Raycap

RAYCAP ARTICLE

More Lightning and More 5G Cells Increase the Need for Surge Protection on Both Macro and Small Cell Sites

By: Tony Surtees, Vice President of Engineering, Raycap

As the number of lightning strikes increases year-on-year, carriers and cellular operators need to better protect their sensitive 5G infrastructures.

5G Service Is More Susceptible To Lightning Strikes

One of the trends making 5G service possible is the increasing density of electronics (the shrinking size of transistor junctions on ICs). These electronics help satisfy the high frequencies and processing needs of the 5G infrastructure. However, these sub-micron transistor junctions are also more susceptible to damage from overvoltages such as those created by lightning strikes and surge transients.

The accelerating rollout of C-band services is co-locating 5G radios on the same macro towers and rooftop sites where 4G radios are currently housed. These tall structures are natural targets for lightning strike—but they are not the only sites at risk. Carriers are deploying mmWave 5G across many thousands of small cell sites which can also be impacted. By the end of 2020, more than 417,000 5G cell sites were operating in the U.S. and this number continues to grow substantially each year.[1] Much of the 5G municipal infrastructure is going to be located at the street level in the form of streetlight poles, so they are shielded from direct lightning strikes by the taller surrounding infrastructure. However, these small cells are still susceptible to induced overvoltages from the radiated magnetic effects of nearby lightning strikes, requiring protection for their sensitive electronic circuits.

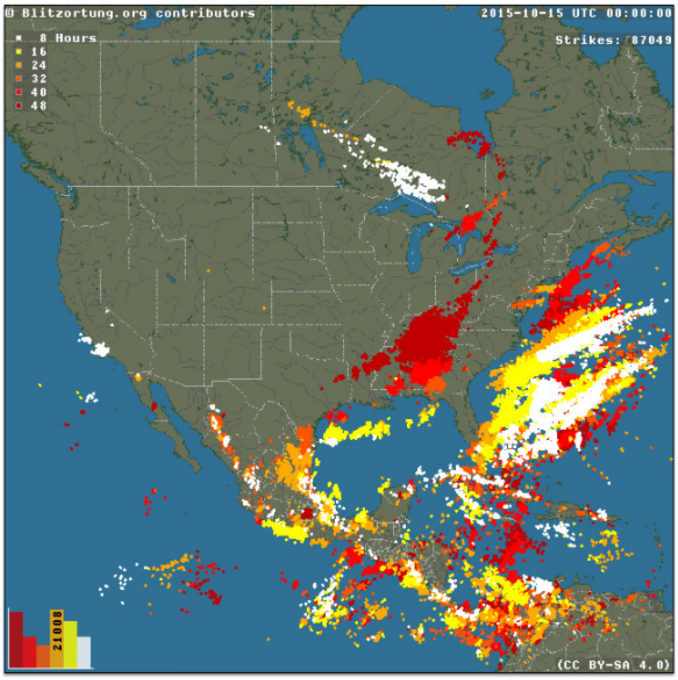

Figure 1. Lightning activity across the U.S. in one 24-hour period in 2015.

Increased Severity Of Localized Thunderstorms And Lightning Events

Lightning activity has been increasing in recent years with the latest climate models predicting that this trend could increase up to 50% by the end of the century.[2] While the number of thunder days per year is higher in the mid-west and southern states such as Arkansas and Florida, other geographical areas including the U.S. west may also be at risk. One recent California storm was noted to spawn more than 15,000 strikes during the course of a 24-hour period (Figure 1)[3]. Moreover, lightning strikes are more likely in the vicinity of elevated structures such as telecommunication towers, high-rise buildings, and wind turbines – all of which are becoming more pervasive in today's metropolitan landscapes.

Engineers can look to Lightning Protection Standards such as the IEC 62305 series to predict and manage lightning risk. Using these, they can see that geographic areas with a high density of towers exceeding 200 ft, have up to 150% more cloud-to-ground flashes than surrounding areas 2 km to 5 km away where there are fewer tall structures.

