Monitoring the Environmental Factors of Endangered Plant Paphiopedilum Armeniacum

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Abstract

Paphiopedilum armeniacum is level-one protected species. As the original habitat destruction, Paphiopedilum armeniacum is at the brink of extinction now. In order to monitor the environment of the endangered plants such as Paphiopedilum armeniacum, to master the real-time changes of their environment factors such as temperature, humidity, light intensity, the design is based on AT89C51, regarded temperature, humidity and light intensity as the monitoring parameters, choosing temperature sensor DS18B20, humidity sensor HS1101, light-frequency converter TSL235 for data collection. The collection values of the environmental factors are displayed on light emitting diode, and the data transmission is fulfilled by using the PTR2000 short-range wireless transmission module. The micro control unit can accomplish joint factors monitoring such as temperature, humidity and light intensity. Now monitoring the environmental factors of Paphiopedilum armeniacum is a powerful move of protecting endangered plants, protecting the environment.

Keywords: paphiopedilum armeniacum, endangered plant, monitoring, transmission

1. Introduction

Paphiopedilum armeniacum is native to Fugong, Bijiang, and Lushui in the northwest of Yunnan, China. As the original habitat destruction, Paphiopedilum armeniacum is at the brink of extinction, is classified as a protected species by the International Convention, People's Republic of China Regulations on the Protection of Wild Plants "(1996) listed it as the national level protected plants, and has the title of "Panda among the plants" [1]. In order to save this rare and endangered plants, protect its resources effectively, it is important to understand the wild state environment of Paphiopedilum armeniacum. Paphiopedilum armeniacum is highly dependent on the environment, especially for temperature, humidity, and light intensity [2]. Now monitoring the environmental factors of Paphiopedilum armeniacum is a powerful move of protecting endangered plants, protecting the environment. At present, through the continuous efforts of researchers domestic and broad, the greenhouse environment control and management system development have been perfect, but the monitoring of outdoor environmental factors is not mature enough, especially for endangered plants applications such as Paphiopedilum armeniacum etc. the temperature and humidity monitor, light monitor will continue to improve update. Environmental factors monitor will develop in the direction toward the wider measurement range, higher accuracy, faster refresh rate, longer data retention time, starting and ending patterns to choose diverse communication interface [3]. This study describes the monitoring method of temperature, humidity, light intensity and other environmental factors using 51 MCU (Micro Control Unit) based on the traditional single environmental factors in the past, and selecting PTR2000 data collecting module to achieve short-range transmission. These are important for further real-time controlling the environment parameters, promoting growth and reproduction of the species, preventing the extinction of endangered species, protecting the environment. This is a relatively good method for automatic environment monitoring and data transmission outdoor automatically.

2.   Design Principles

The design is based on AT89C51. Regarded temperature, humidity and light intensity as the monitoring parameters, choosing temperature sensor DS18B20, humidity sensor HS1101, light-frequency converter TSL235 for data collection. The collection values of the environmental factors are displayed on light emitting diode, and the data transmission is fulfilled by using the PTR2000 short-range wireless transmission module. System block diagram is shown as Figure 1.
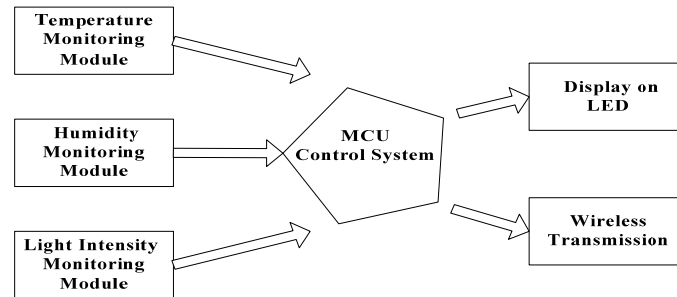

Figure 1.   The System Block Diagram

3.   Hardware Design
3.1. MCU Control System

AT89C51 is a kind of 4K bytes flash erasable programmable read only memory, low voltage, high performance CMOS 8-bit microprocessor. Owing to the multi-function 8-bit CPU and flash memory combined in a single chip, it is a highly efficient micro-controller.

