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SERIES K: PROTECTION AGAINST INTERFERENCE

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, this technical information (rationale) has not yet been organized in the form of an 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*
1.0	ITU-T K Suppl. 24	2021-05-20	5	11.1002/1000/14753
2.0	ITU-T K Suppl. 24	2022-07-01	5	11.1002/1000/15089

Keywords

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

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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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.40] Recommendation ITU-T K.40 (2019), *Protection against lightning electromagnetic impulses in telecommunication centres*.

[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*.

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

[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 Vo1. 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

NPD Network Powered Device

PoE Power over Ethernet

PoDL Power over Data Line

PSE Power Source Equipment

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 show references to clause No. (numbers) containing rationale with test No. in [ITU-T K.20], in the same table structure as Table 1a of [ITU-T K.20] and Table 1b of [ITU-T K.20], for external port and internal port 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	**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)

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	Co-axial port	Dedicated power feed port	Mains power port
		Port to external port	No	n/a	n/a	Not clarified (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)
		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	Not clarified (4.1.2c)	Clause 6.1.4 (5.1.2c)
	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
		Power over Ethernet (PoE)	No	Not clarified (2.1.11)		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	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

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	Co-axial port	Dedicated power feed port	Mains power port
		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 That test is not applicable to that 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		Not clarified (7.2)			
	USB shielded cable to earth	No		Not clarified (7.3)			
	STP_E Ethernet simultaneous port to earth	No		Clause 6.2 (7.4)			
	UTP_E/STP_E Ethernet transverse	No	Clause 6.1.1 (7.7)	Clause 6.1.1 (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 Ethernet port rated impulse voltage	No	Clause 6.2 (7.6)	Clause 6.2 (7.6)			

6.1 Ports connected to external cables

6.1.1 External symmetric pair cables

Table 2-1 shows references to the 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 kV R = 25 Ω	Table 2-2 No.1, No.5, No.6
			Enhanced	$U_{c(max)}$ = 1.5 kV R = 25 Ω	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 kV R = 25 Ω	To be clarified.
			Enhanced	$U_{c(max)}$ = 4.0 kV R = 25 Ω	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 kV R = 25 Ω	To be clarified.
			Enhanced	$U_{c(max)}$ = 1.5 kV R = 25 Ω	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 kV R = 25 Ω	To be clarified.
			Enhanced	$U_{c(max)}$ = 6.0 kV R = 25 Ω	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 Ω	Basic	$U_{c(max)}$ = 2.5 kV	Table 2-2 No.3, No.4
			Enhanced	$U_{c(max)}$ = 6.0 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 Ω	Basic	$U_{c(max)}$ = 2.5 kV	Table 2-2 No.3, No.4
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 2-2 No.3
2.1.10	UTPE 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 2-2 No.3, No.4
			Enhanced	$U_{c(max)}$ = 6.0 kV	Table 2-2 No.3

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

No.	Source	Rationale	Added date of rationale
1	"Lightning Surge Waves Induced in Transmission Lines", Hiroaki Koga, Tamio Motomitsu, Morihiko Taguchi, Review of the electrical communication labolatories volume 29, numbers 7-8, July-August, 1981 Clause 4.3.1 "Lightning Surge Voltage Distribution"	Quoted from source document; Office end. $Ns = 3.6 * 10^{3} * V^{-1.8}$ (See dashed line in Figure 2-1.)	9/2019
2	Agreed in SG5	This enhanced test level of coordination test level is in line with 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 SG5	This "Ethernet port" test level is in line with the test level of "Mains power port, lightning, inherent, port to earth (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 µs (1.2 µs virtual front time, 50 µs virtual time of half value), as defined in IEC 60950-1:2001 Annex N	3/2020
5	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 2-2 and Figure 2-3.)	3/2020
6	The Handbook "The Protection of Telecommunication Lines and Equipment Against Lightning Discharges" – Appendix Chapters 9 and 10, ITU-T, 1995 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

