Design of intelligent guide device based on ultrasonic phased array technology

Siqi Zhu [a] and Zhiyuan Dong [b]

School of Mechatronic Engineering, Southwest Petroleum University, Chengdu 610500, China

[a]352321768@qq.com, [b]1392915507@qq.com

Abstract

Aiming at the shortage of the existing guide system stability difference, ultrasonic reflection of weak signals, obstacle detection accuracy is low, obstacle positioning poor performance and the impact of environmental factors, this paper puts forward a kind of ultrasonic phased array technology based on the selection of a powerful signal processing ability of the STM32F103 as the central control device, the guide system design by using precise time control accuracy EPM1270 as the phased array beam drive controller. The system scheme, hardware and software are designed, which can detect the obstacles in front of the road in real time, recognize the danger of the road ahead and warn the user correctly. The utility model has the advantages of low cost, simple operation, portability, low power consumption, portability, high practicability and cost performance, and can play an important role in the field of the guide.

Keywords

phased array technology; ultrasonic; STM32.

1. Introduction

According to the second survey data for the disabled in China in 2006 show that in China about 12 million 330 thousand blind.China is the world's most populous country, accounted for 1/5 of the whole world blind, and It continues to grow at a rate of 450, 000 a year [1]. For such special groups, society needs more care and care, so that they can share the fruits of the development of science and technology. How do you get them to travel independently and safely is one of the most important issues that the blind people need to solve today [2].

For a long time, many scientists and technicians in many countries have been committed to the research and development of guide devices, and have made certain achievements. [3] However, although the existing devices have solved some of the problems of blind people to some extent, there are still many shortcomings. Therefore, it is urgent to develop a new generation of guide devices with strong reliability, high detection accuracy and high intelligence. The research of new generation of guiding blind devices is not only beneficial to improve the quality of life and happiness index of blind people, but also has great practical significance for the improvement of independent research and innovation ability.

This article is based on ultrasonic phased array technology, selects STM32F103 with powerful signal processing ability as central control device, and realizes the detection of space obstacle.

2. Design of phased array technology and probe array

2.1 The principle of phased array technology

Ultrasonic phased array is an array of independent ultrasonic piezoelectric probes according to certain geometric rules[6-7]. The schematic diagram of phased array beam deflection is shown in FIG. 1. The focusing principle diagram is shown in FIG.2. The control circuit according to the excitation position and direction of ultrasonic sound beam focusing of certain rules and timing adjustment of the ultrasonic piezoelectric probe control, which is flexible and convenient to control the shape of the ultrasonic beam, the distribution of sound pressure and easy to realize scanning probe of obstacles of a wide range of areas.

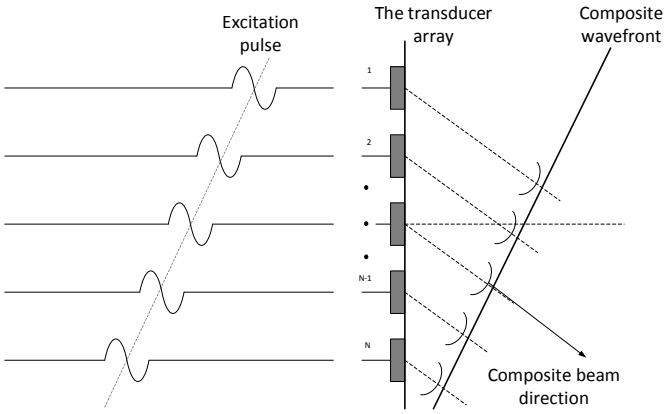

Fig. 1 schematic diagram of phased array beam deflection

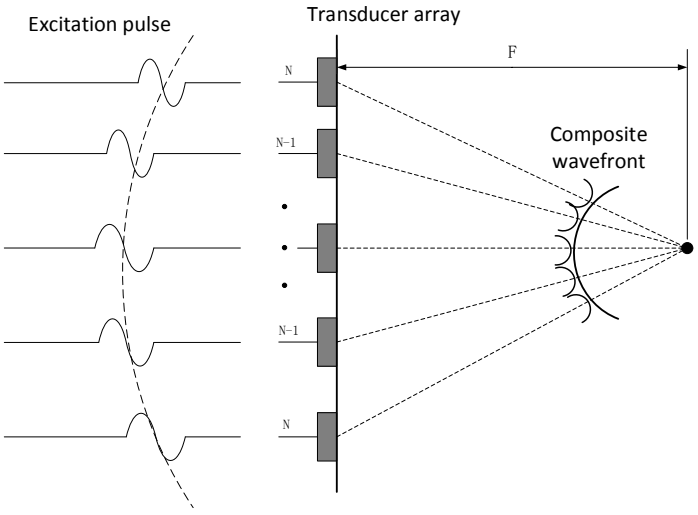

Fig. 2 schematic diagram of phased array beam focusing 1.2 the design probe array

Ultrasonic phased array requirements can be realized in front of all predetermined focus. Considering the requirements and cost of the system, the design USES five frequencies to design a four-part ultrasonic phase-controlled array with a four-part ultrasonic probe. As shown in FIG. 3, the phased array is composed of five ultrasound probe, 5 probe as a receiving probe, and the rest of the no. 1, 2, 3, 4 four probe composed of two-dimensional arrays, as emission probe.

