

Design of Obstructed Sight Traffic Warning Device Based on Pyroelectric Infrared Sensor

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Abstract: In recent years, the occurrence of traffic accidents in China has been generally on the rise. Especially in some curved areas where the line of sight is obstructed, due to mountains, trees and other objects blocking, vehicle drivers can not know the road ahead, making traffic accidents occur frequently. In this paper, the combination of pyroelectric infrared sensor and Fresnel lens group is used to increase the distance and range of detecting vehicles and pedestrians on the road, improve the detection and reception sensitivity, monitor the road situation in real time, and transmit the signal to the control device after processing, and the control device will control the work of the warning device in order to guarantee the traffic safety of the curves with obstructed view. On the basis of retaining the traditional convex mirror device, warning lights and alarms have been added to provide three different ways of reminding oncoming vehicles or pedestrians in different directions, playing a triple warning role to protect people's safe travel.

1. Introduction

Nowadays, among the many factors that cause road traffic accidents, poor road geometry is one of the most prominent factors, and the curved road section is an important manifestation of poor road geometry, with complex linear conditions and poor vehicle driving environment, which has become a key area of road traffic safety, mainly because of the existence of higher objects at the turn to block the driver's line of sight. Existing means of traffic warning is mainly placed in the turn of the sign or convex mirror, but these two means are easy to be ignored, and by the environmental impact is greater. Therefore, it is particularly important to develop an automated and intelligent turn warning device.

Scholars have already studied traffic safety warnings on curved road sections. Yang Bo et al. designed a colorful safety pavement to provide road safety warning from people's psychological aspect^[1]. Fu Ting et al. used ultrasonic sensors to detect the vehicle width, and the microcontroller processed the data and then sent signals to control the red light on and off through the radio frequency module^[2]. Hu Yong et al. used a microcontroller as the control core, judged the vehicle passing situation by inductive coil type vehicle detector, and controlled the signal light flashing by wireless transmission^[3]. Lv Xingchen et al. used radar to detect the incoming vehicles on the curved road, and used a microcontroller as the core to form a signal processing circuit^[4]. Xie Rui et al. used a wireless vehicle detector as a detection device, and installed LED warning screens and bend-inducing signs at

both the entry and exit points of the bend^[5]. Existing warning devices generally have the disadvantages of high cost, difficult installation, inconvenient maintenance, and greater influence by the environment.

Aiming at the defects of the existing devices, this paper adopts high-precision, economical and practical, real-time dynamic pyroelectric infrared sensors to detect and warn vehicles and pedestrians, and adopts a standardized structural design to make it easier to install and maintain, which can be used in conjunction with the original convex mirror device, or installed and used individually; it can be installed with either a single device or a combination of multiple devices for continuous warnings.

2. Design Ideas

In researching the causes of curved road sections becoming key areas for road traffic safety, it was found that the main reason was the existence of structures within the sight triangle of curved road sections that obstructed the driver's line of sight. Sight distance triangle is defined as the intersection of the rightmost straight lane centerline and the leftmost straight lane centerline of the intersecting road as the apex, the two lanes of the centerline of each according to the length of its specified speed stopping sight distance for the two sides of the triangle formed. The schematic diagram shown in Figure 1. It is stipulated that there should be no obstacle higher than 1.2m within the sight triangle, otherwise it will block the line of sight and cause traffic accidents.



Figure 1: Schematic diagram of sight triangle.

In order to effectively alleviate the occurrence of traffic accidents due to obstructed vision, this paper proposes an obstructed vision curve warning device with real-time dynamic vehicle-pedestrian detection and audible and visual warning functions. On the basis of retaining the traditional convex mirror device, a solar panel, two sets of power supply devices, detection devices, control devices and warning devices are added.

The convex mirror device consists of convex mirrors to warn drivers and pedestrians by reflecting the road traffic situation at the place where the line of sight is obstructed. The power supply device consists of a power supply circuit module, which converts AC voltage into DC voltage to supply power to the device to ensure the normal operation of the whole system. The detection device mainly consists of pyroelectric infrared sensors and amplifier circuit module, pyroelectric infrared sensors in the form of non-contact detection of infrared radiation from vehicles and pedestrians, and transformed into a small AC signal, through the amplifier circuit module will be transformed into an effective DC signal, real-time detection of the road coming to the car and people information. The control device consists of a relay and its circuit module, the converted effective current makes the relay turn on and play the role of a switch, while the relay circuit module also has the function of anti-flash, so as not

to mistakenly make the warning device work due to lightning. The warning device consists of a flashing warning light and an alarm, and the relay is turned on to make the warning device work, and the red light continues to flash and emit an alarm sound.

