Fiber-to-the-Antenna: Benefits and Protection Requirements

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INSPIRING INNOVATIONS

What is the RRH Concept?

Paradigm shift - RRH Concept

High frequency and power electronic segments shifted from base station to the RRH.

Power Improvements

Efficiency of power amplifiers improved

Reduced power cable transmission weight

Reduced power consumption/requirements

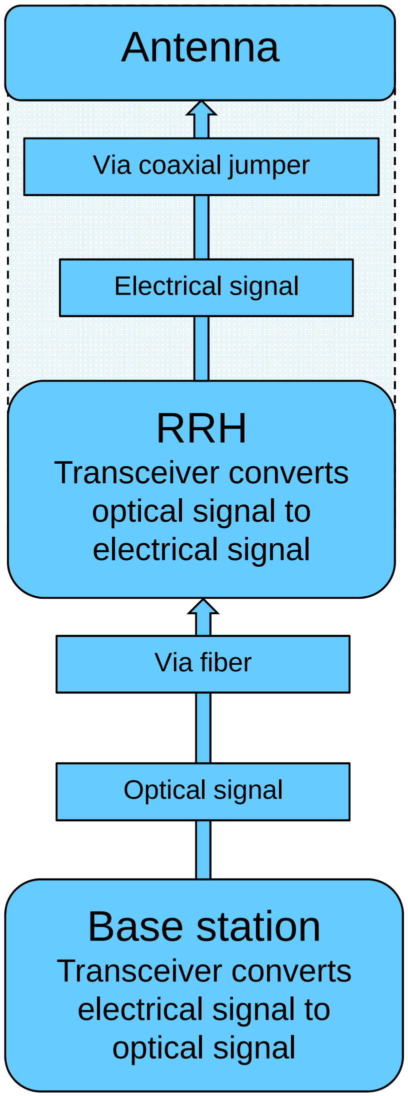
- Elimination of power losses due to Coax cable
- Power amplifiers moved to RRH

Size, Space and Control benefits

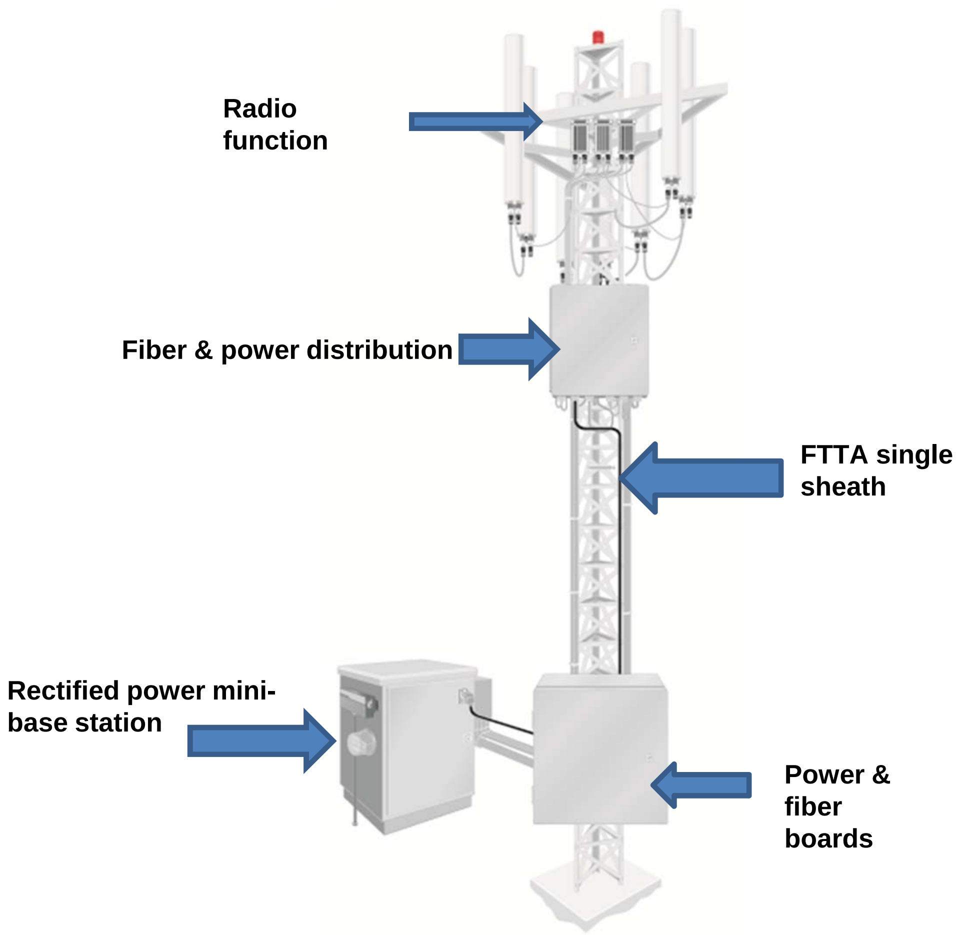
Single cable feed with power and fiber conductors

Distributed antenna systems

- Reduced size of the footprint
- Reduced power requirements
- Control multiple antenna systems from one base station

