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SERIES K: PROTECTION AGAINST INTERFERENCE

Rationale for setting resistibility requirements of telecommunication equipment installed in customer premises against lightning

ITU-T K-series Recommendations – Supplement 21

International Telecommunication Union

Supplement 21 to ITU-T K-series Recommendations

Rationale for setting resistibility requirements of telecommunication equipment installed in customer premises against lightning

Summary

Supplement 21 to ITU-T K-series Recommendations includes the technical information (rationale) on resistibility against lightning contained in Recommendation ITU-T K.21, "*Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*".

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

ITU-T K.21, ITU-T K.44, customer premises, lightning, resistibility, telecommunication equipment.

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Table of Contents

Supplement 21 to ITU-T K-series Recommendations

Rationale for setting resistibility requirements of telecommunication equipment installed in customer premises against lightning

1 Scope

This Supplement provides technical information (rationale) for setting the resistibility requirements against lightning contained in [ITU-T K.21]. This information should be referred to in the case of revision of [ITU-T K.21]. The rationale described in this Supplement is mainly quoted from past contributions and other documents discussed in ITU-T SG5 at the stage of establishment and revision of [ITU-T K.21].

This is a living document in that the rational justifying any future changes in Recommendation ITU-T K.21 testing should be added to this Supplement.

This Supplement references the tables, test numbers and test conditions found in [ITU-T K.21]. Rational information for the [ITU-T K.21] test values originates from various events, surveys, standards and ITU-T SG5 contributions.

2 References

[ITU-T K.21] Recommendation ITU-T K.21 (2019), *Resistibility of telecommunication equipment installed in customer premises 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.66] Recommendation ITU-T K.66 (2019), *Protection of customer premises from overvoltages*.

[ITU-T K.98] Recommendation ITU-T K.98 (2014), *Overvoltage protection guide for telecommunication equipment installed in customer premises*.

[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*.

[IEC 60664-1] IEC 60664-1:2020, *Insulation Coordination For Equipment Within Low-Voltage Systems – Part 1: Principles, Requirements and Tests*.

[IEC 60950-1] IEC 60950-1:2001, *Information technology equipment – Safety – Part 1: General requirements*.

[Handbook] Handbook *The Protection of Telecommunication Lines and Equipment Against Lightning Discharges* – Chapters 9 and 10, ITU-T, 1995.

[Miyazaki] Teru Miyazaki, Shigemitsu Okabe, Kiyoshi Aiba, Takao Hirai, Jun Yoshinaga, *A Lightning Surge Analysis for the Rationalization of the Ground System in Power Distribution Lines*, IEEJ Trans. PE, Vol. 127, No.2, 2007.

[Taguchi] *Lightning Surge Waves Induced in Transmission Lines*, Hiroaki Koga, Tamio Motomitsu, Morihiko Taguchi, Review of the Electrical Communication Laboratories, Volume 29, Numbers 7-8, July-August, 1981.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses terms defined in [ITU-T K.21].

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

a.c. Alternating Current

CWG Combination Wave Generator

d.c. 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

5 Conventions

None.

6 Rationale

Table 1a and Table 1b, adapted from [ITU-T K.21], show references to clause numbers containing the rationale with each test number in [ITU-T K.21]. These tables (Table 1a and Table 1b) have the same table structure as Table 1a and Table 1b of [ITU-T K.21], 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.21]			
				Symmetric port	Co-axial 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	Clause 6.1.1 (2.1.1c)	n/a	Clause 6.1.3 (4.1.1c)	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)

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.21]			
				Symmetric port	**Co-axial port**	**Dedicated power feed port**	**Mains power port**
		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	Clause 6.1.1 (2.1.2c)	n/a	Clause 6.1.3 (4.1.2c)	Clause 6.1.4 (5.1.2c)
	Multiple	Port to earth	No	Clause 6.1.1 (2.1.3a)	n/a	n/a	n/a
		Port to external port	No	Clause 6.1.1 (2.1.3b)	n/a	n/a	n/a
		Port to earth	Yes	Clause 6.1.1 (2.1.4a)	n/a	n/a	n/a
		Port to external port	Yes	Clause 6.1.1 (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 (2.1.9)		n/a	n/a
		Port to earth	No	Clause 6.1.1 (2.1.8)		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	Not clarified (2.1.5b)	n/a	Not clarified (4.1.5b)	n/a
	Multiple	Port to earth	No	Not clarified (2.1.6a, 2.1.10)	n/a	n/a	n/a
		Port to external port	No	Not clarified (2.1.6b)	n/a	n/a	n/a
		Differential	n/a	n/a	Not clarified (3.1.3)	n/a	n/a
		Shield to earth	n/a	n/a	Not clarified (3.1.4)	n/a	n/a
		Shield to external port	n/a	n/a	Not clarified (3.1.5)	n/a	n/a
n/a That test is not applicable to that port in [ITU-T K.21].							

