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# Design of Intelligent Electronic Scale Based on Single Chip Microcomputer

Feng Zhou

Suzhou Vocational Institute of Industrial Technology, Suzhou 215104, China.

00285@siit.edu.cn

## Abstract

**This design is based on the STM32 microcontroller and aims to provide a high-precision, user-friendly, multifunctional, and low-power weighing solution for home health management, kitchen weighing, and commercial use. The system adopts the HX711 weighing module to achieve high-precision weight measurement, and displays the measurement results in real time through the LCD1602 display screen. The user interface design is simple and intuitive, equipped with buttons for operation and mode switching, making it convenient for users to perform different weighing tasks. The buzzer provides sound prompts to ensure that users receive timely feedback during the operation process. The overall system design focuses on low power consumption characteristics to extend the service life of the equipment. Intelligent electronic scales not only meet daily weighing needs, but also provide users with more accurate weight data and a more convenient user experience through their high precision and multifunctional features.**

## Keywords

**STM32 Microcontroller, Intelligent electronic scale, HX711 weighing module, LCD1602 display.**

## 1. Introduction

Intelligent electronic scales, by incorporating advanced single-chip microcontroller technology, can effectively overcome the limitations of traditional electronic scales to achieve high-precision, intelligent, and multifunctional weighing solutions. The single-chip microcontroller offers significant advantages such as high integration, robust control capabilities, compact size, low power consumption, and high reliability, making it highly promising for developing intelligent electronic scales. By utilizing the single-chip microcontroller to acquire and process sensor signals while managing peripherals like displays and communication modules, electronic scales can achieve intelligent and automated operation[1-6].

In the design of intelligent electronic scales, the use of high-precision load cells and analog-to-digital conversion modules, such as the HX711, significantly enhances the accuracy and stability of weighing data. Real-time signal acquisition and processing through the STM32 microcontroller, combined with filtering and calibration algorithms, effectively eliminate environmental interference to ensure measurement precision. Additionally, intelligent electronic scales can integrate various sensors, such as temperature-humidity and barometric sensors, enabling comprehensive monitoring of environmental parameters and expanding measurement capabilities[7-9].

In this paper, we explore the design and research of an STM32-based intelligent electronic scale to deliver a high-precision, user-friendly weighing solution. Key aspects include:

Defining the system architecture and functional modules.

Selecting the STM32 microcontroller as the core control unit.

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Designing hardware circuits with the HX711 weighing module, LCD1602 display, buzzer, and keypad modules.

Developing and optimizing programs for data acquisition, processing, and display.

Validating and refining the system through simulation software to ensure performance and stability.

This approach enhances the convenience and accuracy of intelligent electronic scales, delivering an improved user experience.

## 2. Hardware system design

In this project, the selection of the microcontroller is the core part of the hardware design. When choosing the MCU, the following factors must be considered: system performance, processor bit-width, input/output characteristics, power consumption, and number of ports. The STM32F103C8T6, designed by STMicroelectronics, is a 32-bit microcontroller based on the ARM Cortex-M3 core. It features 64KB of program memory and operates at a voltage range of 2V to 3.6V, with an operating temperature range of -20°C to +45°C. The key characteristics of this microcontroller include:

ARM Cortex-M3 Core: Provides fast computing power and responsiveness, meeting the requirements of most embedded control systems.

Advanced Power Management: Incorporates multiple low-power modes to reduce energy consumption without compromising performance.

Mature Development Tools and Programming Languages: Supports development frameworks such as the standard library and HAL library, simplifying workflows and shortening development cycles.

Based on this analysis, the STM32F103C8T6 offers strong performance, low power consumption, and rapid response capabilities, making it a suitable choice as the microprocessor for the air quality detection system. Figure 2-1 illustrates the principle block diagram of the STM32 series.

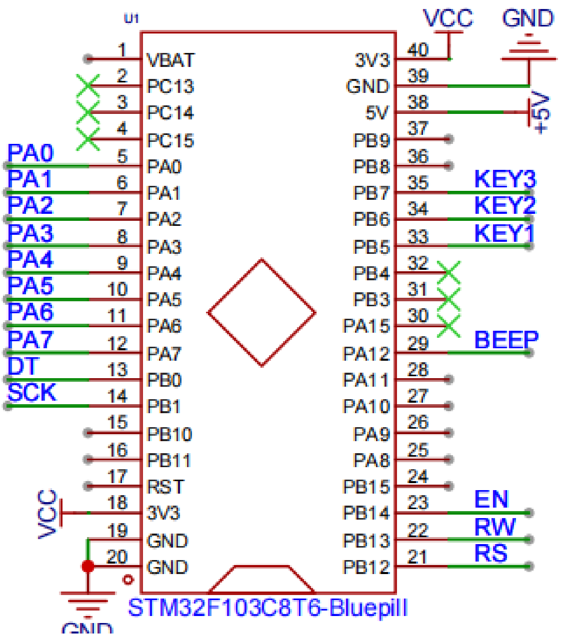


Figure 3-1 Minimum System Circuit Diagram

LCD1602 Liquid Crystal Display Module Specifications and Display Capabilities The LCD1602 display module consists of multiple character display positions arranged in a 5×7 or 5×10 dot matrix format, where each position can display one character. These

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modules are categorized by their number of characters per row (e.g., 8, 16, 20, 24, 32, or 40) and number of rows (1, 2, or 4). Different module specifications accommodate varying display requirements by offering distinct configurations of character positions.