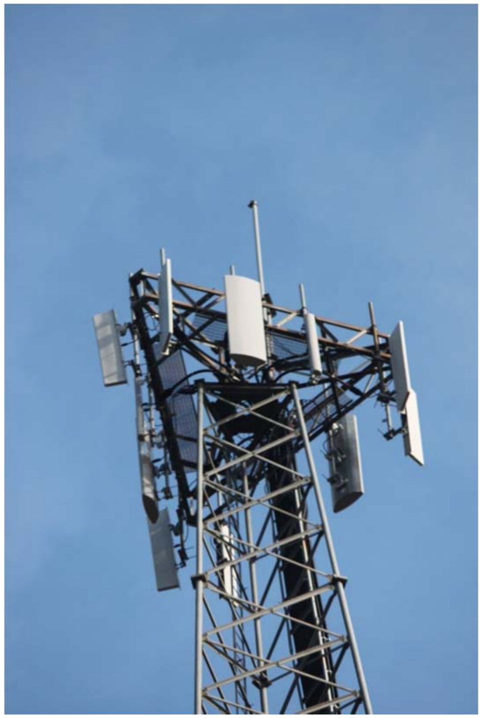


Fiber-to-the-Antenna Solutions
Transition to Fiber-Fed Remote Radio Heads



Packaging Configurations that Reflect Environmental Changes – Generation 3

Top of the Tower

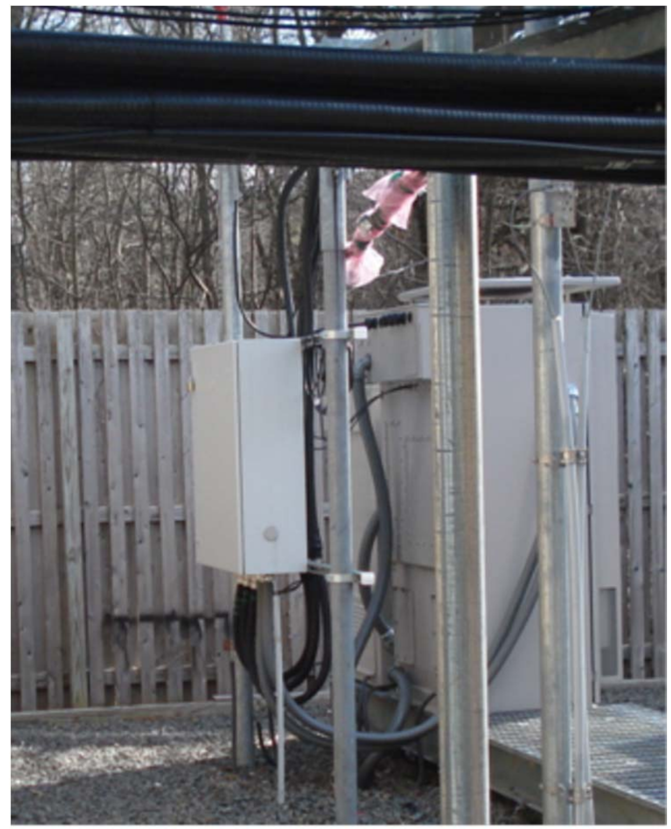


Base Station

Packaging Configurations that Reflect Environmental Changes – Generation 4

Top of the Tower

Base Station



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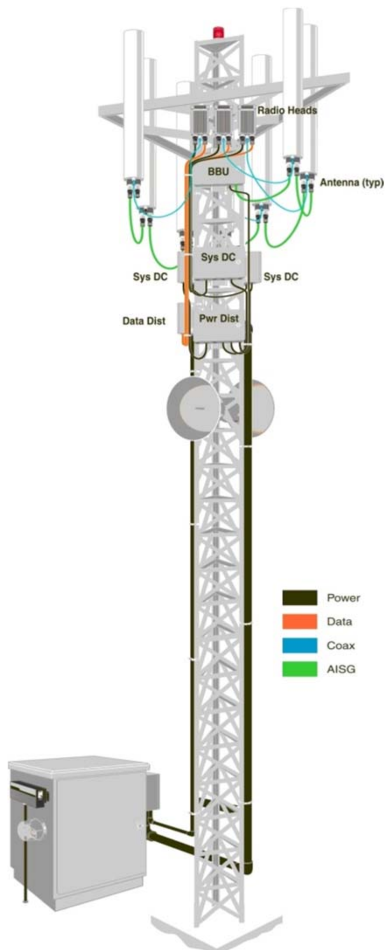
The Application:
FTTA (Fiber-to-the-Antenna)

RRH Base Station Architecture



- CAPEX/OPEX Savings
  - Eliminates long coaxial cable runs
  - Reduced size, weight, wind loading
  - 50% power savings
  - Reduced installation time and cost
  - Reduced space and cooling requirements
  - Future proof design
- Requires fiber and -48VDC power distribution at base and top of tower.

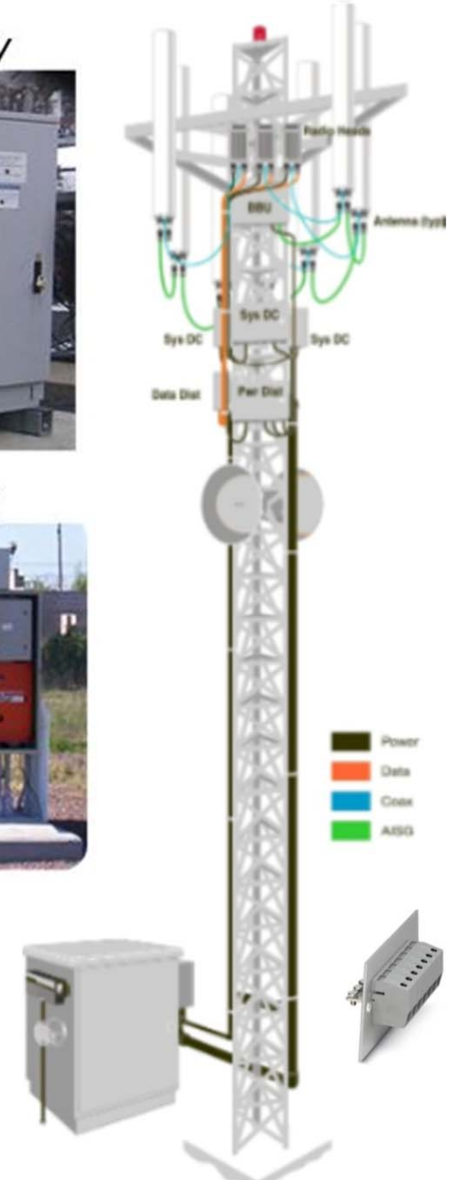
Alcatel-lucent - RRH

Alcatel-Lucent:
Sites-
(2012 – 11,500)
(2013- forecast 11,590)

Product line/lines:

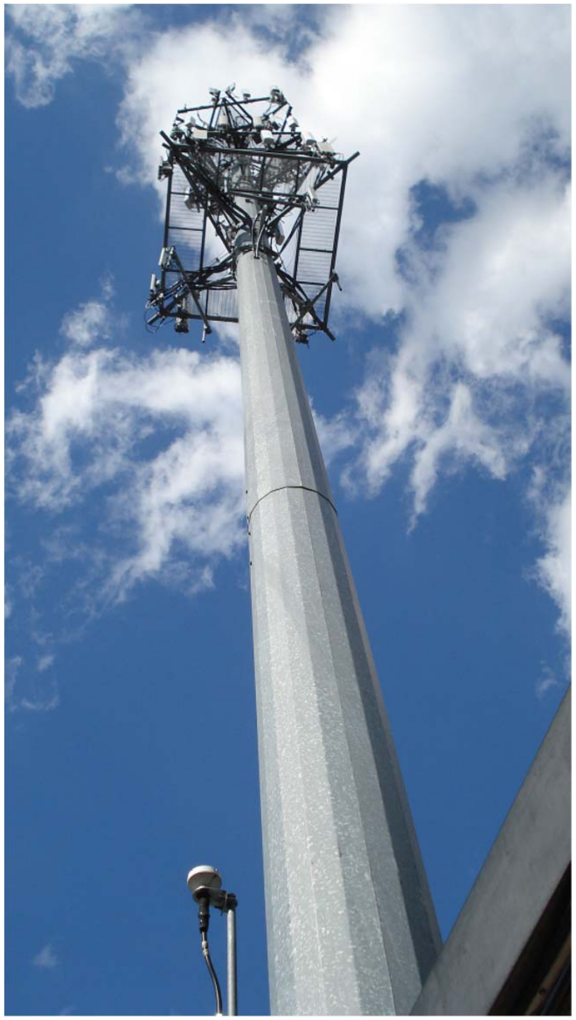
Individual 3G and 4G base stations today

Network Vision multi-mode base station



4G RRH/ FIBER/ POWER DISTRIBUTION

FTTA Sprint Site
Power and Fiber distribution box UL considerations



RRH Environmental Factors

High power and electronic components located in the RRH implies:

Wide temperature range requirement

Higher vibration and shock

More hostile electromagnetic environment

Table 1 – Comparison of Environmental Specifications*

***Per ETS 300 019-1-3,4**

Specifications	Base Station	Top of the Mast
Low air temperature (°C)	-5°	-45°
High air temperature (°C)	+45°	+45°
Stationary vibration displacement amplitude, (mm)	1.5	3.0
Stationary vibration acceleration amplitude (m/s) @ 2-9 & 9-200 MHz	5.0	10.0
Solar radiation (w/m^2)	700	1120
Movement of surrounding air (m/s)	5	50
Conditions of wind driven rain, snow, etc.	No	Yes

