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June 2019

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Be Prepared When Lightning Strikes

Your transmitter and RF plant are mission-critical. Are they ready for lightning season?

With summer arriving for much of our readership, this Radio World ebook will help you to answer that question.

What characteristics of lightning should you know about to manage a transmitter site properly? What are the principles of good protection? What choices in facility design can you make to help protect the equipment? How should your transmitter site be laid out? What should you know about AC line protection products?

And if your site does take a lightning hit, what should you do next? What best practices should you know about ahead of time to plan against that eventuality?

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— **Paul McLane**
Editor in Chief
Emily M. Reigart
Content Manager
Radio World

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Before Lightning Strikes: Avoid Downtime With These Recommendations

Follow grounding and inspection best practices to protect your transmitter site

by **David Brender**

Communications facilities, both broadcast and public service, share vulnerable points in common. Of course, there are differences in the value of the equipment, the possible loss of air time versus life safety, and obviously, one-way versus two-way communication. But the threat of downtime is common to all.

Owners face two alternatives in addressing these points: wait for a disaster to address the source, or be proactive and address proper wiring, bonding and grounding before problems occur. The latter method is preferred.

There are a number of common conditions at these sites; I will address the major topics pertaining to these issues.

A thorough inspection of the facility is first required to determine the specific deficiencies that should be addressed at each location. The initial consideration is to review and examine the existing wiring, grounding, bonding and surge device situation.

Is the grounding truly a system of low impedance, with one point of connection to the facility? How is it laid out? Do the conductors exceed minimums? Is it sustainable? Inspected? Installed correctly?

Lightning is often the most common, though not the only, transient encountered. Imagine lightning as a large aerial energy collection that is trying to reach the earth. It has two alternatives to get there, one of which is through the facility and possibly its equipment. The other is through a robust, low-impedance path as direct as possible to the earth.

The principal of a current divider will dictate that the amount of energy through either will be inversely proportional to the impedance of the parallel paths.

ROLLING BALL THEORY

Accepted theory for a lightning strike is to picture a 150-foot rolling ball. Everything under the rolling ball perimeter is considered protected from a direct lightning strike. Everything within the 150-foot radius is considered vulnerable. Thus, a building like that illustrated in Fig. 1, housing sensitive equipment, should be protected by a roof-mounted lightning array.

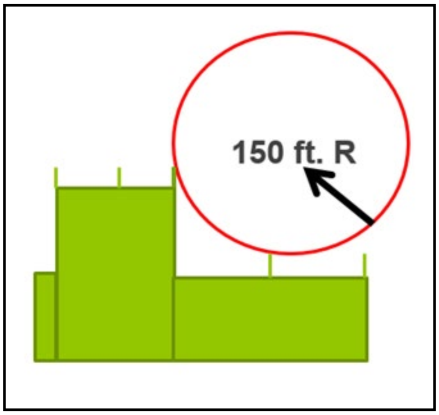
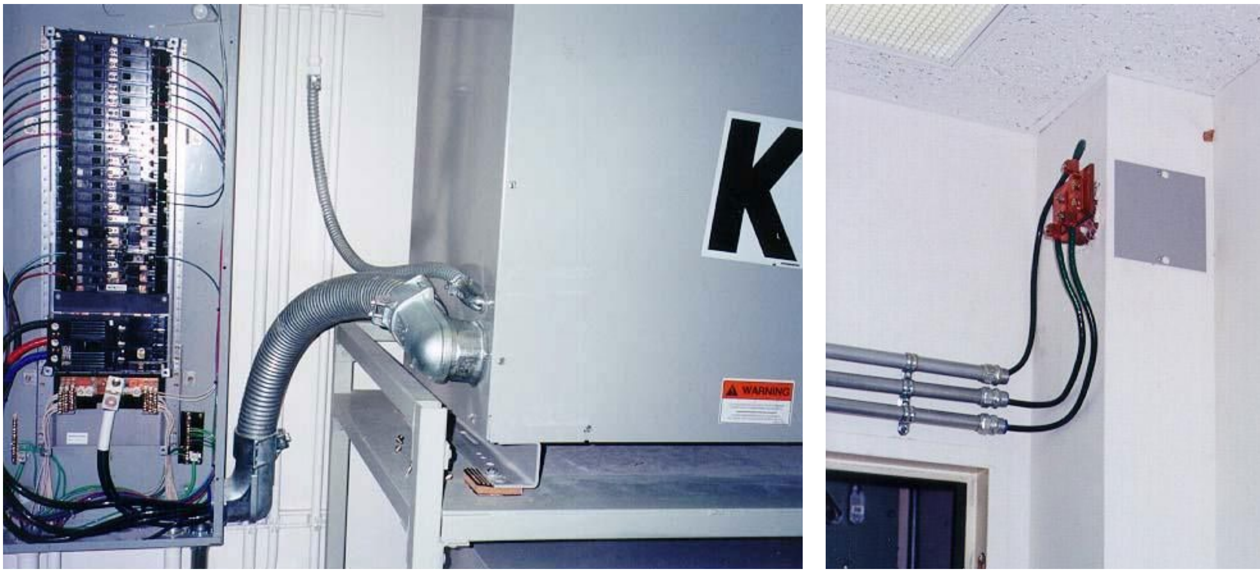


Fig. 1: Rolling ball of 150-foot radius; structures outside that radius are considered protected from direct strikes.

That does not prevent nearby strikes, though not direct, from inducing transients within the facility, or preventing strikes to the utility or communications services. Therefore, installing a lightning array may not totally prevent interruptions, unless you've addressed bonding and grounding conditions.

DOWN-CONDUCTORS

While considering a lightning collection array, never use the building steel as a down-conductor. Not only is the steel sometimes non-continuous, it is vulnerable to lightning and other



Figs. 2A and 2B: A K-rated transformer (harmonic-rated) and associated breaker panel are legally, but inappropriately, grounded to building steel. Everything electrical served from that panel is rendered vulnerable because of this connection.

transients. In the case when the steel is hit, everything electrical connected to it will suffer the consequences.

Always use a separate, copper down-conductor if possible, isolated and insulated from building steel.

GROUND RESISTANCE

The National Electrical Code alludes to an acceptable ground resistance of 25 ohms to earth, with many caveats. If 25 ohms is not achieved, one can sink a second ground rod only 6 feet away and be done. It does not matter what the resultant resistance is. This figure is also mentioned in other standards as acceptable. For sensitive loads, it is not.

In my experience, as well as the recommendation of IEEE, 5 ohms to ground should be the maximum accepted resistance, or as close to that figure as can reasonably be achieved.

In my experience, as well as the recommendation of IEEE, 5 ohms to ground should be the maximum accepted resistance, or as close to that figure as can reasonably be achieved. Less is better. Sometimes an electrode has to be placed in a bored hole of several hundred feet depth and backfilled to achieve this figure, but it usually can be accomplished.

