Centralized Monitoring System of Rail Transit Multiple Signals Based on Bus Technology

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Abstract. Conventional rail transit signal monitoring systems are prone to being affected by pooling aggregation during image downsampling processing, resulting in abnormal monitoring functions. Therefore, this study designs a new centralized monitoring system for multi-channel signals in rail transit based on bus technology. In the hardware part of the system, SBMA RF receiver, SZ45XIT magnetic random access memory, and SPACECOM electric zoom monitoring camera are installed to support smooth operation of the system. In the system software section, based on the design of traffic multi-channel monitoring signal processing algorithms, a signal centralized monitoring function module was generated based on bus technology. The test results indicate that the various functions of the system operate in an orderly manner, with reliability and application value. In addition, compared to traditional systems, the signal monitoring delay of this system is lower.

Keywords: Bus technology · Rail transit · Multiple · Signal · Centralized monitoring system

1 Introduction

In recent years, China's economy has risen rapidly and developed into the second largest economy in the world. With the continuous improvement of people's living standards and the upgrading of resident consumption [1] in China, the automobile market is experiencing rapid growth. The popularity of cars and the number of cars owned by thousands of people are increasing year by year. According to the data of the National Bureau of Statistics, China's civil automobile ownership in 2018 was about 240 million [2], an increase of 10.5% over last year. The development of the automobile era has led to an explosive growth in the number of cars, which has led to traffic accidents and congestion. Both developed and developing countries are facing many traffic problems, which greatly reduces the efficiency of people in production and life [3]. In order to solve these problems, traditional means such as increasing the number of roads, widening the original roads, and establishing overpasses have been used to alleviate the contradiction between cars and roads. However, due to the huge population of China [4], the development of urban roads is limited, and this method cannot fundamentally improve the traffic

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conditions of cities. The introduction of intelligent transportation system is a change of traditional thinking mode, which conforms to the development of the automobile era and can effectively improve the acute traffic problems [5].

The intelligent transportation system integrates the intelligent achievements in scientific information technology, sensor technology, data communication technology, artificial intelligence and other fields, and is committed to creating a comprehensive, multifunctional, efficient and intelligent traffic monitoring system [6]. Since the intelligent transportation system was put forward to the gradual improvement of the system, the level of road management in China has been greatly improved. The number of deaths caused by traffic accidents can be reduced by 30% every year, and the utilization rate of vehicles can be increased by 50%. The intelligent transportation system has achieved effective results. The proposed intelligent transportation system conforms to the development trend of informatization in the world today [7], can effectively coordinate the relationship between roads, people and vehicles, and improve the tense traffic situation, which is the mainstream direction of future transportation system development.

The intelligent transportation system is composed of various subsystems, each of which is responsible for different fields and processes different information. These information are collected and correlated through the established intelligent information processing platform, in which the acquisition of vehicle information is crucial. At present, the acquisition of vehicle information mainly includes loop detection, infrared detection, video detection and radar detection. Compared with foreign countries [8], domestic involvement in the field of intelligent transportation started relatively late. Before the start of the research on intelligent transportation, the detection of various violations of vehicles is mainly to judge and distinguish according to the situation, and in most cases still rely on manual judgment and decision, while the traffic videos recorded on urban roads are only used as evidence after the occurrence of traffic accidents, and there is no subsequent data. Under the above background [9], in order to improve the safety of China's rail transit, this paper designs a new centralized monitoring system for rail transit multi-channel signals based on bus technology.

2 Hardware Design

2.1 SBMA RF Receiver

The traffic multi-channel signal centralized monitoring system mainly works in the 315 MHz and 433 MHz Sub GHz frequency bands, and adopts ASK and FSK coding methods. At present, there are mature RKE schemes in the market, such as RF transceivers produced by Infineon, Cypress and other companies, and separate RF transmitters and receivers [10]. This design focuses on signal reception, so a separate SBMA RF receiver with more friendly cost will be selected. The SBMA RF receiver has added a microcontroller. The development process is more complex, and the receiver integration is high. All circuits of the RF receiver are configured by external circuits, so the flexibility is high [11].

