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Design and Implement of a smart garden system using STM32 microcontroller

Nguyen Van Cong[1], Nguyen Thi Huyen Trang[2]
[1,2] Vietnam Korea University of Information and Communications Technology – Danang University, Viet Nam

Abstract: *Before the industrial revolution 4.0, the domestic agriculture industry faced the requirement of innovation to abandon old and outdated production methods. Instead, it is the timely and selective application of advanced techniques of the 4.0 revolution period in agricultural production. This will contribute to increasing the efficiency of the production chain and commercializing the product. However, it is necessary to select technologies that are practical and effective. This is a decisive factor in the success of agricultural development with high technology applications, and especially in the 4.0 period, the output of products. This paper will introduce how to build an IoT system for garden that are capable of monitoring and automatically adjusting temperature, humidity, light intensity (through sensors), stabilizing environmental conditions (via water pump, misting, lights, fans, sunshades). The main components used in this IoT system include the temperature and humidity sensor SHT11, chip STM32F103RCT6, RS485 Serial Communication and others.*

Keywords: *IoT, smart garden, sensor, STM32, RS485*

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I. INTRODUCTION

Currently, science and technology are increasingly achieving great achievements, including agriculture. However, most plant care processes are manual. In addition, in recent years, agricultural production has faced many difficulties due to increasingly complex weather events, greatly affecting the productivity and quality of agricultural products along with that.

Therefore, finding new solutions to stabilize and improve product quality and yield becomes a top priority. So, technological applications are included in the care and harvesting of agriculture to overcome the problems of environmental conditions and weather, as well as save time, and human resources, and increase productivity of crops. However, a system to ensure these factors needs the high investment cost. Thus, it is necessary to research these devices in an appropriate way to reduce costs, in accordance with the requirements of use and economic conditions of farmers and environmental conditions. To solve this problem, the paper aims to build an IoT system which allows to perform monitoring - control operations on the computer using STM32F103RCT6 microcontroller via the RS485 network and Altium Designer and Visual Studio softwares. The combination between STM32F103RCT6 and RS485 is expected to build a lower-cost system give the easy approach for famers to save time, and human resources, and increase productivity of crops.

The contents of paper are arranged in sequence: Part 1 will introduce components used in the smart garden, part 2 is steps to design and implement the system and result, part 3 is the conclusion and give some evaluations on the built system.

II. HARDWARE COMPONENTS

2.1 STM32F103RCT6 microprocessor

The outstanding features of the ARM Cortex series have attracted IC manufacturers, and more than 240 series of Cortex-based microcontrollers have been introduced. STM32 is a low-power and high performance microcontroller. It can operate at 2V, runs at 72MHz and consumes only 36mA with all the blocks inside the microcontroller working. Combined with Cortex's power saving modes, the STM32 consumes only 2µA when in Standby mode. An 8MHz RC internal oscillator allows the chip to quickly exit power saving mode while the external oscillator is starting up. The ability to quickly enter and exit energy-saving modes greatly reduces overall energy consumption.

2.2 The temperature and humidity sensor SHT11

The sensor integrates sensing elements plus signal processing and provides a digital output. Special capacitive sensors are used to measure relative humidity. CMOSens® technology has been applied with excellent accuracy and long-term stability, fast response time and insensitivity to external disturbances (EMC). SHT11 uses

I2C communication standards including 2 pins SDA and SCL. Where the SDA pin is a bidirectional data transmission pin, SCL is the direction clock pin from the microprocessor to the sensor.

2.3 Soil moisture sensor

The soil moisture sensor module is an electronic circuit that detects whether the soil moisture has exceeded a certain threshold or not. Soil moisture sensor helps to read soil moisture, and application in the automatic irrigation system.

2.4 Real-time IC DS1307

DS1307 is a real-time clock chip (RTC: Real-time clock), the concept of real-time here is used with the meaning of absolute time that people are using, in seconds, minutes, hours... DS1307 is a product of Dallas Semiconductor (a company of Maxim Integrated Products). This chip has 7 8-bit registers containing the time: seconds, minutes, hours, day (of the week), day, month, year. In addition, the DS1307 has an auxiliary output control register and 56 empty registers that can be used as RAM. The DS1307 is read and written through the I2C serial interface (TWI of the AVR) so the external structure is very simple.

2.5 IC MAX485

Max485 is a signal converter of RS232 communication standard to the signal of RS485 communication standard so that the signal can be transmitted on the RS485 line and from there can transmit the signal long and fast.

2.6 Other components

- **Relay** is a switch, used to turn on of turn off the control circuit, it works by electricity. The relay is ON or OFF depending on whether current flows through the relay or not.
- **Pump motor 12V – 3W** is used to pump water to plants.

