TEST Engineering & Management

July-August 2020
ISSN: 0193-4120 Page No. 5283 - 5290

Application of Embedded Single Chip Microcomputer in Array Belt Scale under Artificial Intelligence Environment

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Article Info
Volume 83
Page Number: 5283 – 5290
Publication Issue:
July - August 2020

Article History
Article Received: *25 April 2020*
Revised: *29 May 2020*
Accepted: *20 June 2020*
Publication: *28 August 2020*

Abstract

With the continuous iterative development of belt weigher technology, the accuracy of various electronic belt scales can be greatly improved. In the process of operation, the belt scale will be affected by various external factors, and also by the belt tension of the belt scale itself, resulting in measurement error. Based on this, this paper first studies the array belt scale technology, then analyses the design of the array belt scale based on embedded single chip microcomputer, and finally gives the practical application of the array belt scale based on the embedded MCU in the artificial intelligence environment.

Keywords: *Embedded Single Chip Microcomputer,Array Belt Scale, Artificial Intelligence;*

1. Introduction

The rapid development of social economy, especially the rapid growth of e-commerce trade in recent years, not only drives the growth of goods trade, but also makes the circulation of logistics industry bring great opportunities and market prospects. As an important evidence of the process of commodity trade in several aspects as shown in Figure 1 below, based on the accurate measurement of goods or materials by belt scale, the normal operation of goods trade is carried out. Due to the low accuracy of the traditional belt weigher, the measurement data is not only large deviation, but also not stable, resulting in the normal operation of goods trade is affected. With the continuous iterative development of belt weigher technology, the accuracy of various electronic belt weighers has been greatly improved, and has been widely used[1]. However, in the process of operation, the belt weigher will inevitably be affected by various external factors, which will lead to its measurement accuracy being greatly disturbed. Therefore, it is necessary to monitor and calibrate the measurement accuracy, so as to ensure the normal flow of related goods trade[2, 3].

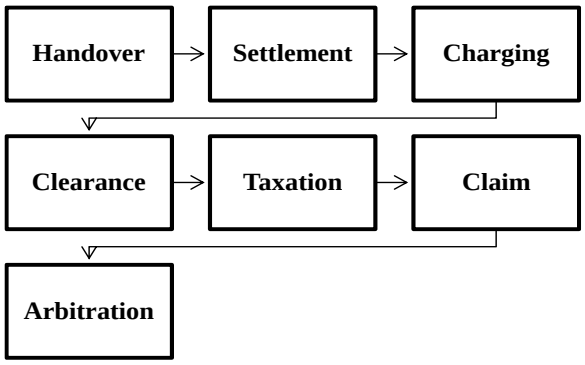

Figure 1. Commodity logistics trade transaction process.

In addition, as a dynamic measuring equipment, belt scale can weigh the flow of goods or materials in the process of transmission, and the weighing process is fully automatic, without manual intervention, so it has high efficiency and

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convenience. At present, belt weigher has become one of the important equipment in various industries, especially in the industries related to material transaction, such as ports, mines and so on. It plays a vital role in the normal operation of these industries. The structure of belt scale weighing frame has various forms, and each form has different characteristics, as shown in Table 1 below.

During the operation of belt weigher, in addition to the influence of various external factors, it will also be affected by the belt tension of the belt scale itself, thus resulting in measurement error[1]. In order to reduce the impact of belt tension, the single point detection method is generally used. However, the belt tension will be affected by a variety of external factors, which leads to the belt tension in the process of continuous dynamic change, so it is difficult to correct, so the single point detection method is difficult to fundamentally solve the error caused by belt tension[4-6]. On the other hand, the single point detection method has higher requirements for the installation and maintenance of the belt scale, so its practical operability is poor.

Table 1. Structure of weighing frame of belt weigher.

