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Novel Online Detection System on Optical Performance of Automobile Glasses

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With the development of automobile industry, automobile glass type and quantity increased quickly. Automobile glass not only protects the passenger, but also affects the security, appearance of automobile and passenger's comfort. As a result, optical performance of automobile glass, which is the most parameter, has provoked the attention of manufacturer and consumer. At present, the detection technology on optical performance of automobile glass has played more and more role in industry. In order to improve production efficiency and rate of finished products, a novel on-line detection system was proposed. The system utilized photoelectric technology, weak signal process and SCM technology, can detect the reflectivity and transmissivity on-line. The system was debugged by the Proteus, and the result indicated that the system has strong immunity from interference, and can regulate self-parameters, so as to ensure the reliability and stability.

1. Introduction

Glasses, as the essential material of automobile, Fahad Almutawa et al (2013), Qing Hua Li (2014), and Megan N. C. Grainger (2012) reported that its quality affects the safety of lives and property. At present, automobile glass mainly include laminated glass and armoured glass, it is a kind of coated glasses which was reported by R. I. Makarov (2010). With the increasing development of glass industry, M. Y. Zhang (2007), F. S. Ji (1998) and Wei Xu (2014) reported that the quality detection on automobile glass is more and more important. In the quality specification, Yu. A. Knyazev (1969) and N. I. Amosov (1960) has reported that optical performance is the most important characteristic, also is the main parameters to detect. The optical performances of automobile glass are mainly reflectivity and transmissivity. The detection methods on reflectivity and transmissivity include off-line manual detection, off-line automatic detection and on-line automatic detection. Off-line manual detection requires massive labour, and exists measurement error caused by human factors. Off-line automatic detection requires spectrophotometer to measure optical performance of glass, however, inconformity Lambert-Beer Law factors, color reaction conditions, stray light and so on will affect the result. As a result, off-line detection can meet the requirement of industrial production. So on-line detection method was proposed in 2000. This method solved temperature shift and realized on-line detection on optical performance of automobile glass. However, only single frequency light source could be utilized, and could only detect transmissivity of coated glass at special frequency, while could not detect reflectivity and absorptivity. Above mentioned, a novel on-line detection method is urgently needed. Based on the research before, a novel detection method was proposed in this paper.

2. System Design

The system mainly aims at the reflectivity and transmissivity, utilizes photoelectric detect technology to realize on-line detection on reflectivity and transmissivity of automobile glass. In this system, laser, fiber, photoelectric detection, microsignal process and SCM technology are utilized.
First, light of laser was chopped by chopper and obtained pulsed light whose frequency is 1kHz. Second pulsed light was split into two beams, one beam illuminated on measured glass verticality, then transmission

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light was obtained. The other illuminated on measured glass 5 degree angle with normal, then reflected light was obtained. The light was transmitted through fiber to decrease light loss. Third, the transmission light and reflected light were converted into electrical signal by photo detector. Considering the field environment and influence of interference signal, also simplifying the light path, increasing the scope of photo detection, photodiode was adopted as photo detector. Then the converted electrical signal was filtered, amplified, and converted into digital signal. Finally, the digital signal was processed by SCM, and realized the function of keyboard controlling, alarming and display. The whole system principle frame was shown in figure 1.

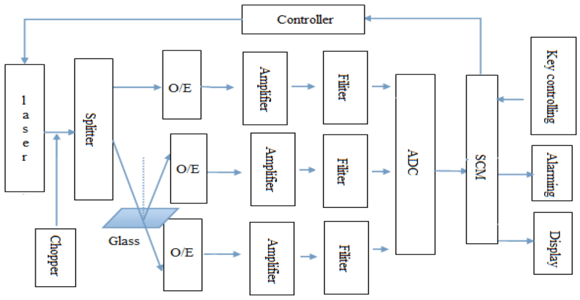

Figure 1: Diagram of system principle

2.1 Hardware design

The hardware mainly included light source, fiber, photo detector, amplifying and filtering circuit, ADC circuit. The main modules were shown as following.

Light source option

The light source of this system was very important for detection precise and system stability. As we all known, laser is the novel coherent light source, it has the characteristics such as better directionality, monochromaticity, high intensity and luminance, Zhang Hui (2006) reported that it has been applied in some fields to acquire unprecedented benefit and achievement. As a result, 532nm laser was adopted as light source. Because the detection system require pulsed light, high accuracy MC1000A chopper was utilized to convert the laser into pulsed light.

Fiber

The interference of stray light is a difficulty for the fabrication of optic on-line measurement instruments, and causes detector cannot receive accurate optical signal. To improve the interference immunity of measurement system, fiber was utilized as detector. Pei Li (2004) and Zhan Sheng-bao (2009) reported that the fiber transmission system was consisted of reflectivity and transmissivity measurement. Because of the small diameter of fiber, seven fibers were tied together, which was shown in figure 2, and the center fiber was utilized to transmit emitted light, others was utilized to collect reflected light, and transmission light was collected by a fiber on the other side of glass.

