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Design of intelligent dishwasher control circuit based on 51 SU

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Abstract: With the acceleration of the pace of modern urbanites, the requirements for dishwasher is more towards the functional direction. People hope that the dishwasher can realize the function of automatic and fast cleaning of the tableware, and the intelligent dishwasher arises at the historic moment. This design is an intelligent dishwasher based on the 51 single chip computer. There are three washing modes, etc. the whole process is automatically completed by the intelligent dishwasher, and the user only needs to set the mode. If the water level is too high, it will be alerted to remind the user, and the working status information of the intelligent dishwasher can be displayed. The system has low cost, simple structure, stable work, the use of less devices, to realize the intelligent dishwasher intelligent control, can meet the different needs of users, has a certain practical value.

1. The development of smart dishwasher at home and abroad

In Europe and North America, the dishwasher market is quite mature, and new technologies are constantly being used in the products. In terms of cleaning results, some high-end dishwashers use advanced high-pressure spray technology and ultrasonic cleaning techniques that can more effectively remove stubborn stains and ensure tableware cleanliness. In addition, the hydroxide ion cleaning technology has also been introduced, which uses the strong oxidation of the hydroxide ions to decompose the dirt, so as to achieve a better cleaning effect. In terms of energy conservation and environmental protection, many brands are trying to reduce the energy consumption of dishwashers. Intelligence is another important direction that the dishwasher develops. Users can remotely control the dishwasher through a smartphone app, and even automatically adjust the cleaning program according to how dirty the tableware is. Voice control technology has also been introduced into the dishwasher, where users can control the operation of the dishwasher through voice commands, making it easier to use.

However, in China, the research of dishwasher started late, and the market development is relatively slow. At present, the domestic dishwasher market is mainly occupied by imported brands and domestic brands. Domestic brands still need to strengthen in technology research and development, mainly focusing on improving the cleaning effect, reducing the sound, improving durability and other aspects, but the attention and investment of intelligent dishwasher has been greatly improved than before.

2. Characteristics and development prospects of intelligent dishwasher

Intelligent dishwasher, with its unique intelligent function, has brought the revolutionary change for the modern family life. Users simply need to put the tableware to be washed, open the water source, touch the start button, to leave, the dishwasher will automatically complete the whole washing process. Its strong decontamination ability and thorough disinfection function, to ensure the health and safety of tableware, effectively prevent the spread of disease. In addition, the intelligent dishwasher also has a humanized design, according to different washing needs, to provide a variety of washing modes, taking into account energy saving and environmental protection. Intelligent dishwasher not only improves the quality of home life, but also reflects the perfect combination of science and technology and daily life. China's smart dishwasher industry is an emerging industry, has been highly concerned by consumers, but also by the strong support of government departments, which has also attracted the attention of the market size and development trend of China's smart dishwasher industry. With the development of science and technology, the market size of China's intelligent dishwasher industry will continue to expand. According to the latest data, by 2025, the market size of China's smart dishwasher industry is expected to reach 76.5 billion yuan, up 93.8% year on year, the export volume is expected to reach 45.5000 units, the total export will reach 6 billion yuan, an increase of 93.1% year on year.

3. Main content of intelligent dishwasher system design

In the process of designing an intelligent dishwasher, the user can intuitively understand the working state and washing progress of the dishwasher through the LCD display module. The design of the key module allows the user to easily choose different washing modes, including intelligent washing, timing washing and quick washing, to suit different washing needs. The buzzer module acts as a reminder during the washing process, sounding an alarm when the water level exceeds the preset threshold or the washing time ends. The motor module is responsible for controlling the water inlet and outlet process to ensure the normal operation of the dishwasher. The water level simulation detection module and the turbidity simulation detection module can collect the water level and turbidity information in real time through the ADC0832 chip to provide data support for the intelligent washing mode[1]. During the whole washing process, the intelligent dishwasher will automatically adjust the washing time according to the turbidity percentage to achieve high efficiency and energy-saving washing effect. At the same time, users can set their own washing time according to the needs, to meet the personalized needs. Fast washing mode provides a fast and efficient washing solution, taking only 30 seconds to complete the washing task.

