Postprint: Research on Signal Source Transmission Schemes for Radio and Television Engineering

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Abstract

Purpose: With the development of information technology and the transformation and upgrading of broadcast television media, traditional analog transmission methods can no longer meet current demands. Research on signal source transmission schemes for broadcast television engineering aims to explore effective signal transmission methods, achieve high quality, high reliability, and wide coverage of signal transmission, and improve the broadcasting effect of television programs and the viewing experience of audiences.

Methods: Through analyzing and comparing the practical transmission experience of different transmission methods, modulation techniques, and other schemes, this article analyzes the transmission quality and effectiveness of various transmission methods, and identifies technical issues such as signal quality and signal transmission faced by signal source transmission in broadcast television engineering.

Results: By adopting advanced signal processing technologies and compression algorithms, and through approaches such as increasing transmission power and optimizing signal transmission parameters, the quality of signal source transmission in broadcast television engineering can be effectively improved, enhancing audience viewing experience.

Conclusion: Applying technical means such as signal enhancement, noise reduction, and filtering, or compression algorithms can improve signal quality; adjusting encoding parameters, optimizing bitrate control, and reducing noise impact can effectively address signal transmission problems caused by terrain obstacles such as highways.

Full Text

Abstract

With the development of information technology and the transformation of broadcast television media, traditional analog transmission methods no longer meet current demands. This study investigates signal source transmission schemes in broadcast television engineering to explore effective transmission approaches that achieve high quality, high reliability, and extensive coverage, thereby improving broadcast program quality and audience viewing experience. Through analysis and comparison of practical transmission experiences across different transmission methods and modulation techniques, this paper examines the quality and effectiveness of various approaches, identifying key technical challenges in broadcast television engineering signal source transmission related to signal quality and transmission. The results demonstrate that employing advanced signal processing technologies and compression algorithms, combined with increased transmission power and optimized signal transmission parameters, can effectively improve signal source transmission quality and enhance audience experience. In conclusion, applying signal enhancement, noise reduction, filtering techniques, or compression algorithms can improve signal quality, while adjusting encoding parameters, optimizing rate control, and reducing noise effects can effectively address signal transmission issues caused by terrain obstacles such as highways.

Keywords: broadcast television; signal transmission; mobile broadcasting; signal coverage; bandwidth limitation

Introduction

With the development of digitalization and intelligence, traditional analog transmission methods can no longer meet current audience viewing needs. Against this backdrop of continuous technological upgrading, various transmission methods such as digital transmission, IPTV transmission, OTT transmission, and mobile broadcasting have gradually gained public recognition. However, as the digitalization process continues to advance, broadcast television engineering faces increasingly severe technical challenges in signal source transmission. Signal quality often cannot be guaranteed during propagation, with issues such as weak signal coverage or deep coverage frequently occurring. Therefore, research on broadcast television engineering signal source transmission schemes is of great significance. This paper explores the technical challenges and solutions in broadcast television engineering signal source transmission from the perspectives of different transmission methods and technical approaches, aiming to provide references for related research.

1.2 Signal Source Types

Signal source types mainly include audio signal sources, video signal sources, integrated signal sources, VR and AR signal sources, and signal sources generated from big data analysis. Audio signal sources refer to equipment that collects and transmits audio signals, while video signal sources refer to equipment that collects and transmits video signals. Integrated signal sources combine both audio and video signal sources. VR and AR signal sources are generated through virtual reality or augmented reality technologies, and signal sources generated from big data analysis are produced based on big data processing and analysis. The quality and stability of signal sources directly affect broadcast program quality and audience viewing experience.

1.3 Broadcast Television Engineering Signal Source Transmission Methods

1.3.1 Traditional Transmission Methods

1.3.1.1 Analog Transmission The analog transmission method for broadcast television engineering signal sources is a traditional approach that uses analog signal transmission technology. Transmission is susceptible to factors such as transmission distance, transmission lines, and signal-to-noise ratio, which may lead to degraded signal quality. Additionally, analog signal transmission is subject to frequency band limitations and cannot achieve high-quality transmission such as high-definition or ultra-high-definition signals. However, analog transmission equipment is simple, has long transmission distances, and low latency, making it suitable for certain special real-time transmission scenarios in broadcast television engineering. Overall, while analog transmission still has certain applicability in broadcast television engineering, digital transmission has gradually replaced it as the mainstream signal transmission method with the continuous development of digital signal transmission technology.

1.3.1.2 Digital Transmission The digital transmission method for broadcast television engineering signal sources is a modern approach following analog transmission. This method employs digital signal transmission technology to achieve high-quality, high-definition signal transmission. Digital transmission utilizes compression algorithms, error correction coding, and other technologies to ensure signal quality during transmission and support high-bandwidth signal transmission requirements. Furthermore, digital transmission offers better flexibility and controllability, meeting various complex transmission requirements in broadcast television engineering. Overall, digital transmission has become the mainstream signal transmission method in broadcast television engineering, forming an important component of broadcast television transmission technology and serving as a driving force for continuous development and progress.

