International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Series K

Supplement 22

(10/2020)

SERIES K: PROTECTION AGAINST INTERFERENCE

Rationale for setting resistibility requirements of telecommunication equipment installed in the access and trunk networks against lightning

ITU-T K-series Recommendations – Supplement 22

International Telecommunication Union

Supplement 22 to ITU-T K-series Recommendations

Rationale for setting resistibility requirements of telecommunication equipment installed in the access and trunk networks against lightning

Summary

Supplement 22 to ITU-T K-series Recommendations includes the technical information (rationale) on resistibility against lightning contained in Recommendation ITU-T K.45 "*Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents*".

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K Suppl. 22	2020-10-23	5	11.1002/1000/14580

Keywords

Access network, ITU-T K.44, ITU-T K.45, lightning, resistibility, telecommunication equipment, trunk network.

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Supplement 22 to ITU-T K-series Recommendations

Rationale for setting resistibility requirements of telecommunication equipment installed in the access and trunk networks against lightning

1 Scope

This Supplement provides technical information (rationale) for setting the resistibility requirements against lightning in [ITU-T K.45]. This information should be referred to in the case of revision of [ITU-T K.45]. 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.45].

This is a living document in that the rational justifying any future changes in [ITU-T K.45] testing should be added to this Supplement.

This Supplement references the tables, test numbers and test conditions found in [ITU-T K.45]. Rational information for the [ITU-T K.45] 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.45] Recommendation ITU-T K.45 (2019), *Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents*.

[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*.

[IEEE 802.3] IEEE Std. 802.3-2012, *IEEE Standard for Ethernet*.

[Miyazaki] Teru Miyazaki, Shigemitsu Okabe, Kiyoshi Aiba, Takao Hirai, Jun 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.45].

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 1 shows references to clause numbers containing the rationale with each test number in [ITU-T K.45], in the same table structure as Table 1 of [ITU-T K.45].

Table 1 – Reference to rationale of 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.45])			
				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)	(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	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

Table 1 – Reference to rationale of 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.45])			
				Symmetric port	Co-axial port	Dedicated power feed port	Mains power port
		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 (2.1.8)		n/a	n/a
		Port to earth	No	Clause 6.1.1 (2.1.9)		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	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	Not clarified (2.1.6b)	n/a	n/a	n/a

n/a That test is not applicable to that port in [ITU-T K.45].

6.1 Ports connected to external cables

6.1.1 External symmetric pair cables

Table 2 shows the references to the rationale shown in Table 3 for ports connected to external symmetric pair cables.

Table 2 – 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 3 No.1
			Enhanced	$U_{c(max)}$ = 1.5 kV R = 25 Ω	To be clarified. It should also be considered including the revision of the test level.
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 3 No.1
			Enhanced	$U_{c(max)}$ = 1.5 kV R = 25 Ω	To be clarified.
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	$U_{c(max)}$ = 4.0 kV R = 25 Ω	
			Special	$U_{c(max)}$ = 13 kV R = 25 Ω, R_1 = 100 Ω	Table 3 No.1
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	$U_{c(max)}$ = 4.0 kV R = 25 Ω	
			Special	$U_{c(max)}$ = 13 kV R = 25 Ω, R_1 = 100 Ω	Table 3 No.1
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 3 No.1
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 3 No.1
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 3 No.1
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 3 No.1
2.1.8	Ethernet longitudinal/ common mode to transverse/ differential	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 3 No.1, No.2, No.3
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 3 No.1, No.2

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

Test no.	Test description	Test circuit and waveform	Test levels		Reference to rationale
	mode conversion tests				
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 3 No.1, No.2, No.3
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 3 No.1, No.2
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 3 No.1, No.2, No.3
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 3 No.1, No.2

Table 3 – Rationale for ports connected to external symmetric pair cables

No.	Source	Rationale	Added date of rationale
1	Agreed in SG5	This test level is in line with the test of the same Test No. and resistibility requirement (i.e., basic, enhanced, and special) in [ITU-T K.21].	3/2020
2	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 (clause 5.1.1b of [ITU-T K.45])"; 2.5kV (Basic), 6.0kV (Enhanced).	3/2020
3	[IEEE 802.3] 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 Annex N of [IEC 60950-1]	3/2020

6.1.2 Lightning test for ports connected to external coaxial cables

Table 4 shows the references to rationale for ports connected to external coaxial cables.

Table 4 – 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/equipment exposed to direct lightning currents, e.g., connected to antennas/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 5 shows the references to the rationale shown in Table 6 for ports connected to external d.c. or a.c. dedicated power feeding cables.

Table 5 – 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 6 No.1
			Enhanced	$U_{c(max)}$ = 1.5 kV R = 25 Ω	To be clarified.
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 6 No.1
			Enhanced	$U_{c(max)}$ = 1.5 kV R = 25 Ω	To be clarified.

