International Civil Aviation Organization (ICAO) Navigation Systems Panel (NSP) Spectrum Working Group (SWG)

LED RF Devices update

Montreal, April 2018

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Philips Lighting

PHILIPS

Agenda

- **Scope**
- CISPR and NA Emission Limits
- Conducted Emissions
- Radiated Emissions
- Applications
- Conclusions

Why are we here?

We learned about a reported interference case from a LED lamp with a airplane communication through a presentation at the last year CISPR meeting.

The presenter used an ICAO presentation from Mr. Biggs posted in the internet.

We found it interesting and contacted Mr. Biggs to follow up.

Mr Biggs suggested to have a EMI from LED lighting presentation at this conference .

We have experience testing LED devices for FCC and CISPR.

We hope our inputs about LED lighting become useful to all.

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Presentation Scope

- Understanding whether LED lighting devices are intruding into the radio frequency spectrum more than traditionally installed systems (such as electronic fluorescent lighting or self ballasted compact fluorescent lamps) is relevant for communications reliability.
- Review of the CISPR 15 (Lighting Devices) upcoming changes
- Radio Frequency LED lighting devices are regulated under CISPR 15 (IEC countries), and ICES 005 -FCC Part 15 (as described by the United States Federal Communications Commission FCC[1,2]). Whereas, radio frequency discharge lighting devices (fluorescent and high intensity discharge) are regulated under CISPR 15, and ICES 005 - FCC Part 18[3].
- A comprehensive comparison of these three regulations, as well as implications for spectrum protection, are discussed.

Presentation Scope

- This presentation focuses on RF LED devices as non-intentional radiators. LED Drivers and self-ballasted LED lamps are typical non-intentional radiators when they do not include a radio.
- LED Drivers and self-ballasted LED lamps are non-intentional radiators when
  a) They operate with internal or external signals higher than or equal to 9 KHz (radio frequency energy).
  b) They are not intended to produce Radio Frequency energy; high frequency emissions are an unintended consequence of normal operation.

Agenda

- Scope
- **CISPR and NA Emission Limits**
- Conducted Emissions
- Radiated Emissions
- Applications
- Conclusions

CISPR 15

CISPR 15

Edition 8.1 2015-03

FINAL VERSION

VERSION FINALE

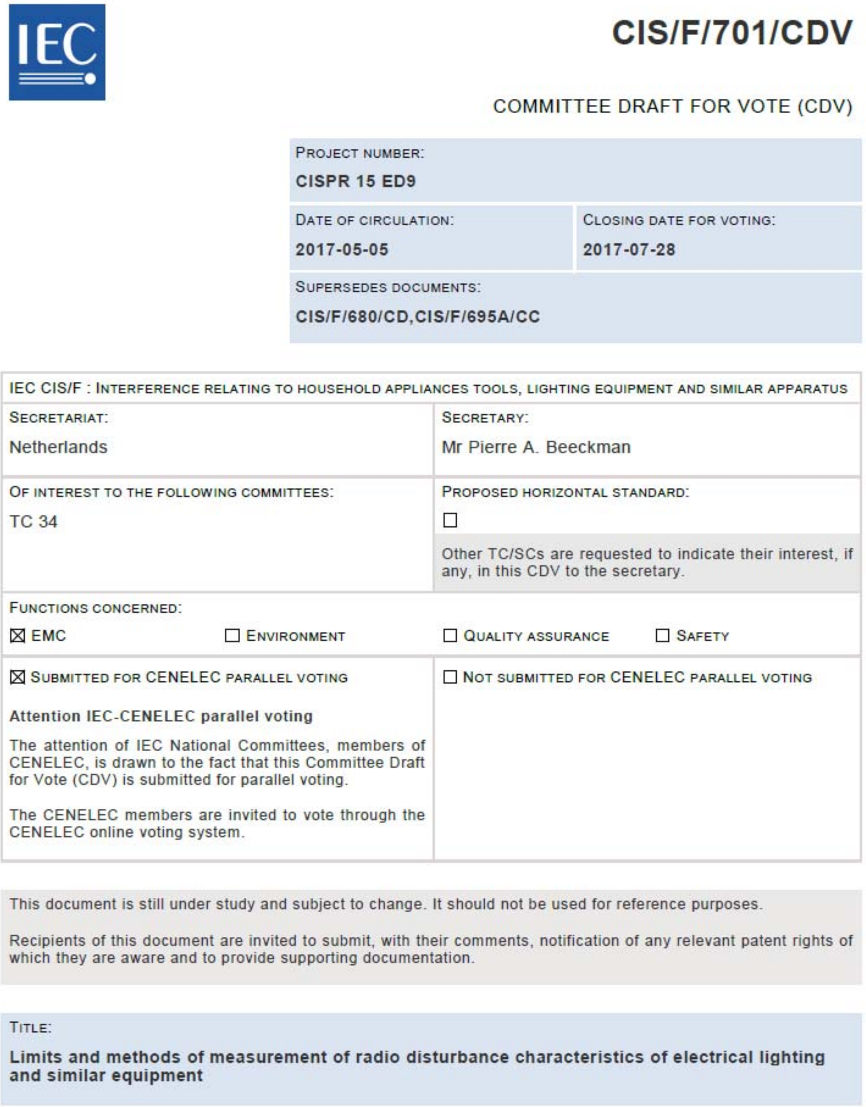
colour inside

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE
COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

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

Limites et méthodes de mesure des perturbations radioélectriques produites par les appareils électriques d'éclairage et les appareils analogues

SV(en-fr)



CIS/F/701/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **CISPR 15 ED9**	
DATE OF CIRCULATION: **2017-05-05**	CLOSING DATE FOR VOTING: **2017-07-28**
SUPERSEDES DOCUMENTS: **CIS/F/680/CD,CIS/F/695A/CC**	

IEC CIS/F : INTERFERENCE RELATING TO HOUSEHOLD APPLIANCES TOOLS, LIGHTING EQUIPMENT AND SIMILAR APPARATUS

SECRETARIAT: Netherlands	SECRETARY: Mr Pierre A. Beeckman
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 34	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:
☒ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY

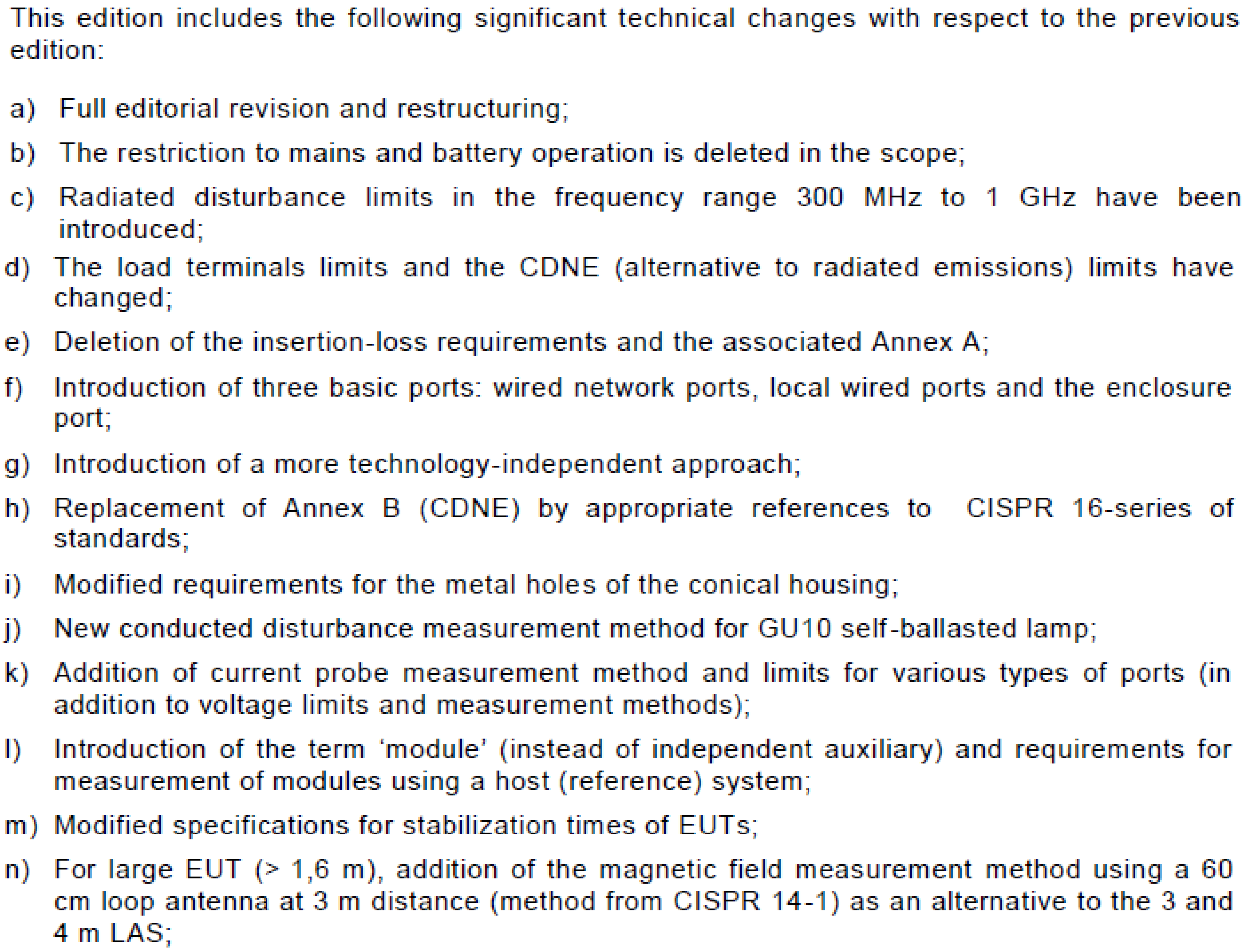
☒ SUBMITTED FOR CENELEC PARALLEL VOTING **Attention IEC-CENELEC parallel voting** The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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

CISPR 15



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;

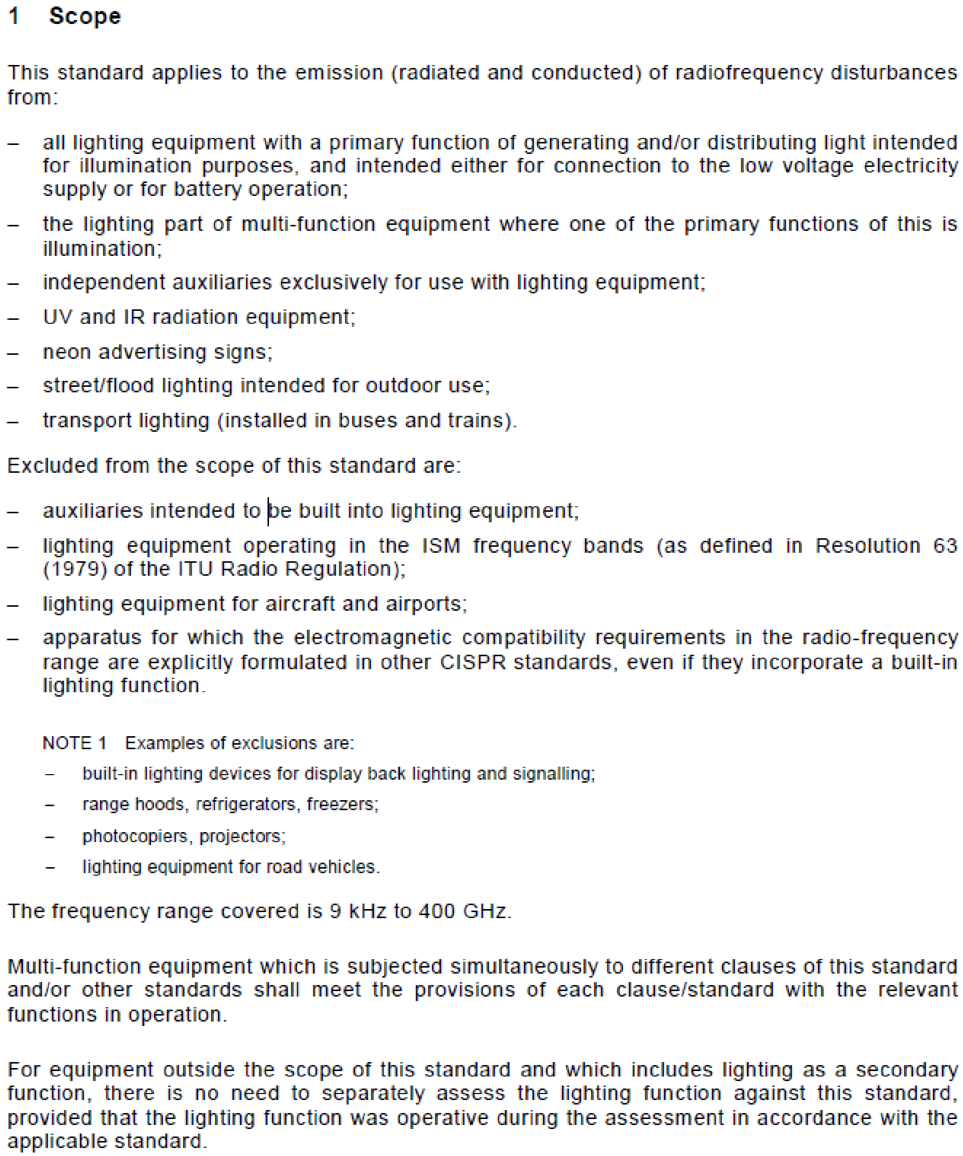
n) For large EUT (> 1,6 m), addition of the magnetic field measurement method using a 60 cm loop antenna at 3 m distance (method from CISPR 14-1) as an alternative to the 3 and 4 m LAS;

Stop at 300 MHz before

Obsolescence

Component in NA

CISPR 15



1 Scope

This standard applies to the emission (radiated and conducted) of radiofrequency disturbances from:

- all lighting equipment with a primary function of generating and/or distributing light intended for illumination purposes, and intended either for connection to the low voltage electricity supply or for battery operation;
- the lighting part of multi-function equipment where one of the primary functions of this is illumination;
- independent auxiliaries exclusively for use with lighting equipment;
- UV and IR radiation equipment;
- neon advertising signs;
- street/flood lighting intended for outdoor use;
- transport lighting (installed in buses and trains).

Excluded from the scope of this standard are:

- auxiliaries intended to be built into lighting equipment;
- lighting equipment operating in the ISM frequency bands (as defined in Resolution 63 (1979) of the ITU Radio Regulation);
- lighting equipment for aircraft and airports;
- apparatus for which the electromagnetic compatibility requirements in the radio-frequency range are explicitly formulated in other CISPR standards, even if they incorporate a built-in lighting function.

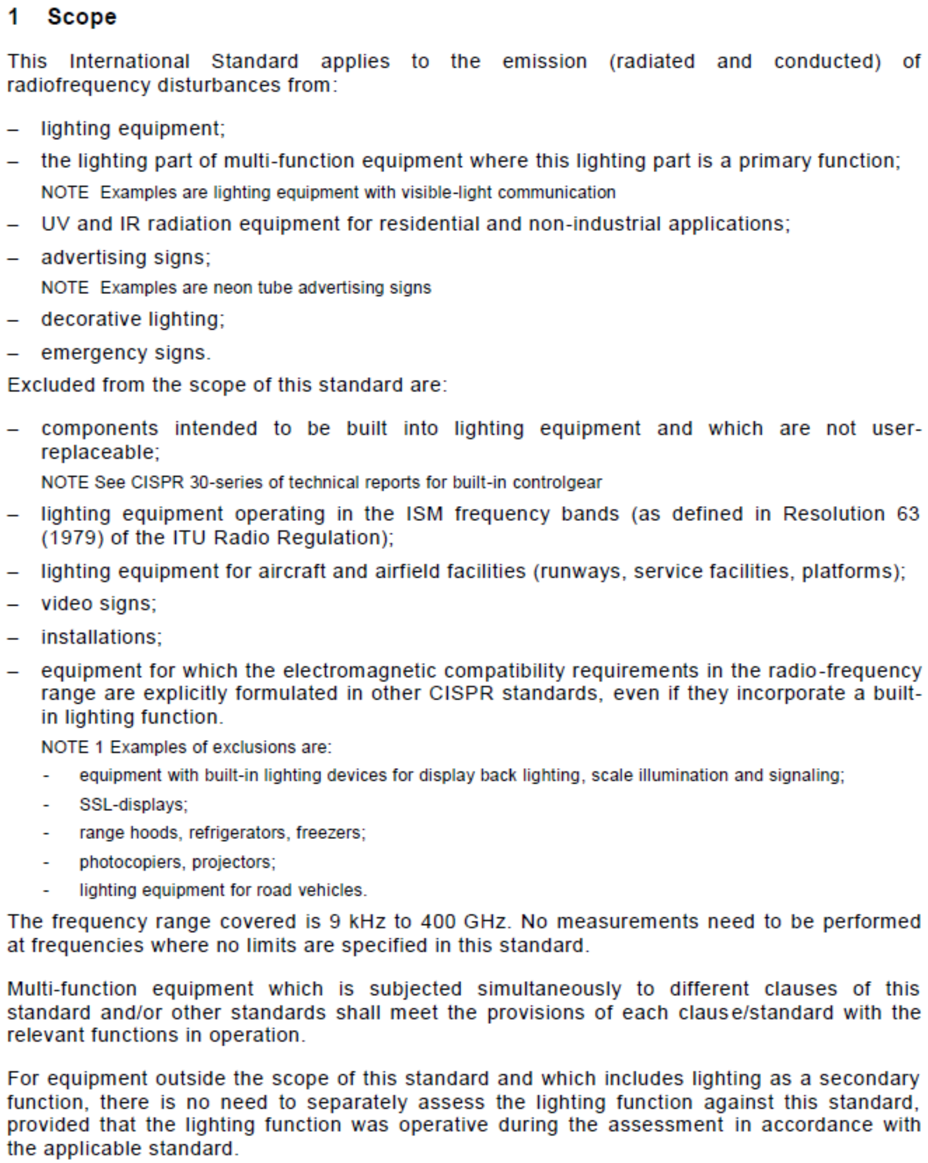
NOTE 1 Examples of exclusions are:

- built-in lighting devices for display back lighting and signalling;
- range hoods, refrigerators, freezers;
- photocopiers, projectors;
- lighting equipment for road vehicles.

The frequency range covered is 9 kHz to 400 GHz.

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

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



1 Scope

This International Standard applies to the emission (radiated and conducted) of radiofrequency disturbances from:

- lighting equipment;
- the lighting part of multi-function equipment where this lighting part is a primary function;

  NOTE Examples are lighting equipment with visible-light communication
- UV and IR radiation equipment for residential and non-industrial applications;
- advertising signs;

  NOTE Examples are neon tube advertising signs
- decorative lighting;
- emergency signs.

Excluded from the scope of this standard are:

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

  NOTE See CISPR 30-series of technical reports for built-in controlgear
- 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;
- installations;
- equipment for which the electromagnetic compatibility requirements in the radio-frequency range are explicitly formulated in other CISPR standards, even if they incorporate a built-in lighting function.

  NOTE 1 Examples of exclusions are:

  - equipment with built-in lighting devices for display back lighting, scale illumination and signaling;
  - SSL-displays;
  - range hoods, refrigerators, freezers;
  - photocopiers, projectors;
  - lighting equipment for road vehicles.

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 standard.

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

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

CISPR 15

General Conducted Emissions Remains the Same

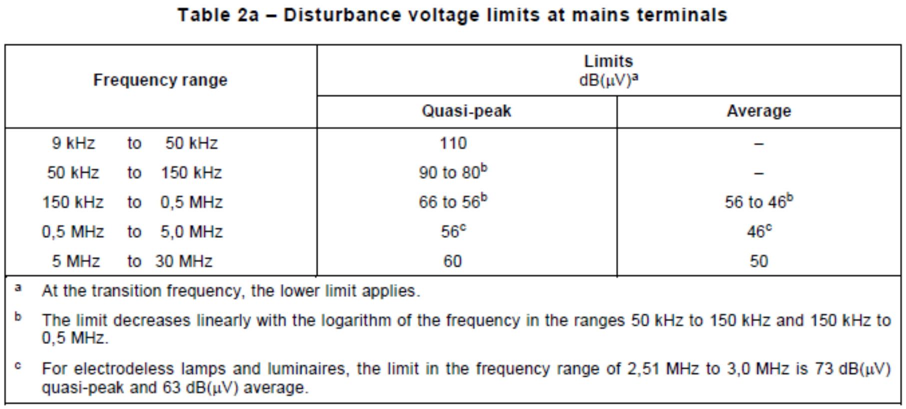


Table 2a – Disturbance voltage limits at mains terminals

Frequency range	Limits dB(μV)[a]	
	Quasi-peak	Average
9 kHz to 50 kHz	110	–
50 kHz to 150 kHz	90 to 80[b]	–
150 kHz to 0,5 MHz	66 to 56[b]	56 to 46[b]
0,5 MHz to 5,0 MHz	56[c]	46[c]
5 MHz to 30 MHz	60	50

[a] At the transition frequency, the lower limit applies.

[b] The limit decreases linearly with the logarithm of the frequency in the ranges 50 kHz to 150 kHz and 150 kHz to 0,5 MHz.

[c] For electrodeless lamps and luminaires, the limit in the frequency range of 2,51 MHz to 3,0 MHz is 73 dB(μV) quasi-peak and 63 dB(μV) average.

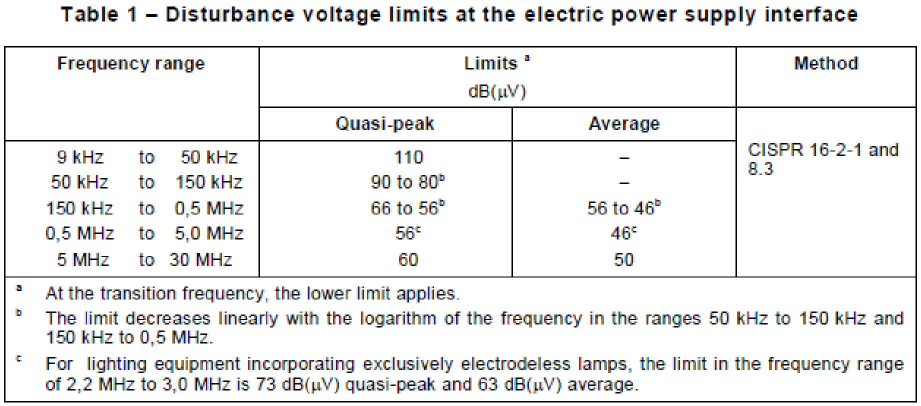


Table 1 – Disturbance voltage limits at the electric power supply interface

Frequency range	Limits [a] dB(μV)		Method
	Quasi-peak	Average	
9 kHz to 50 kHz	110	–	CISPR 16-2-1 and 8.3
50 kHz to 150 kHz	90 to 80[b]	–	
150 kHz to 0,5 MHz	66 to 56[b]	56 to 46[b]	
0,5 MHz to 5,0 MHz	56[c]	46[c]	
5 MHz to 30 MHz	60	50	

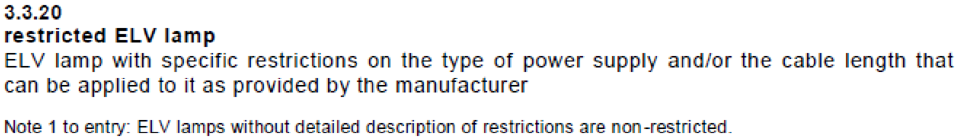
[a] At the transition frequency, the lower limit applies.

[b] The limit decreases linearly with the logarithm of the frequency in the ranges 50 kHz to 150 kHz and 150 kHz to 0,5 MHz.

[c] For lighting equipment incorporating exclusively electrodeless lamps, the limit in the frequency range of 2,2 MHz to 3,0 MHz is 73 dB(μV) quasi-peak and 63 dB(μV) average.

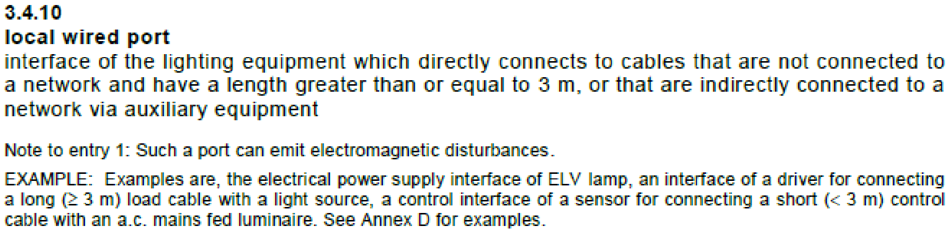
CISPR 15

NEW



3.3.20
restricted ELV lamp
ELV lamp with specific restrictions on the type of power supply and/or the cable length that can be applied to it as provided by the manufacturer

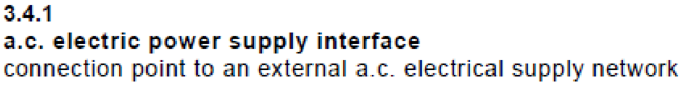
Note 1 to entry: ELV lamps without detailed description of restrictions are non-restricted.



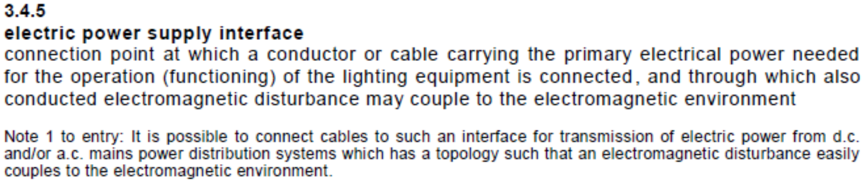
3.4.10
local wired port
interface of the lighting equipment which directly connects to cables that are not connected to a network and have a length greater than or equal to 3 m, or that are indirectly connected to a network via auxiliary equipment

Note to entry 1: Such a port can emit electromagnetic disturbances.

EXAMPLE: Examples are, the electrical power supply interface of ELV lamp, an interface of a driver for connecting a long (≥ 3 m) load cable with a light source, a control interface of a sensor for connecting a short (< 3 m) control cable with an a.c. mains fed luminaire. See Annex D for examples.

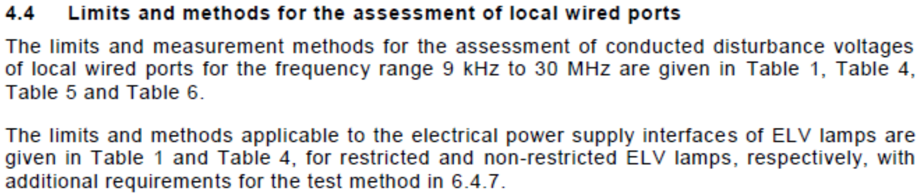


3.4.1
a.c. electric power supply interface
connection point to an external a.c. electrical supply network



3.4.5
electric power supply interface
connection point at which a conductor or cable carrying the primary electrical power needed for the operation (functioning) of the lighting equipment is connected, and through which also conducted electromagnetic disturbance may couple to the electromagnetic environment

Note 1 to entry: It is possible to connect cables to such an interface for transmission of electric power from d.c. and/or a.c. mains power distribution systems which has a topology such that an electromagnetic disturbance easily couples to the electromagnetic environment.



4.4 Limits and methods for the assessment of local wired ports

The limits and measurement methods for the assessment of conducted disturbance voltages of local wired ports for the frequency range 9 kHz to 30 MHz are given in Table 1, Table 4, Table 5 and Table 6.

The limits and methods applicable to the electrical power supply interfaces of ELV lamps are given in Table 1 and Table 4, for restricted and non-restricted ELV lamps, respectively, with additional requirements for the test method in 6.4.7.

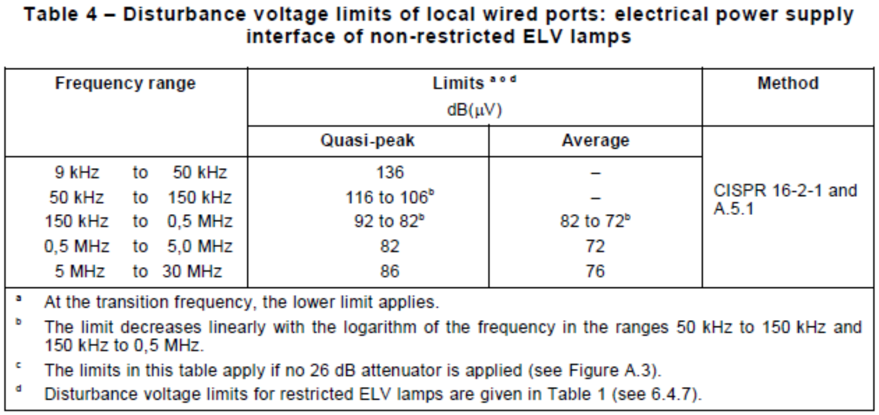


Table 4 – Disturbance voltage limits of local wired ports: electrical power supply interface of non-restricted ELV lamps

Frequency range	Limits [a c d] dB(μV)		Method
	Quasi-peak	Average	
9 kHz to 50 kHz	136	–	CISPR 16-2-1 and A.5.1
50 kHz to 150 kHz	116 to 106[b]	–	
150 kHz to 0,5 MHz	92 to 82[b]	82 to 72[b]	
0,5 MHz to 5,0 MHz	82	72	
5 MHz to 30 MHz	86	76	

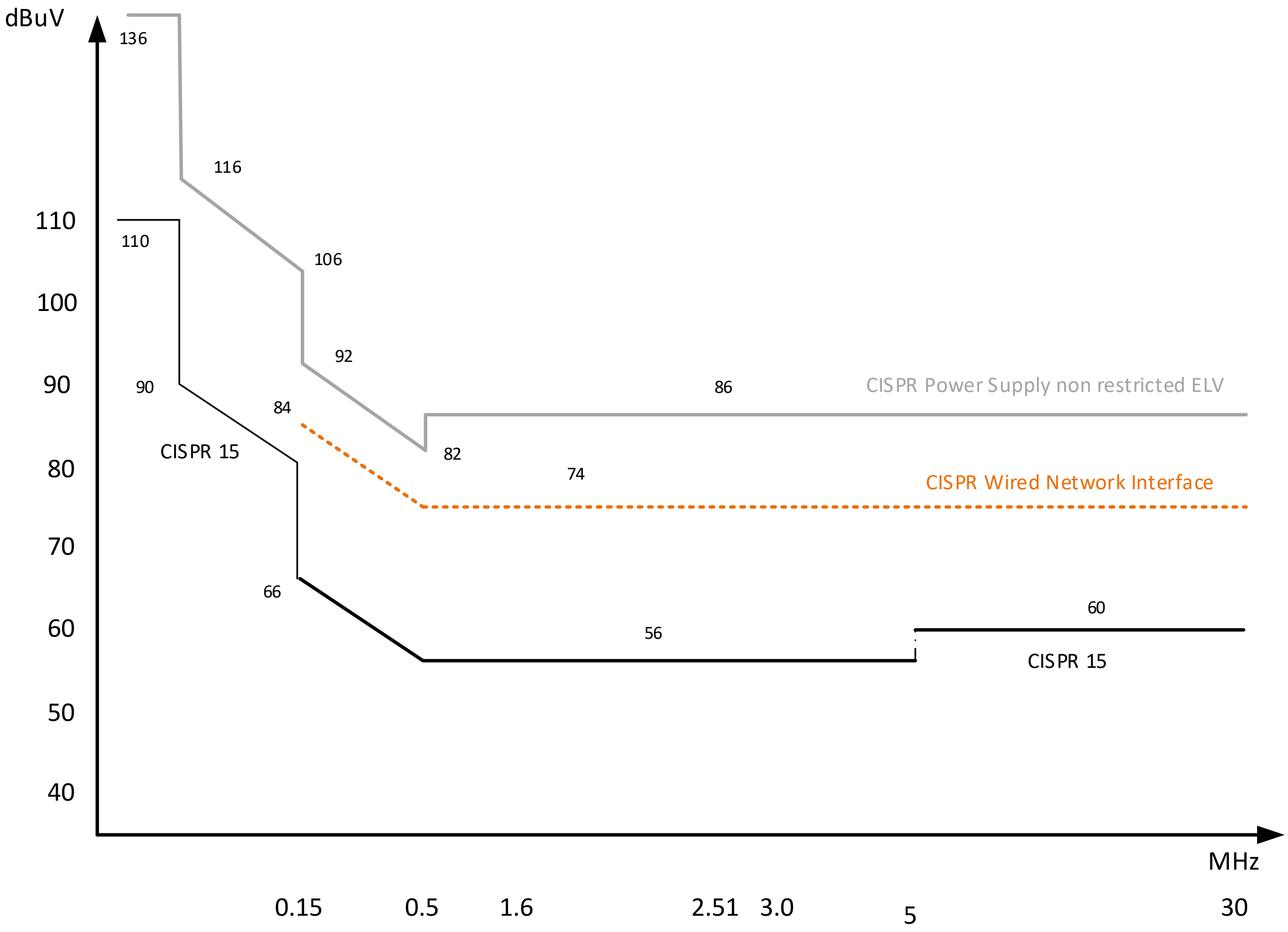
[a] At the transition frequency, the lower limit applies.

[b] The limit decreases linearly with the logarithm of the frequency in the ranges 50 kHz to 150 kHz and 150 kHz to 0,5 MHz.

[c] The limits in this table apply if no 26 dB attenuator is applied (see Figure A.3).

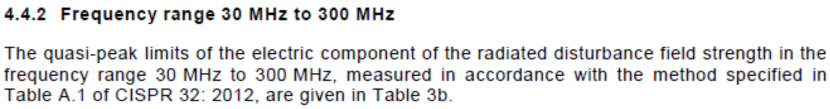
[d] Disturbance voltage limits for restricted ELV lamps are given in Table 1 (see 6.4.7).

CISPR 15


dBuV
110
100
90
80
70
60
50
40
136
116
106
92
86
82
CISPR Power Supply non restricted ELV
110
90
84
74
CISPR Wired Network Interface
CISPR 15
66
56
60
CISPR 15
MHz
0.15
0.5
1.6
2.51
3.0
5
30

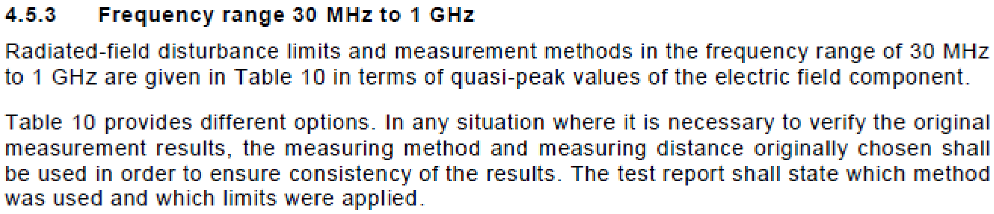
CISPR 15

NEW



4.4.2 Frequency range 30 MHz to 300 MHz

The quasi-peak limits of the electric component of the radiated disturbance field strength in the frequency range 30 MHz to 300 MHz, measured in accordance with the method specified in Table A.1 of CISPR 32: 2012, are given in Table 3b.



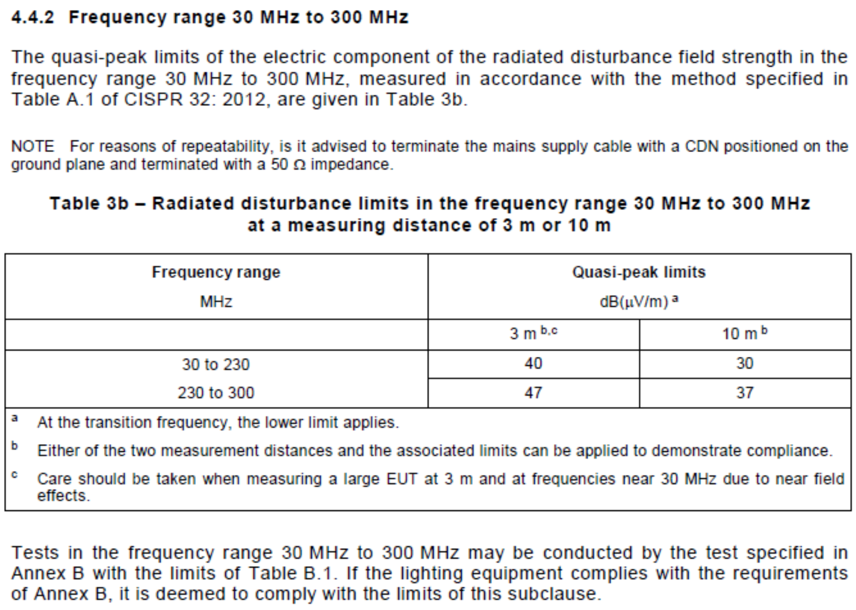
4.5.3 Frequency range 30 MHz to 1 GHz

Radiated-field disturbance limits and measurement methods in the frequency range of 30 MHz to 1 GHz are given in Table 10 in terms of quasi-peak values of the electric field component.

Table 10 provides different options. In any situation where it is necessary to verify the original measurement results, the measuring method and measuring distance originally chosen shall be used in order to ensure consistency of the results. The test report shall state which method was used and which limits were applied.

CISPR 15

NEW



4.4.2 Frequency range 30 MHz to 300 MHz

The quasi-peak limits of the electric component of the radiated disturbance field strength in the frequency range 30 MHz to 300 MHz, measured in accordance with the method specified in Table A.1 of CISPR 32: 2012, are given in Table 3b.

NOTE For reasons of repeatability, is it advised to terminate the mains supply cable with a CDN positioned on the ground plane and terminated with a 50 Ω impedance.