3.2. Temperature Monitoring

Paphiopedilum armeniacum is native to Fugong, Bijiang, Lushui in the northwest of Yunnan, China. It grows at an altitude of 1400-2100 meters on limestone wall or at multi-stone and drainage on the grassy bank. The distribution area is about 12~18 degrees Celsius, the average temperature is 16~18 degrees from March to September, and 12~16 degrees from September to next March [4]. The highly integrated single-bus digital temperature measurement circuit DS18B20 of DALLAS can meet the measurement requirements. The temperature range is -55 - +125 degrees Celsius.

DS18B20 has two kinds of supply ways, parasitic power supply and external power supply. The external power supply way is the best working way, it is stable and reliable, has strong anti-jamming capability, and circuit is relatively simple. The external power supply can give full play to the wide supply range advantage of DS18B20 [5]. Even if the power voltage VCC down to 3 V, it still be able to ensure measurement accuracy [6]. Using external power supply method can make the structure simpler and more reliable. Circuit is shown as Figure 2.
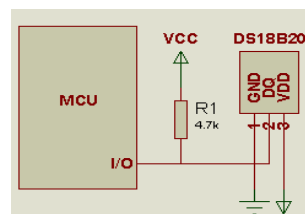

Figure 2. The External Power Supply Diagram of DS18B20

3.3. Humidity Monitoring

Humiral capacitive humidity   sensor HS1101, its principle is   based on the film capacitance humidity environment at   different capacitance changes to   reflect   the

different humidity. The supplying voltage range is 5-10V, its humidity measuring range of 1-99% RH. The annual relative humidity can maintain 60%~70% [7]. The extreme humidity value is in the measurement range of HS1101. Therefore, this selection of the sensor is appropriate.

HS1101 together with 555 oscillator circuit can transform capacitance into frequency and transferred data to the microcontroller [8]. Figure 3 is the typical circuit of multivibrator with 555 timers.
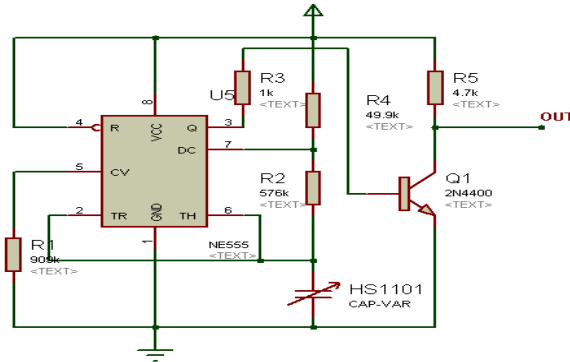

Figure 3.   The Humidity Measurement Circuit

HS1101 can charge and discharge by resistors R2 and R4 of different value. The working cycle can be described as follows:

$$T1=(R2+R4)×C@\%RH×\ln2 \tag{1}$$

$$T2=R2×C@\%RH×\ln2 \tag{2}$$

$$T=T1+T2 \tag{3}$$

$$F=1/T=1/(T1+T2)=1/[(2×R2+R4)×C@\%RH×\ln2] \tag{4}$$

Table 1 is shown the fixed resistor of 555 harmonic oscillator. The design chooses TLC555 multi-vibrator, according to the Table 1, the corresponding resistor R1 = 909K, R2 = 576 K.

Table 1. Fixed Resistor of 555 Harmonic Oscillator

555	R1(ohm)	R2(ohm)
TLC555	909K	576K
TS555	100nF capacity	523K
7555	1732K	549K
LMC555	1238K	562K

Table 2. HS1101 Frequency Output Parameters

Humidity Range (%)	Frequency (Hz)
0	7351
10	7224
20	7100
30	6976
40	6853
50	6728
60	6600
70	6468
80	6330
90	6186
100	6033

The growth environment of Paphiopedilum armeniacum is dark, damp and humid, the annual humidity values is at the range of 60% to 90%, according to the Table 2, the annual humidity values corresponding to a frequency of approximately 6600~6033Hz. The specific frequency output parameter is shown as Table 2.

