



CISPR 15

Edition 9.1 2024-07
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

Corrected version
2026-05



INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment





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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.10

ISBN 978-2-8322-0000-0

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CISPR 15
 Edition 9.0 2018-05

**LIMITS AND METHODS OF MEASUREMENT
 OF RADIO DISTURBANCE CHARACTERISTICS OF
 ELECTRICAL LIGHTING AND SIMILAR EQUIPMENT**
INTERPRETATION SHEET 1

This interpretation sheet has been prepared by subcommittee CISPR F: Interference relating to household appliances tools, lighting equipment and similar apparatus, of IEC technical committee CISPR: International special committee on radio interference.

The text of this interpretation sheet is based on the following documents:

DISH	Report on voting
CIS/F/777/DISH	CIS/F/790/RVDISH

Full information on the voting for the approval of this interpretation sheet can be found in the report on voting indicated in the above table.

CISPR 15 interpretation sheet on the worst-case mode of operation
Introduction

Subclause 7.5 specifies the operating modes of lighting equipment that must be considered during an emission test. A few examples are given to support the explanation of what 'different operating modes' means. The list of examples is of course not exhaustive. Apparently, the example of 'colour shifting' is not clear enough and it is sometimes interpreted as if any possible colour and/or correlated colour temperature (CCT) setting that lighting equipment may produce shall be assessed during measurements. Many types of LED lighting may be set in many different colours and CCTs. Compared to other operational-mode related influence quantities such as light level regulation, flashing or radio communication, the risk of not capturing the maximum level of electromagnetic (EM) disturbances due to different colour or CCT settings is very small, provided that all channels of a LED driver used to change colour or CCT are operative. The 'colour shifting'-example was meant for example for a mode where the light output continuously switches from one colour to another with a certain repetition frequency (e.g. applied for entertainment, events etc.), instead of emitting a single stable colour and/or CCT.

Question

What is the meaning of example 'colour shifting' as mode of operation to be considered during testing? What colour and/or colour temperature should be selected in case lighting equipment can be set in a wide range of colours and/or CCTs?

Interpretation

The example 'colour shifting' in the first paragraph of 7.5 of CISPR 15:2018 must not be interpreted as if any possible colour and/or CCT setting that lighting equipment may produce shall be assessed during measurements.

Generally, according to 7.5 the worst case shall be found by prescanning every mode of operation over at least one repetition interval of the specific mode.

Alternatively, measurements can be performed using the setting(s) that are expected to produce the highest amplitude emissions relative to the limit; and, the reasons for the selection shall be given in the test report.

A reason could be that highest level of electromagnetic (EM) disturbances will be captured if all channels of a LED driver used to create different colours and/or CCTs are operative. The number of channels applied depends on the LED-driver/LED-light-source architecture. Often, maximum EM disturbances can be achieved by selecting a white colour and/or a CCT setting in the middle of the specified CCT range.

EXAMPLE Colour variation and CCT variation may be achieved using a 5-channel LED driver powering three LED strings for colour (RGB) setting and two cool white and warm white LED strings for CCT setting. Hence, in case the lighting equipment under test is capable to operate at different colours and/or CCTs, a white colour and/or a single CCT in the middle of the specified CCT range may be selected¹.

¹ 7.4 of CISPR 15:2018, also still applies.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Amendment 1 2024-07

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The text of this interpretation sheet is based on the following documents:

DISH	Report on voting
CIS/F/926/DISH	CIS/F/932/RVDISH

Full information on the voting for the approval of this interpretation sheet can be found in the report on voting indicated in the above table.

CISPR 15 interpretation sheet on the use of the current probe on wires with high differential currents

INTRODUCTION

This document is an interpretation sheet to CISPR 15:2018 and CISPR 15:2018/AMD1:2024. It answers the question how to avoid the measurement of false common mode disturbance currents in CISPR 15 with the current probe.

This interpretation sheet is an interim solution that will not automatically be included into future CISPR 15 amendments and editions. A permanent solution will be based on a future amendment of CISPR 16-2-1.

The proposed measurement procedure is based on investigations and measurements done in Japan (JLMA), Germany (Bundesnetzagentur BNetzA) and by Manufacturers of electronic LED drivers. Based on these investigations and discussions within CISPR/F the proposal for an interpretation sheet has been created.

When measuring conducted disturbances according to Clause B.3 (local wired ports), it has been observed that reproducibility of common mode disturbance measurements performed with a current probe (see B.3.5 and Table 3, Table 6 for the limits) is under special circumstances low. This low reproducibility has been observed when measuring the common mode current with a current clamp on the wires from the electronic control gear or halogen converter (EuT = Equipment under Test) to the load (LED or halogen lamp).

Various measurements have been done to find out the reason for this low reproducibility.

As a result of these measurements, it has been found that there is a significant impact on the reading at the receiver depending on the spatial position and orientation of the local wired port cable within the current probe. The measurement results are showing that the variations in the readings are large if there are high differential mode currents flowing in these wires (several amperes).

The typical LED control-gear generates a high (pulse-width-modulated) differential mode output current.

The reason for this variation in the measurement results seems to be the non-ideal behaviour of the current probe. An ideal current probe will suppress the differential mode perfectly, no matter where the two wires of the cable – carrying the differential and common mode current – are located within the current probe.

However, even according to CISPR 16-1-2:2014, 5.1.3, a current probe is allowed to have an “influence of orientation” of up to 1 dB up to 30 MHz and 2,5 dB from 30 MHz to 1 000 MHz.

A calculation has been done showing that even this “low” value of 1 dB influence by the orientation of the wire within the probe hole can cause significant change of readings in a receiver if high differential mode currents are present (see Figure 1).

Calculation of the influence of orientation in case of strong differential currents in a CISPR current					
Differential current:	1,0 A		1,0 A		0,01 A
Differential current in dB μ A:	120 dB μ A		120,0 dB μ A		80 dB μ A
Influence of orientation Value (Difference between the two conductors)	1 dB		0,01 dB		0,1 dB
Conductor 1 Current reading:	120 dB μ A		120,0 dB μ A		80 dB μ A
Conductor 2 Current reading:	119 dB μ A		120,0 dB μ A		79,9 dB μ A
Conductor 1 Current reading:	1,000 0 A		1,000 0 A		0,010 0 A
Conductor 2 Current reading:	0,891 3 A		0,998 8 A		0,009 9 A
Delta (Conductor 1 minus Conductor 2)	0,108 7 A		0,001 2 A		0,000 1 A
Receiver reading ("Artificial" Signal/false common mode):	100,7 dBμA		61,2 dBμA		41,2 dBμA

IEC

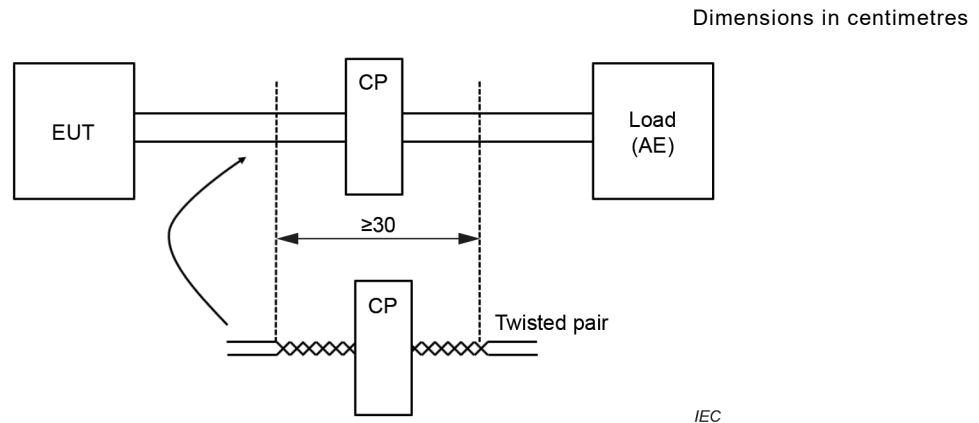
Table 1 – Calculation of the false common mode current in case of high differential currents

