Resistibility vs. IEC 62305 “Lightning protection” standard and for ports connected to multiple conductors

Roberto Pomponi
Telecom Italia, Italy

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- Resistibility requirements for ports connected to multiple conductors of external d.c. or a.c. dedicated power feeding cables

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Rated impulse withstand voltage U_w

- Definition (IEC 62305-2 standard, clause 3.1.8)
  - Impulse withstand voltage assigned by the manufacturer to the equipment or part of it, characterizing the specified withstand capability of its insulation against overvoltages

    Note – For the purpose of this standard, only withstand voltage between live conductors and earth is considered

Equipment impulse withstand voltage according to IEC 62305-4 standard (1)

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- The withstand level of the power installation is defined in IEC 60664-1 (rated impulse withstand voltage 1,5 – 2,5 – 4 and 6 kV)
  - This is only an insulation coordination test. During the test the equipment is de-energized
- The withstand level of telecommunication equipment is defined in ITU-T K.20 and K.21
- The withstand level of general equipment is defined in their product specifications or can be tested
  - against conducted surges, using IEC 61000-4-5 with test levels for voltage: 0,5 – 1 – 2 - 4 kV at 1,2/50 µs waveshape and with test levels for current: 0,25 – 0,5 – 1 – 2 kA at 8/20 µs waveshape
  - against magnetic fields, using IEC 61000-4-9 with test levels: 100 – 300 – 1 000 A/m at 8/20 µs waveshape and IEC 61000-4-10 with test levels: 10-30-100 A/m at 1 MHz.

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Equipment impulse withstand voltage according to IEC 62305-4 standard (2)

- Equipment not complying with radio frequency (RF), radiated emission and immunity tests, as defined by the relevant EMC product standards, can be at risk due to directly radiated magnetic fields into it. On the other hand, the failure of equipment complying with these standards can be neglected.

Conclusion proposal:
SG 5 should suggests to IEC TC 77 to define for power interface port of any type of equipment:
• resistibility requirements and test procedure in accordance with K.20 or K.21 taking into account IEC 60664-1 requirements

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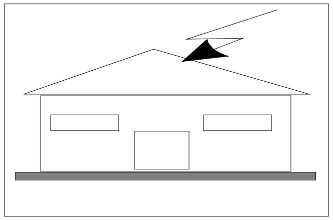
Risk components

Risks

Lightning as source of damages (IEC 62305 standard)

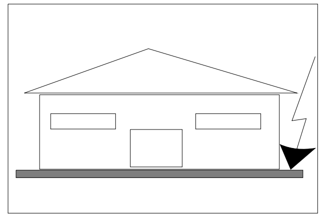


Direct to the structure

R_A Injury to people

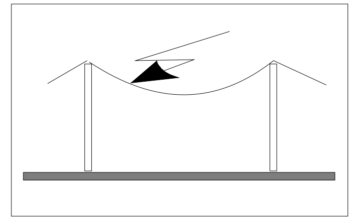
R_B Physical damage

R_C Equipment failure



Close to the structure

R_M Equipment failure

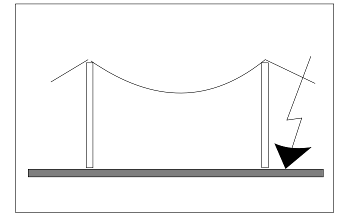


Direct to the tlc line

R_U Injury to people

R_V Physical damage

R_W Equipment failure



Close to the tlc line

R_Z Equipment failure

R1: Risk of loss of human life = $R_A+R_B+R_U+R_V$ $+(R_C+R_W+R_M+R_Z)$

R2: Risk of loss of service = $R_B+R_C+R_V+R_W+R_M+R_Z$

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Risk components: Basic equations

$$R_x = N_x \times P_x \times L_x$$

N_x Number of dangerous events
P_x Probability of damage
L_x Consequent loss of the damage

$$N_x = N_g \times A_x$$

N_g Ground flash density [Flash number/km²×year]
A_x Collection area

- A_d for direct strokes
- A_M for lightning close to the structure
- A_L for direct lightning to the service
- A_i for lightning near the service

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Probability due to direct lightning to the services

