Chroma

LED Power Driver

Test Guide

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Version 1.2
June 2014

Revision History

The following lists the additions, deletions and modifications in this manual at each revision.

Date	Version	Revised Sections
Oct. 2012	1.0	Complete this manual.
Nov. 2012	1.1	Modify the following: – The description of “dimming frequency” and “dimming duty” in the section of “*Dimming Current, Dimming Frequency & Dimming Duty*” – Specifications in “*Appendix A LED Driver Technical Specification*”
Jun. 2014	1.2	Add the following: - “*Dielectric Withstand / Hipot Test*”, “*Insulation Resistance Test*”, “*Leakage Current Test*”, “*Protective Ground*” sections in the chapter of “*Terminology & Definition*.” - “*Electrical Safety Test*” section in the chapter of “*Test Item, Specification & Purpose*.” ◦ Update the following: - “*Test Device Diagram*” and “*Recommended Device Function & Specification*” section in the chapter of “*Test Set-up*.” - Contents in the chapter of “*Reference Documents*.”

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Preface

With no suitable test standards for LED drivers in the present market, validation has been minimal causing a variance in the quality of LED drivers. This brings potential concern for the development of the entire market as competition increases and quality as well as quantity is unable to improve. For lighting manufacturers, it could bring great risk to their own lighting product quality if they do not source drivers that meet or exceed quality standards. For power manufacturers, currently the produced power source is only applicable for one or few lighting manufacturers and the development of orders and production is limited. Without validated specifications the power supply manufacturer is unable to predict the power usage and unable to stock inventory accurately for mass production. From maintenance perspective, lack of unified specifications and compatibility among products could result in repair and service problems when LED lighting malfunctions occur.

To further advance the technical development of the LED driver for secure, high performance and reliability, Chroma has defined this test specification based on its 26 years of specialized knowledge in the power testing field and the professional testing experiences from various manufacturers.

1. Scope

This technical document specifies the terminologies, their definitions, and describes the product categories and test items, etc. This guide is applicable for LED driver test for luminance.

2. Terminology & Definition

The definitions and objectives of the following are applicable for this guide.

2.1 LED Power Driver

It is the power supply device to drive LED which is also called LED driver.

2.2 Output Voltage

It is the output voltage of LED driver.

$$V_{DC} = \frac{1}{T}\int_0^T v(t)dt$$

2.3 Output Current

It is the output current of LED driver.

$$I_{DC} = \frac{1}{T}\int_0^T i(t)dt$$

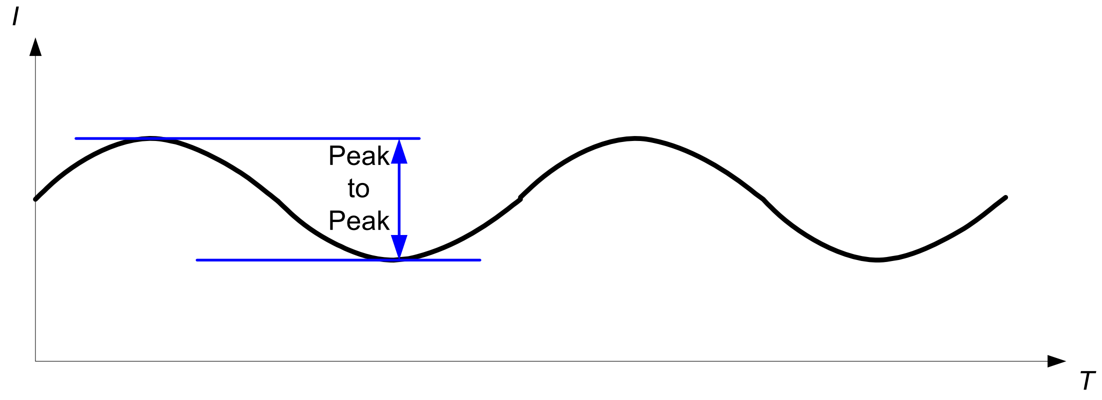
2.4 Ripple Current

It is the output current ripple size of LED driver which is the AC component of output current.

$$I_{ripple} = \sqrt{\frac{1}{T}\int_0^T i_{ac}^2(t)dt}$$

2.5 Peak to Peak Current

It is the peak to peak current of LED driver.

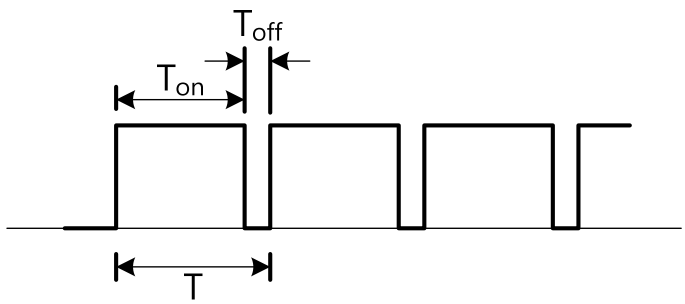


2.6 Dimming Current

It is the output current when the LED driver performs dimming.

2.7 Dimming Frequency

It is the frequency when the LED driver performs dimming using PWM.



$$F_{Dimming} = \frac{1}{T} = \frac{1}{(T_{on} + T_{off})}$$

The frequency is the countdown of LED Ton and Toff one cycle time adding up.

2.8 Dimming Duty

It is the Ton and duty percentage of dimming when LED driver uses PWM to perform dimming.

$$Duty = \frac{T_{on}}{(T_{on} + T_{off})} \times 100\%$$

2.9 Efficiency

Efficiency is the percentage of output effective power vs. input effective power.

P_{in}: The real input power of DUT (Device Under Test)

$$P_{in} = \frac{1}{T}\int_{0}^{T} V_{in}(t) \times I_{in}(t)dt$$

P_{out}: The total output power of DUT (Device Under Test)

$$P_{out} = \sum_{i}^{n} V_{out}(i) \times I_{out}(i)$$

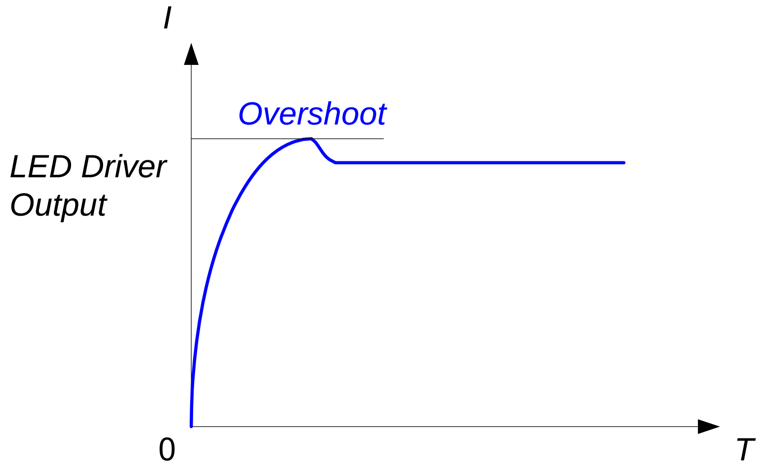
where n is the total output set of DUT (Device Under Test)
$V_{out}(i)$ is the output voltage of each set
$I_{out}(i)$ is the output current of each set

Eff: Efficiency (indicated by %)

$$Eff = \frac{P_{out}}{P_{in}} \times 100\%$$

2.10 Turn-on Overshoot Current

It is the transient peak (I peak) of output current when the LED driver is on.



2.11 Input Inrush Current

It is the transient inrush current of LED driver provided by AC. Inrush current means the current to convert to LED power source instantly when the LED driver is in cold start under room temperature. This specification defines the maximum value of inrush current.

2.12 Input RMS Current

It is the RMS current provided to LED.

$$Irms = \sqrt{\frac{1}{T}\int_0^T i^2(t)dt}$$

2.13 Input Peak Current

It is the highest input AC current provided by AC when the LED driver output is in steady state.

$$I_{peak} = I_{rms} \times CF$$

I_{rms}: Input RMS
CF: Crest Factor

2.14 Input Power

It is the Active Power W of LED driver provided by AC.

$$P_{in} = \frac{1}{T}\int_0^T V_{in}(t) \times I_{in}(t)dt$$

2.15 Current Harmonics

Current harmonics is the integer multiple frequencies current value of basic frequency.

$$i_n(t) = I_{n\_peak} \cos n\omega t$$

n: n level of harmonics
I_{n_peak}: The n level of harmonics current peak.