For the common mode current measured, the 1 dB influence of the orientation is not critical because the maximum change in the reading at the receiver is only 1 dB. But for the differential mode current the 1 dB will lead to significant changes in the reading. The calculations in Figure 1 are showing that even with a 0,01 dB influence of variation, which is very low compared to 1 dB, which is currently allowed by CISPR 16-1-2, a reading of 61 dB μ A false common mode current at the receiver input will come up. This is much higher than the limit (Table 3 of CISPR 15:2018) of 40 dB μ A at 150 kHz! Thus, a very limited differential mode rejection of the typical current probes becomes obvious. Also, one can see that a “better” current probe (e.g., having only 0,01 dB influence of orientation) would not solve the problem.

The various measurements which have been done by Japan, Germany and various manufacturers of LED drivers are showing that significant improvements can be achieved when a twisted pair cable or a coaxial cable are used as local wired port cable at the position where the load cable goes through the current probe. It is the assumption that the twisting or the coaxial current distribution through the current probe will lead to a much better suppression of the differential current, thus improving the stability of the readings performed with the current probe.

The reason to choose the twisted pair cable instead or beside of the coaxial cable in this interpretation sheet is, that the coaxial cable has an unsymmetrical behaviour in the high frequency range. As a result of the asymmetric transition between a two wire cable and a coaxial cable, the potential for a “differential to common mode conversion” is much higher when a coaxial cable segment is used.

Additionally, there is no extra benefit of using a coaxial cable compared to the twisted pair solution.



CP = current probe

Figure 1 – Replacing the typical cable between EUT and load by twisted pair through the current probe

The effect of cancellation is due to a spatial averaging of the magnetic field, which is quickly reduced to small values when considering the field at a certain distance from the wires.

Clearly, a consistent number of turns shall fall within the thickness of the CP core, and the wires shall be torqued to have a small gap compared with the size of the core.

Thus, from a theoretical point of view, the twisted pair is not an ideal solution, but its effectiveness is related to the size of the conductors, their spacing and the turn density compared with the size of the CP. The advantage is of being a balanced line (symmetrical).

Figure 3 and Figure 4 are showing examples of a test set-up and of twisted cables.

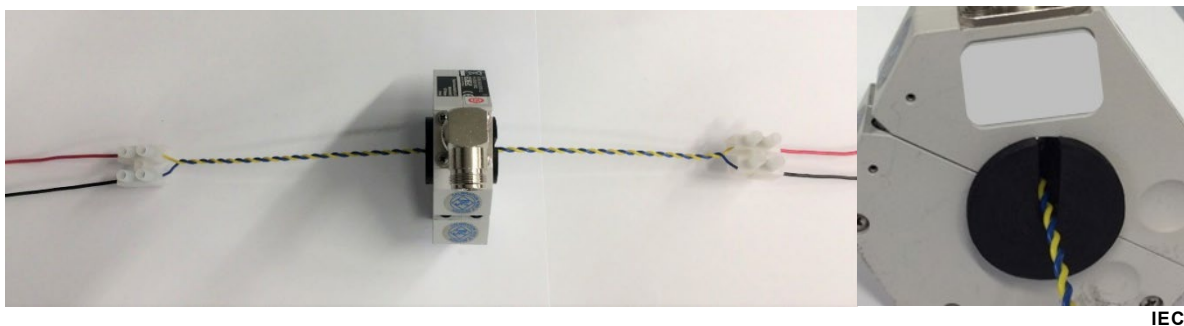


Figure 2 – Example of a measurement setup with a twisted pair

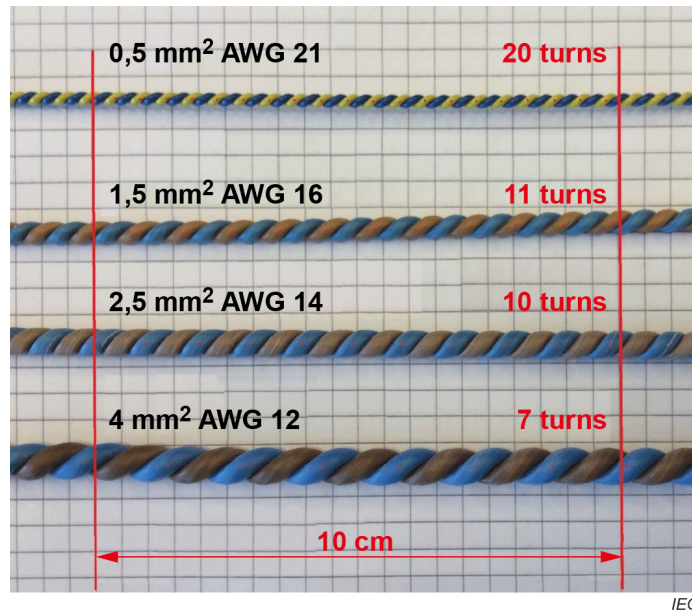


Figure 3 – Examples of twisted pair cables with different cable cross sections

END OF INTRODUCTION

Question:

How can the user of the standard avoid false common mode current indications when measuring with the current probe on wires carrying high differential currents?

Interpretation

When performing measurements with the current probe, the following procedure avoids the measurement of false common mode currents. This procedure can be seen as an explanation on how to interpret the requirements given in B.3.5 about the arrangement of measurement probes.

Before starting the measurement, the user shall verify if there is an impact on the disturbance current measured by performing the measurement on several spatial positions and orientations of the local wired port cable inside the current probe.

If the variability of the measured level of the disturbance current at any frequency with respect to the spatial position inside the current probe exceeds the combined CISPR measurement uncertainty ($U_{CISPR} = 2,9$ dB according to CISPR 16-4-2:2011, CISPR 16-4-2:2011/AMD1:2014 and CISPR 16-4-2:2011/AMD2:2018), the following two measures for the probe arrangement shall be applied to minimize the effect of large differential mode currents.

- 1) The wires in the local wired port cable carrying significant differential mode currents shall be fixed centrally in the clamp's aperture with a nonmetal fixture.
- 2) Additionally, the wires in the local wired port cable carrying significant differential mode currents shall be replaced for the measurement by a twisted pair cable with a length of at least 30 cm as a replacement of the existing local wired port cable.