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. extracted from [ITU-T K.21]				
			Unshielded cable	Shielded cable	PoE power feed	DC powered equipment	DC power source
Single	Shielded cable to earth	No		Not clarified (7.2)			
	USB shielded cable to earth	No		Clause 6.2 (7.3)			
	STP_E simultaneous port to earth	No		Clause 6.2 (7.4)			
	UTP_E/STP_E transverse	No	Not clarified (7.7)	Not clarified (7.7)			
	DC powered equipment port	No				Not clarified (7.8)	
	DC power source port	No					Not clarified (7.9)
Multiple	Unshielded cable with symmetric pairs	No	Not clarified (7.1)				
	PoE Mode A and Mode B transverse testing	No			Not clarified (7.5)		
	UTP_E port rated impulse voltage	No	Clause 6.2 (7.6)				

6.1 Ports connected to external cables

6.1.1 External symmetric pair cables

Table 2a shows the references to the rationale shown in Table 2b for ports connected to external symmetric pair cables.

Table 2a – 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	$U_{c(max)}$ = 1.5 kV R = 25 Ω	Table 2b No.1, No.2, No.3
			Enhanced	$U_{c(max)}$ = 6 kV R = 25 Ω	Table 2b No.2, No.3
2.1.1c	Single pair, lightning, inherent, port to external port	A.3-1 and A.6.1-3 10/700	Basic	$U_{c(max)}$ = 1.5 kV R = 25 Ω	Table 2b No.4
			Enhanced	$U_{c(max)}$ = 6 kV R = 25 Ω	

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

Test no.	Test description	Test circuit and waveform	Test levels		Reference to rationale
2.1.2b	Single pair, lightning, co-ordination, port to earth	A.3-1 and A.6.1-2 10/700	Basic	$U_{c(max)}$ = 4.0 kV R = 25 Ω	To be clarified.
			Enhanced	$U_{c(max)}$ = 6.0 kV R = 25 Ω	Table 2b No.5
			Special	$U_{c(max)}$ = 13 kV R = 25 Ω, R1 = 100 Ω	Table 2b No.2, No.3
2.1.2c	Single pair, lightning, co-ordination, port to external port	A.3-1 and A.6.1-3 10/700	Basic	$U_{c(max)}$ = 4.0 kV R = 25 Ω	To be clarified.
			Enhanced	$U_{c(max)}$ = 6.0 kV R = 25 Ω	Table 2b No.4
			Special	$U_{c(max)}$ = 13 kV R = 25 Ω, R1 = 100 Ω	Table 2b No.4
2.1.3a	Multiple pair, lightning, inherent, port to earth	A.3-1 and A.6.1-4 10/700	Basic	$U_{c(max)}$ = 1.5 kV R = 25 Ω	Table 2b No.6
2.1.3b	Multiple pair, lightning, inherent, port to external port	A.3-1 and A.6.1-5 10/705	Basic	$U_{c(max)}$ = 1.5 kV R = 25 Ω	Table 2b No.4
2.1.4a	Multiple pair, lightning, port to earth	A.3-1 and A.6.1-4 10/700	Enhanced	$U_{c(max)}$ = 6.0 kV R = 25 Ω	Table 2b No.6
2.1.4b	Multiple pair, lightning, port to external port	A.3-1 and A.6.1-5 10/705	Enhanced	$U_{c(max)}$ = 6.0 kV R = 25 Ω	Table 2b No.4
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 Ω	Basic	$U_{c(max)}$ = 2.5 kV	Table 2b No.7, No.9, No.10
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 2b No.7, No.8, No.10
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 Ω	Basic	$U_{c(max)}$ = 2.5 kV	Table 2b No.7, No.9, No.10
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 2b No.7, No.8, No.10
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 Ω	Basic	$U_{c(max)}$ = 2.5 kV	Table 2b No.7, No.9, No.10
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 2b No.7, No.8, No.10

