LIGHT SOURCES IMMUNITY TO SHORT VOLTAGE DIPS AND INTERRUPTIONS

Jiří Drápela
BUT – Czech republic
drapela@feec.vutbr.cz

Jaromír Bok
BUT – Czech republic
xbokja00@stud.feec.vutbr.cz

Jan Šlezingr
BUT – Czech republic
xslezi01@stud.feec.vutbr.cz

Jan Pithart
BUT – Czech republic
xpitha01@stud.feec.vutbr.cz

ABSTRACT

The short voltage dip is a short duration sudden reduction of RMS voltage and as the two dimensional electromagnetic disturbance, depth and duration time is used for its description. So a dip shape is a priori assumed to be a rectangular. Subsequently, the short voltage interruption is the short duration voltage dip to zero value. It is self-evident that no electric appliance can work continuously if its supply is interrupted. In the case of lamps, such voltage event bigger than their immunity level causes their restart with reduction in level of output luminous flux to zero for a restart period or just excessive or disturbing reduction in light level . Moreover in the worst case, it can leads also to their damage.

INTRODUCTION

The testing of electric devices immunity against the short voltage dips is given by the standard EN 61000-4-11 [3] that specifies testing techniques and sets testing levels. Concerning light sources the testing levels are set by the standard EN 61547 [4]. The testing voltage behaviour is based on nominal voltage of concrete lamp. The changes of voltage have to be very quick and can start and finish in any phase-angle of voltage. Pre-dip and post-dip voltage magnitude is equal to nominal voltage. Than resulting shape of the testing voltage dip is very close to rectangular one. The result of testing is determination of the electric appliance function condition during and after approved test. And there are defined three function criterions for light sources (EN 61547 [4]): criterion A) during and after testing without any changes of operation (of luminous flux); B) luminous flux magnitude can change during testing but failure of light source is not acceptable; C) the failure of light source is possible but it has to restore its initial parameters (before testing) until 30 min.

Determination of lamp immunity to voltage dips regarding only individual independent tests according to current standards and subsequent assignment of a function criterion is usually improper for practical usage. Preferable is to know behaviour of a limiting curve for fulfilling particular criterion. Because during described voltage events there always appear light changes, the criterion A cannot be fulfilled if there are no acceptable limits for luminous flux magnitude deviations. So the result of measurements should be determination of a immunity limiting curve to voltage dips fulfilling criterion B.

An equipment real world immunity level is a consequence of the large number of factor that may have an influence on the equipment response to various voltage disturbances and their cumulative effect [2].

Major part of these factors is included in fact in category of voltage supply related electrical characteristics, i.e. harmonic distortion of the testing voltage, the pre-dip and post-dip voltage magnitude, shape of the voltage event different from the rectangular, the initial voltage phase angel at the event beginning, etc. Nevertheless, lamp immunity depends mainly on its function principle, feeding circuit, physical characteristics, etc. The paper is closely focused on the each problem mentioned above and gives a large set of results obtained by well described measurements.

IMMUNITY CURVES

Immunity curve describes the devices sensitivity, which is given as the ability to correct working during short voltage dips and short voltage interruptions. Light sources, computer sources and other IT devices containing switch-mode power supplies (SMPS) are ones of the most sensitive devices to above mentioned voltage events [6]. Increasing usage of SMPS in electric devices led to creating of the well known Computer and Business Equipment Manufacturers Association (CBEMA) curve and its modified version known as the Information Technology Industry Council (ITIC) curve. ITIC curve was standardized by ANSI as IEEE 446 curve (Fig. 1) [7]. The curves are composed by two lines. The lines enclose the area in which the equipment is able to work without function modification. Immunity level to short voltage dips and interruptions is given by bottom curves.

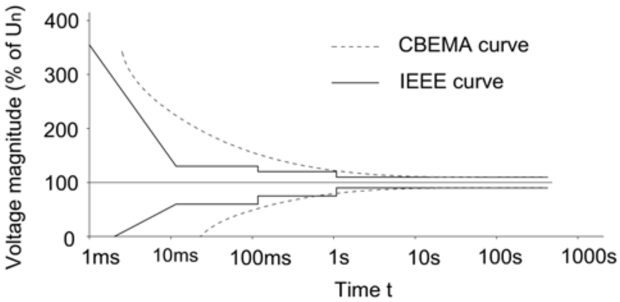


Fig.1 CBEMA and ANSI curve [7]

LAMPS IMMUNITY CURVES

Determination of function criteria

Before start of measuring process it is necessary to choose the function criteria, which will be monitored during the measurement. As it was mentioned above, in the case of lamps a signal corresponding to the luminous flux is the basic monitored value. The luminous flux is directly depended on the supply voltage, so the preferred function criterion is criterion B (EN 61547) - luminous flux magnitude can change during testing but failure of light source is not acceptable. The function criteria (A, B, C) are defined by standard EN 61547 [4], nevertheless this partition is not sufficient because there are a lot of possible changes of luminous flux during the immunity tests.

