Design and Simulation of Sensor Signal Processing System

Jin Shi

Department of Electronic and Electrical, Sheffield University, Sheffield, UK

*Corresponding author e-mail: shij5405@sheffield.ac.uk

Abstract: In particular, the popularity of personal notebooks makes personal notebooks more rapid development, and sensor processors for cars, microwave ovens and other products are more useful, and have a great impact on the design of these products. Because of the rapid development of sensors, there are various sensors, which makes the data manual of these sensors have many different formats, so many sensor systems have their own the data use manual is different. There is also in the sensor acquisition of the signal process often mixed with noise and various interference signals. In order to solve this problem, many scientists at home and abroad have done a lot of research on this aspect. In this paper, compensation method, filtering method and noise suppression method are used to improve the signal-to-noise ratio and resolution of the sensor. And through the experimental practice, the results show that the sensor signal processing system can eliminate the noise, improve the signal-to-noise ratio and improve the resolution of the sensor, and also achieve good results in practical application.

Keywords: Sensor, Processor, Signal Processing, Information

1 Introduction

In recent years, more and more products use microprocessors for functional control [1]. All of these microprocessors require input voltage to receive instructions and data. Therefore, with the emergence of cheap microprocessors, there are more and more kinds of sensors, and their applications in various products are also increasing [2-3]. In addition, the sensor receives physical quantities and outputs electrical signals, so the sensor can also use the description of electronic devices in the process of application [4]. The products need to be equipped with a large number of tens of thousands of sensors to monitor a variety of condition parameters or object information.

The important role of information technology is mainly reflected in the continuous use of machinery to replace and expand people's physical and mental work, liberate more labor force, let these liberated labor force function in other places, so as to improve social productivity. In order to achieve this goal, researchers strive and struggle to explore the differences in the functional patterns between electronic devices and people, to find a reasonable way, so there is artificial intelligence [5]. In artificial intelligence, a sensor is a communication between systems Information-exchange interface, which provides the system with accurate decision-making and behavior of the machine object information, is a high automation system and the implementation of top-level information technology essential key components.
In industry, now that the country has entered the information age, many of the former dangerous or labor-intensive jobs have now been replaced by machines, liberating a lot of labor, and the machine can also do those high speed and high precision work. But the inside of these machines is because they are equipped with a large number of sensors that allow them to work so accurately and without errors [6-7]; in home appliances: sensors also have a good position. With the rapid development of national science and technology, people's living standards are also constantly improving, and the household appliances equipped with sensors are more popular. Nowadays, the function and automation of household appliances are also rapidly improved because of the high precision sensors, which make the household appliances more convenient and safe for people to use [8-9].

2 Sensor Applications

2.1 Sensor Sensors
Sensors represent an important interface between the physical world and the information world. Micro, digital, intelligent, multi-functional, systematized and networked are the functions of sensors now or in the future. Sensors are one of the most important sensors in artificial intelligence. And with the development of sensors, scientists have also invented a variety of sensors, those machines after the configuration of high-precision and a large number of sensors to make cold machines have touch, taste and smell and other senses, these machines equipped with sensors can also achieve some people's functions, which achieve mechanical artificial intelligence [10].

2.2 Capacitive Displacement Sensors
The principle of capacitive displacement sensor is very simple, when the displacement of two plates, the capacitance between the two plates also changes with the change. In this way, we can obtain the distance information between the probe and the measured surface by calculating the capacitance between the plates.

Capacitance of parallel plate capacitors:

\[ C = \frac{\varepsilon_0 \varepsilon_r A}{d} \]  (1)

\( \varepsilon_0 \) Is the dielectric constant in vacuum, \( \varepsilon_r \) is the relative dielectric constant of the dielectric between the two poles plates, the A is the effective polar plate area, and the d is the distance between the two poles plates. When the two-pole plate displacement, the capacitance will also change, its variation is:

\[ \Delta C = -\frac{\Delta d}{d} = -\frac{\varepsilon_0 \varepsilon_r A}{d^2} \Delta d \]  (2)

It can be seen that the change of capacitance value is proportional to the change of distance, but the sensitivity coefficient will decrease with the increase of distance. Because of its high resolution, linearity and stability, capacitive displacement sensor is the most widely used in nano-positioning platform [11].

3 Experiments

3.1 Experimental Subjects
This article is based on the previous experience, and then I also searched the relevant literature books, asked the experts about this, summed up some common types of sensors and their working principles, after adding some of their own understanding and insights. A simulation model is established to quantitatively analyze the electromagnetic coupling between the probe coil and the measured material. The range and linearity of the sensor will be studied in this experiment, and the influence of
temperature change on sensor hardware will be studied.

3.2 Experimental Design
In the course of the experiment, based on the previous experience, and then referring to the relevant literature and some existing information, combined with their own research direction, the design of the sensor signal processing system and simulation of the experimental scheme. The experimental scheme has four topics, one is the practical application of some common sensors, and get the experimental data, the other is the integration of some shortcomings of the sensor to find the corresponding reasonable solution, the third is to design experiments for these existing problems, get the experimental data, and the fourth is the final analysis of all the obtained data information as a whole, get the transmission.

4 Discussion

4.1 Range and Linearity of Sensors
There is usually a minimum measurement distance Xmin and a maximum measurement distance Xmax, The difference between the two is the range, also known as the full range. In the range of the sensor, there is an error between the actual output voltage and the calibrated displacement-voltage curve, which is called nonlinear error. A non-linear error is usually expressed as a percentage of an entire range of non-linear quantities, such as a 0.1% FSR nonlinearity indicating that the maximum nonlinear error does not exceed 0.1% of the full range. the relationship between the distance of the eddy current sensor and the impedance of the detection coil is usually very nonlinear, so most eddy current sensors have nonlinear correction circuits at the output to eliminate the nonlinearity. the final nonlinear degree error of the eddy current sensor mainly depends on the performance of the correction circuit. as shown below.