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

No.	Source	Rationale	Added date of rationale
1	[ITU-T K.66], *Protection of customer premises from overvoltages*. Clause 7 "Objectives for bonding configurations and earthing"	Quoted from source document; To coordinate with the requirements of [IEC 60950-1], it is necessary to prevent the potential difference which can occur between the symmetric pair conductor and other metallic parts, within the premises, from exceeding 1.5 kV for the majority of di/dt expected to occur. Figures III.1 to III.4 show that this voltage is affected by the individual voltage drops occurring across bonding conductors. The requirements for earthing and bonding given in this Recommendation will achieve the objective of preventing the voltage between the telecommunication conductor and the MET from exceeding 1.5 kV for the majority of di/dt expected to occur.	5/2019
2	[Taguchi] *Lightning Surge Waves Induced in Transmission Lines*, Hiroaki Koga, Tamio Motomitsu, Morihiko Taguchi, Review of the Electrical Communication Laboratories Volume 29, Numbers 7-8, July-August, 1981 Clause 4.3.1 "Lightning Surge Voltage Distribution"	Quoted from source document; Subscriber end. $Ns = 0.6 * 10^{5} * V^{-1.8}$ (See the solid line in Figure 1 of this Supplement.)	9/2019
3	[Handbook] The Handbook *The Protection of Telecommunication Lines and Equipment Against Lightning Discharges* – Chapters 9 and 10, ITU-T, 1995 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 and Figure 3 of this Supplement.)	3/2020
4	Agreed in SG5	This "port to external port" test level is in line with "port to earth" test level, because this test is specified considering the situation that a port of equipment is exposed to overvoltage and the potential of the other port is referenced to local line.	3/2020
5	Agreed in SG5	This enhanced level of "co-ordination test" (2.1.2b of [ITU-T K.21]) is in line with enhanced test level of "inherent" test (2.1.1b of [ITU-T K.21]), because in the environment where enhanced level is applied, there are the case that primary protector is not normally installed or equipotential bonding at customer premises is difficult to achieve.	3/2020

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

No.	Source	Rationale	Added date of rationale
6	Agreed in SG5	This "Multiple pair port" test level is in line with "Single pair port" test level. And also the value of current limiting resistors R is as the same value as "Single pair port" test regardless of the number of pairs, because this constant resister value retains some extent of surge current even when a switching type SPC on the port operates.	3/2020
7	Agreed in SG5	This test level for Ethernet port is in line with the test level of "Mains power port, lightning, inherent, port to earth (5.1.1b of [ITU-T K.21])"; 2.5 kV (Basic), 6.0 kV (Enhanced).	3/2020
8	Damage to Equipment in the US, ITU-T Study Group 5 Technical Session on Home Networks, Geneva, 29/04/2011	Quoted from source document; For severe environments 5 kV isn't enough. One solution being pursued is to use a 5 kV rms withstand transformer to give a 7 kV impulse withstand barrier.	3/2020
9	IEEE Std. 802.3-2012 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] Annex N	3/2020
10	[ITU-T K.98] *Overvoltage protection guide for telecommunication equipment installed in customer premises*	Quoted from source document; Annex A "Simulations" A.2.1 TN-S Power System "The surge voltage on the mains conductors will cause a flashover of the mains transformer, telecommunication port isolation and the Ethernet port. The resulting surge current entering the mains port will exit via the telecommunication and Ethernet ports, thus damaging all".	3/2020

