International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 11, Issue 3 [May.-June. 2022] PP: 819-829

Multi-parameter orchard acquisition system based on NB-IoT

Bowang GUO, Shiji WANG, Yang BAO,YunMU,ZhenghongQIU,YongguangZHANG,Pingchuan ZHANG
School of Information Engineering, Henan Institute of Science and Technology, P.R. of China
Corresponding Author: Pingchuan ZHANG

ABSTRACT:

China is a big agricultural country, and the Internet of Things technology is the current project strongly supporte d by the state.The vigorous development of modern agriculture needs the support of modern information technol ogies such as the Internet of Things and cloud computing.
In this paper, NBIoT.Hardware design in the form of microcomputer, through hardware and software analysis a nd design, build a set of multiparameter acquisition system, can collect temperature, humidity and light intensity , when beyond the predetermined range of sound and light alarm, through the design and debugging, the system runs stable, can reliably realize the parameter acquisition, reached the predetermined goal, is of great significanc e to improve the economic benefit and production efficiency of the orchard.

Key words: Internet of Things; parameter acquisition system; NB-IoT technology; sensor

Date of Submission: 14-06-2022 Date of Acceptance: 29-06-2022

I. INTRODUCTION

Under the premise of scientific and technological progress and the continuous development of society, information technology such as the Internet of Things (IoT) has become an important application in modern agricultural production. Traditional agriculture and the Internet of Things [1] The intelligent agriculture produced by the combination of applied technology is the inevitable trend of contemporary agricultural development. The core part of smart agriculture is intelligent real-time monitoring, which is mainly reflected in that users can remotely and real-time obtain accurate data of the growth environment of fruit trees in orchards, so as to ensure the optimal environment for the growth of fruit trees, effectively control the growth of fruit trees, carry out more scientific management of fruit trees, and achieve the purpose of increasing production and income.
Narrow band Internet of Things Technology (NB-IoT) is a new network that can be deployed on a large scale worldwide, which can be deployed on existing LTE networks and support IoT terminals [3] Connect cellular data in the WAN, achieve smooth upgrades on the existing spectrum and reduce costs, while making data transmission more accurate and secure. Narrowband the use of iot technology, make network design, node setting simpler, adapt to all kinds of real complex environment, to a large extent reduce the external environment interference from the signal, improve the reliability of the relevant data, through real-time data collection, can provide a powerful basis for related industries, promote the development of the industry.
At present, the wireless sensor network isthe main realization way of obtaining the field information. Because the N B-IoT technology has wide coverage, large connection, and low power consumption [5] And other characteristics, just can provide help for the real-time monitoring of the orchard environment. Combine N B-IoT technology and sensor, can realize comprehensive to orchard environment intelligent monitoring, real-time monitoring, let growers timely observe the orchard temperature, humidity, light parameters and its changes, provide strong support for orchard control system, reduce the possible adverse effects on crops, improve the fruit yield, make the orchard environment monitoring system more intelligent.
China is a big fruit country [11] In the traditional fruit tree cultivation and production management stage, it is mainly judged by their direct speculation and long-term accumulated experience. In this way, fruit farmers are not only the "sensor" of the orchard environment, but also the "controller", which limits the quality of fruit trees and fruit output, and cannot improve the economic income of fruit farmers. In addition, most of China's rural areas of the information [12] The level is low, so the combination of the Internet of Things platform and agriculture is a beneficial supplement to agricultural information push.

At present, the development of smart agriculture of the Internet of Things is very rapid, and many developed countries are in the leading position.

Its model is also constantly innovating, and the way of adjusting measures according to local conditions is particularly prominent [16] In terms of improving efficiency and improving energy conservation and emission reduction, it is being gradually improved to carry out more precise management and improve quality.

In all aspects of agricultural production to apply N B-IoT technology, to make the agricultural Internet of things technology results in better development mode, through comprehensive intelligent monitoring of external environment, real-time acquisition temperature, humidity, light and other parameters and record the changes, understand the crop production status and timely adjustment, reduce the possible adverse effects on crops, so as to improve the crop yield.

The system monitors the three parameters of temperature, humidity and light in the orchard. It is an uninterrupted real-time monitoring system that can be left unattended for 24 hours and automatically update the data every 2 seconds. While monitoring and recording the orchard environment, NB-IoT technology is used to transmit the data, display the dashboard displayed by the data received by the sensor, and transmit the parameters to a database platform for storing parameters in real time, for later analysis and comparison. The system can realize the on-site acoustic and light alarm in the case of abnormal temperature, humidity and light intensity, and facilitate the adjustment and management of supervisors.

The whole system can effectively realize the real-time and remote monitoring of the orchard environment, and the real-time monitoring of the temperature and humidity parameters at each time point [18] And to alarm the parameter values above the specified upper and lower limits to prompt the farmer to operate accordingly.