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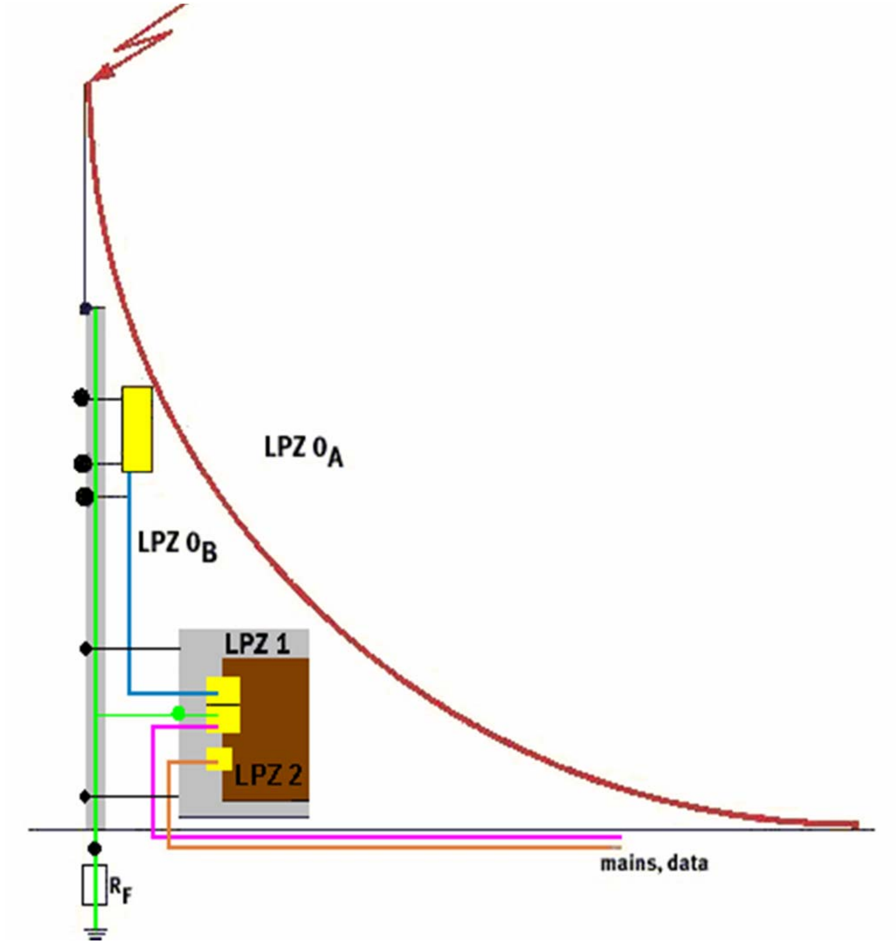
Remote Radio Head
Electromagnetic Environment

Lightning Protection Zone Concept* as Applied to a Cell Tower



*As defined in IEC 62305-4

Lightning Protection Zone Definitions

Lightning protection zones defines where direct or indirect lightning strikes are possible and give a measure of relative field strengths. Below is a summary of the LPZ definitions as defined in IEC 62305-4:

- **LPZ 0_A** Direct strike possible, undamped EM fields. (e.g., top of antenna mast). Lightning current test pulse of first stroke 10/350 µs.
- **LPZ 0_B** Direct strike not likely, undamped EM fields. (e.g., surfaces along mid-point and base of antenna mast). Current test pulse of first stroke 10/350 µs.
- **LPZ 1** Direct strike impossible, damped EM fields, outside wall entrance to a building. 10/350 µs pulse (e.g. interior of base station).
- **LPZ 2** Interior room, surge current further damped by strategically placed SPDs. 8/20 us pulse test.

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Relationship of LPZs to SPD Parameters

LPZ	SPD Requirements
Zone 0_A	Lightning Arrestor – IEC Type 1* (Power) 10/350 µs Waveform I surge = 30 kA $_{AVG}$ @ 50% point
Zone 0_B	Lightning Arrestor – IEC Type 1 (Power) 10/350 µs Waveform I surge = 10 kA $_{AVG}$ @ 50% point
Zone A	Surge Arrester – IEC Type 2 (Rise Time) 8/20 µs Waveform I surge = 5 kA $_{AVG}$ @ 50% point
Zone B	Device Protection – IEC Type 3 (Rise Time) 8/20 µS Waveform I surge = 5 kA $_{AVG}$ @ 50% point

*Classified and tested per requirements of IEC 61643-1

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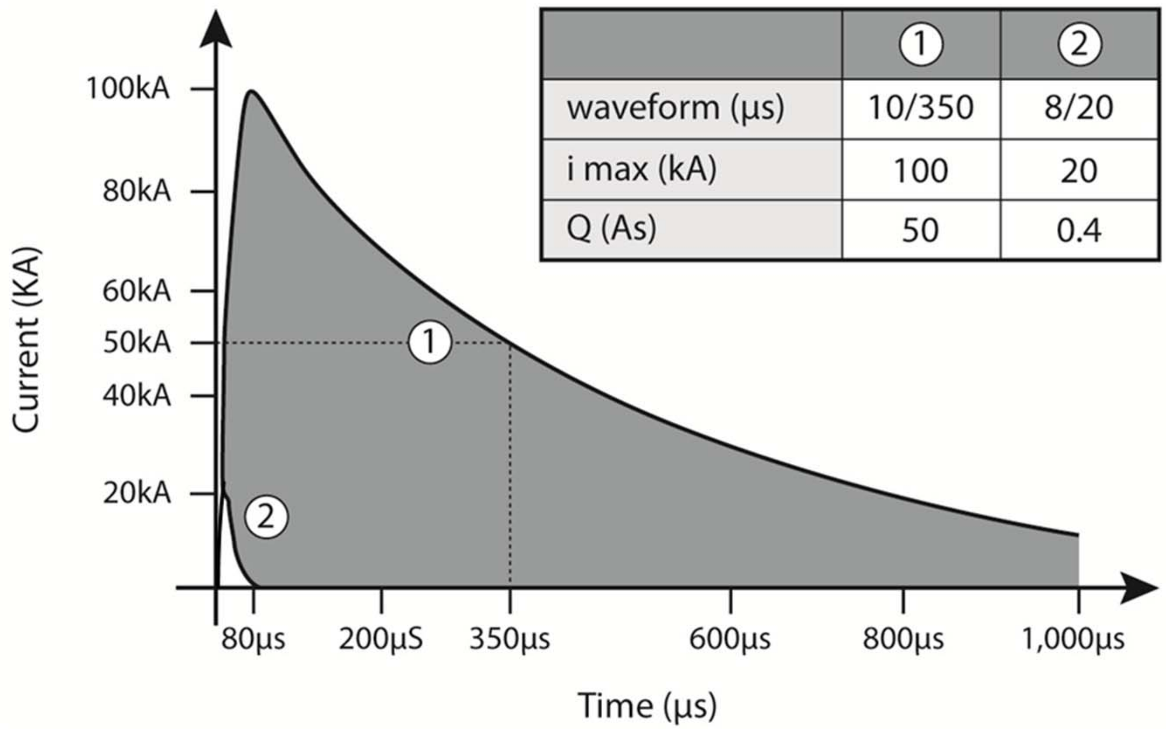
Comparison of Lightning Test Currents



