A Novel Design of Energy-saving Wireless Intelligent Agricultural Detecting System

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Abstract—**In order to meet the needs of modern intelligent agricultural detection, this paper designs and develops a novel energy-saving intelligent wireless agricultural detecting system combined with technologies green power supply, wireless transmission and digital control. This system can be powered by green energy resources such as solar energy or wind power and combined with digital control and wireless communication technologies it can achieve collection of a large amount of parameters in terms of modern agricultural cultivation, which will meet the needs of different application scenarios. Results of repeated experiments have shown that it has such advantages as being green and environment-friendly, flexible and reliable.**

Index Terms—**Digital control, energy-saving, intelligent agriculture, multi-parameter, system design and development, wireless communication.**

I. INTRODUCTION

Crop growth and yield is greatly related to environmental parameters [1]. With the development of modern technology, using new technology for real-time monitoring over crop growth can not only provide protection for agricultural fine management but also improve crop quality and reduce production costs [2]. An increase of both yield and economic efficiency can be achieved by creating optimal conditions for crop growth through measurement and due improvement of greenhouse environmental factors such as temperature, humidity, illumination and so forth [3].

In greenhouses of conventional agricultural production, power supply need to set up wires and farmland has many nodes that need to be detected. Hence, it is not suitable to use conventional AC power supply. However, using green energy resources such as solar energy, wind power, etc. can solve the big problem in terms of power supply for intelligent agricultural data collecting and monitoring.

This design uses solar photovoltaic energy, wind power and other green power to supply power to the designed data collecting system. Meanwhile, it utilizes digital control and wireless communications technologies to design and to develop a new type of energy-saving agricultural wireless intelligent detecting system, which is powered by solar or wind energy in operation and equipped with Bluetooth, wireless and other communications functions to facilitate networking and connection of the system.
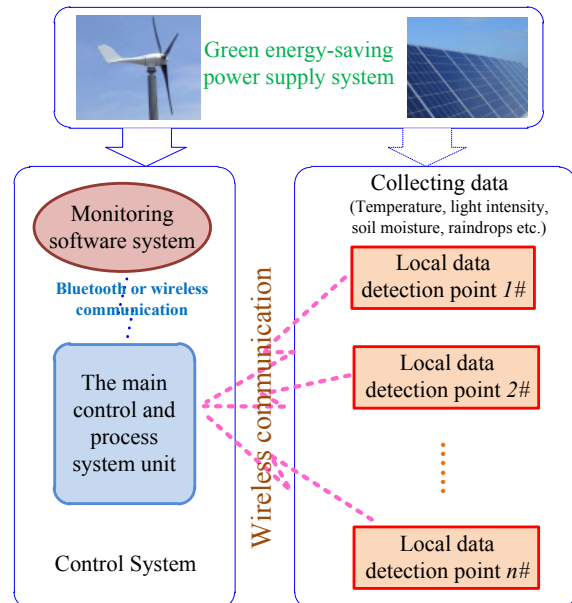

Figure 1.   Block diagram of the system structure

II. SYSTEM DESIGN SCHEME

The structure of the designed system of new energy-saving agricultural wireless intelligent detection is shown in Fig.1. The system consists of green-powered supply, master control unit and data acquisition component. Among them, the green power supply system supplies power to the entire system. The main control unit is responsible for collecting the detection data from the collecting unit and uploads them to the control center, where data monitoring is carried out with the help of software.

The data collecting unit is mainly to collect data from each node in site, including temperature, humidity, light intensity, raindrops and so forth. Data transmission is carried out by means of wireless communication between the data collecting and the main control unit while that is carried out by way of Bluetooth or wireless communication between the main control unit and monitoring software.

III. DESIGN OF CIRCUITRY OF GREEN AND ENERGY-SAVING POWER SUPPLY

Because there are some restrictions on using conventional power supply in the general field of agricultural engineer-

ing, so unlimited solar and wind power can be an alternative for green electricity supply.