For more exactness, the function criterion B is possible to divide into three more detailed parts: B1) instantaneous value of luminous flux falls down to zero value and the tested light source is re-started; B2) mean value of the luminous flux smoothed by 1st oder low-pass filter with cut off frequency at 30 Hz, simulating approximate dynamic response of a human eye, decreases during adjusted voltage dip under the value which is equal to the value of luminous flux corresponding to allowed permanent deviation -10% from nominal supply voltage (90%U_n); B3) short voltage dip evokes a short blink of luminous flux and it is assessed in term of short term flicker severity index P_{st}. Short time flicker severity P_{st} measured by an "objective" flickermeter [8] over a period of ten minutes must not be higher than 1.

Factors affecting lamps immunity level

A light source real immunity level is a consequence of the large number of factors that may have an influence on the lamps response to various voltage disturbances and their cumulative effect. In reference to [2] these factors can be divided into the following general categories: 1) Voltage supply related electrical characteristic; 2) Equipment specific electrical characteristic; 3) Other, non-electrical characteristic. That all considering the lamp type, its topology, dimensioning, etc.

The topology of light source is the main parameter which essentially affects the immunity curves results. The topology effect is mostly viewable if we compare the incandescent lamp topology with the topology of the modern fluorescent lamp with the electronic ballast equipped by active power factor corrector (PFC) circuit. A summary of used types of ballasts is for example in [9].

It is evident that luminous flux emitted by incandescent lamp is more depend on the all voltage changes in the supply networks than luminous flux of fluorescent lamp because of the function principle. Otherwise, an incandescent bulb is able to continuously change the luminous flux output to zero during voltage dips without an time-level discontinuity, in comparison with discharge lamps.

Overview of all tested light sources of different types is shown at Table 1.

Table 1 Overview of measured light sources

Sign	Type of the tested light source; type of the used ballast
Lamp 1	Incandescent lamp TUNGSRAM 60W
Lamp 2	Compact fluorescent lamp PHILIPS SL 13W, built-in induction ballast
Lamp 3	Compact fluorescent lamp OSRAM EL 23W/830; built-in electronic ballast
Lamp 4	Linear fluorescent lamp PHILIPS TL-D 18W; induction ballast LAYRTON ARC 20W
Lamp 5	Linear fluorescent lamp PHILIPS TL-D 18W; induction ballast LAYRTON ARC 20W; PFC capacitor 4,7μF
Lamp 6	Linear fluorescent lamp OSRAM L 58W/20; induction ballast LAYRTON ARC 65/23
Lamp 7	Linear fluorescent lamp OSRAM L 36W/20; electronic ballast ZUMTOBEL LM-PCA 2/32
Lamp 8	Linear fluorescent lamp OSRAM L 58W/20; electronic ballast HELVAR 1x58W HFC
Lamp 9	High pressure sodium lamp TESLA SHL 50W; induction ballast VOSSLOCH SCHVABE 50W; 8μF
Lamp 10	High pressure sodium lamp OSRAM VIALox 70W; induction ballast ERC 70W; 12,5μF
Lamp 11	High pressure mercury lamp TESLA RVL-X 80W; induction ballast ERC 80W; 8μF
Lamp 12	High pressure metal-halide lamp OSRAM 150W (POWERSTAR); induction ballast TRIDONIC.ATCO 150W; 20μF
Lamp 13	High pressure metal-halide lamp PHILIPS HPI-T 400W; induction ballast TRM 400W; 30μF

Description of voltage events used during tests

Testing voltage shape parameters were as follows: 1) sine voltage, nominal pre-dip voltage RMS value of 230V, rectangular shape of voltage dip; 2) sine voltage, variable pre-dip voltage RMS value, rectangular shape of voltage dip; 3) sine voltage distorted by harmonics, nominal pre-dip voltage RMS value of 230V, rectangular shape of voltage dip.

Immunity curves measurements

The test set-up is shown at Fig. 2. The measurement was realized by using programmable power source California Instruments CI 15003iX. It is a power simulator of supply network that is intended for testing the electric appliances for all low-frequency conducted phenomena, which are expected to be in the public supply networks.

