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ITU-T K.20 – Rationale for setting resistibility requirements of telecommunication equipment installed in a telecommunication centre against lightning

ITU-T K-series Recommendations – Supplement 24

ITU-T



Supplement 24 to ITU-T K-series Recommendations

ITU-T K.20 – Rationale for setting resistibility requirements of telecommunication equipment installed in a telecommunication centre against lightning

Summary

The technical information (rationale) that the discussions around setting the resistibility requirements of telecommunication equipment installed in a telecommunication centre against lightning in Recommendation ITU-T K.20 were based on is shown in past contributions to ITU-T SG5 and various other documents. However, it has not yet been organized in the form of any informative document and is therefore not easy to find. Furthermore, users of Recommendation ITU-T K.20 who do not have an ITU account cannot access such information in the form of contributions or other documents.

Therefore, Supplement 24 to the ITU-T K-series Recommendations includes the technical information (rationale) on which the requirements for resistibility against lightning in ITU-T K.20 are based, which comes from past contributions and other documents discussed in ITU-T SG5.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

Injector, link, network powered device (NPD), power over data line (PoDL), power over Ethernet (PoE), power source equipment (PSE).

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Supplement 24 to ITU-T K-series Recommendations

ITU-T K.20 – Rationale for setting resistibility requirements of telecommunication equipment installed in a telecommunication centre against lightning

1 Scope

This Supplement provides the technical information (rationale) for setting the resistibility requirements against lightning in [ITU-T K.20]. This information should be referred to for any revision of [ITU-T K.20]. The rationale described in this Supplement is mainly quoted from past contributions and other documents discussed in ITU-T SG5 during the establishment and revision of [ITU-T K.20].

Also, this Supplement intends to include any rationale for the revision of [ITU-T K.20] in case it is revised.

2 References

- [ITU-T K.20] Recommendation ITU-T K.20 (2021), *Resistibility of telecommunication equipment installed in a telecommunication centre to overvoltages and overcurrents*.
- [ITU-T K.44] Recommendation ITU-T K.44 (2019), *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents - Basic Recommendation*.
- [ITU-T K.99] Recommendation ITU-T K.99 (2017), *Surge protective component application guide – Gas discharge tubes*.
- [ITU-T K.126] Recommendation ITU-T K.126 (2017), *Surge protective component application guide – High frequency signal isolation transformers*.
- [ITU-T K.143] Recommendation ITU-T K.143 (2019), *Guidance on safety relating to the use of surge protective devices and surge protective components in telecommunication terminal equipment*.
- [ITU-T Handbook] Handbook ITU-T (1994), *The Protection of Telecommunication Lines and Equipment Against Lightning Discharges*.
- [IEEE 802.3] IEEE 802.3-2012, *IEEE Standard for Ethernet*.
- [Koga] H. Koga, T. Motomitsu, M. Taguchi (1981), *Lightning Surge Waves Induced in Transmission Lines*, Review of the Electrical Communication Laboratories Vol. 29, Nos 7-8.
- [Miyazaki] T. Miyazaki, S. Okabe, K. Aiba, T. Hirai, J. Yoshinaga (2007), *A Lightning Surge Analysis for the Rationalization of the Ground System in Power Distribution Lines*, IEEJ Trans. PE, Vol. 127, No .2.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses terms defined in [ITU-T K.44].

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AC	Alternating Current
CWG	Combination Wave Generator
DC	direct current
DPF	Dedicated Power Feed
n/a	not applicable
PoE	Power over Ethernet
STP _E	Ethernet Shielded Twisted Pair
USB	Universal Serial Bus
UTP _E	Ethernet Unshielded Twisted Pair Ethernet

5 Conventions

The numbering of tables and figures in this Supplement corresponds to the test numbers in [ITU-T K.20].

6 Rationale

Table 1a and Table 1b refer to the rationale by test and clause number of [ITU-T K.20], using the same structure as Table 1a and Table 1b of [ITU-T K.20], for external ports and internal ports, respectively.

Table 1a – Reference to rationale for each test item – ports connected to external cables

Test type	No. of pairs simultaneously tested	Test connections	Primary protection	Port/reference to rationale (Test No. in [ITU-T K.20])			
				Symmetric port	Coaxial port	Dedicated power feed port	Mains power port
Lightning/voltage	Single	Transverse/differential	No	Not clarified (2.1.1a)	Not clarified (3.1.1)	Not clarified (4.1.1a)	Not clarified (5.1.1a)
		Port to earth	No	Clause 6.1.1 (2.1.1b)	n/a	Clause 6.1.3 (4.1.1b)	Clause 6.1.4 (5.1.1b)
		Port to external port	No	n/a	n/a	n/a	Clause 6.1.4 (5.1.1c)
		Coordination /Transverse/differential	Yes	Not clarified (2.1.2a)	Not clarified (3.1.2)	Not clarified (4.1.2a)	Not clarified (5.1.2a)
		Coordination /Port to earth	Yes	Clause 6.1.1 (2.1.2b)	n/a	Clause 6.1.3 (4.1.2b)	Clause 6.1.4 (5.1.2b)
		Coordination /Port to external port	Yes	Not clarified (2.1.2c)	n/a	n/a	Clause 6.1.4 (5.1.2c)

Table 1a – Reference to rationale for each test item – ports connected to external cables

