Escalating Environmental Threats to Cellular Networks Demand Better Surge Protection

More Sites Mean More Potential Failure Points

With the advent of 5G wireless, carriers are expanding their reach as quickly as possible, covering more and more of the U.S. But to maintain reliable 5G service, they must address the potential threats from the growing number of lightning strikes being created by more active and intense weather patterns.

To achieve sufficient coverage, 5G network operators may use sub-6GHz and mmWave frequencies. High frequencies do not propagate as far as lower frequencies, however, which means carriers operating in the millimeter wave (mmWave) range must deploy more nodes.

While C-band radios and antennae are currently integrated on existing macro tower sites, mmWave sites are built by adding equipment to existing wooden or metal poles or installing new small cell poles.

According to the Annual 2022 Survey by CTIA, the wireless industry's trade group, there were 418,887 operational cell sites across the U.S. by the end of 2021, not counting any new 5G base stations that might have been added to existing cell sites. The radios and antenna equipment that comprise the mmWave and C-band sites may be concealed or unconcealed, meaning it might be out in the open or hidden behind pole toppers or screen walls, depending upon the aesthetic regulations of a given municipality. Rather than just filling gaps in radio coverage and increasing capacity, these are primary nodes that provide critical, high-speed services, making outages unacceptable.

Increasingly, small cellular nodes must coexist with many kinds of other equipment. Small cells can pack not only with 5G and 4G radios but other systems, such as smart city hubs with cameras and atmospheric sensors. Equipment may also be co-located with street lighting, electric vehicle charging, and wayfinding kiosks. Such multipurpose sites will likely have multiple power units, power converters, meters, and distribution panels, as well as support systems like intrusion alarms and cooling ventilation. With the addition of sophisticated electronics, this interconnected network equipment is becoming increasingly susceptible to damage from overvoltage surges and transients. And, of course, more sites mean more points of potential failure in the network.

Carriers need high reliability and low operating expenditures (OPEX). The need for high reliability has driven the need to install specially designed 48-volt D.C. overvoltage protection solutions on towers to mitigate the damage that lightning surges can cause and ensure reliable long-term operation. Many small cell sites also have surge protection and A.C. power disconnect equipment to support uptime and provide maximum application flexibility to installers and utility workers who need safe and easy access to a site's power.

Mitigating Surge Events on Macro Tower Sites

While lightning is more prevalent in some areas than others, localized storms are becoming more severe in general. The actual ground strike distribution during a particular time of year or a specific storm may be much higher with the increasing intensity of localized lightning activity.

The exposure to the deleterious effects of lightning are further amplified by the use of Remote Radio Heads being located on tall towers and rooftops and interconnected to their base shelter equipment by long low-voltage D.C. power cables. These long D.C. trunk cables serve as "antennas" to the electric and magnetic fields of near-by lightning strikes which can induce voltages high enough to damage unprotected equipment at either end of the cable.

To reduce the danger from direct lightning strikes, cell towers are equipped with conventional Lightning Protection Systems (LPS) consisting of strike receptors, lightning down conductors, low impedance ground termination systems, and overvoltage protection devices (OVPs) as defined in standards such as NFPA 780 and IEC 62305. The need to install overvoltage surge protective devices to safeguard sensitive electronic equipment is also covered under the IEC 61643 standard.

This is explained by the principle of "Lightning Protection Zones" or LPZs *(Figure 1)*, introduced in the IEC 62305 series of standards, where the threat level of successive zones is first reduced through the deployment of the LPS, intended to divert the direct lightning strike to ground, and then with surge protective devices (SPDs) to reduce the threat further and create the next lower level of LPZ.

According to the IEC 61643 standard, the SPDs used to create these lower-threat level zones need to be suitable for the electrical environment to which they are exposed. For example, an SPD which meets Test Class I is suitable to divert direct lightning currents, while an SPD tested to Class II is only suitably rated to handle the induced effects of nearby lightning.

For such a critical application as telecommunications, the SPD is use has to fulfill both criteria of Class I and Class II i.e. be able to handle a high amount of energy (direct lightning currents) and at the same time provide the lowest possible let-though voltage (to limit induced effects).

Radio manufacturers incorporate a level of surge protection within their radios, but this is primarily to pass EMC compliance. Most protection internal to the radio is only evaluated to test Class II and cannot serve as the primary surge diversion element to protect against direct lightning strikes. The SPDs inside these radios are also not tested together with the PCBs they are connected to. In addition, because the protection is located INSIDE the radio's enclosure, a surge will have to violate the zone of protection provided by the radio's enclosure before it is diverted to ground.

Therefore, the best engineering practice based on the international standards is to install an external SPD to handle the lightning current and keep the radios operational at all times and intact.

