Design and Implementation of Primary-Backup Program Source Switching System for Transmitter Stations: Postprint

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Abstract

The program transmission link, as one of the most critical components in the safe transmission and broadcasting system of transmitter stations, serves as the front-end interface system for the transmitter and holds a pivotal position within the entire broadcasting system. The primary-backup program source switching system effectively resolves the issue of single program sources for transmitters, enhances the reliability level of program sources, and satisfies the requirements for safe broadcasting operations.

Full Text

Abstract

As a critical component of the safe transmission and broadcasting system in radio stations, the program transmission link serves as the front-end program source interface for transmitters and holds a pivotal position in the entire broadcasting system. The main-backup program source switching system effectively addresses the single program source limitation of transmitters, enhances the program source security level, and meets the requirements for safe broadcasting operations.

Keywords: Main-backup program source switching; Four-to-one selection; Guarantee; Safe transmission and broadcasting

1.1 System Composition

The main-backup program source switching system primarily consists of a main satellite receiving antenna, a main digital audio satellite receiver, a backup satellite receiving antenna, a backup digital audio satellite receiver, a four-to-one program selector, and a UPS power supply. The program transmission system

serves as the front-end program source interface for transmitters and represents one of the most critical systems in the safe transmission and broadcasting architecture of radio stations. Improving the reliability of this system plays a vital role in ensuring safe transmission and broadcasting operations. To enhance the program source protection level for our station's FM transmitters, we conducted a technical renovation of the existing program transmission system and redesigned the main-backup program source switching system, which effectively improved the stability and reliability of the program switching system.

1.2 Subsystem Functions

The main satellite antenna receiving system is responsible for receiving C-band satellite electromagnetic wave signals, down-converting and amplifying them into first intermediate frequency signals, and transmitting them to a power divider. The backup satellite antenna receiving system performs the same function for Ku-band satellite signals, down-converting and amplifying them into first intermediate frequency signals for the power divider.

The main digital audio satellite receiver receives the required first intermediate frequency satellite signals from the C-band, extracts the necessary program information and program PIDs, and stores them in memory. It ensures that the locked program PIDs are not lost during power outages. The audio data received from the satellite is decoded by an audio decoding circuit, which outputs both digital and analog audio signals. The backup digital audio satellite receiver performs identical functions for Ku-band signals, also storing program information and PIDs in non-volatile memory and providing decoded AES/EBU digital audio and analog audio outputs.

The four-to-one device handles the reception of main and backup digital audio signals, performs level monitoring, executes main-backup switching, generates anomaly alarms, and transmits the selected audio signals to the transmitter. The UPS power system provides uninterrupted, stable 220V power to all equipment.

2. Four-to-One Switcher

The core equipment of the main-backup program source switching system is the four-to-one switcher, which can switch between four input audio signals based on audio level detection and delay settings. During program broadcasting, if the main audio signal is interrupted, the system automatically switches to the backup signal path while triggering audible and visual alarms, thereby reducing broadcasting accidents and improving transmission quality. The device supports both manual and automatic modes that operate independently. In manual mode, it functions as a standard four-to-one switcher. In automatic mode, it allows configuration of alarm level thresholds and delay times, and features an RS-232 serial port for convenient communication with PCs.

[Figure 1: see original paper] Main-backup program source switching topology diagram

2.1 Front Panel Overview

The front panel includes the following components: a power switch (220V AC main input), a manual/auto switch (for toggling device operating modes), a mute button (to cancel buzzer alarms), DIP switches (for configuring threshold levels, alarm delay times, and buzzer settings), signal input indicators (illuminating when a signal is present on that path), and manual switching buttons (for manually selecting signal paths).

[Figure 2: see original paper] Equipment front panel

2.2 Operation Methods

Operators must first configure the audio threshold level, set the delay switching time, and select the operating mode based on actual broadcasting requirements.

Automatic Mode: When the manual/auto switch is set to the automatic position, the device operates in automatic mode with priority ranking: Path 1 > Path 2 > Path 3 > Path 4.

2.2.1 Audio Switching Logic

In automatic mode, if any channel signal in Path 1 is lost for a duration exceeding the set delay while both left and right channel signals in Path 2 are present, the system immediately switches to Path 2. If any channel in Path 1 is lost and any channel in Path 2 is also lost for longer than the delay while Path 3 has a left channel signal, it switches to Path 3. If any signal is lost in Paths 1 and 2, the left channel is lost in Path 3, and the delay threshold is exceeded while Path 4 has a left channel signal, it switches to Path 4. If signals are lost in all four paths beyond the delay threshold, the system triggers an alarm without switching.