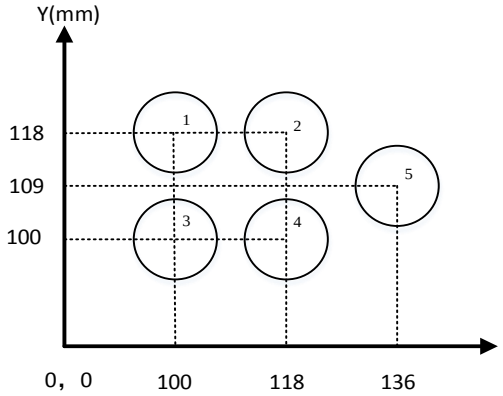

Fig. 3 ultrasonic probe layout

3. Design of device system hardware

As shown in FIG. 4 as a guide device system structure diagram, this design is mainly composed of STM32 processor, CPLD device, signal conditioning circuit, receiving probe, emission probe array, echo signal amplifier circuit, filter circuit and detection circuit.

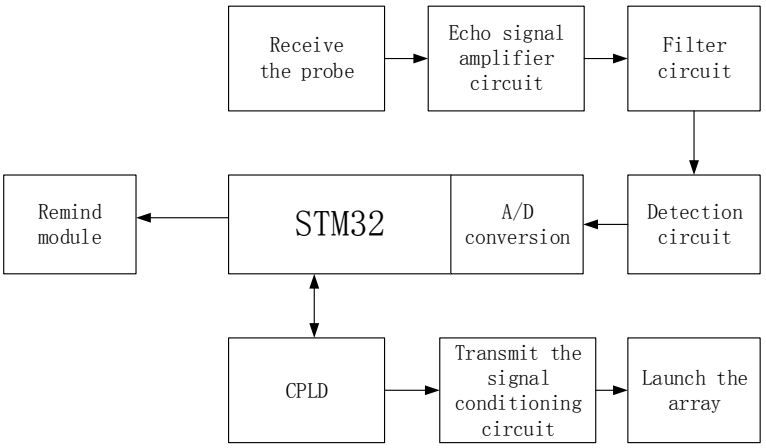

Fig. 4 guide system structure chart

3.1 CPLD device

This design uses Altera's EPM1270 low-power complex programmable logic device, with FLASH memory, the maximum delay of 6.2 ns, I/O number of 116, fully meet the requirements of ultrasonic phased array beam forming technology.

3.2 Transmit signal conditioning circuit

As shown in FIG. 5, the signal conditioning circuit is transmitted, and the driving array of the EPM 1270 controller drives the 40 kHz square wave signal with the amplitude of (0-3.3) V, the amplitude of the driving signal is too small, and the power of the ultrasonic probe is too small. Therefore, the driving signal needs to be converted into a 40 kHz square wave signal that is sufficient to drive the probe with an amplitude of + 10 V through the conditioning circuit

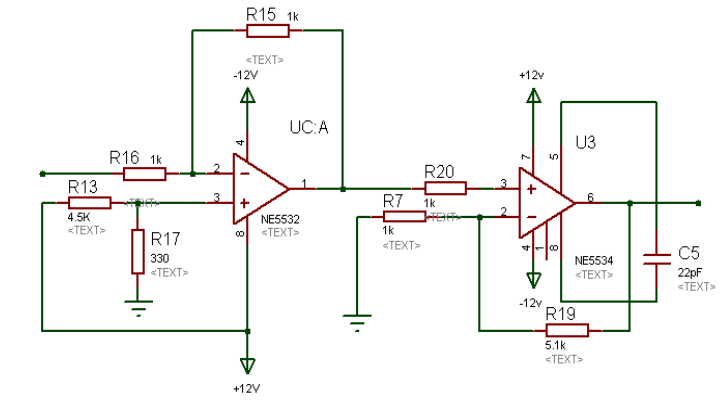

Fig. 5 Transmit signal conditioning circuit

3.3 Echo signal amplifier circuit

As shown in FIG. 6 for the echo signal amplifying circuit, ultrasonic after launch to focus area, when in the focusing area encounter obstacles will be reflected back to the receiving probe, receive the sensor output signal is millivolt level 40 kHz signal. Therefore, it is necessary to enlarge the echo signal hundreds of times and convert it to the standard signal of (0-5) V to facilitate the sampling and processing of it.

