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Lightning Strikes - Techniques and Requirements for a Well-Grounded Tower Installation

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Director of Engineering – Hardware Development

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- Feedback

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Introduction

- Tim Wild
  - Director of Engineering
  - Responsible for the development of hardware at Cambium Networks

- Previous experience in Aircraft electronics, aircraft accident investigation, telecoms/ wireless electronics
- Orthogon, Motorola, Cambium
- Gemini, Spectra, PTP500, 800, 650, 670, 700, PMP450i, cnMedusa 5GHz, 3GHz and supporting devices
- And also Cambium's Lightning Protection Unit - LPU

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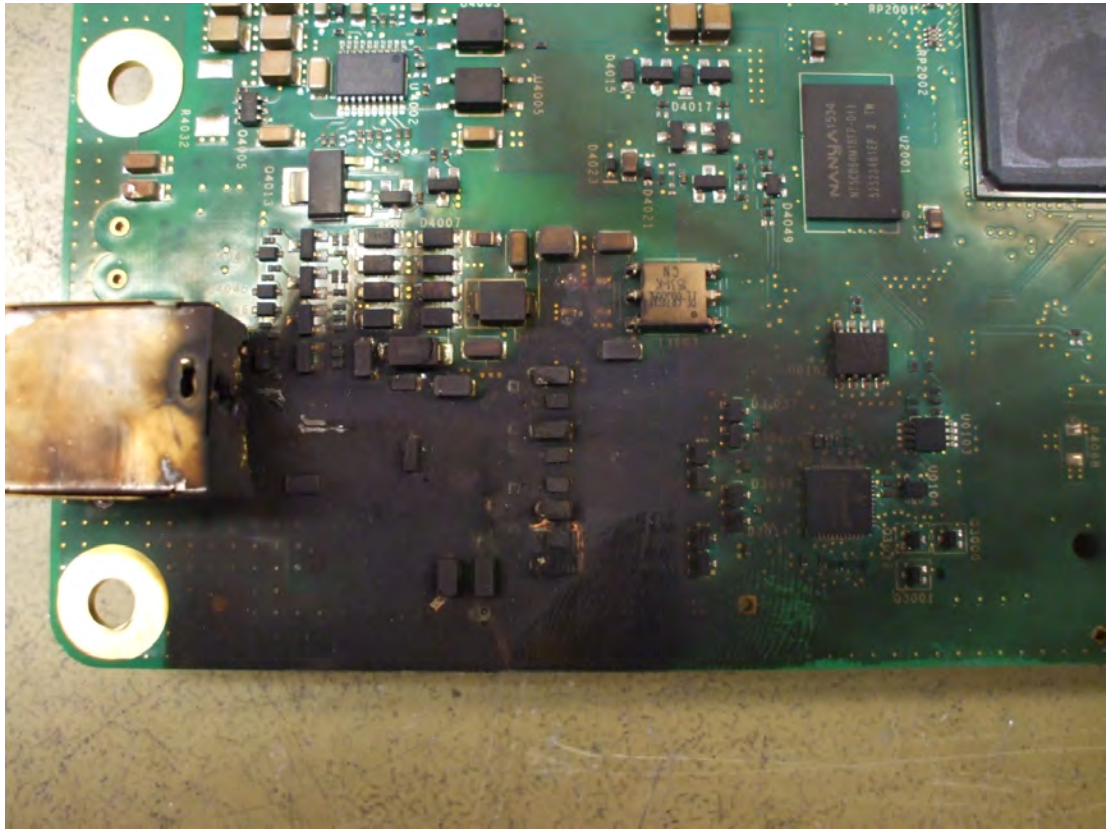
Why is surge protection required 1

- Lightning induces high currents and voltages into cabling which connects the radio equipment to the equipment hut.
- Surge protection devices and robust cabling reduce the chance that those high voltages will damage the radio equipment, building, operators, etc.



- The picture shows that a large amount of energy entered the radio.
- The surge has melted the metal case of the RJ45 and destroyed many components on the board.

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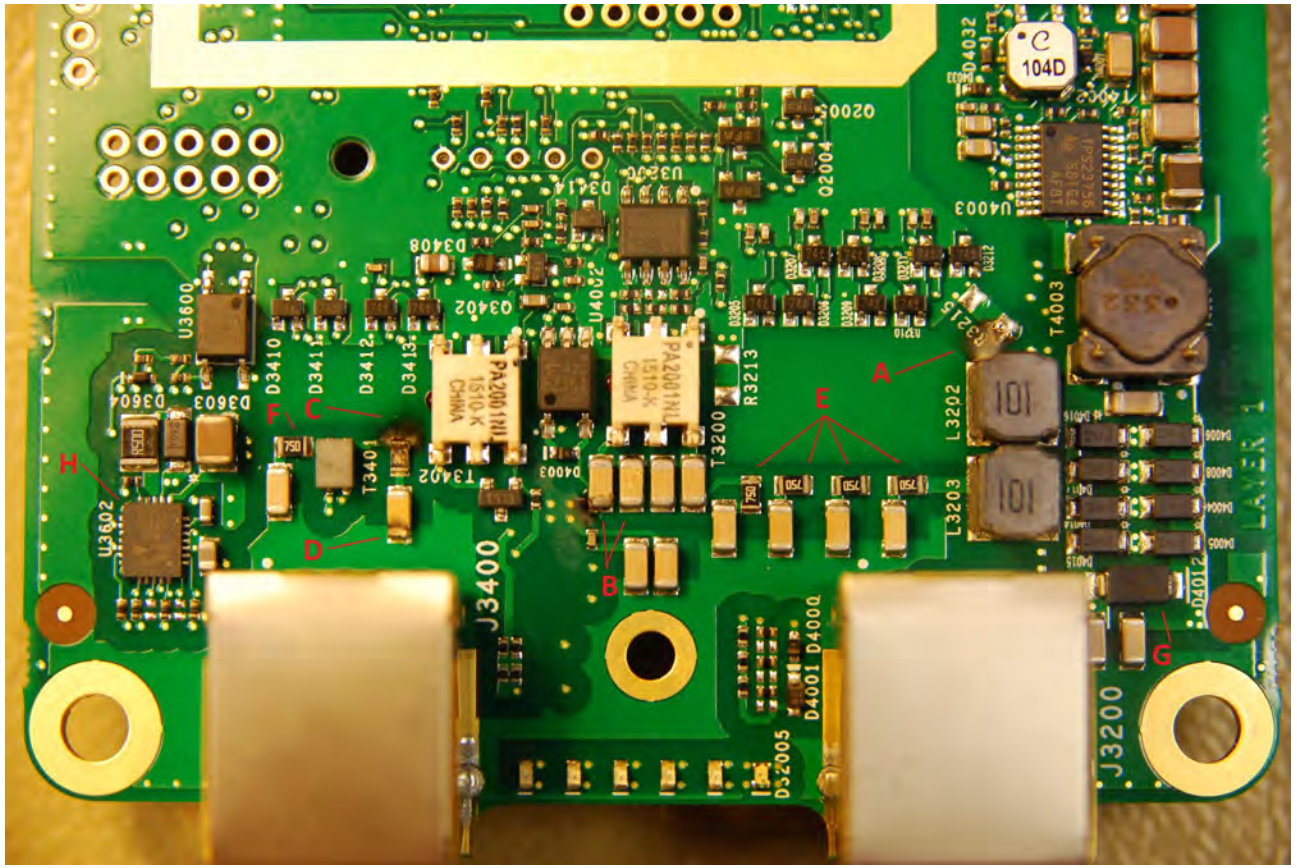
Why is surge protection required 2

- The picture shows multiple failure points on a 450i radio. The radio has previously been shown to achieve a withstand voltage of 2kV.



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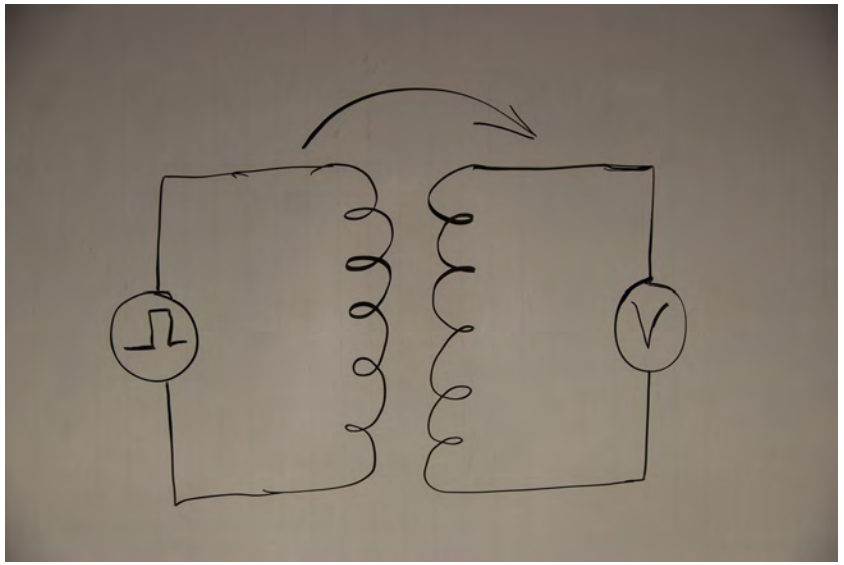
How surges are created 1

- Surges are generated in the tower and cabling when a lightning discharge occurs somewhere in the atmosphere.