It is recommended that the ground resistance, and all connections, be examined and tested annually to gauge whether there have been changes. Determine the reason for any drastic changes and correct deficiencies.

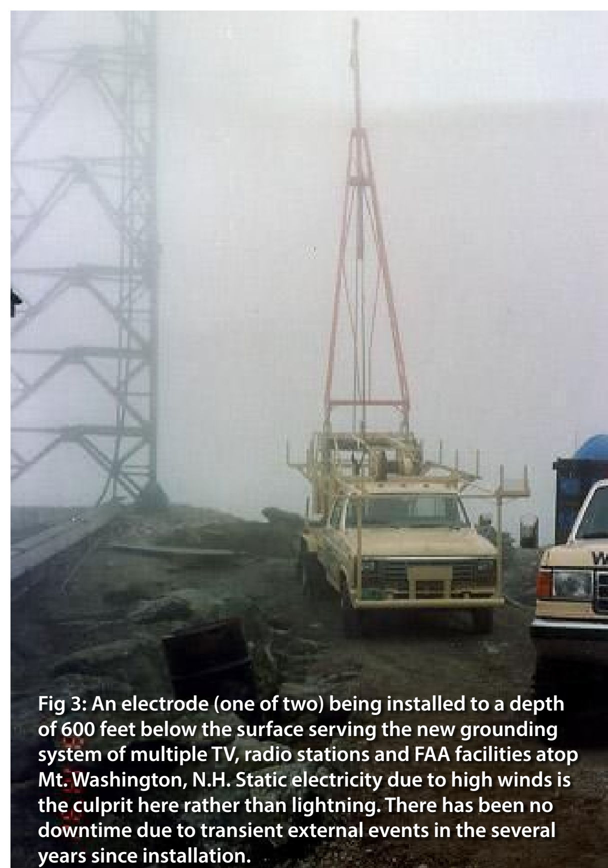


Fig 3: An electrode (one of two) being installed to a depth of 600 feet below the surface serving the new grounding system of multiple TV, radio stations and FAA facilities atop Mt. Washington, N.H. Static electricity due to high winds is the culprit here rather than lightning. There has been no downtime due to transient external events in the several years since installation.

INSPECT FOR PROPER MATERIALS, WORKMANSHIP

Also, was everything installed according to plan? A colleague reports that he inspected a ground ring on a large sports facility after problems have been reported in the

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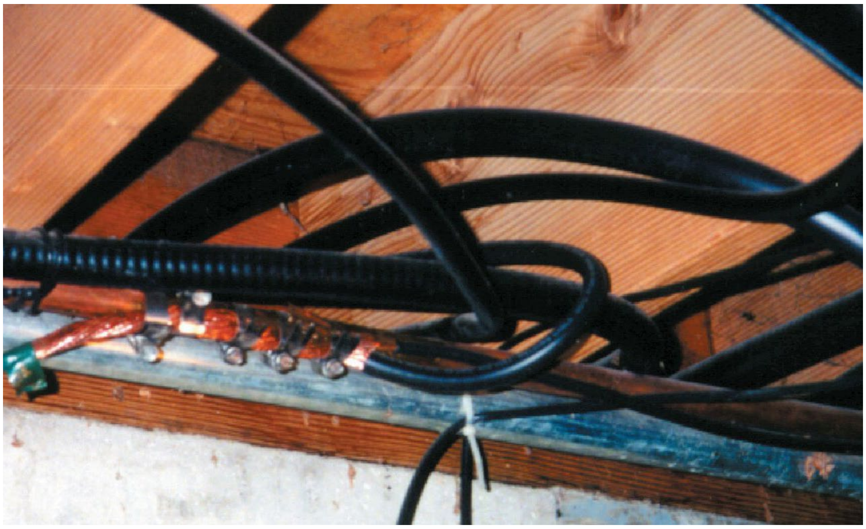

Fig. 4: Hose clamps connected these ground leads to a plumbing tube "bus" at this FM radio station.

Fig. 5: Tower grounding of a New Mexico FM radio station. Aluminum or tinned copper conductor, lap-jointed onto a galvanized steel tower, held in place by stainless steel hose clamps, located on a mountaintop. What could possibly go wrong?

❱ *continued from page* **5**

electronic scoreboard, to find that the paving contractor had cut the ground ring in multiple locations. In effect, there were multiple, separate, unconnected grounds — a disaster for sensitive equipment.

Corrosion, mixed metals and non-listed connections can be a source of problems, and your inspection of the premises must include examination of connectors and materials. I suggest making certain of only copper-based materials and connectors listed for grounding application.

GROUND LOOPS AND BONDING

Ground loops are formed when there are multiple paths for energy to flow rather than one radial path. When a signal has multiple grounds, unwanted currents will flow and the signal may be contaminated. When combined with communication grounds and power grounds, additional loops may be formed. Each piece of equipment should have its own radial connection back to the grounding bus, not be bonded to the adjoining equipment.

Ground loops can also occur when individual equipment utilizes a so-called "clean ground." An individual ground electrode for a specific piece of equipment is sometimes specified by misinformed technicians in the mistaken belief they are getting an "isolated" ground (discussed later). In fact, "clean grounds" are establishing the earth as a ground conductor, a violation of the NEC, and in parallel with the communications path and power path. There should be

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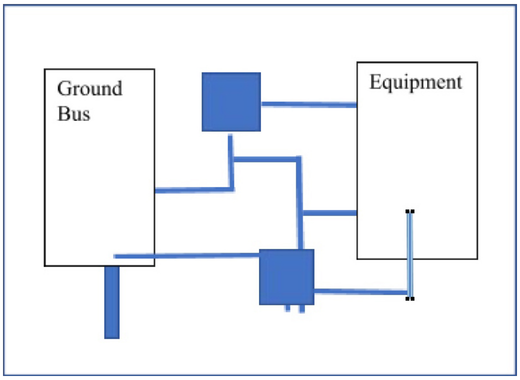

Fig. 6A: Example of "daisy-chaining," forming ground loops.

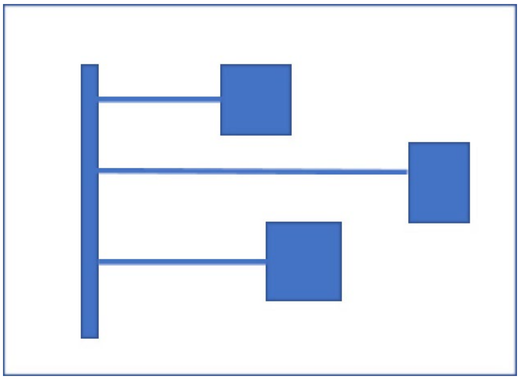

Fig. 6B: Radial feeds to equipment avoids loops.


