

## EMC Requirements and Test Methods for Light Emitting Diodes

**Abstract :** EMC test is important for the reliability improvement of LEDs and their application products. This paper introduces the EMC requirements for LED chips, LED devices and LED application products, focusing on electrostatic discharge, electrical fast transient, thunder stroke surge, voltage dip, conductive interference and radio frequency interference. Corresponding test methods are also given. These EMC requirements and test methods are valuable for LED manufacturer and end users.

**Streszczenie:** W artykule przedstawiono wymagania EMC w stosunku do LEDów oraz urządzeń z nimi współpracujących, takich jak wyładowania elektrostatyczne, stany przejściowe, skoki napięcia, interferencje. Przedstawiono odpowiednie metody badawcze. (Wymagania elektrokompatybilności i metody badania układów LED)

**Keywords:** LED; EMC; EMI; EMS; test method

**Słowa kluczowe:** diody LED, kompatybilność elektromagnetyczna

### Introduction

During the research or the manufacture of the LED (Light Emitting Diode) should be familiar with the phenomenon as followings: LED chips or the LED will go wrong and don't work after they have been touched during the transportation; the LED application products (such as LED lamps, LED display screen) will stop working suddenly and then go on working, in some serious conditions should restarted it and then it can function well; the outdoor using LED application products often burning out during the thunder stroke. The major reason isn't the poor in the reliability. For the LED chips or the LED devices is the weak in the static electric immunity. For the outdoor using LED products is the weak ability in bearing the high power pulse interference, when there is surge pulse in the circuit it will burning out. In summary all those are the EMC issues.

Recently, the EMC (Electromagnetic Compatibility) test has been more and more widely used as an important way in improving the reliability of the LED by the international advanced research and manufacture department<sup>[1][2]</sup>. Some companies have put the EMC test and evaluating in the acceptance of delivery and improve its reliability to strengthen its competitiveness. On the whole, EMC test is still a new field for Chinese LED companies. This paper gives a major introduction for the EMC requirements for the LED chips, LED devices and the LED application products. Such as the electrostatic discharge (ESD) [1][2][3], electrical fast transient (EFT) [1][2], thunder stroke surge and voltage dip, at the same time will give some introductions for the relevant test methods.

### EMC requirements for the LED chips and devices and the test methods

ESD is a normal natural phenomenon which can affect the electronic products everywhere; it's a very harmful electromagnetic energy. Only by improving the static electric immunity can make sure that the electronic products be safety used. And use the electrostatic discharge immunity to measure the static electric immunity of the electronic products. (EN/IEC 61000 4-2) [4]

For the LED chips and devices the most important EMC requirements is the electrostatic discharge immunity, this requirement has a crucial role in ensuring the reliability in anti-static electronic during the transportation, storage and application.

### Test methods

In low humidity environment, human body will get charged by friction. The charged human body will discharge

the equipment when they contacted. And the test for the electrostatic discharge immunity imitates two conditions as following:

- (1) The equipment operator contacts the equipment directly at the same time discharge the equipment and the influence on the equipment caused by the discharge.
- (2) The equipment operator contacts the equipment nearby, and the influence on other equipment which is concerned with this equipment.

And in condition (1) which is called directly discharge and condition (2) indirectly discharge.

For the LED chips and devices, the electrostatic discharge test should prefer to the electro-contact discharge, following are the reasons:

1. Electro-contact discharge has few uncertain reasons.
2. Electro-contact discharge has a sharp wave in the rise time, so the discharge current has abundant harmonic wave component, even under the lower voltage condition, we can also get the more stringent result when compared with higher voltage air discharge in the same degree.

### Test system

The test system contains the sensitive electrostatic discharge generator (specifically used for the anti-static electronic test of the sensitive semiconductor devices, electronic circuit and equipment, electrostatic discharge voltage is between 0—40Kv) and the test bed special for the electrostatic discharge, better earthing line but no special request for shielding room conditions. But we should pay special attention to that, the size of the LED chips is so small that a probe station special for LED is needed during the test.

