Design and Research of Personal Maritime Search and Rescue System Based on AIS

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Abstract. Based on AIS technology, this paper proposes a design scheme of personal maritime search and rescue system. The system includes two parts: base station and user terminal. Design the hardware and software of the system according to relevant standards and actual needs. After testing, it proves that the system can automatically send AIS distress information after startup, and the information can be successfully received by the base station and displayed through the search and rescue platform. The maximum receiving distance can reach more than 5 nautical miles, providing powerful technical support for search and rescue work.

1. Introduction

In recent years, with the advancement of society, the maritime transportation industry has developed rapidly, which has made the maritime traffic situation very complicated and increased the probability of marine accidents. Therefore, it is necessary to improve the maritime search and rescue capability and provide effective maritime services to reduce the losses caused by marine accidents[1].

Automatic Identification System (AIS) is a new type of ship-assisted navigation system emerging in recent years and has been widely used in marine transportation[2,3]. The AIS system operates in the Very High Frequency (VHF) and uses SOTDMA technology to send AIS messages containing ship-related information to the outside at a certain period. This message can be received by other ships or shore-based installations equipped with AIS equipment[4]. Since AIS has the function of information transmission, it is also applied to the navigation and collision avoidance of ships, sea surface supervision and analysis of marine accidents[5,6].

This paper designs a personal maritime search and rescue system based on AIS. The system can receive the positioning information from the satellite through the user terminal and send the standard AIS message to the base station. The base station displays the AIS message received in the electronic chart. The system based on AIS can obtain the specific location of the drowning person more accurately and display it, which effectively improves the search and rescue efficiency and is of great significance to the search and rescue work.

2. Functional analysis of the system

Unlike Search and rescue operations on land, the environment at sea is complex and changeable, making it more difficult for search and rescue work. By using modern communication technology and computer technology, the equipment developed by AIS can effectively expand the scope of maritime search and rescue, and can quickly and accurately obtain positioning information. Furthermore, the
equipment is simple to operate, which makes the search and rescue work is easier to carry out. The functions that the system needs to complete mainly include the collection, transmission and display of the help information. It consists of a transmitting terminal and a receiving terminal.

AIS-MOB is a unique personal portable distress indicator and alarm equipment[7]. The device has built-in GNSS positioning module and high-speed VHF data station. It uses advanced AIS to automatically broadcast and transmit the location of the person in distress and other relevant information when the person falls into the water, the equipment is flooded or manually triggered. The information can be received by AIS shore stations and ships, aircraft, lifeboats with installed AIS equipment. It is conducive to locate search and rescue targets quickly and accurately, providing a fast and effective information channel for rescued people in distress[8]. According to the needs of the system, the main functional requirements of AIS-MOB are as follows:

1. Alarm function: When the alarm is activated, the module cycles to transmit information to the ship or nearby equipment or base station periodically with the AIS system, including the exact location and identification code information of the vessel in question.

2. Parameter setting function: The working parameters of the module can be set through serial port before leaving the factory.

3. Test function: Test the battery power of the module and its working condition.

The main purpose of the base station is to check the status of the user terminal by polling or reporting the working mode, and then determine the security of the personnel. The search and rescue platform obtains the distress alert information by communicating with the base station, and displays the information on the display screen to provide an intuitive user location report and safety related information for the search and rescue team.

3. Design and implementation of the system

3.1. The hardware of the system

3.1.1. Design of user terminals

The user terminal is composed of GPS module, main control module, wireless transmission module, starter, indicator and power supply, as shown in figure 1.

![Figure 1. Composition of the AIS-MOB system.](image)

The main control module is the core part of the whole system. Mainly to complete the analysis of GPS information, extracts the location, UTC time and other messages, and encodes and encapsulates the AIS message for the obtained information. In practical use, the system needs to work continuously for a long time, and the amount of AIS messages sent is large. Therefore, the low-power and high-performance work of the equipment is the key factor to be considered. In this study, STM32F103VET6 microprocessor of ST company was selected as the main control module.