After tested lamp connection to supply network the luminous flux has an increasing tendency till it will be stabilized on the nominal value. In the case of some specific lamp types the process of luminous flux stabilization can run for several minutes; typically up to 30 minutes. As soon as the luminous flux is stabilized, it is necessary to note its value. This value is a nominal luminous flux and it is important for later measurements, because if the luminous flux after previous voltage dip does not reach its nominal value, it is not possible to start the next voltage event.

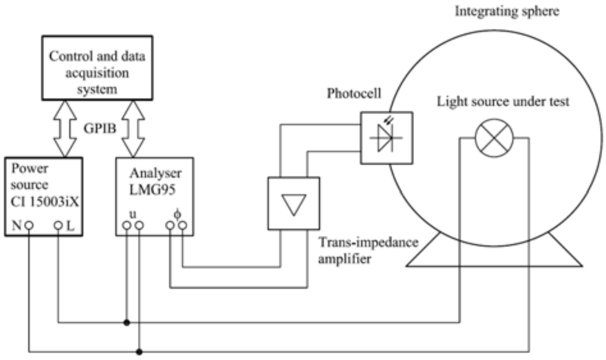
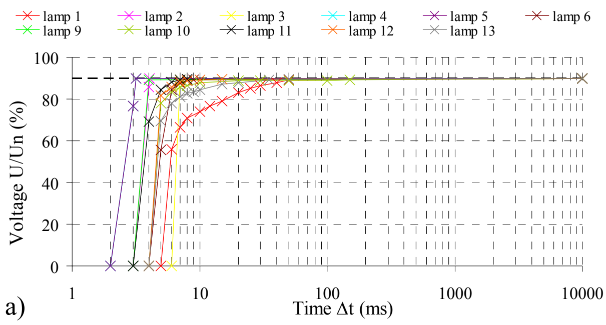


Fig. 2 Block diagram of all equipments used for tests

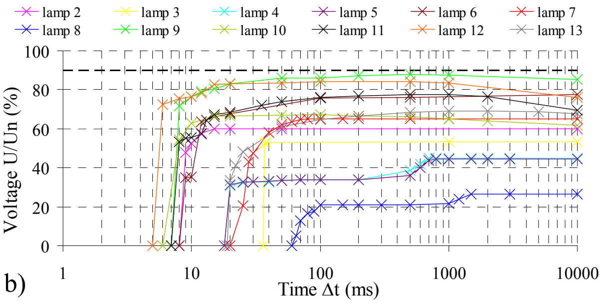
The same process must be done for the 90% of nominal voltage U_n. The luminous flux evoked by this value of supply voltage is still tolerable, because 90% of nominal voltage value is in the allowable limit $U_n \pm 10\%$ (EN 50160). This value of luminous flux is equal to the limit for immunity curves measurements on the basis of function criterion B2. For function criterion B1 the bottom limit is one percentage of the nominal luminous flux. The transients fulfilling the set-up conditions, according to each criterion, for measured and conditioned signal are recorded by LMG 95 measuring device.

Measurement results

Influence of lamp types on resulting immunity curves is shown in Fig. 3. Difference between curves fulfilling the criteria B1 and B2 is shown in Fig. 4. Influence of variable pre-dip voltage RMS value is shown in Fig. 5 and in Fig.6. Influence of harmonic distortion of supply voltage is shown in Fig. 7 and in Fig. 8. And finally, influence of a light source output regulation level is shown in Fig. 9.



a)



b)

Fig. 3 Immunity curves of all tested light sources for a) function criterion B2; and b) for function criterion B1; sine wave, nominal pre-dip voltage RMS value of 230V, rectangular shape of voltage dip.

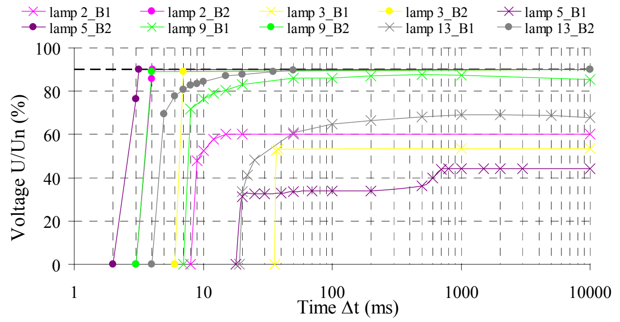


Fig. 4 Immunity curves of some of tested light sources, criteria B1 and B2; sin wave, nominal pre-dip voltage RMS value of 230V, rectangular shape of voltage dip