3. Design Principles

3.1. Structural Design

The sight obstruction bend warning device mainly consists of solar panels, convex mirrors, control boxes and audible and visual warning devices, of which the solar panels and convex mirrors are one each, and the control boxes and audible and visual warning devices are two each, and its structural schematic diagram is shown in Figure 2.

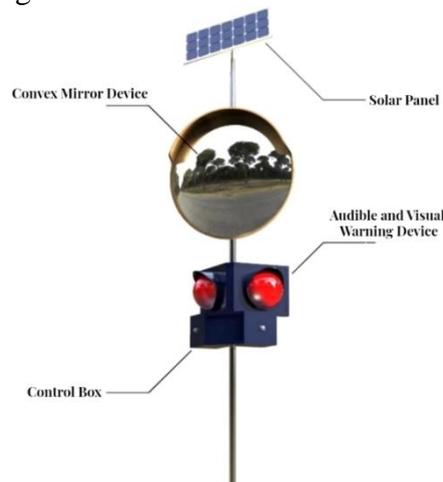


Figure 2: Schematic diagram of the structure of the traffic warning device

The convex mirror device is mounted on the column, which is made of high-quality steel pipe material. The detection device is attached to the surface of the control box to realize the real-time dynamic detection of vehicles and pedestrians, the control box includes the power supply device and the control device, and the three independent devices are connected with the electric circuit. The control box shell is made of stainless steel, waterproof, not easy to rust and corrosion, and long service life. The audible and visual warning device is installed on the top of the control box, and the alarm sound is issued at the same time when the red light is flashing, so as to achieve the warning effect. The control box on the left controls the audible and visual warning device on the right, which is a set of warning device. The control box and the warning device are mounted on the column by means of hoop, which is convenient for dismantling and installation.

3.2. Circuit Design

The core circuit of the sight-obstructed curve warning device mainly consists of three modules: power supply circuit module, amplifier circuit module and relay circuit module, as shown in Figure. 3.

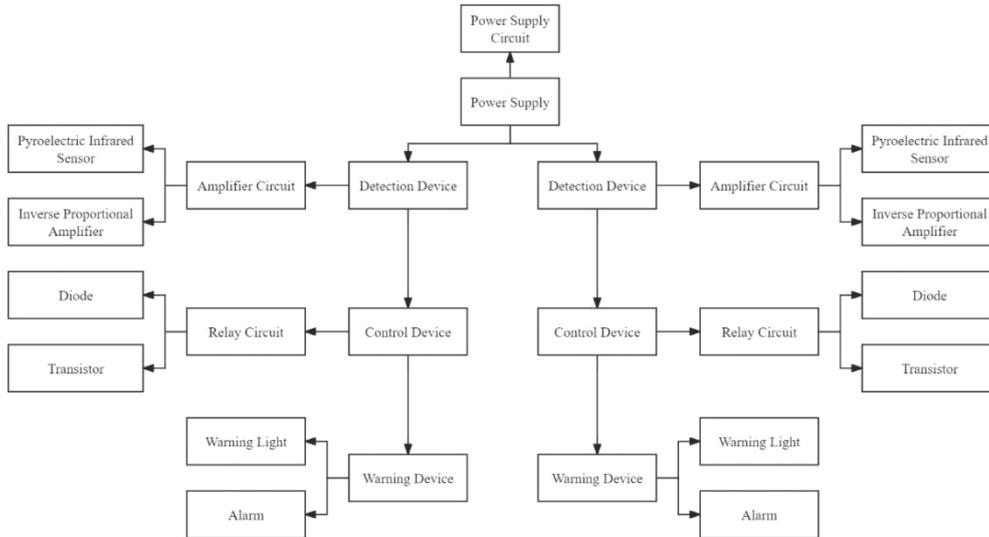


Figure 3: Structure of the core circuit

The power supply circuit module is connected to the additional 9V and 12V power supply, and the AMS1117 chip is used to convert the input 12V voltage into 3.3V voltage to supply power to other chips and amplifiers to ensure the normal operation of the whole system, and its circuit diagram is shown in Figure 4.

