International Journal of Science and Engineering Applications
Volume 15-Issue 03, 56 – 59, 2026, ISSN:- 2319 - 7560
DOI: 10.7753/IJSEA1503.1012

High-Precision Digital Display Mass Analyzer

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Abstract:This paper designs and implements a high-precision digital display mass analyzer based on a microcontroller. The system uses an STM32 series microcontroller as the core control unit and employs a high-precision resistive strain gauge pressure sensor as the signal acquisition front end. It is paired with an HX711 dedicated analog-to-digital conversion chip to convert the weight signal into a digital value. The system software, through digital filtering and calibration algorithms, effectively eliminates zero drift and non-linear errors, achieving precise measurement of object mass. In addition, the system integrates functions such as LCD display, numerical calculation, and keyboard calibration. It features a simple structure, low cost, high measurement accuracy, and good stability. Experimental test results show that the system meets the high-precision weighing requirements of daily commercial and laboratory environments, demonstrating certain practical value and potential for wider application.

Keywords: Microcontroller; Mass analysis; High-precision; HX711; Sensor

1. INTRODUCTION

With the rapid development of modern industry and the commercialization of retail, the efficiency and accuracy of weighing instruments directly impact production costs and trading fairness. Traditional mechanical scales, due to their slow response speed, low accuracy, and poor readability, have gradually been phased out of the market. In contrast, electronic weighing devices, based on sensor technology and microelectronics, have become the mainstream solution in fields such as industrial manufacturing, logistics warehousing, and laboratory research due to their advantages of intuitive reading, high precision, and easy integration .As the core of an electronic weighing system, the measurement accuracy is often affected by multiple factors, including the non-linearity of the sensor, temperature drift of the analog front end, and power supply noise. Therefore, developing a high-precision mass analyzer with strong anti-interference capability and intelligent processing algorithms is of significant practical importance.

2. 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. 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. 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.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.The main flowchart of the program is shown in Figure 2-1.

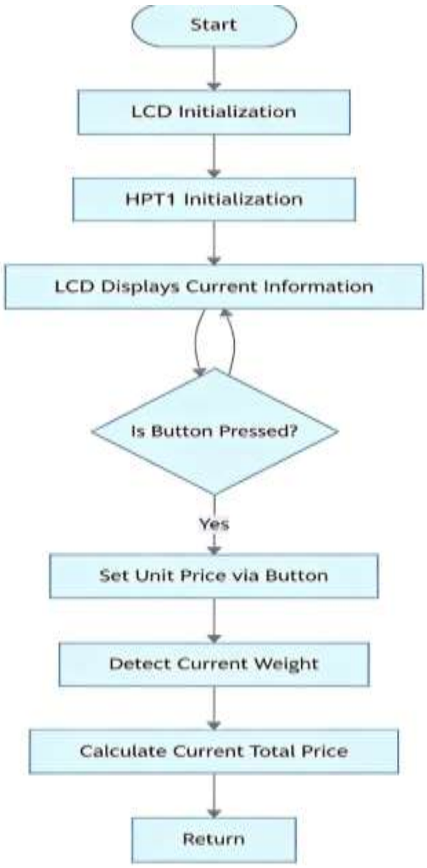

Figure 2-1 Main Flowchart

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3. System Design

3.1 Hardware Design

In this project, the selection of the microcontroller is a central aspect of the hardware design. When choosing an MCU, several key factors must be taken into account, including system performance, processor bit-width, input/output capabilities, power consumption, and the number of I/O ports. The STM32F103C8T6, developed by STMicroelectronics, is a 32-bit microcontroller based on the ARM Cortex-M3 core. It features 64KB of program memory, operates within a voltage range of 2V to 3.6V, and supports an operating temperature range of -20°C to +45°C. The key characteristics of this microcontroller are as follows: ARM Cortex-M3 Core – Delivers high-speed computing power and responsiveness, making it suitable for most embedded control applications. Advanced Power Management – Integrates multiple low-power modes that reduce energy consumption while maintaining performance. Mature Development Ecosystem – Supports development frameworks such as the Standard Peripheral Library and the HAL (Hardware Abstraction Layer) Library, streamlining the development process and reducing time-to-market. Based on the above analysis, the STM32F103C8T6 offers robust performance, low power consumption, and fast response times, making it an appropriate choice as the core microprocessor for the air quality detection system. The minimum system circuit diagram is shown in Figure 3-1 below.