The twisted pair cable shall have at least or exactly the following number of twists:

Wire cross-section (w) in mm ²	Minimum twists per 10 cm
$w \leq 0,5$	20
$0,5 < w \leq 1,5$	11
$1,5 < w \leq 2,5$	10
$w > 2,5$	7

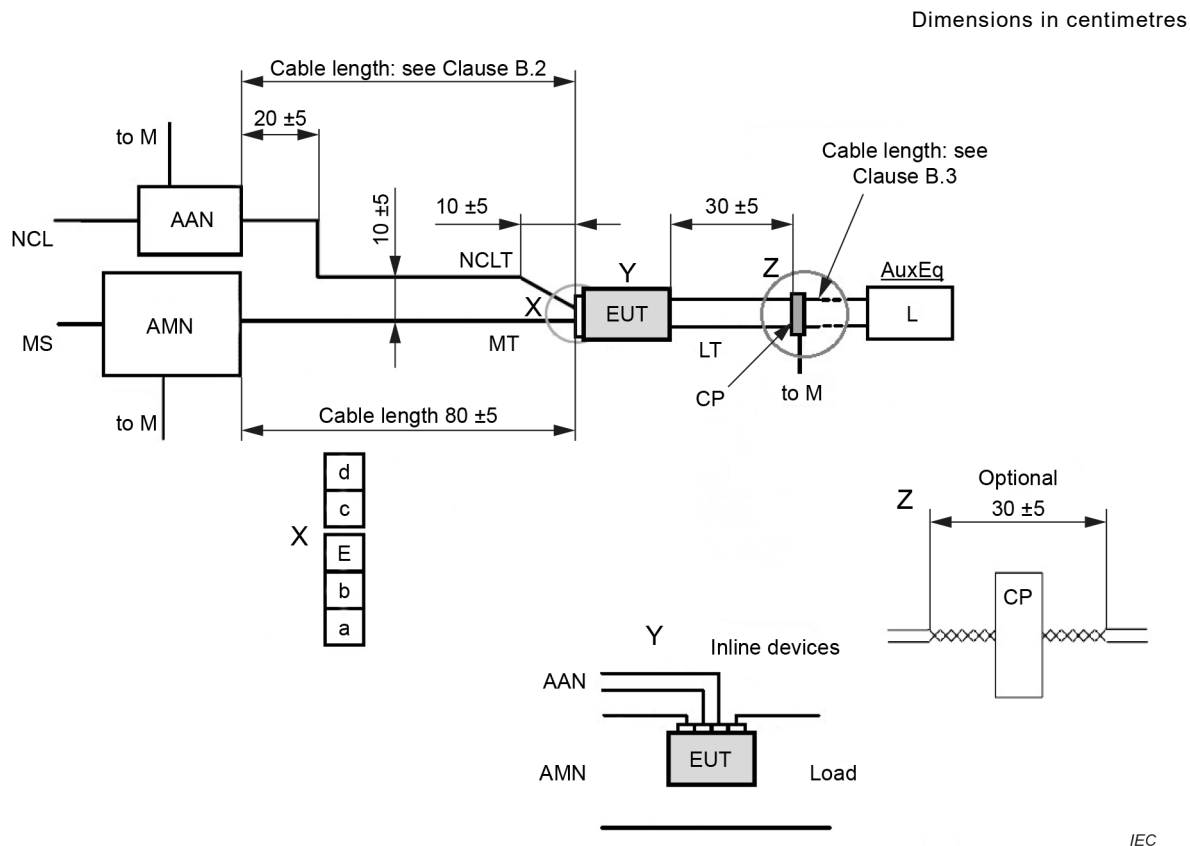
The method of twisting the wires is not relevant in case of shielded cables or cable assemblies or in case of a single wire.

Multi-wire cables shall be centred within the current probe and twisted in a similar way. The way the twisting is performed shall be noted in the test report.

NOTE 1 Other non-twisted cables have been observed to cause significant measurement artefacts (false common mode currents) due to non-ideal electromagnetic field patterns within the current probe and the influence of orientation (see CISPR 16-1-2:2014 + CISPR 16-1-2:2014/AMD1:2017, 5.1.3).

NOTE 2 If a twisted cable is very soft and untwists itself, a typical method to fix the twisting is to use non-conducting (plastic) cable ties or other non-conducting material. is used as a practical reference for deciding whether interim countermeasures should be taken.

Figure B.2 of CISPR 15:2018/AMD1:2024 can be interpreted as shown in Figure 5 below (adding the current probe position with a twisted pair cable):



Key

- | | | | |
|-------|--|------|-------------------------------|
| a – b | Supply terminals | MS | Mains supply |
| c – d | Control terminals | MT | Mains terminals |
| AAN | Asymmetric artificial network | NCL | Network control line |
| AMN | Artificial mains network | NCLT | Network control line terminal |
| CP | Current probe | | |
| E | Earth terminal | | |
| L | Load | | |
| LT | Load terminals | | |
| M | CISPR measuring receiver (for AMN and AAN: replace by 50 Ω if not connected) | | |

The earth of the measuring receiver and the earth terminal of the EUT shall be connected to the AMN ground. Where an inline device is inserted in only one lead of the supply, measurements shall be made by connecting the second supply lead as indicated in the figure under inline devices. See CISPR 15:2018/AMD1:2024, Figure B.3 for details on the arrangement.

Figure 4 – Circuit for measuring conducted disturbances from an external module (with the option to apply the current probe position with twisted pair cable)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

LIMITS AND METHODS OF MEASUREMENT OF RADIO DISTURBANCE CHARACTERISTICS OF ELECTRICAL LIGHTING AND SIMILAR EQUIPMENT

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

CISPR 15 edition 9.1 contains the ninth edition (2018-05) [documents CIS/F/733/FDIS and CIS/F/736/RVD], its interpretation sheet (2019-11), its amendment 1 (2024-07) [documents CIS/F/851/FDIS and CIS/F/854/RVD] and its interpretation sheet (2026-05).

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough

red text. A separate Final version with all changes accepted is available in this publication.

International Standard CISPR 15 has been prepared by subcommittee CIS/F: Interference relating to household appliances tools, lighting equipment and similar apparatus, of IEC technical committee CISPR: International special committee on radio interference.

This ninth edition cancels and replaces the eighth edition published in 2013 and its Amendment 1:2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) full editorial revision and restructuring;
- b) the restriction to mains and battery operation is deleted in the scope;
- c) radiated disturbance limits in the frequency range 300 MHz to 1 GHz have been introduced;
- d) the load terminals limits and the CDNE (alternative to radiated emissions) limits have changed;
- e) deletion of the insertion-loss requirements and the associated Annex A;
- f) introduction of three basic ports: wired network ports, local wired ports and the enclosure port;
- g) introduction of a more technology-independent approach;
- h) replacement of Annex B (CDNE) by appropriate references to CISPR 16-series of standards;
- i) modified requirements for the metal holes of the conical housing;
- j) new conducted disturbance measurement method for GU10 self-ballasted lamp;
- k) addition of current probe measurement method and limits for various types of ports (in addition to voltage limits and measurement methods);
- l) introduction of the term 'module' (instead of independent auxiliary) and requirements for measurement of modules using a host (reference) system;
- m) modified specifications for stabilization times of EUTs;
- n) for large EUT (> 1,6 m), addition of the magnetic field measurement method using a 60 cm loop antenna at 3 m distance (method from CISPR 14-1) as an alternative to the 3 m and 4 m LAS.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
CIS/F/733/FDIS	CIS/F/736/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION to Amendment 1

This Amendment includes the following significant technical changes with respect to CISPR 15:2018.

