Design and Research of Reconfigurable CNC System

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Abstract: In the field of modern manufacturing, the extensive application of CNC system has greatly promoted the progress of manufacturing technology. With the continuous improvement of market demand and the development of related support technologies, CNC system is experiencing a technological change characterized by the combination of openness and function, which will inevitably lead to the changeable development of system architecture and control strategy. This article based on ARM + FPGA design reconfigurable CNC system with integrated openness, improve the intelligent equipment manufacturing industry, can be applied to a variety of industrial areas.

1 INTRODUCTION

China's economy is in the process of transformation and upgrading. Equipment manufacturing industry is a pillar industry of the national economy. Its level of development determines the industrial height of a country. In the field of modern industry, CNC technology and CNC equipment are the core components in the equipment manufacturing industry. The CNC system is the key link. It combines a variety of technologies such as computer technology, network technology, automatic control technology and information processing technology to promote Manufacturing to achieve high precision and efficient processing operations. The traditional CNC system belongs to a closed dedicated system. Nowadays, with the development of the equipment manufacturing industry toward an open generic type, it is necessary for us to propose a reconfigurable CNC system to match different industrial manufacturing needs (Wang Tianmiao, 2006).

2 CNC SYSTEM OVERVIEW

CNC system is the core control part of CNC equipment. With the improvement of user's requirements on accuracy and efficiency of CNC system, we must constantly improve the software system, hardware system and communication system of CNC system to meet the needs of customers. The processing accuracy and speed requirements increase, CNC system control algorithm also will be complicated, which requires CNC system hardware and software platforms and communication systems must improve performance, improve the system of real-time, accuracy, safety, Great. At the same time, out of the perspective of national security, CNC hardware and software platform must be gradually achieved localization (WANG Rong, 2009; QIU Ruu-sheu, 2006).

Based on the requirement of openness and integration of CNC system, a new reconfigurable CNC system is proposed and a modular reconfigurable CNC system based on embedded system platform is designed. The embedded CNC system uses embedded Hardware and open source operating system, the system has the advantages of low cost, easy development, compact structure, and high reliability. In the process of using the system can be static or dynamic reconfiguration, the use of software multiplexing technology, without the need to re-design the hardware to shorten the enterprise secondary development time and provide production efficiency.

3 SYSTEM DESIGN

The reconfigurable CNC system designed in this paper uses ARM + FPGA as the control hardware platform, transplants the open source real-time operating system μC / OS_Ⅱ, builds a stable software platform for the whole system, develops

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the application software required by the CNC system, designs the motion control Algorithm, FPGA-based genetic algorithm to improve the PID module, design a real-time, high reliability reconfigurable embedded CNC system.

3.1 Hardware System Design

Build high-performance embedded hardware development platform with ARM + FPGA as the core; the designed CNC system adopts high performance and low power 32-bit embedded ARM processor and high-speed large-capacity FPGA as hardware core (Cai ruilong, 2016; YUE Feng, 2016); ARM is a high performance, Low-power microprocessors. With small size, low power consumption, low cost, high performance; using ARM (LPC2214) development of embedded CNC system can reduce hardware costs and improve system integration and enhance stability. FPGA selection EP2C5T144C8, can be flexible to achieve control functions, when you need to modify the FPGA function, just overwrite the EPROM can be. In this way, use the same piece of FPGA with different programming data, can produce different circuit functions. Therefore, the use of FPGA is very flexible, using FPGA can achieve I / 0 processing, counting, pulse generation, logic operations and other functions, can greatly simplify the design of embedded systems. The biggest advantage of an FPGA is the online configurability of its internal logic. Based on this, choose to use ARM + FPGA as the control core to build embedded reconfigurable CNC system hardware development platform; design system is small, high performance, low power consumption, high reliability (LI Ming-Shi, 2017).

