A MEASURING INSTRUMENT FOR MULTIPOINT SOIL TEMPERATURE UNDERGROUND

Cheng Wang, Chunjiang Zhao*, Xiaojun Qiao, Zhilong Xu

National Engineering Research Center for Information Technology in Agriculture, Beijing, P. R. China, 100097

* *Corresponding author, Address: Shuguang Huayuan Middle Road 11#, Beijing, 100097, P. R. China, Tel:+86-10-51503411, Fax:+86-10-51503449, Email: zhaocj@nercita.org.cn*

Abstract: A new measuring instrument for 10 points soil temperatures in 0~50 centimeters depth underground was designed. System was based on Silicon Laboratories' MCU C8051F310, single chip digital temperature sensor DS18B20, and other peripheral circuits. It was simultaneously able to measure, memory and display, and also convey data to computer via a standard RS232 interface.

Keywords: Multi-point Soil Temperature; Portable; DS18B20; C8051F310

1. INTRODUCTION

The temperature of soil is a vital environmental factor, which directly influences the activity of microorganisms and the decomposition of organic substances. It can affect roots absorbing water and mineral elements. It also plays an important role in the growth rate and range of roots. Statistically, roots of most plants are within 50 centimeters underground, so it becomes very significant to measure the soil temperature of different depth in this level.

The Soil Temperature Measuring Instruments used nowadays mainly fall into three types, the first type is the measure temperature by making use of the relationship between the soil temperature and the temperature-sensitive resistor. Before using this sort of instruments, the system parameters need to

be adjusted; it is inconvenient to repair when the system runs into trouble. The second type is non-contact Soil Temperature Measuring Instrument which use infrared ray to measure temperature, this sort of instruments is quite expensive. The third type is instrument measure temperature by making use of digital thermometer, at the present time, this sort of instruments can only measure one point of soil temperature, and the data can not be stored or transmitted.

In all, the products mentioned above can hardly become popular for they are either costly too expensive or functionally too simple. So a new kind of cheaper and more advanced instrument is required to be invented.

2. MATIERIALS AND METHOD

This system applies the high quality Single Chip C8051F310 (Li Gang, et al. 2002; He Limin. 2000.) as the core controller, it mainly includes some functional blocks such as Data Collection Block, Display and Storage Block, Real Clock Block, Serial Communication Block, Keying Control Block and Power Source Block. Fig.1 shows what the system consists and how it functions.

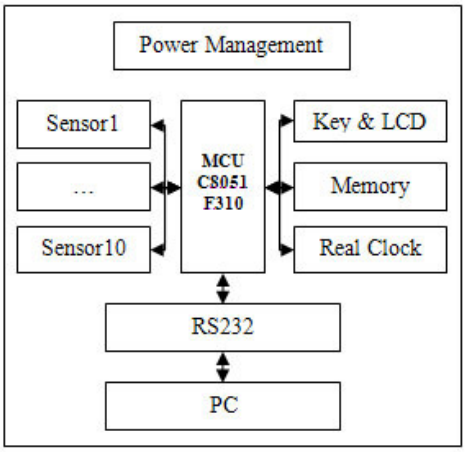

Fig.1 System Block Diagram

The system can measure soil temperature of ten points in different depth, it can display and store both the data of temperature and the time, at which the data is collected, after that, it can transmit the data to the computer through serial communication port. The user can set system parameter or operate the system by pressing keys. By experiment, this cost-effective and portable instrument works stably and operates well.

2.1 Hardware design

In the hardware design, the system utilizes parts including MCU C8051F310, Digital Thermometer DS18B20s, power charge Chip ISL6292, voltage management Chip NCP500 and real-clock Chip DS1302, combining with corresponding peripheral circuits, and these parts make the main structure of the system. Some of the main parts and its peripheral circuits will be introduced as follows.

