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Design of Weighing System Based on Improved Moving Average Filter Algorithm

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Abstract: In order to improve the accuracy and stability of the weighing system, under the actual conditions of rapid weighing of static truck scales, a design of weighing system based on improved moving average filter algorithm is proposed. The weighing system consists of data acquisition, analog-to-digital conversion module, processor, control module and display module. Being combined the median filtering method and the moving average filtering method, an improved moving average filtering algorithm that can eliminate occasional pulse interference signals and suppress periodic interference signals is proposed. Through the comparison and analysis of the experiment with the improved moving average filter algorithm, the weighing accuracy of the system optimized by the algorithm is effectively improved, and the display effect is faster and smoother.

1. Introduction

In the case of high frequency weighing operations of electronic truck scale, the truck driver stops at the weighing platform and waits for weighing. In order to save production time, he will not choose to turn off the engine to keep the truck in absolute static weighing state, so it is necessary to accurately measure the truck weight under the condition that the truck engine is in standby operation. Based on this working condition, a design scheme of high-precision weighing system based on improved moving average filtering method is proposed. The analog sensor is used to collect the weighing signal, the STM32 series single-chip microcomputer is used as the main control chip, and the 24 bit ADS1232 module is used for AD conversion. Through the combination of good design and layout of hardware circuit board and the realization of improved moving average filtering algorithm in STM32 to get software filtering, it can not only eliminate the instantaneous peak interference signal, but also suppress the periodic interference caused by the truck engine not flamed out, and maintain the rapid effect of data display[1].

2. Design of Weighing System

2.1 The Total Design Project of Weighing System

The weighing system designed in this project consists of analog weighing sensor, analog-to-digital conversion module, STM32 controller, control module and display module. The

main hardware design diagram of the weighing system is shown in Figure 1.

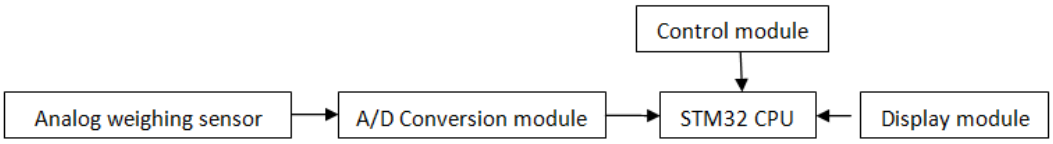

Fig.1 Hardware Design Diagram of Weighing System

2.2 Layout Design of Weighing Hardware Circuit

The noise produced by the power supply will increase the signal-to-noise ratio and reduce the effective resolution of the A / D conversion module. For the weak weighing signal, it is very important to choose a low voltage linear regulator with excellent performance and low noise to produce stable voltage for the weighing sensor. This solution selects a high-precision analog-to-digital conversion module ADS1232 introduced by Texas Instruments company. The effective resolution of the module is as high as 23.5 bits, which is composed of a third-order modulator and a fourth-order digital filter. The main function block diagram is shown in Figure 2[2].

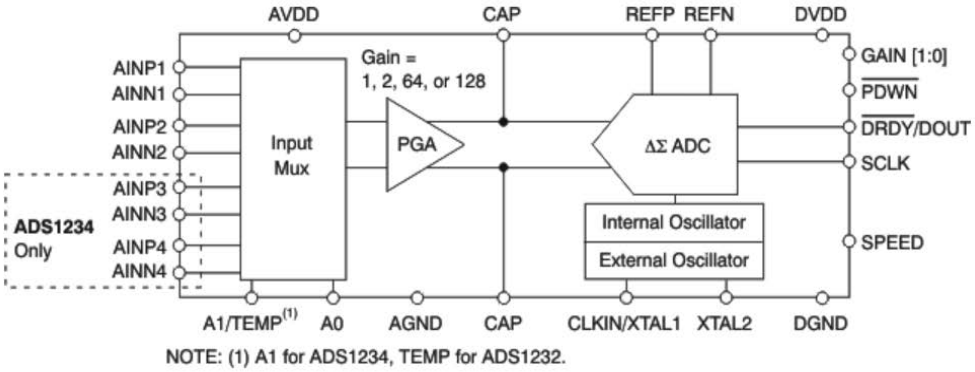

Fig.2 Ads1232 Function Block Diagram

Secondly, in order to avoid the influence of large nonlinear integration and temperature drift error, the high-precision off chip reference (ref5025) is used in the ADC module. Besides, the capacitor with high ESR is used in the reference output to ensure the stability of the reference source voltage. As can be seen from the block diagram shown in Fig. 2, the analog processing area and the digital area are completely independent. The digital ground and analog ground are separated to reduce the coupling path and prevent the cross-talk of ground signals from affecting the weighing processing signals. The low-pass filter composed of low-temperature drift metal film resistor and multilayer ceramic capacitor in front of A / D conversion module can not only reduce the noise interference caused by resistor and capacitor, but also improve the total harmonic distortion and eliminate the influence of over drive signal outside the filter bandwidth.

2.3 Design of Weighing Filter Algorithm

In practical weighing system applications, due to the differences in the weighing field environment and weighing structure, it is affected by periodic interference signals and aperiodic random signals. Due to the different interference signals, the filtering algorithms used in the system are also different. In the current filtering algorithms, the limiting filtering method and median filtering method can effectively filter the pulse interference caused by accidental factors, but can not

suppress the periodic interference signal; The moving average filtering method has a good inhibition effect on the periodic interference, with a high smoothness, but it has a poor inhibition effect on the occasional impulsive interference, so it is not easy to eliminate the sampling value deviation caused by the impulsive interference[3].

Based on the analysis of the above situation, combined with the actual application that the engine is in operation when the truck weighs of the scheme, the flow chart of the improved sliding mean filtering algorithm is proposed as shown in Figure 3.