Ⅱ. SYSTEM REQUIREMENTS ANALYSIS AND OVERALL DESIGN

China has been a major agricultural country since ancient times [19] Moreover, the rapid development of Internet of Things technology and computer science and technology provides technical support for the realization of agricultural informatization and intelligence. Based on the characteristics of incomplete and untimely information collection in the process of traditional agricultural production, the application of the Internet of Things technology in agricultural planting makes the development of modern agriculture produce a qualitative leap once again. Therefore, by combining the characteristics of NB-IoT technology and computer software and hardware, we propose a new orchard multiparameter acquisition system based on NB-IoT.

Based on the above situation, the system aims to realize the real-time unattended monitoring of the temperature, humidity and light in the orchard environment [20]. Its advantage is to ensure the timeliness and accuracy of the temperature and humidity and light intensity parameters collection, so as to provide users with more convenient and effective services, improve the production efficiency of the orchard, and realize the standardization and intelligence of the orchard management. The overall design scheme of the system is shown in Fig. 1

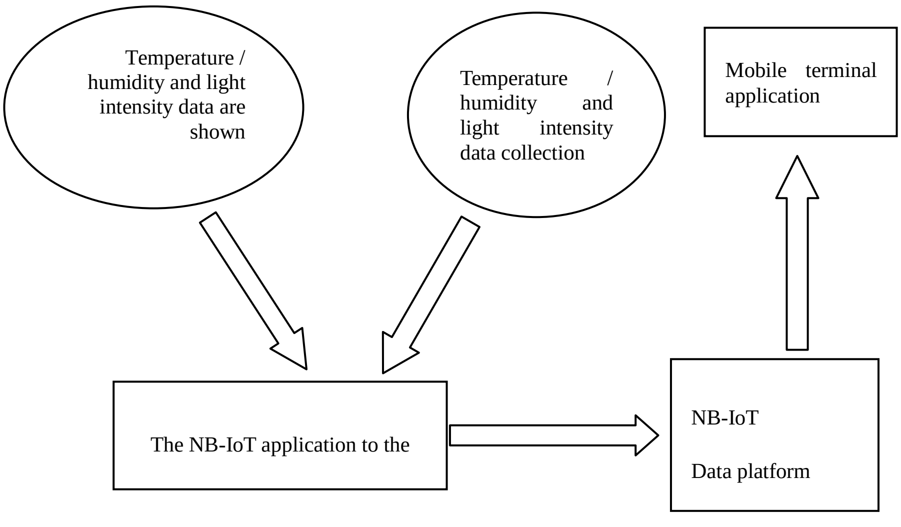

Fig. 1 The system framework

In order to effectively monitor the temperature, humidity, and light intensity of the crops in the orchard, the system uses the parameter sensor on the single-chip computer, stores the collected data in the NB-IoT data platform through the NB-IoT technology, and uses the buzzer and LED lamp to present the sound and light effect of the alarm when the overvalue data appears[21]Finally, it can remotely observe on the mobile terminal and operate the upper and lower limit thresholds to achieve the purpose of environmental monitoring.

The main body of the system is composed of STC89C52 microcontroller, DH T 11 temperature and humidity sensor, LCD display module of model LCD1602, buzzer alarm, Bluetooth module, key system, GM205 photostor, and excessive indicator display module.
The block diagram of the system design is shown in Fig. 2:

