Design and Implementation of Master Control Security Monitoring for Wuhan Radio Station: Postprint

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Abstract

This article provides a detailed introduction to the security monitoring architecture design of the broadcast master control system at Wuhan Radio and Television Station in the context of new broadcast technologies, along with the specific functions that can be implemented.

Full Text

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Abstract: This paper presents a comprehensive design of the safety monitoring architecture for the broadcast master control system of Wuhan Radio and Television Station under new broadcast technology conditions, along with the specific functions implemented.

Keywords: monitoring; safety; functionality

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1. Overall Architecture of the Master Control System

The master control system of Wuhan Radio and Television Station employs digital passive audio distributors, digital audio matrices, and network audio

matrices as key components of its overall architecture to accomplish signal aggregation, scheduling, distribution, and transmission for all studios, external transfers, and relay broadcasts. Building upon this foundation, we have designed an advanced intelligent monitoring and emergency response system, creating a complete intelligent digital master control system that enables comprehensive monitoring and supervision of the entire broadcast workflow, including audio workstation system monitoring, key-point audio signal monitoring and listening, critical equipment monitoring in all studios, system fault alarming, fault analysis and emergency handling, audio program recording, and video signal monitoring. This ensures safe broadcast operations while implementing effective safety monitoring for the master control system. The safety monitoring design is detailed below.

1.1 Signal Transmission and Distribution in the Audio Network

Studio console output signals are directly fed to intelligent switchers and then transmitted to optical transmitters. Seven channels of external transfer signals are input into the digital matrix, enabling transmission and switching of external signals with level adjustments.

1.2 Audio Signal Monitoring

Key-node audio signals in the transmission chain of each frequency are monitored and listened to visually. All critical node audio signals for each frequency are displayed on workstation screens.

1.3 Equipment Monitoring

Critical audio equipment throughout the program broadcast process (such as consoles, delay units, digital audio distributors, and other peripheral devices) is monitored in real time, with fault warnings issued when failures occur. The system signal flow and key equipment are displayed on large screens through monitoring workstations.

1.4 Video Monitoring

Video signals collected from studios, director rooms, and corridors are connected to the digital master control network through a real-time video recording and encoding host, enabling linkage between monitoring points and video images.

1.5 Environmental Monitoring

ESM-888 status collectors are configured for critical equipment in each studio, director room, and master control room to monitor temperature, humidity, and level values. The collected data is displayed on screens in real time, with alarms triggered when monitored parameters exceed preset thresholds.

1.6 Audio-Video Signal Control and Emergency Handling

The control room is equipped with six application workstations for fault analysis, emergency handling, integrated management, network control, preview, and listening. These workstations can monitor, control, and manage each frequency's program broadcast, and implement emergency response measures when various faults occur.

1.7 Slow-Recording Audio and Monitoring Signal Storage Media

Four servers are installed in the master control room: an audio server for slow-recording of five frequencies of Wuhan Radio and Television Station, an ESM-888 monitoring data collection server, a CAS2000 and IASP status collection server, and a video monitoring server. The system framework is shown in Figure 1 [Figure 1: see original paper].

2.1 Master Control Broadcast Signal Transmission

The system architecture is designed to implement signal transmission and switching functions for the master control system. All input and output signal lines of the master control system are aggregated to patch panels in the master control room (15 sets of 16-channel XLR input/output) for signal scheduling and distribution.

All six studio console source signals include microphones, computer workstations, peripheral equipment, output signals from the other five studios, direct signals from the central console, and external transfer signals from the digital audio matrix, with primary and backup lines laid for each. Signals output from the six studios pass through audio distributors and delay units. The primary signal is sent directly as a mutual backup signal for each studio, while another path passes through a delay unit into an audio distributor, where it is split into three channels: one directly to an automatic program filler as the main output signal, one into the intelligent monitoring network as a backup main output, and one into the digital matrix for in-station signal scheduling.

The digital audio matrix is primarily used for scheduling external transfer signals and backing up studio output signals. The intelligent monitoring network simultaneously monitors external transfer signals and studio output signals while providing output backup.

