ISSN: 2688-8645

Drip Detection System based on STM32 Microcontroller

Feng Zhou

Suzhou Vocational Institute of Industrial Technology, Suzhou 215104, China

00285@siit.edu.cn

Abstract

This design of the drip detection system is based on the STM32 microcontroller, making it highly practical and innovative. The system combines multiple sensors and control modules to achieve high-precision detection and monitoring of intravenous drip infusions. By integrating various sensors such as a drip rate detection module, a temperature sensor, and a water level detection module, the system can comprehensively monitor the status of the intravenous drip, including drip rate, liquid level, and temperature. Through data processing and control by the STM32 microcontroller, the system can real-time monitor the drip rate, liquid level, and temperature of the intravenous drip, and display these data on an OLED screen, providing intuitive information feedback. After conducting tests and analysis on the system, its stability and reliability have been verified. With its high-precision drip detection capability, the system can meet the needs of life science experiments for droplet detection. This system is widely applicable in various fields such as medical, chemistry, and biology. In the medical field, it can be used for precise drug delivery, thereby improving treatment effectiveness. In chemical and biological experiments, it can be used for accurate dispensing of liquid reagents, ensuring the accuracy of experimental results. The system features an OLED display, providing a user-friendly interface, and also comes with button operations, enabling users to conveniently set and operate system parameters. Overall, this drip detection system based on the STM32 microcontroller not only possesses a high level of technological sophistication but also has broad prospects for practical applications. It provides an efficient and accurate solution for droplet detection and will play a significant role in related fields.

Keywords

STM32 Microcontroller; Droplet Speed Detection; OLED Liquid Crystal Display.

1. Introduction

The drip detection system based on the STM32 microcontroller represents an innovative project that integrates modern electronics with medical applications. In the medical field, intravenous infusion is a commonly used treatment method to provide patients with necessary medications and nutrients. However, traditional intravenous infusion processes mainly rely on medical staff's observation and manual adjustments, which not only results in low work efficiency but also poses certain safety risks. Therefore, developing a system that can automatically detect, control, and record the intravenous infusion process is crucial for improving the efficiency and quality of medical services. With the continuous development of microcontroller technology, the STM32 microcontroller has become the preferred choice for embedded system design due to its high performance, low power consumption, and ease of development. The STM32 microcontroller boasts rich peripheral interfaces and powerful computing capabilities, enabling real-time monitoring and precise control of the intravenous infusion process. The drip detection system based on the STM32 microcontroller can achieve the following functions: Firstly, it monitors the speed and flow rate of intravenous infusion in real-time through sensors, ensuring the stability and safety of the infusion process. Secondly, the system can automatically adjust the speed of the infusion pump based on preset parameters to cater to the needs of different patients. Furthermore, it records key data during the infusion process, such as infusion volume and infusion time, providing medical staff with detailed patient treatment records. Lastly, the system supports remote monitoring and alarm functions, enabling prompt alerts to medical staff in case of abnormalities, thereby ensuring patient safety. In practical applications, the drip detection system based on the STM32 microcontroller offers several advantages. Firstly, it improves work efficiency by automatically completing the tasks of monitoring and controlling intravenous infusion, reducing the workload of medical staff. Secondly, it enhances treatment safety by continuously monitoring abnormalities during the infusion process and promptly issuing alarms to prevent medical accidents caused by human error. Thirdly, it provides rich data support by recording detailed infusion information, assisting medical staff in making more scientific and reasonable treatment plans. However, there are also some challenges in the design and implementation of the drip detection system based on the STM32 microcontroller. Firstly, the system requires precise and stable monitoring and control of the intravenous infusion process, necessitating careful sensor selection and calibration. Secondly, the system must possess high reliability and anti-interference capabilities to ensure stable operation in complex medical environments. Additionally, the communication protocol and data security of the system must be thoroughly considered to protect patient privacy and information security[1-10].

In conclusion, the drip detection system based on the STM32 microcontroller represents an innovative project with broad application prospects. By fully utilizing the performance advantages and technical characteristics of the STM32 microcontroller and combining them with the actual needs of the medical field, an efficient, safe, and reliable drip detection system can be developed, contributing significantly to improving the quality of medical services. With continuous technological advancements and the increasing popularity of its applications, this system is expected to play a more prominent role in the future[11-16].

