The research and realization based on position measurement system of magneto resistive sensor

Zhou Jing
(ECRIM)

Abstract: With the development in technology, there are many researches of measuring moving object’s position without touching it in domestic and overseas in succession. The paper introduces a non-touching measurement’s research and realization based on position measurement system of magneto resistive sensor. It includes signal conditioning, channel select design, data acquisition and output display circuit design as well as describe its design process in detail.

Key words: magneto resistive sensor, position measurement, data acquisition.

1. Introduction

The traditional position measurement mostly uses contact style and often wears out due to the components moving mechanically, which misses local signals at the wearing position. Besides, it is sensitive to impact and oscillation. The non-touching measurement can improve them greatly. The paper will introduce a non-touching measurement’s research and realization based on position measurement system of magneto resistive sensor. The angular or linear mobile can ensure the related direction in the composite magnetic field with the sensor, fixed magnet and sensing element, which realizes the angular or linear displacement measurement based on the data acquisition circuit.

2. The principle of ARM sensor

The magnetic sensor is the oldest sensor and the compass belongs to its earliest application. As the modern sensor, the easy signal processing is finished by the magnetic sensor transforming magnetic signal into electrical signal. The magnetic sensor is mainly produced by some principles such as material magneto electric effect, magneto resistive effect, magneto optic effect, thermal sensitive effect. It includes Hall Device, semiconductor magnetic resistor, magnetic diode and fluxgate, which applies in linear displacement measurement, angular displacement measurement, anti-block brake system, motor measurement and so on.

In this paper, Honeywell’s ARM sensors are used for magnetic position sensors. ARM sensors usually use perm alloy-containing ferrous materials. The figure 1 shows perm alloy components with applied magnetic fields and currents. θ is the angle between magnetic moment vector M and current I. In ferromagnetic materials, when a current is applied along the length of a long, thin ferromagnetic alloy strip, applying a magnetic field in the direction of the vertical current, the resistance of the alloy strip itself changes. It is made up of four resistance components consisting of the Huiston bridge sensor, the ARM bridge, as shown in Figure 2. Each strip magneto resistor has the ability to change resistance in a COS2θ relationship.
3. The scheme design

3.1 The scheme design of circuit

Using multiple Honeywell's ARM sensors to measure the position of the magnetic field, convert the magnetic field information into a voltage signal, amplify and select the signal through signal processing, convert the digital to analog signal into a digital signal, and use a single-chip microcomputer for data acquisition and corresponding control. Converted data information. In order to facilitate the display, the output uses a digital tube display. The block diagram is shown in the figure below. The circuit design of this solution mainly includes the following contents.

3.2 The design of magnetic measuring circuit

The induction of the magnetic field uses Honeywell magneto resistive sensor HMC1512, which contains two ARM bridges. With small size, low power consumption, surface mount, non-contact, ultra-low deviation and so on.

The HMC1512 has an angle range of ±90 degrees and a resolution of less than 0.07 degrees. The differential output voltages of the two bridges A and B are:

$\Delta V_d = V_s \cdot S \cdot SIN(2\theta)$
\[ \Delta V_B = V_s \cdot S \cdot \cos(2\theta) \]

Among them, \( V_s \) is the supply voltage; \( S \) is the material constant; \( \theta \) is the magnetic field reference angle.

Because the sine (sensor bridge A) and the cosine (sensor bridge B), after subtracting the offset error, are proportional, the ratio of bridge A to bridge B will produce a \( \tan \theta \) function and cancel the amplitude. Therefore, the angle \( \theta \) can be calculated as:

\[ \theta = 0.5 \times \arctan(\Delta V_A / \Delta V_B) \]

The trigonometric function is revised according to the angular range and the +180 degree or 0 degree to 360 degree angle solution is completed. By using multiple sensors arranged in a linear or circular shape, the distance between the sensor and the sensor is determined, the distance between the magnet and the sensor is adjusted, and the magnetic field is converted into a voltage signal for signal processing.

