Design of Power System Remote Video Monitoring System Based on RTP Technology

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Abstract. Most of the conventional power system remote video monitoring systems are designed based on the SIP principle. In the actual monitoring operation process, there are problems such as poor real-time monitoring and high packet loss rate. In order to solve this problem, RTP technology is introduced and a remote video monitoring system for power system based on RTP technology is designed. Based on the optimized design of the monitoring system hardware, the monitoring system software and software functions are designed. First, the remote video surveillance image of power system is filtered to remove most of the signal noise in the remote video surveillance image. Secondly, the background of power system remote video monitoring is updated to achieve the ideal segmentation effect of video monitoring image. The remote video monitoring module is designed to carry out remote video real-time monitoring of the operating conditions of the power system. The real-time transmission function of remote video image in power system is designed by using RTP technology. According to the system test results, after the proposed monitoring system is applied, with the increase of system running time, its packet loss rate is below 1%, and the real-time performance of remote video monitoring is high.

Keywords: RTP Technology · Power System · Long-Range · Video · Monitor · System

1 Introduction

Nowadays, with the continuous development of energy related technologies, the economic level has also been gradually improved. Electric power energy can be used as the secondary energy converted from primary energy, which is clean and renewable, in line with the concept of sustainable development proposed by the country, and also has a far-reaching impact on building a harmonious society [1]. However, in the power supply process, for example, if the power supply fails to provide stable electric energy, there is a problem in the power operation, or the power system fails to operate, the economic loss caused by the power failure in a large range is very huge [2]. At the current stage, the power development in China is very rapid, and has reached the working stage of ultra-high voltage, large power grid and large units. In addition, the application fields

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of power technology are increasing, and the scale of the system formed by it is also increasing. This situation puts forward very high requirements for the safe and stable operation of power [3]. Therefore, we should take security and stability as the first consideration for all problems and solutions, and reflect them in the layout, operation and maintenance of the power system [4]. With the continuous improvement of technology, the hardware facilities and software performance of the power system remote video monitoring system we used earlier can no longer be applied to the current large-scale power system. Therefore, optimizing and improving the traditional power system remote video monitoring system has become our current focus of work. In order to realize the true remote video monitoring, it is necessary to add the functions of substation image monitoring and image transmission on the basis of the original telemetering, remote signaling, remote adjustment and remote control of the substation, and then realize the remote viewing function. At present, the image monitoring systems applied in power system include industrial television system and computer managed image monitoring system [5]. The industrial television system is that the camera installed on the site transmits the video signal through the video cable to the monitor through the video switcher. Because the video cable will cause loss of analog video signal, the transmitted image is limited to 500 m and can only be used for local monitoring: the image monitoring system managed by computer is to digitally process and re compress the analog or digital video signal collected by the camera through the computer video capture card, and then carry out local or remote monitoring. When the number of acquisition points increases, the workload of the computer is huge, forming a bottleneck of information transmission, image distortion, and system instability.

RTP (Real time Transport Protocol) is a real-time network transport protocol for multimedia data streams. In modern life, RTP plays an important role [6] when TCP/IP, UDP and other network protocols in the field of streaming media transmission cannot meet people's needs. For example, RTP protocol has been applied to video surveillance, video conference, voice phone and network transmission of audio and video.

Based on this, on the basis of the traditional power system remote video monitoring system, this paper makes an optimization design, introduces RTP technology, and carries out an all-round research on the power system remote video monitoring system based on RTP technology. The hardware system is designed through EWS, bus controller, video capture card, and high-speed intelligent ball camera, providing high-quality images for the remote video monitoring system of the power system. Real time transmission of remote video images is achieved based on RTP technology, improving the stability of the system.

2 Hardware Design of Power System Remote Video Monitoring System

2.1 EWS Hardware Design

EWS hardware includes microcontroller, memory, peripheral devices and IO ports, and its core is embedded microcontroller. In order to meet the demand of Internet access, embedded microcontroller should not only have the traditional control function, but also have the function of connecting to the Internet. Through comprehensive comparison of performance requirements and implementation costs, Ubicom's SX52BD is used as the EWS microcontroller: as for the transmission medium, the Internet is connected through Ethernet, and the data link layer protocol is implemented using Realtek's NF2000 compatible chip RTL8019AS. The EWS hardware structure block diagram is shown in Fig. 1.

