CONNECT AND PROTECT

Grounding and Protection of Small Cells in 5G and 4G Networks

nVent

ERICO

The deployment of small cells has shifted in focus from coverage to large-scale densification. Operators are looking to increase the capacity in their LTE networks in more diverse locations, to address rising consumer and enterprise use of mobile broadband. Many operators are already planning hyperdense networks in the 4G, and they expect the trend to intensify with the migration to 5G. The deployment of small cells is expected to increase exponentially.

The attractiveness of this technology from a data network availability point of view is obvious. However, considerations for powering & grounding of these small cells continue to be a challenge for the industry.

nVent ERICO offers a range of solutions for grounding and surge protection of power supply to small cells.

Grounding

The purpose of this local ground electrode at the small cell is to provide

- Public safety
- Low impedance ground for noise control
- A path for surge current dissipations from the power system
- Compliance to regulatory requirements
- Suitable AC and telecommunications equipment ground
- Lightning protection ground in very high lightning zones

The local AC ground electrode may be used for the purpose of grounding the small cell equipment if it exists. There can be concerns about the integrity of these existing electrodes due to their age, poor resistance, corrosion, uncertainly about material used, inadequate theft prevention and reliability of connection methods used.

There will be many instances when a new ground electrode will be required. This poses challenges in built up areas for two main reasons. Cutting and re-instating the ground surface can be costly and obtrusive. There are usually concerns about damaging underground services like gas pipelines and AC power utility cables.

Several methods of grounding may be feasible.

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VERTICAL DRIVEN ELECTRODES

Vertical electrodes are the least obtrusive, as they require less foot-print and are often the easiest to install, however when utilizing these, the information available on buried services, near the electrodes needs to be known. The consequences of driving an electrode into an essential service like power cable or gas pipe could be catastrophic. Many countries have services and records like "call before you dig" to alleviate such risks.

Vertical driven electrodes also provide an effective means of reducing the ground resistance which will decrease with the depth of the electrode.

Multiple electrodes can be joined using ground rod couplers, for example 1.5 m – 3.0 m (5 ft – 10 ft) lengths to greater depths of 4.5 m – 6.0 m (15 ft – 20 ft).

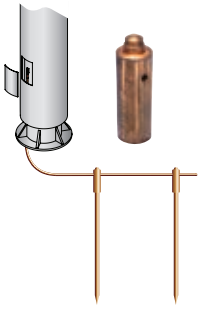
There are four types of vertically driven grounding systems than can be considered for pole & street mounted antennas in modern radio communication networks. These can be used on sites with AC Main powering, DC Powering with or without batteries and other powered sites.

Recommended configurations include:

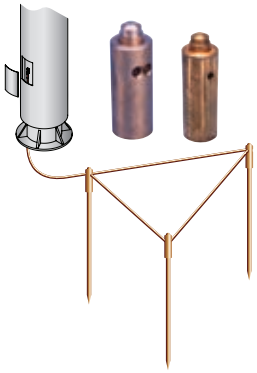
1. Two copper bonded steel ground rods in a straight line
2. Three copper bonded steel ground rods in a triangular formation with the triangle lengths of a minimum of three electrodes length
3. Two or more electrodes at distance or one electrode apart installed at an angle of 45º forming an inverted V shape
4. One deep driven copper bonded ground rod

The conductors shall be a minimum of 2 AWG Solid copper (USA), 16 mm^2 stranded (Australia) or other sizes depending on the country of application.

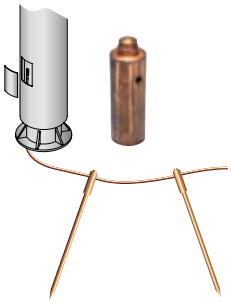
nVent ERICO Cadweld is the recommended connection method for all underground systems for any telecommunications installation. Where widespread rapid deployments are required, and trained Cadweld installers are not available across the sites to be deployed, the nVent ERICO hammerlock system is the recommended alternative.