Number of idlers	Advantages	Disadvantages
Single holding stick	Weighing accuracy is general	Simple of installation and structure
Double idler	Quantify precision	Complex installation and structure
Multi idler	Good measurement accuracy and stability	Complex installation and structure

With the development of belt weigher, the precision of belt weigher has been improved, so the belt tension measurement accuracy can be eliminated. In addition, the installation and operation of the array belt scale has high flexibility, so it also has a strong adaptability to application scenarios[2]. The array belt weigher based on traditional integrated circuit and single chip microcomputer has some shortcomings, which can be further improved in terms of function integration and data running speed. The array belt scale based on artificial intelligence embedded MCU can further improve the accuracy, efficiency and overall performance of its operation, and has stronger stability, communication function and friendly display interface. Therefore, it has important practical value to study the application of embedded MCU in array belt scale based on artificial intelligence environment[7-9].

2. The technology of array belt weigher

2.1. The error source of belt scale

As one of the main error sources of traditional belt weigher, belt tension is not only the basic property of belt conveyor operation, but also to overcome the horizontal resistance of belt to ensure the belt conveyor to transport materials. The belt tension of belt weigher is related to the flow size and position of conveying materials. Under the action of belt tension, the materials in the weighing section are pulled up by the belt outside this section, thus affecting the accuracy and accuracy of weighing. The error caused by belt tension is shown in Figure 2 below.

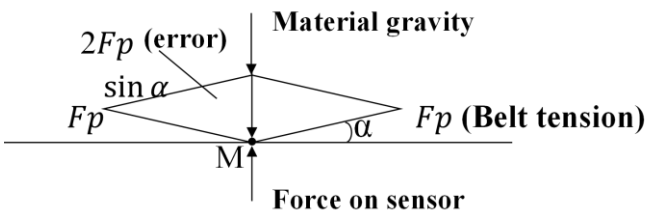

Figure 2. The error caused by belt tension.

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The error theory of traditional belt weigher is as shown in equation 1:

$$E = \pm\frac{2KdF_p}{nq\alpha^2} \quad (1)$$

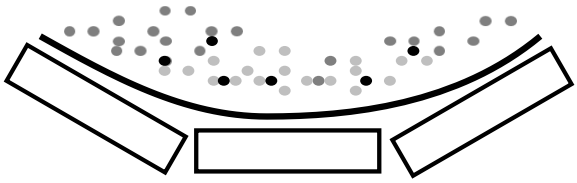
In which, E is the relative error, K is the belt effect coefficient, F_p is the belt tension, d is the vertical displacement of the weighing roller, n is the number of weighing roller groups, q is the material weight per meter, and α is the idler spacing.The belt tension F_p and horizontal direction produce an angleα, which results in $2F_p \times \sin\alpha$ error term[3].

2.1.1. Influence of belt effect

The main source of belt scale error is not belt tension, but the influence of belt state, which is belt effect. Belt effect refers to the effect produced by the physical characteristics of belt such as hardness, elasticity and symmetry of cross-section shape. The belt effect depends on the belt condition and the environment. The belt state will change greatly with the influence of external environmental factors, such as ambient temperature, belt material flow and time. The dynamic effect of these factors on the belt effect will have a greater impact on the measurement accuracy. At present, the belt effect has become one of the key factors affecting the stability of belt scale measurement.

2.1.2. Wavy effect of belt effect

The U-belt of belt weigher becomes quasi rigid body under the action of tension, which forms wave like oscillation in the running direction of belt, and the position of wave crest and trough determines the error of belt scale. The external environmental temperature and humidity change will change the stiffness of the belt, leading to the change of oscillation waveform, thus changing the weighing results. The rigidity of U-belt is produced under tension. Due to the change of support point height, the belt will have wavy change along the running direction. The section of U-belt is shown in Figure 3 below.



U-belt section of belt scale

Figure 3.Risk response operation level of MOOC.

2.1.3. End effect of belt effect

Under the action of tension, the belt of belt weigher will produce wavy oscillation, and the belt near the scale frame of belt scale will be lifted or pressed down to redistribute the material weight on the opposite end roll or fixed section and weighing roller[4]. The distribution ratio varies with the belt stiffness and waveform, and the symmetrical weight has a great influence.

