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Control System Design of Threshing Separator Based on ARM

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Abstract

In order to realize the safe operation of the amphibious multifunctional threshing separator, designing the control system based on the ARM embedded processor, the system through the CAN industrial field bus, connected with the temperature sensor, the infrared sensor, the stroke sensor, the revolution speed sensor, control the automatic clutch and the brake system through the electric relay. When the equipment overheating, personnel illegal operation, speed anomalies, equipment location errors, etc., the system can be timely control of the device brake and shut-down, to avoid serious safety accidents.

Key words: Threshing separator; ARM; Control system; Equipment protection

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INTRODUCTION

In the west of China and Sichuan region, the landform is hilly terrain, plots and plots of land areas are less, big natural slope, not suitable for the use of large agricultural harvesting machinery. In Sichuan area analysis, and suitable for crops in hilly widely, suitable for the cultivation of all kinds of grain and economic crops, especially in rice planting area is the largest, but paddy muddy feet deep, not easy to harvest, high labor intensity, high cost of harvesting crops, it is an urgent need for a simple, portable, safe and effective small harvesting machinery (Li, Ma, Jin, & Gao, 2015). According to the Sichuan area topographical features and crop characteristics, development of an amphibious multifunctional automatic threshing separator, by a small gasoline engine as power, innovative design of mechanical structure design, the centrifugal force generated by threshing to achieve grain weed separation, greatly improve work efficiency. In order to realize the safe operation of the device, based on ARM embedded computer system (Wang, Yu, & Wang, 2015), the design of the threshing separator control system, using the technology of computer sensing, to realize the monitoring of illegal operation, through the setting of a variety of sensors, to complete the system working status monitoring, by shut-down, brake, alarm and other protective devices, in case of emergency or abnormal system, the implementation of the protection of the operator, improve the safety of the device.

1. THE OVERALL STRUCTURE OF THE CONTROL SYSTEM

Figure 1 is the overall structural diagram of control system of amphibious multifunctional automatic threshing separator system by the ARM embedded processor, temperature sensor, infrared thermal release part of the sensor, speed sensor, travel switch, alarm, automatic clutch, a braking device, etc.. ARM embedded processor through reading the temperature sensor data, can realize the centrifuge bearing temperature, clutch temperature, power system temperature monitoring, judge system

working state; ARM embedded processor through reading the travel switch state, can determine the location of each component right or not; ARM embedded processor through reading the speed sensor data, can judge the speed of the system is normal or not, indirect judgment of the strength of the centrifugal force; ARM embedded processor through reading infrared pyroelectric sensor data, can determine whether the emergence of illegal operations, such as the hands or feet into the dangerous area, etc.. When the device is working abnormal, the system can be alarm by the alarm, in the case of danger, ARM embedded processor through the automatic clutch and brake control, automatic shutdown system, to avoid major accidents. Figure 2 is the photo of threshing separator and control system.

