



The Critical Role of Surge Protection and Power Distribution in Protecting 5G mmWave Small Cell Networks



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5G small cell sites typically consist of existing poles with attached concealed radio equipment and antennas, or more integrated poles packed with expensive electronic hardware. These densely packed nodes are increasingly susceptible to damage from overvoltage surges and transients, especially conducted disturbances through cables and radiated disturbances, from nearby events like lightning discharges. Since 5G networks will operate over large numbers of small cell sites, carriers, tower companies and A&E firms must make sure each site integrates high performance and flexible AC power distribution and protection devices to ensure continuous operation.

More Sites Provide More Bandwidth—and More Potential Points of Failure

5G wireless has arrived, bringing growing challenges for service providers. The four tier-1 carriers have 5G up and running across dozens of cities, and are expanding their reach as quickly as they can. But to maintain reliable 5G service, carriers need to address the potential threats from overvoltage surges and transients to the new small cell nodes they deploy.

To achieve sufficient coverage, 5G networks may need to use both sub-6 GHz and mmWave frequencies. The mmWave frequencies make use of previously unused spectrum, but their high frequencies do not propagate as far as lower frequencies in earlier generations. This means carriers need to deploy a large number of small cell nodes which are often integrated with existing street furniture such as lighting or utility poles.

The new “small cell light poles” may consist of existing poles with attached concealed radio equipment and antennas, or more integrated poles packed with expensive electronic hardware. This can include multiple 5G and 4G radios, as well as other systems such as smart city hubs with sensors, cameras and atmospheric sensors. The poles may also provide street lighting and electric vehicle charging, and therefore require multiple power units, power converters, meters and distribution panels, as well as support systems like intrusion alarms and ventilation. With the addition of sophisticated electronics, small cell poles are increasingly susceptible to damage from overvoltage surges and transients—and more small cell sites mean more points of potential failure in the network.

Trade group CTIA has said it expects more than 700,000 new small cells to be rolled out by 2026, in the USA alone. Rather than just filling gaps in radio coverage and increasing capacity, small cells in 5G networks are the primary nodes, providing critical, high-speed services where outages are unacceptable. With so many new sites to pay for and run, reliability must be high and operating costs low. This is why carriers and tower companies must install AC power distribution devices equipped with surge protective devices (SPDs) at small cell sites to provide both core functionality—as well as maximum application flexibility to ensure quick and easy site installation and reliable long-term operation.

High-performance, maintenance-free surge protection is important, but other power distribution considerations include further simplifying engineering, installation and maintenance. For example, Raycap has incorporated single-enclosure service-entrance functionality and conduit/cable-access from the top, bottom, sides and rear of enclosures into its broad lineup of AC disconnect and distribution products. These



Figure 1: AC power and equipment compartments in an integrated 5G small cell pole assembly.

designs accommodate multiple 120VAC or 240VAC loads (up to 16 or 8 respectively) and operate in harsh environments with challenging requirements ranging from sprinkler-directed water or temporary submersion to the need for external On/Off power-disconnects and 42kAIC-ratings. There are also options for color-matched exteriors for optimum concealment.

Overvoltage Risks: Conducted and Radiated

There are two main types of overvoltages that small cells need to be able to handle: those caused by conducted electrical disturbances, and those caused by radiated atmospheric disturbances.

The first class of overvoltage, conducted disturbances, mostly enter the pole via conductive cables. These include utility power conductors and signal lines, which can couple the internal electronic systems contained within the pole to the external environment. The small cell will typically have a direct connection to a nearby transformer, which could involve currents of 10,000A or more. If the surge protector fails, it must do so safely—with no risk of follow-on current arcing over to potentially create a risk of fire or even an explosion.

To re-use existing street lighting infrastructure, and keep costs down, small cells will often rely on existing power distribution wiring. In most of the U.S., this wiring is aerial rather than buried, which means it is vulnerable to overvoltages and is a primary conduit for surge energy to enter the pole and damage the internal electronics.

Additionally, traditional macro cell sites go from the utility AC power service to a rectification component (AC to DC converter) that also typically has battery backup, before power is fed to the down line radios. This AC to DC conversion provides some degree of isolation, or a buffer, to limit damage to some of those radios. Conversely, in a small cell site, there are AC circuit breakers that feed those radios directly, without that AC to DC buffer—so, by stripping some of the protection inherent with AC to DC separation, the small cells are inherently more susceptible to costly damage and downtime.

The second class of disturbances, called radiated disturbances, are usually created by airborne events, such as nearby lightning discharges that create rapid changes in both electromagnetic and electrostatic fields around the structure. Although they are relatively low in height compared to macro cell sites, small cell sites are still vulnerable to lightning strikes, which don't always hit the tallest building in an area. Even without a direct strike, damage can be caused by large induced currents in power lines due to lightning nearby or longer-term degradation from grid-switching and power-factor correction from utility companies, which happens in all locations.