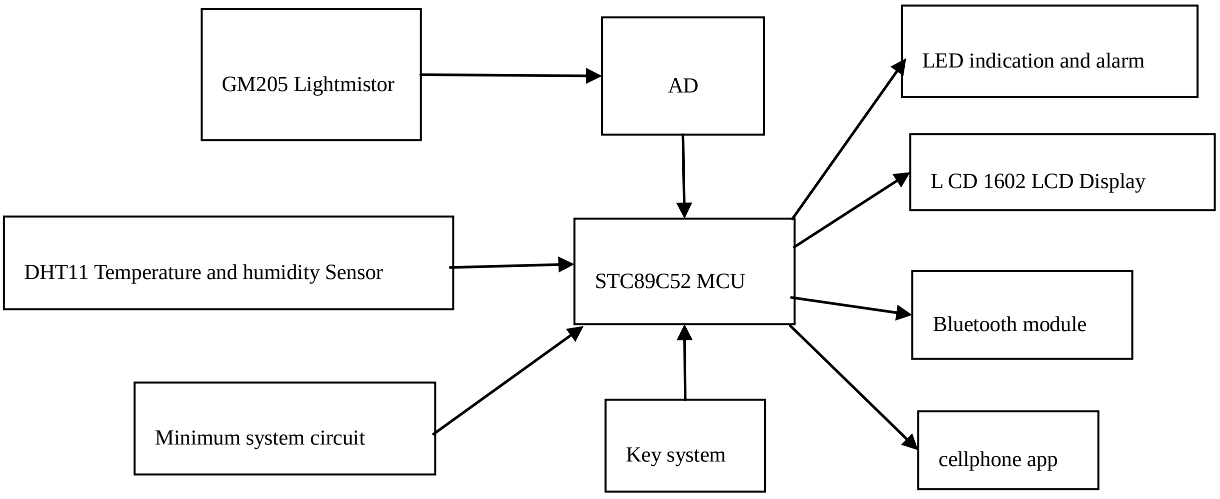

Fig.2 System block diagram

TheNB-IoT network system architecture is shown in Fig. 3:

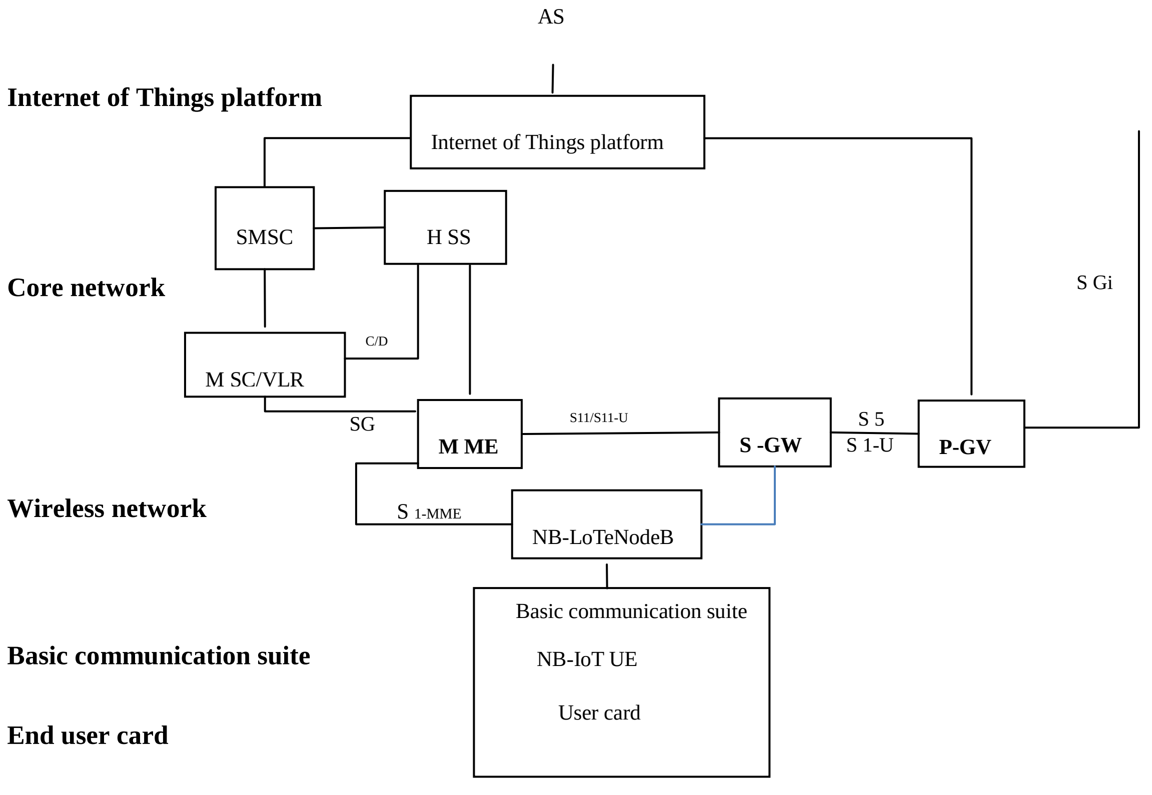

Fig.3 System Architecture

The basic structure of the network includes the wireless access network (E-UTRAN), the core network, the service platform, the application servers, the basic communication terminals, and the suite and the user cards.

Corenetwork [23]. It is mainly divided into user database (Home Subscriber Server, HSS), packet domain core network and circuit domain core network. The functional units of the packet domain core network mainly include mobile management entities (Mobility Management Entity, MME), service gateway (Serving Gateway, S-CW) and PDN Gateway, packet data gateway (P-CW), realizing packet data transmission and open capability. Circuit domain core network [24]. The functional units are mainly Short Message Service (SMSC) and mobile service switch Mobile switching Center / Visiting Location Register (MSC/VLR), which can realize SMS transmission.