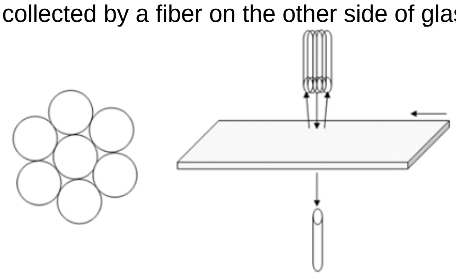

Figure 2: The sketch map of fiber detector

Photoelectric conversion

At present, the silicon photodiode is the main photoelectric conversion module, and Gutiérrez J L et al. reported that the characteristics of it can affect the performance of measurement system. In this system, the center wavelength of light source is 808nm, and the frequency of pulsed light is 1kHz, as a result, the FDS010 silicon photodiode, which was installed on ceramics substrate and has the maximum effective area, was utilized as detector, whose material object scheme and spectral response were shown in figure 3 and 4.

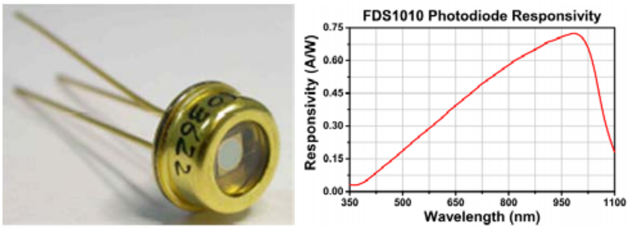

Figure 3: The material object scheme and spectral response scheme of FDS010 silicon photodiode

The photoelectric conversion circuit was consisted of two operational amplifiers, internal feedback and external feedback were utilized in circuit. This circuit can decrease noise bandwidth and has no effect on signal noise bandwidth. The circuit was shown in figure 4.

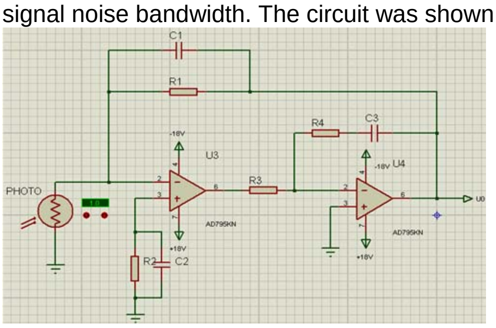

Figure 4: The circuit of photoelectric conversion

In this circuit, gain response was controlled by R3, R4 and C3, and reasonable design on R4/R3 can decrease noise bandwidth effectively.

Electrical signal process

The output signal of photoelectric conversion is weak current, and easily interfered by noise, so it cannot be applied directly. To overcome this problem, pre-operational amplifier was utilized to convert current into voltage. To meet the requirement of sampling, Zakaria, Z et al. (2015) reported that main operational amplifier and filter are necessary. The circuit was shown in figure 5.

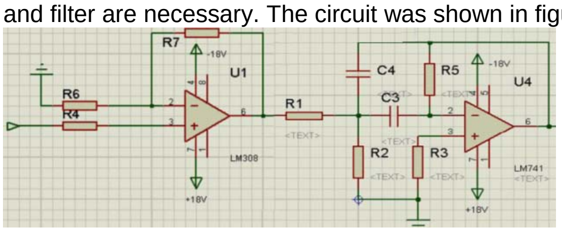

Figure 5: The circuit of main operational amplifier and filter

AD conversation and singlechip

The voltage signal was processed by amplifier and filter, it can be larger and stable. However, it cannot be processed by singlechip, so AD conversation is necessary. In this system, ADC0808 was adopted to accomplish conversation. By appropriate process of splitter, amplifiers, and filter, three stable voltage signals IN0, IN1, IN2 were acquired, IN0 was reference signal, IN1 was transmission signal and IN2 was reflectivity signal. These three signals input into ADC0808 and were converted into digital signals. Jian Chao Yu pointed that the digital signals were input singlechip to be processed appropriately. The circuit was shown in figure 6.

