EPH - International Journal Of Science And Engineering
ISSN (Online): 2454-2016
Volume 05 Issue 01 February 2019

DOI: https://doi.org/10.53555/eijse.v5i1.119

RESEARCH ON CAR REVERSING RADAR SYSTEM BASED ON ULTRASONIC

Jiang Xiaoqi[1*] , Zhang Mingming[2] , Lu Jiaqi[3] , You Qianliang[4]
[*1,2,3,4]*(School of Electronics and Information, Jiangsu University of Science and Technology Zhenjiang 212003 China)*

***Corresponding Author:-**

Abstract:-
Due to the increasing number of private cars in today's society, there are a lot of safety problems in car reversing. This paper proposes a research program of ultrasonic ranging car reversing radar system with higher accuracy and better warning effect. According to the principle of ultrasonic ranging, the AT89C51 single-chip microcomputer is selected as the core circuit, and the anti-interference error processing is adopted in the processing of the single-chip microcomputer to solve the multiple measurement, the transmission time interval and the dead zone measurement problem of the ultrasonic ranging. Car reversing radar system based on ultrasonic ranging adopt transmitting and receiving circuit, will determine the time difference in the single chip microcomputer. the results are sent to the digital display circuit and voice broadcast circuit. Finally, it is verified by experiments that after ultrasonic error measurement adopts error processing, under the complicated environmental conditions, the accuracy of ranging is higher, the number of false alarms is reduced, and the device has high reliability and practicability.

Keywords:- *ultrasonic ranging; single-chip microcomputer; error processing; digital display; voice broadcast*

1. INTRODUCTION

Due to the rapid growth of the automobile industry in our country, our country has begun to enter the era of private cars, and more and more cars. While enjoying the convenience of cars, the problems caused by reversing are becoming more and more prominent. According to statistics, 15% of car accidents are caused by poor rear view of the car. Early reversing bumpers were able to test for obstacles within a certain distance behind the car to alert them, and later developed to segment alarms based on distance [1-3]. As people's requirements for the ease of use of the car driving assistance system increase, the requirements for the car reversing radar are also increasing. However, with the increasingly complex environment, simple radar rangefinders have been unable to meet the needs of mass users [4-8].

In order to effectively solve the problem of indirect observation of the rear blind zone when the user is reversing, the user is assured of reversing the car and less traffic loss caused by reversing. In recent years, domestic and foreign scholars have made a lot of experimental research on the car reversing radar system in the accuracy of reversing ranging. In the literature [9-10], a small laser range finder using a semiconductor laser diode as a light source, the method of selecting a pulse ranging method, that is, using a device to measure the time difference between the emitted laser pulse and the received laser pulse, and data on the time difference is performed. The distance between the vehicle body and the obstacle is obtained. However, it is greatly affected by the external environment, and the detection accuracy is low in harsh environments. In the literature [11-12], aiming at the current situation that most minivans do not have reversing radar, a reversing anti-collision device based on STM32 single-chip microcomputer is proposed. The infrared measurement technology is used to calculate the signal pulse flight by using the time proportional amplification circuit. Time, and finally get the test distance. Since the device is very susceptible to light and temperature, the measurement accuracy is greatly affected when the weather temperature varies greatly. In the literature [13-15], in order to effectively measure the safety distance when the bus travels in real time, the machine vision CCD camera is selected as the sensor and identified by MATLAB, so as to realize real-time monitoring of the distance between the bus and the car, but it The cost is very high and the response speed is slow, so it cannot be fully promoted.

Aiming at the several ranging methods selected above, this paper proposes an automobile reversing radar device based on improved ultrasonic ranging, which adds anti-interference error processing to the ranging error encountered during ranging. Measures [16]. The selection is based on AT89C51 single-chip microcomputer, supplemented by ultrasonic receiving and transmitting circuit, digital display circuit and voice broadcast circuit. The experiment is carried out under artificial complicated environment conditions. The experimental results show that the accuracy of the car reversing radar device with error processing is higher. The scope is larger, and at the same time, the product is as small as possible and low in cost, so that the system can meet the commercial standard.