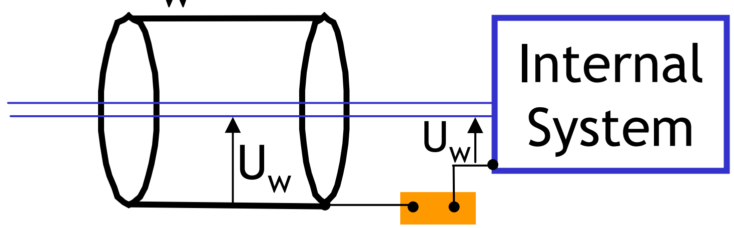
P_U (injury to living beings)

P_V (physical damage)

- ⇨ P = $p(I_a)$; I_a is the failure current
- ⇨ For unshielded line I_a = 0 and P = 1 (approximation)
- ⇨ For shielded line I_a depends on:
- \- Shield resistance per unit length of the service: R_s;
- \- Impulse withstand voltage of the internal systems connected to the services: U_w

K.47

$$I_a = \frac{2 \times U_w}{8 \times R_s \times K_p \times \sqrt{\rho}}$$



K_p	Protection factor value of the protection measure
ρ	soil resistivity for buried cable
	effective soil resistivity for aerial cable

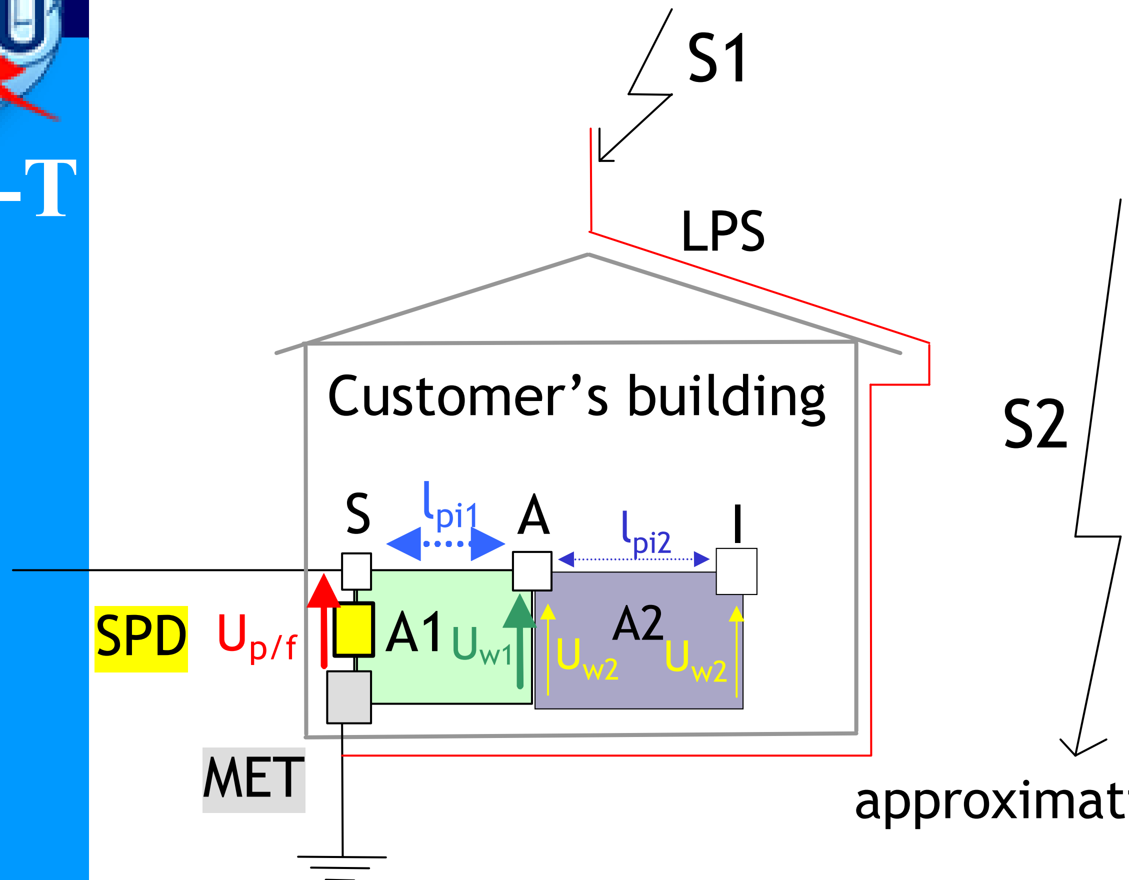
Probability Table P_U and P_V

Red values missed in the IEC standard

Probability P_U and P_V			
U_w kV	$5<R_S\leq20$ (Ω/km)	$1<R_S\leq 5$ (Ω/km)	$R_S\leq1$ (Ω/km)
1	1	0,9	0,6
1,5	1	0,8	0,4
2,5	0,95	0,6	0,2
4	0,9	0,3	0,04
6	0,8	0,1	0,02

- P_U and P_V ⇨ U_W is the insulation breakdown voltage of the line, including the terminal equipment
  - The lowest U_w is inside the equipment
  - The values of this voltage U_w are the resistibility levels. Is it correct?

