**Input paper:** [[1]](#footnote-1) EM1-5.1.3.5

**Input paper for the following Committee(s):** **Purpose of paper:**

(Select as appropriate)

ARM  ENG  PAP  Input

ENAV VTS  Information

**Agenda item** [[2]](#footnote-2)2 n.n

**Technical domain/ Task number** 2 …………………………………

**Author(s)/Submitter(s)** China MSA………………………

Application of Portable AIS Equipment Comprehensive Analyzer[[3]](#footnote-3)3

# summary

In order to ensure the normal AIS signal at sea and enable ships at sea to navigate safely, China MSA has conducted research on AIS signal monitoring and analysis methods since 2019. By adopting the "software radio" technology architecture, the portable AIS equipment comprehensive analyzer has been successfully developed. This analyzer has the advantages of compact size, light weight, high efficiency. And it can help maritime administration personnel to carry out AIS equipment detection, signal monitoring and other work anytime and anywhere. It provides a new intelligent monitoring method for traditional AIS equipment signal management.

# The purpose of the document

This paper introduces the relevant technical solution and application results of China's portable AIS equipment comprehensive analyzer, which can provide practical experience and reference for other countries in the development and transformation of relevant equipment, and can also facilitate maritime administration personnel to carry out offline law enforcement, patrol inspection and other work.

# Related documents

ITU-R M.1371-5: International Telecommunication Union Recommendation 1371, fifth edition, technical characteristics of ship-borne automatic identification systems using ad hoc time division multiple access technology in the VHF maritime communication band;

IEC 61162-1 ed4: International Electro-technical Commission No. 61162-1 International Standard Fourth Edition, Digital Interface (Part 1): Single Transmitter Multiple Receivers;

IEC 61993-2 ed1: International Electro-technical Commission No. 61993-2 International Standard First Edition, Class A AIS Ship-borne Communication Equipment Performance Requirements;

IEC 62287-1 ed2: International Electro-technical Commission No. 62287-1 International Standard, Second Edition, Performance Requirements for Class B AIS Ship-borne Communication Equipment Based on CS-TDMA;

IEC 62320-1 ed1: International Electro-technical Commission No. 62320-1 International Standard 1st Edition, Performance Requirements for AIS Base Stations;

IEC 60945: International Electro-technical Commission No. 60945 International Standard, Requirements for Maritime Navigation and Radio Communication Equipment and Systems.

# background

AIS system is a shore based and shipborne broadcast automatic identification system, which plays an important role in the organization of maritime traffic and safe navigation. With the rapid development of AIS technology, AIS derivative equipment such as AIS SART, MOB, AIS Aids to Navigation, and network position meter have also been produced. However, some AIS equipment manufacturers have arbitrarily set the transmission power, transmission frequency, communication access mode and other equipment parameters, resulting in the massive occupation of AIS timeslot resources, affecting the collision avoidance of ships at sea, and reducing the safety of navigation. In addition, some AIS equipment users operate improperly, resulting in serious errors and omissions of ship AIS dynamic and static information, which has a negative impact on ship collision avoidance, maritime traffic command, and AIS data analysis. At the same time, before the construction of the AIS model station, how to monitor the signals of the selected construction sites to avoid the overlapping of AIS base station signals also needs to be solved.

The portable AIS comprehensive analyzer introduced in this paper can solve the above problems. The analyzer is an intelligent detection device for monitoring and analyzing AIS equipment signals. It can solve the technical problems of traditional AIS signal analysis equipment, such as inconvenient carrying, poor compatibility of transmission protocols, and low universality of signal processing. At the same time, compared with the existing technology, it has the characteristics of high efficiency, reliability, accuracy, practicality, strong compatibility, less data synchronization and resource occupation. It can monitor the signal strength and communication distance of AIS equipment in a short time, quickly narrow the scope of troubleshooting, and quickly identify abnormal AIS equipment.

# discussion

The Portable AIS equipment comprehensive analyzer is an integrated software and hardware device based on embedded portable terminal. This paper mainly introduces its principle, components, function and application.

## Principle of Portable AIS Equipment Comprehensive Analyzer

The portable AIS equipment comprehensive analyzer mainly adopts the "software radio" technical architecture, which uses software functions to realize hardware functions. This architecture can reduce the complexity of hardware development, improve the flexibility of signal processing, shorten the product development cycle, and reduce the cost of hardware.

Its main principle: VHF antenna transmits the coupled signal to the radio transceiver unit. The transceiver unit converts the analog signal into digital signal by ADC, and analyzes and demodulates the digital signal through the processor to calculate the signal characteristics of AIS signal. Then, the data after AIS signal analysis and demodulation are packaged according to the standard, uploaded to the display and control platform through the communication interface between the AIS receiver and the display and control platform, and displayed to the user the AIS radio spectrum characteristics and AIS performance indicators. The logic diagram of the analyzer is shown in Figure 1.