Total Harmonic Distortion (THDi) is the sum of each harmonic RMS and ratio of basic frequency RMS.

$$THDi = \frac{\sqrt{\sum_{n \neq 1}^{\infty} I^2_{n,\ rms}}}{I_{1,\ rms}} \times 100\%$$

2.16 Input Power Factor

The input power factor is the ratio of input valid voltage and current product.

$$PF = \frac{P_{in}}{V_{in(rms)} \times I_{in(rms)}}$$

2.17 Power Line Disturbance Simulation

It is the required condition for voltage interference test to LED power. That is to change the input voltage, input frequency to make sure if the output voltage, output current will be affected by the change of input.

2.18 Line Regulation

When the voltage of LED driver provided by AC is changed, it causes the LED driver output voltage or current to change.

2.19 Load Regulation

When the LED driver output changes due to load, it causes the LED driver output voltage or current to change.

2.20 Total Regulation

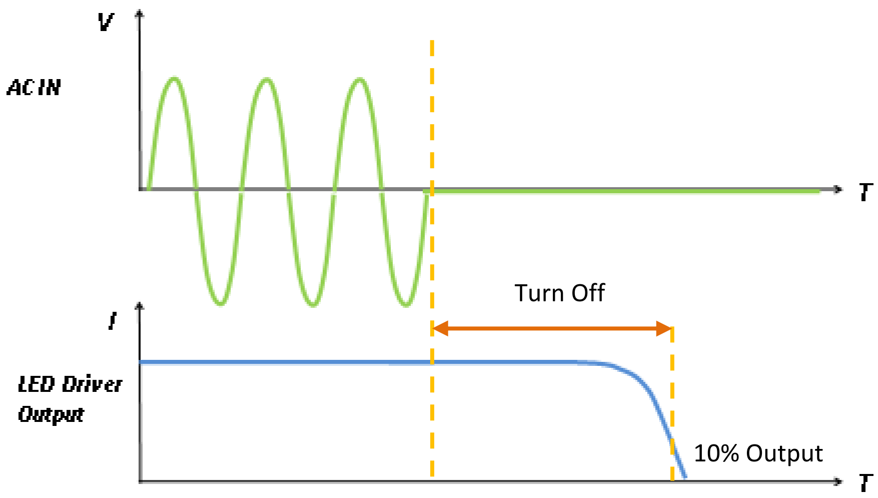
When the AC input voltage and output terminal change due to load, it causes the LED driver output voltage or current to change.

2.21 Turn On Time

When the LED driver is under static load condition, the time in which the AC input start to LED driver output voltage or current rises to the specified time.

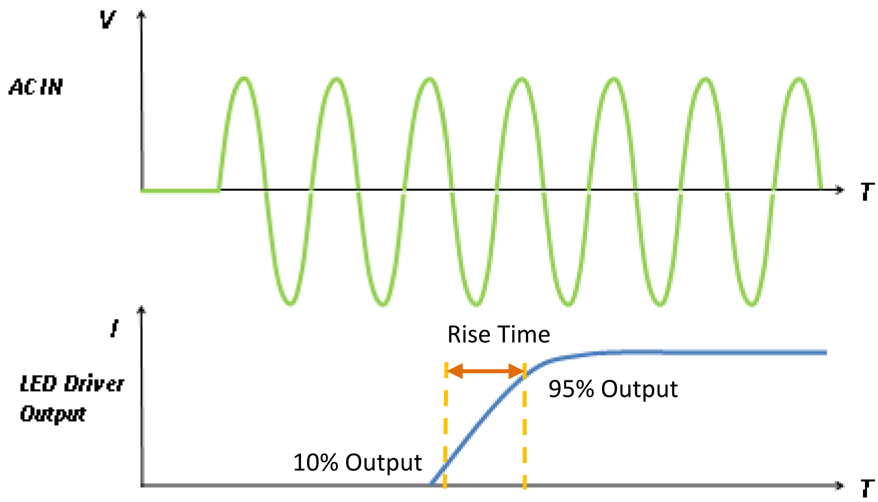
2.22 Turn Off Time

When the LED driver is under static load condition, the time of AC input stop to LED driver output voltage or current falls to the specified time means turn off time.



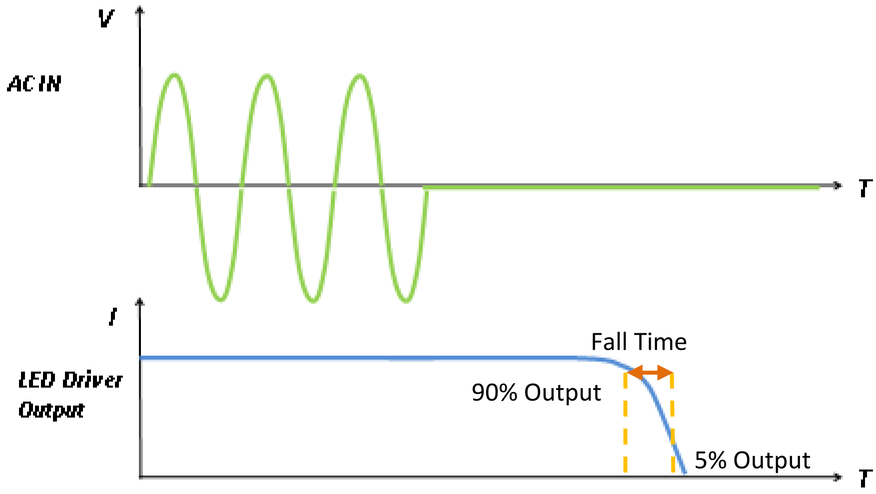
2.23 Rise Time

The rise time is specified for output current such as 10%~95% when the LED driver is in static load condition.



2.24 Fall Time

The fall time specified for output current such as 90%~5% when the LED driver is in static load condition.



2.25 Short Circuit

It is the self-protection mechanism when the LED driver is shorted during output.

2.26 Over Voltage Protection

It is the self-protection mechanism when the LED driver outputs over voltage.

2.27 Over Current Protection

It is the self-protection mechanism when the LED driver outputs over current.

2.28 Over Power Protection

It is the self-protection mechanism when the LED driver outputs over power.

2.29 Dielectric Withstand / Hipot Test

The withstand voltage test is to apply a high voltage on the product's power and ground ends to measure the leakage current and judge the product's insulation status.

2.30 Insulation Resistance Test

It measures the product's electrical insulation status.

2.31 Leakage Current Test

It inspects if the leakage current of AC/DC power source to ground is over the standard.

2.32 Protective Ground

It inspects if the touchable metal parts are properly grounded to earth.

3. Product Categories

3.1 Product Types

3.1.1 By Industry

a. Lighting.
b. Backlighting.

3.1.2 By Current Output

a. AC voltage to DC current.
b. DC voltage to DC current.

3.1.3 By Voltage Output

a. AC voltage to DC voltage.
b. DC voltage to DC voltage.
c. AC voltage to AC voltage.

4. Test Item, Specification & Purpose

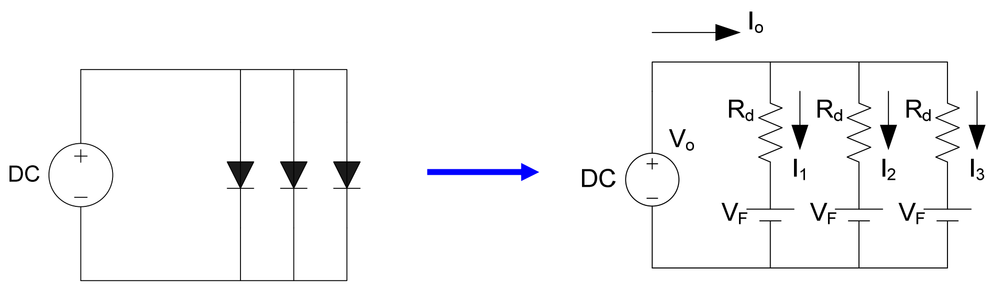
4.1 Output Performances

4.1.1 Output Voltage

Test Specification:
The permissible range of rated voltage should be within ±5% of constant voltage for LED driver output.

Purpose & Influence:
The output voltage test is to inspect the stability of LED output voltage to ensure the following would not happen to LED due to unstable voltage.

a. LED is unable to light up (when the output voltage is too low.)
   As the figure shown below, when the output voltage (V_o) is smaller than forward bias (V_F), it cannot light up.
b. Shorten the LED life (when the output voltage is too high.)
   When the output voltage (V_o) is too high, the forward current ($I_1 = \frac{V_o - V_F}{R_d}$) will be too large shortening the LED life.



4.1.2 Output Current

Test Specification:
The permissible range of rated current should be within ±10% of constant current for LED driver output.