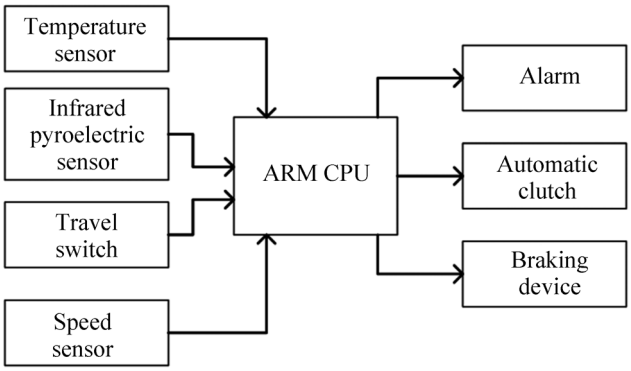

Figure 1
Overall Structural of Control System

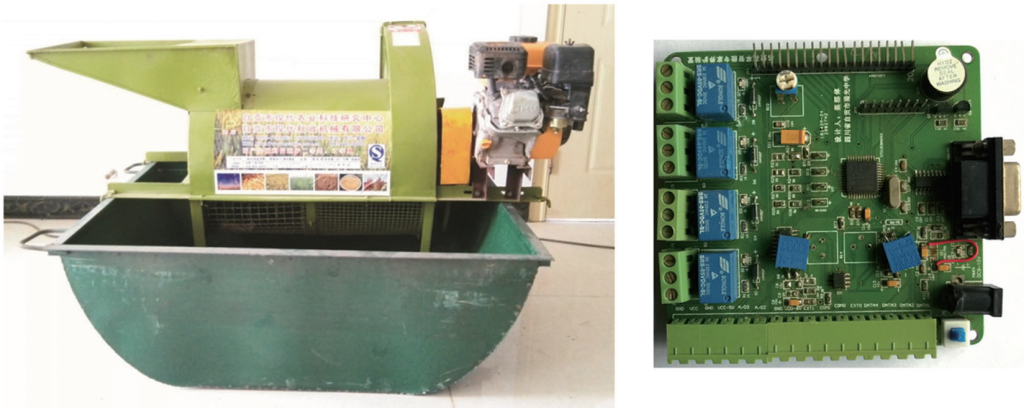

Figure 2
Photo of Threshing Separator and Control System

2. HARDWARE CIRCUIT

Threshing separator control system based on ARM embedded system design, the hardware circuit mainly consists of a CPU core circuit, CAN bus interface circuit, a relay control circuit and each sensor module, as described below.

2.1 CPU Core Circuit

Figure 3 for control system of the CPU core circuit, ARM embedded processor is based on Cortex™-M3 core 32-bit ARM processor, the operating frequency for 72MHz, work rate 1.25MIPS/MHz. Specific models is STM32-103VT, the chip is using the TQFP100 package, built in FLASH memory capacity of 512K, the built-in SRAM 64KB memory, with a standard JTAG/SWD debugging download port, chip working power 2.0-3.6V, with 3 low-power modes: sleep, stop, standby mode. Built in RTC and backup registers, can use battery supply power. The chip's built-in external devices include: 12 channel DMA controller. 3 pieces 12 bit us A/D converter (16 channel); 2 channel 12 bit D/A converter; up to 112 fast I/O port; 4 pieces 16 -bit hardware timer, can work in PWM or counter mode. 2 pieces 16 bit 6 channel timer: each channel can be used for PWM output. 2 watchdog timer. 2 IIC interfaces. 5 USART interfaces. 3 SPI interface, the maximum speed of 18 Mbit/S. CAN interface (2.0B). USB 2 full speed interfaces. SDIO interface.

2.2 CAN Bus Interface

Figure 4 for control system of CAN bus interface circuit, control system's various sensors, such as temperature sensor, infrared heat release sensor, travel switch, speed sensor with CAN bus and embedded ARM processor connected, CAN bus is a kind of excellent industrial field bus (Wang & Zhu, 2015) and has fast transmission speed, connecting multiple nodes, flexible network topology structure, the Distributed Multiprocessor Architectures, no conflict bus arbitration mechanism and reliable error detection and handling. The circuit is simple, cost low, etc. characteristic, in industrial equipment field are widely used. Threshing separator control system uses CAN bus as a means of transmission between each module and the processor, can effectively improve the reliability and stability of the system.