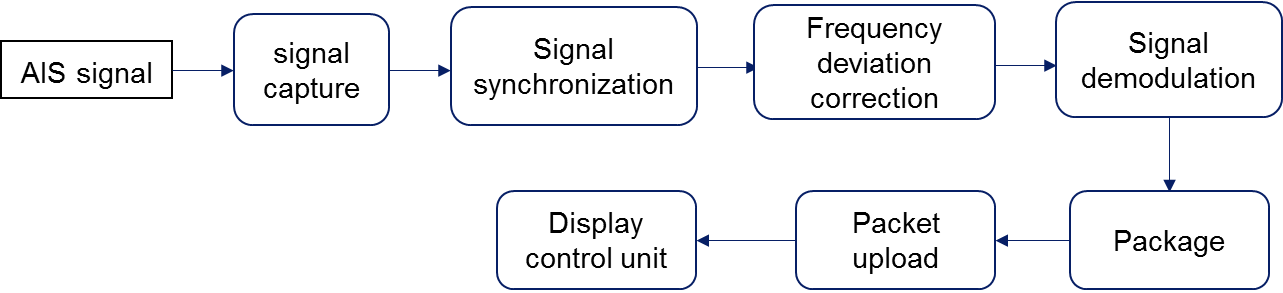


Figure 1 The principle flow diagram of the analyzer

The technical architecture of this analyzer is based on ZYNQ7020 and Cortex-A72 processor platforms. They mainly communicate with hardware through e-PCI, USB, TCP/IP to control the radio hardware. The ZYNQ7020 platform mainly implements the program software functions of the physical layer, link layer and transmission layer of AIS; Cortex-A72 platform is to realize the application layer functions of AIS, mainly realizing the human-computer interactive display operation of equipment. In addition, software development is mainly implemented in hardware language. Since ZYNQ7020's own upper system supports the Linux operating system, it can effectively reduce the development of hardware language, and significantly improve the software inheritance and maintainability of the entire system. The functional realization schematic diagram of this analyzer is shown in Figure 2.

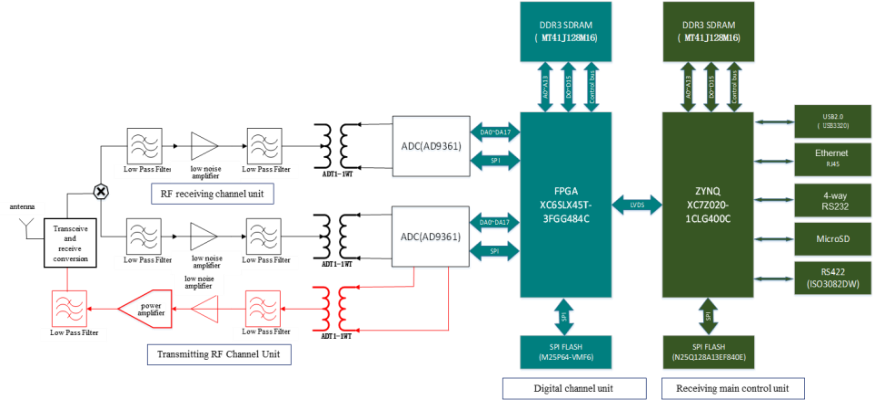
****

Figure 2 The functional realization schematic diagram

## Components of Portable AIS Equipment Comprehensive Analyzer

The portable AIS equipment comprehensive analyzer is mainly composed of VHF radio transceiver unit, display control unit, power management unit, external conversion terminal and antenna unit. Its size is 310mm × 225mm × 75mm, the total weight is about 2.6kg, the shell is made of PC plastic, the interior is coated with metal, the 10.1inch IPS display is used, and the resolution can reach 1920 × 1200, support screen touch, built-in 7000mAh large capacity battery, appearance as shown in Figure 3.



Figure 3 Appearance of the Equipment

(1) Radio transceiver unit: it is connected with display control unit through e-PCI, TCP/IP, UARTS and USB to realize AIS signal receiving and broadcasting, AIS signal spectrum monitoring and other functions.

(2) Display and control unit: the processor based on CORTEX-A72 is adopted, with built-in GPU. The main chip is RK3399, a 64 bit 6-core ARM architecture CPU, and functional software is loaded to control the radio transceiver unit, so as to analyze and monitor the working state of the AIS signal and VDL link.

(3) Power supply unit: it is composed of a power control panel, which controls the charge and discharge of the internal battery pack, and can switch the power supply between the external adapter and the internal battery pack.

(4) External conversion terminal and antenna unit: external interfaces include VHF antenna interface, GNSS antenna interface, RS232 interface, battery charging interface and equipment switch. VHF antenna and GNSS antenna are externally connected for easy maintenance.

