Design and Application of External Maintenance Bypass System for UPS in the Transmitter Room of Zhongyuan Tower (Postprint)

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Abstract

This paper presents the design and installation scheme of the UPS external maintenance bypass system for the transmitter room of Zhongyuan Tower, which resolves broadcast interruption incidents of transmitter equipment caused by internal faults within the uninterruptible power supply system itself and significantly enhances the power supply reliability of the entire transmission system.

Full Text

Preamble

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Abstract: This paper presents the design and installation scheme of an external maintenance bypass system for the UPS (Uninterruptible Power Supply) in the transmitter room of Zhongyuan Tower. This solution effectively addresses transmitter shutdown incidents caused by failures within the UPS system itself, significantly enhancing the reliability of power supply for the entire transmission system.

Keywords: UPS; maintenance bypass; power supply safety

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Maintaining equipment in broadcast transmitter rooms and minimizing transmission failures caused by external power faults or momentary interruptions is of critical importance. The deployment of Uninterruptible Power Supply (UPS) systems provides excellent protection for broadcast equipment through stabilized voltage and frequency output. By connecting battery banks to inverters, these systems effectively mitigate external power issues such as voltage loss, harmonic interference, surges, and outages. The system's DC battery power is converted into AC sinusoidal voltage via an inverter to supply the transmitter load. When external power is restored but the UPS system fails to respond, the external maintenance bypass system switches the transmitter equipment to external power supply without interruption, thereby providing ample time for UPS system maintenance.

Since our station currently utilizes dual external power sources with automatic transfer devices in the distribution cabinets that can switch to the alternate power source within 2 seconds when one fails, we plan to leverage this existing advantage by making minor modifications to the distribution cabinet. Specifically, we will remove the connection between the original automatic transfer device output and the transmitter circuit breaker, connect the input and output terminals of the UPS external maintenance bypass system to these two points, and integrate the UPS system into the external maintenance bypass system to form a complete physical loop. This approach reduces construction material consumption, minimizes circuit components, and decreases the risk of equipment power loss and transmission interruption caused by component failures.

However, several limitations in existing UPS systems necessitated the development of an external maintenance bypass solution. First, when the contactor control signal board and static power switch in the UPS detection circuit fail, the static power switch or control signal board cannot operate, preventing manual transfer to bypass power supply. Second, during site renovation or capacity expansion, the UPS requires relocation without power interruption. Third, while most UPS systems include built-in maintenance bypasses, failed units can only be repaired in place without disconnecting wiring for relocation, making maintenance extremely difficult in constrained spaces. Based on these considerations, our transmitter room designed and installed an external maintenance bypass system for the UPS. A properly designed external maintenance bypass system not only provides robust guarantee for uninterrupted power supply but also resolves broadcast interruptions caused by UPS system component failures, representing a crucial improvement for ensuring broadcast equipment operation.

2. UPS External Maintenance Bypass System Design Scheme

The newly installed large-capacity UPS external maintenance bypass system in the transmitter room can effectively improve the quality of the uninterrupted

power supply system, eliminate broadcast interruptions caused by UPS system issues, and enhance the safety and reliability of broadcast signal transmission. Our station has focused on the following aspects to improve overall system reliability.

2.1 Rational External Bypass Design

Since our station currently utilizes dual external power sources with automatic transfer devices in the distribution cabinets that can switch to the alternate power source within 2 seconds when one fails, we plan to leverage this existing advantage by making minor modifications to the distribution cabinet. Specifically, we will remove the connection between the original automatic transfer device output and the transmitter circuit breaker, connect the input and output terminals of the UPS external maintenance bypass system to these two points, and integrate the UPS system into the external maintenance bypass system to form a complete physical loop. This approach reduces construction material consumption, minimizes circuit components, and decreases the risk of equipment power loss and transmission interruption caused by component failures.

2.2 Characteristics of UPS External Maintenance Bypass System

2.2.1 Independent Power Supply Loop During Maintenance The UPS external maintenance bypass system serves as an emergency switching and equipment maintenance bypass. Installing this bypass ensures that when the UPS requires maintenance or fails, the entire load can be transferred to external power supply while the transmitter equipment remains powered by the UPS. This resolves the single-node power supply issue and guarantees safe broadcast transmission.

2.2.2 Human-Machine Interaction System for Real-Time Query The transmitter room UPS external maintenance bypass system should have intelligent capabilities to monitor operating status, record relevant parameters during operation, and provide fault diagnosis and self-checking functions. When system anomalies occur, it should prompt and automatically record relevant information for fault review and response.

