

Application and Development of FM Synchronous Broadcasting in Radio Stations (Post-print)

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Abstract

With the continuous advancement of science and technology in the information era, increasing attention is being directed toward the development of FM synchronous broadcasting technology. This paper primarily elaborates on the fundamental principles, basic characteristics, issues requiring attention in synchronous network implementation, and future development trends of FM synchronous broadcasting within FM broadcasting, providing a reference for achieving regional coverage through FM synchronous broadcasting.

Full Text

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1.1 Overview

As society and technology continue to develop, increasingly scarce FM frequency resources have failed to meet public demand. New FM technologies are urgently needed to address this challenge. Multi-site broadcast synchronization technology enables multiple transmitters to operate with identical program sources, identical frequencies, and identical transmission wave phases, thereby resolving co-channel interference between adjacent transmitting stations.

FM synchronous broadcasting refers to the simultaneous transmission of the same program on the same frequency, which significantly reduces frequency resource waste while expanding broadcast coverage. Synchronous FM technology has become the primary broadcasting format and an important technical solution for mitigating co-channel interference in relevant regions.

1.2 Development Status at Home and Abroad

FM radio programs have become increasingly integrated with public daily life. On one hand, audiences demand the ability to listen to the same program on the same frequency anytime and anywhere; on the other hand, even increasing the number of program channels cannot satisfy public needs due to severe frequency resource constraints.

Recognizing the numerous advantages of synchronous FM broadcasting technology, the State Administration of Radio, Film and Television issued the technical standard *FM Synchronous Broadcasting System Technical Specification* (GY/T154-2000) in 2000 and has actively promoted the construction of synchronous FM broadcasting systems nationwide and at provincial levels ever since. In July 2001, the administration convened a pilot acceptance and technical seminar for FM synchronous broadcasting in Hangzhou, where the “Hangzhou-Ningbo Expressway FM Synchronous Broadcasting Application Experiment” passed acceptance review. This milestone marked the entry of synchronous FM broadcasting into practical application in China, and the gradual establishment of such systems has contributed significantly to the development of national radio broadcasting.

1.3 Main Advantages of FM Synchronous Broadcasting

- (1) To achieve balanced and reasonable radio wave coverage while expanding transmission range, small-power transmitters can be deployed in overlapping regions to create uniform coverage networks tailored to building distribution, area size, and terrain characteristics.
- (2) FM synchronous broadcasting does not degrade the local electromagnetic environment. Since each transmitter operates with relatively low effective radiated power, the minimum usable field strength can be employed to ensure listening quality without causing electromagnetic pollution from excessive field strength.

- (3) Synchronous FM broadcasting technology can provide complete coverage along highways spanning hundreds of kilometers, enabling listeners to receive programs without changing frequencies.
- (4) The system features lower construction costs and relatively reliable operation. The expense of deploying multiple small transmitters represents only a small fraction of the cost of a single high-power transmitter. Moreover, with numerous transmitters operating simultaneously, a single transmitter failure only affects local coverage rather than causing system-wide outages.

2. Basic Theory of FM Synchronous Broadcasting

The fundamental concept of synchronous FM broadcasting involves using multiple transmitters operating on the same frequency to broadcast the same program, enabling interference-free reception in overlapping coverage areas. The small-power transmitters employed in FM synchronous broadcasting can provide comprehensive coverage of each region and can be successfully networked according to service area shape and terrain conditions, thereby expanding transmission coverage. Additionally, FM synchronous broadcasting does not affect the existing electromagnetic environment because its transmitters radiate at relatively low power and provide balanced coverage across all overlapping regions, thus preserving listening quality without electromagnetic environmental degradation. Compared with traditional FM technology, synchronous broadcasting technology demonstrates two particularly outstanding aspects.

First, to effectively ensure coverage of a large area, the effectiveness and accuracy of transmitter frequencies must be guaranteed. Therefore, within the same FM broadcasting network, multiple transmission stations can be constructed at different locations while using identical frequencies to transmit the same program, with all transmitters maintaining highly stable operation.

Second, all transmitters in the network must guarantee high-efficiency operation capabilities. Long-term stable high efficiency ensures that transmitters generate minimal frequency errors during operation, maintaining identical frequency, phase, and modulation to prevent co-channel interference in overlapping coverage areas.

3. Basic Conditions for System Operation

Extensive theoretical research and practical experience over many years have established that FM synchronous broadcasting requires four key elements to achieve synchronous coverage with identical programs and frequencies without gaps. The basic requirements are as follows: sufficiently small frequency differences between adjacent transmitters; sufficiently small signal waveform phase differences between adjacent transmitters; sufficiently small modulation differences between adjacent transmitters; and adequate field strength within the required coverage area. The industry standard GY-154 *FM Broadcasting Sys-*

tem Technical Specification must be observed when constructing such networks. This specification provides clear technical requirements, mandating identical frequency, phase, and modulation while ensuring minimum usable field strength.