The output frequency range of HS1101 is 6033 ~7351 Hz; the adjustable capacitor should range from 165 to 200 pF by Equation (4). When the adjustable capacitance value is 165 pF, the humidity value reaches the minimum value; when the adjustable capacitance value is 200 pF, the humidity value reaches the maximum value.

3.4. Light-frequency Converter

Paphiopedilum armeniacum is native to the dark environment, intolerant to bright light. TSL235 light-frequency converter, which is a combination of a silicon photodiode and current-frequency converters on the monolithic integrated circuit, its output is square wave which is proportional to light intensity. Component is more sensitive to the wavelength range from 300nm to 700nm, and this band of light has a great impact on the growth of Paphiopedilum armeniacum [9]. The light intensity of Bijiang, Lushui vicinity throughout the year is 1000-20000LX [10], that is, 1000-20000 W/m2. It can be transformed into the frequency estimate 100-2000MHz.

The output of TSL235 is allowed to connect directly with a microcontroller or other logic circuit without external component; it can achieve high-resolution light intensity to frequency conversion. In order to achieve optimal device performance, connecting 0.IμF decoupling capacitors to the power. Circuit is shown as Figure 4.
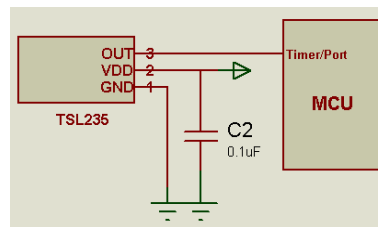

Figure 4. The Relationship between Output Frequency and Light Irradiance of TSL235

3.5. Output Display

Environmental factors measured values of temperature, humidity, light intensity displayed on the 7SEG-MPX4-CC LED via microcontroller processing.

4.   Software Design
4.1. The Main Program Design

After program initialized, when the partakers button pressed, start environmental factors monitoring subroutine, MCU collect temperature, humidity and light intensity environmental actors, actors are displayed on LED (Light Emitting Diode); LED will change the display parameters until the next button is pressed; when the total key is pressed, start cycle monitoring, MCU collect temperature, humidity and light intensity environmental actors, and actors are displayed on LED circularly. The main program flow chart is shown as Figure 5.

4.2. Temperature Acquisition Program Design

Temperature sensor DS18B20, its output digital signal can be directly identified by microcontroller, which can work without analog-digital conversion. The data output DQ can directly connect to the microcontroller P1.0. Temperature acquisition program flow chart is shown as Figure 6.

4.3. Humidity Acquisition Program Design

According to the principle of HS1101, in the humidity conversion process, when the output frequency is between 6033Hz to 7351 Hz, the relative humidity is between 0% to 100%. Humidity acquisition program flow chart is shown as Figure 7.
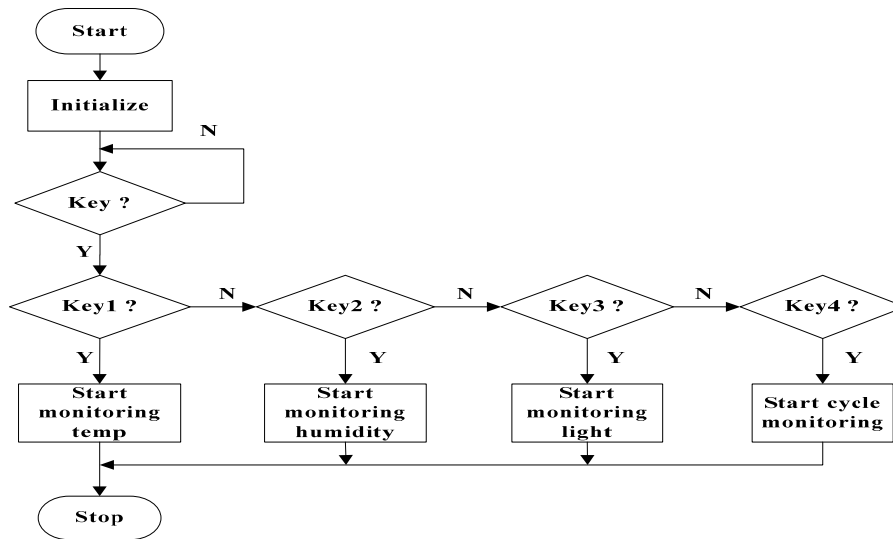
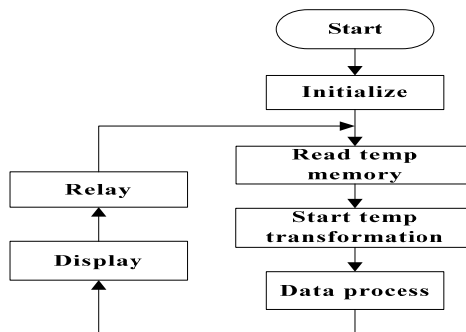Figure 5. The Main Program Flow Chart