Ⅲ. HARDWARE DESIGN

The design is applied to the acquisition of orchard parameters, and the hardware is divided into five modules: main control circuit, detection circuit, AD conversion circuit, alarm circuit and liquid crystal display circuit. This chapter mainly introduces the design implementation of these five parts and the completion of the PCB diagram.

The schematic block diagram of the hardware circuit is shown in Fig. 4:

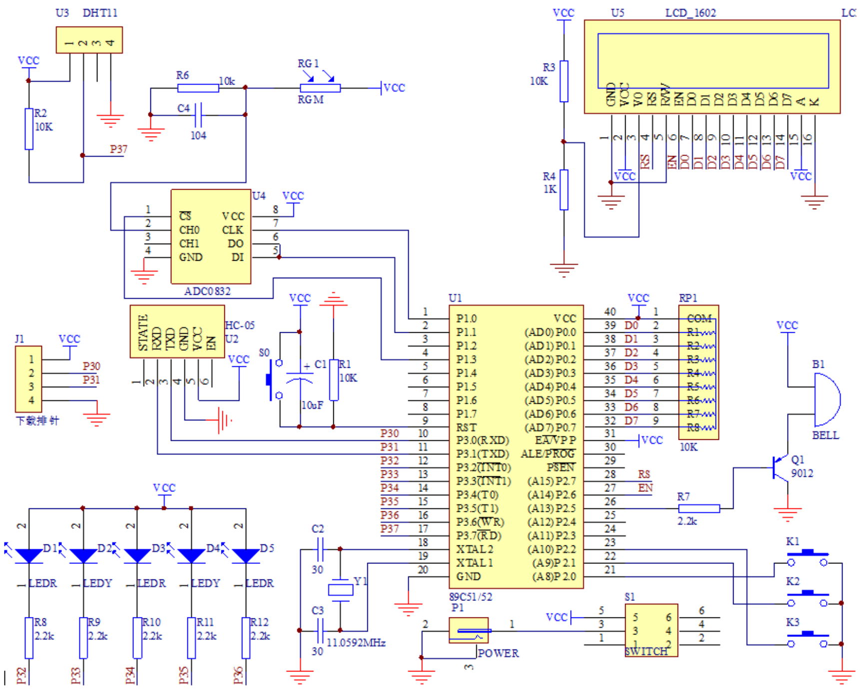

Fig.4 Hardware circuit simulation diagram

MAIN CONTROL CIRCUIT DESIGN

The main control circuit STC89C52 acts as a CMOS8-bit microcontroller. For a single chip, there is an 8-bit CPU whose Flash is capable of writing code. Based on the above description, this microCM will be preferred in many demanding applications. It haslow power consumption, high performance, 8K byte system and programmable Flash memory. Compared to the 8051 SCM, the two used by the syntax and instruction code are the same, and can arbitrarily specify the cycle of its clock. User's application space is 8K bytes. There are 32 general I / 0 ports, after reset: P1/P2/P3/P4 is quasi-bidirectional / weak pull: P 0 port is the drain open circuit output, without the drag resistance, as the bus extension; plus, the pull resistance, as I/0 port. The operating temperature range is: -40 ~ + 85℃, which fully fits the production environment of the orchard.

Compared to A T89C52 microU[26], AT89C52 does not have an ISP download feature and must use a download device, while STC89C52 is able to download with a USB connected to the STC manufacturer. The STC89C52 can be programmed with a low 5V voltage to work properly, but the AT89C52 cannot do this requirement. So using STC89C52 in one system works fine and using AT89C52 cannot.

The main functions of S TC89C52 are shown in Table 3-1, and the pin map of S TC89C52 is shown in Fig.6.

Fig. 5: Main functions of STC89C52

Main functions and features	
Compatible with the MCS51 instruction system	4K can be repeatedly erased by Flash ROM
32 Bidirectional I / O ports	256x8bit Internal RAM
Three 16-bit programmable timing / counter interrupts	Clock frequency of 0-24MHz
2 Serial interruptions	Programmable UART serial channel
2 external interrupt sources	A total of 6 interrupt sources
2 Read and write interrupt mouth lines	Level 3 encryption bits
Low power idle and off mode	The software sets up the sleep and wake-up functions

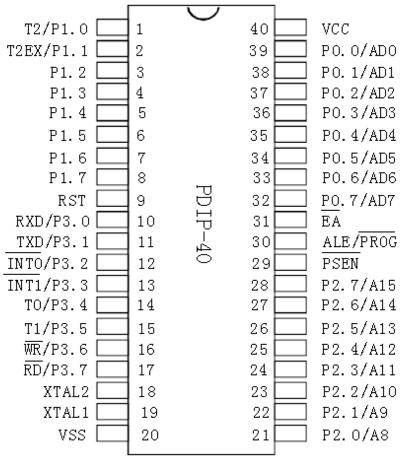

Fig. 6 The STC89C52RC pin diagram

STC89C52 has ROM/EPROM, so it can form a reliable, simple minimal system. The composition of the minimum system can be realized by completing the clock circuit and the reset circuit of the STC89C52, whose structure is shown in Fig. 7:

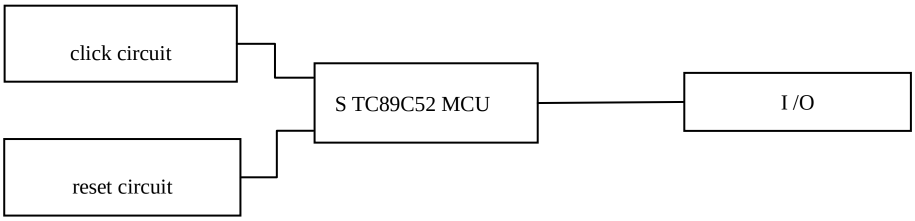

Fig. 7 Clock circuit reset circuit structure

The minimum system consists of the S TC89C52 clock, power supply, reset and these circuits [27]can ensure the normal operation of the system. Clock and power supply are essential in the process of S TC89C52 operation, and the minimum system can therefore become an important part of the application system. By extending it to A / D, the system can do relatively complex work.

1.Reduction Circuit

If there is a crash or if you want to restart the measurement, there must be a circuit to reset. The function of the 10u F capacitor is that the capacitor can be charged when the reset button is pressed, so as to form a pull-down resistance, a high-level output, and the program can be reset operation. In general, the capacitor is used as a low level output. The reset circuit is shown in Fig. 8:

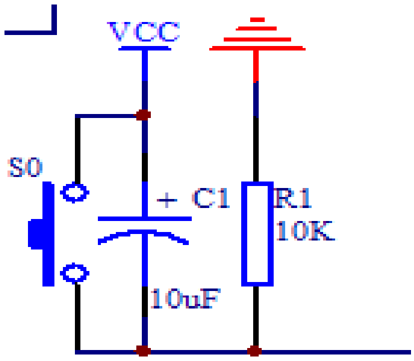

Fig. 8 Reset circuit

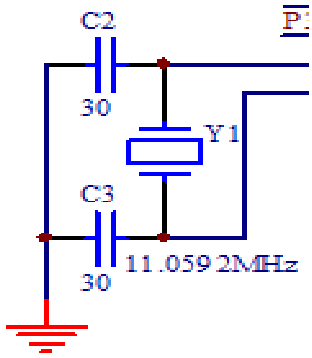

Fig. 9 Crystal vibration circuit

2.Clock Circuit

There are two ways used to generate clock signals: internal clock, and external clock. If the crystal vibration circuit cannot provide the clock signal required for operation, the operating state of the MCU will be affected. The Bluetooth module is used in the hardware, so the wave rate of 9600 is used for window communication. As shown in Fig. 9:

Ⅳ. TEMPERATURE AND HUMIDITY AND LIGHT DETECTION CIRCUIT
INTRODUCTION OF TEMPERATURE AND HUMIDITY DETECTION CIRCUIT

The DHT11 is an integrated temperature and humidity sensor with a moisture-sensing resistance and the NTC temperature measurement elements [28]and can be directly connected through the port and the 8-bit MCcontroller.It has the function of temperature, humidity detection and parameter collection, and makes the device particularly reliable and stable. Simply connecting to the MCU can collect the temperature and humidity in real time, and transmit the temperature and humidity data to the MCU at one time. Its measurement range is 20% to 90% R H, and 0℃ to 50℃.While the temperature measurement error is- \ + 2℃, and the wet measurement error is- \ + 5%RH.verifying the collected parameters can ensure the transmitted data more accurate and reliable to the maximum extent. The DHT11 has an extremely low power consumption and has a maximum operating current of 0.5mA at a 5V voltage operating environment. Due to its low cost, stable work and fast response speed, it meets the design requirements of the system.
Physical maps and pin maps of the DHT11 sensor are shown in Fig. 10:

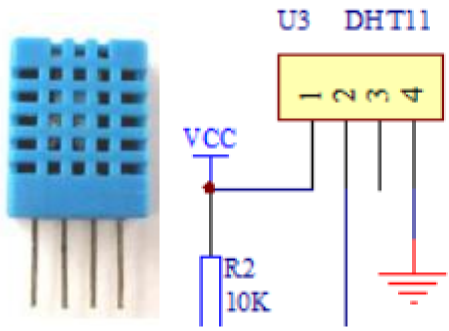

Fig. 10 DHT11

The first pin is connected to the positive power supply; the second pin is as the data end and can connect the MCI/O port; the third pin is as the empty pin; the fourth pin is as the ground end. To improve the stability, the stability can be improved by the upper pull resistance between the data side and the positive power source.

