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Electromagnetic compatibility requirements for electrical equipment in telecommunication facilities

Recommendation ITU-T K.123

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Electromagnetic compatibility requirements for electrical equipment in telecommunication facilities

Summary

Recommendation ITU-T K.123 describes the requirements for radiated and conducted emissions from electrical systems installed in telecommunication facilities. Electrical systems in the scope of this Recommendation include rectifiers that supply direct current (DC) voltages of up to 400 V, power conditioning systems (PCSs) including grid connected power converters (GCPCs), uninterruptible power supplies (UPSs) and inverter driven electrical equipment including the air conditioners needed for the operation of telecommunication systems. Their electrical systems include power conversion devices and may generate conducted and radiated electromagnetic disturbances and cause degradation of the performance of telecommunication systems.

History

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Introduction

Recently, an increasing number of electrical devices that involve high power switching circuits have been installed in telecommunication facilities. These include rectifiers that supply DC voltages up to 400 V, power conditioning systems (PCSs) including grid connected power converters (GCPCs), uninterruptible power supplies (UPSs) and air conditioners. Moreover, the power dealt with in these electrical devices has been increasing with their increase in number and the consumption requirements of telecommunication equipment installed in a facility, in accordance with the growth of information and communication technology (ICT) companies. Therefore, the possibility of interference with telecommunication systems due to emissions from these electrical systems is increasing.

Even though [ITU-T K.48] specifies emission requirements for telecommunication equipment, including power equipment, such as rectifier units, UPSs and DC distribution systems, the emission requirements for electrical systems that are not integral parts of telecommunication systems are not clearly specified in the Recommendation.

[CISPR 11] specifies emission requirements for switching power equipment, however, it does not specify requirements above 1 GHz and below 150 kHz. Also, the emission level limit in [CISPR 11] from photovoltaic power generating systems with a rated power from 20 kVA to 75 kVA is about 20 dB higher than the requirements for the telecommunication equipment regulated in [CISPR 32].

The systems installed in a telecommunication centre are sensitive to electromagnetic disturbances, since their immunity is designed and tested to meet the requirements of the controlled electromagnetic environment of the centre. Therefore, the telecommunication systems are at risk of malfunction if large power appliances are installed in such centres without limiting their electromagnetic emissions appropriately.

Consequently, the limits of emission levels from electrical systems installed in telecommunication facilities should be the same as the levels required for class A equipment in [CISPR 32].

Recommendation ITU-T K.123

Electromagnetic compatibility requirements for electrical equipment in telecommunication facilities

1 Scope

This Recommendation defines the emission requirements for electrical equipment that is installed inside or on the roof of telecommunication facilities.

This Recommendation applies to power supply systems with embedded power conversion devices (e.g., *DC* to *AC inverters*, *DC* to *DC*, *AC to DC and AC to AC converters*), PCSs including GCPCs, UPSs and air conditioning systems. Lighting equipment is not addressed by this Recommendation.

Telecommunication equipment that directly provides telecommunication services are excluded from the scope of this Recommendation as they are covered by specific EMC Recommendations.

This Recommendation specifies measurement methods and limits for conducted emissions in the frequencies from 9 kHz to 30 MHz and for radiated emissions from 30 MHz to 6 GHz. Guidance on any unintentional voltage/current at AC and DC power ports is provided in this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T K.38] Recommendation ITU-T K.38 (1996), *Radiated emission test procedure for physically large systems.*

[ITU-T K.48] Recommendation ITU-T K.48 (2006), *EMC requirements for telecommunication equipment – Product family Recommendation.*

[CISPR 11] CISPR 11:2019 (Ed. 6.2), *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement.*

[CISPR 16-1-2] CISPR 16-1-2:2014 (Ed. 2.0), *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Coupling devices for conducted disturbance measurements.*

[CISPR 16-1-4] CISPR 16-1-4:2019 (Ed. 4.0), *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements*.

[CISPR 16-2-1] CISPR 16-2-1:2014 (Ed.3.0), *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*.

[CISPR 16-2-3] CISPR 16-2-3:2016 (Ed.4.0), *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*.