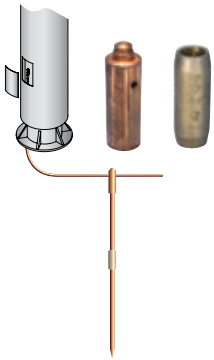
Two Ground Rods in Line



Three Ground Rods in Triangle



Two Ground Rods Inverted V



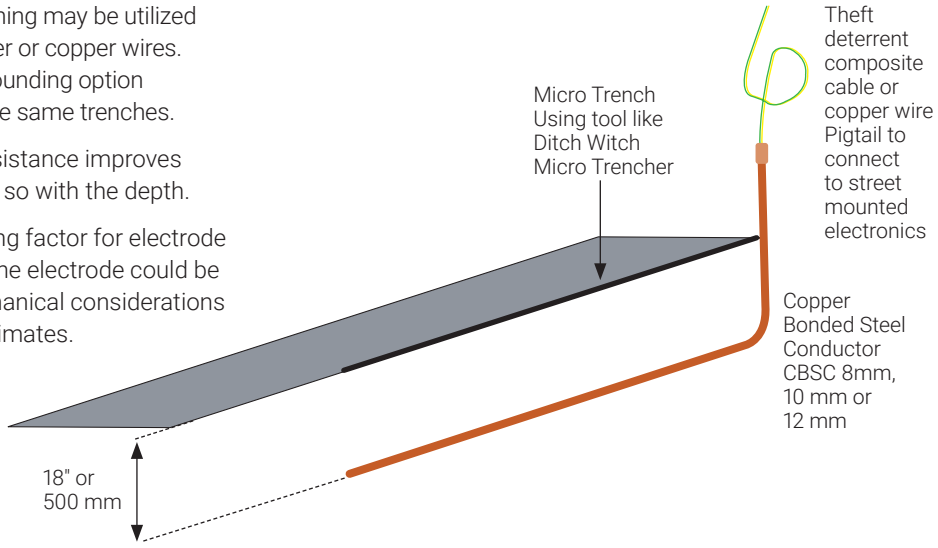
Two or more in-line, coupled ground rods

HORIZONTAL ELECTRODES

Micro-trenching or other horizontal trenching may be utilized to provide access to the small cell via fiber or copper wires. Horizontal electrodes may be a viable grounding option provided it is practical to place them in the same trenches.

For horizontal ground electrodes, the resistance improves with the length of the electrode and less so with the depth.

However, the depth may be the over-riding factor for electrode orientation due to practicality of where the electrode could be laid, due to local legislation, due to mechanical considerations or due to the freeze depth in very cold climates.



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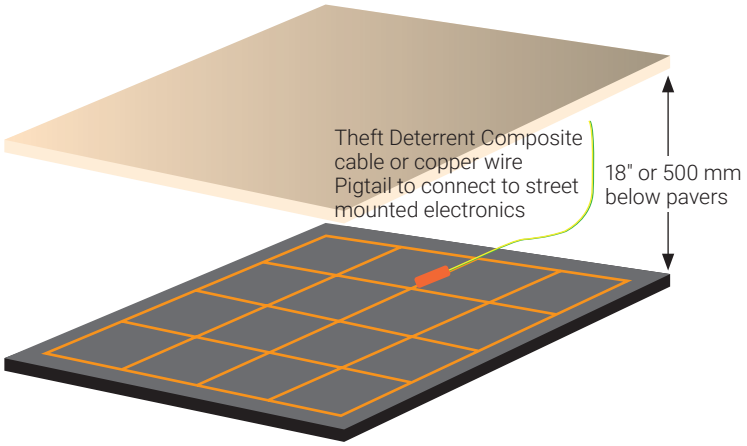
MESH ELECTRODES



Steel wire mesh embedded in solidly molded ground enhancement material.

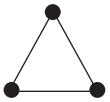
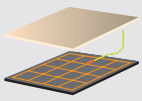
Mesh electrodes are suited where deep driving and trenching is not possible and the equipment is mounted in a street cabinet, or there are existing pavers at the ground level.

A 600 mm x 600 mm (2 ft x 2 ft), 1200 mm x 1200 mm (6 ft x 6 ft) or larger mesh of copper coated steel is used in these applications. All joints within the mesh are pre-welded and a pigtail can also be pre-welded. The mesh can be placed in 50 mm (2 inches) of nVent ERICO GEM25A or Quickfill ground enhancement material to provide further stability and consistency of ground resistance with low ground impedance.

The table below shows the comparison of resistance values for the various types of grounding systems discussed here across different soil resistivities. Soil resistivity is not discussed here but it is suffice to understand that in a uniform soil, the resistance of the ground electrode is directly proportional to the resistivity of the soil, which is a characteristic of the local soil. In real life, the soil resistivity will vary with depth and hence some examples in Table 1 show modelling results with varying soil resistivities. While the modelling and calculations done in the table are at certain resistivity values, it is well understood that resistivity varies significantly with location even in the same country, city or even town.