3.3 The design of amplifying circuit

Magneto resistive sensor HMC1512 rated peak-to-peak range within 120mV, so need to design the signal amplifier circuit, circuit diagram as shown in Figure A sensor A amplifier circuit. Gain design is 25. In order to offset the zero offset voltage on the bridge, set the potentiometer to fine-tune.

3.4 The design of channel select circuit

Since the distance between a single sensor and a magnet is small, the linear distance is usually 8mm. Therefore, it is necessary to study how to use multiple sensor arrangements to solve the problem of short switching distances and to expand the position range. In this scheme, 8 ARM sensors are selected as an example, and the channel selection circuit design is used to determine the boundary conditions selected for each channel. According to the actual channel, the circuit uses an analog switch. The selection principle is to satisfy the number of channels of the circuit, power supply, and low on-resistance. For example, the ADG526 (8/16-channel analog switch) is used. The pin out and logic are shown in the figure below.
3.5 The design of analog conversion circuit

This circuit design mainly uses a dedicated A/D conversion chip. Taking into account the accuracy and the number of channels, the AD7705 16-bit serial interface is used.

3.6 The hardware design of communication interface RS232

RS232 is the most commonly used serial communication interface at present. In serial communication, both sides of communication are required to use a standard interface so that different devices can be easily connected for communication. The circuit design is shown in Figure 6.

3.7 The design of digital display circuit

In order to visually display the output value, 5 digital tubes are used for display. Figure 7 shows a digital display circuit.

3.8 The software design of data processing and control

The design uses single-chip microcomputer for data acquisition and circuit control, and the flow chart shown in Figure 8.
Each channel boundary determination condition is:

- Channel 1: $0 \leq \text{channel acquisition value} < 0.5$
- Channel 2: $0.5 \leq \text{channel acquisition value} < 1.0$
- Channel 3: $1.0 \leq \text{channel acquisition value} < 1.5$
- Channel 4: $1.5 \leq \text{channel acquisition value} < 2.0$
- Channel 5: $2.0 \leq \text{channel acquisition value} < 2.5$
- Channel 6: $2.5 \leq \text{channel acquisition value} < 3.0$
- Channel 7: $3.0 \leq \text{channel acquisition value} < 3.5$
- Channel 8: $3.5 \leq \text{channel acquisition value}$

Serial data transmission uses interrupt transmission, and to determine whether the main loop’s the end of the transmission flag is 1 or not. If it is 1, the transmission is end, and flag is cleared.

4 Conclusions

The linear distance between a common single sensor and the magnet is small, and if multiple sensors are used together, the linear distance may increase. By arranging multiple sensors and performing data processing, it is theoretically possible to perform long-distance testing. The program uses a high-resolution, low-power magneto resistive sensor to complete the conversion of magnetic signals to electrical signals. Changes in the magnetic resistance under the influence of an external magnetic field cause changes in the output voltage and directly indicate the strength of the magnetic field, which can be measured from a magnet. The magnetic field direction angle. Has the following advantages:

A. This program can withstand large changes in the gap between the sensor and the magnet.

B. The program unlike the incremental "encoder" class sensors, there is no need for indexing to provide output at the appropriate location.

C. This solution has no moving parts, no wear, and no loss of signal in the worn position, unlike traditional contact-type rotary transformers.

In addition, in order to obtain the best performance, it is required to meet a certain magnetic field strength at the sensor position. At the same time, research on different magnetic field environments is also required. A simple dipole magnet usually has the strongest magnetic field strength near its pole, and the magnetic field intensity gradually decreases with increasing distance.
Different magnet materials or different distances have an effect on the conversion. Typical linear displacement measurements have a resolution of 2 mils and an accuracy of 0.1%, but this depends to a large extent on the auxiliary interface electronics. Therefore, it is necessary to carry out technical research on the material and assembly method of the magnet and the direction angle of the magnetic field to determine the best assembly position.

Reference

[1] The application of magnetic position sensor. Honeywell
[2] HMC1501/1502.PDF