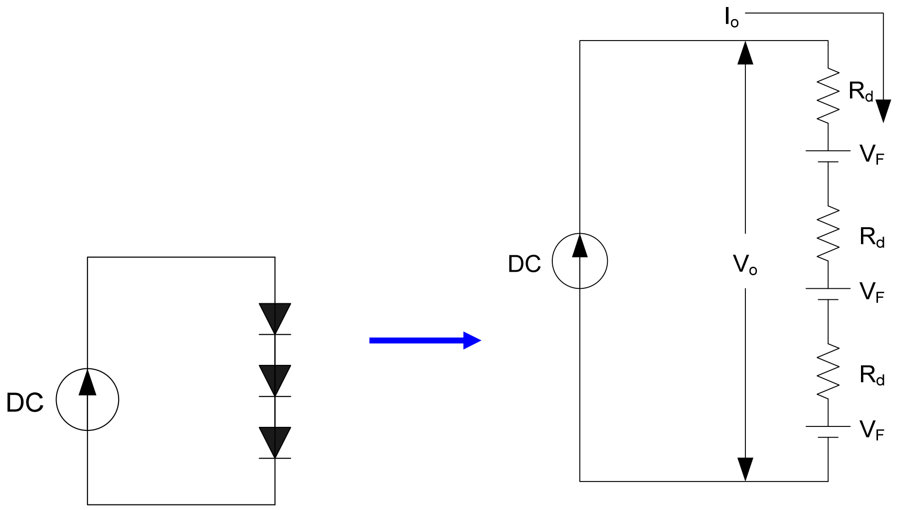
Purpose & Influence:
The output current test is very important to the constant current of LED power. It tests the output current stability of LED driver to ensure the following would not happen to LED due to unstable current.

a. LED is unable to light up.
   The LED is unable to light up when the output current (I_o) is smaller than the minimum current to drive LED.
b. Luminance non-uniformity for multichannel LED

When driving the parallel LED, the current varies easily for each channel (for instance I_1, I_2, I_3) and causes the LED luminance non-uniformity for multichannel.

c. Shorten the LED life
Unstable output current (I_o) is easy to shorten the LED life.

d. LED luminance does not meet the design requirement.
LED is driving by current and if the output current (I_o) does not meet the design, the LED luminance is unable to reach the design requirement.



4.1.3 Ripple Current

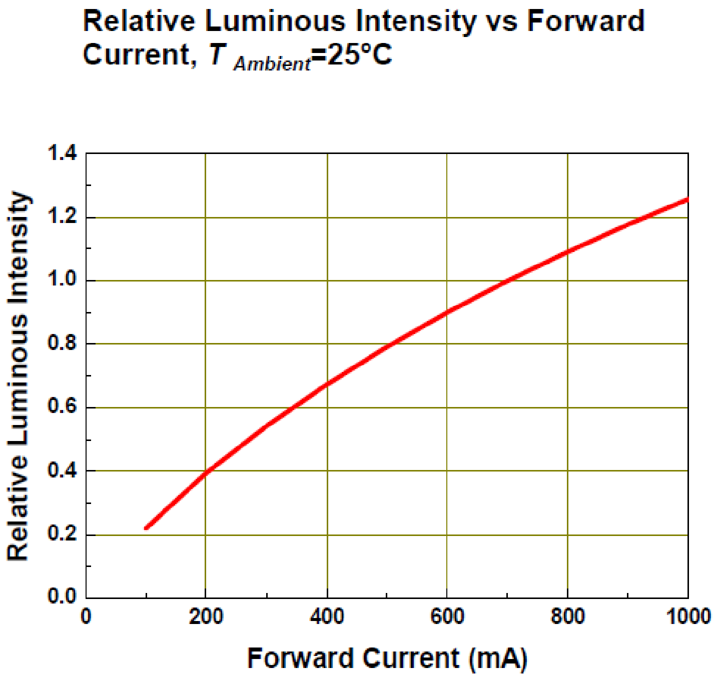
Test Specification:
The ripple current of constant current should be less than 20%.

Purpose & Influence:

a. The LED light output will be affected when the ripple current gets higher.
b. The LED junction temperature will increase and affect the LED performance when the ripple current gets higher.
c. If the ripple current gets higher, the usage of LED life will be reduced when in severe cases.
(Based on the experience, the usage life is half shortened when the junction temperature is 10°C higher every time.)
d. When the ripple current is bigger the more LED driver output capacitance is affected.
e. It increases public doubts regarding the LED lighting life.

The figure below shows the relative luminous intensity vs. forward current. In the figure the bigger forward current the higher relative luminous flux density, thus if the ripple current is too big, the luminous flux will be uneven and increase the LED junction temperature, also affect the LED performance and usage life.

When there is no ripple current or ripple current is small, the luminous flux is more even and the LED junction temperature is more even, in addition it can sustain the LED usage life.



PS. The basic structure of LED is a semiconductor P-N junction. The experiment indicates when the current passes through LED, the temperature of P-N junction will rise which is defined as LED junction temperature. Since the component chip usually in very small, the temperature of LED chip can be seen as junction temperature. (Refer to “Junction Temperature” from: http://www.ledinside.com.tw/led_pn_temp_issue_200812)

From the characteristics of physics, the ripple current is generated due to ripple voltage passing through the resistance (R_d) of LED dynamic operating point. The formula is

$$I_{ripple} = \frac{V_{ripple}}{R_d}.$$

When the ripple voltage (V_{ripple}) of LED power is fixed, the ripple current size is varied with R_d. Figure 4-1 and Figure 4-2 shows the voltage (CH1) and current waveform (CH2) when the 18V LED powers on. Figure 4-3 and Figure 4-4 show the voltage (CH1) and current waveform (CH2) of steady output after the LED is powered on. From the comparison of Figure 4-1, Figure 4-2, Figure 4-3 and Figure 4-4, it can see the ripple size is varied with R_d, thus when testing the LED power, the matching quality of LED power and LED light should also be considered.