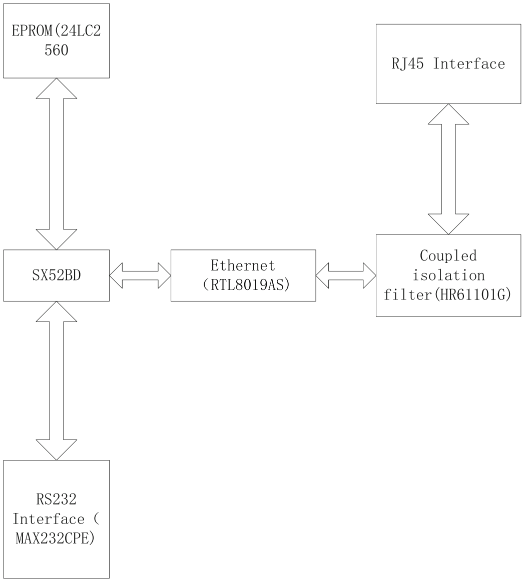

Fig. 1. EWS Hardware Structure Diagram

As shown in Fig. 1, the data flow direction is: request and control information comes from the network and is sent to RTL8019AS through RJ45. RTL8019AS is responsible for stripping the header and trailer information of the Ethernet frame, sending the processed data packet to the TCP/IP protocol stack of SX52BD, and the protocol stack parses the data packet to obtain the original request and control information [7]. The request and control information is encapsulated in protocol format by MAX232CPE, and then communicated with the on-site equipment. The process of requesting and controlling reply information to the network is just the opposite. First, set the technical parameters of microcontroller and serial memory in EWS hardware, as shown in Table 1.

Table 1 shows the technical parameters of the microcontroller and serial memory in the EWS hardware of the power system remote video monitoring system designed in this paper. Secondly, set the technical parameters of other sub hardware in EWS hardware, as shown in Table 2.

As shown in Table 2, it is the technical parameters of other sub hardware in EWS hardware. In the protection or measurement and control equipment of the remote video monitoring system, EWS is mainly used to realize the remote control, adjustment and maintenance of the equipment through IE on the client side, and browse the real-time

Table 1. Technical Parameters of EWS Microcontroller and Serial Memory

Number	Hardware	Parameter
1	SX52BD microcontroller	The instruction execution speed is 100 Mbps;It is internally integrated with fast on-chip program memory, data memory, analog comparator, timer, internal R/C oscillator and other functional devices; It supports the "virtual peripheral" function, that is, it can flexibly configure the five I/O ports of the SX52BD microcontroller, and simulate the function of hardware peripherals by executing virtual software modules to drive I/O ports
2	Serial memory	Produced by Microchip, 24LC256 chip uses 32 KB serial EPROM memory to store webpage resources of embedded web server. The stored web page resources include web pages, image files, PDF documents and other files in various formats.24LC256 is compatible with rc bus interface to communicate with external controllers

Table 2. EWS Sub hardware Technical Parameter Settings

Number	Hardware	Parameter
1	Ethernet control interface	It is implemented by RTL8019AS, a highly integrated full duplex Ethernet controller chip produced by Realte. It has a 16 bit data bus and a 24 bit address bus, which are used in the 10 megabit ISA (Industrial Standard Architecture) interface network adapter
2	Coupling isolation adapter	HR61101G chip, produced by Hanren Company, is used to convert and filter the pulse on the network.RJ45 connector is also integrated in the chip, so that it can be directly connected to twisted pair to access Ethernet
3	Serial communication level conversion interface	The MAX232CPE chip is selected, which is a special serial level conversion chip produced by Maxim Company and conforms to all EARS-22C interface standards. The chip contains a voltage multiplier circuit and a conversion circuit. Only+5 V power supply is needed to realize the conversion of TIL level to RS-232C level

information of the equipment. In order to make the operation and maintenance personnel more convenient to control and operate the equipment and monitor the equipment status more intuitively, the realization forms of its basic functions should be diversified. In addition, considering the limited resources of embedded devices, some unimportant functions should be restricted.