[CISPR 32] CISPR 32:2015 (Ed. 2.0), *Electromagnetic compatibility of multimedia equipment – Emission requirements.*

[ETSI 300 132-2] ETSI EN 300 132-2 (2019), *Environmental Engineering (EE); Power supply interface at the input to telecommunications and data com (ICT) equipment; Part 2: Operated by –48 V direct current (dc).* http://www.etsi.org/deliver/etsi_en/300100_300199/30013202/02.05.01_60/en_30013202v020501p.pdf

[IEC 60050-161] IEC 60050-161:1990 (Ed.1.0), *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility.*

[IEC 61000-3-2] IEC 61000-3-2:2018 (Ed. 5.0), *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current up to and including 16 A per phase).*

[IEC 61000-3-3] IEC 61000-3-3:2013 (Ed. 3.0), *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current up to and including 16 A per phase and not subject to conditional connection.*

[IEC 62040-3] IEC 62040-3:2011 (Ed.2.0), *Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements.*

[IEC TS 62578] IEC TS 62578:2015 (Ed.2.0), *Power electronics systems and equipment - Operation conditions and characteristics of active infeed converter (AIC) applications including design recommendations for their emission values below 150 kHz.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 AC mains power port [CISPR 11]: Port used to connect to a public low voltage AC mains power distribution network or other low voltage AC mains installation.

3.1.2 artificial mains network (AMN) [CISPR 11]: Network that provides defined impedance to the equipment under test (EUT) at radio frequencies, couples the disturbance voltage to the measuring receivers and decouples the test circuit from the supply mains.

3.1.3 DC artificial mains network (DC-AN) [CISPR 11]: Artificial network that provides defined termination to the EUT's DC power port under test while also providing the necessary decoupling from conducted disturbances originating from the laboratory DC power source or from the load.

3.1.4 DC power port [CISPR 11]: Port used to connect to a low voltage DC power generating system or energy storage, or to another source/load.

3.1.5 DC network power port [CISPR 32]: Port, not powered by a dedicated AC/DC power converter and not supporting communication that connects to a DC supply network.

3.1.6 electromagnetic disturbance [IEC 60050-161]: Any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter.

3.1.7 electromagnetic interference (EMI) [IEC 60050-161]: Degradation of the performance of an equipment, transmission channel or system caused by an electromagnetic disturbance.

3.1.8 enclosure port [IEC 61000-6-6]: A physical boundary of the apparatus which electromagnetic fields may radiate through or impinge upon. The equipment case is normally considered the enclosure port.

3.1.9 continuous disturbance [ITU-T K.48]: Electromagnetic disturbance whose effects on a particular device or piece of equipment cannot be resolved into a succession of distinct effects.

3.1.10 grid connected power converters [CISPR 11]: Power converter connected to an AC mains power distribution network or other AC mains installation and used in a power generating system.

3.1.11 high power electronic system and equipment [CISPR 11]: One or more semiconductor power converters with a combined rated power greater than 75 kVA, or an equipment containing such converters.

3.1.12 industrial, scientific and medical applications [CISPR 11]: Operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications.

3.1.13 signal/control port [CISPR 32]: Port intended for the interconnection of components of an EUT, or between an EUT and local AE and used in accordance with relevant functional specifications (for example for the maximum length of cable connected to it).

3.1.14 photovoltaic power generating system [CISPR 11]: Electric power generating system which used the photovoltaic effect to convert solar power into electricity.

3.1.15 power supply [ITU-T K.48]: A power source to which telecommunication equipment is intended to be connected.

3.1.16 minimum representative system [ITU-T K.38]: A system which contains the minimum number of units needed to perform all functions specified for the system.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 telecommunication facility: A building or place that provides telecommunication services or is used for telecommunication equipment and is controlled by a telecommunication operator.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
AE	Auxiliary Equipment
AMN	Artificial Mains Network
CISPR	International Special Committee on Radio Interference
CMAD	Common Mode Absorption Device
DC	Direct Current
DC-AN	D.C. Artificial Network
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ETSI	European Telecommunications Standards Institute
EUT	Equipment Under Test
FSOATS	Free Space Open Area Test Site

GCPC	Grid Connected Power Converters
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
ISM	Industrial, Scientific and Medical
OATS	Open Area Test Site
PCS	Power Conditioning System
POTS	Plain Old Telephone Service
SAC	Semi Anechoic Chamber
UPS	Uninterruptible Power Supply

5 Conventions

None.

6 Connection of equipment in a telecommunication centre

Figures 1 and 2 illustrate examples of the configuration of equipment and connection of power lines in telecommunication centres.

