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On the Printout After Digital FM Transmission System Renovation

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Date: 2023-10-08T00:00:00+00:00

Abstract

This paper presents a case study on the installation and commissioning of the Italian Elenos (Yilinos) digital FM synchronized broadcast transmitter, elaborating on the performance characteristics of this FM transmitter and its remote monitoring system. It describes the installation and commissioning process as well as the post-commissioning test and measurement results, thereby accumulating experience for further enhancing broadcast security and transmission quality at FM transmitter stations.

Full Text

Abstract

This paper examines the installation and commissioning of the Italian Elenos digital FM synchronous broadcasting transmitter, elaborating on its performance characteristics and remote monitoring system. It describes the installation and commissioning process along with post-deployment field measurement results, providing valuable experience for enhancing the safe broadcasting capabilities and transmission quality of FM transmitter stations.

Keywords: Broadcasting FM transmitter; Monitoring system; Coaxial switching
CLC Number: TN934.81
Document Code: A
Article ID: 1671-0134(2018)01-044-02
DOI: 10.19483/j.cnki.11-4653/n.2018.01.012

1. Overview of Equipment Upgrade

The existing domestic FM transmitters at our station had been in operation for over ten years, experiencing frequent failures and high energy consumption,

necessitating reduced-power broadcasting. To ensure safe broadcasting during the 19th National Congress of the Communist Party of China, we conducted extensive data comparisons between imported and domestic transmitters and consulted with multiple peer organizations within the province before proceeding with the upgrade and retrofit of our FM transmission equipment.

The upgraded equipment consists of imported Italian Elenos digital FM synchronous broadcasting transmitters, with the original domestic units retained as backups. A BED coaxial switch enables automatic main-backup switching, while the Elenos remote monitoring system provides intelligent management for safe broadcasting assurance. The upgrade was scheduled during midnight shutdown periods, with full participation from our station's transmission technical staff working alongside manufacturer engineers. The project involved installing the new transmission system, overhauling and cleaning existing transmitters, and completely renovating the power supply system, audio transmission lines, and grounding infrastructure. Through detailed explanations from manufacturer engineers, our technical personnel gained comprehensive understanding of the new equipment and practiced operation of the 1+1 main-backup system, facilitating future maintenance and ensuring broadcast security.

Following the upgrade, all transmitters now operate at rated full power with digital AES/EBU audio transmission. This foundation enables future upgrades to digital FM synchronous broadcasting systems without requiring redundant investment in transmission infrastructure.

2.1 Key Technical Features of the Elenos Digital FM Transmitter

The Elenos transmitter employs state-of-the-art Digital Signal Processing (DSP) and Direct Digital Synthesis (DDS) technology, utilizing large-scale integrated circuits to replace traditional analog circuits, thereby significantly improving technical specifications and equipment stability. Featuring a 2.4 GHz clock and advanced digital signal processing, the system achieves globally leading digital audio processing technology. Audio quality metrics have achieved qualitative breakthroughs, with measured signal-to-noise ratio S/N $\geq$ 85 dB, frequency response $\leq$ \$±\$0.1 dB, distortion $\leq$ 0.01%, and stereo separation $\geq$ 65 dB—all reaching internationally advanced levels.

The system incorporates proprietary "ICEFET & ECOSAVING" technology that automatically monitors each power transistor group's temperature, enabling intelligent cooling and protection when overheating occurs. It also automatically detects input and output power for each transistor group, automatically adjusting for unstable data to achieve intelligent current sharing, ensuring no transistor damage under normal operating conditions. The proprietary one-time power distribution and synthesis technology minimizes power loss during power amplifier distribution and synthesis, reducing power consumption by 50% compared to traditional combiners. This reduction in power consumption de-

creases operational costs while lowering equipment temperatures, fundamentally improving system stability.

The transmitter features full-band design for FM 87.5–108 MHz, with measured power at any frequency meeting or exceeding rated values. Intelligent design ensures maximum uptime even under extreme environmental conditions, aiming to create the world's most stable FM transmitter. The system provides comprehensive over-current, over-voltage, and over-temperature protection, along with complete transmitter output short-circuit and open-circuit protection and intelligent VSWR protection control circuits. Overall efficiency exceeds 70% at full power, and through specific circuit design, maintains $ $70% efficiency even when operating at 50–100% power, reducing our station's operational costs including electricity and auxiliary facilities.

The compact 4U form factor is lightweight and space-efficient, accommodating four transmitters in a single rack. The system provides free and complete communication protocols via DB9 interface, enabling monitoring and control of all parameters displayed on the high-brightness OLED screen—all in digital format. Connection to a PC via DB9 allows monitoring of all transmitter parameters using Microsoft HyperTerminal or our 配套 remote monitoring system. The entire Elenos series of FM transmitters and power amplifiers (including digital and traditional models) uses fully compatible monitoring protocols, eliminating the need to replace any hardware or software when upgrading transmitter power levels within the brand.