The SBMA RF receiver does not need to configure more external components in actual operation. The operating ISM frequency band is between 300 MHz and 450 MHz. The current popular 32 pin thin QFN package is selected, and the applicable temperature range is –40 ~ +125 °C. The temperature range meets the environmental requirements of the centralized signal monitoring system. The SBMA RF receiver is equipped with various active components to maintain the normal operation process of superheterodyne, such as a low-noise amplifier supporting AGC function, a fully integrated phase-locked loop, local oscillator, etc., to better adapt to the low power consumption operation mode. The SBMA RF receiver is integrated with a discontinuous reception mode, which can be configured scientifically and reasonably using the serial interface bus. The requirements for centralized monitoring of signals are met. The composition of the RF receiver is shown in Fig. 1 below.

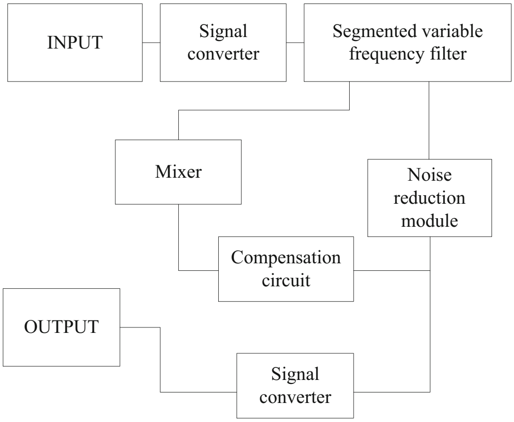

Fig. 1. Structure of SBMA RF Receiver

It can be seen from Fig. 1 that the peripheral components of the SBMA RF receiver are in rich demand. In addition to ensuring the matching network design of the antenna input, it can also better suppress the adjacent band interference and improve the sensitivity of the receiver. The operating frequency can be fine tuned by adjusting the system clock, which is theoretically within 300–450 MHz [12]. In view of the important role of the clock in frequency selection, the clock used in this system is replaced by a temperature compensated crystal oscillator clock.

2.2 SZ45XIT Magnetic Random Access Memory

In the process of centralized monitoring of multiple signals of rail transit, some emergencies may occur, and the reliability problem is mainly manifested in emergencies such as power failure. Dynamic random access memory.

The capacitance can only be refreshed through current during power on to store the information operation program. All data transmitted from the camera at the time of power off cannot be retained in case of emergency power off. In practical applications, the data at the moment of power failure are often important evidence. Dynamic random access memory (DRAM) has a simple and efficient structure. Each bit requires only one transistor and one capacitor. However, the DRAM capacitor inevitably has leakage.

As long as the charge is insufficient, data errors will occur, and the capacitor must be refreshed periodically. Therefore, using dynamic random access memory as program operation and data cache is easy to lose important data or cause system paralysis with low reliability.

Each time the system restarts, the master microprocessor needs to find the startup code from the flash memory and load the system program into the dynamic random access memory [13]. Moreover, the process of charging and discharging capacitors in dynamic random access memory takes time, and the refresh frequency can easily reach the upper limit in advanced technology. The above process and the limitations of flash memory's read/write speed and read/write times affect the efficiency of information interaction, reduce the system's smoothness, and make the system unable to run at high speed. In view of the storage defects of the conventional monitoring system, this paper selects SZ45XIT memory as the core memory of the system. The operating parameters of this memory are shown in Table 1 below.

Table 1. Operation parameters of magnetic random access memory

Name	Parameter
Package	Cut Tape (CT)
Life cycle	Active
Overall dimensions	4 mm\5 mm\1.5 mm (Dimensions)
Package	SOIC-8
Pin count	8
Installation method	Surface Mount
Power supply current	5 mA
Supply voltage	4.5~5.5 V
Output voltage	0.0~5.3 V
Output current	1.6 mA
Supply voltage	4.50 V
Operation temperature	125 °C
ECC Ncode	EAR99

It can be seen from Table 1 that the nonvolatility of the above memory improves the reliability of the video monitoring system. When the video monitoring system is powered down suddenly, the audio data just imported into the system cache can be saved, so there is no need to worry about the loss of important real-time data, and the reliability of RAM in the same environment is higher than that of dynamic RAM. This is very important for the video monitoring system in important places [14].