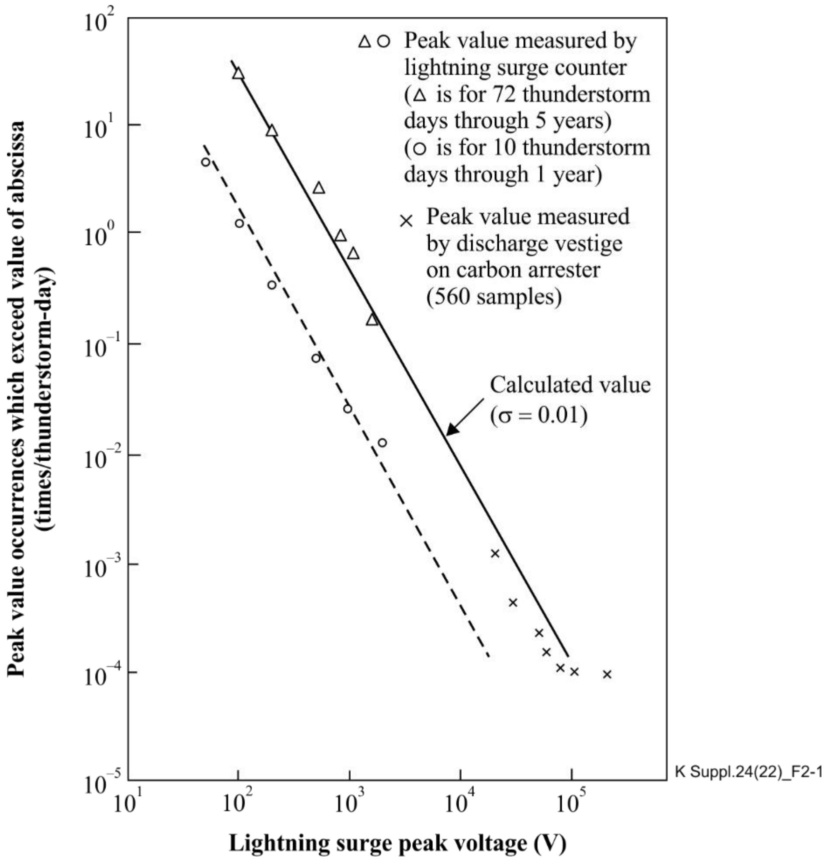

Figure 2-1 – Peak voltage distribution

TABLE 10-4

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: $N_{1v} = 1.3 \cdot 10^5 \cdot T_d \cdot V_p^{-2.1}$ 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 30-100 700-8000	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 30-100 700-8000	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 10-6

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 2-3 – Voltage end current occurrences in urban/suburban area