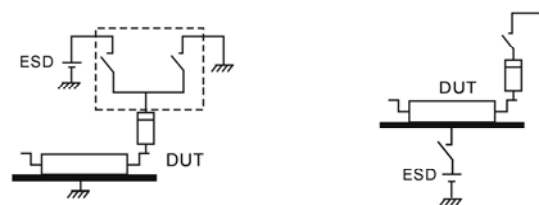


Fig.1. Diagrammatic sketch for the LED chips' electrostatic discharge test

The typical test method is as figure 1, and the figure 2 is the typical discharge waveform for the electrostatic discharge test, figure a is discharge waveform for human body's electrostatic discharge test and figure b is discharge

waveform for machine's electrostatic discharge test, figure c is the latest internationally used standard waveform (combination waveform) ruled by the IEC (International Electrotechnical Commission). And during the test for LED; the latest standard waveform ruled by IEC is preferred.

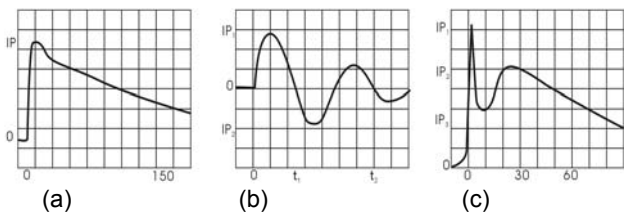


Fig.2. Waveform output from the electrostatic discharge generator

### EMC requirements and test method for LED application products

In real applications, commonly have plural LEDs and control circuit together in groups, such as the LED modules, LED lamps, LED screen display, it is necessary for improving the reliability of LED application products to test the EMC of the control circuit. And the main EMC test contains the electrostatic discharge (ESD), electrical fast transient (EFT), thunderstroke surge and voltage dip and the electromagnetic interference (including the conducted interference and the radiated interference), the paper will give a detailed introduction.[9][10]

### Electrostatic discharge immunity

For LED application products, the Electrostatic discharge immunity test method is basically the same as the LED chips and the LED devices, but the differences are: for the LED application products should take the contact discharge and air discharge those two methods together and use the ESD operator which is according to the IEC61000-4-2 standard, also higher requirements for the test degree.[4][8]

### Electrical fast transient immunity

EFT (Electrical Fast Transient) [1][2] means the pulse train has the specific duration (15ms) and the specific pulse period (300ms), and the single pulse in the pulse train has the specific repetition period, voltage, rise time and the pulse width. The duration of the pulse train is 15ms, the gap time between the pulse trains is 300ms, the width for the single pulse is  $50\text{ns} \pm 30\%$ , the pulse amplitude is 2KV, and the pulse leading edge is  $5\text{ns} \pm 30\%$ , pulse repetition rate is  $2.5\text{KHz} \pm 20\%$ . The positive and negative pulse train interference time is one minute. (IEC61000-4-4) [5].

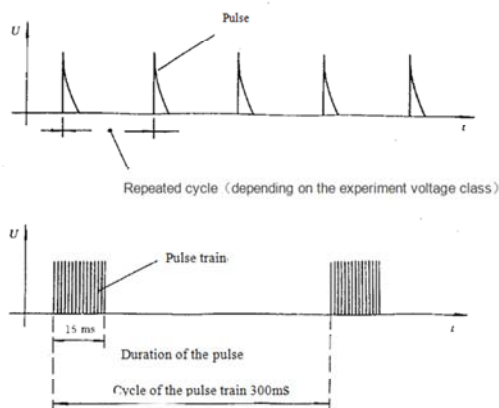


Fig.3. Waveform of the EFT pulse strain

The EFT immunity test is very important for LED application products' control circuit. The waveform is shown in figure 3. The principle of the test is: when the EFT pulse strain operator imitates the interference caused by the power system machinery switch on the inductive load, the high voltage and fast electric pulse caused by the operator via the specific CDN (coupling decoupling net) or the capacitive coupling clamp coupling to the power line or the signal port of the tested equipment.

