THE CIRCUIT DESIGN TO REDUCE THE ZERO DRIFT OF THE SENSOR AMPLIFIER

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Summary. In the sensor measurement system, the zero drifting question of sensor amplifier result in low accuracy of measuring .The reason of the zero drifting was analyzed. Several kinds of sensor circuits of automatic zero setting compensating was designed, according to analysis operational principle kinds of compensating circuits. This has a positive impact on increasing the sensor testing precision.

Key words: sensor, amplifying circuit, zero drifting

Foreword. In the modern production of coal mine, sensor is used more and more widely in the measuring technical field, and it’s the primary link to realize the automatic detection and automatic control. Weak signal sensor must pass through the amplifier amplification before it can be measured and used. However, the zero drift problem of sensor amplifier has been a big problem. It is an effective method the sensor amplifier circuit with automatic zero adjustment technology can compensate automatically and continuously for the zero drift signal.

The basic requirements of measuring amplifier

In the field of sensor testing, it needs amplifying circuit to support the signal acquisition of the sensor because the output signal of the sensor is weak. In general, it asks the sensor amplifier has high magnification to be able to amplify the weak signal; has the high input impedance to reduce the influence on the measured signal; and has the high common-mode rejection ratio in order to suppress the common mode interference which may be on line.

Some practical problems in the process of using the sensor amplifier

Sensor amplifier is mainly integrated sensor. There are many kinds of types at home and abroad which have very wide application. In addition to universal integrated operational amplifier, there have many amplifier circuits with special function, some properties of them are much better than the general. For example, high input impedance is mainly used for measuring amplifier and analog regulator. Active filter and sampling - hold circuit; high precision for precise detection, automatic meter and so on; low consumption type for general telemetry, remote sensing, biomedicine and space technology situation that energy consumption is limited.

In the selection of the sensor amplifier, in order to meet the use requirements and precision the most important is zero except eliminating the self-excited oscillation, in addition to the correct selection according to the purposes and requirements. It is the elimination of sensor zero drift. The so-called zero drift is the output of the amplifier is not zero when the input signal of the sensor is zero. The main reason is the semiconductor material does not mean or triode asymmetry. Therefore, most of the actual operational amplifier at pin is provided with a zero terminal. It raised the zero potentiometer to zero. But in the actual test, the zero only some static zero, the zero method cannot eliminate because there are various interference factors in the actual test site. Here are several automatic zero adjustment circuit.

The working principle of automatic zero adjustment circuit.

Automatic zero adjustment principle is to design a zero adjustment circuit, installed in the original sensor amplifier circuit front-end. Before each measurement, sampled and preserved zero drift signal caused by sensor amplifier and a variety of other factors, in the formal measurement from the amplified output signal minus zero drift signal to gain real signal, so as to eliminate the effects of zero drift. Automatic zero adjustment circuit can generally be divided into digital and analog two types. The principle of automatic zero adjustment circuit digital is: before the test to measure zero drift signal, converted by the A/D to zero drift memory preserved, in the formal measurement, use the good (including zero drift signal) to minus the zero drift number in zero register. It can eliminate the influence of zero drift to get correct measurement results. This method is of high accuracy, fast speed and simple. But the circuit must have microprocessor and the corresponding data processing software. In the analog signal circuit for zero, the zero drift signal is stored in a capacitor or a sample-and-hold circuit, minus the zero drift signal to eliminate influence of zero drift in the formal measurement. This method has the advantages of simple structure, reliable work, adding a plurality of components in the circuit design.

The Basic automatic zero adjustment circuit.

The Automatic zero adjustment circuit (Figure 1) consists of the main amplifier (the amplifier in the original instrument or circuit, composed of A1), time keeping circuit (from S1 to A2),arithmetic operation circuit (A3 and the related resistance) and some simple logic circuit.

