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Research on ARM Numerical Control System

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Abstract

Computerized Numerical Control (CNC) machine tools is the foundation of modern manufacturing systems, whose advanced digital technology is the key to solve the problem of sustainable development of machine tool manufacturing industry. The paper is to design CNC system embedded on ARM and indicates the hardware design and the software systems supported. On the hardware side: the driving chip of the motor control unit, as the core of components, is MCX314AL of DSP motion control which is developed by NOVA Electronics Co., Ltd. of Japan. It make convenient to control machine because of its excellent performance, simple interface, easy programming. On the Software side, the uC/OS-2 is selected as the embedded operating system of the open source, which makes a detailed breakdown of the modules of the CNC system. Those priorities are designed according to their actual requirements. The ways of communication between the module and the interrupt response are so different that it guarantees real-time property and reliability of the numerical control system. Therefore, it not only meets the requirements of the current social precision machining, but has good man-machine interface and network support to facilitate a variety of craftsmen use.

Keywords:ARM;Computerized Numerical Control system (CNC system); UC/OS-2

1. Introduction

With the rapid development of network technology, the network technology and industrial control technology is increasingly closely linked. The combination of the embedded technology and internet technology has been driving the rapid development of embedded systems, which is due to become the world's most popular technologies. NC system is the core of modern manufacturing technology, marking the level of a country's manufacturing development. Compared with the numerical control technology developed in Europe, the United States, Japan China has been lagged behind although it is considered as a big manufacturing country. It poses a challenge for us. NC based on PC machine without restrictions of hardware and software has brought new opportunities for the development of NC system in China.

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Currently, the application of embedded system has become the trend in all businesses, while providing opportunities for the development of small and medium sized CNC systems.

This paper is to study the machine tool control system based on ARM-core embedded numerical control system, which has a powerful microprocessor to meet the needs of high speed computing during the high-speed motion control. Movement control section should perform so well that linear interpolation and circular interpolation are more accurate which guarantees the real-time processing under the abnormal situations. Because key part of the system is the motion control, MCX314 chip specialized for DSP Motion Control is responsible for motion control in order to improve system performance and reduce development cycle. Meanwhile, STR71O as the embedded ARM microprocessor charges for management and scheduling .

2. The Overall Design Of An Embedded Numerical Control System

The overall structure model of CNC system, shown in Figure 1, is composed of the hardware, OS and software. Hardware includes the ARM microprocessor and motion control chips, while ARM microprocessor as the heart of this system manages the scheduling and the motion control chip is used to complete the complex motion control to guarantee better system performance owing to greatly reducing the of work and time of developing.

The operating system of the embedded CNC system uses uC/OS-2, uC/0S-2 of open source embedded operating system. That is a multitasking kernel operating system whose deprivation of real-time can reduce the needs as required. uC/OS-2 facilitates embedded numerical control system to control the software more simple and convenient. Meanwhile the system with multi-tasking ability and a good real-time realize. Operating system includes memory management, task management, equipment management, motion control chip interfaces, communication interfaces and so on.

At the top is the software matched with the numerical control system, including a variety of motion control specific functions.

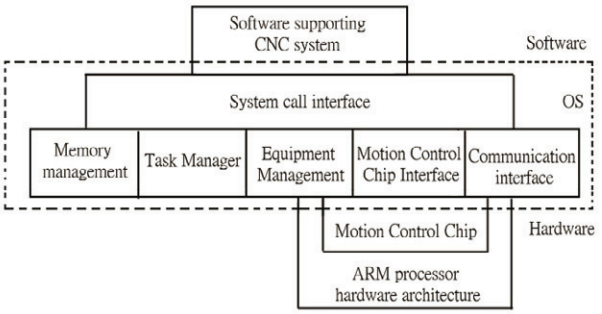

Figure 1. The overall structure model of CNC system

3. The Overall Structure Design Of The Hardware Of CNC System

The ARM processor, as the core of control circuit, is composed of 6 parts, which are the power supply circuits, communication circuits, LCD circuits, the keyboard circuit, spindle control circuit, and motion control interface circuit chip. ARM microprocessor is used which is the IP core of ARM intellectual property. For motion control chips, MCX314AL is used, which is particularly for DSP motion control developed by NOVA Electronics Co., Ltd. of Japan. It can make order, read and send motion parameters to monitor the motion. In this structural system, microprocessor completes the numerical control and monitor, such as processing input of machine tools. data preprocessing, processed by interaction, data input and output ,fault diagnoses and so on . MCX314 as the motion control chip is directed by ARM

