A Preliminary Analysis of the Causes of Cooling Failure in the DX-200 Transmitter (Postprint)

Authors: Cai Xincen

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Abstract

Our station's two DX-200 transmitters and two DX-50 transmitters are air-cooled solid-state transmitters. During daily operation, cooling failure phenomena such as "air volume attenuation" or "air flow fault" frequently occur. "Air volume attenuation" refers to insufficient wind speed, resulting in immediate operation at reduced power; "air flow fault" indicates excessive temperature, leading to immediate shutdown and broadcast interruption. Excessive temperature primarily affects components by reducing their service life and causing burnout, rendering the transmitter unable to operate normally. Therefore, numerous temperature detection circuit boards are installed at various locations on DX series transmitters to monitor temperatures in different parts. Moreover, our station's transmitters employ not only the most effective method of direct fan cooling for components, but also utilize commercial air conditioning for transmitter cooling, achieving excellent results. The objective is to reduce component temperatures to the lowest practically achievable level, thereby enabling safer and more reliable transmitter operation. The following provides a brief analysis of the causes of cooling failures, treatment methods, and operational measures adopted, for mutual reference.

Full Text

Analysis of Causes for Cooling Faults in DX-200 Transmitters

Abstract: Our station operates two DX-200 transmitters and two DX-50 transmitters, which are air-cooled, all-solid-state units. During daily operation, cooling failures frequently manifest as either "airflow attenuation" or "airflow fault." Airflow attenuation—insufficient wind speed—results in immediate power reduction, while airflow fault—excessive temperature—triggers immediate shutdown and broadcast interruption. High temperatures primarily degrade component lifespan and cause burnout, leading to transmitter malfunction. Consequently, numerous temperature detection circuit boards are installed at various locations throughout DX series transmitters to monitor system temperatures. Our station employs both direct fan cooling—the most effective method—and commercial air conditioning to cool the transmitters, achieving excellent results. The goal is to reduce component temperatures to the lowest practically achievable level, ensuring safer and more reliable operation. This paper analyzes the causes of cooling failures and discusses treatment methods and measures adopted in our work for mutual learning.

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Author: Cai Xincen

Cooling system failures in all-solid-state transmitters constitute "cooling failures," classified as Class I faults that trigger immediate shutdown and broadcast interruption. High operating temperatures, if not promptly addressed, cause component damage and extensive circuit board burnout, resulting in prolonged downtime. Therefore, reliable cooling system operation is critical for transmitter performance, and cooling failures must be resolved promptly to ensure normal operation. In practice, these failures typically arise from: transformer temperature faults, choke temperature faults, RF amplifier temperature faults, rectifier component temperature faults, and fan failures. If not largely prevented, these temperature-related faults cause component burnout and major broadcast interruptions.

1.1 Fault Phenomenon

When these faults occur, the relevant status indicator lights on the LED board of the transmitter rectifier cabinet turn red, signaling localized overheating and causing immediate transmitter shutdown.

1.2 Fault Causes

During broadcasting, the "RF Amplifier Temperature" status indicator on the LED board illuminates red, indicating a fault; the "A/D Conversion Error" indicator turns red; and the "Temperature Fault Generated by Bleeder Circuit Board" indicator turns red. Any single component failure generates a shutdown signal, causing immediate shutdown.

The transmitter comprises six cabinets, each containing three fans. During operation, all fans must activate to provide cooling airflow. Prolonged operation leads to bearing and blade damage, abnormal noise, and occasionally blown three-phase fuses. These issues affect airflow volume and cooling effectiveness, and in severe cases generate shutdown signals.

According to Figure 1 [Figure 1: see original paper], the elimination method can identify the specific location of cooling failures. The logic and handling methods for thyristor temperature faults are summarized below:

When a "thyristor temperature fault" occurs, under normal conditions the thyristor temperature sensor contact is normally closed, the input of inverter U10-1 is low-level, and the output of U10-2 is high-level, indicating normal status. When thyristor temperature rises to 67°C, the normally closed contacts of temperature sensors TS1 and TS2 open, making the input of inverter U10-1 high-level. After inversion by U10, the output of U10-2 flips to low-level. Following a series of logic circuits, the output of inverter U20 becomes high-level, which splits into three paths: First, it inputs to terminal J6-4 of the power control board, controlling the coil voltage of rectifier cabinet driver relay K6. When thyristor temperature reaches the limit, relay K6's coil voltage is lost, ultimately cutting off driver stage power. Second, it inputs to the PBI controller in the PB interface board, generating a shutdown signal sent to the ignition board in the transmitter rectifier cabinet to control thyristor conduction and cutoff. Third, it inputs to the LED display board on the rectifier cabinet for fault indication.

Similarly, regardless of which component in the diagram experiences temperature rise exceeding the sensor's rated upper limit, a shutdown signal is generated that directly shuts down the transmitter. This Class I fault prevents automatic restart. The mandatory shutdown design protects against component burnout and transmitter destruction.

During broadcasting, a "thyristor overtemperature" event occurred where the monitoring temperature sensor was damaged. Its contact TS1 could not open, creating a permanent short-circuit state. Consequently, when the thyristor temperature fault occurred, the logic circuit could not operate, ultimately burning out the thyristor. The 10kV rectifier transformer's 205V/1600A AC power supply connection joints also burned out, causing prolonged downtime. Routine maintenance must include regular temperature sensor testing (DX transmitters use two sensor types: normally closed contacts during normal operation that open during faults, such as TS1-TS6; and normally open contacts that close during faults, such as TS7-TS10 in the power bleeder circuit board). Additionally, high-current, high-voltage component connection terminals must be regularly tightened to minimize such failures.

The dashed box contains seven airflow detection boards distributed throughout the transmitter cabinets (output network cabinet, power amplifier extension cabinet, left power amplifier cabinet, right power amplifier cabinet, center power amplifier cabinet, and rectifier cabinet) to monitor fan status and airflow attenuation. When any cabinet's fan fails or airflow attenuates, an "airflow fault" signal is generated. This fault voltage sends a signal to the modulation encoding board, whose logic circuit compares and determines the fault, then outputs a fault signal from J9-5 to the control board for direct shutdown. Thus, an airflow fault causes immediate transmitter shutdown without automatic restart capability, requiring fault location and resolution before manual restart.

2. Cooling Failures Caused by Fan Faults

Fan faults typically produce abnormal noise and bearing damage. Air duct blockage also occurs: Our station's two DX-200 and DX-50 air-cooled transmitters are cooled by rear-mounted air conditioning and central air conditioning systems. Dust and airborne particles enter with fan rotation, accumulating on internal components and cabinet surfaces over time, causing arcing, discharge, and reduced insulation. The compact internal design with limited space and densely packed components makes cleaning extremely difficult. To prevent dust ingress, sponge filters are used. When excessive dust accumulates, filter permeability becomes blocked, causing airflow attenuation and power reduction. Regular filter cleaning effectively prevents such failures.

3. Conclusion

Through systematic circuit principle analysis, all causes of transmitter cooling failures have been enumerated. When cooling failures recur, the fault flow chart enables rapid fault location and emergency handling, significantly reducing off-air time and improving broadcast safety and efficiency.

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(Author's affiliation: Henan Provincial Press, Publication, Radio, Film and Television Bureau, Station 104)

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