2.1.1 High quality MCU C8051F310

C8051F310 device is fully integrated mixed-signal system-on-a-chip MCU, whose microcontroller is compatible with 8051 instruction set. C8051F310 mainly composes of microcontroller core CIP-51, analog peripherals, digital I/Os and the power unit. The CIP-51 core employs a pipelined architecture that greatly increases its instruction throughput, with a maximum system clock at 25MHZ, it has a peak throughout of 25MIPS. The CIP-51 core offers all the peripherals included with a standard 8052, which is familiar to Chinese technologists. The Digital Crossbar allows mapping of internal digital system resources to Port I/O pins; C8051F310 device includes a total of 29 I/O pins.

2.1.2 The DS18B20 digital thermometer

The DS18B20 Digital Thermometer (He Xicai. 2001; Chen Liangguang. 2001.) measures temperatures from -55°C to +125°C. DS18B20 includes three pins, respectively are data I/O Pin DQ, power supply Pin VDD and the GND Pin.Fig.2 shows the DS18B20 application chart.

Because each DS18B20 contains a unique silicon serial number, multiple DS18B20s can exist on the same 1-Wire bus. This allows for placing temperature sensors in many different places and provides convenience for the hardware design in this system.

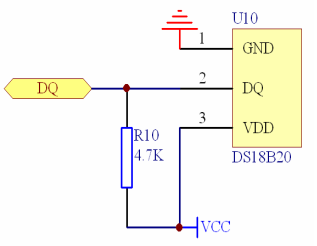

Fig. 2 Application Chart of DS18B20

This system utilizes ten DS18B20s to measure temperature of ten points soil in different depth within 50 centimeters. The first DS18B20 and the

second share a 1-Wire bus, the third and the fourth share one, the other six DS18B20s communicate through their own 1-Wire bus respectively. The system applies external power source, as there are too many DS18B20s. The data collected by DS18B20s is filtered by a 0.1uF capacitor, and then lead to the I/O port of MCU by interface circuits.

2.1.3 Power source and recharge circuits

The whole system is contained in a sealed box; it employs a rechargeable lithium battery so as not to open the box frequently.

The ISL6292 is an integrated single-cell Li-ion or Li- polymer Battery Charger, which is capable of operating with an input voltage as low as 2.4V. The ISL6292 can be used as a traditional linear charger.

For the output voltage of lithium battery ranges from 2.8V to 4.2V, and the system works at a constant voltage of 3V, so it utilizes a voltage variation chip NCP500 to supply the system with a stable voltage. Fig.3 shows the application chart of NCP500, the Pin VIN connects to the output of lithium battery; Pin AIN0 outputs to an analog pin of C8051F310, the digital value of lithium voltage can be acquired after a A/D conversion.

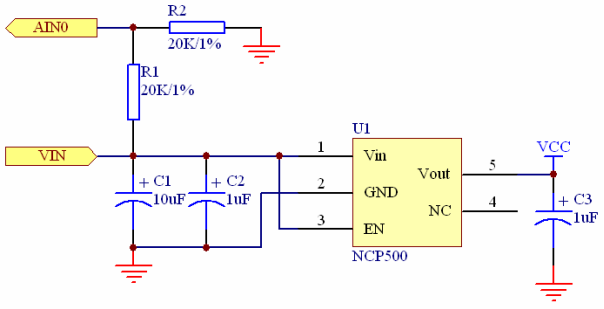

Fig.3 Application Chart of NCP500

2.2 Software design

The MCU program written in C Language was assembled and debugged in Keil C Assembler (Ma Zhongmei, et al. 1998.).

2.2.1 The main program

In order to realize its functions, the structure of the main program is designed as follow.

When the system is powered on, the system starts initialization, then the program runs into a circle, firstly it check the source voltage, secondly the MCU reads data from DS18B20s and real clock DS1302, thirdly the data is displayed and stored, after that, the main program check whether the

interruption flag is set or not, if it equals one, the program runs into the part of interruption program, if not, the main program runs into another circle.Fig.4 shows the flow chart of the main program.