INTRODUCTION OF THE LIGHT DETECTION CIRCUIT

The G M205 photostor is very small[29], Using epoxy resin for packaging, with extremely high reliability and reaction speed. This resistance is an excellent choice for light acquisition.Photomistor is made of semiconductor material, different light intensity will change the conductivity of the device, it is based on the photoelectric effect. The maximum voltage was 150 V-dc, the spectral peak was 540nm, and the response time usually rose to 20ms and decreased to 30ms.The positive and negative electrode comb can increase its sensitivity.
The circuit diagram of photomistor is shown in Fig,11 and Fig. 12:

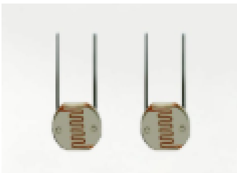

Fig. 11Photomistor

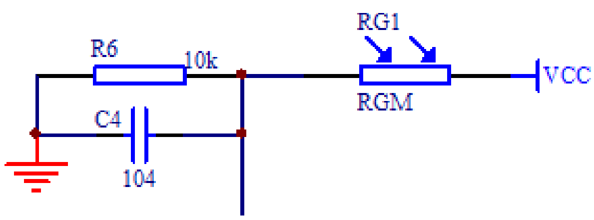

Fig. 12 Construction of photomistor

The alarm circuits

The light alarm is controlled by the LED flashing [32] Under normal conditions, the LED does not emit light. If the temperature exceeds the upper limit, the D1 red light and the D2 yellow light; when the humidity exceeds the upper limit, the D3 red light is below the lower limit and the D4 yellow light when the illumination exceeds the threshold limit.

The circuit diagram is shown in Fig.13:

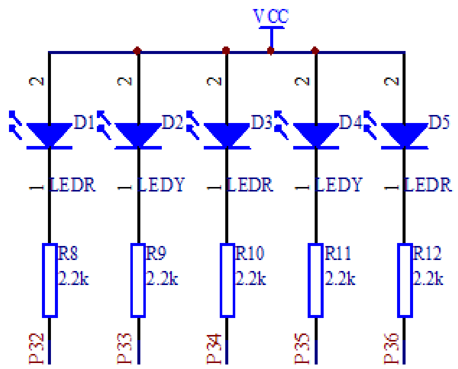

Fig.13 Light alarm circuit

The buzzer in the system [33] The positive electrode is connected to the tertiary tube collector, the negative electrode is grounded, the triple emitter is connected to the high level, and the base electrode is connected to the 21 feet of the single chip. If the base is extremely low, the alarm is raised, but not otherwise. This controls the audible alarm circuit.
The circuit diagram is shown in Fig. 14

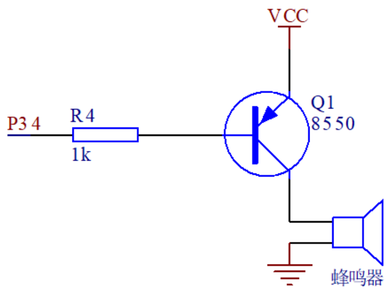

Fig. 14 Sound alarm circuit

SOFTWARE DESIGN

The software design part of the system is designed based on the C language, including the main program, the A D conversion program, the data conversion program, and the display program.

Main program, flow chart

The software work steps are mainly as follows: First, initialize the flag bits, pins and variables in the CM used. After the initialization procedure is completed, the three parameters of temperature, humidity and light intensity collected by sensor and photomistor are converted into voltage value through AD[36]Then the voltage value calculation is converted into decimal data is sent to the single chip computer buffer, and finally the temperature and humidity and light intensity values of the buffer are taken out and displayed, and the whole process of the program is over.
Flow chart is shown in Fig. 15:

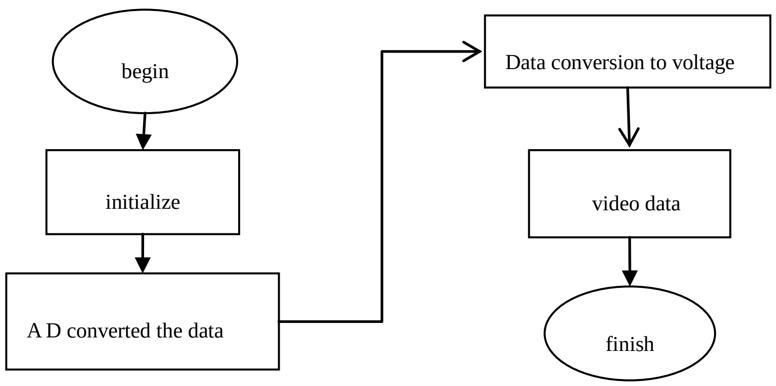

Fig. 15 Flow chart of the main program

Flow chart of the data conversion program

The digital signal to be used by the microcontroller is transmitted through a certain line, so it is necessary to convert the digital signal into analog signal, and finally convert the analog signal into digital signal. So you need to convert the AD through the data conversion circuit[38]The resulting voltage value is converted into a decimal analog signal and stored in the MCU buffer for direct extraction when display.
The entire flow chart of the data conversion circuit is shown in Fig. 16