Induction protection distance, l_{pi}



Loop A1

$$l_{pi1} = \frac{U_{w1} - U_{p(f)}}{h}$$

$h = f(.., K_{S2}, ..)$

K_{S2} internal shields

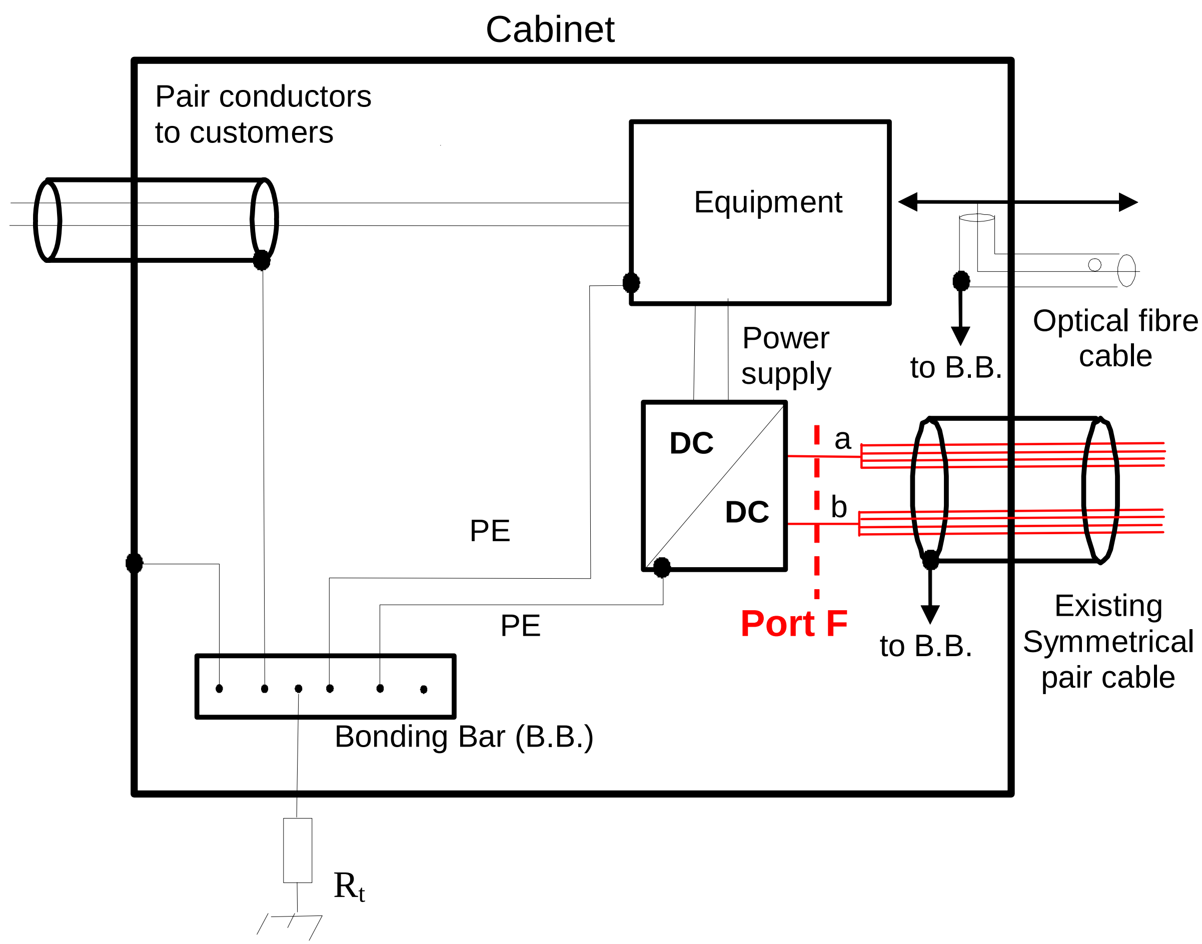
Loop A2: not in the IEC standard

approximation $$l_{pi2} = \frac{U_{w2}}{h}$$

U_{w2} withstand voltage of the equipment port connected to both an unshielded or shielded cable.