Table 3b – Radiated disturbance limits in the frequency range 30 MHz to 300 MHz at a measuring distance of 3 m or 10 m

Frequency range MHz	Quasi-peak limits dB(μV/m) [a]	
	3 m [b,c]	10 m [b]
30 to 230	40	30
230 to 300	47	37

[a] At the transition frequency, the lower limit applies.

[b] Either of the two measurement distances and the associated limits can be applied to demonstrate compliance.

[c] Care should be taken when measuring a large EUT at 3 m and at frequencies near 30 MHz due to near field effects.

Tests in the frequency range 30 MHz to 300 MHz may be conducted by the test specified in Annex B with the limits of Table B.1. If the lighting equipment complies with the requirements of Annex B, it is deemed to comply with the limits of this subclause.

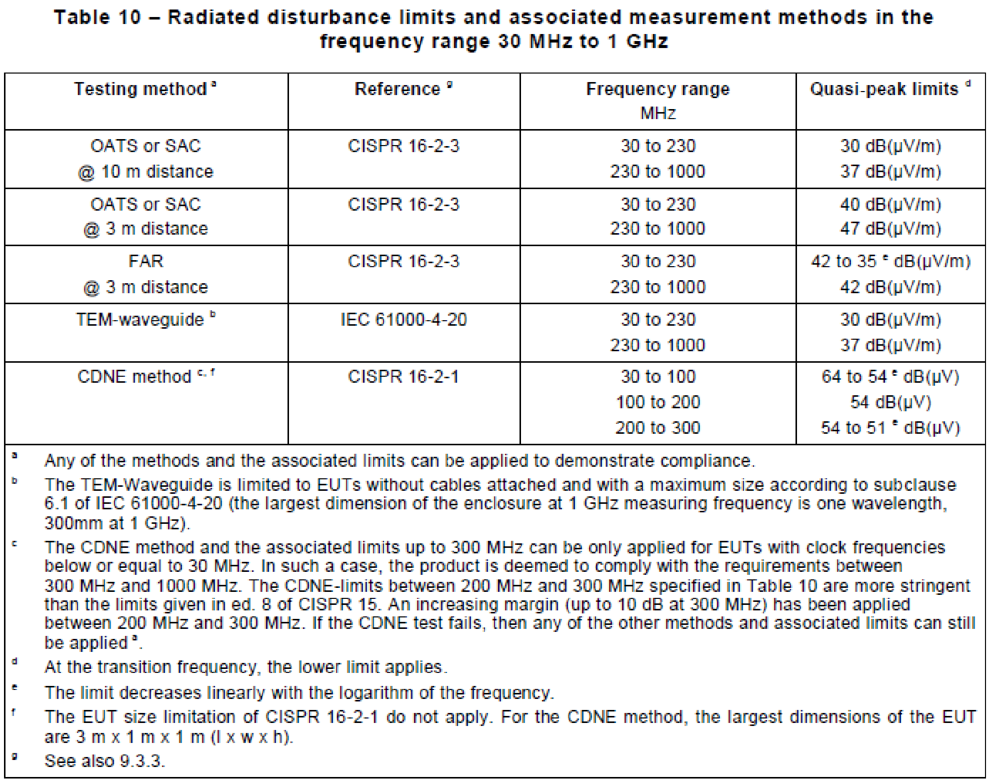


Table 10 – Radiated disturbance limits and associated measurement methods in the frequency range 30 MHz to 1 GHz

Testing method [a]	Reference [g]	Frequency range MHz	Quasi-peak limits [d]
OATS or SAC @ 10 m distance	CISPR 16-2-3	30 to 230	30 dB(μV/m)
		230 to 1000	37 dB(μV/m)
OATS or SAC @ 3 m distance	CISPR 16-2-3	30 to 230	40 dB(μV/m)
		230 to 1000	47 dB(μV/m)
FAR @ 3 m distance	CISPR 16-2-3	30 to 230	42 to 35 [e] dB(μV/m)
		230 to 1000	42 dB(μV/m)
TEM-waveguide [b]	IEC 61000-4-20	30 to 230	30 dB(μV/m)
		230 to 1000	37 dB(μV/m)
CDNE method [c, f]	CISPR 16-2-1	30 to 100	64 to 54 [e] dB(μV)
		100 to 200	54 dB(μV)
		200 to 300	54 to 51 [e] dB(μV)

[a] Any of the methods and the associated limits can be applied to demonstrate compliance.

[b] The TEM-Waveguide is limited to EUTs without cables attached and with a maximum size according to subclause 6.1 of IEC 61000-4-20 (the largest dimension of the enclosure at 1 GHz measuring frequency is one wavelength, 300mm at 1 GHz).

[c] The CDNE method and the associated limits up to 300 MHz can be only applied for EUTs with clock frequencies below or equal to 30 MHz. In such a case, the product is deemed to comply with the requirements between 300 MHz and 1000 MHz. The CDNE-limits between 200 MHz and 300 MHz specified in Table 10 are more stringent than the limits given in ed. 8 of CISPR 15. An increasing margin (up to 10 dB at 300 MHz) has been applied between 200 MHz and 300 MHz. If the CDNE test fails, then any of the other methods and associated limits can still be applied [a].

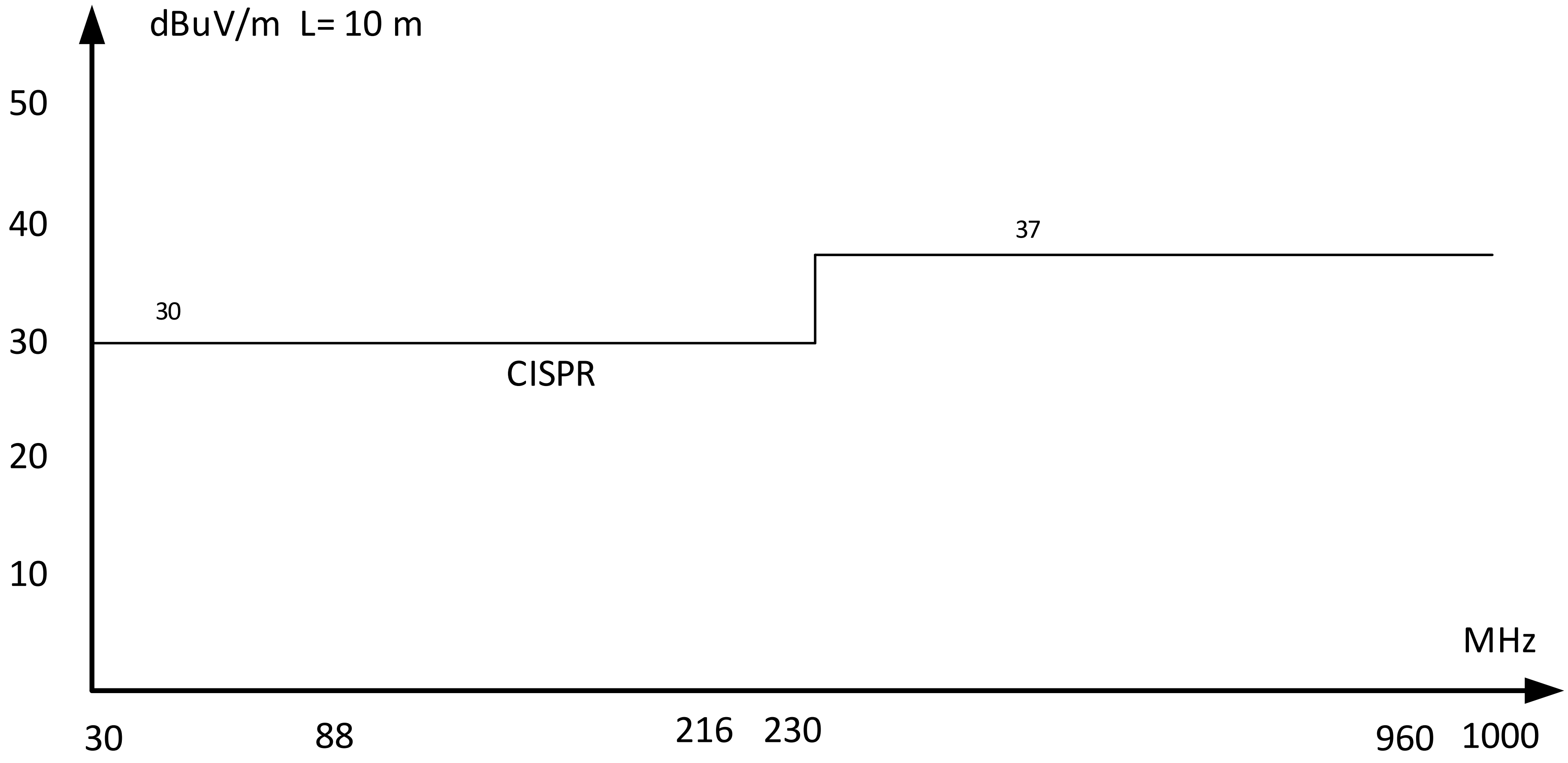
[d] At the transition frequency, the lower limit applies.

[e] The limit decreases linearly with the logarithm of the frequency.

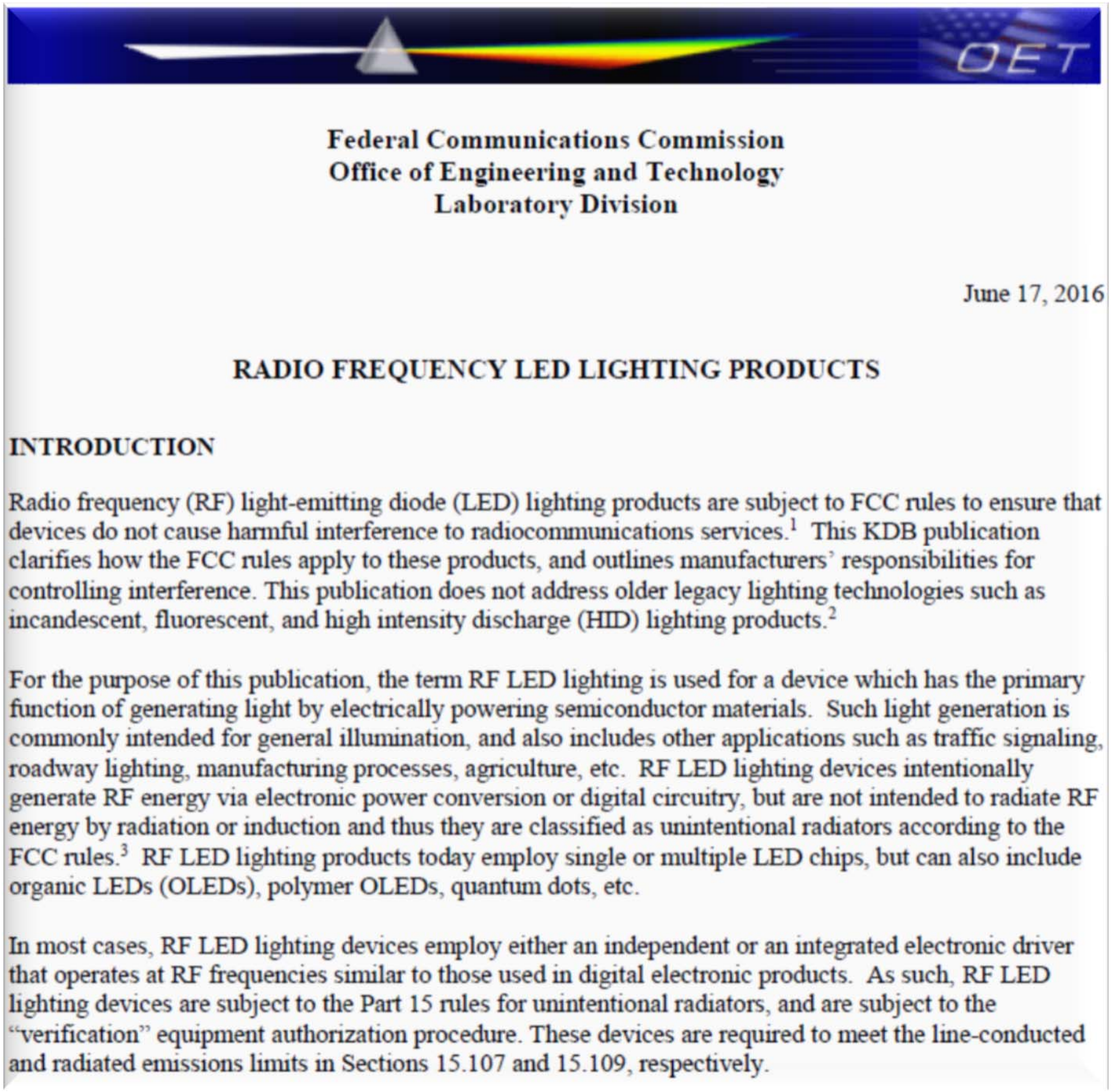
[f] The EUT size limitation of CISPR 16-2-1 do not apply. For the CDNE method, the largest dimensions of the EUT are 3 m x 1 m x 1 m (l x w x h).

[g] See also 9.3.3.

CISPR 15



NA RF Lighting Device Emission Limits Update



Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

June 17, 2016

RADIO FREQUENCY LED LIGHTING PRODUCTS

INTRODUCTION

Radio frequency (RF) light-emitting diode (LED) lighting products are subject to FCC rules to ensure that devices do not cause harmful interference to radiocommunications services.[1] This KDB publication clarifies how the FCC rules apply to these products, and outlines manufacturers' responsibilities for controlling interference. This publication does not address older legacy lighting technologies such as incandescent, fluorescent, and high intensity discharge (HID) lighting products.[2]

For the purpose of this publication, the term RF LED lighting is used for a device which has the primary function of generating light by electrically powering semiconductor materials. Such light generation is commonly intended for general illumination, and also includes other applications such as traffic signaling, roadway lighting, manufacturing processes, agriculture, etc. RF LED lighting devices intentionally generate RF energy via electronic power conversion or digital circuitry, but are not intended to radiate RF energy by radiation or induction and thus they are classified as unintentional radiators according to the FCC rules.[3] RF LED lighting products today employ single or multiple LED chips, but can also include organic LEDs (OLEDs), polymer OLEDs, quantum dots, etc.

In most cases, RF LED lighting devices employ either an independent or an integrated electronic driver that operates at RF frequencies similar to those used in digital electronic products. As such, RF LED lighting devices are subject to the Part 15 rules for unintentional radiators, and are subject to the "verification" equipment authorization procedure. These devices are required to meet the line-conducted and radiated emissions limits in Sections 15.107 and 15.109, respectively.

The U.S. LED regulation Update

The scope is to ensure that Lighting Devices do not interfere.

LED devices are approved to operate under the verification method.

PHILIPS

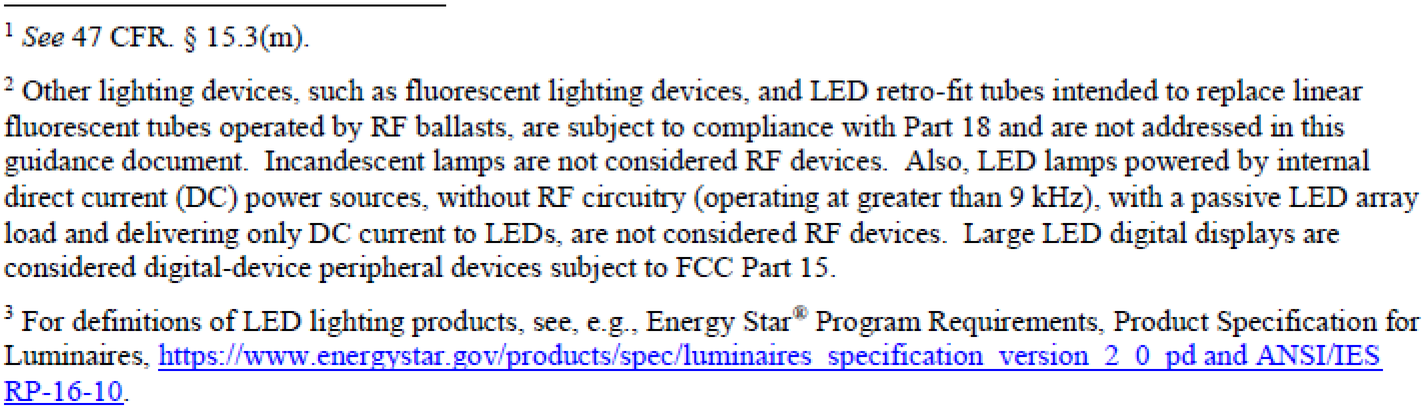
NA RF Lighting Devices Emissions Limits Update

The FCC Update specifically addressed TLEDs.

TLEDs operated from the mains are under FCC PART 15.

Ballasts used to operate TLEDs are under FCC part 18.

Drivers used to operate TLEDs are under FCC part 15.



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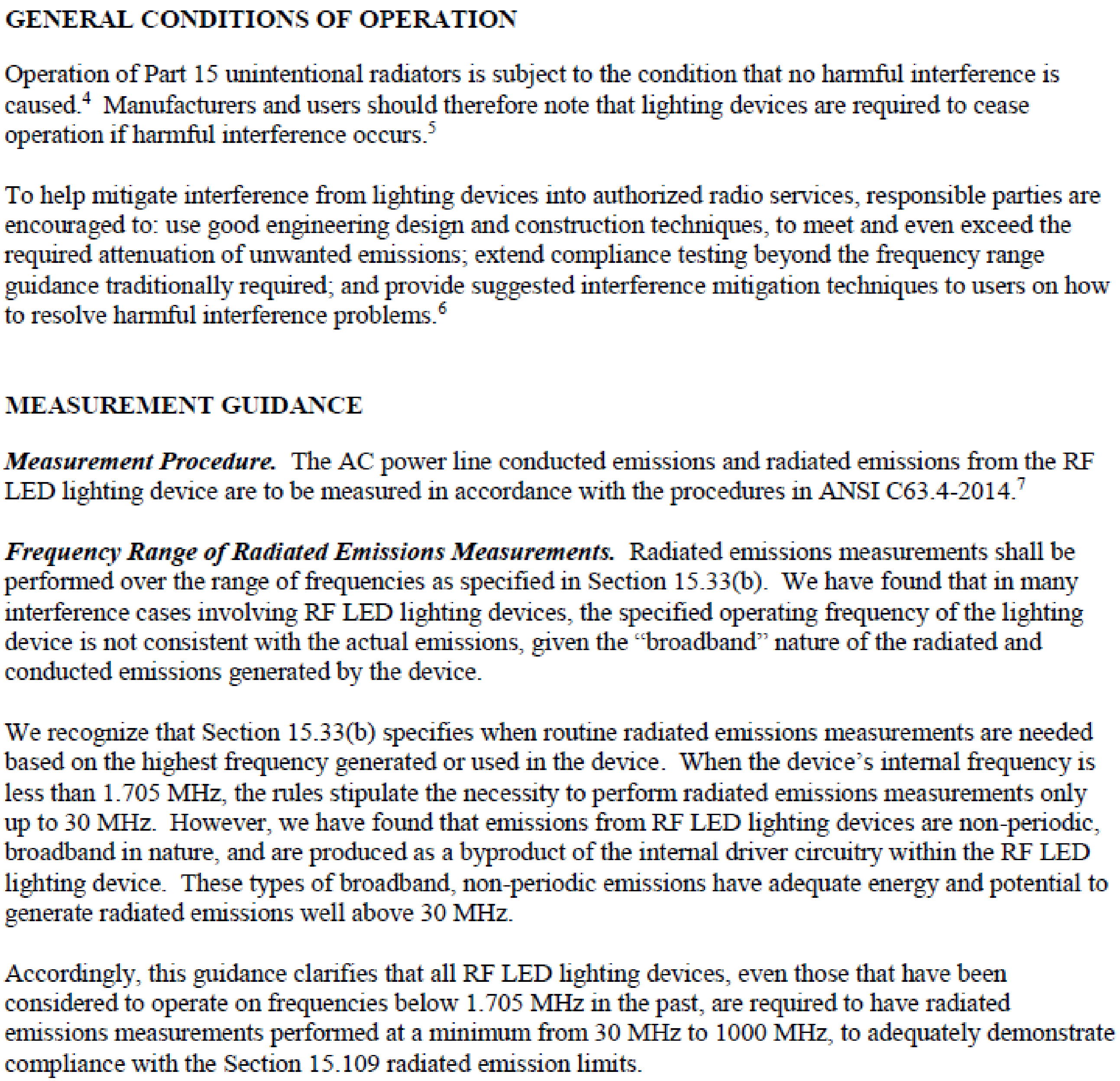
[1] *See* 47 CFR. § 15.3(m).

[2] Other lighting devices, such as fluorescent lighting devices, and LED retro-fit tubes intended to replace linear fluorescent tubes operated by RF ballasts, are subject to compliance with Part 18 and are not addressed in this guidance document. Incandescent lamps are not considered RF devices. Also, LED lamps powered by internal direct current (DC) power sources, without RF circuitry (operating at greater than 9 kHz), with a passive LED array load and delivering only DC current to LEDs, are not considered RF devices. Large LED digital displays are considered digital-device peripheral devices subject to FCC Part 15.

[3] For definitions of LED lighting products, see, e.g., Energy Star® Program Requirements, Product Specification for Luminaires, https://www.energystar.gov/products/spec/luminaires_specification_version_2_0_pd and ANSI/IES RP-16-10.

NA RF Lighting Device Emission Limits Update



GENERAL CONDITIONS OF OPERATION

Operation of Part 15 unintentional radiators is subject to the condition that no harmful interference is caused.[4] Manufacturers and users should therefore note that lighting devices are required to cease operation if harmful interference occurs.[5]

To help mitigate interference from lighting devices into authorized radio services, responsible parties are encouraged to: use good engineering design and construction techniques, to meet and even exceed the required attenuation of unwanted emissions; extend compliance testing beyond the frequency range guidance traditionally required; and provide suggested interference mitigation techniques to users on how to resolve harmful interference problems.[6]

MEASUREMENT GUIDANCE

Measurement Procedure. The AC power line conducted emissions and radiated emissions from the RF LED lighting device are to be measured in accordance with the procedures in ANSI C63.4-2014.[7]

Frequency Range of Radiated Emissions Measurements. Radiated emissions measurements shall be performed over the range of frequencies as specified in Section 15.33(b). We have found that in many interference cases involving RF LED lighting devices, the specified operating frequency of the lighting device is not consistent with the actual emissions, given the "broadband" nature of the radiated and conducted emissions generated by the device.

We recognize that Section 15.33(b) specifies when routine radiated emissions measurements are needed based on the highest frequency generated or used in the device. When the device's internal frequency is less than 1.705 MHz, the rules stipulate the necessity to perform radiated emissions measurements only up to 30 MHz. However, we have found that emissions from RF LED lighting devices are non-periodic, broadband in nature, and are produced as a byproduct of the internal driver circuitry within the RF LED lighting device. These types of broadband, non-periodic emissions have adequate energy and potential to generate radiated emissions well above 30 MHz.

Accordingly, this guidance clarifies that all RF LED lighting devices, even those that have been considered to operate on frequencies below 1.705 MHz in the past, are required to have radiated emissions measurements performed at a minimum from 30 MHz to 1000 MHz, to adequately demonstrate compliance with the Section 15.109 radiated emission limits.

The radiated scans exemption has been clarified.

NA RF LED Equipment Maximum Radiated Emissions

Frequency	Class A (Non-consumer) Maximum Radiated Emissions (L=10 m)		Class B (Consumer) Maximum Radiated Emissions (L=3 m)	
MHz	uV/m	dBuV/m	uV/m	dBuV/m
30-88	90	39.1	100	40.0
88-216	150	43.5	150	43.5
261-960	210	46.4	200	46
>960	300	49.5	500	54

NA RF Lighting Devices (discharge) Max Radiated Emissions

Frequency	Class A (Non-consumer) Maximum Radiated Emissions (L=10 m)		Class B (Consumer) Maximum Radiated Emissions (L=3 m)	
MHz	uV/m	dBuV/m	uV/m	dBuV/m
30-88	90	39.1	100	40.0
88-216	150	43.5	150	43.5
261-1000	210	46.4	200	46

Agenda

- Scope
- CISPR and NA
  Emission Limits
- **Conducted Emissions**
- Radiated Emissions
- Applications
- Conclusions

Conducted Emissions

- Measurements of conducted emissions (CE) estimate the amount and frequency of the current superimposed onto the mains current (60Hz).
- This is accomplished by interconnecting an HF Line Stabilization Network in series with the LED driver mains connection.
- This high frequency filter is called a “Line Impedance Stabilization Network” (LISN)[4].

RF LED Lighting Equipment Conducted Emission Limits

Class A (Non-consumer) Maximum Conducted Emissions				
Frequency	Quasi-Peak		Average	
MHz	uV	dBuV	uV	dBuV
0.15 to 0.5	8912.5	79.0	1995	66.0
0.5 to 30	4467	73.0	1000	60.0
Class B (Consumer) Maximum Conducted Emissions				
0.15 to 0.5	1995 to 631	66.0 to 56.0	631 to 199.5	56.0 to 46.0
0.5 to 5	631	56.0	199.5	46.0
5 to 30	1000	60.0	316	50.0

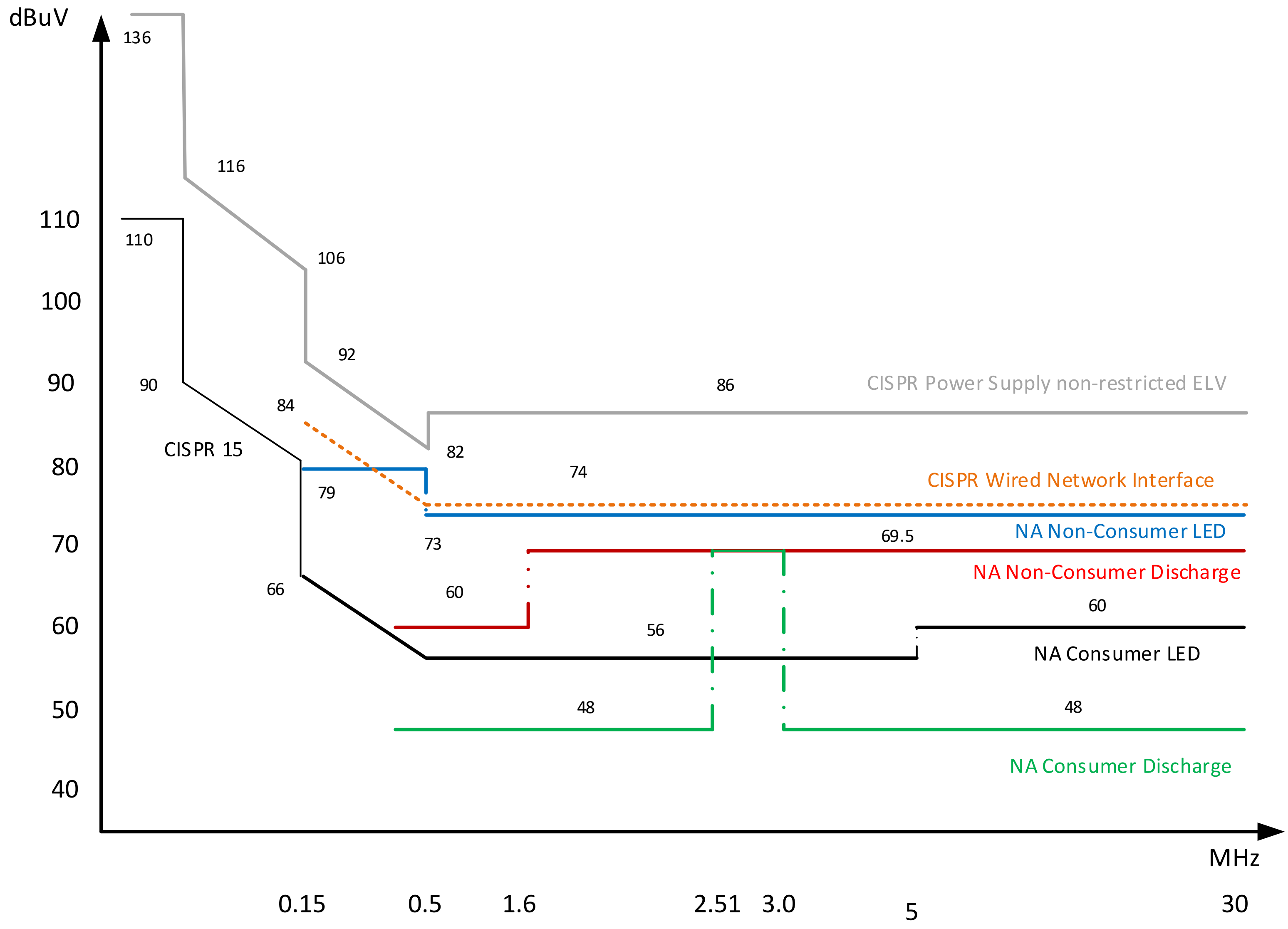
RF Discharge Lighting Conducted Emission Limits

Class A (Non-consumer) Maximum Conducted Emissions		
	Quasi-Peak	
Frequency (MHz)	uV	dBuV
0.45 to 1.6	1000	60
1.6 to 30	3000	69.5
Class B (Consumer) Maximum Conducted Emissions		
0.45 to 2.51	250	48
2.51 to 3.0	3000	69.5
3.0 to 30	250	48

Comparison of LED and Discharge Lighting CE Limits

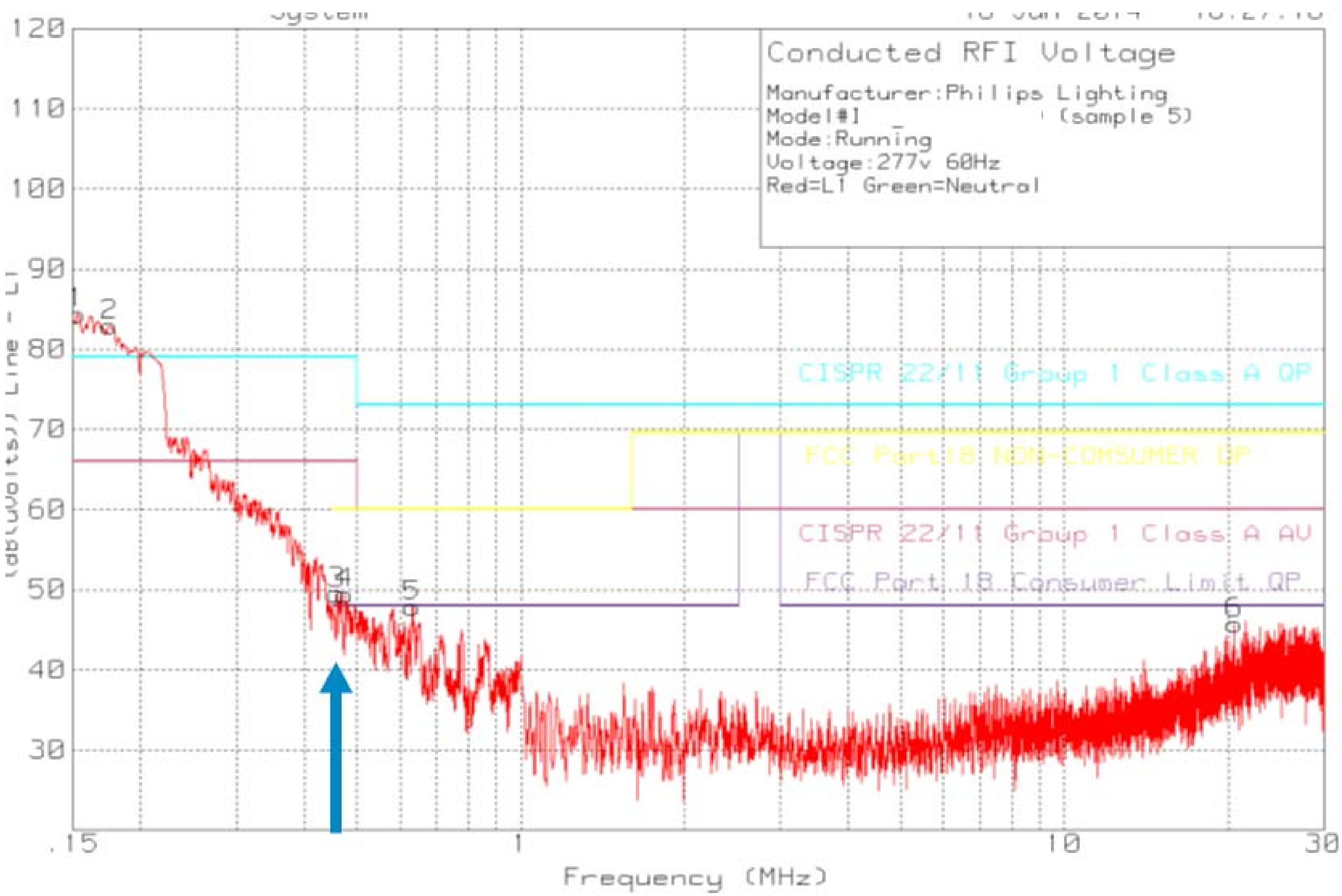
Class A (Non-consumer) Maximum Conducted Emissions (Quasi-Peak)		
MHz	dBuV LED	dBuV Discharge
0.15 to 0.45	79	
0.45 to 0.5	79	60
0.5 to 1.6	73	60
1.6 to 30	73	69.5
Class B (Consumer) Maximum Conducted Emissions (Quasi-Peak)		
0.15 to 0.45	66 to 57.4	
0.45 to 0.5	57.4 to 56	48
0.5 to 2.51	56	48
2.51 to 3.0	56	69.5
3 to 5	56	48
5 to 30	60	48

Comparison of CISPR and NA Conducted Emissions



PHILIPS

CFL Ballast CE Measured in a Representative Luminaire



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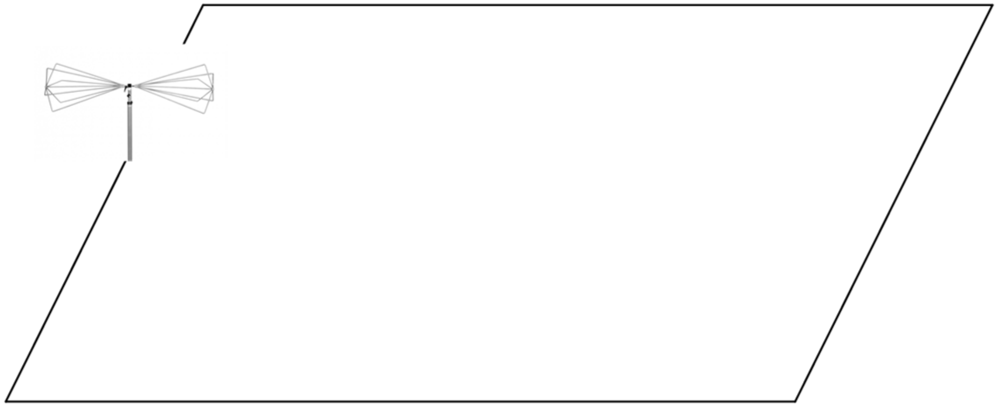
Agenda

- Scope
- CISPR and NA Emission Limits
- Conducted Emissions
- **Radiated Emissions**
- CISPR 15
- Applications
- Conclusions

Radiated Emissions

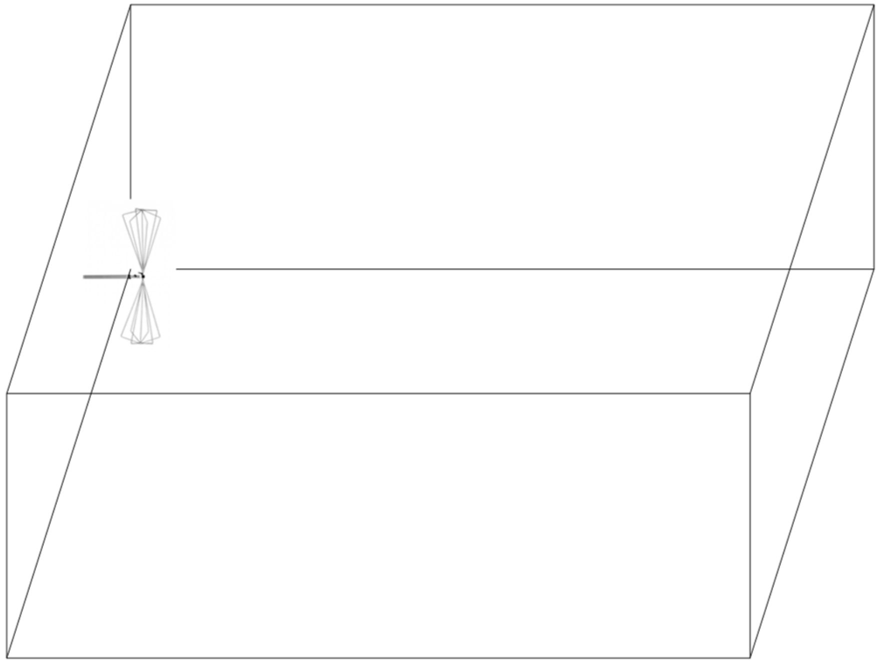
- Radiated emissions (RE) are determined by measuring the electromagnetic field that has emanated from the LED driver using an antenna.
- Measuring the electromagnetic field from an LED driver requires placing the antenna in an open field, free of other HF signals (such as TV, cellular, Wifi, etc.), to eliminate field reflections from walls and other objects[4].
- Alternatively, radiated emissions may be conducted in a testing chamber constructed with HF absorbing walls and ceiling, with a reflective floor, encased in a building designed to prevent HF signals from penetrating the testing chamber.