To get more use from this table, one can assume that the ground electrode resistance will vary proportionally with the soil resistivity in a linear manner. For example, if the resistivity doubles then the resistance will double.

Ground Electrode Simulation Scenarios for Small Cells

Scheme	Grounding Scheme	Resistivity 50 ohm-m Uniform	Resistivity, 50 ohm-m (5 ft Depth) 25 ohm-m (5 ft – 10 ft Depth)	Resistivity 100 ohm-m (5 ft Depth) 50 ohm-m (5 ft – 10 ft Depth) 25 ohm-m (10 ft – 15 ft)	Resistivity 50 ohm-m (5 ft Depth) 50 ohm-m (5 ft – 10 ft Depth) 100 ohm-m (10 ft – 15 ft)
1	Single Vertically Driven Ground Rod 5 ft or 1.5 m deep	29.0	33.3	47.7	30.1
2	Single Vertically Driven Ground Rod 10 ft or 3 m deep	16.5	10.3	19.9	18.4
3	Single Vertically Driven Ground Rod 20 ft or 6 m deep	11.8	6.8	12.1	15.3
4	Single Vertically Driven Ground Rod 5 ft or 1.5 m deep	9.2	5.1	7.4	13.1
5	3 Rods 8 ft, in equilateral triangle formation, with 8 ft sides of triangle 	7.0	4.7	8.7	8.1
6	Horizontal Electrode (say 35 mm² wire, #2 wire or similar) 0.5 m or 18" deep and 15 ft or 4.5 m long	13.3	11.9	23.4	14.3
7	Horizontal Electrode (say 35 mm² wire, #2 wire or similar) 1 mm or 36" deep and 15 ft or 4.5 m long	12.4	10.9	21.2	13.4
8	Prefabricated wire Mesh 600 mm x 600 mm (2 ft x 2 ft) 	20.3	18.4	36.1	21.4
9	As above 1200 mm x 1200 mm	11.1	9.3	18.1	12.2

Grounding and Protection of Small Cells in 5G and 4G Networks

GROUND POTENTIAL RISE CONSIDERATIONS

The densification of the network also means that in the modern telecommunications network, the installations are closer to the public domain and often in densely populated areas. Examples of such infrastructure could include small cells, macro cells, fiber cabinets and other facilities. Some of these facilities, when located in metropolitan areas, would be powered via the AC mains from the local power supply network and would require a local telecommunications ground electrode and perhaps an additional AC protective ground electrode.

Newer considerations, have to be given to ground potential rise that can occur at or near a telecommunication facility that is close to power utility assets and near to other consumers. nVent can provide design assistance to model the ground potential rise and associated step and touch voltages that could occur at the telecommunication facility.

COPPER THEFT CONSIDERATION

As many of the installations are located in public spaces and areas that may be prone to copper theft, consideration should be given to the use of alternative materials to copper for use as conductors and pigtails.

Two commonly available alternatives used are:

- nVent ERICO Cu-Bond Round Conductor (Copper Bonded Steel Conductor, CBSC) complying with IEC 62561-2 with diameter of 8 mm – 10 mm (0.315 - 394 inches)
- nVent ERICO Cu-Bond Composite Conductor

The Alliance for Telecommunications Industry Solutions ATIS-0600037 Testing Guidelines for Copper Theft Deterrents in the Telecom Industry, provides guidelines for testing of alternative conductors.

nVent ERICO Cu-Bond Round Conductor

The Cu-Bond Round Conductor (Copper Bonded Steel Conductor, CBSC) is comprised of an electro-plated coating of copper deposited over a layer of nickel surrounding a steel core. This process helps ensure a long-lasting molecular bond between the copper layer and the steel. The conductor core consists of a low-carbon steel grade for improved flexibility in the field. The copper surface of the conductor provides high conductivity and corrosion-resistant properties.

Features

- Theft Deterrent: Due to its steel core, the conductor is very difficult to cut with hand tools
- Cost Effective: The cost of the conductor is minimized by reducing the total amount of copper in the cable, because the copper is bonded to a steel core
- Superior Corrosion Resistance: In comparison to other steel-based products, Cu-Bond Round Conductor provides excellent application life of typically 30 – 40 years in most soil conditions

Cu Bond round Conductor

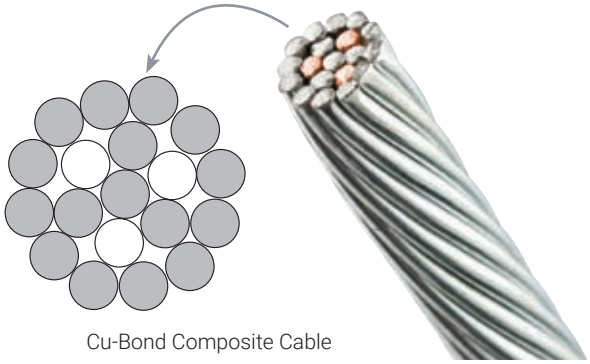
nVent ERICO Cu-Bond Composite Conductor

Cu-Bond Composite Conductor is a bare concentric stranded conductor that consists of peripheral tinned copper plated steel which protects and conceals the internal copper stranding.