These rapidly varying electric and magnetic fields can couple with the electrical and electronic systems within the pole to produce damaging surges of current and voltage. While lightning is much more common in some areas, such as Florida, there are at least some strikes basically everywhere, so protection is still required wherever a small cell is located.

Unfortunately, the sensitive antenna systems of small cells are mostly tuned to the frequencies at which much of the energy in the lightning discharge is centralized. This means they can act as conduits for this energy to enter the pole, damaging both the radio front-ends and other systems within the pole. While the Faraday shielding of a metal pole will help reduce this somewhat, it cannot fully mitigate the problem.



Figure 2: Enclosures attached to poles need protective electronics gear built in.



Figure 3: Lightning doesn't always hit the tallest structure.

Overvoltage Protection (OVP) Using High Performance SPDs

Standards such as IEC 61643 describe the use of SPDs to mitigate the effects of these types of overvoltages. SPDs are classified by test class for the electrical environment within which they are intended to operate. For example, a Class I SPD is one that has been tested to withstand—using IEC terminology—“a direct or partial direct lightning discharge.” This means that the SPD has been tested to withstand the energy and waveform associated with the discharge most likely to enter a structure in an exposed location.

The SPDs selected to protect the primary service entrance utility feed must be suitably rated for an outdoor electrical environment and meet Class I testing. They should also have an impulse withstand level (I_{imp}) of 12.5kA, in order to safely withstand the threat level of such locations.

Choosing an SPD capable of withstanding the associated threat level is not in itself enough to protect the equipment. The SPD must also limit the incident conducted surge to a voltage protection level (U_p) lower than the withstand level (U_w) of the electronic equipment within the pole. IEC recommends that $U_p < 0.8 U_w$.

Raycap's line of AC disconnects feature its patented Strikesorb® SPD technology that provides the required voltage protection level to protect sensitive, mission-critical electronic equipment in small cell sites, and specifically, it provides the required I_{imp} and U_p .

Strikesorb incorporates a heavy duty, distribution grade Metal Oxide Varistor (MOV) disk, assembled under pressure in an environmentally sealed aluminum casing. This means a Strikesorb SPD has very low internal contact resistance and excellent thermal management, and the surge current is distributed uniformly over the total area of the protection element. This results in an extremely high energy handling capability combined with very low let through voltage.

The Strikesorb technology is maintenance-free and can withstand thousands of repetitive surge events without failure or degradation. This has been essential for tier-one carriers, who have deployed Strikesorb SPDs on the tops of their towers—the cost of rolling a truck or having someone climb that tower to replace the SPD is hugely expensive. With millions of modules deployed on the tops of towers, Raycap's experience proves it can provide a safe and reliable solution in small cell networks as well. Based on years of field performance, Strikesorb's expected lifetime is more than 20 years, and all modules are supplied with a 10-year limited lifetime warranty.

The products are tested according to international safety standards (UL and IEC) and offer unparalleled performance against lightning and power surges, and eliminate the use of materials that could burn, smoke or explode.



Figure 4: Strikesorb SPDs are tested and certified according to international safety and performance standards, IEC and UL.



Figure 5: Raycap AC Disconnect products

AC power distribution and protection devices protect 5G networks

5G small cells are critical to wireless network operation, and usually contain densely-packed, high-cost and sensitive electronic systems that can be vulnerable to overvoltages and surges.

By selecting high performance and highly flexible AC power distribution and protection devices (utilizing Strikesorb technology from Raycap), engineers can ensure their small cell designs provide the robustness needed for continuous operation, regardless of lightning strikes or other disturbances as well as the core features required for power distribution at even the most challenging sites. Further, by working with an experienced, customer-centric solution provider like Raycap, they can choose a **complete** product that will work in any small cell node optimizing installation and power delivery—whether it's on a utility pole, or in a different enclosure—and provide maintenance-free protection for years to come.

About Raycap

Raycap is a solutions provider and manufacturer of telecommunications infrastructure products for mobile and broadband networks with operations throughout Europe and North America. In 2019, Raycap acquired STEALTH® Concealment Solutions, the pioneer in concealment solutions for RF antenna equipment. Raycap acquired Apelio, a manufacturer of telecommunication network accessories and electrical switchgear, in 2020 to bolster its engineering and manufacturing capabilities in the U.S. and expanding its product offering for the small cell 5G telecom market.

Raycap has a large installed base in the U.S. and Europe, including connectivity and lightning protection solutions for telecommunications infrastructure and RF concealments. As a known and trusted vendor for Tier-1, Tier-2 and Tier-3 carriers, Raycap products can be found in a wide variety of telecom sites with more than 400,000 site installations across North America alone.

Raycap has the small cell experience, technology and the reputation for delivering the right product on-time for smooth installation.

Talk to Raycap about its 5G small cell solutions that include AC power distribution and protection.

Contact us today at info@raycap.com.

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