1.3.2 Emerging Transmission Methods

1.3.2.1 IPTV Transmission IPTV is a digital transmission method in broadcast television engineering that uses Internet protocol technology to achieve audio and video content transmission and playback. IPTV offers more flexible and efficient network distribution, capable of transmitting high-definition and ultra-high-definition video signals through broadband networks while supporting various playback modes such as on-demand, time-shifted, and live broadcasting. Additionally, IPTV supports personalized user requirements such as channel subscription and independent playback control. Compared with traditional cable and satellite television, IPTV better reflects the characteristics of the Internet era by providing more personalized and interactive services, gaining increasing favor among users. Therefore, IPTV has become a notable digital transmission method in broadcast television engineering with broad market prospects and development potential.

1.3.2.2 OTT Transmission OTT (Over-The-Top) is a digital transmission method that delivers audio and video content to end-user devices via the Internet without relying on traditional broadcast television networks. OTT transmission offers more flexible and efficient content distribution, allowing users to access and watch high-definition and ultra-high-definition audio and video content anytime and anywhere. Moreover, OTT supports user autonomous selection, on-demand, time-shifting, and other playback modes with stronger personalization and interactivity. Compared with traditional cable and satellite television, OTT transmission has lower costs and wider coverage, enabling more services and applications. Consequently, OTT has become one of the notable digital transmission methods in broadcast television engineering.

1.3.2.3 Mobile Broadcasting Mobile broadcasting is a digital transmission method in broadcast television engineering that utilizes mobile communication networks to transmit audio and video content to user mobile devices for playback. Mobile broadcasting features wide coverage, rich content, and strong interactivity, making it suitable for mobile users to obtain and watch high-quality audio and video content while traveling. Mobile broadcasting typically employs digital signal transmission technology, using various encoding and compression techniques to convert audio and video signals into data streams suitable for transmission over mobile communication networks. The application scope of mobile broadcasting is extensive, including mobile television, mobile video, and mobile music, providing broader space and market prospects for the development of digital transmission technology in broadcast television engineering.

2. Challenges in Broadcast Television Engineering Signal Source Transmission

2.1 Signal Quality Vulnerability

Ensuring signal quality represents a significant technical challenge in broadcast television engineering signal transmission. During transmission, signal quality degradation occurs due to factors such as transmission distance, transmission lines, and signal-to-noise ratio, affecting broadcast program quality and audience viewing experience. Transmission distance is a primary factor affecting signal quality. In broadcast television engineering, signals must be transmitted via radio waves or transmission lines; the longer the distance, the more attenuation and interference the signal experiences, leading to quality degradation. For example, in digital television broadcasting, signals are susceptible to multipath fading and Doppler effects over long distances, causing image blurring and distortion. Transmission lines also significantly affect signal quality. In cable television transmission, signals travel through coaxial cables; poor cable quality or impedance mismatch leads to signal attenuation and distortion. Furthermore, signal-to-noise ratio affects signal quality. The signal-to-noise ratio refers to the ratio between signal and noise strength; stronger signals and weaker noise produce higher ratios. In broadcast television engineering, noise mainly originates from electromagnetic interference and circuit noise. Low signal-to-noise ratios cause signal distortion, interference, and noise reduction issues.

2.2 Weak Signal Coverage or Deep Coverage

Weak signal coverage and deep coverage are two major problems in broadcast television engineering that affect signal transmission and reception quality, thereby impacting broadcast program quality and audience viewing experience. Weak signal coverage primarily refers to situations where the receiving end obtains weak and unclear signals due to long transmission distances, poor transmission lines, and interference. In television broadcasting, weak signal coverage may cause image distortion, screen artifacts, and noise, affecting audience experience. In digital audio broadcasting, it may cause audio artifacts and signal noise, affecting listener experience. In mobile broadcasting, it may cause signal interruption, stuttering, and connection failures, affecting user experience. Deep coverage refers to situations where signals must pass through obstacles such as buildings and mountainous terrain, causing signal quality degradation or complete transmission failure. In cable television transmission, when coaxial cables encounter obstacles, signal quality is easily affected, causing image distortion and noise. In digital television broadcasting, when radio wave signals encounter buildings or mountains, transmission quality decreases or fails completely, causing image distortion and stuttering. In mobile broadcasting, radio wave signals may be interrupted when encountering obstacles, causing discontinuous reception.

3. Solutions

3.1 Signal Processing Technology

To ensure signal quality, broadcast television engineering employs various technical methods and solutions. Signal processing technology is a common approach that uses digital signal processing techniques to improve signal quality and stability. For example, signal enhancement, noise reduction, and filtering techniques can eliminate noise and interference to improve signal quality.

3.1.1.1 Signal Enhancement Technology Signal enhancement technology improves signal quality and stability by increasing signal strength or modifying signal waveforms. Signal enhancement includes various processing methods such as amplification, compensation, and supplementation. For example, increasing signal gain amplifies signal strength, improving clarity and readability. Compensation technology reduces signal distortion and loss, enhancing stability and accuracy.

