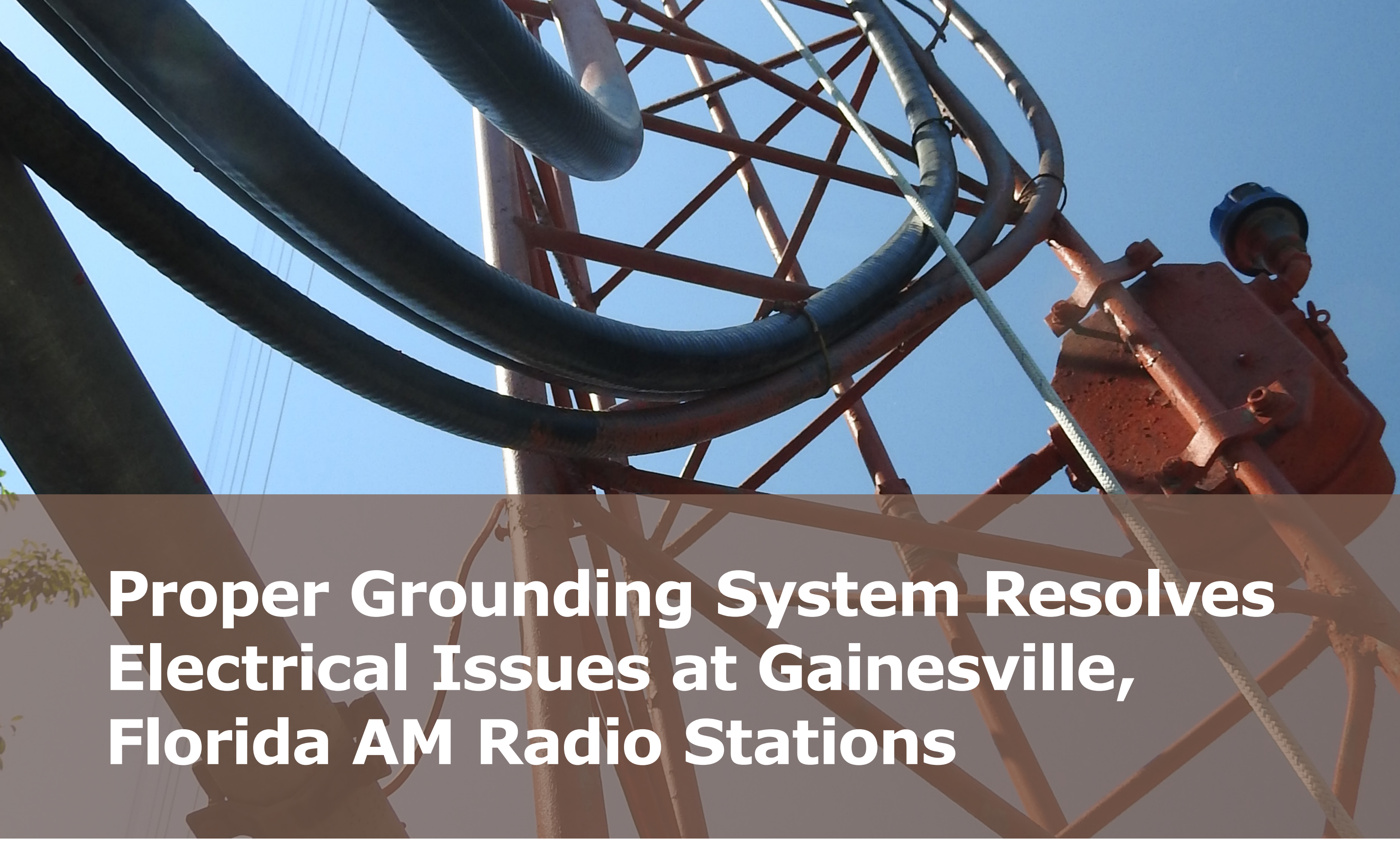

Proper Grounding System Resolves Electrical Issues at Gainesville, Florida AM Radio Stations

Two Florida AM radio stations were regularly experiencing transmission failures that would result in them going off-the-air, not only losing customers but the company money. To investigate the problem, the station's owner called in John West Sr., a consultant specializing in grounding, bonding and lightning protection solutions, who has saved dozens of broadcast stations from going dark.

WDVH and WTMN were recently acquired by MARC Radio Group, LLC., Gainsville, Florida. The two stations share transmission facilities and a tower **(Cover Photo)**. They were in poor shape at the time, regularly beset with lightning strikes and power surges that resulted in damaged equipment and off-the-air downtime. Both very costly. The station owners wanted to find out what was causing these electrical mishaps, and how they could prevent them from happening again.