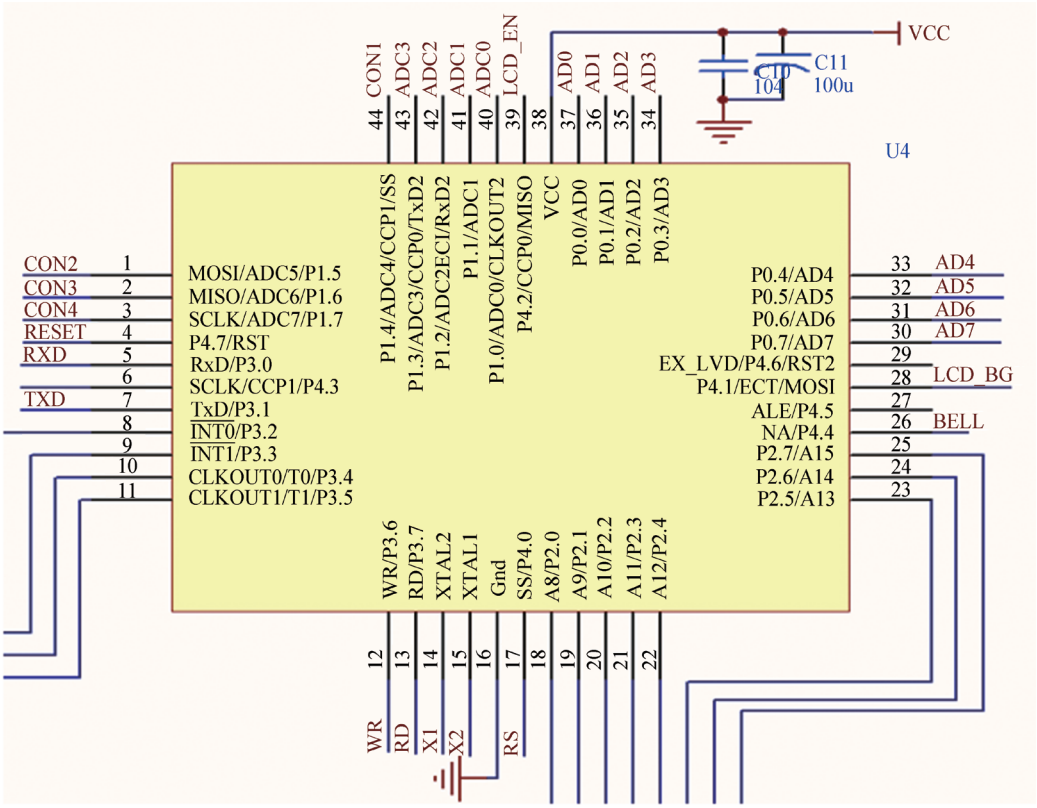

Figure 3
CPU Core Circuit Diagram

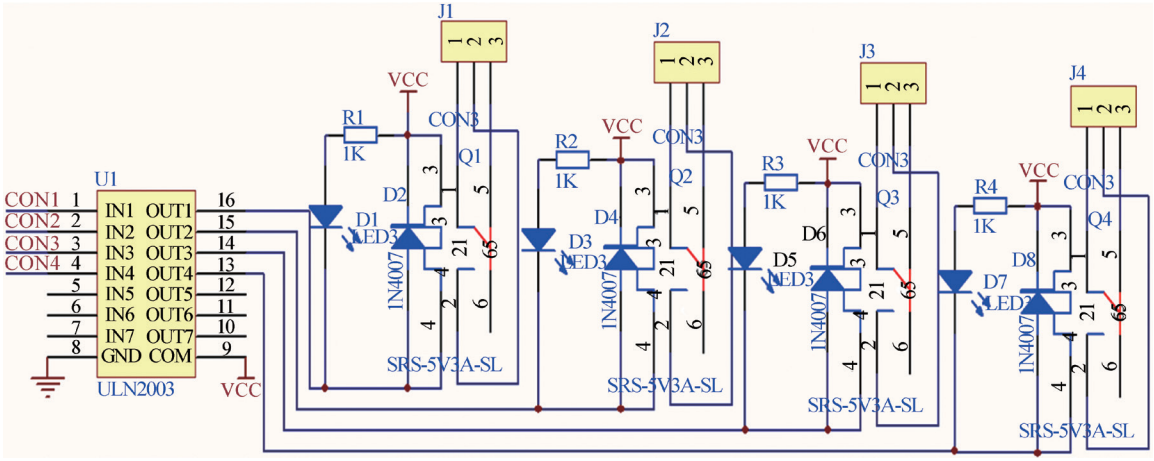

Figure 4
CAN Bus Interface Circuit

2.3 Relay Control Circuit

Figure 5 is the control system of relay control circuit, control system based on each sensor to collect the working state information of the device, by controlling the relay to control device of alarm, automatic clutch, braking device, etc., realize the security of threshing separator.