2. Hardware System Design

The STM32F103C8T6 microcontroller is a micro-controller based on the ARM Cortex-M3 core, boasting high performance and low power consumption, making it suitable for the design of embedded systems. It is equipped with a rich array of peripherals and interfaces, providing flexible options for various applications. By utilizing three independent buttons, basic user-system interaction can be achieved, enabling threshold adjustment functionality. These three buttons are specifically the set button, the increment button, and the decrement button. By grounding one end of the button and connecting the other end to a microcontroller pin, the state change of the pin can be detected to determine whether the button is pressed. This simple yet effective button detection method is commonly used in embedded systems, realizing basic user-system interaction while reducing system complexity and cost. This design allows users to conveniently adjust system parameters, enhancing the system's customizability and user-friendliness. Additionally, due to the simplicity of the button functions, users can easily understand and operate them, making the system's usage more intuitive and convenient.

The buzzer module plays a vital role in the intravenous drip detection system, triggering alert reminders. Using an active buzzer is a simple and effective choice because it has a built-in drive circuit that can directly generate sound through a voltage signal, eliminating the complexity of controlling external PWM signals. In the design, the output signal of the STM32 microcontroller is used to control the buzzer's operation. Since the buzzer requires a 5V power supply, while the STM32 microcontroller typically outputs a 3.3V signal, a triode is required to amplify the signal and drive the buzzer. Typically, an NPN-type triode (such as the commonly used PN2222)

ISSN: 2688-8645

can be selected as the amplifier. Under this connection, when the output pin of the STM32 microcontroller outputs a high voltage level, the triode conducts, enabling the buzzer to work and emit sound.

OLED is indeed a widely used display technology in embedded systems. Connection methods for OLED display modules are as follows: 1. VCC (power positive): It is connected to the positive pole of the power supply, which is usually the positive pole of the system's power supply. 2. GND (ground): It is connected to the ground (GND) of the system to ensure the common ground of the circuit. 3. SCL (clock signal line): SCL is the clock signal line of the I2C bus, used to synchronize the clock signal for data transmission. 4. SDA (data transmission line): SDA is the data transmission line of the I2C bus, used to transmit actual data. 5. OLED display module is a very popular display device, which has been widely used in single-chip applications.

This photoelectric sensor module is used in the intravenous drip detection system to detect the speed of the drip in real time, with high sensitivity, high speed, adjustable sensitivity, and other features. In the system, the DO pin is connected to a certain GPIO pin of the STM32 microcontroller, and the microcontroller reads signals from the ITR9606 speed detection module through this pin. When the DO pin outputs a high voltage level, it indicates that the medicine liquid has been detected passing through; when the DO pin outputs a low voltage level, it indicates that no medicine liquid has been detected. By monitoring the state changes of the DO pin, the system can detect the flow of intravenous liquid in real time, thereby calculating the speed of the drip. This simple and effective working principle makes the ITR9606 module an ideal choice for intravenous drip detection systems.

LM393 is a dual comparator, commonly used to convert analog signals into digital signals. It features two comparators, and the voltage difference (threshold voltage) between the non-inverting input (-) and the inverting input (+) of each comparator determines the trigger point of the comparator. When the voltage of the non-inverting input is higher than that of the inverting input, the comparator outputs a high voltage level; when the voltage of the non-inverting input is lower than that of the inverting input, the comparator outputs a low voltage level. The non-inverting input of the LM393 comparator is connected to the output of the SW-A1 water level detection module, and the inverting input is connected to a fixed reference voltage (which can be a fixed voltage generated by a voltage divider circuit), thus determining the trigger point of the comparator. When the output voltage of the SW-A1 water level detection module is higher than the reference voltage, the LM393 comparator outputs a high voltage level, indicating that the water level has been detected; when the output voltage is lower than the reference voltage, the comparator outputs a low voltage level, indicating that the water level has not been detected.

The DS18B20 temperature sensor is a commonly used digital temperature sensor that communicates through a single-bus interface. The DS18B20 temperature sensor uses a three-wire interface, including a data line (DQ), a power line (VCC), and a ground line (GND). Here is a summary of the functions of these connections: Data Line (DQ): The data line is used for transmitting temperature data and control signals. During communication, the STM32 microcontroller sends a temperature reading command through the data line, and the sensor returns the current temperature value to the STM32 microcontroller in binary form. The data line should use a single-bus interface during communication. Power Line (VCC): The power line is used for power supply, providing the operating voltage required by the DS18B20 sensor. According to the information you provided, the operating voltage should range from 3.0V to 5.5V. Ground Line (GND): The ground line is used for grounding, ensuring a stable potential reference in the circuit.