- a) The voltage probe method for the conducted disturbance measurement of local wired port other than the electrical power supply interface of ELV lamps has been deleted.
- b) Limits and measurement methods have been introduced for radiated disturbance of the enclosure port in the frequency range 1 GHz to 6 GHz.
- c) The test set-up for the conical metal housing for single capped lamps has been rotated.
- d) The arrangement of cables connected to interfaces of wired network ports has been modified. Cable length has been extended to 1,0 m.
- e) Measuring arrangements for conducted disturbances for very large EUTs have been clarified.
- f) Annex E regarding statistical methods has been deleted.

LIMITS AND METHODS OF MEASUREMENT OF RADIO DISTURBANCE CHARACTERISTICS OF ELECTRICAL LIGHTING AND SIMILAR EQUIPMENT

1 Scope

This document ~~applies to~~ sets out requirements for controlling the emission (radiated and conducted) of radiofrequency disturbances from:

- lighting equipment (3.3.16) and modules, except for the types excluded in the second paragraph;
- the lighting part of multi-function equipment where this lighting part is a primary function;

NOTE 1 Examples are lighting equipment with visible-light communication, ~~entertainment lighting~~.

- UV and IR radiation equipment for residential and non-industrial applications;
- simple advertising signs (see 3.3.1);

~~NOTE 2 Examples are neon tube advertising signs.~~

- decorative and entertainment lighting (see 3.3.6);
- emergency signs.

Excluded from the scope of this document are:

- components or modules intended to be built into lighting equipment and which are not user-replaceable;

~~NOTE 3 See CISPR 30 (all parts) for built-in control gear.~~

~~— lighting equipment operating in the ISM frequency bands (as defined in Resolution 63 (1979) of the ITU Radio Regulation);~~

~~— lighting equipment for aircraft and airfield facilities (runways, service facilities, platforms);~~

~~— video signs;~~

- lighting equipment intended exclusively for aircraft or airfield facilities (runways, service facilities, platforms). However, general-purpose lighting that can be installed in many locations, including installations not related to aircraft or airfield, is not excluded from the scope of this document;

- installations;

- equipment for which the electromagnetic compatibility requirements in the radio-frequency range are explicitly formulated in other ~~CISPR~~ IEC standards, even if they incorporate a built-in lighting function.

NOTE 42 Examples of exclusions are:

- equipment with built-in lighting devices for display back lighting, scale illumination and signalling;

~~— SSL displays;~~

- video signs and dynamic displays (in scope of CISPR 32);
- range hoods, refrigerators, freezers (in scope of CISPR 14);
- photocopiers, projectors (in scope of CISPR 32);
- lighting equipment for road vehicles (in scope of CISPR 12);
- maritime equipment (in scope of IEC TC 18 and TC 80);
- lighting equipment operating in the ISM frequency bands (in scope of CISPR 11).

The frequency range covered is 9 kHz to 400 GHz. No measurements need to be performed at frequencies where no limits are specified in this document.

Multi-function equipment which is subjected simultaneously to different clauses of this document and/or other standards need to meet the provisions of each clause/standard with the relevant functions in operation.

For equipment outside the scope of this document and which includes lighting as a secondary function, there is no need to separately assess the lighting function against this document, provided that the lighting function was operative during the assessment in accordance with the applicable standard.

NOTE 5 Examples of equipment with a secondary lighting function can be range hoods, fans, refrigerators, freezers, ovens and TV with ambient lighting.

The ~~radiated~~ emission requirements in this document are not intended to be applicable to the intentional transmissions from a radio transmitter as defined by the ITU, ~~nor to any spurious emissions related to these intentional transmissions~~ including their spurious emissions.

Within the remainder of this document, wherever the term "lighting equipment" or "EUT" is used, it is meant to be the electrical lighting and similar equipment falling in the scope of this document as specified in this clause.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 60050-845:1987, *International Electrotechnical Vocabulary – Chapter 845: Lighting*

IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 1: Lamp caps*

IEC 60081, *Double-capped fluorescent lamps – Performance specifications*

IEC 60598-1:2014, *Luminaires – Part 1: General requirements and tests*
IEC 60598-1:2014/AMD1:2017

IEC 60921, *Ballasts for tubular fluorescent lamps – Performance requirements*

IEC 61000-4-20:2010, *Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides*

IEC 61195, *Double-capped fluorescent lamps – Safety specifications*

IEC 62504:2014, *General lighting – Light emitting diode (LED) products and related equipment – Terms and definitions*

CISPR 16-1-1:~~2015~~2019, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-2:2014, *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 16-1-2:2014/AMD1:2017

CISPR 16-1-4:~~2010~~2019, *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 16-1-4:~~2010~~2019/AMD1:~~2012~~2020
CISPR 16-1-4:~~2010~~2019/AMD2:~~2017~~2023

CISPR 16-2-1:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*
CISPR 16-2-1:2014/AMD1:2017

CISPR 16-2-3:2016, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*
CISPR 16-2-3:2016/AMD1:2019
CISPR 16-2-3:2016/AMD2:2023

CISPR 16-4-2:2011, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty*
CISPR 16-4-2:2011/AMD1:2014
CISPR 16-4-2:2011/AMD2:2018

CISPR TR 30-1:2012, *Test method on electromagnetic emissions – Part 1: Electronic control gear for single- and double-capped fluorescent lamps*

CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment – Emission requirements*
CISPR 32:2015/AMD1:2019

ISO/IEC 17025:2005¹, *General requirements for the competence of testing and calibration laboratories*

¹ This edition was replaced by ISO/IEC 17025:2017 but the listed edition applies.

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- [1] CISPR TR 16-4-5:2006, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-5: Uncertainties, statistics and limit modelling – Conditions for the use of alternative test methods*
CISPR TR 16-4-5:2006/AMD1:2014
- [2] CISPR TR 16-4-1:2009, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests*
- [3] ~~CISPR TR 16-4-3:2004, *Specification for radio disturbance and immunity measuring apparatus and methods. Part 4-3: Uncertainties, statistics and limit modelling – Statistical considerations in the determination of EMC compliance of mass-produced products*~~
~~CISPR TR 16-4-3:2004/AMD1:2006~~
- [4] CISPR TR 30-2:2012, *Test method on electromagnetic emissions – Part 2: Electronic control gear for discharge lamps excluding fluorescent lamps*
- [5] CISPR TR 16-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*
- [6] IEC 60050-731:1991, *International Electrotechnical Vocabulary (IEV) – Part 731: Optical fibre communication*
IEC 60050-731:1991/AMD1:2016
IEC 60050-731:1991/AMD2:2017
- [7] IEC 60155:1993, *Glow-starters for fluorescent lamps*
IEC 60155:1993/AMD1:1995
IEC 60155:1993/AMD2:2006
- [8] IEC 60449, *Voltage bands for electrical installations of buildings*³
- [9] IEC 61000-6-3:2006, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*
IEC 61000-6-3:2006/AMD1:2010
- [10] IEC 61347-1:2015, *Lamp controlgear – Part 1: General and safety requirements*
IEC 61347-1:2015/AMD1:2017
- [11] IEC 62776:2014, *Double-capped LED lamps designed to retrofit linear fluorescent lamps – Safety specifications*
- [12] IEC PAS 62825:2013, *Methods of measurement and limits for radiated disturbances from plasma display panel TVs in the frequency range 150 kHz to 30 MHz*

³ This publication was withdrawn and replaced by IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*.

