International Journal of Control and Automation
Vol. 8, No. 6 (2015), pp. 113-120
http://dx.doi.org/10.14257/ijca.2015.8.6.12

# Research of Measurement of Large Displacement and Velocity Based on Hall

Xue-yu Lu

*School of Mechanical Engineering, Jiangnan University, Wuxi 214122, China*

***Abstract***

*With the further development of production, a higher request to the measurement of straight2line long displacement has been put forward. This article introduces one technique sayings mechanical contact wheel based on Hall components to measure straight line long displacement. This method directly takes movement part oneself as static reference datum, converting two objects relative movement to the rotation of wheel. The Hall components detect t he rotation angle and the direction of roll wheel, t hen t he displacement is calculated. The measuring technique has many merits, such as simple and small measuring structure, large measuring range, broaden adoption environment and so on, so having certain application value.*

***Keywords:*** *big displacement; roll wheel; Hall components; magnetic pillar; pulse numbers.*

## 1. Introduction

With the further development of production, a higher request to the measurement of straight-line long displacement has been put forward. The displacement and velocity measurement device with a potentiometer displacement sensors, sensor, magnetic scale of linear synchronous sensor, magneto-astrictive sensor, eddy current sensor, ultrasonic, laser and optical fiber sensor and electromagnetic speed sensor, capacitive sensor measuring speed, Doppler effect, correlation, spatial filtering veto-cemetery [1-4], differential pressure measuring device and so on.

However, the above sensors and measurement methods or because of limited range and slow response, or because the price is expensive and can not meet the requirements of the system in this paper and the larger the size of the overall structure, measurement performance vulnerable to humidity, dust and other effects these measurement sensors have a certain similarity, are basically composed of two parts consisting of the scale and the detecting element [5-9].

In use, the scale and the detection elements are fixed to the stationary and moving parts, and by detecting the movement of the stationary member calculate the amount of change in the relative position of displacement [10]. A hall element based on mechanical contact roller swing measurement method is designed in this paper, which is suitable for large flat linear displacement measurements.

This method directly takes movement part oneself as static reference datum, converting two objects relative movement to the rotation of wheel [11]. The Hall components detect the rotation angle and the direction of roll wheel, and then the displacement is calculated.

## 2. The Measuring Principle

Switching integrated Hall element refers to as the Hall switch, which is composed by the voltage regulator integrated circuit, a Hall element, a differential amplifier, Schmitt trigger and an output stage thereof. Is the magnetic induction intensity of the input, the output is a digital signal. Its internal structure of the pin and the output characteristics are shown in Figure 1.

ISSN: 2005-4297 IJCA

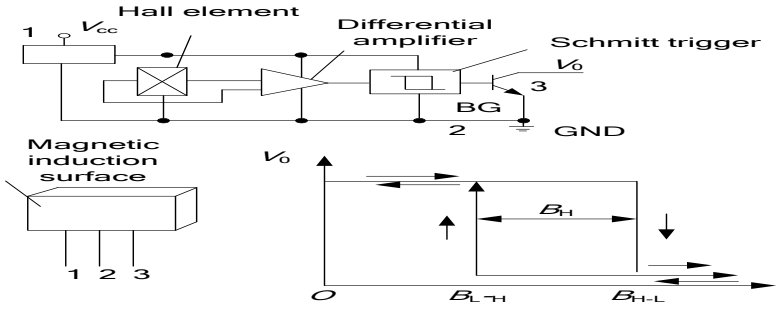


**Figure 1. Internal Structure and Pin and Output Characteristics of the Hall Switch**

When the magnetic sensing surfaces Hall switch feel a rising magnetic field, and the magnetic flux density is greater than B HL, Hall switch is turned on, and the output is low[12]; When the feel is a decline in the magnetic field and the magnetic flux density is less than B LH, the Hall switch off, and the output is high. The difference Magnetic induction between BH-L and B LH is produced by the magnetic hysteretic effects, which greatly improved anti-jamming performance of the switch circuit. The measurement principle is as shown in Figure 2.