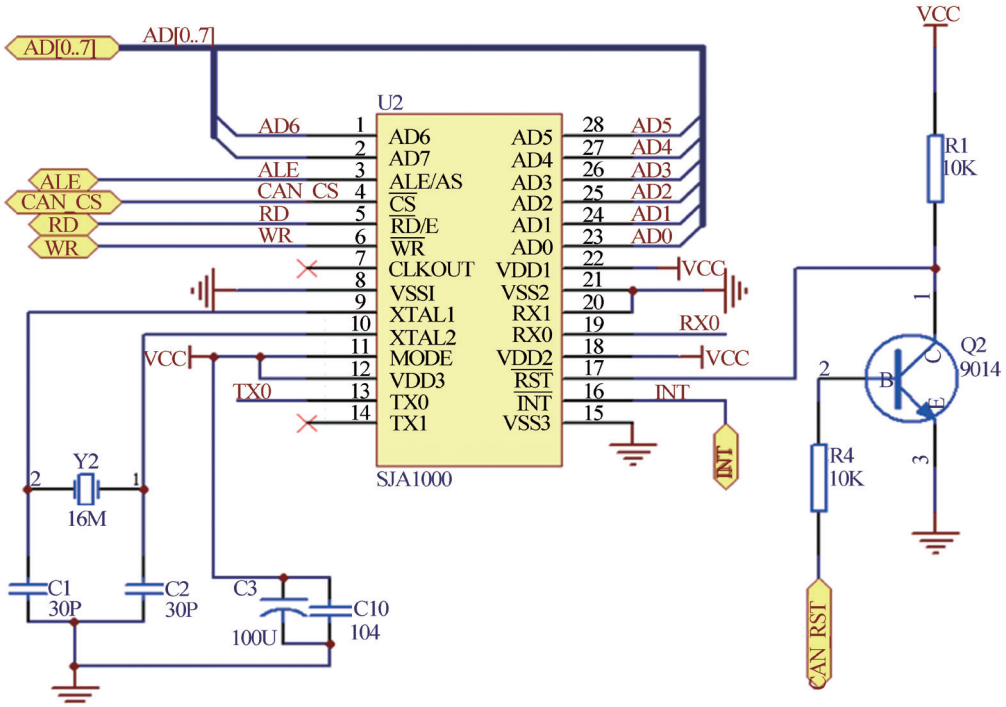

Figure 5
Relay Control Circuit

3. SOFTWARE SYSTEM

Threshing separator control system software, based on embedded real time operating system (RTOS) (Ju, 2012) design, for the multi task embedded software systems (Wang & Ju, 2008), in order to ensure the system real-time performance, usually using to the priority of task allocation and control system of division of tasks as shown in Figure 6.

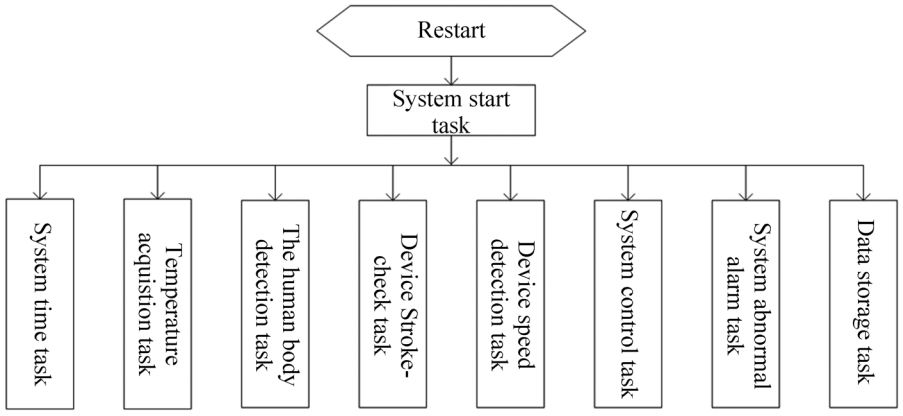

Figure 6
Control System Software Task Allocation

A) System start task: The implementation of the system initialization, initialization system interrupt, timer, CAN bus interface, serial interface, etc., to create the system for other tasks.

B) System time tasks: Statistical system working time, computing system CPU occupancy rate, the maintenance of the system clock.

C) Temperature acquisition task: Read the temperature sensor data through the CAN bus, get the working temperature of the equipment components, provide basic data for the device overheating inspection.

D) The human body sensors detection task: Read pyroelectric sensor data through the CAN bus, provide basic data for the device to protect the human body. To prevent the occurrence of illegal operations, such as hands or feet into the danger zone and so on.

E) Device stroke-check task: Read the travel switch data through the CAN bus, to determine whether the work position of each component is in place.

F) Equipment speed detection task: Read speed sensor data through the CAN bus, judge whether the operating speed of the system is normal, to judge the strength of the centrifugal force.

G) The system abnormal alarm task: When the equipment overheating, personnel irregularities, working parts are not in place, the speed of the abnormal situation, etc. carry out alarm.

H) Data storage tasks: The sensor data storage to the ARM embedded processor built-in FLASH memory for data analysis and use.

I) System control task: By controlling the relay to control the device alarm, automatic clutch, braking device, etc., to achieve the safety protection for the operator and threshing separator.

CONCLUSION

This paper detail analyzed a threshing separator's control system design based on ARM, the whole system use ARM embedded processor as the core, through the CAN bus and the sensor connection, obtain variety of data system through the relay control the external device, when the abnormal situation occurs, the rapid realization of equipment shut-down, emergency braking operation, on the one hand can protect the operator safety. On the other hand can safety protection equipment. This paper analyzes the overall structure of the control system and the main parts of the hardware circuit diagram, carefully analyzes the embedded software system of the task allocation and function. The design of the control system introduced in this paper is of practical value to the design and development of related equipment.

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