Reasonable selection and design of peripheral circuits of ARM and FPGA. Different control modules of different types adopt the same software design framework to realize the technical realization of specific control modules, so as to reduce the development and maintenance costs and make the system easy to expand and redevelop. ARM is connected to the FPGA through the bus to control the dynamic reconfiguration process of the FPGA, which can speed up the rebuild speed and avoid over reliance on the CPU in the refactoring process and affect the execution of other tasks. The FPGA chip is connected to the backplane via 32 general-purpose IO lines, allowing management of different peripherals. System design in figure 1:

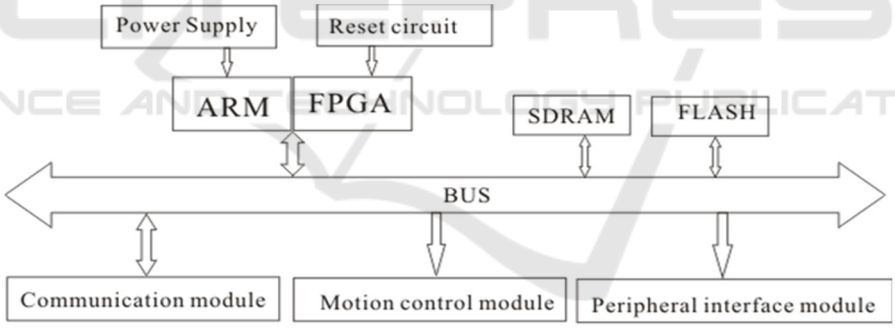

Figure1.Hardware system diagram

3.2 Software System Design

System software using a practical compact embedded real-time operating system μC / OS_II, to provide a guarantee for real-time system. The μC / OS_II is ported to ARM, ARM processor can fully combine the advantages of both, and can further simplify the development of the ARM system. Software design on the ARM subsystem includes the porting of operating system、embedded GUI、 TCP / IP, FPGA configuration programming and application programming. Software design in figure 2:

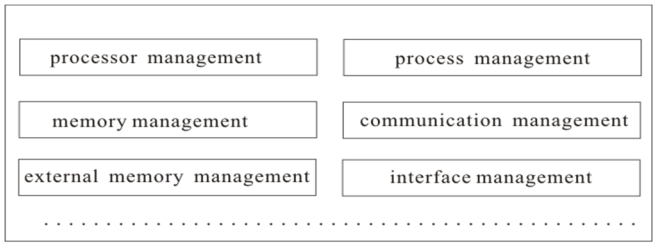

Figure 2. Software Functional Framework

3.3 System Analysis

Reconfigurable features make the system hardware and CNC functions linked through the core part of the CNC system according to the function of the module division, and then use the software method for logic description, by the function, timing, circuit testing, module packaging, made of Dedicated CNC IP, using FPGA software to harden the technology, quickly and effectively respond to new processing needs or develop new CNC system, FPGA motion control module integrated intelligent control algorithm, the use of neural network curve interpolation, genetic algorithm-based improvement PID control, design a more general control platform.

4 EXPERIMENTS AND ANALYSIS

In order to verify the basic functions of the numerical control system developed in this paper, the following is designed:

1 Single-axis motion commands to verify each axis forward reversal movement, and verify the boot stop and limit switches and alarm devices work.

2 Multi-axis motion commands to verify xyz three axes linkage is normal.

3 Design straight line and arc machining path, verify the linear and circular interpolation algorithm.

4 Add tool compensation in the code to verify the tool compensation function.

During the experiment, the cutter runs smoothly, and the experiment proves that the basic function of the reconfigurable CNC system developed in this paper is complete and has certain practical value.

5 CONCLUSIONS

The use of embedded hardware and open source operating system development of independent intellectual property rights of CNC system with low price, high reliability, compact structure, and easy development, to improve the competitiveness of China's CNC products of great significance; product development process, No need to re-design the hardware and debugging, combined with software reuse technology, shorten the development cycle, rapid response to the market, access to competitive advantage in the development of the main control system can continue to update the existing technology and integration of new technologies; can be static or dynamic Structure to meet the needs of different control functions, to provide the underlying support for reconfigurable manufacturing system.

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