	1	2
waveform (µs)	10/350	8/20
i max (kA)	100	20
Q (As)	50	0.4

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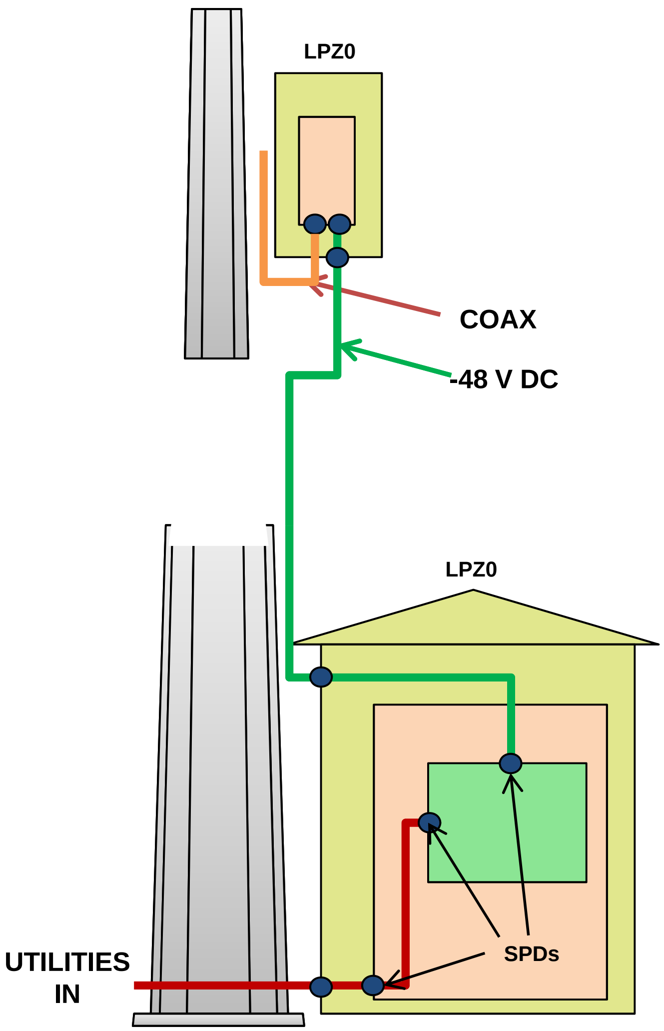
Lightning Protection Zones (LPZ)



Outdoors

- **LPZ 0**

  direct lightning strike possible
  no shielding against LEMP

Indoors

- **LPZ 1**

  partial lightning currents high-energy transients

- **LPZ 2**

  low-energy transients

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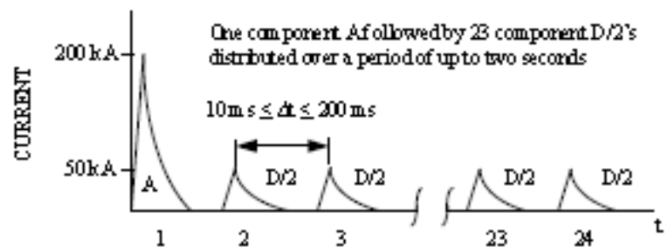
Characteristic Data of Lightning Strokes

Probability		50%	10%	5%	≈ 1%
Peak value of the lightning current	kA	30	80	100	200
Max. steepness of the current	kA/μs	20	90	100	100