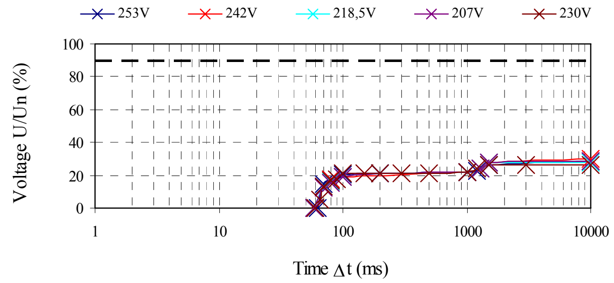


Fig. 5 Immunity curves of linear fluorescent lamp OSRAM L58W/20 with electronic ballast (lamp 8), criterion B1; sine wave, rectangular shape of voltage dip, variable pre-dip voltage RMS values

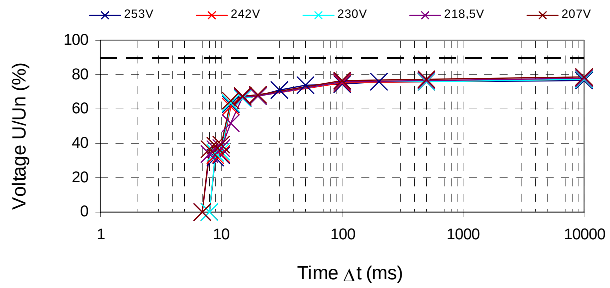


Fig. 6 Immunity curves of linear fluorescent lamp OSRAM L58W/20 with induction ballast (lamp 6), criterion B1; sine wave, rectangular shape of voltage dip, variable pre-dip RMS voltage values

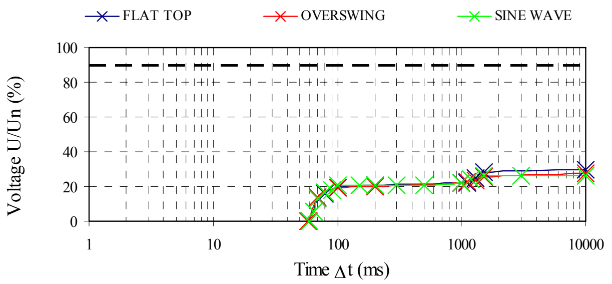


Fig. 7 Immunity curves of linear fluorescent lamp OSRAM L58W/20 with electronic ballast (lamp 8), criterion B1; distortion wave (THD = 8% [6]), rectangular shape of voltage dip, nominal pre-dip RMS voltage value of 230V

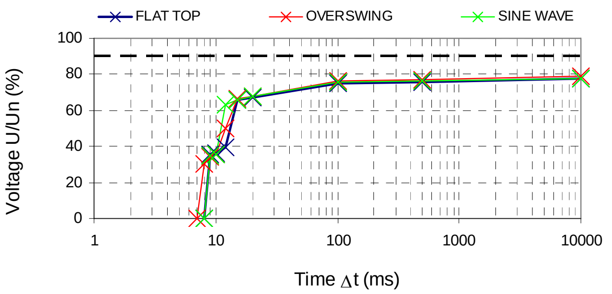


Fig. 8 Immunity curves of linear fluorescent lamp OSRAM L58W/20 with induction ballast (lamp 6), criterion B1; distortion wave (THD = 8%), rectangular shape of voltage dip, nominal pre-dip RMS voltage value of 230V

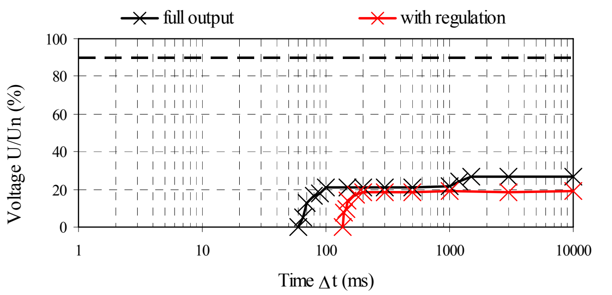


Fig. 9 Immunity curves of linear fluorescent lamp OSRAM L58W/20 with electronic ballast (lamp 8), criterion B1; sine wave, rectangular shape of voltage dip, nominal pre-dip voltage RMS value of 230V, influence of luminous flux regulation to 10% of its nominal value

CONCLUSION

The classification of the light sources immunity level to short voltage dips and interruptions according to the standard EN 61547 is not sufficiently described because the test result do not determine the immunity level, but only the function condition during and after approved test. Moreover, there are not included all kinds of disturbing factors which are possible in real world conditions. The classification of immunity level would be evaluated by the real voltage events in the public supply networks. The results will have a better predicative ability above the tested equipment.

Acknowledgments

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