Test type	No. of pairs simultaneously tested	Test connections	Primary protection	Port/reference to rationale (Test No. in [ITU-T K.20])				
				Symmetric port	Coaxial port	Dedicated power feed port	Mains power port	
	Multiple	Port to earth	No	Not clarified (2.1.3a)	n/a	n/a	n/a	
		Port to external port	No	Not clarified (2.1.3b)	n/a	n/a	n/a	
		Port to earth	Yes	Not clarified (2.1.4a)	n/a	n/a	n/a	
		Port to external port	Yes	Not clarified (2.1.4b)	n/a	n/a	n/a	
	Ethernet unshielded twisted pair (UTP _E)	Port to earth	No	Clause 6.1.1 (2.1.8)	n/a	n/a	n/a	
		Transverse	No	Not clarified (2.1.7)	n/a	n/a	n/a	
		Voltage impulse test	No	Clause 6.1.1 (2.1.10)	n/a	n/a	n/a	
		Power over Ethernet (PoE)	No	Not clarified (2.1.11)	n/a	n/a	n/a	
	Ethernet shielded twisted pair (STP _E)	Shield to earth	No	Clause 6.1.1 (2.1.8)	n/a	n/a	n/a	
		Port to earth	No	Clause 6.1.1 (2.1.9)	n/a	n/a	n/a	
	Lightning current	Single	Port to earth	No	Not clarified (2.1.5a)	n/a	Not clarified (4.1.5a)	n/a
			Port to external port	No	n/a	n/a	n/a	n/a
		Multiple	Port to earth	No	n/a	Not clarified (3.1.3)	n/a	n/a
			Port to external port	No	n/a	Not clarified (3.1.4)	n/a	n/a
Differential			n/a	n/a	Not clarified (3.1.5)	n/a	n/a	
Shield to earth			n/a	Not clarified (2.1.6a)	n/a	n/a	n/a	
Shield to external port	n/a	n/a	n/a	n/a	n/a	n/a		

n/a: This test is not applicable to this port in [ITU-T K.20].

Table 1b – Reference to rationale for each test item – internal port

No. of pairs simultaneously tested	Test connection	Primary protection	Port/reference to rationale (Test No. in [ITU-T K.20])				
			Unshielded cable	Shielded cable	PoE power feed	DC powered equipment	DC power source
Single	Shielded cable to earth	No	n/a	Not clarified (7.2)	n/a	n/a	n/a
	USB shielded cable to earth	No	n/a	Not clarified (7.3)	n/a	n/a	n/a
	STP _E Ethernet simultaneous port to earth	No	n/a	Clause 6.2 (7.4)	n/a	n/a	n/a
	UTP _E /STP _E Ethernet transverse	No	Clause 6.1.1 (7.7)	Clause 6.1.1 (7.7)	n/a	n/a	n/a
	DC powered equipment port	No	n/a	n/a	n/a	Not clarified (7.8)	n/a
	DC power source port	No	n/a	n/a	n/a	n/a	Not clarified (7.9)
Multiple	Unshielded cable with symmetric pairs	No	Not clarified (7.1)	n/a	n/a	n/a	n/a
	PoE Mode A and Mode B transverse testing	No	n/a	n/a	Not clarified (7.5)	n/a	n/a
	UTP _E Ethernet port rated impulse voltage	No	Clause 6.2 (7.6)	n/a	n/a	n/a	n/a

6.1 Ports connected to external cables

6.1.1 External symmetric pair cables

Table 2-1 shows references to table No. and rationale No. for ports connected to external symmetric pair cables. Table 2-2 shows the rationale for ports connected to external symmetric pair cables.

Table 2-1 – Reference to rationale for ports connected to external symmetric pair cables

Test no.	Test description	Test circuit and waveform	Test levels		Reference to rationale
2.1.1b	Single pair, lightning, inherent, port to earth	A.3-1 and A.6.1-2 10/700	Basic	$U_{c(max)} = 1.0 \text{ kV}$ $R = 25 \Omega$	Table 2-2 No.1, No.5, No.6
			Enhanced	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	To be clarified
2.1.2b	Single pair, lightning, coordination, port to earth	A.3-1 and A.6.1-2 10/700	Basic	$U_{c(max)} = 4.0 \text{ kV}$ $R = 25 \Omega$	To be clarified
			Enhanced	$U_{c(max)} = 4.0 \text{ kV}$ $R = 25 \Omega$	Table 2-2 No.2
2.1.3a	Single pair, lightning, coordination, port to earth	A.3-1 and A.6.1-4 10/700	Basic	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	To be clarified
			Enhanced	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	To be clarified
2.1.4a	Single pair, lightning, coordination, port to earth	A.3-1 and A.6.1-4 10/700	Basic	$U_{c(max)} = 4.0 \text{ kV}$ $R = 25 \Omega$	To be clarified
			Enhanced	$U_{c(max)} = 6.0 \text{ kV}$ $R = 25 \Omega$	To be clarified
2.1.8	Ethernet longitudinal/ common mode to transverse/ differential mode conversion tests	A.3-5 and A.6.7-4 1.2/50-8/20 CWG $R = 10 \Omega$	Basic	$U_{c(max)} = 2.5 \text{ kV}$	Table 2-2 No.3, No.4
			Enhanced	$U_{c(max)} = 6.0 \text{ kV}$	Table 2-2 No.3
2.1.9	Screen/shield connection high current test	A.3-5 and A.6.7-6 1.2/50-8/20 CWG $R = 5 \Omega$	Basic	$U_{c(max)} = 2.5 \text{ kV}$	Table 2-2 No.3, No.4
			Enhanced	$U_{c(max)} = 6.0 \text{ kV}$	Table 2-2 No.3
2.1.10	UTP _E port rated impulse voltage test	A.3-5 and A.6.7-3a 1.2/50-8/20 CWG $R = 5 \Omega$	Basic	$U_{c(max)} = 2.5 \text{ kV}$	Table 2-2 No.3, No.4
			Enhanced	$U_{c(max)} = 6.0 \text{ kV}$	Table 2-2 No.3

