Analysis of Wireless Digital Transmission Technology for Television Stations (Postprint)

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Abstract

【目的】This paper provides an in-depth investigation into wireless digital transmission technology for television stations, aiming to comprehend its functions in enhancing program transmission quality, expanding coverage range, and improving user experience. 【方法】Through detailed analysis of critical stages including signal encoding, modulation, power amplification, and antenna feed systems, this study achieves mastery of the technology. 【结果】Wireless digital transmission technology significantly enhances signal transmission stability and clarity, expands program coverage, and delivers a superior audio-visual experience to users. 【结论】Television station wireless digital transmission technology represents a key driving force in the digital transformation of the broadcasting industry, and is expected to continue playing a vital role in fostering innovative development within the sector.

Full Text

Analysis of Wireless Digital Transmission and Broadcasting Technologies for Television Stations

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Abstract

[**Objective**] This paper provides an in-depth examination of wireless digital transmission and broadcasting technologies for television stations, exploring their role in enhancing program transmission quality, expanding coverage, and improving user experience. [**Methods**] Through detailed analysis of critical components including signal encoding, modulation, power amplification, and

antenna-feeder systems, this study systematically investigates the technical foundations of these systems. [**Results**] Wireless digital transmission technology significantly improves signal transmission stability and clarity, expands program coverage, and delivers superior audio-visual experiences for audiences. [**Conclusion**] Wireless digital transmission and broadcasting technology represents a critical force driving digital transformation in the radio and television industry, with substantial potential for continued innovation and development in the future.

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Wireless digital transmission technology has emerged as a key solution for television stations to meet contemporary information dissemination demands, offering efficient data processing capabilities, robust anti-interference performance, and flexible transmission methods. According to the predictive report *China Wireless Transmitter Data Monitoring Research Report 2025-2030*, transmission efficiency using advanced wireless digital broadcasting equipment has reached 20%, with high-end devices achieving transmission rates of up to 40%—representing significant achievements through comprehensive utilization of wireless digital transmission technology. As technology continues to evolve, these efficiency metrics are expected to improve further, injecting stronger momentum into media development. Moreover, wireless transmission technology can effectively amplify signal frequencies, addressing attenuation and interference issues during signal transmission to prevent distortion and ensure smooth, efficient, and stable delivery. This eliminates problems of signal unavailability or intermittent reception, significantly improving signal quality. Wireless transmission also enables precise signal management and control, providing media organizations with more flexible and convenient transmission solutions.

In this context, media organizations have enhanced operational efficiency and improved development platforms by fully utilizing and continuously updating advanced scientific technologies to adapt to evolving market conditions and audience demands. The equipment used for program transmission features higher power and superior performance, resulting in substantially improved power supply quality. This not only reduces resource consumption and waste, facilitating sustainable program utilization and recycling, but also promotes green development across the media industry—aligning with modern ecological concepts and sustainability requirements while enhancing overall service quality and competitiveness.

1. Current Status of Wireless Digital Program Transmission at Television Stations

In today's era of information explosion, the media sector is undergoing a profound transformation driven by emerging technologies, which not only propels industry upgrading but also continuously reshapes media product forms and content. The rapid rise of new media technologies has created unprecedented opportunities while presenting significant challenges. Audiences increasingly demand novel, unique content and intelligent transmission methods, compelling media organizations to explore new technologies and approaches to revolutionize traditional program transmission, break free from homogenization constraints, and gain competitive advantages.

Overall, wireless transmission technology demonstrates increasingly significant advantages in the media domain. Compared to traditional program transmission technologies, wireless transmission has achieved substantial progress in both equipment utilization and transmission methods. Through continuous technological innovation and refinement, wireless transmission has undergone a qualitative leap, dramatically improving program transmission efficiency and stability while effectively solving resource waste issues inherent in traditional methods.

2. Methods for Wireless Digital Program Transmission at Television Stations

The implementation of wireless digital program transmission encompasses various technical approaches and methodologies, with system design and equipment selection tailored to specific transmission requirements and environmental conditions.

2.1 Wired Transmission Methods

In practice, wired transmission systems require initial optical cable deployment followed by necessary debugging and configuration at signal reception points—critical steps for ensuring smooth installation and commissioning processes. During end-to-end transmission, program content is typically embedded into SDI digital television optical transceivers, which serve as information transmission bridges to achieve efficient delivery. SDI technology is widely acclaimed for its extremely high transmission accuracy, ensuring signals reach end-users without obstruction. SDI technology demonstrates broad applicability, particularly in handling various television signals. When operating independently, SDI systems can achieve transmission distances up to 40 kilometers without auxiliary equipment—far exceeding traditional television tower coverage ranges while maintaining stable and clear signals. Consequently, SDI technology has established a unique position in signal transmission due to its technical characteristics and significant advantages. Based on specific transmission requirements and conditions, wireless digital program transmission systems must select appropriate optical transceiver models to ensure efficient and stable signal transmission

along predetermined paths.