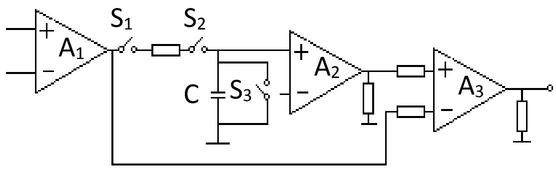

Figure 1 The diagram of automatic zero adjustment circuit

Analysis on the work process of zero adjustment circuit:

The working process is as follows: In the beginning of the measurement, the logic circuit accepted a start pulse, the S3 was connected, the capacitor was short. After a certain period of time, the S3 was disconnected, S1,S2 were connected at the same time. The zero drift signal was sent to the retaining circuit through S1, S2. The retaining circuit exported the signal with the same amplitude and polarity with the zero drift signal. Then, the logic circuit send out a start pulse that made S1, S2 disconnected. The sampling zero drift signal was still maintained in the retaining circuit. The formal testing work began immediately. Because S1, S2 was disconnected, the output signal of main amplifier was no longer sent to the retaining circuit, but only sent to an input terminal of the arithmetic operational amplifier. The two input terminals of the differential operational amplifier A3 received two signals at the same time, one of them was the zero drift signal, the other was the measurement signal that included the zero drift signal. The difference of the test signal minus zero drift signal was the true signal because of the symmetry function of the differential amplifier. The influence of zero drift error was automatically eliminated in each measurement process.

Because of the zero drift is a slow and gradual process, so this method is effective. The problem lies in the zero drift signal can be obtained only at no load or non state detection, measurement process often sustained for a long time. It needs to measure the zero drift signal in the whole measurement process. In order to ensure the accuracy of automatic zero adjustment, it requires zero drift signal keeping in the measuring process as small as possible. This must have certain requirements on the retention time of hold circuit. It requires for hours in special cases. The hold circuit designed according to the general method obviously can not meet the requirements.

In general, it's more difficult to let the capacitor to maintain a small signal long time, with RC charging circuit as an example, as shown in figure 2. Let C=10μF, R=10MΩ(can be seen as input impedance of a circuit). The time constant of the circuit for the t=R•C=100 seconds, that is the signal capacitance has disappeared 100 seconds later.

The time is too short for the analog automatic zero adjustment circuit. A larger time constant can be acquired by increasing the capacitance or resistance, but capacitance with small electric leakage is very difficult to obtain because of restrictions on technology. In addition, time constant can not be too high, because the long discharge time, charging time is extended accordingly. This is not allowed when the signal is zero.

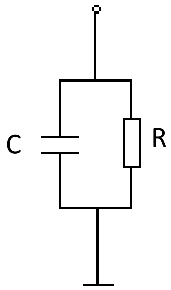

Figure 2

The circuit design of long time keeping signal

A long time keep circuit with a high impedance amplifier is designed. The charging time is less than one second. The discharge time is up to 1000 seconds. Figure 3 is the working principle of the circuit.

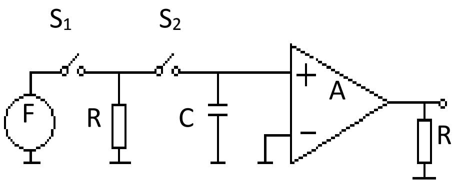

Figure 3 The principle diagram of the long time keeping circuit

Figure "F" is the signal source, "A" is an operational amplifier. When the zero signal was sampled, S1, S2 were connected by using the control signal, the capacitor is immediately charged by zero drift signal through RC circuit.

Let C=10μF, R=50kΩ, the constant of charging time: t=R•C=50 × 103×10×10-6=0.5 seconds. S1, S2 were disconnected when sampling is over. The obtained zero signal by sampling was maintained on capacitance C. R, C were no longer paralleled, C could not discharge through R. Discharge could be possible only through the leakage current of the high impedance amplifier. When the leakage current of the high impedance amplifier was 10-10 A and the voltage across the capacitor was 10 MV, the charge remained on capacitance : Q=C•U=10×10-6×10×10-3=10^{-7}C;
the discharge time of capacitor: T=10-7／10-10＝1000 S.