Figure 1 shows an example of a traditional telecommunication centre, where a −48 V DC power supply system is used for the telecommunication network. A conducted emission from GCPCs, air conditioners and lighting equipment will enter the rectifier and this may cause malfunction of the rectifier itself and also cause malfunction of telecommunication equipment by conducted disturbance through the DC power line. The electromagnetic field emitted from the power line and the enclosure of the equipment may also cause interference in the telecommunication equipment. The emitted harmonic current to the AC power line may cause malfunction in the power distribution system external to the telecommunication facility.

For telecommunication equipment supporting an analogue subscriber line that is sensitive to noise below 20 kHz, a specific requirement such as [ETSI 300 132-2] is applied to avoid interference.

Figure 2 shows an example of a telecommunication centre where 400 V DC power supply systems are used for telecommunication network equipment. The interferences transmitted through power lines present a situation similar to the case of the −48 V DC power supply and electromagnetic fields are emitted from lines and enclosures in the same way. Therefore the same kinds of requirements are applied to the equipment.

The requirement for interfaces feeding up to 400 V DC at the input to telecommunication equipment is shown in [b-ITU-T L.1200]. However, this is not within the scope of this Recommendation.

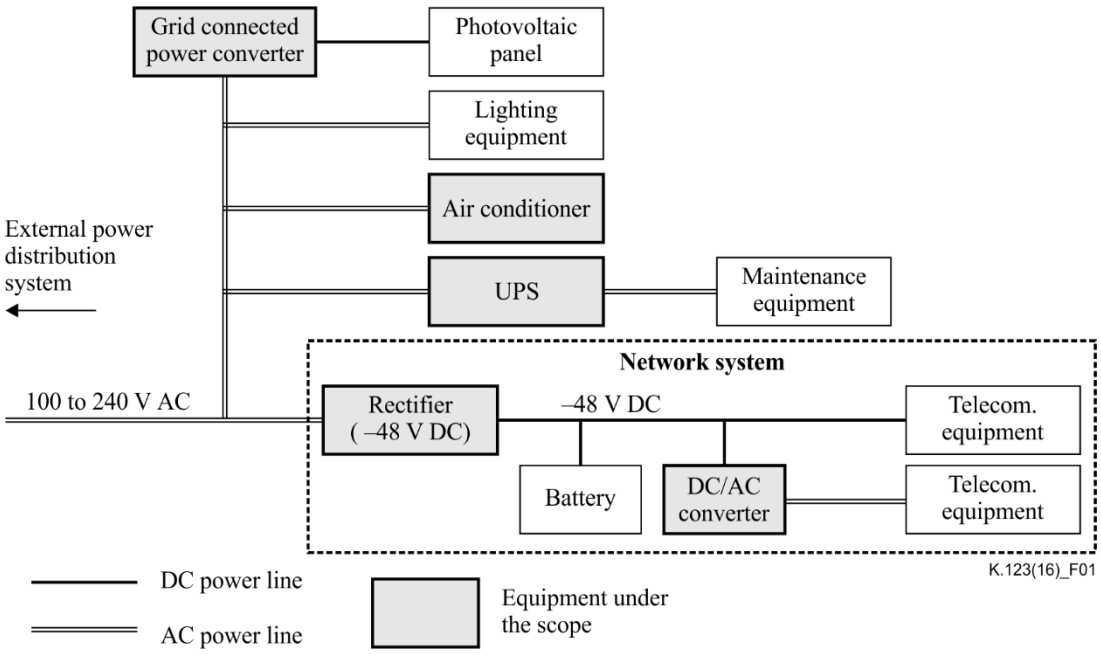


Figure 1 – An example of a −48 V DC power supply system

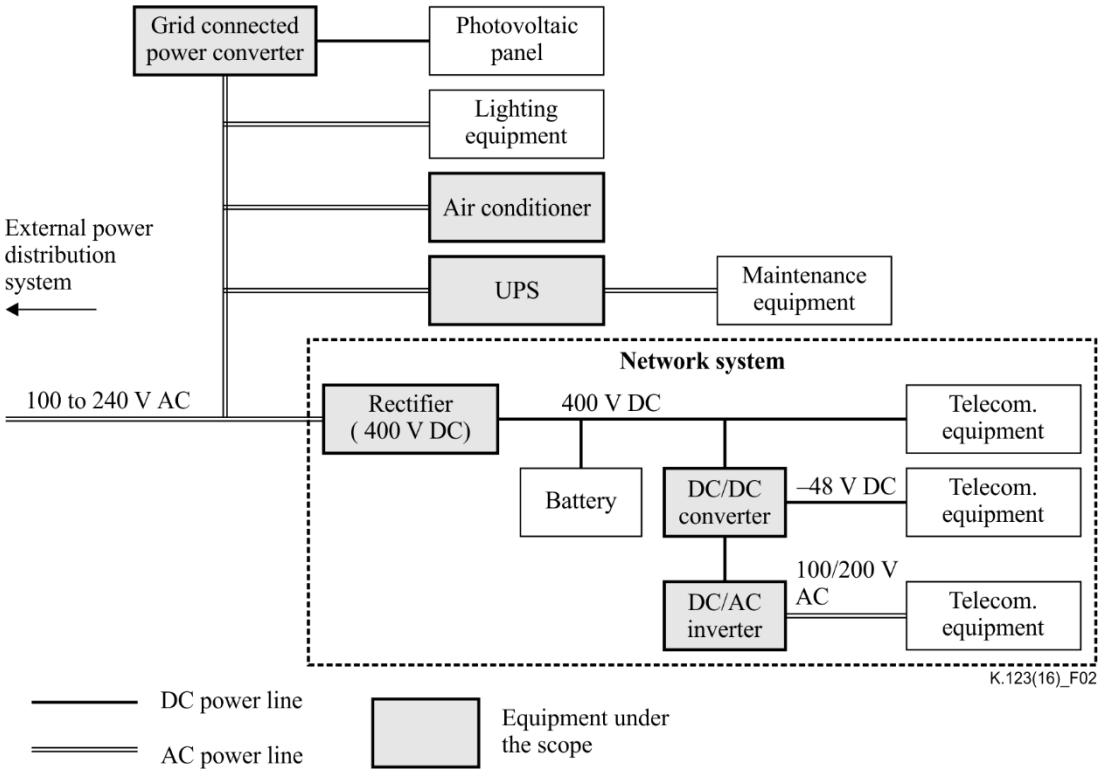


Figure 2 – An example of a 400 V DC power supply system

7 Emissions from 9 kHz to 6 GHz

7.1 Test methods and limits