- We are familiar with the concept of how a current pulse on the left hand side of the transformer is coupled to the right hand side causing a current and voltage to occur on the secondary.

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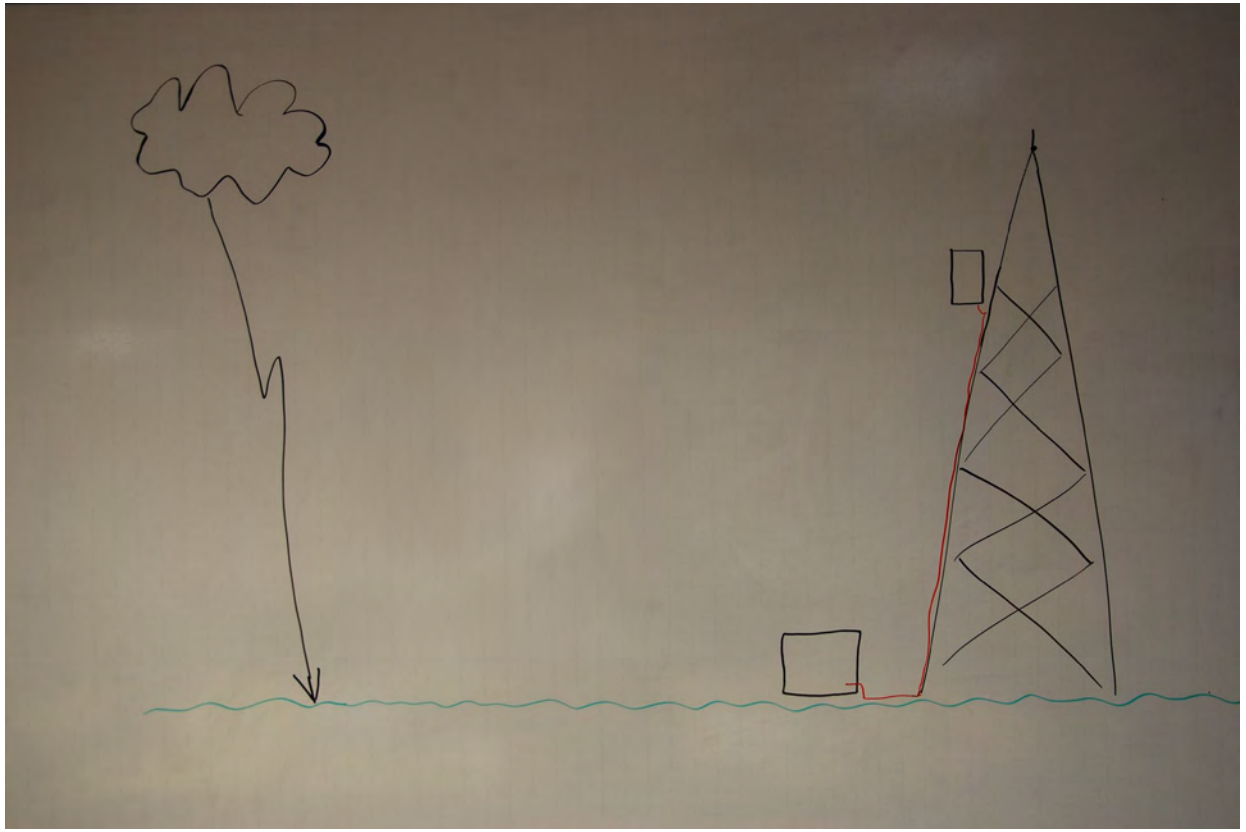
How surges are created 2

- The components of our installation are the tower, the radio, cabling and the equipment hut. It is hoped that there is also a lightning conductor.
- The model also applies to installations on buildings, whether high rise or single storey residential.



- Discharges and strikes are high current events where thousands of Amps flow.
- The high discharge currents cause currents to be induced in nearby conductors.

  ✓ Lightning discharges to ground some distance from the installation
  ✓ Lightning strike to the tower on which the equipment is mounted
  ✓ Cloud to cloud discharge (sheet lightning)

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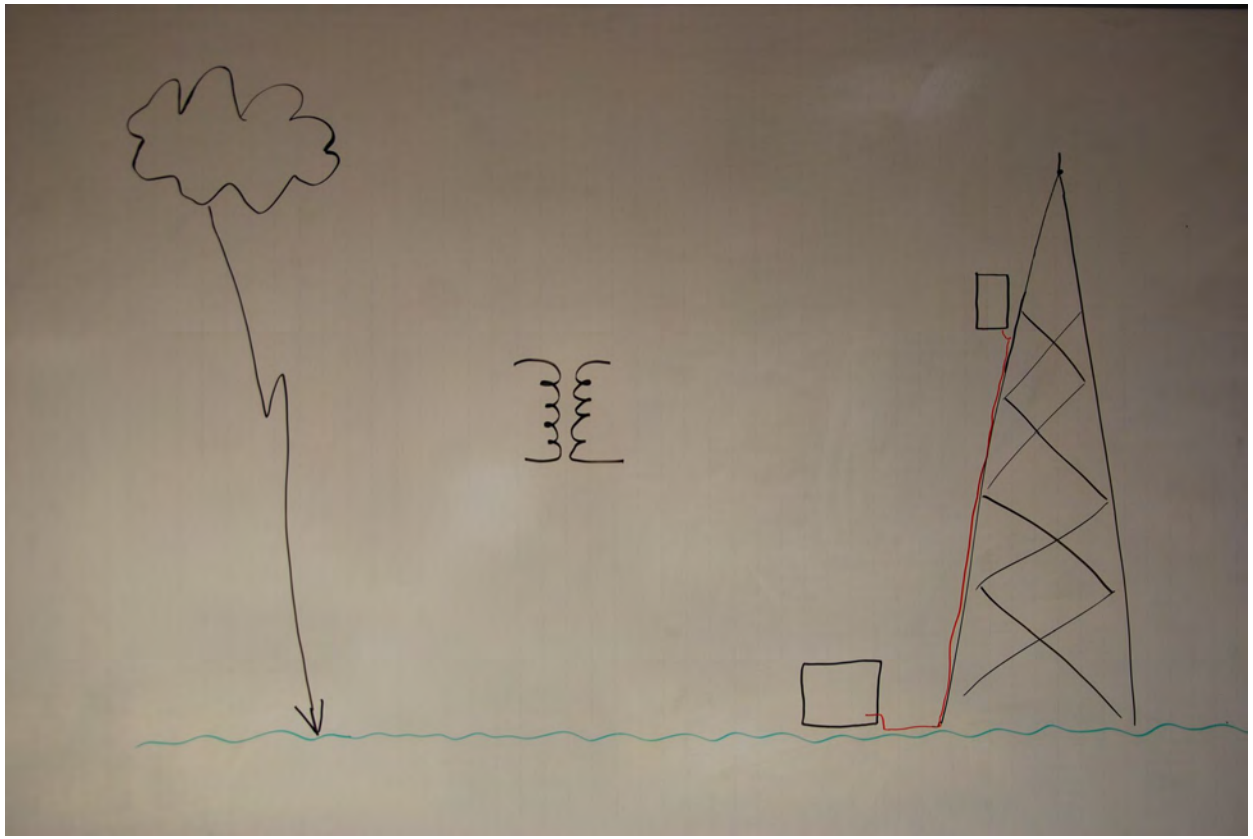
How surges are created 3

- The surge induces a voltage into the tower. The voltage at the top of the tower can differ from the voltage at the bottom by thousands of volts.



- Where the voltage exceeds the breakdown capability of the cabling or the radio, surge currents will flow and damage will occur.

