Design and Optimization of Precision Signal Chain Circuit

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Abstract. In electronic design, sensor has been used to measure external signal, but the tested signal also is weak. It should be magnify, filter, A/D transfer and input to a microprocessor. But due to many kinds of noise interfere, the sample data accuracy is not reach the standard required. In order to solve this problem, we carefully analysis the interference situation and provide many methods, such as selection refine device, optimization PCB design, add filter circuit, in order to optimization the design circuit continuously and finally to reach prefect result.

Introduction

In engineering practice and electronic design, designers often have to establish a signal link to complete the signal detection and processing. The front end of the link signal is detected by a sensor signal detected by an external signal, usually are very weak, such as ultrasonic echo signal and pressure signal of the pressure sensor, often to the signal amplification, filtering, the input to the high precision A/D converter, and then convert it to digital signal, finally to the microprocessor. However, due to the presence of white noise, power supply noise, PCB design unreasonable and other factors, will lead to the accuracy of the collected data is not enough, serious deviation from the normal value of [1-2]. In view of this problem, this article will be through a specific example - pressure bridge amplifier link design, step by step analysis of the causes of interference and propose improvements, in the hope that electronic designers can help.

System Design

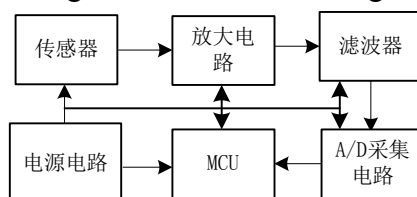**Signal Chain Diagram.** The common signal link is shown in Fig. 1

Figure 1.   Finite block diagram of signal chain

In Fig. 1, the power supply provides the voltage for the other modules. To detect the signal through the sensor acquisition, amplification, filtering, A/D sampling, and finally sent to MCU for processing[3-4].

Specific Application Examples. In order to better solve the problem, through a specific example for analysis. Figure 2 shows a pressure bridge detection and amplification circuit[5].
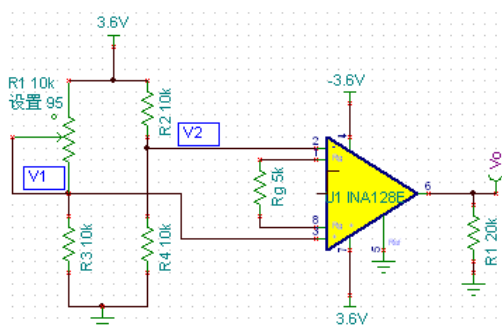
Figure 2 pressure bridge detection and amplification circuit

In Fig. 2, the pressure bridge adopts 10kg pressure sensor, in order to remove the interference, the instrument amplifier INA128 is adopted. When the maximum load is 10000g, the output of the pressure sensor is 10mv. For INA128, its magnification is calculated by formula (1) [6-7]. Select Rg=5K in the experiment, so the INA128 magnification is 101 times, then enter the ADC voltage is 10mV*101=1.01V. ADC select 12 bit ADS7829.

$$G=1+50K/Rg \tag{1}$$

Detailed Design and Analysis

Preliminary Printed Board Production. According to the schematic diagram, the printed circuit board is designed as shown in Fig. 3 and fig. 4.
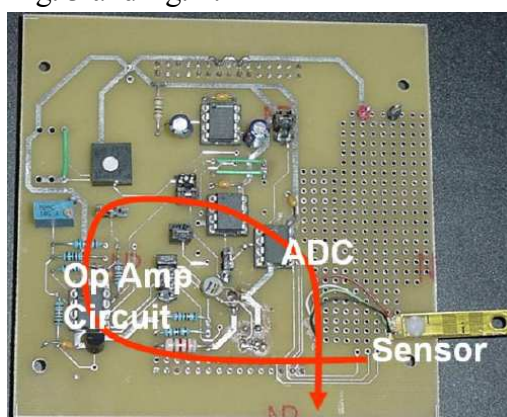

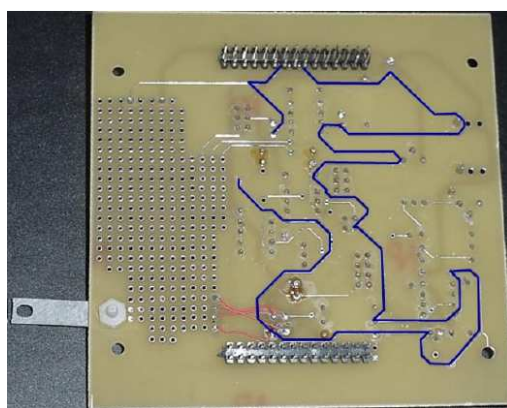Figure 3.   Finite top circuit board design