Basically, both conducted and radiated emission for electrical systems including the air conditioners needed for the operation of telecommunication systems should be tested in accordance with [CISPR 32] and [IEC TS 62578]. Test for photovoltaic equipment should be conducted according to configurations specified in [CISPR 11]. Conducted emission measurement at power input and output ports should be made using the artificial mains network (AMN) at each port, if available, as detailed in [CISPR 32]. In order to demonstrate compliance of the radiated emission test for physically large systems, [ITU-T K.38] applies to such systems. A minimum representative system is defined in [ITU-T K.38] and it is representative of installed systems in terms of function (which includes at least one of each functional unit type) and electromagnetic radiation characteristics.

7.1.1 Conducted emission at AC and DC power input ports

The conducted emission above 150 kHz at an AC power input port (mains) should be measured in accordance with Clause A.3 Annex A of [CISPR 32] and below 150 kHz, should be measured in accordance with [IEC TS 62578] using the AMN. EUT, local AE and associated cabling should be arranged in accordance with Annex D of [CISPR 32]. The conducted emission at DC power input ports should be measured using DC-AN. Table 1 shows measurement method and limits of conducted emission at AC and DC mains ports. The requirements below 150 kHz are tentative conducted emission limits and are not, for the time being, normative requirements. These limits will be aligned with IEC/CISPR limits when available.

Table 1 – Measurement method and limits of conducted emission at AC and DC mains ports

Coupling device	Frequency	Quasi-peak limit (dBµV)	Average limit (dBµV)	Basic standard	Validation method
AC mains power input ports					
AMN	9 to 50 kHz (Note 1)	138 to 127.5	125 to 114.5	Clause 7 of [CISPR 16-2-1]	Clause 4 of [CISPR 16-1-2]
	50 to 150 kHz (Note 1)	127.5 to 100	114.5 to 87		
	0.15 to 0.5 MHz	79	66	Clause 7 of [CISPR 16-2-1]	Clause 4 of [CISPR 16-1-2]
	0.5 to 30 MHz	73	60		
DC mains power input ports (Note 2)					
DC-AN	9 to 50 kHz (Note 1)	148 to 137.5	135 to 124.5	Clause 7 of [CISPR 16-2-1]	Clause 4 of [CISPR 16-1-2]
	50 to 150 kHz (Note 1)	137.5 to 110	124.5 to 97		
	0.15 to 0.5 MHz	89	76	Clause 7 of [CISPR 16-2-1]	Clause 4 of [CISPR 16-1-2]
	0.5 to 30 MHz	83	70		

