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Comparison of Emission Measurement Methods for Electromagnetic Disturbances in the Frequency Range from 30 MHz to 300 MHz for LED Lamps According to EN 55015

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Abstract

The results of measurements of electromagnetic disturbances emitted by LED lamps, in the frequency range from 30 MHz to 300 MHz, which were made using two methods described in the EN 55015/2013 standard have been presented in the paper. In order to compare both methods, each tested lamp was first measured using the traditional method described in Section 4.4.2 and then tested by an alternative, equivalent method described in Annex B of the above-mentioned standard. The comparison of results for both methods indicates that using first method, a given LED lamp emits disturbances below the acceptable limits, while the same LED lamp tested with the second method emits disturbances that are at the limit of admissible values. Additionally, used statistical tools in the form of calculated linear correlation coefficient show that the nature of the emission of disturbances measured for the same lamp is very comparable in both methods. The reference of these quasi-peak values to the permissible limits applicable in one or the other method may lead to different decisions.

Keywords

EMC, LED lamps, EN 55015 standard, electromagnetic disturbances

1 Introduction

Every electrical device admitted to be traded in the European Union must comply with the EMC Directive 2014/30/EU and standards harmonized with this directive [1]. These requirements also apply to light sources, including LED lamps. In recent times, they have become very popular and are gradually replacing traditional bulbs and fluorescent lamps. However, LED lamps contain electronic power circuits in their structure that can be the source of emission of electromagnetic disturbances [2, 3]. Therefore, before releasing them in the market, they must be tested, among others due to the emission of EMC disturbances in accordance with the EN 55015 standard [4].

The EN 55015 standard contains limit values and methods for measuring radioelectric disturbances generated by lighting devices and similar equipment. According to this standard, LED light sources and integrated with them lighting fittings, where the active electronic components are placed, should be tested:

- the level of conducted disturbances measured at power terminals, in the frequency range from 9 kHz to 30 kHz,
- the level of radiated disturbances in the frequency range from 9 kHz to 30 kHz (magnetic component of field strength) and in the frequency range from 30 MHz to 300 MHz (electric component of field strength).

In the case of lighting equipment measurements in the frequency range from 30 MHz to 300 MHz, the EN 55015 standard permits for two alternative measurement methods. The first traditional method requires measurements in an anechoic chamber. For this method, acceptable levels of disturbances are specified in Section 4.4.2 of the above-mentioned standard. The second method is described in Annex B. The advantage of the new method is that it does not require an anechoic chamber and it is faster, compared to the first method.

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The EN 55015 standard provides that: "if the lighting device complies with the requirements specified in the Annex (ie. Annex B, EN 55015 standard), they are considered compatible in the frequency range from 30 MHz to 300 MHz, with the requirements for radiated disturbances specified in chapter 4.4.2 of this standard" [4].

It follows from this record that both methods should be treated as alternative, equivalent methods.

2 Measurement methodology

The both methods allow to measure the emission of radiated electromagnetic disturbances in the range from 30 MHz to 300 MHz and they can be used alternatively (interchangeably). However, both methods differ in terms of the type of measured signal, the permissible emission levels of the disturbances and the way in which the tests are performed.

In the first traditional method, the value of the electrical component of the field strength of the radiated disturbances is measured, which is expressed in dBμV/m. It is measured by a quasi-peak detector. However, in the new, alternative method (NM-New Method), described in Annex B, the voltage of disturbances at the power terminals of the tested lighting device is measured. The value of the disturbance voltage is measured by a quasi- peak detector and it is expressed in dBμV. Both methods also differ in the permissible limits. Table 1 shows the permissible radiation emission limits for the first method and Table 2 for the second new method (NM).

