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Design of Multi-sensor Monitoring System for Baijiu Fermentation Process

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Abstract

The fermentation process is very important for the entire Baijiu production. During the fermentation period, various substances ebb and flow. These substance components have an important effect on the taste and taste of the final wine. Therefore, the monitoring of the parameter indicators during the fermentation process helps people understand in time. The fermentation situation is extremely important. Based on ZigBee and Wi-Fi technology, this paper designs an automated monitoring system for fermentation parameters, uses modern industrial Internet of Things and sensor technology to monitor O2, CO2, humidity and temperature in the pit environment online, and develops and designs Android APP at the same time. And PC visualization software allows people to understand the situation in the pit at any time.

Keywords

ZigBee, Multi-sensor monitoring, Baijiu fermentation, Android, VB, Wi-Fi.

1. Introduction

At present, most of the traditional brewing process of Chinese Baijiu is manually operated. The labor density is high, the production efficiency is low, and the degree of uniformity, standardization, automation and digitization of the production process is generally not high, especially in today's modern society with increasing labor costs. Traditional production technology has shown more and more disadvantages[1]. The fermentation process of Baijiu is extremely complicated. With the passage of time, what kind of change will occur in the content of the mash in the pit, what are the factors that affect the change, etc., without a more scientific statistics, it is impossible to grasp. Even use these factors to improve the quality of Baijiu, so as to obtain higher corporate benefits. By establishing a multi-sensor monitoring system, people can understand the fermentation process in time. Timely discovery of the changes in various ingredients in the mash is a prerequisite for controlling and regulating the production method, reducing the waste of raw materials and brewing better quality Baijiu[2].

2. Hardware Design

2.1. Overall Design

During the fermentation process, the pit is a closed environment containing various complex chemical components, and the monitoring system cannot affect the normal fermentation. Therefore, the selection of oxygen sensor, carbon dioxide sensor, humidity sensor and temperature sensor, and the reliability of data transmission need to be fully and reasonably considered.

This design uses the classic ZigBee tree network topology. The entire multi-sensor fermentation parameter intelligent monitoring system is mainly composed of ZigBee

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temperature data collection node, data transmission, data visualization terminal and other parts. After collecting the pit data, the terminal node sends the data to the router, which is forwarded to the coordinator, or directly to the coordinator device. Then the coordinator prints to the ESP8266 Wi-Fi module through the serial port, and the module sends an HTTP POST request to store the parameters to the database. The staff can consult, count and analyze the data, so as to realize the online collection, monitoring and analysis of the pit data. The overall system architecture is shown in Figure 1.