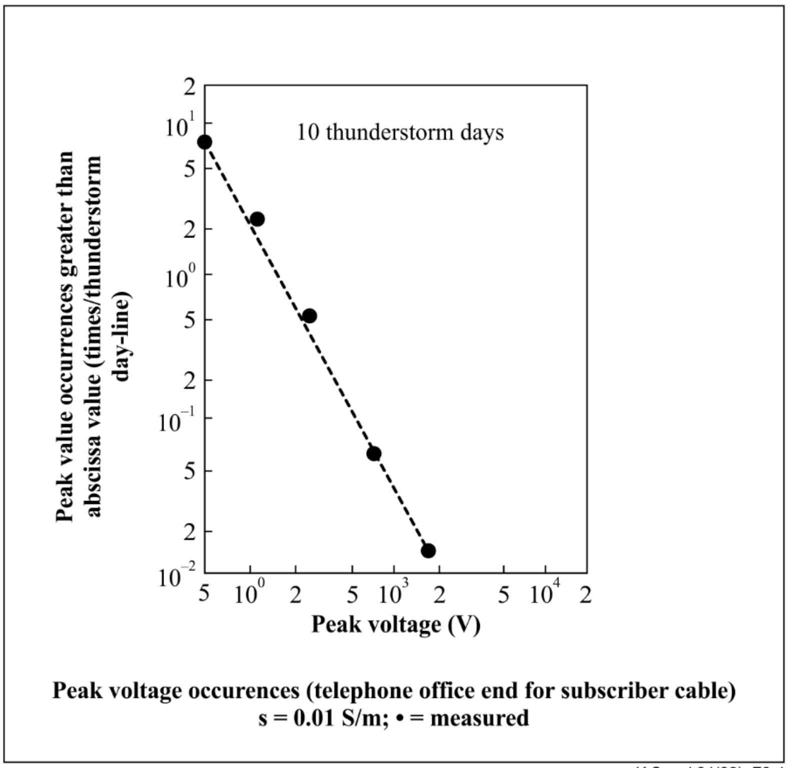

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Figure 2-4 – Peak voltage occurrences (telephone end for subscriber cable) in Japan

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 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 = 2.0 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 – Application 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 4-1 shows the references to the rationale shown in Table 4-2 for ports connected to external d.c. or a.c. dedicated power feeding cables.

Table 4-1 – 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	$U_{c(max)}$ = 1.0 kV R = 25 Ω	Table 4-2 No.1
			Enhanced	$U_{c(max)}$ = 1.5 kV R = 25 Ω	
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 kV R = 25 Ω	Table 4-2 No.1
			Enhanced	$U_{c(max)}$ = 4.0 kV R = 25 Ω	

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

Table 5-2 – 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 5-1) "The occurrence rate for lightning surges on low-voltage (LV) power distribution lines in Japan is shown in Figure 5."	10/2020
2	"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 5-2)	10/2020
3	Agreed in SG5	This requirement is specified based on the situation that overvoltage of approximately 1 kV/floor appears on AC mains power cable, especially supplying AC mains to equipment installed on different floor, such as rectifier, air conditioning equipment within telecommunication centre building, in the case of direct lightning strike on a building.	5/2021