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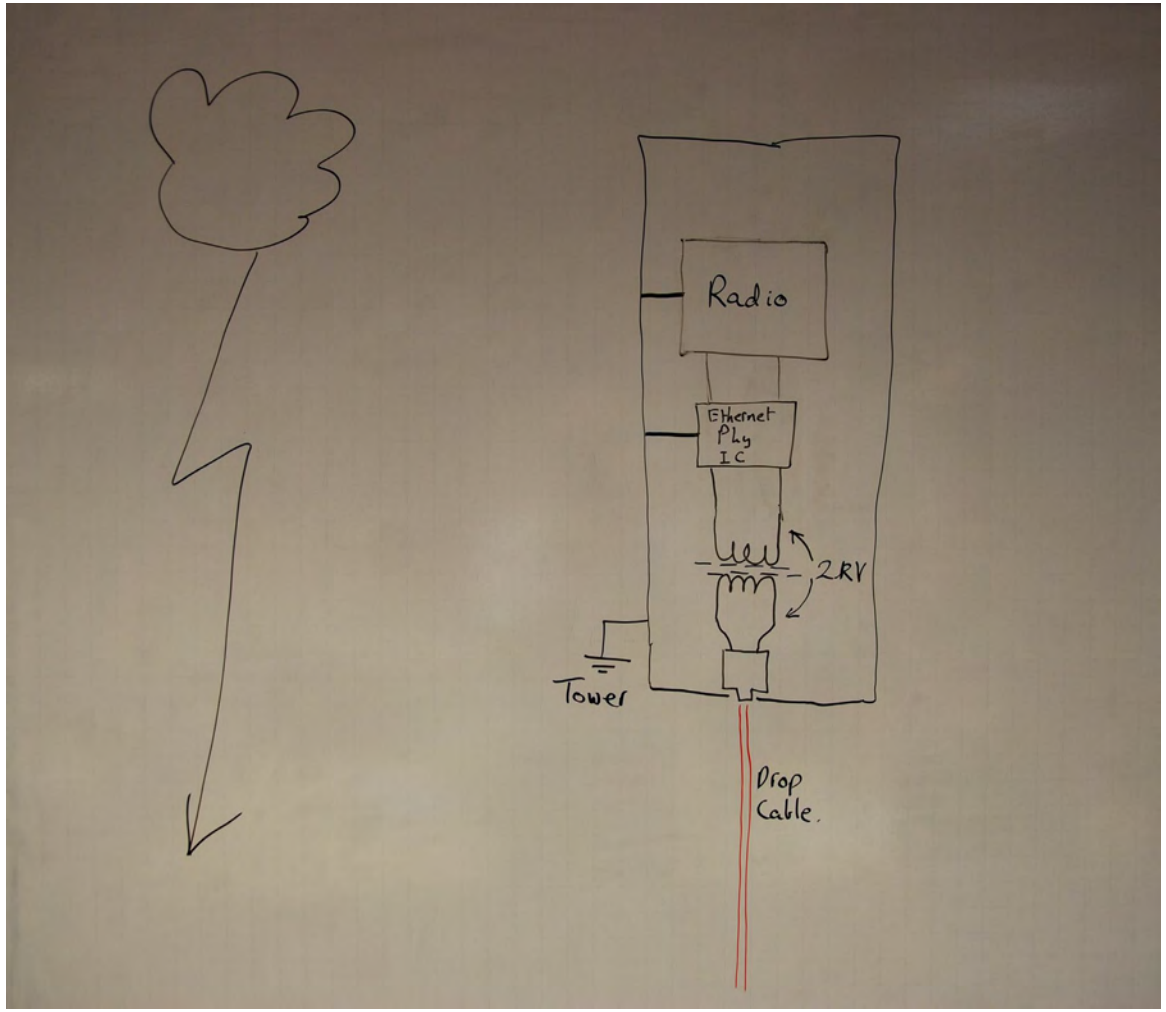
Why is the equipment susceptible



- The casing of the radio is attached to ground.
- The incoming Ethernet cable is isolated from the radio ground but has a breakdown voltage of 2kV typical.

- Surges lower than 2kV cannot exceed the isolation voltage so no breakdown current flows, no damage occurs.

- A surge exceeding 2kV will exceed the breakdown voltage of the transformer.
- Once breakdown occurs large destructive currents can flow.

- It’s a problem at the top and at the bottom of the mast.

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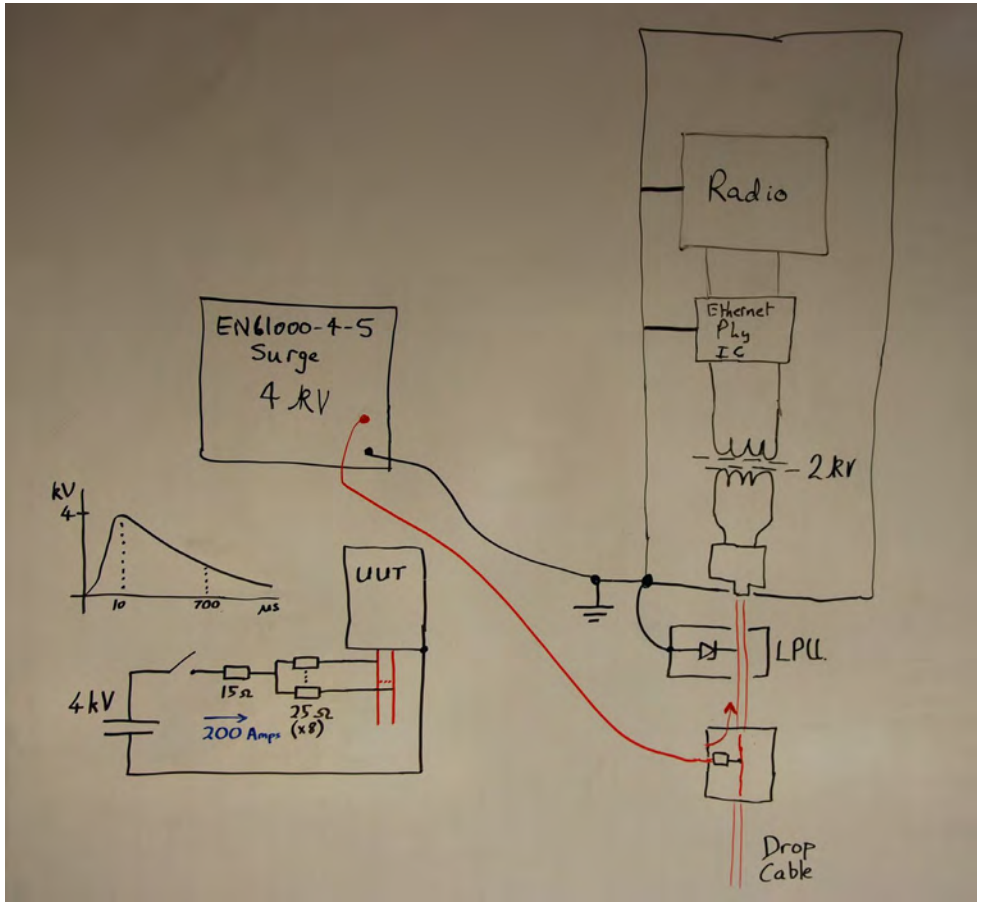
Applicable standards 1

- To facilitate the design of robust systems, standardised tests for use by designers and test houses have been developed to emulate surge levels seen in deployments.



- Equipment is tested with different levels of test surge depending on the expected location of the installation.
- IEC 61000-4-5 Level 4 is applicable to tower mount equipment.
- Testing is performed with the surge generator injecting the surge, 4kV, 10/700us, 200A, directly into the equipment under test.
- The test setup shown requires the use of a surge protector (Lightning Protection Unit – LPU) as part of the system under test.

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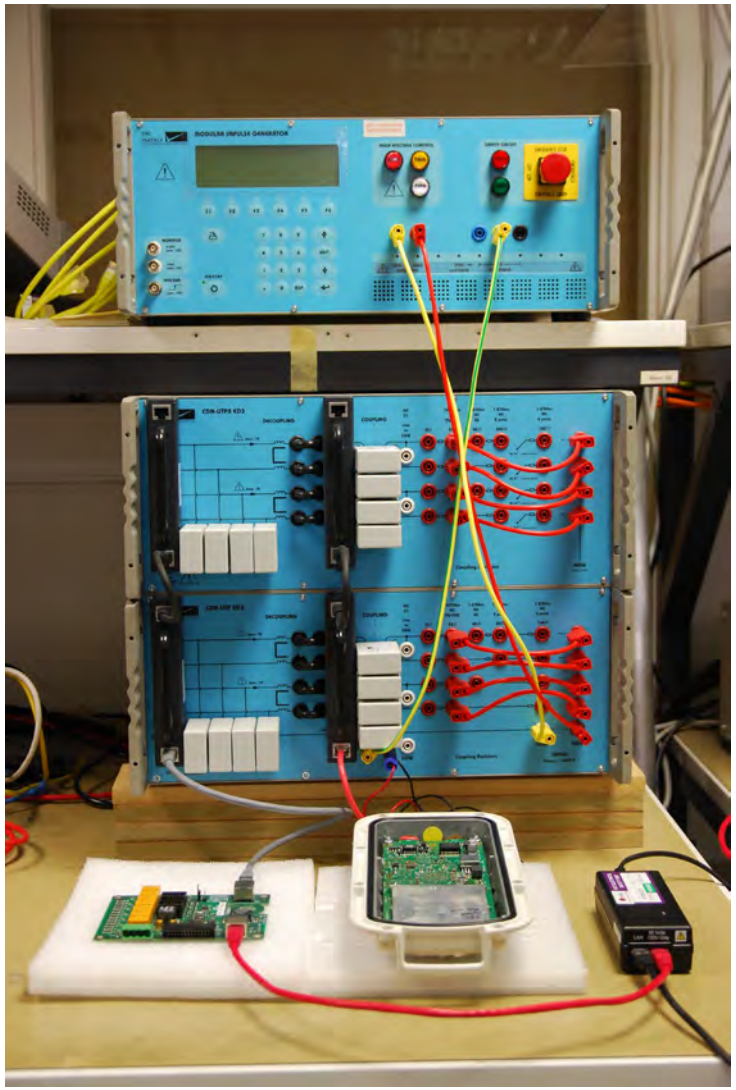
Applicable standards 2



- Equipment under test at Cambium
- 2kV capability without external surge suppression.