Table 6 – 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 is in line with the test of the same Test No. and resistibility requirement (i.e., basic) in [ITU-T K.21].	3/2020

6.1.4 Test for mains power ports

Table 7 shows the references to the rationale shown in Table 8 for mains power ports.

Table 7 – 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 8 No.1, No.2, No.3, No.4
			Enhanced	$U_{c(max)}$ = 6.0 kV R = 0 Ω	Table 8 No.1, No.2, No.3, No.4
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 8 No.1, No.2, No.3, No.4, No.5
			Enhanced	$U_{c(max)}$ = 6.0 kV R = 0 Ω	Table 8 No.1, No.2, No.3, No.4, No.5
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 8 No.1, No.2, No.3, No.4
			Enhanced	$U_{c(max)}$ = 10.0 kV R = 0 Ω	Table 8 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 8 No.1, No.2, No.3, No.4, No.5
			Enhanced	$U_{c(max)}$ = 10.0 kV R = 0 Ω	Table 8 No.1, No.2, No.4, No.5

Table 8 – 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 1 of this Supplement) "The occurrence rate for lightning surges on low-voltage (LV) power distribution lines in Japan is shown in Figure 5." (See Figure 5-11 of this Supplement)	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 2 of this Supplement)	10/2020

Table 8 – Rationale for mains power ports

No.	Source	Rationale	Added date of rationale
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
4	Agreed in SG5	This test level is in line with the test of the same Test No. and resistibility requirement (i.e., basic, enhanced) in [ITU-T K.21].	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

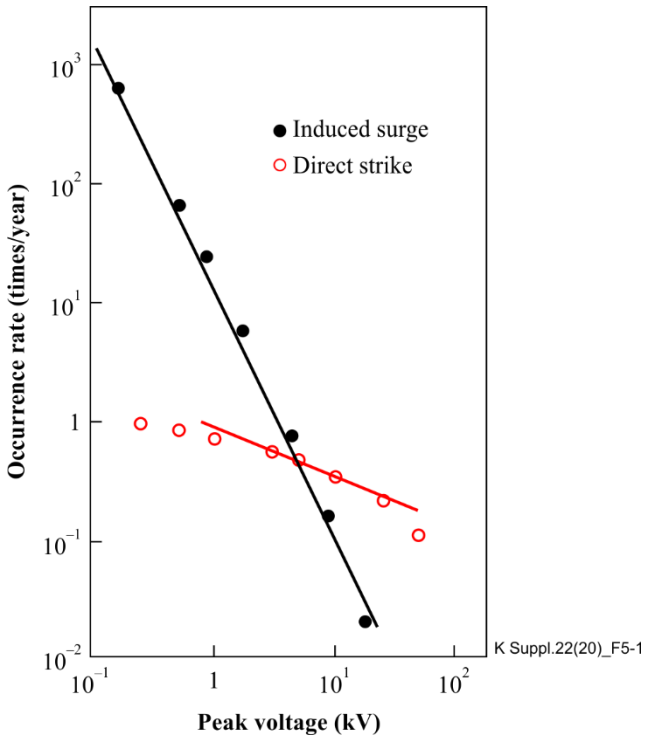

Figure 1 – Occurrence rate of lightning voltage on LV power distribution line

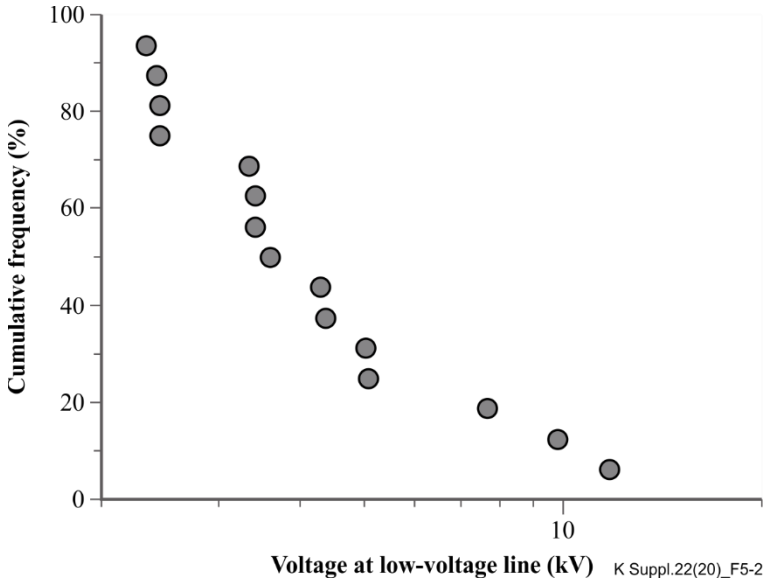

Figure 2 – Distribution of voltage at low-voltage line in Japan

7 Addition of rationale to this Supplement

Rationale for revision of [ITU-T K.45] will be added in the case that [ITU-T K.45] is revised.

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Printed in Switzerland
Geneva, 2021