Design of Building Vertical Instrument Based on STM32

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Abstract. Ensuring the flatness and verticality of the formwork system during building wall construction is crucial. However, challenges such as limited space on site, uneven formwork surfaces, and difficulties in establishing a datum point hinder accurate assessment of formwork flatness. Therefore, developing an intelligent and efficient formwork flatness measuring instrument is essential to help workers achieve desired standards during formwork adjustments. This approach aims to reduce costs associated with additional plastering and materials due to non-compliance with perpendicularity standards after concrete pouring. This paper addresses these challenges by employing displacement sensors, inclination sensors, and other technologies to capture data related to building templates. The data is then displayed on an LCD screen and transmitted and recorded via Bluetooth. The test results show that the intelligent leaning rule can efficiently test the building formwork's perpendicularity and flatness, which meets the project requirements.

Keywords: wireless communication, building template installation detection, STM32, three-axis accelerometer, displacement sensor

1 Introduction

Aluminum formwork construction technology [1, 2] for high-rise buildings is widely used in construction projects. In the construction process of reinforced concrete projects, the supporting system is an indispensable and important part of the concrete components to ensure the formation of concrete elements, which refers to a system of construction tools consisting of supporting molds, scaffolding templates, etc., which is used to simulate the shape and dimensions of the concrete structure and to provide support and protection, to ensure that the structure of the concrete casting stability and accuracy of the structure during concrete placement. However, the formwork of the supporting mold system cannot guarantee a certain degree of flatness and perpendicularity during the installation process, which easily leads to problems such as misplaced platforms or leaking grout due to formwork splicing problems after the forming of concrete components, greatly increasing the cost of labor and materials[3].

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A verticality ruler can be used to check the building's verticality, levelness, and flatness, but the measuring efficiency is low. To solve the above problems, it is proposed to design a kind of intelligent ruler, that collects displacement through a displacement sensor, tilts through an accelerometer, and digitally displays the obtained measurement information on the screen after transferring it to the main control chip. Its operation is simple, fast, and convenient reading errors can be small wireless transmission of data, reducing the labor intensity of measurement workers, and measurement costs, and improving the efficiency of measurement.

2 System Hardware Design

2.1 Foot Structure Design

The structural design of the ruler is a fundamental part of the realization of its function. It utilizes a detachable, movable, and foldable solution to increase its portability. Its principal structure can be divided into a probe rod and a folding ruler. The folding ruler is composed of two one-meter-long metal rulers and a hinge assembly. The two metal rulers are graduated, with a continuous scale measuring two meters in length. The ruler can be opened and closed between 0° and 180°, allowing for precise adjustment. One foot is flanked by screens and control buttons. The probe is divided into two kinds of contact with the wall and clamped with displacement sensors. The structure of the storage space is a small, simple operation, and can realize a learning that is measured, convenient, and quick. The overall design is shown in Figure 1.

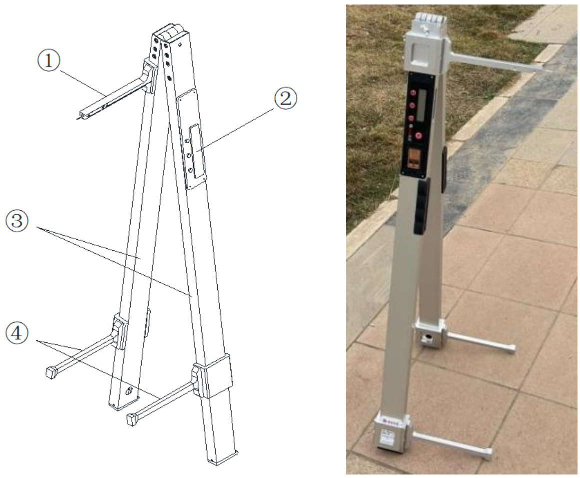

Fig. 1. Overall design of the tester (① Install a probe rod with a displacement sensor; ② Control board and screen; ③A meter ruler with a scale; ④ probe rod in contact with the wall.)

The probe rod structure is designed as a detachable unit, with the matching component comprising a C-shaped groove. A threaded hole above the groove allows for manual tightening of a fixed screw, enabling the probe rod to be fixed in place after movement on the ruler. The chute shape ensures a secure closure of the ruler, completing the storage state. The C-shaped groove of the part equipped with a displacement sensor is consistent with the probe rod in contact with the wall, as shown in Figure 2. The probe rod in contact with the wall is shown in Figure 3.