NOTE 1 – The limit shall decrease linearly with the logarithm of the frequency in the range of 9 kHz to 150 kHz.

NOTE 2 – There is no requirement in [CISPR 11] and [CISPR 32] for DC mains ports. The limit value for a DC mains power input port is tentative. The value is determined assuming that the emission is from a current source and considering the impedance difference of AMN and DC-AN, i.e., 50 ohms and 150 ohms.

7.1.2 Conducted emission at AC and DC power output ports

The conducted emission at an AC power output port (mains) should be measured using the AMN.The conducted emission at a DC power input port should be measured using DC-AN.

The measurement method and limit can be applied to a port which is intended to be connected to a cable longer than 3 m. Table 2 shows measurement method and limits of conducted emission at AC and DC power output ports. The requirements below 150 kHz are tentative conducted emission limits and are not, for the time being, normative requirements.

Table 2 – Measurement method and limits of conducted emission from AC and DC power output ports

Coupling device	Frequency	Quasi-peak limit (dBμV)	Average limit (dBμV)	Basic standard	Validation method
AC mains power output ports					
AMN	9 to 50 kHz (Note 1)	138 to 127.5	125 to 114.5	Clause 7 of [CISPR 16-2-1]	Clause 4 of [CISPR 16-1-2]
	50 to 150 kHz (Note 1)	127.5 to 100	114.5 to 87		
	0.15 to 0.5 MHz	79	66	Clause 7 of [CISPR 16-2-1]	Clause 4 of [CISPR 16-1-2]
	0.5 to 30 MHz	73	60		
DC mains power output ports (Note 2)					
DC-AN	9 to 50 kHz (Note 1)	148 to 137.5	135 to 124.5	Clause 7 of [CISPR 16-2-1]	Clause 4 of [CISPR 16-1-2]
	50 to 150 kHz (Note 1)	137.5 to 110	124.5 to 97		
	0.15 to 0.5 MHz	89	76	Clause 7 of [CISPR 16-2-1]	Clause 4 of [CISPR 16-1-2]
	0.5 to 30 MHz	83	70		

NOTE 1 – The limit shall decrease linearly with the logarithm of the frequency in the range of 9 kHz to 150 kHz.

NOTE 2 – The limit value for DC mains power input ports is tentative. The value is determined assuming that the emission is from a current source and considering the impedance difference of AMN and DC-AN, i.e., 50 ohms and 150 ohms.

7.1.3 Conducted emission at signal ports

The conducted emission at a signal port such as an interface to control equipment should be measured in accordance with Clause A.3 Annexes A and C of [CISPR 32] using the AAN. EUT, local AE and associated cabling should be arranged in accordance with Annexes D and C.4.1.1 of [CISPR 32].

The measurement method and limit can be applied to a port which is intended to be connected to a cable longer than 3 m. Table 3 shows measurement method and limits of conducted emission from signal ports.

Table 3 – Measurement method and limits of conducted emission from signal ports

Coupling device	Frequency	Quasi-peak limit (dBμV)	Average limit (dBμV)	Basic standard	Validation method
Signal ports					
AAN	0.15 to 0.5 MHz	79	66	Clause 7 of [CISPR 16-2-1]	Clause 7 of [CISPR 16-1-2] Table C.2. of [CISPR 32]
	0.5 to 30 MHz	73	60		

7.1.4 Conducted emission specifically from GCPC

The conducted emission at AC and DC power input ports should be measured in accordance with clause 7.6.10 of [CISPR 11]. The test setup for GCPC shall be in accordance with Annex J of [CISPR 11]. Table 4 shows measurement method and limits of conducted emission from GCPC.

