Postprint: Improved Application of Uninterruptible Power Supply for Hub Base Stations

Authors: Lu Minghui, Xiu Qingbo, Ma Guochun

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

Abstract

Our station serves as a hub base station for microwave broadcast television program transmission. The shutdown of microwave equipment would impact the transmission and broadcasting of microwave broadcast television programs across multiple regions. Statistical data indicates that the majority of equipment shutdowns are triggered by external power supply abnormalities. Therefore, to achieve uninterrupted power supply during external power outages or faults, facilitate timely and effective handling, and minimize broadcast interruption duration caused by external power issues to the greatest extent, this power supply system solution was ultimately finalized and implemented through progressive refinement.

Full Text

Uninterrupted Power Supply Improvement Application for Hub Base Stations

ChinaXiv Cooperative Journal

Abstract: Our station serves as a hub base station for microwave radio and television program transmission. Equipment shutdowns directly impact the delivery and broadcasting of microwave radio and TV programs across multiple regions. According to statistics, the majority of equipment shutdowns are caused by external power supply anomalies. Therefore, to achieve uninterrupted power supply during external power outages or faults, enable timely and effective response, and minimize broadcast downtime caused by external power issues, we have gradually refined and ultimately determined the power supply system solution presented herein.

Keywords: power supply; uninterrupted; primary-backup

Classification: TN86

Document Code: A

Article ID: 1671-0134(2018)01-062-02

DOI: 10.19483/j.cnki.11-4653/n.2018.01.021

Authors: Lu Minghui, Xiu Qingbo, Ma Guochun

Our station currently employs a primary-backup configuration with two 10 kV high-voltage external power lines, both sourced from the same high-voltage substation under the municipal power bureau, sharing a single power origin. Due to rapid urban development and numerous construction sites throughout the city, the probability of destructive faults in urban high-voltage lines has increased significantly. Additionally, as our station is located in mountainous terrain, lightning strikes during summer rainy seasons frequently cause external power interruptions and faults.

The ability to promptly implement effective measures for rapidly supplying power to equipment rooms during emergencies, thereby avoiding or minimizing broadcast downtime, represents a critical challenge for our base station personnel and constitutes the primary objective of this power supply system improvement. This paper focuses on the low-voltage power supply system composed of 380/220 V low-voltage feeder lines and low-voltage distribution equipment after voltage transformation.

We have relocated the transformer room adjacent to the equipment room distribution panel with temperature control, redesigned the wiring, and procured a new generator featuring automatic and manual start capabilities. These improvements have significantly enhanced efficiency for both automatic control and manual operations. To ensure truly uninterrupted and transient-free power supply for equipment, and because our station also undertakes FM transmission tasks requiring continuous 380 V AC power, we installed UPS systems downstream of the dual external power lines and generator circuits. Path switching for the above power lines is accomplished through manual switches. The schematic diagram of the uninterrupted power supply is shown below:

1. Uninterrupted Power Supply Improvement

To enhance power supply reliability, we have implemented a dual high-voltage source configuration with one primary and one backup line. Both high-voltage sources are stepped down through two transformers and provide mutual backup at the low-voltage distribution cabinet, with each transformer capable of supporting full load independently. Prior to improvement, the base station used exposed transformers with overhead low-voltage lines entering the equipment room. After years of operation, the transformers and wiring had deteriorated. Considering fire prevention and lightning protection requirements due to the mountainous location, this improvement replaced the original exposed transformers with outdoor prefabricated substations, and the low-voltage lines from

the substation to the equipment room were changed from overhead to direct burial according to relevant standards, significantly improving electrical safety.

2.1 Automatic Transfer Switch

The two low-voltage external power lines entering the equipment room are interlocked at the low-voltage cabinet and capable of automatic switching. When one external power source fails, the system automatically transfers to the alternate line. Previously, we designed custom transfer switches utilizing the electromagnetic attraction characteristics of AC contactors. However, prolonged use revealed several drawbacks: the switches lacked enclosure integrity, allowing small animals to enter and cause circuit interruption faults, and contact corrosion led to poor connectivity. Consequently, we procured integrated, sealed automatic transfer switches as replacements.

To achieve uninterrupted power supply, we equipped the station with a generator for self-powered operation when both utility lines fail. Previously, the generator room was located far from the equipment room, and the generator lacked automatic transfer and self-start capabilities with the external power supply. On several occasions when both external power lines failed, duty personnel had to manually start the generator for emergency response. Since the generator room was remote and incidents sometimes occurred during winter when engine startup requires preheating, this significantly delayed emergency generator activation, resulting in broadcast interruptions. To prevent such incidents from recurring, this improvement…

2.1.1 Normal Operation: Dual Power Lines Engaged, Generator Disconnected

Under normal operation, both power lines are engaged, with the frequently used line designated as the primary and the other as backup. When either line becomes abnormal due to power outage, phase loss, or phase drop, the automatic transfer switch performs automatic switching between primary and backup external power sources. When both primary and backup lines experience complete power failure, the backup line is disconnected, the generator circuit is closed, and the generator is started.