3.1 Intelligence

Wireless digital program transmission technology for television stations is characterized by remarkable intelligence, leading innovation trends in the media sector. This technology not only enables digital transmission of program signals but also incorporates intelligent regulation and management mechanisms during transmission. Through advanced encoding techniques and modulation methods, wireless digital transmission ensures high-quality, high-stability signal delivery while employing intelligent algorithms for real-time signal monitoring and optimization to effectively address various transmission interferences and attenuations. Furthermore, the technology features intelligent transmitter equipment management capabilities, enabling automatic adjustment of transmission power and frequency to adapt to different transmission environments and requirements. This intelligent characteristic not only improves program transmission efficiency and reliability but also allows television stations to respond more flexibly to market demands and user preferences.

3.2 Practicality and Accuracy

Television station wireless digital program transmission technology demonstrates outstanding practicality and accuracy, serving as a critical foundation for modern media operations. Through efficient digital signal processing, the technology converts program content into stable digital signals, substantially enhancing anti-interference capabilities and transmission quality while ensuring complete accuracy of program content. Its practicality manifests in broad adaptability to complex environments and transmission conditions, achieving stable and clear signal reception in both densely populated urban areas and remote rural regions. Additionally, wireless digital transmission technology offers powerful compatibility, easily interfacing with various receiving devices to meet diverse audience needs. In terms of accuracy, the technology employs precise synchronization mechanisms and error correction coding to effectively prevent signal distortion and bit errors during transmission, ensuring program content integrity.

3.3 Reliability

Television station wireless digital program transmission technology establishes new benchmarks in the media sector through its high reliability. By employing advanced digital signal processing technology, the system ensures program signal stability and accuracy during transmission, maintaining signal clarity and continuity even in complex and variable environments. Wireless digital transmission technology utilizes efficient encoding and modulation schemes to effectively resist external interference and noise, significantly reducing risks of signal distortion and loss. Moreover, the technology possesses powerful error

detection and correction capabilities, enabling timely identification and repair of errors during transmission to further enhance reliability. Whether in bustling urban centers or vast remote areas, television stations can deliver high-quality program signals stably and accurately to millions of households through this technology, providing audiences with rich and colorful audio-visual experiences.

4.1 Digital Signal Transmission Technology

In the technical architecture of wireless digital program transmission for radio and television stations, digital signal transmission technology plays a crucial role. By converting traditional analog signals to digital format, this technology dramatically improves program transmission efficiency and stability, bringing revolutionary progress to the broadcasting industry. The core advantage of digital signal transmission technology lies in its powerful anti-interference capability and transmission stability. Compared to analog signals, digital signals better resist noise and interference during transmission, ensuring program signal clarity and continuity. This characteristic enables radio and television stations to deliver high-quality, stable program content even in complex transmission environments, such as areas with dense high-rise buildings and severe electromagnetic interference.

Furthermore, digital signal transmission technology offers efficient data compression capabilities. Through encoding and compression of digital signals during transmission, bandwidth requirements can be significantly reduced while improving transmission efficiency. This not only helps lower operational costs for radio and television stations but also provides audiences with richer program selections. Data compression technology also enables stations to transmit more diverse program content using limited spectrum resources, meeting growing audience demands. Another key feature is powerful error detection and correction capability. During transmission, digital signals can automatically detect and correct errors caused by various factors such as signal attenuation and noise interference, ensuring program content integrity and authenticity—critical for transmission quality and audience viewing experience.

4.2 Modulation Technology

In wireless digital program transmission, modulation technology plays a vital role as the key process for converting digital signals into carrier signals suitable for wireless transmission. This technology determines signal quality and efficiency during transmission by adjusting carrier amplitude, frequency, or phase to embed program-carrying digital signals into the carrier for wireless delivery. In television station transmitter systems, modulation technology must not only accurately and efficiently convert digital signals to carrier signals but also possess robust anti-interference capabilities and adaptability to ensure stability and clarity in complex transmission environments.

Typically, modulation technology precisely controls carrier parameters through

amplitude shift keying (ASK), frequency shift keying (FSK), or phase shift keying (PSK) to map digital signal information onto the carrier. These modulation schemes offer different characteristics, providing flexible and efficient signal transmission solutions based on specific requirements and scenarios. For instance, high-order phase modulation can be employed in scenarios requiring high data rates to improve spectral efficiency and transmission capacity. Additionally, modulation technology incorporates powerful error detection and correction capabilities. During signal transmission, channel noise and multipath effects may cause signal distortion or errors. Modulation technology addresses this by introducing redundant information and employing error correction coding to automatically detect and correct errors, ensuring signal integrity and reliability.