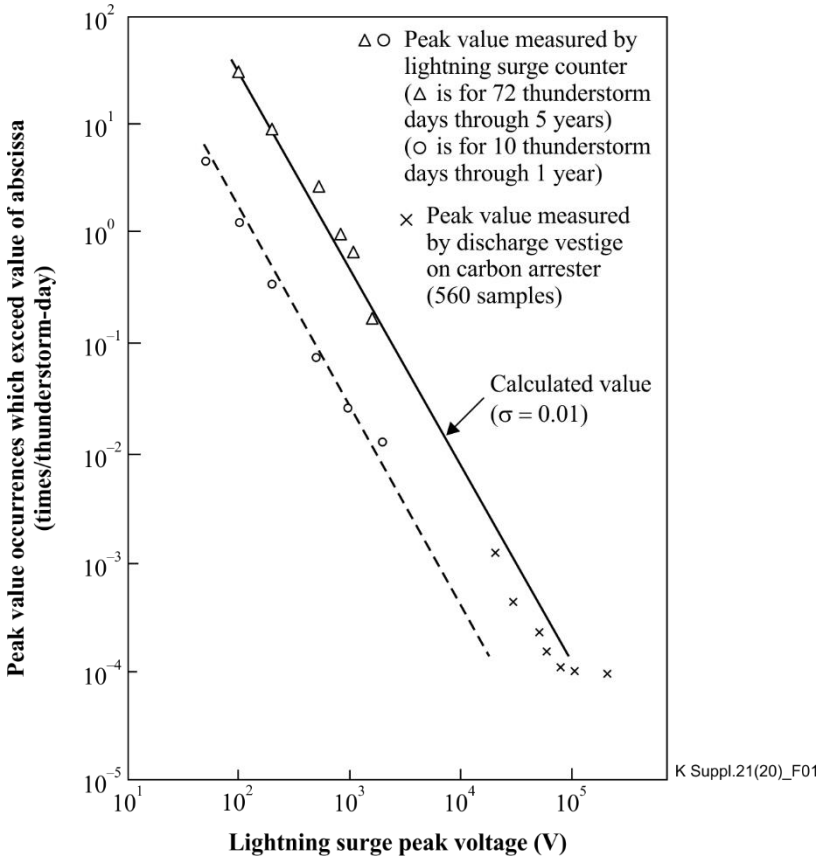

Figure 1 – Peak voltage distribution

Voltage end current occurrences in rural area

Location		Voltage and current occurrences: N_i (Time/year · lines)	Soil resistivity (Ω · m)	Average length l (m)	Number of lines
Exchange end	Voltage	F: $N_{1v} = 1.3 \cdot 10^5 \cdot T_d \cdot V_p^{-2.1}$	~300	6 200	54
		D: $N_{1v} = 4.4 \cdot 10^5 \cdot T_d \cdot V_p^{-2.1}$	30-60	5 000	18
		I: $N_{1v} = 1.5 \cdot 10^4 \cdot T_d \cdot V_p^{-1.7}$	900	4 500	9
		J: $N_{1v} = 12.5 \cdot 10^3 \cdot T_d \cdot V_p^{-2}$	30-100	4 400	10
		USA: $N_{1v} = 5.7 \cdot 10^5 \cdot T_d \cdot V_p^{-2.1}$	700-8000	12 750	1
	Current	I: $N_{1i} = 7.3 \cdot T_d \cdot I_p^{-1.1}$	1500	6 725	2
		J: $N_{1i} = 1.2 \cdot T_d \cdot I_p^{-1.8}$	30-100	3 000	100
		USA: $N_{1i} = 1.9 \cdot T_d \cdot I_p^{-1.2}$	700-8000	12 750	1
Subscriber end	Voltage	I: $N_{2v} = 2.3 \cdot 10^5 \cdot T_d \cdot V_p^{-1.8}$	875	3 800	12
		J: $N_{2v} = 1.05 \cdot 10^5 \cdot T_d \cdot V_p^{-1.8}$	30-100	4 400	10
		USA: $N_{2v} = 5.3 \cdot 10^5 \cdot T_d \cdot V_p^{-1.8}$	~700	11 700	3
	Current	I: $N_{2i} = 43.3 \cdot T_d \cdot I_p^{-1.55}$	1000	4 000	5
		J: $N_{2i} = 11 \cdot T_d \cdot I_p^{-1.8}$	50-100	3 000	100
		USA: $N_{2i} = 26 \cdot T_d \cdot I_p^{-1.45}$	~700	11 700	3

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

Figure 2 – Voltage end current occurrences in rural area

Voltage end current occurrences in urban/suburban area

Location	Voltage and current occurrences: N_i (Time/year · lines)		Soil resistivity (Ω · m)	Average length l (m)	Number of lines
Exchange end: Voltage	Suburban Urban	D: $N_{1v} = 5.2 \cdot 10^4 \cdot T_d \cdot V_p^{-2.1}$ D: $N_{1v} = 5.8 \cdot 10^3 \cdot T_d \cdot V_p^{-2.1}$	30-60 30-60	3200 1200	34 19
Exchange and Subscriber end: Current	Urban/ Suburban	CAN: $N_{2i} = 1.4 \cdot 10^{-2} \cdot T_d \cdot I_p^{-0.8}$	10-1000		2350