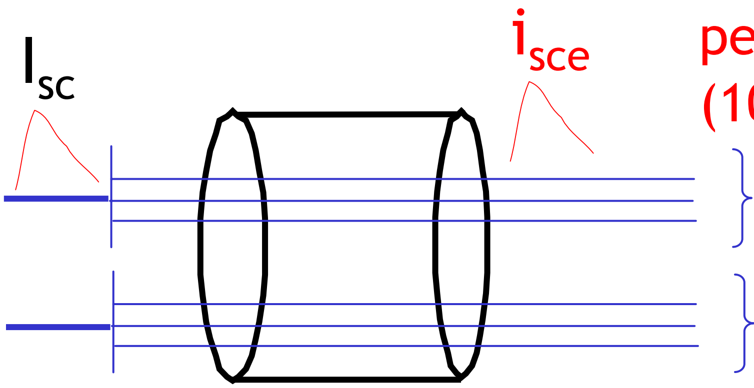
- For shielded line, this value is not defined by K.20 or K.21:
  - the test voltage is applied between shield and earth

Broadband services: Fibre to the curb



Remote site: Multiple conductors of an external dc or a.c. dedicated remote power feeding circuit

Expected lightning overcurrents



peak value of short circuit current (10/350 μs) of each conductor

m conductors

e.g. m = 30 - 50

m conductors

Short circuit current of each conductor in the remote site can be assumed equal to the short circuit current measured at the exchange end

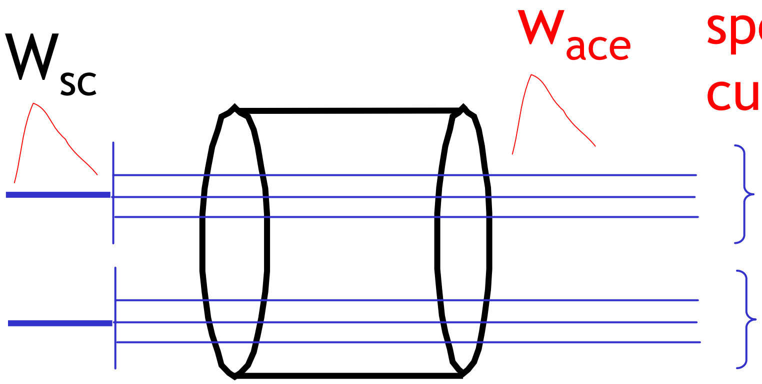
Table 5/K.67	
i_{sce} [A]	p
35	0,01
25	0,02
15	0,05

$$I_{sc} = m \times i_{sce} \times f(k_s, m)$$

$f(k_s, m)$ shielding factor

Probably this shielding factor is already included in the value of Table 5/K.67

Expected power frequency overcurrents



specific energy of short circuit current of each conductor

m conductors

m conductors

$w_{ace} = 0{,}2\ A^2s$ Rec. K.45

$$W_{sc} = m \times i_{sce} \times g(k_s, m)$$

$g(k_s, m)$ shielding factor

Resistibility requirements for ports connected to multiple conductors

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- After the evaluation of the expected overcurrents, the definition of the resistibility and protection requirements for port connected to multiple conductors of external d.c. or a.c. dedicated power feeding circuit could be discussed
- For example:
  - $f(k_s,m) = 1$; $m = 50$; $i_{sce} = 35A$
    $I_{sc} = 1750$ A 10/350 μs
  - Possible resistibility requirements:
    - Port tested with 1750 A 10/350 or equivalent

    or

    - Port always protected with GDTs with $I_{imp} \geq 2$ kA 10/350
    - Inherent resistibility requirements: in accordance with K.45

Conclusion

- SG 5 should suggest to IEC TC 77 to define resistibility requirements and test procedure for power ports of any type of equipment based on K.21 test procedure and IEC 60664-1 requirements
- The insulation flashover inside the equipment is equivalent to the equipment resistibility value?
- For internal shielded lines, is it convenient that the equipment resistibility value is given in a different manner respect to the all other cases?
  - Possible solution: same resistibility requirement for unshielded or shielded internal line
- In the development of the broadband services, it could be useful to define the Resistibility requirements for ports connected to multiple conductors

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