Thanks to the non-volatile nature of the magnetic random access memory, the memory connected to the main control microprocessor does not need to carry out code input and manned operation data after each power on after the first power on. Moreover, the magnetic random access memory itself has the advantage of high-speed reading and writing, which can greatly save the startup time and enable high-speed data transmission of the video monitoring system. The magnetic random access memory (MRAM) can be infinitely rewritten, which reduces the number of times and costs of maintenance of the system's storage part. The low power consumption also saves costs. The nonvolatile and low-power nature of magnetic random access memory eliminates the trouble of traditional video surveillance systems matching backup batteries or super capacitors, and greatly reduces the cost.

2.3 SPACECOM Electric Zoom Monitoring Camera

In the process of centralized monitoring of multiple signals in rail transit, it is necessary to continuously collect monitoring images for multi-target analysis. Therefore, SPACECOM electric zoom monitoring camera is selected as the acquisition hardware of the system. SPACECOM camera belongs to the day and night lens, which is used in forest fire prevention, coastal defense, border defense and other industries. It belongs to the long focus electric zoom lens with good comprehensive performance. The performance parameters of the electric zoom monitoring camera are shown in Table 2 below.

Table 2. SPACECOM Surveillance Camera Parameters

Name	Parameter
Focal length	15~500 mm
Canvas Size	1\1.8
Aperture ratio	1:4.0
Aperture Range	F4.0~360
Installation interface	C
Viewing angle	23.19° × 17.49°
Operating mode	Electric
Close object distance	2.9 m
Filter size	105 mm
Overall dimensions (mm)	122\125\267
Weight (g)	2900

It can be seen from Table 2 that the image quality and color of SPACECOM electric zoom monitoring camera are clear. The built-in auto focus function of the lens makes the operation more convenient. The fog penetration function can penetrate the fog, which solves the problem that objects cannot be seen in the heavy fog environment. Multiple sets of filters are used, suitable for different application scenarios. It has 24-h monitoring capability. Provide high definition color images in the daytime; Fine black and white images are available at night. The built-in temperature sensing device can sense the thermal expansion and contraction caused by the temperature information of the lens, which can automatically compensate the back focus position and prevent the image from being blurred. That is, when used in an environment with large temperature difference, the image can always be kept clear without refocusing. The lens adopts advanced standards, which can work normally in bad weather and has good environmental adaptability. It is used in monitoring scenarios such as railway, forest fire prevention, border and coastal defense, urban commanding heights, and environmental monitoring, and meets the monitoring requirements of the centralized signal monitoring system designed in this paper.

3 Software Design

3.1 Design Traffic Multi-channel Monitoring Signal Processing Algorithm

As mentioned earlier, conventional rail transit signal monitoring systems are susceptible to the influence of pooling aggregation during image downsampling processing, which affects the final monitoring effect. In response to this issue, this study utilized Tiny-YOLOv3 technology to design an effective centralized monitoring algorithm for traffic multi-channel signals.

In Tiny-YOLOv3 technology, the polarized beam is placed according to the antenna, and the three-dimensional information of the rail transit target is solved using the spectrum pairing ratio method.

Phase comparison angle measurement is based on the phase error of the echo signal between two antennas. When the radar antenna radiates electromagnetic waves, the direction of the target is determined according to the characteristics that the echo signal is strongest when the antenna beam axis is aligned with the target, and the echo signal becomes weaker when the antenna beam axis deviates from the target. The schematic diagram of the phase angle test at this time is shown in Fig. 2 below.

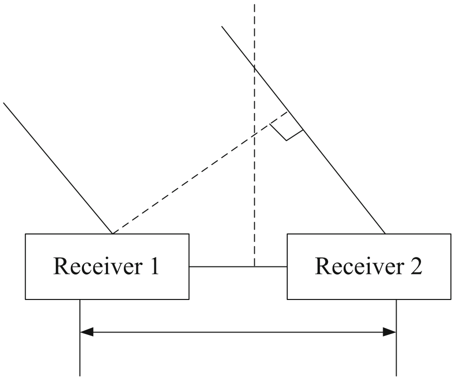

Fig. 2. Schematic diagram of monitoring phase angle test

In the environment of Fig. 2, the processing phase difference $\Delta\varphi(\theta)$ of the multi-channel monitoring signal for rail transit is:

$$\Delta\varphi(\theta) = \varphi(1) - \varphi(2) \tag{1}$$

In formula (1), $\varphi(1)$ Represents the phase angle of receiver 1, $\varphi(2)$ It represents the phase angle of receiver 2. When the electromagnetic wave encounters an object, it will bounce back and be received by the receiver. At this time, the monitoring wave path difference of the collected signal can be calculated according to the included angle between the echo and the normal direction of receiver 1 and receiver 2, as shown in (2) below.

