

Design of General-purpose Industrial signal acquisition system in a large scientific device

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Abstract—In order to measure the industrial signal of a large scientific device experiment, a set of industrial data general-purpose acquisition system has been designed. It can collect 4~20mA current signal and 0~10V voltage signal. Through the practical experiments, it shows that the system is flexible, reliable, convenient and economical, and the system has characters of high definition and strong anti-interference ability. Thus, the system fully meets the design requirements..

1. Introduction

Today while the industrial manufacturing is so developed, 0~10V voltage signal and 4~20mA current signal has become the current industrial signal description of the standard, which also includes the switch signal, digital signals, etc. So the industrial signal acquisition technology is also all flowers are in bloom and hundreds of schools of thoughts contend, and each has its own characteristics. With the popularity of computer applications, our most common industrial signal acquisition program should be the use of PCI interface acquisition card to collect industrial signal, and then use the computer system to develop the appropriate acquisition and processing software and (HMI) human-machine interface to get what we need to collect Data[1]. These acquisition system is characterized by powerful data processing capabilities, friendly (HMI) human-machine interface, and then generally have a network interface to facilitate networking, but these PCI acquisition card collection channel is not much, the price is high, with its large industrial computer, And the price is high. Which makes its scope of application has been greatly limited.

A large scientific device experimental industrial signal acquisition system requires the ability to collect the standard industrial voltage signal and current signal[2~4]. So these requires the data acquisition system to both miniaturization, high reliability.

The whole system is divided into voltage module and current module, each module is independent work, do not interfere with each other. So that the reliability of the system will be a very good guarantee, and save the cost of the system.

2. System overall design

From Fig.1 can understand that we design the industrial signal acquisition system, which voltage/current acquisition system shares a PCB board, as long as the voltage acquisition circuit input



terminal behind the circuit into a 200 ohm precision sampling resistance can be input to the current signal into a voltage signal for acquisition, so that not only saves the cost of PCB board, but also further improve the combination board flexibility. We need to collect the industrial voltage signal range is 0~10V, the current signal range is 4~20mA, a voltage / current acquisition board has five input channels, welding components can be selected according to our actual requirements for welding voltage acquisition channel Or current acquisition channels. The switchboard has 8 channels, each 4 channel has a common end, the board also has two separate isolated DC-DC module to provide 24V power supply. All of the acquisition boards are optimized for component layout prior to PCB routing. The components of the different functional circuits are centrally arranged and separated from each other, and the ground and the ground are separated, and at the same time only at a certain point connected. The signal flow on the board is also consistent, the signal flow as far as possible to avoid clutter conflict, the top line and the bottom line into a vertical intersection angle, in order to reduce the mutual interference between the signal interference. And all critical node power supplies are fully isolated DC-DC power supplies for complete isolation on each channel. Strict PCB layout and wiring specification processing makes the circuit's anti-jamming capability very well guaranteed, the circuit design process and the final performance is in full compliance with the strict requirements of industrial signal acquisition and safety standards.

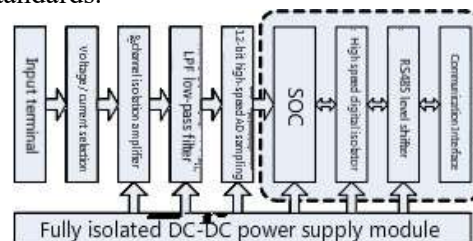


Figure 1 Voltage /Current Acquisition System Structure Diagram

3. Design of voltage/current acquisition system

3.1 Input interface circuit

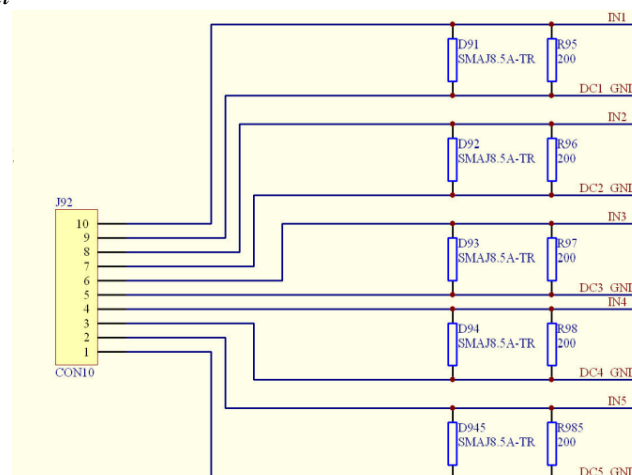


Figure 2 Voltage/current acquisition input interface circuit

The working principle of voltage/current acquisition module is more complicated than the input and output module of the switch, and the requirements for circuit design are higher. The target of our design is to collect the industrial standard voltage signal from 0~10V and the industrial standard current signal of 4~20mA, and design 5 collection channels. In order to realize the current signal acquisition, we can let the current signal through a sophisticated sampling resistor to get the

corresponding voltage signal, then can current signal according to the sampling method of voltage signal. This will not only save the cost of PCB, but also make our collection of modules more flexible and convenient. As be seen from the figure 2, we choose the precision of sampling resistance $R = 200\ \Omega$, because the current known is 4~20 ma, so The obtained sampling voltage is

$$U = I * R = (4 \sim 20 \text{ mA}) * 200 = 800 \sim 4000 \text{ mV} \quad (1)$$

This voltage is in the best area of the range of 0~5V of the ADC chip MAX1270, which is helpful to improve the precision of system measurement.

