

Overall Scheme Design of the System

Tingting Han

School of Mechanical and Electronic Engineering, Shandong University of Science and Technology, Qingdao 266590, China;

1421035698@qq.com,

Abstract: According to the functional requirements of the control system, the overall scheme of distributed motion control system is proposed. This paper introduces the system composition and task allocation of each part, and then introduces and selects the system's main and slave station processor, servo interface form, communication bus and communication medium.

Keywords: Distributed motion control system, sexperiment platform.

1. MIO THEORY

With the rapid development of network technology, electronic information technology and automatic control technology, servo motion control system has been more widely applied in the field of industrial automation, playing an increasingly important role [1]. Traditional motion control can no longer meet the ever-changing market demand. In order to improve the competitiveness of products, it is necessary to develop efficient, stable, flexible and intelligent motion control system. In recent years, field bus technology and industrial Ethernet technology have become increasingly mature.

1.1 Research background and significance of the subject

Motion control is the foundation of modern manufacturing. The automation equipment is developing towards high stability, high speed and high accuracy, which puts forward higher requirements for the servo motion control network. It not only needs to improve the speed and position control accuracy of single shaft, but also needs to pursue the precision of coordination and linkage among multiple motion axes. With the continuous development of servo control technology, networked motion control system, as the main solution for multi-axis control, has gradually become the development trend in the field of industrial automation [2].

In recent years, the number of motion axes on numerical control equipment has been increasing, and the relative positions of each axis have been gradually dispersed. Synchronous control between servo axes and real-time information transmission have become the main obstacle for the development of networked motion control system to high-speed and high-precision . In synchronicity, multiple distributed servo from standing in the form of cascade together to form a motion control network and data transmission between each node has certain delay, unable to adopt a unified global clock, so they can't be fully synchronous, reasonable clock synchronization algorithm must be used to compensate

the synchronization time delay of the system. In terms of real-time ability, the master controller is required to have strong information processing capability, which can complete data calculation, sending control information and receiving feedback information within the specified time . Moreover, the controller, actuator and sensor of the slave station should respond quickly, so that the control command and feedback information can be transmitted accurately and real-time.

Industrial Ethernet technology has strong compatibility and openness, and rich software and hardware products, so it is widely used in motion control of CNC system. High performance industrial Ethernet such as EtherCAT can meet the requirement of synchronization and real-time of networked motion control system, but the realization of its function needs to be based on special hardware platform. At present, there are many core processing units that use ARM and FPGA to build the motion control system in the market [3]. If it can be integrated into the existing motion control system, it can not only meet the real-time and synchronization requirements of the networked motion control system, but also provide the possibility for the updating and technical upgrading of motion controllers .

To sum up, based on the general networked motion control system, a distributed motion control system based on serial bus is proposed in this paper. The system is a master-slave distributed topology, and the real-time control is completed by the master station. The PC based on Windows system is used as the upper computer operating platform of the motion control network, which can greatly reduce the real-time requirements for the upper computer operating system. The information transmission between each node of the system adopts the simple serial communication mode, which realizes the cascade connection between each movement unit and constitutes a complete motion control network, making the system more flexible, real-time and reliable.

1.2 Overview of traditional motion control system architecture

The motion control system has gone through a series of development processes, from dc motor to ac motor, from open-loop control to closed-loop control, from single-axis motion to multi-axis linkage control, to personal pc-based servo control and networked motion control. Each change has promoted the progress of motion control technology to a certain extent . At present, motion control technology has been widely used in various fields of industrial manufacturing in China, which has made great contributions to China's economic development.

The advantages and disadvantages of the motion control system reflect the advanced nature of the industrial automation industry. In order to adapt to the rapidly changing market demand and meet the requirements of the static and dynamic performance of the motion control system, a variety of automatic control technologies have emerged. Along with high speed and high precision nc machining technology, the networked manufacturing technology and precision machinery processing technology unceasing development and mature, motion controller will toward the direction of network, digital, intelligent, high precision, high stability, high real time capability of the drive control to meet the demand of high performance industrial automation field market [4].

In the past 30 years, thanks to the rapid development of computer technology, communication technology and automatic control technology, motion control technology has also achieved unprecedented achievements, and the products related to motion control at home and abroad are also in full bloom . The following is a brief introduction of several traditional motion control methods.

1.2.1 movement control system based on PLC

PLC (programmable logic controller) is a kind of controller for automatic production line and industrial robot. The hardware part of the PLC system is similar to the microcomputer, which is developed based on the logic control with the microprocessor as the core [5].

With the development of computer technology, PLC motion control technology plays an important role in every field of industrial manufacturing. PLC realizes the specified motion of the motion axis by logic control, interpolation calculation and point control. Plc-based motion control system is usually realized by sensor, executive component and digital quantity interface for motion control and position feedback of CNC machine tools, which is difficult to achieve high control accuracy . In recent years, with the increasing maturity of servo control technology, PLC control can also achieve higher point motion accuracy, but its hardware drive equipment and software development costs are higher.

