Application of the storage system on variable rate fertilizer applicator

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Abstract. The important problem of the research on the technology of fertilization is how to improve the utilization rate of fertilizer, and the variable rate fertilizer applicator will be the future development direction. This paper studies how to use SD card to store the data of variable rate fertilization applicator based on MCU, system hardware and software design solutions. Introduce the file system in SD card.

Introduction

In recent years, the consumption of chemical fertilizer and the yield of crops in our country are increasing year by year, but the input and output are not appropriate. This has caused serious environmental pollution problems because of the increase of fertilizer application rate and the decrease of utilization efficiency. Therefore, the reasonable application of fertilizer should be the core of the future Recommended Fertilization Technology. [1]

Variable fertilization technology is a kind of precision agriculture, it requires according to the differences in soil fertility and crop growth between small scale fields, with different fertilizers. So it can reduce the amount of fertilizer and increase the utilization rate of fertilizer. [2] The spectral analysis of the leaves or groups can effectively estimate the amount of fertilizer needed by the crop. The variable rate fertilizer applicator makes real time analysis of crop spectrum information returned by hyper spectral sensor through microcontroller. Use the stepping motor to adjust the size of the amount of fertilizer to achieve precise fertilization. The storage of fertilization information has become a major problem. In recent years, with the development of storage technology, many large capacity memory cards based on Flash storage technology have been developed. The SD card is widely used in a variety of digital products with its small size, low power consumption advantages. The SD card provides an ideal storage medium for the storage system of precision fertilizer application. In this study, the SD card controller designed was based on C51 MCU. The data were read and written by the serial peripheral protocol bus structure.

Design of hardware

Communication mode

SD card has two communication protocols: SD mode and SPI mode. The SD model uses four data lines parallel transmit data. It has high transmission rate, but the transmission protocol is complex, only a few MCU have this interface. There is only one data transmission line in SPI mode, and its data transmission rate is low, but a lot of MCU all support SPI bus. In addition, the transmission protocol of SPI bus mode is simple, and it is easy to simulate by software method. [3] This system is not strict to the speed of data reading and writing, we used SPI model was the best solution.

The interface circuit of the system adopted C51 MCU. In SPI mode, there had four main lines between the microcontroller and the SD card: master input/slave output data wire MISO, master output/slave input data wire MOSI, synchronous clock line SCK, slave selected wire CS. SD card provides 9Pin interface to facilitate the peripheral circuit for its operation. The Pin2 was used as the data output cable of SPI bus MOSI, the Pin7 was used as the data input cable of SPI bus MISO, the Pin5 was used as SCK, the Pin1 was used as CS. In addition to the power and ground wire, other pins have been floated. The hardware connection was shown in figure 1.
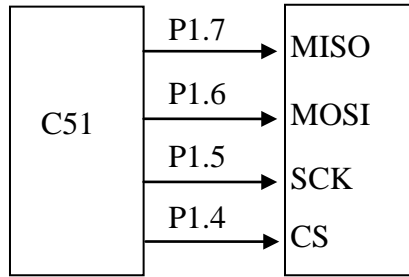
Fig.1 MCU and SD card connection diagram

Level matching

The logic level of SD card was equivalent to TTL 3.3V level, the logic level of C51 MCU was CMOS 5V level, and they can't be directly linked. We must solve the problem of compatibility of the interface level. We used SN74ALVC164245 level conversion chip which was a general level conversion scheme.

Design of software

Initialization of SD card

There had a process of power up initialization from SD card power up to the correct reading and writing. The flow chart was shown in figure 2.

When the SD card powered on, the host sent 74 clock cycles to the SD card, in order to complete the SD card powered on. Then SD card entered SD bus mode, and sent a reset command (CMD0) to the SD card. If the CS chip select signal at a low level state, while the SD card and enter the SPI bus mode, otherwise the SD card worked in the SD bus mode. When the SD card entered the SPI mode would sent a response signal. If the host read the answer signal was 01, which indicated that the SD card had entered the SPI mode. The host constantly sent command word (CMD1) to the SD card and read the SD card's response signal until the response signal was 00. Then the system could read and wrote SD card and other operations.