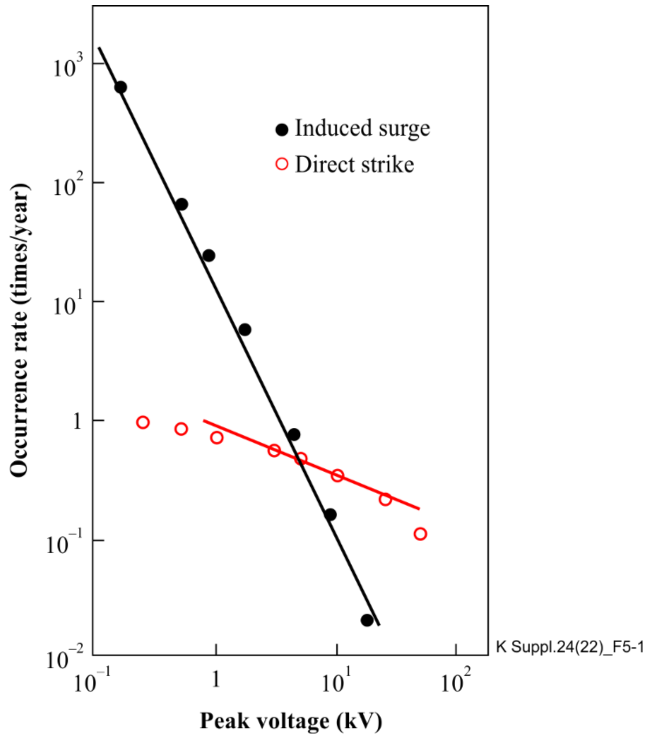


Figure 5-1 – Occurrence rate of lightning voltage on LV power distribution line

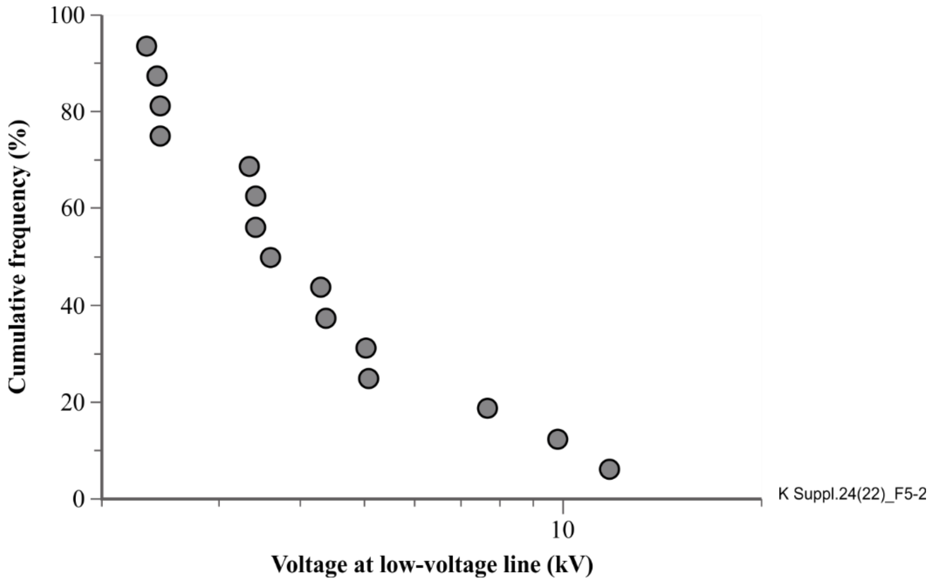


Figure 5-2 – Distribution of voltage at low-voltage line in Japan

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 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 6-2 No.1, No.2
			Enhanced	$U_{c(max)}$ = 4.0 kV (Note 1)	Table 6-2 No.3, No.4
7.6	Ethernet longitudinal/common mode withstand test Note 2	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 6-2 No.1, No.2, No.8
			Enhanced	$U_{c(max)}$ = 4.0 kV (Note 1)	Table 6-2 No.3, No.4, No.8
7.7	Ethernet transverse Note 2	A.3-5 and A.6.7-5 1.2/50-8/20 CWG	Basic	$U_{c(max)}$ = 2.5 kV	Table 6-2 No.5, No.6, No.7, No.9
			Enhanced	$U_{c(max)}$ = 4.0 kV (Note 1)	Table 6-2 No.5, No.6, No.7, No.9
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 kV	To be clarified.
			Enhanced	$U_{c(max)}$ = 1.0 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 kV	To be clarified.
			Enhanced	$U_{c(max)}$ = 1.0 kV	
7.10	Twisted pair port transverse/differential Note 2	A.3-5 and A.6.7-5 1.2/50-8/20 CWG	Basic	$U_{c(max)}$ = 0.5 kV	No.9
			Enhanced	$U_{c(max)}$ = 1.0 kV	

NOTE 1 – The enhanced test level can be 6 kV for equipment intended to be installed in locations with radio towers on the roof of telecom centre, see [ITU-T K.40].