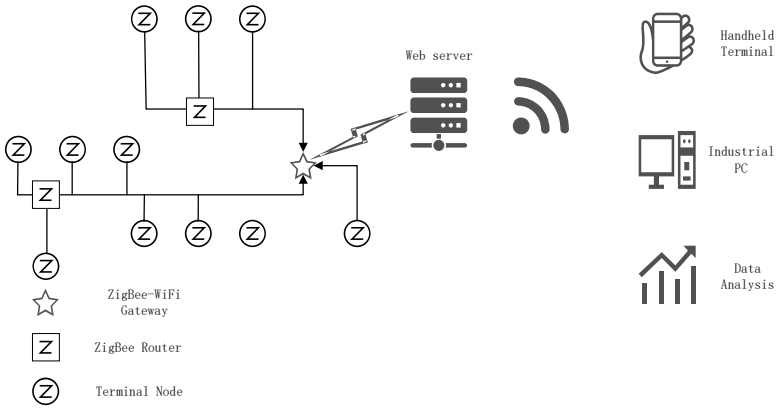

Figure 1: Schematic diagram of overall system structure

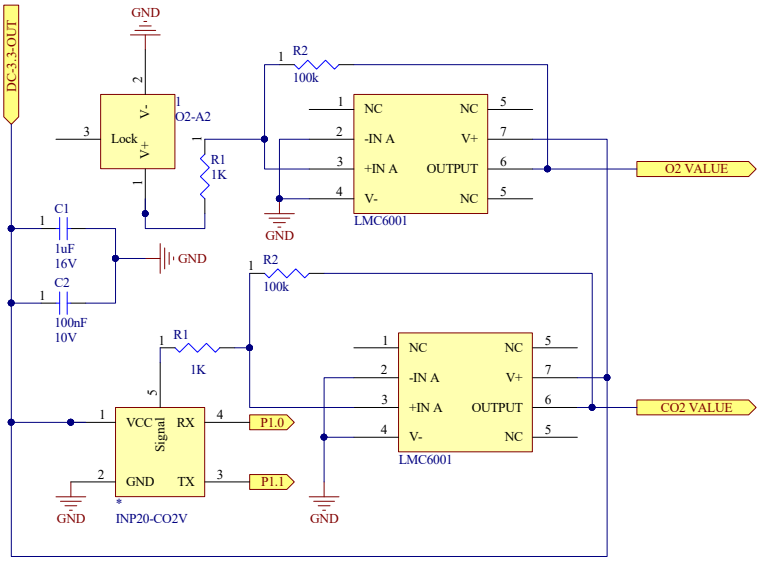

Figure 2 Circuit diagram of oxygen and carbon dioxide sensor

2.2. Data Collection Terminal

2.2.1. Master Chip

Considering the reliability, cost and difficulty of networking, CC2530 ZigBee chip is selected. CC2530 is a SoC (System on Chip) solution for IEEE802.15.4, ZigBee and RF4CE applications launched by TI. This article uses the E18-MS1PA1-IPX module independently produced by Chengdu Ebyte Electronic Technology Co., Ltd. This module uses CC2530F256 core processor and CC2592 power amplifier chip, which can build a sufficiently strong ZigBee network at a very low cost[3].

2.2.2. Oxygen and Carbon Dioxide unit

The oxygen sensor adopts Alphasnse's electrochemical O_2-A_2 high-precision sensor. The resolution and accuracy can reach 0.01%Vol and±1%FS under the range of 0-30%Vol. Carbon dioxide uses NET's INP20-CO2V-EXVSP carbon dioxide infrared sensor using non-dispersive

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(NDIR) infrared technology to detect carbon dioxide and hydrocarbons [4].Although the detection principles of the two sensors are not the same, they ultimately convert the concentration of the detection volume into a weak current signal output through a series of processes. Therefore, only the current size needs to be read through the MCU to know the gas concentration. The circuit diagram is shown in the figure. Shown.

The LMC6001 mainly contains an operational amplifier. The determination of the resistance of the Rf feedback resistor and the R1 sampling resistor is the key to determining the current amplification factor. The operational amplifier's multiple A can be calculated by the following formula (1):

$$A = \frac{R_f}{R_1} \tag{1}$$

The average output current of the sensor is 80 ~ 250uA, the detection voltage range is set between 0.8V ~ 2.5V, and the amplification factor is set to 100 times. From this, the voltage value on the sampling resistor can be calculated as 8×10^{-3}V.

$$R_1 = \frac{8\times10^{-3}V}{8\times10^{-6}A} = 1000 \tag{2}$$

According to formula (2), it can be determined that the resistance value of R1 is 1K ohms, and the feedback resistance is 100K ohms. It should be noted that these two resistors are required to be high-precision resistors and cannot be replaced by general resistors.

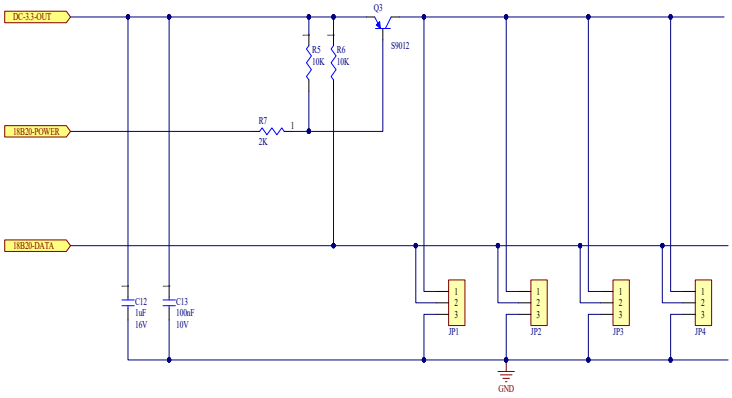

Figure 3 Single bus DS18B20 acquisition circuit

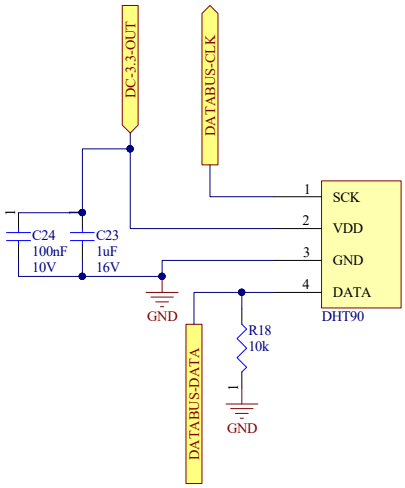

Figure 4 Circuit of Humidity sensor module

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2.2.3. Temperature Module

DS18B20 adopts single-bus communication mode. For multi-point temperature measurement circuit, the data bus of each sensor can be serially connected to a data line. When reading, it can be identified by the globally unique 64-bit ROM code in the chip. It greatly saves the limited IO port resources of the CC2530, and controls the sensor power enable through the transistor. Figure 3 shows the temperature acquisition circuit.

