

Lightning Protection and Grounding Project at W2MMD



This ground system implements a single-point ground panel, followed by an external perimeter ground system.

An aerial view of the Gloucester County Amateur Radio Club, W2MMD, clubhouse. [Jon Pearce, WB2MNF, photo]

Ron Block, NR2B

The Gloucester County Amateur Radio Club, W2MMD (www.w2mmd.org), founded in 1959, is fortunate to have a clubhouse on the 4-H grounds in Mullica Hill, New Jersey. It accommodates several different radio operating positions, as well as five towers and antenna supports. The HF station is located at the right-hand side of the clubhouse, with the VHF and satellite stations located at the left-hand side. The club recently faced an interesting challenge after club member John Hill, W2HUV, offered to provide the club with a new Elecraft KPA1500 amplifier. This offer came at the behest of John's friend and mentor, Donald W. Stribling, KH6DX (SK), with only one requirement — the equipment must be grounded for RF performance and to prevent damage from lightning. While such a capability should be part of any amateur radio installation, at our clubhouse, there are six independent, non-inter-

connected grounds — one at the base of each tower, plus the utility ground (see Figure 1). In the radio rooms, there are no external ground connections — only the ac outlet ground.

The Plan

John's persistence caused the resurrection of an old *Lightning Protection and Grounding Plan* that had been proposed to the club several years ago but had never been implemented. That plan called for the creation of a zone of protection within each of the two

Tornado Causes Significant Antenna Damage

On September 1, 2021, an EF-3 tornado passed just behind the Gloucester County Amateur Radio Club, W2MMD, station and took down both of our towers. We have started acquiring replacement towers and antennas.

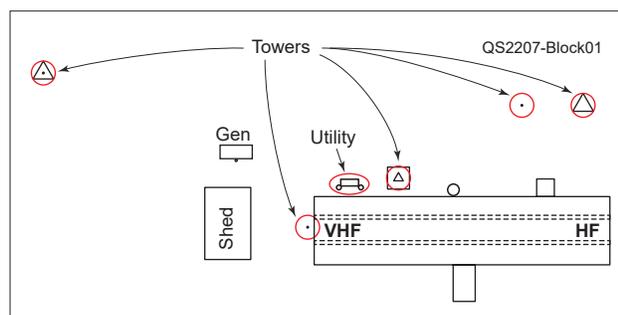


Figure 1 — This drawing provides an aerial view of the clubhouse, showing non-interconnected earth grounds.

radio rooms (HF and VHF), and a substantial external ground system in accordance with the guidelines found in my 2002 QST article series, "Lightning Protection for the Amateur Radio Station."

The ground system implementation plan covers the creation of the single-point ground panel (SPGP) in the HF radio room, where the Elecraft amplifier will be installed. The plan is divided into two distinct phases. Phase I is the creation of an SPGP within each of the HF and VHF radio rooms, to which all equipment is connected. In Phase II, the plan lays out the creation of a unified external ground system, consisting of a perimeter ground that comprises a shorting and bonding bus that surrounds the building itself. The addition of radials on each tower is also a vital aspect of the plan, because that will distribute lightning energy and lower the ground system impedance.

The Problem

Figure 2 shows the simplest possible radio installation — a single radio with an integrated power supply and an outside antenna connection. Many of us employ this type of installation because it is easy and straightforward. The problem is the radio is bridged between two independent and non-interconnected ground systems — the antenna ground and the ac utility ground.

During a lightning strike, the surge energy would follow the coax into the building and to the radio. Because the radio is connected to the ac electrical system, which has both a neutral and a safety ground connection to the earth, the energy would flow through the radio and follow the ac wiring to the utility ground and the electrical distribution system. The radio, of course, is not designed to handle that kind of energy, which would subsequently cause damage to its front end through to the power supply. This same situation exists in reverse if the surge energy were to arrive at the radio via the electrical distribution network.