4. Circuit design of the intelligent dishwasher system

4.1 System overall circuit

In the designed intelligent dishwasher, the cooperative work of each module ensures the efficient operation of the device and the convenient operation of the user. The LCD module provides the user with an intuitive interface showing the working status of the dishwasher, the time left, and any error information that may occur. The module is designed to improve the user experience and ensure that users are abreast of the dishwasher. The key module allows the user to choose different washing modes, such as intelligent washing, scheduled washing, and quick washing. Each mode has its specific washing parameters such as temperature, time, and water flow to accommodate different washing requirements. The design of the keys is simple and easy to operate, ensuring that users can easily switch the washing mode. The buzzer module serves as a reminder in the washing process[2].

It sounds an alarm when the water level exceeds the preset threshold or the washing time ends. This design aims to increase users' safety awareness and avoid potential problems caused by forgetting to turn off the dishwasher. The motor module is responsible for controlling the water inlet and outlet process. It precisely controls the opening and closing of water flow by receiving signals from the control unit. The motor design ensures the stable operation of the dishwasher during the washing process, while saving water resources. The water level simulation detection module and the turbidity simulation detection module collect the water level and turbidity information in real time through the ADC0832 chip[2]. This information is crucial for smart washing modes because they determine the washing time and water flow. The design of these two modules ensures that the dishwasher can accurately detect the water level and turbidity, thus providing the optimal washing effect.

4.2 SCM minimum system board

In the design of the intelligent dishwasher control system, we use STC89C52 single microcomputer as the core processing unit. To simplify the hardware design[3], we chose the STC89C52 minimum system board with integrated crystal oscillator and reset circuit. The minimum system board provides stable clock source and necessary power management functions for MCCM[4], so that we do not need to design these parts independently. Only provide the appropriate power supply voltage to the system board to ensure the normal start and operation of the MCU. In addition, the minimum system board also has rich I / O interface and expansion capabilities[4], which is easy to connect and communicate with external sensors, actuators and other devices, and provides a solid hardware foundation for intelligent dishwasher intelligent control.

4.3 Simulation and detection design of turbidity and water level

Feet function:
CS: chip selection enabled, low level chip enabled
CHO: Analog input channel 0, or used as an IN + / -
CH 1: analog input channel 1, or used as IN + / -
GND: Chip reference voltage zero potential (ground)
DI: Data signal input, select channel control
DO: Data signal output, conversion of data output
CLK: chip clock input
Vcc: Power input and reference voltage input (reuse)

In the control system of intelligent dishwasher, ADC0832 analog-to-digital converter plays a vital role, responsible for converting the analog signal of water level and turbidity into digital signal for CM processing. According to the specifications of ADC0832[3], the standard interface configuration with MCU shall contain four data lines: chip selection signal (CS)[5], clock signal (CLK), data output (DO) and data input (DI). However, in practical application scenarios, DO and DI are not effective in the communication process, and the single chip interface has two-way transmission capability. Therefore, in the circuit design stage, we adopted the strategy of connecting DO and DI terminals in parallel to a single single chip data line[6]. This design scheme not only simplifies the hardware connectivity, but also ensures the accuracy and efficiency of data transmission. After the circuit design, we conducted a comprehensive evaluation of the circuit performance through a series of testing and verification procedures. The test results show that the circuit can accurately identify and convert the voltage signal in the range of 0 to VCC, when the voltage exceeds the VCC threshold, the AD value will enter a saturation state, that is, the value is fixed to 255. This feature ensures the stability and reliability of the circuit under various working conditions.Through this test validation process, we further optimize the circuit design and improve the overall performance of the system.

ADC0832 Is an 8-bit analog-to-digital converter, which can convert the analog voltage signal into a digital signal[5], so that the single-chip microcomputer for processing. In the interface design with MCU, four data lines are usually required: CS (chip selection signal), CLK (clock signal), DO (data output) and DI (data input). However, because DO and DI are not effective in the communication process, and the data interface of microcontroller is bidirectional, DO and DI can be used in parallel on one data cable. When designing the circuit, the circuit design needs to be conducted according to the ADC0832 chip manual and the requirements of this design. First, CS, CLK[7], DO (in parallel with DI) should be connected to the corresponding I / O port of the MCU. Then, provide proper power and ground connections for the ADC0832. The supply voltage shall meet the specifications of ADC0832 and the grounding connection shall be good to ensure the stability of the circuit. After the circuit design is completed, testing and verification are required. Test can verify that the function of the circuit is normal and whether the performance meets the requirements. If problems are found, they need to be adjusted and optimized in time. We ensure the reliability and stability of the circuit through verification. In practice, changes in water level and turbidity can be simulated by changing the resistance magnitude by rotating the potentiometer. Different resistance values correspond to different voltage signals, and the output value of ADC0832 will change accordingly. The output value of ADC0832 is converted into a percentage and displayed on the LCD screen[8]. In this way, the user can intuitively understand the changes in the water level and turbidity.