ON THE AIR

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one, and only one ground "system" for the facility. If an isolated ground is dictated, it can be installed in conformance with the Code as discussed later.

DISSIPATING AND REDUCING LIGHTNING CURRENT FROM COAX

One method for helping to dissipate transient energy before it affects the equipment is using the principal of a current divider in multiple stages. As coax travels down the tower in this example shown in Fig. 7, the first current division occurs on the tower itself, where lightning energy is dissipated off the outer braid to a copper busbar on the tower itself, via Andrews cuffs (or similar) on the coax. The bus is connected via a large diameter cable (usually 4/0 AWG or larger) to a ring ground surrounding the tower base. This is the first current division.

The second current division takes place at the exterior bulkhead, where the coax enters the building. Again, the remaining energy is diverted via 4/0 or larger cable to the ring ground surrounding the transmitter building.

The third division takes place at the interior bulkhead, so that when the energy reaches the transmitter equipment and its surge suppression, it is a small fraction of the original strike.

Fig. 7: First lightning energy is bled off the coax shield right on the tower and immediately bonded to the ring ground surrounding the tower.

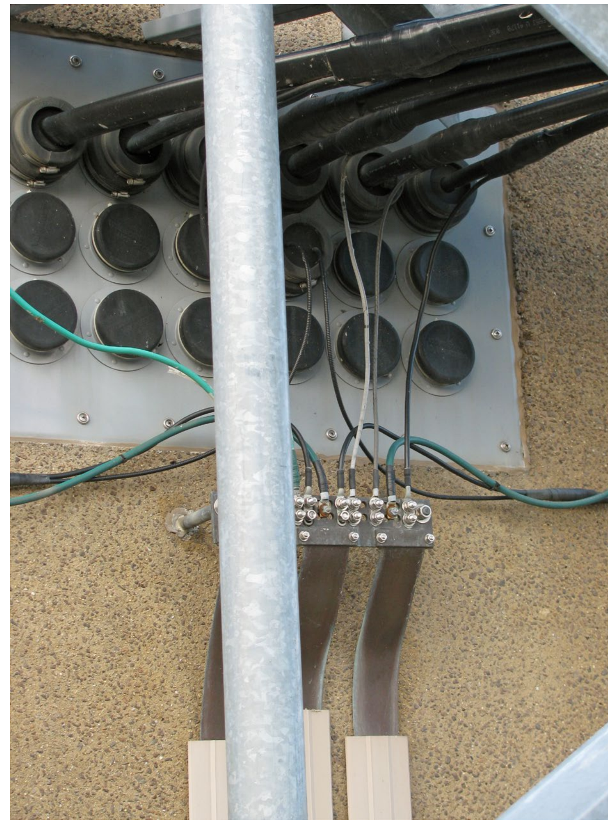


Fig. 8: More energy bled off at exterior bulkhead.

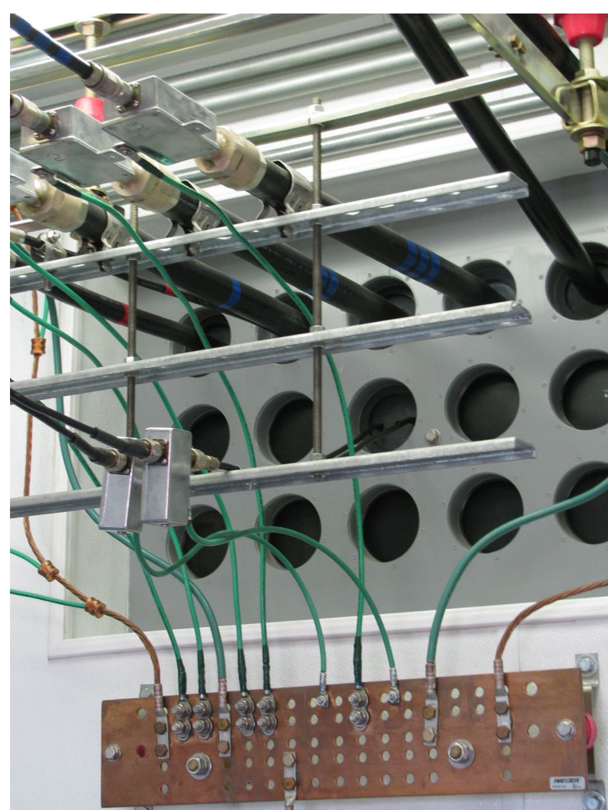


Fig. 9: Still more energy is bled off at interior bulkhead. What reaches the transmitter is a fraction of the original energy.

ISOLATED GROUNDS

Many times interfering signals can be transmitted by shared grounding conductors. An isolated ground circuit attempts to prevent this interference by isolating the grounding conductors of an IG circuit from other loads within the building.

In an IG arrangement, the grounding pin is not electrically connected to the device yoke, and so not connected to the metallic outlet box. It is therefore "isolated" from the green wire ground. A separate conductor, green with a yellow stripe, is run to the panelboard with the rest of the circuit conductors, but it is not connected to the metallic enclosure. Instead, it is insulated from the enclosure and runs all the way through to the ground bus of the service equipment or the ground connection of a separately derived system.

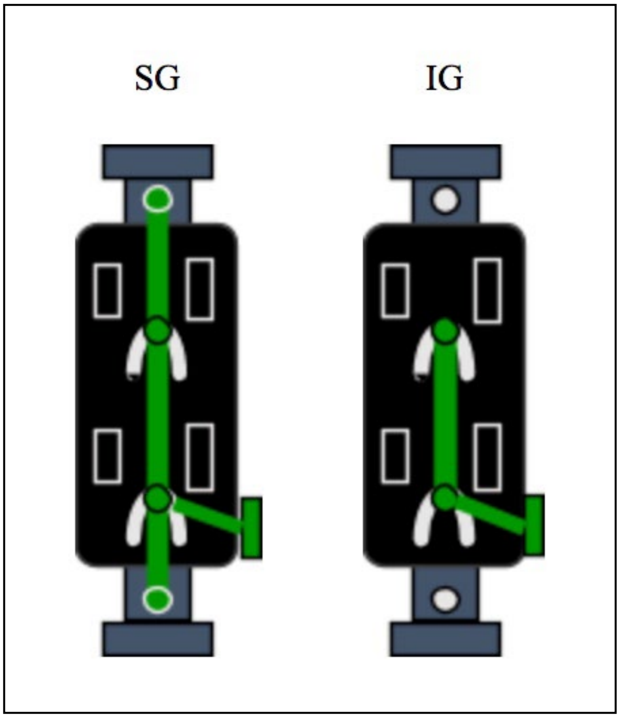


Fig 10: Solid Ground (left) receptacle provides connection from the ground pin to the strap, thus the box, feeder and panelboard. Isolated Ground (right) receptacle has no connection from the ground pin to the strap.

