The Downward Path to Broadcast Engineering—No. 29

A big transmitter, a shorted transformer, and no money for a replacement—what to do?

By Joseph M. Davis, P.E.
President
Chesapeake RF Consultants, LLC

During my junior year of college (more than 40 years ago), I was lucky enough to be named chief engineer of a 50 kW (ERP) FM station. I had worked part-time at this station for several years in various capacities and was very familiar with the studio and transmitter operations, and I coveted becoming a radio CE one day.

The bad news was that the station had a longstanding "cashflow problem," as the manager put it. On payday employees proceeded immediately to the radio station's bank to cash their paychecks while there was still enough money in the account to cover them. The equipment was low-budget with no backups, some items requiring frequent repair, and certainly no opportunity for replacement.

Any transmitter failure would be an immediate off-the-air problem, sometimes taking me out of class to resolve it. A recurring transmitter issue was a shorted rectifier stack on the three-phase high-voltage power amplifier supply, sometimes triggered by a lightning storm, sometimes for no apparent reason. Upon arriving at the site, I quickly learned that if the transmitter's main breaker (200 Amps) was tripped, indicating that one of the six rectifier stacks had shorted and I would use an Ohmmeter to find out which was at fault.

Fortunately, there were some spare rectifier stack assemblies for getting the transmitter back on the air without too much delay, and my task was to solder in new rectifier diodes on the bad assembly for next time. But with the so-called "cashflow problem," the station's business account at the local electronic parts store had been suspended, requiring me to buy the parts for cash and turn in an expense report for reimbursement.

The tower site was in a very rural area about 40 minutes from the studio. The 25 kW FM transmitter had been installed in a used mobile home trailer. The site's telephone had been disconnected for nonpayment of the bill, leaving me to a 20-minute drive to the nearest payphone. I had rigged up a microphone to the 67 kHz subcarrier generator so I could talk back to the studio for meter calibration and other purposes, but this was useless if the station was not on the air.

One day an "off-the-air" call came in and when I arrived at the trailer site, I found the transmitter's main breaker tripped again. A quick check of the rectifier stacks showed all were okay, so I reset the breaker and hit the startup sequence. Fans and filaments came up fine. After a warm-up delay the plate contactor engaged, and simultaneously the main 200 Amp breaker violently tripped. Uh-oh. Checking the rectifier stacks more thoroughly, by using the Ohmmeter on each diode (12 diodes per stack; six stacks total) showed no obvious issues.

I remembered that a couple years earlier one of the high voltage chokes had shorted to ground and was replaced to restore operartion, so I disconnected the rectifier output from the rest of the high voltage supply. Again, the main breaker tripped so violently that the whole trailer shook when the contactor engaged. So, it was now down to either something undetected with the rectifier stacks, the high voltage or primary wiring, or (given the station's shaky economic situation) a possibility that I really didn't want to consider—failure of the transmitter's three-phase 40 kVA plate transformer.

An Incandescent Light Bulb Troubleshooting Tool

I checked, but the Ohmmeter wasn't particularly helpful in this case, as the normal DC resistance on the transformer's primary windings was very low. Not wanting to keep using the three-phase 200 Amp main breaker as a troubleshooting device, I sat down to think a bit. In my mind a light bulb came on, literally! One of my electronics instructors had previously described a light bulb technique for troubleshooting, where a 60-Watt incandescent light bulb is placed in series with the transformer primary winding and then connected across the 120 Volt AC line (all with the secondary disconnected). If the lightbulb glows dimly or not at all then the transformer's impedance at 60 Hz is high and should be OK. If it's at full brightness then the transformer winding is shorted.

About this time there was a knock at the trailer's door. One of the station's salesmen had stopped by to see when the station would be back on the air. He'd had to drive there thanks to that pesky cashflow problem and the disconnected transmitter site telephone. However, at that time, I could offer no prediction for him. I also had no incandescent light bulb, as all the working lights at the site were fluorescent tubes. So, I turned everything off and went for food and supplies.

Upon returning with a supply of light bulbs, I checked each of the three-phase plate transformer's primary windings. The first one made a 60-Watt bulb glow dimly, so did the second. At the third winding, the bulb went to full brightness. So now I knew where the specific problem was, but of course there was no spare plate transformer.

Reconnecting everything a piece at a time except for the shorted transformer phase primary winding, and setting the other two primaries to lower voltage (via a front-panel delta-wye switch) I was able to achieve a reasonable plate voltage for reduced power operation. The station was back on the air at about 25 percent of normal power.

Big Three-Phase Transformers Don't Come Cheap

I returned to the studio location and briefed the station manager about the situation before calling the transmitter manufacturer to see about a new plate transformer. Sure, they had one, but it would cost five thousand dollars, and it would have to be sent COD (collect on delivery), and that was after first paying off several other past-due bills the station had accumulated.

Given the station's continuing cashflow problem, the manager informed me that funds simply were not available and instructed me to shop around for a cheaper alternative solution. During the next few days, I found out the source for the transformers used by the transmitter company and gave them a call. They also quoted $5,000 and said it would also have to be a COD shipment. My next call was to a custom transformer manufacturer with basically the same story—they wanted several thousand dollars, and would expect the money to be paid on delivery of the transformer. My instructions from the station manager were to keep on shopping around.