4.4 LCD display module

On the basis of analyzing the timing diagram, the process of operation 1602 liquid crystal can be summarized in the following steps:

First, it is determined whether to send commands or data to the LCD via the RS pin. If it is a command, for example controlling the display, flashing, move, or locating the cursor, the RS pin shall be connected to a low level. If it is data, that is, text or numbers to be displayed on the liquid crystal, the RS pin shall be connected to a high level. Secondly, the read and write control end is set to the write mode, that is, the RW pin should be connected to a low level. This step is intended to tell the LCD controller that we are ready to write the data or the commands. Next, send the data or command to the data line D0-D7. This step involves the transmission of the data, ensuring that the data is correctly transmitted to the liquid crystal controller. Finally, a high pulse was given to the E pin, usually at a high level lasting 1-2 microseconds. This high pulse triggers the LCD controller to write the data or commands to the internal memory, completing the write operation. The initialization of the LCD display, command writing and data writing all need to follow the above timing. In this design, we use the 1602 liquid crystal interface built into the 51 SU and simply connect the 1602 liquid crystal to the corresponding pin. By writing the corresponding program, we can display the working mode of the dishwasher, the washing remaining time, the water level, the turbidity and the washing status information on the 1602 LCD. In this way, the user can intuitively understand the working state of the dishwasher, and improve the convenience of the operation.

5. General design of software

Intelligent dishwasher is one of the essential equipment in modern family life, aiming to simplify the process of tableware cleaning and improve life efficiency. This design scheme details the three working modes of intelligent dishwasher: intelligent washing, quick washing and regular washing. Users can select the appropriate washing mode by pressing the button according to the actual needs.

In the intelligent washing mode, the dishwasher will automatically detect the dirt level of the tableware, and optimize the washing cycle and water volume according to the preset algorithm to achieve efficient cleaning. Fast washing mode is suitable for slightly contaminated tableware, by

reducing the washing time and water volume, to achieve fast cleaning, save energy and water resources. The ed washing mode allows the user to set a specific washing time, and the dishwasher will start automatically at the specified time without manual intervention.

In the washing process, the dishwasher follows the process of water intake, washing, water outlet and alarm. First, the dishwasher controls the amount of water received according to the selected washing mode. The tableware is then high-pressure sprayed by a built-in sprinkler system to remove food scraps and stains. After the washing, the dishwasher discharges the sewage and enters the drying stage. Finally, when the washing cycle is over, the dishwasher will sound an alarm to remind the user to take the cutlery.

In addition, in order to ensure the safety of the water level, this design scheme is also equipped with the water level monitoring function. When the water level exceeds 80%, the buzzer will sound an alarm until the water level drops below the safe range. This design not only improves the safety of the device, but also extends the service life.

The intelligent dishwasher of this design scheme provides users with convenient and efficient tableware cleaning experience through the integration of advanced control technology and humanized operation interface.

6. Intelligent dishwasher system debugging

6.1 ADC0832 Collect the turbidity and water level display and debugging

In the design and implementation of the intelligent dishwasher, we encountered a technical problem: the water level and turbidity data collected by the ADC0832 analog-to-digital converter was not successfully mapped to the LCD screen. After careful code review and system test, we ruled out the possibility of ADC0832 hardware interface configuration error and abnormal analog volume acquisition. After in-depth analysis, we identified the key omissions in the data transmission process: in the process of converting the ADC0832 analog signal into digital data and transmitting it to the LCD screen[9], the necessary intermediate data storage mechanism was not implemented. The lack of this link directly leads to the failure of the LCD screen to correctly analyze and display the corresponding water level and turbidity data. To solve this problem, we introduce a data buffer to temporarily store the output data of ADC0832, and conduct the necessary formatting and conversion processing before the data is transmitted to the LCD screen. Through this improvement measure, the water level and turbidity data can be accurately displayed on the LCD screen, so as to realize the real-time monitoring function of the intelligent dishwasher. This practical experience profoundly reveals the importance of data flow management in the development of embedded systems, especially when involving multi-sensor data fusion and human-computer interaction interface display, the rigor of data processing process on the overall performance of the system cannot be ignored.

