Research on High-Definition Broadcast Control System for Television Stations (Postprint)

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Abstract

To promote the development of television broadcast control, this paper briefly analyzes the defects inherent in television standard-definition systems and subsequently investigates the design and implementation of high-definition broadcast control systems for television stations, aiming to enhance understanding of their design, testing, performance, operation, and related aspects, thereby enabling better adaptation to the requirements of television high-definition broadcast control.

Full Text

Preamble

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Abstract: To promote the development of television broadcast control, this paper analyzes the defects inherent in standard-definition systems and investigates the design and implementation of high-definition broadcast control systems for television stations. The study aims to deepen understanding of system design, testing, performance, and operational aspects to better adapt to the requirements of HD broadcast control.

Keywords: Television station; Standard-definition system; HD broadcast control; System design

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With continuous technological advancement, domestic television in China has gradually transitioned from standard-definition to high-definition, though HD television has not yet achieved full market penetration. For television station HD broadcast control systems, thorough research is essential to meet operational requirements. Since 2009, the State Administration of Radio, Film and Television has prioritized HD television as a key focus in broadcasting and film work, requiring satellite TV channels to transition toward HD simulcasting. Consequently, the gradual popularization of HD broadcast control has become an urgent priority for television stations.

2.1.1 Overall Technical Design

The design of HD/SD-compatible television broadcast video and audio systems primarily encompasses two aspects: First, the expansion and improvement of the HD master control system can satisfy system-level backup requirements, enabling coordinated processing of HD input and output signals and achieving interconnectivity between them. Second, through the establishment of HD/SD simulcast channels and channel sub-control systems, the overall design must adhere to the fundamental principle of complete HD upgrading to ensure the achievement of full HD broadcast control objectives [2].

2.1.2 Sub-Control System Overall Technical Design

In constructing sub-control systems, the selection of management strategies and technical standards is critical. During the design process, attention must also be paid to simplifying complex systems, ensuring smooth transition of production and broadcast workflows, improving technical quality, and meeting industry development requirements.

2.2.1 Master Control System Technical Composition

The master control system comprises two parallel structures, as illustrated in [Figure 1: see original paper]. Both matrices receive identical input source signals, yet any downstream system simultaneously receives actual signals from both primary and backup matrices, with each matrix transmitting and receiving only half of the total signals [3].

The system employs a primary-backup heterogeneous matrix configuration consisting of a Jebsen matrix and an imported GV matrix. Integration of micro recording signals, HD OB van signals, and other sources ensures synchronized operation with the HD broadcast control system. Up/down converters facilitate interconnection between standard-definition and high-definition signals. Each channel's broadcast signal is divided into primary and backup paths that directly enter the primary and backup matrices, which process signals using processors and delay units.

Comparatively, the dual-matrix architecture offers higher security with system-level backup capability. Should either matrix fail, the scheduling system can receive alternative input signals and maintain scheduling control over all inputs. Following the principle of link independence, the master control chassis deployment configuration allows equipment from the same link to be arranged within a single chassis group, minimizing the number of affected links during power failures. The master monitoring system utilizes multi-viewers, enabling new signal source addition and reconfiguration. The system supports multiple alarm methods including audible/visual alarms, SMS alerts, and telephone notifications, providing real-time channel monitoring, real-time audio/video stream content monitoring, automatic or manual recording functions, and automatic fault recording capabilities.

2.2.2 Sub-Control System Technical Composition

The sub-control system adopts a video server plus switching matrix architecture, primarily composed of primary and backup links. The primary and backup broadcast switching matrices and switches achieve synchronous switching requirements through the automatic broadcast control network, with one-key switching capability also implemented. During system design, to ensure the effectiveness of one-key emergency operations, it is essential to guarantee independence between primary and backup signal sources, complete isolation of primary and backup broadcast links (including clock, synchronization, and power distribution), and validate the effectiveness of the two-selection-one process [4]. Subtitle machines capable of simultaneously outputting both HD and SD subtitles are selected to ensure subtitle consistency across HD and SD channels. The HD final stage employs an integrated HD logo keyer to overlay HD corner bugs before distribution.

The broadcast system demands safe and reliable 24/7 operation, necessitating enhanced security and redundancy. Equipment including video servers, keyers, three-selection-one switches, switchers, and loudness controllers operate in primary-backup mode, with chassis also utilizing primary-backup dual power supplies. Each channel' s sub-control system employs a dual-switcher dual-keyer design for primary and backup links, with signals processed through loudness controllers before reaching the three-selection-one switch. The signal flow design for HD/SD simulcast channels is shown in [Figure 2: see original paper].

System signal monitoring employs a combination of signal node monitoring and multi-viewer implementation.