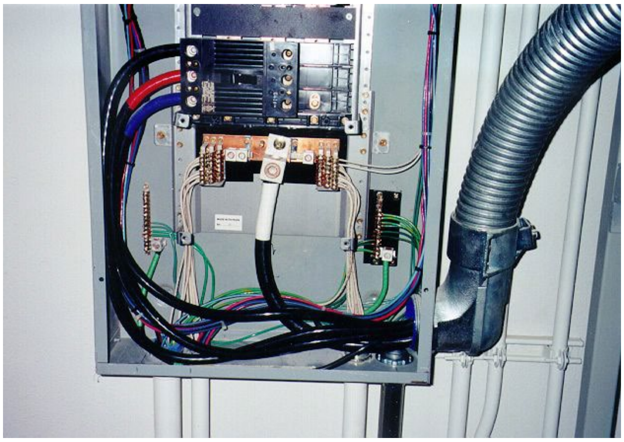
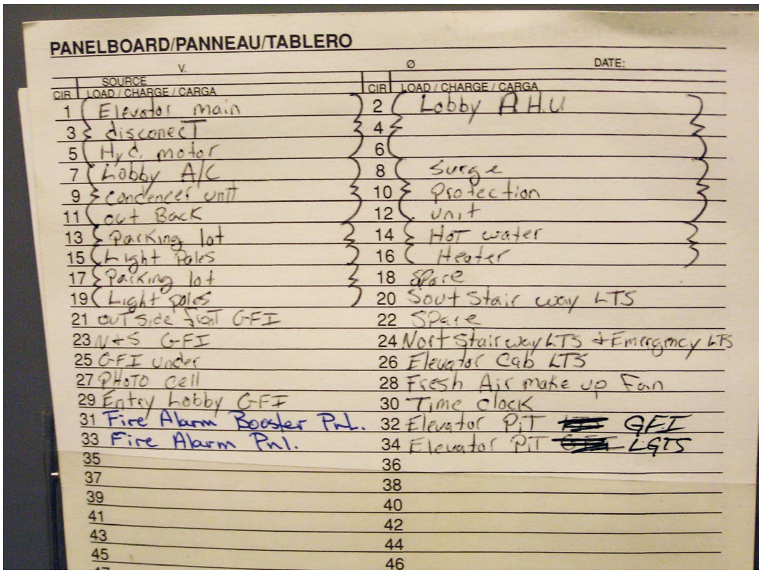


Fig. 11: Isolated grounds at the panel are not connected to the metallic box; rather they are insulated on a separate bus (right). From here they are not connected to other grounds until reaching the main ground busbar at the service.

SEPARATE PANELS

Sensitive equipment should have its own circuit, from its own feeder on its own panel, and never be shared with non-sensitive standard equipment. In addition, it is recommended that such equipment have an isolated ground circuit.



PANELBOARD/PANNEAU/TABLERO

V. Ø DATE:

CIR	SOURCE LOAD / CHARGE / CARGA	CIR	LOAD / CHARGE / CARGA
1	Elevator main	2	Lobby AHU
3	disconect	4	
5	Hyd. motor	6	
7	Lobby A/C	8	Surge
9	condencer unit	10	Protection
11	out Back	12	unit
13	Parking lot	14	Hot water
15	Light Poles	16	Heater
17	Parking lot	18	Spare
19	Light poles	20	Sout Stair way LTS
21	out Side front GFI	22	Spare
23	N+S GFI	24	Nort Stairway LTS + Emergency LTS
25	GFI under	26	Elevator Cab LTS
27	PHOTO cell	28	Fresh Air make up Fan
29	Entry Lobby GFI	30	Time clock
31	Fire Alarm Booster Pnl.	32	Elevator PiT GFI
33	Fire Alarm Pnl.	34	Elevator PiT LGTS
35		36	
37		38	
39		40	
41		42	
43		44	
45		46	

Fig. 12: Electronic and standard loads on the same panelboard, along with the parking lot lighting poles. A recipe for possible disaster.

Examine the schedule of the panel in Fig. 12. The electrical panel, which has since been corrected, served the studios of five commercial radio stations in central Florida.

Notice that the fire alarm (31) is on the same panel as the outdoor parking lot light poles (11, 13, 15, 17, 19) and various motor loads. In the event of a nearby lightning event or a strike on the lighting poles, there may have been no fire protection of this facility. Additionally, there may be no indication the fire alarm has failed until it is examined, creating an unsafe condition.

SPDS

Surge suppression devices, formerly called transient voltage surge suppression, protect downstream equipment from over-voltages that occur during a transient event. They are an essential part of a protection scheme if applied properly.

There are certain rules of thumb regarding size and

Continued on page **12**

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90%
EFFICIENCY

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NXSeries

3 kW–2,000 kW Digital/Analog AM Transmitters

	NX3	NX5	NX10	NX15	NX25	NX50	NX100	NX200	NX300	NX400	Combined Systems
ANALOG	3 kW	5 kW	10 kW	15 kW	25 kW	50 kW	100 kW	200 kW	300 kW	400 kW	up to 2 MW
Modules	2	2	4	10	10	20	40	80	120	160	
Efficiency	82%	86%		84%	88%		90%				
AM Frequency	532 kHz – 1700 kHz			531 kHz – 1,620 kHz							
LW Frequency	Contact your Sales Rep.			120 kHz – 370 kHz							

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Fig. 13: Conduit run in a data center. Would you consider allowing a joint every 10 feet in this application?

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placement and type that should be followed for these devices, including:

1. SPDs should protect every phase conductor, neutral and ground. In other words, phase-to-phase, phase-to-neutral, phase-to ground and neutral-to-ground.
2. SPDs discharge the over-voltage to ground. Therefore, the ground path needs to be very low resistance to earth. Without a good, robust ground path, the SPD will not work properly.
3. At the service, a Type 1 device of 150 kA per mode, minimum is suggested.
4. At the feeder level, a Type 2 device of a minimum of 75 kA rating per mode is recommended.
5. At the branch circuit level, a Type 3 device of 15 kA per mode is recommended.
6. SPDs should be as close as possible to the load protected. Length means delay.

CONDUIT AS A GROUND PATH

The use of conduit as a ground path is allowed by code, but not recommended, especially for critical circuits. Always insist on a separate conductor for grounding. Never rely on the conduit.

Remember, critical loads should have their own, dedicated circuit, preferably one size larger than minimum, their own ground conductor (preferably IG), in their own conduit, served by a sensitive load panelboard.

SUMMARY

These are a few recommended guidelines for critical circuits. However, there are more to consider, some dependent on geography, age, budget and other factors.

For example, I had occasion to visit a site where 21st century electronics were scheduled to be installed in 1940s-vintage buildings without thorough determination of all electrical needs.

