Research on Embedded Network Numerical Control Technology and System

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Abstract. With the rapid development of the economy and the continuous improvement of the level of science and technology, China's digital control technology has made a great degree of progress, making important contributions to the development of China's national economy and the improvement of industrial level. As far as the development of digital control technology is concerned, it has gone through several stages, mainly including discrete component system phase, dedicated computer system phase and general computer system phase. As far as the general computer system is widely used, it has a certain degree of drawbacks, mainly because the system resources and requirements do not match, and the operating system is difficult to adapt to real-time control. In view of this situation, this paper proposes an embedded network digital control technology, and researches and analyzes it.

Introduction

The development phase of CNC technology is from the original discrete component system to the dedicated computer system to the current general computer system.[1] In the discrete component system, the numerical control operation is realized by a combination of many logic circuits, and the numerical control functions of such systems are all completed by the hardware system. The special computer system is the result of the emergence of microprocessor technology, but it is designed for numerical control. [2] Only a few large enterprises in the world can develop a special computer numerical control system. The general-purpose computer system, which is still widely used until now, has strong advantages in all aspects, but it does not meet the needs of real-time control.[3-5]

With the rapid development of information network technology, CNC technology has gradually become networked. An embedded system is a "special computer system designed to be built into a controlled device and designed for a specific application." The central processing unit of an embedded system can be divided into a micro controller, a digital signal processor, and a microprocessor. [6] The central processing unit is fast and simple, which increases the computing power of the embedded system. Embedded systems tend to be networked, and development tools are gradually getting better. Because embedded has many advantages, it is widely used in real-time state monitoring, digital manufacturing and other process areas.

Digital Control Related Research

The development of Numeric control (NC) technology has so far experienced stages such as discrete component systems, dedicated computer systems, and general purpose computer systems. In the initial discrete component system phase, CNC operations were performed by a combination of various logic circuits, all of which were performed by hardware systems. With the rapid development of computer technology, especially microprocessor technology, a numerical control system based on micro or small computer has appeared. This numerical control system is also called Computer Digital Control (CNC). At this time, the numerical control system adopts The computer platform was designed for CNC and was widely used in the 1960s and 1980s, but at the time there were only a few companies with strong technical and financial resources (such as Siemens in Germany, GE in the US, FANUC in Japan). Only have the ability to develop such a dedicated

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computer numerical control system.

Since the 1980s, 16-bit, 32-bit microprocessors have grown rapidly. General-purpose PCs have developed rapidly in terms of computing power, processing speed, human-computer interaction, and development environment. Therefore, many companies and research institutes have begun to adopt CNC technology and systems based on (industrial) PCs.

At present, the open CNC technology based on general-purpose PC has been rapidly developed, and PC+NC (which can be divided into PC embedded NC, NC embedded PC, etc.) and PC full soft integrated NC system structure, but also It should be noted that there are still some unavoidable problems with this kind of general-purpose PC-based CNC technology and system. Since the PC was originally designed for data processing and file management, its structure is relatively complicated and costly. More importantly, since the hardware of the PC system is not designed for real-time control, it cannot meet the requirements of real-time control well. For example, the hardware functions of the CNC system are not available for existing modules, and hardware expansion is often required to meet real-time control. Need, at the same time, many functions provided by the PC are not needed in real-time control, and the operating system of the PC system is not designed for real-time control.

With the development of network technology, the networking of numerical control technology has become the development direction of digital manufacturing technology. At present, many calculation and processing functions of the CNC system itself, in addition to real-time control functions, will be completed by remote control in the future. That is to say, with the network development of numerical control technology, the numerical control system of manufacturing equipment in the field is in the entire network manufacturing environment. Under this trend, CNC technology and systems must adapt to the needs of future network technologies and digital manufacturing development. Compared with industrial general-purpose PCs, embedded systems have their unique advantages in adapting to network.

Another unavoidable problem with the industrial PC-based CNC technology platform is that the core hardware and software of the system does not have independent intellectual property rights. At present, the most widely used operating system for industrial control machines is Windows and its hardware and software modules are not developed independently, while embedded technology can be developed by hardware and software, and the operating system and system modules are tailored to form an embedded system with independent intellectual property rights. New network CNC system. An embedded system is a "special computer system embedded in a controlled object or host system." With the development of computer technology, 32-bit or even 64-bit embedded CPU chips have emerged, such as MIPS64 from MIPS Corporation of the United States. The central processing unit used in the embedded system can be roughly classified into a micro processor unit (MPU), a micro control unit (MCU), and a digital signal processing (DSP) according to its design purpose. . The central processing unit for the embedded system has the characteristics of simple instruction and fast instruction execution, and hardware floating-point operation instructions to realize hardware single and double-precision floating-point operations, thereby greatly enhancing the computing power of the embedded system.

At present, some embedded processing chips integrate multiple processors (such as MCU and DSP) into one chip to form a dedicated processing chip for specific applications. This chip not only greatly enhances the capabilities of embedded systems, but also simplifies system development. An embedded processor chip provides almost all the hardware functions required by the real-time control system, enabling the basic functions of the entire control system, the so-called System on Chip (SoC).