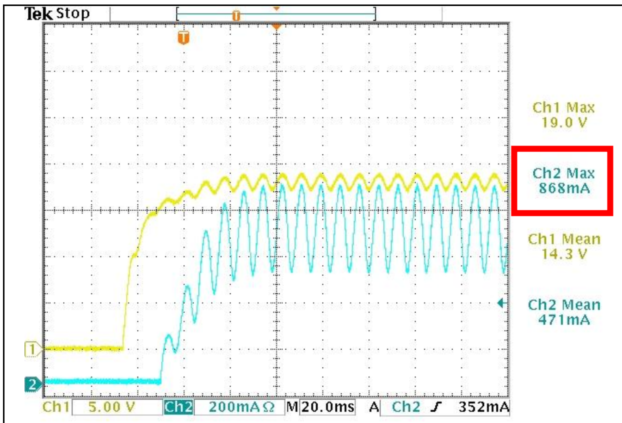


Figure 4-1 18V Power-on, R_d= 3.85Ω

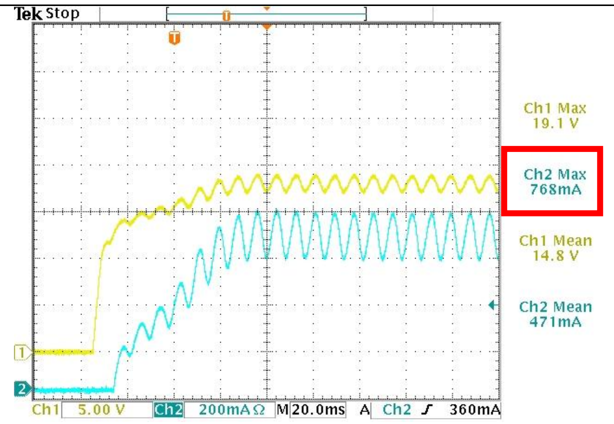


Figure 4-2 18V Power-on, R_d= 7.71Ω

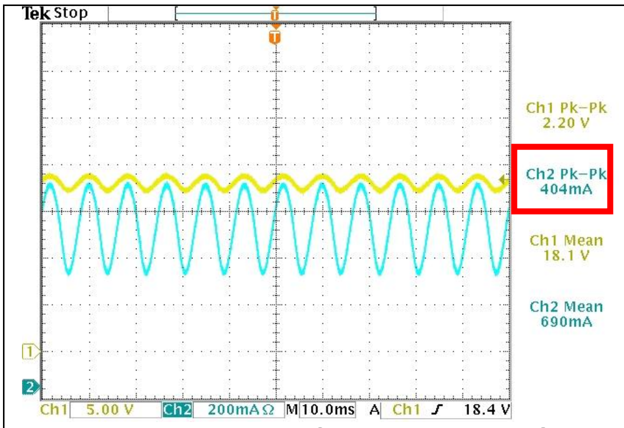


Figure 4-3 18V Steady, R_d= 3.85Ω

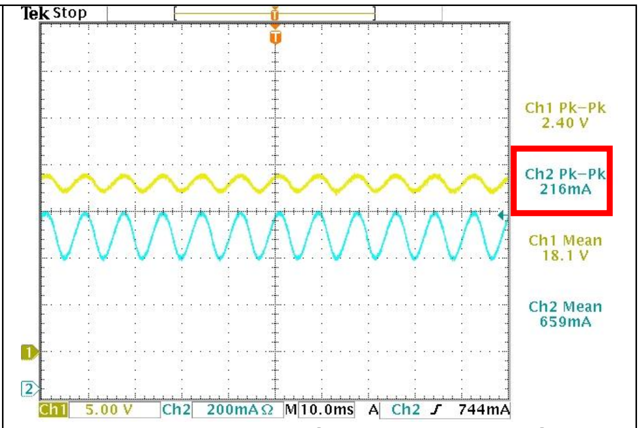
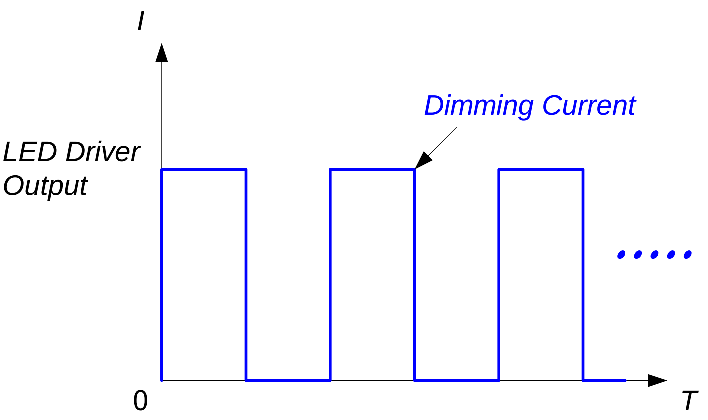


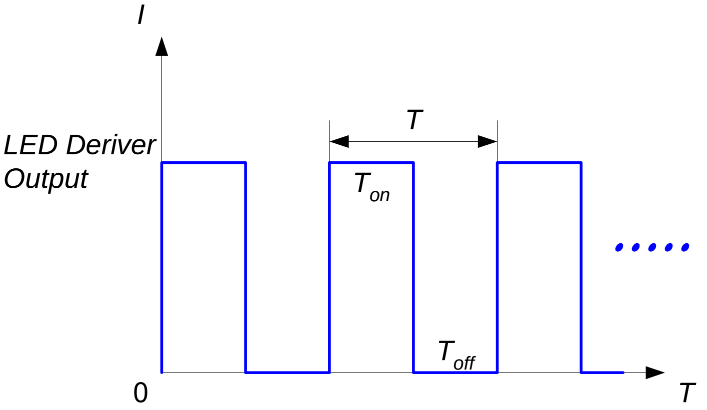
Figure 4-4 18V Steady, R_d= 7.71Ω

4.1.4 Dimming Current, Dimming Frequency & Dimming Duty

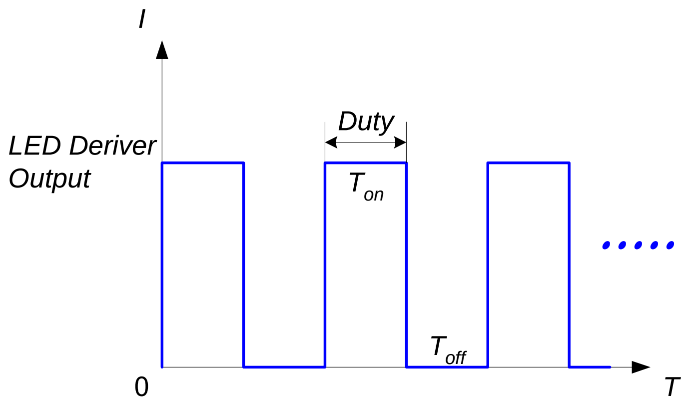
Test Specification:
The permissible range of set current should be within ±5% for the average of dimming current.



The accuracy of **dimming frequency** cannot be higher than ±1%.



The accuracy of **dimming duty** cannot be higher than ±1%.



Purpose & Influence:
The dimming function is equipped by energy saving LED lighting products and is in high demand in European and the US high end markets. LED dimming has Analog dimming, Triac dimming and PWM dimming. PWM dimming provides the best performance and is the future trend.

Advantages and disadvantages of Analog dimming:
Advantage: Intuitive control, adjust the LED output current to small directly
Disadvantage: a. It will blink when adjust to very low forward current.
b. The color cast of lamp is visible.

Advantages and disadvantages of Triac dimming:
Advantage: AC input voltage angle control, easy to use.
Disadvantage: a. Poor power factor. The power factor is lower than 0.25 when adjusted to 1/4 brightness.
b. Adds voltage harmonic component.
c. A discharge resistor is required when under low load to increase power consumption.
d. Poor efficiency. The LED light is not stable and blinking when dimmed.
e. The LED driver output ripple current is larger.
f. The color cast of lamp is visible.

Advantages and disadvantages of PWM dimming:
Advantage: a. It does not change the LED current size pass through.
b. Color cast does not appear on the lamp.
c. Avoid energy loss due to resistor dimming.
d. LED lamp does not blink.
e. Ultra high dimming accuracy.
f. Maintain high efficiency for LED lighting.
Disadvantage: Higher cost.

The test of dimming current, dimming frequency and dimming duty is to verify if the output dimming frequency of LED lighting with PWM dimming functions comply with the original design. The dimming frequency and duty are the main reference source of dimming current. Inaccurate dimming current will affect the dimming current of the LED driver and output efficiency.

4.1.5 Efficiency

Test Specification:

Performance Level	Non-isolated Output LED Module Control Device			Isolated Output LED Module C Control Device		
	P≦5W	5W＜P≦25W	P＞25W	P≦5W	5W＜P≦25W	P＞25W
Level 1 (%)	84.5	89.0	92.0	78.5	84.0	88.0
Level 2 (%)	80.5	85.0	87.0	75.0	80.5	85.0
Level 3 (%)	75.0	80.0	82.0	67.0	72.0	76.0

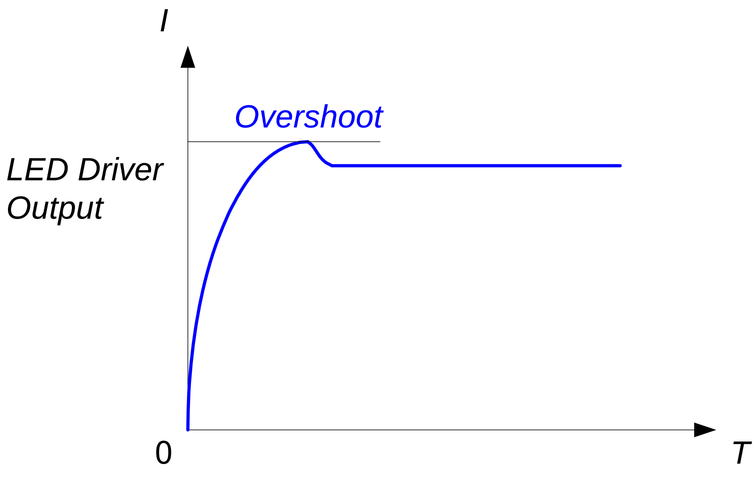
(Data source: "A Brief Analysis of LED Lighting Power Driver Standard", Power-one SED China JV)

Purpose & Influence:
Poor efficiency will generate heat causing damage to the LED driver and shorten the life of the LED lamp.

The LED luminous efficiency will decrease by the rising of LED temperature; therefore, the cooling of the LED is very important. When the LED driver efficiency is high, the consumption is low and the temperature of lamp is reduced delaying the lumens depreciation of the LED.

4.1.6 Turn-On Overshoot Current

Test Specification:
The output current overshoot range should be less than ±10% for the constant current source during turn-on and off.

