Analysis and Maintenance of the Power Amplifier Circuit in the Harris FAX 10kW FM Transmitter (Postprint)

Authors: Wu Bojin, Liu Dexi

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

Abstract

This paper analyzes the principles and power amplifier circuit of the Harris Flexiva FAX 10kW FM transmitter. Combining practical work experience, it examines failures in the transmitter's power amplifier module and identifies that the module' s circuit suffers from "design and soldering process defects." Our organization communicated with Harris' s Chinese distributor and after-sales technical staff, and forwarded our concerns to Harris Corporation in the United States. The company acknowledged the issue and processed the power amplifier modules in a manner analogous to a "car recall." The transmitter has now been operating for nearly a year without any similar failures, functioning stably and normally.

Full Text

Preamble

Harris FAX 10kW FM Transmitter Power Amplifier Circuit Analysis and Maintenance

Wu Bojin[1], Liu Dexi[2]
[1] Hubei Radio and Television Station Suizhou Transmission Station, Suizhou, Hubei 441300, China
[2] Inner Mongolia Ergun City Media Convergence Center, Ergun, Inner Mongolia 022250, China

Abstract: This paper analyzes the operating principles and power amplifier circuits of the Harris Flexiva FAX 10kW FM transmitter. Based on practical maintenance experience, we examine failures in the transmitter's power amplifier modules and identify inherent "design and soldering process defects" in the module circuitry. Our station communicated with Harris' s Chinese distributor

and technical support staff, conveying our findings to Harris Corporation in the United States. The company acknowledged the issue and addressed the power amplifier modules through a process analogous to an "automotive recall." The transmitters have now operated for nearly a year without similar failures, demonstrating stable and normal performance.

Keywords: Harris (HARRIS); Flexiva FAX 10kW; Power Amplifier Module; Circuit Analysis
CLC Number: TN934.81
Document Code: A
Article ID: 1671-0134(2021)02-111-03
DOI: 10.19483/j.cnki.11-4653/n.2021.02.033

1. Overview

The Flexiva FAX series FM transmitter from Harris Corporation represents a new generation of FM broadcast equipment characterized by compact size, light weight, and notably small power supply and amplifier modules that facilitate maintenance. The system delivers excellent technical specifications and high transmission efficiency with substantial output redundancy and versatile operating modes to meet diverse broadcast station requirements. In October 2013, Hubei Radio and Television Station Suizhou Transmission Station installed two Harris Flexiva FAX 10kW air-cooled transmitters, which operated reliably until spring 2018 when two power amplifier modules in one transmitter failed simultaneously. Fault analysis revealed that failures occurred at identical locations on the modules. Upon examining the circuit diagrams, we deduced that defects existed in the amplifier board' s design and soldering 工艺. Without corrective action, similar failures would inevitably recur.

The RF signal path operates as follows: RF output from the exciter feeds the pre-amplifier (IPA). After IPA power amplification, the signal enters a power divider that distributes power equally to the input stages of 14 transistors across seven power amplifier modules. The amplified RF power from these transistors is then combined by a 14-way power combiner to produce the 10kW output. A switching control board located between the exciter relay and the IPA provides 3 dB isolation. When the IPA output drops below 0.5 V, this board automatically switches to the backup transistor within the IPA. The switching mechanism employs two relays—one at the IPA input and another at its output—connected in series. During switching, the transmitter enters a brief protection state that acts as a buffer to prevent damage to internal circuits. Within the IPA, only one of the two transistors operates at any given time while the other remains in standby, with the control system ensuring mutual backup operation.

2. System Principle

As shown in [Figure 1: see original paper], under normal operation, RF output from Exciter A passes through the exciter relay. In dual-exciter systems, automatic switching to Exciter B occurs when Exciter A' s RF power falls below the preset threshold; this relay resides within the system interface control module. The exciter' s output power drives the pre-amplifier (IPA). The two transistors within the IPA operate in a redundant configuration where only one is active while the other serves as backup, with the switching control system enabling mutual backup protection.

[Figure 2: see original paper] illustrates the physical power amplifier module and circuit board.