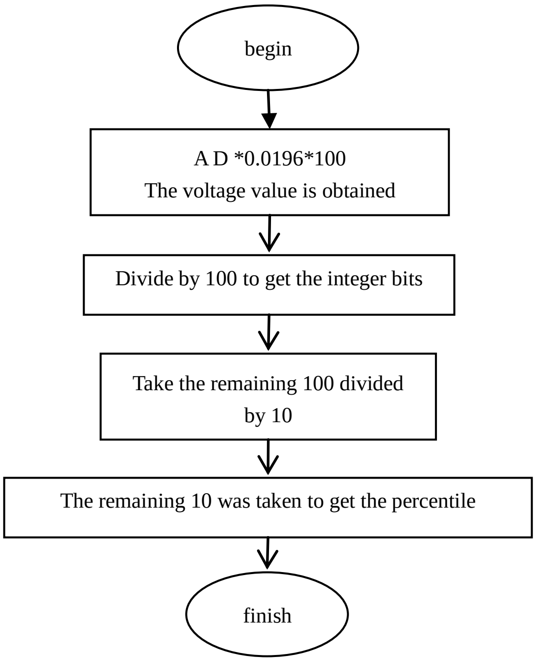

Fig. 16 Electrical circuit of pumps

V. TESTRESULTSANDANALYSIS

Through the design of software and hardware, the chip and the chip supply, LCD screen bright, indicating the normal power supply, through the K ILL4 editing program [40] Download the program to the master control chip, and run in an environment with the appropriate voltage, to detect whether there is a short circuit in the MCU and each module. If there is no such problem, the S TC89C52 will be connected to the MCU.After completing the design, the system will debug and analyze the system. The hardware circuit of the whole system downloads the APP on the mobile terminal, adjusts the threshold limit of the system through the A PP, and obtains the currently collected parameters in real time, and prompts for exceeding the parameters when the threshold limit is exceeded.

Before starting commissioning, first turn on the power switch and check that the circuit is smooth. The LCD screen then displays the current parameter value. Press the menu button to switch the interface to modify the threshold operation [41], Then it can be modified by pressing the key.
After opening the mobile A PP and CM, the sensitivity is detected and tested as follows:
First, the display and hardware display of the mobile APP are shown in Fig.17:

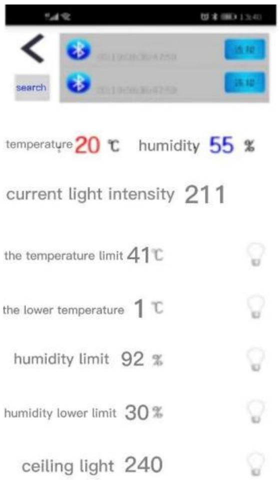

Fig.17 Mobile phone app interface

Second, the change of the upper and lower threshold limits of the mobile phone APP and the alarm when the parameters exceed the standard, as shown in 18:

Fig.18 Change of the upper and lower APP threshold value

Third, the detection value pairs at different times of the day are shown in Fig.19:

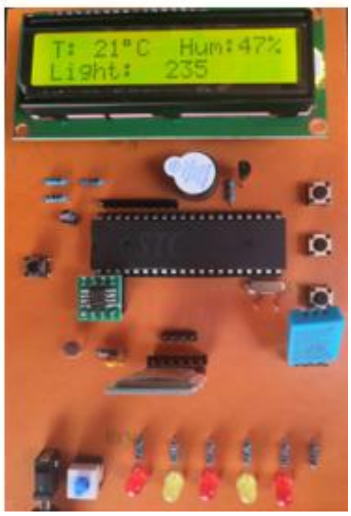

Fig.19 Comparison of detection values across different times of the day

Through repeated detection of the system, we can see the function of parameter acquisition basic implementation, combined with N B-I o T technology can well implement real-time transmission orchard parameters, and upload to the cloud server, make growers can better understand their orchard environment, in order to make timely adjustments to improve the environment, improve the yield of fruit trees, better cultivate high quality fruit. For our life, we can enjoy the convenience of scientific and technological achievements.

