The most serious threat to reliable communications is weather, and the city of Winter Park, Florida, is especially vulnerable. Located in Florida’s “Lightning Alley,” the city can expect more than 100 days with thunderstorms every year, and any one of those storms could disrupt or destroy the city’s communications system just when it might be most urgently needed.

To reduce weather-related threats to its emergency response system, the Winter Park Communication Center is housed in a 2,000-square-foot (200-square-meter), reinforced-concrete building. Both the building and its 90-foot (27-meter) antenna tower can withstand 200-mph (322-km/h) winds, and both are equipped with a lightning protection/grounding system (see Figure 1).

The communication center shares its antenna tower with a cellular-phone/long-distance service provider, which based its lightning protection/grounding system on its own and telephone-industry specifications. In this case, the structure is grounded through reinforcing rods in the concrete footers.

The telephone company houses its switches and communications equipment in a nearby modular building, separate from the communication center. Since the two buildings have separate electrical services, they require separate grounding systems, each with its own primary grounding electrodes. The communication center’s is a copper-clad rod driven near the building’s service entrance panel.

“[Since] we knew there would always be a potential risk for serious damage, and because of that risk and the fact that our dispatchers routinely deal with life-critical situations, we decided to upgrade our center with the most reliable grounding and lightning protection system available,” according to Joe Serrano, Winter Park’s director of Communication.

Serrano called in Power & Systems Innovations, Inc. (PSI), an electrical design firm located in Orlando. John West, the firm’s president, had a very personal reason to give Winter Park the most reliable system available. “My parents live in Winter Park,” he says. “They are over 80 years old and might need 911 assistance one day. I made absolutely certain this facility would be safe from lightning damage.”

West began with the tower’s grounding system. In place of the #2 AWG conductors the telephone service used to ground its coax cables, he installed #29X tinned copper lightning cable and 4/0 copper. Lightning cable is a hollow braided conductor that resembles a Chinese finger trap toy.

For each coax cable, he split a length of the lightning cable, wrapped it around an exposed portion of coax shield, soldered it in place, and clamped and re-insulated the assembly (see Figure 2). He then soldered the lightning cable to lengths of 4/0 copper and bonded the 4/0 to a short horizontal bus mounted on a nearby cable tray. From there, he bonded to a vertical length of bare 4/0 copper, running the 4/0 straight down to a new grounding electrode driven directly below (see Figure 3).

Bonds to the coax shields were made above the point where the cables take a 90° turn toward the communication center building so that if a lightning strike were to come down the cable shield and encounter a turn in the cable, odds are that the strike will continue straight downward.

“For extra protection,” West continued, “we also bond to the coax shield at the point where it enters the building see (Figure 4). We first mounted a ⅛-inch-thick (6.4-millimeter) copper grounding plate to the building wall. The plate has cutouts for the coax to pass through. We exposed a section of cable shield and bonded it to...
Figure 1. The 90-foot (27-meter) antenna tower is shared by the 911 call center and a telephone service provider.

Figure 2. Braided, tinned-copper #29X lightning cables are soldered to the shields of coax cables. The #29X leads are bonded to 4/0 copper cables, which are connected to a horizontal bus on the tower.

Figure 3. John West, Power & Systems Innovations, Inc. (PSI), indicates where a length of bare 4/0 copper extends downward to a grounding electrode directly below.

Figure 4. Coax cables enter the communication center through a ¼-inch-thick (6.4-milimeter) copper plate mounted on an exterior wall. The cables’ shields are bonded to the plate, and the plate is connected to a buried ring-ground by the bare 4/0 copper cable visible at the left side of the plate.

Figure 5. The antenna tower was grounded during construction using #2 AWG bare copper bonded to reinforcing rods in the footers. PSI augmented this system by bonding each of the tower’s four legs to two electrodes driven on diagonals extending outward from the tower. The new grounding-electrode conductors are bare 4/0 copper.

Figure 6. The service entrance and sub-panels are bonded to a buried 4/0 copper ring-ground, as are all other exterior metal objects, including downspouts. Note the large TVSS beneath the middle panel.
the plate. Then we bonded the plate to the building’s grounding system using a vertical length of 4/0.

“We also wanted to improve on the tower’s ground originally installed by the phone company, so we drove two more electrodes on diagonals leading outward from each of the tower’s legs see (Figure 5). Those electrodes form what is called a star-ground. We used bare 4/0 copper to connect all electrodes. We then bonded a lead from the nine new electrodes to the center’s primary electrode, which is located below the service entrance panel. The entire system has a ground resistance of less than 4 ohms.”