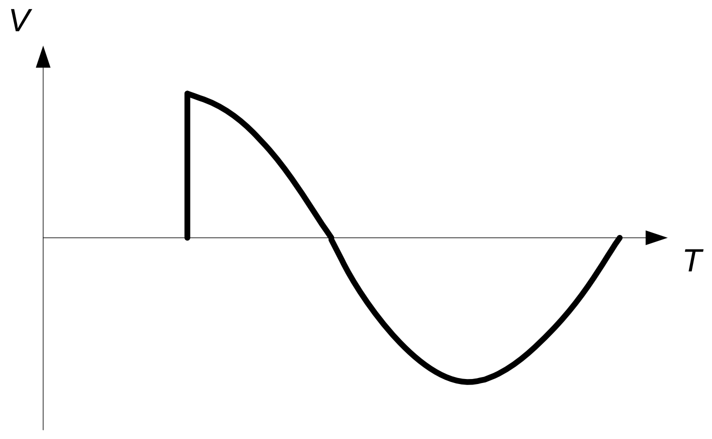


Purpose & Influence:
The overshoot current size at turn-on affects the LED and reduces its life, and may create public doubt to the usage life of LED lighting. When the LED driver outputs overshoot peak current Ipk+ at power-on, if the LED is unable to ventilate the heat in time, it may affect the LED usage life. Thus, it is suggested to have current limit designed into the LED driver.

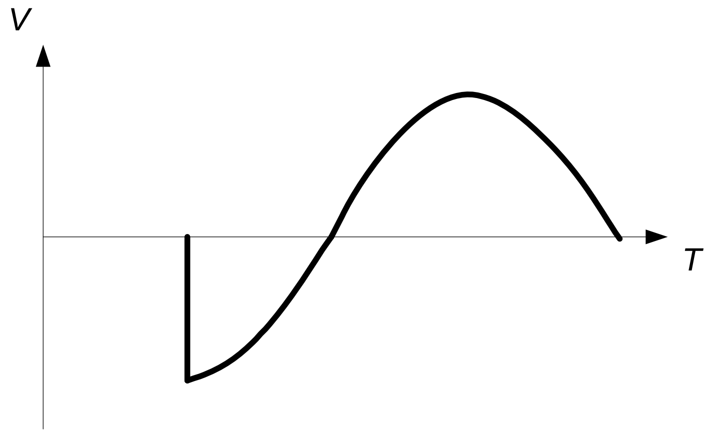
4.2 Input Characteristics

4.2.1 Input Inrush Current

Test Specification:
The input inrush current reaches its maximum when the AC voltage is at 90 and 270 degrees during cold start. The input inrush current spec. can be defined by the ratings of certain LED driver parts such as the input fuse, rectifier and anti-surge components. Basically the input inrush current should be less than the component ratings.



AC Input Voltage 90 Degrees Waveform



AC Input Current 270 Degrees Waveform

Purpose & Influence:
Input inrush current will cause fuse or breaker to be opened as well as the switch of UUT primary side to be damaged. In addition, the inrush current will recharge the current of noise and distortion back to the mains and contaminate it.

4.2.2 Input RMS Current

Test Specification:
The permissible range of input RMS current should not less than ±5%.

Purpose & Influence:
It measures the RMS of LED driver input current. If the RMS of input current is too big and the fuse is not selected properly, it could cause damage to the LED driver.

4.2.3 Input Peak Current

Test Specification:
It is defined based on the input peak current specification of the LED driver.

Purpose & Influence:
It measures the input peak current of the LED driver to calculate the Crest Factor (CF). The crest factor is the ratio of waveform peak and RMS. When the crest factor is too large, it will affect the quality of the mains.

4.2.4 Input Power

Test Specification:
It is defined based on the input power specification of LED driver.

Purpose & Influence:
It measures the input power of the LED driver for efficiency calculation.

4.2.5 Current Harmonics

Test Specification:
The LED driver needs to comply with IEC 61000-3-2 class C harmonics limits as listed below. When the active power consumed by LED driver is >25W, the current harmonics need to comply with the following limits.

Harmonic order n	Maximum permissible harmonic currrent expressed as a percentage of the input current at the fundamental frequency %
2	2
3	30 · λ *
5	10
7	7
9	5
11 ≤ n ≤ 39 (odd harmonics only)	3
* λ is the circuit power factor	

(Data Source: IEC 61000-3-2)

When the active power consumed by LED driver is≦25W, the current harmonics need to comply with one of the following limits.

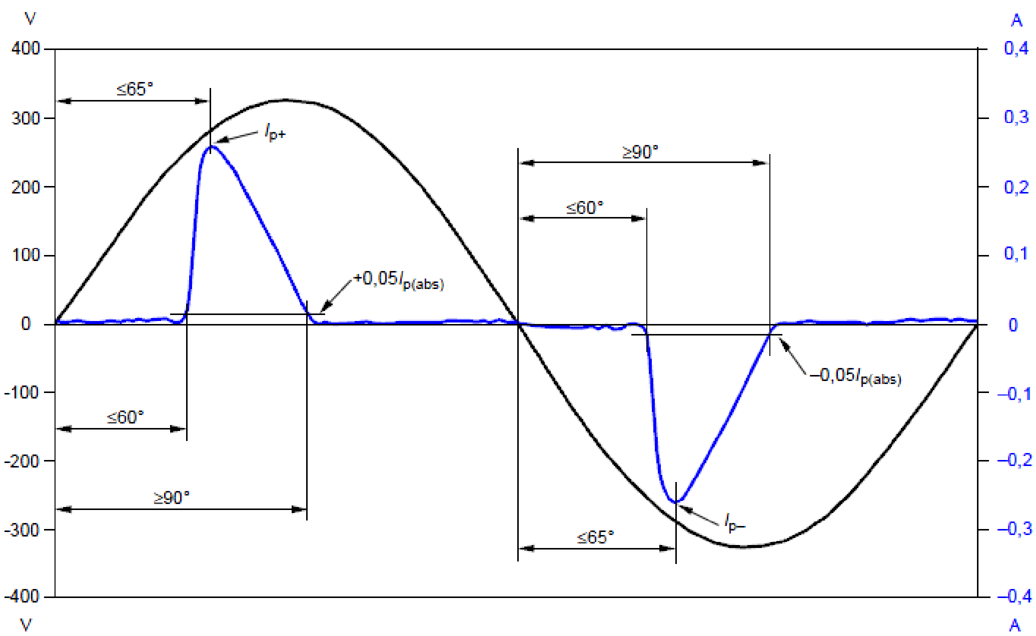
Method 1:

Harmonic order n	Maximum permissible harmonic current per watt mA/W	Maximum permissible harmonic current A
3	3,4	2,30
5	1,9	1,14
7	1,0	0,77
9	0,5	0,40
11	0,35	0,33
13	$\frac{3,85}{n}$	0,21
$15 \le n \le 39$ (odd harmonics only)	$\frac{3,85}{n}$	$0,15\ \frac{15}{n}$

(Data Source: IEC 61000-3-2)

Method 2:
All the conditions below should be met:

- The 3rd level harmonics cannot be larger than 86%.
- The 5th level harmonics cannot be larger than 61%.
- Use voltage 0 crossing point as the bench mark 0°, the input current has to reach 5% of current before reaching 60°.
- Current peak has to occur before 65°.
- The current cannot be smaller than 5% before falling to 90°.



(Data Source: IEC 61000-3-2)

Purpose & Influence:
The purpose for LED driver to run current harmonic test is to ensure the LED driver complies with the IEC 61000-3-2 class C harmonics limits requirements with no affect the quality of the mains.

4.2.6 Input Power Factor

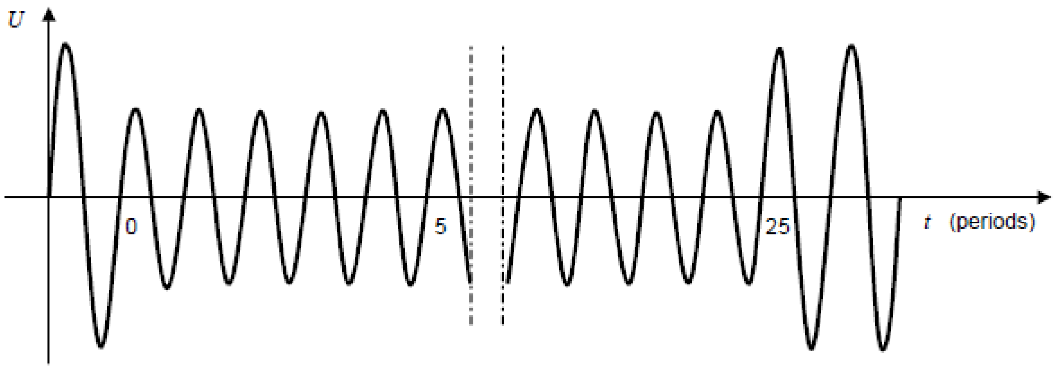
Test Specification:
When in rated input and output, ENERGY STAR® defines the power factor should be ≧0.7 for household and ≧0.9 for commercial.