MARC Radio brought in West for a site inspection to determine what was causing the electrical issues. What he found at the transmitter facility was that the grounding did not meet even minimum National Electrical Code standards and the bonding was not designed properly. There was also no surge protection. The facility was losing transmitter equipment, connectivity equipment, routers, hubs and the line to the tower.

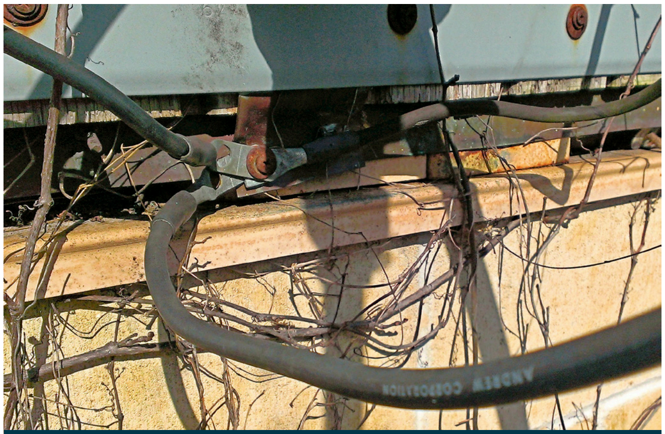

FIGURE 1.

At the first inspection, all ground connections from the transmitter building we bonded to the painted metallic band surrounding the building. Note the rust and several connections under one screw.

Where Do You Start?

West found that all grounds were bonded to the painted metallic skin of the transmission building and nothing else. There were no ground rods or a connection to earth other than through the building steel, which sits on a concrete slab **(Figure 1)**. Obviously, it didn't work.

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West started by mounting a ground bar on the outside of the building that's connected to a ground bar inside that serves all the inside equipment **(Figure 2)**. He connected the external ground bar to a ground field consisting of stranded 4/0 AWG copper wire and 40-foot ground rods spaced about every 40 feet. The field goes around the building and is terminated at a four-inch steel well casing in front of the building that penetrates some 150 feet into the earth **(Figure 3)**. West took advantage of the well on the property as a very effective grounding electrode. He said a ground can't get much better than that. In fact, the ground resistance is so far below 1 ohm, it's barely measurable **(Figure 4)**.

FIGURE 2.

First step was a new grounding bar under the coax lines to which a 4/0 stranded copper bond from an inside ground bar and connection to the grounding field consisting verticle rods and water well were made.

FIGURE 3a.

FIGURE 3b.

The building has a 150 foot steel water well which provides for an excellent vertical electrode, but not previously connected. Bonding from the 4/0 copper lead from the ground field was made exothermically.

All ground field connections are exothermically welded. "That way I don't have to worry about clamps being torqued or tightened; I don't have to worry about a mechanical connection failing," West said. "The connection becomes essentially one piece of metal, and there's no maintenance requirement."

FIGURE 4.

After the new grounding and bonding was installed, the ground resistance of the resultant system measured below 1 ohm. All internal equipment was bonded to a new interior grounding busbar, including the telephone system and transmitter equipment. The interior bar was further connected to the external ground system.

Although solid #6 AWG copper is the minimum required by code, West insists it's inadequate, especially for this kind of application. He points out that the smaller solid conductor doesn't have enough surface area to carry the high-frequency energy of a lightning strike. As an example, he would compare the surface area of a solid #6 wire with that of a frozen juice can – that's the effective surface area of 4/0. Incredibly more protection.

According to West, 4/0 stranded copper or larger should always be used as the grounding conductor, particularly in lightning prone areas. His practice for all installations is to use a ground conductor that's at least the same size as the service feed conductor. For example, if the service is 750 MCM, the ground should be 750 MCM. That's the only way to divert all the energy to ground, West said

West was quite precise in laying out the ground field. He explained that a ground rod is very much like a radio antenna. It transmits electrical energy a distance based upon the resistivity of the soil. The soil's resistivity depends upon its composition, as well as contaminants, moisture content and temperature. He performed several four-point soil resistivity tests, using a Fall-of-Potential earth ground tester with four stakes. This was to find what the ground resistance was in soil areas that were consistent and not disturbed so he could locate the right spots for the ground rods.

The length and separation of the ground rods is critical, too. “If you drive two ground rods real close together – say two 20-foot rods 6 feet apart – you might as well just put in one rod,” West said. “Electrically, they are one rod, and you’ve wasted a whole lot of money.