The acceptable limits for both methods are presented in Fig. 1. The red line indicates acceptable limits for the traditional method and the green line for the new NM method. It should be noticed that the admissible values for both methods differ significantly. The existing differences

Table 1 Permissible emission levels of radiated disturbances in the frequency range from 30 MHz to 300 MHz for a measuring distance of 3 m for the traditional method

Frequency range MHz	Permissible levels for the quasi-peak value dBμV/m
30 to 230	40
230 to 300	47

Table 2 Limits of voltage emission of disturbances at power terminals in the frequency range from 30 MHz to 300 MHz for the new method (NM)

Frequency range MHz	Permissible levels for the quasi-peak value dBμV
30 to 100	64 to 54
100 to 230	54
230 to 300	61

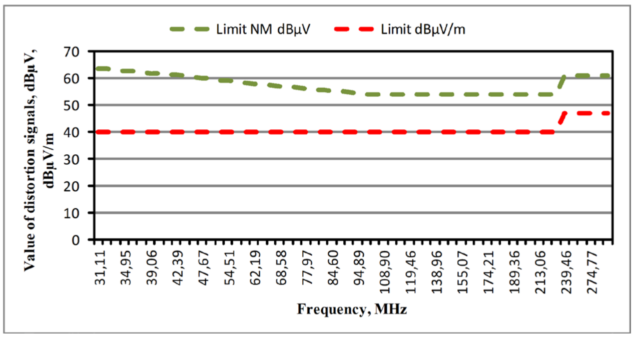

Fig. 1 Acceptable limits for both methods

between the permissible limits for both methods generate doubts whether these methods can be used interchangeably and alternatively and if the obtained results for one and the other method can be basis for making the same decision about construction even the devices pass the tests.

2.1 Test setup for traditional method

In the traditional method, the device under test and the antenna must be placed in the anechoic chamber. The view of the measurement stand located in the Department of Electronic and Telecommunications Systems at the Rzeszów University of Technology is presented in Fig. 2. In this method, the tested LED lamp is supplied from the 230 V mains via a suitable EMC filter and the CDN (Coupling-Decoupling Network). The purpose of the EMC filter is to filter out disturbances coming from the power system grid as well as the CDN network's is to ensure repeatability of measurements and prevent entering disturbances from the network. The RF output of this network was loaded during testing with a 50 Ω resistor. The CDN network, due to its construction, must be placed on the metal reference plane, which was the INNCO rotary table DS2000S1t-H300. The table has the ability to make a full 360° rotation. The tested LED lamp was placed on a wooden base with a height of 0.8 m, which stood on the above-mentioned rotating table.

The HK116 antenna, shown in Fig. 2, is placed on a 4 m mast. During the tests, the antenna can change its height in the range from 1 to 4 m and its polarization horizontally or vertically.

The measurement signal from the antenna was delivered to the ESU - 26 measuring receiver from Rohde&Schwarz.

2.2 Test setup for the new method (NM)

This method also uses a CDN coupling and decoupling network. However, here the BNC measuring socket of the network is connected via a 6 dB attenuator to the

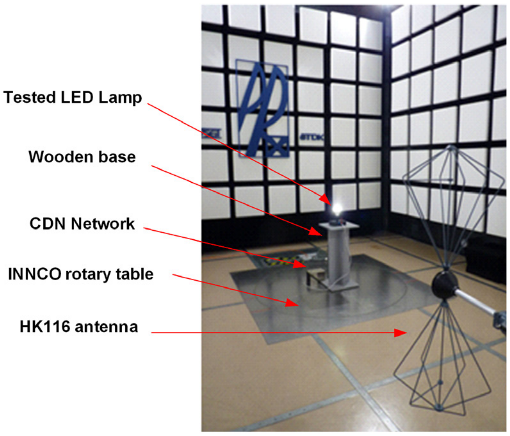

Fig. 2 Measurement stand for the traditional method

measuring receiver. The ESU-26 measuring receiver was also used in this method. The attenuation of individual components, i.e.: wires, CDN networks, and a 6 dB attenuator, has been included in the balance of the measurement path. The test setup for the new, alternative method in accordance with the recommendations of the EN 55015 standard, Annex B is presented in Fig. 3.

The measuring stand where the LED lamps were tested according to the new method is presented in Fig. 4.

3 Experimental and test results

Each LED lamp was turned on 5 minutes earlier before measurements. This was to stabilize the thermal conditions of the power supply system in the LED lamp.