To sum up, the motion control system based on PLC has a short development cycle, high stability, convenient maintenance, and the advantages of strong anti-interference ability, but the PLC control applies only to position control and single axis movement, difficult to achieve coordination control of multiple moving axis, so you can't complete complex contour interpolation, this is also the important factors which restrict the development of the PLC motion control system further.

1.2.2 CNC motion control system

ComputerNumericalControl refers to ComputerNumericalControl system. The block diagram of basic structure is shown in FIG. 1-1. Its core component is computer numerical control device. The CNC system can realize single-axis position control and multi-axis linkage control, and has high control accuracy and reliability. At present, it has been widely used in CNC machine tools in the field of industrial automation. As an important part of the automation industry, the development of numerical control technology directly determines the degree of automation of China's industrial production and also reflects the level of industrial development of a country.

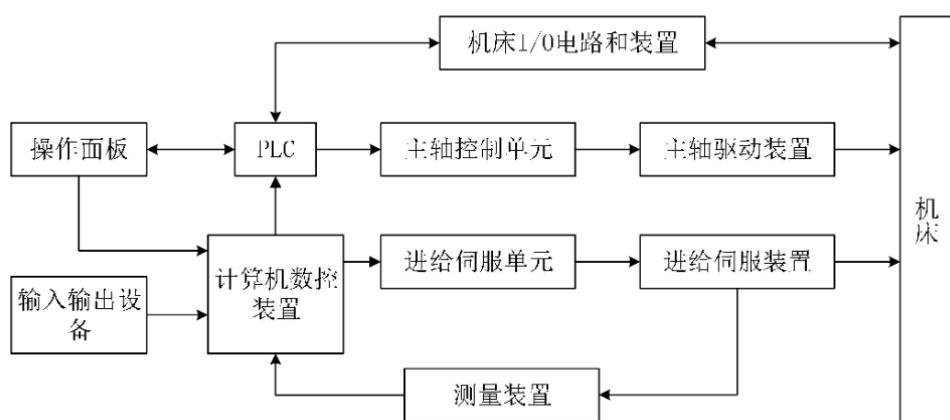


Fig. 1-1 Computer numerical control system schematic

The CNC system is controlled by the program, and the control instructions are processed and calculated through the operation panel or other input devices to obtain the feed amount of each movement mechanism, and then the information is sent to the servo unit for drive

The moving parts carry out spot movement and real-time feedback control of position. Compared with traditional machining, CNC system has the following characteristics:

(1) Universality

The software programming and hardware equipment of CNC motion control system are modularized. Many functional modules have standard interfaces, which can be directly used for different numerical control equipment. Therefore, CNC system has universality.

(2) Reliability

Most of the functions of the CNC system are realized by software. Before normal operation, the running program is burned into the processor, which can be executed after debugging. Therefore, the hardware structure is simple, which effectively reduces the influence of complex industrial environment on the hardware circuit and enhances the stability of the CNC system.

(3) Abundant numerical control functions

The CNC system makes full use of the powerful computing power of the computer and can realize many complex motion relations, such as complex curve interpolation, dynamic graph display and various compensation functions.

However, a computer numerical control device can only connect a fixed number of moving units, multi-axis expansion is difficult, so the flexibility of CNC control system is relatively poor.

1.2.3 plate-card motion control system based on PCI bus

Board card based on PCI bus motion control system structure diagram as shown in figure 1 and 2, the system with PC and motion control unit as the core, dedicated controller through standard bus interface between PC and realize the information each other, PC machine has powerful information processing ability, the controller can achieve precise trajectory control, the combination to get a high speed, high precision, high reliability and good commonality movement control system .

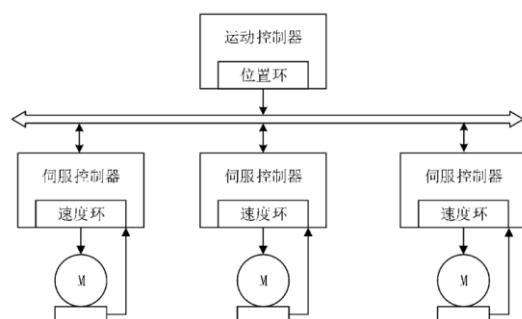


Fig. 1-2 Board motion control system based on PCI bus

The motion controller of the board card motion control system is mostly based on the high-performance microprocessor such as ARM, DSP or FPGA/CPLD, which has powerful data processing ability and logical operation ability and can meet the performance requirements of the motion control system. The motion controller receives the position instruction from PC through PCI bus, analyzes, processes and computes it, then outputs the stable digital pulse signal, at the same time collects the feedback information of each motion axis, and finally realizes the high-precision coordinated linkage control of each movement unit. This kind of motion control system has high reliability, is easy to realize linkage control, can complete interpolation motion of complex curve, and is suitable for machining of complex parts.

At present, the board card with PCI bus motion controller at home and abroad are widely used in the field of automation, the technology is mature, while the motion control card can only be connected

to a fixed number of moving axis, but by multiple boards are free to expand to multiple servo axis, using a relatively flexible, due to limited by industrial PC slot, the number of servo axes is limited, and software development capabilities have higher requirements for the user. Therefore, it is not competitive enough in the market.