Solar and photovoltaic power is all new green renewable energy resources, but their use is largely influenced by environmental conditions and thus has certain volatility. For agricultural data collecting, different using modes can be adopted according to the conditions in different regions. For areas with better light conditions, separate photovoltaic power generation can be selected [4]; for areas with better wind resources, wind power supply can be chosen. In order to improve the stability and reliability of power supply, the above-mentioned two ways can be adopted in complementation. The structure of solar or wind power supply system is shown in Fig.2.

After the green electricity generated by solar and wind is transmitted via the control circuit, it will be stored in the storage circuit and then by the discharge circuit will discharge electricity to supply power to the entire data collection system.

Charge-discharge circuits are mainly DC/DC conversion ones. Depending on the supply voltage and requirements of the system, different conversion circuit topologies may be used and a dedicated control chip or digital control circuit can be used as well.

IV. SYSTEM HARDWARE DESIGN

System hardware in the design is mainly divided into two parts, namely a main controller and data acquisition nodes. The former can connect to several sub-nodes to collect detecting data.

A. Controller chips

The main controller selects STM32F103 and the node controller selects STC89C52. The former is set to fulfill wireless data acquisition, upload, display and other functions. Its block diagram is shown in Fig.3.

Microprocessor STM32F103ZET6 [5] is a 32 Cortex-M3 core processor with an operating frequency at 72 MHz. It has a built-in high-speed memory and a wealth of enhanced GPIO ports that can be achieve data transmission between peripherals and memories in high-speed. The designed minimum system circuit of the main control chip is shown in Fig.4.

The node controller is mainly to collect data and parameters including temperature, light intensity, soil moisture, raindrops, etc. and then to send them back to the host controller through a wireless path. The designed minimum system circuit of the node controller is shown in Fig.5.

The node controller uses STC89S52RC microcontroller [6] as the main control chip and its node controller minimum system circuit is shown in Fig.6.
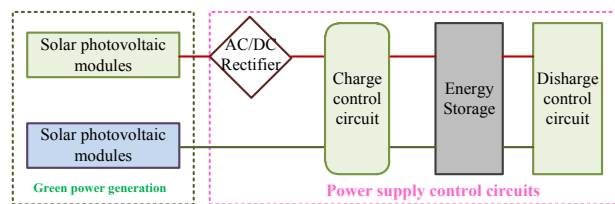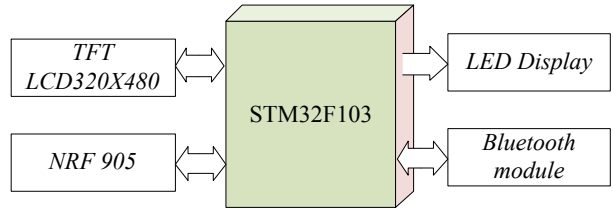

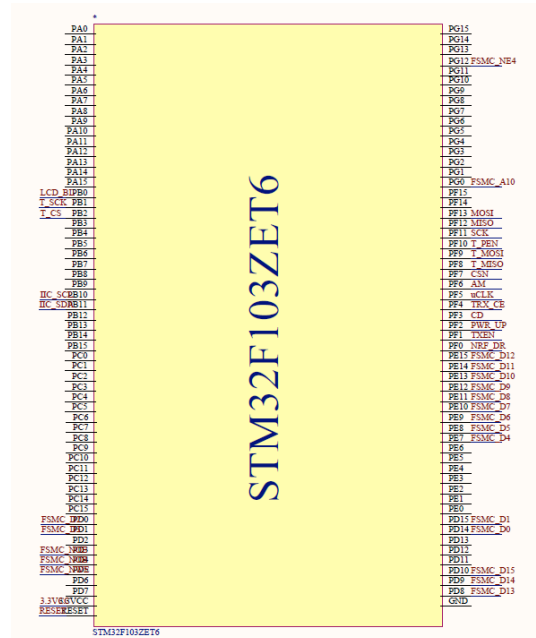Figure 3.   Block diagram of the main control circuit