Table 2-2 – Rationale for ports connected to external symmetric pair cables

No.	Source	Rationale	Date rationale added
1	[Koga] Clause 4.3.1 "Lightning Surge Voltage Distribution"	Quoted from source document; Office end. $N_s = 3.6 * 103 * V - 1.8$ (See dashed line in Figure 2-1)	9/2019
2	Agreed in ITU-T SG5	This enhanced coordination test level is in line with the basic test level of this test, because it is not necessary to consider bad condition of earthing and bonding in contrast to customer premise.	3/2020
3	Agreed in ITU-T SG5	This "Ethernet port" test level is in line with the test level of "Mains power port, lightning, inherent, port to earth (clause 5.1.1b of [ITU-T K.20])"; 2.5 kV (basic), 6.0 kV (enhanced).	3/2020
4	[IEEE 802.3] Clause 25.4.6 "UTP isolation requirement"	Quoted from source document: "This electrical isolation shall withstand at least one of the following electrical strength tests... c) A sequence of ten 2400 V impulse alternative polarity, applied at intervals of not less than 1 s. The shape of the impulse shall be 1.2/50 μ sec (1.2 μ s virtual front time, 50 μ s virtual time of half value), as defined in IEC 60950-1:2001 Annex N"	3/2020
5	[ITU-T Handbook] Chapters 9 and 10 Chapter 10 "Overvoltages and overcurrents measured on telecommunication subscriber lines"	Quoted from source document; Table 10-4 "Voltage end current occurrences in rural area" Table 10-5 "Voltage end current occurrences in urban/suburban area" (See "Subscriber end – voltage" in Figure 2-2 and Figure 2-3.)	3/2020
6	[ITU-T Handbook] Appendix, Chapters 9 and 10, Appendix V "Measurement result in Japan"	Quoted from source document; Figure V-4 "Peak voltage occurrences (telephone end for subscriber cable)" (See Figure 2-4.)	3/2020

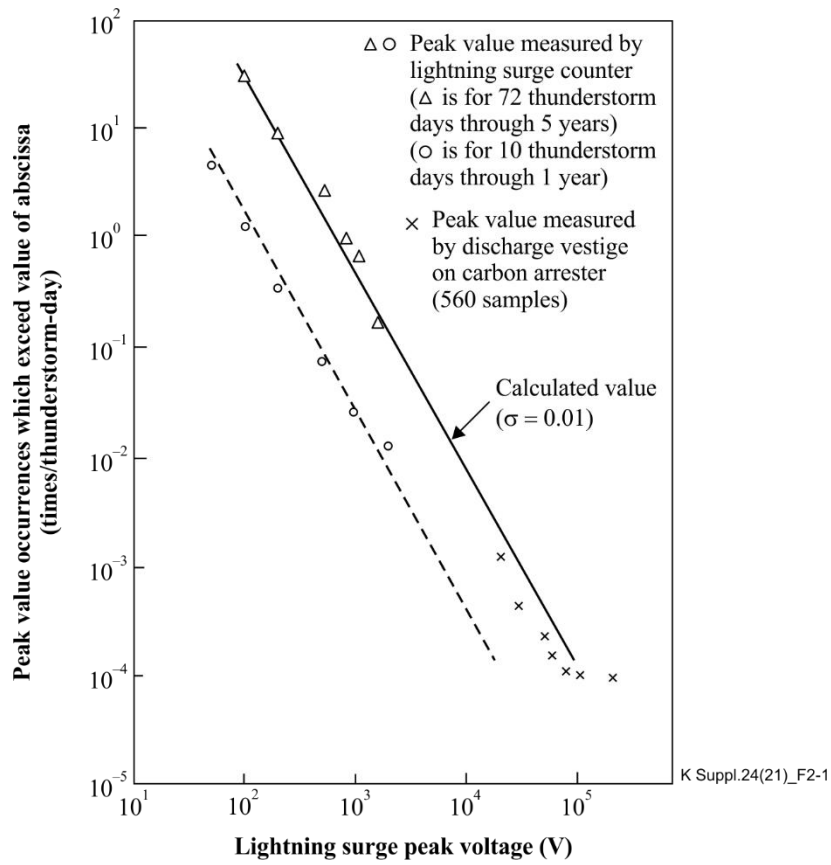


Figure 2-1 – Peak voltage distribution (Figure 15 of [Koga])

Location		Voltage and current occurrences: N_i (Time/year · lines)	Soil resistivity (Ω -m)	Average length (m)	Number of lines
Exchange end	Voltage	F: $N_{1v} = 1.3 \cdot 10^5 \cdot T_d \cdot V_p^{-2.1}$ D: $N_{1v} = 4.4 \cdot 10^5 \cdot T_d \cdot V_p^{-2.1}$ I: $N_{1v} = 1.5 \cdot 10^4 \cdot T_d \cdot V_p^{-1.7}$ J: $N_{1v} = 12.5 \cdot 10^3 \cdot T_d \cdot V_p^{-2}$ USA: $N_{1v} = 5.7 \cdot 10^5 \cdot T_d \cdot V_p^{-2.1}$	~300 30-60 900 30-100 700-8 000	6 200 5 000 4 500 4 400 12 750	54 18 9 10 1
	Current	I: $N_{1i} = 7.3 \cdot T_d \cdot I_p^{-1.1}$ J: $N_{1i} = 1.2 \cdot T_d \cdot I_p^{-1.8}$ USA: $N_{1i} = 1.9 \cdot T_d \cdot I_p^{-1.2}$	1500 30-100 700-8 000	6 725 3 000 12 750	2 100 1
Subscriber end	Voltage	I: $N_{2v} = 2.3 \cdot 10^5 \cdot T_d \cdot V_p^{-1.8}$ J: $N_{2v} = 1.05 \cdot 10^5 \cdot T_d \cdot V_p^{-1.8}$ USA: $N_{2v} = 5.3 \cdot 10^5 \cdot T_d \cdot V_p^{-1.8}$	875 30-100 ~700	3 800 4 400 11 700	12 10 3
	Current	I: $N_{2i} = 43.3 \cdot T_d \cdot I_p^{-1.55}$ J: $N_{2i} = 11 \cdot T_d \cdot I_p^{-1.8}$ USA: $N_{2i} = 26 \cdot T_d \cdot I_p^{-1.45}$	1000 50-100 ~700	4 000 3 000 11 700	5 100 3

