THE RESEARCH OF ULTRASONIC DETECTION METHOD FOR CAR BACK OBSTRUCTION

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Abstract: Ultrasonic, used in security technology such as car collision avoidance and distance measurement, also can be used in detecting obstruction behind the car when backing up. In this paper, we analyze the interference of ultrasonic signal when transmitting and receiving, and then resolve it by software.

There is a blind area and distance limitation in ultrasonic distance measurement .The cause of distance limitation is that the amplitude value of received signal is at least larger than the specified threshold value. However the requirement is low, the minimum amplitude value of received signal must be lager than that of the noise, otherwise it is difficult to distinguish the signal we need from the noise. The software signal resolvent mainly are: system error compensation, transmitted pulse modulation technique, delayed receiving technique, digital filter technique and time delay killing transmitting vibration.

The result of experiment shows that the system's dead band is less than eight centimetres; the distance measurement is farther than ten meters; the three-point-detection-overlay zone is wide; measurement accuracy is high, relative error is less than 2%.

Obviously, when all-around ultrasonic software signal resolvent is applied, low-cost ultrasonic sensors is used widely and ability of system is strengthened to adapt to the environment

Introduction: Presently, the detection technique of laser, radar, infrared ray and ultrasonic have been widely applied at the aspects of safety technique of car collision avoidance and distance measurement. At the aspect of collision avoidance laser, radar and infrared ray are commonly applied to measure the control range between two cars and the range which should be measured behind the car. At the aspect of distance measurement the technique of ultrasonic is applied to measure the detection range when a car change the driveway and to detect the obstruction behind the car when backing up or parking|.

Because of the expensive price, the distance measurement system of backing up with the technique of laser and radar is only set on the minority of slap-up cars, so the research of the distance measurement system of backing up with high ratio of capability and price for the medium cars and the low-end cars is an important task of auto-electron industry.

The automatic distance measurement system of backing up introduced in this paper can automatically measure the distance between the trail of the car and detect the obstruction behind the car, further more it can show the distance and give a sound-light alarm in real time, so it can ensure the car to run safely and reduce the accident ratio. The driver does not need to intermeddle in or manipulate this system. This system will have a prosperous application prospect. It will cut a way through the market of the medium cars and the low-end cars and provide a new research method for the car collision avoidance.

The automatic distance measurement system of backing up is an electro-mechanical integrative instrument, which adopts the technique of ultrasonic sensor and SCM. When the electric signal is imported into the emitter, the emitter transmits ultrasonic, the receiver receives the reflected wave, the sound wave transmitting time and the distance are in direct ratio, so obtain the function of distance measurement.

The important research content of this system is: the research of method about ultrasonic distance measurement and the system about ultrasonic distance measurement. This part includes how to choose the model of distance measurement sensors and design the detection system, the research and the application of ultrasonic, transmitted and received technique. The research and the design of processing system about measuring signal channels and calculating signal .The important part is the hardware and the software design about the SCM signal processing system, the compensation and the emendation of the system error and the random error of signal measured, design of the interface about distance display system and the sound-light alarm system and the drivers, the research of the anti-jamming and reliability of the automatic distance measurement system of backing up.

Results: The ultrasonic distance measurement is an untouchable detection mode. Compared with else detection modes, it does not influenced by ray, temperature and colour etc, and it has the great capability to adapt to the circumstance.

The ultrasonic sensor adopts transmission mode or reflection mode on the physical configuration, the reflection mode has the single explore-head and the double explore-head, his system adopts double explore-head reflection mode, it is that the sending signal and the receiving signal are on the same side.

The double explore-head mode has a unique advantage, which is that there is much less blind area than single explore-head mode. Because the sending explore-head is separated from the receiving explore-head, the sending explore-head does not have sending voltage directly, theoretically, it does not have blind area. But the receiving circuit is influenced by the sending circuit more or less, and the ultrasonic from the sending explore-head possibly move around to the receiving explore-head directly. So there should be existed some blind area, but in fact more less than the blind area of single explore-head .

