A Brief Talk on Sensors

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Abstract: With the rapid development of the information age, human beings have higher and higher requirements for the perception of the natural environment. Sensors are the extension of human senses. If we want to discover more natural phenomena, we can't do it without the help of sensors. This paper mainly introduces the development history of sensors, and then briefly describes the definition of sensors as well as the main structure of sensors, and then mainly introduces the classification of sensors and some typical sensor working principle and the scope of application of them and advantages and disadvantages of these sensors. Finally, we mainly introduce some sensors combined with new technologies, including fiber optic sensors, integrated sensors and smart sensors, and introduce the main principles and working characteristics of these sensors.

Keywords: Sensor; Fiber Optic Sensors; Integrated Sensors; Smart Sensor; Science Development

1. Introduction and Company Background

The sensor, as we all know, this is a machine that can transmit perception. A sensor is a detection device that can detect specific information and can convert and output the detected information. The sensor is an extension of human senses and an important assistant for our deeper and wider exploration of the world. Sensors are vital to the development of modern technology, enabling us to feel the world more clearly [1].

Before 1870, our ancestors invented some specific machines that could better guide their production. The earliest sensor recorded in human history should be China 's compass car. It is said that more than 4000 years ago, our ancestor Huangdi invented the compass car which helped him to defeat Chiyou in the fog. Also ' Han Feizi ' recorded that Sinan (compass) appeared in the Warring States period. In some other ancient books, there are descriptions of Sinan which also named compass, and some books have descriptions of the specific structure of the compass.

After 1870, due to the rise of the second and the third industrial revolution, automatic control theory and information theory boom, sensor technology has made great progress. In 1876, Siemens produced a platinum resistance thermometer, which is the earliest sensor in human history which output electrical signals, greatly promoting the progress of human history of science and technology [2]. The principle of platinum resistance thermometer is based on the thermoelectric effect and the variation of metal resistance with temperature.

Now sensors are one of the biggest contributors to our information age which are everywhere in our lives and have profoundly changed our world.

2. Definition of Sensor

According to China 's national standard GB 7665-87, the sensors are defined as devices that can sense the specified measured quantity and convert it into a usable output signal according to certain rules, usually being composed of sensitive elements and conversion elements. The composition diagram of the sensor is shown in Figure 1.

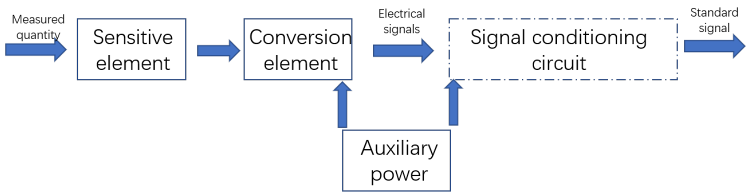

Figure 1: Sensor Block Diagram [3].

As shown in Figure 1 above, when the measured quantity input to the sensor, it will input to the sensitive element part of the sensor first. The sensitive element is a component in a sensor that can directly sense the measured quantities and transform them to other physical quantities. For example, the piezoelectric material in the piezoelectric sensor is the sensitive element, which can convert the pressure into the charge on the two surfaces of the piezoelectric material. The sensitive element of strain gauge resistance sensor is elastic diaphragm, which can convert external force into deformation of elastic diaphragm. The function of the conversion element is to convert the measured quantity output of the sensitive element into a physical quantity that is easy to measure and output. This physical quantity is generally an electrical signal. However, there are some sensitive elements of the sensor can directly output electrical signals, then the sensor sensitive element and the conversion element are integrated, such as the piezoelectric sensor just mentioned. The function of the signal conditioning circuit is to partially adjust the electrical signal output by the conversion element for better signal processing. Generally speaking, the output signal of the sensor conversion element is extremely weak, and some signals also have a large degree of nonlinearity and error, and the signal conditioning circuit can be used at this time to convert the nonlinear signal into a linear signal, and eliminate some errors, so that the results are more accurate, meanwhile, it also amplifies the weak signal, in order to better output.

3. Classification and Working Principle of Sensors

Sensor is a device that converts physical quantities into digital quantities. Because the physical quantities in nature are diverse, the types of sensors are diverse.

According to different working principles, sensors can be divided into three categories : physical sensors, chemical sensors and biological sensors.

Physical sensors mainly use the physical properties of sensitive elements to work, for example, the strain gauge resistance sensor, its principle is converting the different deformation of the strain gauge to the changing value of the resistance, which can be applied to the sensor force size.

Chemical sensors are often used to detect humidity in our daily life. Humidity sensor is a kind of very important chemical sensors. Chemical sensors can also be used to measure the concentration of harmful gases in the air, so it is of great significance to our production and life. Especially in the face of increasingly severe environmental tests today, a sensitive and easy-to-use gas sensor can enable us to find ' black heart ' enterprises faster. It is of great significance to protect the environment. The chemical sensor works by using the electrochemical reaction of the sensitive element with the measured gas or water. For example, the working principle of the humidity sensor is to use the water in the air to react with the sensitive element. The higher the humidity in the air, the more intense the reaction, and the greater the output of the sensitive element and the conversion element.