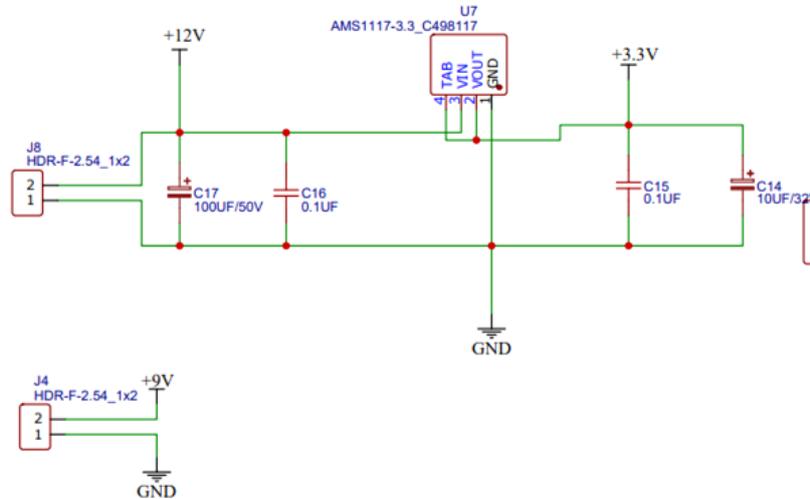


Figure 4: Circuit diagram of power supply circuit module

The amplifier circuit module uses a two-stage inverse proportional amplifier to amplify the AC small signal generated by RD624, the first stage amplification is 27 times, the second stage amplification is 150 times. Then, a comparator and diode are then used to transform and rectify the AC signal into an effective DC signal capable of driving the relay. Its circuit diagram is shown in Figure 5.

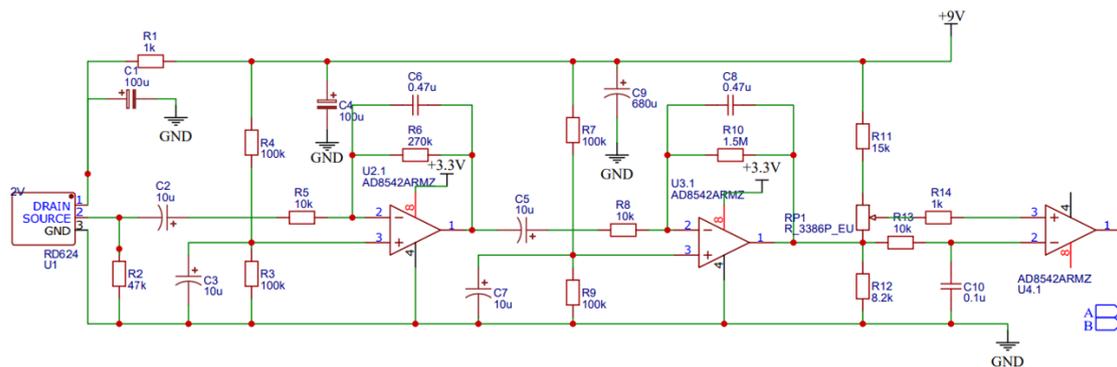


Figure 5: Circuit diagram of amplifier circuit module

The function of the pyroelectric infrared sensor is realized using the RD624 chip. When it is irradiated by infrared light of non-constant intensity, the detection element receives the radiant energy and causes a change in temperature, which in turn causes a change in the temperature-dependent properties in the detector, and the resulting change in temperature leads to a change in the charge density of the electrodes on its surface, which generates a pyroelectric current. The rectangular window at the top of the sensor is equipped with a filter, so that infrared radiation of a specific wavelength selectively passes through the infrared radiation outside the cutoff range of the pyroelectric detection element can not pass, greatly improving the anti-jamming ability. The upper part of the sensor is equipped with a Fresnel lens group, which enhances the infrared rays radiated by the object and gathers them on the detection element, greatly increasing the detection distance and range, and is used to improve the detection and reception sensitivity. The sensor itself does not emit any type of radiation and also has the advantages of low device power consumption, good concealment and low cost.

The relay circuit module uses a diode and a transistor to control the relay. When a voltage greater than 2.1V passes through the diode and the transistor, the relay turns on, allowing the warning device to operate. In order to prevent the warning device from flashing, the circuit module uses resistors and capacitors in parallel to achieve the anti-flash function. Its circuit diagram is shown in Figure 6.