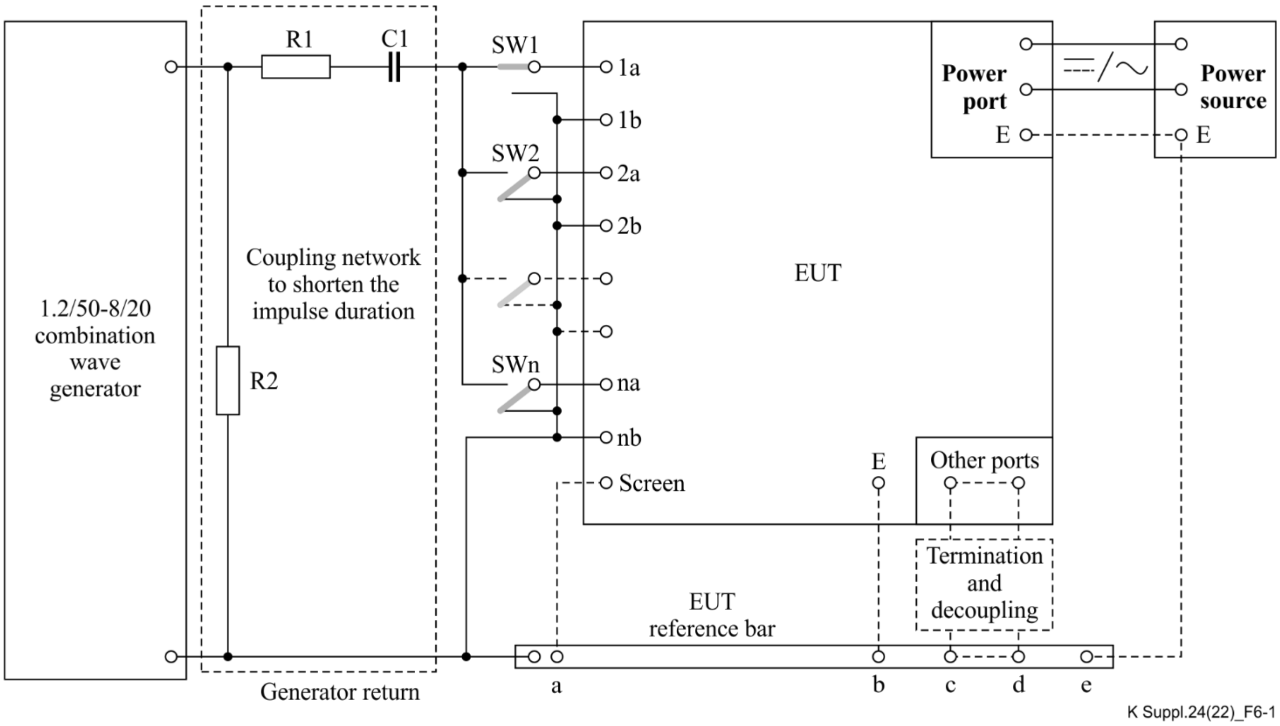
NOTE 2 – Shielded cable tests 7.6, 7.7 and 7.10 do not apply when the equipment is guaranteed to be installed using a shielded cable bonded at both ends and there are no voltage limiters in the system, such as surge protective devices (SPDs) and surge protective components in the equipment port or connecting cable. (The operation of longitudinal/common-mode voltage limiters, such as surge protective devices (SPDs) and surge protective components, can produce transverse/differential surges.) (Note 6 in clause 6 of [ITU-T K.20]).

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

No.	Source	Rationale	Added date of rationale
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 µs (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 SG5	This basic 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.20])"; 2.5 kV.	3/2020
3	Agreed in SG5	Until the version of [ITU-T K.20] (10/2018), this enhanced test level for Ethernet port was in line with enhanced test level of "Mains power port, lightning, inherent, port to earth (5.1.1b of [ITU-T K.20])"; 6.0 kV. As a result of the discussion in SG5, this enhanced test level was revised as 4kV at the version of 11/2019, because 4kV represent better general K.20 environment for internal Ethernet port.	3/2020
4	Agreed in SG5	This requirement is specified based on the situation that overvoltage of approximately 1 kV/floor appears on internal Ethernet cable within telecommunication centre building, in the case of direct lightning strike on a building.	3/2020
5	Agreed in 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 current that appears on the secondary side of pulse transformer, etc..	5/2021
6	[ITU-T K.99], Surge protective component application guide – Gas discharge tubes. Appendix IV "Three-electrode GDT operation in Ethernet circuits" IV.2.2 GDT operation	Quoted from source document; Figure IV.2* substitutes the port magnetics for a low value resistor, RAB, 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, RA and RB to the port and GDT. If the GDT electrode connected to B is the first to spark-over, it draws current, IB, from the B conductor and current, IA, from the A conductor via the resistance RAB, see Figure IV.3**. * See Figure 6-2 ** See Figure 6-3	5/2021