When in automatic state, if Path 1 fails and switches to Path 2, the system immediately returns to Path 1 if both left and right channels in Path 1 recover. If the signal has switched to Path 3 and both channels in Path 1 recover, it switches back to Path 1. If only one channel in Path 1 recovers but both channels in Path 2 have recovered, it switches to Path 2. If both Path 1 and Path 2 have fully recovered, it returns to Path 1. If the signal has switched to Path 4 and both channels in Path 1 recover, it returns to Path 1. If only one channel in Path 1 recovers but Path 2 is fully restored, it switches to Path 2. If both Path 1 and Path 2 are fully restored, it returns to Path 1. If neither Path 1 nor Path 2 are fully restored but the left channel of Path 3 recovers, it switches to Path 3.

In automatic mode, manual switching buttons are disabled.

2.2.2 Manual Mode

To use manual mode, first toggle the auto/manual switch to the manual position, then select the desired signal path according to switching requirements.

2.3 Switching Principle

The differential signal enters through the XLR connector, passes through a relay, then through a differential amplifier circuit (the common-mode rejection ratio is adjusted via potentiometer S2, and the output signal level is adjusted via potentiometer VR1), and enters pins 33 of the MT8816 chip. The signal then exits from pin 1 (OUT1) of the MT8816, passes through a filtering circuit, an amplifier circuit (signal level controlled by potentiometer S3), a differential circuit, another relay, and finally exits through the XLR connector.

Signals from OUT3-OUT8 of the MT8816 pass through amplifier circuits (with signal level adjusted via potentiometer S11) and enter pins 3-8 of the STC60S2 microcontroller for threshold level detection. Pins 21-28 of the STC60S2 microcontroller connect to pins 39-32 of the C55 microcontroller and then to the front panel to control signal indicator lights. When the threshold level from OUT3-OUT8 exceeds the set value, the corresponding LED illuminates.

Pins 39-34 of the STC60S2 microcontroller control the front panel DIP switches for threshold level configuration. Pin 33 controls the mute button, and pin 32 controls the manual/auto switch.

The STC60S2 microcontroller's Port P1 performs AD acquisition of six audio signals output from the MT8816 (eight total channels, with two connected to output to avoid affecting the signal during acquisition). Port P2 connects to eight LED indicators and the P0 port of the 89C55 microcontroller, sending data about signal presence to the 89C55 while driving the corresponding indicator lights.

The 89C55 microcontroller's Port P0 connects to the P2 port of the STC12C5A60S2 microcontroller to receive audio input status data. Port P1 controls the MT8816. Pin P2.0 connects to pin P0.7 of the STC12C5A60S2 for mode selection. Pins P2.1, P2.2, P2.3, and P3.3 control channel selection indicators. Pins P3.4-P3.7 handle channel selection buttons.

2.4 Debugging Procedure

1. Program the STC12C5A60S2 microcontroller.
2. Inspect the circuit board: Before powering on, check for cold solder joints, incorrect component placement, or missing components. Verify all component models, orientations, and connector directions.
3. Test the power circuit: (i) Check for short circuits by using a multimeter's continuity mode in the powered-off state to test for shorts between power socket terminals, ensuring power supply integrity. Any short circuit

will damage the board when powered. (ii) Verify correct voltage values throughout the power circuit using a multimeter after confirming no shorts exist.

3. System Maintenance

During daily operation, technical personnel must implement periodic maintenance procedures for the audio four-to-one switching system. Primary maintenance items include: (1) regular equipment cleaning; (2) periodic inspection of power connectors and BNC terminals for proper contact; (3) regular testing of automatic/manual switching functions between main and backup audio paths; (4) periodic verification of backup audio path integrity; and (5) regular inspection of UPS power supply voltage and current parameters, with scheduled discharge testing of backup batteries.

Through the implementation of the main-backup program source technical renovation, the FM transmission room has significantly enhanced transmitter program source security levels. After more than two years of operation, the main-backup program source switching system has demonstrated stable performance, effectively ensuring normal program transmission during severe weather and solar interference periods. This has greatly improved program transmission reliability, particularly during critical security periods, establishing a solid foundation for safe transmission and broadcasting operations.

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