2.2. Influence of temperature change on sensor

With the development of electronic application of belt scale, the application of electronic sensor of belt scale is more and more widely used. The sensor is sensitive to the change of external environment temperature, and is easy to be interfered and affected. Generally speaking, the sensor of belt scale will have relevant zero temperature coefficient and sensitivity temperature coefficient to evaluate the influence of temperature change on the sensor.

In a word, the ripple effect, end effect and temperature change of belt effect of belt scale will lead to poor long-term stability of belt scale, which will restrict the further application of belt scale, and lead to adverse effects on its popularization and application.

2.3. Principle of array belt weigher

As the latest development situation of belt weigher, the array belt scale is based on the load cell as the support, adopts a special scale structure to install two groups of weighing idlers to form an independent weighing unit single point suspension weighing unit. N weighing units are installed

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continuously to form a weighing array. The principle frame of array belt scale is shown in Figure 4 below.

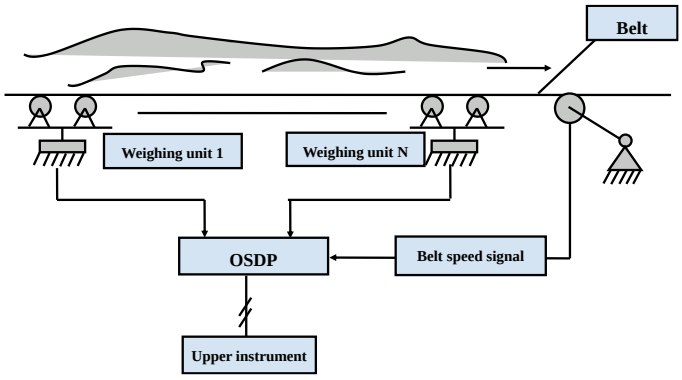

Figure 4. The principle frame of array belt scale.

2.4. Composition of array belt weigher

The key indexes of array belt scale include rated flow, belt width, belt speed, physical verification error and array unit number. The composition of array belt scale mainly includes suspension weighing unit, signal acquisition unit, terminal processor, output adapter, wireless transmission unit, etc. Among them, the suspended weighing unit is supported by two groups of weighing idlers by sensors, so it has strong ability to resist eccentric load and horizontal force[5]. Its typical structure is shown in Figure 5 below. The signal acquisition unit can collect and process the key signals of the belt scale on site, including different signals such as weight, speed and temperature.

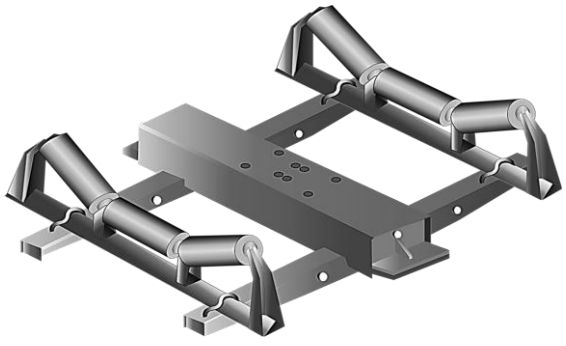

Figure 5. Suspended weighing unit of the array belt weigher.

With the application of single chip microcomputer, the processed data is sent to the terminal processor in the control room through the data interface. Based on the embedded industrial computer, high-precision signal amplification and high-speed A/D conversion are realized. After receiving the data sent by the signal acquisition unit, the terminal processor will carry out subsequent calculation and processing on the collected data to generate the final weighing result and display it. In addition, the unit will store further data, and has the function of query and analysis[6]. The output adapter can output other control signals based on user requirements. The wireless transmission unit realizes the wireless transmission of data based on the mobile data communication technology, so as to construct the data link and realize various real-time data requests required by the information station transmission center.