2.2 Bus Controller

In the power monitoring system, the monitored equipment is scattered and the distance between the equipment is relatively far. In such application systems, stable, reliable, convenient and fast data communication is the basis and guarantee for realizing the functions of the application system. Therefore, it is very important to select appropriate communication interfaces and protocols, and reasonably design communication software and hardware control circuits according to the actual working environment conditions of the system. When EWS is applied in power system, it is necessary to connect several relatively scattered equipment. Due to the short transmission distance of RS232 bus, other communication protocols [8] are required to enable communication in a wide range.

RS485 is the most widely used two-way and balanced transmission standard interface in the industry. It communicates in half duplex mode, supports multipoint connection, allows the creation of a network of up to 32 nodes (some driver modules can be increased to 128), has the advantages of long transmission distance (the maximum transmission distance is 1200 m), fast transmission speed (100 kbits/s when 1200 m), and is easy to set up when used for multi station interconnection Bus network with high reliability and wide distribution range [9]. Therefore, the bottom part of the designed power monitoring system adopts RS485 bus structure.

2.3 Video Capture Card

Video Capture Card, also known as video card, can be used to digitize video information, that is, convert it into digital data that can be recognized by the computer, and input the digitized information into the computer for editing, processing, storage or playback. In addition, many video capture cards also have the function of hardware compression, and the acquisition speed is very fast. Using the video capture card, the original videotape video can be converted into digital information that can be recognized by the computer and saved, and then made into VCD, DVD and other video situations. Video capture cards can be divided into broadcast video capture cards, professional video capture cards and civil video capture cards according to the quality level of captured images. The quality of captured images can be divided into high, medium and low levels. The technical parameters of the video capture card are shown in Table 3.

According to the technical parameters shown in Table 3, considering the functional requirements of the design system, the performance of the acquisition card, the system cost and other factors, we decided to use the 10MOONSSDK-2000 video acquisition card of Tianmin. It is compatible with Windows, including Windows VFW software architecture and WDM mode, plug and play, and supports one computer with multiple cards; The video capture speed can reach 30 frames per second, and the images obtained

Table 3. Technical Parameters of Video Capture Card

Number	Project	Parameter
1	Acquisition speed	25 fps
2	Maximum image resolution	1024 * 768
3	Acquisition card	Vision RGB PRO card
4	Graphics card	AGP card above 32 M
5	Video conference software	Comply with rrUH.324 video conference standard

are fluent and smooth; Support to provide a variety of save formats to complete dynamic image capture.

2.4 High Speed Intelligent Spherical Camera

In the remote video surveillance system, the selection of camera hardware is very important, which directly determines the clarity of the system output video surveillance image [10]. After comprehensive consideration of various performance and models of camera equipment, this paper selects high-speed intelligent spherical camera as the remote video surveillance image acquisition hardware equipment of the monitoring system. Table 4 shows the basic configuration parameter settings of the high-speed intelligent spherical camera.

Table 4. Basic configuration parameter settings of high-speed intelligent spherical camera

Number	Project	To configure
1	Optical Zoom	Not less than 22 times
2	Electronic zoom multiple	Not less than 10 times
3	Focal length	3.6–82.8 mm, variable
4	Minimum illumination	Not less than 0.01lx, with automatic color conversion function of day and night images
5	Signal system	PAL
6	Horizontal resolution	Not less than 480 TV lines, with backlight compensation and automatic white balance function
7	Signal-to-noise ratio	50 db
8	Working temperature	−35~+60 °C
9	Rotation angle	Horizontal continuous 360°;Vertical 0–90°
10	Rotation speed	Horizontal 0.5–300°/s manual;300°/s preset cruise
11	Programmable preset position	No less than 64

As shown in Table 4, it is the basic configuration parameters of the high-speed intelligent spherical camera used in the power system remote video monitoring system set in this paper. The camera has automatic scanning, automatic cruise and alarm linkage output functions, which can collect remote video images of power system in real time and ensure the quality of collected video images.