The GPS module completes positioning and timing functions. By communicating with the satellite, relevant information such as latitude and longitude and UTC time is obtained, and the received information is transmitted to the main control module through the serial port. In this design, the neo-m8 module of u-blox company is adopted.

The wireless sending module is responsible for transmitting the standard AIS message through the control function of the control port. The AIS message is transmitted on the VHF channel and SOTDMA technology is used to establish contact with surrounding ships and base stations. The
AIT20 chip selected in this system is a dual-band AIS transmission module that operates at 161.975MHz (CHA) and 162.025MHz (CHB) frequencies by time sharing.

3.1.2. Design of the base station
The basic task of the base station is to establish a communication with each user terminal to monitor the security of the personnel. The block diagram is shown in Figure 2. When people are in distress, alarm sounds will be issued, and different alarm sounds will be issued according to different alarm signals received. Besides, the information of the drowning person will be sent to the display system. The wireless communication module is responsible for communicating with the user terminal and receiving standard AIS messages. The received signal needs to be analyzed in the signal processing module. If it is an alarm signal, it will be alarmed by the alarm. At the same time, the parsed information is transmitted to the display system for display to assist the search and rescue work.

3.2. The software of the system
The workflow of the system is shown in Figure 3. First, the GPS module, serial port, clock and other modules should be initialized. The GPS module transmits the received positioning information to STM32 through the serial port. The STM32 parses the received GPS information, extracts information such as latitude and longitude, UTC time, speed, and encodes and encapsulates the information according to the standard format of the AIS message. When the sending gap is reached, the encapsulated AIS message is sent according to the SOTDMA communication protocol.
The software system of the base station is mainly responsible for analyzing the AIS messages received and displaying the parsed data on the display. On the display interface, it is necessary to have real-time information such as the location and speed of the drowning, as well as the identifier of the locator worn by the personnel are required.

4. Testing of the system

4.1. Construction of system operating environment
The main equipment required for system testing is shown in Figure 4. a is the search and rescue terminal worn by the personnel, b is the test instrument, including the spectrum analyzer and the oscilloscope, and c is the display interface of the search and rescue platform.

![Figure 4. Physical map of the user terminal.](image)

4.2. Testing of the system

4.2.1. Testing the system for receiving information
The tester walked around the ship with a beacon in his hand. As shown in Figure 5, the search and rescue platform can normally receive the alarm signal, and the signal strength is between 130-200 (250 is the full strength). When the beacon is dropped into the water, the receiver can still receive the alarm signal normally.

![Figure 5. The reception of a signal by a receiver.](image)

4.2.2. Test the communication distance of the system
Three beacons were installed on the experimental ship, the No. 1 beacon was held in the hand, the No. 2 beacon was tied to the moving boat, and the No. 4 beacon was placed on the boat deck, as shown in Figure 6.
As the ship moves away from shore, the strength of the signals it receives changes. As shown in Figure 7, the farthest receiving distance is 5.08 nautical miles and the signal strength is 52. When the distance exceeds 4 nautical miles, bags will be occasionally lost, and more than 4.9 nautical miles, bags will be seriously lost. In addition, if the machine is turned on at 5 nautical miles, no signal is received, but there is no problem at 4.5 nautical miles. The No. 4 beacon is weak due to the reverse.
5. Conclusion
The personal maritime search and rescue system based on AIS is a system that integrates high-tech technologies such as positioning, communication and network. The base station and user terminal of the system are designed in this paper. The design of the user terminal includes the hardware and the software. After testing, the system can successfully realize the transmission of AIS messages, and the communication distance can reach 5 nautical miles. The personal maritime search and rescue system based on AIS can provide powerful support for search and rescue work. The system can save time effectively and play an important role in maritime search and rescue.

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