To begin your lightning protection process, plan a thorough inspection of the facility for these and other suggested practices, conducted by an expert in power quality considerations. Remember, you only get what you inspect, not what you expect. And the best time to assess your needs is before disaster strikes.

David Brender, P.E., is president of Brender & Associates LLC. Reach him at 561-894-8901 or dtbrender@gmail.com.

Seeking Enlightenment About Lightning Protection?

We asked Jeff Welton to share best practices in preparing your transmitter site

Jeff Welton, CBRE, is Nautel's central U.S. regional sales manager. He often shares best practices about lightning protection, grounding and other important subjects; he also wrote the chapter on Facility Grounding Practice and Lightning Protection for the 11th edition of the NAB Engineering Handbook.

In light of that work, the Society of Broadcast Engineers recognized him with the 2018 James C. Wulliman Educator of the Year Award, and the Association of Public Radio Engineers recently honored him with the APRE Engineering Achievement Award.

We picked his brain in an emailed Q&A about lightning and radio broadcast engineering.

Radio World: *How effective are "lightning dissipation hats or arrays" installed at the top of towers and promoted by various companies? How do they function?*

Jeff Welton: Well, they're not only installed at the top. Depending on the height of the tower, they may also be installed at various points up the tower as well, or on guy wires. They work by point discharge theory — what I call "intentional corona," in that they will tend to arc as the tower ionizes while a storm approaches.

Some claim they will reduce the chances of a direct strike. I'm not convinced in that area, but I do believe they reduce the arcs that happen as energy builds up without a strike being involved.

I've heard enough anecdotal evidence of reduced off-air time or damage after installing them to believe they can help, but they're certainly not a replacement for a good grounding system.

RW: *How effective are lightning suppression systems connected across the incoming power lines at the main breaker/disconnect box? Some use rather sophisticated electronics, but others use only MOV devices. A few are series connected, while most are just shunt/parallel connected. Which type is better and why — or is it situational?*

Welton: At the base level, a simple MOV to ground from each power line, with a fuse in series, is good protection. The series units just involve two legs of these with a series choke between them, and yes, they can be more effective, at a multiple of the price.

More advanced devices, such as silicon avalanche diodes, are also available and will tend to fire faster — I'm sure that may make a difference in some cases — but for the most part, the MOV-based protector is usually quite sufficient.

As to your first question — how effective they are — the best grounding in the world will give a lot less protection without a good quality surge protector installed between that grounding and the incoming AC entrance, both for surges on the incoming AC and for surges on ground as lightning strikes a tower and sends massive amounts of current through ground resistance.

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RW: *Ground resistance around a tower base or building is an important factor in designing and implementing an effective grounding system for lightning protection. How is ground resistance best measured?*

Welton: Well, ground resistance is important only in determining the ground's ability to dissipate lightning energy. Ultimately, even the best ground resistance isn't going to be good enough.

NEC specifies a system impedance to ground of 25 ohms or less, 5 ohms for sensitive equipment (Article 250.6). If you have a tower strike carrying 50,000 amps of lightning energy to ground, E=I*R indicates that 5 ohms will result in a quarter million volts of potential damage.

> *"For lightning protection, copper in the ground beats earth any day, ideally connected to ground rods reaching the water table."*

This is why we stress that proper grounding practices, with copper strap are critical. I say strap because it has lower resistance per foot than copper cable and less inductance per foot for any high frequency components of the lightning strike.

So yes, to determine compliance with NEC, measuring ground resistance is useful, and there are several meters on the market for measuring this, including our friends at Fluke (model 1621 is the one I'm aware of, although there may be new ones now).

However, for lightning protection, copper in the ground beats earth any day, ideally connected to ground rods reaching the water table. I understand that this isn't always feasible, but the closer you can get, the better your odds.

RW: *Is single point ground reference always the best method to achieve good grounding? Or do you suggest the collector ring method with a number of ground rods connected at various locations around the facility?*

Welton: I'm not sure the two are mutually exclusive.

Ultimately, single point grounding is the absolute best way to control grounding at a facility and to reduce the chance of ground loops, with attendant loss of control over where discharge energy is flowing. However, you could have a set of ground rods at the base of the tower, tied together, with a strap running back to a ground rod at the building and another ground rod at the AC power pole, also connected with strap to the one at the building.

As long as only one lightning safety ground enters the building, you've still accomplished the goal of single point grounding. Obviously, this doesn't include the AC entrance safety ground, which, relatively speaking, is such a high resistance that it doesn't factor into the equation. The same with halo grounds inside the building. A lot of folks love them; I'm of the opinion that they make it too easy to create inadvertent ground loops; but again, as long as we've only got one egress from the building for our lightning ground, the end result doesn't change much.

RW: *Should engineers connect a separate ground reference from the station's equipment to the power company's ground reference? What if your power company doesn't allow or recommend doing that?*

Welton: If your power company resists, refer them to NEC Article 250, which basically says that equipment needs to be connected to the supply source, along with any other conductor that could be carrying a ground fault current. While lightning is not specifically a fault current, from a safety aspect, there's a strong argument that minimizing the resistance from one point to another, thus minimizing the potential that can build up between the two points, is the end goal of Article 250.

RW: *How effective are toroid ring "snubbers" placed around coax, communications and power cables in suppressing lightning energy?*

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Photo courtesy Andrew Skotdal

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Welton: I'm told I should have a toroid tattooed around my wrist, so my position is pretty clear. Toroids on their own do very little. However, in conjunction with a properly installed surge protector at the AC power entrance and a properly implemented grounding system, toroids add another layer of protection that can raise the effective impedance of the equipment being protected and help to minimize any surge energy that does get to that equipment.

Again, I've got dozens of anecdotal tales of strikes causing repeated damage, which ceased when ferrites were installed. Again, ferrites alone are not a solution — but in addition to grounding and surge protection, they certainly can make a difference.

RW: *Is it possible to prevent lightning that strikes a tower from entering a nearby building with connecting lines into the building? If it is, how can that be accomplished?*
Welton: Prevent? Probably not totally, no. There's still a voltage divider theory in play that indicates that some energy will still make it into the building. However, with proper grounding and surge protection (and ferrites!), that level can usually be reduced to an amount that causes minimal damage, if any.

"I'm told I should have a toroid tattooed around my wrist, so my position is pretty clear."

RW: *Fiber optic cables rather than copper wiring seem to be largely immune as a conduit for lightning energy. But can they or their terminating equipment still be damaged by a lightning strike? If so, what kind of suppression techniques are available for such installations?*
Welton: The cables themselves, I would assume, are quite immune from lightning energy, being glass (an insulator) with a protective jacket. However, their terminating equipment would still have power supply connections, which would be susceptible and should be protected by the standard means (ferrites, surge protector on the facility, etc.).