This conductor is ideal for exposed electrical grounding applications where copper theft may occur due to its tinned outer strands. The conductor is difficult to cut with hand tools, but the copper core makes it easier to install than other theft deterrent conductors. The outer stranding is magnetic, which further deters thieves looking for copper. The CC5A05CB is suitable for telecommunications radio sites.

Features

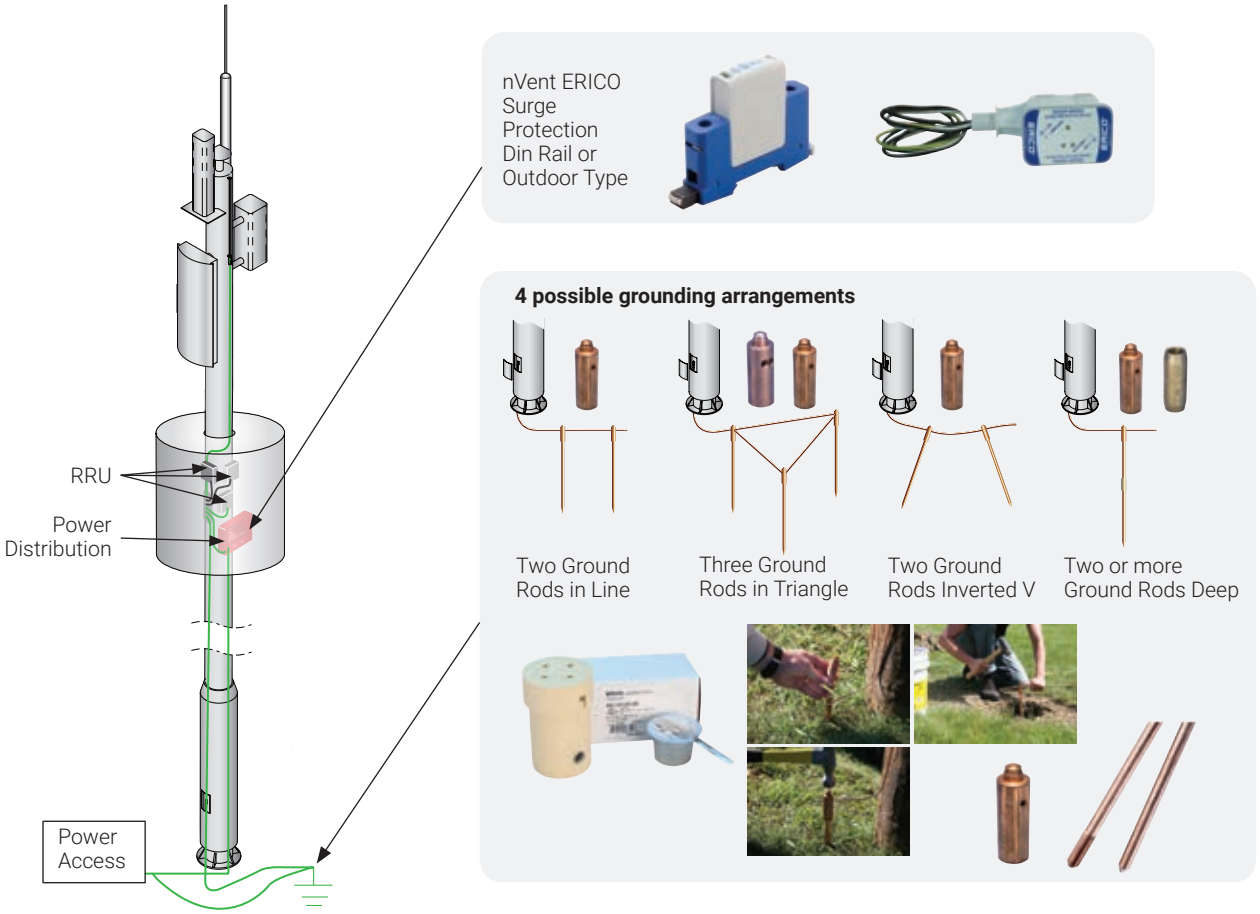
- Outer strands comprised of tinned copper-bonded steel for theft deterrence and improved corrosion resistance
- Inner copper stranding is tinned for superior corrosion resistance
- Copper stranding inside of conductor increases conductivity and conductor flexibility
- Copper strands are hidden by outer tinned copper bonded steel strands
- Suitable for direct burial applications