- [13] ITU Radio Regulations Resolutions and Recommendations: 2012, RESOLUTION 63 (REV.WRC-12), *Protection of radiocommunication services against interference caused by radiation from industrial, scientific and medical (ISM) equipment*; http://www.itu.int/dms_pub/itu-s/oth/02/02/S02020000244503PDFE.pdf [viewed 2018-02-05]
 - [14] CISPR 12, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers*
 - [15] CISPR 14-1, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*
 - [16] CISPR 30 (all parts), *Test methods on electromagnetic emissions*
 - [17] CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CISPR 15
 Edition 9.0 2018-05

**LIMITS AND METHODS OF MEASUREMENT
 OF RADIO DISTURBANCE CHARACTERISTICS OF
 ELECTRICAL LIGHTING AND SIMILAR EQUIPMENT**
INTERPRETATION SHEET 1

This interpretation sheet has been prepared by subcommittee CISPR F: Interference relating to household appliances tools, lighting equipment and similar apparatus, of IEC technical committee CISPR: International special committee on radio interference.

The text of this interpretation sheet is based on the following documents:

DISH	Report on voting
CIS/F/777/DISH	CIS/F/790/RVDISH

Full information on the voting for the approval of this interpretation sheet can be found in the report on voting indicated in the above table.

CISPR 15 interpretation sheet on the worst-case mode of operation
Introduction

Subclause 7.5 specifies the operating modes of lighting equipment that must be considered during an emission test. A few examples are given to support the explanation of what 'different operating modes' means. The list of examples is of course not exhaustive. Apparently, the example of 'colour shifting' is not clear enough and it is sometimes interpreted as if any possible colour and/or correlated colour temperature (CCT) setting that lighting equipment may produce shall be assessed during measurements. Many types of LED lighting may be set in many different colours and CCTs. Compared to other operational-mode related influence quantities such as light level regulation, flashing or radio communication, the risk of not capturing the maximum level of electromagnetic (EM) disturbances due to different colour or CCT settings is very small, provided that all channels of a LED driver used to change colour or CCT are operative. The 'colour shifting'-example was meant for example for a mode where the light output continuously switches from one colour to another with a certain repetition frequency (e.g. applied for entertainment, events etc.), instead of emitting a single stable colour and/or CCT.

Question

What is the meaning of example 'colour shifting' as mode of operation to be considered during testing? What colour and/or colour temperature should be selected in case lighting equipment can be set in a wide range of colours and/or CCTs?

Interpretation

The example 'colour shifting' in the first paragraph of 7.5 of CISPR 15:2018 must not be interpreted as if any possible colour and/or CCT setting that lighting equipment may produce shall be assessed during measurements.

Generally, according to 7.5 the worst case shall be found by prescanning every mode of operation over at least one repetition interval of the specific mode.

Alternatively, measurements can be performed using the setting(s) that are expected to produce the highest amplitude emissions relative to the limit; and, the reasons for the selection shall be given in the test report.

A reason could be that highest level of electromagnetic (EM) disturbances will be captured if all channels of a LED driver used to create different colours and/or CCTs are operative. The number of channels applied depends on the LED-driver/LED-light-source architecture. Often, maximum EM disturbances can be achieved by selecting a white colour and/or a CCT setting in the middle of the specified CCT range.

EXAMPLE Colour variation and CCT variation may be achieved using a 5-channel LED driver powering three LED strings for colour (RGB) setting and two cool white and warm white LED strings for CCT setting. Hence, in case the lighting equipment under test is capable to operate at different colours and/or CCTs, a white colour and/or a single CCT in the middle of the specified CCT range may be selected¹.

¹ 7.4 of CISPR 15:2018, also still applies.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CISPR 15
Edition 9.0 2018-05
Amendment 1 2024-07

**Limits and methods of measurement of radio disturbance characteristics
of electrical lighting and similar equipment**

INTERPRETATION SHEET 1

This interpretation sheet has been prepared by subcommittee CISPR F: Interference relating to household appliances, electric tools, electrical lighting equipment, and similar apparatus, of IEC technical committee CISPR: International special committee on radio interference.

The text of this interpretation sheet is based on the following documents:

DISH	Report on voting
CIS/F/926/DISH	CIS/F/932/RVDISH

Full information on the voting for the approval of this interpretation sheet can be found in the report on voting indicated in the above table.

CISPR 15 interpretation sheet on the use of the current probe on wires with high differential currents

INTRODUCTION

This document is an interpretation sheet to CISPR 15:2018 and CISPR 15:2018/AMD1:2024. It answers the question how to avoid the measurement of false common mode disturbance currents in CISPR 15 with the current probe.

This interpretation sheet is an interim solution that will not automatically be included into future CISPR 15 amendments and editions. A permanent solution will be based on a future amendment of CISPR 16-2-1.

The proposed measurement procedure is based on investigations and measurements done in Japan (JLMA), Germany (Bundesnetzagentur BNetzA) and by Manufacturers of electronic LED drivers. Based on these investigations and discussions within CISPR/F the proposal for an interpretation sheet has been created.

When measuring conducted disturbances according to Clause B.3 (local wired ports), it has been observed that reproducibility of common mode disturbance measurements performed with a current probe (see B.3.5 and Table 3, Table 6 for the limits) is under special circumstances low. This low reproducibility has been observed when measuring the common mode current with a current clamp on the wires from the electronic control gear or halogen converter (EuT = Equipment under Test) to the load (LED or halogen lamp).

Various measurements have been done to find out the reason for this low reproducibility.

As a result of these measurements, it has been found that there is a significant impact on the reading at the receiver depending on the spatial position and orientation of the local wired port cable within the current probe. The measurement results are showing that the variations in the readings are large if there are high differential mode currents flowing in these wires (several amperes).

The typical LED control-gear generates a high (pulse-width-modulated) differential mode output current.

The reason for this variation in the measurement results seems to be the non-ideal behaviour of the current probe. An ideal current probe will suppress the differential mode perfectly, no matter where the two wires of the cable – carrying the differential and common mode current – are located within the current probe.

However, even according to CISPR 16-1-2:2014, 5.1.3, a current probe is allowed to have an “influence of orientation” of up to 1 dB up to 30 MHz and 2,5 dB from 30 MHz to 1 000 MHz.

A calculation has been done showing that even this “low” value of 1 dB influence by the orientation of the wire within the probe hole can cause significant change of readings in a receiver if high differential mode currents are present (see Figure 1).