Finding a Solution

Non-radio equipment that is outside of the protection zones is, at least for now, vulnerable. The first step in saving the radios from surge destruction is to establish a local SPGP. In this simplified case, the SPGP consists of a conductive surface upon which a coaxial pro-

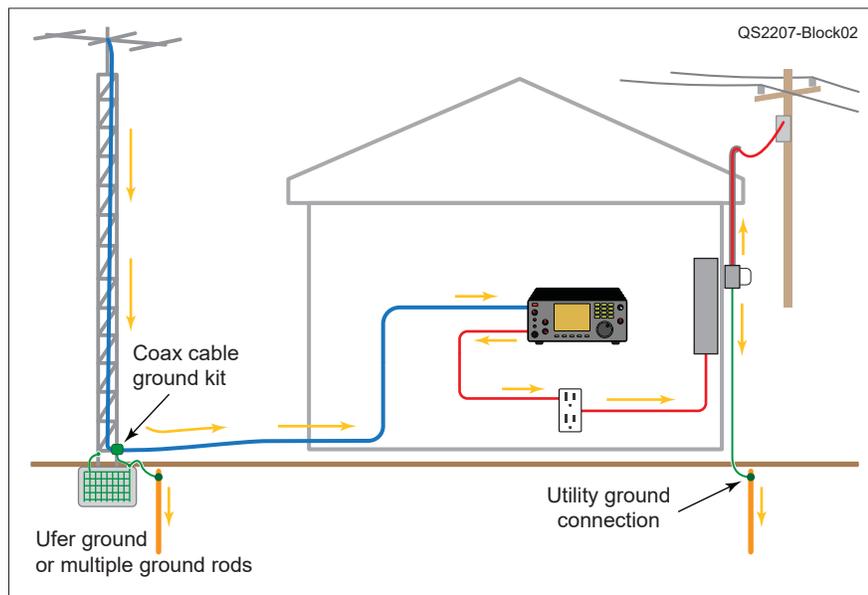


Figure 2 — A simple installation where the radio is bridged across two non-interconnected grounds. The antenna ground is on the left and the ac utility ground is on the right. The surge energy is represented by the yellow arrows.

tor and an ac power protector are mounted. Just this step alone is sufficient to offer a minimal level of protection to the radio. I highly recommend enhancing this arrangement by connecting the SPGP to an external earth ground system. Although that is not absolutely necessary for equipment protection, it should be connected to an external earth ground system for station safety and overall station performance.

The protectors (coax, rotator, ac power, etc.) have a relatively simple job to do, which is to short all the wires in the connection to the protector housing in the face of an overvoltage. By mounting all of the protectors on a common conductive surface, the cables connecting the radio to the outside are shorted together, thus preventing any current flow through the internal components of the radio. In addition, the chassis of the radio should also be bonded to the SPGP to keep it at the same potential.

With the creation of a temporarily ungrounded SPGP with protectors (see Figure 3), the current flow changes as a result of the surge energy. The energy does not flow through the radio, but it does continue onto the ac power ground. Please keep in mind that the chassis of the radio, as well as the SPGP, will be significantly elevated by thousands of volts, and it will take several seconds to return to a voltage that approaches a normal ground reference level. Physically touching the radio will allow current to flow through the radio and through you, as the new ground path.