Cu-Bond Composite Cable

Grounding and Protection of Small Cells in 5G and 4G Networks

METAL POLE CABLE RETICULATION INTERNAL



TWO GROUND RODS IN A LINE

Part Number	Description	Image
615880	5/8" x 8 ft Copper Bonded Ground Rod	
615800	5/8" x 10 ft Copper Bonded	
Conductor Size	2 AWG tinned copper or 35 mm² stranded copper	
EHL58C1V1V	Hammerlock – 2 hole	

TWO GROUND RODS INVERTED V

Part Number	Description	Image
615880	5/8" x 8 ft Copper Bonded Ground Rod	
615800	5/8" x 10 ft Copper Bonded	
Conductor Size	2 AWG tinned copper or 35 mm² stranded copper	
EHL58C1V1V	Hammerlock – 2 hole	

THREE GROUNDS IN TRIANGLE

Part Number	Description	Image
615880	5/8" x 8 ft Copper Bonded Ground Rod	
615800	5/8" x 10 ft Copper Bonded	
Conductor Size	2AWG tinned copper or 35 mm² stranded copper	
EHL58C1V1V	Hammerlock – 2 Hole	

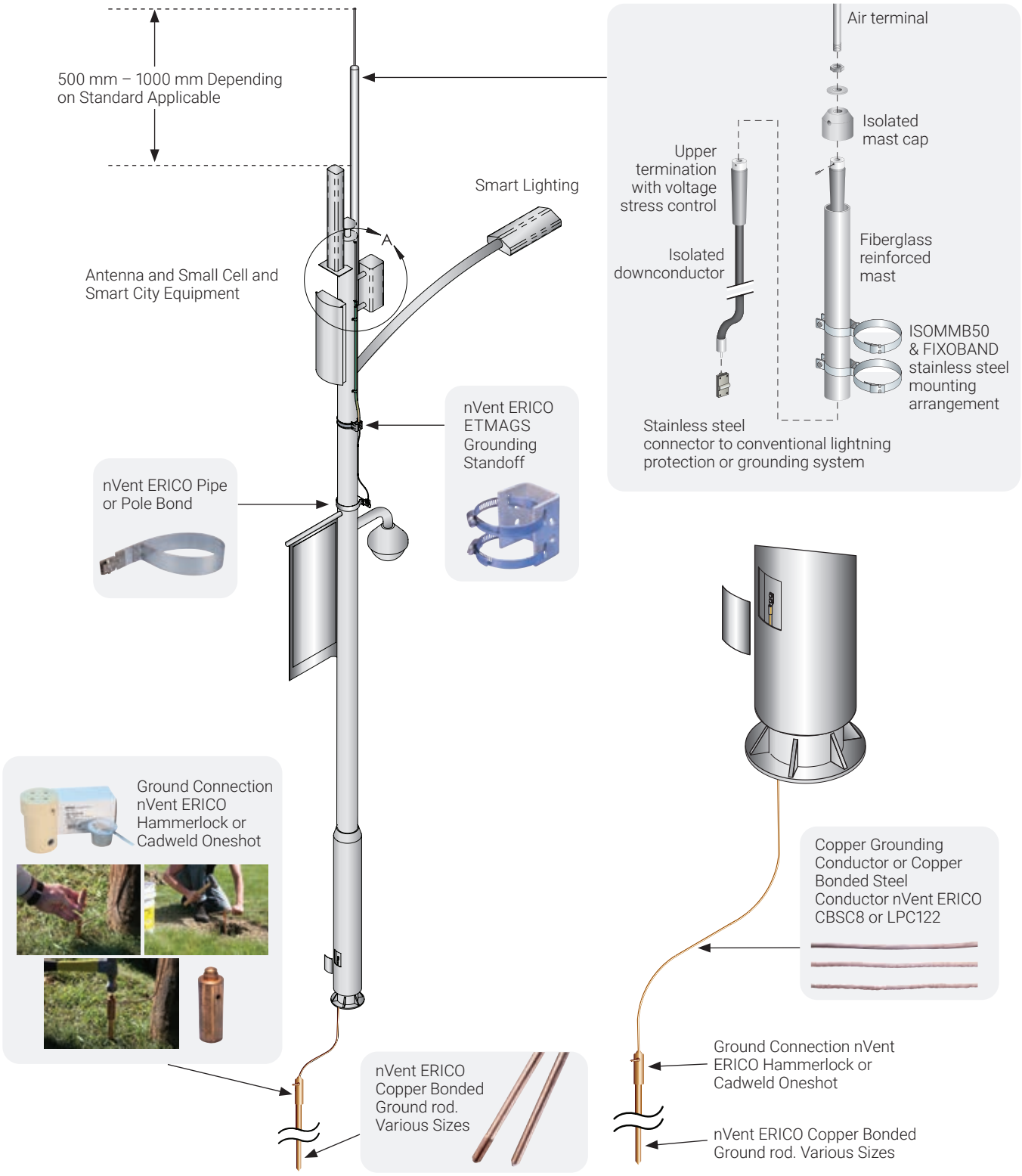
Part Number	Description	Image
B13716	Ground Rod Driver	