The single-chip microcomputer only needs to simulate the I^2C timing sequence through the single-chip microcomputer program according to the I^2C communication protocol given in the data manual to read the sensor value.

2.3. Gateway Transmission

Since the ZigBee router is only responsible for data forwarding, its circuit configuration only requires the CC2530 minimum system, radio frequency wireless circuit and power supply circuit. Therefore, the redundant function circuit of the terminal node does not need to be welded, and constitutes the ZigBee router and the coordinator, so I will not introduce too much here. The coordinator gateway device uses the terminal node to retain the minimum working system and then connects the ZigBee protocol to the TCP/IP protocol to access the Internet server through the serial port and the ESP8266.

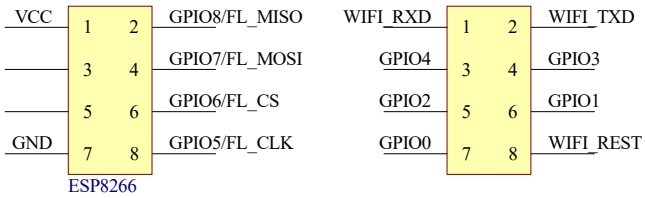

Figure 5 ESP8266 wiring diagram

3. Software Module

3.1. Android APP

The original meaning of the word Android refers to "robot", and it is now well known as an operating system for smart phones. Android system is a free and open source operating system based on Linux system[5].

3.1.1. Login Interface

The user name and password are stored in SharedPreferences, which is a lightweight data storage method. Through SharedPreferences, NVP (Name/Value Pair, name/value pair) can be saved to the Android file system, and it shields the file system The operation process of NVP can be easily realized by saving and reading the NVP only through the functions provided by SharedPreferences.

3.1.2. User Filtering and Display Module

In this part of the filter bar, place a LinearLayout vertical layout, and then divide it into multiple parts, and then put a TextView and ImageView in each part, and then listen to the click event of each part. For this part of the filter bar, use CheckBox, and you can easily complete the style change by setting the selector. You only need to manage the state of the CheckBox. For the pop-up box, customize a PopWindow control. Complete related processing by monitoring the changes of popWindow. The filtered data is processed by the web background program, calling the SQL query statement, and then returning the data to Android.

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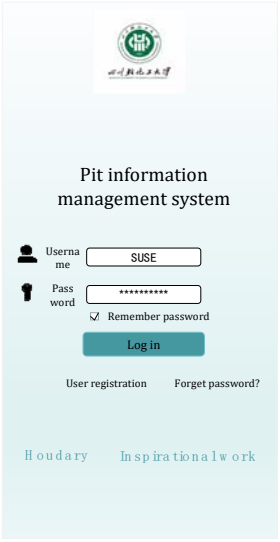

Figure 6 APP login interface

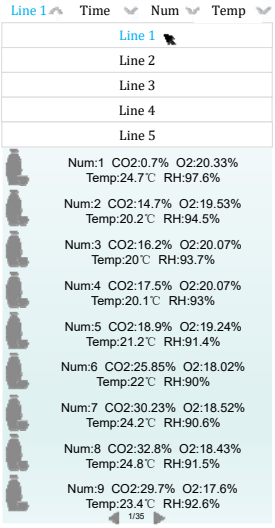

Figure 7 Android filtering function and data display interface

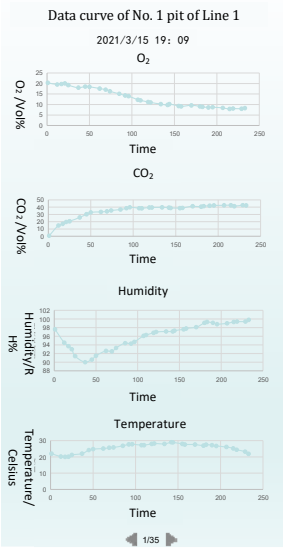

Figure 8 Android historical data curve display interface

At the same time, click on a certain pit to enter to view the detailed pit historical data changes. The system will automatically record the parameter information during a fermentation cycle

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and draw it into a graph, so that people can understand the previous fermentation situation more intuitively and the curve display The interface is shown in the figure below.

3.2. VB Visualization unit

Visual Basic is a general object-based programming language developed by Microsoft. It is a structured, modular, object-oriented, visual programming language that includes an event-driven mechanism that assists in the development environment. It is a language that can be used for the development of Microsoft's own products[6].

3.2.1. Data Collection

The most common way to connect VB and SQL Server is to connect through the ADO control. The ConnectionString property of the ADO control can be directly connected to SQL Server. This property contains a string of argument=value statements to establish and specify a connection to a specified data source. parameter.