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

Figure 3 – Voltage end current occurrences in urban/suburban area

6.1.2 Lightning test for ports connected to external coaxial cables

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

Table 3 – 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 kV R = 0 Ω	To be clarified.
			Enhanced	$U_{c(max)}$ = 1.5 kV R = 0 Ω	To be clarified.
3.1.2	Lightning, co-ordination, differential	A.3-5 and A.6.2-1 1.2/50 – 8/20 CWG	Basic	$U_{c(max)}$ = 4.0 kV R = 0 Ω	To be clarified.
			Enhanced	$U_{c(max)}$ = 6.0 kV R = 0 Ω	To be clarified.
3.1.3	Lightning, current, differential	A.3-4 and A.6.2-1 8/20	Basic	I = 1.0 kA	To be clarified.
			Enhanced	I = 5.0 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 kA (Note 1) I = 2.0 kA (Note 2)	To be clarified.
			Enhanced	I = 20.0 kA (Note 1) I = 5.0 kA (Note 2)	To be clarified.
3.1.5	Lightning, shield, port to external port	A.3-4 and A.6.2-3 8/20	Basic	I = 4.0 kA (Note 1) I = 2.0 kA (Note 2)	To be clarified.
			Enhanced	I = 20.0 kA (Note 1) I = 5.0 kA (Note 2)	To be clarified.
NOTE 1 – Equipment designed to be connected to antennas or equipment exposed to direct lightning currents, e.g., connected to antennas or equipment mounted on a tower. NOTE 2 – Applicable equipment not covered by NOTE 1.					

6.1.3 Lightning test for ports connected to external d.c. or a.c. dedicated power feeding cables

Table 4a shows the references to the rationale shown in Table 4b for ports connected to external d.c. or a.c. dedicated power feeding cables.

Table 4a – Reference to rationale for ports connected to external d.c. or a.c. 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	$U_{c(max)}$ = 1.5 kV R = 25 Ω	Table 4b No.1
			Enhanced	$U_{c(max)}$ = 6 kV R = 25 Ω	
4.1.1c	Single pair, lightning, inherent, port to external port	A.3-1 and A.6.3-3 10/700	Basic	$U_{c(max)}$ = 1.5 kV R = 25 Ω	Table 4b No.1
			Enhanced	$U_{c(max)}$ = 6 kV R = 25 Ω	
4.1.2b	Single pair, lightning, co-ordination, port to earth	A.3-1 and A.6.1-2 10/700	Enhanced	$U_{c(max)}$ = 6.0 kV R = 25 Ω	Table 4b No.1
4.1.2c	Single pair, lightning, co-ordination, port to external port	A.3-1 and A.6.1-3 10/700	Enhanced	$U_{c(max)}$ = 6.0 kV R = 25 Ω	Table 4b No.1

Table 4b – Rationale for ports connected to external d.c. or a.c. dedicated power feeding cables

No.	Source	Rationale	Added date of rationale
1	Agreed in SG5	This test level for ports connected to external d.c. or a.c. dedicated power feeding cables 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 5a shows the references to the rationale shown in Table 5b for mains power ports.

Table 5a – 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 kV R = 0 Ω	Table 5b No.1, No.2 , No.3
			Enhanced	$U_{c(max)}$ = 6.0 kV R = 0 Ω	Table 5b No.1, No.2, No.3
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 kV R = 0 Ω	Table 5b No.1, No.2, No.3, No.5
			Enhanced	$U_{c(max)}$ = 6.0 kV R = 0 Ω	Table 5b No.1, No.2, No.3 No.5

Table 5a – 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/co-ordination, port to earth	A.3-5 and A.6.4-2 1.2/50-8/20 CWG	Basic	$U_{c(max)}$ = 6.0 kV R = 0 Ω	Table 5b No.1, No.2, No.3
			Enhanced	$U_{c(max)}$ = 10.0 kV R = 0 Ω	Table 5b No.1, No.2, No.4
5.1.2c	Lightning, inherent/co-ordination, port to external port	A.3-5 and A.6.4-3 1.2/50-8/20 CWG	Basic	$U_{c(max)}$ = 6.0 kV R = 0 Ω	Table 5b No.1, No.2, No.3, No.5
			Enhanced	$U_{c(max)}$ = 10.0 kV R = 0 Ω	Table 5b No.1, No.2, No.4, No.5