2. Ultrasonic Ranging

2.1 Principle of Ranging

The operating principle of the reversing radar is based on the fact that the bat is flying fast in the dark and does not have to worry about any obstacles. There are three main methods for using ultrasonic ranging: phase detection, amplitude detection, and transit time detection. Although the accuracy of the ultrasonic phase detection method is high, its detectable distance is relatively small. Ultrasonic amplitude detection is more susceptible to environmental factors and produces large errors in the measured results. Therefore, this system research uses the ultrasonic transit time detection method, which has the advantages of simple device, low cost, easy control, and wide range of measurable distance. The ultrasonic wave of ranging generally refers to mechanical waves whose frequency exceeds 40KHz, and has the advantages of strong penetrating ability, slow attenuation, strong reflection force and the like. The schematic diagram of ultrasonic ranging is shown in Figure 1.

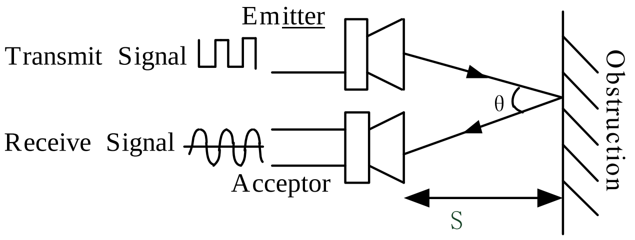

Figure 1 Ultrasonic ranging schematic

In this study, the principle of ultrasonic measurement distance is that a very short 40 kHz square wave signal is sent by the single chip microcomputer, and then amplified by the ultrasonic transmitting device. The reflected wave is input as an input through the ultrasonic receiving device, and the phase locked loop locks the signal. The lock signal is issued to start the interrupt program of the chip, and the time difference is calculated. The transmitting device is adjacent to the receiving device, so the angle can be ignored, and finally the distance is obtained:

$$s = \frac{C\Delta t}{2} \qquad (1)$$

In equation (1), the rate of ultrasonic propagation is 15. The environment selected in this paper is 15 and the corresponding propagation velocity is 340.

2.2 Error Handling

Due to the complexity of the environment, the use of ultrasonic ranging will encounter a variety of factors that affect ranging. For example, there are a variety of obstacles in the rear, there will be a variety of reflection problems; the ultrasonic receiving device receives the ultrasonic waves and then sends them to the MCU and the processing, there will be a time difference; thus, a variety of factors will affect the accuracy of the final measurement distance.

(1). Multiple reflection problems

Due to the complicated environment, the obstacles behind the car generally do not reflect only one kind of ultrasonic wave, so there will be multiple repeated reflections when the ultrasonic reflection. If it is only measured once, there is no error. When the interrupt is taken, when the falling edge of the first pulse is received, the MCU will turn off the interrupt, and the incoming ultrasonic signal will be invalid. However, the reversing radar device system is a continuous ranging. If it is not processed, it may cause a false alarm and affect the final judgment of obstacles.

For this kind of error solution, a delay time T can be set in advance to ensure that the last time the ultrasonic signal is not present, the MCU will send a signal to start the next measurement. This method can greatly reduce the number of ultrasonic false alarms.

(2). Impact of transmission and connection time interval

The ultrasonic emission signal is controlled by the single chip microcomputer and emits ultrasonic waves with a frequency of 40 kHz. When the receiving device receives the reflected wave, the ultrasonic wave will be greatly attenuated for the received echo, and its attenuation law is exponential. Assuming that the distance from the ultrasonic transmitter to the object is, then the amplitude formula for its propagation is:

$$A = A_0 e^{-2\omega k} \cos(\omega t + kt) \qquad (2)$$

According to the formula (2), the real-time amplitude is propagated for the ultrasonic wave, and the initial value of the ultrasonic wave propagation is the ultrasonic attenuation coefficient. When ultrasonic waves are transmitted in the air, they are consumed and will continue to weaken, and the higher its frequency, the greater the degree of attenuation.