2.5. Composition of array belt weigher

3. The array belt scale has strong measurement accuracy, which is mainly due to its ability to eliminate the influence of belt tension based on internal force theory, complete the mathematical modeling of belt tension and belt effect, and realize compensation and correction. The influence of the belt tension of the weighing unit of the array belt scale is the same as that of the traditional belt weigher, and the continuous installation of the weighing array can effectively counteract most of the influence caused by the pull-up effect, so that the influence of the belt tension of the array belt scale is limited to the units at the entrance and exit of the array. The internal force theory principle of array belt weigher is shown in Figure 6.

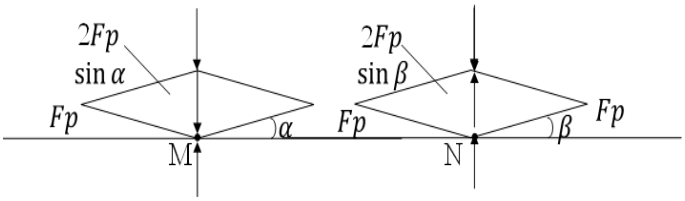

Figure 6. Internal force theory of array belt weigher.

2.5.1. Functional structure of array belt weigher

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TEST Engineering & Management

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The structure function of the array belt weigher has direct connection structure and non-direct connection structure. When the belt of non-direct connection structure is running, the scale frame will rotate, because the horizontal thrust acts on the upper part of the roller, and the sensor is installed on the frame beam[7]. When the non-direct connected scale frame works, the rotation angle corresponds to the pressure of the material on the roller, the influence and error of belt tension result in the difference of linearity, and the correction of linearity difference is difficult.

2.5.2. Comparison of array belt weigher structure

The direct connection structure eliminates the error caused by the mechanical deformation of the lever system, and eliminates the influence of the change of material flow on the accuracy of the belt weigher. When the belt of array type belt weigher is in direct connection structure, the weight of material is pressed on the weighing idler through the belt, which produces forward resistance, and at the same time, it generates horizontal driving force on the scale frame through the idler.The direct connection structure of the array belt weigher adopts a single point type weighing sensor and a rigid direct connection of the scale body, so it has better linearity, repeatability and long-term stability, and has good accuracy in the full range.

4. Design of array belt scale based on embedded MCU

4.1. The embedded system

Embedded system technology is widely used in the field of electronic products and communication, and mainly consists of embedded processor, hardware, operating system and corresponding applications. The embedded operating system and application program constitute the software layer, while the embedded processor and peripheral devices constitute the hardware layer. With the rapid development of artificial intelligence and the Internet of things technology, embedded system gradually towards the network, intelligent and low power consumption direction of rapid development. And thanks to the rapid iteration of communication technology and electronic technology, embedded system is developing towards the direction of stronger performance, richer functions, smaller volume, more convenient operation and lower energy consumption, providing better applicability and operability for its application in various fields.

4.2. Design of embedded system architecture

Firstly, in the instruction set architecture of embedded system, the system architecture is designed based on the principles of low power consumption, high performance and high stability. Based on the operation level of high certainty, the cache free operation is realized, and the debugging and software configuration file support are provided[8]. Secondly, in the kernel level of the system, high-performance processor is used to achieve high-efficiency processing performance and system functions, and the security of the system architecture is improved based on the switching of different modes. In addition, based on the excellent architecture design, the following features are realized at the processor level, namely, the system processing unit with high performance, low power consumption, high real-time performance and strong ecological support.

4.3. Overall structure of array belt weigher based on embedded single chip microcomputer

The overall structure of the array belt weigher based on embedded single chip microcomputer is mainly composed of several parts as shown in Figure 7 below. Among them, the measuring unit converts the pressure signal to the electric signal based on the sensor, and processes the converted electrical signal through filtering and differential circuit, and converts the signal into digital quantity for final output[9]. The controller outputs the final weight of the digital signal after processing and calculation on the display. The controller can also be programmed based on keyboard to control and store the system contents.