It is the ultrasonic pulse echo technique (sonar technique) that is most widely used in the continuous distance measurement technique. The working principle is: the sender sends ultrasonic pulse, then the sound wave transmits in the medium. The sound wave is reflected when it comes up against the objects. Recording the time from sending to receiving, we can calculate the distance from the sensor to reflection point according to the velocity of sound in the medium.

If the vertical distance from the sensor to the object detected is L, the time from sending to receiving is t, the velocity of sound is c, then the distance measured $L=(c*t)/2$.For the sending and the receiving reflection mode ,if the distance between the centers of the two sensors is 2a,the diagonal path from the sensor to the object detected is s, then $s=(c*t)/2$,Generally speaking ,the sending sensor and the receiving sensor are put close, when $s>>a$, $L\approx s$.

The ultrasonic detection distance relates with size, figure, material and position of the object. The bigger the reflector is, the better the reflectance is, and the stronger the reflection signal is. Generally speaking, the detection distance is farther if the facade of the reflector is smooth and flat than that if the facade of the reflector is coarse, the detection distance of the reflector with solidity facade is farther than that with loose facade, the detection distance is farther if the reflector facade is vertical to the sending signal than that if there is a obliquity between the reflector facade and the sending signal (the reflected ultrasonic does not return to the explore-head along the primary path, so the reflected signal received by the receiving explored-head will be greatly weakened).

The figure 1 illustrates the principle of the hardware circuit of the system, which includes three parts: ultrasonic sending and receiving circuit; signal process and SCM control circuit; display and alarm circuit.
The working principle of the system hardware is: the control signal A from SCM use conversion multiplexer and the driver to control the three couples of sensors to work in time-sharing (B is control signal from one group of sender), transmit 40KHZ ultrasonic, after the receiver receives the return ultrasonic, transformed into rectangle wave C through the magnifying and modulation circuit, delivered to the signal process circuit through conversion multiplexer (D is the synchronous control signal from SCM to signal process circuit).The signal process circuit changes the time signal measured into width of level signal E, and outputs it to the SCM to be processed. The SCM displays F after being processed, and gives the adjustable-volume alarm G according to the distance
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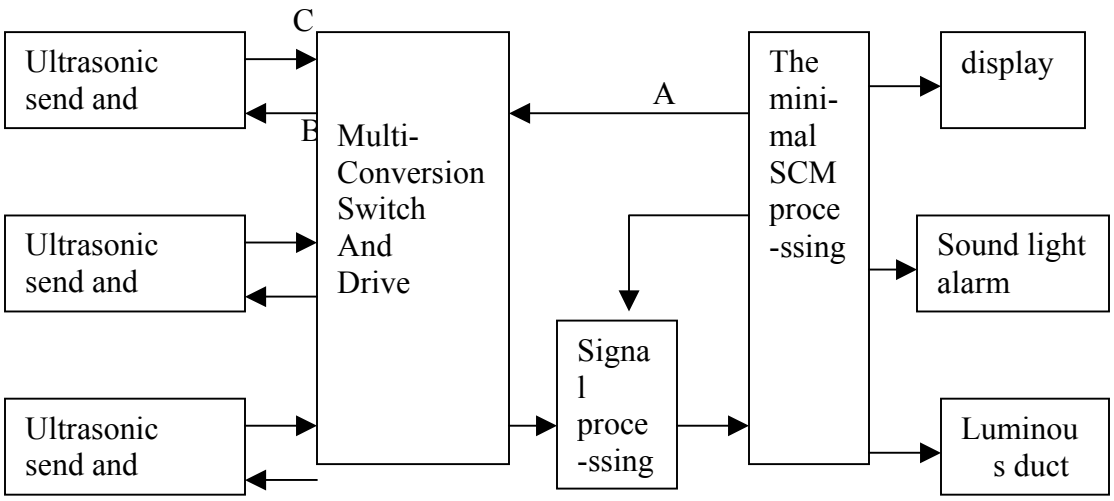

Figure 1: System hardware structural chart
The major technique of the system hardware design is as follows:
Ultrasonic sensor: the system adopts mini-type ultrasonic sensor T/R 40-60 of T/R 40 series. Ultrasonic distance measurement algorithm adopts pulse echo method.
The ultrasonic sending circuit: because the ultrasonic sender changes the alternating current signal into machine shake through piezoelectricity wafer, so the driver circuit must provide a group of alternating current signal .The system adopts a universal hardware timer to produce rectangle wave to drive ultrasonic sender T40-60.