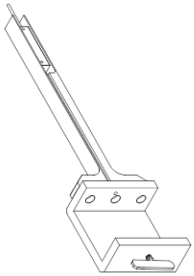

Fig. 2. A probe rod with a displacement sensor

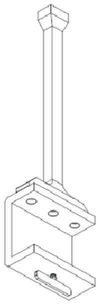

Fig. 3. Contact wall probe rod

The probe rod situated in the middle can be relocated to the target position, the contact sensor probe is in contact with the wall, and the bulge or collapse of the wall can be determined according to the comparison with the reference position. Further details can be found in Figures 4-6.

Fig. 4. A probe rod with a displacement sensor

Fig. 5. Contact wall probe rod

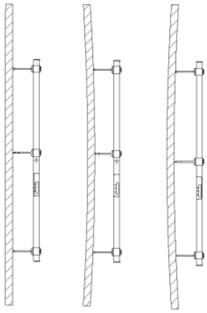

Fig. 6. Schematic diagram of templates for different conditions of instrument testing

2.2 CPU Control Module

The STM32F103C8T6 chip is selected. Commands input to the key cause the displacement sensor and inclination sensor to transmit signals, which are then processed by the chip and transmitted to the LCD screen and mobile device via Bluetooth. In essence, the functions of the primary control chip encompass LCD, key control, Bluetooth communication, clock circuitry, displacement sensor, inclination sensor, and voltage detection.

2.3 Inclination Module Design

The inclination module is one of the core components of the smart ruler, and the accuracy and stability of this module directly affect the key performance of the ruler. Generally speaking, it is simple and reliable to obtain acceleration and angular velocity information through accelerometers and gyroscopes. The selection of the MMA8452Q three-axis digital accelerometer [4, 5], with a moderate measuring range and a resolution of 14 bits, enables more accurate detection of small vibrations and deformations in the building template, thereby improving the test accuracy. Figure 7 illustrates the circuit connection design.

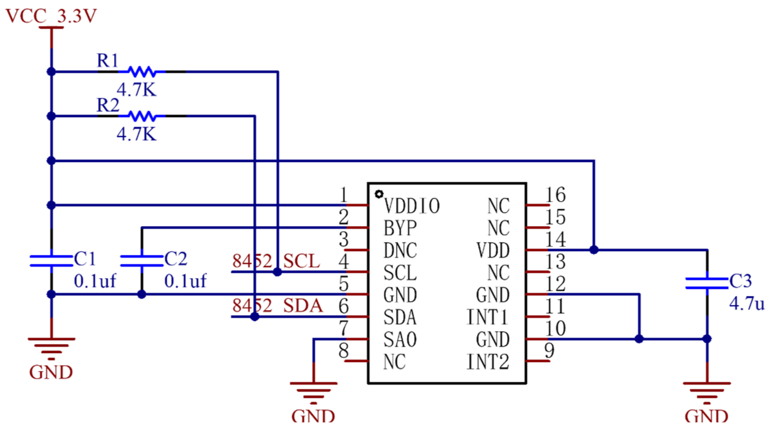

Fig. 7. Schematic diagram of triaxial accelerometer MM8452Q circuit

2.4 Displacement Sensor Module Design

When testing the flatness of the building template installation, it is necessary to view the installation status through the data of the displacement sensor, and its accuracy determines the accuracy of the detector test flatness. Different displacement sensors have their characteristics in terms of structure, accuracy, measurement range, linearity, adaptation to the environment, anti-interference ability, etc., and the potentiometer displacement sensor is selected through comprehensive comparison. The measurement principle of the potentiometer displacement sensor is based on the change of resistance, the measurement accuracy can reach 0.1%, the structure is simple, it is not affected by environmental factors such as temperature and humidity, and the output is a voltage signal, which can be converted and processed by the internal ADC of the chip, which is less expensive than other displacement sensors with the same accuracy. Finally, the KS8-25 potentiometer displacement sensor was selected [6].

2.5 Digital Display Module Design

The LCD serves a dual purpose: to remind the user and to display the result in the product. It then assists the tester in evaluating the installation of the building template. Therefore, accurate response results and clear display are the basic requirements of the display. In the design, the LCD1602 is the optimal choice, as its larger screen size can better prompt users, and the cost is low.

2.6 Bluetooth Module

Wall formwork data in the feedback to the screen at the same time, but also needs to feed back to the mobile device for data storage, which needs to meet the real-time transmission, accurate transmission requirements. JDY-31 Bluetooth module works in the frequency band of 2.4Hz, with fast transmission speed, high stability, low power consumption, and a maximum transmission distance of up to 30 meters, which can meet the requirements.