A TVS diode is also attached to the front end of the sampling resistor (transient interference suppression devices). When TVS's poles reverse high-energy shock, it can change the impedance between the poles from low to high at a rate of 10~12, to absorb as much as several kilowatts of power surge, which make the potential between the poles clamp to locate in the preset value, effectively protect the electronic components of equipment from the damage of surge pulse. TVS has the advantages of fast response time, the transient power, low leakage current, low breakdown voltage deviation, easy clamping voltage control and having small volume. At present it has been widely used in household appliances, electronic instruments, communications equipment, power supply, computer systems and other fields. The TVS tube used in the voltage acquisition channel is SMAJ12A-TR (breakdown voltage of 13.3 V), and the TVS tube model used in the current acquisition channel is SMAJ8.5 A-TR (the breakdown voltage is 9.44 V).

After we sure we need a few road after voltage acquisition channel and current acquisition channel, we can freely match the voltage/current acquisition boards we need according to the needs of our welding interface part of selective element.

3.2 Isolating amplifier circuit

Industrial applications have high requirements on equipment, and the signal interference sources of industrial environment are complex. The main types of interference include: ground circulation interference, natural interference and human disturbance. The three elements of interference are the interference source, the sensitive source and the coupling path. If lacking one of the elements, the electromagnetic compatibility problems will not exist, so we should start with these three elements, to find the most convenient solution to the problem. Generally, there is no way to solve the interference source and sensitive source. Usually the method is came up from the coupling path, and it is also the most commonly used method, such as adding screen, adding filter mean. We use the isolation method to eliminate the interference that the system may introduce.

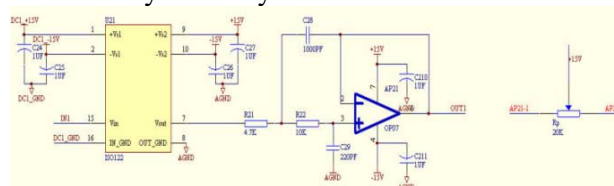


Figure 3 Isolation amplifier circuit

After the necessary preprocessing of the signal through the front-end interface circuit, the input signal enters the isolated amplifying circuit in this part. As can be seen from figure 3, the isolation amplifier ISO122 is the core component of this part of the circuit. ISO122 is the isolation amplifier of the capacitance isolation technology produced by TI company in the United States[5]. Its working voltage is $\pm 4.5 \sim \pm 18\text{V}$, the maximum nonlinear is 0.2 %, the isolation voltage is at least 2000VDC, and the gain is fixed to 1.

The ISO122 requires each power supply to attach a 1uF decoupling capacitor (recommended tantalum capacitor) in the PCB layout, this capacitor should be as close as possible to the chip power pin to reduce offset voltage. The ISO122 requires each power supply to attach a 1uF decoupling capacitor (recommended tantalum capacitor) in the PCB layout, this capacitor should be as close as possible to the chip power pin to reduce offset voltage. The input interface of ISO122 voltage signal to the isolation amplifier 0~10V, the gain of ISO122 is 1, so the output voltage signal of the equivalent of

the 0~10V, but the output of the ISO122 with a ripple 500KHz, about 20mV, in order to reduce the output ripple, ensure the linear amplifier, the output of each ISO122 in the end and one by OP07 the two order Butterworth type quality factor $Q=1$ low pass filter, the cut-off frequency is set to 50KHz[6]. The signal after the filter is added to the input interface of the AD converter.