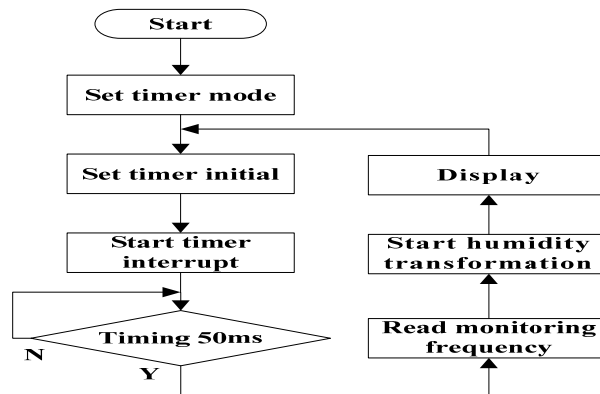Figure 6. The Flow Chart of Temperature Acquisition

Figure 7. The Flow Chart of Humidity Acquisition

4.4. Light Intensity Acquisition Program Design

TSL235 output frequency is 100-2000MHz, which converted to light irradiance is 100-2000W/cm2. Light intensity acquisition program flow chart is shown as Figure 8.
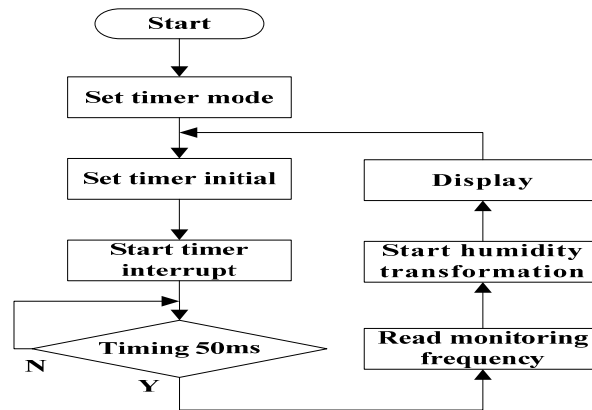
Figure 8. The Flow Chart of Light Intensity Acquisition

5. Transmission Systems

Wireless transceiver data transmission module PTR2000 chip has excellent performance, its distinguishing feature is required less external components, facilitate to design [11]. The device has strong anti-interference ability of FSK modulation and demodulation, the frequency is stable and reliable, low power consumption and easy to design and production [12]. These outstanding features make PTR2000 leading the industry level, and is the ideal choose of low-power wireless data transmission. Short-range wireless data transmission system functional block diagram is shown as Figure 9.
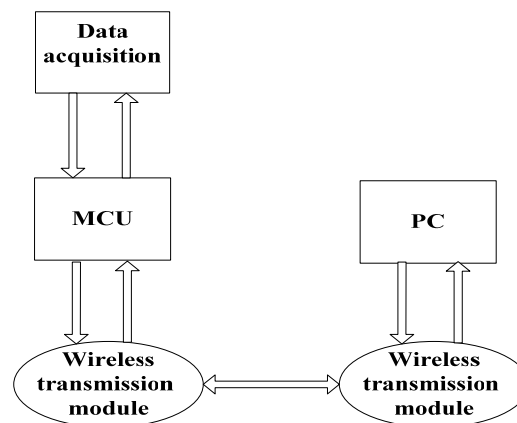

