Solving Multiple Triggering Problem of Ultrasonic Distance Measurement by Debouncing

Zhenhua Xiang
Three Gorges University, Xiantao City, Hubei Province, Postcode: 443000, China
*Corresponding author’s e-mail: Billy_xzh@163.com

Abstract. In recent years, multiple measurement systems fusion technologies have developed rapidly. Ultrasonic ranging is paid much attention because it has the advantages of directly measuring short-distance targets, high longitudinal resolution, and a wide application range. However, when the ultrasonic distance measurement is carried out by assembling the circuit board, it is found that the switch is triggered multiple times, and the measurement data is inaccurate. This paper proposes a new method that adding debounce to improve the accuracy of measurement. Besides, Some suggestions are provided to decrease the operation difficulty in the actual measurement process. Based on the experimental result, the accuracy and efficiency of ultrasonic distance measurement are greatly improved via this method proposed in this paper. By the way, the single-chip computer simulation technology simulates the ranging phenomenon in the experiment.

1. Introduction
With the rapid development of science and technology, ultrasound is widely used in rangefinders. However, as far as the current level of technology is concerned, the available ranging technology is still limited. The ultrasonic rangefinder will have a lot of room for development in all aspects. It will develop in the direction of higher positioning and high precision to meet the growing social needs. However, the original circuit drawings have multiple triggering problems [1][2]. This paper proposes to add a debounce circuit to solve this problem. To test the accuracy of this new method, we simulated the total circuit diagram in Proteus. Specifically, we divided the circuit diagram into the circuit diagram with debounce and the non-joined circuit diagram to run the program. The 74LS279 was selected to achieve the purpose of debouncing. Finally, we found that adding a de-jitter ranging system can effectively measure the distance accurately in a specific range.

In short, the efficiency of the system after adding de-jitter is dramatically improved. Besides, this system has satisfying software and hardware design, strong anti-interference ability, and good real-time performance.

2. Ultrasonic ranging
2.1. Ultrasonic ranging principle
The most commonly used ultrasonic ranging method is the echo detection method [3][4]. Its working principle is to make the transducer emit acoustic pulse to the medium. The reflected acoustic wave (echo) must act on the transducer when the acoustic wave meets the measured object (target). Suppose the acoustic velocity of the medium is known to be $v$ and the time difference between the
arrival time of the first echo and the time of the emission pulse is t. In that case, the distance between the transducer and the target can be calculated by the formula \( d = vt/2 \) [5].

2.2. Design block diagram of an ultrasonic ranging circuit
The block diagram of an ultrasonic ranging circuit is given in Fig.1. It comprises an oscillating circuit, a gate circuit, a HC-SR04, a debouncing switch, a reset switch, and three decoders [6][7]. Since the sound velocity is 340 m per second, the module measures the return and return distance. An oscillator circuit that can provide a stable 17 kHz is required. Firstly, the trig port of HC-SR04 is connected in parallel with a 1K resistor on the switch. The ultrasonic wave starts from the transmitter and returns after reaching the measured object, which is received by echo (receiver) and generates a square wave about distance. The ultrasonic signal from the module and the clock pulse signal provided by the oscillation circuit is received by the gate (74LS00), resulting in a new pulse signal received by the counter (74LS90). We added a switch in it to clear zero. The counting method is decimal; 74LS90 gets the signal and converts it into the distance. The counter further sends out the signal to be received by the decoder. The number is directly converted into the display number of the digital tube through decoder decoding. So you can see that the number on display is the measured distance. In centimeters, the module theoretical measurement distance is 4 meters to 4.5 meters. Since there are too many external interference factors in ultrasonic ranging, when the ultrasonic wave is emitted, the receiving sensor will be subject to strong interference signals, resulting in unstable experimental data measured each time. After research, the problem is that the switch is triggered repeatedly. To prevent the system's error, we add a debouncing circuit before the trigger switch to further improve the experiment to make the measurement data more accurate.

![Fig. 1: block diagram of an ultrasonic ranging circuit](image)

2.3. Simulation of the debouncer circuit
Proteus conducted the debouncer circuit simulations. The overall simulation model of the debouncer circuit can be seen in Fig.2.

![Fig. 2: The overall design drawing of the first generation circuit simulation](image)
The simulation steps are provided in the following:

Step 1: build the whole circuit in Proteus.

Step 2: start the switch. Press the switch to perform the first circuit simulation experiment, and the digital tube shows the number is normal.

Step 3: measurement. Press the switch again, the experimental distance remains the same, but it is found that the number displayed by the digital tube is different from the first experimental data and has a multiple relationship.

The simulation result shows that multiple runs in the case of a specific current and the given distance. The experimental data are inconsistent, and each measurement found that the experimental data are multiples of a certain distance. Then, it is speculated that there are many trigger switch phenomena because the switch is too sensitive, and we cannot improve it under artificial conditions. Therefore, we add a debouncing circuit to prevent this phenomenon from happening again.

2.4. Experimental test

The overall test method is as following statements: First, turn on the power supply, slide the knob, let CH2 emit 5.0 V voltage, access the breadboard, and press the output button to provide 5.0 V voltage to the breadboard. Then, the monitor is cleared by pressing the clearing switch, and the ultrasonic emission switch is pressed to detect whether the number on the monitor is consistent with the actual distance, and multiple experiments are carried out to eliminate the error. The detailed test steps are explained in the following. Fig.3 also gives the diagrams.

Step 1: turn on the power and connect to the breadboard;
Step 2: clear to zero;
Step 3: press the ultrasonic test switch, measure the selected position distance;
Step 4: measure the actual distance with a tape measure;
Step 5: error correction again, using the same method to measure a close distance.

Fig. 3: The detailed test steps
The experimental result shows that there is not much error between actual distance and measured distance, no matter the exact distance is long or short.

### 3. Conclusion

In this ultrasonic-ranging experiment, it was found that the experimental data appeared many times. After many experiments, it was found that there was a problem of multiple triggering of the switch. Therefore, it is recommended to add a debounced switch on the original basis. To reduce the number of experimental failures, the experiment adopted a single-chip simulation. A de-jitter circuit is added on the premise of successful simulation, and the experiment can complete the goal. It shows that debouncing can effectively realize the problem of multiple trigger switches in the circuit, solve the interference of unnecessary factors, and provide reliability and accuracy for many aspects. Adding debounce is significant because the ultrasonic distance measuring device can effectively avoid physical problems such as unstable current, susceptible switches, and excessive temperature drop due to external factors. In this way, the setting can perform distance measurement well and provide convenience for people in different environments. In addition, according to the problems in the experiment, we summarize the following points.

1. HC-SR04 should be placed horizontally. Otherwise, the measurement distance will be too large.
2. Because the air's humidity, density, and sound velocity are not necessarily 340m / s, the frequency is not necessarily 17kHz; it needs to be adjusted.
3. Display wiring due to equipment defects, resulting in a poor display of part of the display strokes.
4. Be careful not to trigger many times when you press the startup switch.

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