Open Field Testing Site



Open Area with
Reflective Floor

Test Chamber



Reflective Floor,
Absorbing Walls
& Ceiling

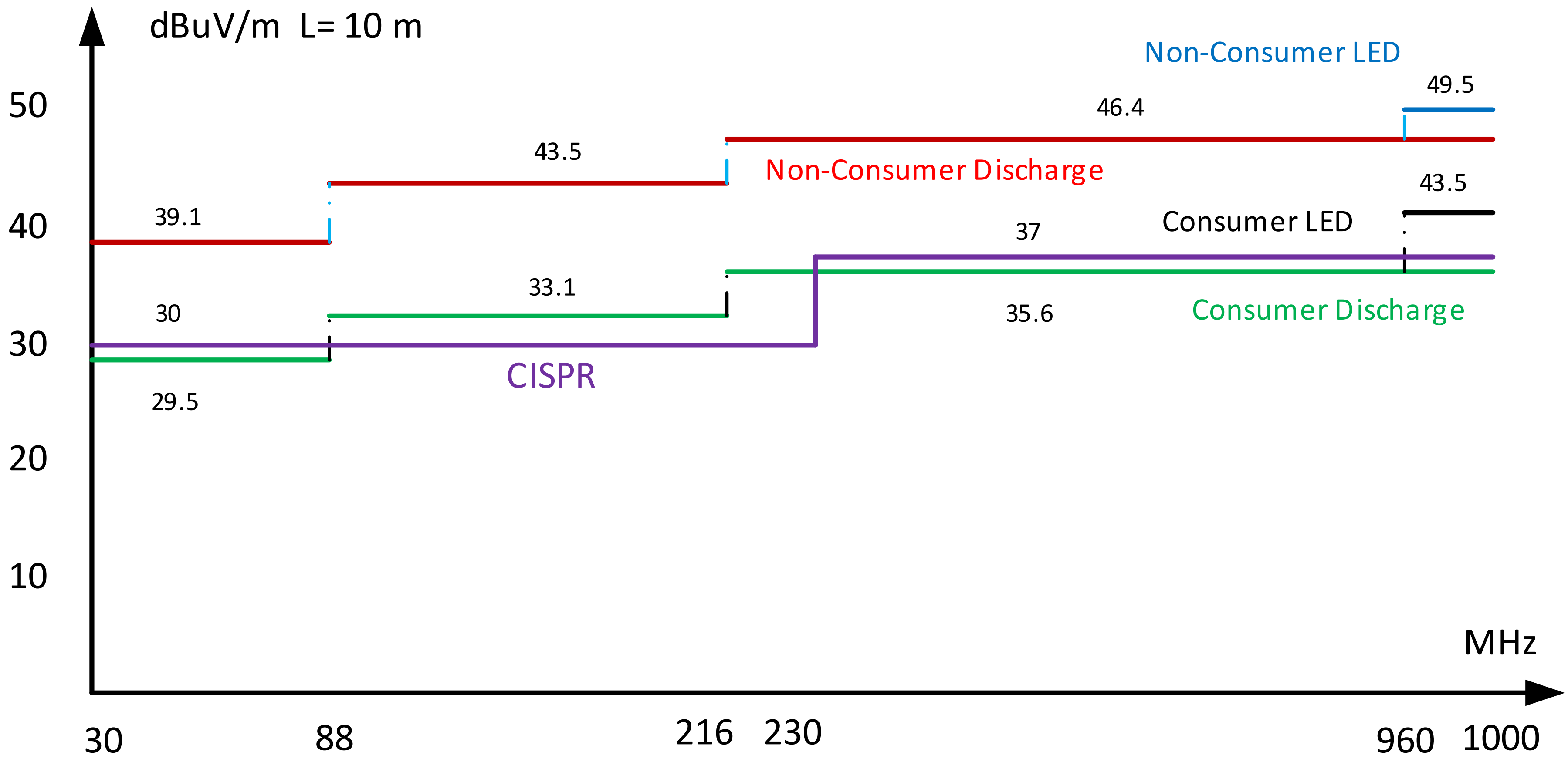
Two Classes, Consumer and Non-consumer

- RE and CE limits for both RF LED equipment and RF (discharge) lighting devices are classified by consumer and non-consumer products.
- The ANSI C63.12 standard recommended practice for (establishing) Electromagnetic Compatibility Limits is described as:
- *"The adoption of two protection distances, one for equipments used in a residential (Class B) environment and the other for equipments used in an industrial (Class A) environment, has the potential for reducing costs while still providing adequate protection. Thus, one set of limits applies to equipments used in a commercial/ industrial environment where the ambient noise level tends to be high and the likelihood of sensitive receivers is low. A second stricter emissions limit applies to equipments that will be operated in a residential/ domestic environment where noise levels tend to be lower and where there are generally larger numbers of sensitive receivers"*[5]

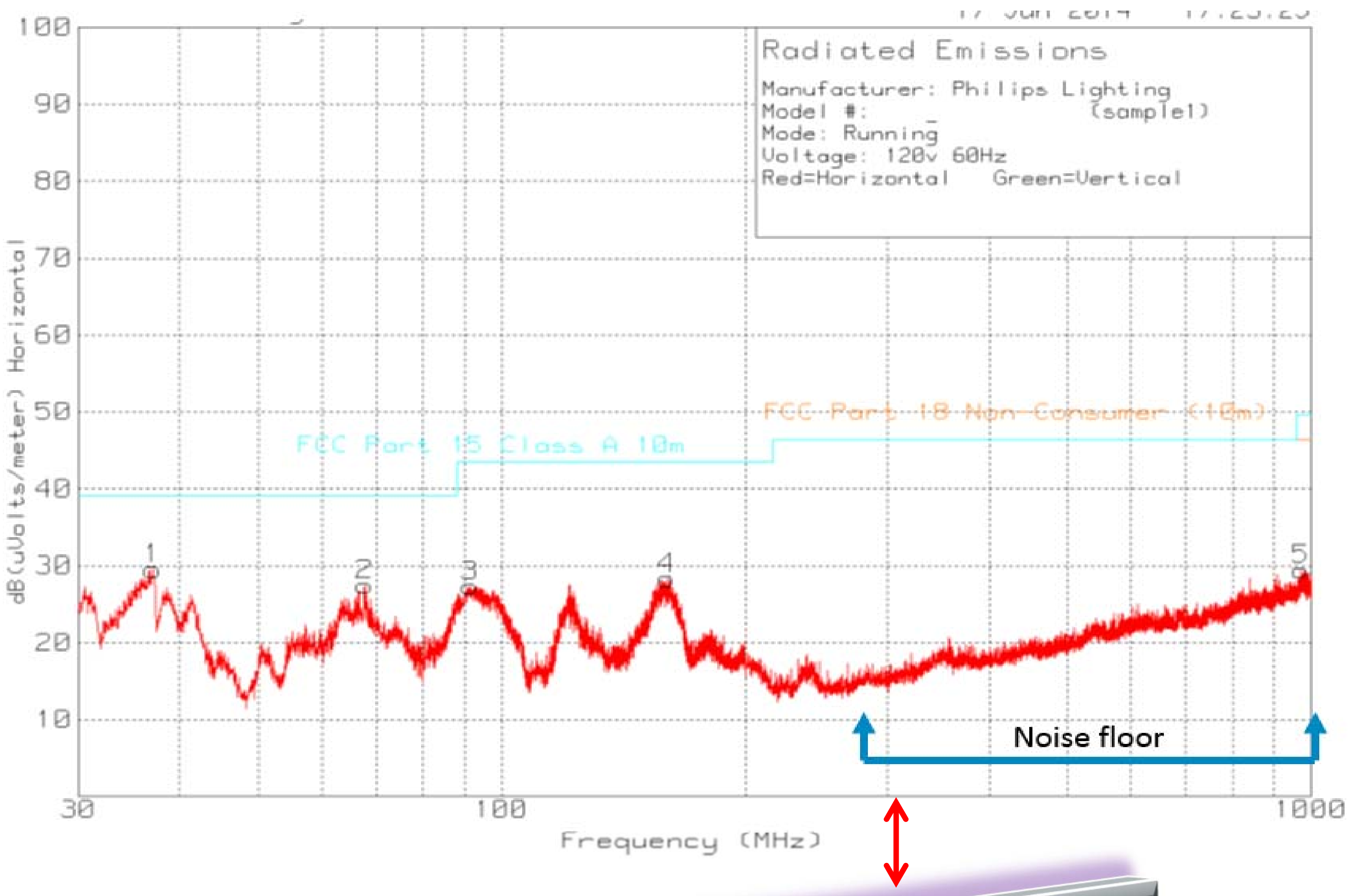
RF LED and Discharge Device RE Limits Comparison

Frequency	Class A (Non-consumer) Maximum Radiated Emissions (L=10 m)		Class B (Consumer) Maximum Radiated Emissions (L=10 m)	
MHz	dBuV/m (LED)	dBuV/m (RF)	dBuV/m (LED)	dBuV/m (RF)
30-88	39.1	39.1	29.5	29.5
88-216	43.5	43.5	33.1	33.1
216-960	46.4	46.4	35.6	35.6
960-1000	49.5	46.4	43.5	35.6

CISPR and NA Radiated Emissions Comparison



CFL Ballast RE Measured in a Representative Luminaire



Noise floor

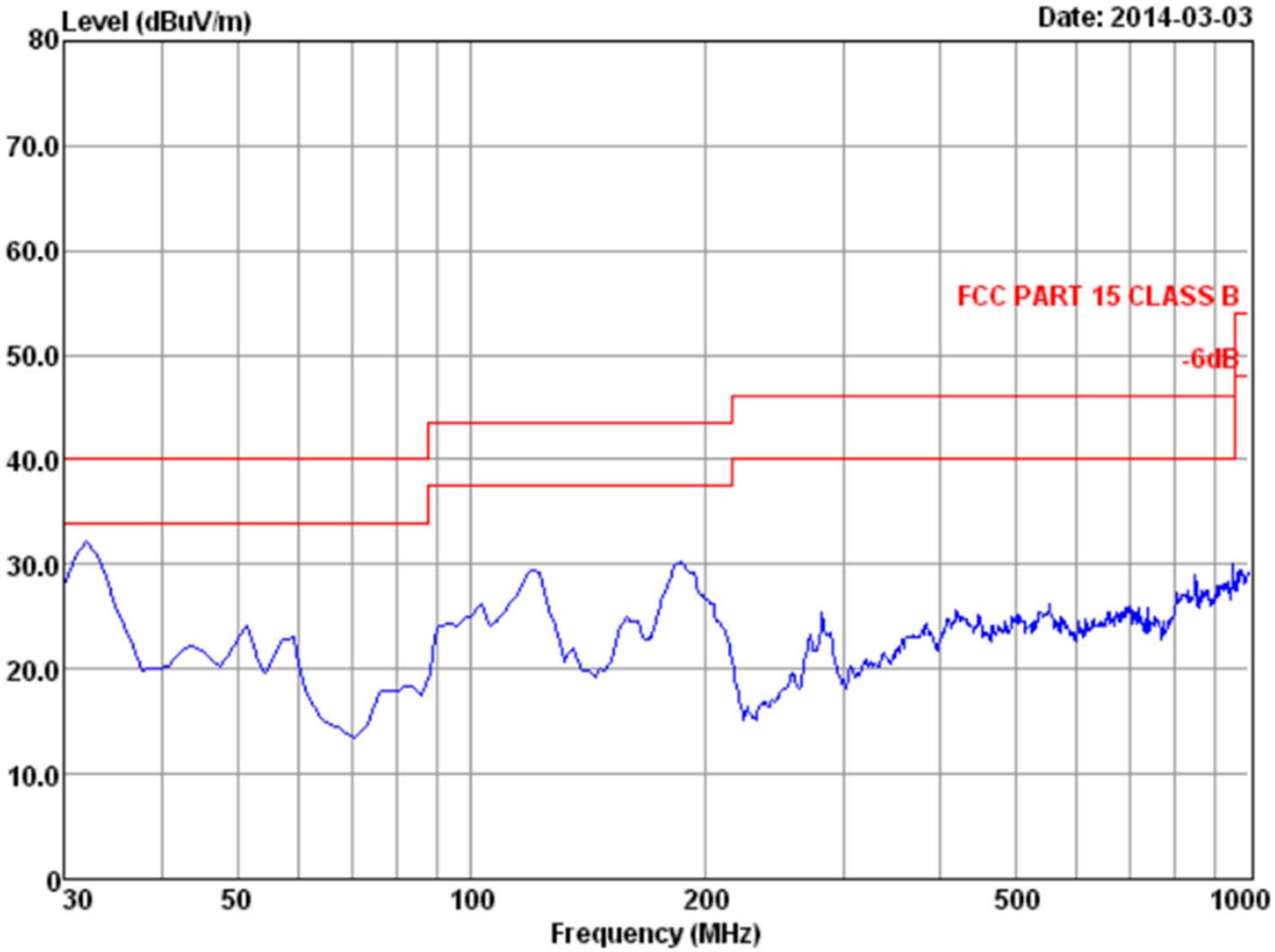
Most Lighting Devices Do Not Emit Above 300 MHz

PHILIPS

Chart illustrating self-ballasted LED lamp radiated emissions

Class B Limit

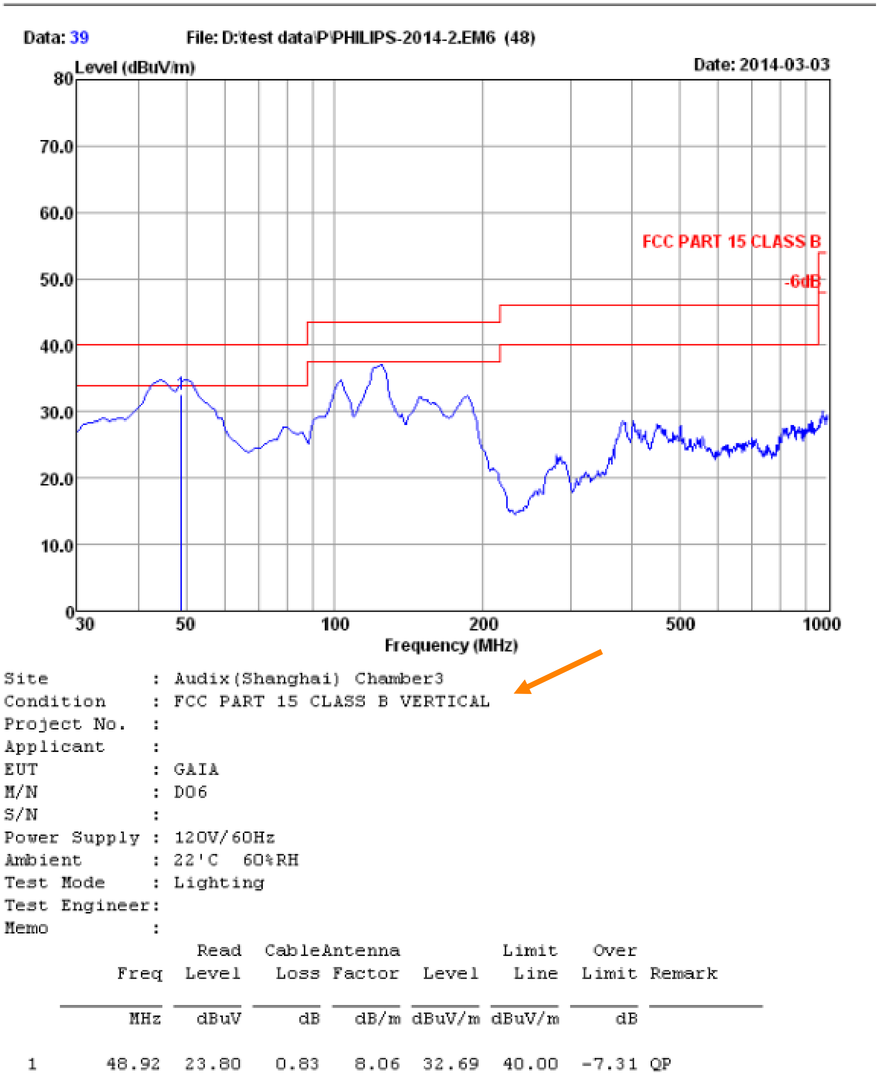
6 db Margin



Agenda

- Scope
- CISPR and NA Emission Limits
- Conducted Emissions
- Radiated Emissions
- **Applications**
- Conclusions

Applications LED Lamps, Orientation Effect



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                                                   Date: 2014-03-03

Site          : Audix(Shanghai) Chamber3
Condition     : FCC PART 15 CLASS B VERTICAL
Project No.   :
Applicant     :
EUT           : GAIA
M/N           : D06
S/N           :
Power Supply  : 120V/60Hz
Ambient       : 22'C   60%RH
Test Mode     : Lighting
Test Engineer:
Memo          :

                 Read  CableAntenna          Limit   Over
          Freq  Level   Loss Factor  Level   Line  Limit Remark

           MHz   dBuV     dB   dB/m dBuV/m dBuV/m     dB

  1      48.92  23.80   0.83   8.06  32.69  40.00  -7.31 QP
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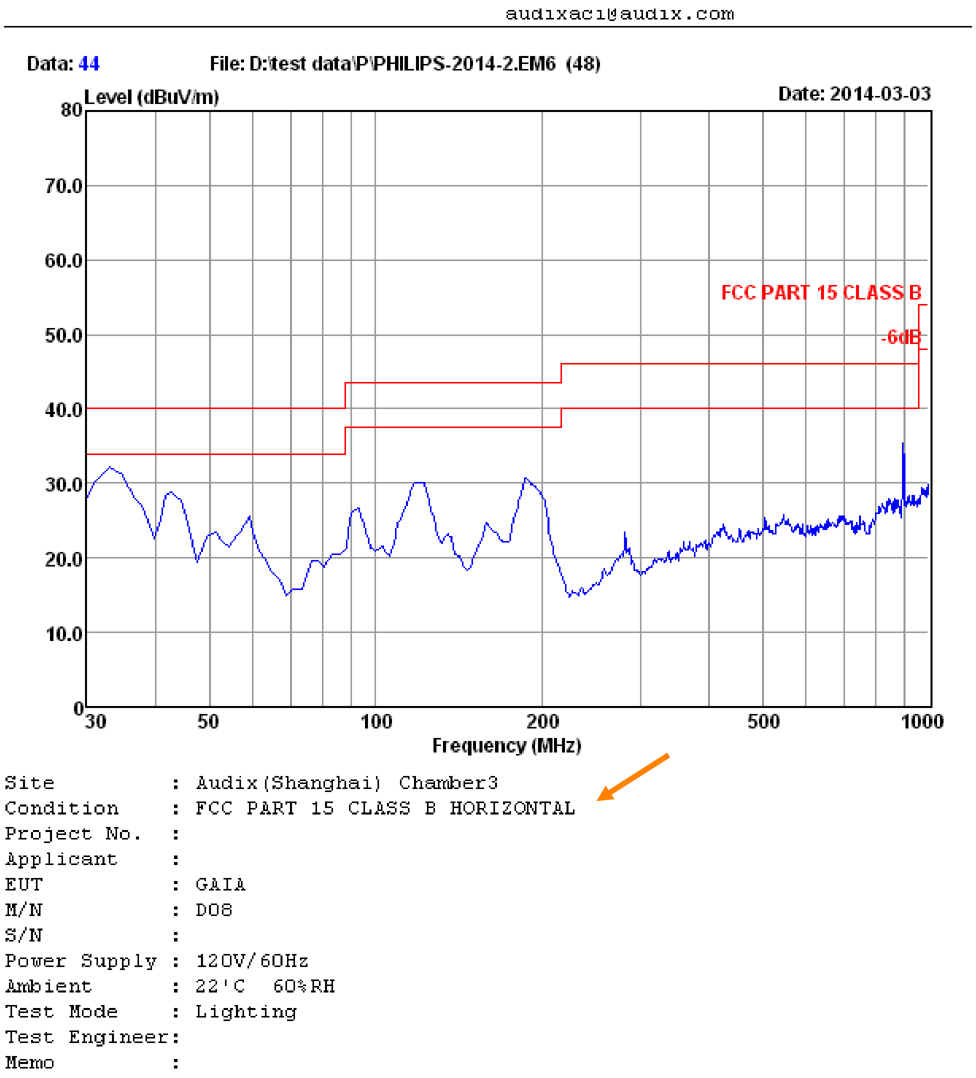

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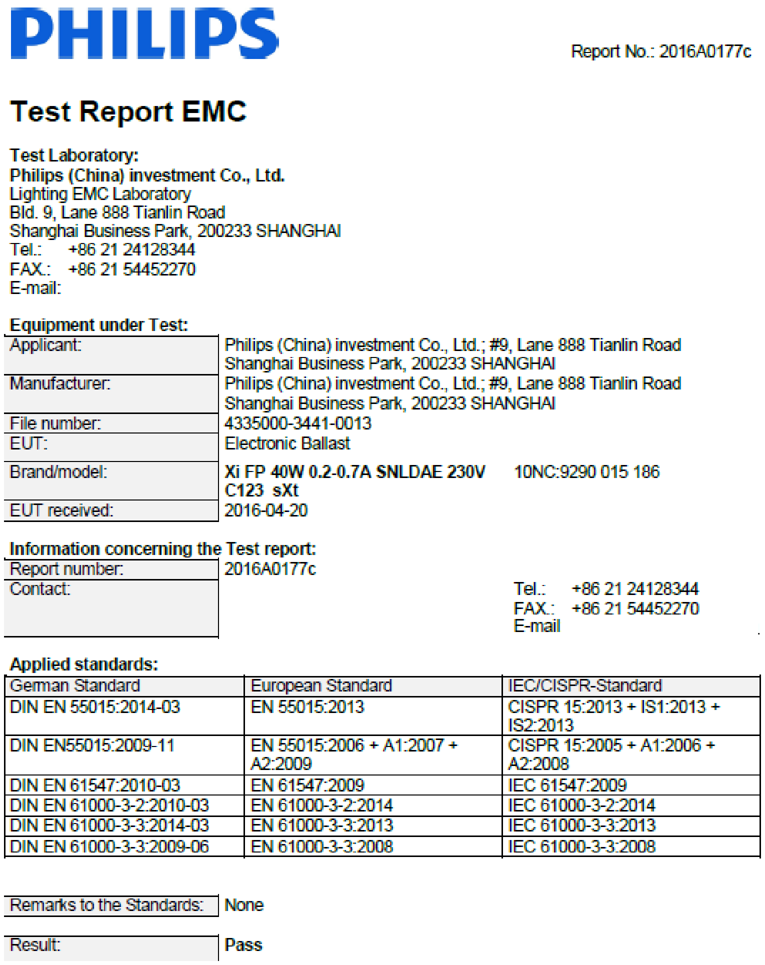
                                              audixac1@audix.com
Data: 44          File: D:\test data\P\PHILIPS-2014-2.EM6  (48)
                                                   Date: 2014-03-03