Each lamp was first tested by one method, measuring e.g. 60 quasi-peak values (QP) and the corresponding frequency value, and then the same lamp was measured with the second method for the same frequency values. Those frequency values were determined by EMC32 software from Rhode&Schwarz which supports the measuring system. This measurement method allowed to compare the measured QP values with both methods for the same frequency values. Examples of QP values for one of the lamps, measured by both methods, are given in Table 3.

The measured QP values are given in the form of a set of points related to the corresponding frequency. Therefore, in general, QP charts are point graphs on which the frequency values are presented in a logarithmic scale.

However, in this article, QP values are presented in the form of linear graphs, and the frequency is presented in a linear scale. Such presentation of the results makes easier to compare QP values measured with both methods and show correlation similarities. For similar reasons, the

Table 3 Examples of QP values measured by traditional and alternative methods for the same frequencies for the same lamp (5 W)

Fequency MHz	QP NM dBμV	QP dBμV/m
31.11	79.02	62.18
31.56	78.97	62.06
33.30	78.59	61.88
34.95	78.26	63.26
	New, alternative method (NM)	Traditional method

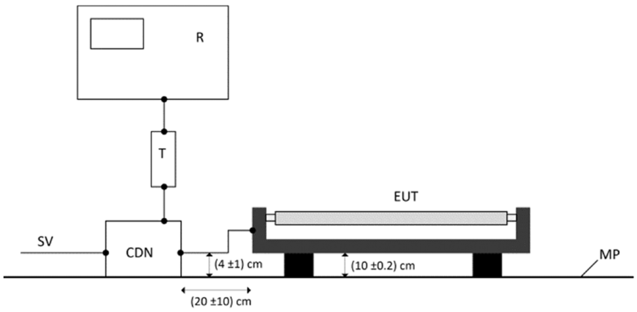

Fig. 3 Test setup for the new, alternative method: R– measuring receiver, SV– power supply, MP – grounded metal plate, CDN – coupling and decoupling network, T – attenuator 6 dB, EUT – tested LED lamp (according to EN 55015, Annex B)

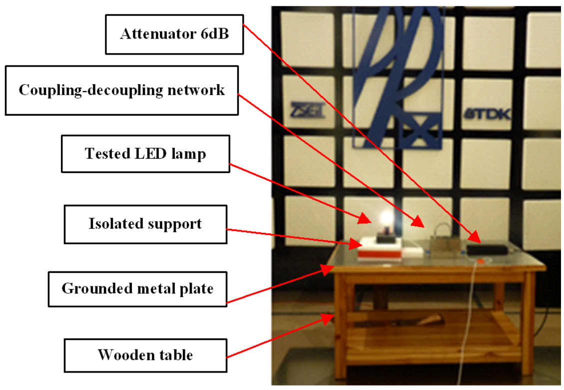

Fig. 4 Measurement stand for the new, alternative method

logarithmic scale was omitted and a linear scale was used for frequency values.

A series of LED lamps have been tested during research. In this paper only special three cases were presented with the following specifications:

- LED lamps did not meet the acceptable limits for both methods (one case analyzed – 18 W lamp);
- LED lamps met the requirements, while for the one selected method the recorded QP values were at the border of the acceptable limit (two cases were analyzed – 5 W and 10 W lamps).

3.1 First case

This case shows a situation where the tested LED lamp (5 W) measured by the traditional method obtained results with only 1 dB of margin in relation to the allowed limit (Table 1). However, when a second alternative method was used for this lamp, about 7 dB margin was obtained up to the limit value.

The comparison of the quasi-peak (QP) values measured using the traditional method and the alternative method is presented in Fig. 5. The presented results are related to the frequency range from 30 MHz to 230 MHz.

In comparison of both methods, the statistical tools (correlations) were used. The comparison of the obtained QP values for both methods is illustrated in Fig. 6. The obtained linear correlation coefficient is very high and equal to 0.91. Its value indicates a very strong correlation relationship between the two analyzed signals.