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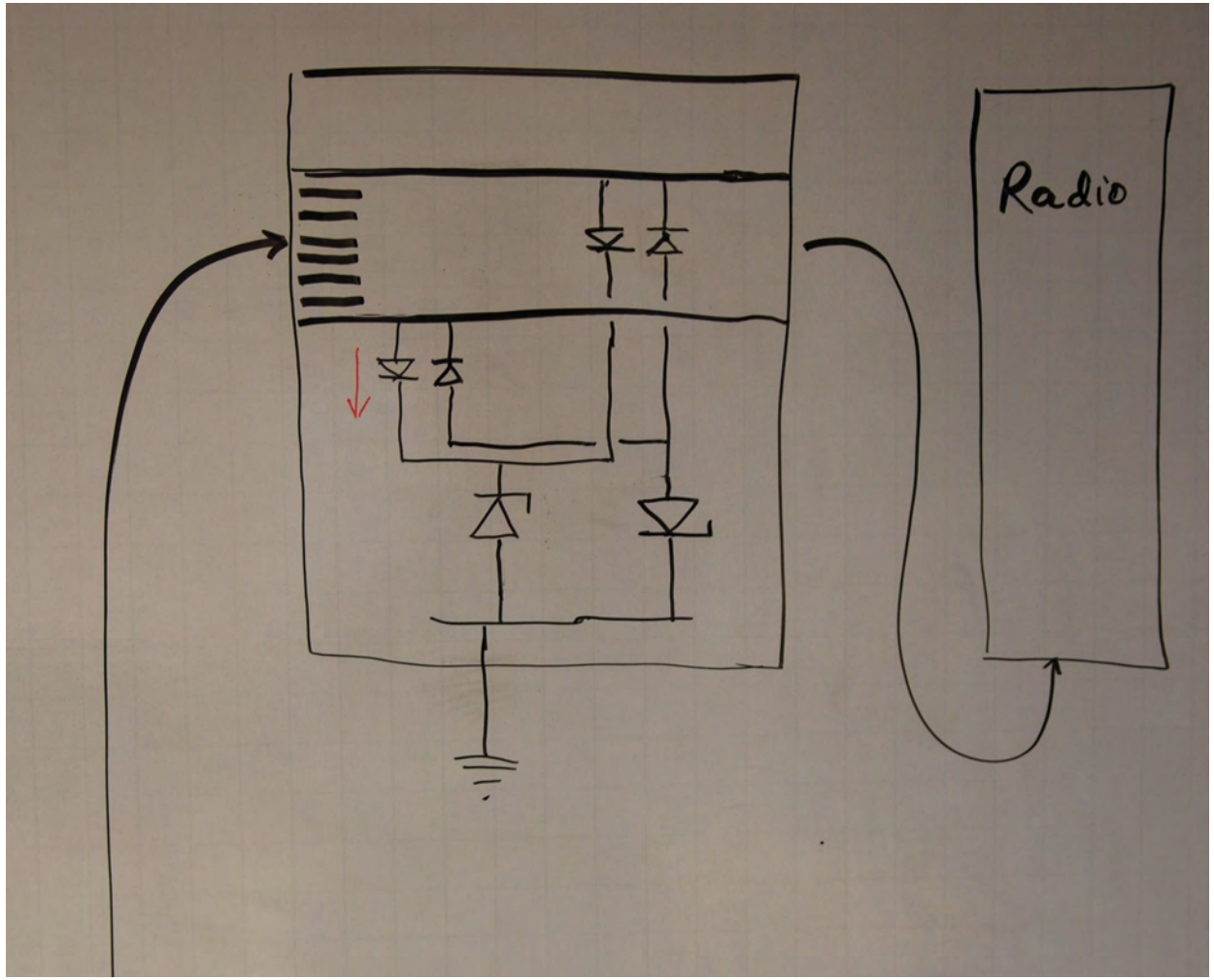
How surge protection devices work 1



- The drop cable is connected to the surge protector before carrying on to the radio.
- The surge protection device limits the voltage on any pin to less than 200V.
- Zeners are able to absorb 100s of Amps during the brief surge period.

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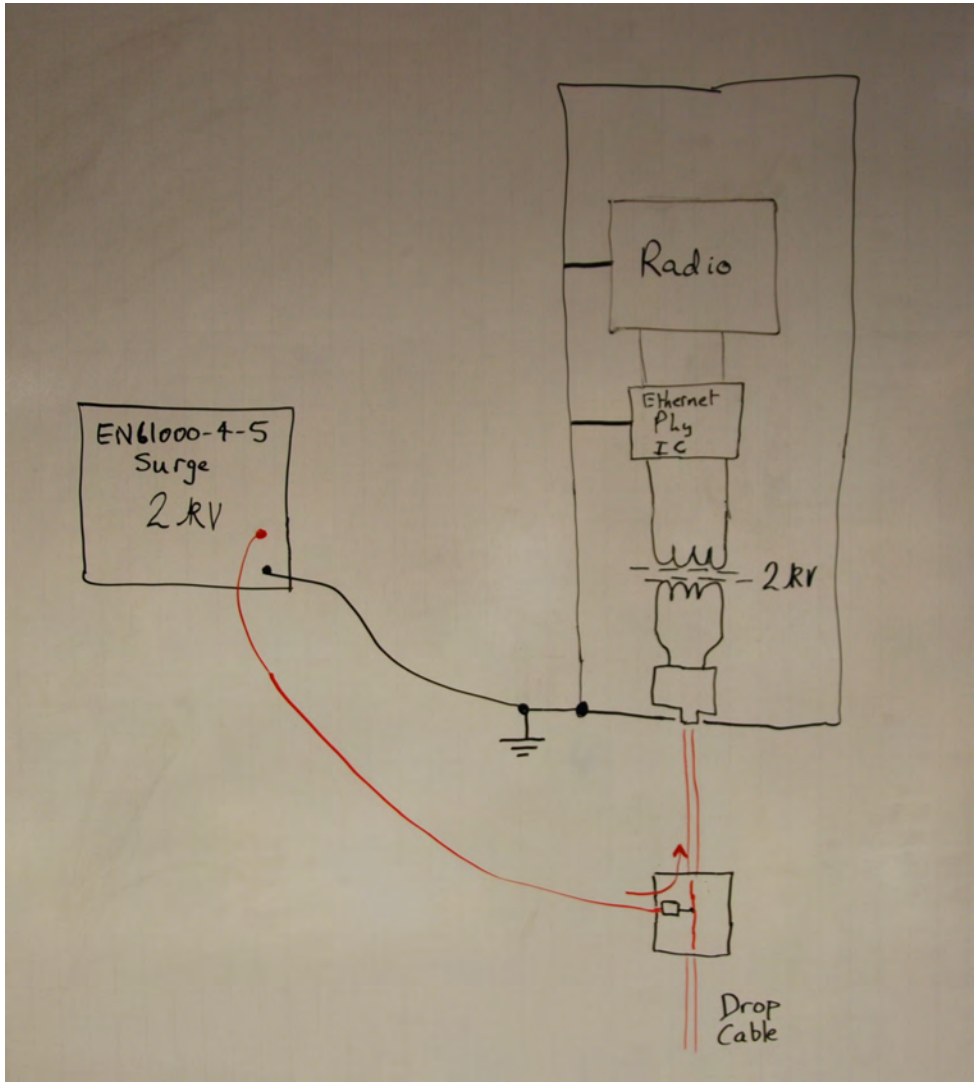
How surge protection devices work 2



- The radio has been shown to survive 2kV surges in the lab.

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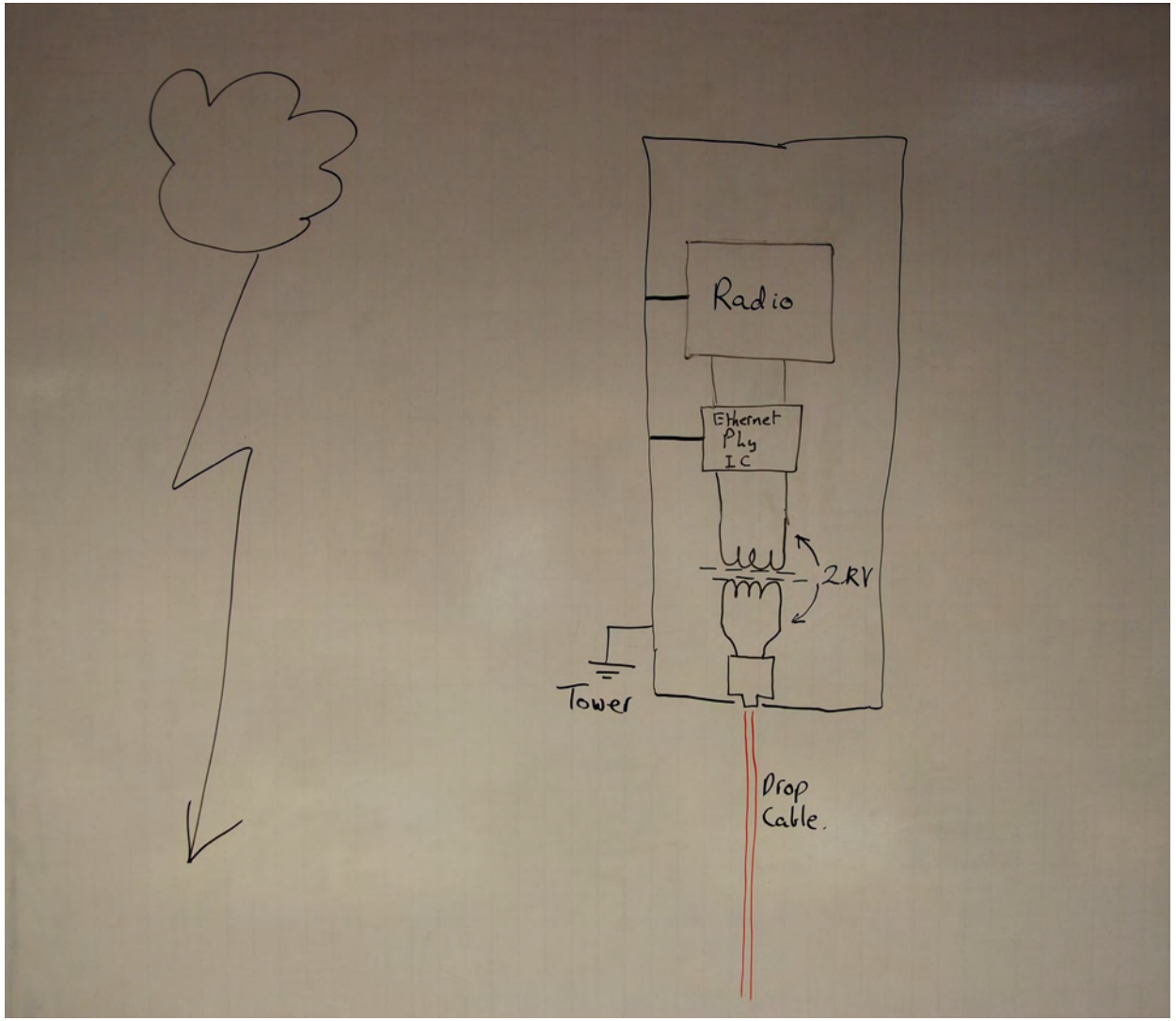
How surge protection devices work 3