2.3 Addition of UPS External Maintenance Bypass

Our station's original UPS only featured a static bypass without a maintenance bypass. The UPS static bypass refers to a circuit path between the UPS input and output, which is not simply a direct wire but may include series-connected circuit breakers, electronic switches, and simple filtering devices. For UPS systems, there are two types of bypasses: static bypass and external maintenance bypass. When a UPS malfunctions, the system automatically transfers to the static bypass, which can also be manually activated. The static bypass ensures uninterrupted switching between the UPS and external power when the UPS

fails. The external maintenance bypass is used to isolate the UPS system during maintenance, allowing the load to receive power directly from external sources without UPS protection. The system is configured with input switches, output switches, and maintenance switches. Under normal utility power conditions, the UPS operates in two states: normal state and bypass state. In normal state, the UPS inverter operates, delivering standard voltage to the load with significant input-output voltage differential because the external power and UPS inverter output differ in voltage amplitude and harmonic distortion. In bypass state, the internal bypass static switch closes, allowing external power to supply the load directly through the static switch with minimal input-output voltage differential (approximately 1V). Under normal conditions, the input and output switches remain closed while the maintenance switch remains open; during maintenance or emergency situations, the input and output switches open while the maintenance switch closes. In summary, the static bypass is an internal bypass that ensures uninterrupted switching between the UPS and external power when the UPS fails. The maintenance bypass is an external bypass used to isolate the UPS system during maintenance. Therefore, adding an external maintenance bypass is a necessary measure to ensure safe broadcasting.

3. Working Principle of UPS External Maintenance Bypass System

[Figure 1: see original paper] shows the circuit diagram of the UPS external maintenance bypass system. When external power supply input is normal, three circuit paths are established.

The first main circuit path connects external power to the charger and inverter through the K3 air switch. The charging device converts AC power to DC through an autotransformer, rectification, and filtering, then delivers it to the inverter. By closing the K4 switch, stable AC power is obtained while simultaneously charging the K5 battery bank. The UPS system inverter operates using DC power provided by the battery bank, enabling synchronous conversion to inverter power supply without requiring external power. This device employs high-power IGBT module full-bridge inverter circuits with ample power margin and low output impedance.

The second path is the UPS static bypass. Due to the UPS system's overload protection function, when system overload occurs, it automatically transfers to the UPS static bypass through bypass switch K2 and the SSM rectifier bridge, automatically returning when the load returns to normal. If the overload is severe, the inverter stops working and transfers to the UPS static bypass, causing the K3 air switch to trip. The system can only resume main circuit supply after the fault is cleared and the K3 air switch is closed.

The third path is the UPS external maintenance bypass state, which is activated only during UPS maintenance and servicing. The K4 and K1 switches are interlocked; when the K1 switch is manually closed, the K4 switch automatically

opens to achieve safe isolation.

4. Testing of UPS External Maintenance Bypass System

To ensure the UPS external maintenance bypass system functions properly, testing its stability and reliability is essential. The testing primarily consists of two parts: switching to maintenance bypass state and switching back to normal state.

4.1 Switching to External Maintenance Bypass Steps (UPS Load Remains Powered)

Press the "Inverter Stop" button on the UPS panel for more than 2 seconds, then press the corresponding confirmation key to shut down the inverter. Observation: The inverter indicator light on the UPS panel extinguishes, while the bypass indicator illuminates green, indicating bypass power supply.

Disconnect the battery switch on the battery cabinet, open the non-operation latch on the UPS external maintenance bypass, and close the UPS external maintenance bypass switch K1. Observation: The UPS panel displays input current as "0."

Sequentially disconnect the UPS external maintenance bypass input switch K3 and output switch K4. Observation: The UPS panel display and indicator lights extinguish, while the system remains powered in UPS external maintenance bypass state.

4.2 Switching from External Maintenance Bypass to Inverter Power Supply Steps

Close the UPS external maintenance bypass output circuit breaker K4. Observation: The bypass power indicator and load indicator on the UPS panel illuminate green.

Sequentially close each UPS external maintenance bypass switch K3 and corresponding battery bank switch. Observation: Wait for the rectifier indicator on each UPS panel to change from flashing to steady green, indicating rectifier startup completion. After each battery contactor closes, the battery indicator red light extinguishes.

Disconnect the UPS external maintenance bypass K1, then press the "Inverter Start" button on the UPS operation panel for more than 2 seconds. Observation: Each UPS inverter starts until the inverter indicator on the panel turns green, indicating inverter startup completion, while the bypass indicator green light extinguishes.

Testing confirmed that all indicators of the UPS external maintenance bypass system meet project design requirements with stable and reliable performance.

Conclusion

The application of UPS power supply systems in broadcast television transmission stations not only improves power grid quality but also provides crucial protection for transmission operations. Based on several months of operation, the equipment is easy to operate and performs stably, achieving the original design objectives. Particularly during a recent external power momentary interruption, when continuous power surges caused the UPS to have no output, immediately switching to the maintenance bypass allowed the system to perform effectively.

References

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