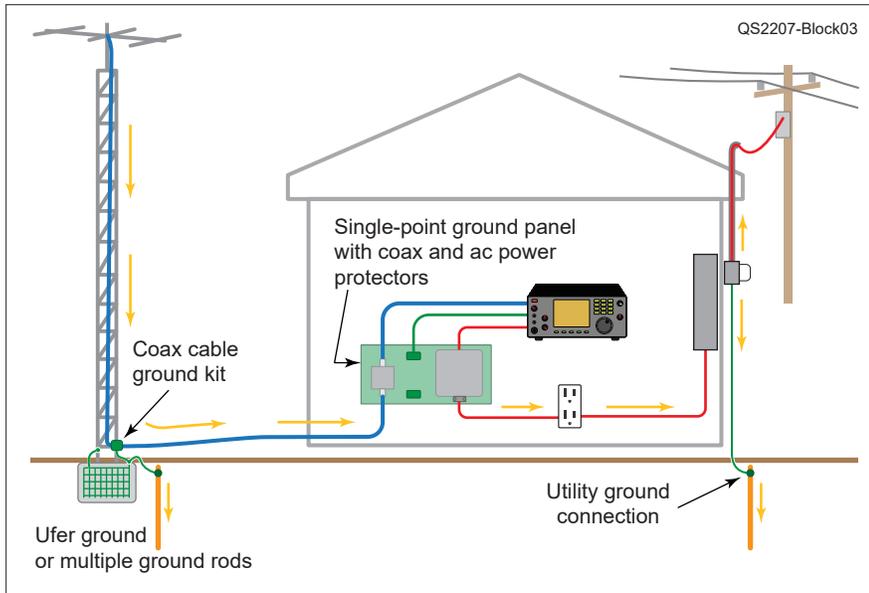


Figure 3 — A simple radio station installation with single-point ground panel and protectors. The yellow arrows show a revised current flow as a result of the shorted protectors.

Bonding the Grounds

The proposed solution solved one problem, which was the lack of a good ground at the operating position. The lack of a consistent outdoor ground remains. The clubhouse currently has six independent, non-interconnected ground systems — one at the utility entrance (required by US code) and the others at the base of each tower (required by the National Electrical Code in the US).

Without the existence of a perimeter ground to bond these independent grounds together, most of the light-

ning strike current will follow the coax cables into the clubhouse, across the SPGP, and into the earth ground. While this does work, it exposes the coax cabling to excessive current and allows that current to enter the clubhouse on its way to an earth ground. This is not a safe or a desirable situation. If a perimeter ground were in place, a significant amount of the energy would remain outside the clubhouse.

To solve the problem, it is necessary to bond the multiple independent grounds together using the perimeter ground (see Figure 4). Ideally, the perimeter ground is a bare, buried wire or copper strap that goes completely around the building. Its function is to act as a

shorting bar in the soil, minimizing the ground potential differences underneath the building (inside the loop). Without a perimeter ground, it is possible for the earth at one corner of the building to be significantly elevated while the adjacent portions of the earth beneath the building are at a much lower potential. This situation is frequently equalized by using the building itself as an electrical conductor, which is not beneficial for the building, its contents, nor its inhabitants. The perimeter ground also serves as a bonding conductor to link together the independent grounds, such as the AC utility, the towers, and the antennas. Because this