Biosensors use active substances extracted from organisms to interact with sensitive elements that can convert the physical quantities corresponding to the active substances into electrical signals, thereby detecting a certain aspect of the organism we are concerned with. The use of biosensors is also gaining popularity on a large scale in our lives. For example, now that people are more concerned about our physical condition than before, glucose meters are sensors that convert the amount of glucose in our blood to digital quantities.

Sensor classification method in addition to according to the working principle, can also be classified according to different input, such as force sensor, thermal sensor, color sensor, magnetic sensor, etc.

3.1 Resistance Strain Sensor

The working principle of the resistance strain sensor is that the measured quantity applies to the resistance wire, and the resistance wire is deformed, which leads to the change of the resistance of the sensor, and then the measured quantity can be calculated, so as to complete the process of transforming the external force into an electrical signal.

The main components of resistance strain sensor are elastic sensitive element, resistance strain gauge, compensation resistor and case.

The resistance strain sensor can be used to measure physical quantities such as force, torque, and acceleration. It is now widely used in our daily life and scientific research work.

3.2 Inductive Sensor

Inductive sensors work based on the principle of electromagnetic induction. After measured quantity input to the sensitive element of the sensor, the self-inductance or mutual inductance of the inductance inside the inductive sensor will change, which will be reflected in the change of the output current or voltage of the sensor. Finally, we can get the measured quantity, so as to complete the transformation of other physical quantities to electrical signals.

Inductive sensor according to its different working principle, can be roughly divided into self-inductive sensor, mutual inductance sensor and eddy current sensor.

Inductive sensors are mainly used to measure parameters such as displacement, flow and vibration. Its advantages are high sensitivity and simple structure, but the reaction speed of the inductive sensor is slow and the reaction time is long, which is not suitable for the application of fast-changing occasions.

3.3 Capacitive Sensor

The working principle of the capacitive sensor is using the capacitance in the capacitive sensor changing with the change of the measured quantity, and then change the parameters in the circuit, so that the output current or voltage of the circuit changes, thus completing the conversion from the measured quantity to the electrical signal.

Capacitive sensors can be divided into variable pole distance type, variable area type and variable electrolyte type according to the different way of changing capacitance. Among them, the variable electrolyte type capacitive sensor can be used to measure the characteristics of the medium, which is the ability that other types of sensors do not have.

The capacitive sensor can measure parameters such as displacement, angle and medium characteristics. Capacitive sensor's advantages are good stability, good dynamic performance, the disadvantage is that the accuracy of the measurement may be affected by parasitic resistance and produce relatively large error.

3.4 Piezoelectric Sensor

Piezoelectric effect means that when the crystal is subjected to a force from a specific direction, polar opposite charges will be generated on the two surfaces of the crystal. When the force acts in the opposite direction, the crystal surface will produce polar opposite charges. When the force disappears, the charge on the crystal surface will also disappear.

Piezoelectric sensor is a sensor based on piezoelectric effect, which is a self-generating sensor. The sensitive element of the piezoelectric sensor is made of piezoelectric material. The charge generated by the piezoelectric material on the surface will become an output proportional to the force through the amplifier and subsequent circuit processing, so as to realize the transformation from other physical quantities to electrical signals.

Piezoelectric sensor can be used to measure the size of the force and acceleration, can also be used to make piezoelectric glass broken alarm. The advantages of piezoelectric sensor are reliable operation, simple structure and high sensitivity. The disadvantage is that the DC characteristics of the circuit output is not good, need to rely on other circuits to achieve better DC output.

3.5 Thermocouple Sensor

Thermoelectric effect means that when two different materials of conductors or semiconductor materials form a closed loop, when the contact points of the two conductors at different temperatures, the potential of the two contact points will be different, and in the closed loop will be weak current flows through.

The thermocouple sensor is based on thermoelectric effect. When it is used for temperature measurement, two electromotive forces will be generated at the contact point, which are contact electromotive force and Thermoelectromotive force[4]. Contact electromotive force is due to the different nature of the two conductors and the temperature difference caused, for example, one conductor has more free electrons, so the electrons with more free electrons will move toward the one with less free electrons, and contact electromotive force will be formed. Thermoelectromotive force is caused by the difference in temperature between the two ends of the same conductor. The free electrons at the high temperature end have greater energy and faster movement speed, so the number of free electrons migrating from the high temperature end to the low temperature end is far more than the number of free electrons migrating from the low temperature end to the high temperature end, which forms the so-called temperature difference electromotive force. When we use thermocouple sensors to measure temperature, we place two contacts in a conductor circuit in different temperature environments, measure the potential difference between the two contacts, and then calculate the temperature difference between the two environments. If we fix one temperature at 0°C, then we can determine the temperature of the other environment.