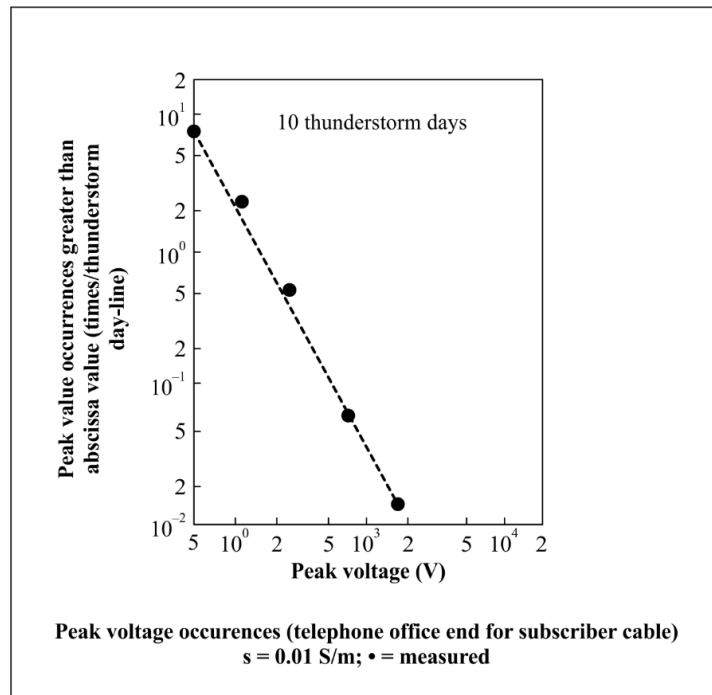
(Labelled: France (F), Germany (D), Italy (I), Japan (J) and the United States of America (USA))

**Figure 2-2 – Voltage end current occurrences in rural area
(Table 10-4 of [ITU-T Handbook])**

Location		Voltage and current occurrences: N_i (Time/year · lines)	Soil resistivity ($\Omega \cdot m$)	Average length l (m)	Number of lines
Exchange end: Voltage	Suburban urban	D: $N_{1v} = 5.2 \cdot 10^4 \cdot T_d \cdot V_p^{-2.1}$	30-60	3 200	34
		D: $N_{1v} = 5.8 \cdot 10^3 \cdot T_d \cdot V_p^{-2.1}$	30-60	1 200	19
Exchange and Subscriber end: Current	Urban/ suburban	CAN: $N_{2i} = 1.4 \cdot 10^{-2} \cdot T_d \cdot I_p^{-0.8}$	10-1 000		2 350

(Labelled: Canada (CAN), Germany (D))

**Figure 2-3 – Voltage end current occurrences in urban/suburban area
(Table 10-6 of [ITU-T Handbook])**



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Figure 2-4 – Peak voltage occurrences (telephone end for subscriber cable) in Japan (Figure V-5 of [ITU-T Handbook])

6.1.2 Lightning test for ports connected to external coaxial cables

Table 3-1 shows the references to rationale for ports connected to external coaxial cables.

Table 3-1 – Reference to rationale for ports connected to external symmetric pair cables

Test no.	Test description	Test circuit and waveform	Test levels		Reference to rationale
3.1.1	Lightning, inherent, differential	A.3-5 and A.6.2-1 1.2/50 – 8/20 CWG	Basic	$U_{c(max)} = 1.0 \text{ kV}$ $R = 0 \Omega$	To be clarified
			Enhanced	$U_{c(max)} = 1.5 \text{ kV}$ $R = 0 \Omega$	To be clarified
3.1.2	Lightning, coordination, differential	A.3-5 and A.6.2-1 1.2/50 – 8/20 CWG	Basic	$U_{c(max)} = 4.0 \text{ kV}$ $R = 0 \Omega$	To be clarified
			Enhanced	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	To be clarified
3.1.3	Lightning, current, differential	A.3-4 and A.6.2-1 8/20	Basic	$I = 1.0 \text{ kA}$	To be clarified
			Enhanced	$I = 5.0 \text{ kA}$	To be clarified
3.1.4	Lightning, shield test, port to earth	A.3-4 and A.6.2-2 8/20	Basic	$I = 4.0 \text{ kA}$ (Note 1) $I = 2.0 \text{ kA}$ (Note 2)	To be clarified
			Enhanced	$I = 20.0 \text{ kA}$ (Note 1) $I = 2.0 \text{ kA}$ (Note 2)	To be clarified

NOTE 1 – Equipment designed to be connected to antennas/equipment exposed to direct lightning currents, e.g., connected to antennas/equipment mounted on a tower.

NOTE 2 – Application equipment not covered by Note 1.

6.1.3 Lightning test for ports connected to external DC or AC dedicated power feeding cables

Table 4-1 shows the references to the rationale shown in Table 4-2 for ports connected to external DC or AC dedicated power feeding cables.

Table 4-1 – Reference to rationale for ports connected to external DC or AC dedicated power feeding cables

Test no.	Test description	Test circuit and waveform	Test levels		Reference to rationale
4.1.1b	Single pair, lightning, inherent, port to earth	A.3-1 and A.6.3-2 10/700	Basic	$U_{c(max)} = 1.0 \text{ kV}$ $R = 25 \Omega$	Table 4-2 No.1
			Enhanced	$U_{c(max)} = 1.5 \text{ kV}$ $R = 25 \Omega$	
4.1.2b	Single pair, lightning, coordination, port to earth	A.3-1 and A.6.3-2 10/700	Basic	$U_{c(max)} = 4.0 \text{ kV}$ $R = 25 \Omega$	Table 4-2 No.1
			Enhanced	$U_{c(max)} = 4.0 \text{ kV}$ $R = 25 \Omega$	

Table 4-2 – Rationale for ports connected to external DC or AC dedicated power feeding cables

No.	Source	Rationale	Date rationale added
1	Agreed in ITU-T SG5	This test level is in line with the test levels of the port connected to external symmetric pair cables.	3/2020

6.1.4 Test for mains power ports

Table 5-1 shows the references to the rationale shown in Table 5-2 for mains power ports.