3 Software Design of Remote Video Monitoring System for Power System

3.1 Power System Remote Video Monitoring Image Filtering Processing

In the power system remote video monitoring system, the monitoring image acquisition and filtering processing are very important, which directly affects the quality of video monitoring.

Whether we can directly obtain the gray-scale image or the gray-scale image obtained by color conversion, there will be some noise in these images. Noise will have a great impact on the quality of the image, so we usually take the method of removing noise to correlate the image.

There are common methods to remove noise. We usually use the median filtering method. Its working principle is to replace each point in the picture with the median value of each point in its field, so that the pixel values around it can be close to each other, reducing the impact of noise on the picture. At first, this method is suitable for single dimension digital signal processing, and then it can be applied to two-dimensional images. The processing method of median filtering can reduce the effect of unclear picture caused by linear filtering, and can also alleviate the interference of filtering pulse and the scanning noise of picture [11].

Median filtering can not only deal with the characteristics of isolated point noise, but also maintain the edge characteristics of the image, which is very suitable for the relevant experiments of face images. During the operation of median filtering, a single sliding window containing several points is often selected, and the median value of the gray value of each point in the window replaces the gray value of the specified point. Since the image is a two-dimensional distribution, the size and shape of the selected window will greatly affect the filter effect. The median value is defined as follows: if N the observed values are $X1, X2, XN$, the input expression of the median filter is:

$$med(x_i) = \begin{cases} x_{k+1}, n = 2k + 1 \\ \frac{1}{2}\left[x_k + x_{k+1}\right], n = 2k \end{cases} \tag{1}$$

among them, x_k in the window $2k + 1$ or $2k$ median of data.set up $\{x_i\}(1 \leq x \leq N)$ is the image signal containing noise, m_i for with x_i is the center and the length is $n = 2k + 1$ the median value of all data in the sliding window of, that is:

$$f_i = \begin{cases} 1, |x_i - m_i| \geq T_d \\ 0 \end{cases} \tag{2}$$

Among them, T_d represents the noise threshold of the power system remote video surveillance image; $f_i = 1$ indicates that this point is the noise point to be removed; $f_i = 0$ it indicates that this point is a normal signal point. Through constant adjustment T_d most of the signal noise in the remote video surveillance image can be removed.

3.2 Power System Remote Video Monitoring Background Update

After the system remote video monitoring image filtering processing is completed, the next step is to update the design of the power system remote video monitoring background to achieve the ideal segmentation effect of the video monitoring image. Avoid the problem of undesirable segmentation and wrong segmentation when directly subtracting the current frame from the original background image for image segmentation.

Because the change of light is a kind of interference information, the change of pixel gray value caused by this change will be far less than the change of pixel gray value caused by moving objects when they pass, so the background update can only update those pixels whose gray change is less than the threshold value through threshold comparison, that is, the area where no moving objects appear. The selection update method is expressed by the formula:

$$D_{p1} \succ T \tag{3}$$

$$B_{pt1} = B_{pt-1} \tag{4}$$

$$B_{pt1} = C_{pt-1} \tag{5}$$

Among them, D_{p1} indicates the gray difference between the current remote video surveillance image and the background image; T represents threshold pixels; B_{pt1} represents the updated background image pixel value; B_{pt-1} indicates the pixel value of the background image that has not been updated; C_{pt-1} indicates the pixel value of the field input image of the power system in the previous frame. In the designed power system remote video monitoring system, threshold pixels should be strictly selected. If the threshold is not properly selected, it is difficult to distinguish moving objects from background, resulting in a large gap between the updated background image and the actual background image, and losing the value of tracking the actual background.

3.3 Remote Video Monitoring of Power System Operation Conditions

After the above power system remote video monitoring background is updated, on this basis, a remote video monitoring module is designed to carry out remote video real-time monitoring of power system operating conditions. The functional composition structure of the remote video monitoring module designed in this paper is shown in Fig. 2.