2.1.2 Automatic Transfer Switch Controller

The controller supports automatic and manual mode configuration, allowing parameter settings based on actual conditions, such as under-voltage, over-voltage, dual-source transfer delay, power supply mode settings, and other parameters.

2.2 Voltage Regulator

Neither of our station's two external power lines are dedicated circuits, exhibiting issues such as excessive voltage, instability, and intermittent fluctuations.

With increasing equipment loads and stability requirements, voltage regulators become necessary. Regulator operating ranges are limited, generally not exceeding 323–455 V. Therefore, regulator selection must be based on actual external power conditions. If three-phase external voltage fluctuations exceed the regulator's operating range, customized regulators must be considered to ensure stable 380 V three-phase output.

This design incorporates two voltage regulators with bypass functionality. The primary regulator supplies power to microwave and FM transmission equipment in the base station equipment room, as well as lighting and heating systems. The secondary regulator supplies office building and other domestic loads while serving as backup for the primary equipment room regulator. When the primary regulator fails and cannot operate normally, both regulators are shut down, the regulator transfer switch is moved to the backup regulator side, and the backup regulator is activated. In this scenario, actual voltage and current data from the backup regulator must be monitored. Since the backup regulator also serves domestic loads, domestic power should be disconnected when current exceeds certain thresholds. When both regulators fail and cannot provide voltage regulation, resulting in power loss, the regulator bypass switch must be engaged to supply external power directly to the equipment room without regulation, ensuring timely power restoration.

2.3 Generator

The diesel generator selected for this improvement features high load capacity, reliable operation, and a 120 kVA rating, with automatic and manual start capabilities, capable of supplying power to the base station equipment room for over 8 hours during emergencies. The generator and external power are interlocked through a CHINT transfer switch. Initially, the generator was configured for automatic start mode. However, operational experience revealed that during periods of frequent external power faults, particularly continuous flickering, the generator would start automatically too frequently due to its interlocked backup relationship with external power. After UPS installation, the generator was set to manual mode. When external power flickering occurs frequently, manual switches are used to disconnect the external power path and start the generator to isolate external power faults.

2.4 Uninterruptible Power Supply (UPS)

UPS is an AC uninterruptible power supply system. Since critical equipment such as our station's FM transmitters utilize AC power, UPS systems are employed to provide short-term power supply assurance for uninterrupted operation. After comparative evaluation, we procured three SANTAK FX33 series UPS units, each rated at 60 kVA, operating in parallel. Under normal conditions, the UPS operates in bypass mode while external power supplies the equipment room and simultaneously performs float charging of the UPS batteries. When external power fails, the UPS can provide stable 380 V AC power to

equipment for over 30 minutes at maximum load, truly achieving uninterrupted power supply.

3. Practical Automatic External Power Alarm Device

This is an automatic power failure and restoration alarm device independently developed by our station. By installing automatic external power information alarm devices, duty personnel can promptly monitor the status of both external power lines and prepare emergency responses when either line fails.

XJ3 is a phase-loss and phase-sequence protection relay that operates normally after verification. Switches K1 and K2 are set to the power-failure alarm position. When power loss, phase loss, or phase error faults occur, XJ3 ceases operation, and its internal pins 7 and 8 become connected. AC 220 V voltage from the UPS is converted through an AC/DC converter to output a DC 12 V startup voltage that activates the alarm, generating audible and visual alerts to promptly notify duty personnel of power failure and other fault information for inspection and emergency preparation.

When the switch is set to the power-restoration alarm position and external power returns to normal, XJ3 resumes normal operation. Pins 5 and 6 become connected, and the alarm again issues audible and visual alerts to inform duty personnel that external power has been restored and the emergency is resolved.

The primary objective of this power supply improvement application is to achieve stable, uninterrupted power, representing the optimal solution summarized from numerous external power failures at our base station, approaching or meeting Class I standards for power supply at national communication stations. The design employs redundant architecture. Although the principles may appear straightforward, they constitute practical experience gained from real-world applications and can essentially eliminate equipment signal transmission interruptions caused by external power issues. With technological advancement, the emergence of equipment or improvement methods that balance economic viability, environmental protection, and safety would be highly desirable for base station operators.

[1] Ji Changpeng. Modern Communication Power Supply [M]. Beijing: National Defense Industry Press. [2] Qiang Shengze, Yang Guiheng, Li Long, et al. Principles and Design of Modern Communication Power Supply Systems [M]. Beijing: China Electric Power Press, 2009. [3] Du Runhong. Electrical and Electronic Technology [M]. Beijing: Beijing Institute of Technology Press.

(Author Affiliation: Station 652, Jilin Province Press, Publication, Radio, Film and Television Bureau)

Technology and Application • Research

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