The strict requirements for the LED EFT test are as follows: waveform's rise time is 5ns and half peak time is 50ns, repetition frequency is 5kHz, different port has the different voltage requirements, and detailed requirements are: signal /control port: 0.5kV (peak value), DC power supply input/output port: 0.5kV (peak value), AC power supply input/output port: 1kV (peak value), and up to 4kV test under the most harsh condition, shown in figure 4.

This test can be in unshielded conditions but has to accord to the requirements of the provision for earthing.

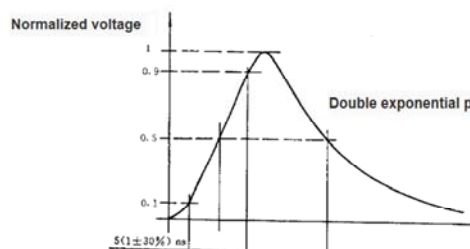


Fig.4. Waveform of single pulse under 50Ω load

### Thunderstroke surge immunity

Thunderstroke is a normal physical phenomenon, according to the statistics, there are more than 40,000 thunderstroke center in the world, everyday more than 8,000,000 times thunderstroke happens. This means there are about 100 times thunderstroke in a minute. So it is important to test the thunderstroke surge for evaluating the suffered high power pulse interference of the LED products' control circuit.

The test equipment contains: thunderstroke surge generator, CDN, safety isolating transformer, the test shouldn't be in the shielding room but well isolating power supply and filtering are necessary. Special attention should pay to that: the energy of the thunderstroke surge is so powerful that can be harmful to people's life, so should be careful during the operation.

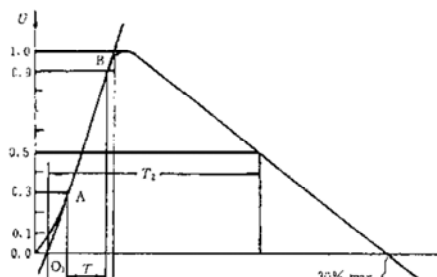


Fig. 5. Waveform of the open circuit voltage for thunderstroke surge generator (time to crest:  $T_1=1.67 \times T=1.2\mu\text{s} \pm 30\%$ , half peak time:  $T_2=50\mu\text{s} \pm 20\%$ )

This test only measure the AC power supply input port, both five negative and positive pulse should be added to the peak and zero crossing point of the AC voltage (totally 20

pulses), pulse waveform 1.2/50 $\mu$ s, the test voltage should be different according to the test object and put 1.0kV or 2.0kV peak voltage to the "line-ground", 0.5kV or 1.0kV peak voltage to the "line-line". Of course if necessary 6kV test is allowable. The test waveform is shown in figure 5 and figure 6.

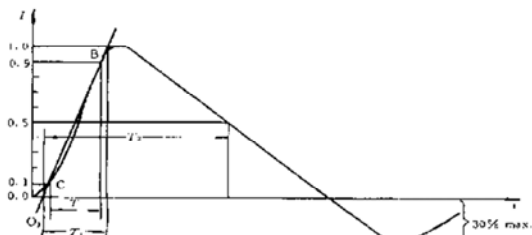


Fig. 6 Waveform of the short circuit current for thunderstroke surge generator (time to crest:  $T_1=1.25 \times T=8s \pm 20\%$ , half peak time:  $T_2=20\mu s \pm 20\%$ )

### Voltage dip immunity

Voltage dip is the dip test for the power supply system in integral multiple time of the mains frequency (50Hz) cycle. Usually 0.05-3000cycle time, which equals 10ms-1 min.<sup>[1][2]</sup> The waveform of the voltage sags in the power system is shown in figure 7.