3.1.1.2 Noise Reduction Technology Noise reduction technology improves signal quality and clarity by eliminating noise from signals. Noise reduction 主要包括滤波、谱减和自适应降噪等多种处理方式。For example, low-pass filters can remove high-frequency noise, while spectral subtraction techniques analyze signal frequency distribution to reduce noise interference.

3.1.1.3 Filtering Technology Filtering technology improves signal quality and accuracy by removing noise and interference from signals. Filtering 主要包括低通、高通、带通和带阻滤波等多种处理方式。For example, low-pass filters remove high-frequency noise, making signals smoother and more stable.

3.2 Increase Transmission Power and Optimize Signal Transmission Parameters

Increasing transmission power can expand signal coverage and improve quality, enabling broadcast television programs to better reach distant audiences and enhance viewing quality. This requires upgrading or replacing transmitters, antennas, and other components in broadcast equipment to increase transmission power and effectiveness. Beyond increasing power, optimizing signal transmission parameters can also improve transmission effectiveness. Common optimization methods include adjusting video encoding parameters, optimizing rate control, and reducing noise.

3.2.1 Adjust Encoding Parameters Adjusting video encoding parameters is a common method for optimizing signal transmission parameters. The parameter adjustment formula is shown in Equation (3):

$$QP = QstepQc + 6$$

In Equation (3), Qstep represents the quantization step size and Qc represents the quantization coefficient, both adjustable parameters. Video encoding parameter settings affect the compression ratio and clarity of video signals. By adjusting these parameters, video signals can achieve better compression effects while maintaining certain clarity, thereby reducing required bandwidth. For example, in H.264 video encoding, adjusting the QP value (quantization parameter) and frame rate can reduce video data volume without affecting picture quality.

3.2.2 Optimize Rate Control Rate control refers to the process of controlling bitrate size during video compression. In Constant Bit Rate (CBR) mode, the rate control formula is shown in Equation (4), while in Variable Bit Rate (VBR) mode, the formula is shown in Equation (5):

$$CBR = /(*)$$

$$VBR = \Sigma(\quad)/$$

In Equation (4), the numerator represents the total number of bits and the denominator represents the product of frame count and duration. In Equation (5), the average bitrate represents the number of bits required per video frame. By optimizing rate control algorithms, video signal bitrate can be stabilized, reducing bandwidth fluctuations during transmission. For example, in H.264 video encoding, setting CBR or VBR modes enables more reasonable rate control, thereby optimizing signal transmission effectiveness.

3.2.3 Reduce Noise During signal transmission, various interference factors may introduce noise that affects signal quality. Adaptive filtering algorithms can reduce noise impact and improve signal clarity and reliability. Adaptive filtering algorithms automatically adjust filter parameters based on input signal characteristics to produce clearer and more reliable output signals. Common adaptive filtering algorithms include the Least Mean Squares (LMS) algorithm and the Recursive Least Squares (RLS) algorithm. In the LMS algorithm, the filter parameter update formula is shown in Equation (6):

$$w(n+1) = w(n) + e(n)u(n)$$

In the RLS algorithm, the filter parameter update formula is shown in Equation (7):

$$w(n+1) = w(n) + K(n)e(n)$$

In Equation (6), w(n) represents the filter parameter vector, μ is the step size (controlling parameter update speed), e(n) is the error between desired and actual output, and u(n) is the input signal. In Equation (7), w(n) represents the filter parameter vector, e(n) is the error between desired and actual output, and K(n) and P(n) are the gain vector and covariance matrix of the RLS filter, respectively, which can be recursively calculated using Equation (8):

$$K(n) = P(n-1)u(n)/(\lambda + u^T(n)P(n-1)u(n))$$

$$P(n) = (1/\lambda)[P(n-1) - K(n)u^T(n)P(n-1)]$$

In Equation (8), λ is a regularization parameter controlling filter stability. In practical applications, selecting appropriate adaptive filtering algorithms and adjusting parameters according to specific scenarios can achieve optimal noise reduction effects.

In summary, based on broadcast television signal characteristics and transmission environments, employing multiple methods such as adjusting encoding parameters, optimizing rate control, and reducing noise can effectively address signal transmission issues caused by terrain obstacles like highways, thereby improving broadcast program quality and audience viewing experience.

Conclusion

In the digital era, broadcast television program transmission methods and technologies have undergone tremendous development and transformation. The continuous emergence and widespread application of emerging technologies have brought more possibilities and opportunities for research and application of broadcast television engineering signal source transmission schemes. Broadcast television engineering signal source transmission scheme research is a comprehensive subject requiring multidisciplinary knowledge and technology integration. Along with technological innovation, broadcast television signal source transmission faces increasing technical challenges. By addressing transmission methods, signal processing, and modulation techniques, we can improve broadcast television signal transmission quality and coverage. In the future, with continuous technological development and application expansion, we must strengthen research and application of new technologies, continuously improve traditional broadcast television signal transmission technologies, enhance the quality and efficiency of broadcast television engineering signal source transmission schemes, and meet audience demands for high-definition, stable broadcast television programs.

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