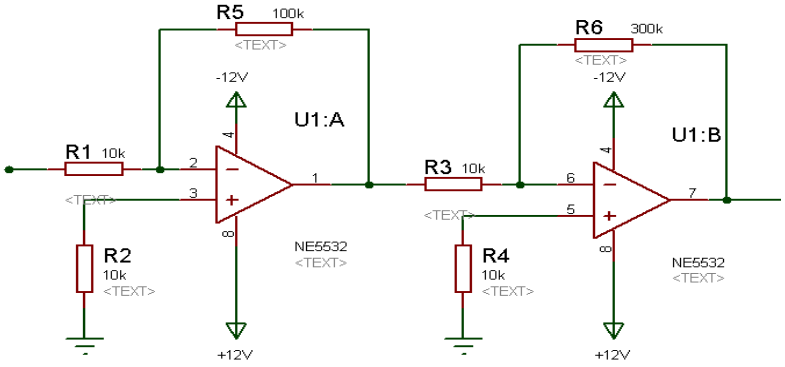

Fig. 5 Echo signal amplifier circuit

3.4 Filter circuit

The batwoz bandpass filter circuit of 40 kHz is shown in FIG. 7. The ultrasonic echo signal is accompanied by a large amount of noise, especially after the signal amplification, the noise signal has seriously affected the echo signal. Therefore, the echo signal needs to be filtered.

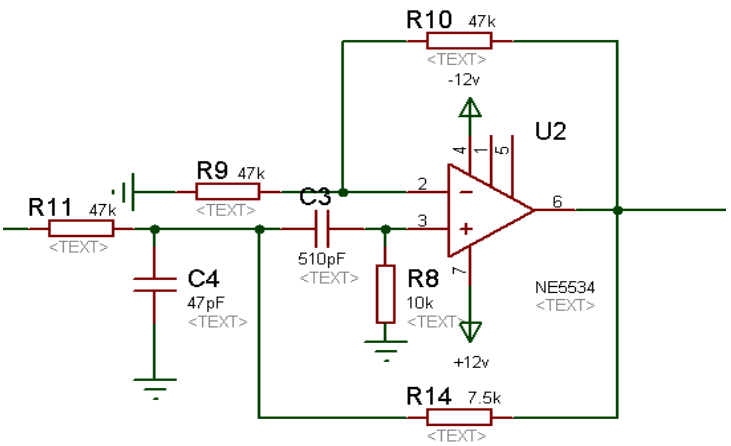

Fig. 7 bandpass filter circuit

3.5 detection circuit

Shown in FIG. 8 for detection circuit, using the peak detection circuit, the charging time constant is very small, even the very narrow pulse can also be charged to the stable value is very wide, when the intermediate frequency signal disappears, due to put on some of the circuit time constant is large, detection of the output voltage can be keep for a long time on the peak, is advantageous to the sampling and data analysis of the system.

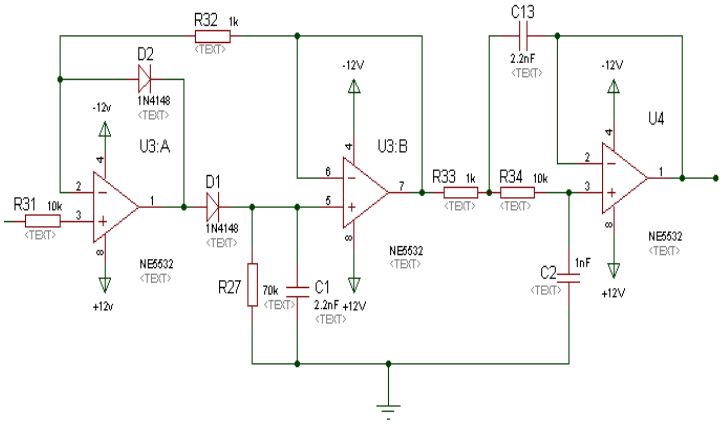

Fig. 8 detection circuit

4. The design of system software

The array scan scope schematic is shown in FIG.9. The design of ultrasonic phased array beam forming emission control program using VHDL language programming the QUARTUS II platform development, using array scanning program, realize the user in front of the 2.0 m, 25 in the plane of the scanned area of the scan.