PS. ENERGY STAR® Program Requirements for Solid State Lighting Luminaires

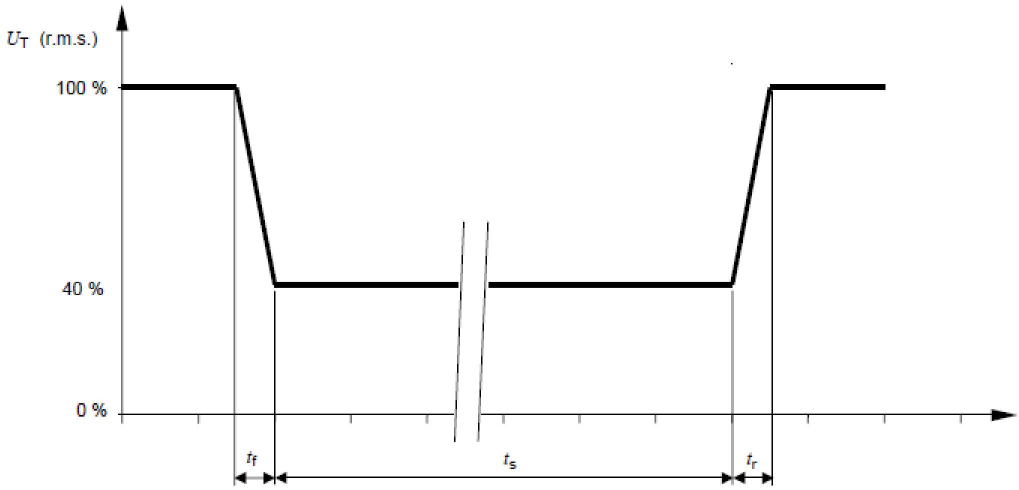
Purpose & Influence:
As the requirements for power supply quality increases, the power quality of electrical equipment and harmonic problems receive more attention. For example, the EU has released the standard EN 61000-3-2 to regulate that power devices larger than 25W has to be equipped with a power factor correction circuit.

4.2.7 PLD Simulation

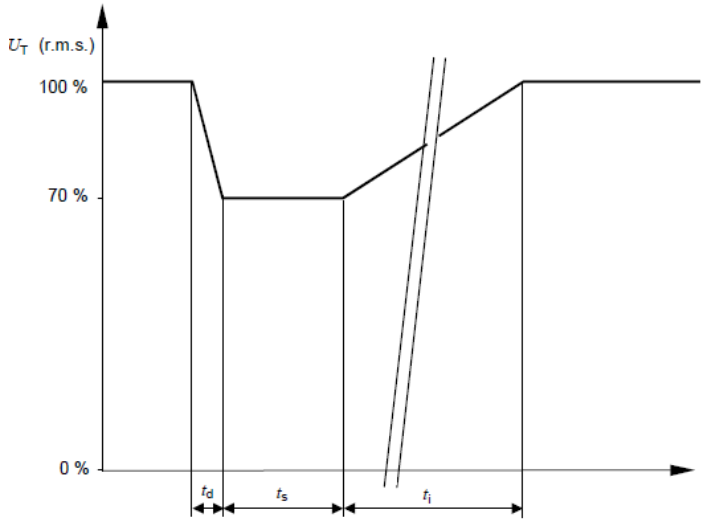
Test Specification:
It is defined based on the output specification of the LED driver. The LED driver should stay within the specifications of the fixed output voltage or current.



The voltage decreases to 70 % for 25 periods. Step at zero crossing.
(Data Source: IEC 61000-4-11)



(Data Source: IEC 61000-4-11)



(Data Source: IEC 61000-4-11)

Purpose & Influence:
The main purpose of executing input power distortion simulation on the LED driver is to see if the LED driver is complying with the electromagnetic compatibility testing for Voltage immunity test (see IEC 61000-4-11).

4.3 Regulation Tests

4.3.1 Line Regulation

Test Specification:
It is defined based on the line regulation specification of the LED driver. The common specification is 90Vrms~264Vrms.

Purpose & Influence:
The purpose of testing the line regulation on the LED driver is to ensure the output voltage or current is stays within the allowed range when a change occurs to the input voltage. If the output current is affected, the LED luminance is affected as well.

4.3.2 Load Regulation

Test Specification:
Constant voltage output – defined by the specification of LED driver voltage regulation.
Constant current output – defined by the specification of LED driver current regulation.

Purpose & Influence:
The LED driver has two types of voltage and current sources.

The purpose of running voltage regulation tests on the LED driver is to see the output voltage influence to the LED driver when the output current changes. That is the output voltage variation when the LED driver is connected to different numbers of LED lights in parallel.

The purpose of running current regulation tests on the LED driver is to see the output current influence to the LED driver when the output voltage changes. That is the output current variation when the LED driver is connected to different numbers of LED lights in series.

4.3.3 Total Regulation

Test Specification:
It is defined by the specification of LED driver's total regulation.

Purpose & Influence:
For the current output of the LED driver, it tests the influence of output current to the LED driver when AC input voltage/frequency and output voltage varies due to load changes.

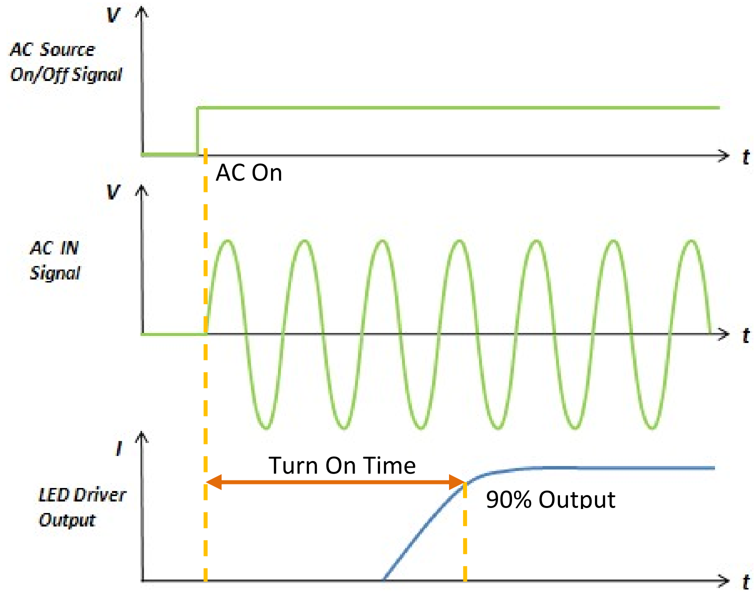
For the voltage output of the LED driver, it tests the influence of output voltage to the LED driver when AC input voltage/frequency and output current varies due to load changes.

4.4 Timing & Transient

4.4.1 Turn On Time

Test Specification:
It tests the time required when AC Source is on to LED driver outputs normally under static load condition. The LED driver normal output usually means the output current reaches 90%.

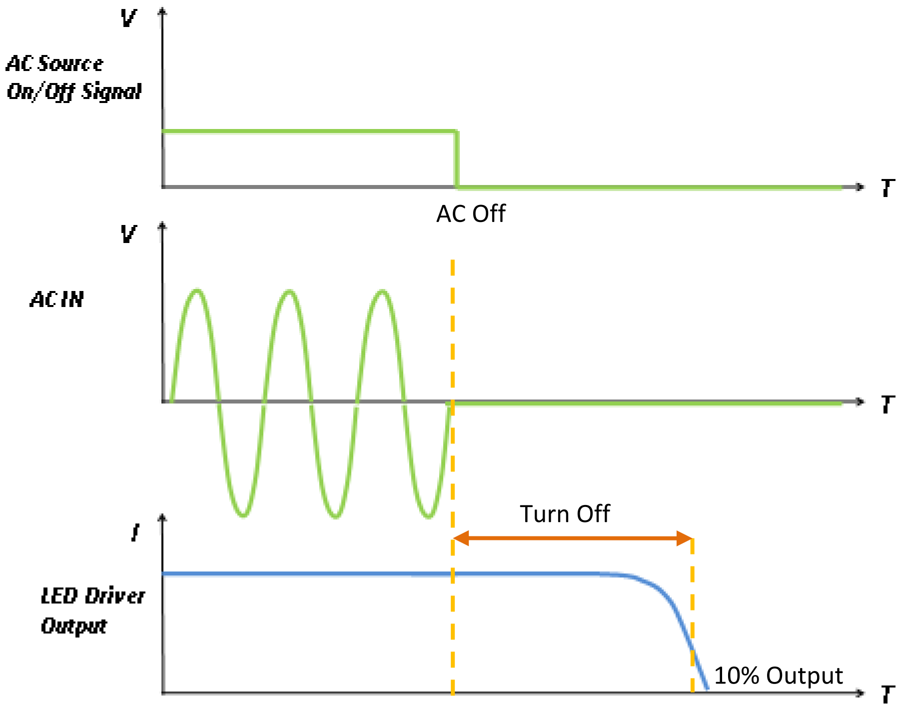
PS. It is suggested to discharge LED driver in advance to ensure the accuracy of test results.