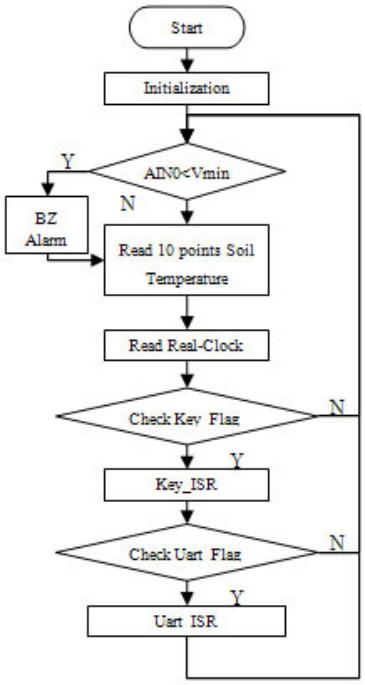

Fig.4 Flow Chart of Main Programme

2.2.2 The interruption sub-programs

The interruption sub-programs are at the end of the main program, when the main program discovers the interruption flag true, it will runs into the interruption sub-programs.

The Key-Interruption helps to set the system parameters by pressing keys on the box to intrigue the interruption program. The structure of Key-Interruption Sub-Program is somehow similar to the Serial Communication Interruption Sub-Program, so only the later is described in detail.

The instrument and the computer are connected via RS-232 Serial Communication Port. According to the communication protocol, every instrument is assigned a unique machine number. When the instrument receives instructions from the computer, the program first compare its own machine number with the machine number sampled from the instructions, if the machine number is matched, the instrument then respond to the instructions.Fig.5 shows the flow chart of Serial Communication Interruption Program.

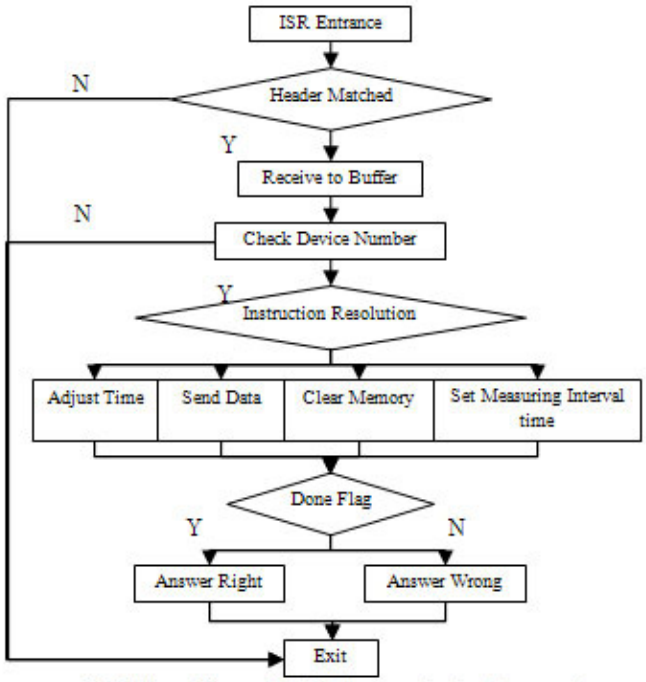

Fig.5 Flow Chart of Serial Communication Interruption

3. RESULTS AND DISCUSSION

Combining with functions such as display, storage and transmission, this system is mainly used in measuring soil temperature. User can connect this instrument to computer via RS-232 Serial Port, through which the data of temperature and time can be transmitted to the PC. It makes a lot of improvements as well as makes full use of the previous products. First, this instrument is capable of obtaining temperature of multipoint soil, so the temperature data is adequate. Second, this system employs rechargeable lithium battery, which largely prolongs the span of the instrument. Furthermore, in the process of hardware and software design, low power consumption was always taken into consideration. In a word, this instrument is cost-effective, portable and precise.

ACKNOWLEDGMENTS

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