- Mounted on the tower, the radio can survive 2kV surges.
- The Ethernet transformer provides the isolation.

- What if the surge exceeds 2kV?

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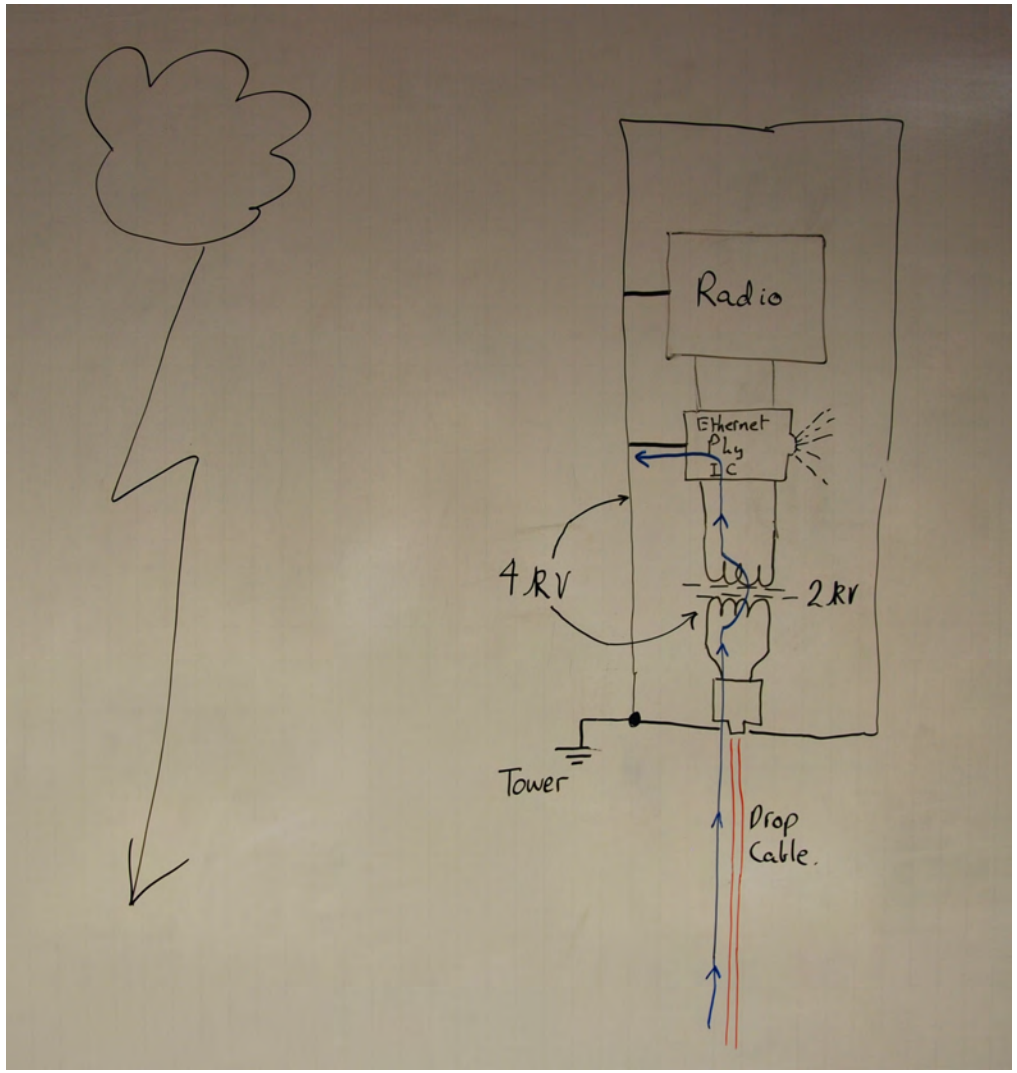
How surge protection devices work 4



- Let’s suppose the incoming surge is 4kV.
- The Ethernet cable cores are now 4,000 Volts different in potential from the radio case. The radio case is at the same potential as the local tower ground.
- Isolation barriers are breached.
- Damage is catastrophic.

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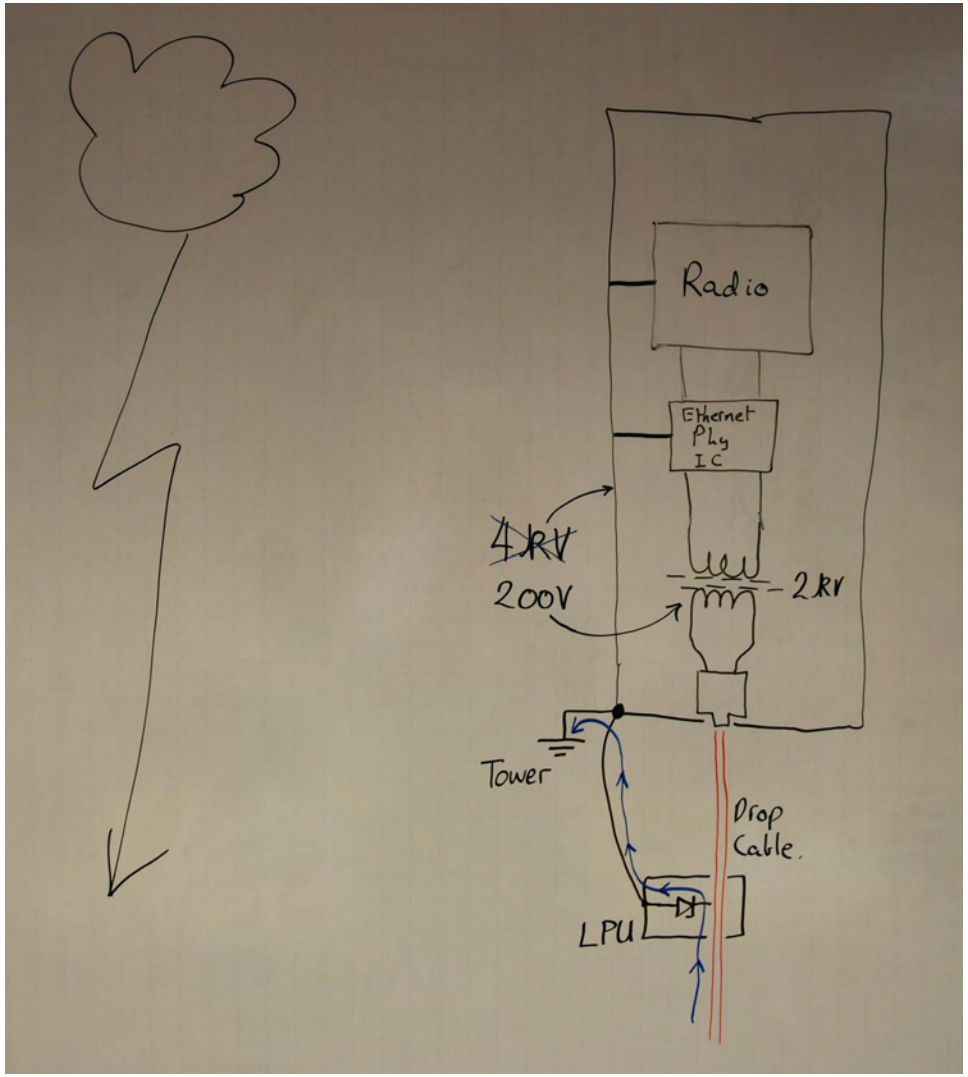
How surge protection devices work 5



- The surge protector limits the voltage of the surge to 200V.
- The energy and current in the surge are shunted to ground by the diodes (100A, kW).
- The radio sees a small surge of 200V, well within its 2kV capability.