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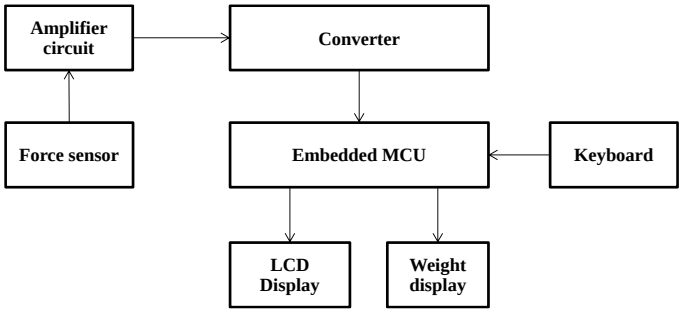

Figure 7. Structure of array belt weigher based on embedded MCU

In addition, in the controller selection level of the system, the application program is directly stored in the external extended memory to realize the automation of the measurement process, the data of the measurement results and the diversification of the functions, and meet the control requirements of the measurement data. In the sensor selection level of the system, the circuit architecture and sensor performance parameters should be considered comprehensively to meet the information collection and processing requirements of the system. In the selection of amplifier circuit, the pre-processing circuit can be formed based on ordinary low-temperature drift operational amplifier, or differential amplifier based on high-precision low drift operational amplifier.

In the selection level of the converter of the array belt scale system, since the converter has a variety of types as shown in Table 2 below, therefore, the specific application requirements of the system should be determined based on the characteristics, advantages and disadvantages of each type.

Table 2. Featuresof various converter types.

Converter types	Advantages	Disadvantages
Parallel	The conversion is completed at the same time	Poor anti-jamming ability and low resolution
Successive approximation	Low power consumption and price	The signal needs conditioning
Integral	High resolution, low cost and power consumption	Low conversion rate
Voltage frequency conversion	High resolution, low cost and power consumption	Conversion rate is limited

4.4. Keyboard processing scheme of array belt scale

In the structure of matrix keyboard of array belt scale based on Embedded MCU, each horizontal line and vertical line are not directly connected at the intersection. The key recognition of matrix keyboard is to judge whether there is a key pressed in the keyboard, so as to realize the judgment of the position of the close key. The keyboard interface circuit of matrix keyboard structure is shown in Figure 8 below. The interrupt service program is executed after the processor responds, and the keyboard is scanned after the interrupt program.

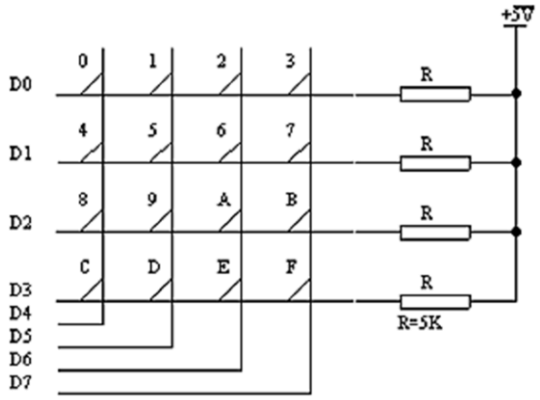

Figure 8. The keyboard interface circuit of matrix keyboard structure.

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4.5. Software design of embedded single chip microcomputer array belt weigher system

First of all, in the software development environment of embedded single chip microcomputer array belt scale system, assembly language is selected to meet the needs of the system for memory operation, interrupt processing and other occasions. Secondly, the software design process of the system, first of all, initialize the system, and then schedule several key tasks, such as scheduling, weighing signal acquisition, speed signal acquisition, key pressing and display control, and realize the real-time display of data, the setting of parameters and the display of historical data.

In addition, in the design of weighing signal acquisition driver, the whole sampling process is completed based on module initialization, AD conversion, data conversion and data return. In the speed signal acquisition task, the real-time speed of material transportation is obtained based on the pulse form. In the display control task, first clear the memories, read the display state, and then send instructions or data to complete the whole data display process. In the matrix keyboard driver, the keyboard is initialized first, and then the keyboard is pressed to remove the jitter. After scanning the rows and columns, the key values are determined and determined. Finally, the processing subroutine is called to complete the keyboard driving process.