Table 4 – Measurement method and limits of conducted emission from GCPC

Coupling device	Frequency	Quasi-peak limit (dBμV)	Average limit (dBμV)	Basic standard	Validation method
AC mains ports					
AMN	0.15 to 0.5 MHz	79	66	Annex J of [CISPR 11]	
	0.5 to 30 MHz	73	60		
DC power generator port					
DC-AN	0.15 to 0.5 MHz	97 to 89	84 to 76	Annex J of [CISPR 11]	
	0.5 to 30 MHz	89	76		

7.1.5 Radiated emission at enclosure port

The test methods for radiated emission are based on [CISPR 32]. Refer to [CISPR 11] for measurement of radiated emission from specific features of electrical systems. Table 5 shows measurement method and limits of radiated emission from enclosure ports.

Table 5 – Measurement method and limits of radiated emission from enclosure ports

Frequency	Measurement facility	Validation method	Measurement procedure	Quasi-peak limit (dB μV/m)	Average limit (dB μV/m)	Peak limit (dB μV/m)
30 to 230 MHz	SAC or OATS 10 m distance	5.3 of [CISPR 16-1-4]	7.3 of [CISPR 16-2-3]	40	–	–
230 to 1000 MHz				47	–	–
1000 to 3000 MHz	FSOATS 3 m distance	8.3 of [CISPR 16-1-4]	7.6.6 of [CISPR 16-2-3]	–	56	76
3000 to 6000 MHz				–	60	80

7.2 Operational conditions

All measurements should be made in the operating mode that produces the largest emissions consistent with normal use. The operating conditions and power consumption level of the EUT shall be selected to maximize the emission level. The EUT load should be adjusted within the normal operating range in order to maximize emissions.

If the emission spectrum changes depending on the operation mode, measurement should be conducted in more than one mode, so as not to overlook the maximum emission at different frequencies.

Concerning devices for power supply systems and PCSs the following conditions shall apply:

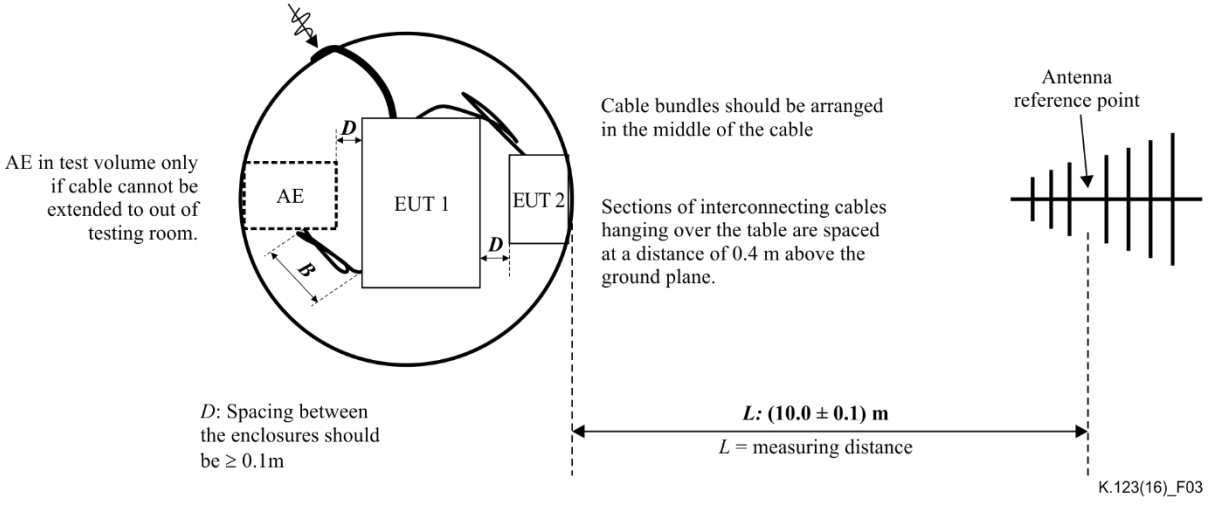
- The load on the EUT terminating the power output should be resistive unless otherwise specified in the agreement between operator and manufacturer.
- The test shall be carried out at the nominal input voltage.
- The measurement shall be conducted in consideration of whether the AC mains are on or off.
- The signal and/or control ports should be correctly terminated either by the AE necessary to exercise the ports, or by its nominal impedance.