III. IMPLEMENTING THE SYSTEM

3.1. Requirements

The system is a model of a vegetable garden that fulfills the following requirements:

- Displays the value of temperature, air humidity, and soil moisture.
- Collect air temperature and humidity data.
- Collect soil moisture data by taking data from the soil moisture sensor
- Communication with the software on PC via RS485 network.

3.2 Characteristics of agricultural products

We should have some knowledge of agriculture, especially temperature and humidity of plants:

- The right temperature for vegetables to grow well is about 18-24 degrees Celsius.
- Preferred humidity: 70% to 80%.

3.3 Steps to implement the system

- Draw SCH principle circuit diagram, PCB printed circuit diagram
- Programming software to collect and display data on computers

3.3.1 Draw SCH principle circuit diagram, PCB printed circuit diagram

Draw schematic diagrams and circuits in Altium designer version 6.9. The schematic diagram includes the following components:

- Microprocessor STM32F103RCT6

The microprocessor runs at 3.3V. The functions programmed in the firmware are: Communicate with the SHT11 air temperature and humidity sensor by I2C protocol, communicate with the control monitoring software on the computer using the UART protocol, communicate with the sensor which can change soil moisture by ADC, control pump switch pins, blower switch by GPIO pins K1, K2, K3 for backup.

- Air temperature and humidity sensor SHT11

SHT11 uses I2C communication standards including 2 pins SDA and SCL. Where the SDA pin is a bidirectional data transmission pin, SCL is the direction clock pin from the microprocessor to the sensor. The connection circuit from the microcontroller to the SHT11 uses the I2C protocol.

- IC MAX485 to convert UART protocol to RS485 communication with the computer
- The DS1307 real-time IC communicates around the microprocessor via the I2C protocol

- Intermediate relays for pump and blower control
- LDO power block converts 5V to 3.3V to feed the processor and LED indicator