Key features include:

Dot Matrix Layout: Each character is formed by a grid of dots (5×7 or 5×10), ensuring clear and customizable character rendering.

Configurable Rows and Columns: Supports flexible row and column combinations (e.g., 16 characters × 2 rows for the "1602" model).

Compatibility: Designed for seamless integration with microcontrollers, enabling straightforward control via digital interfaces.

The connection circuit between the LCD1602 module and the microcontroller is illustrated in Figure 3-2.

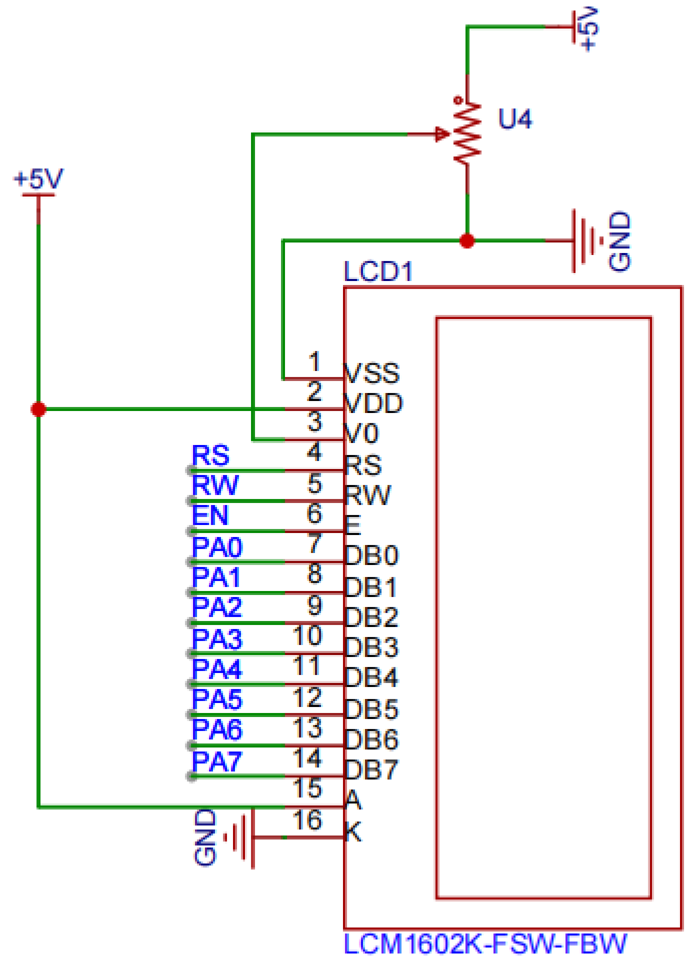


Figure 2-2 Display Circuit Design Diagram

In physics, weight measurement can be interpreted as the detection of force. The primary method for measuring weight involves strain gauges, materials that alter their state under mechanical stress. There are two types: capacitive and resistive. Here, a resistive strain gauge is employed, which changes its resistance value proportionally to the applied pressure. By integrating this gauge into a Wheatstone bridge circuit, the resistance change can be measured to determine the pressure magnitude. However, these resistance variations are typically minimal, necessitating signal amplification. Instead of using an external operational amplifier, the HX711 chip is adopted as the core of the detection circuit. The hardware circuit, shown in Figure 3.2, includes four primary pins: GND, VCC, DT, and SCK. GND: Connects to the ground to ensure proper circuit operation. VCC: Supplies power (typically +5V) to the module. DT: Handles data transmission between the module and the microcontroller. SCK: Provides clock synchronization for data transfer. These pins enable seamless integration with other electronic components, ensuring reliable data communication and control. The complete weight detection circuit is illustrated in Figure 2-3.

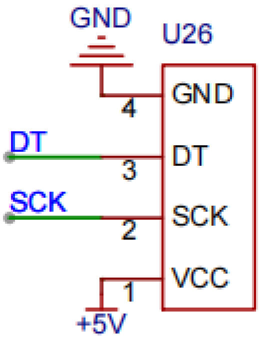


Figure 2-3 Weight Detection Circuit Diagram

The button circuit is used to input different signals. The design concept of the button circuit is to detect the button status by setting different level signals in different rows. The microcontroller sets one row to low level and the remaining rows to high level. When a button is pressed, the closure of the button will cause a change in the level signal, resulting in a difference between high and low levels. By detecting changes in this level, the microcontroller can determine which button has been pressed, thereby achieving the function of key input. This design method, also known as matrix keyboard, has the advantage of saving pins, reducing space occupation, and avoiding resource waste. Secondly, there is the issue of button stabilization. During the process of pressing and releasing buttons, there may be shaking, which can cause the microcontroller to misjudge the button status. When designing the program, it is necessary to perform key debounce processing to ensure stable key state signals are obtained and avoid false triggering or multiple triggering caused by shaking. The schematic design of the button switch module is clear, and each button has a clearly defined function, allowing users to flexibly choose according to their needs. Pressing buttons to adjust the threshold is an interactive design that conforms to users' intuitive habits and improves the usability and friendliness of the system. The button switch module provides a convenient human-computer interaction method for the monitoring system, allowing users to easily set and adjust system parameters to better meet the needs of different usage scenarios.