RW: *Other than installing and maintaining ball arc gaps across the base insulator of AM towers, what are recommended methods to achieve optimal lightning suppression at AM transmitter sites?*
Welton: Obviously, good grounding and protection practices, as outlined already, but in addition to that, there are several things that can be done in the ATU enclosures to help.

Photo by Mark Persons

First, a static drain choke to ground, to bleed off energy as it builds up while the tower ionizes during an approaching storm. Secondly, a DC blocking capacitor to force that energy to go through the drain choke to ground, rather than down the coax to the equipment.

In addition, there should be a ball gap inside the ATU (this would apply to both base insulated and skirt fed towers where the tower itself is grounded). A ball gap inside the ATU can be set much closer than one at the tower base, without having nuisance trips by raindrops or insects, so it would offer a higher degree of protection.

One other thing related to AM towers is that guy wire insulators should be inspected frequently. Folks complain about transmitters tripping as storms approach or about damage whenever a storm passes by without going directly over the site. Frequently, this is the result of guy wire insulators arcing, which momentarily puts a capacitive load on the transmitter.

Once an insulator arcs, it develops a carbon track that makes it more prone to arc the next time. In some cases, ceramic rod insulators, phillystran or bleeder resistors/discharge devices around the insulators are the solutions, but the problem will typically only get worse until it is resolved.

RW: *Transmitters are more frequently using SNMP and web-based remote control, and IP gear can be a big lightning path. How can this be best mitigated?*
Welton: For IP connections themselves, having a fiber link in the middle will make a difference; glass doesn't conduct, as mentioned above.

On the power supplies, surge protection and ferrites on the AC line to the outlet would help. Most of these devices are fed by wall warts, so it's no good to put fer-

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rite after that, the power supply/wall wart would still fail. That's not going to do anything for the feed coming into the building.

You're at the mercy of your ISP there, so having a backup IP link, whether a P2P wireless bridge or other alternate, is a really good idea.

RW: *Could you explain Ufer grounds?*
Welton: In short, an Ufer ground is a concrete-encased electrode. For example, in a tower pier, rebar used to strengthen the pier could be bonded together to form a Ufer ground. It relies on the natural moisture content and conductivity of concrete to provide a safety ground connection.

From a lightning protection perspective, it's a fairly high resistance — only having to meet the NEC requirement of 25 ohms — so it's of minimal value. However, having the bonded conductors inside the concrete carrying any lightning current, vs. the concrete itself, can help to prevent spalling or failure of the concrete in the event of a lightning strike, so from the aspect of protecting a tower, it's quite beneficial.

A side note: The conductive and moisture retaining properties of concrete are the main reason I like to see our transmitters installed on nonconductive material in a site with concrete floors — whether left on their shipping pallets or installed on a sheet of plywood or other insulator.

We provide carefully controlled single point grounding within the transmitter to the insulated ground lug on the rear (which is internally connected directly to the output connector). By sitting the transmitter on a concrete floor, we've introduced an alternate path to ground that reduces the value of the single point grounding scheme.

RW: *Preparation is obviously crucial, but sometimes Mother Nature will do her best to outsmart you. If the worst happens — the tower is hit and efforts to shield the transmitter failed — what's next?*
Welton: I'm not sure I like the wording of this question, as it infers some sort of intelligence and nefarious intent on the part of nature, which simply isn't true. This is just physics, and while we certainly can't predict how it will behave in all circumstances, the things we can do are quite well documented.

Granted, we're not going to protect against the "mother of all strikes" — when a 200 kA bolt comes out from the blue, so to speak! So, once that happens, the first step (after the storm has passed) is to head out to the site to count the red lights or see what's got smoke coming out.

At that point, it's logical to call your manufacturer's support department and let them walk you through your options. They can help identify what's gone awry, and let you know if the options include module replacement/exchange, or whether you'll need to send something in for repair, or if it's something you can fix on site. Obviously, your decision will be influenced by budget, whether there's a backup available or time off-air, but knowing the options is a great starting point.

Thanks to Tom McGinley, Chris Wygal and Michael Leclair for your assistance in compiling and phrasing these questions. We couldn't do our jobs without you!

Getty Images/Dnes Mszros/500px

Protect Your Transmitter Building From Damage

Learn how to design around lightning's dangers

The following is edited and excerpted from the Nautel white paper "Lightning Protection for Radio Transmitter Stations."

The geometry of the interconnections in and around the transmitter building are of vital significance to the effectiveness of the lightning protection system. The objective is to provide a path for the potentially destructive lightning current flowing from the antenna to the AC line supply, which does not include the interior of the building.

IDEAL BUILDING LAYOUT

Fig. 1 illustrates the ideal building geometry, in which the coaxial feeder cable and the AC line service enter the building in close proximity to one another. That station reference ground is established as a single point at this