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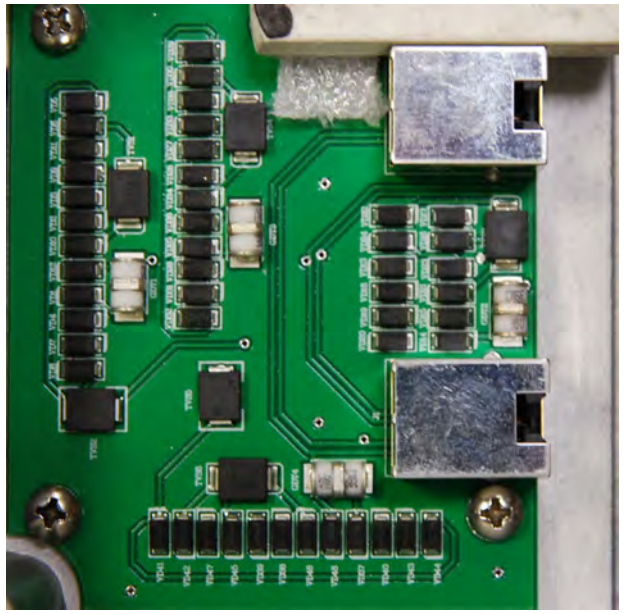
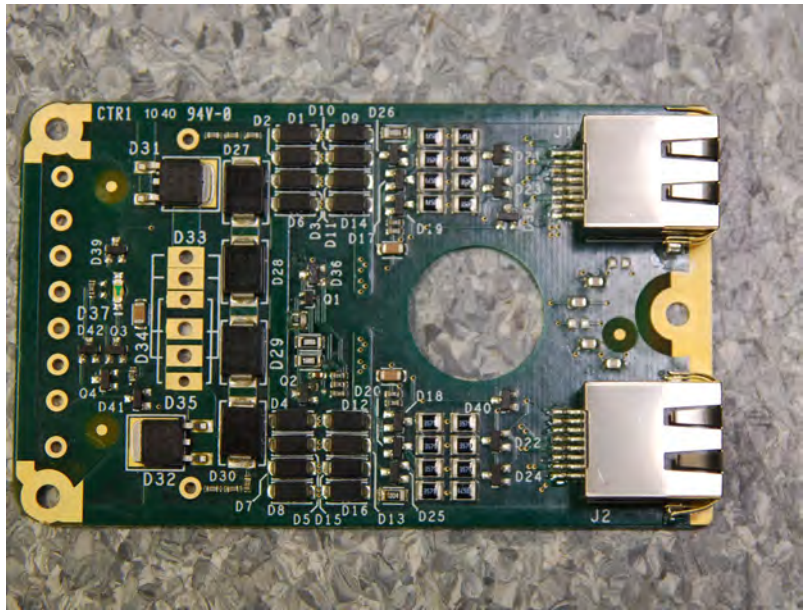
How surge protection devices work 6

- Most surge protection devices use either Gas Discharge Tubes (GDT) or semiconductor diodes, or a combination of the two.
- GDT solutions tend to be cheaper for a given power handling capability.
- However, GDT devices have a lifetime limited to a maximum number of surges.
- Silicon-based solutions do not suffer wear out due to surge absorption.





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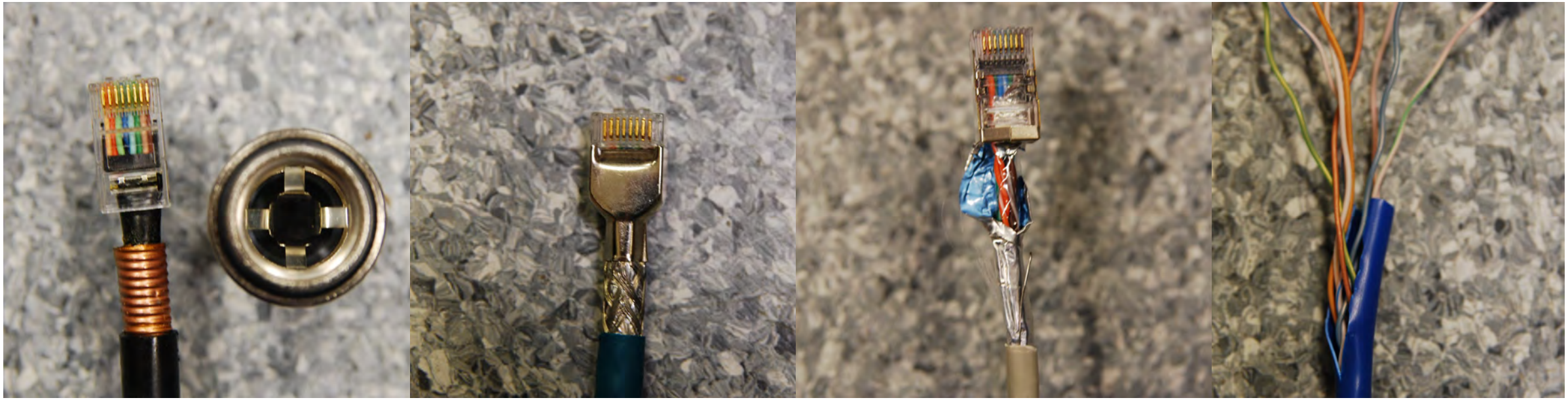
Cable shielding 1

- We have seen that current is induced into conductors by nearby lightning strikes.
- Conductors with a shield around them are protected, most of the surge current is induced into the shield.
- Use a drop cable with a good conductive shield.
- Bond the shield to local ground at the top, bottom and at points up the tower.



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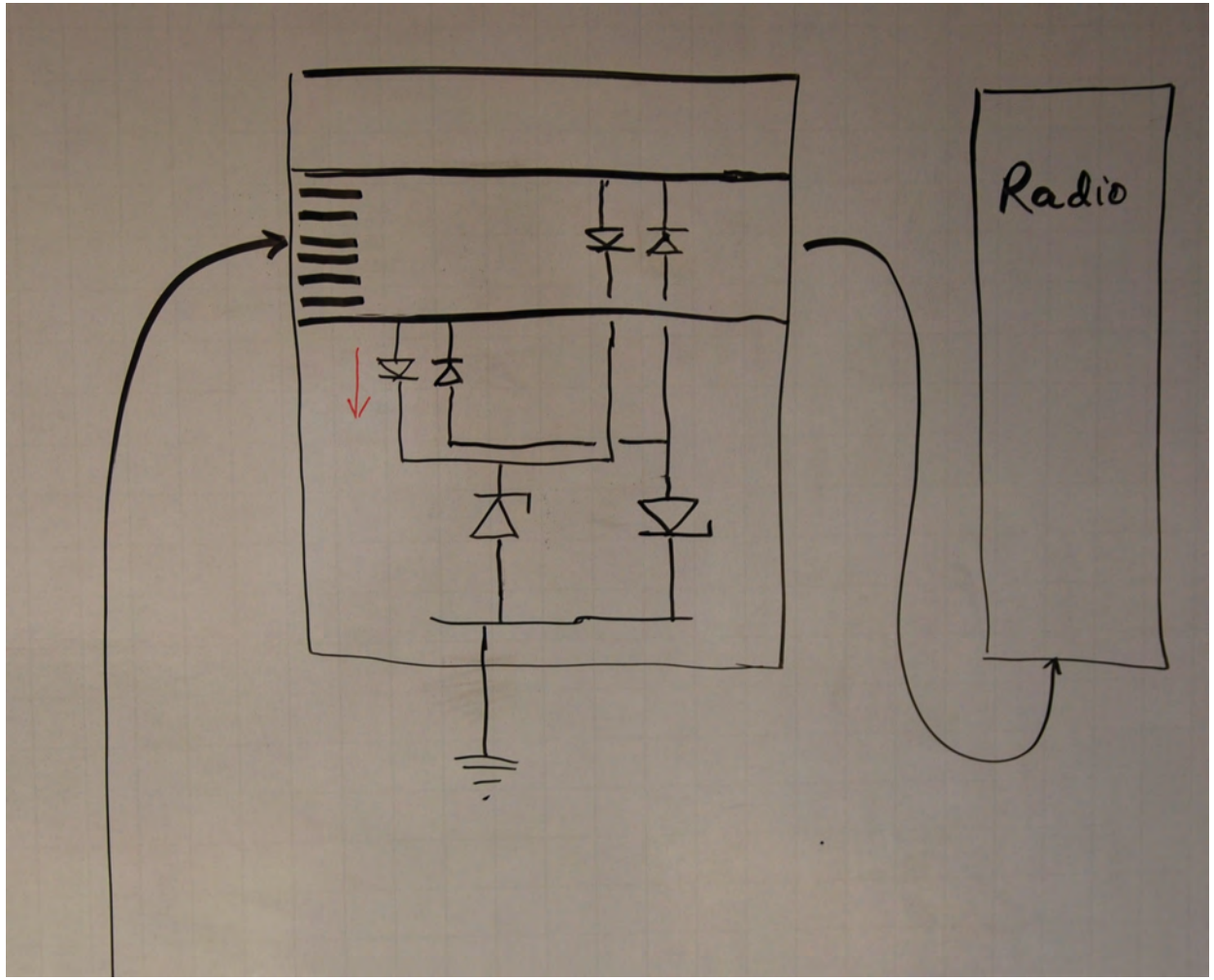
Cable shielding 2



- Without a shield the surge is induced directly onto the Ethernet wires, the surge protection devices have to handle a large surge.