This example shows that the results obtained for the same LED lamp, but obtained by two methods are not comparable. Although the tests in both cases gave a positive result, the margin for the traditional method is definitely smaller. However, the correlation coefficient is not always so high. This was considered in the second case.

3.2 Second case

The second case concerns a situation where the higher margin to the admissible limit is reached by the characteristics of the quasi-peak value measured using traditional method (tested lamp – 10 W). This margin was about 8 dB (at 95 MHz). On the other hand, the characteristics of QP values obtained by an alternative, new method have a small 2.5 dB margin (at 95 MHz). These relations between the obtained QP characteristics and the corresponding limits are shown in Fig. 7.

It can be seen from the figure that the graph of changes in the quasi-peak value (dBμV/m) recorded using the traditional method shows a slight increase in the value in the initial phase of the measurement (from 30 to 44 MHz). Later, in the range of higher frequencies (from 44 to 100 MHz), the QP values change to a small extent and oscillate around 28.5 dBμV/m with a standard deviation of 1.9 dBμV/m.

However, for the same LED lamp tested with a new, alternative method, its characteristics of changes in registered quasi-peak values (dBμV) shows an initial increase, but for a wider frequency range, i.e. from 30 to 60 MHz. Later, for the frequency range from 60 to 100 MHz, a small change in oscillating around value 51 dBμV with a standard deviation of 0.72 dBμV is observed. Then there

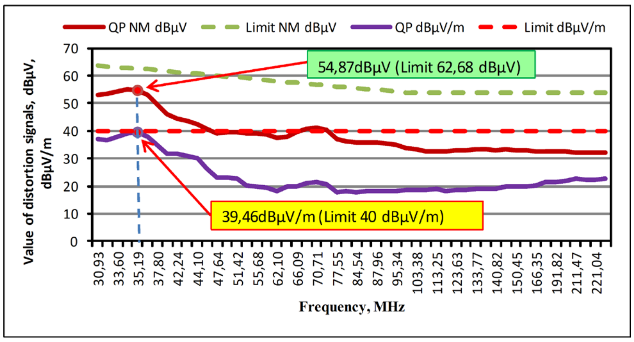

Fig. 5 Graphs of changes in QP values measured with the traditional and alternative method (NM) against the background of acceptable limits (first case)

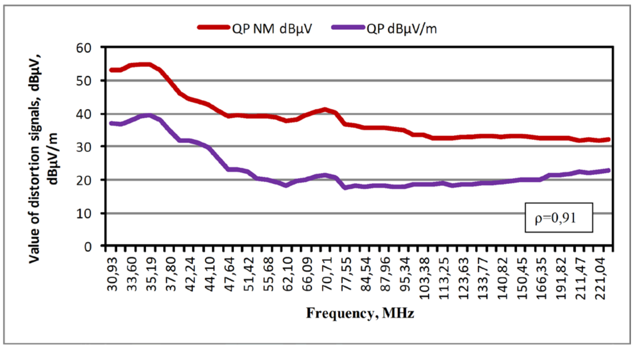

Fig. 6 Graphs of changes of QP values measured by traditional and alternative methods with calculated linear correlation coefficient (first case)

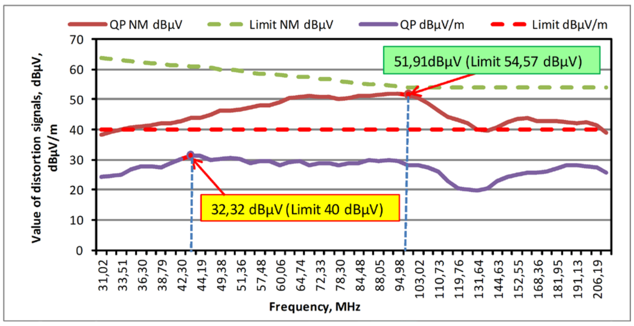

Fig. 7 Graphs of changes in QP values measured with the traditional and alternative method (NM) against the background of acceptable limits (second case)

is a noticeable decrease in the value with a characteristic visible point at 120 MHz.

The obtained correlation coefficient between QP values measured with both methods has a moderate value and reached 0.44 The graphs of recorded QP values for this lamp are presented in Fig. 8.