Finally, I spoke with an electrical industrial manufacturer located about an hour away that could repair the existing transformer. The shop said they would have no problem in rewinding a three phase 40 kVA dry transformer—just bring it in for a two-week turnaround. The cost of the rewinding job would be $5,000, and they would bill us later. The manager loved this and told me to make it happen.

A 21-year-old Davis with the big AEL FM25KD and its even bigger power supply problems.

As One Problem Is Solved Another Surfaces

While rewinding the transformer solved the station manager's payment issue, it presented a new problem as to how to stay on the air for the two-weeks the job would require.

There was another radio station in the region that had a similar transmitter, but with an upgrade from 12 kW to 25 kW that had required a larger plate transformer. I knew that they had kept the smaller plate transformer and my next call was to them to see about borrowing it. I figured I could use their old one to keep our transmitter on the air at reduced power while the rewinding job took place. Unfortunately, the owner of the other station was only too aware of our station owner's financial situation and declined to loan the transformer as he figured the chances of ever getting it back were very small.

Finally, I contacted a "friend of a friend" and through this connection was ultimately able to borrow a plate transformer from a 5 kW AM station that was temporarily silent pending a sale. The stipulation was that there was a "drop dead" date for returning the transformer, as the station had to be ready to go back on the air when their new owner took charge in about a month.

Our station worked fine with the AM loaner transformer, albeit at reduced power, but even with the lower power the owner was happy to have the station on the air.

Broadcast Engineering Sometimes Requires A Lot of Physical Labor

Moving these three-phase power transformers around was quite an experience for me and some helpers. The defective 40 kVA transformer was the size of a large ice chest and weighed about 400 pounds. In order to get the transformer out of the mobile home trailer transmitter "building" and into a pickup truck we had to disassemble the chain-link fence around the transmitter building. (Matters were a bit easier at the electrical manufacturer's plant, as they were equipped with an overhead hoist and trolley for handling such big transformers.)

Two weeks passed and I was informed the rewinding process was running a little behind, but should wrap up soon. Finally, two days before the loaner transformer had to be returned the repair was done and I went to get it. The helpers met me at the site that night and we got it into position. I was anxious about it working after all of the violent breaker trips from before. I took the time to check things out with the light bulb, and the rewound transformer passed that test with flying colors. I then powered everything powered up and was gratified (and relieved) to see that the transmitter plate voltage was now normal.

No Rejoicing Just Yet, Though

I slowly increased the RF power to the licensed level with no issues at first, but shortly after achieving this I noticed a slight burning odor. My first thought was that it was just some paint or varnish on the rebuilt transformer that was responsible for the smell and this would go away in time. However, I then noticed an orange glow down low in the transmitter cubicle. This was on one of the transformer mounting bolts. There was no doubt about it—for reasons yet to be discovered, the mounting bolt was heating to the point of an orange incandescence.

After some experimentation, we found that by setting the transmitter's front-panel control to the low power position (switching the transformer input from delta to wye) the heating did not occur and the transmitter would able to operate at about 50 percent power.

I felt compelled to leave the rewound transformer in place at reduced power, since a commitment had been made to return the loaner transformer by the next day. So, we loaded up the loaner transformer and I took it back to its home station.

Another Transformer Swapping Exercise

My next step was to contact the company that had rewound the 40 kVA transformer. When I described the glowing bolt, the product manager said to bring it back and they would resolve that problem. Upon discussion of the loaner transformer being no longer available, he agreed to loan us a 25 kVA single phase electrical utility company "pole pig" step-down transformer to use in reverse while the bolt heating problem was being resolved. So, in one long night, it was off to the electrical manufacturer to pick up the "pole pig" then back to the tower site to remove the newly rewound 40 kVA transformer and temporarily wire in the "pole pig" for reduced power operation, and back to the electrical manufacturer with the 40 kVA transformer to be repaired further.

A week later the 40 kVA transformer was ready, again. This time at installation there were no complications and full power was achieved. Within a few months our station had a new owner running things and cashflow was no longer a problem.

The main lesson here is that working at a financially unstable low-budget operation—while sometimes frustrating—can provide considerable troubleshooting and work-around experience. Jumping into that "frying pan" was a terrific way for me to get going as a new CE, and I would not change a thing.

About The Author

Joe Davis *is a television and radio consulting engineer with more than 40 years of experience, and is president of the consulting firm Chesapeake RF Consultants LLC. He received his Bachelor of Science in Electrical Engineering Technology degree in 1982 from Old Dominion University in Norfolk, Virginia, and since 1980 has worked directly for and then served as a consultant to various television and radio stations in engineering capacities, including transmitter and tower site relocation, facility upgrade, signal propagation, interference evaluation, FCC technical regulatory matters, and in the evaluation of human exposure to radiofrequency (RF) electromagnetic fields. He is a licensed Professional Engineer in Virginia and is a full member of the Association of Federal Communications Consulting Engineers (AFCCE), and has served two terms as that organization's president. He is also a member of the Institute of Electrical and Electronic Engineers (IEEE), the National Society of Professional Engineers (NSPE), and the Society of Broadcast Engineers, and holds an FCC General Radiotelephone License (formerly First Class) as well as an amateur radio Extra Class license. He was the 2016 winner of the BTS's Matti S. Siukola award.*