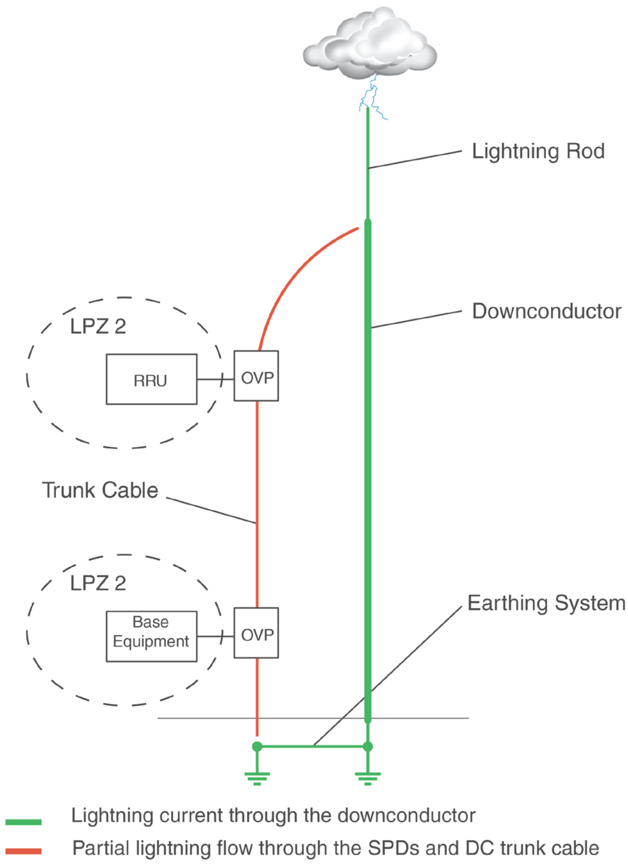

Figure 1: Lightning Protection Zones (LPZ)

Electrical Protection of Small Cell Sites

At small cell sites, existing street lighting infrastructure and power distribution wiring are often relied upon to keep costs down. Here there will be a direct connection to a nearby transformer, which could involve currents of 10,000 A or more. In most of the U.S., this wiring is aerial rather than buried, which means it is even more vulnerable to overvoltages. It is a primary conduit for surge energy to enter the pole and damage the internal electronics.

Damage can also be caused by large induced currents on power lines due to lightning nearby, trees falling, or as a result of 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 cell to produce damaging surges of current and voltage, so small cell sites also require electrical protection.

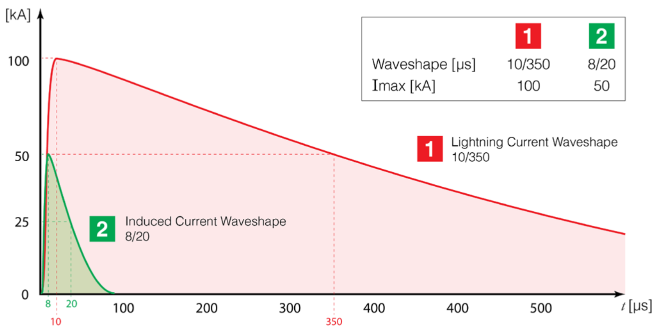

Figure 2: Surge Transient Illustration

Choosing the Right SPD

As previously mentioned, SPDs are classified by the IEC 61643 standard by test class for the electrical environment where they are expected to operate. 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 will have 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 (Uimp) of 12.5 kA, 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 have a voltage protection level (Up) lower than the withstand level (Uw) of the electronic equipment it is there to protect. Lower let-through voltage levels are typically attributed to SPDs that meet Class II testing.

Raycap's Proprietary Strikesorb Technology

Raycap's Strikesorb technology is specifically well suited for the protection of telecommunication equipment because it is able to meet the requirements of both the Class I and the Class II test standards, and as such it produces the LPZ2 where the sensitive electronics at a cellular site must be located. The designs incorporate a heavy-duty, distribution-grade metal oxide varistor (MOV) disk, assembled under pressure in an environmentally sealed aluminum casing.

Strikesorb 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, resulting in an extremely high energy handling capability combined with very low let-through voltage and safe operation. It is compliant with the UL 1449 5th Edition, IEC 61643-31, and EN 61643-31 standards. Strikesorb is a maintenance-free technology that can withstand thousands of repetitive surge events without failure or degradation.

This reliability has been essential for carriers, who have deployed the technology extensively of a site to lower the OPEX by reducing the need to replace equipment damaged by electrical surges. With millions of modules currently deployed, Raycap's experience proves it can provide safe and reliable power protection solutions for any wireless network.

5G cell sites, whether being C-band or mmWave, typically consist of cells packed with expensive electronic hardware. Wherever the location, these densely packed nodes are increasingly susceptible to damage from overvoltage surges and especially radiated disturbances from nearby events like lightning discharges, and conducted disturbances coming through attached cabling systems.

Since 5G networks will operate over large numbers of cell sites, carriers, and tower companies must make sure each site integrates high-performance surge protection to ensure continuous operation.

Contact Raycap if you need technical assistance about how to protect against surge or overvoltage damage, or if you have questions about your applications.

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