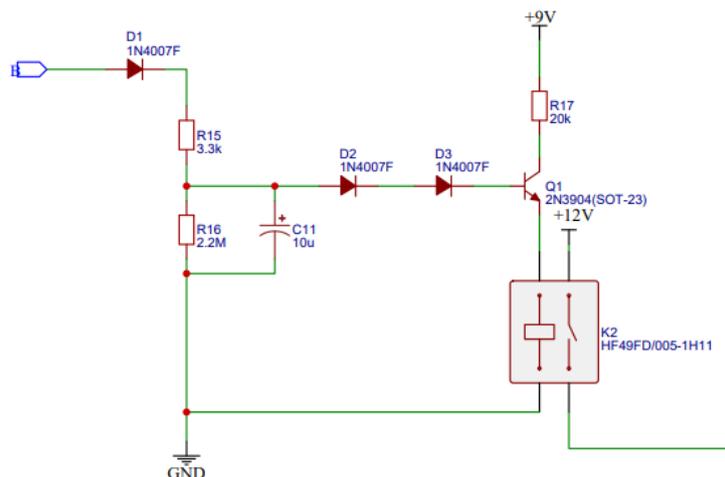


Figure 6: Circuit diagram of relay circuit module

The core circuit adopts a rational topology, and the fact that no microcontroller is used makes the system more responsive, while reducing the cost and facilitating mass production. The whole circuit combines the advantages of digital and analog circuits, strong anti-interference ability and convenient operation. At the same time the product uses a chip with low energy consumption and good stability,

in line with the modern concept of energy saving and environmental protection.

3.3. Organizational modalities

In this paper, on the basis of not destroying the original convex mirror device, a warning device is added to alert the situation of oncoming traffic or people in both directions. A set of warning device contains a control box and audible and visual warning device, and is placed on both sides of the column. The specific working process of the warning device is as follows: when the pyroelectric infrared sensor detects vehicles or pedestrians on the road, the infrared light changes the internal temperature of the sensor, resulting in a change in charge density, thus generating an AC signal. After processing through the amplifier circuit to get a strong DC signal that can drive the relay, the relay is turned on so that the other side of the warning device starts to work. As a result, the red light flashes and the alarm sound, playing a double warning role from both visual and auditory aspects.

4. Conclusions

In order to reduce the probability of traffic accidents on the road at the place where the line of sight is obstructed, this paper, in response to the shortcomings of the existing warning device, adopts a high-precision pyroelectric infrared sensor as the detector, and ensures the reliability, low cost and portability of signal acquisition through structural and circuit design. The warning device is directly installed on the original convex mirror device, which is easy to operate and easy to replace. Traffic participants can not only be alerted through the curve warning device, but also observe the opposite direction of traffic through the convex mirror, so as to realize the maximum use of resources. Through the Fresnel lens group to expand the range of detection and distance of the sensor, when the pyroelectric infrared sensor detects a vehicle or pedestrian, the resulting signal is processed by the circuit to control the warning lights and alarms work, to provide traffic participants with sight obstruction within the curve of the traffic intelligence. According to the radius of the curve of different roads can be field-adjusted angle of the warning device herein, can also be installed multiple warning lights, to play a continuous warning effect. Its application scope includes mountainous areas by the mountain blocked road, urban roads, residential neighborhoods by the trees or buildings or billboards blocked turn, etc., with high practical application and promotion value.

Acknowledgements

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References

- [1] Yang Bo, Yan Xuliang, Wu ping, et al. Research on Colorful Safety Pavement Design Method Based on Driver Behavior Model[J]. Highway Transportation Science and Technology (Applied Technology Edition), 2019,15(10):276-281.
- [2] Fu Ting, Li Jun, Lu Lili. Hardware Design of Crossing Warning System on Country Roads[J]. Journal of Southwest China Normal University(Natural Science Edition), 2012,37(03):137-140.
- [3] Hu Yong, Wang Xiao, Dong Xinyu, et al. Design of the Traffic Early Warning Equipment Based on Single Chip[J]. Instrumentation Technology, 2010(12):4-5.
- [4] Lv Xingchen, Yang Guojing, Song Hao.A New Type of Vehicle Meeting Warning System for Curved Roads[J]. China Science & Technology Overview, 2017(10):1-2.
- [5] Xie Rui, Dong Xueshen, Deng Kaiwen, et al. Design of Traffic Intelligence Early Warning System for Blind Spots on Mountain Roads[J]. Highway, 2020,65(07):223-227.