The characteristics of they are as follows:1 because there is no intermediate circuit, direct measurement of the potential difference between two contact points, small error, high precision; 2 the structure of thermocouple sensor is very simple, and the main part is only composed of two electric conductors with different properties; 3 wide measurement range, we use the thermocouple sensor measurement range is about -50 ~ + 1600 °C, and some of the better performance of the thermocouple sensor minimum temperature can reach -256 °C.

Here, we just briefly introduce the sensors that are commonly used and simple in structure. There are many kinds of sensors that are not mentioned above, such as magnetoelectric sensors, photoelectric sensors, magnetic sensors and so on. What we're going to talk about next is new directions for the future of sensors.

4 Development Direction of Modern Sensors

Sensor technology is a huge new discipline, which not only involves the contents of engineering, such as electronic information technology, but also requires other related disciplines. For example, the sensor for detecting blood glucose concentration mentioned above is related to life science. Modern sensor technology is already a very complex subject; the following will introduce several sensors that combine the new technology.

4.1 Fiber Optic Sensors

Optical modulation effect, a phenomenon in which the optical transmission properties of optical fibers change when the external environment changes.

Optical fiber sensor is to use the optical modulation effect to measure the degree of external environment change, when the incident light enters the fiber, if the external environment does not change, the fiber sends the incident light into the modulator, and the signal output from the sensor is the set value [5]. If the external environment changes, the nature of light from fiber input to modulator will change due to the optical modulation effect, so the signal output of sensor will be different from the set value. We can measure the factors and degree of environmental change according to the degree of signal difference and other information [6].

Fiber optic sensor has very good chemical stability. In high temperature environment, in water, in corrosive environment them can work normally. The fiber optic sensor also has anti-electromagnetic interference and no induction electrical ability which allow them to be used in high voltage environment.

Optical fiber sensor application range is very wide. It can be used to measure temperature, magnetic field, voltage, current, humidity, PH value and other very many physical quantities. Optical fiber sensor plays an important role in modern sensors.

4.2 Integrated Sensor

The integrated sensor uses the integrated technology to integrate all the components of the sensor into a chip. The circuit structure of the integrated circuit is shown in Figure 2.

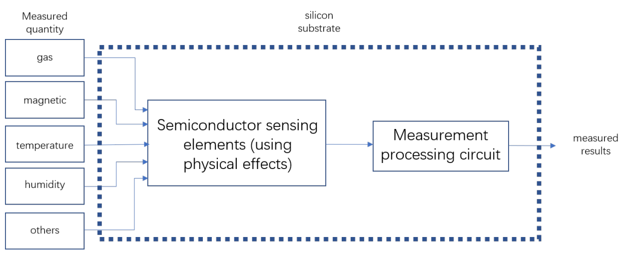

Figure 2: The Circuit Structure of the Integrated Circuit [7].

The integrated sensor has the characteristics of small size, light weight, low power consumption and long life. However, due to the limitations of the integrated sensor itself, its function is relatively simple, although some sensors can measure a variety of different physical quantities at the same time, since its various components are integrated into a chip, the integrated sensor can only measure a specific physical quantity.

4.3 Smart Sensor

The intelligent sensor is equipped with a microprocessor, which can be used for information collection, information processing and information exchange. Figure 3 shows the block diagram of a smart sensor.

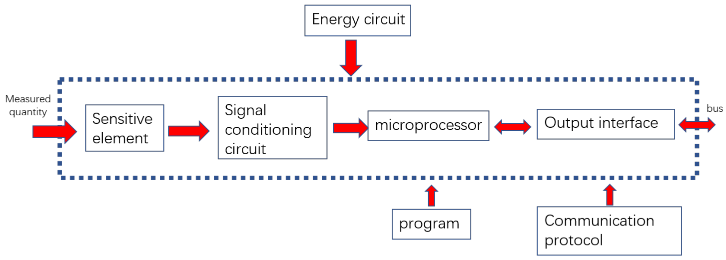

Figure 3: The Block Diagram of a Smart Sensor [8].

The smart sensor can store the detected information in the storage device, and then process the required data according to the instructions from the microprocessor, and the smart processor can transmit the information to each other.

The main functions of the smart sensor are:

1 to realize the information storage and transmission function, the intelligent sensor can realize the information storage and the data transmission function, which is also the biggest advantage of the intelligent sensor.

2 self-compensation and calculation function, smart sensor can be based on the microprocessor for multiple calculations, can be measured data compensation and nonlinear calculation [9].

4. Conclusion

Sensors and sensor technology are of great significance to the progress of modern science and technology. In the past 200 years since Siemens made the platinum electronic thermometer, scientists have developed a variety of sensors with different functions. As the extension of human senses, these sensors have helped researchers discover one secret after another in nature. With the development of modern science and technology, sensors should also keep pace with the times [10]. Some creators have developed a variety of sensors with good performance based on the scientific and technological theories in recent years. But this is far from enough, humans still need to continue to advance on the road of sensor development, pioneering progress.

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