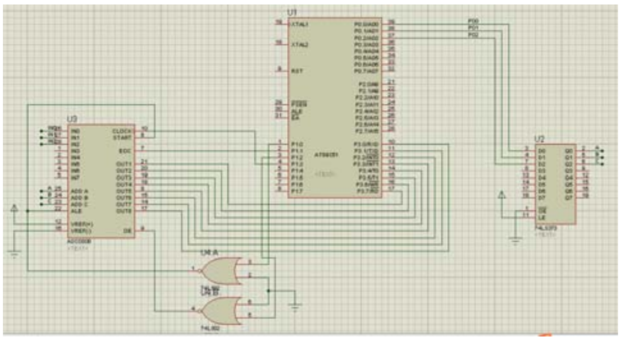

Figure 6: The circuit of AD conversation and singlechip

2.2 Software design

The software of system mainly achieves the following functions.
(1). The on-line detection on reflectivity and transmissivity of automobile glass.
(2). The optional display on reflectivity or transmissivity respectively by button control.
(3). Alarming function when detection data exceed provided range.
(4). The selection of optical path.
The design thought of software is achieving the online detection on reflectivity and transmissivity of automobile glass by singlechip AT89C51, meantime achieving alarm automatically when detection data exceed provided range. The flow chart of main program was shown in figure 7.

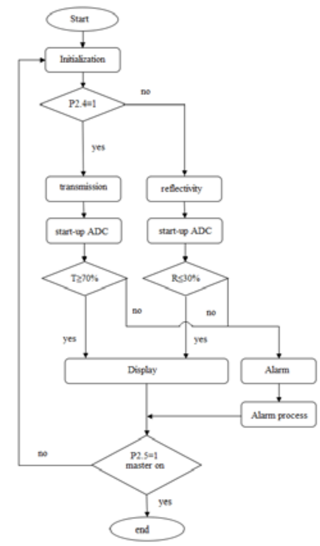

Figure 7: The flow chart of main program

The design idea of main program is described as follows.
First, outside button key2 was utilized as system switch to control main program entering detection status whether or not. Key1 was utilized as system switch to achieve the option of detection on reflectivity or transmissivity of automobile glass. When key1 is high level, the system detects and displays on transmissivity, while key1 is low level, the system detects and displays on reflectivity. Meantime, system can achieve over range alarm by comparing detection result.

3. Results and Discussion

The system was simulated by Proteus Software combined with hardware and C Langue program.
Transmissivity simulation
The optical signal was converted into electronic signal, and was amplified and filtered, then output three voltage, namely IN0, IN1, IN2, which represent reference voltage, transmissivity voltage and reflectivity voltage respectively. These three voltage were input into ADC0808, then the simulation software was started. Then Key1 was cut, ADC0808 was started to receive IN1, namely transmissivity voltage. Then the singlechip process signal and output the transmissivity, which was shown in figure 8.

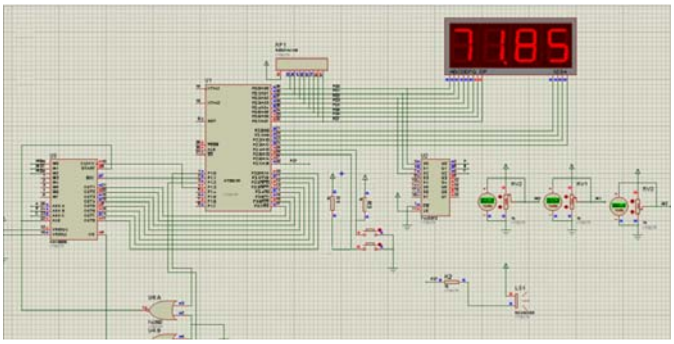

Figure 8: The result of transmissivity

Reflectivity simulation

When simulation system was started, press Key1, then ADC0808 was started to receive IN2, namely reflectivity voltage. Then the singlechip process signal and output the reflectivity, which was shown in figure 9.

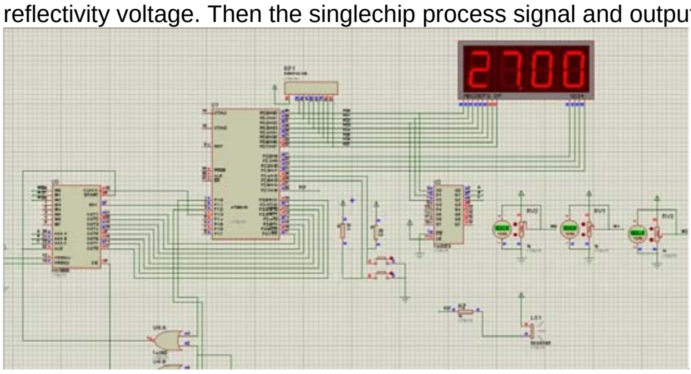

Figure 9: The result transmissivity

4. Conclusions

This article elaborated the on-line detection system on reflectivity and transmissivity of automobile glass. Based on laser and fiber technology, combined with signal process and singlechip, the real time display and out of limit alarming were achieved. From the experiment results, this system can be utilized to detect the reflectivity and transmissivity of automobile glass, it can work continuously, and stray light and temperature shift are unaffected. This system can provide the novel thought for detection on automobile glass, it has important actual significance and application prospect.

Acknowledgments

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