Current Status and Development of Satellite Earth Station Monitoring Systems (Postprint)

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Abstract

Broadcast television satellite earth stations undertake the critical task of long-distance transmission and coverage of uplink programs, with extremely high requirements for broadcast safety and security levels. For the monitoring systems of satellite earth stations, in addition to machine room equipment, it is also necessary to monitor the signal transmission process. Only by ensuring that the monitoring and control of both achieve the objectives of precision and efficiency can the effectiveness of the broadcast television monitoring system be guaranteed. This article primarily takes the monitoring system of broadcast television satellite earth stations as the entry point, analyzes the current status and development of monitoring systems, and explores the core technologies in monitoring system design on this basis.

Full Text

Status and Development of Satellite Earth Station Monitoring Systems

Abstract: Broadcast television satellite earth stations undertake the critical task of long-distance transmission and coverage of uplink programs, with extremely stringent requirements for broadcast safety standards. For satellite earth station monitoring systems, in addition to equipment in the machine room, it is also necessary to monitor the signal transmission process. Only by ensuring precise and efficient monitoring and control of both can the effectiveness of broadcast television monitoring systems be ensured. This article focuses on broadcast television satellite earth station monitoring systems as the starting point, analyzing the current status and development trends of such systems, and exploring the core technologies in monitoring system design.

Keywords: Broadcast Television; Satellite Earth Station; Monitoring System; Current Status; Development

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With the rapid development of broadcast television today, an increasing number of digital, networked, and intelligent devices are being deployed. Compared to the past, broadcasting systems may appear more complex, but the application of numerous new devices has made the entire signal flow clearer and fault node identification faster, significantly improving the reliability of safe broadcasting. To further ensure broadcasting safety, we recognize that monitoring systems must evolve toward digitalization, networking, and intelligence. As satellite earth stations constitute a critical link in broadcast television program signal modulation and transmission, and given the extremely wide coverage of satellite broadcast signals, it is essential to emphasize their role in ensuring program signal security. Based on this, this article begins with this focus to analyze the current status and development of satellite earth station monitoring systems, thereby identifying optimal design approaches for these critical systems.

1. Current Status Analysis of Satellite Earth Station Monitoring Systems

Current satellite earth station monitoring systems can be primarily divided into two components: monitoring and control. The former is responsible for data collection, alarm generation, and presentation of equipment and signals, while the latter processes monitoring data and alarm information to control system equipment and ensure normal output. The control component can be automated, manual, or automatically executed after confirmation by monitoring personnel.

1.1 Monitoring Objects

The primary function of satellite earth station monitoring systems is to effectively monitor the status of the monitored system. Since a complete system consists mainly of equipment and connection lines, specific monitoring tasks include monitoring of both equipment and signals. Equipment monitoring is primarily implemented through polling and reading interfaces, while signal monitoring employs bypass listening or store-and-forward methods, passively monitoring transmitted data and copying the information[1]. In the broadcast television industry, both equipment and signal monitoring require focused attention.

Since signal monitoring depends on specific signal types, bit rates, interfaces, and monitoring requirements, making detailed description difficult, this article will not delve deeply into this topic. Equipment monitoring also depends on device interface protocols, which specifically include the following connection methods:

(1) **Serial device connection method.** Also known as the COM port method, this is an early data communication interface that has been widely used in communication and computer equipment due to its easily

implementable physical characteristics. In subsequent developments, this interface has evolved into varieties such as RS323, RS422, and RS485 with different speeds. In practical use, normal communication can be achieved simply by configuring both devices with the same mode and parameters[2].

(2) **RJ45 Ethernet port connection method.** This connection method is widely used in equipment and signal monitoring. Based on TCP/IP protocol network applications, this port is extremely convenient to use. The disadvantage is that the TCP/IP protocol is primarily operating system-based, making the design of low-level devices relatively complex. Of course, derivatives of this interface now exist. Through the Simple Network Management Protocol (SNMP), which provides a method for directly collecting management information from network devices, this protocol can poll devices for data, thereby enabling proactive provision of device data.

(3) **Other connection methods.** Connection methods not belonging to the above two categories are collectively referred to as other methods, such as SCSI interfaces accessible via the ASPI protocol, or fiber optics compatible with TCP/IP protocols accessible through sockets[3].

1.2 Monitoring Objectives

In the broadcast television industry, the quality of program video and audio received by end users serves as the two criteria for determining signal normality. Once a signal error occurs at a specific time point, it cannot be remedied through retransmission. Therefore, in broadcast television systems, how to ensure normal video and audio is a critical issue. Based on the characteristics of current satellite earth stations, monitoring objectives can be primarily divided into the following points:

(1) **Real-time monitoring.** Presenting data to duty personnel in real time. Signal monitoring includes both real-time signals and background query of cached images, as well as simultaneous monitoring at multiple distributed points.

(2) **Archival for future reference.** Data under normal system operation is not particularly important; the purpose of data storage is to enable fault data review and cause analysis when problems occur.

(3) **Statistical analysis.** Comparing and analyzing equipment status, signal status, internal logical structures, and protocols to verify compliance with standards and protocol requirements.

(4) **Alarm alerts.** Detecting abnormalities through signal analysis, generating alarm alerts, and classifying severity levels based on the degree of signal anomaly.