Figure 9. The System Block Diagram of Short-range Wireless Data Transmission

5.1. Microcontroller Communication Design with PTR2000

Microcontroller serial data input pin RXD, serial data output pin TXD, respectively connected to the data output pin PTR2000 DO, data input pin DI, to achieve serial data transmission; transmitting and receiving control pin TXEN, channel select pins CS, energy-saving control pin PWR respectively connected to MCU controlling port P2.0, P2.1, P2.2 to determine operating mode of PTR2000. In actual operation, PTR2000 module's operating mode is determined real-time by the microcontroller software program decision.

5.2. The Software Design of MCU-side

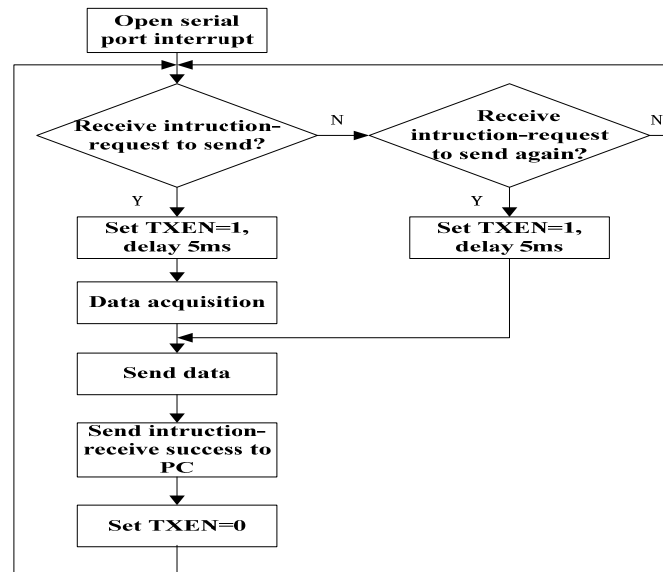The flow chart of MCU-side is shown as Figure 10.

Figure 10. The Flow Chart of MCU-side

5.3. PC Communication Design with PTR2000

PTR2000 energy-saving control pin PWR connected to the high level, that is fixed in normal working condition (sending or receiving state); Channel select pin CS to low, that is used communication channel 1, fixed working at 433.92MHz; transmitting and receiving control pin TXEN controlled by PC serial port signal pin RTS which is converted by MAX232 [13].

5.4. The Software Design of PC-side

Using VB (Visual Basic) MSComm control programming can achieve the communication between MCU and PC of the PC-side [14].

The VB MSComm controller provides a tremendously powerful serial communication control, its programming is extremely simple, users can set the status of serial communication data, and set the message format and protocol of the serial communication port. MSComm control is not in VB universal tool window, users must add the controls when need [15]. This controller can realize communication between the MCU with PC, a PC with another PC.

6. Conclusion

The design is applicable to Fugong, Bijiang, Lushui in the northwest of Yunnan, China where Paphiopedilum armeniacum grow, sensors selection is in accordance with the local environmental requirements, data collection and transmission way is reasonable and effective. It can achieve the jointly monitoring and wireless transmission of multiple environmental factors, can change status quo of today's most environmental factors monitoring system which is applies only to the general environmental fact. It is more focused and constructive, and can provide a scientific basis and support for the habitat of endangered plants on theory and practice.

The design is implemented the contents of the design requirements in the debugging process, temperature, humidity and light intensity data can be collected and displayed, enabling to perform short-range wireless transmission of the monitoring data, it can transmit more than 300 meters, all monitoring requirements can be achieved. It is a relatively good method for automatic environment monitoring and data transmission outdoor automatically. Controlling the environmental factors of Paphiopedilum armeniacum on the basis of monitoring, adjusting environmental parameters real-time, thus contributing to its superior growth and reproduction, is an effective measure to protect endangered plants, and also the next step of the research topic.

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