Figure1. SCH principle circuit diagram

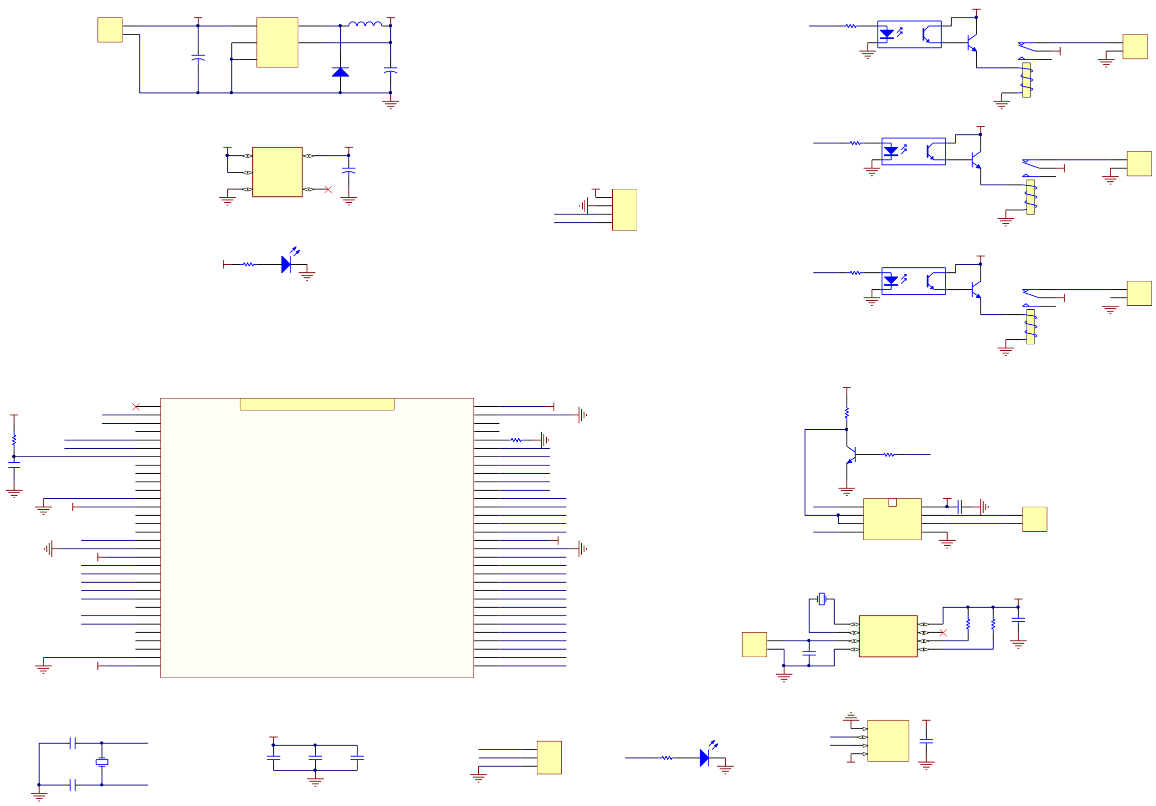
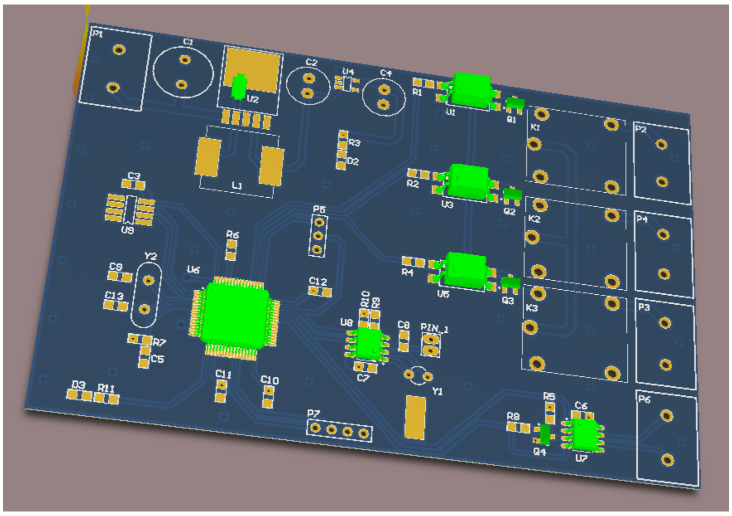
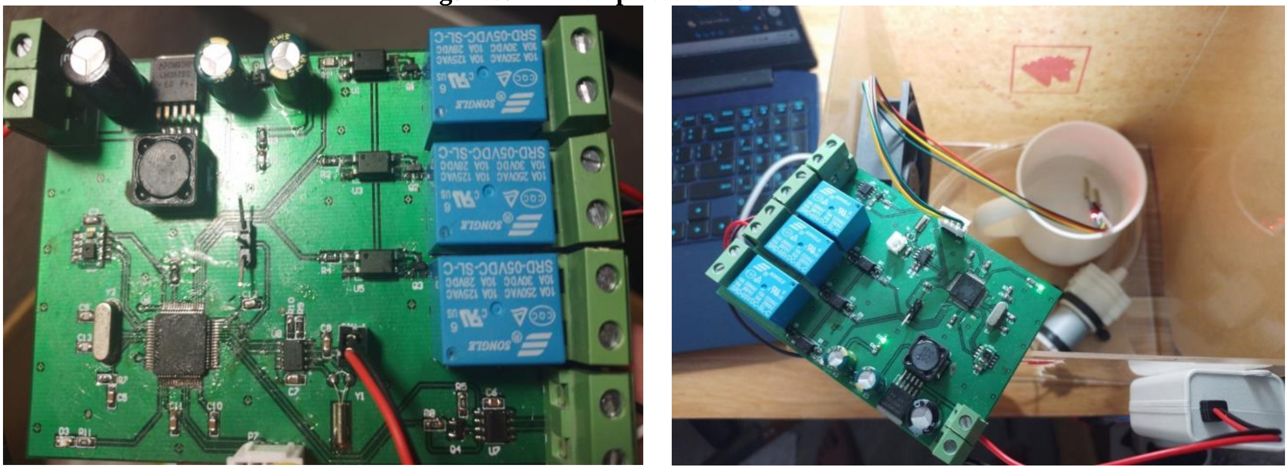


Figure2. SCH principle circuit diagram



After finishing PCB printed circuit, the components will be put on it, then there are a completed circuit as following picture:

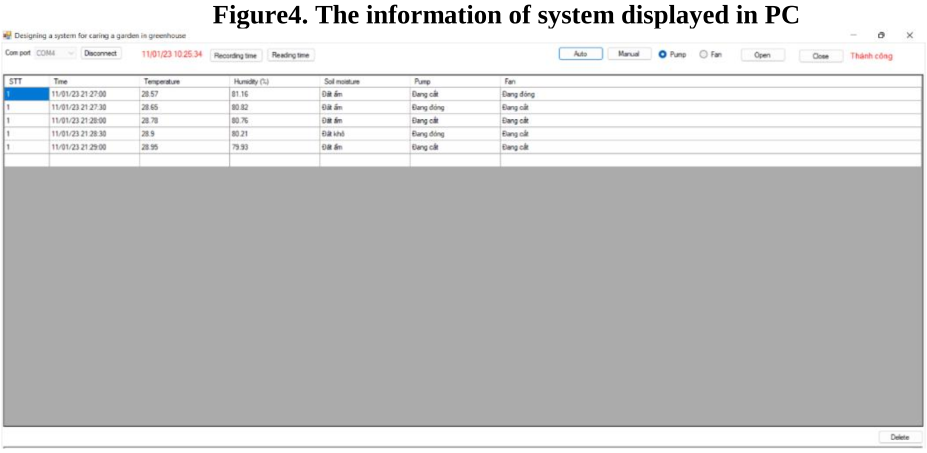
Figure3. The completed circuit



3.3.2 Implementing an apllication to collect and dispaly data on computer

The software is written on the Visual Studio 2013 C# environment with the interface as following:

Figure4. The information of system displayed in PC



The functions of this application on computer:

- Function to select COM port RS232 and connect to the device
- RTC time reading and writing function
- Function to configure the operating mode manually or automatically down the device
- Turn on and off the pump, fan when the device operates in manual mode.
- The datagrid section to show data of temperature, air humidity, soil moisture, on/off status of pump and blower.

The system has the function of controlling the pump, controlling the blower in 2 modes: manual and automatic mode.

In automatic mode, the system will automatically collect data on soil moisture, compared with the threshold, if the soil moisture is less than the set threshold, the pump will be turned on, otherwise the pump will be turned off.

When in manual mode, the system will check and compare the button pressed state from the keyboard when the user presses the key, the system will make a decision on and off the device.

Figure5. Block diagram of the system in automatic mode

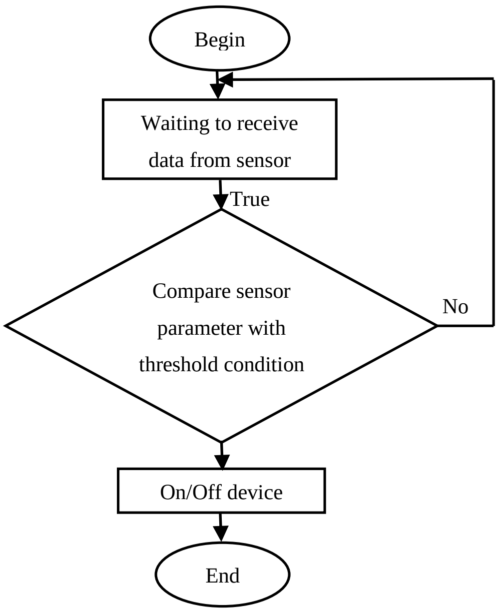
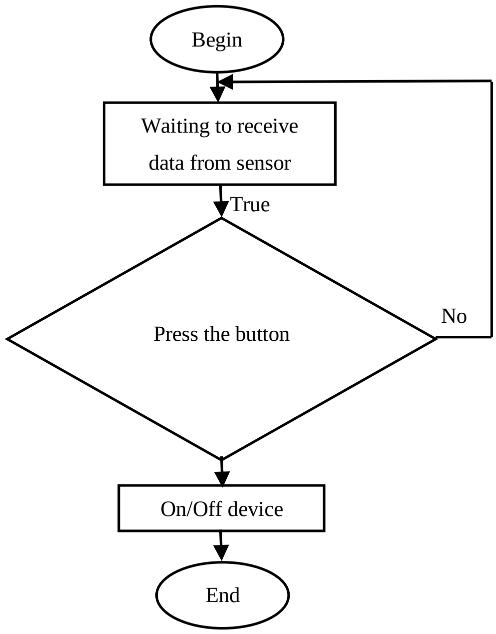


Figure6. Block diagram of the system in manual mode



3.4 Result

This IoT system's features include:

- Collect air temperature and humidity data from the temperature and humidity sensor SHT11.
- Collect soil moisture data by taking data from the soil moisture sensor.
- The system has the function of controlling the pump, controlling the blower in 2 modes manually and automatically. In automatic mode, the system will automatically collect data on soil moisture, compared with the threshold, if the soil moisture is less than the set threshold, the pump will be turned on, otherwise the pump will be turned off.
- Communicate with the software on the computer via the RS485 network and display the temperature, air humidity, soil moisture, pump status, blower status, and the system time on the screen.

IV. CONCLUSION

In general, basically, the system meets the requirements for measurement and information collection of measured data from sensors with the accuracy required initially and performs the function of controlling devices according to the user's request. The system was done with the low cost, high reliability and quick response. Actually, to build an automatic and remote watering system, there has been many models designed, we hope that our model will be a useful reference for others to develop a bigger technical system.

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