processor who commands controls and real-time monitors its data and status register. The block diagram of the overall structure of hardware is shown in Figure 2.

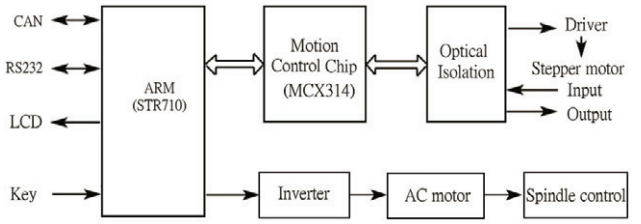

Figure 2. The block diagram of the overall structure of hardware

3.1 Interface Design of STR71O and MCX314AL

The data exchange between STR710 of ARM microprocessor and MCX314AL chip is by means of 2 ways. One the one side, the first 8 digitals at the beginning of WR of the internal of MCX314AL can be written into the register. On the other, the first 8 digitals at the beginning of RR can be read-only into the register, which register with the same figure is the same mapping address.

STR710 have a non-multiplexed 16-bit data bus and 24-bit address bus that can support four 16M of external memory segment. Specific design will be in MAX314 16 data lines and the STR710 corresponding phase. It has to connect the 16-bit bus mode of MCX314AL with the address lines of A0, A1, A2 to respectively address lines A0, A1, A2 of STR710. Worth mentioning is to set H16L8 pin high, connect RESTN pin to the system reset, connect STR710 literacy wire with RDN and WRN of MCX314AL , whose specific circuit connection diagram is shown in Figure 3:

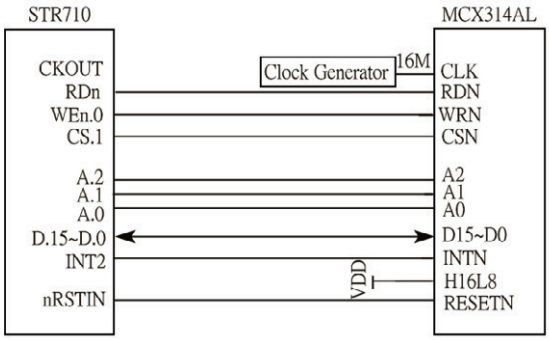

Figure 3. The connection diagram ofSTR71O and MCX314AL

3.2 The control system of stepper motor

Stepper motor is to transfer an electrical pulse into the angular displacement. The rotation of the angular displacement is proportional to the number of input pulse, while the frequency of input is proportional to the speed of the rotation. As an internal performer inside the numerical control system, stepper motor is with a simple structure, easy control, high reliability and low cost. So it has been wildly applied in a variety of automatic control systems. In this system, motion control chips MCX314AL will command a digital pulse signal sent to, and then drive motor rotation according to instructions accordingly after motor drivers converse the power conversion.

The stepping driving system made of the stepper motor has the following advantages:

- Stepper motor is a discrete movement actuator and easier to be connected with other digital devices owing to its internal link with the modern digital control technology;
- There is no position error accumulation for the stepper motor;
- Stepper motor position is so stable that it can be controlled open-loop mode without position feedback;

Open-loop control system structure of stepper motor is shown in Figure 4, mainly including stepping motor controller, stepper motor driver and stepper motor.