3. Flexiva FAX 10kW FM Transmitter Power Amplifier Module

The Flexiva FAX 10kW FM transmitter incorporates eight functionally identical and interchangeable power amplifier modules, with one serving as the pre-amplifier (IPA) and the remaining seven as final-stage amplifiers, as depicted in [Figure 2: see original paper]. Each module contains two MRFE6VP61K25H field-effect transistors. These FETs feature balanced input and output configurations, permitting utilization across a broad frequency range from 1.8 to 600 MHz. The devices support both single-ended and push-pull configurations, operate with VDD up to 50 V (with a characteristic range of 30–50 V for extended power operation), and are suitable for linear applications with appropriate biasing. Integrated ESD protection and an expanded negative gate-source voltage range enhance reliability. Within the FM broadcast band of 87.5–108 MHz, each transistor can deliver maximum peak output power of 1100 W, though the circuit design targets approximately 800 W per device.

[Figure 1: see original paper] shows the RF block diagram of the Flexiva FAX 10kW FM transmitter. As illustrated in [Figure 3: see original paper], the two transistors in each power amplifier module feature independent input and output stages.

[Figure 3: see original paper] Power Amplifier Module Circuit Diagram

[Figure 4: see original paper] presents the solid-state power amplifier circuit using MRFE6VP61K25H field-effect transistors. This typical push-pull FET power amplifier forms the basic building block for high-power amplification. The MRFE6VP61K25H is a push-pull transistor pair requiring balanced input and output. The circuit comprises: an input matching network consisting of balun and input matching circuits; a push-pull power amplifier stage; an output matching network comprising balun and output matching circuits; a bias circuit for adjusting the amplifier' s operating point and class; and DC power supply circuits. Since this high-power transistor employs push-pull design, although each single transistor conducts alternately, the combined output closely

approximates a sine wave.

[Figure 4: see original paper] MRFE6VP61K25H Field-Effect Transistor Power Amplifier Schematic

[Figure 5: see original paper] shows a circuit excerpt for the MRFE6VP61K25H transistor. The transistor design delivers over 800 W output power. As a push-pull pair, each transistor contributes over 400 W. Circuit analysis reveals that the transistor output couples to the balun through six surface-mount capacitors: C26, C27, C28, C30, C31, and C32. These components carry approximately 25 A of current. However, the solder joints connecting these capacitors' input and output terminals to the PCB are small and relatively thin. Under high-power, high-current operation, these points generate significant heat, leading to circuit board burnout during extended operation.

During operation at our station, two power amplifier modules experienced sudden loss of output from one transistor each. Inspection revealed that in one module, capacitors C26, C27, C28, C30, C31, and C32 at the input and output terminals were burned, with minor PCB damage. In the other module, these capacitors and the entire circuit board were severely burned beyond repair. Through careful circuit analysis and discussion, we concluded that defects existed in both the circuit board design and soldering process. Without corrective measures, similar failures would inevitably occur in other modules, posing significant safety risks to our broadcast operations and causing substantial economic losses.

We promptly communicated our findings regarding the design and soldering defects to Harris Corporation' s Chinese distributor and technical support team, who forwarded our concerns to Harris Corporation in the United States. The company acknowledged the issue and addressed all power amplifier modules through a process analogous to an "automotive recall."This included free replacement of the irreparable module, free repair of the damaged module, and batch recall and processing of all modules from both transmitters. The corrective action involved thickening the solder joints at the input and output terminals of capacitors C26, C27, C28, C30, C31, and C32 to increase the solder contact area with the circuit board. Since this remediation, the transmitters have operated for nearly a year without any similar failures, demonstrating stable and normal performance.

As critical equipment for radio and television broadcasting stations, transmitters require diligent routine maintenance, including regular cleaning, comprehensive monitoring of temperature, current, and voltage parameters, and necessary dust removal from power supplies and amplifiers. Preventive maintenance is key to ensuring reliable operation. We hope this analysis of power transistor output failures and their resolution will assist other broadcast stations using Harris FA series transmitters and their maintenance personnel.

References: [1] Huang Hai. Wind Speed Detection Fault Analysis of HARRIS FAX10kW FM Transmitter at Xiaoguan Transmission Station [J]. Electronic

World, 2018(03): 134-135.
[2] Zhou Kun. Principle and Maintenance of Harris Flexiva FAX FM Transmitter [J]. Shanxi Electronic Technology, 2015(3): 70-72.
[3] Wang Yi, Kang Xun. Technical Analysis of Harris FA X 10K FM Transmitter [J]. West China Broadcasting TV, 2014(1): 149-151.

Author Profile: Wu Bojin (1967-), male, from Suizhou, Hubei, Senior Engineer; Research Direction: Broadcast Engineering.
(Executive Editor: Hu Yang)

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