Figure 4.   Minimum system circuit of the main controller

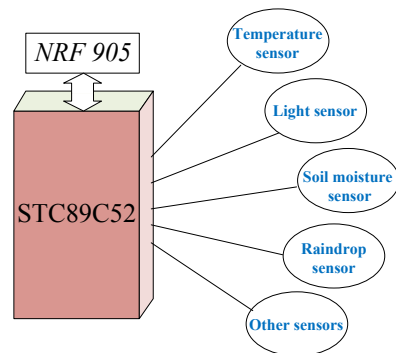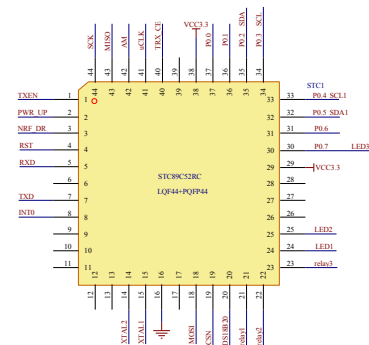Figure 5.   Schematic of node control circuit

Figure 6.   Minimum system of the node controller

Figure 2.   Green power supply system

B. Sensor curcuit design

The temperature sensor selects DS1820—a digital temperature sensor of single-bus system produced by DALLAS Company in the US, which can not only provide binary 9 temperature information with a resolution of 0.5℃ but also measure the temperature within the range of -55 ~ +125℃ [7]. The temperature sensor connection circuit is shown in Fig.6, which enables single-bus communication with the microcontroller for reading digital temperature value.

Light sensor, which can read the light intensity data in real time, selects the digital type of BH1750FVI and it uses an I2C interface to connect to the node controller [8]. The light sensor connection circuit is shown in Fig.7.

The AD data acquisition circuit uses a dedicated chip PCF8591 [9] to achieve related data acquisition, which can read multiple AD data input. The schematic of PCF8591 circuit is shown in Fig. 9. The soil moisture, raindrops and CO_2 sensors will switch signals collected by the dedicated AD chip into voltage ones.

Wireless communication is enabled between the main and the node controller based on nRF905 wireless communication interface circuit [10], as shown in Fig.10. Wireless transceiver board is composed of nRF905 chips and discrete components [11]. Thus, it can meet the communication requirements of environmental parameters acquisition.

C. Other circuit design

The control node provides relay output control circuit that can automatically control external devices. It can be connected to related equipment including ventilation, heating devices and so forth to achieve the automated control of modern intelligent agriculture.

The schematic of communication and power LED indicator circuit is shown in Fig.12, which can indicate the working status of the power and wireless communication.

V. SOFTWARE DESIGN

The system software is divided into controller software and PC monitoring software. The controller software includes that of the main controller and that of the node controller. The diagram of the total software configuration is shown in Fig.13, wherein the controller software is programmed in C language and the PC software in C# language.

The main programming flow chart of the main controller system is shown in Fig.14. After the initialization of the controller system, a process of data collecting is carried out to achieve the acquisition of various parameters. Subsequently, the collected data is identified as whether exceeds the set limit. If exceeded, the program will go to alarm handling. Finally, the data display will be updated as a result.
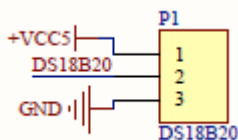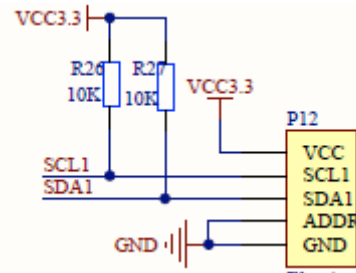