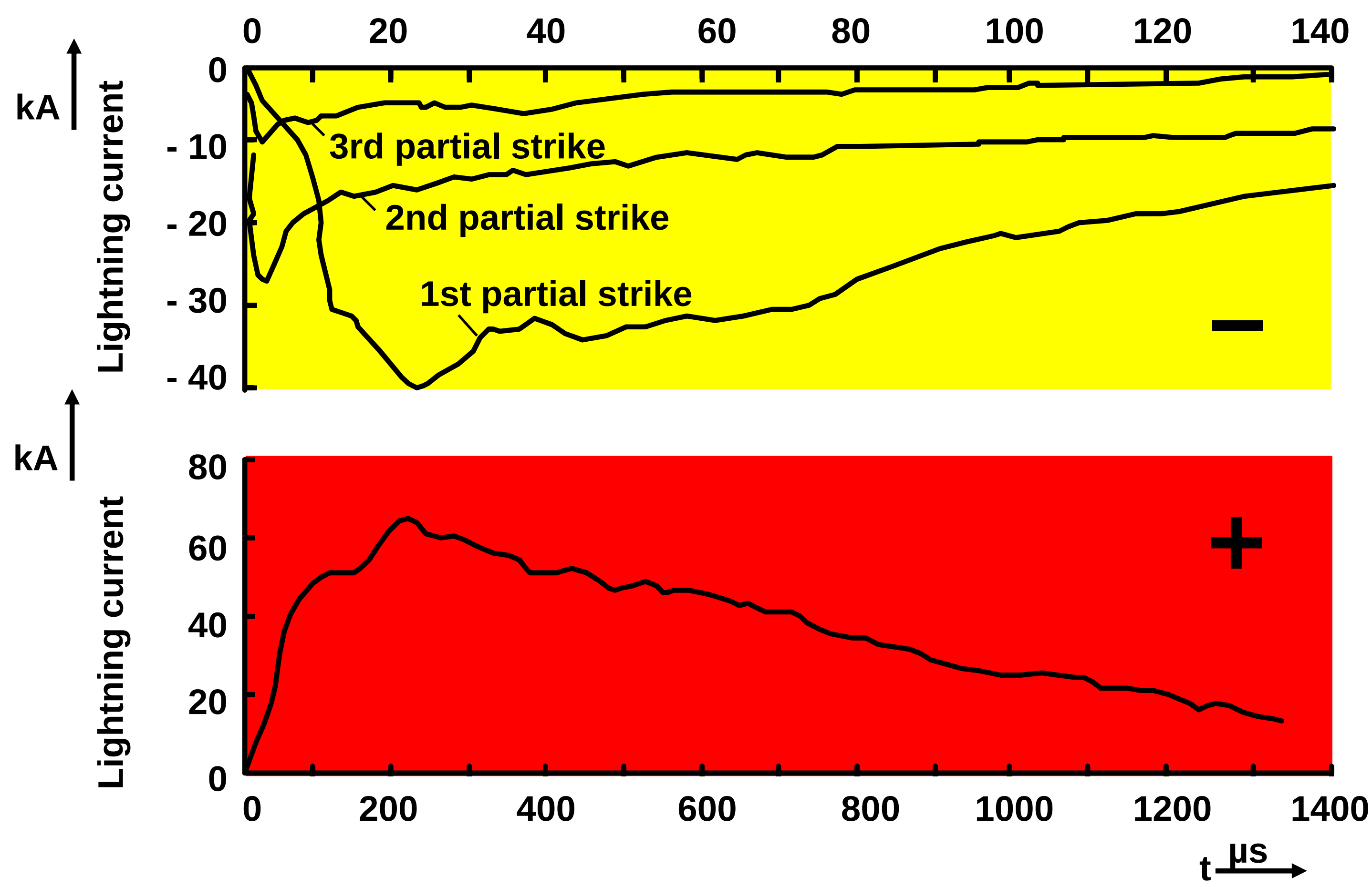
* Ref: MIL-STD 464

MIL-STD-464
APPENDIX

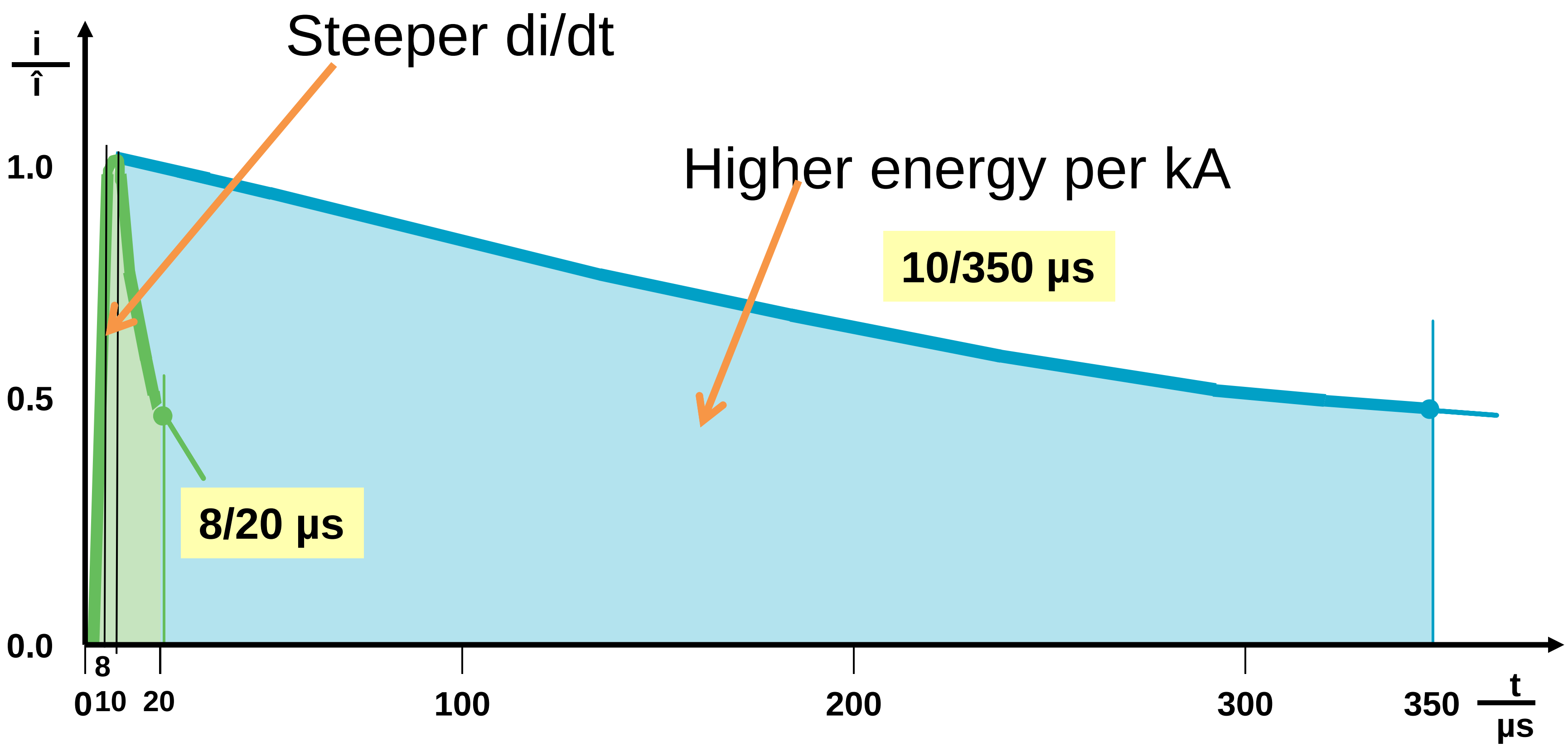


MULTIPLE STROKE WAVEFORM

Oscillograms of Negative and Positive Cloud-to-Ground Strikes



Surge Current Comparison



IEEE Definition

IEEE C62.41 defines the “typical” surge for Class II / LPZ1 (& 2) locations

This wave form is specifically defined as a combo wave with 1.2/50us voltage and 8/20 current.

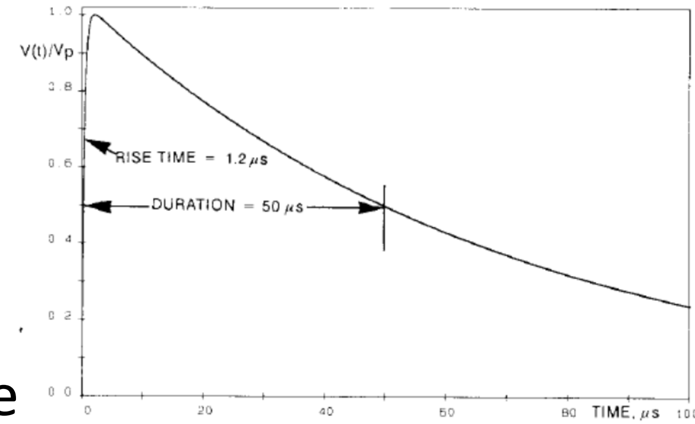


Figure 12—Combination Wave, Open-Circuit Voltage

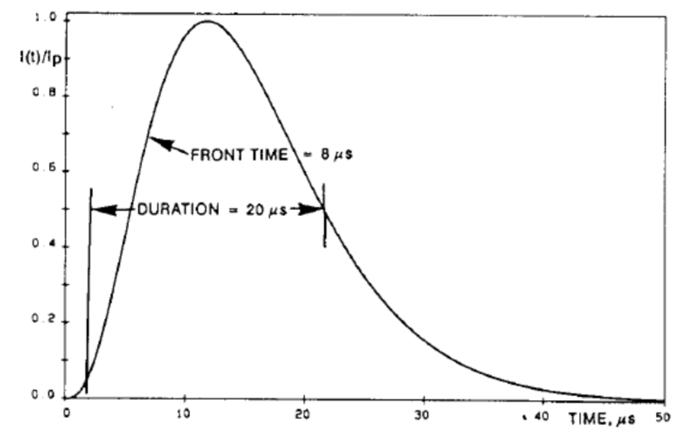


Figure 13—Combination Wave, Short-Circuit Current

IEEE Treatment of Surge Risk

IEEE C62.41 defines "Location Categories." These gradually increase :

Highest Threat/Risk:

- C3 with 20 kV/10 kA combo wave

…

Lowest Threat/Risk:

- A1 – 2 kV/70 A ringwave

Table 3—Standard 0.5 µs–100 kHz Ring Wave
Voltages and Current Surges Expected in Location Categories* A and B†
Low, Medium, and High Exposures‡
Single-Phase Modes:** L-N, L-G, and [L&N]-G
Polyphase Modes: L-L, L-G, and [L's]-G
(See Table 5 for N-G Mode)