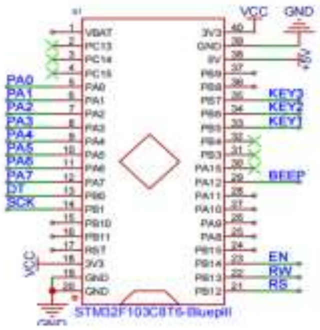

Figure 3-1 minimum system circuit diagram

The LCD1602 liquid crystal display module consists of multiple character display positions arranged in a 5×7 or 5×10 dot matrix format, with each position capable of displaying one character independently. Depending on the number of characters per line (such as 8, 16, 20, 24, 32, or 40) and the number of lines (1, 2, or 4), this module can be divided into various specifications to meet different display requirements. Its core features include that each character is formed by a dot matrix grid to ensure clear and standardized display, while supporting flexible row and column combinations (for example, model "1602" represents 2 lines with 16 characters per line). Additionally, it is designed for seamless integration with microcontrollers, enabling straightforward control through digital interfaces. The specific connection circuit between the LCD1602 module and the microcontroller is shown in Figure 3-2. OLED displays offer several significant advantages over traditional LCDs, primarily due to their self-emissive nature where each pixel produces its own light, which enables perfect blacks and infinite contrast ratios by completely turning off pixels to display true black, resulting in more vibrant and accurate colors with greater depth and realism; additionally, OLED technology provides faster response times for smoother motion handling, superior viewing angles without color distortion, and thinner, more flexible designs since they don't require backlighting, all of which contribute to a markedly superior visual experience despite some concerns about longevity and burn-in compared to LCD technology.The schematic diagram of the OLED is shown in Figure 3-3. Here is the comparison between LCD and OLED presented as Table 3-4 。 Both options have their own advantages and are equally capable of fulfilling this research.

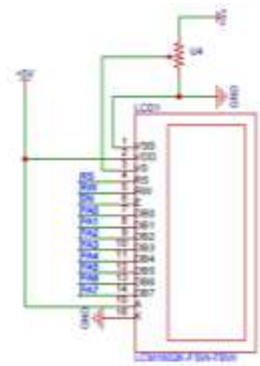

Figure 3-2 LCD1602 module and the microcontroller

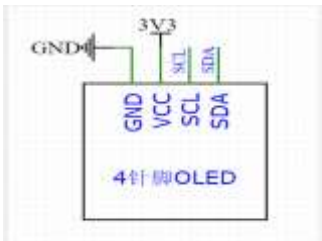

Figure 3-3 OLED Schematic Diagram

Key Characteristic	LCD	OLED
Working Principle	Passive (relies on backlight)	Active (self-emissive pixels)
Black Level	Dark gray (light bleed)	Perfect black

Key Characteristic	LCD	OLED
Response Time	Slower (ms)	Faster (μs)
Viewing Angles	Limited	Excellent
Power Consumption	Relatively constant	Dynamic (more efficient)
Cost	Low (mature technology)	Higher

Figure 3-4 Comparison between LCD and OLED

In physics, weight measurement can be interpreted as force detection, and the primary method for measuring weight involves strain gauges, which are materials that alter their characteristics under mechanical stress. There are two main types of strain gauges: capacitive and resistive. In this application, resistive strain gauges are used, whose resistance changes proportionally with the applied pressure. By integrating such pressure sensors into a Wheatstone bridge circuit, the resistance variation can be measured to determine the magnitude of the applied pressure. However, these resistance changes are typically minimal and thus require signal amplification. Instead of using external operational amplifiers, the HX711 chip is adopted as the core of the detection circuit.GND serves as the ground connection to ensure stable circuit operation, VCC supplies power to the module, usually at +5 V, DT handles data transmission between the module and the microcontroller, and SCK provides clock synchronization for data transfer. These pins allow seamless integration with other electronic components, ensuring reliable data communication and control.

3.2 Software Design

The software development environment selected for this project is Keil, which supports both C and assembly languages. Utilizing this environment significantly improves programming efficiency. After comparing assembly and C languages, C language was chosen due to its simplicity, conciseness, high execution efficiency, and strong portability. The compilation environment is Keil5, which integrates editors, compilers, debuggers, and other tools into a unified interface, streamlining the entire development workflow. This integration allows developers to write, compile, and debug code seamlessly, thereby enhancing productivity. Keil5 offers excellent compatibility with ARM-based microcontrollers, powerful debugging features, an optimized compiler, and extensive development resources. These advantages make it particularly suitable for developing applications targeting ARM architecture MCUs such as the STM32F103C8T6.