The protection of cellular equipment installed on building rooftops and walls should not be neglected on the basis that adjacent taller structures will protect them. These sites are also at risk because lightning does not always hit the tallest structure, as shown in Figure 2.

Figure 2. Lightning does not always strike the highest structure

[1] https://www.fiercewireless.com/wireless/u-s-counts-more-than-417k-cell-sites-as-2020
[2] https://www.science.org/doi/10.1126/science.1259100
[3] https://calmatters.org/environment/2021/09/california-fires-lightning/

It is important to note that the magnetic field radiating from a strike to a nearby building can induce significant overvoltages in the building wiring on which a rooftop telecommunication infrastructure is located. This can expose connected electronics systems to damage if adequate surge protection is not installed on the AC power system.

For these reasons, all of our modern cellular infrastructure, from the macro tower to the small cell, must be well protected to remain operational.

Creating Lightning Protection Zones Using IEC 62305 Methods

While the manufacturers of 5G radio equipment may incorporate a level of surge protection within their equipment, this is generally not adequate to ensure continued operation in the event of direct lightning activity. It is good engineering practice to install external overvoltage protection at the top and bottom of the tower to fully protect the equipment.

IEC 62305 Parts 1 and 4 define methods to create lightning protection zones (LPZs) around sensitive electronic equipment to mitigate the effects of the lightning discharge. These LPZs are regions of diminishing surge exposure and are created using two primary tools: metallic shielding (Faraday cages) and Surge Protective Devices (SPDs). The use of external SPDs ensures that the lightning energy is diverted before it enters the protective zone of the radio's enclosure.

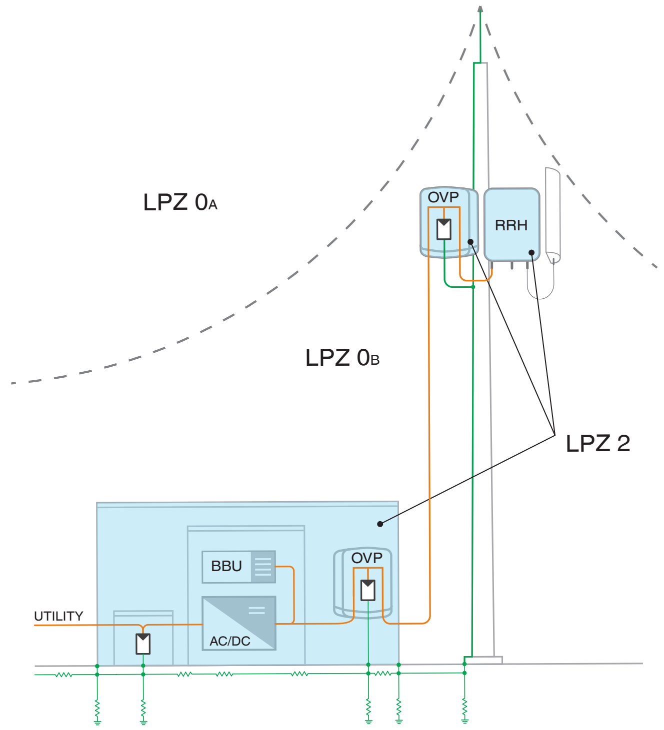

Figure 3. Lightning protection zones of a cellular site and appropriate installation points of SPDs for the protection of sensitive equipment.

Figure 3 illustrates the LPZs important in a cellular site. The Remote Radio Head (RRH) is installed/attached to the tower below the LPS strike termination rod (Franklin Rod). This location has typical LPZ 0B exposure, which is characterized by extreme lightning currents and electro-magnetic fields. The metallic shield of the RRH enclosure, in combination with an SPD at the power cable entry, creates a zone LPZ 2 inside the radio enclosure, where the sensitive electronics are located. In this LPZ 2, the effects of the electro-magnetic field are reduced to a level that can be tolerated by the electronics. Note that any SPD integral to the radio does nothing to reduce exposure because it is already within the metallic enclosure.