To solve this inevitable error, multiple ultrasonic transducers can be used as a design model for multi-channel ultrasonic reception, and multiple amplifications can be extended to the range to be measured and the error can be reduced. Because the time of the first echo is accurately recorded, the signal received by the receiving device is continuously amplified.

(3). Blind zone measurement

Since the distance between the ultrasonic transmitting device and the receiving device is very small, the transmitting device relies on the vibration of the ceramic piece to emit ultrasonic waves. When the ultrasonic wave is just emitted, the receiving device generates the sensing and receives it without being reflected by the obstacle, and is short. The multiple of the amplifier will drop in time, and it may have no effect. It is usually called blocking. Targeted detection of defects according to defect echoes in the blocking range may result in a decrease in the test results, and it may be impossible to find any obstacles. Therefore, this range is called a blind zone.

For the blind spot problem, at the moment when the ultrasonic wave is emitted, although the signal is emitted for a very short time, once the signal is emitted, the transmitting device may have some aftershocks. Therefore, when receiving the ultrasonic wave, the received electrical signal of the ultrasonic wave has a limited value, that is, the received signal is larger than the limit value, and the receiving device can receive and process the signal.

3. System Program Research

The research on the vehicle reversing radar device is based on the single-chip microcomputer, using the principle of ultrasonic ranging, and applying various anti-interference measures to the ultrasonic ranging to realize the accurate detection of obstacles by the reversing radar system. When the car starts to reverse, the reversing radar system is started, and a square wave with a frequency of 40 kHz is programmed by the single-chip microcomputer, and then the ultrasonic wave is transmitted through the crystal oscillator of the transmitting circuit to emit an ultrasonic wave. When an obstacle is encountered, reflection occurs, and when the reflected wave of the ultrasonic wave is received, The receiving port of the receiving circuit will generate a high level. There will be an interrupt request signal at the external interrupt source input port of the chip. The microcontroller will process the external interrupt request signal and import it into the subroutine of the external interrupt service in the memory to calculate the time difference. And the distance is obtained, and the result is output to the digital display circuit and the voice broadcast circuit. The overall design block diagram of the car reversing radar is shown in Figure 2 below:

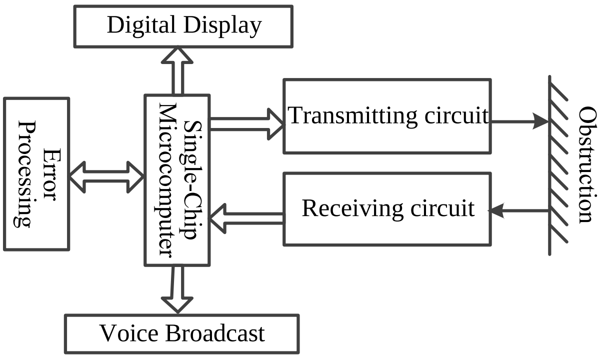

Figure 2 Ultrasonic ranging system block diagram

3.1 Ultrasonic launcher

The power and accuracy of the ultrasonic waves are proportional to the frequency, and ultrasonic waves with a frequency of 40 kHz are used. The ultrasonic transmitting device portion is a microcomputer P1.0 port composed of an ultrasonic transducer and an inverter device 74LS04, and outputs an intermittent square wave of 40 kHz. The schematic diagram of the ultrasonic transmitting circuit is shown in Figure 3:

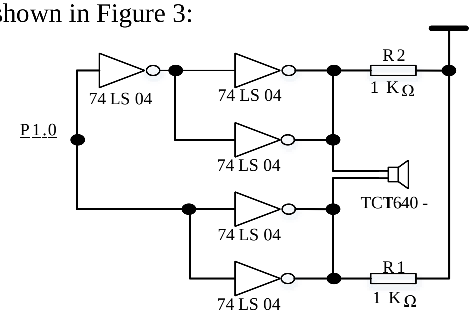

Figure 3 Ultrasonic Transmitting Circuit

The start time of the single-chip timer starts, and the signal passes through two two inverting elements to the two electrodes of the ultrasonic transducer, which can improve the emission intensity of the ultrasonic wave. Resistors R1 and R2 can significantly enhance the damping effect of the ultrasonic device, and can also reduce the oscillating time and enhance the driving performance of the 74LS04 output.