A relay is an electrical control component that can control the current after being turned on. It can convert a small current into a large current and is often used to control the switch of a single-chip microcomputer. The relay consists of a coil, an iron core, contacts, and fixed contacts.

During its operation, once the coil outside the iron core is connected to the power supply, a magnetic field will be generated in the iron core. This magnetic field may cause the contacts to engage or disengage. When the contacts engage, the fixed contacts of the relay are connected to the contacts, allowing the control of the large current path.

The STM32 main control module, button module, display module, stepper motor drive module, drip rate detection module, water level detection module, DS18B20, and power module jointly constitute the hardware of the personnel access management system under epidemic prevention and control. The hardware works in a sequential order as follows: The STM32 reads and parses the temperature, and simultaneously retrieves the numerical value from the drip rate detection module. The current data of the system is displayed through the OLED display module. Check if any buttons have been triggered, and execute the corresponding instructions only if no buttons are triggered. The system automatically detects the water temperature. If it detects that the temperature is below the threshold, it will issue an alarm, and the relay will close to activate the heating element for warming. The system automatically detects the drip rate. If it detects that the drip rate is not within the threshold, the relay will automatically drive the stepper motor to rotate, thus bringing the drip rate back within the desired range.

3. Software Design

The current drip detection system mainly consists of five modules: DS18B20 temperature detection module, drip rate detection module, water level detection module, alarm module, and display module. These modules mainly function as follows: responsible for detecting the temperature data within the medicine; responsible for detecting the dripping speed of the intravenous drip; responsible for checking if there is any remaining medicine inside; responsible for initiating the alarm when the system value triggers the threshold; and responsible for displaying the sensor data of the system. The OLED display module used this time requires the I2C protocol for communication. It cannot complete the subsequent processes by directly using the OLED display module. It also needs to initialize its communication port before use and set the OLED parameters, including resolution, brightness, and contrast. These parameter settings need to be done in the initialization function. Additionally, the size of fonts and characters should also be set appropriately. After initialization, the STM32 microcontroller will transmit the content to the OLED display module for display in the corresponding location. When programming the drip rate detection module, not only the external interrupt within the STM32 is used, but also a timer. Before using the timer, its time needs to be set to 1 second. When a drop of medicine passes through the drip rate detection module, it will detect and trigger an external interrupt. The number of external interrupts triggered within the 1-second timer period can be used to calculate the liquid dripping rate. Since the signal generated by the water level sensor is not an actual signal but an analog signal, it cannot be processed on the microcontroller. Although the signal cannot be processed, the water level detection circuit designed this time completes the signal processing by converting the analog signal into a digital signal. The key to this process is the LM393 comparator. This allows the water level sensor to react differently when it detects the presence or absence of liquid in the medicine. When there is liquid, it will transmit a high-level signal to the microcontroller through the IO port. When there is no liquid, it will transmit a low-level signal to the microcontroller through the IO port. The alarm program is mainly used for reminders. When the system detects that the sensor value is out of range and exceeds the threshold, it will trigger the alarm device to send an alert. It will not only detect the value but also check if there is water in the medicine bottle, and if the dripping rate and temperature are within a reasonable range. If these are not within the reasonable range, the alarm device will also be triggered to activate the buzzer as a reminder.