4.3 Antenna Technology

In wireless digital program transmission, antenna technology plays a pivotal role, influencing not only signal transmission efficiency and quality but also determining extensive coverage and stable reception of program content. As a core component of broadcasting signal transmission, antenna design principles and performance optimization focus on improving transmission efficiency and anti-interference capability. For wireless digital program transmission, antenna technology must feature high sensitivity, wide bandwidth, and strong directivity to ensure stable transmission and clear reception in complex electromagnetic environments, such as dense urban high-rise areas and regions with severe electromagnetic interference.

Radio and television stations typically employ various antenna types, including high-gain antennas, directional antennas, and smart antennas. High-gain antennas optimize structure and design to increase signal gain, maintaining signal strength during long-distance transmission and ensuring high-quality program coverage. Directional antennas adjust radiation patterns to concentrate signals in specific directions, reducing multipath transmission losses and interference while improving stability and clarity. Smart antennas utilize advanced signal processing algorithms for adaptive adjustment and optimization, enabling real-time parameter tuning based on environmental changes to ensure optimal signal transmission. Furthermore, antenna technology involves feed selection, reflector material and design, focal point determination, and high-frequency head support rod design—optimization and combination of these elements enhance antenna performance and ensure efficient, stable signal transmission.

4.4 FM Transmission Technology

FM transmission technology is crucial for television stations in wireless digital program broadcasting, directly affecting signal stability and transmission quality. Frequency modulation technology transmits audio or video program information by varying carrier signal frequency. This technology serves as a bridge

in television transmitter systems, converting digitally encoded and modulated program signals into carrier signals suitable for wireless transmission.

During wireless digital program transmission, television stations first digitize audio or video signals, then use FM technology to convert these digital signals into carrier signals. In the modulation process, transmitters adjust carrier frequency in real-time according to program content changes, enabling wireless transmission of program information. The key to this technology lies in frequency stability and modulation precision, as any minor frequency fluctuation or modulation error may cause signal distortion or transmission interruption, affecting audience viewing experience. FM transmission technology requires not only frequency stability and modulation precision but also robust anti-interference capability and adaptability. In complex electromagnetic environments, FM technology must resist various interfering signals to ensure stable program transmission. Television stations typically employ high-quality FM transmitters and advanced frequency synthesis technology to improve FM stability and precision, while implementing multiple anti-interference measures such as differential coding and frequency diversity to further enhance signal anti-interference capability. Additionally, FM transmission technology must integrate closely with digital signal processing, encoding, and antenna technologies to achieve efficient signal transmission and reception.

4.5 Power Amplification Technology

Power amplification technology is an indispensable key technology for television stations in wireless digital program transmission, primarily used to enhance signal power and ensure long-distance, high-quality transmission to receiving ends through antennas. In television station transmitter systems, power amplifiers serve as core equipment, receiving weak signals from signal sources and converting them into sufficiently powerful signals through modulation and amplification for antenna transmission. This process requires power amplifiers to deliver high power output while maintaining signal linearity and stability to avoid signal distortion and transmission interruption.

Power amplification technology encompasses various amplifier types, including Class A, Class B, Class AB, and Class C, each with unique characteristics and application scenarios. Television stations typically select appropriate amplifier types based on actual requirements. For instance, Class A amplifiers offer high linearity but low efficiency, suitable for applications demanding extremely high signal fidelity; Class C amplifiers provide extremely high efficiency but poor linearity, applicable for high-efficiency scenarios with less stringent linearity requirements. In practice, television stations often adopt Class AB amplifiers, which combine the advantages of Class A and Class B amplifiers, ensuring both signal linearity and relatively high efficiency. Furthermore, power amplification technology must integrate closely with digital signal processing, encoding, and modulation technologies to achieve efficient signal transmission and reception.

4.6 Antenna-Feeder System

The antenna-feeder system constitutes a core component in television station wireless digital program transmission architecture, responsible for efficiently transmitting encoded, modulated, and power-amplified digital signals to receiving devices within coverage areas. The antenna-feeder system primarily consists of two subsystems—antenna and feeder—working collaboratively to ensure signal stability and quality during transmission.

As the key element of the antenna-feeder system, antenna design directly affects radiation efficiency and directivity. Television stations typically employ high-performance antennas such as directional or omnidirectional antennas to accommodate different transmission requirements and coverage scenarios. Directional antennas concentrate signal energy in specific directions to achieve long-distance point-to-point communication, suitable for precisely covering targeted areas; omnidirectional antennas radiate signals uniformly in all directions, appropriate for wide coverage with dispersed receiving points. Antenna design must also consider polarization—vertical or horizontal—to accommodate different receiving device characteristics.

The feeder system serves as the bridge connecting antennas and transmitters, responsible for losslessly transmitting high-power signals from power amplifiers to antennas. Feeder selection must consider impedance matching, loss characteristics, and mechanical strength. High-quality feeders ensure low-loss signal transmission, thereby improving transmission efficiency and coverage range.

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Author Biography

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