5. Application of embedded MCUarray belt scale in artificial intelligence environment

5.1. Tare detection of array belt weigher

Compared with the traditional belt weigher, the array belt scale based on embedded MCU has higher weighing accuracy, stronger installation flexibility, and stronger measurement stability and maintainability. In practical application, the array belt scale based on embedded single chip microcomputer is applied to specific measurement and settlement scenarios. After installation, the tare value is detected regularly, and the measurement results are compared with the tare value data of other belt scales in the same period. Based on the stability of the numerical variation, the stability of the empty scale of the array belt scale based on the embedded single-chip microcomputer is verified. Through the actual test verification, it can be found that the stability of the array belt scale is significantly improved.

5.2. Signal temperature compensation of array belt weigher

Temperature has a strong effect on the accuracy and durability of the weighing instrument. This is because the belt tension and sensor deformation will be caused under the condition of large temperature difference change, which will cause measurement error. Based on the temperature compensation of the weighing sensor, the durability index of the belt scale can be greatly improved. The accuracy of the array belt scale can be greatly improved by the temperature compensation correction according to the signal difference generated by different weighing units in the signal processing system.

5.3. Application of embedded MCU array belt scale in artificial intelligence environment

Based on the technology of artificial intelligence internet of things, the remote fault detection and service system of embedded single chip microcomputer array belt scale is constructed. The architecture of the remote intelligent system is shown in Figure 9 below, so as to realize the data conversion and wireless transmission, and connect the users of the array belt scale with the server. The system can collect and record the data of embedded single chip microcomputer array belt scale remotely, so it has the functions of running state analysis, fault diagnosis and maintenance warning.

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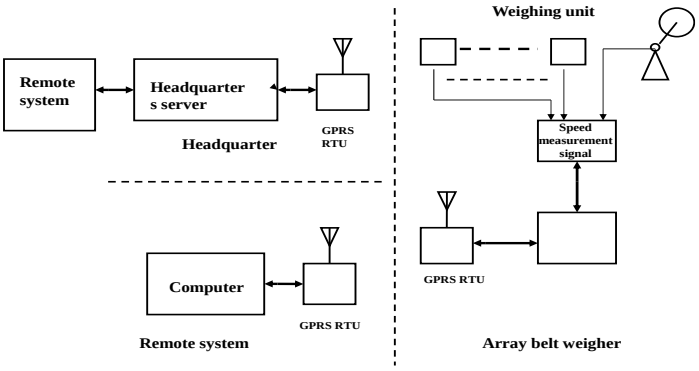

Figure 9. The architecture of the remote intelligent system.

In addition, in the artificial intelligence environment, the network constructed by embedded single-chip microcomputer array belt weigher can realize the timely management of logistics planning, scheduling and statistics, so as to prevent artificial cheating, early warning of failure, unattended, tag calibration and technical support, so it has applicability and operability in special sites and industries.

6. Conclusion

In summary, with the continuous development of artificial intelligence and electronic technology, the array belt scale based on single chip microcomputer can convert the belt tension of weighing unit into internal force, thus eliminating the interference and influence of belt tension on its measurement accuracy, so as to greatly improve the measurement accuracy and measurement stability of belt scale. In addition, the array belt scale based on Embedded MCU can further improve the accuracy, efficiency and overall performance of its operation, and has stronger stability, communication function and friendly display interface.

In this paper, the structure, composition, principle, error source and function structure of array belt scale are analyzed through the research of array belt scale technology. Secondly, through the design and analysis of the array belt scale based on embedded single chip microcomputer, the embedded system architecture design, the overall architecture of the array belt scale based on embedded single chip microcomputer, and its software design are studied. Finally, the practical application of embedded single chip microcomputer array belt scale in artificial intelligence environment is given, including the application of tare detection, temperature compensation and remote intelligent detection of array belt scale.

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