Site          : Audix(Shanghai) Chamber3
Condition     : FCC PART 15 CLASS B HORIZONTAL
Project No.   :
Applicant     :
EUT           : GAIA
M/N           : D08
S/N           :
Power Supply  : 120V/60Hz
Ambient       : 22'C   60%RH
Test Mode     : Lighting
Test Engineer:
Memo          :
```

LED EMC Control Gear Report +272 Pages



PHILIPS Report No.: 2016A0177c

Test Report EMC

Test Laboratory:
Philips (China) investment Co., Ltd.
Lighting EMC Laboratory
Bld. 9, Lane 888 Tianlin Road
Shanghai Business Park, 200233 SHANGHAI
Tel.: +86 21 24128344
FAX.: +86 21 54452270
E-mail:

Equipment under Test:

Applicant:	Philips (China) investment Co., Ltd.; #9, Lane 888 Tianlin Road Shanghai Business Park, 200233 SHANGHAI
Manufacturer:	Philips (China) investment Co., Ltd.; #9, Lane 888 Tianlin Road Shanghai Business Park, 200233 SHANGHAI
File number:	4335000-3441-0013
EUT:	Electronic Ballast
Brand/model:	**Xi FP 40W 0.2-0.7A SNLDAE 230V C123 sXt** 10NC:9290 015 186
EUT received:	2016-04-20

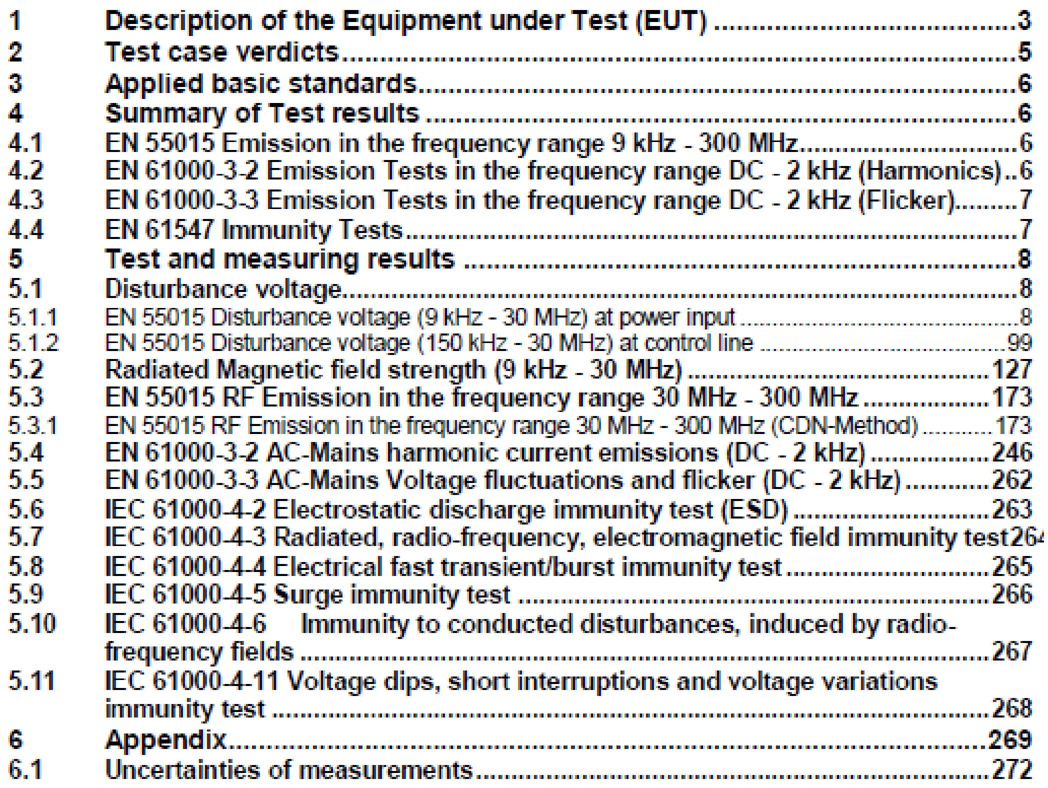
Information concerning the Test report:

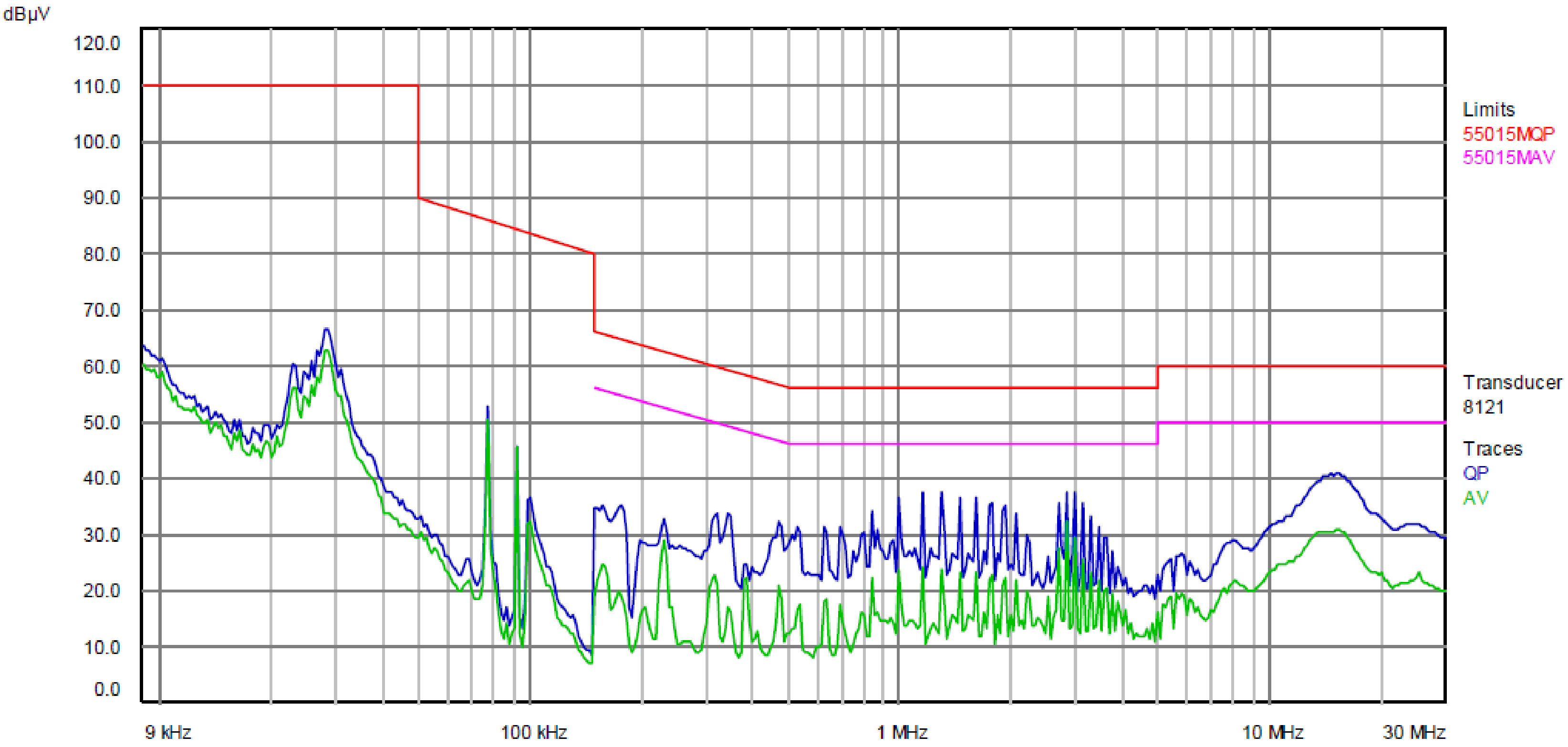
Report number:	2016A0177c
Contact:	Tel.: +86 21 24128344 FAX.: +86 21 54452270 E-mail

Applied standards:

German Standard	European Standard	IEC/CISPR-Standard
DIN EN 55015:2014-03	EN 55015:2013	CISPR 15:2013 + IS1:2013 + IS2:2013
DIN EN55015:2009-11	EN 55015:2006 + A1:2007 + A2:2009	CISPR 15:2005 + A1:2006 + A2:2008
DIN EN 61547:2010-03	EN 61547:2009	IEC 61547:2009
DIN EN 61000-3-2:2010-03	EN 61000-3-2:2014	IEC 61000-3-2:2014
DIN EN 61000-3-3:2014-03	EN 61000-3-3:2013	IEC 61000-3-3:2013
DIN EN 61000-3-3:2009-06	EN 61000-3-3:2008	IEC 61000-3-3:2008

Remarks to the Standards:	None
Result:	Pass





Conducted Emission Limits CISPR 15

Frequency	Quasi Peck		Average	
MHz	uV	dBuV	uV	dBuV
0.009-0.05		110		
0.05-0.15		90-80		
0.15-0.5		66-56		56-46
0.5-5.0		56		46
5-30		60		50

PHILIPS

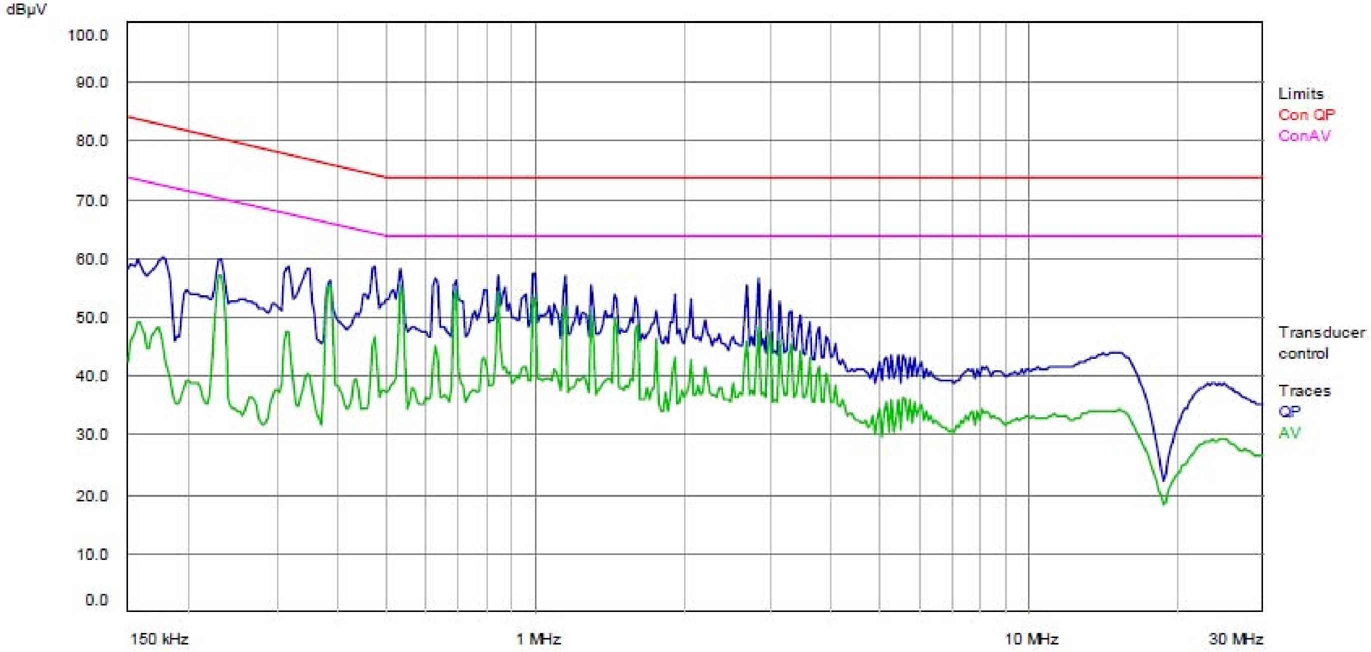
PHILIPS

Report No.: 2016A0177c

Standard Testing Laboratory
RFI Voltage Test at Control Line

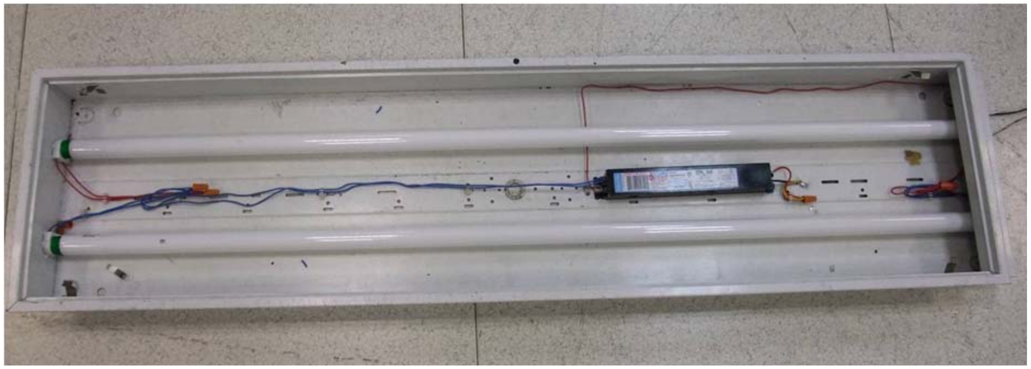
Manufacture:	Philips Lighting Electronics	Test date	30-May-2016
Test Spec:	CISPR15/EN55015	EUT	Xi FP 40W 0.2-0.7A SNLDAE 230V C123 sXt
Phase	Control line	Control number:	LED-2016-0158-01
Operating mode:	230V/50Hz class I	Operator:	
Comment:	Output 0.2A 57V L/S open Dall set to full		
Scan setting:			

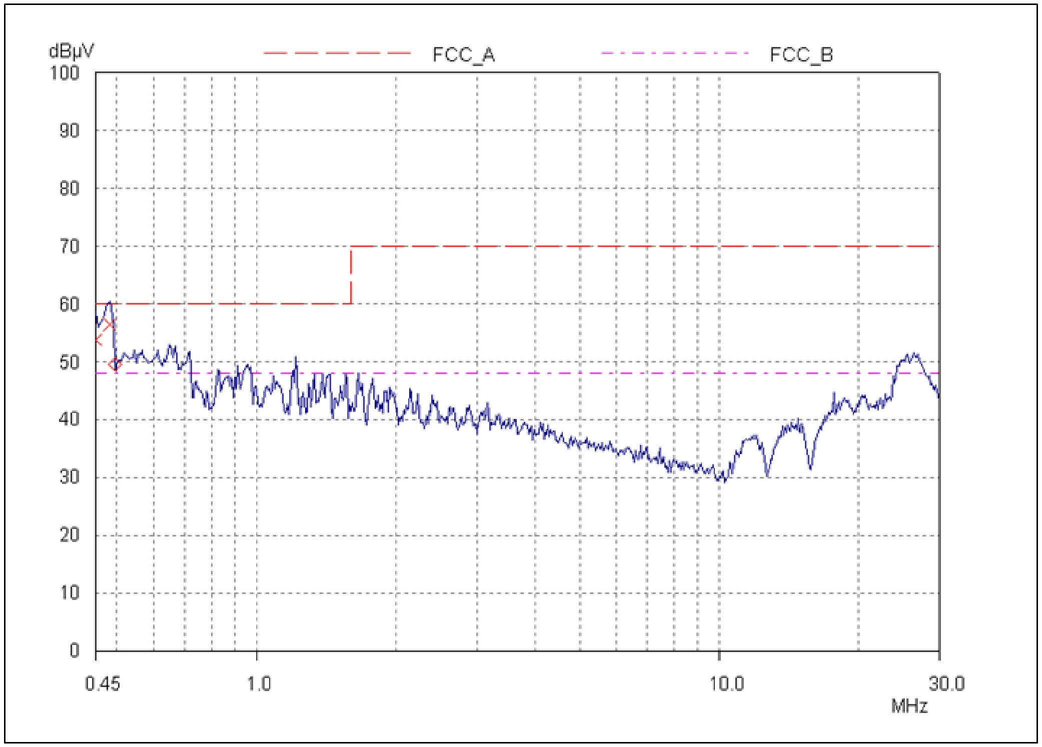
Frequency			Receiver setting					
Start	Stop	Step	IF BW	detector	Meas-time	Atten	Preamp	OpRge
150KHz	30MHz	2.25KHz	9KHz	QP+AV	2 sec	Auto	OFF	60dB



PHILIPS

Fluorescent Conducted

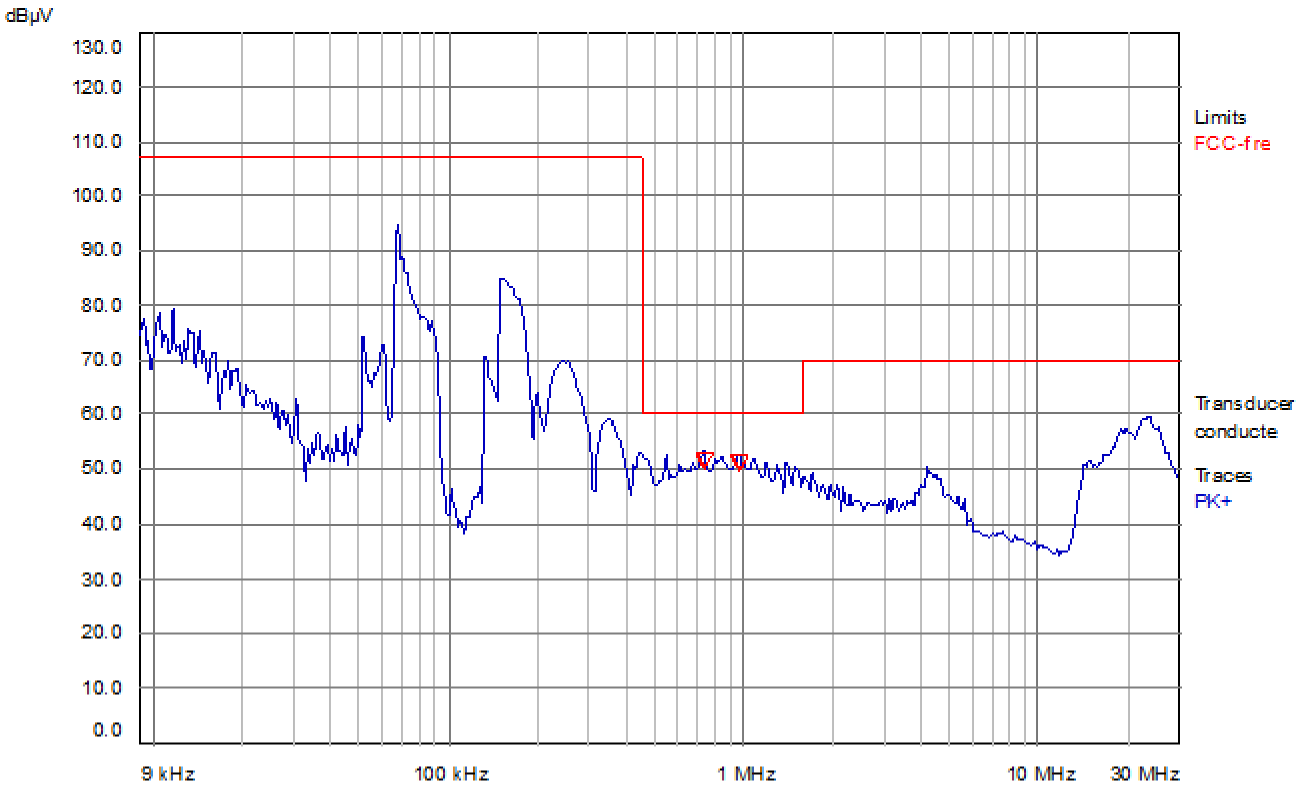




Final measurement result:

Freq	QP level	Limit	Margin	Phase	PE
0.45	53.88	60.00	6.12	L	gnd
0.48	56.54	60.00	3.46	L	gnd

T LED



Final Measurement Results

Trace	Frequency (MHz)	Level (dBµV)	Limit (dBµV)	Delta Limit (dB)	Delta Ref (dB)	Comment
1 QP	0.73	49.90	60.00	-10.10		L1 gnd
1 QP	0.97	49.56	60.00	-10.44		L1 gnd

Report No.: 2016A0177c

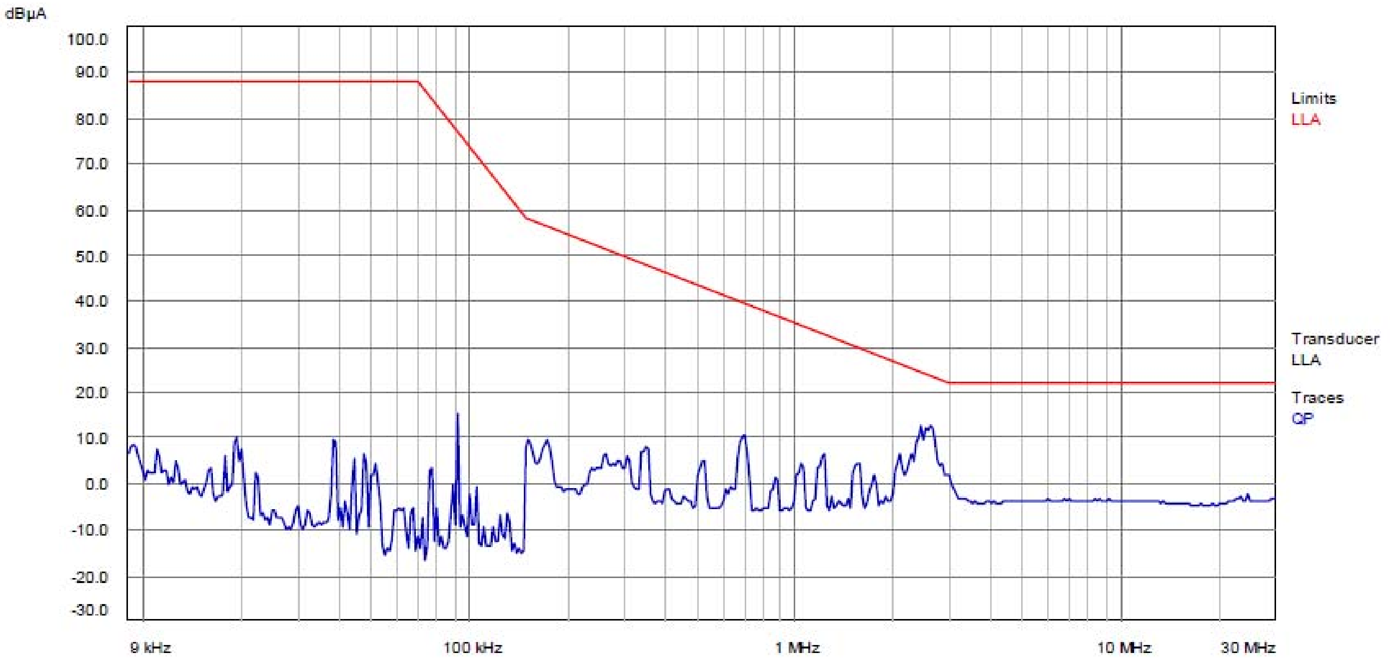
Standard Testing Laboratory

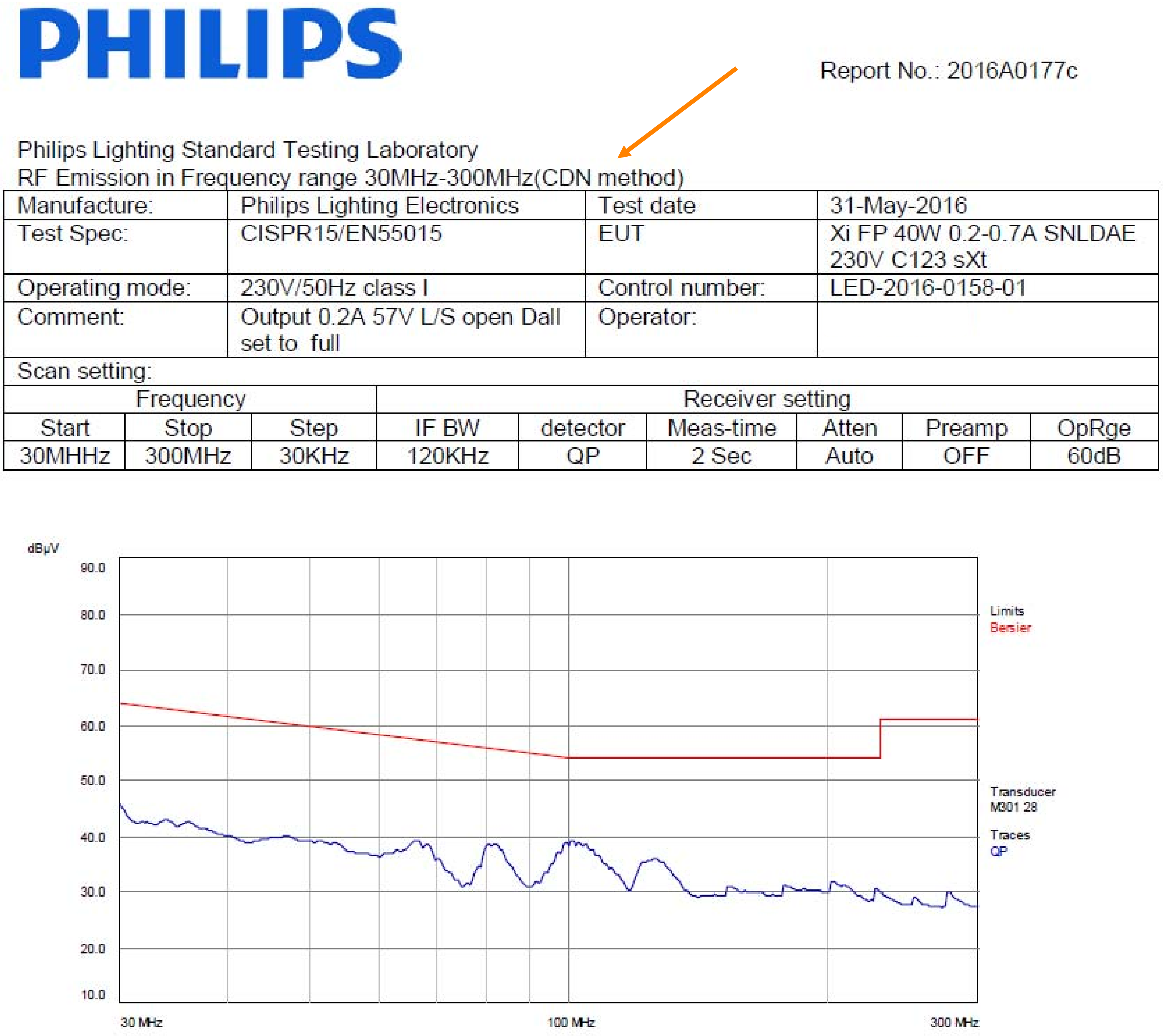
Radiated Magnetic Field Strength(Loop Antenna)

Manufacture:	Philips Lighting Electronics	TEST DATE	30-June-2016
Test Spec:	CISPR15/EN55015	EUT	Xi FP 40W 0.2-0.7A SNLDAE 230V C123 sXt
Antenna	X	Control number:	LED-2016-0158-01
Operating mode:	230V/50Hz class I	Operator:	
Comment:	Output 0.2A 57V L/S open Dall set to full		

Scan setting:

Frequency			Receiver setting					
Start	Stop	Step	IF BW	detector	Meas-time	Atten	Preamp	OpRge
9KHz	150KHz	50Hz	200Hz	QP	2 Sec	Auto	OFF	60dB
150KHz	30MHz	2.25KHz	9KHz	QP	2 Sec	Auto	OFF	60dB





PHILIPS

Report No.: 2016A0177c

Philips Lighting Standard Testing Laboratory

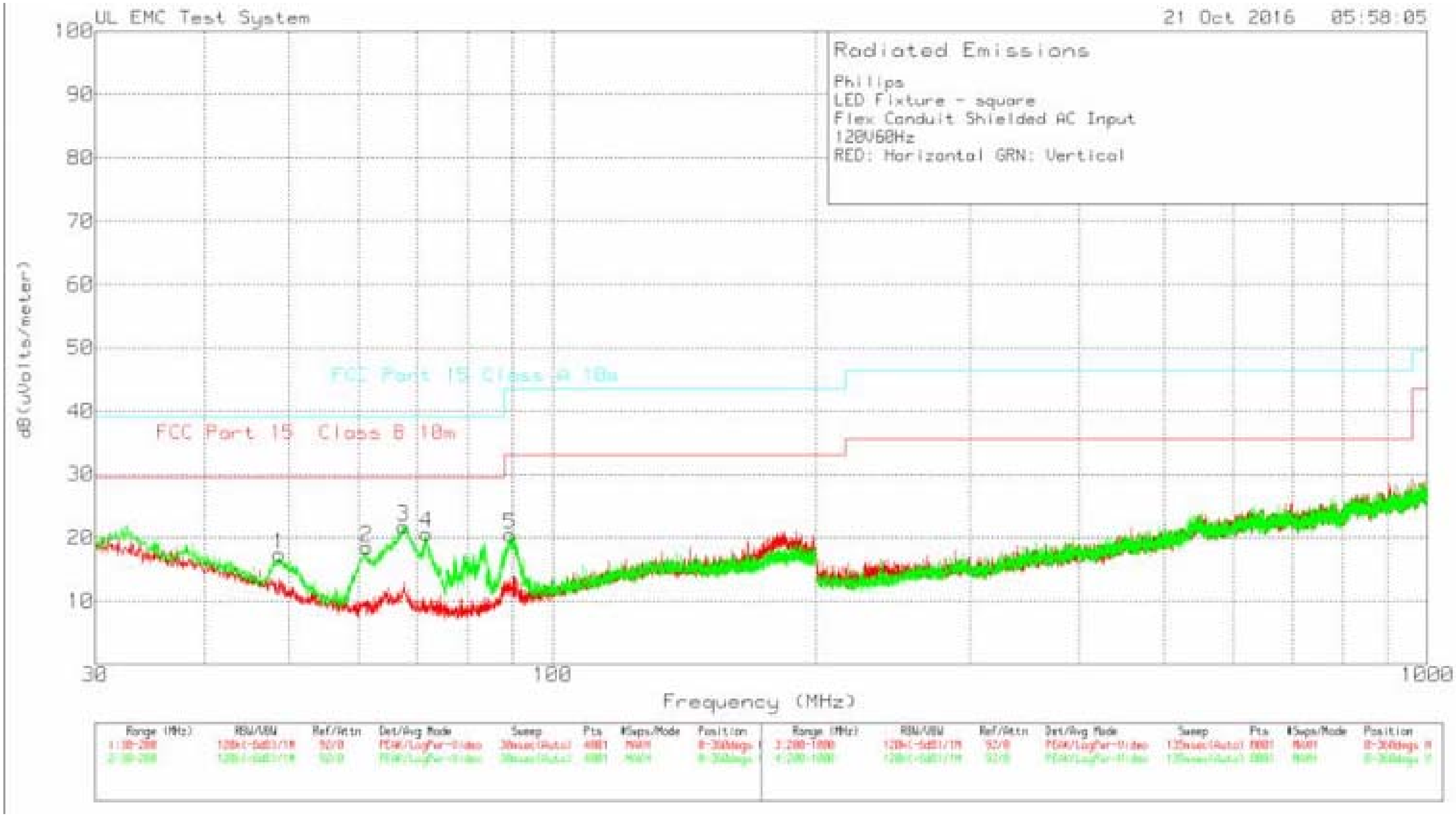
RF Emission in Frequency range 30MHz-300MHz(CDN method)

Manufacture:	Philips Lighting Electronics	Test date	31-May-2016
Test Spec:	CISPR15/EN55015	EUT	Xi FP 40W 0.2-0.7A SNLDAE 230V C123 sXt
Operating mode:	230V/50Hz class I	Control number:	LED-2016-0158-01
Comment:	Output 0.2A 57V L/S open Dall set to full	Operator:	

Scan setting:

Frequency			Receiver setting					
Start	Stop	Step	IF BW	detector	Meas-time	Atten	Preamp	OpRge
30MHHz	300MHz	30KHz	120KHz	QP	2 Sec	Auto	OFF	60dB

PHILIPS


UL EMC Test System
21 Oct 2016 05:58:05
Radiated Emissions
Philips
LED Fixture - square
Flex Conduit Shielded AC Input
120V60Hz
RED: Horizontal GRN: Vertical
FCC Part 15 Class A 10m
FCC Part 15 Class B 10m
dB(uVolts/meter)
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
30
100
1000
Frequency (MHz)
Range (MHz)
RBW/VBW
Ref/Attn
Det/Avg Mode
Sweep
Pts
#Swps/Mode
Position
1:30-200
2:30-200
3:200-1000
4:200-1000

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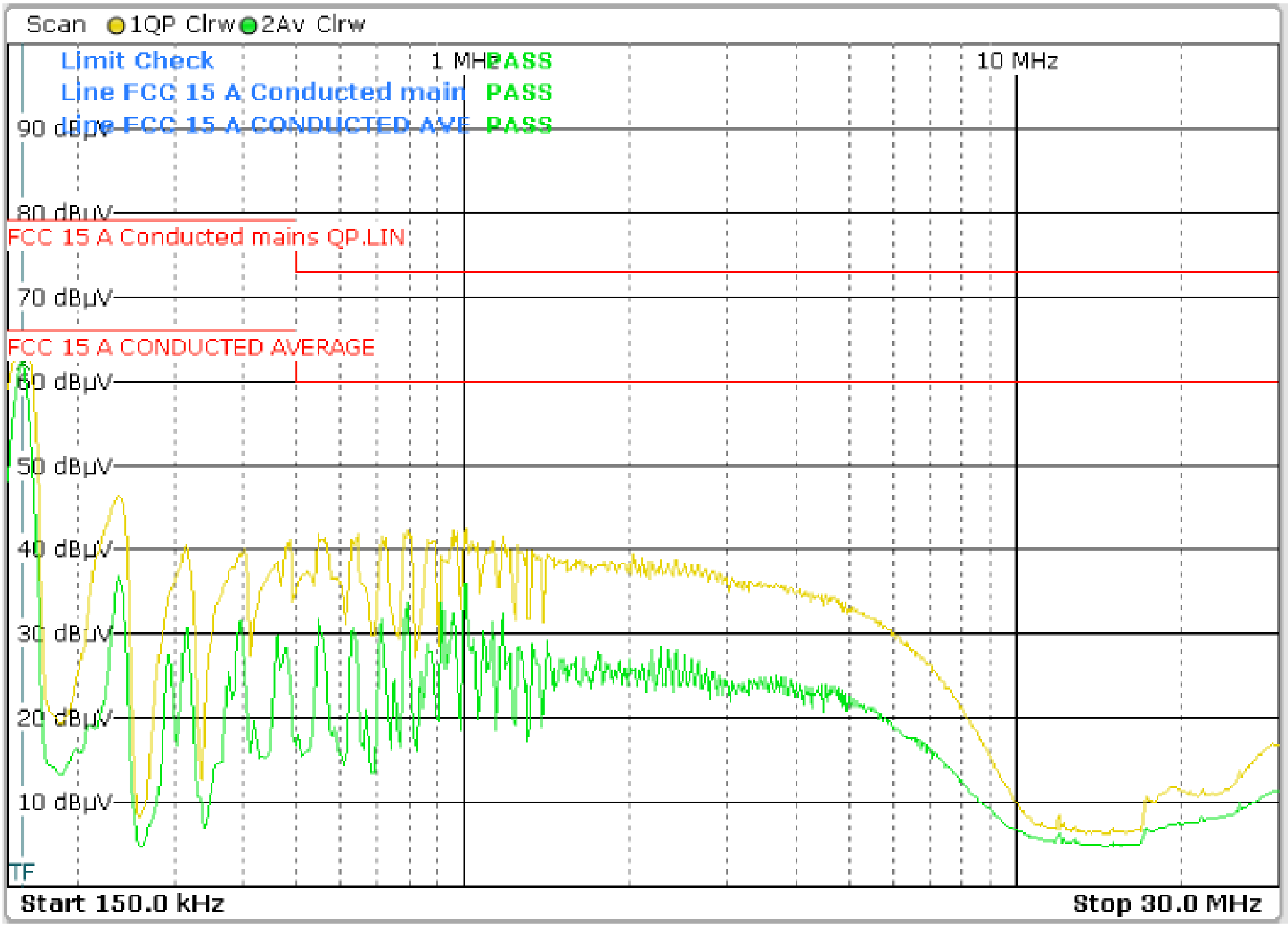
ROSEMONT IL
USA

FCC Class A
Conductive Mains
Conditions:
Scan Diagram

Driver: XI040C110V054BST1 Date Code: 16055L36

LINE - 120Vac - 22.5Vdc/1100mA



PHILIPS

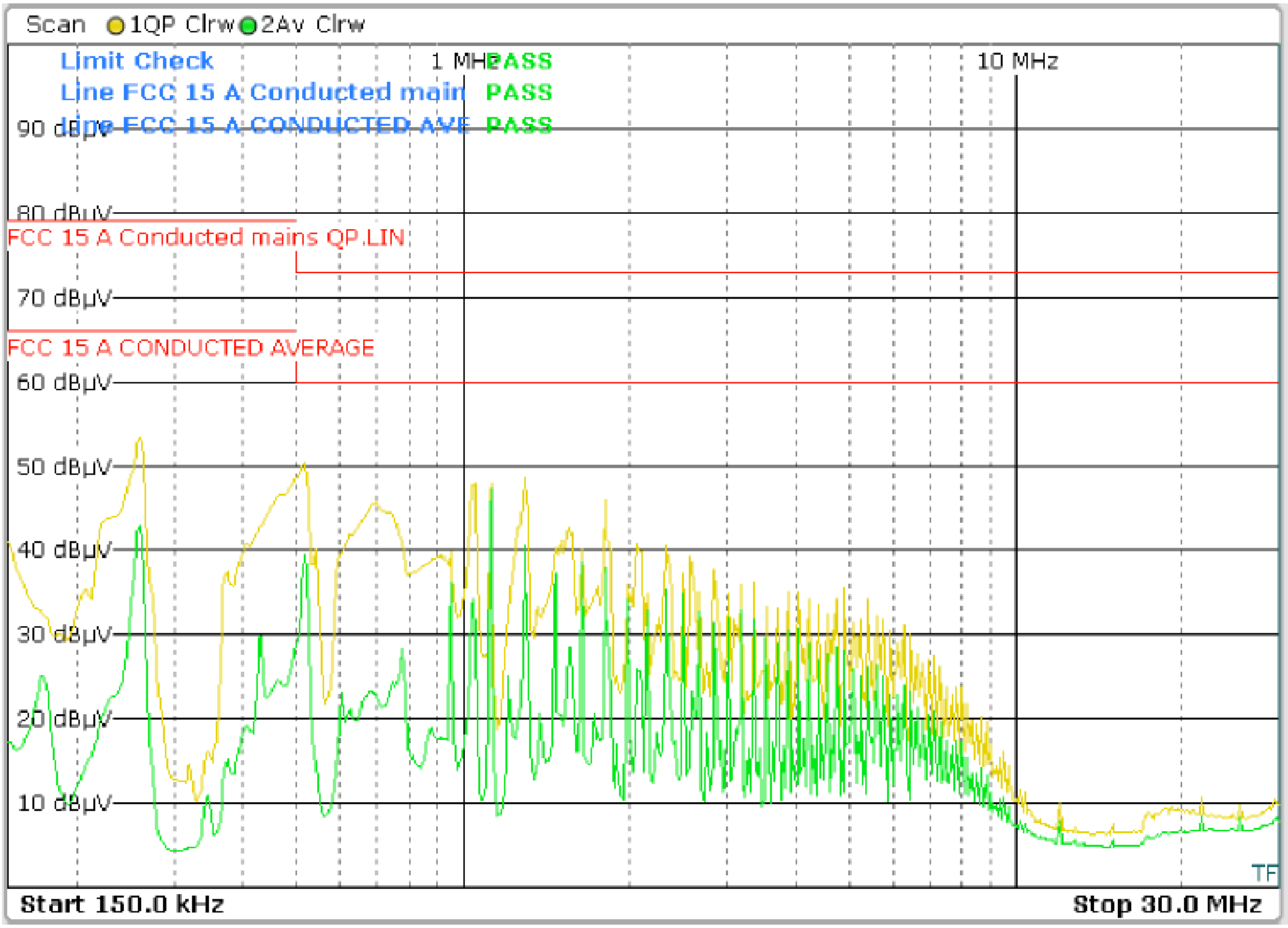
PHILIPS
ROSEMONT IL
USA

This 40W LED application is compliant at full output and full dim.

FCC Class A Conductive Mains Conditions: Scan Diagram

Driver: XI040C110V054BST1 Date Code: 16055L36

LINE - 120Vac - 22.5Vdc/2.5mA



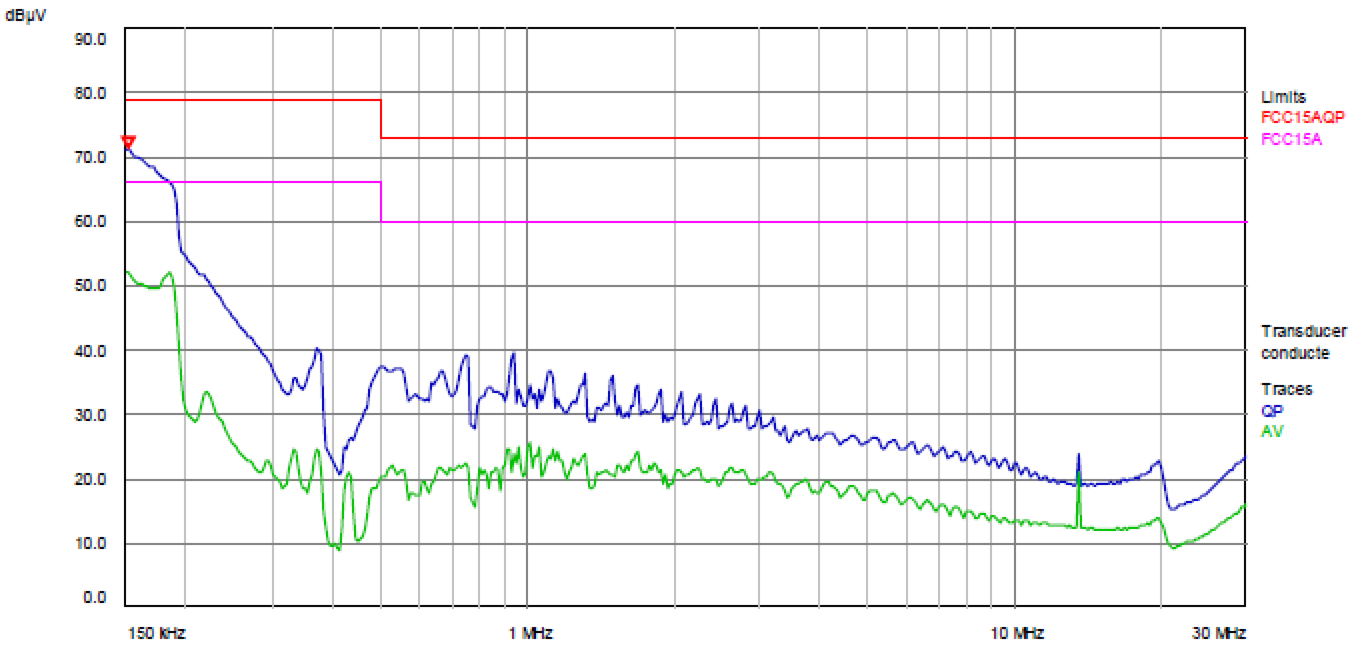
PHILIPS

Philips Lighting Standard Testing Laboratory

RFI Voltage Test at Mains Input

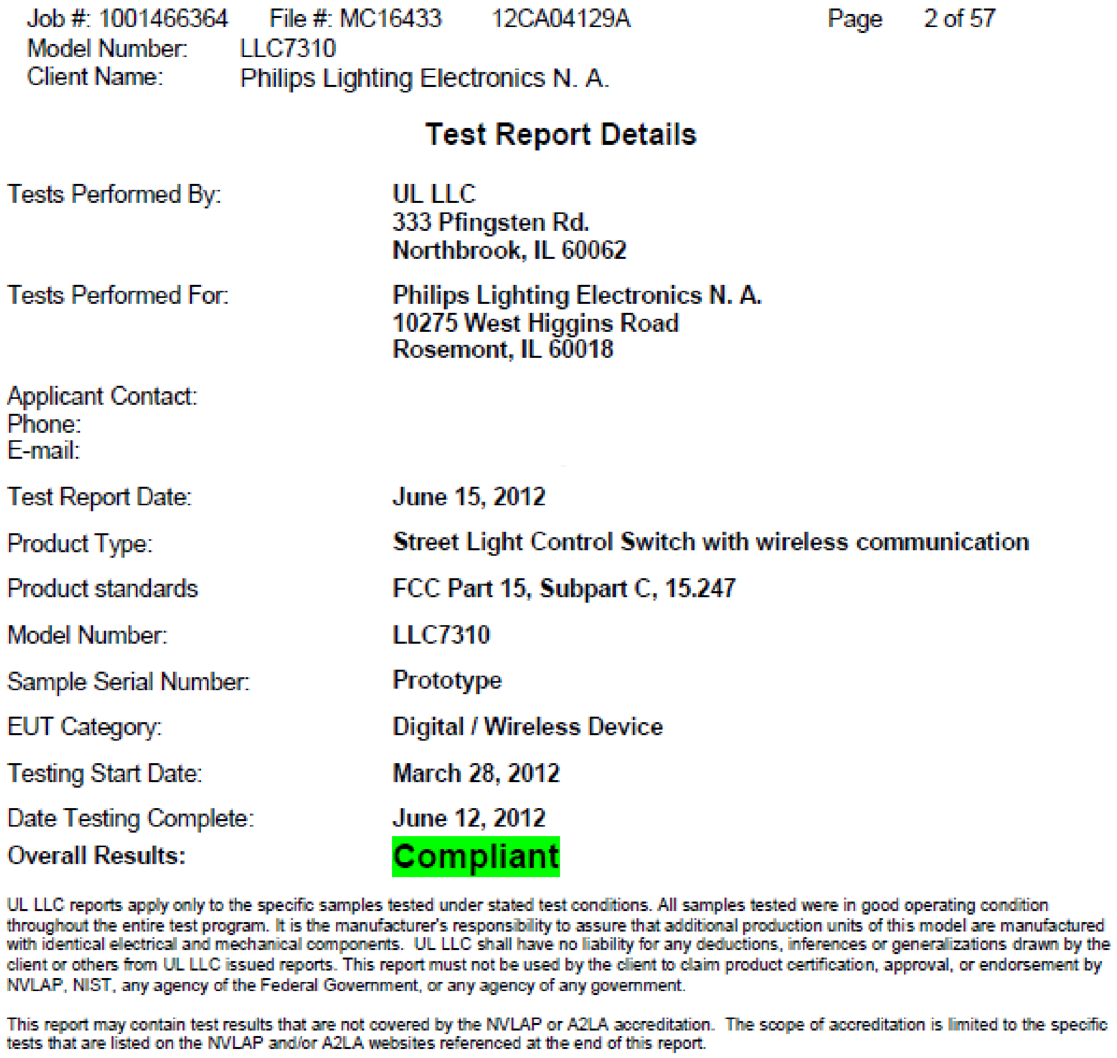
Manufacture:	Philips Lighting Electronics	Test date	22-Jan-2016
Test Spec:	FCC15 subpart B	EUT	XI040C110V054ST1
Phase	L	Control number:	LED-2016-0002-01
Operating mode:	277V//60Hz	Operator:	Xu zhongwei
Comment:	Dimming terminal open , connect LED to 54V 0.74A		
Scan setting:			

Frequency			Receiver setting					
Start	Stop	Step	IF BW	detector	Meas-time	Atten	Preamp	OpRge
150KHz	30MHz	2.25KHz	9KHz	QP+AV	2 Sec	Auto	OFF	60dB



IoT Street Lighting

IoT Street Lighting



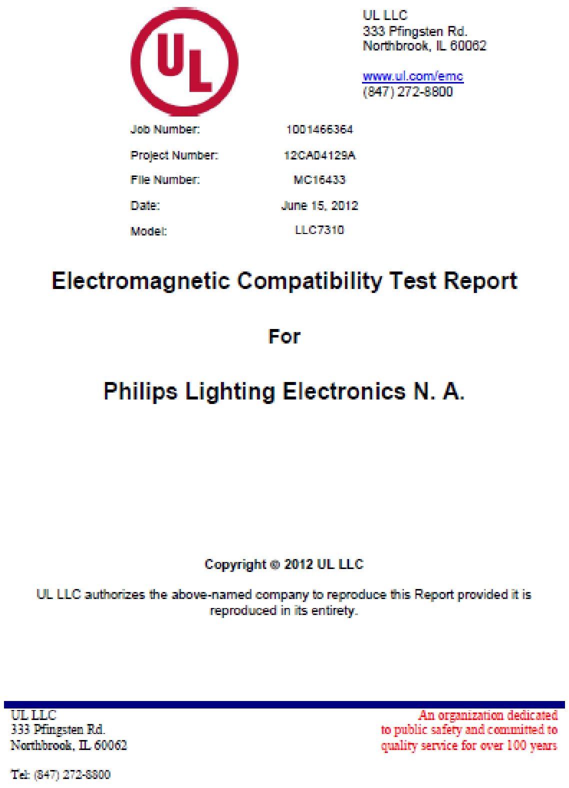
Job #: 1001466364 File #: MC16433 12CA04129A Page 2 of 57
Model Number: LLC7310
Client Name: Philips Lighting Electronics N. A.

Test Report Details

Tests Performed By:	**UL LLC 333 Pfingsten Rd. Northbrook, IL 60062**
Tests Performed For:	**Philips Lighting Electronics N. A. 10275 West Higgins Road Rosemont, IL 60018**
Applicant Contact: Phone: E-mail:	
Test Report Date:	**June 15, 2012**
Product Type:	**Street Light Control Switch with wireless communication**
Product standards	**FCC Part 15, Subpart C, 15.247**
Model Number:	**LLC7310**
Sample Serial Number:	**Prototype**
EUT Category:	**Digital / Wireless Device**
Testing Start Date:	**March 28, 2012**
Date Testing Complete:	**June 12, 2012**
Overall Results:	**Compliant**

UL LLC reports apply only to the specific samples tested under stated test conditions. All samples tested were in good operating condition throughout the entire test program. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. UL LLC shall have no liability for any deductions, inferences or generalizations drawn by the client or others from UL LLC issued reports. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

This report may contain test results that are not covered by the NVLAP or A2LA accreditation. The scope of accreditation is limited to the specific tests that are listed on the NVLAP and/or A2LA websites referenced at the end of this report.



UL LLC
333 Pfingsten Rd.
Northbrook, IL 60062

www.ul.com/emc
(847) 272-8800

Job Number:	1001466364
Project Number:	12CA04129A
File Number:	MC16433
Date:	June 15, 2012
Model:	LLC7310

Electromagnetic Compatibility Test Report

For

Philips Lighting Electronics N. A.

UL LLC
333 Pfingsten Rd.
Northbrook, IL 60062

Tel: (847) 272-8800

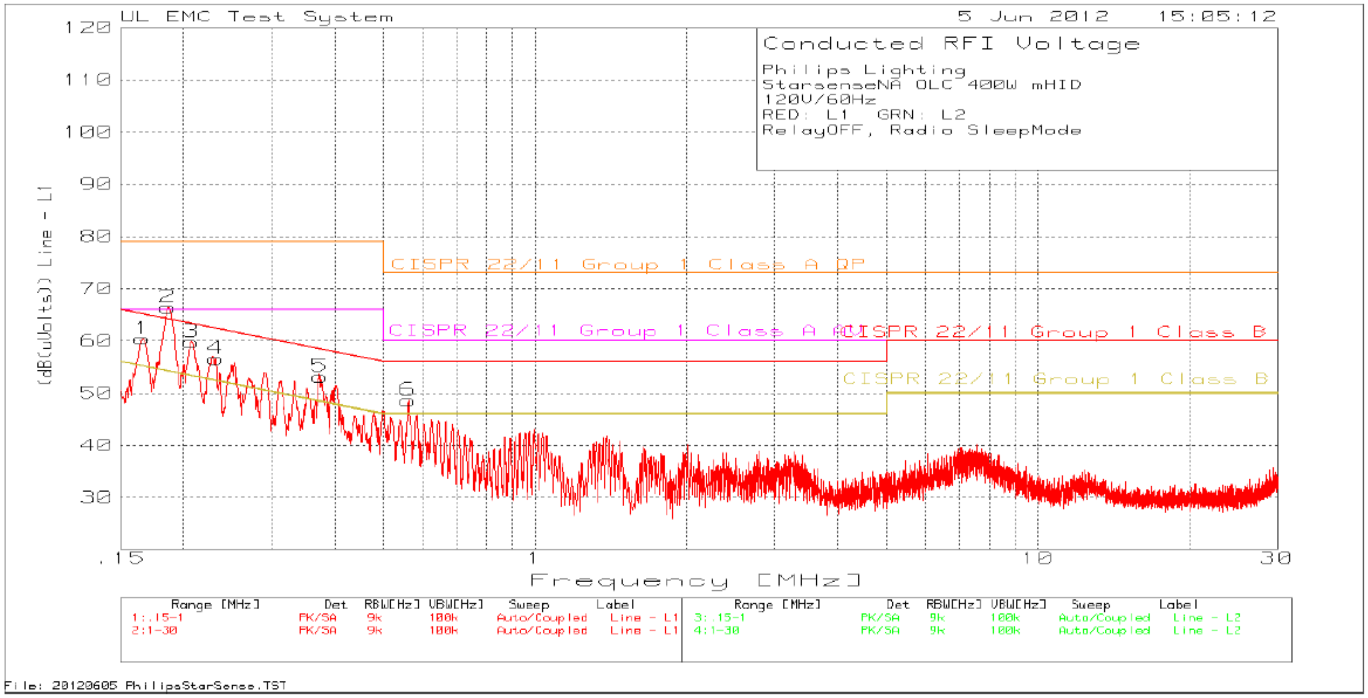
An organization dedicated
to public safety and committed to
quality service for over 100 years

PHILIPS

IoT Street Lighting

Conducted Emission Limits CISPR 32 FCC Part 15 Class A				
Frequency	QPK		Average	
MHz	uV	dBuV	uV	dBuV
0.15-0.5	8912.5	79.0	1995	66.0
0.5-30	4467	73.0	1000	60.0

Figure 1 Conducted Emissions Graph – Relay Off, Radio Sleep Mode



UL EMC Test System 5 Jun 2012 15:05:12

Conducted RFI Voltage

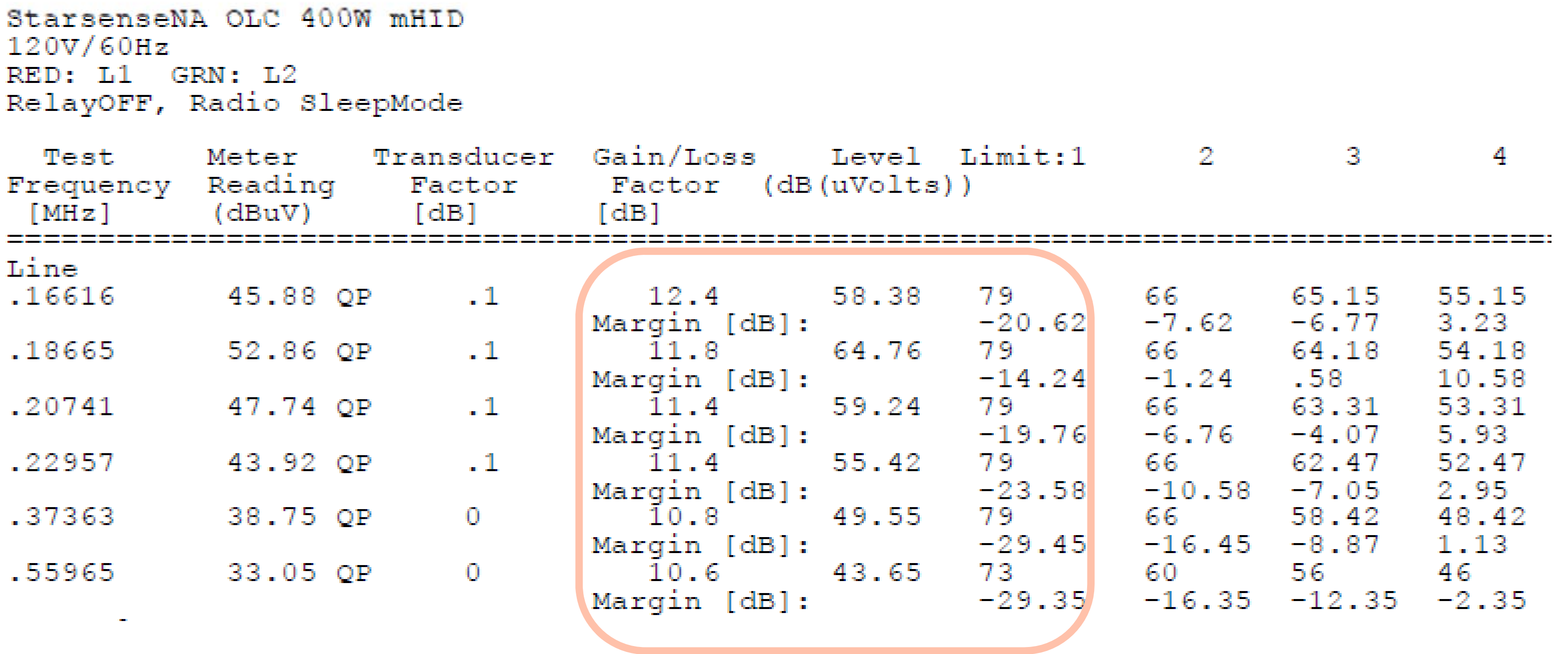
Philips Lighting
StarsenseNA OLC 400W mHID
120V/60Hz
RED: L1 GRN: L2
RelayOFF, Radio SleepMode

Range [MHz]	Det	RBW[Hz]	VBW[Hz]	Sweep	Label
1:.15-1	PK/SA	9k	100k	Auto/Coupled	Line - L1
2:1-30	PK/SA	9k	100k	Auto/Coupled	Line - L1

Range [MHz]	Det	RBW[Hz]	VBW[Hz]	Sweep	Label
3:.15-1	PK/SA	9k	100k	Auto/Coupled	Line - L2
4:1-30	PK/SA	9k	100k	Auto/Coupled	Line - L2

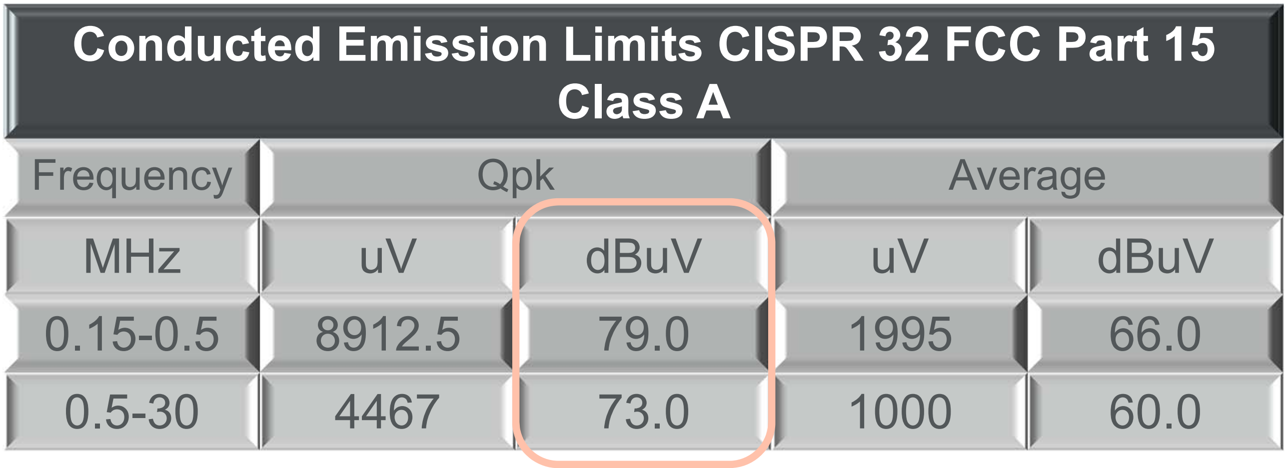
File: 20120605 PhilipsStarSense.TST

IoT Street Lighting



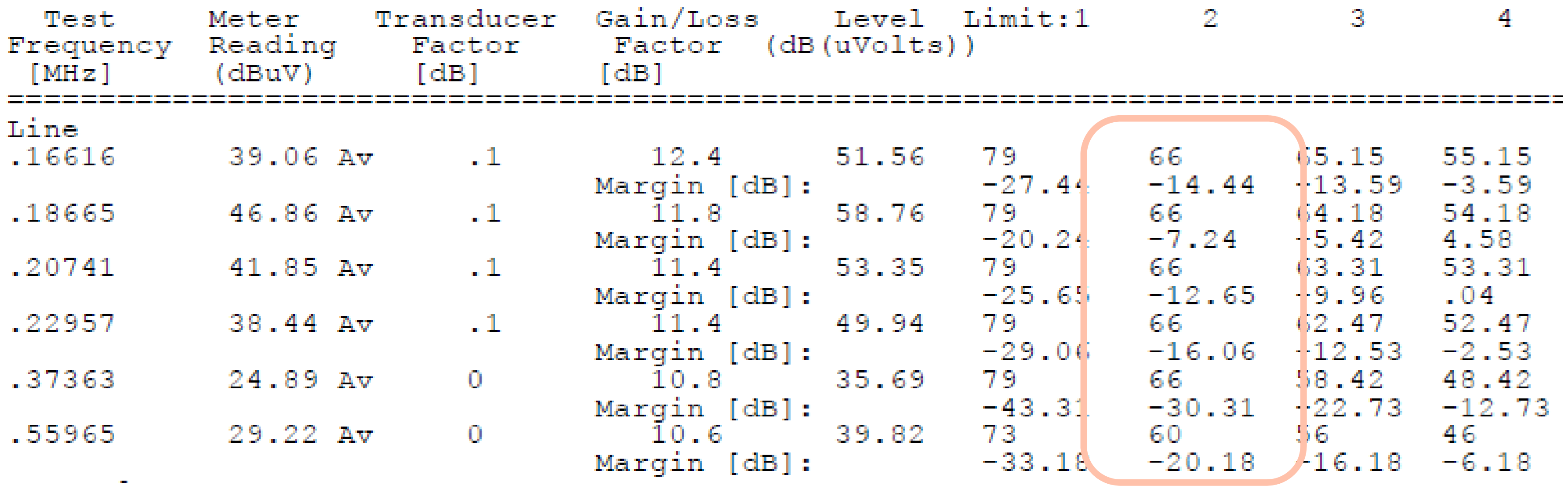
```
StarsenseNA OLC 400W mHID
120V/60Hz
RED: L1   GRN: L2
RelayOFF, Radio SleepMode