Using SPDs To Protect Cellular Sites Against Lightning Events

Elevated structures such as telecommunication towers generally rely on a Lightning Protection System (LPS) as the first stage in a protection scheme. The purpose of the LPS is to capture the direct lightning discharge to a known and controlled point (the Franklin Rod) and then to safely divert this current via the lightning down-conductor, to a low impedance grounding system. The LPS serves to mitigate the risk from direct lightning strikes (reducing the site's exposure from an LPZ0 to LPZ1 per IEC 62305-1), but on its own this will still leave the sensitive RRHs exposed. The exposure of the LPZ in which the RRH is located, needs to be further reduced from LPZ1 to LPZ2. This is achieved through the strategic use of SPDs which further limit overvoltages to levels which can be withstood by the equipment and essentially creating the LPZ2 region around the RRH.

The IEC standards define the test the SPD needs to meet to be able to reduce the threat level from Level 1 to Level 2. The IEC 61643 Series defines that an SPD used to protect against partial or direct lightning currents must be tested to IEC Test Class I, to ensure it is able to withstand the lightning exposure it will encounter in the LPZ1-2 zone. SPDs that satisfy these tests are classified as Class 1, naturally.

The internal protection provided in most remote radiohead units (RRUs) is only tested to Test Class II and will not withstand the Test Class I exposure – again requiring that additional external SPDs be installed to ensure effective protection and reliable system operation.

When choosing the type of SPD to be installed at a cellular site, engineers must consider the operational characteristics of the equipment requiring protection. IEC 61643 classifies SPDs by test class for the electrical environment they are intended to operate within. For example, a Class I SPD is one which 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 which is likely to enter a structure in an exposed location. Class II SPDs are typically installed in areas where only induced currents are likely, such as small cell streetlights.

Raycap's Strikesorb® technology combines the properties of both Class I and Class II devices in a single design which can withstand lightning currents (rated at up to 25kA 10/350) while also maintaining let-through (residual) voltage levels at close to 100V. The technology has been purpose-designed to provide the required $I_{im}p$ and U_p ratings needed to protect sensitive electronic equipment found in cell site infrastructures.

Figure 4. Two of the Strikesorb SPDs from Raycap

Summary

Higher levels of circuit integration are making advanced technologies like 5G possible. However, these must be able to withstand the challenges of ever-changing environmental conditions. Engineers must consider important considerations in adequately protecting telecommunication facilities from both the direct lightning discharge and the effects of induced overvoltages from nearby strikes. The IEC Zone of Protection method seeks to reduce the exposure to which the sensitive electronic equipment will be exposed by adopting methods of shielding and overvoltage mitigation. The internal protection provided by most equipment manufacturers is not sufficient to withstand the exposure of the lightning protection zone (LPZ) in which such equipment is located. The additional overvoltage protection of SPDs, which have been tested to the appropriate Test Class for such locations, is necessary to ensure reliable and trouble-free operations of such infrastructure.

About Raycap

Raycap is an international manufacturer and technology leader with decades of experience in lightning and surge protection for power, signal, and data transmission applications. Its maintenance-free surge protection solutions protect people and mission-critical applications and ensure the best possible system availability. Raycap is also a leader in passive telecommunications infrastructure for broadband and mobile networks. Its product portfolio includes structured cabling systems for "Fiber and Power to the Antenna," power supply and distribution enclosures for mobile networks, and a wide range of indoor and outdoor enclosures for copper and fiber optic cable networks; including "Fiber to the Home." The company has experienced continuous growth since its founding in 1987 and currently has more than 1,800 employees. Its test laboratories and numerous patents guarantee quality, reliability, and innovation; and are the basis for independently conducted international approvals of products according to UL, IEC, and EN.

Raycap solutions support customers from a wide range of industries, including telecommunications, energy storage and generation, photovoltaics, wind turbines, e-mobility, building construction, and rail technology. Product brands include Strikesorb®, Rayvoss®, ProTec, SafeTec, ACData®, STEALTH® and InvisiWave®.

[1] https://www.fiercewireless.com/wireless/u-s-counts-more-than-417k-cell-sites-as-2020

raycap.com

G09-00-189 220110