The ultrasonic receiving circuit: the signal received by the ultrasonic receiver is usually weak, only tens to hundreds millivolts, and includes direct current heft, so the ultrasonic receiving circuit composes of ultrasonic sensor R40-60, isolation circuit, filter wave circuit, magnifying circuit, plastic circuit etc.

The conversion multiplexer: the system adopts three couples of ultrasonic sensors, distributed evenly at the trial of the car, only one couple of sensors are on the job every moment. It adopts CD4052 to switch control signal and input signal of the three couples of the sensor boards.

The SCM signal process module: the kernel of system adopts 8751 of the MCS-51 series, it has 4K EPROM, 128 bits RAM, and it can attain the demand of the resource. Intercalate drivers, improve the signal transmitting distance, and adjust the signal impedance to match for the input signal.

The display and the alarm circuit: the system adopts three bits sharing-anode seven sect display, the maximal display distance is 9.99 metres, adopts working of serial output, parallel conversion, static display. The alarm circuit controls the buzzer to give an alarm by receiving the interrupt from the timer at regular time, the frequency of the alarm relates with the distance between the car and the obstruction behind the car.

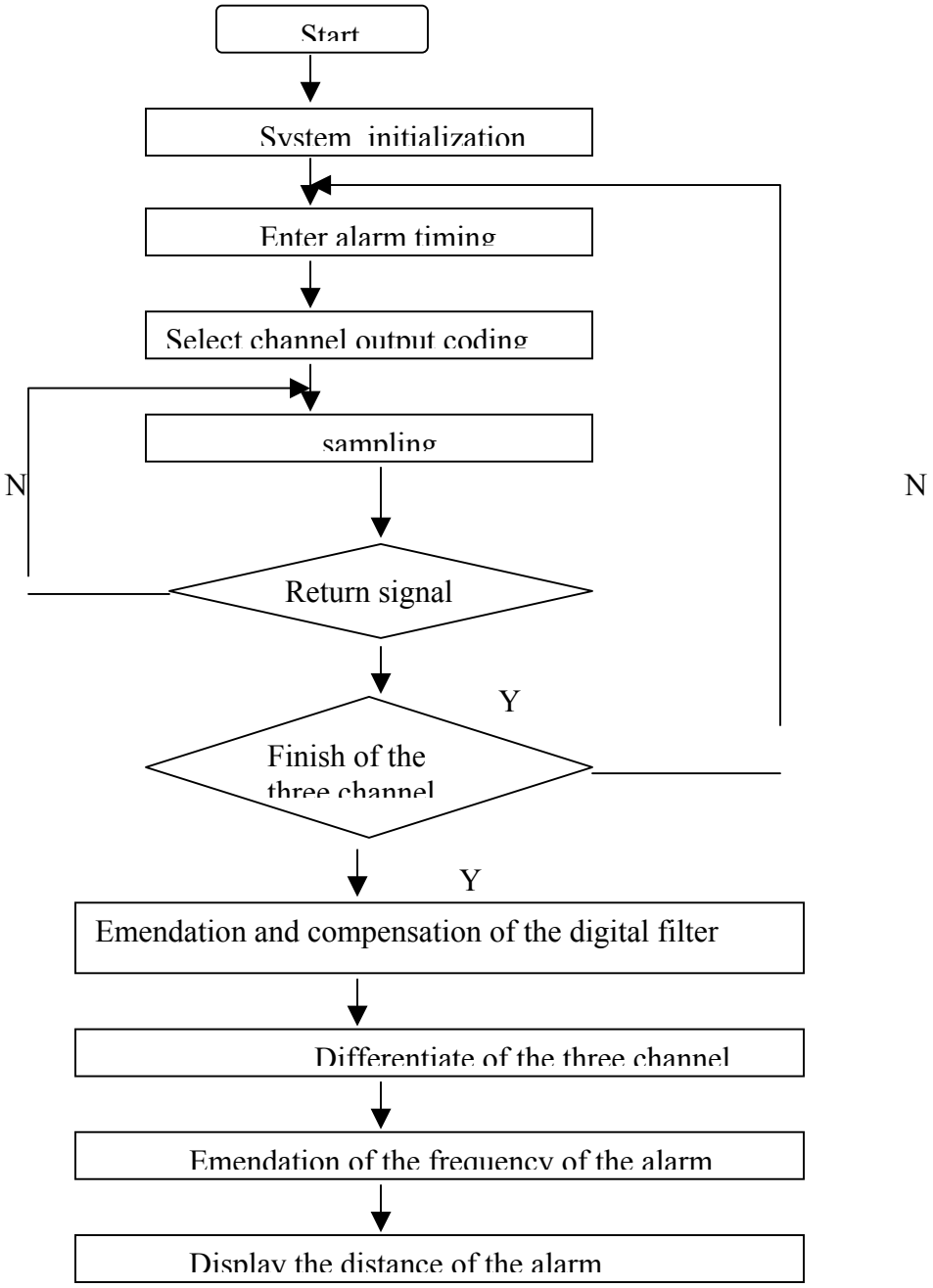

Figure 2: system software flow chart

The system power supply meets the car backup light directly. When backing up the backup lights are electrified, at the same time the system electrified and begin to work; when stopping backing up, the system stops working at once.

According to the demands of the system, the functions of the software are as follows:

Data collection: the SCM controls the sensors to work by turns. It records the ultrasonic transferring time when the sensor is at work.
Data process: including digital filter, emendation and compensation, data differentiate, distance subsection detection to the sampling data.
Distance display: change the distance value into BCD code format, and send the value of the distance in BCD code format to the display tube to display in serial way.
Sound-light alarm: give different alarm according to the different distance between the trail of the car and the obstruction.
Figure 2 is the system software flow chart, which includes system initialization, data collection and process, distance display, giving an alarm etc.
Discussion: Ultrasonic distance measurement has blind area and distance limitation. The reason of existing blind area has been discussed in the ultrasonic distance measurement working principle, the reason of existing distance limitation is that the amplitude value of received signal should be larger than the set threshold value at least. The threshold value is decided by the demand of the ratio of signal and noise. If the demand is higher, we can demand that the threshold value is larger than decuple of the noise. No matter how low the demand is, the least amplitude value of the received signal should be bigger than that of the noise, or it is difficult to distinguish the needed signal from the noise.