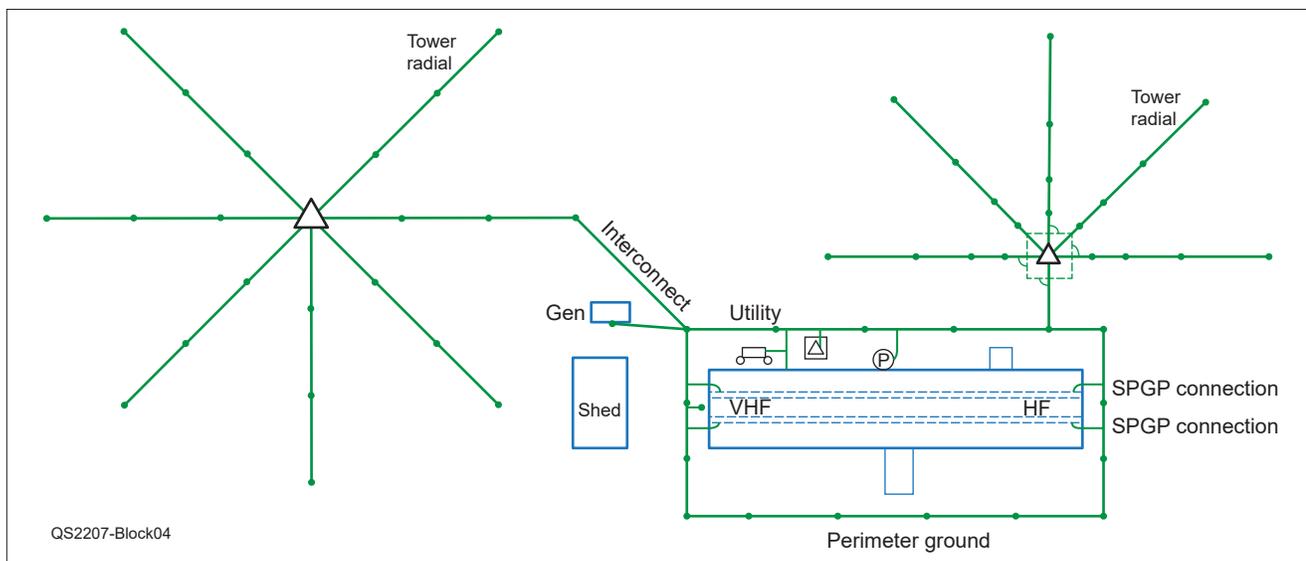


Figure 4 — An aerial view of the clubhouse shows the perimeter ground bonding together the non-interconnected earth grounds. The tower radials distribute the strike energy and contribute to a low-impedance ground system.



Figure 5 — Shown are a rotator protector, the four coaxial protectors, an electronically controlled coaxial switch, and a 120 V ac power protector. [Ron Block, NR2B, photo]

bonding occurs outside of the structure, the majority of the strike energy does not flow through the structure looking for an earth ground.

For many hams, it may be difficult or impossible to have a perimeter ground around their house, but there are some minimum requirements for it to be effective. All non-interconnected grounds must be bonded by the perimeter ground, and the path must be on the outside of the building, using a bare, buried conductor going as far around the building as possible. Ground-mounted antennas should be on the outside of the perimeter ground loop. For more information, consult Ward Silver's, NØAX, book, *Grounding and Bonding for the Radio Amateur*.

Implementation

In our HF radio room, we created an SPGP, which is a 6-inch-wide copper strip running a little less than three-quarters of the way around the room. It is mounted on a plywood backing panel affixed to the wall studs. Because all ac power must only be sourced from an SPGP-mounted protector, the existing ac power outlets were relocated from desktop height to below the SPGP and restricted to a single connection. The ac power is then distributed at the desktop level by a power strip connected to the ac power protector. A smaller vertical copper strap from the SPGP connects to the wall-mounted air conditioner chassis to prevent surge energy flash-over.

Mounted on the SPGP (see Figure 5) are the rotator protector, the four coaxial protectors, the electronically controlled coaxial switch, and a 120 V ac power pro-

jector. A 240 V ac power protector for the Elecraft amplifier is located further to the right, beyond the figure in the center of the room. All unprotected cabling is kept between the floor and the bottom of the SPGP, while protected cabling is kept above the SPGP and is aided by the cable brackets on the wall. There is no excess length or coils of excess cabling. All cables are cut to length and re-terminated.

Connecting the SPGP to the external ground system is another 6-inch-wide copper strap going straight down through the floor between the unprotected wall receptacle and the ac power protector. On its way to connect with the perimeter ground, it is bonded to the steel frame of the building. Because the perimeter ground has not yet been installed, the ground connection terminates with a temporary ground rod. There is a second 6-inch-wide copper strap connection from the SPGP to the ground system a few feet to the right, making a total width of 12 inches for a low-inductance ground connection.

The HF station is frequently operated remotely via the internet. The CAT-5 copper connection is delicate (low-voltage, easily damaged), and even with the appropriate SPGP-mounted protector, it could represent a ground path (time difference) to the distant end of the clubhouse. To eliminate this problem, we ran flexible conduit through the ceiling, into which a fiber-optic cable was inserted and interfaced with the rest of the clubhouse network.

For more details on the implementation of the SPGP, visit the *QST* in Depth web page at arrl.org/qst-in-depth.

Thanks

Many very dedicated club members made this happen. I'd like to offer special thanks to Technical Committee Chairperson Jon Pearce, WB2MNF, as well as our work team leaders Frank Romeo, Jr., N3PUU, and Lenny Rust, W2LJR. I'd also like to thank Mike Pecorini, K2MRP; John O'Connell, K2QA; Sheldon Parker, K2MEN, and Al Arrison, KB2AYU.

ARRL member Ron Block, NR2B, holds an Amateur Extra-class license. He worked for 20 years in the computer industry as a project manager for complex one-time computer-based projects. In parallel, he became a PolyPhaser distributor and consulted in lightning protection and grounding. You can reach Ron at ron@wrblock.com.

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