Table 5-1 – Reference to rationale for mains power ports

Test no.	Test description	Test circuit and waveform	Test levels		Reference to rationale
5.1.1b	Lightning, inherent, port to earth	A.3-5 and A.6.4-2 1.2/50-8/20 CWG	Basic	$U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$	Table 5-1 No.1, No.2, No.3
			Enhanced	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	
5.1.1c	Lightning, inherent, port to external port	A.3-5 and A.6.4-3 1.2/50-8/20 CWG	Basic	$U_{c(max)} = 2.5 \text{ kV}$ $R = 0 \Omega$	Table 5-1 No.1, No.2, No.3
			Enhanced	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \Omega$	

Table 5-1 – Reference to rationale for mains power ports

Test no.	Test description	Test circuit and waveform	Test levels		Reference to rationale
5.1.2b	Lightning, inherent/coordination, port to earth	A.3-5 and A.6.4-2 1.2/50-8/20 CWG	Basic	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \ \Omega$	Table 5-1 No.1, No.2, No.3
			Enhanced	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \ \Omega$	Table 5-1 No.1, No.2, No.3
5.1.2c	Lightning, inherent/coordination, port to external port	A.3-5 and A.6.4-3 1.2/50-8/20 CWG	Basic	$U_{c(max)} = 6.0 \text{ kV}$ $R = 0 \ \Omega$	Table 5-1 No.1, No.2, No.3
			Enhanced	$U_{c(max)} = 10.0 \text{ kV}$ $R = 0 \ \Omega$	Table 5-1 No.1, No.2, No.3

Table 5-2 – Rationale for mains power ports

No.	Source	Rationale	Date rationale added
1	[ITU-T K.143]	Quoted from source document; Fig. 5 "Occurrence rate of lightning voltage on LV power distribution line" (See Figure 5-1) "The occurrence rate for lightning surges on low-voltage (LV) power distribution lines in Japan is shown in Figure 5 (of [ITU-T K.143])."	10/2020
2	[Miyazaki]	Quoted from source document; Fig.6 "Distribution of voltage at low-voltage line" (See Figure 5-2)	10/2020
3	Agreed in ITU-T SG5	This requirement is specified based on the situation that overvoltage of approximately 1 kV/floor appears on the AC mains power cable, especially if supplying AC mains to equipment installed on a different floor, such as a rectifier or air conditioning equipment within a telecommunication centre building, in the case of direct lightning strike on the building.	5/2021

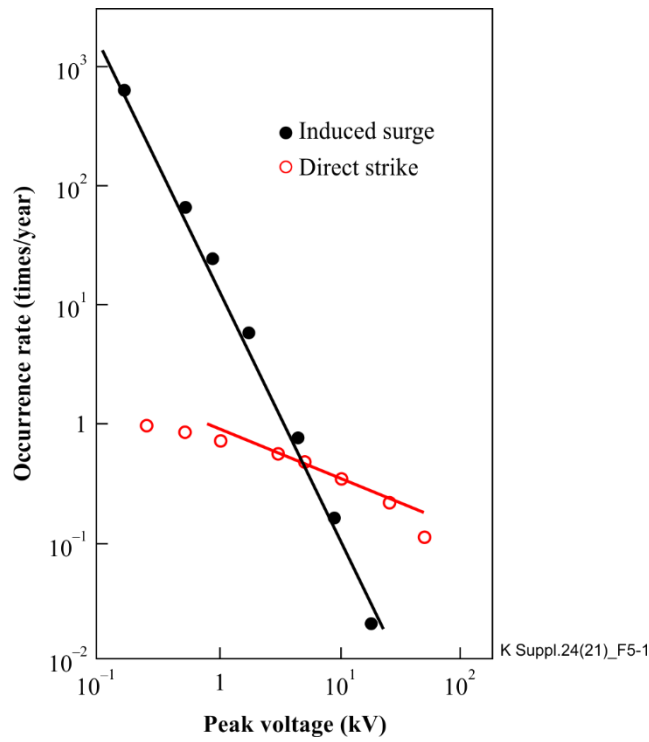


Figure 5-1 – Occurrence rate of lightning voltage on LV power distribution line (Figure 5 of [ITU-T K.143])

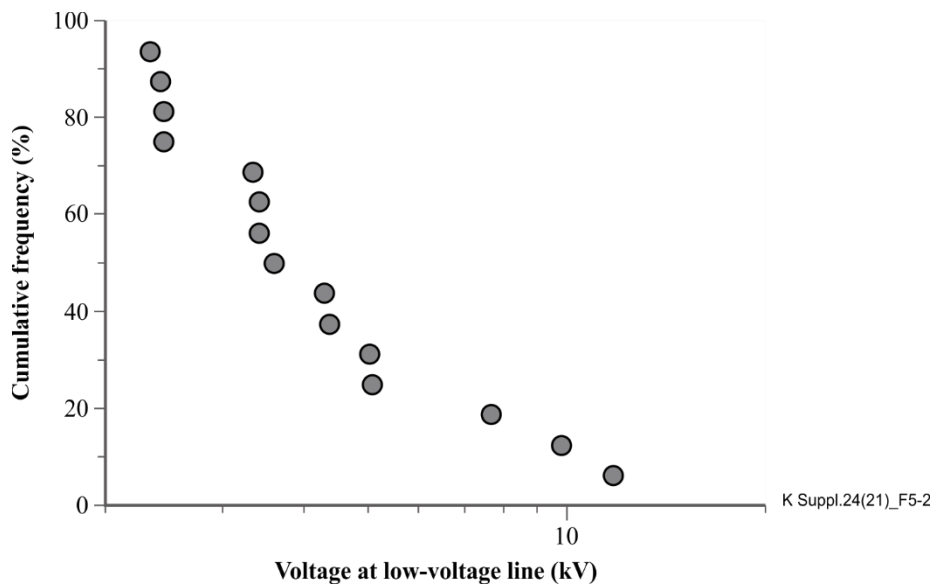


Figure 5-2 – Distribution of voltage at low-voltage line in Japan (Figure 6 of [Miyazaki])

6.2 Ports connected to internal cables

Table 6-1 shows the references to the rationale shown in Table 6-2 for ports connected to internal cables.