  Test      Meter     Transducer  Gain/Loss     Level  Limit:1       2         3         4
Frequency  Reading      Factor     Factor   (dB(uVolts))
 [MHz]      (dBuV)       [dB]      [dB]
=================================================================================================
Line
.16616       45.88 QP      .1        12.4       58.38    79        66       65.15    55.15
                                 Margin [dB]:            -20.62    -7.62    -6.77    3.23
.18665       52.86 QP      .1        11.8       64.76    79        66       64.18    54.18
                                 Margin [dB]:            -14.24    -1.24    .58      10.58
.20741       47.74 QP      .1        11.4       59.24    79        66       63.31    53.31
                                 Margin [dB]:            -19.76    -6.76    -4.07    5.93
.22957       43.92 QP      .1        11.4       55.42    79        66       62.47    52.47
                                 Margin [dB]:            -23.58    -10.58   -7.05    2.95
.37363       38.75 QP      0         10.8       49.55    79        66       58.42    48.42
                                 Margin [dB]:            -29.45    -16.45   -8.87    1.13
.55965       33.05 QP      0         10.6       43.65    73        60       56       46
                                 Margin [dB]:            -29.35    -16.35   -12.35   -2.35
      -
```

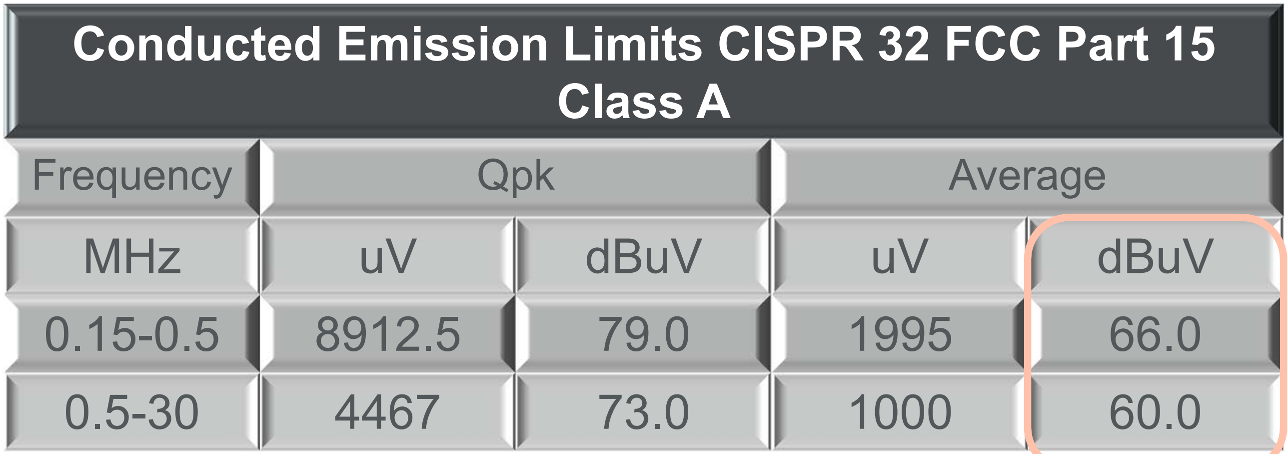


Conducted Emission Limits CISPR 32 FCC Part 15 Class A				
Frequency	Qpk		Average	
MHz	uV	dBuV	uV	dBuV
0.15-0.5	8912.5	79.0	1995	66.0
0.5-30	4467	73.0	1000	60.0

IoT Street Lighting



```
  Test       Meter     Transducer   Gain/Loss     Level  Limit:1      2        3        4
Frequency   Reading     Factor       Factor   (dB(uVolts))
 [MHz]      (dBuV)       [dB]       [dB]
==========================================================================================
Line
.16616       39.06 Av      .1         12.4       51.56   79         66       65.15    55.15
                                  Margin [dB]:           -27.44     -14.44   -13.59   -3.59
.18665       46.86 Av      .1         11.8       58.76   79         66       64.18    54.18
                                  Margin [dB]:           -20.24     -7.24    -5.42    4.58
.20741       41.85 Av      .1         11.4       53.35   79         66       63.31    53.31
                                  Margin [dB]:           -25.65     -12.65   -9.96    .04
.22957       38.44 Av      .1         11.4       49.94   79         66       62.47    52.47
                                  Margin [dB]:           -29.06     -16.06   -12.53   -2.53
.37363       24.89 Av      0          10.8       35.69   79         66       58.42    48.42
                                  Margin [dB]:           -43.31     -30.31   -22.73   -12.73
.55965       29.22 Av      0          10.6       39.82   73         60       56       46
                                  Margin [dB]:           -33.18     -20.18   -16.18   -6.18
```



Conducted Emission Limits CISPR 32 FCC Part 15 Class A				
Frequency	Qpk		Average	
MHz	uV	dBuV	uV	dBuV
0.15-0.5	8912.5	79.0	1995	66.0
0.5-30	4467	73.0	1000	60.0

PHILIPS

Street Lighting

Figure 4 Radiated Emissions Graph 30MHz – 1GHz, Relay Off, RX Mode, Ch5

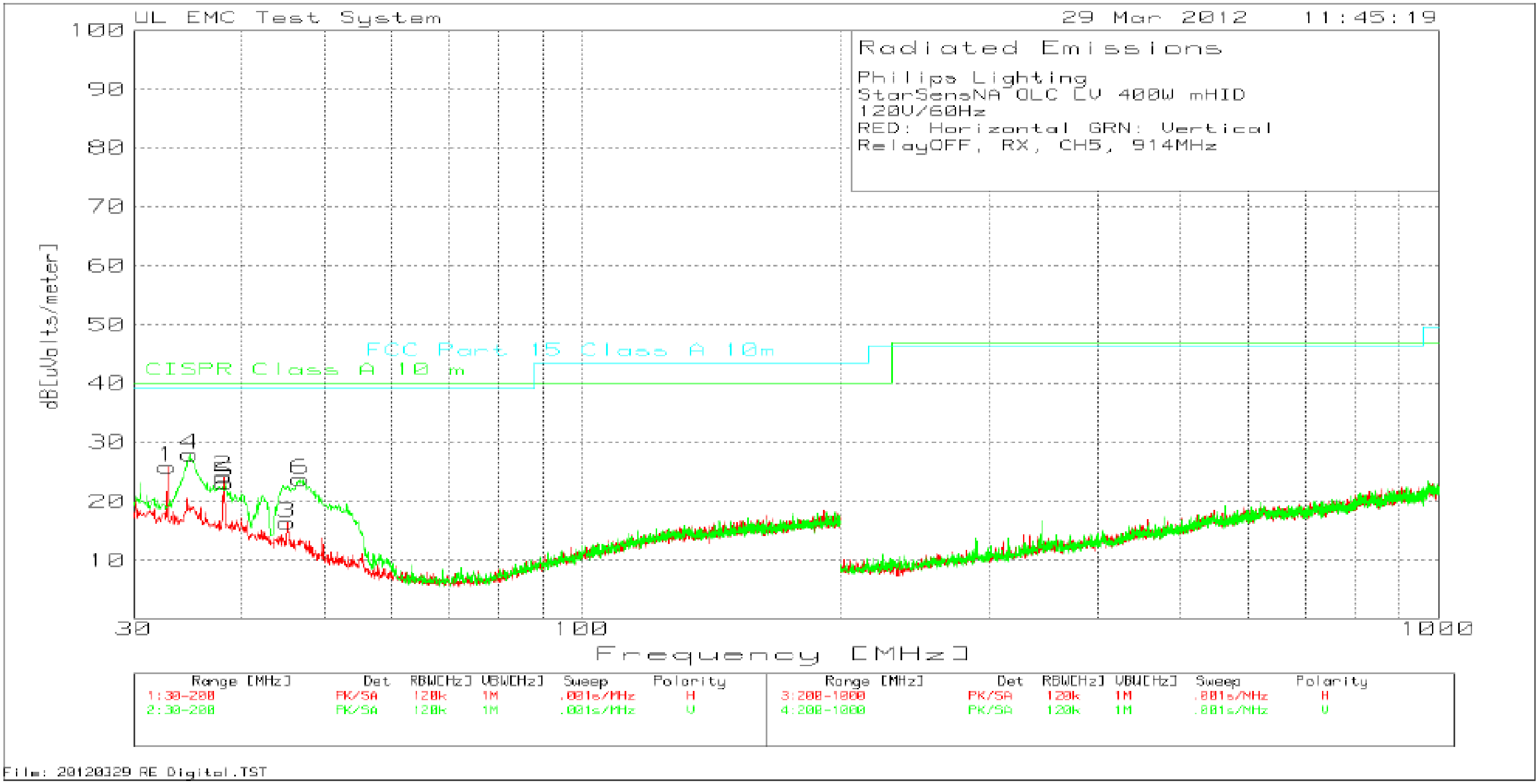
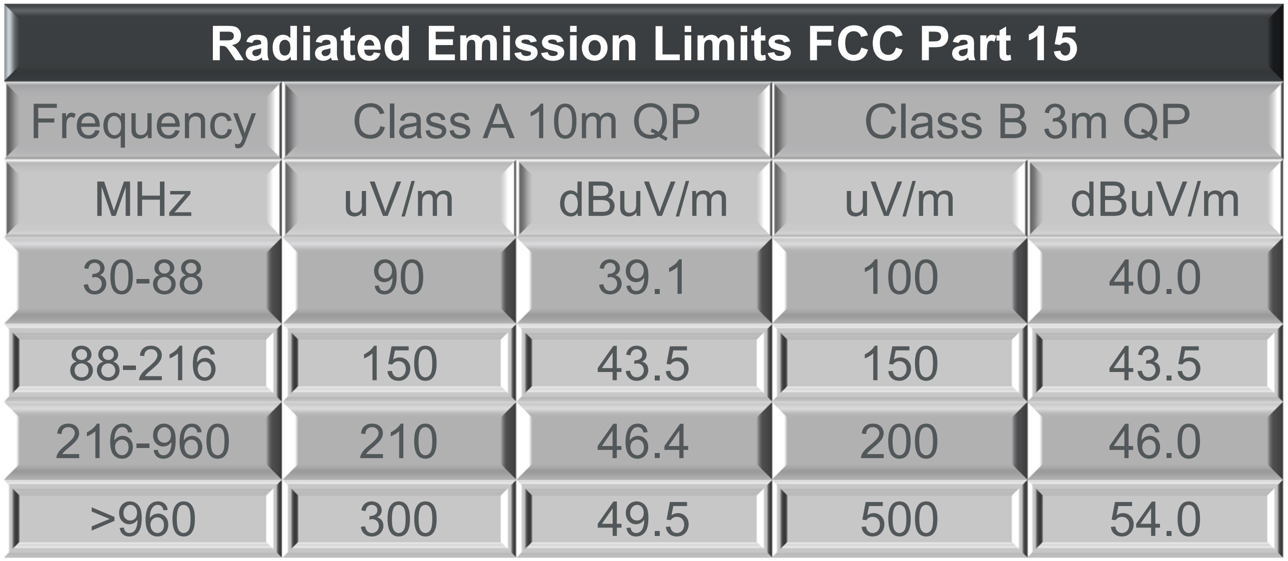


Table 8 Radiated Emissions Data Points 30MHz – 1GHz, Relay Off, RX Mode, Ch5