By comparing the received QP characteristics to their limits, a different situation than in the first case described above is observed.

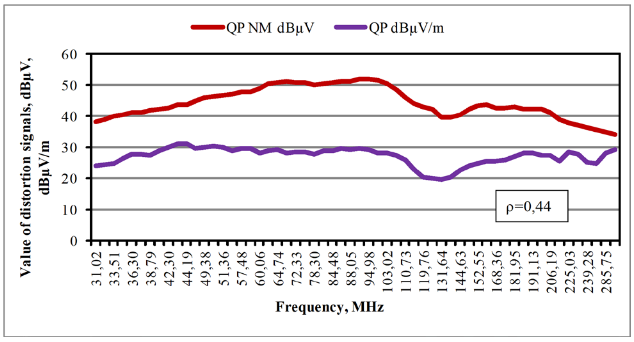

Fig. 8 Graphs of changes of QP values measured by traditional and alternative methods with calculated linear correlation coefficient (second case)

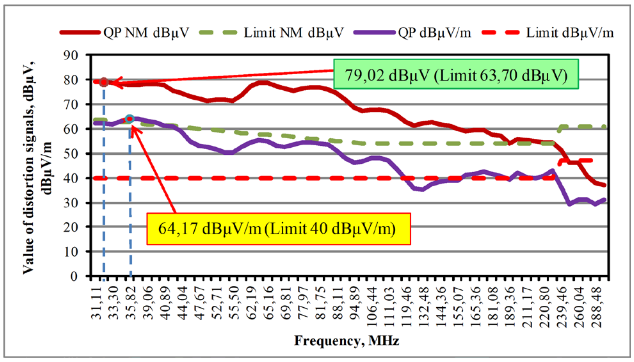

Fig. 9 Graphs of changes in QP values measured with the traditional and alternative method (NM) against the background of acceptable limits (third case)

3.3 Third case

The third case concerns a 18 W LED lamp where the QP values measured with both methods exceed the permitted limits. The characteristics of QP values against their permitted limits are presented in Fig. 9.

The quasi-peak (QP) values (presented in Fig. 9) exceeded acceptable limits in the broad frequency band, i.e.: from 30 MHz to 230 MHz. The disturbance signal emitted by this lamp (measured by both methods) had the highest overshoots for low frequency values. As the frequency increased, those values decreased reaching values close to the acceptable limits. The some selected, exemplary quasi-peak values measured using the traditional method (dBµV/m) and the corresponding values of frequency, limits and margins are listed in Table 4.

The values with minus sign in the "Margin" column indicate overshoots above the limit ("Limit" column), while positive values mean the existing QP value margin to the permitted limit. The changes in the QP value measured using the new and traditional method can be analyzed more precisely using statistical tools [5]. The results of statistical calculations for QP values measured with both methods and which showed overshoots beyond the acceptable limits are presented in Table 5.

The statistical quantities included in the table are: the mean value (x_{AV}), standard deviation (S), maximum value (Max), minimum value (Min), difference between the maximum and minimum value (R) and the number of QP values subjected to statistical analysis (L).

Analyzing the results, it can be concluded that in the case of using the traditional method 45 QP values per 60 registered ones exceeded the permissible limit (40 dB).

Table 4 Selected QP values measured with the traditional method together with limits and margins

Frequency MHz	QP dBµV/m	Limit dBµV/m	Margin dB
31.11	62.18	40.00	**-22.18**
31.56	62.06	40.00	**-22.07**
33.30	61.88	40.00	**-21.88**
…	…	…	…
94.89	46.18	40.00	**-6.18**
102.36	46.69	40.00	**-6.69**
106.44	47.92	40.00	**-7.92**
…	…	…	…
274.77	31.13	47.00	15.87
288.48	29.42	47.00	17.58
298.89	31.07	47.00	15.93

Table 5 The results of statistical analysis of QP values registered by traditional and new methods