TWO OR MORE GROUND RODS DEEP

Part Number	Description	Image
615880	5/8" x 8 ft Copper Bonded Ground Rod	
615800	5/8" x 10 ft Copper Bonded	
Conductor Size	2 AWG tinned copper or 35 mm² stranded copper	
EHL58C1V	Hammerlock – 1 hole	
CC58	Ground Rod Coupler	

Grounding and Protection of Small Cells in 5G and 4G Networks

GROUNDING OF POLE MOUNTED-ISOLATED LIGHTNING PROTECTION SYSTEM IN HIGH LIGHTNING ZONE



Grounding and Protection of Small Cells in 5G and 4G Networks

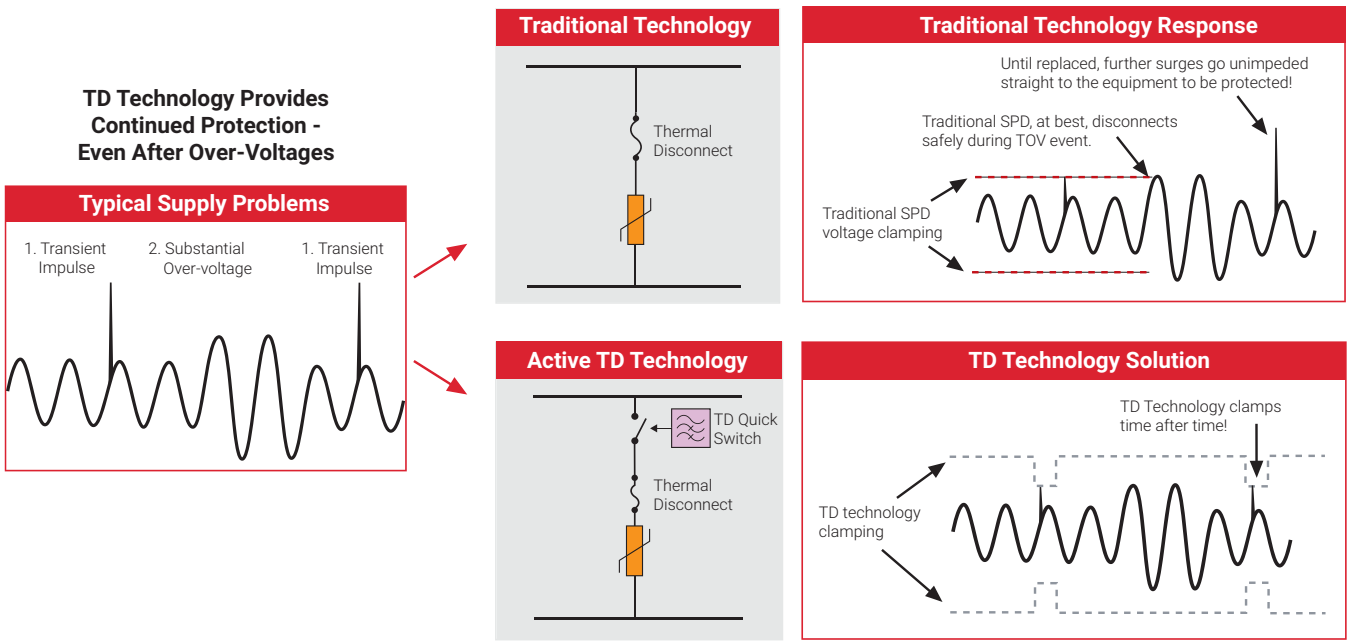
SURGE PROTECTION

nVent ERICO surge protective devices (SPDs) provide the option for traditional construction or nVent ERICO's patented Transient Discriminating (TD) Technology. For example, the DT product line features traditional construction, while the EDT product line utilizes TD technology. These product lines have been designed, independently tested and certified to the latest editions of both IEC61643-11 and UL1449 Ed4. This provides the user of the peace of mind that the products will perform safely in application, and also perform to the claimed ratings provided. Our SPDs with TD technology have been designed to be unaffected by the AC overvoltages, while not compromising the clamping performance. This provides them with the ability to survive extreme overvoltage conditions and still be operational afterwards to protect your valuable equipment from subsequent surges and transients. This extends greatly the life expectancy of the SPD within the most extreme environments, saving maintenance work and reducing operational costs.

Grounding and Protection of Small Cells in 5G and 4G Networks

The secret to nVent ERICO's Transient Discriminating Technology is its active frequency discrimination circuit. This patented device can discriminate between a temporary over-voltage (TOV) condition and a very fast transient, which is associated with lightning or switching-induced surges. When the transient frequencies are detected, the patented Quick-Switch within TD activates a robust protection circuit that limits the incoming transient. The frequency discriminating circuit that controls the Quick-Switch helps ensure that the SPD device is immune to the effects of a sustained 50 or 60 Hz TOV. This allows the device to keep operating, in order to help provide safe and reliable transient protection, even after an abnormal over-voltage condition has occurred .