Calculation of the influence of orientation in case of strong differential currents in a CISPR current					
Differential current:	1,0 A		1,0 A		0,01 A
Differential current in dB μ A:	120 dB μ A		120,0 dB μ A		80 dB μ A
Influence of orientation Value (Difference between the two conductors)	1 dB		0,01 dB		0,1 dB
Conductor 1 Current reading:	120 dB μ A		120,0 dB μ A		80 dB μ A
Conductor 2 Current reading:	119 dB μ A		120,0 dB μ A		79,9 dB μ A
Conductor 1 Current reading:	1,000 0 A		1,000 0 A		0,010 0 A
Conductor 2 Current reading:	0,891 3 A		0,998 8 A		0,009 9 A
Delta (Conductor 1 minus Conductor 2)	0,108 7 A		0,001 2 A		0,000 1 A
Receiver reading ("Artificial" Signal/false common mode):	100,7 dBμA		61,2 dBμA		41,2 dBμA

IEC

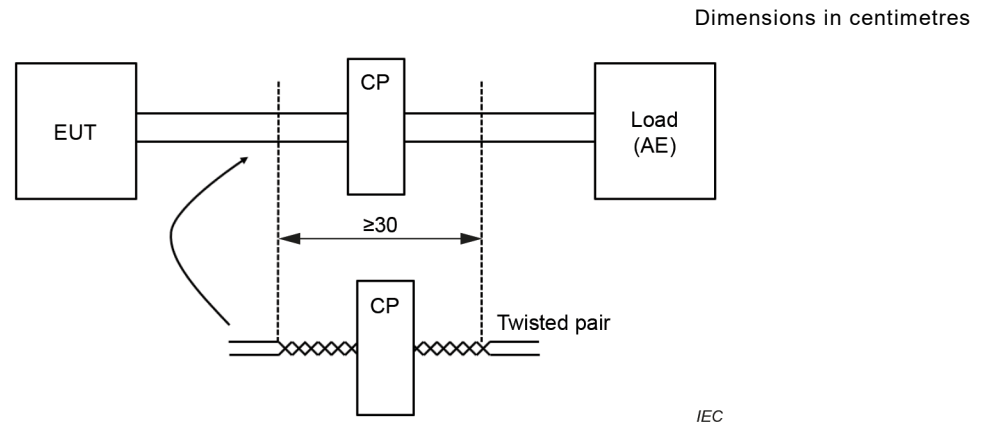
Table 1 – Calculation of the false common mode current in case of high differential currents

For the common mode current measured, the 1 dB influence of the orientation is not critical because the maximum change in the reading at the receiver is only 1 dB. But for the differential mode current the 1 dB will lead to significant changes in the reading. The calculations in Figure 1 are showing that even with a 0,01 dB influence of variation, which is very low compared to 1 dB, which is currently allowed by CISPR 16-1-2, a reading of 61 dB μ A false common mode current at the receiver input will come up. This is much higher than the limit (Table 3 of CISPR 15:2018) of 40 dB μ A at 150 kHz! Thus, a very limited differential mode rejection of the typical current probes becomes obvious. Also, one can see that a “better” current probe (e.g., having only 0,01 dB influence of orientation) would not solve the problem.

The various measurements which have been done by Japan, Germany and various manufacturers of LED drivers are showing that significant improvements can be achieved when a twisted pair cable or a coaxial cable are used as local wired port cable at the position where the load cable goes through the current probe. It is the assumption that the twisting or the coaxial current distribution through the current probe will lead to a much better suppression of the differential current, thus improving the stability of the readings performed with the current probe.

The reason to choose the twisted pair cable instead or beside of the coaxial cable in this interpretation sheet is, that the coaxial cable has an unsymmetrical behaviour in the high frequency range. As a result of the asymmetric transition between a two wire cable and a coaxial cable, the potential for a “differential to common mode conversion” is much higher when a coaxial cable segment is used.

Additionally, there is no extra benefit of using a coaxial cable compared to the twisted pair solution.



CP = current probe

Figure 1 – Replacing the typical cable between EUT and load by twisted pair through the current probe

The effect of cancellation is due to a spatial averaging of the magnetic field, which is quickly reduced to small values when considering the field at a certain distance from the wires.

Clearly, a consistent number of turns shall fall within the thickness of the CP core, and the wires shall be torqued to have a small gap compared with the size of the core.

Thus, from a theoretical point of view, the twisted pair is not an ideal solution, but its effectiveness is related to the size of the conductors, their spacing and the turn density compared with the size of the CP. The advantage is of being a balanced line (symmetrical).

Figure 3 and Figure 4 are showing examples of a test set-up and of twisted cables.

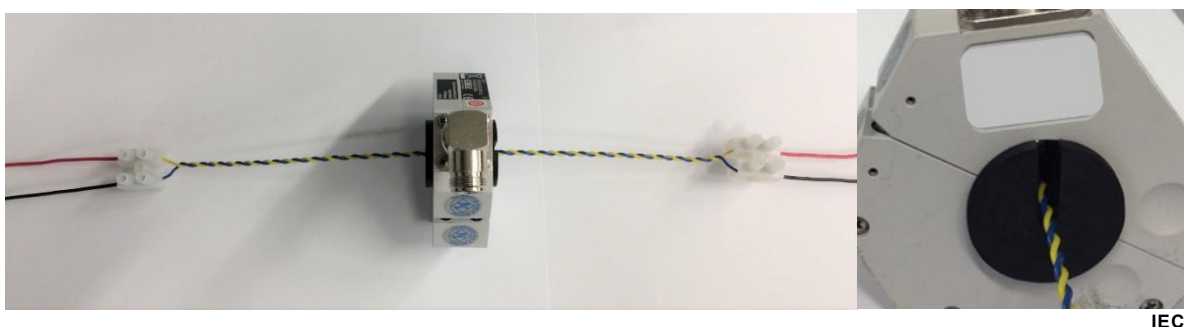


Figure 2 – Example of a measurement setup with a twisted pair

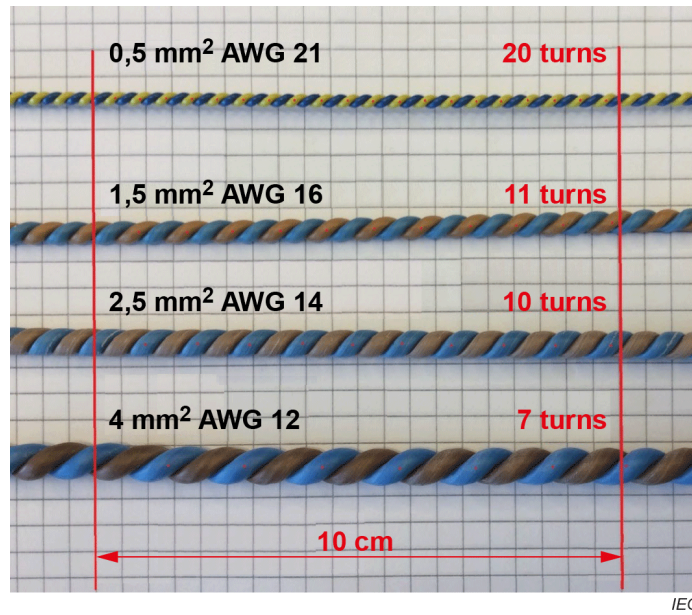


Figure 3 – Examples of twisted pair cables with different cable cross sections

END OF INTRODUCTION

Question:

How can the user of the standard avoid false common mode current indications when measuring with the current probe on wires carrying high differential currents?

Interpretation

When performing measurements with the current probe, the following procedure avoids the measurement of false common mode currents. This procedure can be seen as an explanation on how to interpret the requirements given in B.3.5 about the arrangement of measurement probes.

Before starting the measurement, the user shall verify if there is an impact on the disturbance current measured by performing the measurement on several spatial positions and orientations of the local wired port cable inside the current probe.

If the variability of the measured level of the disturbance current at any frequency with respect to the spatial position inside the current probe exceeds the combined CISPR measurement uncertainty ($U_{CISPR} = 2,9$ dB according to CISPR 16-4-2:2011, CISPR 16-4-2:2011/AMD1:2014 and CISPR 16-4-2:2011/AMD2:2018), the following two measures for the probe arrangement shall be applied to minimize the effect of large differential mode currents.