$$\Delta R = d \cdot \sin\theta \tag{2}$$

In formula (2), d Represents the distance between receiver 1 and receiver 2, θ Represents the included angle of the monitoring receiver. Under the condition that the distance d between the radar receiving antenna 1 and receiving antenna 2 is fixed, the incident angle of the echo signal is related to the phase difference. Determine the phase difference corresponding to the receiving antenna 1 and receiving antenna 2 to determine the incident angle of the echo signal, find the location of the target, and then monitor the average value of the echo signal a As shown in (3) below.

$$a = \frac{\sum\limits_{i=1}^{N} \theta_i}{N} \tag{3}$$

In formula (3), θ_i Represents the average signal acquisition angle, N It represents the incident amount of echo signal. According to the above calculated signal monitoring parameters, signal processing steps can be designed.

Step 1: AD sampling is performed on the multi-channel signals of the horizontal polarization beam and the vertical polarization beam receiving channels, converting the analog signal into a digital signal, and reordering the sampled data to obtain multiple sets of beat signal data.

Step 2: FFT transform each group of LFSK beat signals. In order to solve the problem of spectrum leakage, this paper introduces Blank man window to get N spectrum graphs when the signal is transformed, and the expression of Blank man window at this time $w[n]$ As shown in (4) below.

$$w[n] = S_i^k \left(4\pi \frac{n}{N-1}\right) \tag{4}$$

In formula (4), S_i^k Represents spectrum leakage parameters, n Represent the number of spectrum graphs, and calculate the modulus square of the spectrum graph obtained in step 2 to obtain the amplitude frequency response. Then sum the amplitude frequency responses of horizontal receiving channel 1, horizontal receiving channel 2, vertical receiving channel 1 and vertical receiving channel 2 respectively. Finally, the frequency spectrum of the horizontally polarized beam is cumulated into periodic patterns, and the corresponding amplitude frequency response D As shown in (5) below.

$$D = \frac{w[n]}{a} \cdot s_a \tag{5}$$

In formula (5), s_a Represents the periodic pattern accumulation of the spectrum of the vertically polarized beam, and the corresponding amplitude frequency response S_S^A

As shown in (6) below.

$$S_S^A = S_F + D \backslash s_a \tag{6}$$

In formula (6), S_F It represents polarization accumulation response. According to the results obtained from formula (6), the design of a multi-channel monitoring signal processing algorithm for rail transit is completed using the following process:

Process 1: Understand the amplitude frequency response of the signal. The amplitude frequency response describes the amplitude variation of a signal at different frequencies. By analyzing the amplitude frequency response of a signal, the frequency domain characteristics and frequency distribution of the signal can be understood.

Process 2: Preprocess the signal. Before applying the algorithm, it is necessary to preprocess the signal, including filtering, denoising, enhancement, and other operations. Select an appropriate filter based on the amplitude frequency response of the signal to remove unnecessary frequency components or enhance the frequency components of interest.

Process 3: Feature extraction. Feature extraction is the process of converting signals into feature vectors or feature matrices with recognition and representation capabilities. Frequency domain characteristics (such as spectrum characteristics, power Spectral density), time domain characteristics (such as mean, variance, energy) or other characteristics (such as wavelet transform coefficients) can be used.

Process 4: Algorithm design. Based on the results of feature extraction, signal processing and analysis are realized through Time–frequency analysis.

3.2 Generate Centralized Monitoring Structure Based on Bus Technology

The bus technology can effectively classify data and improve the comprehensive performance of the monitoring system. It can connect each monitoring component to the computer processing unit to form an effective centralized monitoring structure. Fieldbus is a decentralized, digital, intelligent, bidirectional, multipoint, multistation, and multivariable communication system used between field control terminals and control centers. It provides network services according to standards, and is characterized by high reliability, good stability, strong anti-interference ability, high communication speed, and low maintenance cost. Based on the above characteristics, this paper designs a centralized monitoring structure, as shown in Fig. 3 below.