Upon system startup, power is connected to supply the system. When entering the main() function, initialization of the key pins, buzzer pin, HX711 pins, and LCD1602 display pins is performed. This is followed by key scanning to ensure normal key functionality and proper screen display. During normal operation, the microcontroller acquires the weight of the object under measurement. If the weight exceeds a preset threshold, an alarm is triggered; otherwise, the weight is displayed, the total price is calculated, and the result is shown on the LCD.

At system startup, the LCD1602 displays an initialization interface, showing welcome messages or system prompts to provide user-friendly guidance. The LCD content is dynamically updated based on user operations or system status, ensuring the displayed information remains timely and accurate. During weighing, the LCD shows real-time weight information along with additional relevant data such as units and unit price as needed. This allows users to intuitively understand the weighing results and obtain sufficient information for subsequent operations and decisions. When users press buttons to adjust parameters, the LCD displays the corresponding adjustment interface, enabling flexible parameter configuration. The updated parameter values are promptly shown on the screen, allowing users to confirm whether the settings have taken effect.

4. Conclusion

This design successfully implements an intelligent electronic scale based on the STM32 microcontroller. The scale features high-precision weighing, real-time display, a user-friendly interface, and multiple functional prompts, ensuring system stability and reliability. The system incorporates an HX711 weighing module, an LCD1602 display module, a buzzer, and a keypad module. It not only provides accurate weight measurements but also delivers operational prompts via the buzzer, significantly enhancing the user experience. The low-power characteristics of the STM32 microcontroller extend the device's operational lifespan, making it suitable for various applications, including household kitchens and commercial settings.

In terms of hardware design, this solution fully leverages the powerful processing capabilities and rich peripheral interfaces of the STM32 microcontroller. The HX711 weighing module ensures the accuracy and stability of weight data through high-precision analog-to-digital conversion technology. The LCD1602 display module presents real-time weighing results and system status, offering users an intuitive and clear interface. The buzzer provides audible feedback on system status and operational results, enhancing the user-friendliness of human-computer interaction. The keypad module facilitates system settings and function switching, allowing users to operate flexibly according to their specific needs.

Through continuous technological innovation and optimization, intelligent electronic scales based on the STM32 microcontroller are expected to play an increasingly important role in the electronic weighing industry. This design not only aims to provide users with a more intelligent, efficient, and convenient weighing solution but also seeks to contribute to the development and technological advancement of the electronic weighing industry.

5. Acknowledgments
Our thanks to the experts who have contributed towards development of the template.

6. References
[1] Zuo Lan. Research on the Design of Intelligent Electronic Scale Based on Single-Chip Microcomputer [J]. Agricultural Technology and Equipment, 2025, (03): 19-20+24.

[2] Wang Guisong, Zhang Zhiping. Design of Intelligent Electronic Scale Control System Based on Single-Chip Microcomputer [J]. Automation Application, 2023, 64(16): 92-94.

[3] Zuo Lan, Xiao Jie. Design and Implementation of Intelligent Electronic Scale Based on Single-Chip Microcomputer [J]. Agricultural Equipment Technology, 2023, 49(03): 42-46.

[4] Liu Zijie, Duan Yuanmei. Design of Intelligent Electronic Scale Based on Single-Chip Microcomputer [J]. Computer Programming Skills & Maintenance, 2023, (04): 127-129. DOI:10.16184/j.cnki.comprg.2023.04.051.

[5] Tang Rongfang. Research on Weighing Calibration Technology Methods for Intelligent Electronic Scales [J]. Electronic Components and Information Technology, 2022, 6(06): 161-163+167. DOI:10.19772/j.cnki.2096-4455.2022.6.039.

[6] Song Haiyan, Chen Jitao, Xiang Maoyun. Design of Multifunctional Intelligent Electronic Scale Based on Single-Chip Microcomputer [J]. Scientific and Technological Innovation, 2025, (15): 13-16.

[7] Cheng Wangbin, Liao Zhaohui, He Qiaoqiao, et al. Design and Implementation of Multifunctional Intelligent Electronic Scale [J]. Journal of Hunan Institute of Science and Technology (Natural Science Edition),2017, 30(04): 28-31. DOI:10.16740/j.cnki.cn43-1421/n.2017.04.008.

[8] Zhou Shuwei, Chen Xiaomei. Design and Research of Intelligent Electronic Scale [J]. Computer Products and Circulation, 2019, (04): 164-165+262.

[9] Dong Xiao. Electronic Scales Lead a New Trend in Connected Health [J]. Beijing Fashion, 2016, (12): 126.