Table 5b – Rationale for mains power ports

No.	Source	Rationale	Added date of rationale
1	[ITU-T K.143] *Guidance on safety relating to the use of surge protective devices and surge protective components in telecommunication terminal equipment*	Quoted from source document; Fig. 5 "Occurrence rate of lightning voltage on LV power distribution line" (See Figure 4 of this Supplement) "The occurrence rate for lightning surges on low-voltage (LV) power distribution lines in Japan is shown in Figure 5".	10/2020
2	[Miyazaki] *A Lightning Surge Analysis for the Rationalization of the Ground System in Power Distribution Lines*, Teru Miyazaki, Shigemitsu Okabe, Kiyoshi Aiba, Takao Hirai, Jun Yoshinaga, IEEJ Trans. PE, Vol. 127, No.2, 2007	Quoted from source document; Fig.6 "Distribution of voltage at low-voltage line" (See Figure 5 of this Supplement)	10/2020
3	[IEC 60664-1] *Insulation Coordination For Equipment Within Low-Voltage Systems – Part 1: Principles, Requirements And Tests*	Table F.1 "Rated impulse voltage for equipment energized directly from the low-voltage mains" Rated impulse voltage: 2500 V for "Overvoltage category II" and 6000 V for "Overvoltage category IV" on "Voltage line to neutral derived from nominal voltages a.c. or d.c. more than 150 V and up to and including 300 V" Quoted from source document; "Equipment of overvoltage category II is energy-consuming equipment to be supplied from the fixed installation. NOTE – Examples of such equipment are appliances, portable tools and other household and similar loads." "Equipment of overvoltage category IV is for use at the origin of the installation. NOTE – Examples of such equipment are electricity meters and primary overcurrent protection equipment."	10/2020

Table 5b – Rationale for mains power ports

No.	Source	Rationale	Added date of rationale
4	Agreed in SG5	In February 2000, SG5 discussed this resistibility level based on the experience that an European telecommunication operator needed to specify this level as their company standard in order to achieve acceptable failure rate of their equipment. This level applied to the draft of [ITU-T K.21] attached to the report of that SG5 meeting.	10/2020
5	Agreed in SG5	This "port to external port" test level is in line with "port to earth" test level, because this test is specified considering the situation that a port of equipment is exposed to overvoltage and the potential of the other port is referenced to local line.	10/2020