It can be seen from Fig. 3 that the traditional CAN bus is a single-layer structure system. The bus controller and the bus terminal module are both attached to a pair of buses, and all bus devices are at the same level. In long-distance communication, if the single-layer bus structure is adopted, the work of the whole bus will be affected when the line fault occurs. In the new multi-layer network structure, the bus centralization module is used as the middle layer. The bus controller is responsible for managing the bus centralized module, while the centralized module manages the terminal module, reducing the number of nodes on the primary bus and reducing bus conflicts.

The system divides the stations of the whole line into several blocks according to the proximity principle. Each block is equipped with CAN bus centralization station. The control host is responsible for managing each bus centralization module, and each bus

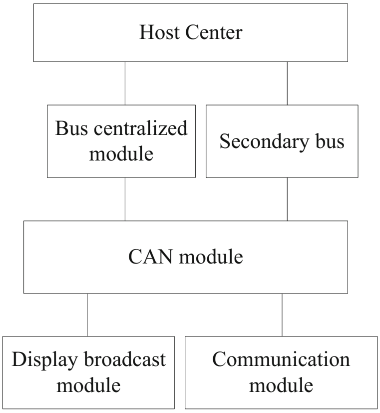

Fig. 3. Bus Centralized Monitoring Structure

centralization module manages the corresponding terminals attached to its subordinate bus.

Here, each centralization station is equipped with two bus centralization modules, of which module 1 is in the main working state, responsible for patrolling each communicator and issuing various commands sent by the control host to the communicator, train number display and automatic broadcast control module. Module 2 is in the hot standby state. It receives the command from the control host and detects whether module 1 is in the working state. When module 1 is found to be faulty or receives the start command sent by the control host, it turns to the main working state.

The two-layer structure reduces the number of nodes on the bus, and reduces the transmission of redundant information, as well as the information round-trip between the field and the control room. The CAN bus adopts the method of closing the node for the node with serious bus conflict, so as to reduce the network failure caused by the conflict. However, after the node is closed, the communication between the field equipment and the center is also interrupted. The reduction of the number of nodes can reduce conflicts and improve the reliability of the bus *MTBF* As shown in (7) below.

$$MTBF = \frac{1}{\lambda}(1 - R) \tag{7}$$

In formula (7), λ Represents the round-trip reliability coefficient of information, R It represents the communication integral. If the reliability calculated at this time is qualified, it proves that the performance of the above structure is good. Otherwise, it needs to detect relevant problems and make reasonable optimization.

3.3 Design Signal Centralized Monitoring Function Module

Combined with the above structure, we can use the drawing class SurfaceView of Android system to write the upper application program and realize the preview of video image on the LED of the development board. There are two ways to install hardware drivers in the kernel: one is static compilation.

When compiling the kernel, it is directly selected and compiled into the kernel, and can be used directly after the kernel is started; The other is dynamic loading. This article creates the spca5xx entry in the driver/usb/media directory.Mkdirspca5xx, return to the/driver/usb grid, place the portal in this directory, and run path-p1.2.6.12.path.If correct, the corresponding file will be generated in the usb/media/spca5xx directory.

Then add and modify the drivers file. Compile the kernel and modules. In the source root directory, execute make, that is, make modules, specify the cross compilation environment, and make changes within the previous level of Makeage.

Copy the module file to the development board directory, insert the USB camera into the development board, and restart the development board. This video monitoring system uses a portable Usb camera for testing, that is, to collect video data. When collecting video, the Android system can achieve real-time automatic capture of video, and then call each frame through interface functions, and then use surface view classes to draw, so as to complete the real-time preview function of the image. The video data collection process is shown in Fig. 4 below.

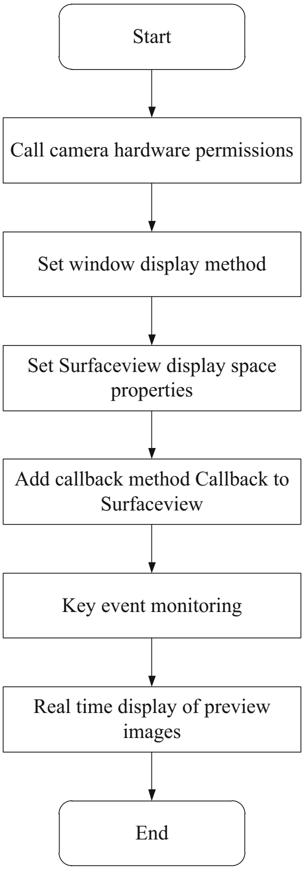

Fig. 4. Flow chart of video capture

As shown in Fig. 4, this article adds hardware permissions to call the camera, adds the following code to the Android manifest file, and sets the window display mode. When performing operations such as modifying, creating, and destroying data, this function is realized by setting a callback function.

