Design of Monitoring and Control System for Radio and Television Transmitter Stations: Postprint

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Abstract

Since entering the 21st century, with the continuous development of scientific and technological information technology, transmission stations have faced increasingly heavy workloads. Consequently, this paper primarily introduces the design concepts and system composition of a monitoring and control system for a transmission station. Addressing the problems and difficulties existing in transmission station system design, it comprehensively elaborates on the technical architecture and specific applications of FM transmission, television transmission, microwave transmission, as well as environmental and video monitoring systems, and proposes appropriate solutions.

Full Text

Preamble

Title: Design of Monitoring and Control Systems for Radio and Television Transmitting Stations
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Abstract: Since the beginning of the 21st century, rapid advancements in information technology have increasingly burdened transmitting stations with heavy workloads. This paper introduces the design philosophy and system architecture of a monitoring and control system for a specific transmitting station. Addressing existing problems and challenges in station system design, it comprehensively elaborates on the technical frameworks and practical applications of FM transmission, television transmission, microwave transmission, and environmental and video monitoring systems, proposing appropriate solutions.

Keywords: Radio and television transmitting station; Monitoring and control; Safe broadcasting

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1. Design Objectives and Principles

A certain radio and television transmitting station is located in a mountainous area at an altitude of 915 meters, approximately 60 km from the city center. The station broadcasts four sets of FM programs, and after renovation, it relays one provincial television program, one FM program, and one terrestrial digital television program, while also relaying two FM programs from China National Radio. The first phase of the station's monitoring and control system utilizes an optical cable network for management and monitoring, including transmitter status and control, video information, and environmental parameters of the machine room. The system aims to transmit monitoring and management data to remote locations, enabling comprehensive monitoring of FM transmitter rooms. Additionally, for terrestrial digital television transmission and microwave transmission systems, the transmitting station implements real-time monitoring through computers.

1.1 Design Objectives

The primary design objective of the FM transmission monitoring system is to achieve effective control and recording of information, including status logging, alarm management, system parameter adjustment, remote switching, and power control. The system must provide comprehensive information on transmitter status, power on/off conditions, and power amplifier module status, with audio and visual alarms triggered when operating conditions exceed preset thresholds. FM signal monitoring employs a light-bar display for visualization, with audio-visual alarms activated when anomalies occur. Through analog-to-digital conversion, the system achieves data acquisition and recording of power supply, ambient temperature, and humidity parameters, enabling both source signal monitoring and post-transmission signal demodulation monitoring.

The FM transmission system is responsible for signal transmission of the station's four FM programs, transmitter operation, and machine room environmental data. Through graphical interface visualization, it implements a series of critical functions such as remote monitoring and query capabilities. The system comprises multiple functional modules, as the transmitter system bears the crucial task of FM broadcasting transmission. Its normal operation directly impacts safe broadcasting, making FM transmission and environmental monitoring

the focal points of the monitoring system. Furthermore, the ultimate verification of FM broadcasting is wireless reception monitoring, as signal source transmission significantly affects the normal operation of the transmission system. Therefore, wireless reception monitoring must be integrated into the monitoring system. Simultaneously, the transmitter monitoring system must include power supply and ambient temperature monitoring to ensure proper functioning of the transmitter system, providing alarms for power, temperature, and humidity anomalies.

For data recording, video and data servers are installed in the machine room to facilitate convenient query functions, collecting and storing one month of monitoring images and data. Image monitoring is achieved through five cameras installed in the machine room for real-time surveillance. The wireless reception signals of the four FM programs are recorded as audio signals and transmitted to the server in video format. Remote management functions are provided through Ethernet networks, enabling real-time monitoring and remote querying of all images and data. Terrestrial digital television transmission monitoring utilizes network transmission means to monitor the terrestrial digital television transmitter installed on the second floor. Microwave signal transmission monitoring employs microwave monitoring interfaces to monitor microwave transmission and prevent faults such as transmission and reception failures.

1.2 Design Principles

Safety and Reliability Principle: In radio and television monitoring systems, the primary consideration is to prevent the monitoring system from affecting broadcast transmission systems. Network monitoring must be strictly isolated from the Internet.

Advanced Technology Principle: Equipment selection should prioritize currently most advanced devices.

Compatibility Principle: System upgrades should minimize investment costs while ensuring upgradeability and expandability.

Scalability Principle: To facilitate business and functional expansion, system design should adopt a modular structure.

Practicality Principle: Based on China's national conditions, practical equipment should be selected to meet current requirements.

