Design of a new buoy night display system

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Abstract. This article through the analysis of the current navigation safety, combining the AIDS to navigation problems, in the light of the short of the AIDS to navigation, using the right technology, the display system to carry on the design of a new type of buoy night, through the design of various modules, the organic combination of display system, form a new type of buoy night finally to the feasibility analysis of system, ensure the accuracy of the model and feasibility. Among them, the model control box module, light emitting component module, the solar panel module, photoelectric sensor module, power module system design circuit design together, make the buoy nighttime display system has a good stability, high consistency, high cost performance, light range, fast response, electromagnetic compatibility and reliability, the product in ensuring the stability of the whole system work at the same time, maximum limit reduce the power consumption of the power supply. It improves the ability of buoys to be identified by ship pilots at night and strengthens the guidance of channel ships, ensures navigation safety and reduces the property loss of ships and navigation marks, which is of extremely high social value and practical significance for the improvement of navigation marks.

Keywords: Buoy, Night display, System design, Navigation safety.

1. Introduction

In order to meet the needs of the rapid development of coastal transport, it is necessary to popularize and apply the new technology of navigation marks to improve the reliability and efficiency of navigation marks. Taking a waterway design project in coastal waters of China as an example, this paper preliminarily discusses the application of synchronous flashing, encryption and equidistant marking technology in the navigation safety of coastal ships. For ships in running state, navigation marks play an irreplaceable important role. Specifically, the function of navigation marks is to position and navigate the ships and ensure the navigation safety of sailing ships. Under normal circumstances, the beacons will be set in the waters of frequently through the ship, its purpose is to help shipping of ocean environment with a more accurate understanding, avoid when the ship sailed into port due to water flow rapidly, ship collision off course and buoy, more and more accident damaged hull, beacons, people often take large high power and material resources to repair. And with the trend of ship upsizing, the loss caused by the collision force of larger ship marks is bound to be larger and larger. In order to enhance the ability of buoys to be identified by ship pilots at night, to strengthen the guidance of channel ships, to ensure navigation safety, and to reduce the loss of ship and buoy property, buoy has become an indispensable part to ensure ship safety. [1]
Ships sailing in dangerous waters cause unnecessary problems for themselves. The practice results show that the navigation mark can not only provide the necessary route navigation for the ship, but also provide the auxiliary information for the ship, such as the mark of no-navigation waters and the turning point of the ship, so that the ship can complete the task in a safer way. In order to ensure the safe navigation of ships, it is of great significance to set up various navigation marks on the channel to mark the direction and limit of the channel. Although light buoys can be identified in ports and waterways by their sign number, body color and shape during the day, they can only be identified at night by the quality of point light sources (including flash period and light color). There are the following problems in beacon identification based on point light source:

1. It is difficult to capture the position of point light source at night, and its navigation performance is poor, bringing potential safety hazards.
2. During night navigation, all kinds of beacon lights are flashing, which makes it difficult to identify the quality of the lights, and it is difficult for navigators to identify the channel boundary, which affects the decision-making of ship handling.
3. The point light source is easy to be confused with fish beacons and lacks the continuity of channel indication.[2]

Based on the night shape display function of the buoy itself, this scheme proposes a night-shape display system and method of the buoy, which can solve the problems existing in the buoy at present.

2. Research content and route

2.1. Research object and content analysis

Figure 1. Technology roadmap
Based on the night shape display function of the buoy itself, this scheme proposes a night-shape display system and method of the buoy. By placing passive or active luminescence devices on the external frame of the buoy, the light and shadow display of the buoy's own form can be enhanced as a supplement to the warning light of the buoy. Provides continuous, uninterrupted fluorescence imaging at intervals between beacon flashes. Multiple sets of buoys with night vision system can provide a clear navigation outline with bright display effect and provide effective guidance for passing ships. Prevent the misjudgment of passing ships from the course at night due to factors such as the spacing of the flashing lights and the brightness of the lights. Night display device can change the brightness of its LED spotlights according to the intensity of external light, which provides a new idea for solving bad weather such as fog. [3]

2.2. Analysis of research routes
The design of each module of the new buoy night visualization system is the focus of this paper, and also the core of this paper. Aiming at designing a new buoy night visualization system and carrying out feasibility analysis, we designed a preliminary research route. The research route is shown in the figure above, and its basic structure is composed of three levels, namely goal setting, module design and feasibility analysis. The research route is a review of the research process and ideas in this paper, which can be used as a reference analysis of the research content. In order to solve the safety problem of ships, a new type of buoy night visualization system should be designed with clear research objectives. The buoy of night visualization system can provide a clear navigation mark outline bright display effect and provide effective guidance for passing ships. The equipment must work regularly for a long time; Solve the traditional light component wire louie connection, easy aging and other problems that may cause the product unable to operate stably; Achieve low energy consumption as far as possible. Then, according to the research objectives, the design of each module of the system, the design of the light module, the enhancement of the buoy's own form of light and shadow display, the design of the power supply module and the power supply circuit module as far as possible equipment energy consumption, and increase the stability of the system; The photoelectric sensor module is designed to adjust lights in different environments. Finally, feasibility analysis is conducted on the design results to ensure that each module can be organically combined to obtain the physical model, and finally achieve the purpose of this paper.