Your readings for soil resistivity will determine the spacing between the rods. One to two times the length of the rods is desirable. If you have poor soil, like Florida, and you go down two feet, the rods have to be two feet apart minimum. In some cases, the resistivity is so good you want to place your rods further apart. That’s how we derived our 40-foot rods spaced 40 feet apart in this case. This provided the lowest impedance and provided a diversion path for any lightning energy.”

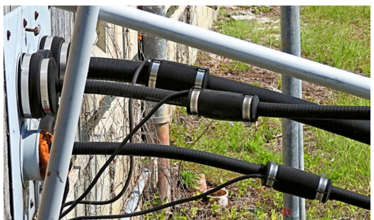


FIGURE 5.

The shield of the coax going to the tower is bonded to the external grounding bar by means of Andrew’s Cuffs. The majority of lightning energy on the shield is thus diverted to the extensive external grounding system, rather than the internal equipment where it can do damage.

The Tower

The coaxial transmission line that goes to the tower is bonded to the external ground bar through an Andrew’s surge arrestor, sometimes called an Andrew’s Cuff **(Figure 5)**. It clamps to the coax shield and catches lightning energy that may come down the shield of the cable toward the facility and the transmission equipment. The cuff is connected through double lugs to the ground bar and then to the buried ground field.

Unlike FM, an AM tower is an RF component only. It does not have electronic circuitry and is not tied to the electrical system in any way. In fact, the tower cannot be bonded to the facility ground, or it wouldn’t work. The tower sits on an insulator, isolated from its own base, with a spark gap to the earth. The tower has buried radials to help send the signal. That tower also has three sets of guy wires bonded to pylons in the earth but insulated from the tower at several points. In effect, the insulators act as spark gaps. With a ground resistance of less than 8 ohms at the guy bases, the guys are effectively grounded, and lightning energy is divided between the tower ground and the guy wire grounds.

Inside The Building

The first step was to have a contractor provide code-minimum grounding and bonding, if for nothing else, life safety. The next step was adding surge protection.

The inside grounding bar supports all the services that come into the building, the electrical system and the flat strap that runs around the floor, connecting all the broadcast equipment. The ground bar is tied into the main electrical service with

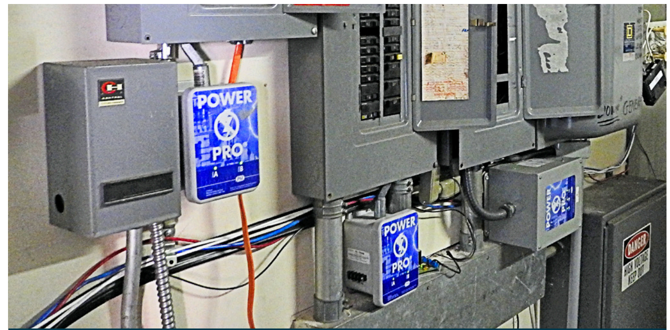


FIGURE 6.

West insists the first thing to do is get all the grounding and bonding done right, if for nothing else, life safety. Then, put in layered levels of surge protection. The first panel loads (right panel) see the heaviest surge first. Following that is a second panel (middle) for typical house loads. A third panel (left) follows for the most sensitive loads, which should have an isolated ground bus bar that terminates back in the main at the XO bonding point (not a case ground).

stranded 4/0 copper, the distribution panels, and to all the surge protectors that were installed after all the grounding and bonding were done. West said there’s still more bonding work to be done, as the station is being remodeled.

Three levels of surge protection were installed **(Figure 6)**. The first panel loads see the heaviest surge first. Following that is a second panel for typical house loads. A third panel follows for the most sensitive loads, which should have an isolated ground bus bar that terminates back in the main at the XO bonding point (not a case ground). Typically this is done using a green wire with a yellow or white tracer. All the ground pins from sensitive equipment should be tied directly back to the isolated ground point.

The final step was to interconnect all new external grounding with the electrical service and all the internal equipment. “When we got here, we found metal equipment racks bolted to a concrete floor,” West said. “Initially, the racks, along with the equipment they supported, were bonded to the electrical system **(Figure 7)**. That sets up a difference in ground potential. You can’t do that. The equipment has to be isolated from the floor. You can’t have two ground references. The equipment must have its own ground reference through the electrical system. It should not have a secondary ground reference.”

FIGURE 7.

Concrete, especially when damp, can be a conductor, allowing current to flow. “We always recommend that racks be insulated from the concrete floor,” said West. Commercially available equipment is available for that purpose.