Table 6-1 – Reference to rationale for ports connected to internal symmetric pair cables

Test no.	Test description	Test circuit and waveform	Test levels		Reference to rationale
7.3	USB shielded cable to earth	A.3-5 and A.6.5-2 1.2/50-8/20 CWG R = 0 Ω	Basic	$U_{c(max)} = 100 \text{ V}$	To be clarified
			Enhanced	$U_{c(max)} = 150 \text{ V}$	
7.4	Screen/shield connection high current test	A.3-5 and A.6.7-3a 1.2/50-8/20 CWG R = 5 Ω	Basic	$U_{c(max)} = 2.5 \text{ kV}$	Table 6-2 No.1, No.2
			Enhanced	$U_{c(max)} = 4.0 \text{ kV}$ (NOTE)	Table 6-2 No.3, No.4
7.6	Ethernet longitudinal/common mode withstand test	A.3-5 and A.6.7-3a 1.2/50-8/20 CWG R = 5 Ω	Basic	$U_{c(max)} = 2.5 \text{ kV}$	Table 6-2 No.1, No.2
			Enhanced	$U_{c(max)} = 4.0 \text{ kV}$ (NOTE)	Table 6-2 No.3, No.4
7.7	Ethernet transverse	A.3-5 and A.6.7-5 1.2/50-8/20 CWG	Basic	$U_{c(max)} = 2.5 \text{ kV}$	Table 6-2 No.5, No.6, No.7
			Enhanced	$U_{c(max)} = 4.0 \text{ kV}$ (NOTE)	Table 6-2 No.5, No.6, No.7
7.8	DC powered equipment port	A.3-5 (1.2/50-8/20 CWG) and A.6.6-1a Coupling element: 10 Ω + 9 μF in series	Basic	$U_{c(max)} = 0.5 \text{ kV}$	To be clarified
			Enhanced	$U_{c(max)} = 1.0 \text{ kV}$	
7.9	DC power source port	A.3-5 (1.2/50-8/20 CWG) and A.6.6-1b Coupling element: 10 Ω + 9 μF in series	Basic	$U_{c(max)} = 0.5 \text{ kV}$	To be clarified
			Enhanced	$U_{c(max)} = 1.0 \text{ kV}$	

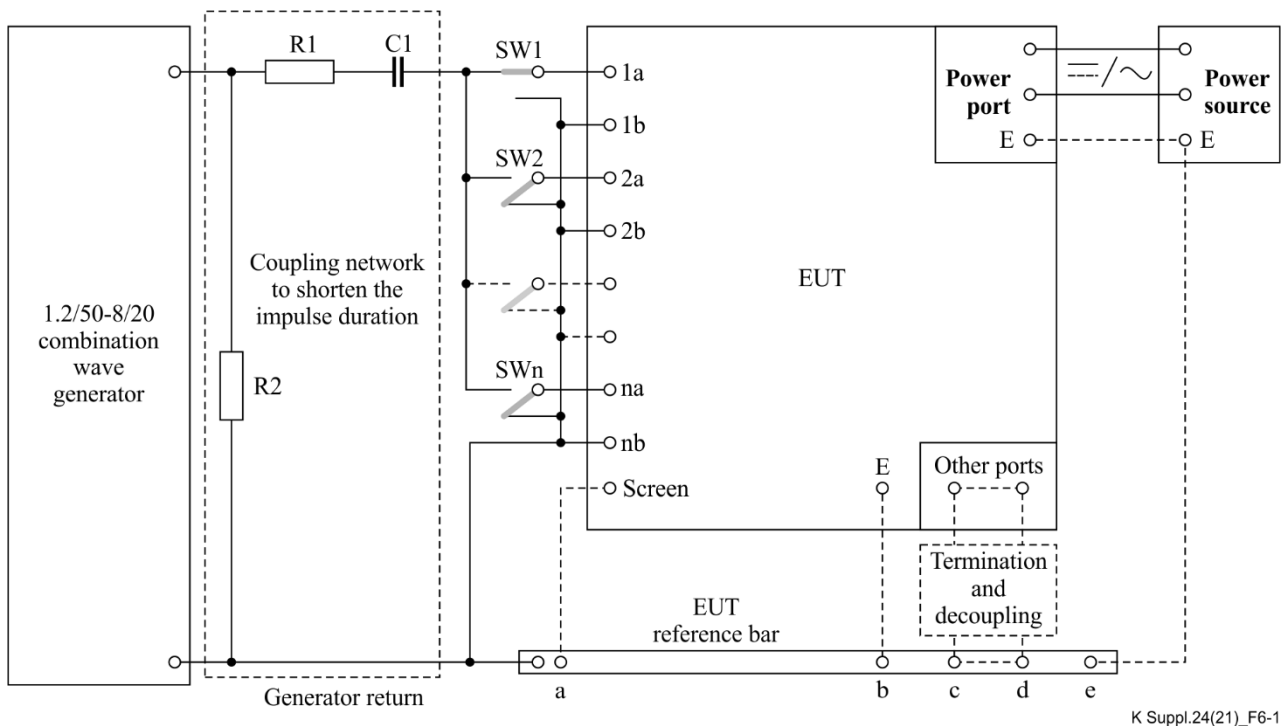
NOTE – The enhanced test level can be 6 kV for equipment intended to be installed in locations with radio towers on the roof of telecommunication centres, see [ITU-T K.40].