3.2.2. Real-Time Monitoring

The main function of the display monitoring interface is to view the data by selecting the production line, pit number and fermentation cycle. The main controls used are Mschart control to draw the data change curve, PictureBOX control to insert pictures, ComboBox to realize the filter box function, Button button to submit data, Label label function description.

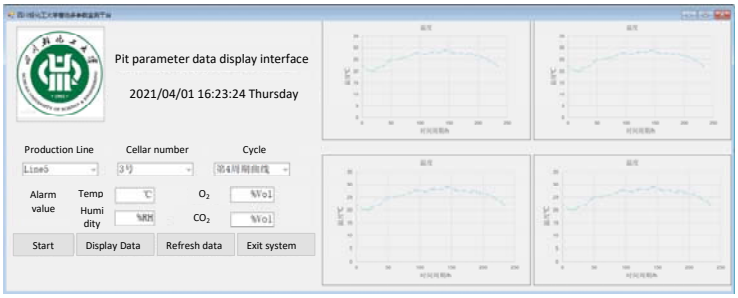

Figure 10 Data display interface on PC

4. System Test

4.1. Circuit Test

In the process of power discharge, ripple is an important parameter for judging the quality of the power supply design, and the peak-to-peak value can be used to express the magnitude of the ripple. Ripple is very harmful in practical applications. Stronger ripple will produce surge voltage or current, which may burn circuit components. The size of the ripple can be monitored through an oscilloscope.

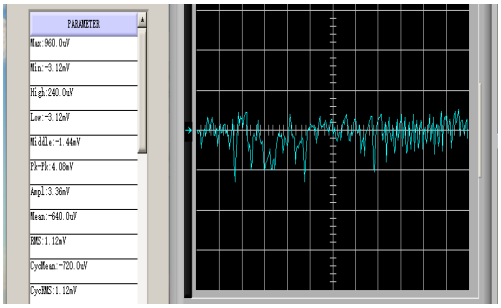

Figure 10 Circuit board ripple test parameters

The actual test 3.3V DC output Pk-Pk value is 4.08mV, which is only 0.1% of the output voltage, which is much lower than the standard value of 1%, which can ensure accurate collection and reliable transmission of pit data.

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4.2. System Integration Test

Through the actual fermentation test, the sensor collects the temperature, humidity, carbon dioxide and oxygen data, and by calling the Matlab Plot function to put the 4 parameter scatter plots together to compare, you can more intuitively see the change process and trend of each component. The abscissa is time, the ordinate is the content value and temperature value.

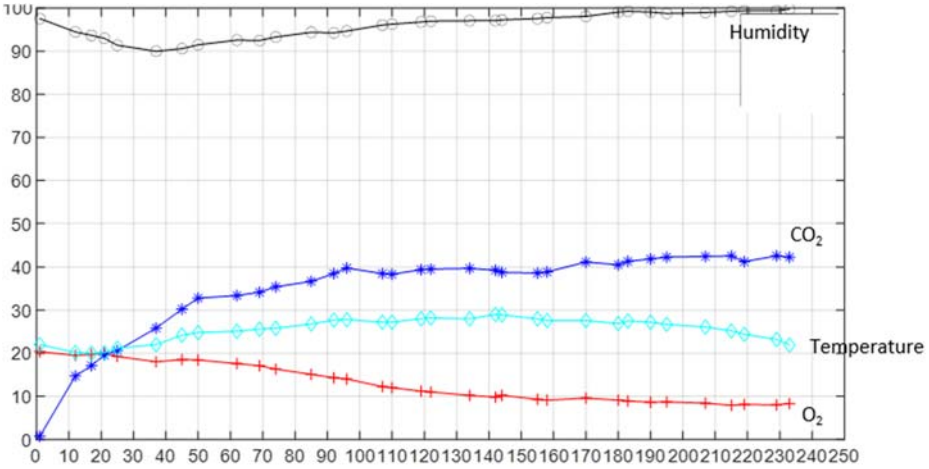

Figure 11 Scatter diagram of fermentation parameters

It can be seen from the figure that the oxygen content has been decreasing during the fermentation process, while carbon dioxide and oxygen have an obvious negative correlation. The whole process has been rising. The temperature index first rises slowly and then stabilizes for a long time. , And finally slowly decline. The humidity parameters and temperature change trends are roughly the same. At the end of the fermentation, the environmental humidity is close to 100% RH.

5. Conclusion

In summary, this article uses the high-performance E18-MS1PA1-IPX ZigBee wireless module as the main control chip to complete the design of data acquisition, data transmission, data storage, fitting analysis, and the characteristics of discharge ripple and system integration reliability. The actual verification was carried out and the expected effect was achieved. According to the process of liquor fermentation and actual demand, it can be flexibly improved, which has the application value of large-scale promotion.

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