As shown in Fig. 2, the power system remote video monitoring module designed in this paper includes a total of 6 functions. The video to be monitored can be selected in the tree form according to the region > regional monitoring center > substations of various voltage levels > monitoring area > cameras (which can be multiple cameras,

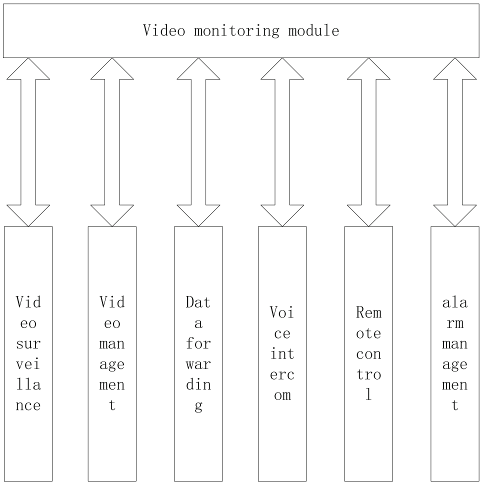

Fig. 2. Functional composition of remote video monitoring module

and can be divided into one main camera and multiple auxiliary cameras according to the monitoring target). The video information of substations under the jurisdiction of the region can be monitored in real time, and multiple (1, 4, 9, 16) real-time videos of the same substation can be monitored in real time, and the simultaneous monitoring of one machine on the same screen can be realized; It can simultaneously monitor single real-time video of multiple substations (1, 4, 9) in real time; Multi angle video of the device can be monitored at the same time. Different regional inspection centers can only monitor the video of their substations. You can click the multi angle real-time video (referred to as multi angle video for short) of multiple cameras of the primary equipment monitored at the same time by the primary equipment in the substation layout plan or primary equipment connection diagram carried by electronic map.

Relevant videos can be directly viewed according to the deployment, withdrawal and alarm status on the layout plan of the substation. On this basis, the automatic patrol function of the remote video monitoring system is set to conduct video patrol on the monitoring points of the system. The objects participating in the round patrol can be set arbitrarily, including the videos of different substations, different cameras of the same substation, different preset positions of the same camera, etc. The interval time of the round patrol can be set, and the cameras that complete the round patrol task can be automatically reset.

3.4 Real Time Transmission of Remote Video Image Based on RTP Technology

Next, RTP technology is used to design the real-time transmission function of remote video image in power system. RTP is a transmission protocol designed by IETF for real-time transmission of video and audio. RTP protocol is generally located above UDP protocol and functionally independent of the underlying transport layer and network layer, but it cannot exist as a single layer. Usually, it uses the low-level UDP protocol to multicast or unicast real-time video and audio data, thus realizing the transmission of multi-point or single point video and audio data.

The connection between RTP transmission service users is called RTP session. For each session participant, the session is identified by a pair of transport layer addresses (that is, one network layer address plus two port addresses, one port is occupied by sending/receiving RTP messages, and the other port is occupied by sending/receiving RTCP messages).

In multimedia data communication, different media types of data are transmitted by different RTP sessions, so RTP sessions correspond to the logical channels contained in the multimedia connection. With the help of RTCP, session participants can not only monitor the quality of data communication, but also perform some basic session control functions, such as participating in/exiting the session, identifying other participants, and controlling other communications. In the RTP protocol, there is no specific limit on the type of transmission services that the underlying network can provide. Generally, the RTP protocol is combined with the IP protocol stack and runs on UDP, as shown in Fig. 3.