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

No.	Source	Rationale	Added date of rationale
7	[ITU-T K.126], Surge protective component application guide – High frequency signal isolation transformers. 9.4 Differential-mode primary winding surge	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, IS, 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·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 ** See Figure 6-5	5/2021
8	Agreed in SG5	Shielded cable port testing was added as written in Table 1b accompanying with the condition of Note 2 (Note 6 in clause 6 of [ITU-T K.20]) at the SG5 meeting in May 2021. This addition intends the situation that a shielded cabling is connected to that port but its shielding may be bonded at only single end or may not be bonded.	5/2022
9	Agreed in SG5	The exception condition of Note 2 in Table 6-1 (Note 6 in clause 6 of [ITU-T K.20]) at the SG5 meeting in May 2021, based on the discussion that there would be less possibility of the occurrence of differential/transverse surge on shielded cable bonded at both ends and there are no voltage limiters in the system for K.20 environment.	5/2022



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])

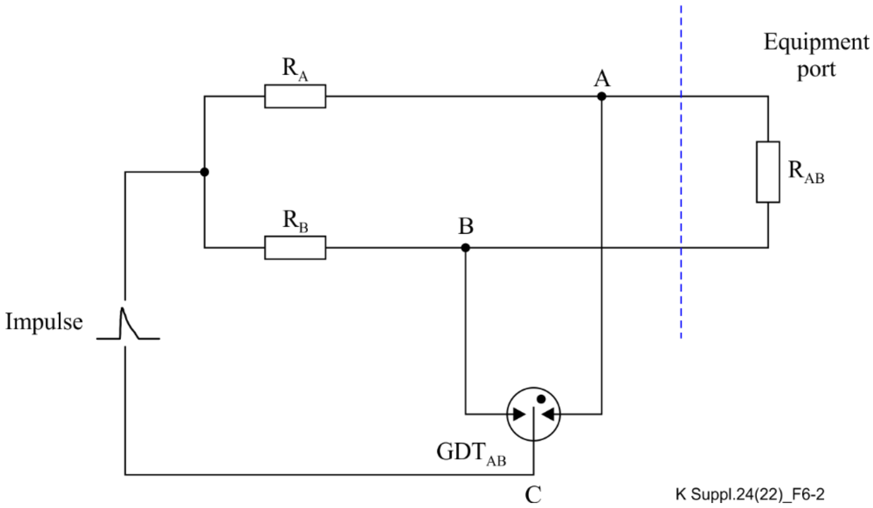


Figure 6-2 – Equivalent circuit under common-mode surge conditions (Figure IV.2 in [ITU-T K.99)