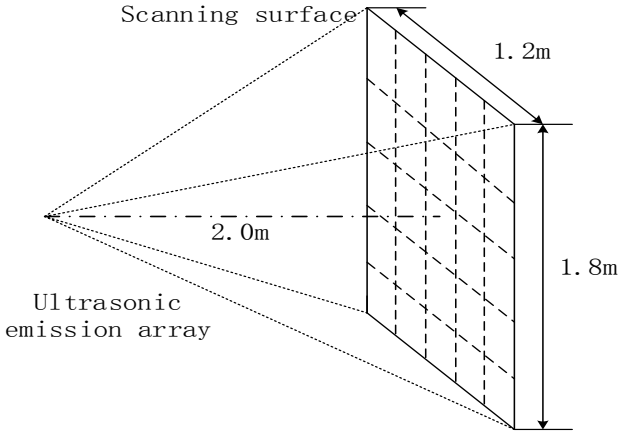

Fig. 9 schematic diagram of array scan scope

The program flow diagram is shown in FIG.10The main program USES C language to program STM32 chip in the software development platform of Keil uVision4 to realize the scanning detection, communication and intelligent alarm of the space obstacle.

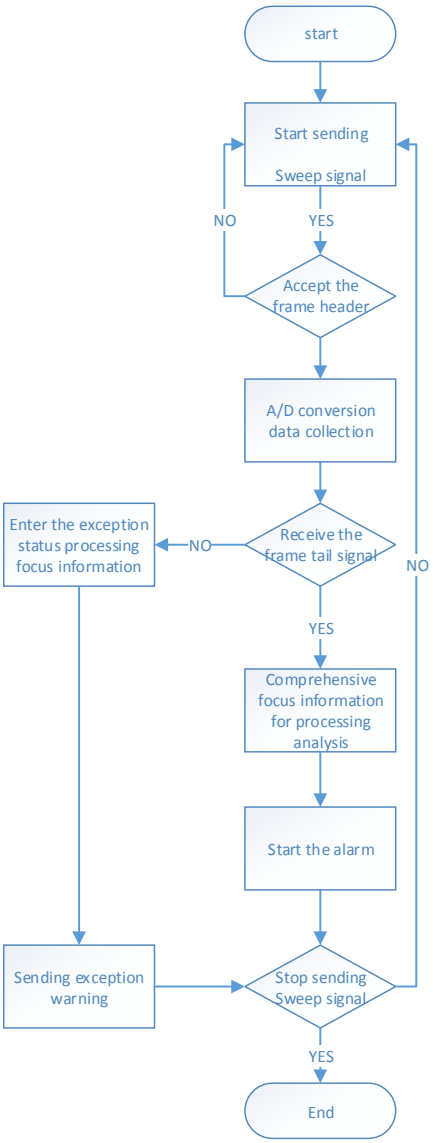

Fig. 10 program flow chart

5. Conclusion

This design embarks from the actual demand, the use of ultrasonic detection range is big, strong directivity, environmental advantages such as strong adaptability, low for obstacles existing guide device detection precision, poor positioning performance and affected by environmental factors such as inadequate. Based on ultrasonic phased array technology, selects the powerful signal processing ability of STM32F103 as a central control device, using the precise time control precision programmable logic devices EPM1270 as phased array beam drive controller, realize space obstacle detection and guide the police. Seeing-eye based on phased array system reliability, high precision, high intelligent degree, low capital cost, simple operation, portable, low power consumption, easy to carry, has the high practical and cost-effective, can play an important role in the field of guide.

References

[1] Luo Xi, Zhang Qinyu, Jiao Jian, et al. Multi target positioning system based on ultrasonic sensors [J]. sensor world, 2007, 13 (9): 25-29.

[2] Li Xiaoya, Gao Han, Zhang Lulu, et al. Ultrasonic guidance system based on single chip microcomputer [J]. electronic world, 2016 (7): 123-124.

[3] Zhang Haitao. Design of obstacle avoidance system based on multi ultrasonic sensors [J]. Shanxi science and technology, 2006 (1): 20-21.

[4] Chen Meiluan, Yin Hao, Li Piao, et al. Design and implementation of an intelligent blind guiding device [J]. application of electronic technology, 2006, 32 (10): 4-6.
[5] Pan Zhongming, aHe. Ultrasonic array obstacle detection technology and its application in the unmanned vehicle [J]. Journal of National University of Defense Technology, in 2009, 31 (2): 121-125.
[6] Ding Chunxiao, Ai Xinyou, Pan Chaowei, et al. Design of ultrasonic sight guide instrument with speech function [J]. science and technology innovation and application, 2014 (6): 35-35.
[7] Lan Tian,Yu Fengning. Ultrasound guide stick [J]. design automation and instrumentation based on MCU, 2013 (4): 73-74.