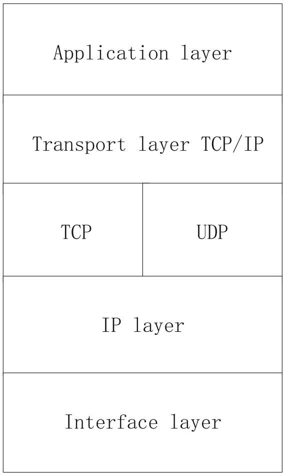

Fig. 3. Location of RTP protocol in protocol stack

As shown in Fig. 3, the RTP protocol itself does not guarantee the reliability of any data transmission. It is not responsible for resource reservation, does not guarantee the quality of service of the transmitted services, and does not guarantee the orderliness of data packets. These tasks are completed by other protocols or the underlying network. This is also the price paid to ensure real-time performance. At the sending end, the upper application program transmits the encoded media data to the RTP communication module in the form of packets. As the payload of the RTP message, the RTP communication module will add the RTP header in front of the payload according to the parameters provided by the upper application to form the RTP message, which will be sent through the socket interface to select the protocol.

The channel from the substation to the main station is optical cable. The optical cable is directly placed to the optical distribution frame in the communication room of the substation. Through the pigtail, it is directly jumpered to the network switch without passing through SDH. The network switch needs to be equipped with optical fiber connection or equipped with optical fiber transceiver. The data signals output by the RPU are directly uploaded to the regional master station or provincial master station through the network switch. The master station is equipped with SDH that provides Ethernet interface, output signal to network switch of master station system through Ethernet interface.

The direct optical fiber transmission mode can be used to transmit video lesson data, which is suitable for occasions with high requirements for image quality. The raw data is not compressed after analog-to-digital conversion, achieving the maximum degree of non damage during transmission, and obtaining the image effect with the lowest distortion when displayed at the back end. After the collected video data is compressed, it is transmitted to the receiving end of the system through the network protocol, thus realizing the goal of real-time image transmission of the remote video monitoring system of the power system.

4 System Test

In order to objectively analyze the feasibility and application effect of the power system remote video monitoring system proposed in this paper, the system test is carried out as shown below. The system is verified in terms of integration stability and effectiveness by means of actual operation, verification test cases and other test means, and the possible errors, causes and distribution are summarized to ensure the normal operation of the system. The system can be put into use in the power system only after the function and performance of the system meet the relevant requirements.

4.1 Test Preparation

For the test of this system, the operating system WINDOWS7 or WINDOWS SERVER 2000 browser E10. According to the above discussion, the remote video monitoring system of power system is built, and the system test environment is built according to the requirements of system operation. The system test environment information is shown in Table 5.

According to the configuration performance parameters shown in Table 5, the system test environment was built to provide a good guarantee for the system test. The system tests the network topology, as shown in Fig. 4.

According to the network topology shown in Fig. 4, the LAN network type is adopted, and the network bandwidth is set to 100 Mbps. Users can connect to the server through the remote login software of the client to view the system operation, which can minimize the impact on the server; Users can use all kinds of mainstream browsers to view the Web server. The types of browsers are unlimited, and there is no need to add any plug-ins; The server needs to install and set various software resources needed to start the system. The

Table 5. System Test Environment Information Description

Model	Configuration/performance parameters
Server compatible computer	CPU: Intel Xeon E5-2620 v4 Main frequency: 10 GHz Memory: 32 GB Hard disk: 100 GB
Client compatible machine	CPU: Intel Core i7-7700 Primary frequency: 3.60 GHz Memory: 16 GB Hard disk: 128 GB+2 TB
Browser	Mainly IE10, IE11 and Google browser
Database system	PostgreSQL 1.0

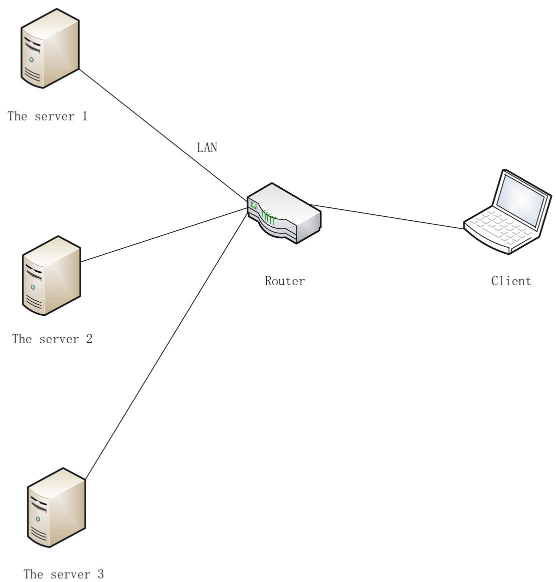

Fig. 4. Schematic diagram of system test network topology

mainstream PostgreSQL database is selected for the database, and it is easy to conduct secondary development later.