- 1) The wires in the local wired port cable carrying significant differential mode currents shall be fixed centrally in the clamp's aperture with a nonmetal fixture.
- 2) Additionally, the wires in the local wired port cable carrying significant differential mode currents shall be replaced for the measurement by a twisted pair cable with a length of at least 30 cm as a replacement of the existing local wired port cable.

The twisted pair cable shall have at least or exactly the following number of twists:

Wire cross-section (w) in mm ²	Minimum twists per 10 cm
$w \leq 0,5$	20
$0,5 < w \leq 1,5$	11
$1,5 < w \leq 2,5$	10
$w > 2,5$	7

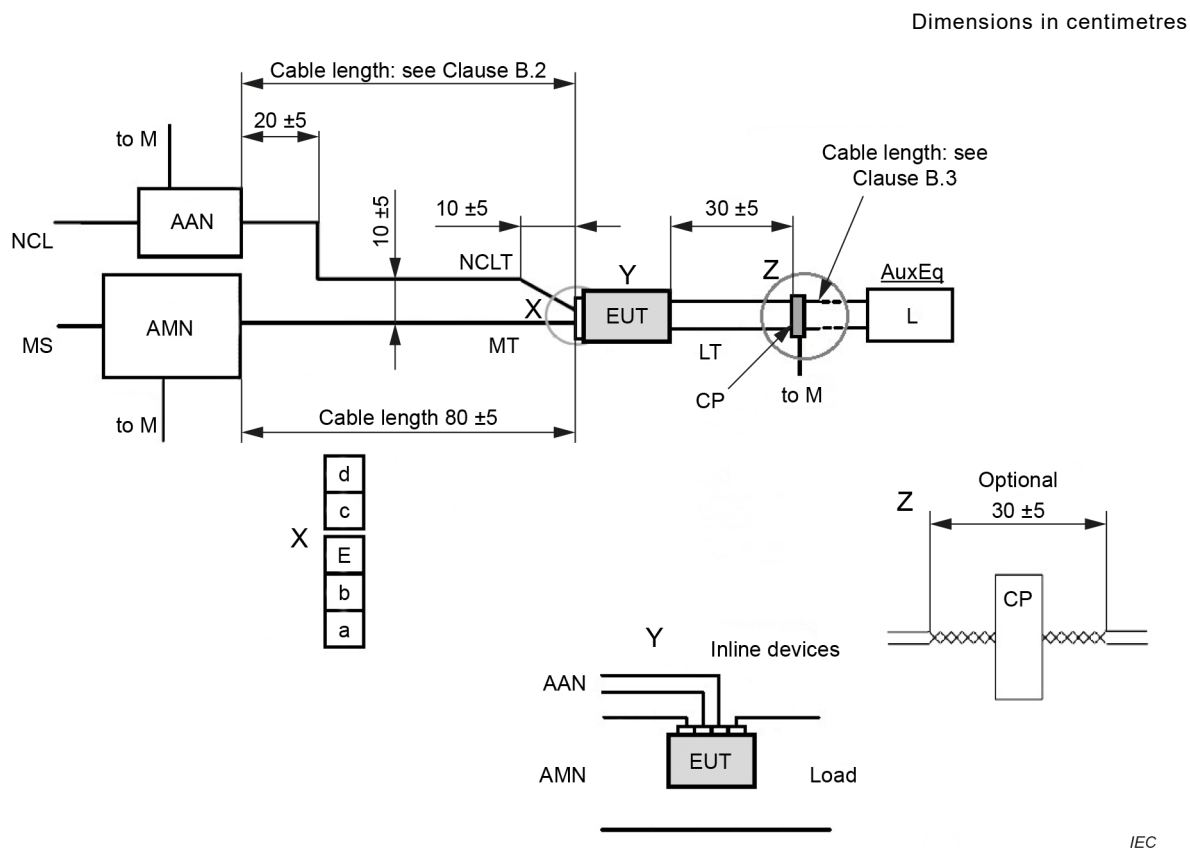
The method of twisting the wires is not relevant in case of shielded cables or cable assemblies or in case of a single wire.

Multi-wire cables shall be centred within the current probe and twisted in a similar way. The way the twisting is performed shall be noted in the test report.

NOTE 1 Other non-twisted cables have been observed to cause significant measurement artefacts (false common mode currents) due to non-ideal electromagnetic field patterns within the current probe and the influence of orientation (see CISPR 16-1-2:2014 + CISPR 16-1-2:2014/AMD1:2017, 5.1.3).

NOTE 2 If a twisted cable is very soft and untwists itself, a typical method to fix the twisting is to use non-conducting (plastic) cable ties or other non-conducting material. is used as a practical reference for deciding whether interim countermeasures should be taken.

Figure B.2 of CISPR 15:2018/AMD1:2024 can be interpreted as shown in Figure 5 below (adding the current probe position with a twisted pair cable):



Key

- | | | | |
|-------|--|------|-------------------------------|
| a – b | Supply terminals | MS | Mains supply |
| c – d | Control terminals | MT | Mains terminals |
| AAN | Asymmetric artificial network | NCL | Network control line |
| AMN | Artificial mains network | NCLT | Network control line terminal |
| CP | Current probe | | |
| E | Earth terminal | | |
| L | Load | | |
| LT | Load terminals | | |
| M | CISPR measuring receiver (for AMN and AAN: replace by 50 Ω if not connected) | | |

The earth of the measuring receiver and the earth terminal of the EUT shall be connected to the AMN ground. Where an inline device is inserted in only one lead of the supply, measurements shall be made by connecting the second supply lead as indicated in the figure under inline devices. See CISPR 15:2018/AMD1:2024, Figure B.3 for details on the arrangement.

Figure 4 – Circuit for measuring conducted disturbances from an external module (with the option to apply the current probe position with twisted pair cable)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

LIMITS AND METHODS OF MEASUREMENT OF RADIO DISTURBANCE CHARACTERISTICS OF ELECTRICAL LIGHTING AND SIMILAR EQUIPMENT

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

CISPR 15 edition 9.1 contains the ninth edition (2018-05) [documents CIS/F/733/FDIS and CIS/F/736/RVD], its interpretation sheet (2019-11), its amendment 1 (2024-07) [documents CIS/F/851/FDIS and CIS/F/854/RVD] and its interpretation sheet (2026-05).

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

International Standard CISPR 15 has been prepared by subcommittee CIS/F: Interference relating to household appliances tools, lighting equipment and similar apparatus, of IEC technical committee CISPR: International special committee on radio interference.

This ninth edition cancels and replaces the eighth edition published in 2013 and its Amendment 1:2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) full editorial revision and restructuring;
- b) the restriction to mains and battery operation is deleted in the scope;
- c) radiated disturbance limits in the frequency range 300 MHz to 1 GHz have been introduced;
- d) the load terminals limits and the CDNE (alternative to radiated emissions) limits have changed;
- e) deletion of the insertion-loss requirements and the associated Annex A;
- f) introduction of three basic ports: wired network ports, local wired ports and the enclosure port;
- g) introduction of a more technology-independent approach;
- h) replacement of Annex B (CDNE) by appropriate references to CISPR 16-series of standards;
- i) modified requirements for the metal holes of the conical housing;
- j) new conducted disturbance measurement method for GU10 self-ballasted lamp;
- k) addition of current probe measurement method and limits for various types of ports (in addition to voltage limits and measurement methods);
- l) introduction of the term 'module' (instead of independent auxiliary) and requirements for measurement of modules using a host (reference) system;
- m) modified specifications for stabilization times of EUTs;
- n) for large EUT (> 1,6 m), addition of the magnetic field measurement method using a 60 cm loop antenna at 3 m distance (method from CISPR 14-1) as an alternative to the 3 m and 4 m LAS.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
CIS/F/733/FDIS	CIS/F/736/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION to Amendment 1

This Amendment includes the following significant technical changes with respect to CISPR 15:2018.