VI.CONCLUSION

This system combines N B-I o T technology, Bluetooth transmission module, sensor and single-chip computer to build a complete set of orchard multi-parameter acquisition system, design the main modules of the system: main control circuit, temperature and humidity and light sensor, NBIOT and alarm circuit selection, complete the construction of the hardware platform; Completed the program design of the system software, including the flow chart of the program, and finally debug the system, through the data comparison of different time periods, the alarm beyond the threshold and the mobile terminal control of the upper and lower threshold is worth the feasibility of the scheme. The system operation is stable, the collected parameters are accurate, and can promote the development of improving the economic benefits and production efficiency of the orchard.

Acknowledgment: this work was supported by Science and Technology Project of Henan Provincial Science and Technology Department (Granted No:212102310553,222102210116), and the Ministry of Education industry and education cooperation and collaborative education project (Granted No:202101346001).

Reference

[1]. Huang Xiuli.[2020] "Design and Implementation of a Smart Home Fire Alarm System Based on STC89C52 and GSM" Electronic Test, Issue 5: pp.25-27.

[2]. Zhou Wanyu, Hu Nairui, Maggie Yang, et al.[2020] Design of greenhouse Environmental monitoring and control system .Electronic Testing, Issue 5, pp.45-47.

[3]. Zhang Wenjing.[2020] Design and implementation of intelligent street lamp control system based on photomistor .Hebei Agricultural Machinery, Issue 2, pp.55.

[4]. Sun Yanjing, Feng Tianxin, Li Song, et al.[2020] "Experimental technology and management of low-rate Monitoring Internet Application Experimental System Based on NB-IoT", Vol.37: Issue3, pp.95-98.

[5]. Yin Zhifeng.[2020] Temperature monitoring system based on Internet of Things technology in facility gardening .Agricultural Development and Equipment, Issue3, pp.84-86.

[6]. Zeng Yanjun, Li Yue, Longwen, et al.[2020] Design of a data-fusion intelligent fire protection system based on NB-IoT and STM32. Vol.10: Issue1, pp.77-82.

[7]. M. LI. [2020] “Internet of Things Technology” Modern Electronic Technology, Vol.43: Issue7, pp.187.

[8]. Xu ZhongSunXiansong., [2020] "Design of Environmental Temperature and Humidity Monitoring System based on NB-IoT ".Internet of Things Technology, Vol.10: Issue2, pp.20-22.

[9]. Wu Zhu, Cui Zhongwei, Zhao Yong, et al. [2020] “Design and implementation of the Web APP” Internet of Things Technology, Vol.10:issue2, pp.29-32.

[10]. Zhu Xingbing.[2019] “Research on Remote Monitoring System of Laser Processing Equipment Based on NB-IoT Technology”.Huazhong University of Science and Technology HUST.

[11]. Zhang Kai.[2020] “Wireless Bluetooth Transmission design based on STM32” Internet of Things Technology, Vol.10: Issue3, pp.40-41+44.

[12]. Yu Gang. [2019] “Application and Development trend under the narrowband Internet of Things” Information and Computer (Theory edition), Vol.31: Issue23, pp. 141-142+145.

[13]. Guo Lingzhi. [2019] “The Design and Implementation of the Water Quality Monitoring System Based on NB-IoT” Anhui University of Science and Technology.

[14]. Gao Yan. [2018] “Design of Environmental Control System Based on MicroCM” Wuhan University of Light Industry.

[15]. Jaeyel Lee,Zugang Mao,Kai He, et al. [2020] “Grain-boundary structure and segregation in Nb 3 Sn coatings on Nb for high-performance superconducting radiofrequency cavity applications” Elsevier Ltd.pp.188.

[16]. Wang Hao. [2020] “Key processes for NB-IoT. Science and Technology Innovation”, Issue 13: pp.24-27.

[17]. AiminYang,HuixiangLiu,Yongjie Chen, et al. [2020] “Digital video intrusion intelligent detection method based on narrowband Internet of Things and its application” Image and Vision Computing.

[18]. Cavo Luis,FuhrmannSÃ©bastien,Liu Liang. [2020] “Design of an area efficient crypto processor for 3GPP-LTE NB-IoT devices” Microprocessors and Microsystems. Vol.72: IssueC.

[19]. MediaTek Inc. [2020] " Patent Application Titled "User Equipment Group Wake-Up Signal In NB-IoT" Published Online (USPTO 20200053645) “Telecommunications Weekly.

[20]. Engineering; [2020] “An Enhanced Random Access Algorithm Based On the Clustering-reuse Preamble Allocation In Nb-iot System” Journal of Mathematics.

[21]. Hua Lei. [2020] Research on Soil and Water Conservation Smart Agriculture in Loess Hilly Area. University of Chinese Academy of Sciences (Research Center for Soil and Water Conservation and Eco-Environment, Ministry of Education, Chinese Academy of Sciences).