## Functions of Portable AIS Equipment Comprehensive Analyzer

The portable AIS comprehensive analyzer is based on the technical architecture of "software radio", which advantages of this architecture are various functions realized through software. Therefore, the functions of the analyzer are mainly realized by AIS signal comprehensive analysis software and marine radio signal monitoring software. At present, the portable AIS comprehensive analyzer can realize the detection of AIS ship-borne equipment, AIS signal analysis, detection of AIS equipment functions and performance indicators, detection of non-standard AIS equipment in AIS network, detection of time slot occupancy in AIS network, AIS base station detection functions such as the detection of AIS signal of site selection before the establishment of the station.

### AIS signal comprehensive analysis function

In the AIS signal comprehensive analysis software, AIS signal can be received and transmitted, and the VDL link can be monitored and analyzed in real time. In addition, it can receive, analyze and count data messages, and display information such as equipment type, distance, longitude and latitude, SOG, COG, navigation status and abnormality of various AIS equipment targets. The interface and functions of AIS signal comprehensive analysis software are shown in Figure 4, Figure 5 and Table 1.

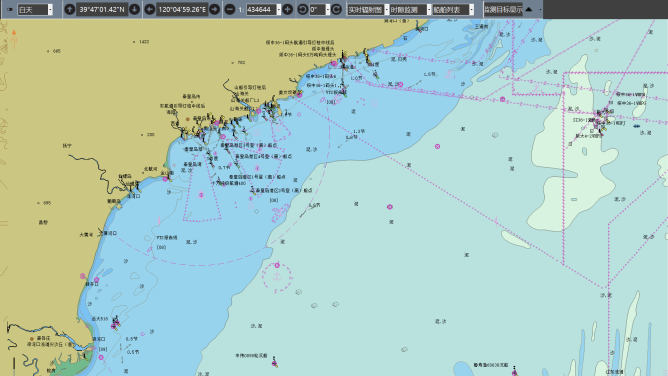


Figure 4 Main work area of AIS signal comprehensive analysis software

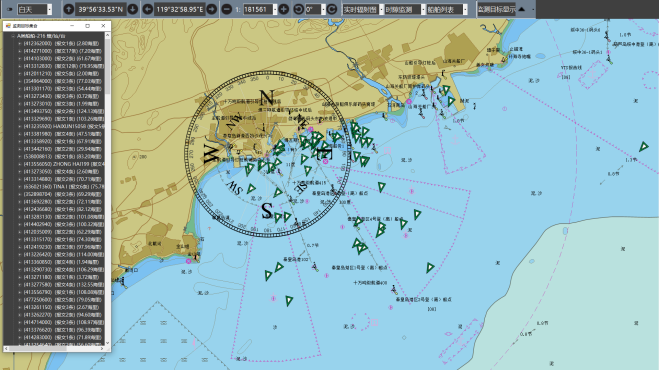


Figure 5 Signal receiving interface in AIS signal comprehensive analysis software

Table 1 AIS signal comprehensive analysis function

|  |  |  |
| --- | --- | --- |
| Function | interface display | Features |
| AIS target information display |  | Display the basic information of AIS target, such as device number, distance, location, and corresponding indicators of AIS target communication status. |
| Timeslot diagram |  | The window that displays the dynamic display of channel A and channel B of the VDL link in timeslots, so that you can clearly see the occupation of timeslots by AIS targets. |
| Information Statistics |  | Count the current status of the AIS receiving device. The status bar displays various targets, including equipment type, distance, longitude and latitude, SOG, COG, navigation status, etc. |
| Target alarm |  | Statistics of abnormal equipment, including receiving time, specific abnormal conditions, etc. |

### Maritime radio signal monitoring function

In the portable AIS comprehensive analyzer is composed of sampling equipment control module, signal processing module, spectrum display, baseband signal oscilloscope, channel analysis, etc. It can be connected to multiple basic radio terminals, including AIS transceiver, RBN-DGNSS Terminals, Loran receivers, shortwave voice radios, VHF radios, etc., can realize the analysis function of AIS signal characteristics, and can analyze the field strength of AIS signals, the signal-to-noise ratio of AIS signals, the frequency offset of AIS signals, and the AIS signals. It can detect the time slot occupancy rate in the AIS network and the transmission of AIS signals across time slots. The main working interface is shown in Figure 6, and its function interface is shown in Table 2.

