Full-Band FM Antenna System and Multiplexer Post-Modification Printout

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Abstract

To better utilize the spatial resources of antenna towers and avoid mutual interference caused by excessively close spacing between antennas that may affect transmitter performance, this paper analyzes and discusses the practical problems encountered during the design and implementation of an actual FM antenna system renovation project, and provides recommendations for related renovation work.

Full Text

Full-Band FM Antenna System and Multiplexer Renovation

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Abstract: To better utilize tower space resources and avoid mutual interference caused by excessively close antenna spacing that affects transmitter performance, this paper analyzes and discusses practical problems encountered during the design and implementation of an actual FM antenna system renovation, and offers recommendations for related upgrade work.

Keywords: FM antenna system; multiplexer; impedance matching

1. Overview

Baishan TV Relay Station currently broadcasts 10 radio programs using analog transmitters. Among these, three transmitters (Jilin Economy, Jilin Tourism, and Jilin Traffic) share one antenna via a triplexer, while the remaining transmitters each use independent antennas. Over time, more than 10 FM antennas

have been installed on the tower. Some antennas have exceeded their design lifespan, resulting in decreased power capacity, increased voltage standing wave ratio (VSWR), degraded coverage, and crosstalk issues due to close proximity between antennas operating at different frequencies. These conditions cannot meet future multiplexer technology requirements or the conditions for broadcasting digital radio CDR. It is necessary to replace the previous 10 antennas with a system where multiplexers enable shared antenna transmission.

Following discussions by the technical department, it was decided to add two full-band FM antennas, with 10 transmitters using two multiplexers to broadcast through these two antennas. A vertically polarized single-dipole antenna installed below the broadcasting platform serves as a backup antenna for both multiplexers, achieving independent backup for the main feed line and both antennas while removing redundant antennas to free up space for future development.[1]

3.1.2 Antenna Technical Specifications

The antenna system must meet the requirements of Jilin Province' s radio program wireless coverage project, with a VSWR ≤ 1.15 across the full operating frequency band. The selected antenna consists of an array of eight dual-dipole horizontally polarized FM transmitting antennas configured as a two-layer, four-sided dual-dipole reflector panel array. The power capacity is 16 kW with gain superior to the original antenna. When the system bandwidth exceeds 19 MHz, the VSWR is ≤ 1.10, meeting multi-frequency usage requirements. The main feed line uses SDY-50-80 air-filled coaxial cable, distributed equally through a 1/8 power divider to eight 50-12 feeders, with adequate design redundancy.[2] The unit panel input interface is L29, with VSWR S ≤ 1.10, rated power of 16 kW, gain of 7.1 dBd, and horizontal polarization. The antenna elements and reflector panels are constructed from stainless steel for corrosion resistance and deformation resistance, with connecting bolts and nuts using hot-dip galvanizing. The simple, robust structure ensures stable operation under harsh weather conditions including high winds, rain, and snow.[3] The radiation pattern diagrams are shown in Figure 1 [Figure 1: see original paper].

3.2 Multiplexer

3.2.1 Multiplexer Design

A multiplexer is a device that enables multiple transmitters to share a single antenna feed system. Currently, two types of FM multiplexers are commonly used: star configuration and bridge configuration.[4] The star configuration is simple and inexpensive but provides isolation only through filters, requiring large spacing between two RF carriers; otherwise, the isolation cannot meet required specifications. Given the numerous frequency channels at our station and the small spacing between some carriers, the bridge configuration is more suitable.[5]

Bridge Diplexer Fundamentals: A bridge diplexer consists of two 3 dB directional couplers (D1, D2), two bandpass filters (B1, B2), and a balance load with connecting feed lines. RF signal F1 is input from port 1 (narrowband port) of D1, outputting half-power signals at ports 3 and 4. Port 3 is in-phase with port 1, while port 4 lags port 1 by 90°. The signals pass through bandpass filters B1 and B2 to reach ports 3 and 4 . Port 4 is in-phase with port 2 , while port 3 reaches port 2 after a 90° delay. For signal F1, this results in in-phase synthesis at port 2 . Similarly, F2 signal input at port 1 outputs half-power F2 signals at ports 3 and 4 , which after full reflection by the bandpass filters synthesize F2 at port 2 . Thus, F1+F2 is synthesized at port 2 . In practice, B1 and B2 do not completely reflect F2; some leakage reaches ports 3 and 4 of D1, adds at port 2, and is absorbed by resistor R without crosstalk to port 1 and F1.

The selected six-channel multiplexer is essentially a cascade of bridge diplexers. To ensure isolation meets required specifications, frequency channels connected to the multiplexer are reasonably allocated. The system schematic is shown in Figure 3 [Figure 3: see original paper]. Both six-channel multiplexers reserve broadband ports with power capacity, providing conditions for future expansion.

3.2.2 Multiplexer Implementation

During installation, engineering personnel first removed all components from their packaging, taking care to protect product surfaces from physical damage such as impacts or scratches. Assembly was performed strictly according to product manuals. After assembly, the engineering team conducted on-site testing to obtain field technical indicators, which were compared with factory specifications in the user manual. If structural differences were significant, the multiplexer was adjusted to achieve matching results. Figure 4 [Figure 4: see original paper] shows a partial physical view of the multiplexer.

During coaxial hard feed and 1/2” jumper cable fabrication, dimensions were strictly calculated, burrs removed, and connections ensured to be tight. Coaxial switches were installed to enable switching between primary and backup antenna feed systems, as shown in Figure 5 [Figure 5: see original paper]. Multiplexer dust covers were then installed. Figure 6 [Figure 6: see original paper] shows the completed multiplexer installation.

After project completion, some frequency points showed excessive reflection during transmitter testing. Analysis revealed this was caused by impedance mismatch due to phase changes in the transmission line. Changing jumper dimensions normalized the reflection values.

4. System Performance and Implementation Results

After complete connection of the antenna feed system, multiplexer indicators were measured in the equipment room: voltage standing wave ratio ≤ 1.10, insertion loss ≤ 0.7 dB, isolation ≥ 45 dB, with no perceptible temperature rise. This

project effectively resolved issues of excessive tower antennas, unbalanced loads, and crosstalk caused by close antenna proximity, while improving transmitter operational efficiency and broadcast safety assurance. Since commissioning, the system has operated stably with satisfactory results.[6]

After renovation completion, Baishan TV Relay Station organized technical personnel to conduct coverage testing and subjective evaluation according to *Method and Technical Requirements for Subjective Assessment of Sound Quality of Broadcast Programs* (GB/T 16463-1996) and *Measurement Methods for TV and FM Broadcasting Field Strength* (GB/T 14109-1993). Coverage area and listening quality met expected targets.[7] Figure 6 [Figure 6: see original paper] shows the field strength coverage map for 101.6 MHz.

The station broadcasts 10 FM radio programs. The 88.8 MHz channel with 300 W nominal power covers the urban area, while other frequencies cover: north to Liangshui Town in Liuhe County; south to Di Tai Team 3 in Sandao 沟 Town; west to Yayuan and Shuidong near Tonghua City; and east to the edges of Jingyu and Linjiang. Coverage is effective, serving an urban population of 620,000 and approximately 100,000 people in Tonghua and surrounding townships. Coverage reaches about 99% of the urban population and 93% of surrounding township and village populations, achieving planned coverage targets.[8] The coverage test results are satisfactory, achieving the objective of multi-frequency transmission through a shared antenna feed system via multiplexers, saving tower space resources, resolving inter-frequency crosstalk issues caused by closely spaced antennas, and providing space for future development.

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