7.3 Test configuration

Conducted emission is measured on the power input and output ports with AMN on both ports and on one signal/control interface of each type found on the equipment. The configuration of the EUT shall be precisely documented in the test reports.

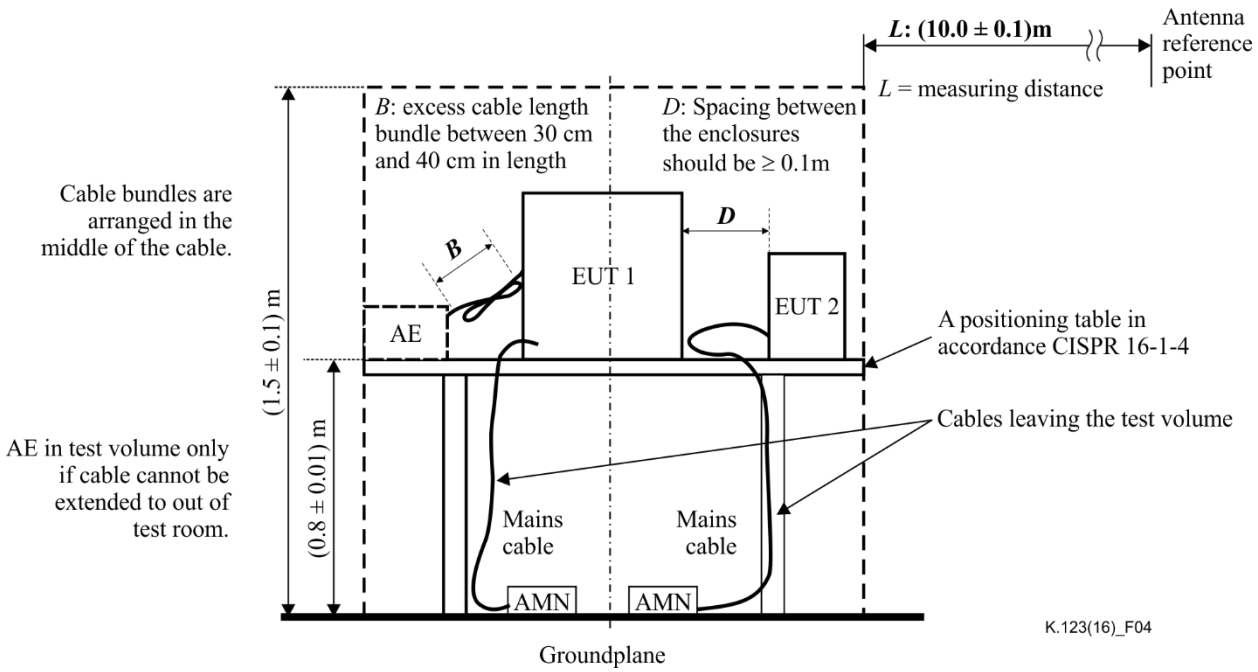
An example of a typical setup for measurement of radiated disturbances from table-top EUTs is provided in [CISPR 11]. However, the use of a common mode absorption device (CMAD) is not recommended for the tests in this Recommendation (see Figures 3 and 4).

An example of a typical unified test setup for floor-standing equipment suitable for measurement of conducted as well as radiated disturbances is shown in Figure 5. Further examples of typical arrangements of the EUT and associated peripherals are given in [CISPR 16-2-1] and [CISPR 16-2-3].