Effectively, TD Technology allows the SPD to have two clamping levels – one well above the peak of a TOV (up to twice its nominal AC voltage!), and the other much lower, to effectively and swiftly clamp lightning transients. As the explanatory illustration shows, this allows the TD circuit to still remain operational after TOV events, thus continuing to clamp transients and providing a much longer operational life. For example, the IEC 61643-11 standard applies a test of 442 Vac for two hours from Line to Neutral for SPDs intended to operate at 230 Vac. While most SPDs fail safely during this test, nVent ERICO's EDT2 Series SPDs are unaffected by this stringent test, and remain completely operational. The IEC 61643-11 standard calls this Withstand mode, as opposed to Safe Failure mode. nVent ERICO SPDs that incorporate TD Technology are especially recommended for any site where sustained over-voltages are known to occur, and where failure of traditional SPD technologies cannot be tolerated.



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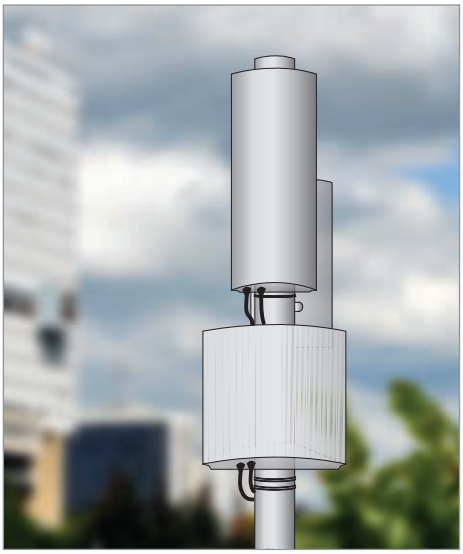


The above application shows the use of nVent ERICO DT230011 products being used to protect small cells.

nVent products suitable for protection of small cells, depending on the country of application, are shown below. It is expected that most small cells will be powered by a single-phase power supply, and the listed products here are all single phase.

nVent ERICO DT and EDT Range Surge Protective Devices – 2 Mode

nVent ERICO SES40P Range Surge Protective Devices – 3 Mode

Part Number	Imax , Max Discharge Current	Nominal Voltage Un	Max Continuous Operating Voltage, Uc	In, Nominal Discharge Current	Protection Modes
DT215011R	50kA	120V	150V	20kA	Phase-Neutral Neutral-Ground
DT215020R	50kA	120V	150V	20kA	Phase-Neutral Phase-Ground
DT230011R	50kA	240V	300V	20kA	Phase-Neutral Neutral-Ground
DT230020R	50kA	240V	300V	20kA	Phase-Neutral Phase-Ground
EDT215011R	50kA	120V	150V	20kA	Phase-Neutral Neutral-Ground
EDT215020R	50kA	120V	150V	20kA	Phase-Neutral Phase-Ground
EDT230011R	50kA	240V	300V	20kA	Phase-Neutral Neutral-Ground
EDT230020R	50kA	240V	150V	20kA	Phase-Neutral Phase-Ground
SES40P1201P	40kA	120V	150V	20kA	Phase-Neutral Phase-Ground Neutral-Ground
SES40P2401P	40kA	240V	300V	20kA	Phase-Neutral Phase-Ground Neutral-Ground

