

Research of Multi-Axis Motion sensor Using MEMS Technologies

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This dissertation relates to the research and development of 3-axis acceleration sensors, 3-axis angular velocity sensors, and 6-axis motion sensors. The author, who embarked on this research and development in 1988, when until then most of these inertial sensors had been 1-axis sensors, has proven by this research that 3-axis components of acceleration and angular velocity can be detected with one detecting element. Also, success has been achieved in the development of 6-axis motion sensors by applying 3-axis angular velocity sensors and devising signal processing circuits. With research and development of these matching market needs, the acceleration sensor market obtained by this research and development in particular has expanded, centering on the IT field, and are now in wide use in many consumer products, after 18 years since the embarkment of the development.

Under such circumstances, the following have been shown in Chapter 1: the progress of the research having been made since the embarkment of the development to date, and the performance and uses, etc., of the piezoresistance type, capacitance type and piezoelectric type 3-axis acceleration sensors that have actually been industrialized based on the technologies obtained. Furthermore, the market expansion and future prospects of multi-axis angular velocity sensors and multi-axis motion sensors have also been shown.

The following have been shown in Chapter 2: the detection principles, production methods and features of the piezoresistance type, piezoelectric type and capacitance type 3-axis acceleration sensors shown in Chapter 1. Additionally, it has been clarified by taking advantage of 3-axis detection that the cross-axis sensitivity can be corrected by a simple matrix operation.

In Chapter 3, the detection principles and design approaches of multi-axis angular velocity sensors have been shown, and it has been proven that 2-axis or 3-axis angular velocity components can be detected with one detecting element in principle by actually developing capacitance type 2-axis angular velocity sensors and piezoelectric type 3-axis angular velocity sensors.

In Chapter 4, it has been established that angular velocity and acceleration are detected simultaneously with one detecting element by applying the angular velocity sensors shown in Chapter 3 and using the difference in frequency components between acceleration and angular velocity, and it has been shown that the developed capacitance type 5-axis and piezoelectric type 6-axis motion sensors have the basic performance required for commercialization. The validity of the design approaches shown in Chapter 3 has also been shown.

In Chapter 5, the 3-axis acceleration sensors, angular velocity sensors, and motion sensors developed by this research have been generalized, showing the differences in performance according to detection principle.