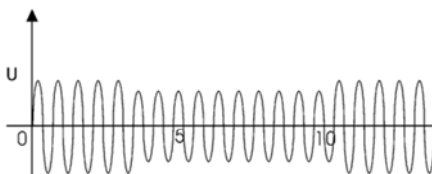


Fig.7. Waveform of the voltage sags in the power system

This test contains the voltage sags, short interruption and the voltage change, to check the LED products' capacity of resisting disturbance in unstable power system. The equipment for the test is just voltage dip imitator no other specific requirement but very meaningful for the products.

The test only measure the AC power supply input port, voltage sags is descend 30%, the number of the cycle is 10 times main frequency cycles, voltage short interruption ( voltage descend 100% ), the number of the cycle is 0.5 times main frequency cycles. Figure 8 is the tested waveform of the voltage change.

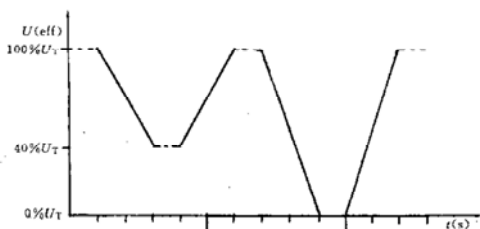


Fig.8. Tested waveform of the voltage change

### Conductive interference

Conductive interference: means coupling the signal from one electronic network to another by the conductive media. The test for the power line's conductive interference is in the shielding room, shown as figure 9.

The test instruments are: EMI receiving measure instrument and artificial mains network.

### 1. EMI receiving measurement instrument

The core measurement instrument for the inductive interference is EMI receiving measurement instrument (short for EMI receiver). Now the IEC standard test frequency band requirement for the lighting equipment is 9 kHz-30MHz, and IEC is thinking about improving the upper limit. Because IEC/CISPR 16<sup>th</sup> edition has just required the receiver's technique data 9 kHz-1GHz, so 9 kHz-1GHz is enough for the LED application products' test.<sup>[6]</sup>

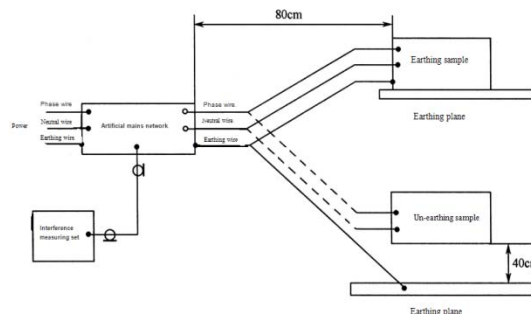


Fig. 9. Typical arrangements for the test of the power line conductive interference

### 2. Artificial mains network

Artificial mains network is essential attachment for EMI conductive interference test, its main function is providing specified impedance for the tested equipment port in the radio frequency range, at the same time separating the useless radio frequency signals in the power source from the tested electronic circuit and coupling the interference voltage to the EMI receiver. Usually choose the 50 $\Omega$  / (50 $\mu$ H+5 $\Omega$ ) double lines V style artificial mains network, figure10 shows the schematic.

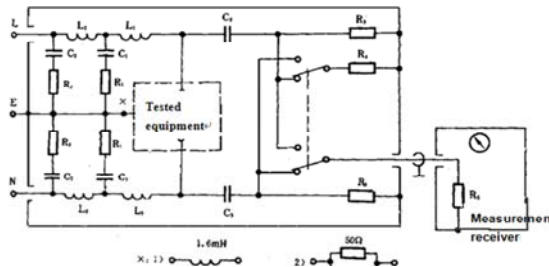


Fig.10. Schematic for the 50 $\Omega$  / (50 $\mu$ H+5 $\Omega$ ) double lines V style artificial mains network

### Radio Frequency Interference

Radio Frequency Interference (RFI) is an electromagnetic interference, existing in the communication equipment or the computer operator equipment, partly of the interference source were emission from the circuit of the equipment or the radio antenna. In some conditions, too much amplitude (interference) can lead to the blocking of the radio transmission or the breakdown of the computer operator equipment. [1][2]

Test method: in the radio frequency range 9 kHz-30MHz, use the 2m diameter big loop antenna to measure the magnetic field component current peak value of the radio frequency interference uniformly intensity, antenna through the current and voltage convertor can export to the EMI receiver directly, and the EMI receiver detect the LED equipment's RIF, shown in figure 11.