3.3 AD conversion circuit

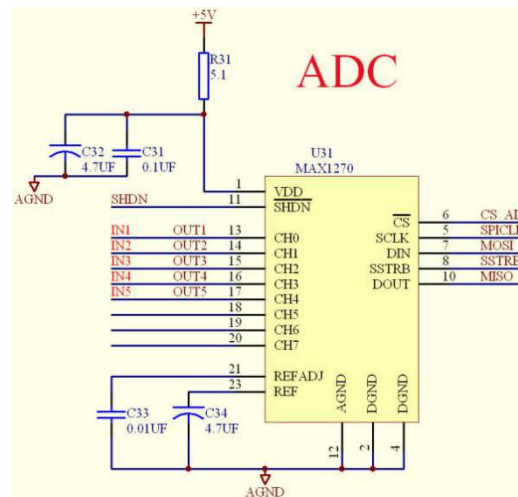


Figure 4 AD gather circuit

The input voltage/current signal through the isolation amplifier and filter, respectively connected to the ADC chip MAX1270 CH0~CH4 five channels, if the acquisition is the industry standard voltage signal input, channel range corresponding to MAX1270 is set to 0~10V, if the acquisition is the voltage signal and current signal conversion to the industrial standard, channel range MAX1270 the corresponding set of 0~5V. The selection of AD converter requires comprehensive consideration of various performance indexes, including resolution, reference power stability, linearity error, temperature drift error, and so on. Therefore, considering the above factors, we select a multi range and 12 bit successive approximation AD converter. MAX1270 introduced by MAXIM. MAX 1270's job voltage is +5V. It has 8 analog input channels, each channel input range can be independently set by software: 0~10V, 0~5V, + 5V, + 10V, this function is very convenient and useful for our system design. MAX1270 sampling rate of up to 110ksps, this speed has been able to meet the system requirements. Its maximum nonlinear error is only 0.5LSB, which guarantees the linearity of data acquisition. MAX1270 can use either an internal or external reference source, and we use its internal 4.096V reference source directly [7].

4. System test and result analysis

The experiment requires that the system linearity is better than 0.1%, which depends directly on the control of the system error. The output module of the switching quantity input and the output of the switch is normal and stable after the test work, which does not exist in the measurement error. For the voltage collection module, the input voltage measurement points are selected on the signal input port of the module, and the output voltage measurement points are selected on the input pins of the module's ADC chip. For the current acquisition module, the input current measurement method is to connect a current meter on the input signal (note: we can use the sampling resistor of 250 Ω), and the measuring point of the output voltage is also the input pin of the ADC chip in the module.

The test equipment is as follows:

Desktop multimeter: ESCORT 3146A 5 bits and half display

Power Supply : GW GPS-3303C 3CH

We measured 21 experimental data for the voltage acquisition module, measured 33 experimental data for the current acquisition module, and fitted the experimental data of the actual measurement respectively, and calculated the error value of the output and fitting calculation. According to the

above error, the data points of Fig.5 and Fig.6 can be found. The abscissa represents the number of data points collected and the ordinate represents the error value in Fig.5 and Fig.6. As shown in Fig.5, the maximum offset of the voltage value is less than 1mV, the full range is 10V, and the linearity is better than 0.1%. As can be seen from figure 6, the maximum offset of the voltage value is less than 1.5 mV, the full range is 5V (the voltage obtained by the sampling resistance of the current signal), and the linearity is better than 0.1%.

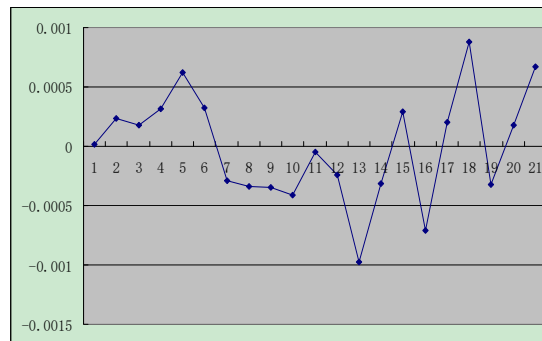


Figure 5 Data point of the voltage measurement data point line graph (vertical coordinate unit : V)

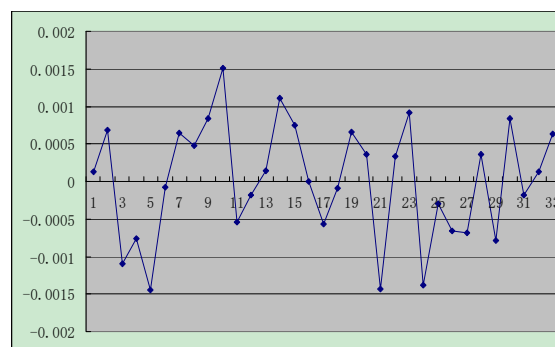


Figure 6 Plot point of the current measurement data point(vertical coordinate unit: V)

Therefore, the measurement accuracy of the system can meet or exceed the design requirement. If the software is added to the digital filter, the precision of the system can be further improved.

5. Conclusion

The system is strictly designed according to the industrial standard, all of which are equipped with DC-DC isolated power supply, and the PCB board design also fully considers the problem of electromagnetic compatibility. The voltage collecting board can realize the collection of the standard industrial voltage signal of 5 channels 0~10V. The current acquisition board can realize the collection of 5 channel 4~20mA standard industrial current signal. The switching volume input board has 8 channels, and every 4 channels has a common end. The switch output board can output 5 channel independent switch volume signal..

Acknowledgment

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