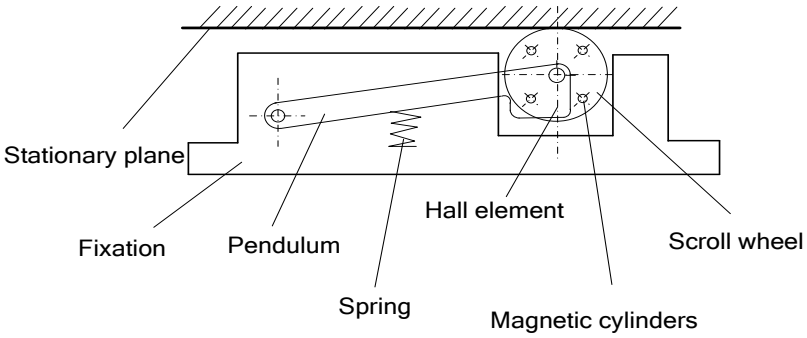


**Figure 2. Schematic Diagram of Measurement**

Swing roller measuring member structure mechanical contact measurement principle of the method is shown in Figure 2. Mounting bracket is mounted on the moving parts. Pendulum under the action of the spring tension on the scroll wheel pressed against the stationary plane. Scroll wheel freely rotatable about the axis of rotation, the circumferential surface of the wear-resistant material is non-slip handle. Cylinders are distributed on a scroll wheel; two Hall elements are mounted switch pendulum rod cylinders and is located on the same side and with the cylinders arc line [13]. The angle between the Hall element angles for cylinders distributed about 1.3 times. When fixation with moving parts around sports, scroll wheel to rotate back and forth due to the action of friction. Each time through the Hall element cylinders will produce a pulse, the pulse waveform by comparing the two Hall elements; can be measured in the direction of wheel rotation. Use record number of pulses can be calculated and the wheel diameter wheels rolling on a stationary plane distance, *i.e.*, the displacement of a moving object.

## 3. Hardware and Software Design of Measurement System

### 3.1. Part of the Hardware

Hall devices are used in part of the hardware. Magnetic sensor used by the Hall device, can detect magnetic field, and can be used for a variety of occasions, with the change of

magnetic field [14-15]. The method has the advantages of simple structure, small volume, large range measurement device and adapts to the environment and other advantages, has certain application value. Hall devices have high precision and good linearity; Hall devices also have non-contact Hall-effect switch devices, no wearing, clear output waveform, no shaking, no rebound, high repeatability position of (up to $\mu m$ level). The relationship between level of sensitivity Hall-effect and strength of the magnetic induction from outside is proportional. Hardware configuration of the measurement system is as shown in Figure 3.

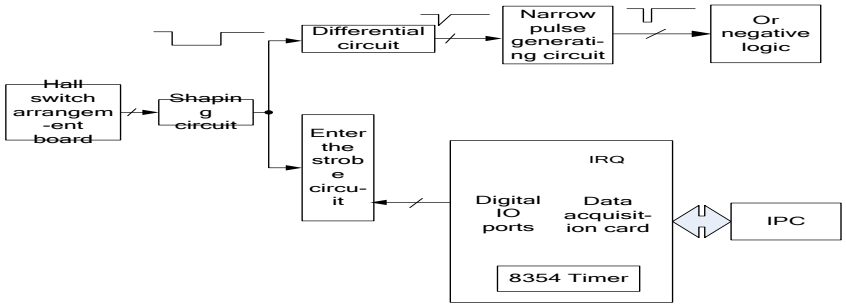


**Figure 3. The Hardware Configuration**

96 Hall switches of the Hall switch arrangement board are arranged in the printed circuit board evenly. Then the board is fixed along the cylinder stroke test bench. Hall switch is used CS3020 Hall Switch ICs. It has a wide operating supply voltage range, switching speed, jitter-free moment, wide frequency range and other characteristics. Because when a Hall switch output is low, if the individual Hall switch output signal directly access or negative logic circuit (*i.e.*, the gate), the other Hall switch output level transitions will not generate an interrupt. Therefore, the output signals of the individual Hall switch through differential circuit and narrow pulse generating circuit and then access or negative logic circuit (*i.e.*, the gate). Enter the gating circuit is the role of 32 digital input data acquisition card extended to 96, the address signal output from the IPC to choose. 8254 data acquisition card timer clock using 10 MHz, it has three 16-bit timer, two timers will make a timer with a cascade, a timer is about to end and another timer OUT CLK end connected. After the timer cascade largest timed cycle: $2^{16} \times 2^{16} \times \frac{1}{10 \times 10^{6}} \approx 429.5$. This ensures that the timer does not overflow; the interval is calculated to simplify the whole process in the cylinder.