Why a star ground for the tower?

“Current flow from a lightning strike tends to spread outward when it enters the ground，“ West explained. “By locating the tower’s grounding electrodes on diagonals and connecting them with heavy-gauge copper, we help dissipate the charge into the ground and away from the building we want to protect.”

They next drove a series of electrodes around the communication center at 20-foot (6-meter) intervals. The electrodes were bonded to a 4/0 copper ring-ground connected to the primary grounding electrode at the service entrance. Additional 4/0 cables were installed from the ring-ground to all metal objects on or near the building’s exterior, including electrical panels, sub-panels, a chain-link fence, and metal downspouts (see Figure 6).

A ring-ground consists of a loop of buried bare copper conductor completely surrounding the structure to be protected. According to IEEE Standard 1100 (the Emerald Book), the ring-ground should be bonded to the building’s structural steel at frequent intervals and to any electrical and metallic plumbing systems that cross it. It should also be bonded to the lightning protection system, including grounding electrodes and down-conductors leading from air terminals. Section 9.10.5 of the Emerald Book specifically recommends ring-grounds for facilities housing sensitive electronic equipment.

The center’s emergency power generator is connected to the ring-ground with 4/0 copper. An additional ground connection is made from the generator frame to reinforcing rods in the concrete pedestal on which the generator stands (see Figure 7).

West installed additional lightning protection in the form of high-capacity transient voltage surge suppressors (TVSSs).

“We strongly recommend that our clients install a TVSS at the service entrance and at all critical sub-panels,” he says. “If the facility contains sensitive electronic equipment, we also recommend they install a TVSS for each branch circuit. That gives you three layers of protection. TVSS units are reliable, not expensive, and easy to install.”

Connections from the exterior grounding system—the primary electrode, ring-ground, and connections to the coax cable shields—lead into the building at two locations. One connection is made by way of a fabricated copper frame at the point where the coax enters the building (see Figure 8). The frame is aligned with the matching copper plate mounted on the exterior wall. A second grounding conductor penetration is located at the service entrance.

Indoors, cables from both penetrations are bonded to halo grounds surrounding each room, approximately 6 inches (15 mm) below the ceiling. The original grounding system already contained halo grounds constructed from #6 AWG conductor. A second halo in 4/0 copper was overlaid, running in parallel with the existing installation.

More 4/0 copper connects the halo grounds to the equipment racks in several of the facility’s rooms (see Figure 9). At first glance, the cables appear to be rather loosely draped; this arrangement is intentional.

“Recommended practice calls for bends in lightning protection/grounding conductors to have generous radii, with no sharp bends,” says West. “This is particularly valuable where high frequencies, such as..."
WHEN IT ENTERS THE GROUND

those associated with communications equipment or lightning, are involved.”

Additional 4/0 grounding conductors lead from the halo to ¼-inch-thick (6.4-millimeter) copper bus plates mounted at convenient locations on the racks (see Figure 10). The plates serve as collectors from which #2 AWG copper cables extend to individual equipment consoles. All connections are made using copper, tinned copper, or copper alloy bolt-on lugs.

Joints between sections of the fabricated equipment racks are jumpered with short lengths of #2 AWG copper (see Figure 11). These connections ensure that all equipment connected to the racks see the same low ground potential.

Finally, grounding connections in the center’s dispatch room are made beneath the room’s raised floor. Jumpers are made from insulated #2 AWG copper. As was done elsewhere in the center, all grounding connections in the dispatch room are made with bolt-on copper-base lugs (see Figure 12).

GUIDANCE FOR LIGHTNING PROTECTION AND GROUNDING

Check the following for guidance on lightning protection and grounding: NFPA 780, Standard for the Installation of Lightning Protection Systems

NEC Requirements:
- 230.209, “Surge Arresters (Lightning Arresters)”
- 250, “Grounding and Bonding”
- 280, “Surge Arresters”
- 725.57, “Installation of Circuit Conductors Extending Beyond One Building”
- 800.53, “Lightning Conductors”
- 800.90, “Protective Devices”
- 800.100, “Cable and Primary Protector Grounding”

Figure 13. Grounding connections to coax cable shields at the cellular-telephone/long-distance service provider that shares Winter Park’s antenna tower are made on the horizontal run of the cables. Connection to vertical runs provide better lightning protection, according to PSI’s John West. The Winter Park Communication Center up-sized its grounding electrode conductors to 4/0 copper.

Figure 14. Grounding connection to a lifting lug on the telephone provider’s modular building. There is no assurance that the lifting lug is actually bonded to the structure’s metal frame.