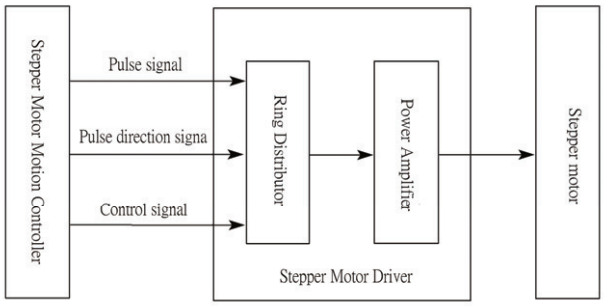

Figure 4. Open-loop control system structure of stepper motor

4. The overall design of the software

In many cases, CNC marks the task through an infinite loop and activate this mission by interruption. In this case, it would not occupy most of the time for waiting for the tasks in the process of the infinite loop, but other tasks with the same priority are not allowed to use the MCU's resources during implementing a certain task. It doubtlessly leads to low efficiency of the system. Specifically, when it occur signals of delay or wait encountered in the process, the signal to wait, that will take up so much time and resources, that more urgent tasks are received response.

Based on the above, the embedded real-time multi-task is used as the operating system. Compared with others software design, this operating system is so different that the multiple independent tasks complete its function where the operating system director the communication and switching between tasks. UC/OS-2 is a simple embedded operating system. The driver is ordered to control the peripheral hardware due to peripheral device driver without a unified interface for the program.

On the position of power or reset, the system will start from the initial code space address ox0000, namely the Main () function. Program first initializes the hardware and software for ARM systems, including the initialization of the operating system, hardware interrupts, timers, network initialization. After wards, Main () function will create the following several tasks:

- Taskstart is a first task after running the system and notably completes initialization and the creation of other tasks. It is deleted immediately after the completion of all work.
- TaskMainMenu is the main task where the system interface display, parameter setting and testing are all completed. It will be suspended on the task of motion control.
- TaskControl is the motion control task who responses for movement in order to send, the control and parameter modification of I / O interface operation and so on.
- TaskErrorControl: the exceptional processing tasks**,** responsible for unexpected movement
- TaskstatusControl: state of motion tasks, responsible for to read and display the motion parameters.
- TaskKeyInt: key processing tasks, responsible for receiving keyboard input

- TaskNetHandle: network tasks, responsible for network packet processing.
- Taskstatus: system state mandate, responsible for displaying system status such as CPU utilization.

Taskstart initializes the system and is deleted after completes the task of creating other 7 tasks. The system is ready to run after Taskstatus and TaskMainMenu ,as two inferior tasks, complete interface display, call the task of the CPU utilization and cycle wait. When the host computer sending intermediate code through the network, system calls TaskNetHandle tasks, accepts the middle of the code and stores in a memory block. On the completion of the intermediate code transmission, it calls OSSemPost (SemON) function and sends signal of SemoN. TaskControl waiting for the semaphore task receives semaphore at this time and resumes operation after the program of interrupt service to exits. TaskControl test data stored on the memory block and compile their conversion to intermediate code if it were the processing code. Then the intermediate code called by function is sent movement order, movement parameters through the bus to motion control chip. On receiving the order, motion control chip begins to control the stepper motor, including linear motion, circular motion and interpolation exercise.

The task of TaskstatusControl is responsible to read the motion parameters and display their status from the motion control chips, and other I / O port in the motion control. During this process, Because CNC system has dozens of abnormal condition or operating results through the OR or logic, motion control chip will generate an interrupt signal to the ARM , where causing disruption and calling TaskERRorControl to handle the exceptional tasks. TaskErrorControl calls TaskstatusControl to read the motion parameters to determine the reasons for interruption, and calls the appropriate exception program to handle. Completing them, TaskControl task comes into the state of wait for SemON semaphore

5. Conclustion

Thesis makes an overall analyses of CNC system on the embedded ARM-based. But it needs further study and improve owing to limited due to time and effort.

CNC system is composed of a number of advanced comprehensive technologies. The emergence of 32-bit micro-controller provides the opportunities for the embedded CNC system to be good reliability, real-time and low cost. In the structure, CNC system trends toward an integrated, modular, network and general-purpose open-loop control mode. In short, the use of embedded micro-controller, will become the trend of CNC system development and design and has a broad prospect and considerable benefits.

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