2.3 System Implementation and Testing

2.3.1 Project Commissioning

During commissioning, corresponding engineers and technicians debug the audio/video signals and paths of the master control and sub-control systems to

ensure correct signal phase and path configuration. Embedded audio is adjusted, with the first group left channel designated for broadcast, followed by video path confirmation to meet system debugging requirements. Technicians must conduct repeated experiments on different broadcast modes to verify that the automatic broadcast control network possesses global management capabilities and intelligent equipment control for networked broadcast systems. Through adjustment, the reliability of the control system backup mechanism can be properly analyzed. Should any issues arise during commissioning, corresponding communication and adjustments must be made to propose solutions meeting the TV station' s broadcast requirements, with adjustments made individually [5].

2.3.2 System Testing

Based on testing of channel video characteristics, synchronization characteristics, and audio characteristics, specific data are presented in Tables through 4.

Table 1: HDTV Program Production Image Characteristics
- Active samples per line
- Active lines per frame
- DC level offset
- 100kHz high-pass filter
- 10Hz high-pass filter

Table 2 : Interface Characteristics
- 800$±$80
- <270
- <270
- $ $100
- $ $0.2

Table 3 : HDTV Program Production Image Scanning Characteristics
- Total samples per line
- Cb, Cr

Table 4 : Interlaced Scanning System Cycle Timing Specifications
- First line of first field
- Last line of first field digital blanking
- First line of first field active video
- Last line of first field active video
- First line of second field digital blanking
- Last line of first field
- First line of second field
- Last line of second field digital blanking
- First line of second field active video
- Last line of second field active video
- First line of first field digital blanking
- Last line of second field

- First line of first field

2.4 Network Performance Testing

2.4.1 Network Status Monitoring

Delay refers to the time difference between data transmission and reception. Based on actual Ethernet dedicated line service requirements, delay testing is implemented using a data network performance analyzer, with results meeting specifications.

Packet loss rate refers to the ratio between data that should be forwarded and data that is discarded during forwarding. By configuring Ethernet dedicated line services on the tested device and using a data network performance analyzer for testing, the results are normal [6].

Jitter refers to the offset between a digital signal' s actual position and its ideal temporal position at a given moment. By connecting the tested SDI audio/video signal and using a broadcast-specific oscilloscope for detection, the jitter value remains within the normal allowable range, indicating normal operation.

Error rate refers to transmission accuracy within a specified time period. Based on normal system service configuration, high-performance error detectors are employed during error rate testing, yielding normal results.

Back-to-back refers to a device' s capacity to accommodate burst packets. By configuring normal business on the tested device and using a data network performance analyzer, the test results are accurate.

Throughput represents the maximum data volume within a fixed time period. Based on Ethernet dedicated line services, data network performance analyzers are used to test throughput requirements, with results showing normal operation.

2.4.2 Program Migration Efficiency Testing

When broadcast time requirements are met, the migration server must fulfill migration task requirements. Test migration material settings must ensure capacity is not less than the actual capacity of migration materials during any peak nighttime period. During testing with migration materials, tasks must be completed within 10 minutes, and the system' s program migration efficiency must meet established broadcast requirements.

2.4.3 Network Storage Read/Write Performance Testing

Within a specified time period, RAID 10 arrays must satisfy read/write and storage requirements. Observation shows that RAID operations can be completed within 5 seconds, meeting broadcast safety requirements within 15 seconds.

2.4.5 Network Health Status

Bandwidth utilization refers to the ratio of system bandwidth to information speed, primarily measuring system effectiveness and describing the relationship between data transmission rate and bandwidth. Test results are normal.

Error frames refer to the proportion and quantity of error frames within a unit time range. Collision refers to primary conflicts when two devices transmit data simultaneously on the same Ethernet network. Multicast rate refers to multicast data size / total transmission data × 100%. Broadcast rate refers to broadcast data size / total transmission data × 100%. Based on testing of network equipment, all results meet normal communication requirements, and network performance is good.

2.5 Project Operation Status

2.5.1 Safety, Efficiency, and Stability

The design scheme demonstrates comprehensive consideration, particularly regarding broadcast safety, resulting in relatively outstanding security. All system equipment incorporates backup processing, and no broadcast accidents have occurred due to system design issues during actual operation.

Broadcast software is simple, reliable, and easy to operate, with relatively complete emergency response capabilities and real-time monitoring of broadcast equipment status. The material upload mechanism is flexible, featuring material monitoring and migration anomaly warning capabilities. With large-capacity nearline and online storage, materials from the most recent six months can utilize nearline storage, thereby addressing repeated upload issues, reducing labor intensity, and improving work efficiency [7].

2.5.2 Convenience and Powerful Functionality

Through investigation, the master control design in the scheme is found to be scientific, with flexible signal scheduling and excellent signal quality that meets the actual requirements of studios and broadcast channels for signal paths, providing technical support for news programs and live events. Since system implementation, hundreds of HD signal live connections have been successfully conducted with stable and reliable signals, fully demonstrating the effectiveness of the master control system.

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