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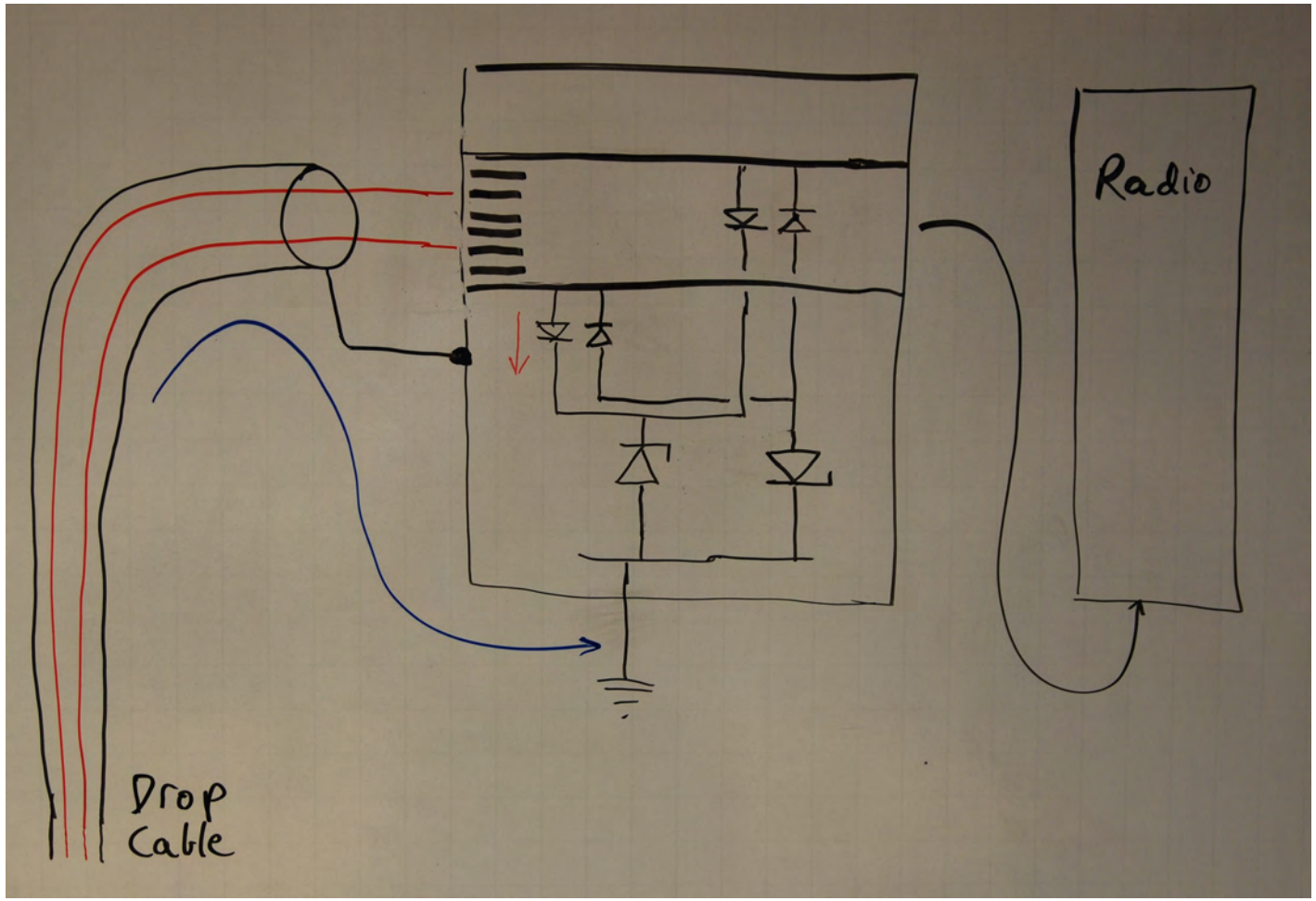
Cable shielding 3



- With a shield most of the surge is induced into that shield.
- The current is able to flow to the local ground.
- A smaller amount of surge appears on the Ethernet cores and is handled by the protection devices in the surge protector.

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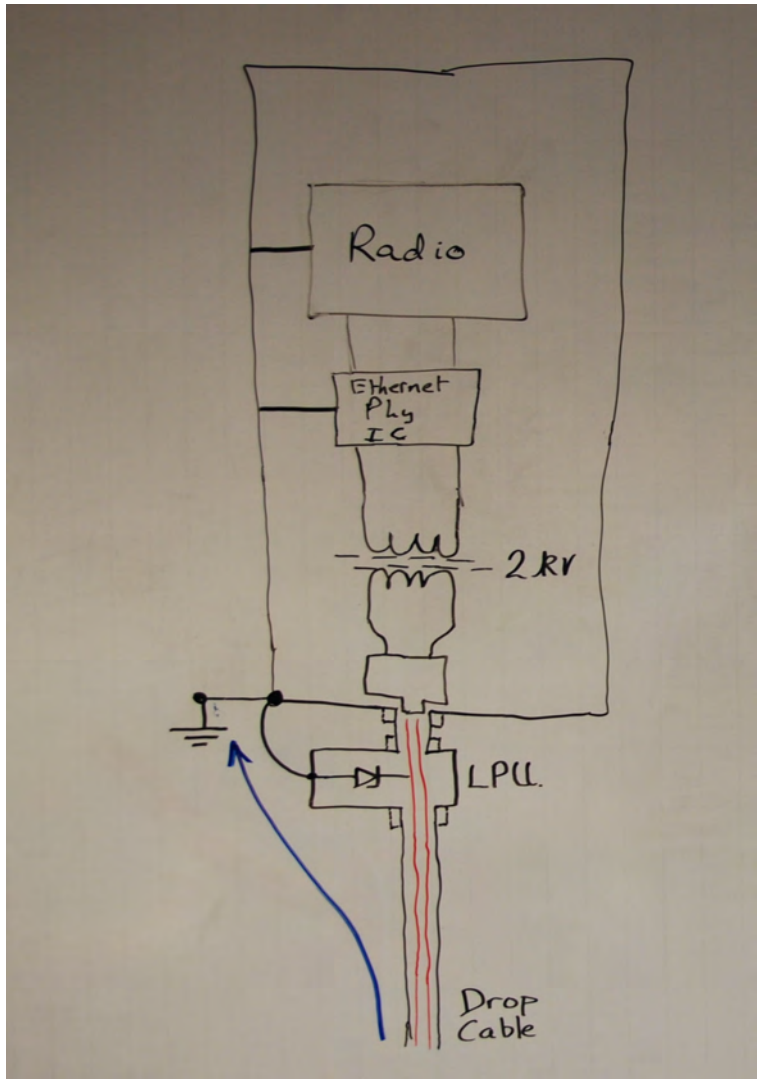
Cable shielding 4



- Here the drop cable screen is bonded to the case of the Lightning Protection Unit (LPU) using conductive, waterproof glands.
- The LPU has a heavy gauge conductor to the case of the radio
- (hold the radio and LPU at the same potential).
- A heavy gauge conductor also connects the case of the radio to local ground.

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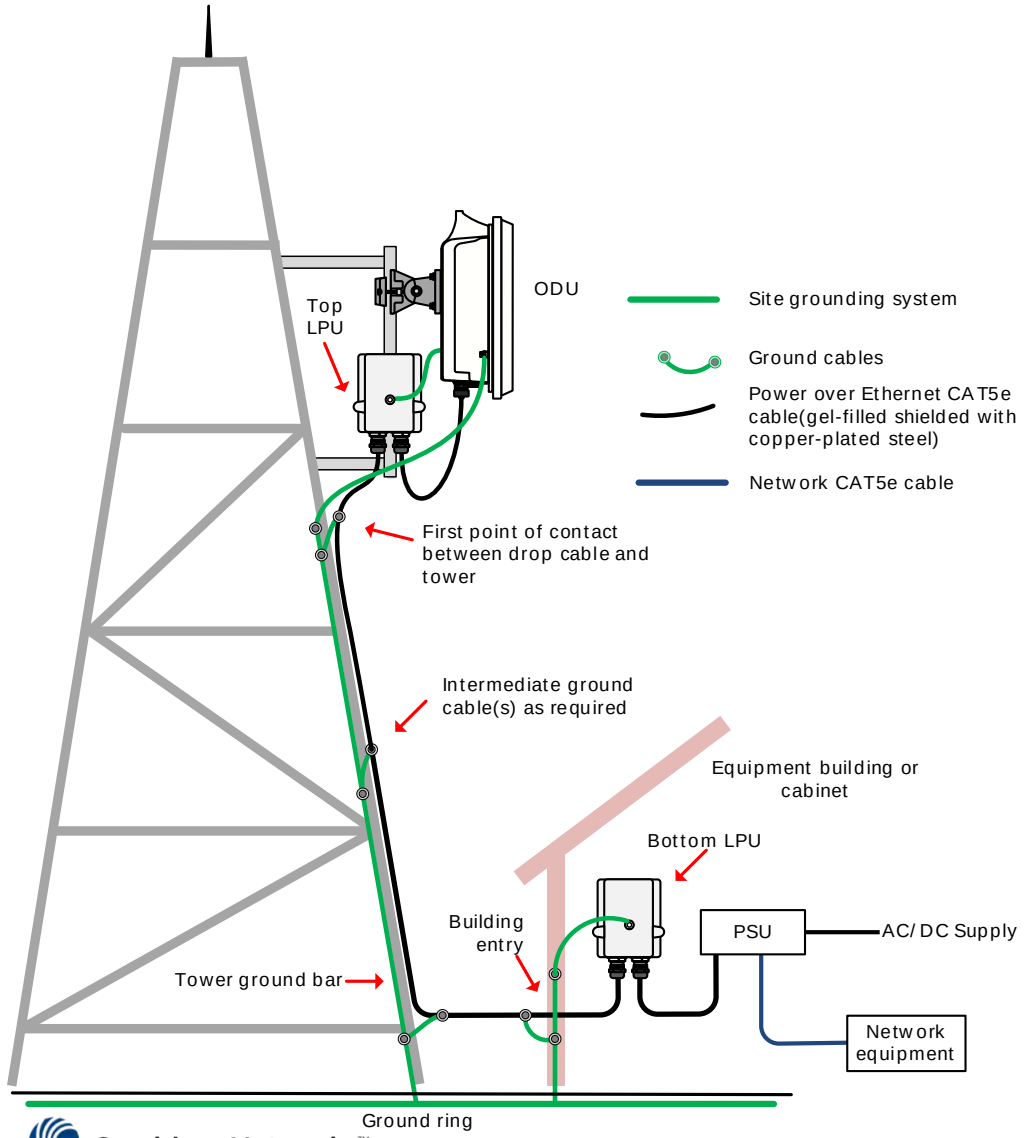
Best installation practice 1