Grounding and Protection of Small Cells in 5G and 4G Networks

NVENT ERICO EXPERTISE

The nVent ERICO advantage is our approach to the complete Facility Electrical Protection Solution. Well designed and high quality Surge Protection is critical to a facility equipment's reliable operation, however it is only part of the solution.

nVent ERICO therefore offers the complete range and expertise in grounding, bonding, surge and lightning protection, providing the complete solution worldwide and across applications including Commercial, Industrial, Telecom, Utility and Railway. Our service and expertise encompasses more than just the product.

PRODUCT TESTING

To effectively meet market requirements and ensure our products are designed and tested to the highest of performance standards, nVent ERICO has invested in state of the art testing equipment that is able to:

- Support application testing for clients – to ensure your equipment is adequately protected
- Participate in the UL Client Test Data Program.
- Support competitive product testing
- Test and evaluate to a range of mechanical, electrical and environmental requirements

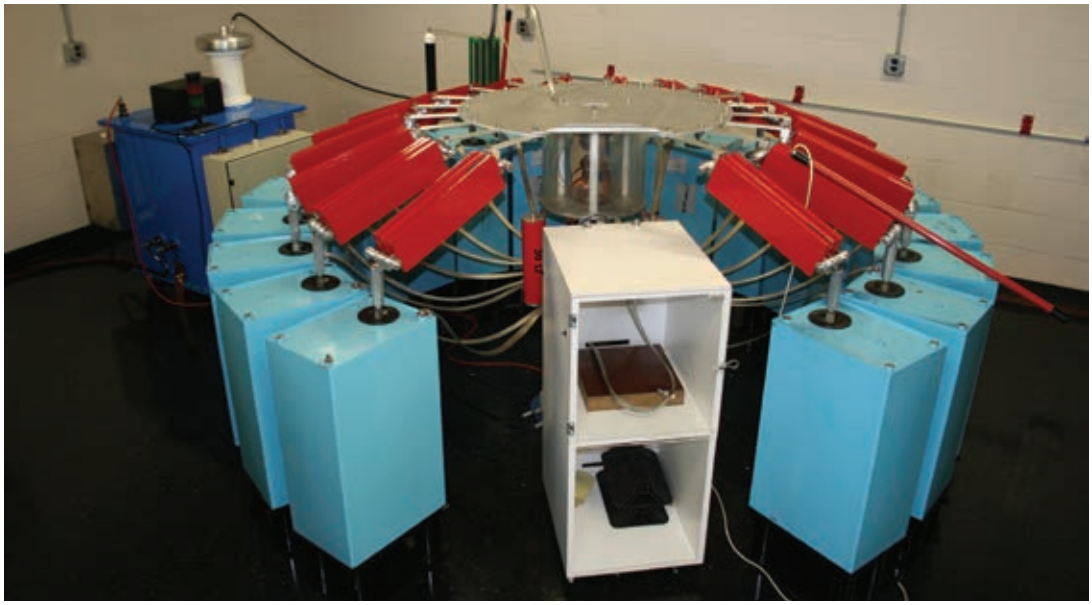
HISTORY

nVent ERICO engineers have been developing grounding & surge solutions for over 100 years. In 1903, the Electric Railway Improvement Company (ERICO®) was created to supply power bonds, signal bonds and related welding equipment to railroads, mining and street railway industries.

They are experts in designing products to achieve a variety of global certifications including, but not limited to, UL 1449 Ed. 4 and IEC 61643-11. In addition to this, nVent ERICO engineers have designed unique, innovative surge technologies like Transient Discriminating (TD) Technology and high-performance surge filters. Our engineers have developed surge products and technologies protecting a variety of industry-specific needs with some examples being: rail signaling, photovoltaics, telecommunications, LED lighting, and wind turbines.

SEMINARS AND SITE AUDITS

Each year nVent ERICO conducts hundreds of seminars in numerous countries around the world, educating specifiers, engineers, and installers on Facility Electrical Protection.



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