Location Category*	System Exposure‡	Peak Values †† Voltage (kV)	Peak Values †† Current (kA)	Effective Impedance (Ω)‡‡
A1	Low	2	0.07	30
A2	Medium	4	0.13	30
A3	High	6	0.2	30
B1	Low	2	0.17	12
B2	Medium	4	0.33	12
B3	High	6	0.5	12

Table 4—Standard 1.2/50 µs–8/20 µs Combination Wave
Voltages and Current Surges Expected in Location Categories* B and C†
Low, Medium, and High Exposures‡
Single-Phase Modes:** L-N, L-G, and [L&N]-G
Polyphase Modes: L-L, L-G, and [L's]-G
(See Table 5 for N-G Mode)

Location Category*	System Exposure‡	Peak Values †† Voltage (kV)	Peak Values †† Current (kA)	Effective Impedance (Ω)‡‡
B1	Low	2	1	2
B2	Medium	4	2	2
B3	High	6	3	2
C1	Low	6	3	2
C2	Medium	10	5	2
C3	High	20	10	2

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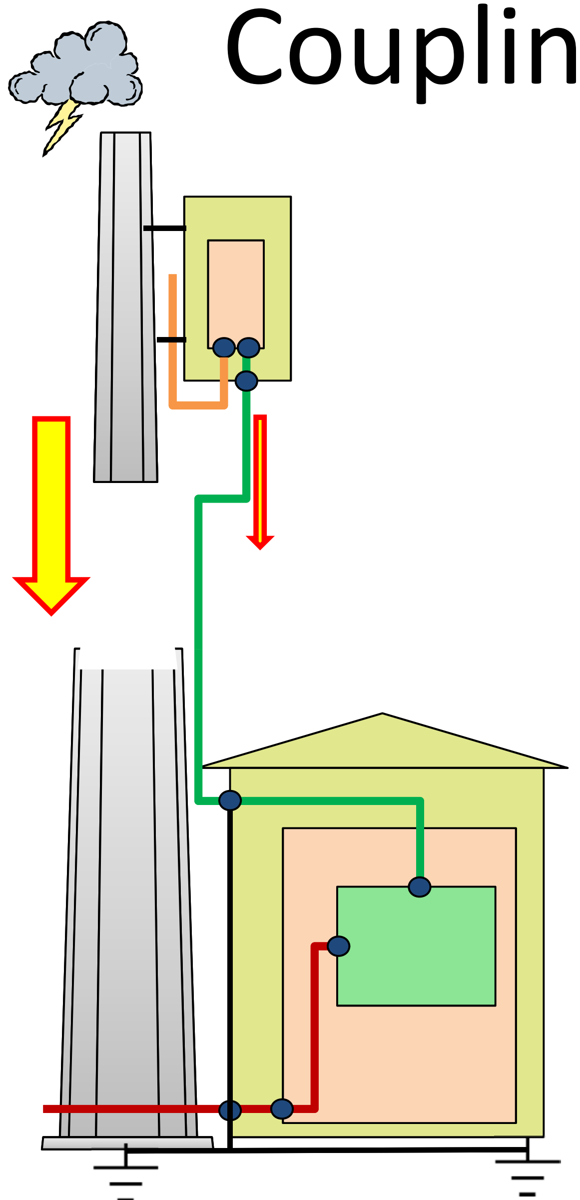
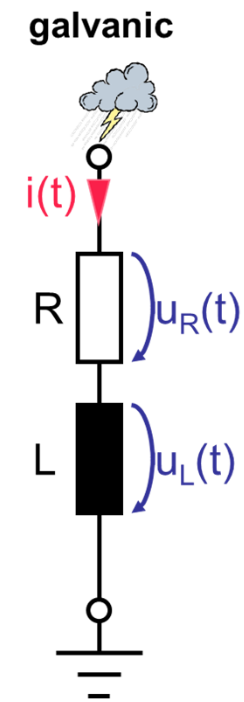
Coupling Mechanism



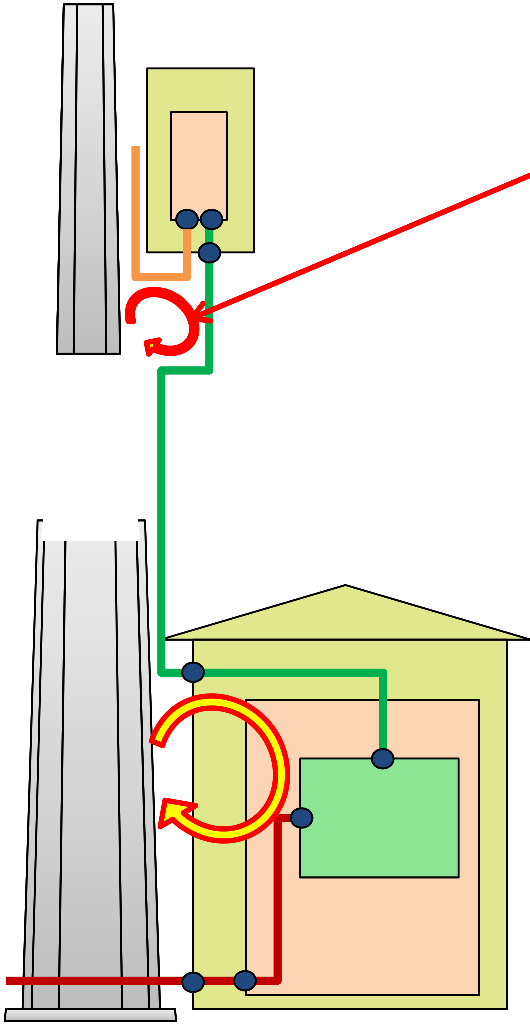
Lightning voltages will jump to other conductors.

Relative low impedance of tower should carry most current.

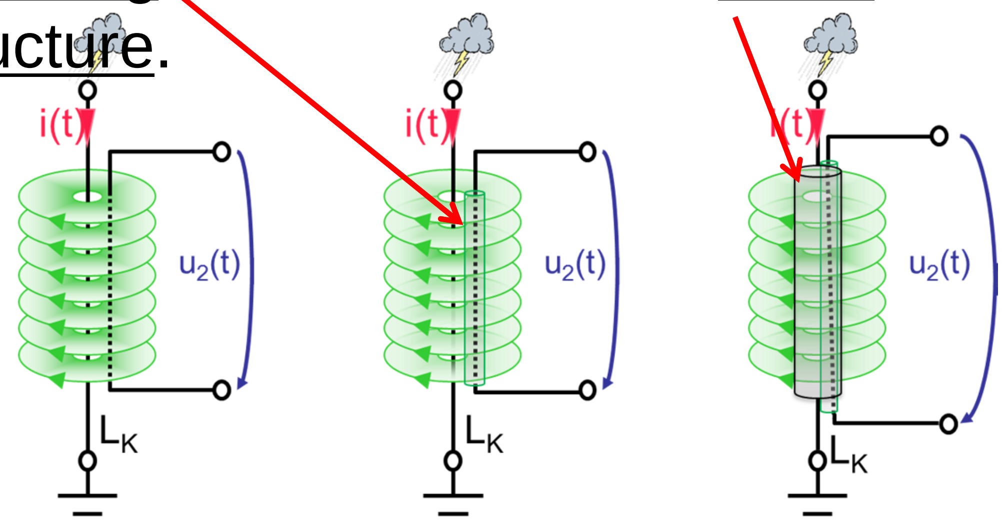
Surge protection at ***top and bottom*** will control the direction of load sharing.