```
Philips Lighting
StarSensNA OLC LV 400W mHID
120V/60Hz
RED: Horizontal GRN: Vertical
RelayOFF, RX, CH5, 914MHz
```

Test Frequency	Meter Reading	Detector	Antenna Factor dB	Path Loss/Gain Factor dB	Level dBuV/m	CISPR Class A 10 m	Margin	FCC Part 15 Class A 10m	Margin	Height [cm]	Polarity
32.8036	38.38	PK	16.9	-29.4	25.88	40	-14.12	39.1	-13.22	400	Horz
38.1559	38.69	PK	14.8	-29.3	24.19	40	-15.81	39.1	-14.91	400	Horz
45.2924	33.78	PK	12	-29.4	16.38	40	-23.62	39.1	-22.72	400	Horz
34.8426	41.26	PK	16.1	-29.4	27.96	40	-12.04	39.1	-11.14	99	Vert
38.3258	37.92	PK	14.7	-29.4	23.22	40	-16.78	39.1	-15.88	99	Vert
46.9065	41.77	PK	11.3	-29.3	23.77	40	-16.23	39.1	-15.33	99	Vert

PK - Peak detector



Radiated Emission Limits FCC Part 15

Frequency	Class A 10m QP		Class B 3m QP	
MHz	uV/m	dBuV/m	uV/m	dBuV/m
30-88	90	39.1	100	40.0
88-216	150	43.5	150	43.5
216-960	210	46.4	200	46.0
>960	300	49.5	500	54.0

Figure 6 30MHz-10GHz Antenna Port Spurious Emissions Plots TX Mode, Low Channel.

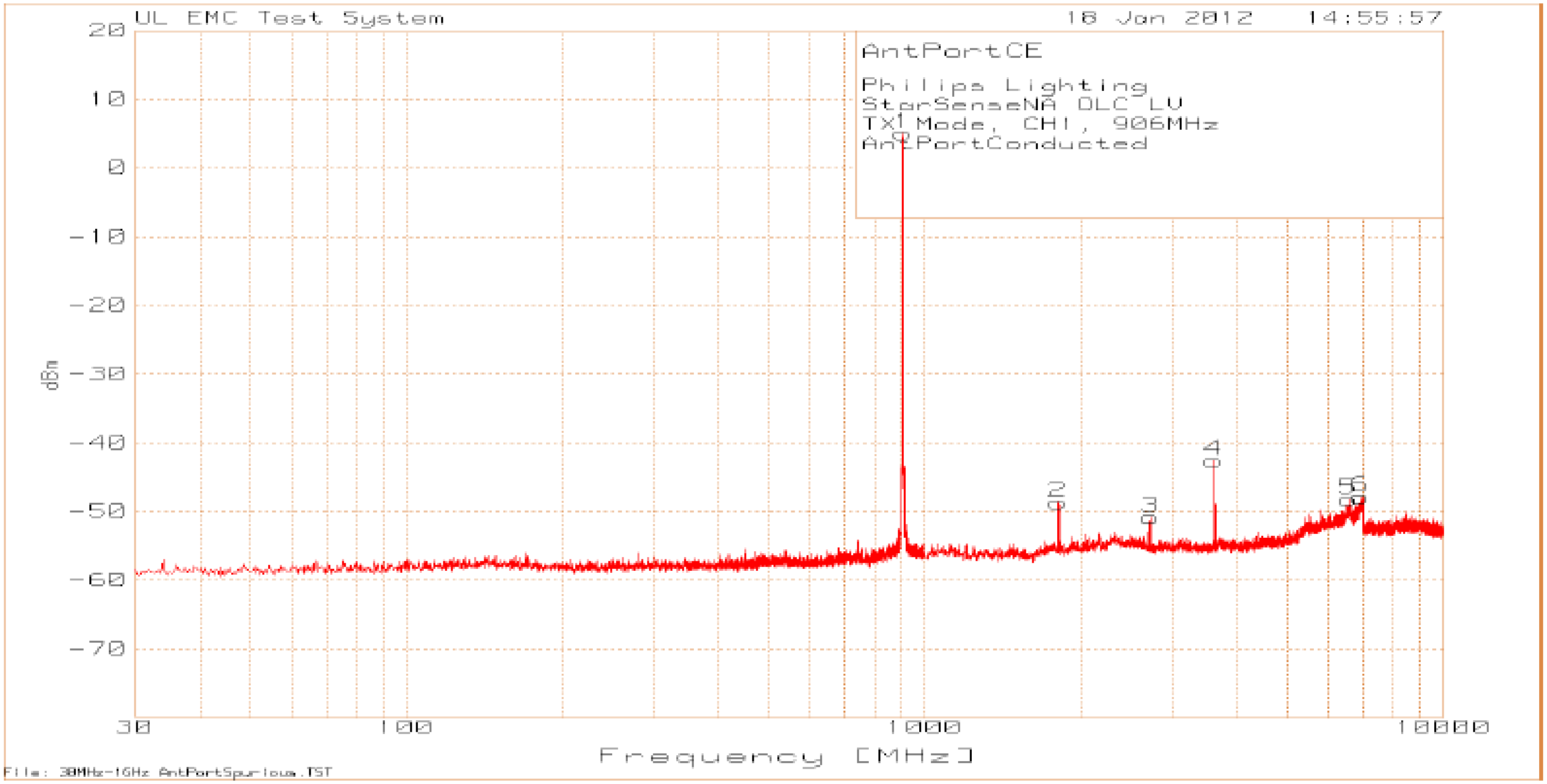
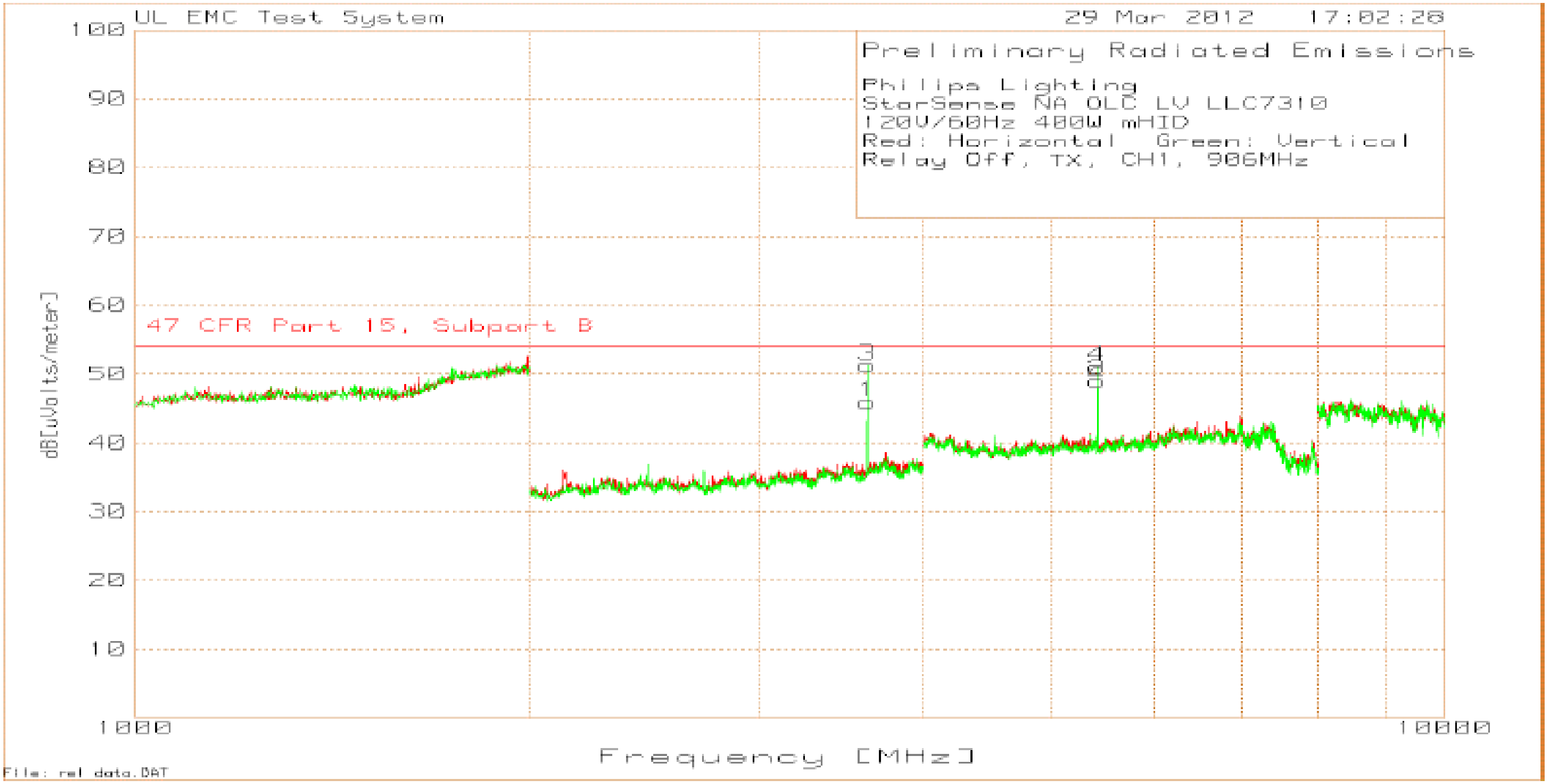


Table 14 Antenna Port Conducted Spurious Emissions 30MHz - 10GHz, Low Channel

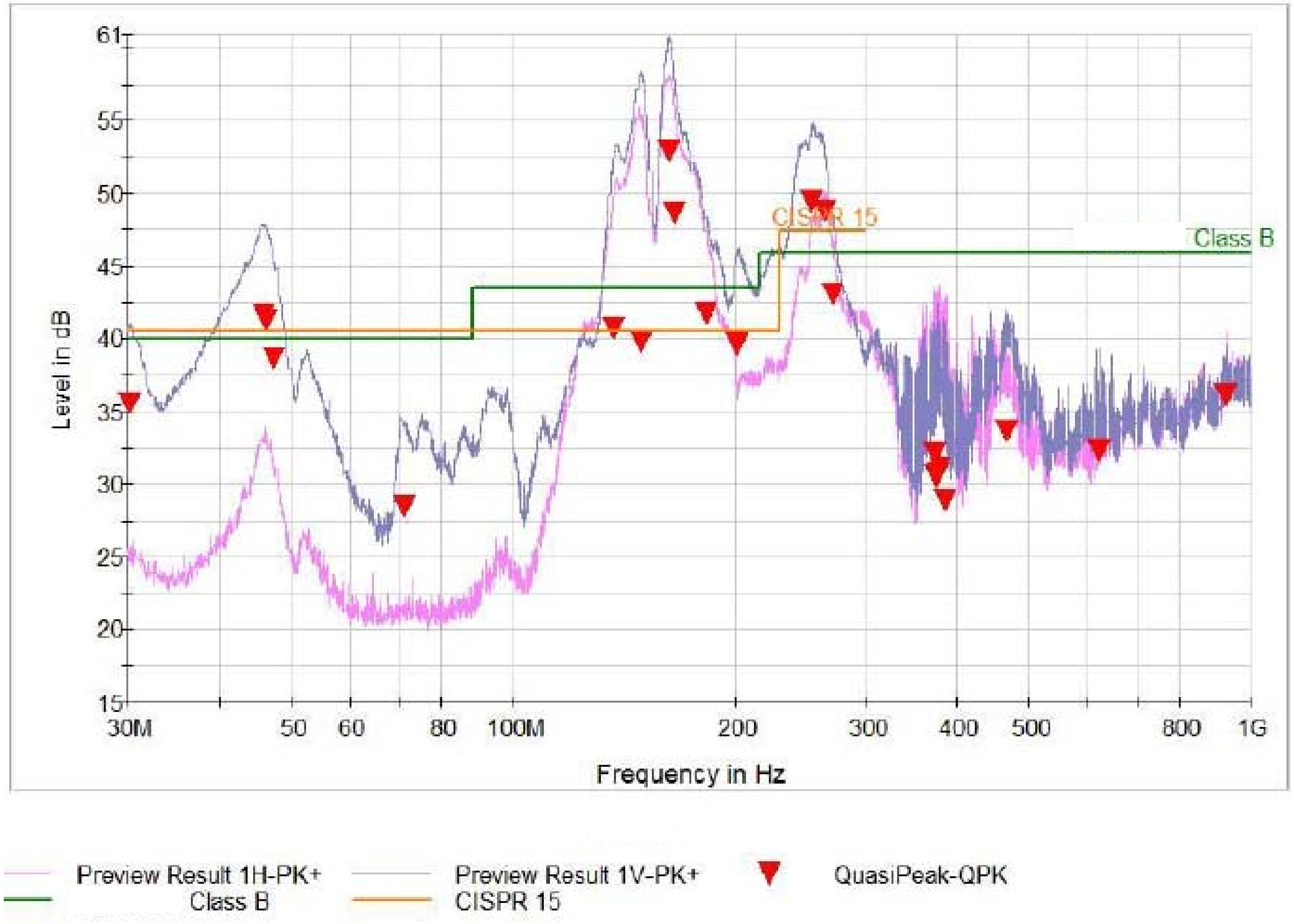
Test Frequency	Meter Reading	Detector	dBuV to dBm [dB]	25MHz-10GHz CF dB.TXT [dB]	Level dBm
906.2989	101.33	PK	-107	10.7	5.03
1810.18	47.36	PK	-107	10.9	-48.74
2718.382	45.04	PK	-107	11.1	-50.86
3624.583	53.06	PK	-107	11.4	-42.54
6555.234	46.85	PK	-107	11.9	-48.25
6943.321	47.06	PK	-107	12	-47.94

PK - Peak detector

Figure 10 Radiated Spurious Emissions above 1GHz, Low Channel



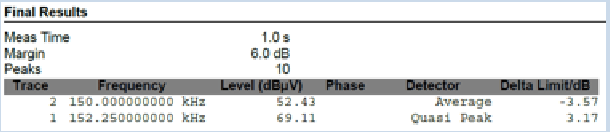
Radiated Emissions Non-compliant LED RF Device



Applications, Improving Methods

1. Good Grounding
2. Avoid lengthy wiring techniques
3. Avoid input-output wires crossover
4. Filtering mains
5. Filtering control interface

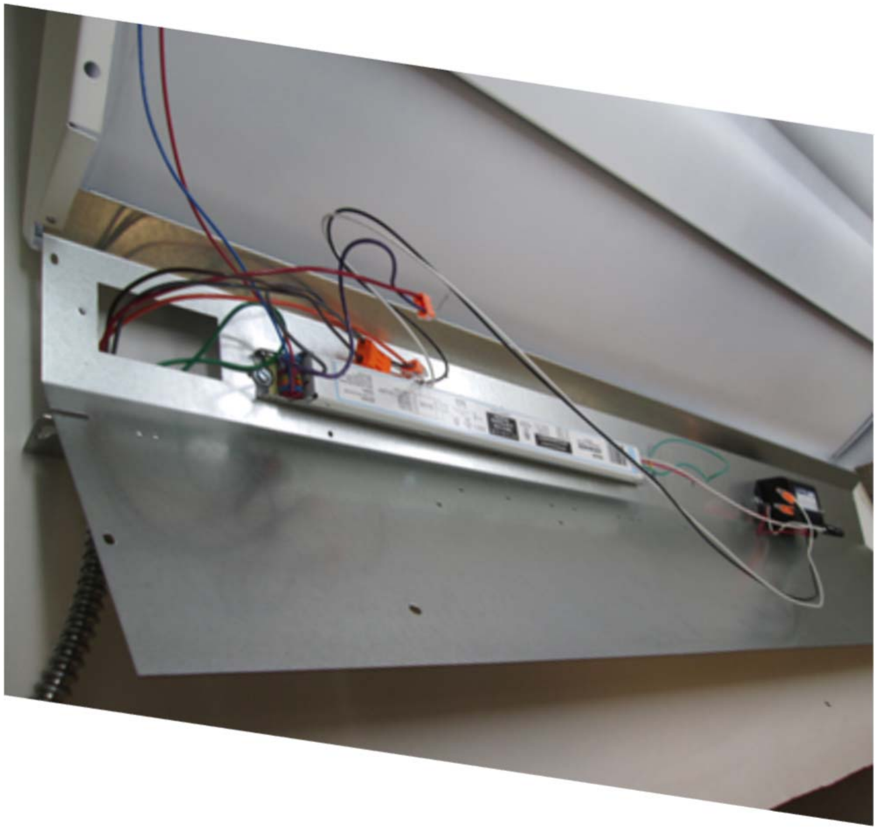
Original set up (Line)



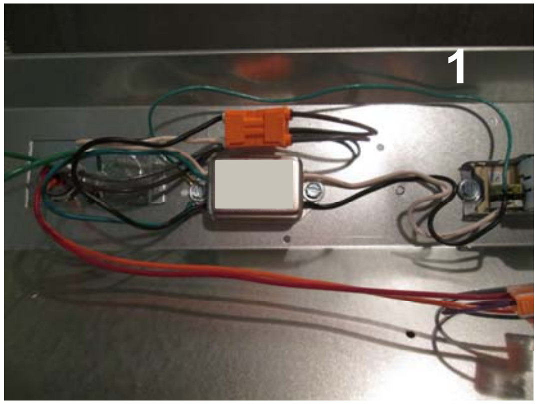
Final Results

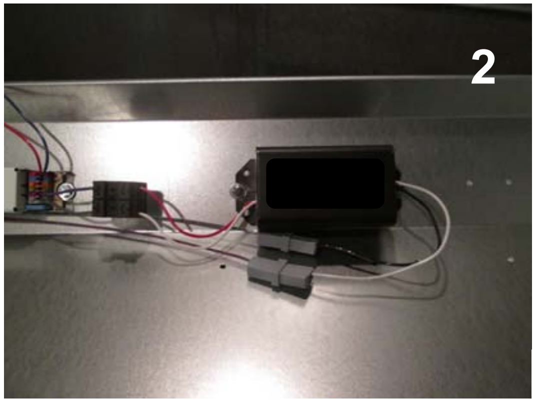
Meas Time 1.0 s
Margin 6.0 dB
Peaks 10

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
2	150.000000000 kHz	52.43		Average	-3.57
1	152.250000000 kHz	69.11		Quasi Peak	3.17



Mechanical design-in(1)





[redacted]

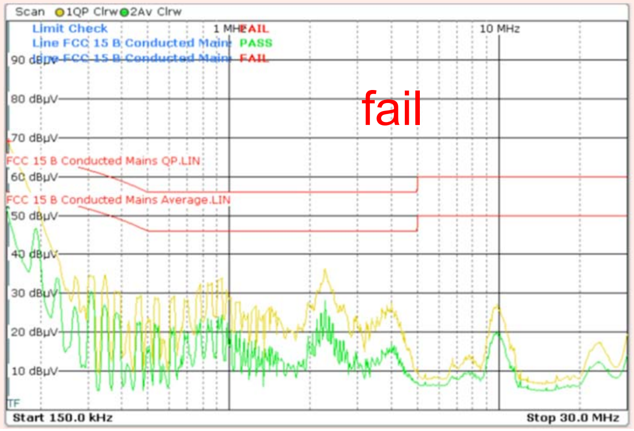
[redacted]

Pic 1-3: One filter is installed between main input wires and driver's input connections, and this new mounting position would make input wires shorter(Pic 1). One filter is installed between the driver's dimming connectors and control wires from conduit (Pic 2). Overall modified wiring connection and filter installation are shown in Pic 3.

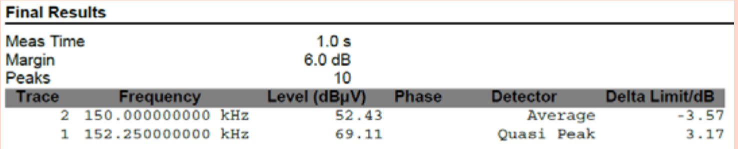
EMC Testing Result - Conductive(3*)

FCC Class B Conductive test result with 277Vac input

Original set up (Line)



fail

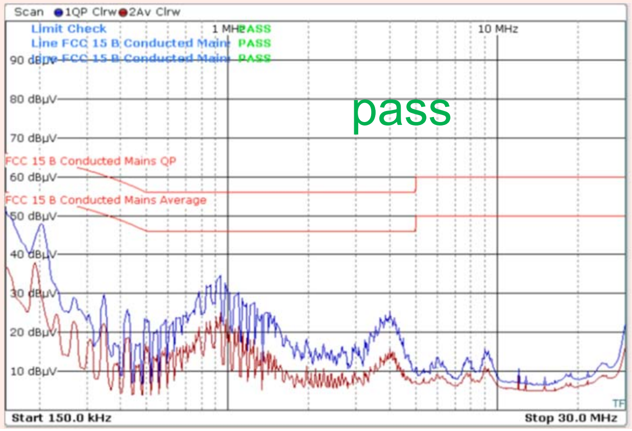


Final Results

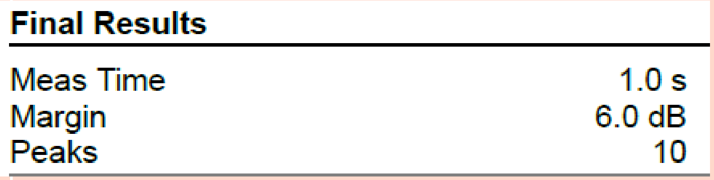
Meas Time	1.0 s
Margin	6.0 dB
Peaks	10

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
2	150.000000000 kHz	52.43		Average	-3.57
1	152.250000000 kHz	69.11		Quasi Peak	3.17

After modification (Line)



pass



Final Results

Meas Time	1.0 s
Margin	6.0 dB
Peaks	10

(*)EMC test results are only indicated to the luminaire tested.

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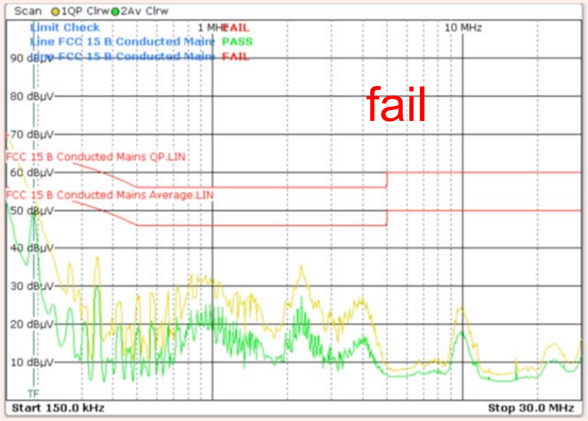
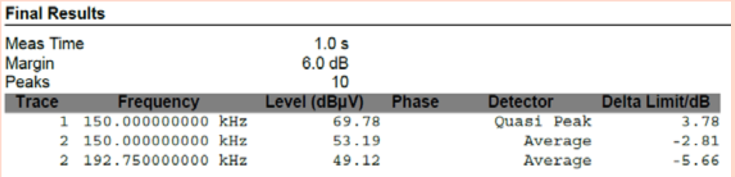
EMC Testing Result - Conductive(4*)

FCC Class B Conductive test result with 277Vac input

Original set up (Neutral)



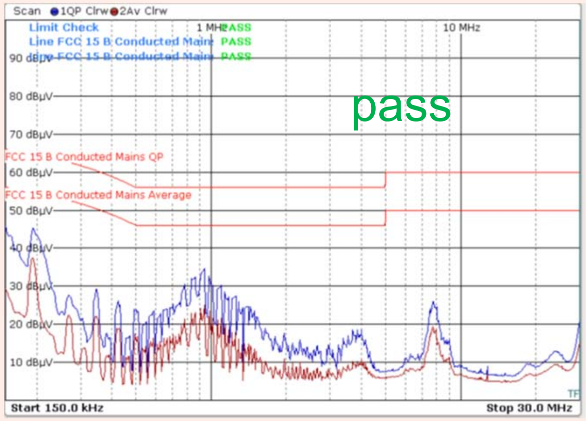


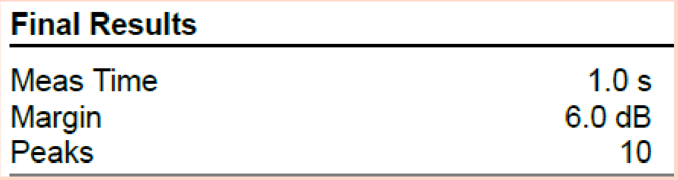
Final Results

Meas Time 1.0 s
Margin 6.0 dB
Peaks 10

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
1	150.000000000 kHz	69.78		Quasi Peak	3.78
2	150.000000000 kHz	53.19		Average	-2.81
2	192.750000000 kHz	49.12		Average	-5.66

After modification (Neutral)





Final Results

Meas Time 1.0 s
Margin 6.0 dB
Peaks 10

Main conclusion :

Indicative test results show that the luminaire is expected to fail EMC conductive test, within 150.0kHz-30.0MHz range applied with FCC Class B Conductive standard with **original set up** at 277Vac input.

Indicative test results show that the luminaire is expected to pass EMC conductive test, within 150.0kHz-30.0MHz range applied with FCC Class B Conductive standard **after modification** at 277Vac input.

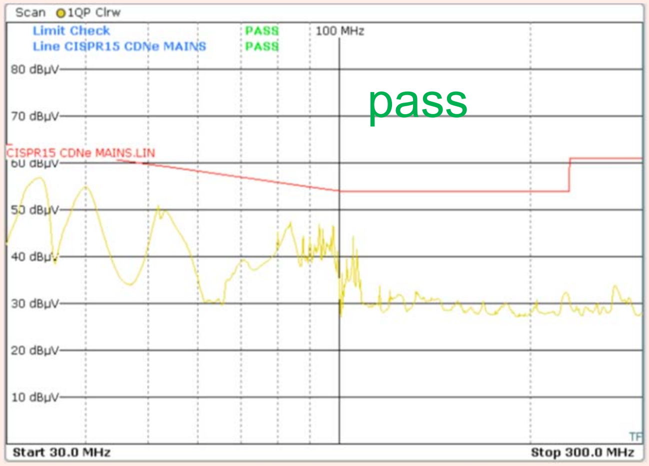
(*)EMC test results are only indicated to the luminaire tested under the test condition from page 3 to page 5.

PHILIPS

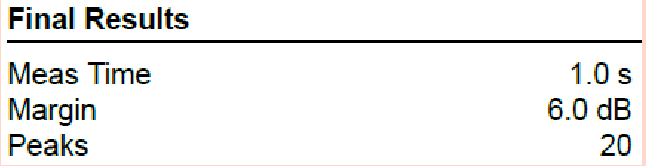
EMC Testing Result - Radiated(1*)

CISPR 15 Radiated test result with 120Vac input (CDN method)

Original set up



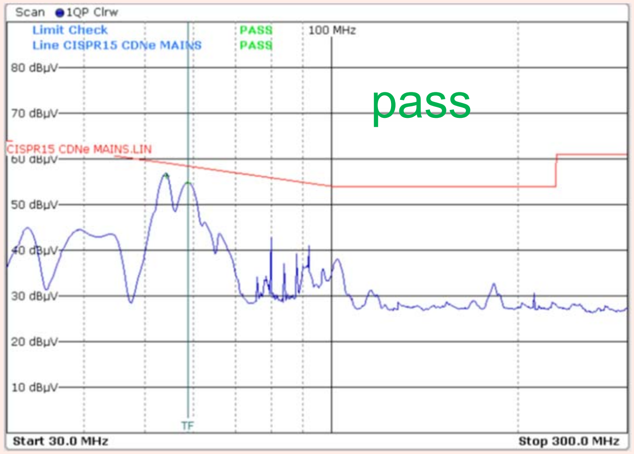
pass



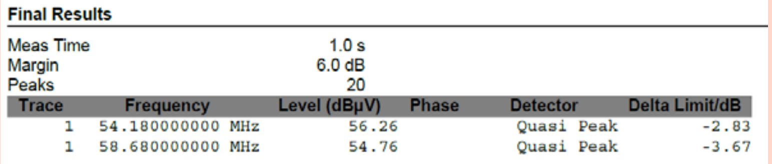
Final Results

Meas Time	1.0 s
Margin	6.0 dB
Peaks	20

After modification



pass



Final Results

Meas Time	1.0 s
Margin	6.0 dB
Peaks	20

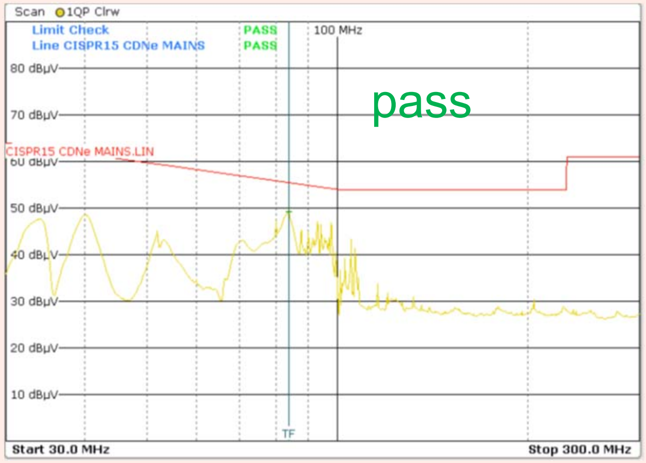
Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
1	54.180000000 MHz	56.26		Quasi Peak	-2.83
1	58.680000000 MHz	54.76		Quasi Peak	-3.67

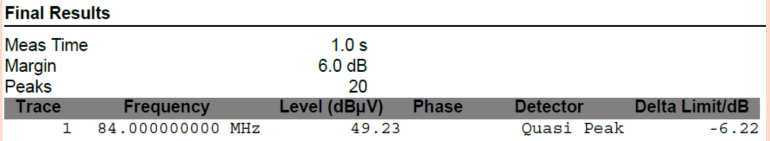
(*)EMC test results are only indicated to the luminaire tested under the test condition from page 3 to page 5.

EMC Testing Result - Radiated(2*)

CISPR 15 Radiated test result with 277Vac input (CDN method)

Original set up



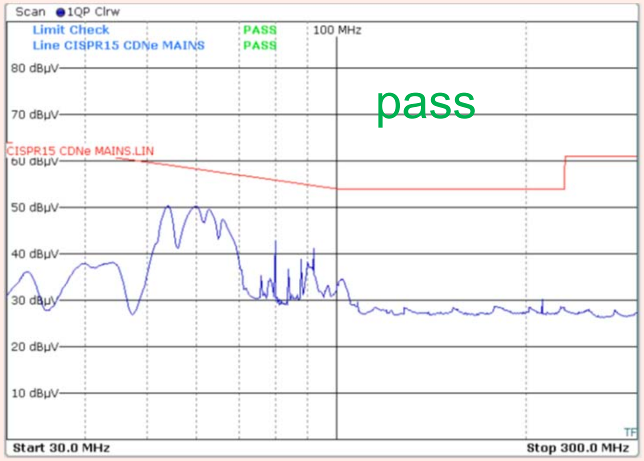


Final Results

Meas Time 1.0 s
Margin 6.0 dB
Peaks 20

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
1	84.000000000 MHz	49.23		Quasi Peak	-6.22

After modification



Final Results

Meas Time 1.0 s
Margin 6.0 dB
Peaks 20

Main conclusion :

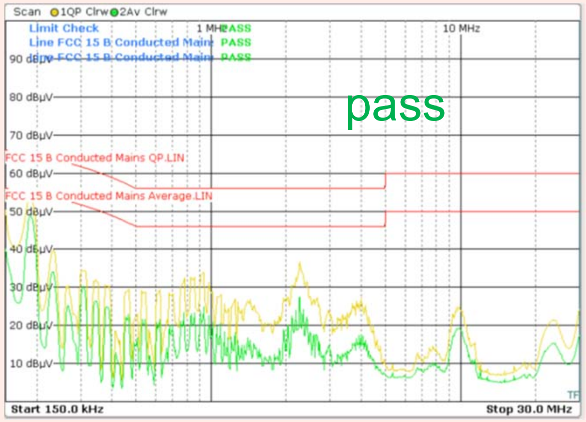
Indicative test results show that the luminaire is expected to pass EMC radiated test within 30.0MHz-300.0MHz range applied with CISPR 15 Radiated standard with original set up and after modification with 120Vac and 277Vac input.

(*)EMC test results are only indicated to the luminaire tested under the test condition from page 3 to page 5.

EMC Testing Result - Conductive(1*)

FCC Class B Conductive test result with 120Vac input

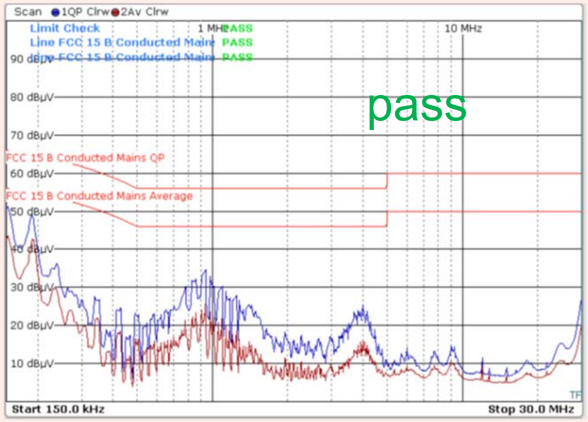
Original set up (Line)



Final Results

Meas Time	1.0 s
Margin	6.0 dB
Peaks	10

After modification (Line)



Final Results

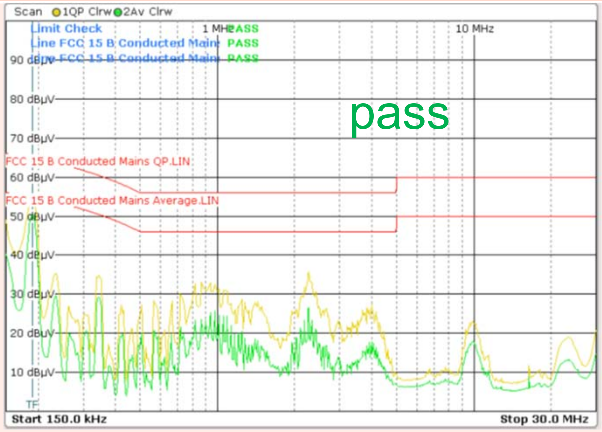
Meas Time	1.0 s
Margin	6.0 dB
Peaks	10

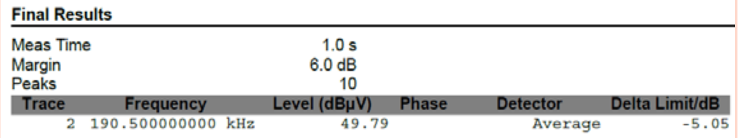
(*)EMC test results are only indicated to the luminaire tested under the test condition from page 3 to page 5.

EMC Testing Result - Conductive(2*)

FCC Class B Conductive test result with 120Vac input

Original set up (Neutral)



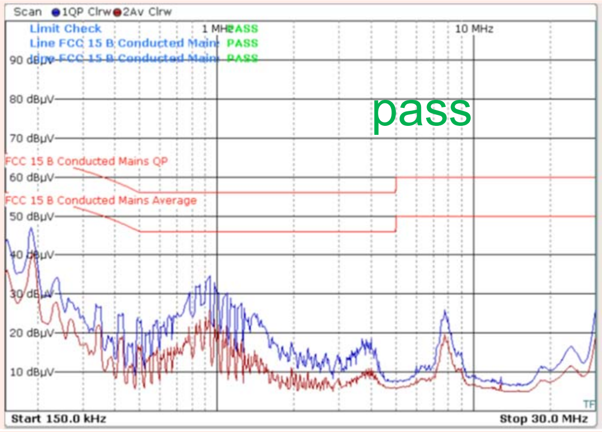


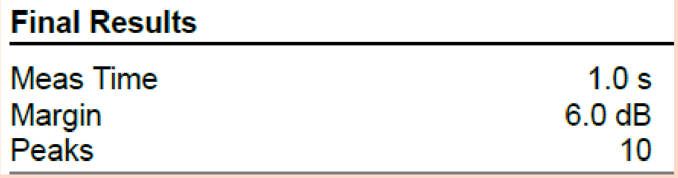
Final Results

Meas Time 1.0 s
Margin 6.0 dB
Peaks 10

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
2	190.500000000 kHz	49.79		Average	-5.05

After modification (Neutral)





Final Results

Meas Time 1.0 s
Margin 6.0 dB
Peaks 10

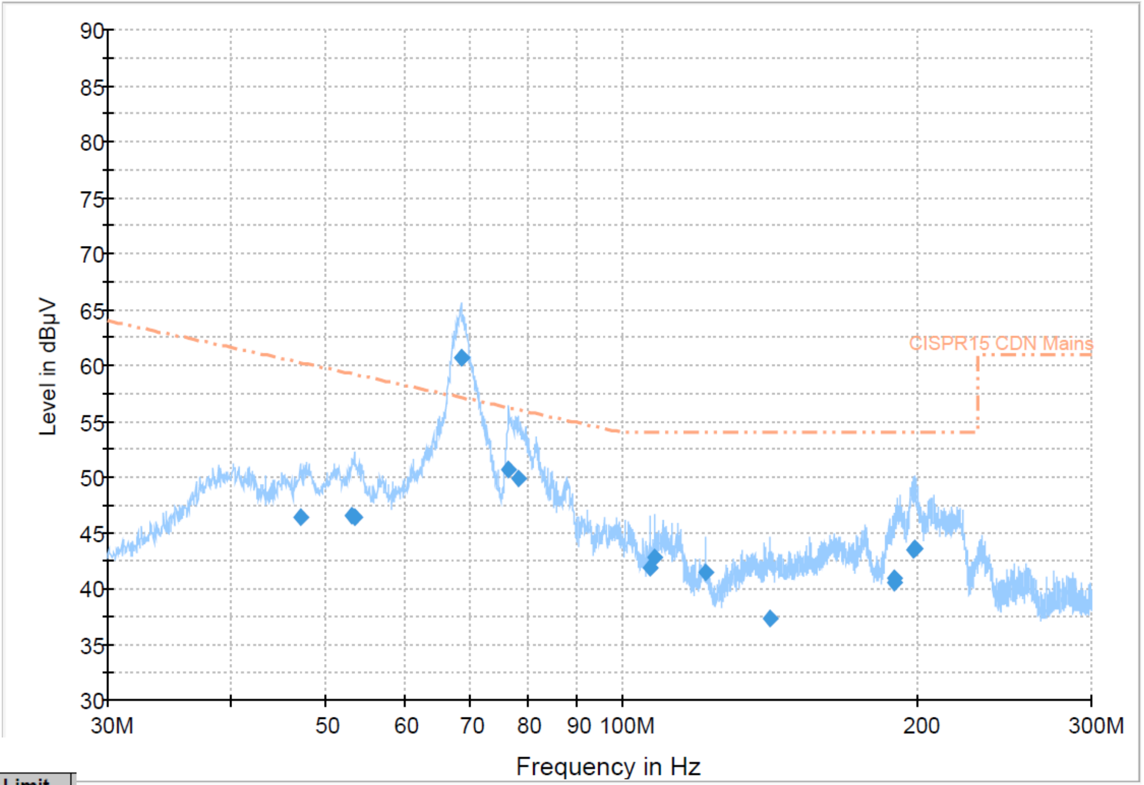
Main conclusion :

Indicative test results show that the luminaire is expected to pass EMC conductive test with minimum margin (6.0 dB), within 150.0kHz-30.0MHz range applied with FCC Class B Conductive standard with **original set up** and **after modifications** at 120Vac input.

(*)EMC test results are only indicated to the luminaire tested under the test condition from page 3 to page 5.

15W LED, DALI 230V 50 Hz

CISPR15 CDN M2 or M3



Final Result 1

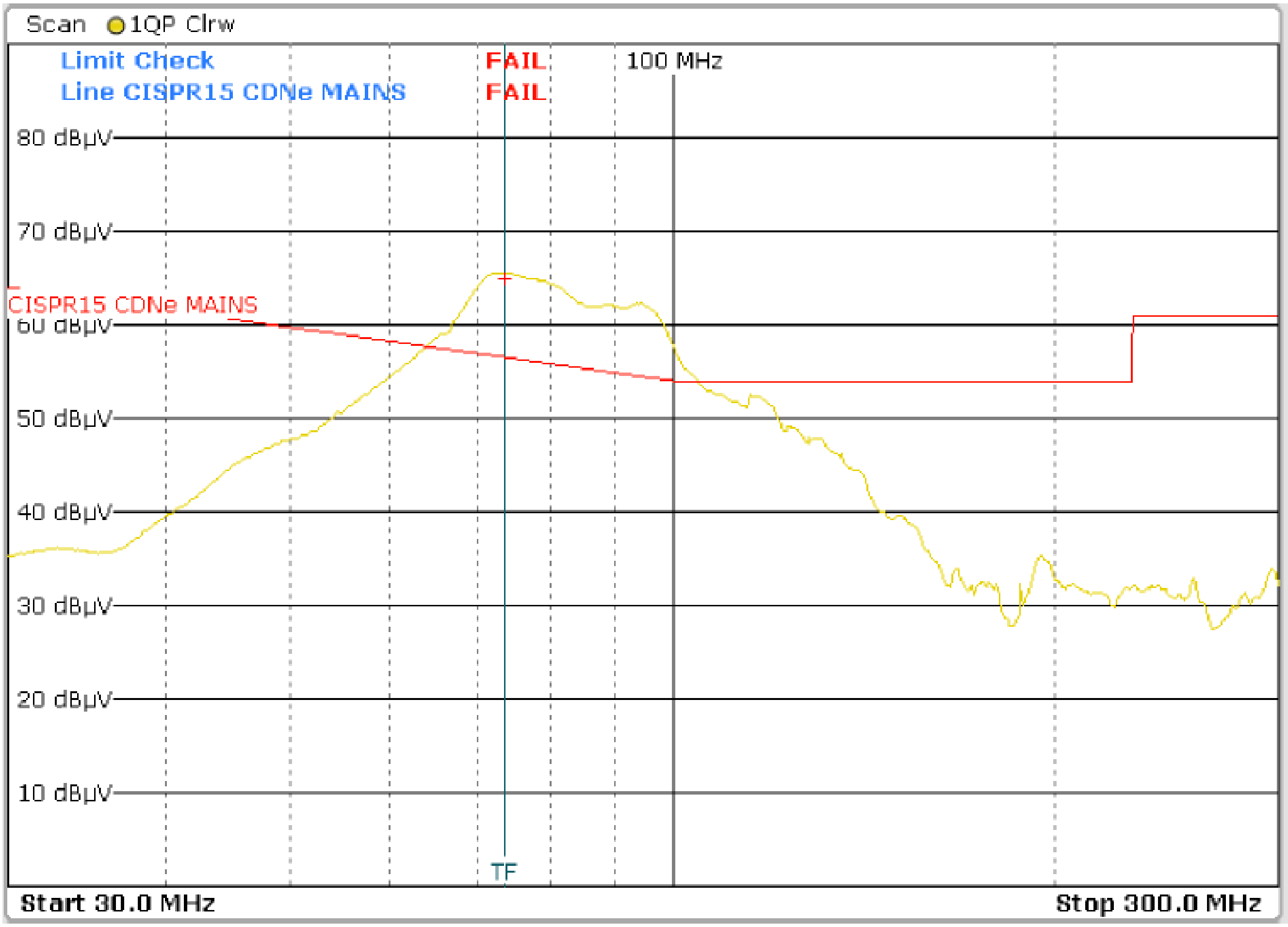
Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)	Margin (dB)	Limit (dBµV)
47.050000	46.4	1000.0	120.000	20.5	13.8	60.3
53.200000	46.6	1000.0	120.000	20.5	12.7	59.2
53.400000	46.5	1000.0	120.000	20.5	12.8	59.2
68.550000	60.7	1000.0	120.000	20.5	-3.6	57.1
68.700000	60.7	1000.0	120.000	20.5	-3.5	57.1
76.700000	50.7	1000.0	120.000	20.5	5.5	56.2
78.350000	49.9	1000.0	120.000	20.5	6.1	56.0
106.700000	41.9	1000.0	120.000	20.5	12.1	54.0
107.900000	42.8	1000.0	120.000	20.5	11.2	54.0
121.650000	41.5	1000.0	120.000	20.5	12.5	54.0
141.200000	37.4	1000.0	120.000	20.5	16.6	54.0
189.100000	40.6	1000.0	120.000	20.5	13.4	54.0
189.300000	40.9	1000.0	120.000	20.5	13.1	54.0
197.800000	43.5	1000.0	120.000	20.5	10.5	54.0
198.050000	43.6	1000.0	120.000	20.5	10.4	54.0

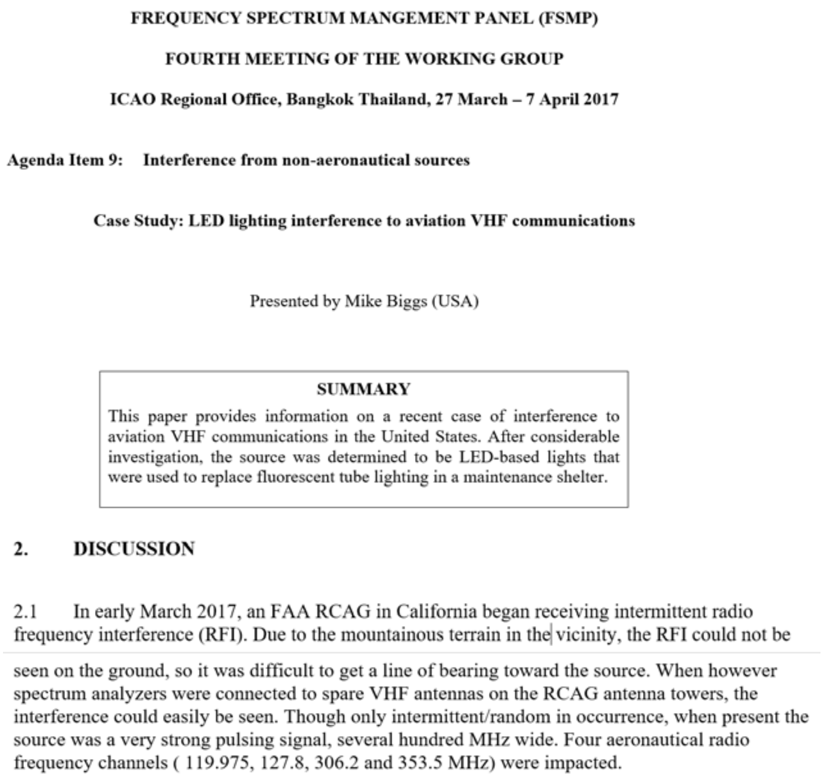
PHILIPS

CISPR 15 Radiated Mains Driver: Date Code: 16055L36

Conditions: LINE - 120Vac - 22.5Vdc/1100mA

Scan Diagram





FREQUENCY SPECTRUM MANGEMENT PANEL (FSMP)

FOURTH MEETING OF THE WORKING GROUP

ICAO Regional Office, Bangkok Thailand, 27 March – 7 April 2017

Agenda Item 9: **Interference from non-aeronautical sources**

Case Study: LED lighting interference to aviation VHF communications

Presented by Mike Biggs (USA)

SUMMARY

This paper provides information on a recent case of interference to aviation VHF communications in the United States. After considerable investigation, the source was determined to be LED-based lights that were used to replace fluorescent tube lighting in a maintenance shelter.

2. DISCUSSION

2.1 In early March 2017, an FAA RCAG in California began receiving intermittent radio frequency interference (RFI). Due to the mountainous terrain in the vicinity, the RFI could not be seen on the ground, so it was difficult to get a line of bearing toward the source. When however spectrum analyzers were connected to spare VHF antennas on the RCAG antenna towers, the interference could easily be seen. Though only intermittent/random in occurrence, when present the source was a very strong pulsing signal, several hundred MHz wide. Four aeronautical radio frequency channels (119.975, 127.8, 306.2 and 353.5 MHz) were impacted.

- Philips Lighting worked with FAA to evaluate and resolve the issue.