3.2 Ultrasonic receiving circuit design

The purpose of the receiving device is to amplify and detect the reflected wave, and input the recognizable interrupt signal to the AT89C51 of the single chip as a flag for receiving the reflected wave. The ultrasonic receiving device part selects the SONY CX 20106A integrated module, and the received signal is amplified and filtered by the probe.

This module is a chip for receiving signals with strong anti-interference ability and sensitivity. After the MCU generates the start signal, after receiving the reflected wave, the ultrasonic receiving device passes the reflected wave signal through amplification, and then passes through the interrupt port of the MCU to adjust the interrupt subroutine and send it to the MCU for processing. The schematic diagram of the ultrasonic receiving device portion is shown in Figure 4.

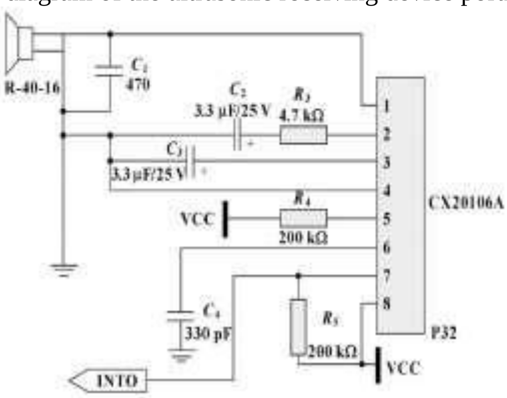

Figure 4 ultrasonic receiving circuit

Pin 1 is used as a signal input port for ultrasonic waves. C2 and R3 of pin 2 determine the overall gain effect of the receiver. By increasing the resistance R or lowering the capacitance C, the amplification of the ultrasonic wave can be adjusted. Since the value of the width of the output pulse varies greatly, a detection capacitor is connected between pin 3 and GND. Pin 7 is the output port of the remote command, which is the output mode when the collector is open, and its output is deliberately detected whether or not the ultrasonic signal is received.

3.3 Digital display circuit design

In this research on the car reversing radar device, a four-in-one common anode digital tube SM410564 was used as the display device for this study. Its non-public port is connected to the P0 port of the microcontroller, and the P2.0 to P2.3 pins of the P2 port are connected to the common port, and the scanning is started by dynamic scanning. Because the drive capacity of the P2 port is limited, port P2 cannot be connected to the digital tube common to allow the P2 port to control the four transistors to turn on and off. The display circuit is shown in Figure 5.

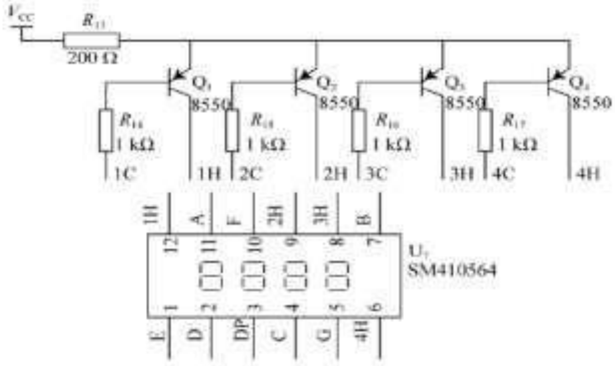

Figure 5 shows the circuit

3.4 Voice prompt circuit design

The chip of the voice broadcast circuit adopts the first recording, and then selectively broadcasts the broadcast. When the set distance is less than 10cm, the broadcast "parking" is broadcast, and the distance is no longer broadcasted. During playback, the corresponding voice segment start address can be found according to the voice content to be played, and sent through the interface line. Then set the P/R terminal to the high level, the PD terminal to the low level, and let it generate a negative pulse to start the playback. At this time, the MCU only needs to wait for the information end signal of the ISD2560 (The EOM is generated). Since the signal is a negative pulse, and the rising edge of the negative pulse, the segment of speech is played, so the microcontroller must detect the rising edge to play the second segment.