The protection system consists of :

- ✓ Finial
- ✓ The tower ground system
- ✓ Surge protectors
- ✓ Ground cabling
- ✓ Shielded and grounded drop cable

- Outdoor Unit (ODU) ground bonded to tower
- Surge protector (LPU) ground bonded to ODU
- Bond the drop cable shield to the tower at the first point of contact and intermediate points down the tower
- Bond at the cable entry point to the equipment hut

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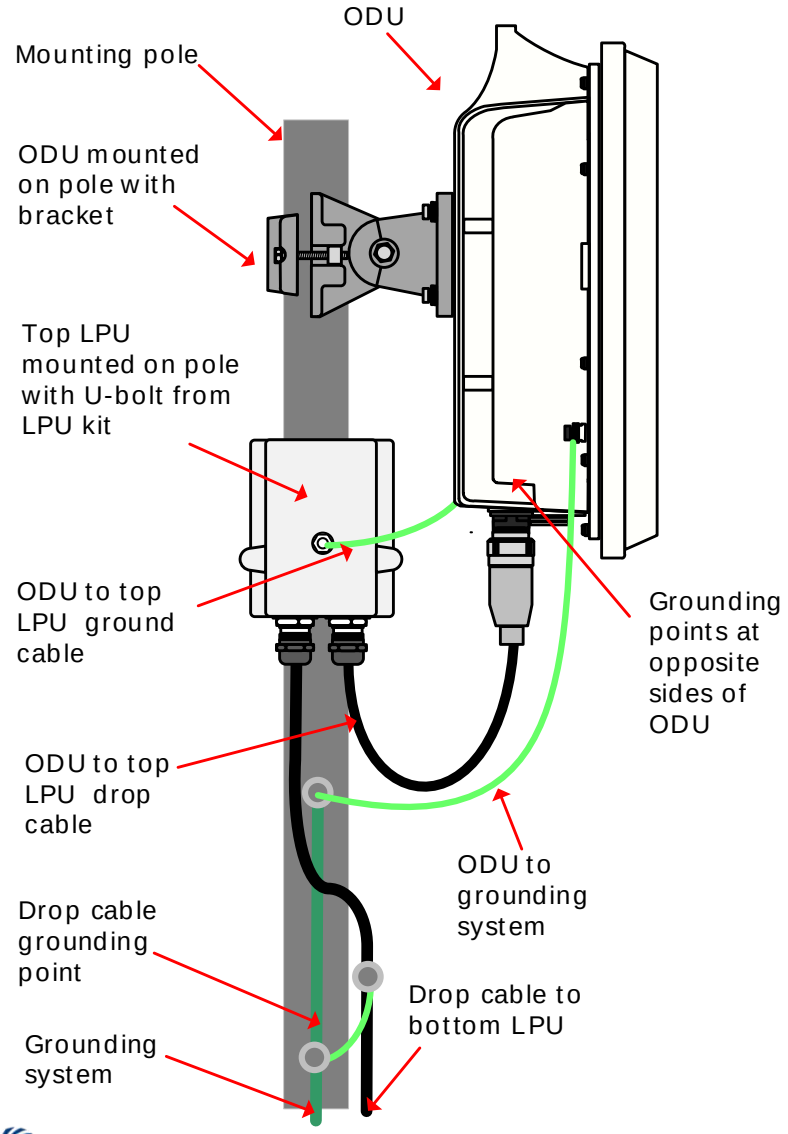
Best installation practice 2



- Grounding system is connected to the tower at frequent intervals.
- The installation is not reliant on metal contact on brackets.
- Self amalgamating tape is used to seal the drop cable where a grounding strap is attached.

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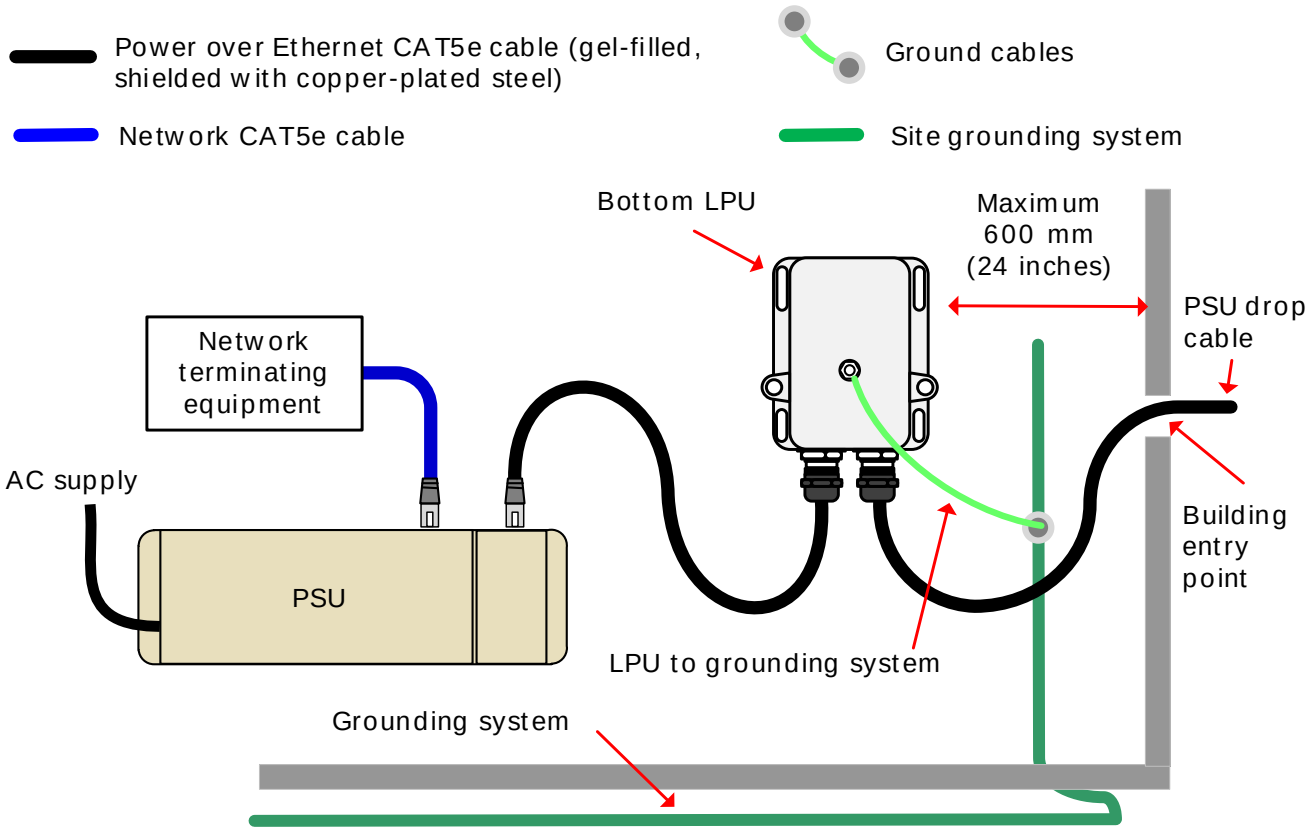
Best installation practice 3



- Protect people and equipment in the base hut.
- Use the hut/ site grounding system.
- Mount the surge protector within 600mm of the building entry point.
- Bond the LPU to the grounding system.

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Conclusions

- Cambium equipment has been designed and proven to survive surge levels experienced on towers.
- A well-designed and implemented installation with good grounding, cabling and surge protection is an essential component in a robust, trouble free communications system.
- Cannot protect against all surge events, but can significantly improve the robustness of the installation.

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Questions

That’s all clear then?

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Feedback

Did you get what you were expecting?

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