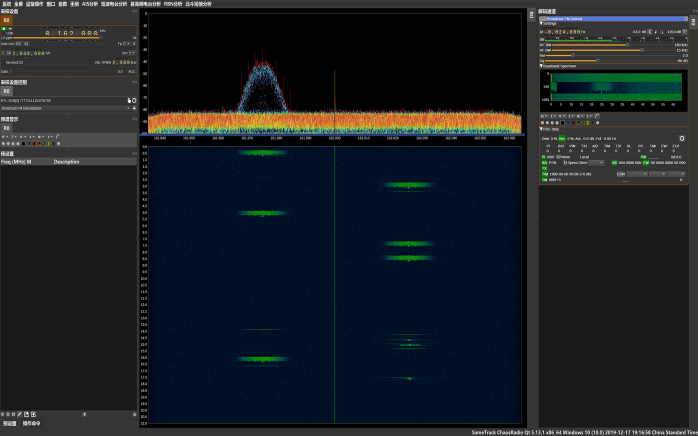
****

Figure 6 Maritime radio signal monitoring software interface

Table 2 Specific function interface of maritime radio signal monitoring software

|  |  |  |
| --- | --- | --- |
| Function | Interface display | Features |
| Radio parameter settings |  | This function can set the frequency point of the monitoring frequency, sampling bandwidth, RF bandwidth, gain, automatic gain mode, etc. |
| Spectrum display |  | Display the signal spectrum of the current frequency point. |
| Channel analysis |  | Observe the state and signal quality of the signal through the channel spectrum and oscilloscope, and measure the signal parameters. Including signal strength, signal-to-noise ratio, etc. |

## Application of Portable AIS Equipment Comprehensive Analyzer

In order to test the integrity and accuracy of the functions of the comprehensive analyzer, they were applied in Nanjiang Wharf of Tianjin Port and Nanshantou Lighthouse of Qinhuangdao respectively. The results are shown in Figure 7.

After scenario application, the portable AIS equipment comprehensive analyzer has the advantages of small size and light weight, which makes it easy for the staff to carry and operate, and the equipment operates normally and the results are accurate. It has played an active role in AIS equipment detection, maritime radio signal supervision, and so on.

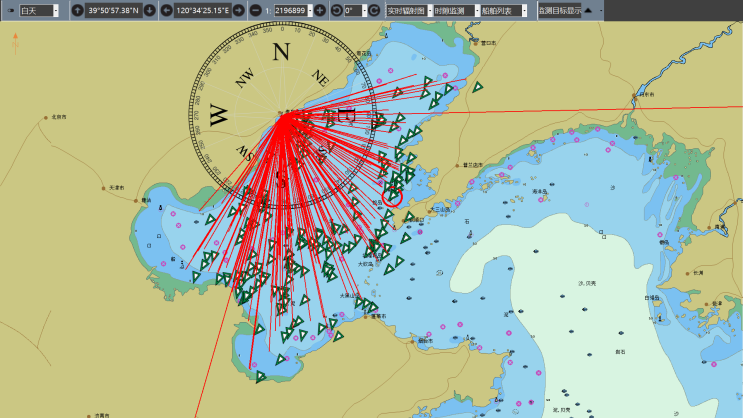
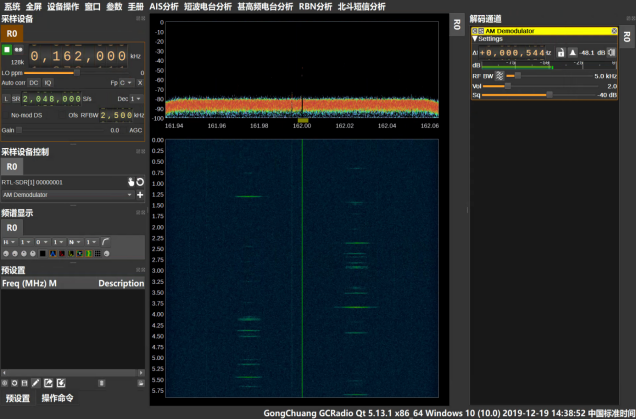
 

Figure 7 Application Results

After the successful development, the analyzer was immediately put into daily maritime patrol inspection and technical measurement. So far, it has been widely used in the maritime patrol inspection work in the northern sea area of China. Especially in the area under the jurisdiction of Qinhuangdao Aids to Navigation Office, it has provided data support for AIS Aids to Navigation patrol inspection and AIS base station signal detection for many times and played an active role. At the same time, in major special activities such as joint patrol inspection at sea and joint maritime radio law enforcement, various types of AIS equipment’s deficiency have been accurately identified for many times, and the abnormalities of onboard AIS equipment have been accurately investigated, further realizing accurate scientific management, and providing technical support for safe navigation of ships. The results are shown in Figure 8.

Figure 8 Joint maritime law enforcement activities

# references

None.

# ACTION requested OF the Committee

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. 2 Leave open if uncertain [↑](#footnote-ref-2)
3. 3 Footer will automatically populate [↑](#footnote-ref-3)