4. System software

The operation procedure of the main program of ultrasonic ranging in this system is as follows: Firstly, the main program initializes the system to set the system working environment; then judges whether the measurement flag of the ultrasonic emission condition is satisfied; if it is satisfied, it transmits the ultrasonic wave, and starts the interrupt subroutine to start timing; receiving After the ultrasonic wave, it is judged whether the distance is greater than the upper limit value, and if it is greater than, the CDC can be displayed as safe; and then it is judged whether it is a blind zone value. If the above conditions are satisfied, the measurement segment code conversion is performed, and the value obtained after the conversion is judged, and the speech value smaller than and closest to it is selected and output to the digital display circuit and the voice broadcast circuit; after this series is completed, the system is restarted. The timer for the next measurement of the main procedure of ultrasonic ranging is shown in Figure 6:

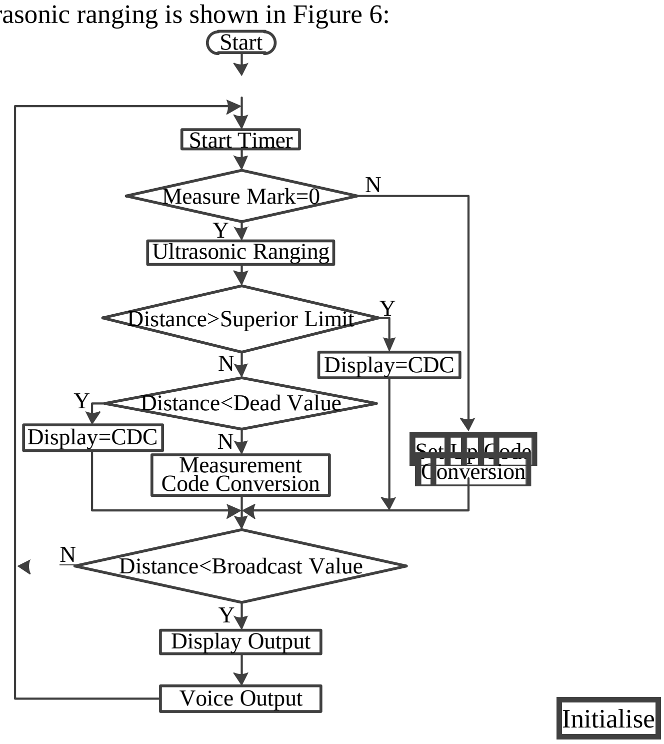

Figure 6 Flow chart of the main program of ultrasonic ranging

When the main program is running, the ultrasonic ranging subroutine is started when the interrupt program is called. Controlling the time, duration, frequency and other factors of the ultrasonic transmitting device to emit ultrasonic waves, until the receiving device receives the reflected wave, generates a level signal, and sends the corresponding signal to the single-chip microcomputer, which is received by the interrupt service part of the main program. The calculation is performed and output to the digital display device and the voice broadcast device. The ultrasonic ranging subroutine is shown in Figure 7 below:

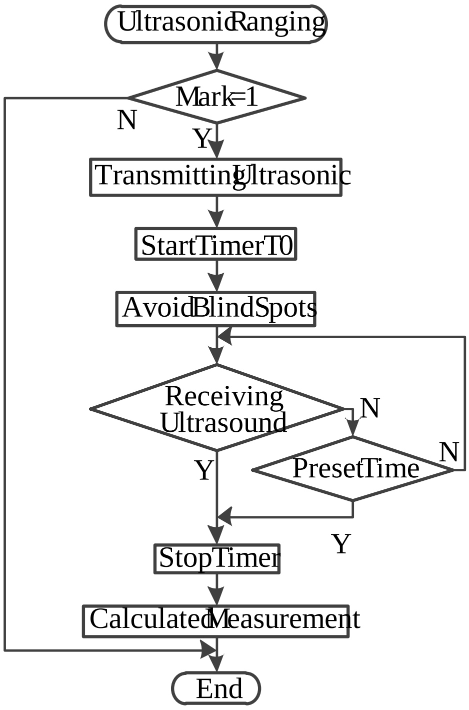

Figure 7 Ultrasonic ranging subroutine flow chart

In this program, the number of ultrasonic ranging is 4-5 times/second. At distance measurement intervals, the program basically works on loop measurements and displays numbers in real time. When running the subroutine of the ultrasonic measurement distance, firstly, it is judged whether the conditional mark of the transmitted ultrasonic wave is satisfied. When it is satisfied, the probe of the ultrasonic transmitting device emits an ultrasonic wave, and immediately the internal timer T0 starts to work immediately; to prevent the occurrence of the ultrasonic wave The internal direct transmission of the device causes triggering. It is only necessary to set a time value of the single-chip microcomputer to achieve the delay effect (this is also the reason why the ultrasonic device can measure the minimum distance); when the receiving device receives the ultrasonic wave, it is first determined whether the preset time is sufficient. The receiving condition is met, and the MCU processes the signal sent by the ultrasonic receiving device after the condition is met; finally, the value of the timer is calculated and the distance is calculated to complete a measurement process. In order to make the ultrasonic calculation more accurate and the program shifting more convenient, this research device uses the distance measurement of the ultrasonic generator and the receiver into the single-chip microcomputer using the C programming language.

5. experimental analysis

Automobile reversing radar system proposed in this study. The principle of the device is ultrasonic ranging, and the accuracy and accuracy of the ranging directly determine the performance of the system. Therefore, whether to perform error processing on the ranging method is selected, and the experimental results are analyzed. The results obtained are shown in Table 1:

Table 1 has error processing and error-free processing test

Test Count	Actual Distance/cm	Error Processing Measuring Distance /cm	hether to Alarm	No Error Processing Measuring Distance /cm	hether to Alarm
1	30	30.8	Yes	29.6	Yes
2	50	48.8	Yes	52.3	No
3	100	102.5	Yes	96.6	Yes
4	150	152.6	Yes	154.2	Yes
5	200	197.6	Yes	196.3	Yes

The system needs to meet the obstacles at different locations. The test results are shown in Table 1. The experimental data is the test of the obstacle distance of the car at different positions. The error is processed in the software without error processing and the error is added to measure the distance. The accuracy of the distance measurement and whether an alarm occurs are compared. The results show that, at different positions, after the error processing in the software, the accuracy of the data measured by the system is closer to the actual measurement distance, and the number of false alarms is relatively small, which is the purpose of this test.

In order to make the car parking radar system device be applied to many different environments, the system chooses to test multiple distances differently, and manually selects some interference measures, and performs error processing on the ranging in the software to observe whether the alarm module can work normally. And the accuracy of the alarm. The test results are shown in Table 2,

Table 2 Distance measurement and actual value

Test Count	Actual Distance/cm	Display distance /cm	Broadcast distance /cm	Whether to Alarm
1	10	9.3	9	Yes
2	30	30.9	30	Yes
3	50	48.9	48	Yes
4	70	702.3	72	Yes
5	100	101.9	101	Yes
6	120	122.2	122	Yes
7	140	138.7	138	Yes
8	160	163.7	163	Yes
9	180	182.2	182	Yes
10	200	205.6	205	No

It shows that in the process of reversing the car, the system will basically trigger the alarm module to issue an alarm, and the voice broadcast can also correctly report the distance. The MCU adopts error processing on the measurement distance mode, which greatly improves the reliability and practicability of the reversing radar system device and satisfies the safety. The purpose of reversing.