Read and write operation of SD card

Read and write operations SD card were completed by sending control commands. The SPI bus mode supported single block (CMD24) and multi block (CMD25) wrote operation. The multi block writes operation was start from the specified location to wrote, until the SD card received a stop command (CMD12) to stop writing. The length of a single block of write operation data block was only 512 bytes. First, the system sent the command word (CMD24) to the SD card, when received a response signal 00 then sent the data start flag 0xFE to the SD card. Then the system sent 512 bytes data, followed two bytes of CRC verification. When the SD card responded signal was E5h, it indicated that the SD card could receive the correct data. Then, the SD card's output port was changed to a low level. It indicates that the SD card was being written, when the output port was changed to high power usually indicated that the write operation was completed. The read operation of SD card was the same to the write operation.
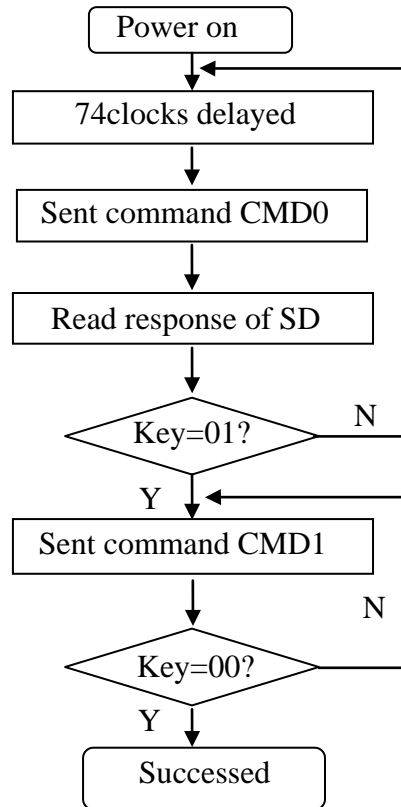
Power on

74clocks delayed

Sent command CMD0

Read response of SD

Key=01? N

Y

Sent command CMD1

N

Key=00?

Y

Successed

Fig.2 The power initialization of SD card flow sheet

The storage system of SD card

When the variable rate fertilizer applicator worked, it stored a lot of fertilizing information every day. In order to facilitate the computer to read the SD card data, we used the FAT16 file allocation table system to store the file. The partitions of the FAT16 have the following parts: The first was reservation which stored the important parameters of the file allocation table file system and the guide procedures; the second was the file allocation table, it was responsible for recorded the usage of the cluster; the third was root directory region, it was recorded the information of root directory region; the last was file and directory data region, it was the actual storage region of all kinds of file data. [4]

The reservation keeps the basic input and output system parameter distribution table, which was related to the file allocation table. It recorded the starting sector of each section of the file allocation table, as well as the number of occupied sectors, the root directory and cluster size, and other important information. The names of the files were recorded in the root directory, by located the existing file name in the root directory, the system could found the specified file for operation. The function of the file allocation table was to record the distribution of clusters on disk. A file usually needed to take up a lot of clusters. The file may not be stored completely in a continuous storage space, but was divided into several segments, such as chain storage. [5]In the file name record, the first record was the header cluster of file chain. And the cluster's file allocation table was stored in a chain of file allocation table value. If it was the end of the file, used a file end flag, it indicated the end of the chain. This showed how the file was stored on the disk in accordance with the chain.

The reading and writing of the data was based on the sector, and the number of sectors in a cluster was determined by the parameters of the basic input and output system. When the system was write operation, it should to create a new file allocation table area and root directory. Through the file allocation table to save the cluster number, complete the corresponding data read and write. When the operation of a cluster was completed, the system found the cluster number of the next cluster according to the chain structure of the file allocation table, and then operated the file until the end of the file.

Summary

We solved the problem of data storage of variable rate fertilizer applicator in this paper. The data can be real-time, accurate stored in the SD card, and can be read by the computer through the experiment proved. SD card will be the preferred storage media in the field of automatic control in the future.

References

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