### 3.2. Part of Software

A signal processing system is as shown in Figure 4.

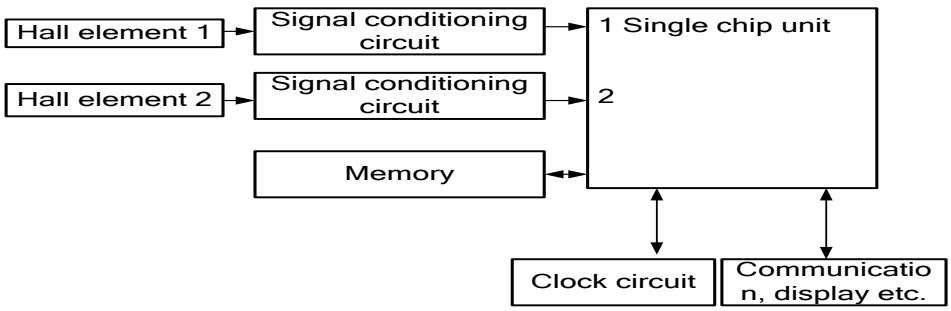


**Figure 4. Signal Detection and Processing Module**

 

Output signal of the switch type Hall element are handled by the signal conditioning circuit, amplifying and filtering processing then input 1, 2. The speed of the moving object is not fixed, the pulse interval of the output Hall element may be varying great, and the signal acquisition chip using interrupt mode. 1 input of microcontroller port is set to fracture, pulse rising edge trigger, 2 input port is for level sampling. Of course you can also set the other interrupt and level acquisition mode, as long as the comparison of the 2 channel sampling. Although the pulse signal may be different, the pulse level correspondence between 2 channels is consistent. Put the four columns in Figure 5 output pulse signal as an example, to illustrate the acquisition method.

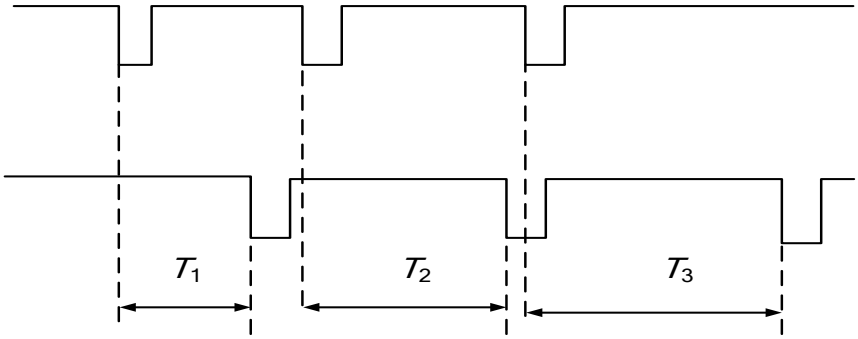


**Figure 5. Diagram of the Two Adjacent Hall Switch Output Waveform**

When the fixed bracket moves from right to left, the scroll wheel rotates clockwise. Depending on the initial relative position of the two Hall elements and cylinders, and the wheel rolling week waveform microcontroller 1, 2 inputs presented four states. By comparing the 4waveforms, we can find that regardless of the initial state of 1 and 2, the input port state are 1/0, 1/1 0/0, 0/1, and the correspondence between the input waveform is the same, *i.e.*, 2 to 4 groups by a group of waveforms can pan the first waveform in time series left certain phase obtained.