The system has unlimited requirements for client hardware. The system server does not need cluster. In the server hardware, the intermediate proxy server needs to receive and process a large number of RTP data packets. The Web end and database are selected to be placed on the same server. Both servers need 16 core CPUs and large hard disk space, while the AES server is a server that connects the external network and the internal network to exchange commands with lower requirements; There is no requirement for mobile phones. You can only receive WeChat enterprise account messages online.

4.2 Result Analysis

After completing the above system test preparation and function test, the next step is to test the operation performance of the power system remote video monitoring system. In order to make the system test results more convincing and comparative, the method and principle of comparative analysis are introduced. The power system remote video monitoring system based on RTP technology proposed in this paper is set as the experimental group, and the an intelligent and cost-effective remote underwater video device for fish size monitoring (The system of reference [4]), Design of the Power System and Remote Control System for the Unmanned Ship (The system of reference [5]) are set as the control group to make an objective comparison and analysis of the operation performance of the 3 systems. The packet loss rate of power system remote video monitoring system is selected as the evaluation index of this test. The packet loss rate (Loss Tolerance or Packet Loss Rate) refers to the ratio of the number of packets lost in the test to the number of data groups sent. The calculation formula of packet loss rate is:

$$Q = [(M_a - M_c)/M_a] \times 100\% \tag{6}$$

Among them, Q indicates packet loss rate of power system remote video monitoring system; M_a indicates system input message; M_c Indicates system output message. The packet loss rate is an important factor that affects the real-time performance of video in the study of real-time performance of remote video monitoring transmission in power system. In the whole system test process, the network data packet loss rate is calculated by the number of video data packets lost during network transmission, so the number of network packet losses must be calculated. The specific process is described as: the video capture device end establishes communication with the network through 3G wireless network, the client software runs on the Windows platform, and is connected to the network in a wired form. During the test process, specify that the sending end of the device sends video packets every 10 min.

Finally, count the amount of video data sent by the sender, add variables in the receiver program to count the total size of the received data, and add timers for encoding start time and encoding end time at the shooting end to calculate encoding time. In addition, the Framecount variable is added to the program to count the number of frames encoded, which is used to calculate the frame rate. The so-called packet loss number is the difference between the sent data and the received data, and the packet loss rate is calculated based on the number of packet losses.

Set the operation time of the power system remote video monitoring system as 24 h, 48 h, 72 h, 96 h, 120 h and 144 h respectively, use MATLAB simulation analysis software to measure and calculate the corresponding packet loss rate of the system when the monitoring time gradually increases, make a comparison, and then judge the performance test effect of the proposed monitoring system. The comparison results are shown in Fig. 5.

From the comparison results in Fig. 5, it can be seen that the packet loss rates of all three monitoring systems increase with the increase of system operation time. Among them, the highest packet loss rates of the system of reference [4] and the system of reference [5] reached 4.7% and 3.2% respectively, while the corresponding packet loss rates of the designed system during each operating period were below 1%, which was

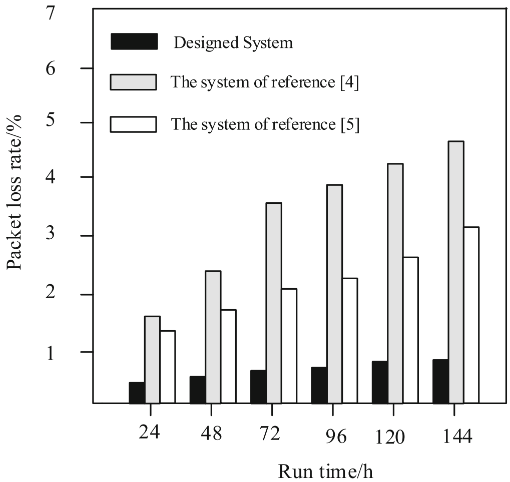

Fig. 5. Comparison Results of Packet Loss Rate of Power System Remote Video Monitoring System