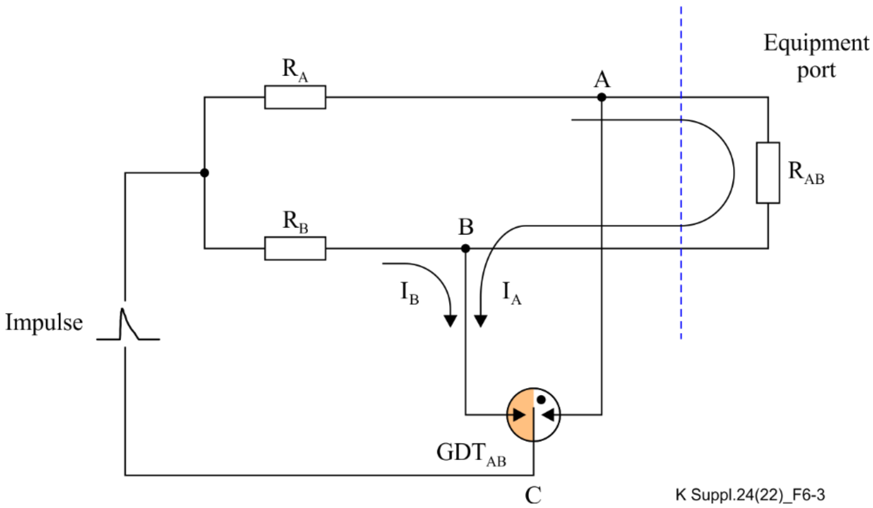
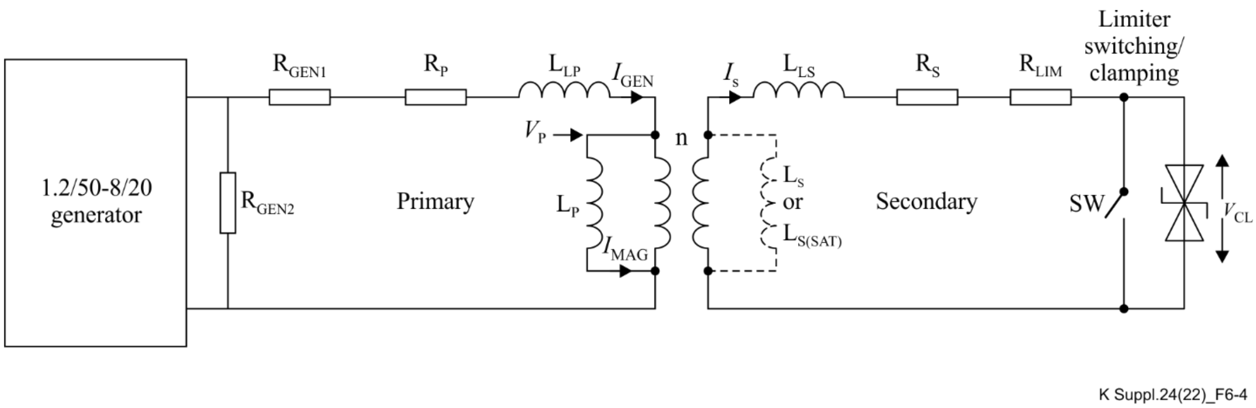


Figure 6-3 – Circuit currents when electrode connected to B is first to spark-over (Figure IV.3 in [ITU-T K.99])



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}	Magnetising current	n	Transformer turns ratio
L_P	Primary magnetising 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])

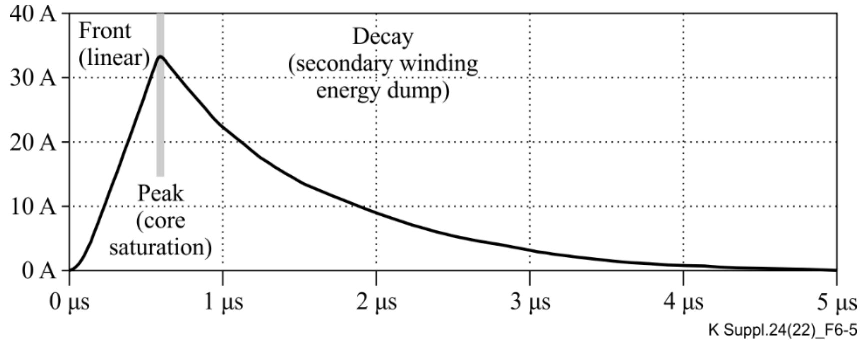


Figure 6-5 – Example waveform of transformer secondary winding differential surge let-through current (Figure 9-9 in [ITU-T K.126])

7 Addition of rationale to this Supplement

Rationale for revision of [ITU-T K.20] is added in case [ITU-T K.20] is revised.

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