2.1 FM Transmission Monitoring System

The station's main transmitter employs a Harris Z10CD all-solid-state 10kW FM transmitter, which uses two duplexers for signal combining and provides an RS232 communication interface. The combined signal is transmitted through two FM antennas. The Hangchun 5kW transmitter serves as the backup unit

with an open communication protocol. However, using the RS232 interface alone for communication is susceptible to interference due to the distance between the monitoring room and transmitter room. Therefore, in the signal transmission scheme, a protocol converter is installed at the transmitter's RS232 interface through the centralized control computer, converting the signal back to RS232. Considering the data line's high anti-interference capability and transmission performance, the Hangchun transmitter manufacturer adopted the CAN communication protocol, providing a CAN-to-RS232 converter before the communication protocol adapter and using direct CAN transmission converted to RS232 communication protocol.

Power Distribution and Environmental Monitoring: To monitor the three-phase power supply voltage and current of the machine room, data is collected by the centralized control computer. The transmitter is powered through a voltage regulator with an RS232 monitoring interface. Smoke detectors and temperature and humidity sensors are installed in the machine room, with data transmitted to the centralized monitoring computer through data transmission units, triggering immediate alarms upon anomalies.

Audio Signal Monitoring: The FM audio program transmission employs primary and backup channels using optical cable communication and the American BCI Company 1208E 8-channel AES digital audio optical transceiver. The backup channel uses digital microwave transmission after encoding and multiplexing to reach the transmitting station, where decoders restore the AES digital signal. After passing through a three-channel selector, the signal splits into two paths: one digital signal goes directly to the Harris digital exciter, while another goes to the Hangchun transmitter. To simplify processing, audio source signal monitoring selects the analog output signal from the audio processor. When each stereo broadcast signal enters the A/D conversion system and is converted to digital, it is combined into a single analog audio channel that enters the monitoring host through the data transmission unit. The wireless transmission system provides cyclic and manual monitoring modes for four FM signals, using a four-channel cyclic monitoring alarm that sets individual operating time slots for each channel. Within the operating time slot, after a certain time delay, if no FM signal is received or the audio amplitude is too low, audio-visual alarms are triggered, and data is collected and sent to the centralized control computer through the data transmission unit.

Database Server and WEB Services: Data recording is performed by a dedicated database server to enhance system stability. To provide remote users with access to real-time data, a WEB server is installed in the database server. To avoid direct network connection and further enhance overall system security, dedicated serial ports are used for communication between the centralized control computer and the database server.

System Functions: The system implements comprehensive functions including automatic data recording, where the centralized control computer in the transmitter room collects operational data through the transmitter monitoring

interface and saves it to the database with customizable collection intervals (e.g., every 60 minutes). The database server provides WEB services for observing transmitter operation through a VLAN private network. Automatic switching capabilities enable control of power on/off according to preset schedules, with automatic delay of shutdown until broadcast ends. The database server management system automatically generates duty reports from the centralized control computer data, which can be printed and saved as independent files. Operation logging allows duty personnel to record actions such as transmitter switching in the database during normal operation. Shift handover recording is automatically logged by the management system for convenient querying. Real-time fault diagnosis automatically identifies fault locations, immediately records fault data, and displays faulty unit numbers and locations. Flexible fault alarm methods allow user-configurable alarm thresholds for analog values to avoid false or missed alarms. Environmental monitoring records power supply data including external voltage, frequency, and stabilized voltage/current. Cyclic monitoring implements scheduled monitoring of all transmission frequencies, with automatic alarms for signal absence. Data query functions using SQL databases facilitate convenient statistics, summarization, and automatic report generation.

2.2 Image Monitoring System

This system installs video cameras at critical locations in the transmitting station to monitor transmitters, equipment, and the machine room environment. Duty personnel can record captured video images through digital video recorders (DVRs), providing clear observation of transmitter room conditions. Through a VLAN private network, the station's video data is provided to other users. Additionally, to achieve broadcast program recording, the image monitoring system provides audio recording functionality by allocating one channel to the DVR, using the four-channel broadcast audio output from the FM cyclic monitoring alarm in the monitoring system. The DVR's retrieval function facilitates convenient location of segments for replay.

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3. Existing Problems and Solutions

First, monitoring data from different transmitter systems varies significantly, and independently used monitoring software creates difficulties in fault recording and broadcast statistics, failing to reflect actual operational conditions. All FM transmitter monitoring must be unified into a single comprehensive system. Different parameter reading functions must be configured for different transmitters to fully reflect transmitter status, with configurable range values for all analog and digital quantities. Wireless reception monitoring must be integrated

into the monitoring system, which must also include environmental monitoring and alarm functions.

Second, the monitoring system cannot provide recording functionality, only recording audio signal levels. To implement broadcast program recording, the audio recording capability of the image monitoring system can be utilized by demodulating each FM broadcast program through a tuner connected to the image monitoring DVR, thereby solving the monitoring and recording problem.

Finally, to simplify processing, digital signals enter the monitoring host through data transmission units, selecting the analog output from the audio processor to combine each broadcast stereo signal into a single analog audio channel.

References: [1] Li Jie. Thoughts on the Construction of Automation and Integrated Monitoring Platforms for Radio and Television Transmitting Stations [J]. China Media Technology. 2018(02).

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