(5) **Emergency strategies.** When the primary broadcast signal fails, monitoring equipment should feature audio alarms and graphical display func-

tions, and achieve broadcast recovery through emergency substitution or automatic signal source switching.

2. Future Development of Satellite Earth Station Monitoring Systems

2.1 Future Development Requirements

With the rapid advancement of digitalization in broadcast television programs, an increasing number of high-definition program signals are being output. For high-definition program production, the investment costs are higher, and monitoring requirements for programs are also more stringent. Therefore, satellite earth station monitoring equipment needs to evolve toward intelligence, while comprehensively considering stability, advanced features, and future scalability. Specifically, the following requirements must be met:

(1) **Standardization of equipment module design.** Currently, broadcast television monitoring systems employ a wide variety of equipment types with complex internal structures. Therefore, in future development, intelligent monitoring systems for satellite earth stations should adhere to design standardization principles, requiring standardization of structures, modules, drivers, etc., thereby effectively enhancing future system function expansion capabilities.

(2) **Humanized display interface.** A humanized, intuitive monitoring display interface enables monitoring personnel to understand the situation more directly. Simultaneously, future development should also implement user-customizable settings with query functions, allowing real-time status of different devices in the monitoring system to be understood directly from a graphical interface.

(3) **Intelligent monitoring alarms and operation management.** Future monitoring and alarm systems need to achieve intelligence, including directly issuing alarm signals through sound and video when faults occur in equipment and signal monitoring, not only identifying fault locations but also providing emergency handling solutions. Simultaneously, data from that moment will be automatically stored to provide a basis for future reference.

2.2 Specific Technical Design for Future Development

We take a broadcast television satellite earth station as an example. The station has over 500 devices of more than 60 types. To ensure real-time collection and alarming of equipment and signals, match emergency strategies and deliver them to staff, while guaranteeing the principle of "one-second alarm, three-second handling," system technical design should proceed from the following aspects:

(1) **System model.** Based on the specific circumstances of broadcast televi-

sion satellite earth station monitoring systems, the model can be divided into four modules: data collection, data control, data storage, and information dissemination. Among these, data collection is primarily responsible for collecting equipment and signal data, generating alarms, and promptly transmitting both types of data to the comprehensive processing module. Alarms in this module are implemented in two main ways: one is directly reading alarm information issued by equipment or signals; the other is generating alarms when read status data exceeds preset thresholds. As mentioned earlier, due to the evolution of equipment diversity, monitoring equipment and signals requires reading data through multiple interfaces, and even controlling equipment to change data status through interfaces. Therefore, to ensure monitoring efficiency, we can create dynamic link libraries for specific devices to serve as a bridge, achieving unified data interfaces, thereby solving the problems of increasing monitoring equipment types and increasingly heavy data collection tasks[4]. The comprehensive processing module is primarily responsible for matching emergency strategies with read data, providing users with a confirmation interface to decide whether to implement emergency operations. Therefore, it has high requirements for processing timeliness and shoulders the responsibility of relaying data transmission. As the interface directly accessed by users, this module can adopt either a client/server structure or a browser/server structure. The former offers convenient operation but requires installation of dedicated software, while the latter allows direct access through web browsers but has lower operational responsiveness.

(2) **Data transmission.** With system modules determined, it is also necessary to research and analyze data transmission issues between different modules, particularly data transmission between the data collection module and the comprehensive processing module. Taking the 500 devices in this television station' s satellite earth station monitoring system as an example, to achieve "one-second alarm," each device must be read at least 3-5 times per second. If each read generates one data packet, this means 1,500-2,500 data packets are generated per second from reading data. Assuming the status read from a single device is 50 bytes, the traffic per second would be 73-122K. Due to the large number of data packets, system operational efficiency decreases. To solve this problem, it is necessary to generate the status data read by the dynamic link library assigned to the program equipment in a single batch and send it centrally to the comprehensive processing server for unified processing, thereby significantly reducing the number of data packets while keeping the total data traffic unchanged.

(3) **Emergency strategies.** Emergency strategies are the core of satellite earth station monitoring systems and the key to achieving "one-second alarm, three-second handling." First, emergency strategies should be triggered by alarms. If alarm signals are matched periodically during normal system operation, overall performance will degrade. Therefore, emergency

strategies should be matched when alarms are issued. Second, preset emergency strategy priorities. When handling alarm emergencies, strategies should be automatically matched to the corresponding level and prioritized from highest to lowest. Finally, due to the strong coupling between different equipment and signals in the broadcast television field, issuing an alarm often triggers a chain reaction, leading to continuous alarms. Therefore, emergency strategy matching must be simple and efficient.

In summary, as broadcast television technology continues to upgrade and evolve toward greater complexity, traditional manual operation methods can no longer meet contemporary demands. As a critical position for broadcast television program signal transmission and coverage, satellite earth stations must adopt more advanced technical means to counter various signal attacks and disruptions, ensuring broadcast television safety. Based on the current status of satellite earth station monitoring systems, future development should move toward digitalization, networking, and intelligence, not only improving monitoring accuracy and response time but also enhancing anti-interference technology, thereby comprehensively ensuring broadcast television safety and contributing to the steady development of China' s broadcast television industry.

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Note: Figure translations are in progress. See original paper for figures.