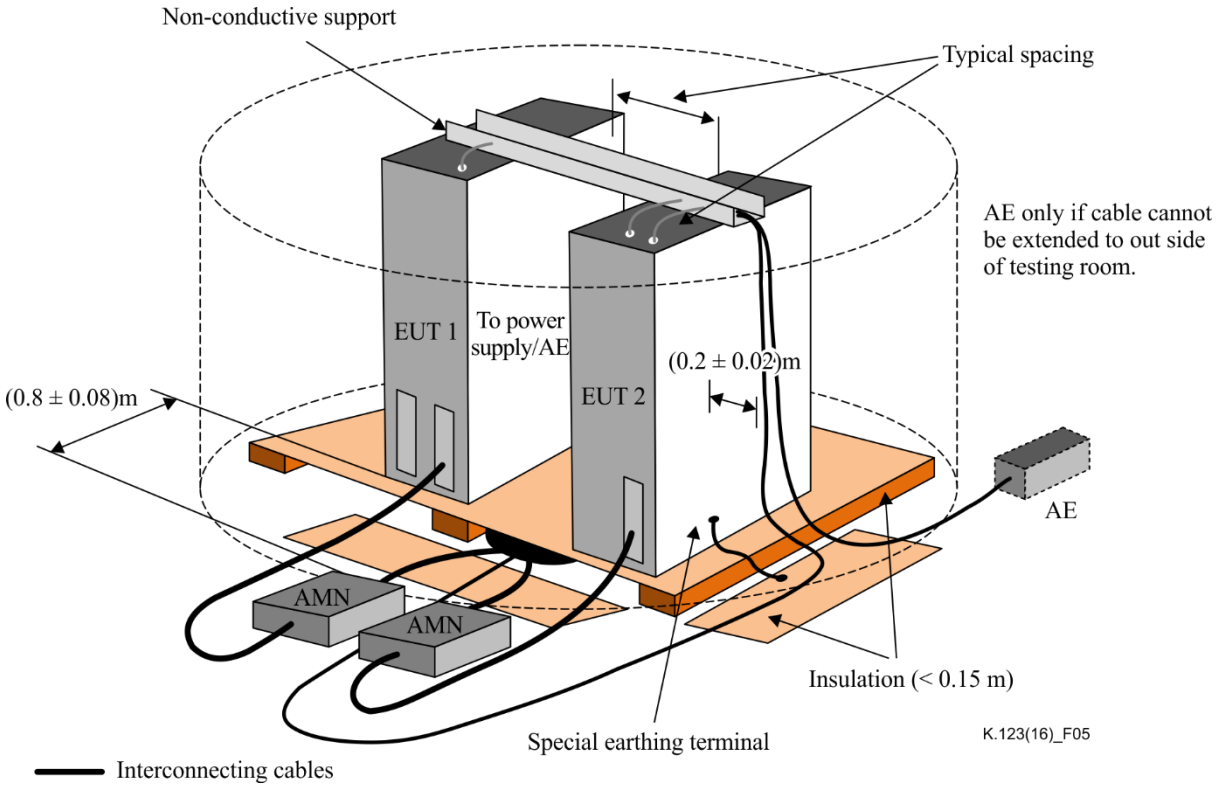
Modified from Fig. 3a in [CISPR 11]

Figure 3 – Example of a typical setup for measurement of radiated disturbances at a 10 m separation distance



Modified from Fig. 3b in [CISPR 11]

Figure 4 – Example of a typical setup for measurement of radiated disturbances from a table-top EUT



Modified from Fig. 4 in [CISPR 11]

Figure 5 – Example of a typical setup for measurement of conducted and/or radiated disturbances from a floor-standing EUT

8 Guidance on noise other than emissions from 9 kHz to 6 GHz

The following issues must be considered when electrical equipment installed in a telecommunication centre is designed or selected from the market. This Clause provides guidance on the noise or unintended voltages other than emissions from 9 kHz to 6 GHz.

8.1 Requirements for harmonic currents and voltage change on AC input ports

Harmonic currents on AC mains input ports can influence power distribution systems connected to the equipment. The requirement in [IEC 61000-3-2] should be referred to for high power equipment.

The requirements in [IEC 61000-3-3] should be referred to for voltage fluctuations on the AC mains port.

8.2 Noise on DC output port.

Equipment having analogue ports such as a plain old telephone service (POTS) interface is sensitive to noise voltages below 20 kHz. Therefore, it is necessary to limit noise voltages below 20 kHz in the −48 V DC output of rectifiers or DC/DC converters used in power supplies for telecommunication equipment. The quality of DC output, including noise voltages below 20 kHz, can be determined, using [ETSI 300 132-2] when applicable.

Regarding 400 V DC rectifiers, requirements other than those for electromagnetic disturbances can be found in [b-ITU-T L.1200].

8.3 Noise on AC output ports

UPSs with a non-sinusoidal output voltage are not appropriate for operation of telecommunication equipment. The output specifications in [IEC 62040-3] should be considered when selecting UPSs to be installed in telecommunication centres. The output voltage performance classification of wave shape should be "S" in clause 5.3.4 of [IEC 62040-3]. The harmonic currents should conform to [IEC 61000-3-2] when terminated by a resistance load.

Bibliography

[b-ITU-T L.1200] Recommendation ITU-T L.1200 (2012), *Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment.*

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