3. Feasibility analysis of the design scheme

3.1. Feasibility analysis of distinguishing different luminance environments
This project uses light sensors to accept external brightness changes. Because the photoelectric sensor can complete the transformation of the optical signal and the electrical signal, and can realize the isolation of the optical and electric signal very well, it meets the performance requirements of many electronic systems and automatic control. The photoelectric sensor takes the photoelectric device as the transducer element, it is the device that transforms the optical signal into the electric signal. Generally, it consists of three parts: transmitter, receiver and detection circuit. It can be used to detect the non-electric quantity such as light intensity, illumination, radiation temperature measurement, gas composition analysis, etc. Through the light sensor, the buoy can quickly identify the environment of different brightness, and then quickly adjust the brightness of the display. [4]

3.2. Feasibility analysis of buoy brightness adaptive adjustment
The degree of influence of various environmental factors on the navigation light of human eye identification needs to discuss the relative relationship between environmental visibility, beacon light intensity, human eye observation distance and observation effect through quantitative calculation, and get the regulation principle, which is equivalent to the algorithm logic of regulation basis, and then analyze the implementation mode of self-adaptive regulation technology. The navigation light needs to adjust the change of light in the atmospheric visibility condition, and the optical physical quantity
involved in the regulation principle and algorithm, including light intensity, light flux and light illumination.

All the lamps have the parameters of light intensity and nominal range, and the light with adjustable brightness also has the change threshold of the light intensity and the range. The adaptive adjustment algorithm needs to analyze the functional relationship among the light intensity, the observable distance and the observed receiving light intensity under any given visibility conditions.

This algorithm mainly applies the optical principles of Allard law, Kosehmieder law, Lambert-Beer law and so on.

In the method, atmospheric horizontal visibility $V$ can be obtained by real-time measurement. According to the formula of atmospheric horizontal visibility,

\[ V = -\ln \varepsilon / \sigma = -\ln 0.05 / \sigma = 3 / \sigma \]

The horizontal extinction coefficient at atmospheric concentration at this time can be calculated

\[ \sigma = 3 / V \]

Where, is the visual sense region, indicating the ability of the human eye to distinguish contrast between objects and background brightness. WMO and ICAO recommend 0.05 as the average visual sense region value of the human eye.

\[ I = \int_0^L \exp(-\sigma dL) \]

The relationship between illuminance attenuation and extinction coefficient and observation distance was investigated.

Where $I_0$ is the initial illuminance $I$ is the received illumination of the observer, $L$ is the distance between the target lamp and the observer, atmospheric uniformity is assumed, and the extinction coefficient obtained based on visibility measurement is fixed as, then

\[ I = I_0 \exp(-\sigma L) \]

In order to keep the illumination received by the observer satisfying the average visual sense region under different weather conditions, the basis for adjusting the initial light illumination is as follows:

\[ I_s = I / \exp(-\sigma L) \]

Where, the value of $I$ is based on the statistical expression of the illumination recognition threshold $I$ given by Bakkwell and the background brightness:

\[ \lg I = -6.95 + 0.887 \lg B \]

Where $B$ is the background brightness.

According to the values of different visibility $V$ conditions, the initial illuminance $I_0$ required for navigation lights can be calculated.[5]

The point sensor receives light signals from different environments, transmits them to the processor, obtains the corresponding display brightness, and adjusts the lamp to emit appropriate brightness.

3.3. Feasibility analysis of low energy consumption

(1) An intelligent external controlled LED light source integrated with WS2812B circuit and light emitting circuit is designed. LED has the advantages of low voltage drive, environmental protection and energy saving, high brightness, large scattering angle, good consistency, ultra-low power, super long life, etc. Moreover, it has a RESET time of more than 300US, and will not cause false RESET if interrupted. It can support MCU with lower frequency and lower price.

(2) Design using photoelectric sensor, by using the basic principle of the photoelectric effect, because of light effect, electrons from the surface by illuminate the phenomenon of escape, and according to the changes in light from the darkness of the outside world, adjust the LED light and shade change, both to the brightness of the necessary guarantee, also can avoid unnecessary waste of brightness, so as to achieve the goal of low energy consumption.