Table 6-2 – Rationale for ports connected to internal symmetric pair cables

No.	Source	Rationale	Date rationale added
1	[IEEE 802.3] Clause 25.4.6 "UTP isolation requirement"	Quoted from source document; "This electrical isolation shall withstand at least one of the following electrical strength tests... c) A sequence of ten 2400 V impulse alternative polarity, applied at intervals of not less than 1 s. The shape of the impulse shall be 1.2/50 µsec (1.2 µs virtual front time, 50 µs virtual time of half value), as defined in IEC 60950-1:2001 Annex N"	3/2020
2	Agreed in ITU-T SG5	This basic test level for Ethernet port is in line with the test level of "Mains power port, lightning, inherent, port to earth (clause 5.1.1b of [ITU-T K.20])", 2.5 kV.	3/2020
3	Agreed in ITU-T SG5	Until the (10/2018) version of ITU-T K.20, this enhanced test level for the Ethernet port was in line with the enhanced test level of "Mains power port, lightning, inherent, port to earth (clause 5.1.1b of [ITU-T K.20])", 6.0 kV. As a result of the discussion in ITU-T SG5, this enhanced test level was revised as 4 kV at the version of 11/2019, because the value better represents the general ITU-T K.20 environment for the internal Ethernet port.	3/2020
4	Agreed in ITU-T SG5	This requirement is specified based on the situation that overvoltage of approximately 1 kV/floor appears on the internal Ethernet cable within a telecommunication centre building in a case of direct lightning strike on it.	3/2020
5	Agreed in ITU-T SG5	This transverse/differential test level for Ethernet port is in line with that of "7.6 Ethernet longitudinal/common mode withstand test", because this test is specified as the worst case, that an entire common mode surge converted to transverse/differential mode. However, the current value is adjusted by the capacitor C1 in the test schematic (see Figure 6-1) considering the current that appears on the secondary side of the pulse transformer, etc..	5/2021

Table 6-2 – Rationale for ports connected to internal symmetric pair cables

No.	Source	Rationale	Date rationale added
6	<p>[ITU-T K.99] Appendix IV "Three-electrode GDT operation in Ethernet circuits" IV.2.2 GDT operation</p>	<p>Quoted from source document; "Figure IV.2* substitutes the port magnetics for a low value resistor, R_{AB}, which effectively shunts the 3-electrode GDT outer A and B connected electrodes together. A common mode surge is applied via two current limiting resistors, R_A and R_B to the port and GDT." "If the GDT electrode connected to B is the first to spark-over, it draws current, I_B, from the B conductor and current, I_A, from the A conductor via the resistance R_{AB}, see Figure IV.3**." * See Figure 6-2 in this Supplement. ** See Figure 6-3 in this Supplement.</p>	5/2021
7	<p>[ITU-T K.126] 9.4 Differential mode primary winding surge</p>	<p>Quoted from source document; "9.4.2 Saturating core transformer surge conditions Under differential surge conditions, see Figure 9-10*, a saturating core signal transformer has a secondary winding surge let-through current, I_S, that is typically triangular and can be described by three surge waveform parameters of front, peak and decay as follows: – Waveform front due to transformer linear surge current transfer from primary winding to secondary winding, the current ratio being set by the transformer's primary to secondary turn's ratio, n. – Waveform peak determined by the transformer core saturation event setting the peak secondary current, the event time being set by the transformer's volt-second ($V \cdot s$) value for core saturation. – Waveform decay due to the saturated core secondary winding stored energy dump, the current waveform of which is set by the transformer saturated core winding inductance, the secondary leakage inductance, the peak secondary current, the secondary winding resistance and the secondary load impedance. Figure 9-9** shows an example waveform with the three waveform parameters indicated." * See Figure 6-4 in this Supplement. ** See Figure 6-5 in this Supplement.</p>	5/2021



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Twisted pair terminal pairs are 1a + 1b, 2a + 2b through to na + nb served by switches SW1, SW2 through to SWn, respectively. For each terminal pair, when the switch is up one terminal is connected to the coupling network. When the switch is down that terminal is connected to functional earth.

a = RJ45 screen cable connection for STP_E connections

b = EUT protective or functional earth connection

c to d = Terminals of all other signal ports

R1 = R2 = 10 Ω

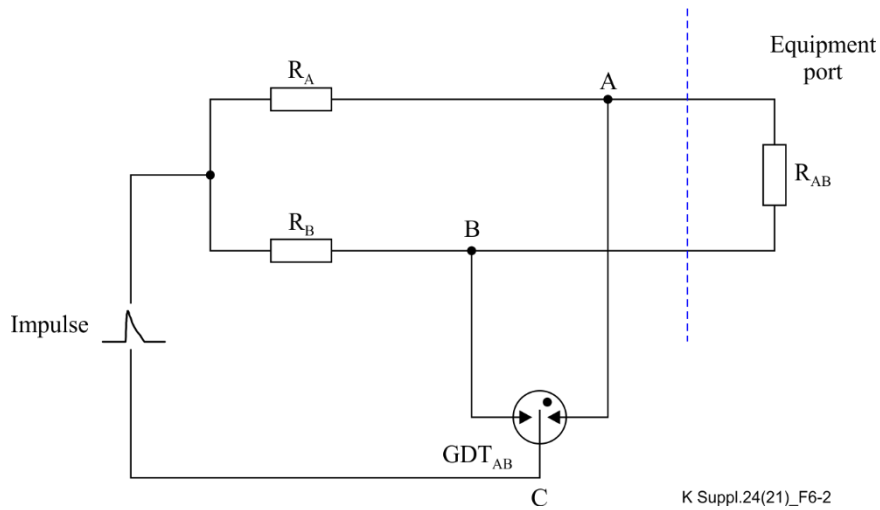
C1 = 0.5 μF, ±10%, 5 kV, equivalent series resistance (ESR) < 0.5 Ω, inductance < 1 μH, different parasitic values are acceptable provided Note 3 conditions are met.

NOTE 1 – This test is conducted on each terminal pair selected by having that pair switch up and the remaining switches down. Surging is done with alternating polarities.