Purpose & Influence:
It is to confirm the time required when the LED driver receives AC source to normal output. Also make sure the designed input capacitance meets the specification.

4.4.2 Turn Off Time

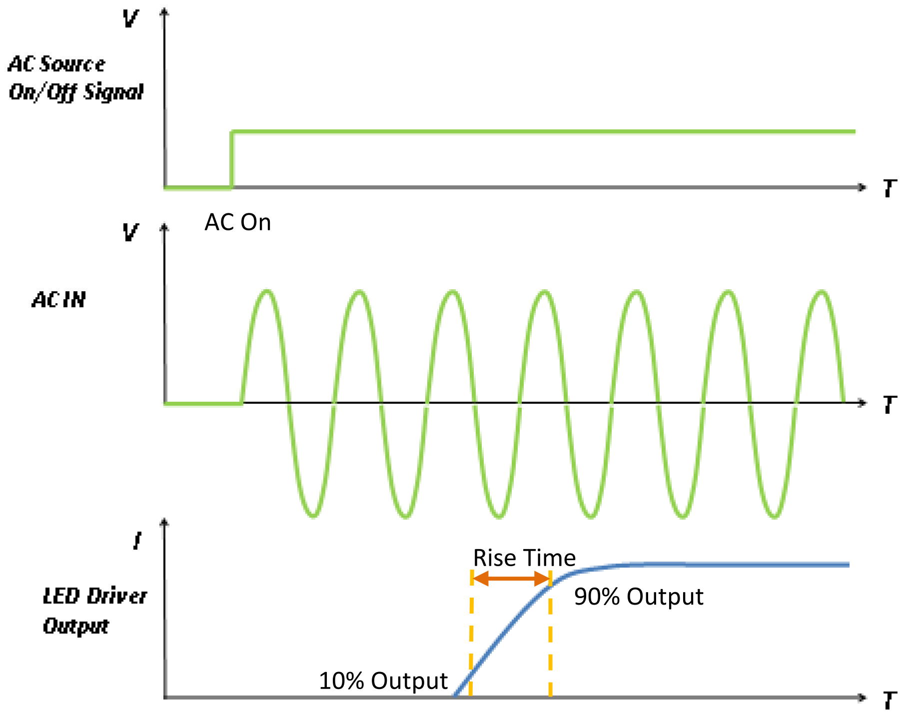
Test Specification:
It tests the time required when AC Source is off to LED driver stops output under static load condition. The LED driver normal output usually means the output current reaches 10%.



Purpose & Influence:
It is to confirm the time required when the AC is off to LED driver stops output. Also makes sure the designed output capacitance meets the specification.

4.4.3 Rise Time

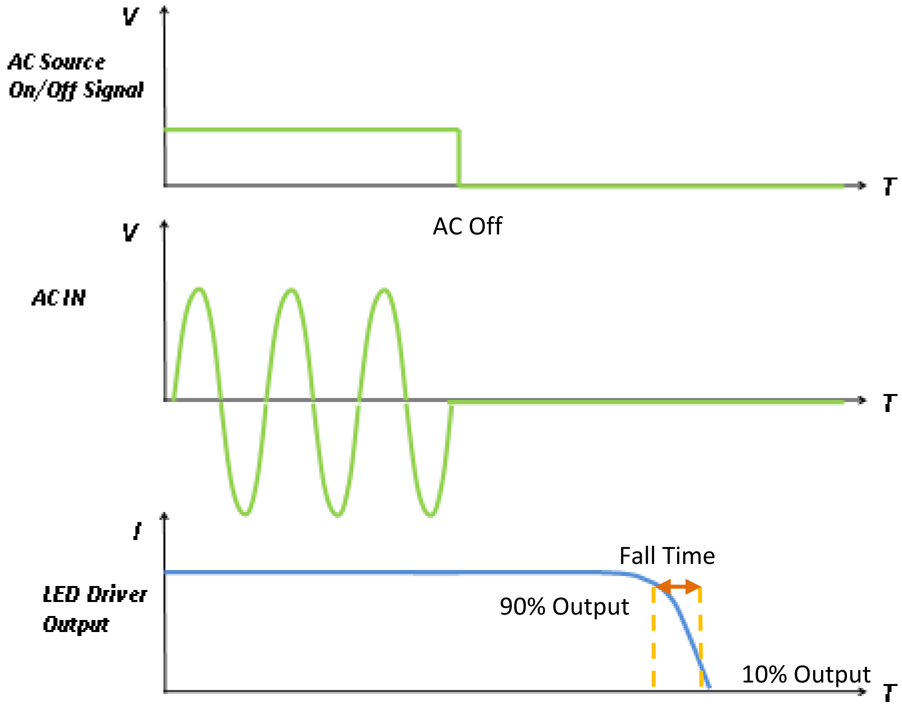
Test Specification:
It tests the time required for output current from 10% - 90% after LED driver is enabled.



Purpose & Influence:
It is to confirm the time required when the output value rises to standard after the LED driver is on. Also make sure the designed input capacitance meets the specification and incorrect input capacitance is inspected.

4.4.4 Fall Time

Test Specification:
It tests the time required for output current from 90% - 10% after LED driver is disabled.



Purpose & Influence:
It is to confirm the time required when the output value falls from standard to no output after the LED driver is off　Also make sure the designed output capacitance meets the specification and incorrect input capacitance is inspected.

4.5 Protection Tests

4.5.1 Short Circuit

Test Specification:
It has to stop output when the LED driver output is short circuited.

If the LED driver is equipped with the function of Auto Recover, it will restore normal output after short circuit is removed.　The test method is to use external relay to do short circuit and use LED to simulate the load short circuit function.

Purpose & Influence:
This test is to confirm if the short circuit protection (judged by short circuit current) and the LED driver with Auto Recover function are acting normally.

LED driver output short circuit will generate larger current that may cause damage to the LED driver or LED.　The short circuit protection function can avoid the damage caused by short circuit current.

4.5.2 Over Voltage Protection

Test Specification:
When the output voltage of the LED driver exceeds the specification, the output should be stopped. If the LED driver has Auto Recover function, it will restore to normal output when over voltage is removed.

Over voltage can be simulated by the following ways:
a. To increase the LED driver output voltage on load (equivalent to add LED number). This is applicable for LED driver with constant current output.
b. To short the internal feedback circuit of LED driver to create over voltage. This is applicable for LED driver with constant voltage output.
c. To infuse voltage to LED driver output terminal with DC source. This is applicable for LED driver with constant voltage output.

Purpose & Influence:
This test is to confirm if the over voltage protection is acting normally, the protection trigger point and Auto Recover function are valid.

The LED driver output voltage may exceed the specification when used improperly. Over voltage protection can prevent the LED driver output voltage from getting too high to cause any damage.

4.5.3 Over Current Protection

Test Specification:
When the output current of the LED driver exceeds specification, the output should be stopped.

If the LED driver has Auto Recover function, it will restore to normal output when over current is removed.

Over current can be simulated by giving over load to the load terminal. This is applicable for LED driver with constant voltage output but not with constant current output.

Purpose & Influence:
This test is to confirm if over load protection is active, the trigger point of over current and Auto Recover functions are valid.

The LED driver output current may exceed the specification when used improperly. Over current protection can prevent the LED driver output voltage from getting too high to cause any damage.

4.5.4 Over Power Protection

Test Specification:
When the output voltage or current of LED driver is too high, it may cause over power and the LED driver output should be stopped. If the LED driver has Auto Recover function, it will restore to normal output when over power is removed.

As over power is caused by over voltage or over current, it can combine the test methods of “Over Voltage Protection” and “Over Load Protection” to conduct the test for over power protection. The test is not applicable for a LED driver with constant current.

Purpose & Influence:
This test is to confirm if over power protection is active, the trigger point of over power and Auto Recover functions are valid.

The LED driver output voltage or current may exceed the specification and cause over power when used improperly. Over power protection can prevent the LED driver output power from getting too high to cause any damage.