3 System Software Design

The intelligent software system employs a modular design methodology, whereby complex functions are decomposed into independent modules. These include, for example, inclination measuring programs, displacement measuring programs, screen display programs, and so on.

3.1 Inclination Module Program

The MM8452Q triaxial acceleration sensor is employed, with its sensing content being the angle between the measuring scale position and the vertical acceleration direction. The microcontroller and triaxial acceleration sensor are communicated via the IIC bus protocol. The results of the calculation are displayed on the LCD screen, and the aforementioned process is repeated. The switch then determines whether to continue the testing of the inclination. The process is illustrated in Figure 8 and 9.

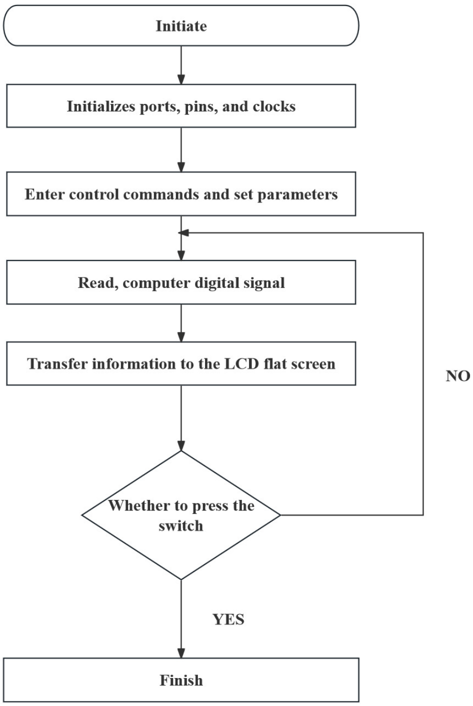

Fig. 8. Working flow chart of the inclination sensor

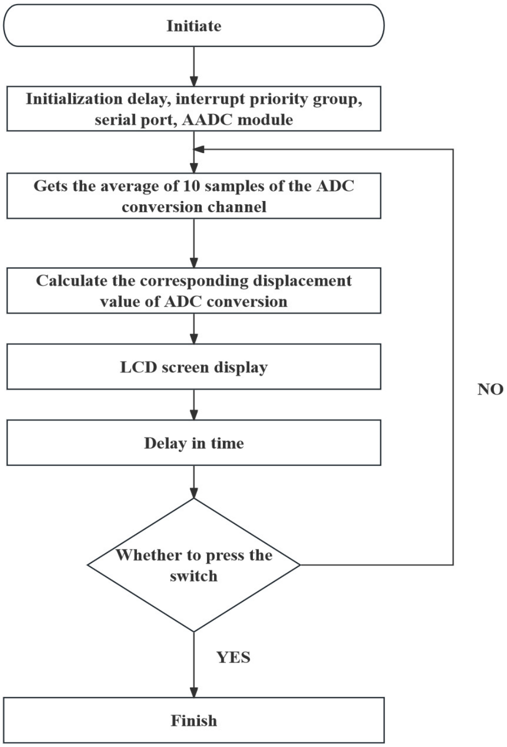

Fig. 9. Flow chart of displacement sensor

3.2 Displacement Sensor Program

Displacement sensor KS8 belongs to the potentiometer displacement sensor, the delay, interrupt priority group, serial port, ADC module initialization, to obtain the average of ten samples of the ADC conversion channel, the average value of the calculation to get the displacement data, and will be transmitted to the displacement data on the LCD screen feedback, delay and then cycle the program again until the switch to control its stop.

3.3 Bluetooth Function Program

The template installation site is characterized by a high level of noise and the inconvenience of using pen and paper to record on-site. Consequently, the test data must be transmitted to the mobile device. Using the Bluetooth JDY-31 module through the circuit design and program configuration to achieve the main chip will be collected and information from the Bluetooth module sent wirelessly.

4 Conclusion

Aiming at the problems of small operation space, high safety risk, and large human reading error when measuring the plumpness of molds in the mold support system, this paper designs a kind of intelligent ruler that can accurately measure the plumpness of building templates, which can be guaranteed by the structural modification of the ruler for the measurement of the plumpness of the irregular wall surface, and then selects the high-precision and high-stability angle sensors and displacement sensors, and designs stable peripheral circuits for them. In addition, the use of Bluetooth to expand the function of the learning rule can be connected through the cell phone to record the measurement data in real time, which greatly simplifies the workflow. Compared with the traditional measurement methods, the use of intelligent leaning gauge measurement has the advantages of low labor cost, convenient operation, reliable data, and stable transmission. In the future, the function of the upper computer will be further improved to realize the function of organizing, checking, and analyzing the recorded data.

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