Similarly, you can draw a fixed bracket overall movement from left to right, a scroll wheel that rotates counterclockwise waveform. What can be seen that waveform of the scroll wheel rotated counterclockwise or clockwise is opposite in phase. Because Waveform 1, 2 input port has maintained a consistent correspondence, scroll wheel rolling back and forth can generate waveforms at a point in time A, the time series obtained from a set of waveforms to the left and right sides to expand. Set the scroll wheel rotated in the clockwise direction is positive displacement. A microcontroller input signal level at 1 point in time at x0 transition from 0 to 1, the pulse rising edge triggered interrupts the microcontroller. Interrupt routine inquiry 2 input level, if it is 0, then the movement of objects in the positive direction, the cumulative number of pulses plus one. When scrolling direction unchanged, the number of pulses will continue to accumulate. If at some point, the scroll wheel is to change to counterclockwise rotation, then x1 point in time, a rising edge of the input pulse triggers the microcontroller interrupt. By 2 input signals to a level, you can determine the scroll wheel to rotate counterclockwise direction change, the cumulative number of pulses minus 1. MCU save time and changes in the cumulative number of pulses that occur after changes in memory in a certain time interval, for the calculation process.

The device for software system detection includes: main gun, binary code and BCD conversion routines and display routines. This paper describes the main program and speed display routines.

As shown in Figure 6, the program starts scanning the cycle of 80 Hall switches in the beginning, then results sent through the serial port to communicate after 8ms time scanning.

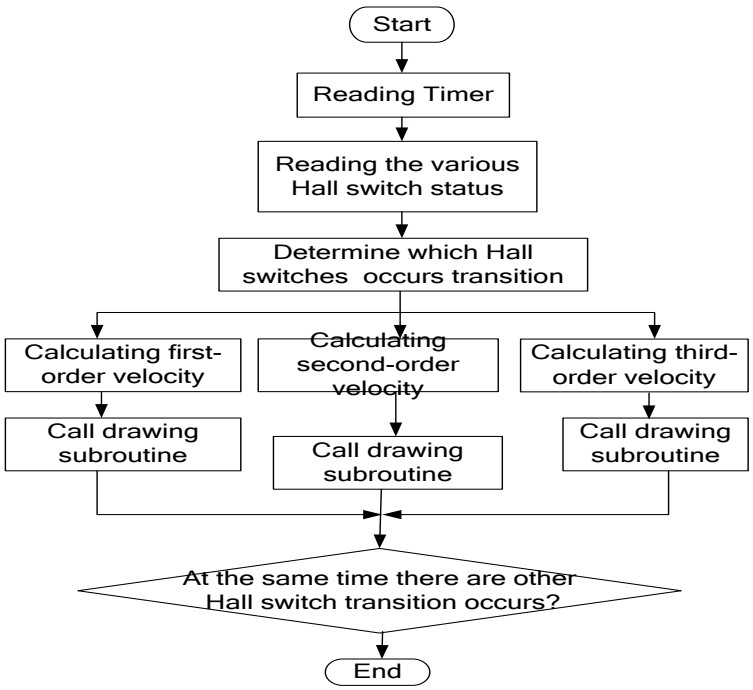


**Figure 6. Flow Chart of Program**

## 4. Error Analysis

Suppose a movement component level through a Hall switch two adjacent intervals of *T*, the distance between these two Hall switch is *L*, then the level of moving parts Hall switch after two average speed *V*:

$$V = \frac{L}{T} \tag{1}$$

Therefore, the average absolute error for velocity *V* is

$$\Delta v = \frac{\partial V}{\partial L} \cdot \Delta L + \frac{\partial V}{\partial T} \cdot \Delta T = \frac{1}{T} \cdot \Delta L - \frac{L}{T^2} \Delta T \tag{2}$$

Where: $\Delta L$ 、 $\Delta T$ is the absolute error of the distance and the time interval respectively.

The average relative error for velocity is

$$\delta v = \frac{\Delta V}{V} = \frac{\Delta L}{L} - \frac{\Delta T}{T} \tag{3}$$

Among them, $\Delta T \ll T$ , which can be ignored, and only consider the effects of $\Delta L$ . Due to the manufacture errors, poor consistency of each switch between Halls, even if the other conditions are consistent, the relative position of magnet by Hall switch state jump is not the same, so the actual value of two adjacent Hall switches state jump position and the distance between the Land L errors $\Delta L$ between theoretical values. After the measurement, $\Delta L \leq \pm 2mm$ . $\Delta L$ is the system error which can be calibrated, by jumping position of each switch to Hall, spacing of $\Delta L$ is modified, the error will be greatly reduced.