6. summary

This paper is mainly to study the alarm device that helps the driver to effectively avoid the danger from the rear of the car when the car is reversing. The automobile reversing radar system mainly adopts the ultrasonic ranging of the single chip as the core, and adopts anti-interference error processing measures to effectively improve the alarm accuracy and accuracy. The experimental results show that: In the ultrasonic distance measurement, the error is processed by the distance measurement, the distance between the vehicle and the obstacle is displayed in real time, and the voice broadcast is performed within the alarm distance, effectively reminding the driver to achieve the indication of reversing. purpose. The system has the characteristics of economy, practicality, simple structure and high reliability, and meets the needs of users for reversing, and can be widely used.

References

[1]. Wu Qiong, Feng Weizhong, Ma Wenjie. Design and Implementation of Vehicle Parking Radar System[J]. Modern Electronic Technology, 2009, 32(9): 191-194.

[2]. Liang Dongyun. Design of Ultrasonic Reversing Radar System Based on Single Chip Microcomputer[J]. Journal of Shangluo University, 2017(2).

[3]. Wang Xiaohong. Design of Vehicle Parking Radar System[J]. Electronic Design Engineering, 2013, 21(17): 187-189.

[4]. Yang Wangxi, Mao Jiawei, Shen Mingming. Design of Ultrasonic Reversing Radar System Based on Single Chip Microcomputer[J]. Science and Technology Information, 2014(9):12-13.

[5]. Hu Fengzhong, Zhao Guangfu. Design of Automobile Parking Sensor Based on AT89C2051 Single Chip Microcomputer[J]. Journal of Computer Measurement and Control, 2010, 18(5): 1174-1175.

[6]. Yang Lingchen, Zhou Wuneng, Tang Wenbing. Research and hardware design of ultrasonic ranging system[J]. Instrumentation Technology and Sensors, 2018.

[7]. Hui Yanbo, Li Yongchao, Wang Li. Design of ultrasonic proximity alarm device[J]. Electronic Measurement Technology, 2016, 39(5): 120-122.

[8]. Wu Wei, Liu Suli, Lu Riwan. Design of Ultrasonic Parking Sensor System[J]. Programmable Controller and Factory Automation, 2006(6): 88-90.

[9]. Zhang Le, Qin Shiqiao, Wang Shengshu. Small LD laser range finder for smart cars[J]. LASER TECHNOLOGY, 2005, 29(2).

[10]. Wu Wei, Liu Suli, Lu Riwan. Design of Ultrasonic Parking Sensor System[J]. Programmable Controller and Factory Automation, 2006(6): 88-90.

[11]. Hu Peng, Qin Huibin. Design of Early Warning System for Parking Sensor Based on Infrared Ranging Vehicle[J]. Sensors and Microsystems, 2018(7).

[12]. Han Ren, Jin Yongwei, Wang Qiang. Design of Parking Sensor Early Warning System Based on STM32 and Ultrasonic Ranging[J]. Journal of Sensors and Microsystems, 2016, 35(4): 63-6.

[13]. Niu Shifeng, Li Li, Ren Chaowei. Research on Bus Distance Monitoring System Based on CCD Camera Technology[J]. Science Technology and Engineering, 2016, 16(11): 198-202.
[14]. YUAN You-xin, WU Hao, LIU Su-min. Design of Visual Car Parking Radar Early Warning System[J]. Journal of Microcomputer, 2007, 23(5).
[15]. Hasan R, Khan M M, Ashek A, et al. Microcontroller Based Home Security System with GSM Technology [J]. Open Journal of Safety Science & Technology, 2015, 5(6): 55-62.
[16]. Hu Yansu, Gao An. Ultrasonic Ranging Error Analysis and Correction Research[J]. Journal of Computer Measurement and Control, 2015, 23(8): 2820-2823.