smaller than the comparison system and did not experience significant fluctuations. From the comparison results, it is easy to see that the monitoring system proposed in this paper has a low packet loss rate, a high real-time remote video monitoring, good network status and system monitoring effect, and a high stability of the system operation, which meets the requirements of the power system remote video monitoring system and can meet the development needs of power enterprises in an all-round way.

5 Conclusion

With the in-depth development of digitalization and networking, the rapid development of video monitoring system has brought good opportunities, which has gradually expanded the application scope and application field of video monitoring system, and has an inseparable relationship with people's life. At present, video surveillance system has become a hot spot in the field of social security. With the development of network, the function and performance of remote video monitoring system are gradually improved. In order to improve the problems and shortcomings of the remote video monitoring system used in the current power system in terms of operation function and performance, this paper introduces RTP technology and proposes a new remote video monitoring system for power system. The hardware system of this article consists of EWS, bus controller, video capture card, and high-speed intelligent ball camera. Based on this, RTP technology effectively improves the quality and efficiency of the monitoring system operation, enhances the real-time performance of the video, and achieves the goal of real-time monitoring. It also lays the foundation for future system upgrades.

In addition to the basic real-time video monitoring function, future research can consider expanding the application scenarios of this design. For example, combining sensor data and Big data analysis, more comprehensive power system status monitoring and fault diagnosis functions can be realized.

References

1. Hidayat, R., Reza, F., Herawati, et al.: Remote monitoring application for automatic power supply system in telecommunication network. J. Phys. Conf. Series **1933**(1), 012103 (2021)
2. Wang, J., Zhao, Q., Ye, Q.: Design of remote monitoring system for substation DC power supply under the background of big data. J. Phys: Conf. Ser. **2037**(1), 012005 (2021)
3. Xu, S., Leng, X.: Design of real-time power quality monitoring system for active distribution network based on computer monitoring. J. Phys. Conf. Ser. **1992**(3), 032127 (2021)
4. Coro, G.: An intelligent and cost-effective remote underwater video device for fish size monitoring. Ecol. Inform. Int. J. Ecoinform. Comput. Ecol. **63**(1), 101311 (2021)
5. Zhang, H., Zhang, Z.: Design of the power system and remote control system for the unmanned ship. J. Phys. Conf. Ser. **2121**(1), 012021 (2021)
6. Cheragee, S.H., Hassan, N., Ahammed, S., et al.: A study of IoT based real-time solar power remote monitoring system. Int. J. Amb. Syst. Appl. **9**(2), 27–36 (2021)
7. Yang, L., Dai, M., Wang, H., et al.: A wireless, low-power, and miniaturized EIT system for remote and long-term monitoring of lung ventilation in the isolation ward of ICU. IEEE Trans. Instrum. Meas. **70**, 1–11 (2021)
8. Abdullah, H.M., Hariati, A.M., Fakhri, M., et al.: Raspberry Pi based IoT for aquaculture realtime remote monitoring system with self energy harvesting. IOP Conf. Series Mater. Sci. Eng. **1077**(1), 012062 (2021)
9. Golovan, A., Honcharuk, I., Deli, O., et al.: System of water vehicle power plant remote condition monitoring. IOP Conf. Series Mater. Sci. Eng. **1199**(1), 012049 (2021)
10. Liu, S., Wang, S., Liu, X., et al.: Human inertial thinking strategy: a novel fuzzy reasoning mechanism for IoT-assisted visual monitoring. IEEE Internet Things J. **10**(5), 3735–3748 (2023)
11. Ahmid, M., Kazar, O., Kahloul, L.: A secure and intelligent real-time health monitoring system for remote cardiac patients. Int. J. Med. Eng. Inform. **14**(2), 134–150 (2022)