## 3. Software design

The software development environment has chosen Keil development environment. Keil is compatible with both C language and assembly language, and using this development environment can make software writing twice the result with half the effort. Language selection considers assembly language and C language. Compared with assembly language, C language has the advantages of simplicity, compactness, high execution rate, and strong portability, so C language is chosen for programming. The compilation environment is Keil5, which provides an integrated development environment including editors, compilers, debuggers, and other tools, making the software development process more efficient and convenient. Developers can complete code writing, compilation, debugging, and other tasks in the same interface, which improves development efficiency. The advantages of compatibility with ARM microcontrollers, powerful debugging capabilities, optimized compilers, abundant development resources, portability, and cross platform compatibility make it suitable for developing microcontroller applications with ARM architectures such as STM32F103C8T6. When the system starts working, connect the power supply to provide power to the system. When entering the main() main function, we need to initialize the key pin, buzzer pin, HX711 pin, and 1602 LCD display pin. Then perform key scanning to ensure that the keys can be used normally and the screen display is normal. Finally, when working normally, the microcontroller obtains the weight of the object being measured. If the weight value exceeds the set value, an alarm will be triggered; If it does not exceed, the weight of the item will be displayed, the total price will be calculated, and the total price will be displayed. At system startup, the LCD1602 display screen will show the initialization interface, displaying welcome messages or system prompts, providing users with user-friendly operation guidance. The system will dynamically update the LCD display content based on user operations or system status, maintaining the timeliness and accuracy of interface information. During the weighing process, the LCD will display real-time weight information of the object being weighed, as well as other relevant information such as units, unit prices, etc. as needed. This enables users to intuitively understand the weighing results and provides more information references, making it convenient for users to make subsequent operations and decisions. When the user presses the button to adjust the parameters, the LCD will display the corresponding adjustment interface, allowing the user to set and adjust the parameters. This interaction method enables users to flexibly adjust system parameters to meet personalized needs, and the LCD will display the adjusted parameter values in a timely manner for users to confirm whether the settings are effective. In the design of the alarm circuit, a buzzer was selected as the alarm component. Buzzers usually require a large operating current to produce sound properly, and conventional operating currents often cannot meet their needs. In order to drive the buzzer, a current amplification circuit is introduced, and its core component is a transistor. After the program starts executing, the alarm circuit will continuously detect whether the weight of the physical object exceeds the set alarm weight. If the weight of the physical object exceeds the set alarm weight, the buzzer will sound an alarm reminder. Connecting the positive pole of the buzzer to the transistor can effectively amplify the current. To ensure that the transistor is not directly damaged by overcurrent, a 2K Ω current limiting resistor can be connected in series between the two.

At the beginning of starting the weighing module program, initialization and configuration work need to be carried out first. After initialization is completed, the program enters the stage of reading the weighing sensor signal. Continuously read the analog signal output from the weighing sensor through an A/D converter and convert it into a digital signal. After data processing, the program calculates the actual weight value of the object based on preset calibration parameters and algorithms. This involves unit conversion, linearization, and error compensation of digital signals to ensure the accuracy and reliability of weighing results. After calculating the weight value, the program transmits it to the display module for display. During the weighing process, the program also needs to continuously monitor the working status of the weighing module to detect and handle possible abnormal situations. Monitor whether the output of the weighing sensor is overweight. When overweight is detected, the program will trigger the corresponding overweight alarm prompt.

## 4. Conclusion

This design successfully implements an intelligent electronic scale based on STM32 microcontroller, which has high-precision weighing, real-time display, user-friendly operation interface, and multiple functional prompts, ensuring the stability and reliability of the system. By using HX711 weighing module, LCD1602 display module, buzzer and button module, the intelligent electronic scale can not only provide accurate weight measurement, but also provide operation prompts through the buzzer, improving the user experience. The low power consumption characteristics of STM32 microcontroller extend the service life of devices, making it suitable for home, kitchen, and commercial use. The hardware part of this design fully utilizes the powerful processing capabilities and rich peripheral interfaces of the STM32 microcontroller. The HX711 weighing module ensures the accuracy of weight data through high-precision analog-to-digital conversion technology. The LCD1602 display module displays real-time weighing results and system status, providing users with an intuitive operating interface. The buzzer prompts users with operation status and results through sound, enhancing user interaction experience. The button module is used for system settings and operations, allowing users to easily perform various function settings and operations. Through continuous technological innovation and optimization, intelligent electronic scales based on STM32 microcontrollers will play an increasingly important role in the electronic weighing industry. We hope that through this design, we can not only provide users with more intelligent, efficient, and convenient weighing solutions, but also promote the development and technological innovation of the electronic weighing industry.

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