Postprint: Application of Integrated Audio Front-End Systems in FM Transmitter Stations

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Abstract

The application of informatization, automation, and intelligent technologies to FM transmitters has facilitated the transition of FM machine rooms to an operation and maintenance model of "manned on-call, unmanned on-duty." This paper elaborates on how, under this operational model, the utilization of integrated audio front-end systems enables accurate real-time monitoring of various transmitter parameters and timely remote alarming for abnormal faults, thereby effectively addressing the challenges of data monitoring and alarm management, and provides a reference for monitoring and alarm management in similar FM machine room operation and maintenance models.

Full Text

Preamble

Title: Application of Integrated Audio Front-End System in FM Transmitter Stations

Abstract: The application of information technology, automation, and intelligent systems in FM transmitters has facilitated the transition of FM transmitter rooms to an operational model of "manned 留守, unmanned 值班." This paper addresses how to achieve accurate real-time monitoring of transmitter parameters and timely remote alarming of abnormal faults under this operational model. Through the deployment of an integrated audio front-end system, the paper demonstrates effective solutions for data monitoring and alarm management in this operational paradigm, providing valuable insights for monitoring and alarm management in similar FM transmitter room operations.

Keywords: audio front-end; system principle; monitoring; remote alarm

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1.1 Overview

The integrated audio front-end system was developed to address the limitations of conventional audio front-ends, which suffer from low integration and intelligence, single functionality, complex and messy wiring, and high failure rates. This new-generation integrated audio front-end platform will play a significant role in preventing various liability accidents and enhancing operational reliability.

1.2 System Functions

The integrated audio front-end system provides comprehensive functionality for modern FM broadcast operations. The schedule function enables real-time tracking and monitoring of transmitter broadcast quality during programmed airtime, immediately triggering alarms for anomalies such as failure to power on, insufficient power output, or inadequate modulation. The main/backup signal source switching function features a default response time of 25 seconds (configurable), automatically bypassing to the backup channel when the main left/right channel signals are lost or fall below acceptable levels, and restoring the main path instantly when signals recover. In cases where both main and backup signals are completely lost, the system maintains the main channel in a pass-through state.

The signal amplitude processing function employs digital processing techniques to adjust audio levels in real-time based on signal strength variations, providing stable signals to transmitters and effectively improving audio intelligibility. The wireless audio open-air signal reception function extracts field strength and signal-to-noise ratio parameters from received wireless signals, intelligently determining transmitter on/off status and broadcast mode (stereo or mono) while continuously tracking open-air signal quality and logging anomalies to prevent broadcast failures caused by late startup, insufficient modulation, or power abnormalities.

The system also includes comprehensive abnormal state alarm capabilities for main, backup, and wireless signals, with monitoring, listening, and visual supervision functions. A power-failure main-path bypass function enables “one-click” forced switching between main and backup direct outputs. Finally, the remote monitoring function provides real-time surveillance of transmitter full-power broadcast status via both computer and mobile device interfaces over internet and 3G networks.

1.3 System Architecture

1.3.1 Signal Monitoring Subsystem

The signal monitoring subsystem primarily performs monitoring, listening, and visual supervision of main and backup signals, intelligent management of main-backup switching, monitoring of FM transmitter broadcast quality, anomaly alarming, and statistical recording and remote transmission of relevant broadcast status data. This subsystem consists of a six-channel serial server, four dual-channel signal monitoring display and intelligent switching boards, a matrix monitoring control board for four programs' main, backup, and wireless signals, a parallel reception and broadcast quality parameter acquisition board for four sets of stereo FM signals, a 16-channel high-speed audio acquisition board, LED audio level display and monitoring button panels, along with associated power supplies, interface boards, and signal display screens.

The main and backup signal display range spans from -21 dB to +6 dB, with an invalid signal threshold adjustable from -21 dB to -6 dB (defaulting at -21 dB). The monitoring board performs matrix switching and monitoring tasks for main, backup, and wireless demodulated signals across four programs. The system utilizes advanced digital demodulation chips to monitor transmitter field strength and modulation in real-time, displaying these parameters via LED bar graphs and LCD screens. Audible and visual alarms are triggered when field strength or modulation falls below preset thresholds. The system includes both RS232 serial and Ethernet interfaces for integration with monitoring software to form a networked broadcast transmitter monitoring system.