1.3 Overview of networked motion control system

In recent years, network communication technology and industrial Ethernet technology have become increasingly mature, and the networked control of traditional motion system architecture has become an inevitable trend. The network connection and centralized control between the upper computer control system and the servo node expands the control scope of the motion control system and facilitates the realization of centralized distributed control. Networked motion control systems can be divided into centralized and distributed structures.

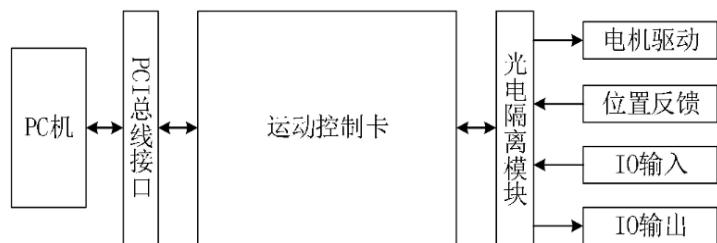


Figure 1-3. Schematic diagram of the centralized structure

Figure 1-3 shows the centralized structure diagram. The system's position closed-loop control is realized in the motion controller and the speed closed-loop control is realized in the servo controller. The motion controller receives the position information from the feedback of each motion axis through the network bus, and then carries out velocity planning to calculate the given value of the speed of the motion axis, and sends it to the servo driver of the corresponding node through the network bus. This centralized motion control system can realize more complex position control algorithms, but the network closed-loop control inevitably has some delay in the data transmission process, which affects the synchronization of the system.

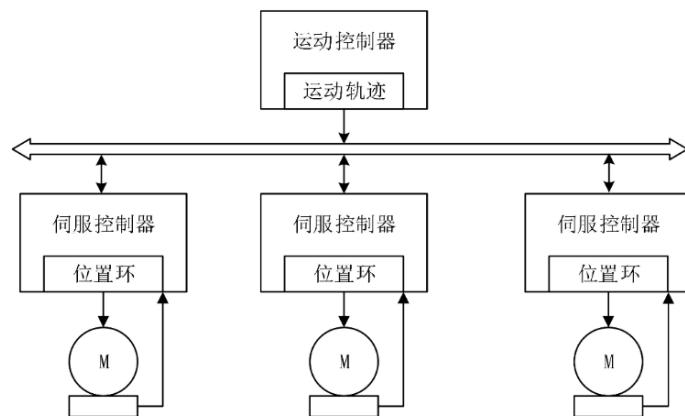


Fig. 1-4 Distributed structure diagram

Figure 1-4 for the distributed structure diagram, system of position loop and speed loop control are implemented in the servo controller, distributed motion control system suitable for moving axis has a wide distribution, high number of occasions, decentralized control, centralized management of multiple motion unit, scattered in various servo motion control algorithm from the station, so the

system of the low required communication .

At present, the movement control network based on EtherCAT is a hot spot, but the network needs the support of real-time operating system, and at present mature real-time operating system is controlled by a few foreign manufacturers. In order to meet the rapidly changing market demand, the motion control system is developing towards the direction of strong operability, low cost, high stability and good compatibility. At present, the theory of networked motion control system has been put forward and gradually perfected. In the networked motion control system, real-time information transmission between the motion controller and the servo slave station is realized through the network bus. Compared with the traditional point-to-point communication, the networked motion control system has more information transmission, higher stability and more reasonable layout. The addition of control network between the servo slave station and the motion controller can guarantee the information interaction between them with high frequency, low delay and low jitter, greatly improving the control accuracy of the motion control system. And will appear in the process of implementing serial control network bandwidth limitations and asynchronous, designer is difficult to found in the traditional motion control system is a powerful theoretical basis, this is a difficult problem in front of you, so you need a different approach, combined with computer technology, automatic control technology, communication technology for multidisciplinary research, theory related to provide theoretical support for the development of high performance network control system .

REFERENCES

- [1] Qi J, Wang L. Networked motion control system design based on EtherCAT[C]. 2009 Second International Conference on Intelligent Computation Technology and Automation, Changsha, Hunan, China: 2009(4):77-79.
- [2]Jung Uk Cho, Quy Ngoc Le, Jae Wook Jeon. An FPGA-Based Multiple-Axis Motion Control Chip[J]. IEEE Transactions on Industiral Electronics. 2009, 3(56): 856-870.
- [3]LinGuo , WenjieLiu, YuehuiLi,LingSun. Implementation of Reusable SPI Bus Based on FPGA[J]. China Integrated PowerRoad, 2012, 21 (04): 34-37.
- [4]BaorenWang . Research on key technologies of multi-axis coordination for networked motion control systems [D]. Jinan: Shandong University, 2008.
- [5]JianLu.Research and Implementation of Serial Bus Based on FPGA [D]. Nanjing: Nanjing University of Aeronautics and Astronautics, 2013.