Five stereo signals from the transmission department (two channels of China Voice, one channel of traffic information, and two channels of live broadcast) and two digital signals are adjusted, converted, and distributed through the digital audio matrix before being sent to the broadcast control system.

To ensure absolute safety of the main transmission channel, the main output signal from the studio console passes through the primary delay unit and audio

distributor directly to an automatic switcher. After selection and switching, the signal is sent to the transmission department for output, minimizing intermediate links.

Another digital audio signal output from each studio console is sent to the CAS1600D network audio monitoring terminal, while eight channels of external transfer signals are sent to the CAS1616D network audio monitoring terminal. In addition to real-time quality parameter analysis of these signals, the audio monitoring terminal encodes the audio signals into IP audio data packets for network transmission and distribution, thereby forming a network audio matrix. The studio console signal output from the network audio matrix is sent to the automatic audio switcher as the third audio source for the switcher.

2.2 Logical Structure Design of the Master Control System

The intelligent network master control system adopts a three-layer structure design, including signal acquisition, signal analysis, and information display. The signal acquisition layer is responsible for data collection, including audio signals, equipment status, and environmental parameters. The signal analysis layer includes data processing, analysis, and computation. The information display layer includes large-screen display, information retrieval, and monitoring applications.

2.3 Intelligent Monitoring of the Master Control System

Based on analysis of various elements for safe broadcasting and according to our station's actual conditions and the spirit of the State Administration of Radio, Film and Television's "White Paper on Networked Construction of Chinese Radio Stations," this system employs digital, modular, networked, and intelligent audio equipment to build a program broadcast master control system with a friendly operation interface, complete functions, and safety monitoring capabilities, thereby improving the station's safe broadcasting efficiency.

2.4 Signal Status Monitoring of the Master Control System

The intelligent monitoring network receives broadcast signals from six studios for each frequency, seven channels of external transfer audio signals, and six channels of FM and four channels of AM off-air signals collected by a specially configured professional multi-channel FM/AM demodulator. Through the ASM-16D, real-time monitoring of audio signal quality is performed. The system displays audio signal status parameters and can perform real-time level analysis of input audio signals, including parameters such as L/R/L+R levels,

phase, distortion, noise, and AES status values. It also features professional instrument-level real-time analysis of phase and Lissajous figures, as well as spectrum analysis capabilities. Monitored signals can be flexibly grouped and displayed on screens by category. When audio signals are abnormal, the system immediately alarms and displays on the large screen while implementing emergency handling according to the response level.

2.5 Equipment Status Monitoring of the Master Control System

The intelligent monitoring network monitors the working status of equipment in real time through equipment status monitoring terminals. When equipment "abnormal states" are detected, the equipment is displayed graphically on the screen and alarm signals are issued.

Delay Unit Monitoring: Graphically displays the working status of delay units and shows important parameters (delay time, deletion). Monitors the working status of broadcast stations and displays important parameters.

Digital Matrix Monitoring: Graphically displays the working status of the matrix. When matrix faults occur, automatic emergency handling is implemented within a specified time limit to ensure transmission signal continuity.

Equipment Abnormal Alarm and Emergency Handling: When equipment operation shows abnormal status or operates in a critical state, the system provides alarms through "text prompts," "sound," "flashing lights," and other methods, as shown in Figure 2 [Figure 2: see original paper].

The intelligent monitoring network management platform is configured with accident levels and publishes alarm information to various management terminals in real time according to requirements, enabling real-time management. The monitoring management platform can query alarm information and logs, and provide equipment fault phenomenon analysis reports, including time, basic parameters, fault points, and environmental data.

2.6 Environmental Monitoring of the Master Control System

Through equipment status monitoring terminals, the working environment of monitored equipment is supervised, including parameters such as temperature and humidity. The system also monitors the electrical load of core broadcast equipment. For situations such as staff absence or leaving their post (exceeding specified time limits), the system automatically issues alarm prompts and publishes information to relevant management terminal devices.

2.7 Closed-Circuit Video Monitoring

High-resolution network cameras with audio collection are deployed in six studios and six director rooms, with four network cameras installed in the fourth and fifth floor corridors. In this video safety monitoring design, a video recording and encoding host is selected, allowing monitored video signals to be monitored and played back in real time by the master control video monitoring and recording workstation.