After the video information is collected, the video monitoring system will preview the video in real time through the LED display, which involves the knowledge of Android interface design. Android user interface is based on GUI system and programmed in Java language. The Android SDK supports a large part of the functionality of the standard Java Runtime Environment (JRE).The Java platform supports the use of XML through many different formulas, and a large number of XML related Java APIs are fully supported on Android.

For the interface design based on the Android platform, including the basic components of building the screen, even if you use XML to define the screen and load it into the code, you also need to handle various tasks for the user interface, and then realize the design of the program UI through a single or multiple active applications. Thus, an effective user interface can be formed to allow users to easily access the periphery and realize the preview of real-time video information.

4 System Test

In order to verify the monitoring effect of the designed rail transit multi-channel signal centralized acquisition and monitoring system based on bus technology, this paper built an experimental platform to verify the operation function of the designed system, and carried out system testing, as follows.

4.1 Test Preparation

During the research and development of the video monitoring system, testing is an indispensable means to measure the correctness, stability and effectiveness of video stream information acquisition, algorithm coding and RTP video transmission protocol in the system. Through the theoretical research and specific development of the system, reasonable and rigorous testing can better test the functionality of the system, It can also reflect the problems existing in the system through testing, provide the direction for improvement, and then optimize the system design to improve the software application effect. The test and development platform is 1.7.0 of Java Development Kit 7, which is a relatively stable version of JDK_The SR2 version of Eclipse software is used to provide the development environment of the system. The Android SDK is. The hardware of the experiment includes a camera, a radar main control board, a radar slave control board and a PC. The relative positions of the camera and the radar master and slave control boards are fixed, which can be reinforced with brackets. The experimental hardware placement diagram is shown in Fig. 5 below.

It can be seen from Fig. 5 that the design and processing of the radar master and slave control boards are the same. The Rogers 5880 material is used as the dielectric board, and XMC4500F100K1024 is used as the microprocessor chip and BGT24MTR12 is used as the RF chip. The thickness is about 10mil. The camera used for shooting is Xinanshi,

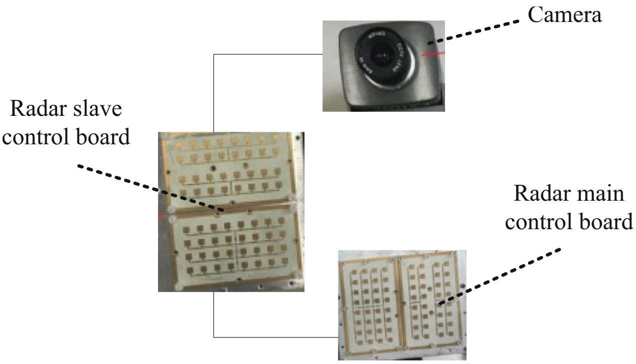

Fig. 5. Schematic diagram of experimental hardware placement

with a pixel size of 720 × 576. This paper uses the convolution neural network target detection model based on YOLO, which has a large number of convolution operations, and has certain requirements for the computing ability of the computer. The software information used in the experimental platform is shown in Table 3.

Table 3. Software Information of Experimental Platform

Device Name	Model
Operating system	Windows7
Processor	Intel Xeon CPU E5-2620 v3
Memory	6 GB
Graphics card	NVIDIA GeForce GTX 1060
Software platform	Visual Studio2015
Programming Language	C/C++
CUDA	10.1
CUDNN	7.0

It can be seen from Table 3 that the above parameters meet the system test requirements. In order to improve the reliability of the system test, the test monitoring radar is preset in this paper. The parameter indicators are shown in Table 4 below.

It can be seen from Table 4 that before the system test, it is necessary to set the target to move 40 m away from the radar and record the speed of the target detected by radar signal processing.