Another important trend in the development of embedded systems is networking, which connects embedded systems into field networks or access to corporate networks, and even the Internet, through serial communications, bus technology and Ethernet. In the embedded hardware and software development environment, development tools are becoming more and more abundant. For example, the Joint Test Action Group (JTAG) test tool makes hardware debugging and testing very easy. In terms of software, for embedded systems, many real-time operating systems (RTOS) and

corresponding software development environments for real-time control have been developed. In short, embedded technology has obvious features such as good application, strong adaptability, sufficient resource utilization, compact system, and convenient development and debugging.

Because of the above characteristics of embedded technology, embedded technology has been highly valued by people, and it has been widely used in industrial fields such as electromechanical control, digital manufacturing, detection and sensing, real-time condition monitoring and fault diagnosis, and becoming one of the future development directions of digital manufacturing.

The Characteristics of the Embedded System Model

An embedded system can be called a dedicated electronic system contained within a complex non-electronic system, and this is also the meaning of the embedded system model. Non-electronic systems can be intended to be external to embedded systems, also known as embedded systems. Within a large system, there are generally many embedded systems. The embedded system can make a communication connection with the outside world. The embedded system can serve to be embedded in the system, and of course it is also responsive to external input, and can be considered as the response of the embedded system data itself.

CPU units within an embedded system are mostly calculated with reduced instructions. Compared to microprocessors and dedicated chip methods, there is a need for a new method and technology route that allows microprocessors to be more programmable and flexible, as well as more reliable and faster performance of dedicated chips. The software controls the reconfigurable functionality of the embedded system. Refactoring the computing platform by using reusable resources can be applied to different application needs. The main meaning of reconfigurability is reusable resources. When the FPGA does not appear, the reconfigurable system basically uses the reorganization method, and the functional components reuse resources. After the emergence of FPG A, reuse the resource utilization profile method to define the nature of each type of wire connection and door, and change the original function of the hardware. Broadly speaking, such features have hardware and software reconfigurability. It is precisely because the embedded system can tailor hardware and software, with reconfigurable functions, can realize the design of network numerical control technology and system, and bring reuse and open performance to the network numerical control system.

The Embedded Network CNC Hardware Architecture

The display and input device realizes on-site human-computer interaction, input of operation commands, manual pulse input, display of processing status and the like.

The embedded numerical control unit is the central control unit of the numerical control system, and performs the following functions: display and input device are connected to complete human-computer interaction; editing or acquisition of processing code; compiling; interpolation, tool compensation and gap compensation; position feed control And M, S, T and other instructions are executed; the logic control command is sent to the PLC through the asynchronous serial bus (using the MOD BUS protocol); it is responsible for monitoring the system (such as monitoring PLC and servo control system); through Ethernet and external network Connection, network development, debugging, operation, management, monitoring and diagnosis of the entire CNC system.

The embedded PLC completes the various logic control of the CNC system and has the function of a general-purpose PLC. The module is connected to the central control unit via an asynchronous serial bus, accepts control commands via the MODBUS protocol, and reports status information via an asynchronous serial bus. The embedded PLC can be composed of multiple independent PLC modules, or it can be composed of one PLC main module plus several expansion modules.

The embedded servo control module accepts the axis feed commands of the control system through the high-speed field bus (CAN bus) or through the feed pulse and direction control signals, and controls the machining position by controlling the servo motor. Embedded servo control

modules typically include position loop and speed loop control. An embedded servo control module can control one or more axes. An embedded networked CNC system can have one or more identical or different embedded servo control modules, and each embedded servo control module is connected to a high speed fieldbus.

High-speed fieldbus is mainly used to transmit real-time data and commands, such as servo feed, and also to transfer position and status information to the CNC unit. The high speed field bus can use a CAN (Controller area network) bus. The asynchronous serial bus is mainly used for command and data transfer between the numerical control unit and the PLC module and between the PLC modules. The bus data exchange uses the MOD BUS protocol.

Ethernet is used to connect to the workshop network, enterprise network or even the Internet. Through the Ethernet interface, it is possible to transfer the machining program, remote operation, status monitoring and fault diagnosis. The biggest feature of the embedded new network CNC system is that the central digital control unit is no longer a general-purpose computer system, but an embedded computer system with strong computing power, flexible structure and low cost. Other units of the embedded numerical control system, such as servo control unit, PLC unit, display unit, etc., may also be embedded systems of different structures and different levels. The system consists of a series of configured embedded control units or modules that are designed for general purpose rather than for specific objects and environments, such as embedded central digital control units, embedded servo control units (or Embedded motion control system), embedded PLC unit, embedded display keying unit, etc. (or human/computer interaction unit). By selecting the appropriate unit or module, a CNC system for a specific object and environment can be formed, just as I/O modules with different PLCs can be easily combined into control systems for different control objects and environments.

Conclusion

Because the embedded new network CNC system has the characteristics of strong function, high performance and flexible system, it can adapt to the requirements of different control objects. Therefore, this system can not only realize all the functions of the CNC system based on the general industrial PC, but also has better cost performance and more powerful functions. It is certain that this new network CNC technology and system based on embedded technology will be a new direction for the development of CNC technology and systems in the future.

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