![Figure 1. Nonlinear error](image)

4.2 Effect of Temperature Change on Sensor Hardware
Probe substrate for sensing the skeleton of the probe, providing a groove attached to the probe coil: the probe coil is the core of the whole sensor probe. when signal processing is carried out, the electrical signal on the probe coil passes through the high frequency ac in the probe coil. the coupling space between the probe coil and the material under test will produce electromagnetic field distribution. the displacement between the probe coil and the material under test will occur, which will affect the output impedance of the probe coil. The signal processing circuit estimates the measured displacement by analyzing the output impedance of the probe coil. As shown below
4.3 Effects of Environmental Pollutant Media on Capacitive Sensors
The displacement change of 0.3 nm measured by capacitive displacement sensor and optical fiber interferometer was compared by German PI Company. The main disadvantage of capacitive sensors is that they are very sensitive to environmental pollutants. The relative permittivity of common gases and liquids is shown in Table 1[12], and it can be seen from the data in the table that the contamination of liquid impurities (water, ethanol, glycerol, etc.) will have a very large effect on the measurement results of capacitive displacement sensors. So capacitive displacement sensors can only work in an integrated closed cavity and in a laboratory environment strictly controlled by the environment.

Table 1. Relative permittivity of common pollutants

| Gas     | Air     | Water vapour | Hydrogen | Gas mercury | Gaseous |
|---------|---------|--------------|----------|-------------|---------|
| $\varepsilon_r$ | 1.00586 | 1.00786 | 1.00027 | 1.00075 | 1.0127 |
| Liquid  | Water   | Ethanol      | Kernel   | Glycerin    | Benzene |
| $\varepsilon_r$ | 81.6    | 25.8         | 3        | 45.5        | 2.285   |
| Solid   | FR-4    | Rubber       | Epoxy resin | High frequency ceramic | Glass |
| $\varepsilon_r$ | 4.3     | 2.5          | 4.5      | 8.1         | 4.2     |

5 Conclusions
At present, with the rapid development of information technology, our country's sensor technology is also in rapid development and innovation breakthrough. This paper briefly introduces the history and present situation of sensor technology development. In the course of experiments, this paper studies the range and linearity of the sensor. It also studies the influence of temperature on sensor hardware. The working principle, concrete realization method and corresponding circuit structure of some displacement sensors are studied. The working principle and principle of displacement sensor are briefly introduced. Implementation methods.

References
[1] Constans C, Deffieux T, Pouget P, et al. A 200 - 1380 kHz Quadrifrequency Focused Ultrasound Transducer for Neurostimulation In Rodents and Primates: Transcranial In Vitro Calibration and Numerical Study of The Influence of Skull Cavity[J]. IEEE Trans Ultrason Ferroelectr Freq Control, 2017, 64(4):717-724.
[2] Na, Wongi S. Distinguishing crack damage from debonding damage of glass fiber reinforced polymer plate using a piezoelectric transducer based nondestructive testing method[J]. Composite Structures, 2017, 159:517-527.
[3] Wang C, Sun M, Yuan X, et al. Enterovirus 71 suppresses interferon responses by blocking Janus kinase (JAK)/signal transducer and activator of transcription (STAT) signaling through inducing karyopherin-α1 degradation[J]. Journal of Biological Chemistry, 2017,
292(24):10262.

[4] Sepulveda D, Rojas-Rivera D, Rodriguez, Diego A, et al. Interactome Screening Identifies the ER Luminal Chaperone Hsp47 as a Regulator of the Unfolded Protein Response Transducer IRE1 alpha[J]. Molecular Cell, 2018, 69(2):238-252.

[5] Talou G D M, Blanco P J, Larrabide I, et al. Registration Methods for IVUS: Transversal and Longitudinal Transducer Motion Compensation[J]. Biomedical Engineering IEEE Transactions on, 2017, 64(4):890-903.

[6] Engelfriet J, Fulop Z, Maletti A. Composition Closure of Linear Extended Top-down Tree Transducers[J]. Theory of computing systems, 2017, 60(2):129-171.

[7] Xu X, Cao D, Yang H, et al. Application of piezoelectric transducer in energy harvesting in pavement[J]. International Journal of Pavement Research and Technology, 2017:S1996681417300408.

[8] Liu Y, Chen W L, Bond L J, et al. An experimental study on the characteristics of wind-driven surface water film flows by using a multi-transducer ultrasonic pulse-echo technique[J]. Physics of Fluids, 2017, 29(1):012102.

[9] Guofeng D, Qingzhao K, Hua Z, et al. Multiple Cracks Detection in Pipeline Using Damage Index Matrix Based on Piezoceramic Transducer-Enabled Stress Wave Propagation[J]. Sensors, 2017, 17(8):1812.

[10] Weihang G, Linsheng H, Hongnan L, et al. An Embedded Tubular PZT Transducer Based Damage Imaging Method for Two-Dimensional Concrete Structures[J]. IEEE Access, 2018, 6:30100-30109.

[11] Shanahan F, Van Sinderen D, O'Toole, Paul W, et al. Feeding the microbiota: transducer of nutrient signals for the host[J]. Gut, 2017:1709.

[12] Weihang G, Linsheng H, Hongnan L, et al. An Embedded Tubular PZT Transducer Based Damage Imaging Method for Two-Dimensional Concrete Structures[J]. IEEE Access, 2018, 6:30100-30109.