- The Luminaire suspected of interference was already repaired, we do not have access to the Luminaire active component parts removed.
- Considering that other Luminaires in the same site were replaced with the same TLED lamps, this suggested that the source of interference was rooted in a defective (end of life) ballast or in a defective installation.

Agenda

- Scope
- CISPR and NA Emission Limits
- Conducted Emissions
- Radiated Emissions
- Applications
- **Conclusions**

Conclusions

- There is no a fundamental reason why LED devices shall produce more electromagnetic emissions than the existing electronic lighting devices.
- The introduction of LED lighting coincides in time with an intensive use of wireless communications. Thus, it will be prudent to manage the electromagnetic spectrum correctly to enable the connected world that society aspires to[8].
- The United States Federal Communications Commission (FCC), and Innovation, Science and Economic Development Canada (IC) have decided that similar rules to those applicable to digital devices are applicable to RF LED lighting devices[2, 6].
- Regulating RF LED devices in a similar way as digital devices resulted in the addition of limits for conducted emissions in the low frequency band of 150 KHz to 450 KHz. However, the RF LED devices' maximum conducted emissions limit for both Class A (non-consumer) and Class B (consumer) lighting devices[1] has become more relaxed than its equivalent for RF (discharge) lighting[3].
- This gap for the conducted emissions limit is about 13 dBuV for the frequency range from 450 KHz to 1.6 MHz, and 3.5 dBuV from 1.6 MHz to 1 GHz.

Conclusions

- The maximum radiated emission limits for RF LED devices[1], and RF Lighting (discharge) devices[3] are exactly the same except for a small difference in the band from 960 MHz to 1 GHz. It appears that most RF LED lighting devices and RF (discharge) lighting devices complying with maximum emission limits do not have significant emissions above 300 MHz; additional research is needed to consider if this observation is correct.

References

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11.) Hammerschmidt, C. (2014). *Broadband Spectrum Survey in the Chicago, Illinois, Area*.

Thank you

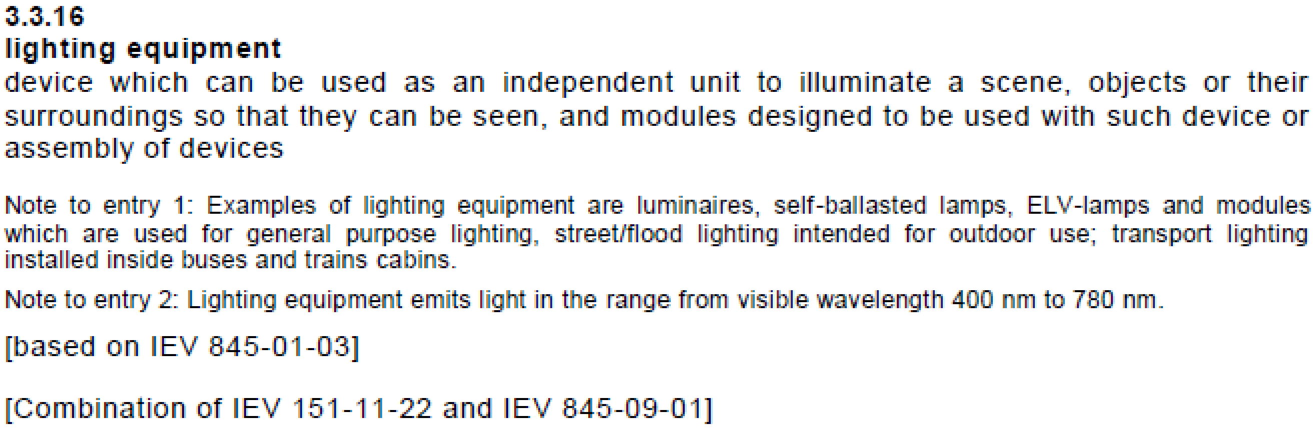
Questions?

Comments?

Backup Slides

CISPR 15

Some New Definitions



3.3.16

lighting equipment

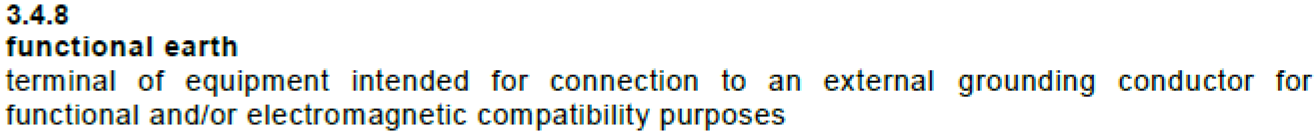
device which can be used as an independent unit to illuminate a scene, objects or their surroundings so that they can be seen, and modules designed to be used with such device or assembly of devices

Note to entry 1: Examples of lighting equipment are luminaires, self-ballasted lamps, ELV-lamps and modules which are used for general purpose lighting, street/flood lighting intended for outdoor use; transport lighting installed inside buses and trains cabins.

Note to entry 2: Lighting equipment emits light in the range from visible wavelength 400 nm to 780 nm.

[based on IEV 845-01-03]

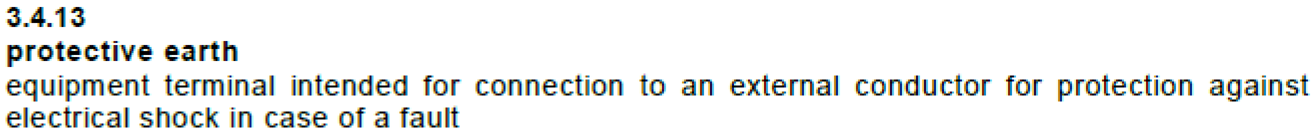
[Combination of IEV 151-11-22 and IEV 845-09-01]



3.4.8

functional earth

terminal of equipment intended for connection to an external grounding conductor for functional and/or electromagnetic compatibility purposes



3.4.13

protective earth

equipment terminal intended for connection to an external conductor for protection against electrical shock in case of a fault

CISPR 15

Generic Test Setup

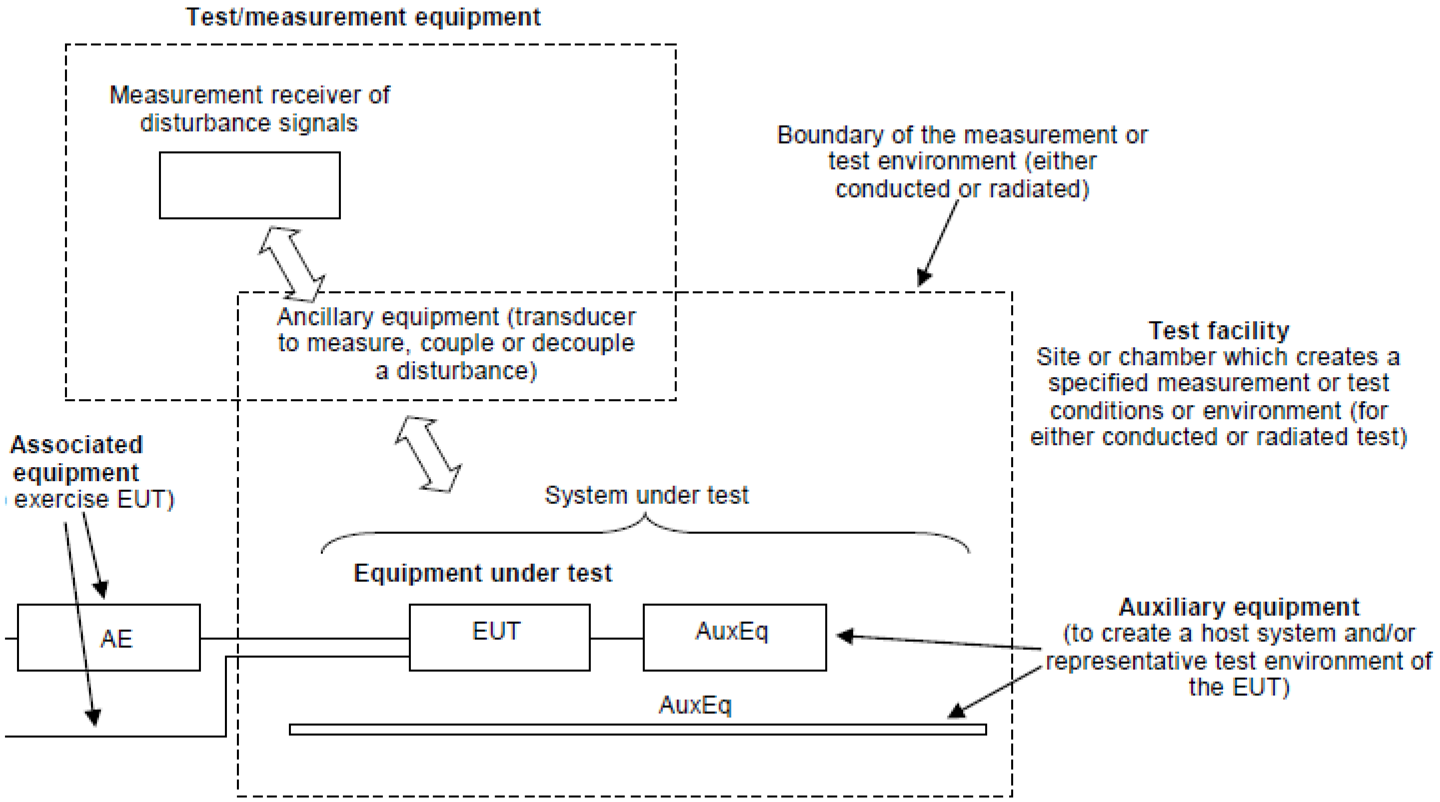
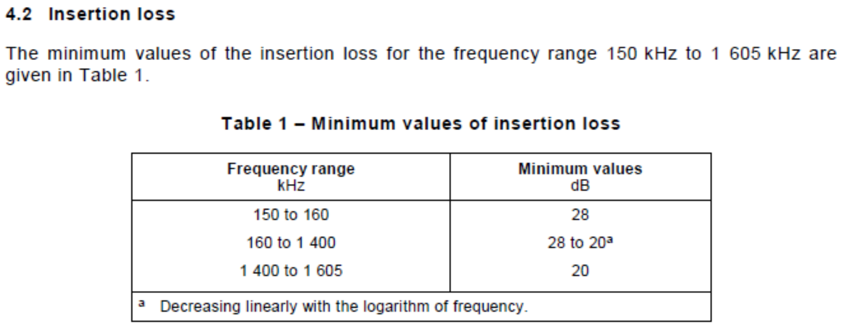


Figure 2 – Generic depiction of the definitions of test-, ancillary-, auxiliary- & associated equipment w.r.t. EUT and the test/measurement environment (definitions given in CISPR 16-2-3)

Not Applicable



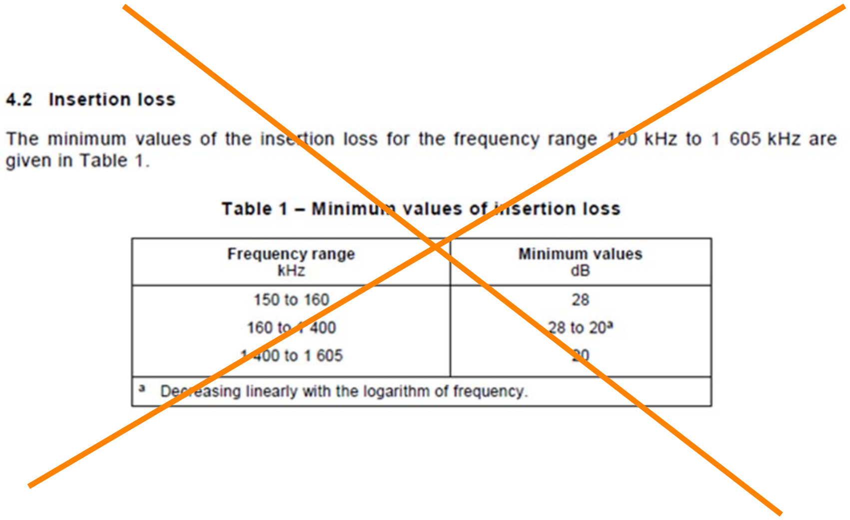
4.2 Insertion loss

The minimum values of the insertion loss for the frequency range 150 kHz to 1 605 kHz are given in Table 1.

Table 1 – Minimum values of insertion loss

Frequency range kHz	Minimum values dB
150 to 160	28
160 to 1 400	28 to 20[a]
1 400 to 1 605	20

[a] Decreasing linearly with the logarithm of frequency.



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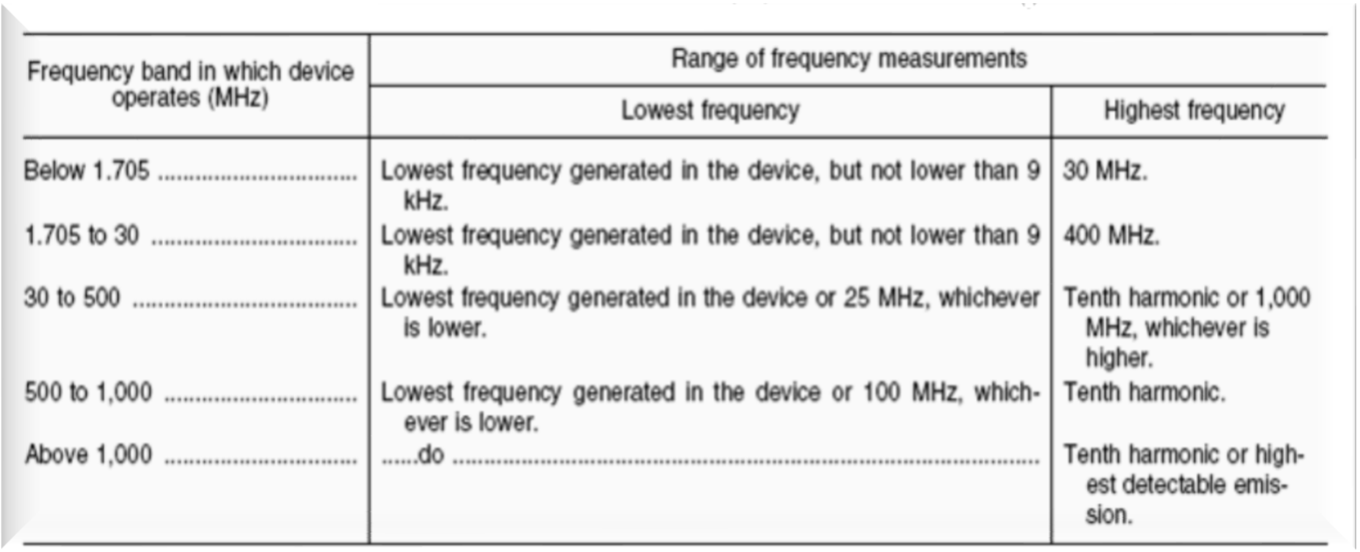
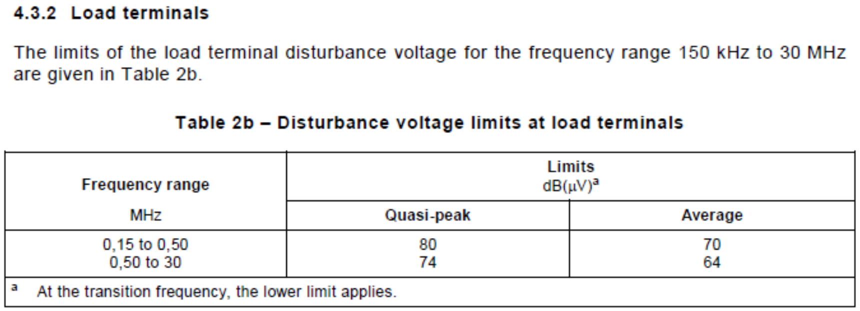
FCC Part 18 Scanning Frequency Requirements



Frequency band in which device operates (MHz)	Range of frequency measurements	
	Lowest frequency	Highest frequency
Below 1.705	Lowest frequency generated in the device, but not lower than 9 kHz.	30 MHz.
1.705 to 30	Lowest frequency generated in the device, but not lower than 9 kHz.	400 MHz.
30 to 500	Lowest frequency generated in the device or 25 MHz, whichever is lower.	Tenth harmonic or 1,000 MHz, whichever is higher.
500 to 1,000	Lowest frequency generated in the device or 100 MHz, whichever is lower.	Tenth harmonic.
Above 1,000	......do	Tenth harmonic or highest detectable emission.

See Reference 3

Updated



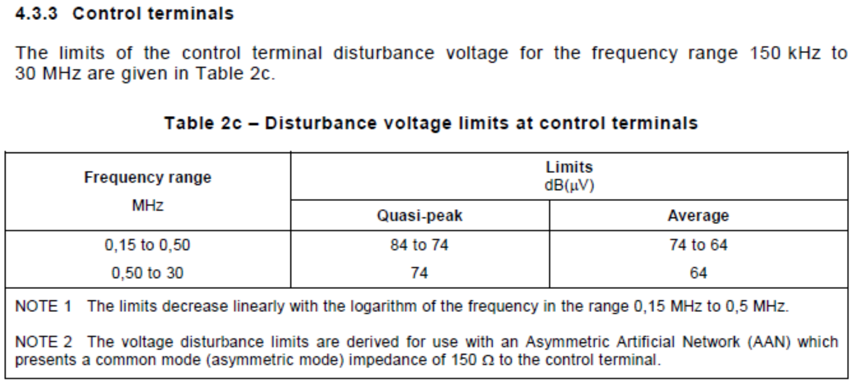
4.3.2 Load terminals

The limits of the load terminal disturbance voltage for the frequency range 150 kHz to 30 MHz are given in Table 2b.

Table 2b – Disturbance voltage limits at load terminals

Frequency range MHz	Limits dB(μV)[a]	
	Quasi-peak	Average
0,15 to 0,50 0,50 to 30	80 74	70 64

[a] At the transition frequency, the lower limit applies.



4.3.3 Control terminals

The limits of the control terminal disturbance voltage for the frequency range 150 kHz to 30 MHz are given in Table 2c.

Table 2c – Disturbance voltage limits at control terminals

Frequency range MHz	Limits dB(μV)	
	Quasi-peak	Average
0,15 to 0,50 0,50 to 30	84 to 74 74	74 to 64 64

NOTE 1 The limits decrease linearly with the logarithm of the frequency in the range 0,15 MHz to 0,5 MHz.

NOTE 2 The voltage disturbance limits are derived for use with an Asymmetric Artificial Network (AAN) which presents a common mode (asymmetric mode) impedance of 150 Ω to the control terminal.

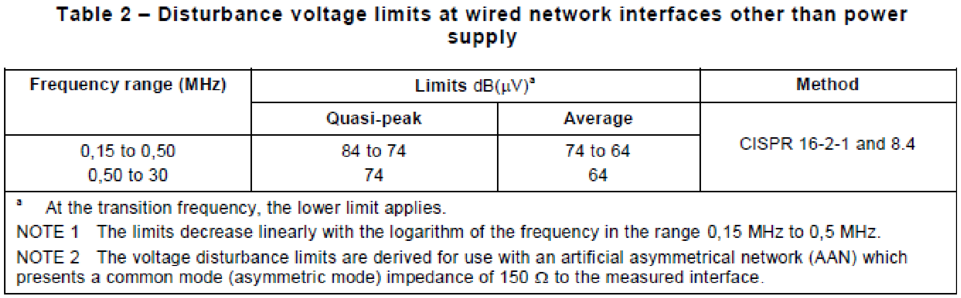


Table 2 – Disturbance voltage limits at wired network interfaces other than power supply

Frequency range (MHz)	Limits dB(μV)[a]		Method
	Quasi-peak	Average	
0,15 to 0,50 0,50 to 30	84 to 74 74	74 to 64 64	CISPR 16-2-1 and 8.4

[a] At the transition frequency, the lower limit applies.

NOTE 1 The limits decrease linearly with the logarithm of the frequency in the range 0,15 MHz to 0,5 MHz.

NOTE 2 The voltage disturbance limits are derived for use with an artificial asymmetrical network (AAN) which presents a common mode (asymmetric mode) impedance of 150 Ω to the measured interface.

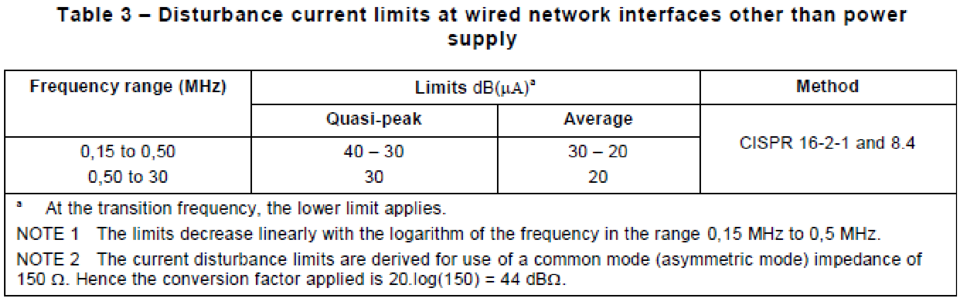


Table 3 – Disturbance current limits at wired network interfaces other than power supply

Frequency range (MHz)	Limits dB(μA)[a]		Method
	Quasi-peak	Average	
0,15 to 0,50 0,50 to 30	40 – 30 30	30 – 20 20	CISPR 16-2-1 and 8.4

[a] At the transition frequency, the lower limit applies.

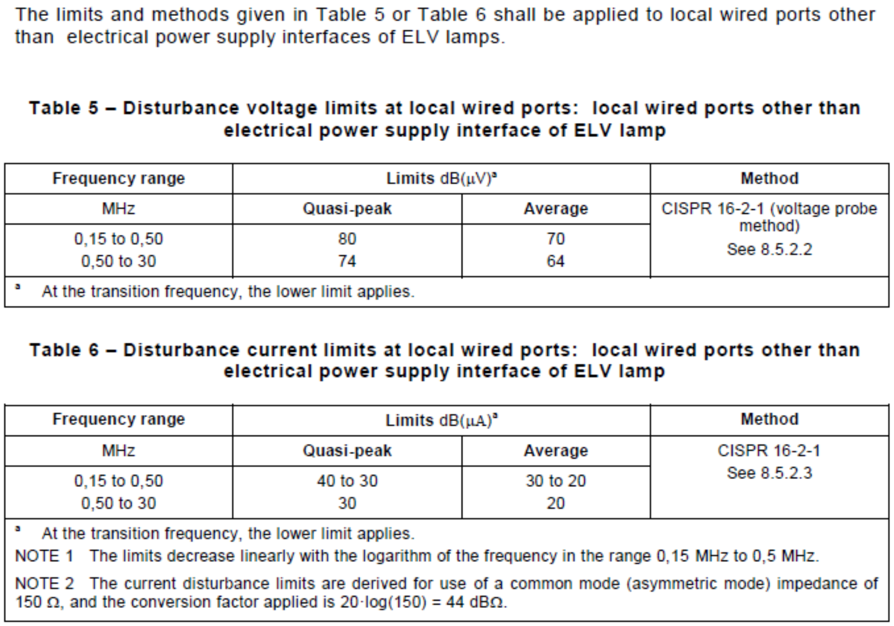
NOTE 1 The limits decrease linearly with the logarithm of the frequency in the range 0,15 MHz to 0,5 MHz.

NOTE 2 The current disturbance limits are derived for use of a common mode (asymmetric mode) impedance of 150 Ω. Hence the conversion factor applied is 20.log(150) = 44 dBΩ.

CISPR 15

NEW

NA



The limits and methods given in Table 5 or Table 6 shall be applied to local wired ports other than electrical power supply interfaces of ELV lamps.

Table 5 – Disturbance voltage limits at local wired ports: local wired ports other than electrical power supply interface of ELV lamp

Frequency range	Limits dB(μV)[a]		Method
MHz	Quasi-peak	Average	CISPR 16-2-1 (voltage probe method) See 8.5.2.2
0,15 to 0,50 0,50 to 30	80 74	70 64	

[a] At the transition frequency, the lower limit applies.

Table 6 – Disturbance current limits at local wired ports: local wired ports other than electrical power supply interface of ELV lamp

Frequency range	Limits dB(μA)[a]		Method
MHz	Quasi-peak	Average	CISPR 16-2-1 See 8.5.2.3
0,15 to 0,50 0,50 to 30	40 to 30 30	30 to 20 20	

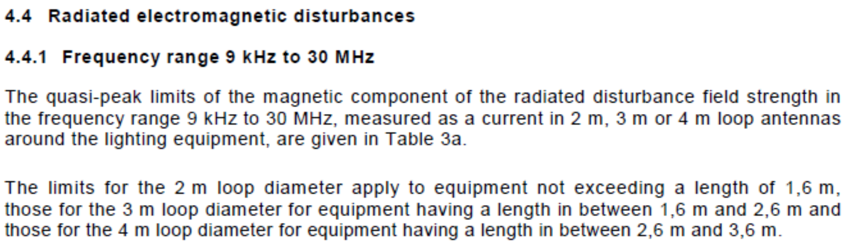
[a] At the transition frequency, the lower limit applies.

NOTE 1 The limits decrease linearly with the logarithm of the frequency in the range 0,15 MHz to 0,5 MHz.

NOTE 2 The current disturbance limits are derived for use of a common mode (asymmetric mode) impedance of 150 Ω, and the conversion factor applied is 20·log(150) = 44 dBΩ.

CISPR 15

Updated

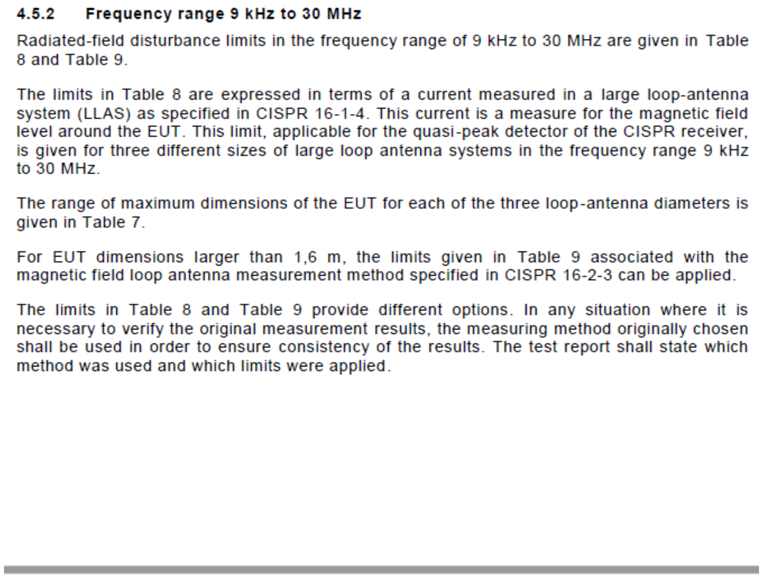


4.4 Radiated electromagnetic disturbances

4.4.1 Frequency range 9 kHz to 30 MHz

The quasi-peak limits of the magnetic component of the radiated disturbance field strength in the frequency range 9 kHz to 30 MHz, measured as a current in 2 m, 3 m or 4 m loop antennas around the lighting equipment, are given in Table 3a.

The limits for the 2 m loop diameter apply to equipment not exceeding a length of 1,6 m, those for the 3 m loop diameter for equipment having a length in between 1,6 m and 2,6 m and those for the 4 m loop diameter for equipment having a length in between 2,6 m and 3,6 m.



4.5.2 Frequency range 9 kHz to 30 MHz

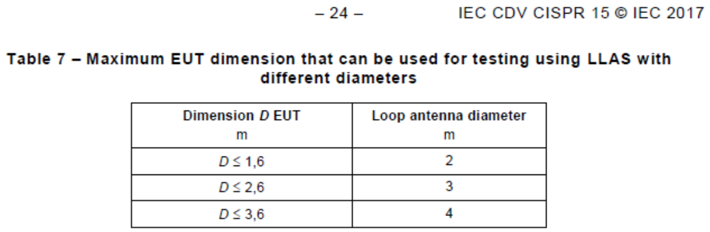
Radiated-field disturbance limits in the frequency range of 9 kHz to 30 MHz are given in Table 8 and Table 9.

The limits in Table 8 are expressed in terms of a current measured in a large loop-antenna system (LLAS) as specified in CISPR 16-1-4. This current is a measure for the magnetic field level around the EUT. This limit, applicable for the quasi-peak detector of the CISPR receiver, is given for three different sizes of large loop antenna systems in the frequency range 9 kHz to 30 MHz.

The range of maximum dimensions of the EUT for each of the three loop-antenna diameters is given in Table 7.