Coupling Mechanism



Inductive coupling can be minimized by first minimizing loops to generate currents, and second by moving the conductors inside shielding, or even inside the tower structure.



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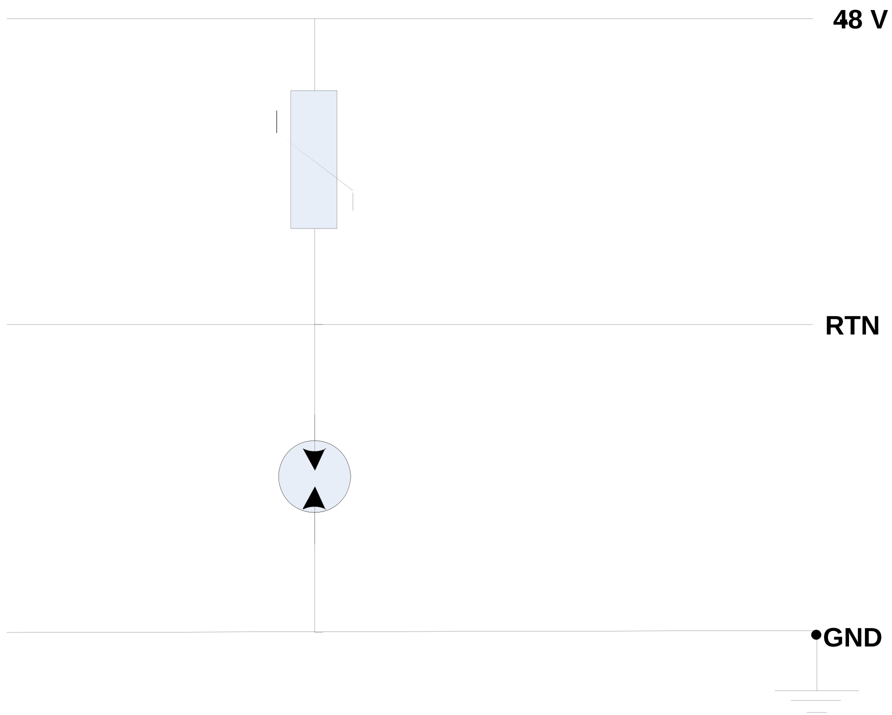
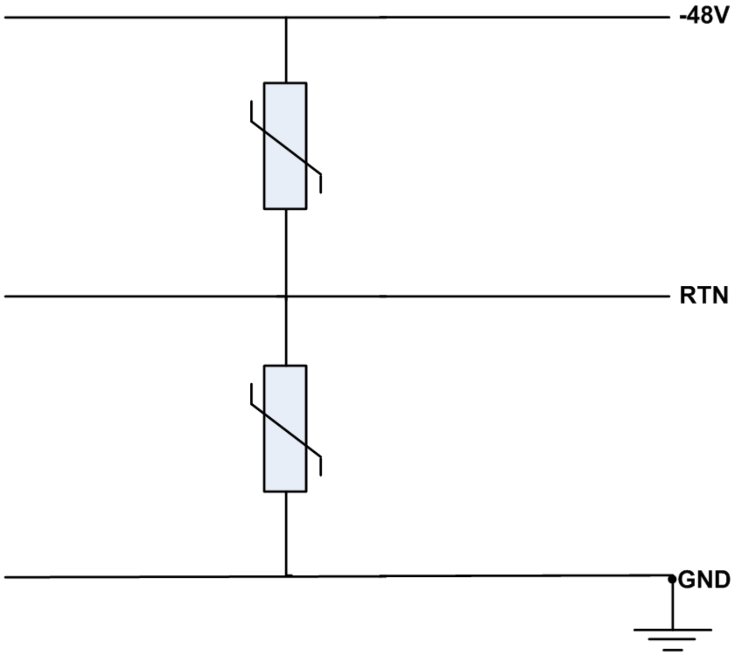
Mobile Telephone/WiFi RRH protection

- The ***legacy*** principal is from AC power protection:
- **MOV protection mode from Line – Return.**
  - Low let-through
  - Lower surge currents
  - Predictable voltage
- **GDT protection mode from Return – Ground**
  - Higher let-through
  - Higher ground swings
  - Crowbars to 0 V



Mobile Telephone/WiFi RRH protection

- Recent changes in DC SPD approvals in IEC and UL requirements will not allow a GDT in the N-G mode.
- If Line is shorted to GND, the RTN will fire the GDT and crowbar fault.
- Now, both modes for DC power protection should be MOVs.



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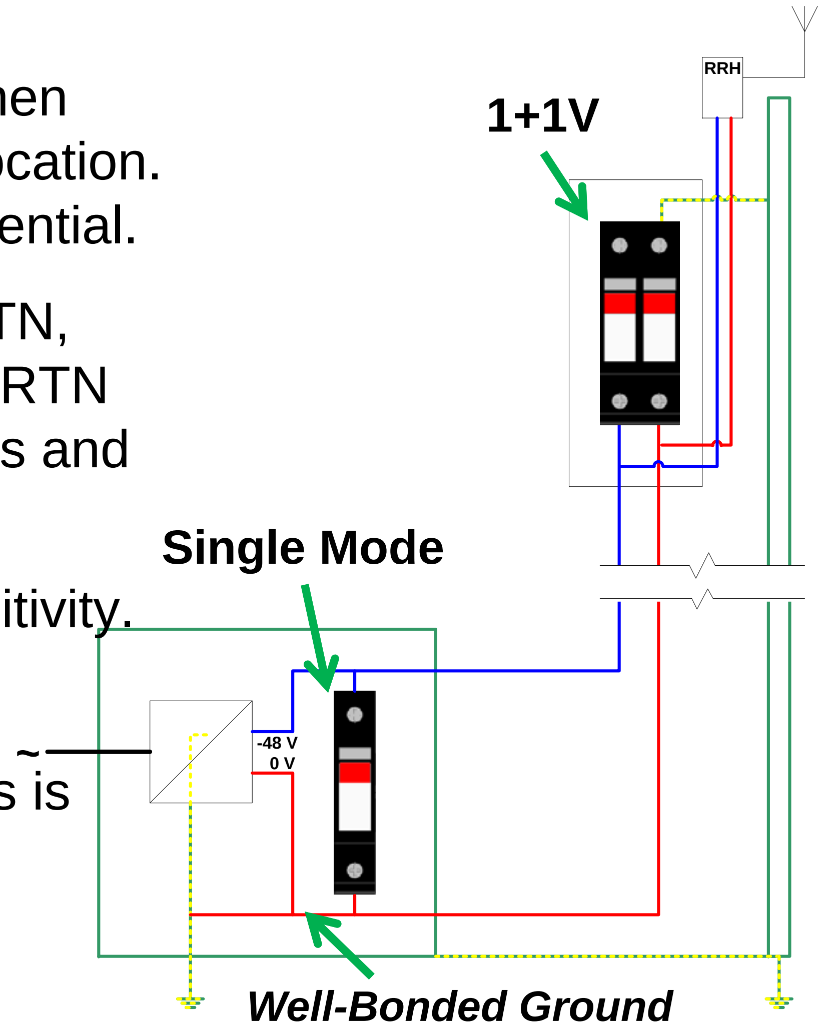
SPD Overview

