Developing and Research on Pulse Motion Controller Based on SCM

Ruili Chang*, Jun Han

School of Information Engineering, Inner Mongolia University of Science and Technology, Baotou, 014010, China

Abstract

As being the core of the machinery and electronic, motion controller is used in industry production widely. In this paper, a motor motion controller based on 16 bits SCM (Single Chip Microcomputer) is designed. Combining peripheral timers, this controller can control four-axes servo motors or stepping motors by sending pulse means. The experiment results have shown that the circuits design is feasible, and the system is stable and reliable, and the desired design objective has achieved. This motion controller can be used in numerical control machine tools, robots, automatic navigation dollies, and so on.

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1. Introduction

In industry production, the motor control is realized usually by motion controller. As being the brains of implement unit, motion controller is the core in the whole system. It takes out instructions or data from memorizer or receives instructions or data come from outer equipments and compiles, operates and logic process them, and outputs control information and instructions to make all parts in system run in line. User only communicates with it, and the interpolating functions can be completed, such as beeline and circular arc interpolating, reamer tools compensating, malfunction diagnosing, and so on. In addition, as the core of machinery and electronic, motion controller is used widely in numerical control machine tool, robot and medicine equipment fields. With the development of science and technology, high capability

* Corresponding author. Tel.: 0472-5951563.
E-mail address: crl2006@126.com.
and low cost motion controller dominates the foreground. The motion controller based on SCM has powerful function, low cost and flexible programming. Accordingly, it is used in all kinds of middle and small numerical control system and automatic navigation dolly.

2. Whole design of controller

In this paper, a digital motion controller is designed, and its whole structure is shown in Fig.1. Its core is a 16 bits SCM SPCE061A. There are 32K FLASH, 2K SRAM, 32 programmable I/O ports, 14 interrupt sources and 2 exterior clock input ports in SPCE061A. This controller can control four servo motors or stepping motors by sending pulse means at the same time. Serial communication circuit is used to monitor motors running state. I/O expanding circuit is used to motor turning, alarming and other signals in-out ports. 32 bits counter is used to count the pulses fed back from the motor. PROBE interfaces are used to download and debug program.

![Whole structure of the system](image)

3. Design of hardware circuits

3.1. Pulse generator

In this paper, pulse signal is generated by outer timer/counter, and it is shown in Fig.2. Channel 1 and channel 3 are used as motor control channels and generate square wave signal to drive the motor. The motor control channels run in mode 3 of 8254 (square wave generator mode). Channel 2 is interpolating control channel and runs in mode 1 (programmable monostable multivibrator mode), and outputs negative pulse signal to control interpolating time. Before interpolating every time, all coordinate values are gotten hold of from last interpolation. The count constant $T_n$ of control channel is:

$$T_n = \frac{T_c}{d}$$  \hspace{1cm} (1)

Here $T_n$ is stepping motor count constant of control channel, and $T_c$ is the count constant of interpolating control channel, $d$ is computed increment in coarse interpolating.

And then, $T_n$ is inputted into corresponding motor control channel, and $T_c$ is inputted into interpolating control channel. Channel 3 runs in mode 1. When the rise edge of gating signal comes, if the count value has been written into, the counter will be start-up.
3.2. Frequency doubling and direction differentiating circuits

Usually, the frequency of the signal come from coder must be doubled in order to improve the positioning precision. The principle of frequency doubling is shown in Fig.3. It shows that signal A and signal B change four times altogether in a period, namely rise edge and fall edge of signal A and signal B. The phase between signal A and signal B decides the turning direction of motor. Four times frequency pulse signal is attained by the four edges of signal A and signal B, namely a pulse shows that the worktable moves a quarter of a bar distance. Accordingly, the resolving power of photoelectricity coder is improved.

Common four times frequency circuits are composed of monostable flip-flop or D flip-flop. Monostable flip-flop needs connect capacitance and resistance to adjust the width of pulse, and the width is constant when the circuit was connected. Therefore, the adaptability is bad. In addition, capacitance and resistance are affected easily by the environment, which disturbs the width of the pulse and can bring count error. In this paper, four times frequency circuit is composed of D flip-flop. 74LS175 (D flip-flop chip) is used to latch next states and present states of signal A and signal B. It is shown in Fig.4. For instance, after signal A passed a D flip-flop, a slight lag signal A1 is obtained. A narrow pulse is produced via Boolean
calculation of not A1 and A. By the same method, four narrow pulses can be obtained in a period. They are inputted into multiplexer 74LS153 and the direction signals (forward direction and inverse direction) are produced. Here, the clock frequency of D flip-flop must be more than four times of the pulse frequency of the coder, but can not be too high because the too narrow pulse will make the count stability bad.

Fig.4. Frequency doubling and direction differentiating circuit

3.3. Counter and latching control circuits

The pulse signal come from the multiplexer is reversed and is inputted into counter circuit to count. The counter is 32 bits and is composed of eight 74LS193 chips (four-bit synchronous reversible binary counter). As synchronous counter, the lag time per 74LS193 is no more than 26ns, and the count frequency can touch 32MHz. However, the lag time of eight connected 74LS193 chips is 208ns, and in this period, the counter output data can be false. Therefore, latching control circuit is designed in order to read count value accurately. Considering that the number of count pulses is uncertain and no pulse appears in some period of time while very high frequency pulses appear when motor speed ascends, latching control circuit of two modes is designed, it is shown in Fig.5. Mode 1 is once reading number mode. After logic process and Y7 control, the direction signals H7, H8 are inputted into B port of monostable flip-flop channel 1. When reading number is needed, the counter is latched by sending control signal Y7, and the count value is outputted accurately by latch reading operating. Mode 2 is continuous reading number mode. When count pulse appears, logic processed count signal continuously latches latch. While reading number is needed, the monostable flip-flop is controlled by IOB6 to stop latching, and the count value can be outputted accurately.

Fig.5. Latching control circuit
4. System software design

The software design of motion controller includes the control interface design of upper layer PC, the main program design of under layer PC and interrupt service routine design. The upper layer PC control interface is designed by Visual C, and achieves managing, monitoring and control for under layer PC and saves sampling data and shows machine tool state in real time. When upper layer PC communicates with under layer PC, communication agreement is stipulated, namely data format, synchronization mode and transmitting speed are stipulated uniformly. According to the data come from upper layer PC, under layer PC judges and does corresponding process and control the direction of program. Thus, the motor can run in line. Here, servo control has high real time characteristic and is achieved in interrupt routine.

5. Conclusion

In this paper, adopting 16-bit SCM with DSP function as core processor and digital AC servo motor as control object an inexpensive and practical pulse four-axes motion controller is developed. It can control four servo motors or stepping motors at the same time. SPCE061A single chip microcomputer not only has big memory but also has very high run frequency which can reach 50MHz. Accordingly, it has very good data process capability and avoids costly DSP. In hardware design, in order to achieve absolute position count, a 32-bit reversible counter and latching control circuit are designed. The experiment shows that the counter runs steadily and reliably, and desired design objectives has achieved. If part hardware circuits are realized by CPLD (Complex Programmable Logic Device), the bulk of circuit board will be reduced greatly, and the controller will be more practical.

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