Figure 8.   Diagram of the Light Sensor Connection Circuit
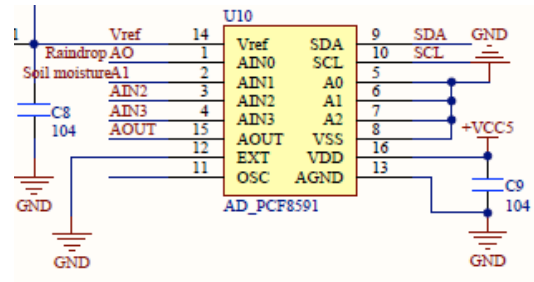

Figure 9.   Schematic of AD data acquisition circuit
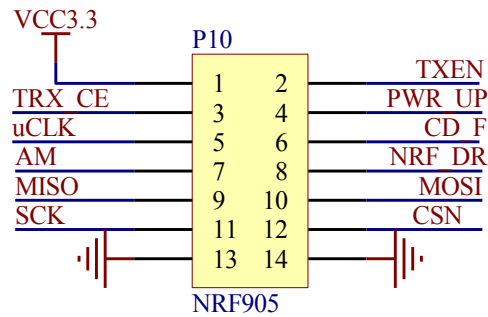

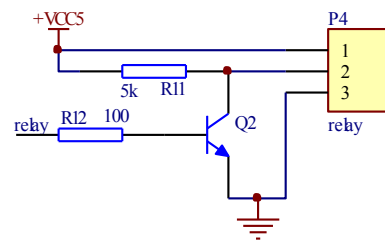Figure 10. Schematic of nRF905 wireless communication interface circuit

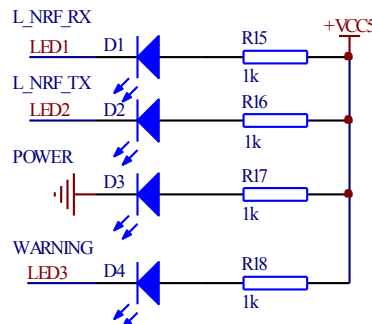Figure 11. Schematic of the relay output control circuit

Figure 12. Schematic of the LED indicator circuit

Figure 7.   Schematic of the temperature sensor connection circuit

The main monitoring interface includes menu settings area, communication settings, real-time data collection and processing, display interface and control output switches. Each monitoring parameter can be set via the menu area. The PC monitoring software interface is shown in Fig.15.

VI. SYSTEM EXPERIMENTAL TEST

In order to verify the feasibility and performance of the system, this research has designed and developed an experimental prototype system for testing experiments. The prototype system is shown in Fig.16.

The prototype system includes one photovoltaic module (power supply system), three node controllers and one main controller (main control system).

The experimental test picture of prototype system is shown in Fig.12. The main controller can receive information from control node of environmental parameter and has it displayed on the TFT screen. Simultaneously, the parameters of node operation can be set by the master node.
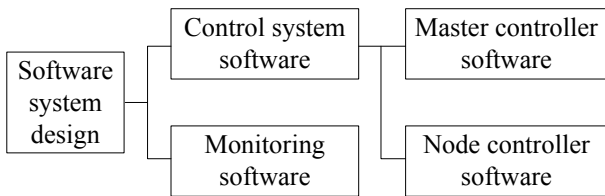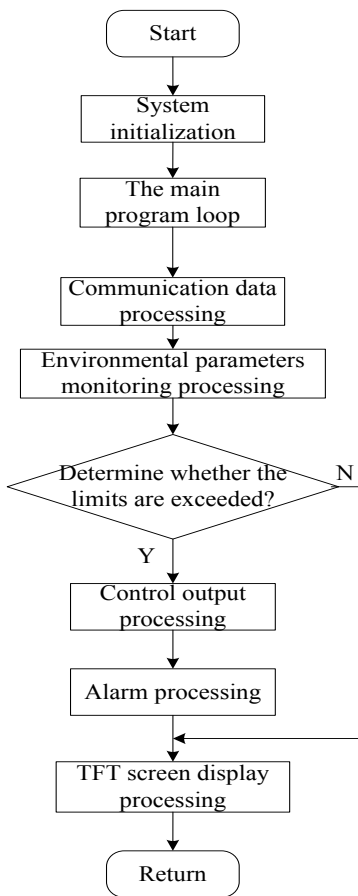

Figure 13. Software System Composition

Figure 14. Main programming flow chart of the master controller system

Wireless communication is enabled between the main controller and the nodes, which can provide convenient and flexible arrangement of position for each node.