Notice that the space between the antenna external

diameter and wall surface, the ground is at least 0.5m. The antenna should be well adjusted. The over load of the antenna will lead to very serious results, so should keep this in mind. The test should be in the shielding room, if in poor conditions the room where the electromagnetic radiation is lower is also be allowable.

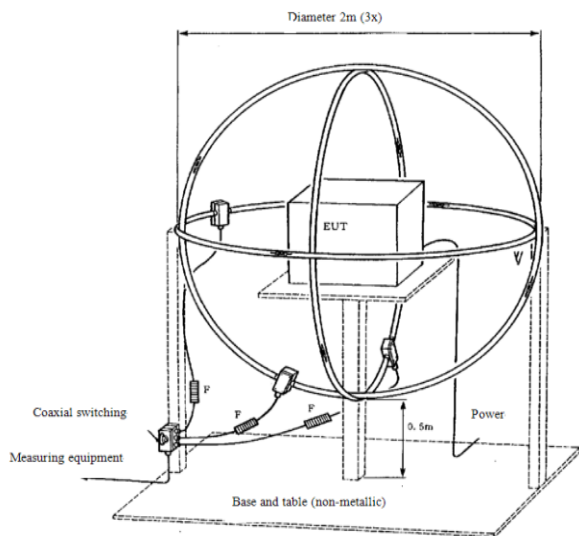


Fig. 11. Schematic diagrams for the big loop antenna

### Conclusion

This paper systematically introduces the EMC requirements, test method and environmental requirements for LED chips, devices and application products. For the LED chips and devices, the most important EMC requirement is the electrostatic discharge immunity. For LED application products, electrostatic discharge, electrical fast transient, thunder stroke surge, voltage dip, conductive interference and radio frequency interference should be

considered. These EMC requirements and test methods are valuable for LED manufacturer and end users.

### REFERENCES

- [1] V.Prasad Kodali Engineering Electromagnetic Compatibility Principles, Measurements, Technologies, and Computer Models (Second Edition) 2005
- [2] Clayton R.Paul Introduction to Electromagnetic Compatibility (Second Edition)
- [3] LIU Jin ,CHEN Yong-guang ,TAN Zhi-liang and CHEN Xiang, Transactions of BeiJing Institute of Technology Research on Irradiation Effect of Electrostatic Discharge Radiation Field 2011
- [4] IEC 61000-4-2 Electromagnetic compatibility (EMC)-Part 4-2: Testing and measurement techniques-electrostatic discharge immunity test. 2002
- [5] Francesco Musolino; Franco Fiori IEEE Transactions on Electromagnetic Compatibility Modeling the IEC 61000-4-4 EFT Injection Clamp 2008, 50 (4)
- [6] IEC/CISPR NO.16 Edition 2008
- [7] Aiyong He, Safety & EMC, Difference of Standard Edition IEC 61000-4-11and Effect to Measurement 2008
- [8] International Electrotechnical Commission. IEC 61000-4-2 : 2001 electromagnetic compatibility (EMC) : part 4-2 : testing and measurement techniques : electrostatic discharge immunity test [ S ] . Geneva, Switzerland : IEC Central Office , 2002.
- [9] National Standards of Peoples Republic of China GB /T 18595-2001 / IEC 61547:1995 Equipment for general lighting purposes-EMC immunity requirements
- [10] National Standards of Peoples Republic of China GB 17625.1-2003 / IEC61000-3-2:2001

**\*Corresponding author:** Dr. Haiping Shen, Fudan University, No. 220 Handan Road, Shanghai 200433, China.Tel: +86-21-55664541, Fax: +86-21-55665163, E-mail: shenhaiping@fudan.edu.cn