- a) The voltage probe method for the conducted disturbance measurement of local wired port other than the electrical power supply interface of ELV lamps has been deleted.
- b) Limits and measurement methods have been introduced for radiated disturbance of the enclosure port in the frequency range 1 GHz to 6 GHz.
- c) The test set-up for the conical metal housing for single capped lamps has been rotated.
- d) The arrangement of cables connected to interfaces of wired network ports has been modified. Cable length has been extended to 1,0 m.
- e) Measuring arrangements for conducted disturbances for very large EUTs have been clarified.
- f) Annex E regarding statistical methods has been deleted.

LIMITS AND METHODS OF MEASUREMENT OF RADIO DISTURBANCE CHARACTERISTICS OF ELECTRICAL LIGHTING AND SIMILAR EQUIPMENT

1 Scope

This document sets out requirements for controlling the emission (radiated and conducted) of radiofrequency disturbances from:

- lighting equipment (3.3.16) and modules, except for the types excluded in the second paragraph;
- the lighting part of multi-function equipment where this lighting part is a primary function;

NOTE 1 Examples are lighting equipment with visible-light communication.

- UV and IR radiation equipment for residential and non-industrial applications;
- simple advertising signs (see 3.3.1);
- decorative and entertainment lighting (see 3.3.6);
- emergency signs.

Excluded from the scope of this document are:

- components or modules intended to be built into lighting equipment and which are not user-replaceable;
- lighting equipment intended exclusively for aircraft or airfield facilities (runways, service facilities, platforms). However, general-purpose lighting that can be installed in many locations, including installations not related to aircraft or airfield, is not excluded from the scope of this document;
- installations;
- equipment for which the electromagnetic compatibility requirements in the radio-frequency range are explicitly formulated in other IEC standards, even if they incorporate a built-in lighting function.

NOTE 2 Examples of exclusions are:

- equipment with built-in lighting devices for display back lighting, scale illumination and signalling;
- video signs and dynamic displays (in scope of CISPR 32);
- range hoods, refrigerators, freezers (in scope of CISPR 14);
- photocopiers, projectors (in scope of CISPR 32);
- lighting equipment for road vehicles (in scope of CISPR 12);
- maritime equipment (in scope of IEC TC 18 and TC 80);
- lighting equipment operating in the ISM frequency bands (in scope of CISPR 11).

The frequency range covered is 9 kHz to 400 GHz. No measurements need to be performed at frequencies where no limits are specified in this document.

Multi-function equipment which is subjected simultaneously to different clauses of this document and/or other standards need to meet the provisions of each clause/standard with the relevant functions in operation.

For equipment outside the scope of this document and which includes lighting as a secondary function, there is no need to separately assess the lighting function against this document, provided that the lighting function was operative during the assessment in accordance with the applicable standard.

NOTE 5 Examples of equipment with a secondary lighting function can be range hoods, fans, refrigerators, freezers, ovens and TV with ambient lighting.

The emission requirements in this document are not intended to be applicable to the intentional transmissions from a radio transmitter as defined by the ITU including their spurious emissions.

Within the remainder of this document, wherever the term "lighting equipment" or "EUT" is used, it is meant to be the electrical lighting and similar equipment falling in the scope of this document as specified in this clause.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 60050-845:1987, *International Electrotechnical Vocabulary – Chapter 845: Lighting*

IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 1: Lamp caps*

IEC 60081, *Double-capped fluorescent lamps – Performance specifications*

IEC 60598-1:2014, *Luminaires – Part 1: General requirements and tests*
IEC 60598-1:2014/AMD1:2017

IEC 60921, *Ballasts for tubular fluorescent lamps – Performance requirements*

IEC 61000-4-20:2010, *Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides*

IEC 61195, *Double-capped fluorescent lamps – Safety specifications*

IEC 62504:2014, *General lighting – Light emitting diode (LED) products and related equipment – Terms and definitions*

CISPR 16-1-1:2019, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-2:2014, *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 16-1-2:2014/AMD1:2017

CISPR 16-1-4:2019, *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 16-1-4:2019/AMD1:2020
CISPR 16-1-4:2019/AMD2:2023

CISPR 16-2-1:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

CISPR 16-2-1:2014/AMD1:2017

CISPR 16-2-3:2016, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

CISPR 16-2-3:2016/AMD1:2019

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CISPR 16-4-2:2011, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty*

CISPR 16-4-2:2011/AMD1:2014

CISPR 16-4-2:2011/AMD2:2018

CISPR TR 30-1:2012, *Test method on electromagnetic emissions – Part 1: Electronic control gear for single- and double-capped fluorescent lamps*

CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment – Emission requirements*

CISPR 32:2015/AMD1:2019

ISO/IEC 17025:2005¹, *General requirements for the competence of testing and calibration laboratories*

¹ This edition was replaced by ISO/IEC 17025:2017 but the listed edition applies.

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CISPR TR 16-4-5:2006/AMD1:2014
- [2] CISPR TR 16-4-1:2009, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests*
- [3]
- [4] CISPR TR 30-2:2012, *Test method on electromagnetic emissions – Part 2: Electronic control gear for discharge lamps excluding fluorescent lamps*
- [5] CISPR TR 16-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*
- [6] IEC 60050-731:1991, *International Electrotechnical Vocabulary (IEV) – Part 731: Optical fibre communication*
IEC 60050-731:1991/AMD1:2016
IEC 60050-731:1991/AMD2:2017
- [7] IEC 60155:1993, *Glow-starters for fluorescent lamps*
IEC 60155:1993/AMD1:1995
IEC 60155:1993/AMD2:2006
- [8] IEC 60449, *Voltage bands for electrical installations of buildings²*
- [9] IEC 61000-6-3:2006, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*
IEC 61000-6-3:2006/AMD1:2010
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IEC 61347-1:2015/AMD1:2017
- [11] IEC 62776:2014, *Double-capped LED lamps designed to retrofit linear fluorescent lamps – Safety specifications*
- [12] IEC PAS 62825:2013, *Methods of measurement and limits for radiated disturbances from plasma display panel TVs in the frequency range 150 kHz to 30 MHz*

² This publication was withdrawn and replaced by IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*.

- [13] ITU Radio Regulations Resolutions and Recommendations: 2012, RESOLUTION 63 (REV.WRC-12), *Protection of radiocommunication services against interference caused by radiation from industrial, scientific and medical (ISM) equipment*; http://www.itu.int/dms_pub/itu-s/oth/02/02/S02020000244503PDFE.pdf [viewed 2018-02-05]

 - [14] CISPR 12, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers*

 - [15] CISPR 14-1, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

 - [16] CISPR 30 (all parts), *Test methods on electromagnetic emissions*

 - [17] *CISPR 11:2015, Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
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