When controlling the 28BYJ-48 stepper motor, the STM32 microcontroller is still required. The driving process of the stepper motor begins with defining the motor's pins. The five pins of the 28BYJ-48 stepper motor serve two purposes. Four of them are used to control the stepping, while the remaining one is for controlling the direction. After defining the pins, it is necessary to determine how to control the signal for each step of the stepper motor. The 28BYJ-48 stepper motor is a four-phase, five-wire motor. To rotate the motor clockwise, different signals need to be sent to each phase. Similarly, to rotate the motor counterclockwise, different signals also need to be sent to each phase. The key to controlling the stepper motor lies in the driving program. When the dripping speed is too high or too fast, the system will detect it and control the stepper motor to reverse. The DS18B20 is a digital temperature sensor that communicates through a single data bus. It cannot be used directly but requires initialization of the connection between the bus type and the DS18B20 before use. During this process, a series of commands need to be sent for reset and initialization. After this operation, the DS18B20 can be used. When using it, it is also necessary to send commands to the sensor, such as reading the sensor ID, initiating temperature conversion, and reading the temperature value. When sending commands, it is essential to follow the protocol specified by the DS18B20 to ensure accurate data transmission. When initiating the temperature converter, it is not advisable to rush the conversion. It is necessary to check the response of the DS18B20 to determine if the conversion can be completed. After the temperature is converted, the temperature value measured by the DS18B20 can be read. When reading the temperature value, it should also be done according to the DS18B20 protocol by sending read commands and receiving data. The temperature read is represented in a 16-bit binary two's complement format, which needs to be converted to the actual temperature value for display.

4. Conclusion

The design scheme introduced in this paper is a drip detection system based on STM32 microcontroller. This system uses photoelectric sensors to detect the liquid level height. The data obtained after measurement will be processed and analyzed by the STM32 microcontroller, and finally displayed. Throughout the design process, it is necessary to continuously conduct practical tests on the system to ensure that it can stably and accurately detect the dripping speed in actual operation, and promptly issue alarms to remind of unreasonable issues.

References

[1] Chandrasekhar P T , Chakravarthi J S .Automatic Drip Irrigation System[J].[2024-03-24].

[2] Wavhal*1 M D N .Intelligent Drip Irrigation System[J].International Journal of Engineering Sciences & Research Technology, 2014, 3(5).

[3] Kumar J , Luthra S K , Ratan R .Design & Development of Zigbee Based Automatic Drip Irrigation system[J].[2024-03-24].

[4] Mahendra S , Bharathy M L .Microcontroller Based Automation of Drip Irrigation System[J].[2024-03-24].

[5] Patel N R , Lanjewar R B , Mathurkar S S ,et al.Microcontroller based drip irrigation system using smart sensor[C]//IEEE India Conference.IEEE, 2013.DOI:10.1109/indcon.2013.6726064.

[6] Ibrahim D , Saeed R R .Design and implementation of a microcontroller based infusion pump system for automatic drug delivery[J].Global Journal on Technology, 2013.

[7] N V Gowtham DeekshithuluG Ravi BabuR Ganesh BabuM Siva Ramakrishna. Performance Evaluation of Developed Low Cost Microcontroller BasedAutomated Drip Irrigation System[J]. Andhra Agricultural Journal, 2016, 63(3).

[8] Parameswaran G , Sivaprasath K , System P S I E .Arduino Based Smart Drip Irrigation System Using Internet of Things[J]. [2024-03-24].

ISSN: 2688-8645

[9] Debnath M , Patel N .Performance of a Developed Low Cost Microcontroller based Automated Drip Irrigation System in Kinnow Crop[J].[2024-03-24].

[10] Prabhu S R B , Sophia S , Mathew A I .A Review of Efficient Information Delivery and Clustering for Drip Irrigation Management using WSN[J].Social Science Electronic Publishing[2024-03-24].

[11] Ruixia T , Jiaosai L , Yunjie L ,et al.Design of the Water Leakage Detection and Alarm System based on EPICS[J]. 2017.

[12] Shiyong,Zheng,Zhao,et al.The design of liquid drip speed monitoring device system based on MCU [C] //2017:20123-20123.DOI:10.1063/1.4992940.

[13] Dutta P K , Mallikarjuna K , Satish A .Sensor based solar tracker system using electronic circuits for moisture detection and auto-irrigation[C]//IEEE International Conference on Power, Control, Signals and Instrumentation Engineering.0[2024-03-24].DOI:10.1109/ ICPCSI. 2017.8391956.

[14] Capraro F , Tosetti S R , Manrique P L C .Sensor Network For Monitoring And Fault Detection In Drip Irrigation Systems Based On Embedded Systems[J].IEEE Latin America Transactions, 2020, 18(2):383-391.DOI:10.1109/TLA.2019.9082252.

[15] Wei-Chao H , Lian-Shuai H , Nan-Hong P .Design of Intelligent Drip Irrigation System Based on STM32[J].Journal of Anhui Agricultural Sciences, 2017.