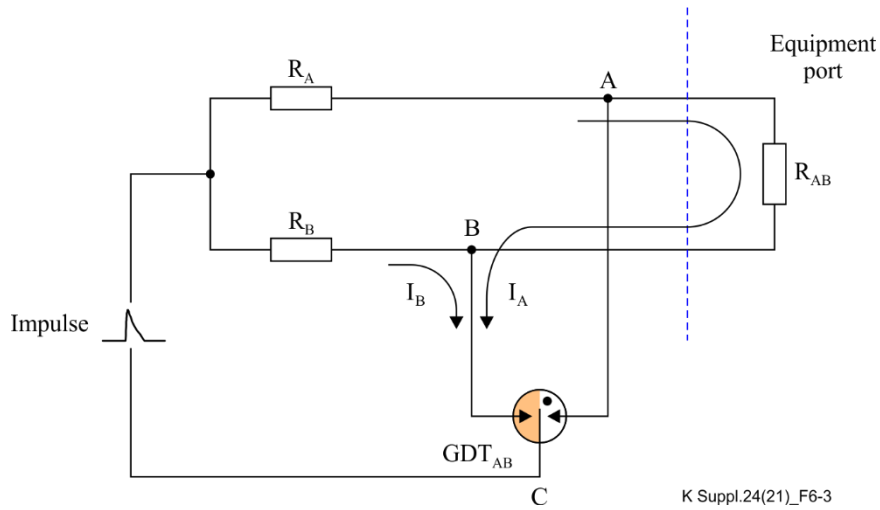
NOTE 2 – This circuit shorts out an injector device or power sourcing equipment power supply. IEEE 802.3 compliant power supplies will not be damaged by this condition.

NOTE 3 – The initial rate of rise of the short circuit current, di/dt, at 2.5 kV generator charging voltage shall be 60 A/μs ±10 A/μs in the first 0.5 μs.

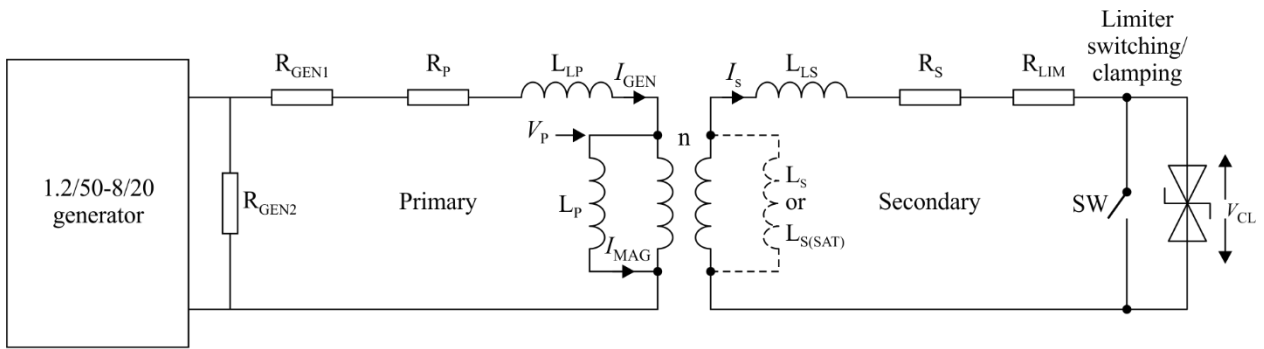
Figure 6-1 – Twisted pair transverse/differential surge test circuit for ports having one or more twisted pair connections such as Ethernet ports, including PoE variants (Figure A.6.7-5 in [ITU-T K.44])



**Figure 6-2 – Equivalent circuit under common mode surge conditions
(Figure IV.2 in [ITU-T K.99])**



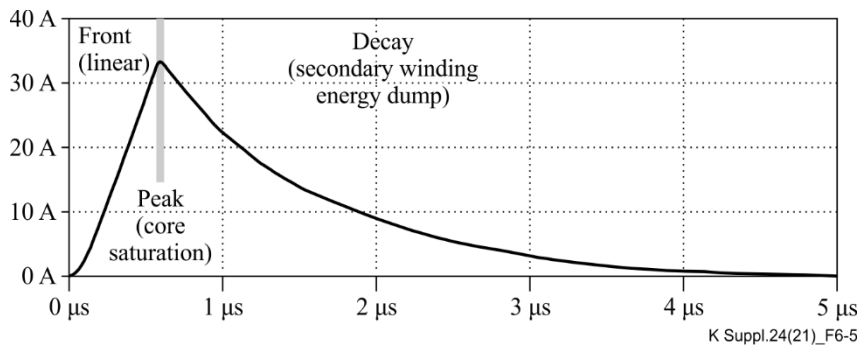
**Figure 6-3 – Circuit currents when electrode connected to B is first to spark-over
(Figure IV.3 in [ITU-T K.99])**



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R_p	Primary winding resistance	R_s	Secondary winding resistance
L_{LP}	Primary leakage inductance	L_{LS}	Secondary leakage inductance
R_{GEN}	Series resistance from generator	R_{LIM}	Series resistance to limiter
V_p	Primary voltage	SW	Switching voltage limiter
C_{P-S}	Inter-winding capacitance	V_{CL}	Clamping limiter voltage
I_{GEN}	Generator current	L_s	Secondary inductance
I_{MAG}	Magnetizing current	n	Transformer turns ratio
L_p	Primary magnetizing inductance	$L_{S(SAT)}$	Saturated core secondary inductance

Figure 6-4 – Effective secondary circuit for differential surge (Figure 9-10 in [ITU-T K.126])



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Figure 6-5 – Example waveform of transformer secondary winding differential surge let-through current (Figure 9-9 in [ITU-T K.126])

7 Addition of rationale to this Supplement

Rationale for the revision of [ITU-T K.20] will be added if [ITU-T K.20] is revised.

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