3.1 Frequency Synchronization Implementation Methods

Currently, three primary technologies enable synchronous FM broadcasting in China: delay device operation, GPS synchronization and frequency locking, and RF distribution.

- (1) The delay device method operates by using a delay unit to transmit audio signals to various stations, ensuring consistent delay across all sites.
- (2) GPS synchronization positioning primarily functions by utilizing GPS to determine frequency signals. During signal reception, source signals can typically establish transmitter GPS technical parameters according to specific indicators and standards.

3.2 Identical Frequency

Identical frequency refers to the stability and relative deviation of carrier frequencies among various transmitters in a synchronous network, rather than absolute frequency accuracy. The national standard GB/4311-2000 specifies that as long as the frequency source meets certain stability and relative frequency difference requirements, the beat frequency between two coherent waves will exceed ten seconds. This is because reception quality is primarily affected by transmission frequency accuracy and will not be significantly impacted by minor deviations. Therefore, the key lies in maintaining relatively stable carrier frequencies. While high-precision atomic clocks offer excellent accuracy, their large size and high cost make them impractical for direct use in broadcast synchronization networks. Phase-locked loop technology represents the most economical and feasible solution, enabling different transmitter carrier frequencies to be locked to the same highly stable reference frequency.

3.3 Identical Phase

Identical phase ensures that receivers in the synchronous network receive signals at the same time. Since transmission distances from the program source to various transmitters differ within an FM synchronous broadcasting network, the delay of modulated signals reaching each transmitter varies. Large delay differences can cause distortion after demodulation and generate intermodulation derivatives or mixing effects, which occur through superposition of received frequencies in the receiver. Conversely, minimal distortion indicates the most similar timing across stations. To address phase differences in modulated waves generated by various transmitters, digital delay methods are most commonly employed, inserting delay lines with different delay amounts at different positions in the transmission path to maintain essentially identical modulation signal phases across all transmitters.

3.4 Identical Modulation

Identical modulation requires maintaining consistent frequency deviation across the synchronous network. Inconsistent transmitter frequency deviation produces additional distortion and derivative components after receiver demodulation. To eliminate additional distortion and unnecessary derivatives at the receiving end, modulation consistency must be ensured as much as possible. The synchronous system must maintain amplitude modulation deviation below 5% when ensuring distortion remains under 1% at 10 kHz modulation frequency. The industry standard for FM transmitters is 2.5%/24h, meaning that through proper adjustment, modulation deviation among various transmitters in a synchronous broadcast can be maintained below 5%.

3.5 Ensuring Minimum Reception Field Strength

When two transmitters are relatively close, narrow valley points appear in the standing waves of transmitted radio waves within their overlapping region. When the radio waves from both transmitters approach these valley points, interfering field strengths emerge. If two carrier signals have identical modulation frequency deviation and phase, the field strength generated by the transmitter's internal "clipping" circuit and mutual "capture effect" can eliminate this interference.

The capture effect is unique to receivers, where only the sound from the relatively stronger transmitter can be received. In some regions where signal strengths are roughly equal, listeners may hear the same or different program signals from different transmitters and can switch between them. This issue requires careful consideration, particularly in areas where signal strengths are very close, especially in transmitter overlapping coverage zones. Fortunately, such regions are very small, resulting in relatively minor reception impacts. Transmitter effective radiated power can be appropriately adjusted to mitigate this effect, which should be avoided as much as possible in densely populated areas.

4. Development Trends

4.1 Digital FM Synchronous Broadcasting Technology

With continuous technological advancement and improvement, broadcasting technology has made significant and obvious progress in recent years through social and market economic development. Digital FM synchronous broadcasting technology has undergone relevant technical research in some developed countries, particularly among manufacturers with advanced technology. These technologies are primarily applied in transmitter RF reception processes. Digital support is essential for transmitters to achieve good stability and efficient operational performance, and these functions can be perfected through increasingly sophisticated digital technology. Furthermore, within the same FM broadcasting network, ensuring stable and efficient operation of multiple transmitters

while guaranteeing frequency accuracy and effectiveness requires corresponding digital transformation through the introduction of digital technology.

4.2 The Role of Information Networks in Managing FM Synchronous Broadcasting Networks

In recent years, network information technology has developed rapidly and been applied across various fields. Since FM synchronous broadcasting networks require regulation and processing of multiple transmitters, equipment and systems are needed to manage and monitor these transmitters. This necessitates connecting computer network systems among various FM synchronous transmitters. The normal operation of FM synchronous broadcasting networks will increasingly rely on information network management, representing a future development trend. This approach not only enhances system efficiency and stability but also enables real-time observation, management, and control of each transmitter's working status.

In conclusion, after years of technological innovation and continuous exploration, FM synchronous broadcasting will undoubtedly become an indispensable part of public life. This technology will continue to be updated and improved, offering tremendous room for future upgrades. The perfect combination of maturity and practicality will define the modernization of FM synchronous broadcasting technology, which will serve larger listening audiences and provide increasingly excellent listening effects and quality.

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

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