Compared with the previously RC circuit, the charging time was l/200, and the discharge time was 10 times. If we want to reduce the error caused by zero drift signal to 1/2 of the original, the sampling must be made every 500 seconds in the circuit.

The improved amplifier.

It is not allowed to take sample on the zero drift signal every 500 seconds in some measurement. It is not conducive to the data processing because of sampling time at short intervals and the huge collected data. The circuit in Figure 4 could significantly increase the time of signal holding, to further improve the accuracy of test results.

The improved amplifier in Figure 4 was similar to integral amplifier circuit in form. The amplifier was 50 times of the original if R2:R1=50:1. The potential at the two ends of capacitance was 50 times of the original at the same time under the influence of zero drift signal.

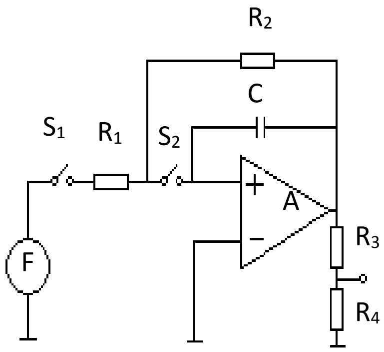

Figure 4 The improved amplifier

The circuit of the R1=lkΩ, R2=50kΩ, C=10μF, leakage currents of amperes amplifier I=10-10A, The zero drift signal is 10 MV, when switch S1, S2 were connected, the output of integral amplifier:

Vo=R2/R1×Vi=0,5 V

the constant of charging time: t=R•C=50×103×10×10-6=0,5 S;

the charge remained on capacitance: Q=C•V=10×10-6×0.5=5×10^{-6} C.

Capacitor discharge rate for the amplifier leakage currents of I=10-11 A, FPS lose electric line 10-11 C, all discharge time:

T= 5×10-6／10-11=5×105S≈140 H

Capacitor loses 50% charge after 70 hours. Considering the leakage of capacitor itself and other factors, the actual holding time decreased, but as long as the selection of high quality capacitor current leakage small (generally can not choose the electrolytic capacitor) and amplifier with high input operational impedance (such as F3l40, F3240 etc., the input resistance is 1.5×1012 Ω), it can be realized to keep the 50% signal for more than 4 hours in the strict craft measures. It can meet the requirements of the vast majority of the detection process.

Conclusion. For the using driver test system, because of the reason amplifier itself and some interference, some errors were brought to the results by the output signal of amplifier. The error (zero drift) can't be eliminated in the sampling process for the parameter testing of high precision. It will reduce the error greatly by using the designed zero adjustment circuit, and also has a certain significance to improve the precision of testing sensor.

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СХЕМА УМЕНЬШЕНИЯ ДРЕЙФА НУЛЯ УСИЛИТЕЛЯ ДАТЧИКА

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***Аннотация* – в системах измерения сенсора вопрос нулевого дрифта усилителя датчика состоит в низкой точности измерений. В статье проанализирован вопрос нулевого дрифтинга усилителя датчика. Несколько типов сенсорных схем автоматически настроенных на нулевой дрифтинг были исследованы, и сравнительный анализ показал операционные принципы, различающие точность показаний. Это дает позитивный эффект для повышение точности датчиков.**

СХЕМА ЗМЕНШЕННЯ ДРЕЙФУ НУЛЯ ПІДСИЛЮВАЧА ДАТЧИКА

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Анотація

В системах вимірювання сенсора питання нульового дріфту підсилювача датчика полягає в низькій точності вимірювань. У статті проаналізовано питання нульового дріфтингу підсилювача датчика. Кілька типів сенсорних схем автоматично налаштованих на нульовий дрифтинг були досліджені, і порівняльний аналіз показав операційні принципи, що розрізняють точність показань. Це дає позитивний ефект для підвищення точності датчиків.