthermore, we implement experiments to measure the dynamic performance of the system using the sinusoidal input. The moving-coil-type actuator on the x-axis has the bandwidth of 65Hz and the resonance frequency of 37Hz with the amplitude of 22. The moving-magnet-type actuator on y-axis has the bandwidth of 70Hz and the resonance frequency of 50Hz with the amplitude of 7. The each resonance frequency of the system is lower than that of the MEMS based mirror actuator, but the each rotational angle is larger. The dynamic bandwidth of the 2-D actuator meets the design specifications for industrial applications such as bar code scanner.

Finally, an optical scan pattern by the new 2-D mirror actuator is shown in figure 2. The input frequencies of x and y axes are 10 and 50 Hz, respectively.

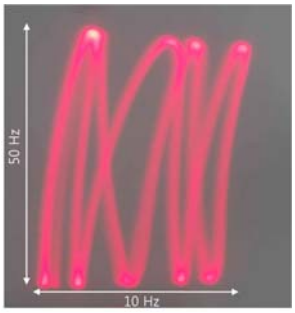

Fig. 2 Laser profile using the proposed 2-D actuator

4. Conclusion

We propose a novel 2-D mirror scanning system using electromagnetic actuators. The 2-D mirror actuator enables large optical angular deflection, moderate bandwidth and low manufacturing cost. The proposed 2-D actuation mechanism is suitable for the commercial and industrial applications of various laser scanning devices.

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