For EUT dimensions larger than 1,6 m, the limits given in Table 9 associated with the magnetic field loop antenna measurement method specified in CISPR 16-2-3 can be applied.

The limits in Table 8 and Table 9 provide different options. In any situation where it is necessary to verify the original measurement results, the measuring method originally chosen shall be used in order to ensure consistency of the results. The test report shall state which method was used and which limits were applied.



– 24 – IEC CDV CISPR 15 © IEC 2017

Table 7 – Maximum EUT dimension that can be used for testing using LLAS with different diameters

Dimension *D* EUT m	Loop antenna diameter m
D ≤ 1,6	2
D ≤ 2,6	3
D ≤ 3,6	4

CISPR 15

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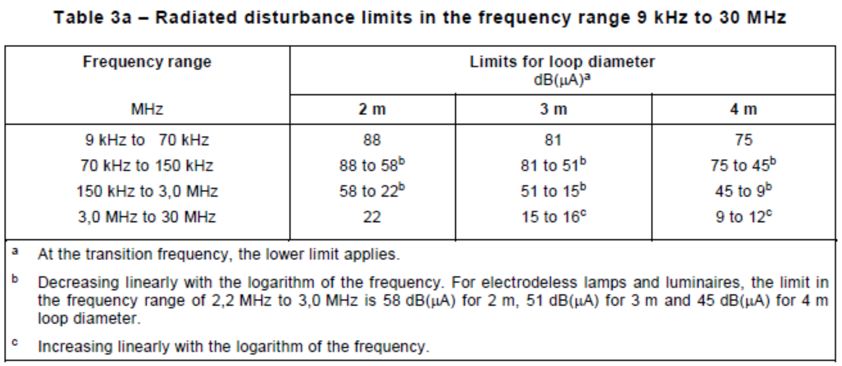


Table 3a – Radiated disturbance limits in the frequency range 9 kHz to 30 MHz

Frequency range MHz	Limits for loop diameter dB(μA)[a]		
	2 m	3 m	4 m
9 kHz to 70 kHz	88	81	75
70 kHz to 150 kHz	88 to 58[b]	81 to 51[b]	75 to 45[b]
150 kHz to 3,0 MHz	58 to 22[b]	51 to 15[b]	45 to 9[b]
3,0 MHz to 30 MHz	22	15 to 16[c]	9 to 12[c]

[a] At the transition frequency, the lower limit applies.

[b] Decreasing linearly with the logarithm of the frequency. For electrodeless lamps and luminaires, the limit in the frequency range of 2,2 MHz to 3,0 MHz is 58 dB(μA) for 2 m, 51 dB(μA) for 3 m and 45 dB(μA) for 4 m loop diameter.

[c] Increasing linearly with the logarithm of the frequency.

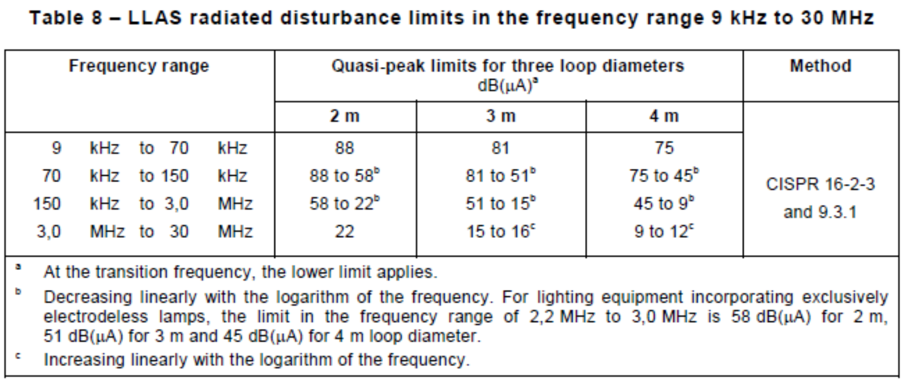


Table 8 – LLAS radiated disturbance limits in the frequency range 9 kHz to 30 MHz

Frequency range	Quasi-peak limits for three loop diameters dB(μA)[a]			Method
	2 m	3 m	4 m	
9 kHz to 70 kHz	88	81	75	CISPR 16-2-3 and 9.3.1
70 kHz to 150 kHz	88 to 58[b]	81 to 51[b]	75 to 45[b]	
150 kHz to 3,0 MHz	58 to 22[b]	51 to 15[b]	45 to 9[b]	
3,0 MHz to 30 MHz	22	15 to 16[c]	9 to 12[c]	

[a] At the transition frequency, the lower limit applies.

[b] Decreasing linearly with the logarithm of the frequency. For lighting equipment incorporating exclusively electrodeless lamps, the limit in the frequency range of 2,2 MHz to 3,0 MHz is 58 dB(μA) for 2 m, 51 dB(μA) for 3 m and 45 dB(μA) for 4 m loop diameter.

[c] Increasing linearly with the logarithm of the frequency.

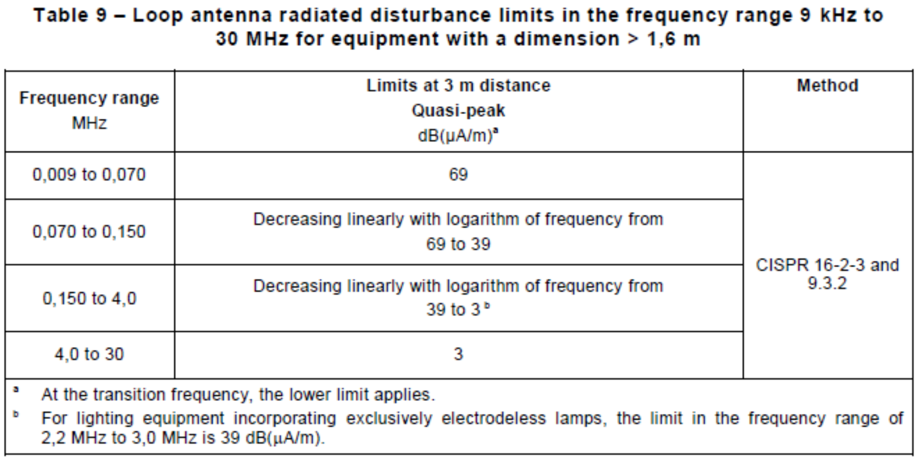


Table 9 – Loop antenna radiated disturbance limits in the frequency range 9 kHz to 30 MHz for equipment with a dimension > 1,6 m

Frequency range MHz	Limits at 3 m distance Quasi-peak dB(μA/m)[a]	Method
0,009 to 0,070	69	CISPR 16-2-3 and 9.3.2
0,070 to 0,150	Decreasing linearly with logarithm of frequency from 69 to 39	
0,150 to 4,0	Decreasing linearly with logarithm of frequency from 39 to 3[b]	
4,0 to 30	3	

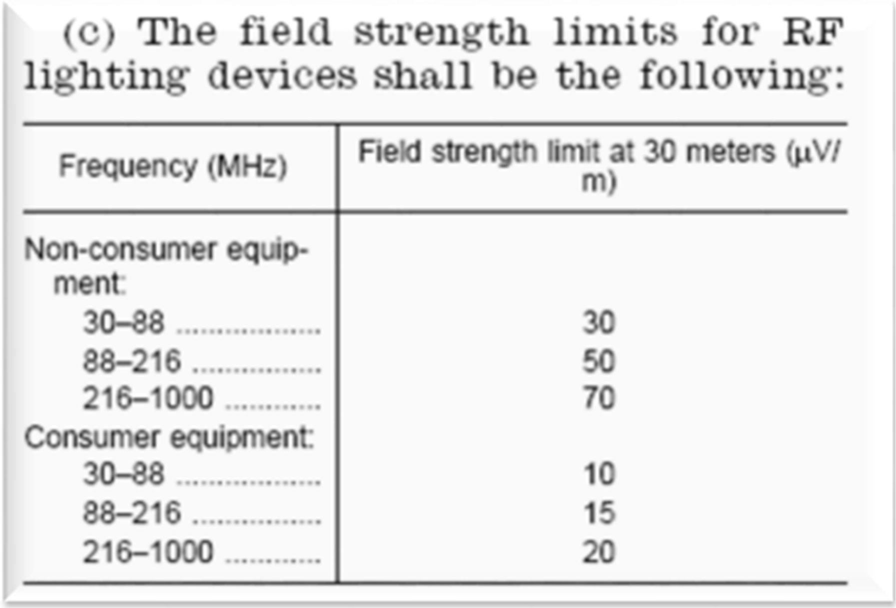
[a] At the transition frequency, the lower limit applies.

[b] For lighting equipment incorporating exclusively electrodeless lamps, the limit in the frequency range of 2,2 MHz to 3,0 MHz is 39 dB(μA/m).

LED Driver Basic Configuration Types

Input	Output	Application Examples
Mains voltage (ac)	Constant Current	General Illumination, Signage, Hazardous Locations, Consumer Products & Others
Mains voltage (ac)	Constant voltage	
Constant (dc) voltage	Constant current	Emergency Lighting, PoE, & Energy Storage Lighting Systems (Solar, etc.),
Constant (dc) voltage	Constant dc voltage	
Mains voltage (ac)	Pulse Width Modulated (PWM)	General Illumination (mostly for dimming systems)

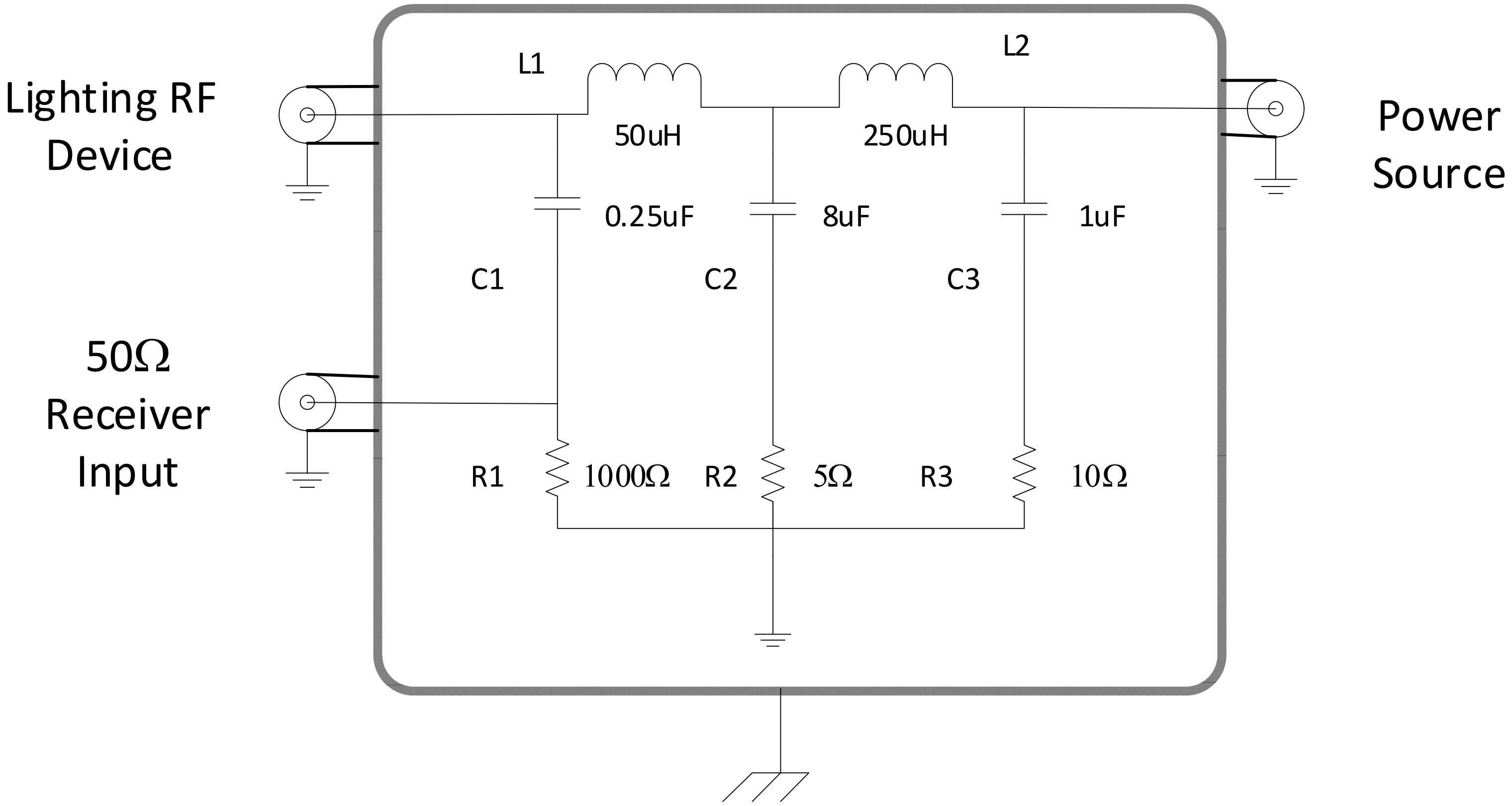
NA Radiated Emission Limits for RF Lighting Devices



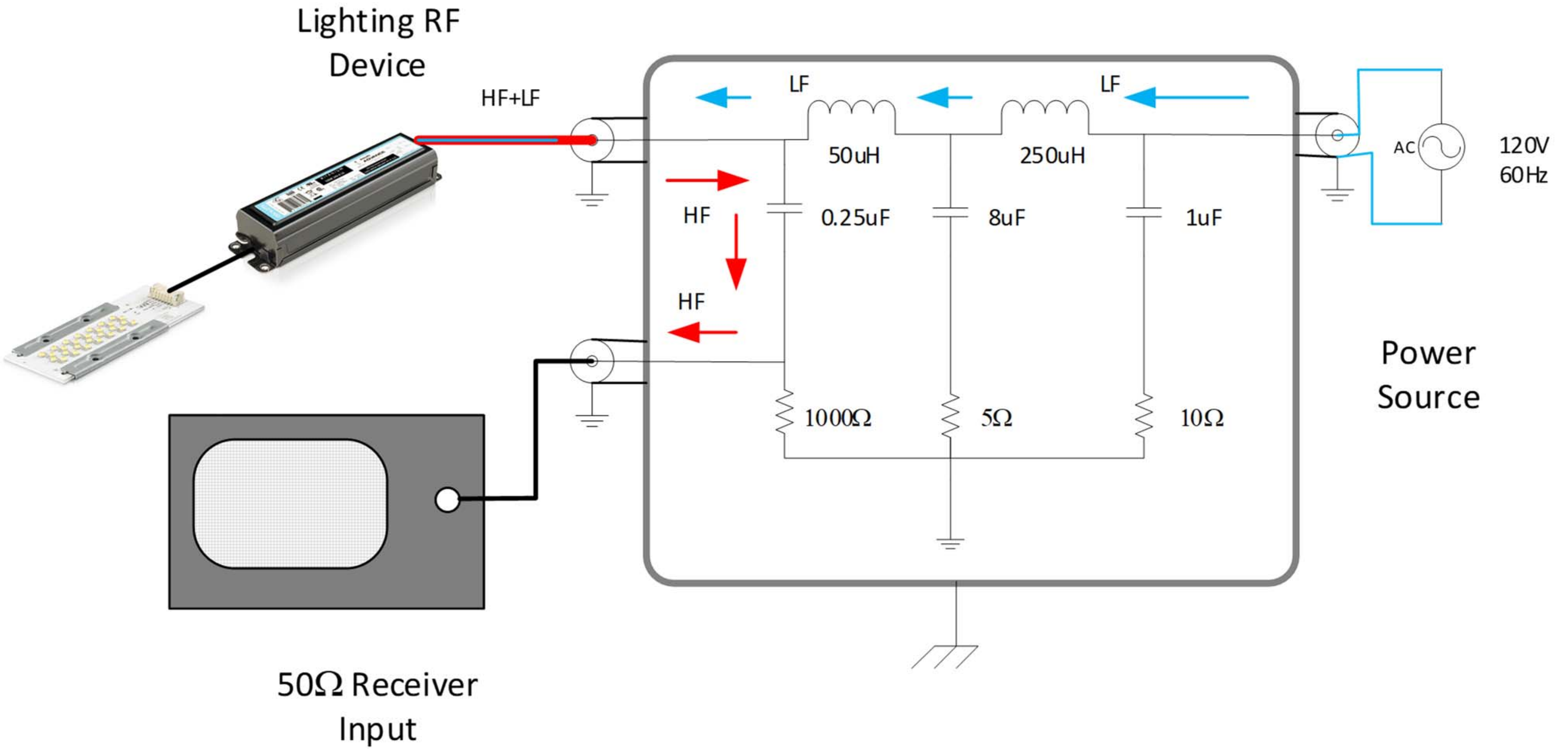
(c) The field strength limits for RF lighting devices shall be the following:

Frequency (MHz)	Field strength limit at 30 meters (µV/m)
Non-consumer equipment:	
30–88	30
88–216	50
216–1000	70
Consumer equipment:	
30–88	10
88–216	15
216–1000	20

Line Impedance Stabilization Network (LISN)



Line Impedance Stabilization Network (LISN)



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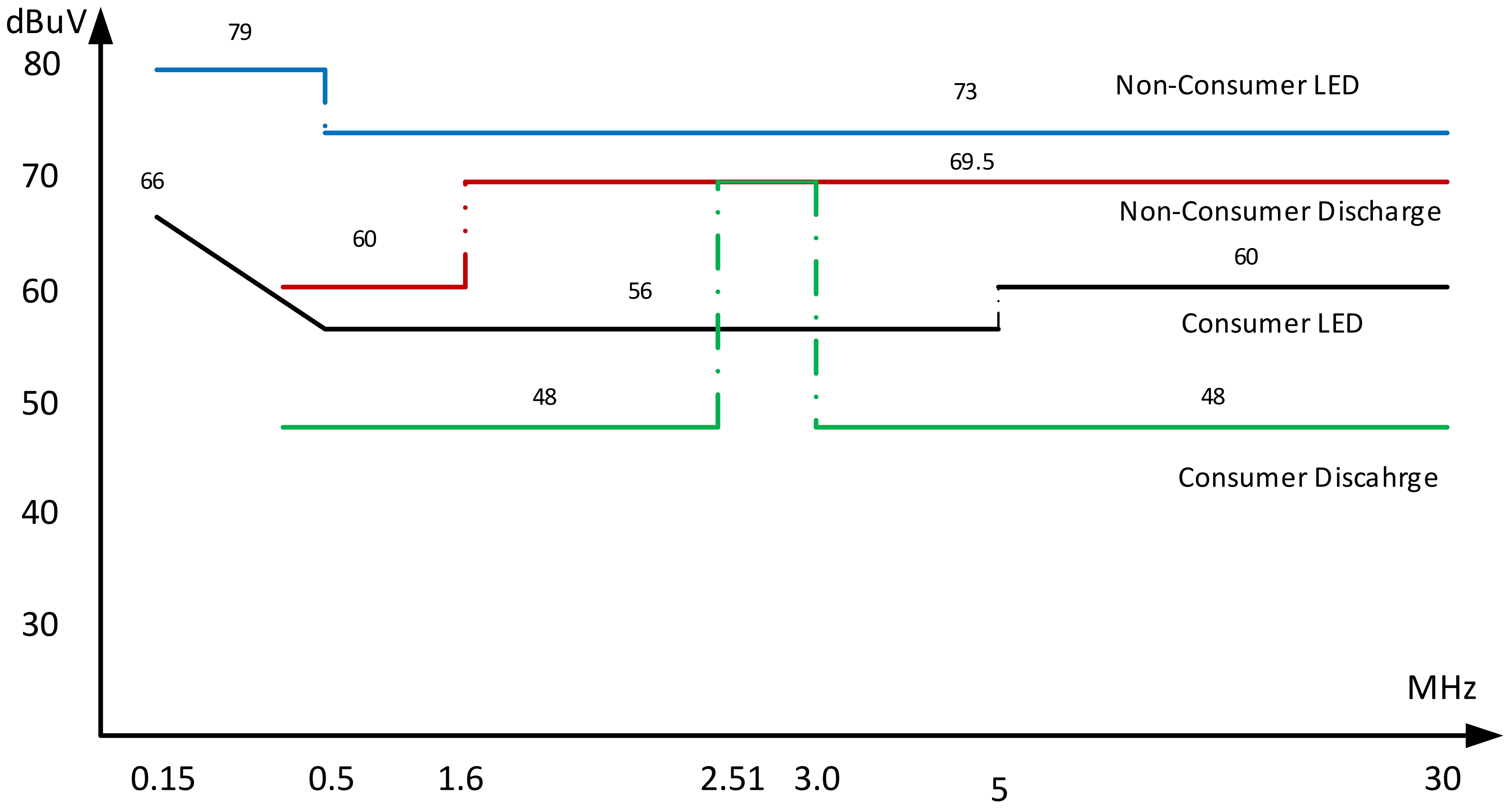
NA Conducted Emissions Comparison



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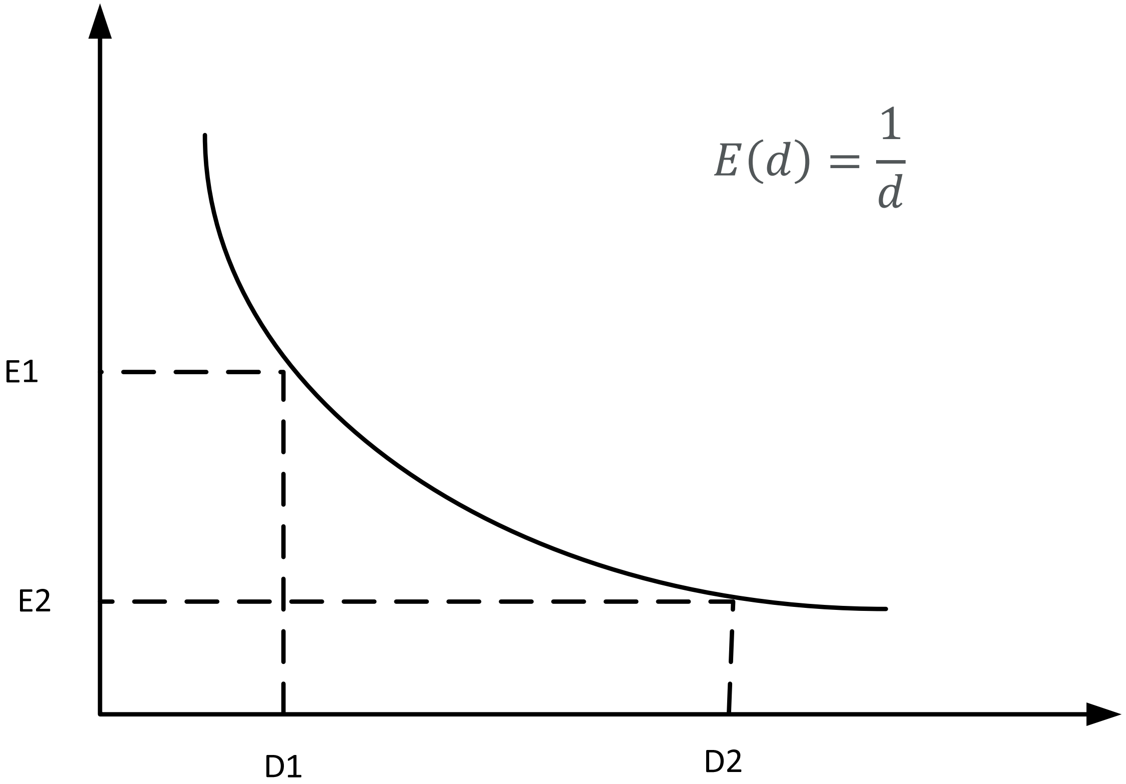
Radiated Emission Limits at Different Distances

Radiated far-field decay according to 1/D



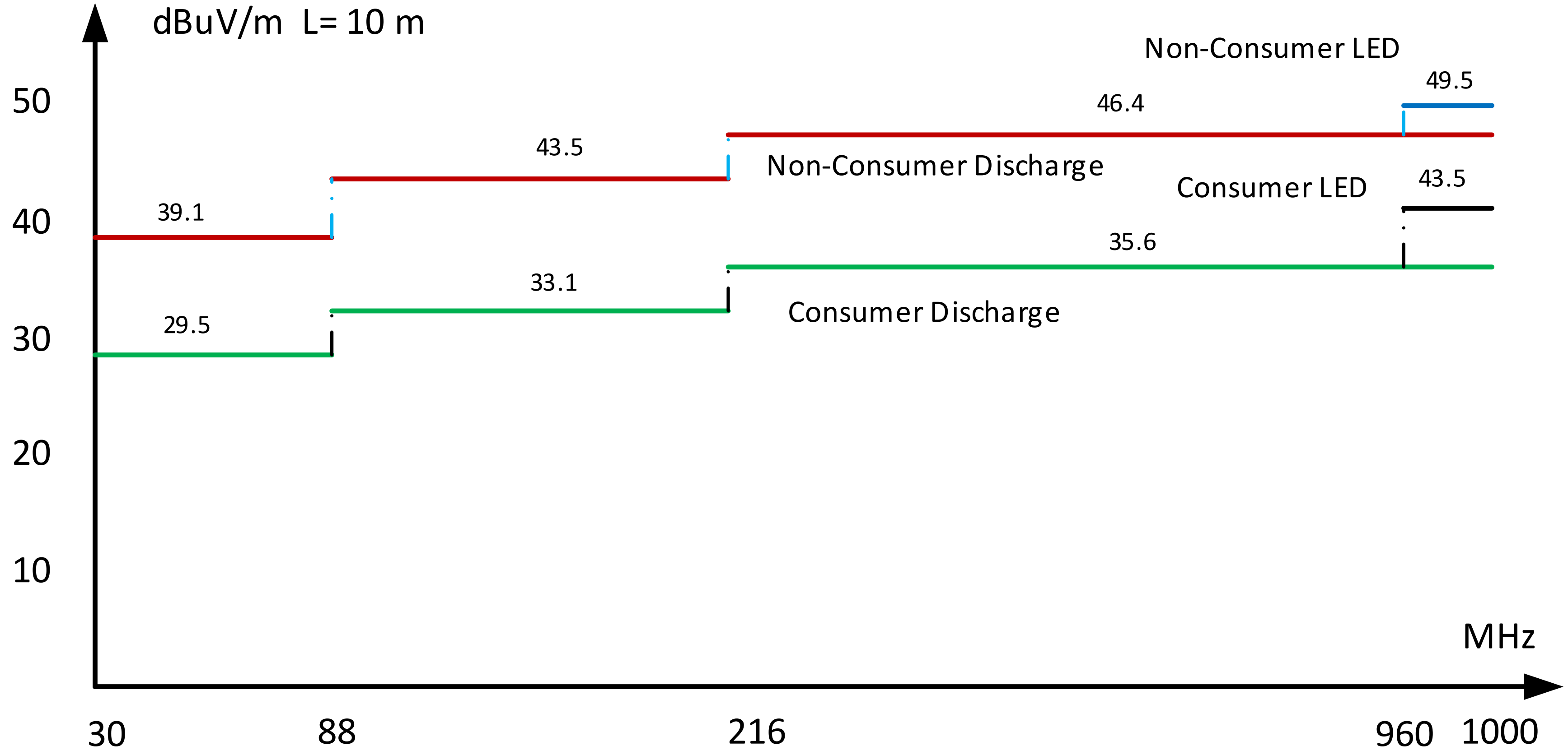
$$\frac{E(D1)}{E(D2)} = \frac{{}^{1}/_{D1}}{{}^{1}/_{D2}} = \frac{D2}{D1}$$

$$E(D2) = \frac{D1}{D2} * E(D1)$$

$$E(D2) = \frac{D1}{D2} * E(D1)$$

Figure 17

NA Radiated Emissions Comparison



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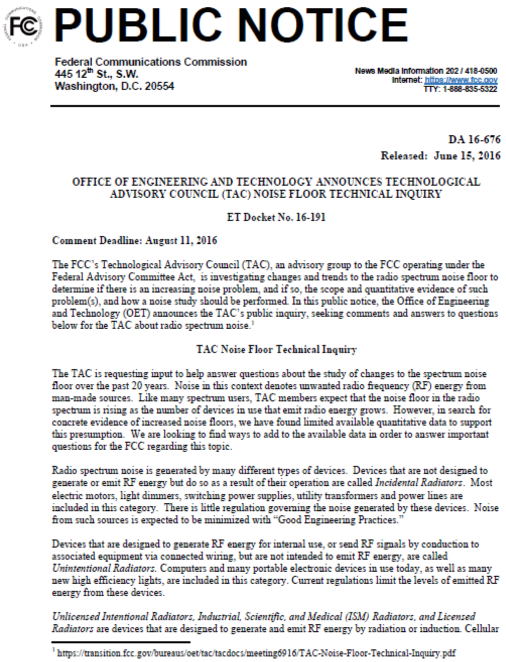
Applications

Noise Floor Inquiry Scope



PUBLIC NOTICE

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DA 16-676
Released: June 15, 2016

OFFICE OF ENGINEERING AND TECHNOLOGY ANNOUNCES TECHNOLOGICAL ADVISORY COUNCIL (TAC) NOISE FLOOR TECHNICAL INQUIRY

ET Docket No. 16-191

Comment Deadline: August 11, 2016

The FCC's Technological Advisory Council (TAC), an advisory group to the FCC operating under the Federal Advisory Committee Act, is investigating changes and trends to the radio spectrum noise floor to determine if there is an increasing noise problem, and if so, the scope and quantitative evidence of such problem(s), and how a noise study should be performed. In this public notice, the Office of Engineering and Technology (OET) announces the TAC's public inquiry, seeking comments and answers to questions below for the TAC about radio spectrum noise.[1]

TAC Noise Floor Technical Inquiry

The TAC is requesting input to help answer questions about the study of changes to the spectrum noise floor over the past 20 years. Noise in this context denotes unwanted radio frequency (RF) energy from man-made sources. Like many spectrum users, TAC members expect that the noise floor in the radio spectrum is rising as the number of devices in use that emit radio energy grows. However, in search for concrete evidence of increased noise floors, we have found limited available quantitative data to support this presumption. We are looking to find ways to add to the available data in order to answer important questions for the FCC regarding this topic.

Radio spectrum noise is generated by many different types of devices. Devices that are not designed to generate or emit RF energy but do so as a result of their operation are called *Incidental Radiators*. Most electric motors, light dimmers, switching power supplies, utility transformers and power lines are included in this category. There is little regulation governing the noise generated by these devices. Noise from such sources is expected to be minimized with "Good Engineering Practices."

Devices that are designed to generate RF energy for internal use, or send RF signals by conduction to associated equipment via connected wiring, but are not intended to emit RF energy, are called *Unintentional Radiators*. Computers and many portable electronic devices in use today, as well as many new high efficiency lights, are included in this category. Current regulations limit the levels of emitted RF energy from these devices.

Unlicensed Intentional Radiators, Industrial, Scientific, and Medical (ISM) Radiators, and Licensed Radiators are devices that are designed to generate and emit RF energy by radiation or induction. Cellular

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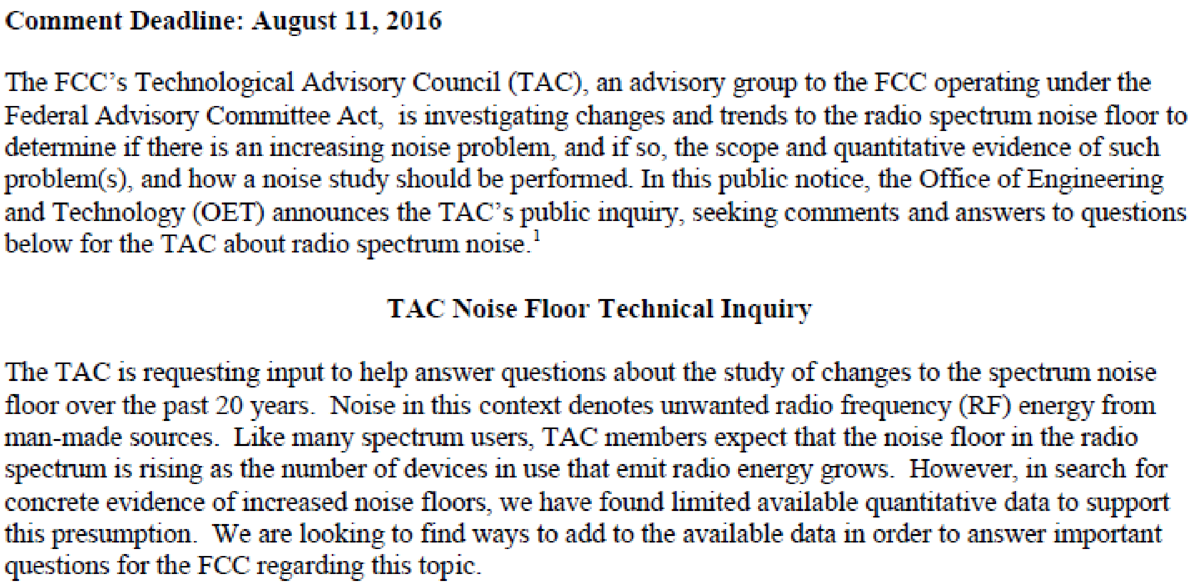
[1] https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting6916/TAC-Noise-Floor-Technical-Inquiry.pdf



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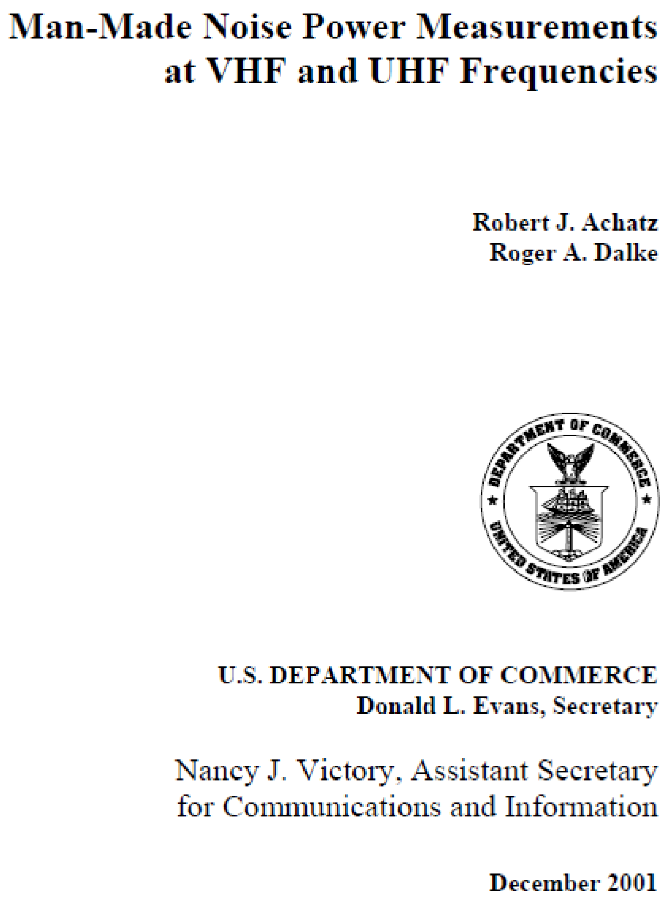
PHILIPS

Applications



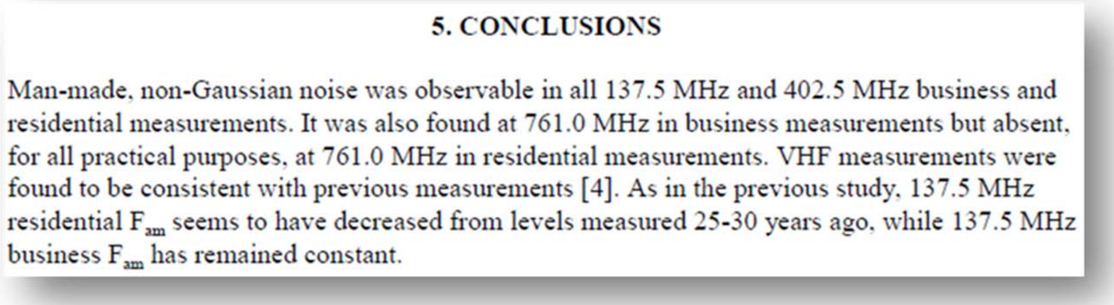
Man-Made Noise Power Measurements at VHF and UHF Frequencies

Robert J. Achatz
Roger A. Dalke

U.S. DEPARTMENT OF COMMERCE
Donald L. Evans, Secretary

Nancy J. Victory, Assistant Secretary
for Communications and Information

December 2001



5. CONCLUSIONS

Man-made, non-Gaussian noise was observable in all 137.5 MHz and 402.5 MHz business and residential measurements. It was also found at 761.0 MHz in business measurements but absent, for all practical purposes, at 761.0 MHz in residential measurements. VHF measurements were found to be consistent with previous measurements [4]. As in the previous study, 137.5 MHz residential F_{am} seems to have decreased from levels measured 25-30 years ago, while 137.5 MHz business F_{am} has remained constant.

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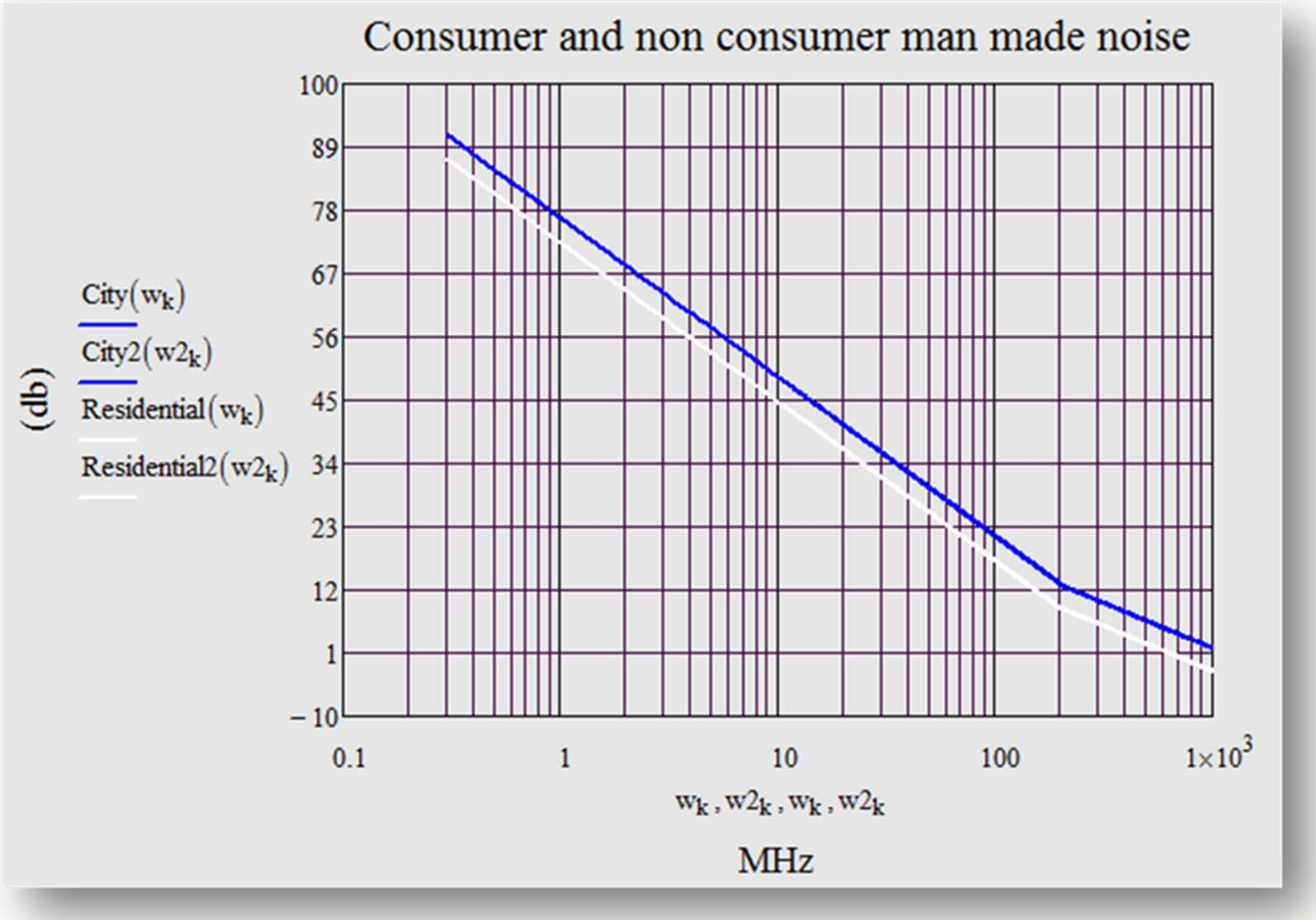
U.S. Floor Noise Model 2002



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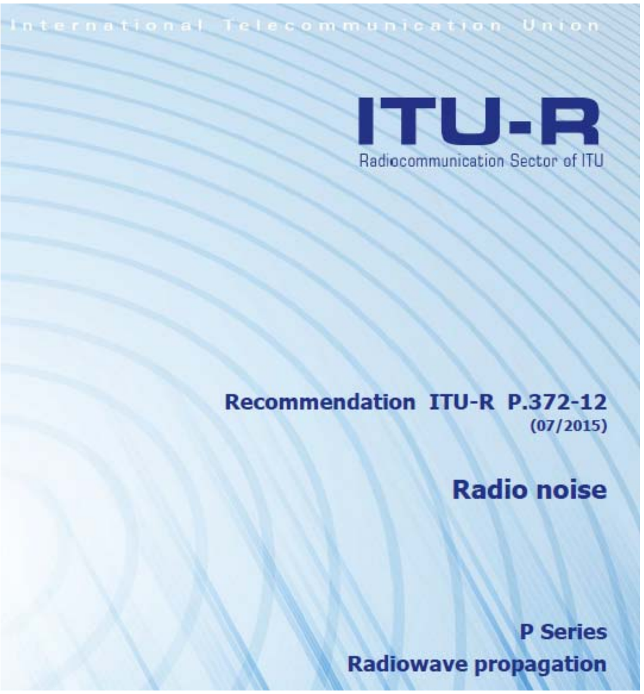


International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R P.372-12

(07/2015)

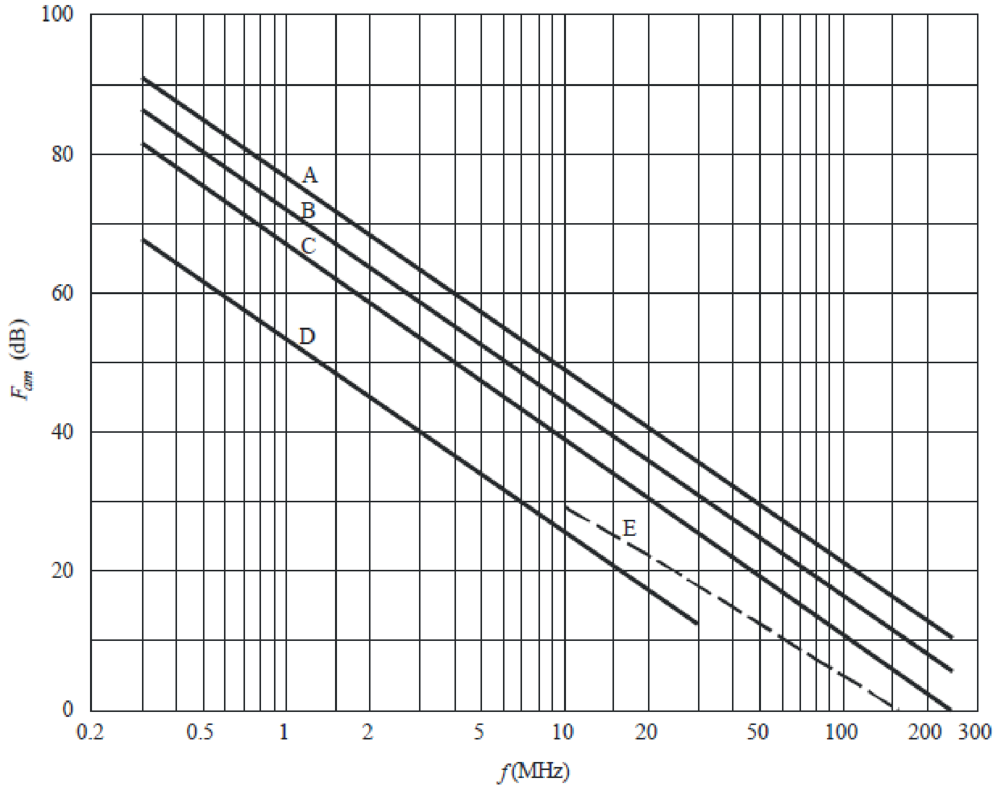
Radio noise

P Series

Radiowave propagation

FIGURE 10

Median values of man-made noise power for a short vertical lossless grounded monopole antenna



Environmental category:

Curves A: city
B: residential
C: rural
D: quiet rural
E: galactic (see § 6)

P.0372-10

The ITU kept the same man-made noise prediction model in their 2015 recommendation.

Control Gear

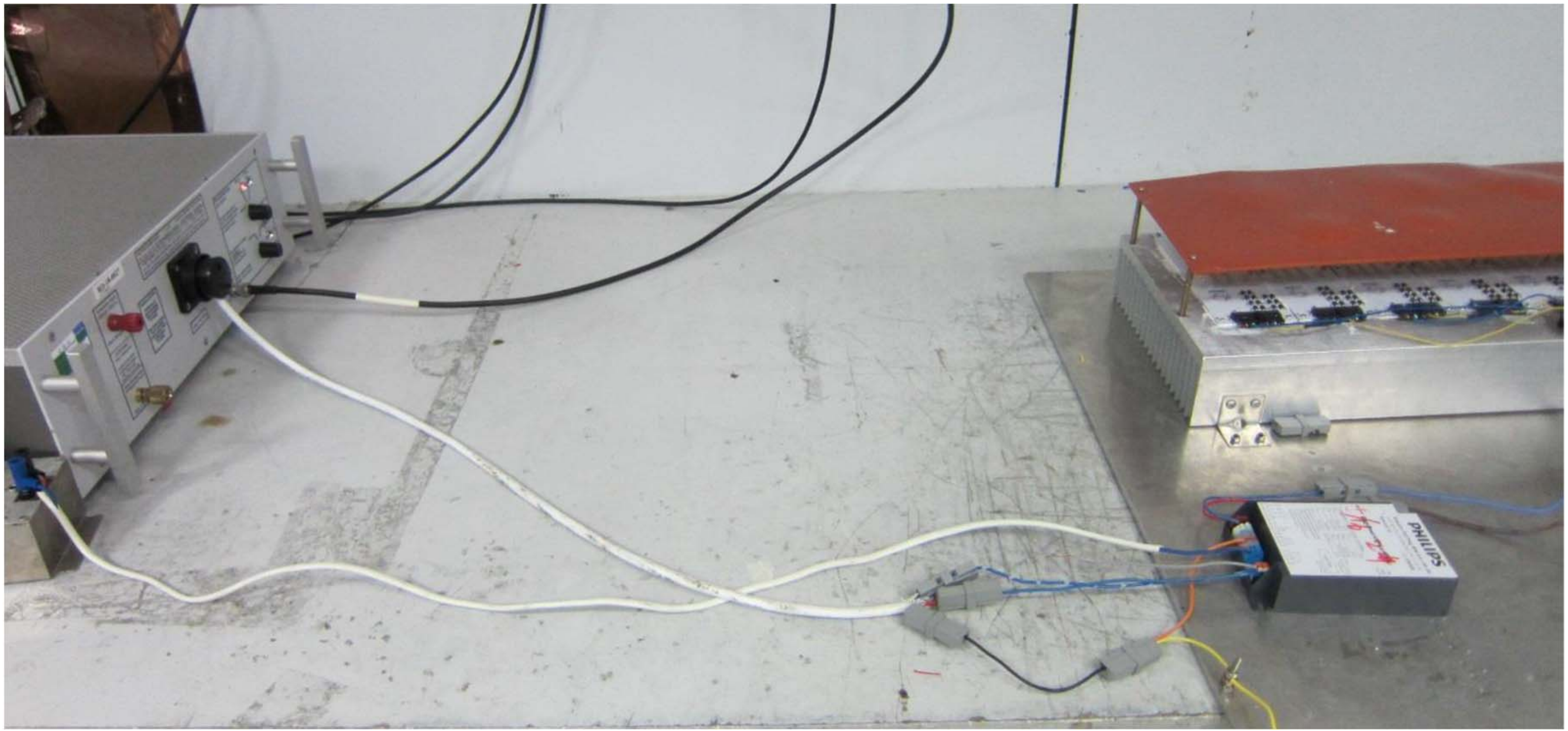


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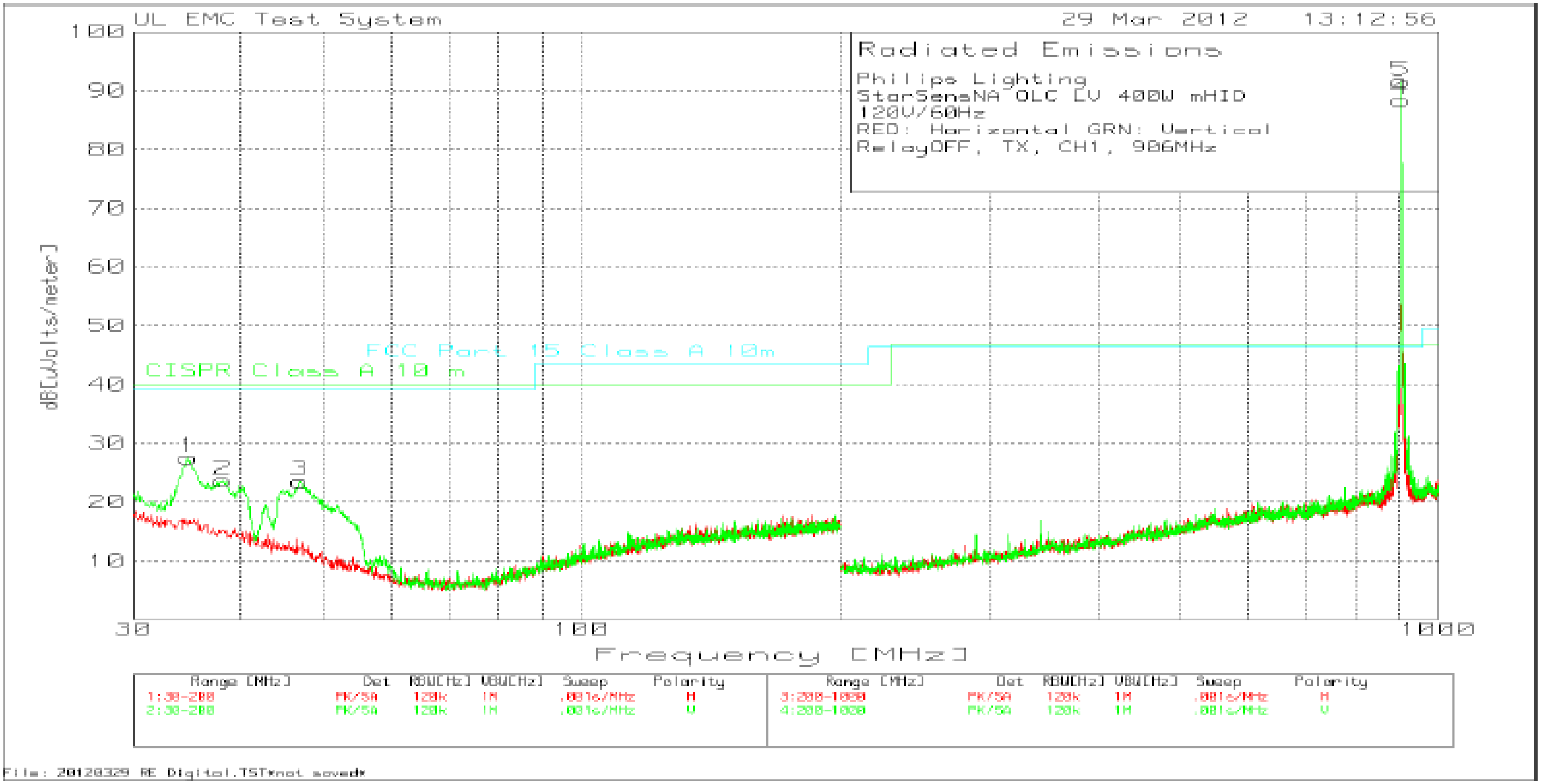
Figure 9 Radiated Spurious Emissions below 1GHz, Low Channel



Range [MHz]	Det	RBW[Hz]	VBW[Hz]	Sweep	Polarity	Range [MHz]	Det	RBW[Hz]	VBW[Hz]	Sweep	Polarity
1:30-200	PK/5A	120k	1M	.001s/MHz	H	3:200-1000	PK/5A	120k	1M	.001s/MHz	H
2:30-200	PK/5A	120k	1M	.001s/MHz	V	4:200-1000	PK/5A	120k	1M	.001s/MHz	V

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