The system contains four identical monitoring channels capable of simultaneously monitoring four FM transmitters, with each channel's monitoring period configurable according to the station's broadcast schedule. Monitoring is active only during each transmitter's operational hours, preventing false alarms during scheduled off-air periods. Beyond field strength and modulation monitoring, the system provides demodulated audio output for audio monitoring and listening purposes, enabling chief operators to track transmitter status in real-time, promptly identify and resolve broadcast faults, and ensure secure program transmission.

1.3.2 Audio Processing Subsystem

The audio processing subsystem incorporates four independent digital stereo audio processing modules to handle audio processing for four programs, with four small LCD screens and four sets of keys on the panel for parameter configuration. The primary functions include: (1) a digital audio processor developed specifically for broadcast stations to enhance broadcast quality and ensure safe transmission, suitable for various medium-wave, short-wave AM transmitters, and FM transmitter systems; (2) one analog stereo input and two analog stereo outputs; (3) real-time processing of input audio with configurable parameters adjustable for different program types to achieve desired processing

effects; (4) two preset parameter sets for speech and music programs; (5) algorithmic solutions tailored for different applications: for AM broadcasting, the system enhances average modulation while maintaining audio quality, while for FM broadcasting, the audio processor provides greater dynamic range; (6) built-in compression limiting algorithms prevent over-modulation of terminal equipment, ensuring broadcast security; and (7) a power bypass function that guarantees audio channel continuity during power failures.

2.1 Device Channel Monitoring Frequency Configuration

The system supports four channels, with the first display interface allowing configuration of frequency, level, and modulation mode. The specific procedure is as follows: (1) Rotate the mechanical encoder to select the channel requiring frequency adjustment, press the encoder once to highlight the frequency parameter, which will begin flashing. Rotate the encoder left to decrease the parameter or right to increase it (in increments of 0.1). (2) Press the encoder once to advance to "Volx: XX," then rotate the encoder to set XX to 63. (3) Press the encoder again to advance to "CHx: XX," then rotate the encoder to set XX to FM.

2.2 Field Strength (Power) and Modulation Alarm Threshold Configuration

The second display interface enables configuration of field strength and modulation thresholds. The specific procedure is: (1) Press the mechanical encoder once to highlight the first parameter on the screen, then rotate the encoder to select "P:". Press the encoder once to make the parameter flash, then rotate left to decrease or right to increase the value (in increments of 5). Press the encoder again to stop the flashing, completing the field strength alarm threshold setting. (2) Rotate the encoder to select the parameter after "M:", press once to make it flash, then rotate left to decrease or right to increase the value (in increments of 1). Press the encoder again to stop the flashing, completing the modulation alarm threshold setting.

2.3.1 SMS Alarm Switch

Four black buttons on the front panel control the alarm switches for the four channels. When alarms are enabled for a channel, a small speaker icon appears next to that channel; when disabled, the icon disappears.

2.3.2 SMS Number and Content Configuration

This configuration requires a USB-to-RS458 hardware module and uses third-party software. The configuration parameters are: host serial port number: 3; baud rate: 9600; module address: 0; information center number: the phone number of the SIM card installed in the device; receiver numbers 1-5: the

phone numbers receiving SMS messages; output channel name setting: not required; input channel name setting: message sent when valid (alert when alarm triggered); message sent when invalid (alert when alarm cleared).

3. Daily Maintenance of Integrated Audio Front-End System

During routine operation, technicians must implement periodic maintenance procedures for the system equipment. The primary maintenance items include: (1) regular cleaning of system equipment; (2) periodic inspection of antenna connectors and power connectors to ensure proper contact; (3) regular verification of monitoring system settings; and (4) periodic testing of the remote alarm system to ensure proper functionality.

The deployment of integrated audio front-end system equipment in FM transmitters has resolved remote monitoring challenges, enabling accurate real-time remote monitoring and mobile terminal abnormal state alarm functionality. This provides robust technical support for the "manned 留守, unmanned 值班" operational model, significantly reducing emergency response times and safeguarding secure broadcast operations.

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