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Fig. 1

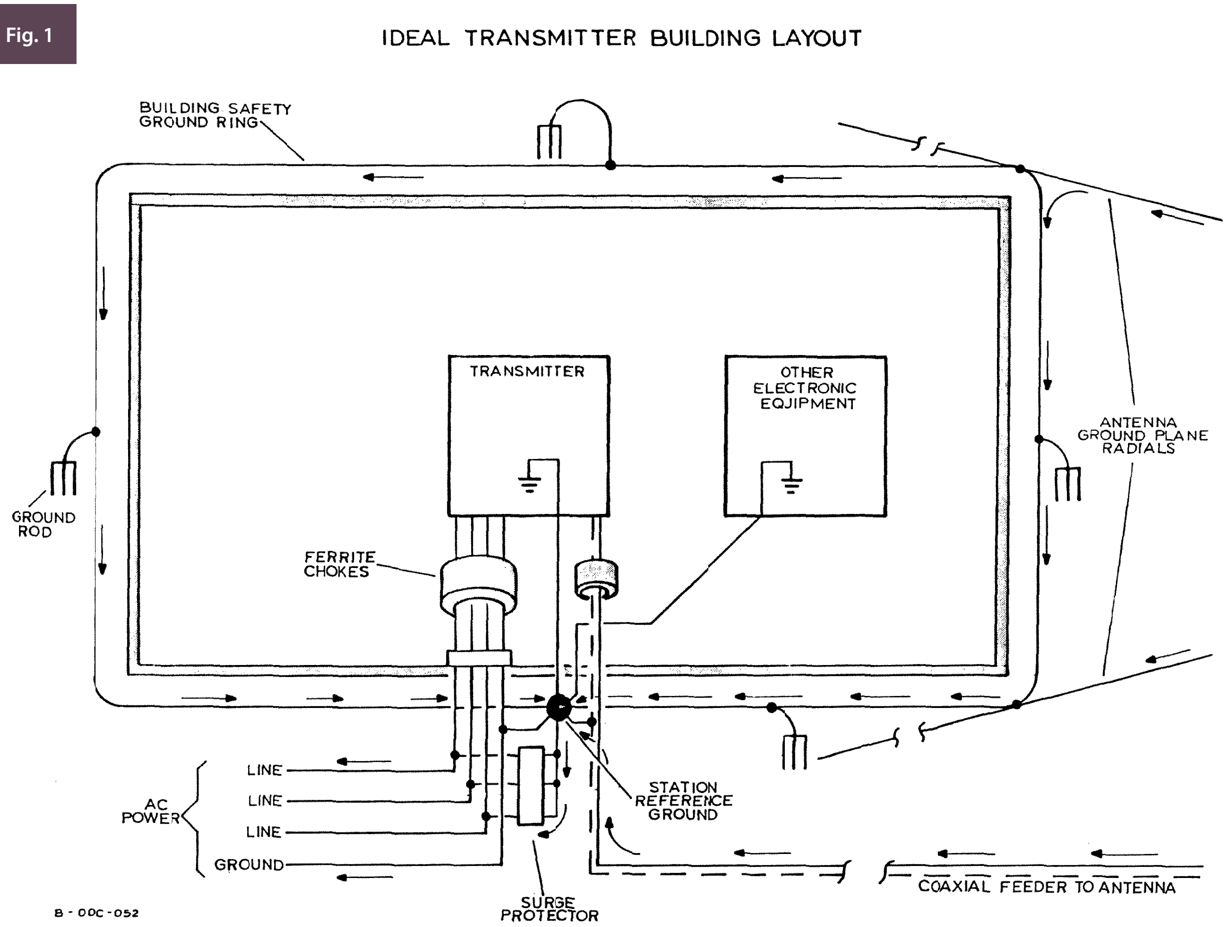
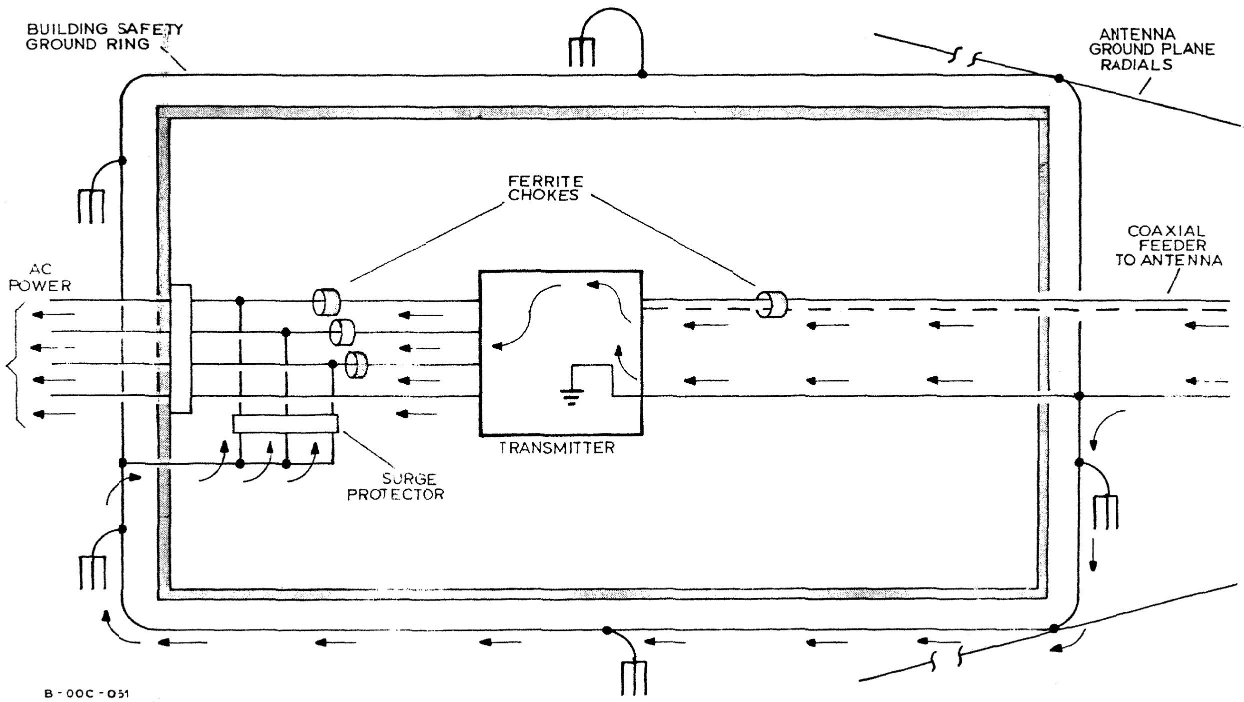


Fig. 2

POOR TRANSMITTER BUILDING LAYOUT



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same location. The shield of the coaxial feeder is connected directly to the station reference ground together with the common terminal of the surge protector device. The line terminals of the surge protector connect, via short low inductance cables, to the lines of the AC power.

When using a phased directional antenna with the phasing equipment installed within the transmitter building, all coaxial feeders should enter at this same point and be grounded to the station reference ground. Where a building safety ground ring is installed, it should be connected directly to the station reference ground point. With this arrangement, most of the lightning current will tend to bypass the building interior due to the relatively low impedance of the desired path through the surge protector compared to that of the long loop in and out of the building which passes through the transmitter.

At power levels up to 10 kW, ferrite toroids may be threaded over the AC power and the coaxial feeder cables inside the building which act as RF chokes to the undesired lightning currents, but are transparent to the normal operating currents. This technique may not be possible for very large transmitters as the maximum internal diameter of commonly available, suitable “ferrite toroids” is limited to about three inches.

POOR BUILDING LAYOUT

Fig. 2 illustrates a very poor transmitter building layout that contains all the elements of the ideal arrangement shown in Fig. 1, but is configured so poorly that little or no benefit will be obtained. This figure has been included *only* to emphasize the importance of using the correct configuration.

The following fundamental errors are illustrated in Fig. 2:

(a) The AC power cable is fed from the left hand side of the building while the coaxial feed.

(b) No station reference ground point has been established and ground points are picked up from the safety ground ring at various locations.

(c) Ferrite toroids have been threaded independently over each of the lines of the AC power source causing them to be completely saturated by the normal operating currents in these lines.

(d) The shield of the coaxial feeder cable is connected directly to the transmitter, hence lightning currents following in it will pass directly through the transmitter. It is worth noting that even if the coaxial shield were connected to the building safety ground ring at the right side of the diagram, most of the lightning current would still tend to flow in the direct path through the transmitter due to its relatively low impedance compared to the alternative longer path through the safety ground ring and the surge protector.

(e) The safety ground connection of the transmitter being connected at the right hand side of the diagram provides another undesired path for lightning currents flowing in other ground interconnection between the antenna and the transmitter building.