The major software anti-jamming measures adopted by the system are as follows:
The system error compensation: the obvious time delay error includes lag time delay of the circuit, time delay of the cable and time delay of sound wave through the coupling layer. After the apparatus, sensors and cables are fixed, these added time delay will not change, it can be regarded as system error.
Sending pulse modulating technique: the number of the pulse is alterable during each sampling period according to the different distance. The farther the distance is, the more the number of the pulses is; the shorter the distance is, the fewer the number of the pulses is.

Delay receiving technique: there are scattering objects widespread in the air, for example dust and fluid drop, and the reflecting surface is not smooth, all the phenomena mentioned above can bring hash. Because a large quantity of dust and rough surface can bring the weak but large number of hash, then the system of distance measurement displays the error reading. The case is inevitable, and it can be cleared up or minished by software anti-jamming technique. The receiving circuit pays no attention to any signal during the short time after the ultrasonic is sent .By this means to minish the interference produced by the echo and the scatter of the diffusing wave.
Digital filter technique: the sampling data is processed by software, gliding filter method, eliminating error value.
Time delay compensating sending remainder swing: delaying some time after sampling to eliminate sending remainder swing from disturbing next sampling.

In fact, the precision and the distance of measurement are influenced by many factors. If you want to improve the precision and the distance of measurement you can adopt the measures as follows:
1) Emendation of the velocity of sound: there are many factors influencing on the velocity of sound, for example the air component, temperature, intensity of pressure, and these factors can influence each other, form great velocity of sound grads. When the condition is relative ideal, it is to say that the component, temperature, pressure of the medium do not have much change, we can think the velocity of sound wave unchanged.

2) Setting focalizing implement: setting focalizing implement can change the open angle of the wave bundle, enhance the ability of distance measurement.

Conclusions: Digital filter technique: the sampling data is processed by software, gliding filter method, eliminating error value.

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