Figure 4.   Finite the bottom circuit board design

According to the design of the circuit board for signal acquisition and processing, can be obtained ADC conversion results shown in fig. 5.
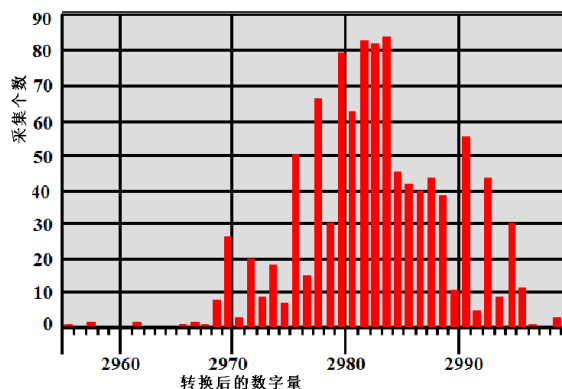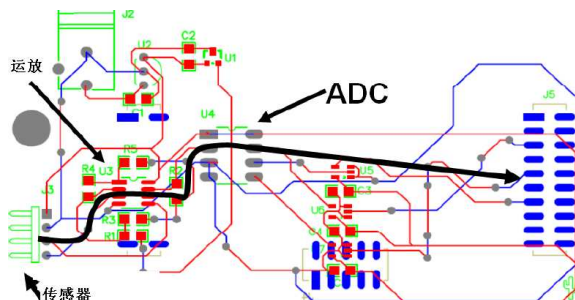

Figure 5.　Finite ADC sampling results

Analysis of the results in Fig. 5, a total of 1024 data points were collected, there are 44 different data. After calculation of 26.5 - 44 shows, for 12 AD, only 5.5 accurate sampling results. Thus, it is different from the expected value. The following will be carefully analyzed and explained how to optimize.

Optimized PCB Printed Board. After the previous analysis, in the production of PCB, we should try to reduce the loop and parallel lines, reduce the coupling between the digital circuit and analog circuit, with a shorter line to suppress radiation noise. The modified PCB is shown in fig. 6:

Figure 6.　Finite PCB layout after noise suppression

Test the printed circuit board in Fig. 6, the same as the selection of the 1024 points, there are only 6 different sampling points, so that the effective bit ADC is 12-log26=9.4. Visible performance has been greatly improved.

Optimization. From the above analysis, we can improve the results of ADC sampling, but it is not the best. In this case, the filter circuit is added. A decoupling capacitor is added in the vicinity of the power supply pin of each integrated circuit chip, usually using a 0.1uF capacitor. In the ground treatment of PCB, to a large area of the floor. If the above approach can not achieve optimal design, before the acquisition signal access to the ADC, to increase the filter design circuit to ensure that the filter interference signal [10]. After further optimization design, the obtained PCB is shown in fig. 7.
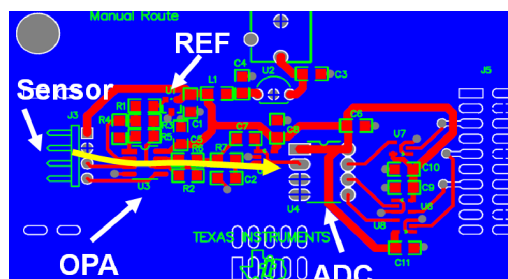
Figure 7.   Finite optimized PCB layout

Summary

In this paper, a careful analysis of the analog circuit design, especially the causes and the interference caused by precision signal link design, and proposes a solution for every situation, optimize and perfect gradually, finally achieved satisfactory results. If we want to design the hardware circuit better, we can use the ADC device with PGA, which can simplify the design of hardware circuit and improve the performance. If the sampling effect of ADC is not satisfactory, it is necessary to remove the interference by software filtering algorithm. The design of this paper has certain practical reference value, and it is helpful for the hardware engineer to design the circuit.

References

[1] TI high performance simulator application guide [M]. Shanghai 2014, China; 4.

[2] Texas Instruments. TI high performance simulator application guide [M]. Shanghai, 2014,3

[3] Xu Yongfeng, He Yucheng, Zhou Lin. Three software filtering algorithm for blood pressure pulse oscillation wave [J], Chinese Journal of electronic measurement and instrument, 2015,29 (3): 454-459.

[4] Chen Qian. Design and implementation of software filtering algorithm based on [J] FPGA, science and technology and engineering, 2014, 14 (3): 166-169.

[5] Gong Zhongliang, Li Yao. Optimization design of pulse signal acquisition circuit based on photoelectric sensor [J], electronic device, 2014, 37 (4): 658-661.