 

## 5. Experimental Methods and Data Analysis

In this paper, the linear motor test platform is American Copley model STA2504-S-206-S-S03Fcylindrical permanent magnet linear synchronous motor, the embedded position Holzer element, can achieve 12um can repeat positioning accuracy. Figure 7 shows the given speed standard at = 2, 4 PMLSM actual velocity waveform:

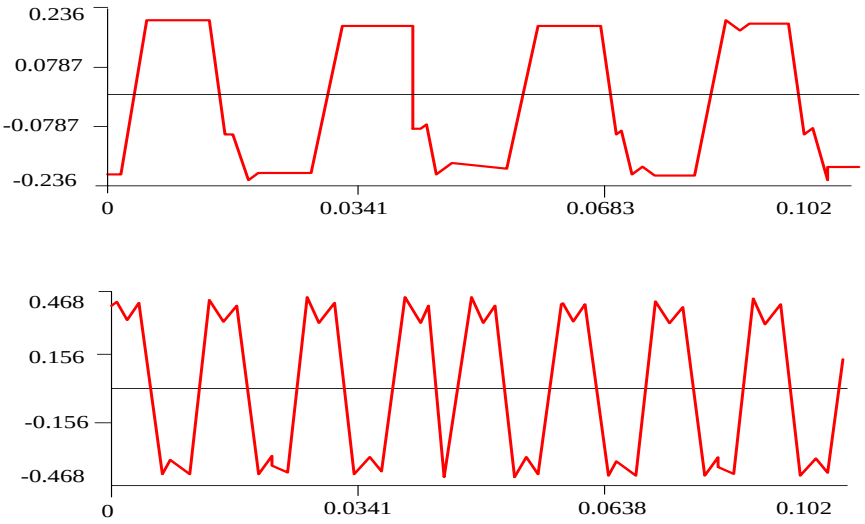


**Figure 7. PMLSM Actual Velocity Waveform**

The vertical axis represents the actual speed of Figure7 PMLSM positive and negative values, says PMLSM is the reverse operation, waveform and data from the chart can be seen, the actual operating speed PMLSM basically consistent with the given speed.

Figure 8 shows the given speed standard at=2, 4 s position for the waveform of 40mmPMLSMposition and the actual position of the given:

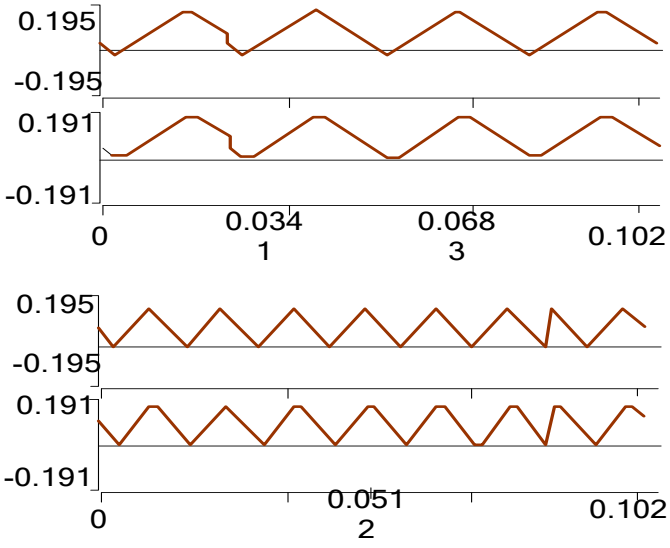


**Figure 8. PMLSM Position and the Actual Position of the Given Waveform**

Figure 8 PMLSM waveform of each waveform from the starting point to run to the given position and return to the starting point and so forth process respectively, as can be

seen from Figure 8, under different speed of PMLSM running the farthest position basically and the given position.

## 6. Conclusion

Large linear displacement detection method, although the measurement accuracy is not high, but the measuring device is small, simple structure, almost free from humidity, dust and other environmental factors. The measurement scheme is a method of self-reference design, without mounting on the moving parts and stationary parts of measuring devices easier to use. The measurement range is infinite, is particularly suitable for large displacements and linear precision is not very high places. After field application testing, has achieved satisfactory results.

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## Author

**Xue-yu Lu**, was born on January 21,1974. She is a woman. She is from Wuxi,China. She is a lecturer in the School of Mechanical Engineering at Jiangnan University. She is mainly engaged in research of mechanical design and theory.

 