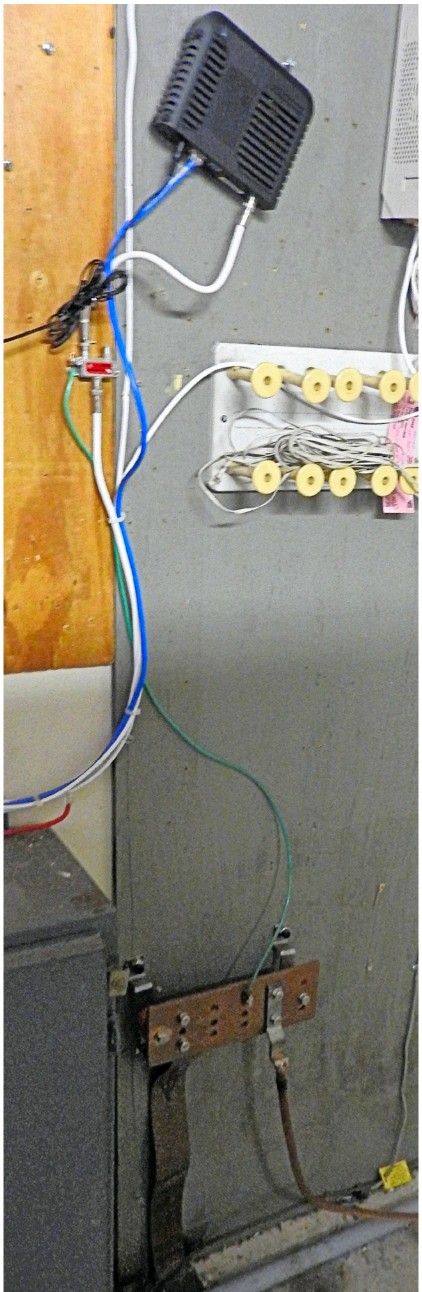


FIGURE 8.

Telco's often undersize the grounding conductor, or route it incorrectly. However, they do not allow anyone to revise their equipment. West retains their undersized #6 conductor for a short distance, but then transition to large, stranded conductor for the run to the internal busbar.

Telephone Service

While inside, West pointed to the telephone service. Telcos bond their gas-tube lightning arrestors to ground. Their function is required by the FCC. Theoretically, they take the lightning off the incoming telephone line and route it to earth.

"The problem here is they are using #6 solid copper wire with three 90-degree bends," West pointed out. "In this case, the wire travels down and then goes back up. Lightning doesn't work that way. First, it will flash straight across before it follows that wire. Plus, the wire is not stranded or of large enough gauge. It doesn't have enough surface area."

Because telcos don't want anyone touching their equipment, West put a small bonding bar near their installation, connected their #6 wire to it, and then properly ran a large, stranded copper conductor directly the rest of the way **(Figure 8)**.

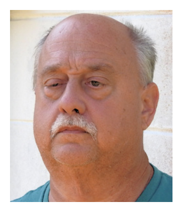
The Bottom Line

"The two solid state transmitters, alone, had taken massive lightning hits, which cost us $1,400 apiece," said Mark Schmucker, consulting broadcast engineer for the station group. "The cost to repair them far exceeded the cost of what was spent on the work that was done. Since the bonding was done, the occasions for damage have drastically decreased."

Although the work at these two stations was ongoing in February 2017, the results to date have been gratifying. Soon all the electrical issues will be incapacitated and the station owners and their bottom line will reap the full benefits of the properly designed and installed electrical grounding and bonding system.

Schmucker said it best, "It makes me feel good when we see proper grounding. You get more satisfaction and more confidence in the facility when everything is grounded and bonded the way it's supposed to be."

John N. West Sr. is president of Power & Systems Innovations of Tampa, Inc. (PSI), Hernando Beach, Florida. Its focus is sustainable electrical systems that will perform for years to come: grounding, bonding, surge protection, and lightning protection, including all aspects of power quality. PSI provides onsite consulting services. In addition, the company designs, installs and services a broad range of protection equipment and systems. For further information about PSI call 407-832-9018 or email JWest@PSITampa.com.



Mark Schmucker, Consulting Broadcast Engineer, MARC Radio Group, LLC, Gainesville, Florida. His responsibilities encompass maintenance of all the group's transmitter sites and broadcast facilities, including electrical, telephone, broadband, microwave, automation, computer and satellite downlink systems, along with IT services for office operations. Since 1972, Mark has provided similar services to other broadcast companies in North Florida markets. You can reach him at mschmucker@marcradio.com.

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