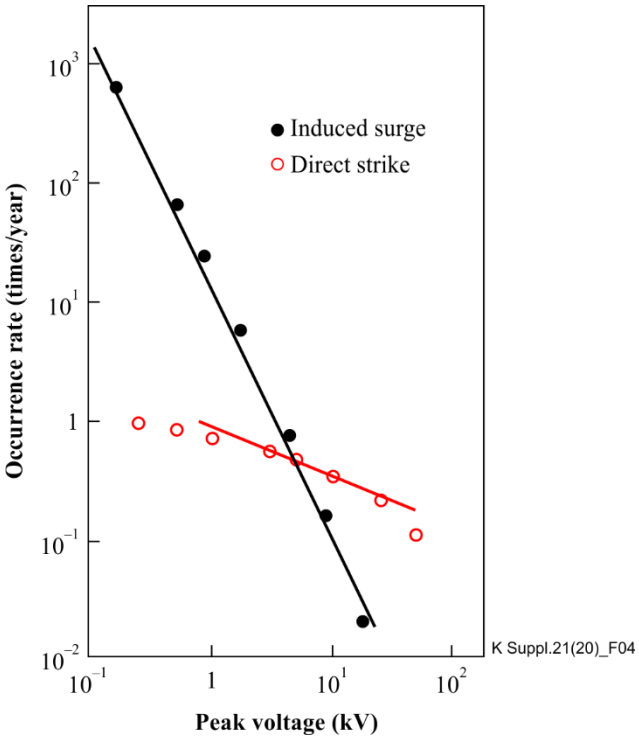

Figure 4 – Occurrence rate of lightning voltage on LV power distribution line

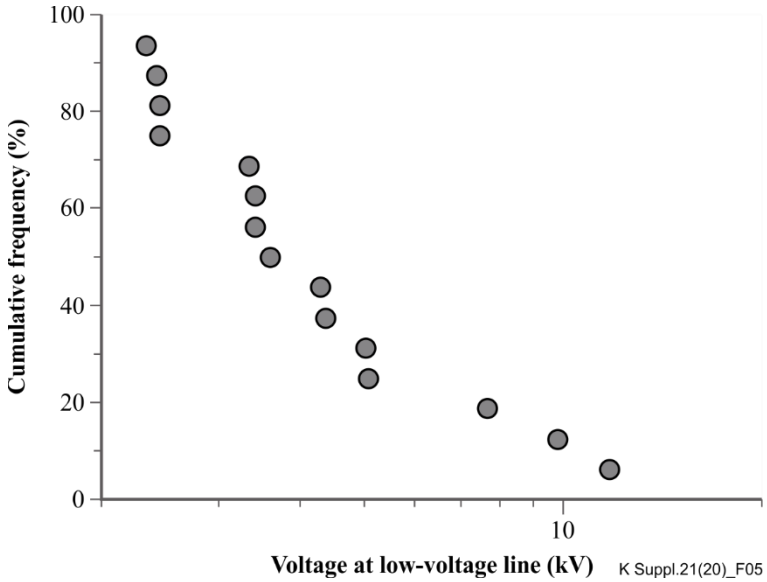

Figure 5 – Distribution of voltage at low-voltage line in Japan

6.2 Ports connected to internal cables

Table 6a shows the references to the rationale shown in Table 6b for ports connected to internal cables.

Table 6a – 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 V	To be clarified.
			Enhanced	$U_{c(max)}$ = 150 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 kV	Table 6b No.3, No.4, No.5
			Intermediate	$U_{c(max)}$ = 4.0 kV	Table 6b No.6, No.7
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 6b No.1, No.2, No.4, No.5
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 kV	Table 6b No.3, No.4, No.5
			Intermediate	$U_{c(max)}$ = 4.0 kV	Table 6b No.6, No.7
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 6b No.1, No.2, No.4, No.5
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	$U_{c(max)}$ = 1.0 kV	To be clarified.
			Enhanced	$U_{c(max)}$ = 1.5 kV	

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

Test no.	Test description	Test circuit and waveform	Test levels		Reference to rationale
7.9	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	$U_{c(max)}$ = 1.0 kV	To be clarified.

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

No.	Source	Rationale	Added date of rationale
1	Damage to Equipment in the US, ITU-T Study Group 5 Technical Session on Home Networks, Geneva, 29/04/2011	Quoted from source document; For severe environments 5 kV is not enough. One solution being pursued is to use a 5 kV rms withstand transformer to give a 7 kV impulse withstand barrier.	5/2019
2	Damage to equipment in Japan, ITU-T Study Group 5 Technical Session on Home Networks, Geneva, 29/04/2011	Quoted from source document; Failure rates is over 0.1%@2 kV and 0.01%@7 kV. Adequate test levels is needed for Internal Port to Internal Port for ONT/HGW	5/2019
3	IEEE Std. 802.3-2012 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] Annex N	9/2019
4	[ITU-T K.98] *Overvoltage protection guide for telecommunication equipment installed in customer premises*	Quoted from source document; Annex A "Simulations" A.2.1 TN-S Power System "The surge voltage on the mains conductors will cause a flashover of the mains transformer, telecommunication port isolation and the Ethernet port. The resulting surge current entering the mains port will exit via the telecommunication and Ethernet ports, thus damaging all."	9/2019
5	Agreed in SG5	This test level for Ethernet port is in line with the test level of "Mains power port, lightning, inherent, port to earth (5.1.1b of [ITU-T K.21])"; 2.5kV (Basic), 6.0kV (Enhanced).	3/2020

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

No.	Source	Rationale	Added date of rationale
6	[ITU-T K.44] *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*	Quoted from source document; 5 Resistibility requirements 5.2 Intermediate resistibility level "This resistibility requirement may be applied to the cases that the basic resistibility is not sufficient considering the aspects of environmental condition, and/or customer's requirement on reliability of service, nevertheless, the enhanced resistibility cannot be applied due to the cost. It has better resistibility than the basic requirement, and also it is achieved by relatively small cost addition and has a good price-performance ratio".	9/2019
7	[ITU-T K.21] *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*	Table 7 – Lightning test conditions for ports connected to internal cables 7.6 Ethernet longitudinal/common mode withstand test Basic test levels: Uc(max) = 2.5 kV Enhanced test levels: Uc(max) = 6.0 kV	9/2019

7 Addition of rationale to this Supplement

Rationale for revision of Recommendation [ITU-T K.21] will be added in the case that [ITU-T K.21] is revised.

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