The purpose of the test is to check whether the program can complete the specified task according to the process set by the requirements during the running process, and whether it can handle correctly in the case of errors or exceptions, so as to avoid downtime or system paralysis. Since the system is based on the BS framework, it is necessary to test the function and performance of the front end, as well as the compatibility under

Table 4. Parameters and Indexes of Experimental Test Monitoring Radar

Name	Parameter indicators
Frequency	24 GHz
Working wavelength	0.0125 m
Maximum detection distance	120 m
Maximum detection speed	±240 km/h
FM bandwidth	200 MHz
Coherent processing cycle	7.68 ms
FFT points	512
LFSK frequency difference	f1:554\f2:13.03
Distance between receiving antennas of horizontally polarized beams	24.15 mm
Distance between receiving antennas of vertically polarized beams	24.15 mm

various browsers. The most important thing is to check the checksum processing on the server side. The requirement is implemented as a program, and then each requirement process is accepted through the program. This analysis method is usually drawn as a V-type test model, as shown in Fig. 6.

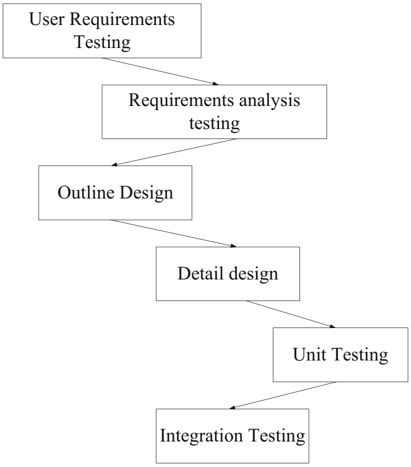

Fig. 6. System test model

As shown in Fig. 6, from the model diagram, the whole system test consists of four parts. They are unit test, integration test, confirmation test system test and acceptance test. Before the unit test of the system, each function test of the system needs to be carried out first when developing each function of the system.

4.2 Test Results and Discussion

Under the above test preparation, the system test can be carried out, that is, the debugging test environment. Run the rail transit multi-channel signal centralized monitoring system designed in this paper based on bus technology. At this time, the test results of each functional module are shown in Table 5 below.

Table 5. System Test Results

TEST	Expected results	Test result
Login Module	Enter the username and password, confirm login, display successful login and enter the system main interface	Test passed
Traffic signal monitoring module	Enter the username and password, confirm login, enter the traffic signal control module, click on manual control of traffic signals, and control the display of lights	Test passed
Monitoring information collection module	Enter the username and password, confirm login, enter the video monitoring module, click on the video screen to display the video information of each intersection normally	Test passed
Information modification module	Log in to the information modification interface, click Modify, and prompt for successful modification	Test passed

It can be seen from Table 5 that each functional module of the rail transit multi-channel signal centralized monitoring system designed in this paper based on bus technology operates orderly. The above test results prove that the performance of the designed signal centralized monitoring system is reliable and has certain application value.

4.3 Comparison of Test Results and Discussion

To further highlight the application advantages of the system in this article, the traditional rail transit signal monitoring system based on heterogeneous Internet of Things (Traditional System 1) and the embedded technology based rail transit signal monitoring system (Traditional System 2) are compared. The application performance of the three systems is analyzed from the perspective of signal monitoring delay, and the results are shown in Table 6.

By analyzing the results shown in Table 6, it can be seen that as the number of experiments increases, there are certain differences in signal monitoring delays among different systems. Among them, the maximum signal monitoring delay for Traditional system 1 is 2952 ms, the maximum signal monitoring delay for Traditional system 2 is 2053 ms, and the maximum signal monitoring delay for System of this paper is only 984 ms. In contrast, the monitoring timeliness of the System of this paper is higher.

Table 6. Comparison of Signal Monitoring Delay in Different Systems (ms)

Number of experiments	System of this paper	Traditional system 1	Traditional system 2
10	980	2952	1763
20	967	2948	1869
30	964	2921	1826
40	981	2945	1955
50	984	2950	2053

5 Conclusion

This article designs an effective centralized monitoring system for traffic multi-channel signals based on bus technology, which improves the application performance of the system from two perspectives of software and hardware design. The test results indicate that the system has good application performance and is effective in reducing signal monitoring latency.

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