The PC monitoring interface is shown in Fig.18. Data from each node is collected and processed by the computer and displayed real-time. The host and the main controller can also communicate with each other through Bluetooth or Wi-fi.
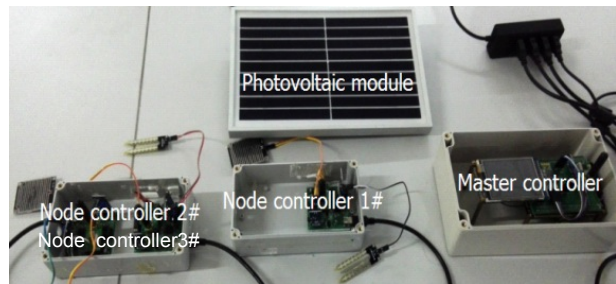

Figure 15. Main monitoring system interface
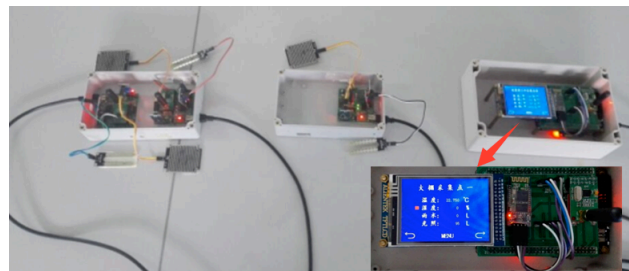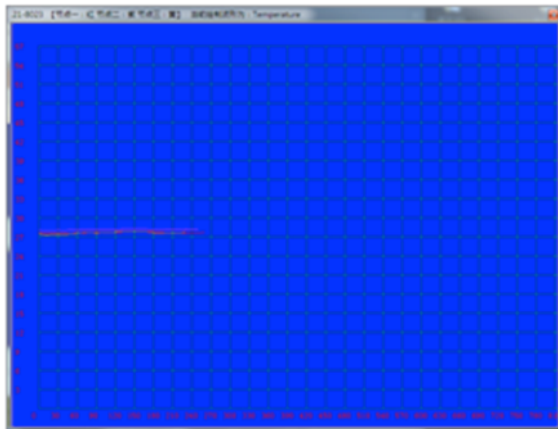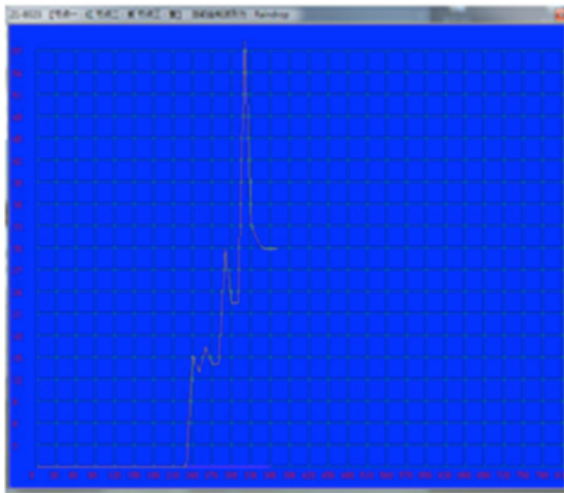