CORRECT A POOR LAYOUT

On existing installations, it is often impractical to reconfigure the layout to conform exactly with the ideal arrangement. The following factors should, however, be carefully considered when attempting to improve the layout.

(a) The AC line supply, the coaxial cable and all other cables including ground connections that connect to the equipment to be protected, must be brought into close proximity with each other at the station reference ground point before feeding to this equipment.

(b) The term "equipment to be protected" used in (a) above will ideally include the entire transmitter building. (With this arrangement, both personnel and all equipment within the building are protected.) The principle may in some cases be applied only to an area in the building or to the radio transmitter alone due to logistical difficulties.

(c) All incoming ground conductors should be connected directly to the station reference ground point, which in turn should be connected radially to all equipment grounds in the building.

(d) A set of varistors or similar devices capable of carrying the lightning current should be connected via short cables between the station reference ground point and the conductors of the AC line supply.

Fig. 3 illustrates a method of corrections for a non-ideal building layout, where the AC line service is connected at a location which is widely separated from the entry point of the coaxial feeder and the antenna ground strap. It should be noted that the coaxial cable should not contact any grounds within the building prior to

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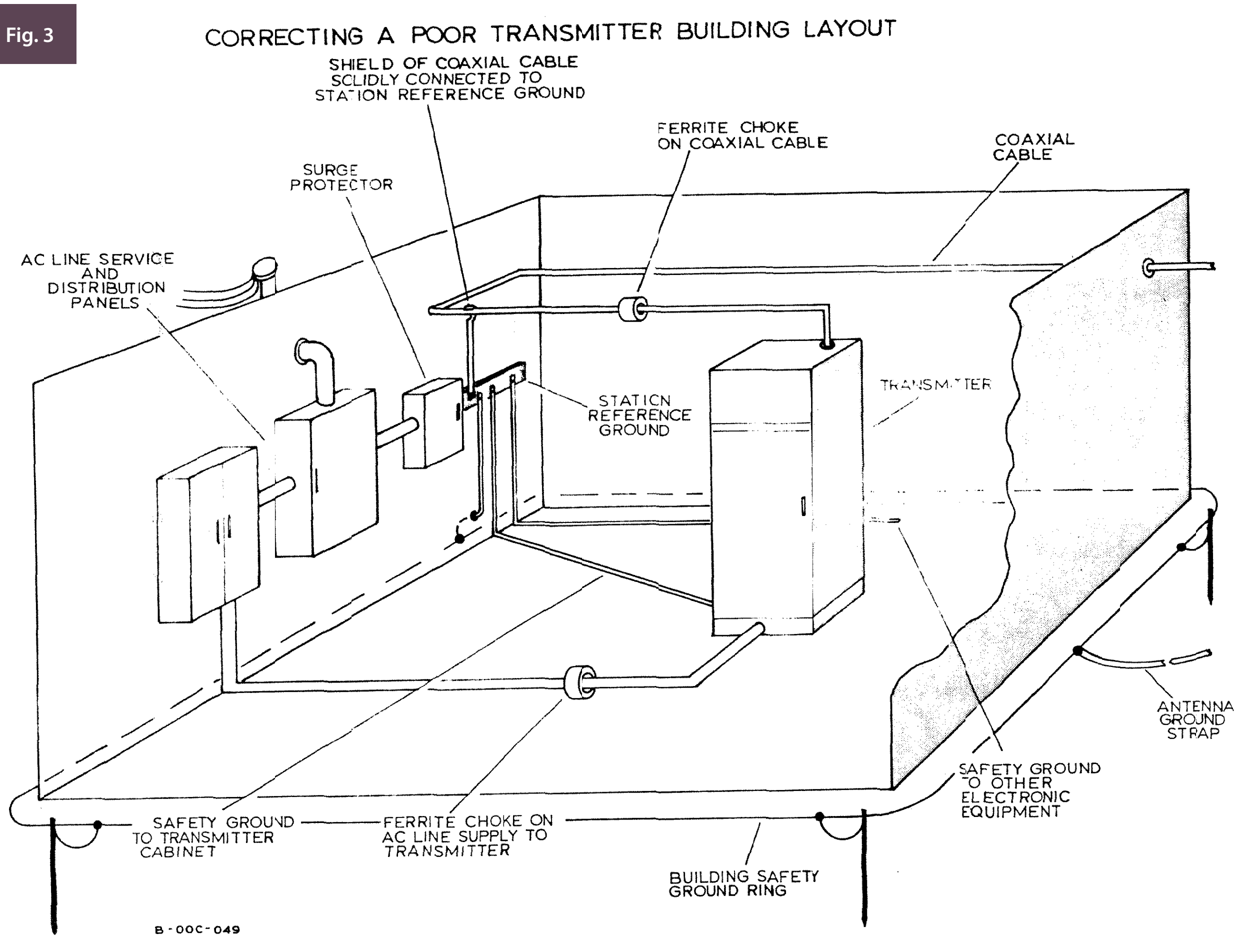
Fig. 3



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being connected via a short strap to the station reference ground. It should also be well out of reach of personnel working in the building to ensure their safety during lightning storms.

AC LINE SURGE PROTECTORS

The AC line supply to the transmitter building usually represents the lowest impedance to remote grounds and will therefore carry most of the lightning current flowing away from the transmitter site. The surge protectors that connect between the station reference ground and the AC line cables must therefore be rated to cany most of the anticipated lightning current.

It is also important that the potential developed across the protectors by the lightning current flowing through them is balanced with respect to all of the lines, so that no net lightning potential appears between any AC supply lines to the transmitter. This is not possible to achieve, however, with single-phase supplies or with some three-phase supplies that are not balanced with respect to ground potential.

The voltage rating of the surge protectors should be chosen such that the prevailing off-load steady state voltage is safely below the minimum turn-on voltage.

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IMPLEMENT PRACTICAL SOLUTIONS

"An ounce of prevention is worth a pound of cure" is a well-known adage that is highly applicable to lightning protection.

It is strongly recommended that comprehensive preventive measures be installed on all transmitter sites. Antenna arrestors and an effective antenna ground are considered mandatory at any site, if for no other reason than the safety of associated personnel.

The configuration of individual transmitter sites will seldom be identical to that layout shown on Fig. 1. It is hoped, however, that this model will give the reader a better understanding of the underlying principles and the ability to design a satisfactory protective scheme for a particular site.

It is worth noting that amount of potentially destructive lightning energy and hence the cost of protecting a transmitter site, is not related to the size of the transmitter. The amount of money worth spending at a particular site is, however, related to the cost of the equipment being protected and to its statistical probability of experiencing lightning strikes.

The full version of the article has a lot of important and useful information about lightning protection, and we encourage readers to check it out. Read the entire paper on the Nautel website at https://tinyurl.com/lightning-whitepaper. ■

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