Traditional Method				
Statistical parameter	Frequency MHz	**QP dBµV/m**	Limit dBµV/m	Margin dB
X_{AV}	90.10	**52.06**	40.00	**-12.06**
S	57.51	7.42	0.00	7.42
R	198.66	**23.73**	0	23.73
Min	31.11	**40.44**	40	**-24.17**
Max	229.77	**64.17**	40	**-0.44**
L	45	45	45	45
New alternative method				
Statistical parameter	Frequency MHz	**QP dBµV**	Limit dBµV	Margin dB
X_{AV}	98.70	**69.43**	56.97	**-12.46**
S	57.78	8.26	3.34	6.14
R	198.66	**24.73**	9.70	20.90
Min	31.11	**54.29**	54.00	**-21.19**
Max	229.77	**79.02**	63.70	**-0.29**
L	53	53	53	53

The QP results recorded using the new alternative method can be analyzed in a similar way. In the case of this method, 53 registered QP values have exceeded the allowed limit (out of 60 registered). This similarity can be seen in the characteristics of QP values recorded using traditional and alternative methods (Fig. 10). The calculated Pearson's linear correlation coefficient is 0.92. The value of this coefficient indicates a very strong correlation relationship between the analyzed characteristics of QP values. The positive value of this coefficient also indicates that when QP values measured with one method are decreased, the similar happens with QP values measured with the second method.

In the analyzed case, the linear correlation coefficient reached a value above 0.9, similar to the first described case. This may indicate that both methods: traditional and new, alternative allow to obtain very similar characteristics of QP values.

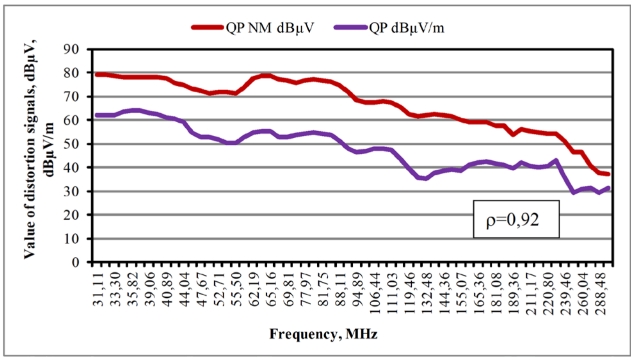

Fig. 10 Graphs of changes of QP values measured by traditional and alternative methods with calculated linear correlation coefficient

4 Conclusions

The two methods of testing the emission of disturbances generated by LED lamps in accordance with the guidelines in the EN 55015 standard have been analyzed in this paper. The advantage of the second method is the lack of the requirement to have an anechoic chamber, as well as that it is less time-consuming than the first, traditional method (about two times).

Comparing the QP values measured with one and the other alternative method in the context of the corresponding limits, it can be concluded that both methods do not give unambiguous equivalent results.

Even if the test results are positive for both methods, the safety margin can be very different and take the limit values.

It can be assumed that an alternative method can be used for light sources with higher nominal powers. However, when LED lamps with small nominal powers are tested, the results obtained using one or the other method may be weakly correlated.

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References

[1] Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility. [online] Available at: https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/electromagnetic-compatibility_en [Accessed: 10 October 2018]

[2] Džierš, G., Asmanis, A., Asmanis, G., Dzenis, A. "LED Lighting Equipment Electromagnetic Compatibility", In: 2017 IEEE 58th International Scientific Conference on Power and Electrical Engineering of Riga Technical University (RTUCON), Riga, Latvia, 2017, pp. 1–6. https://doi.org/10.1109/RTUCON.2017.8124832

[3] Matsumoto, Y, Wu, I., Gotoh, K., Ishigami, S. "Measurement and Modelling of Electromagnetic Noise from LED Lights Bulbs, IEEE Electromagnetic Compatibility Magazine, 2(4), pp. 58–66, 2013. https://doi.org/10.1109/MEMC.2013.6714699

[4] European Committee for Electrical Standardization "EN 55015/2013: Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment", CENELEC, Brussels, 2013.

[5] Ott, L. R., Longnecker M. "Introduction to Statistical Methods and Data Analysis", Brooks/Cole, Belmont, USA, 2010.