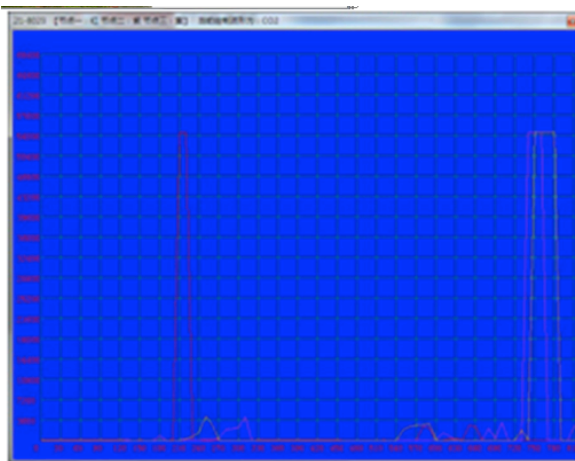Figure 16. The prototype system

Figure 17. Experimental test picture

Figure 18. Main interface of experimental test monitoring
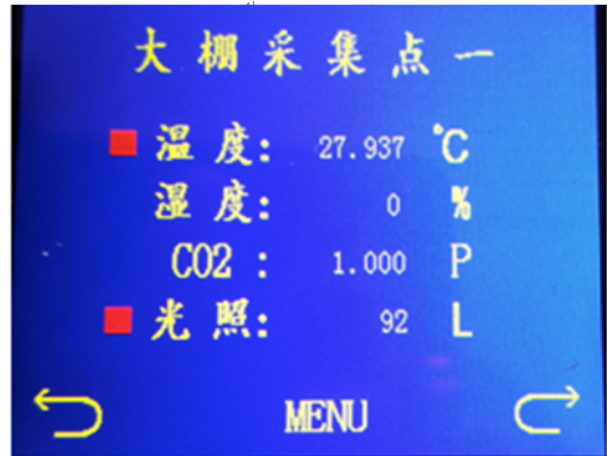
(a)   Node' s temperature curve
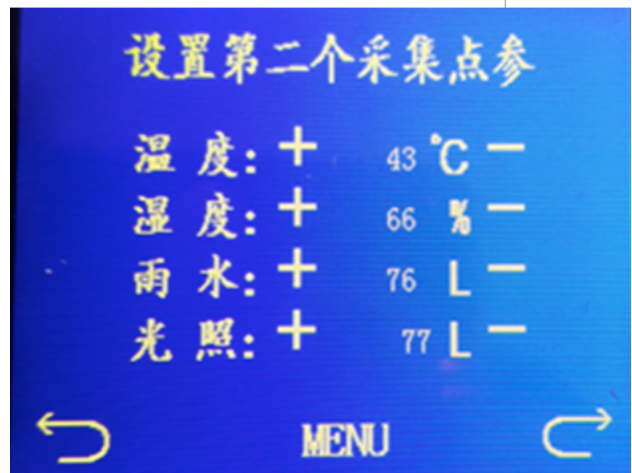

(b)   Node' s raindrop curve

(c)   Node's CO_2 curve

(d)   The No.1 node controller display interface

(e)   The No.2 node controller setting interface

(f)   The No.3 node controller display interface

Figure 19. Some experimental test results

The system has gone through many times of experimenting and the due experimental results have been recorded, among which the data of one case is shown in Fig. 19.

As can be seen from the results of the repeated experiments, the system can complete the task of data acquisition and achieve the intended design goals. Therefore, it is suitable to be applied and promoted in the field of agricultural data collection.

VII.   Conclusion

In this paper, the design has applied brought solar/wind or other green power to the agricultural data collection system to supply green power for intelligent agriculture. This paper has first resolved the detection problem of the conventional monitoring system with the help of digital control and wireless communication technologies. Then, it has designed and developed a novel system of intelligent agricultural data collecting, which is both energy-saving and based on wireless communication. Finally, an experimental prototype has been developed to test the reliability

and feasibility of the system. Through repeated experiments, the results have shown that the designed system, as is green, flexible and reliable, is suitable be applied and promoted in the field of agricultural data collection.

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