A study on small-size high-resolution rotary encoders based on magnetic pattern analysis

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Kazuhiro Nakano

Rotary encoders are fundamental devices for motion control systems. For a compact equipment, small low-cost encoders capable of absolute angle detection with high-resolution are required. Previous approaches such as vector magnetic sensors using two or more elements for X and Y directions are difficult to achieve both the high-resolution and small size. This thesis investigates new magnetic rotary encoders based on magnetic pattern analysis. To achieve high resolution, the proposed system uses a large number of sensor elements set in a square arrangement to sense the magnetic field profile. Several angle detection methods for high-precision angle calculation are investigated. Magnetic sensing devices using natives-substrate and arrangements and connections of the sensing elements for stress-induced offset canceling are proposed.

A rotary encoder chip using magnetic sensor arrays integrated with readout amplifiers, ADCs and angle detection circuits is fabricated with a standard 0.25μm CMOS technology. The effective chip area is approximately 3.8mmx3.8mm.The chip can detect the rotation angle within the error of ±0.36 degrees at sampling rate of 2kHz. The proposed rotary encoder system is robust to the misalignment between a sensor chip and a magnet. These results show the proposed approach is one of the ideal solutions for small and high-resolution absolute rotary encoders.