Video monitoring data is saved by the video real-time recording and encoding host to the monitoring audio-visual storage library. To ensure that monitoring audio-visual data is retained for at least two months for review, and under the requirement that video storage resolution is not lower than 640$×$480, we select a universal format requiring approximately 5-8 TB of storage space. Users can control storage space by adjusting video retention time, storage resolution, and bit rate.

The video monitoring of our station's studios, director rooms, and corridors is shown in Figure 3 [Figure 3: see original paper].

2.8 Large Screen Functionality of the Master Control System

Our master control system primarily implements full-process monitoring, alarming, and control operations for program broadcasting, while also displaying relevant content in the most direct manner. Therefore, we have designed a large-screen display wall that presents monitored equipment and various parameters in intuitive graphical form. By networking the monitoring system with the video surveillance system, video surveillance images and equipment monitoring are linked, enabling duty personnel to have a clear overview of the entire system's operational status.

The large screen is divided into multiple smaller screens, as shown in Figure 4 [Figure 4: see original paper]. Users can customize the content displayed on each screen. For studio signals and external transfer signals, users can customize color bar monitoring interfaces with arbitrary quantities and layouts, enabling mixed display monitoring and alarming of video, audio color bar signals, and temperature/humidity data.

2.9 Monitoring Workstation of the Master Control System

The monitoring workstation primarily performs real-time listening of frequency audio signals. The monitoring workstation in our master control system uses a 17-inch touchscreen for convenience and efficiency.

The monitoring workstation conducts intelligent monitoring through a volume color bar interface. The monitoring interface can be arranged and combined according to signal types and channels. Volume color bars for each signal are displayed in real time on the monitoring interface. The monitoring station is shown in Figure 5 [Figure 5: see original paper].

On the monitoring interface, each monitoring point can be arbitrarily positioned according to the audio signal flow. Four listening modes can be implemented on the interface: cyclic listening, manual selection listening, timed listening, and triggered listening.

2.10 Status Monitoring and Fault Analysis of the Master Control System

The master control system comprehensively monitors the working status of the entire audio broadcast system, including audio signals, equipment status, environmental status, and broadcast system status. The monitoring workstation displays the current operational status of equipment and signals for each frequency throughout the system.

The workstation's main monitoring interface displays the current status of each channel, equipment, and broadcast system. When audio signals or equipment status faults occur, the corresponding status bar changes, flashes, and displays different colors. Simultaneously, the system begins timing the fault duration, enabling rapid assessment of whether the entire system is operating normally. When the audio system experiences faults, alarms are issued through voice, sound, and light methods.

The large-screen display equipment configured for the master control system (including audio signal comprehensive monitoring stations, audio data analysis/equipment status and environmental monitoring servers, and network audio routing control servers) all use dual-screen displays. The display interface allows users to customize the content shown on each screen, and can dynamically display the working status of key equipment or switch to display monitoring signals from designated studios, enabling multi-screen video monitoring.

2.11 Slow-Recording Subsystem of the Master Control System

Our master control system has also established a new slow-recording workstation, configured with the Lianhui ProDS multi-channel recording system. The Lianhui ProDS multi-channel recording system is developed using the latest technology platform and can form both standalone systems and large-scale networked recording systems to meet various requirements.

The ProDS multi-channel recording system features powerful capabilities, supporting multi-channel recording, stop-broadcast alarming, fast network query, and multiple recording format selection. It can fully satisfy all functions required by the radio station and includes self-management, maintenance, and query listening functions, supporting B/S structure queries.

Our station needs to simultaneously slow-record digital signals from five channels for extended periods and retain three months of historical records. We have designed this using MP3 format, requiring more than 1 TB of disk space. Users can rationally utilize storage space by setting the recording audio file format (sampling frequency, bit rate).

The audio source for the slow-recording system comes from five channels of digital signals returned from the post-processor end of the audio processor. We monitor, collect, encode, compress, and store these five channels of digital broadcast signals (for three months).

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