- IF the DC output is RTN-PE bonded, then there is no need to place SPD at this location. There is “no” risk of RTN –to- GND potential.
- At the radio device, at least two of L-RTN, RTN-PE or L-PE modes are required. RTN should be floating to avoid ground loops and associated AC noise.
  - Choice of modes depends on sensitivity.
- AC and data protection from the utilities is also essential



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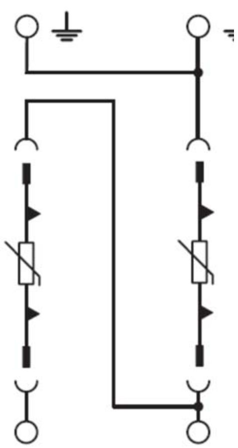
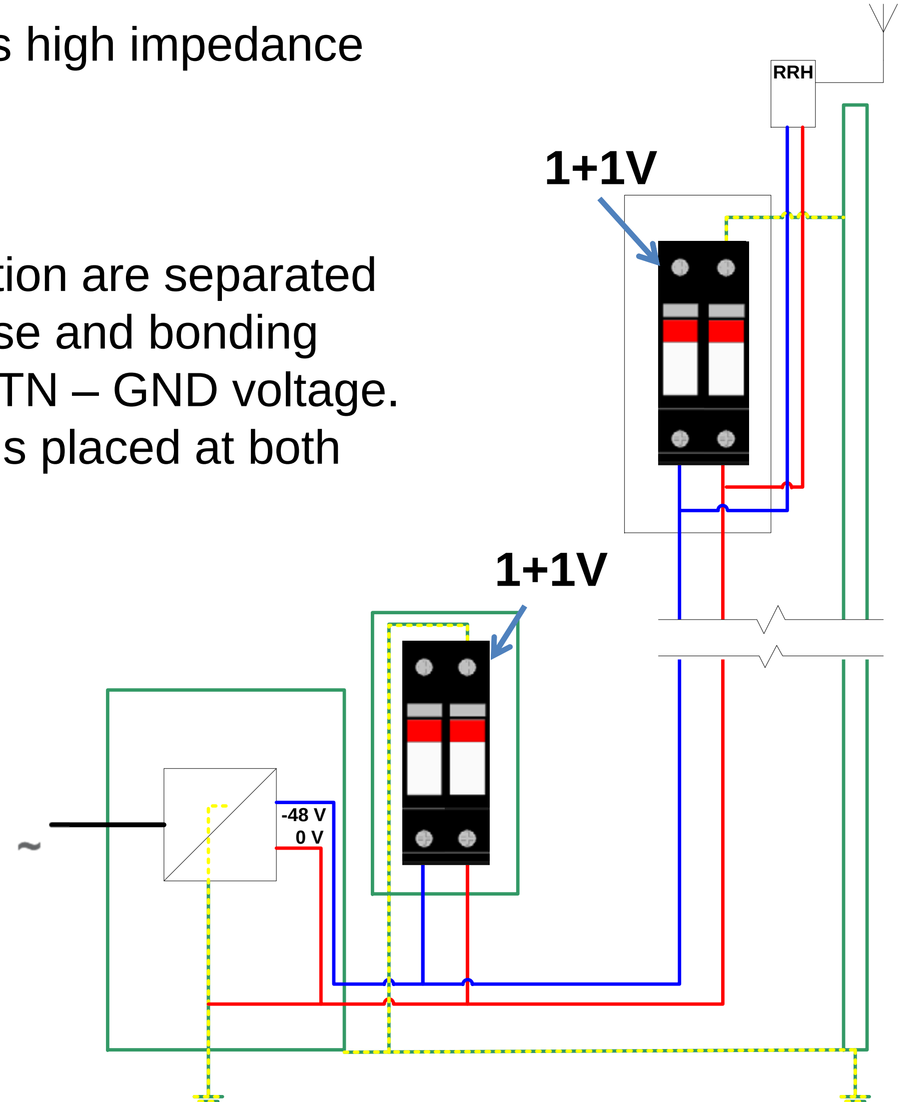
Product Overview

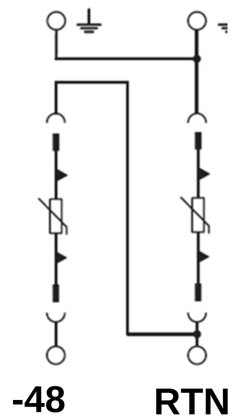
- If DC outputs are floating, or SPD has high impedance bond, 2 modes are required.
- VAL-MS 1+1 Base simplifies wiring.
- When the power rectifier and distribution are separated by as little as 2 m, ground potential rise and bonding impedance can create a significant RTN – GND voltage. In this condition, a 1+1 configuration is placed at both locations.



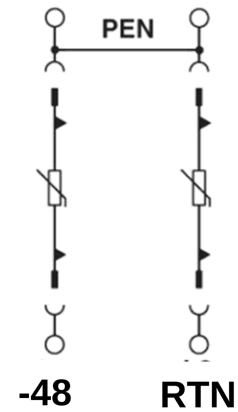


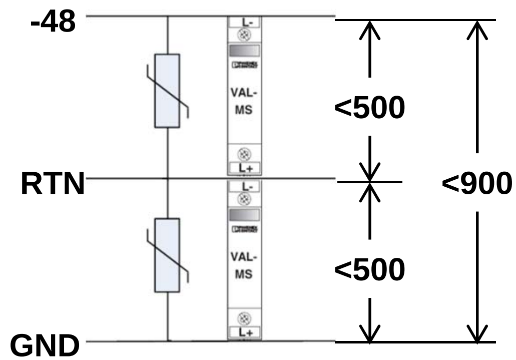
Parallel vs. Series
1+1V vs. 2+0

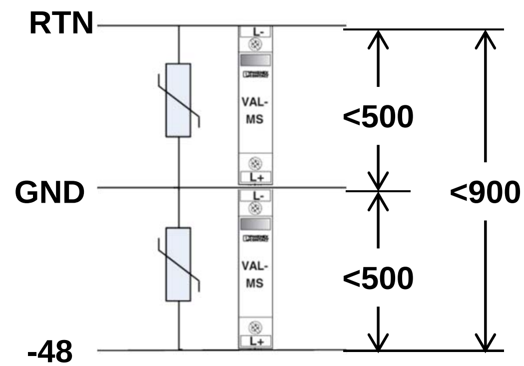
1+1V Configuration



2+0 Configuration







Why Fiber to the Antenna?

- 4G Network Driving Factors
  - Demands of advancing technology
    - Faster data rates
    - Higher data throughput
  - Economic pressures
    - ❑ Reduced power
    - ❑ Smaller base station
    - ❑ Reduced cost of operation
  - Sustainability of design
    - ❑ Reduced weight of tower
    - ❑ Need for lightning & environmental protection

Many Benefits

with Manageable Risks.

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