6.2 LCD display debugging

In the design of the intelligent dishwasher, the LCD screen plays a vital role, showing users the working information and status of the dishwasher in real time. Throughout the work process, the LCD screen can clearly show the current mode, washing remaining time, water level, turbidity, and preparation state of the smart dishwasher. When designing the LCD function, we encountered a key problem: how to display digital variables on the LCD screen. By consulting the relevant information, we learned that the characters stored inside the LCD display are represented in the form of ASCII code. Therefore, to display the digital variable on the LCD screen, we need to convert the digital variable to the corresponding ASCII code. This conversion is achieved by adding "+ 0x30" to the digital variable. The content design of the LCD display is also very important. According to the

workflow of intelligent dishwasher and user needs, we carefully designed the layout of LCD display. In the upper left corner of the LCD screen, we set up the "MODE" logo to display the current washing mode, such as "Z" for smart washing, "K" for quick washing, and "D" for regular washing. Below the "MODE" logo, we set up the "TIME" logo to display the washing time left. In the upper right corner of the LCD screen, we set the "SW" and "ZD" signs, used to display the percentage of water level and turbidity, respectively. In the lower right corner of the LCD screen, we set the "ZB" logo to display the current state of preparation, such as "JS" for water, "XD" for washing, and "CS" for water. Through the above design, we not only solve the problem of how to display the digital variables on the LCD screen, but also realize the comprehensive display of the working information and status of the intelligent dishwasher. This makes it more convenient for users to understand the working state of the dishwasher and improves the user experience.

6.3 Key module debugging

During the debugging process, we encountered some challenges. Initially, we chose five matrix keys, but we were consistently unable to correctly scan which key was pressed. After many attempts and investigations, we found that it may be due to problems with the key layout or the scanning method. So we decided to replace them with two separate buttons and three matrix buttons, and redesigned the way the buttons were scanned. This time, we have successfully implemented the button scanning function. When writing the program, we found that there were more programs in the timer, resulting in a longer timing time than a given time. To address this issue, we have carefully reviewed and debugged the program, optimizing the use of each timer[8]. After many attempts and adjustments, we finally found the appropriate numerical value to make the timer work more stable and accurate. Since the L298 motor drive module requires a high power supply voltage, we have an external 5V power supply module. During the installation and commissioning process, we noticed that the voltage of the power supply module must match the requirements of the motor drive module to ensure the proper operation of the motor. At the same time, we also carefully checked the connection of the power cord to ensure that there is no short circuit or poor contact. Through continuous debugging and optimization, we finally succeeded in solving the problems encountered and enabling the whole system to run normally.

7. Conclusion

In this design practice, we successfully used the 51 single chip computer as the control core, integrated the ADC0832 chip[9], motor drive, LCD display, buzzer and keys and other key components, to build a basic intelligent dishwasher model. By programming in C, we realized the flexible setting of the washing mode, accurate detection of water level and turbidity, and automated control of the washing process. In addition, the application of LCD display provides real-time working status feedback, while the alarm function of the buzzer enhances the interaction and user experience of the device[6]. Although this design simulates the workflow of intelligent dishwasher more, it provides us with a valuable practice platform. Through continuous innovation and improvement, we believe that the smart dishwasher will play a greater role in improving the quality of life, saving resources and protecting the environment.

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References

[1] JIU. Electrolux Dishwasher Features What are the Electrolux dishwasher functions [OL]. http://www.xysc168. com/ news/ 865670.html,2023.5.
[2] Bo research consulting market research. Market size and future development trend of intelligent dishwasher industry in China [0L / EB]. https://baijiahao.baidu.com/s?id=1764379339713499944&wfr=spider&for=pc,2023.5.
[3] Guo Tianxiang. 51 SU C language tutorial [M]. Beijing: Press of Electronic Electronics Industry, December 12, 2018.
[4] Han Rui. Smart home based on zigbee [J]. Electronic world, 2019 (10).
[5] Jay. Character type LCD1602 display analysis and implementation [J]. Technology Information, 2022, 20 (22): 9-12 + 160.
[6] Feng Yulong. Design of a bidirectional reversible control system for a DC motor [J]. Power System Equipment, 2020 (14).
[7] Wang Yaoping. Design of household alarm device based on 51 SU [J]. Electronic production, 2017 (4).
[8] Liu Guoyun. Analysis of the single detection program of four matrix key switches and its application characteristics [J]. Electronic World, 2021.11 (009).
[9] Zheng Feng. 51 Typical application development model [M]. Beijing: China Railway Industry Press, 2011.10.1.1