The transmitter supports up to six channels, each with completely independent parameters including transmission frequency, power, audio gain, input mode, and pre-emphasis, enabling one-key switching—particularly suitable for N+1 backup systems. The built-in digital audio AES/EBU interface supports digital audio priority input. The system uses metallic indium instead of traditional thermal grease, ensuring uniform, effective, and long-lasting heat dissipation for power transistors with low junction temperatures. Advanced planar design optimizes and minimizes the layout of internal RF modules, power dividers, power combiners, and low-pass filters, reducing connectors and employing direct soldering to ensure long-term operational stability. Both heat sink and air duct designs utilize proprietary patented technology, with the main airflow path passing only over heat sink surfaces to enhance overall stability. All DSP+DDS technology transmitters exhibit excellent consistency in audio parameters, with only quantization errors remaining.

The system supports synchronous 10 MHz reference input and can be equipped with built-in GPS modules upon request, achieving carrier and pilot frequency synchronization at 19 kHz for true synchronous broadcasting. With synchronous 1PPS reference input, it enables audio and 19 kHz pilot synchronization. The transmitter features native audio delay capability with total delay of 1 second in 0.1 microsecond steps. Built-in dual-exciter 1+1 automatic switching function allows direct upgrade to dual-exciter FM transmitter when external exciters are connected, without requiring additional hardware or software. The transmit-

ter is directly compatible with digital FM synchronous broadcasting systems, facilitating future synchronous upgrades without equipment modification or redundant investment.

2.2 Elenos Transmitter Intelligent Remote Monitoring System

Our station employs the ELENOS transmitter remote monitoring system for real-time detection and control of transmitter operating status, enabling intelligent management. Specific functions include:

(1) Remote power on/off control of transmitters

(2) Adjustment of transmitter power and frequency

(3) Intelligent switching between main and backup transmitters

(4) Real-time display and adjustment of transmitter audio

(5) Display of operating voltage, current, temperature, and output power for each power supply group

(6) Display of current, temperature, and power consumption for each final-stage power transistor group

(7) Display of overall system efficiency, ambient temperature, and fan speed (temperature-controlled)

(8) Individual parameter configuration for six operating frequencies in N+1 systems, including frequency, power, audio mode, audio level, and pre-emphasis

(9) One-key channel switching for N+1 systems, ideal for backbone station N+1 configurations

(10) Scheduled power on/off and scheduled power ramping

(11) Historical operation curve queries and historical operation record queries

(12) Fault information queries

3. Retrofitting Construction Process

All technical staff from our station's Technical Center Wireless Coverage Department participated in the transmission system retrofit, with complete documentation and archiving of all technical test data. Key activities included:

Power system renovation involved supplying all transmitters via UPS and replacing existing power cables with Chinese Yuantong national standard flame-retardant ZR YJVR5$×$16 cables, with all power lines installed in conduit to prevent rodent damage. Grounding system renovation included replacing existing copper busbars to improve grounding effectiveness. Analog audio lines were replaced with digital AES/EBU audio directly from the ORBAN5500 audio processor in the signal cabinet, using high-quality digital audio cables to avoid interference such as power ripple and improve audio quality. The antenna and multiplexer system was retested and readjusted to ensure VSWR $\leq$ 1.10 at the transmitter input.

Custom brackets were fabricated for the newly purchased BED coaxial switches for centralized mounting, creating a stable and clean RF connection system for easy maintenance. Three transmitters were installed in a single rack with RF outputs using Φ41.3 direct top-feed outlets, with hard feed connections between transmitters, coaxial switches, multiplexers, and antenna systems, making the equipment room neat, aesthetically pleasing, and easy to maintain. All transmitters were uniformly labeled, and equipment in the machine room was reorganized and secured, retaining only three complete 1+1 transmission system setups. Manufacturer technical personnel conducted on-site training for all our coverage technical staff, with hands-on practice for each retrofitted system.

To ensure safe broadcasting during the 19th National Congress, our station completed the FM transmitter installation and commissioning in the shortest possible time while ensuring operational security. Field measurements comparing imported versus domestic transmitter performance showed field strength improvements across all three frequencies: approximately 8 dBu increase at 90.1 MHz, and 3–5 dBu average increase at 93.0 MHz and 106.1 MHz, with coverage area expanding by approximately 10% and noticeable audio quality improvements within the coverage area. This upgrade of imported FM transmitters significantly enhanced our station's safe broadcasting capabilities during the 19th National Congress, reduced outage and degraded broadcast risks, and substantially improved listening quality, earning widespread praise from audiences and excellent social response. The upgrade also filled the gap in our FM transmitter monitoring software capabilities, providing powerful support and assurance for better monitoring of transmitter data, improving utilization efficiency, extending service life, and enabling timely problem detection and resolution, thereby further enhancing safe broadcasting capabilities.

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

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