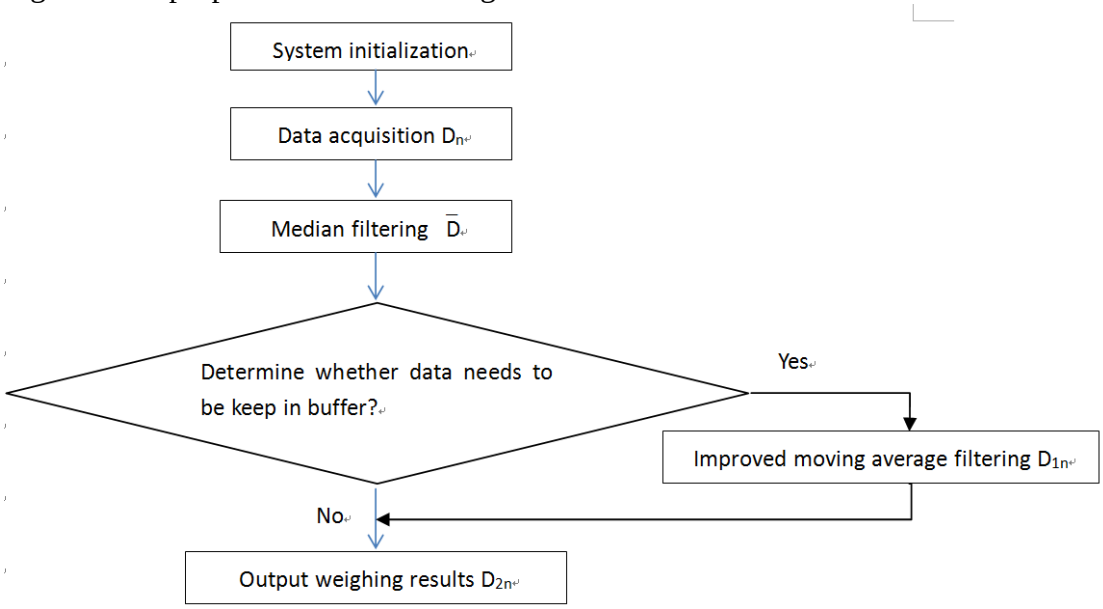

Fig.3 Flow Chart of Improved Moving Average Filtering Algorithm

In the above flowchart, D_n is the nth sampling value from ADC. Firstly, $\bar{D}$ is the result of arithmetic average processing by selecting a certain number of weighing sample values. Next, each time a new D_n is smpled,it is judged with $\bar{D}$, If the difference between the sampling value D_n and $\bar{D}$ is greater than or equal to 1% times $\bar{D}$,then store D_n value in buffer, when the sampling value of buffer window accumulates to a certain amount of N_2, The sample value in the buffer is also processed by arithmetic average operation, and replace the result $\bar{D}_{1n}$ value with $\bar{D}$,as the result of D_{2n} value, and the buffer data is emptied waiting for the next buffer operation; If the difference between the sampling value D_n and $\bar{D}$ is less than 1% times $\bar{D}$, make $\bar{D}$ value as the result of D_{2n} value. Therefore, the final sampling output value D_{2n} is

$$D_{2n} = \begin{cases} \bar{D}_{1n} & |D_n - \bar{D}| \geq 0.01\bar{D} \\ \bar{D} & |D_n - \bar{D}| < 0.01\bar{D} \end{cases} \quad (1)$$

D_{2n} is the final sampling output value; $\bar{D}$ is the historical sampling arithmetic mean value, $\bar{D}_{1n} = \frac{1}{N_2}\sum_{i=0}^{N2} D_{1n}$ is the arithmetic mean value of buffer samples.

3. Experimental Testing

The weighing data system is tested by loading the standard weight traceable by measurement to the weighing platform of the sensor. The IL type load cell of Ningbo Keli sensor company is selected, its range is 100kg, its sensitivity is (2.0 ± 0.2)mv/v, and its linear error is ± 0.03% F.S[4]. ADS1232, a 24 bit analog-to-digital conversion module, is selected for data processing; STM32F103C8T, a 32-bit ARM processor based on arm Cortex-M3 of ST company, is selected as the main control chip. Its powerful performance and rich peripherals are not only competent for the

main control work, but also make the system have a high expansion space.

In the hardware circuit test, a single load cell is used to collect data, and the system using median filtering algorithm and the improved moving average filtering algorithm are tested respectively. In the test, each group of data is weighed three times, and the average value is taken as the final measurement value. The measurement results are shown in Table 1 below.

Weights/kg	median filtering algorithm		improved moving average filtering algorithm		Remarks
	Display value /kg	Relative error/%	Display value /kg	Relative error/%	
10.00	10.07	0.7	10.01	0.1	
15.00	15.12	0.8	15.04	0.27	
40.00	40.16	0.4	39.98	0.05	
50.00	50.18	0.36	50.04	0.08	
60.00	60.24	0.4	59.96	0.07	
75.00	74.86	0.19	75.04	0.05	
100.00	100.32	0.32	100.04	0.04	

It can be seen from the above table that under the same hardware circuit layout, the relative error of the weight processing using the improved moving average filtering algorithm is relatively small and greatly improves the weighing accuracy, and the display speed of the weighing display effect is also faster.

4. Conclusion

In this paper, a weighing system with high stability and precision is designed. The methods of combining hardware and software are used to process the symmetrical weight signals, which optimizes the weighing accuracy of the system and makes the data display effect more rapid and smooth. Through the comparison of test data, it basically meets the above-mentioned using conditions, and has strong practical value in the weighing process of truck scale in mining, sand and stone industries.

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