(3) In recent years, with the progress of new energy technology and electronic technology, solar LED navigation lights tend to improve, has gradually become the mainstream technology, design the use of solar panels, to avoid the traditional use of only ordinary batteries. Use of solar energy
photovoltaic cells absorb sunlight to produce heat (photovoltaic cells is to use light efficiency should be light energy into electrical energy device), which is common solar panels, the layer adhered on the surface of the wafer of semiconductor materials, semiconductor when placed in the sunshine, the other side of the semiconductor wafer and the metal will produce voltage between will be a lot of the semiconductor devices connected in series and parallel way to zero, resulting in a greater voltage and current, and then use the battery energy storage device such as the electricity generated collected.[6]

4. Module design of a new buoy night display system

4.1. Control box module design
In order to facilitate the fast speed drive communication of the system, the high-performance 32-bit MCU STM32F405RGT6 with the operating frequency of 168MHz is selected as the current high-performance kernel. Stmicroelectronics is the world's fifth largest semiconductor manufacturer, leading the world in many markets. STM32F series products are based on the ARM Cortex-M4 processor core with ultra-low power consumption. STM32F series products adopt stMICROelectronics' two unique energy-saving technologies: 130nm dedicated low-leakage current manufacturing process and optimized energy-saving architecture, providing industry-leading energy-saving performance. This series belongs to stMICROelectronics' powerful 32-bit STM32 microcontroller product family, which has more than 200 products. The whole series of products share most of the pins, software and peripherals, and excellent compatibility brings maximum design flexibility for developers.

4.2. Luminescent component design
In this scheme, an intelligent external controlled LED light source with integrated WS2812B circuit and light emitting circuit is adopted.

Improvements made to the existing problems of navigation lights:
(1) Considering that the navigation lights have multiple colors of red, yellow, green and white; In order to enhance the display effect, we plan to provide a variety of flashing, water, synchronization, breathing lights, and other options. The color of the light is highly consistent and cost effective.

(2) A special sealing structure is used in the design of the integrated navigation light, which not only prevents the influence of acid fog, salt fog and various corrosive gases on the internal circuit and battery of the navigation light, but also prevents the pressure in the air chamber of the navigation light from thermal expansion and pressure release in the state of battery charging. The design of integrated navigator not only protects the internal circuit of the navigator, but also reduces the circuit connection between the power supply, thus solving the problems of looseness of the joint and breakage of the connection caused by the complex external connection of the previous navigator system and ensuring the stable operation of the navigator.[7]

(3) The first power supply is the battery, lithium battery is generally selected, because lithium ion battery per unit volume energy storage is high, can be charged and pollution-free.

(4) Convenient disassembly and installation, convenient maintenance, reduce the labor intensity of first-line beacon workers.

5. Conclusions
In this paper, a new nighttime buoy display system is studied, including the function analysis of the new nighttime buoy display system, the determination of design objectives, the design of each module, the analysis of module characteristics and feasibility analysis. The main purpose of the study is to design a new buoy night display system, to correct some defects and shortboards of the existing buoy, and to add some new functions, and finally to carry out feasibility test on the designed system.

According to the current research level and research conditions of this article, we have not produced the corresponding physical model, which could not be more accurate physical tests, which may be affecting the accuracy of this design, in the subsequent study, should be made for using the
physical model test for many times, and into the corresponding waves in the environment, to design scheme for further correction, finally it is concluded that more perfect design, and physical objects, thus to contribute to the further trial, provide convenience for the navigation of ships and provide further protection for the safety transmission.

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References
[1] Chen Yuli. Suggestions on buoy management to improve the service quality and efficiency of buoy [J]. Zhujiangshuiyun, 2018 (22):43-44.
[2] Lin Fang. Application of AIS navigation Mark and Discussion on existing Problems [J]. Pearl River Waterway, 2018 (22):57-58.
[3] Yang Li, Wu Liping, Liang Yan, HE Fuwen. Discussion on the Application of Science and Technology of Navigation Light [J]. China Maritime Affairs, 2016(12):55-56.
[4] Chen Guangtong, Jiang Yue. [J]. China’s Strategic Emerging Industries, 2017(40):57+60.
[5] Wang Anmin, Meng Haiyan, Kong Lingbu. Geomagnetic berth power Supply System Design based on CN3722 [J]. Computer and Digital Engineering, 2016, 46(10):2151-2154.
[6] Wong Tao, Kwong Shi-keung. Application analysis of Photoelectric Sensor in Automatic Control System [J]. Information and Computer (Theoretical Edition), 2017 (09):149-150. Deng Jianyun. Application of Photoelectric Sensor in Automatic Control [J]. Electronic World, 2012 (09):159-160.
[7] Wang Junwen, Zhang Wei, an Xiaogang. Research on key Technology of Navigation Light Brightness Adaptive Intelligent Adjustment [J]. China Water Transport, 2017(11):51-52.