The above test items are for the LED driver designers to understand the definitions of various power specifications as well as the advantages and disadvantages through this LED Power Driver Test Guide. Thus, the LED driver is validated in the design stage avoiding incremental costs to re-design and re-test during manufacturing and getting products to market faster.

4.6 Electrical Safety Test

4.6.1 Dielectric Withstand / Hipot Test

Test Specification:
It uses AC voltage 50Hz or 60Hz for testing. The test time is 1 minute. Refer to the test voltage in Table 1.

Working Voltage (U)		**Test Voltage (V)**
Less than 42V		500
42V ~ 1000V	Basic Insulation	2U + 1000
	Enhanced Insulation	2U + 1750
	Double Insulation	4U + 2750

Table 1

When the test starts, first output the test voltage to half and then execute Ramp time output to the set voltage. The test result cannot have the phenomenon of insulation breakdown or electrical flashover.

Purpose & Influence:
The main purpose of withstand voltage test is to verify the insulation capability of DUT (Device under Test.) This test is to validate if the product complies with the safety requirements so that the hazards of explosion, firing or electric shock won’t occur when there is abnormal inrush voltage to protect the safety of user.

4.6.2 Insulation Resistance Test

Test Specification:
It uses DC voltage 500V for testing. The test time is 1 minute and the test result cannot be less than 2M ohm.

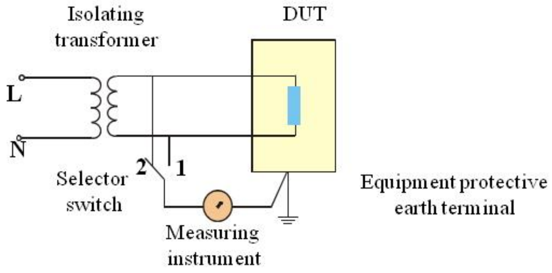
The locations for testing are:
a. Input to output
b. Input to case
c. Input to touchable areas on the outer case.

Purpose & Influence:
This test confirms if the product electrical insulation is good under normal mode.

4.6.3 Leakage Current Test

Test Specification:
The LED power inputs working voltage to measure the product's dynamic leakage current in normal mode.

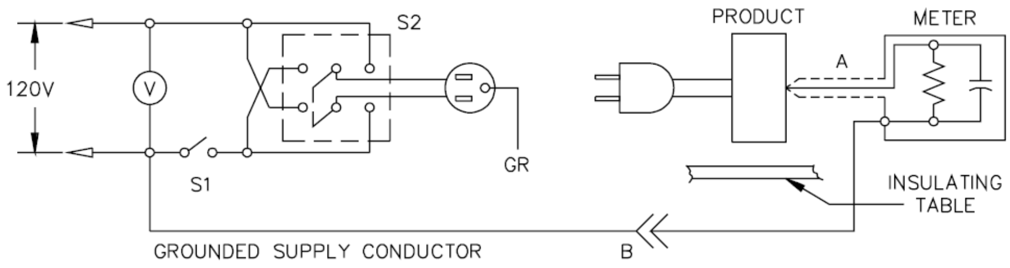
The locations for testing are:
a. Power input terminal to ground (leakage current to ground)
b. Power input terminal to case (case contact leakage current)
c. Power input terminal to output (contact leakage current)



The leakage current test result of portable power cannot exceed 0.5 mA.
The leakage current test result of fixed power cannot exceed 0.75 mA.

Purpose & Influence:
It uses a human simulation circuit to measure and simulate the power product to see if the leakage current complies with the user protection safety regulations under normal usage.

4 types of power input status:
1. Normal power plug-in
2. Reverse power plug-in
3. Normal power plug-in signal fault
4. Reverse power plug-in signal fault reverse



4.6.4 Ground Bond Test

Test Specification:
For the LED power rated current smaller than 16 ampere, use 1.5 times of rated current for test. The test time is 1 minute and the conductor impedance test result should be less than 0.1 ohm.

For the LED power rated current larger than 16 ampere, use 2 times of rated current for test. The test time is 2 minutes and the conductor voltage drop cannot over 2.5 volt.

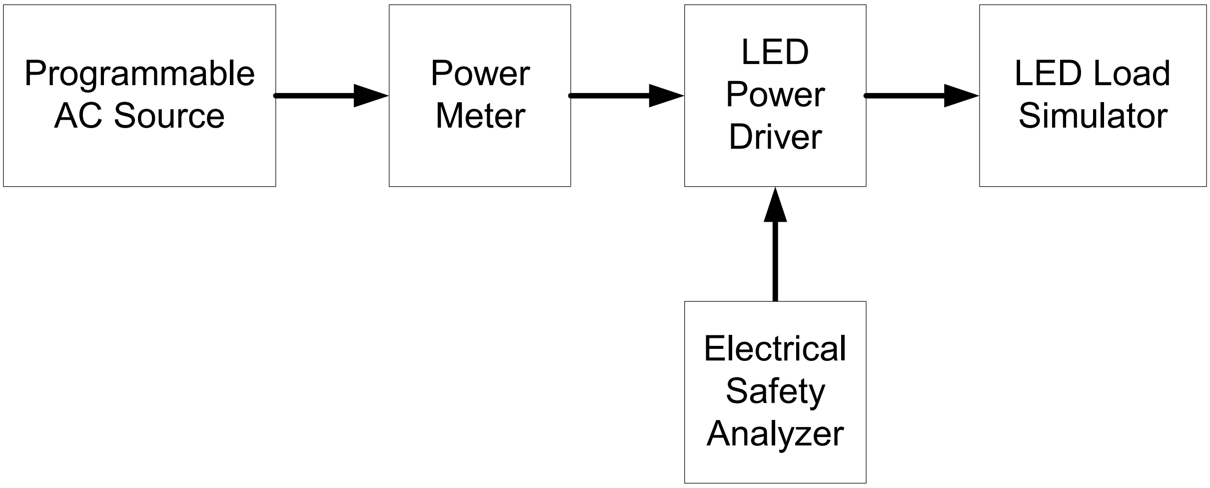
Purpose & Influence:
The purpose of ground bond test is to make sure that the current will flow to the earth when improper current occurs and protects the user from electrical hazards when touching the device. Thus, it is necessary to measure if excessive resistance or deficiency of load capacitance exists on the DUT's touchable areas and power E terminal.

5. Test Set-up

The following definitions and test purposes are applicable for this test guide.

5.1 Test Device Diagram

Take the example of a. AC voltage to DC current in section 3.1.2; it needs a Programmable AC Source, a Power Meter and an LED Load Simulator.



5.2 Recommended Device Function & Specification

Programmable AC Source	
Function	
1. Simulating interference to the mains 2. Simulating voltage dip and changes 3. Harmonics and interharmonics synthesis 4. Simulating AC power distortion 5. Programmable voltage turn on degree (0 – 360°C)	
Specification	
Output Voltage	
Range	150Vrms / 300Vrms
Resolution	0.1Vrms
Accuracy	0.2%+0.2%F.S.
Distortion	0.3% @ 50/60Hz 1% @ 15 – 1kHz
Line Regulation	0.1%
Load Regulation	0.2%
Output Frequency	
Range	47Hz ~ 63Hz
Resolution	0.01Hz
Accuracy	0.15%
Others	
Operating Temperature	0°C – 40°C
Storage Temperature	-40°C – 85°C

Power Meter	
Function	
Able to measure: 1. Vrms 2. Vpk 3. Irms 4. Power, W 5. Apparent Power, VA 6. VAR 7. Power Factor, PF 8. Crest Factor of Current, CF_I 9. Frequency 10. Total Harmonic Distortion of Voltage, THD_V 11. Total Harmonic Distortion of Current, THD_I 12. Energy	
Specification	
AC Voltage	
Range	150/300/500Vrms (CF=1.6)
Accuracy	(0.1%+0.05%×kHz) of reading + 0.08% of range
Input Resistance	1MΩ
AC Current	
Range	0.2/2/8/20Arms
Accuracy	(0.1+0.05%×kHz)% of reading + 0.12% of range
Power	
Range(W)=Vrms×Irms	1.5W ~ 10kW
Accuracy	47Hz – 63Hz: 0.1% of reading + 0.1% of range
Power Factor Accuracy	0.006+(0.003/PF)×kHz
Frequency	
Range	40Hz – 70Hz
Condition	Voltage (10~100% of the voltage range)
Others	
Display Resolution	5 Digits
Display Refresh Rate	0.25 seconds – 2 seconds
Operating Temperature	0°C – 40°C
Storage Temperature	-40°C – 85°C

LED Load Simulator	
Function	
1. Simulating LED V-I characteristic curve, able to set LED Forward Voltage or dynamic resistance (R_d) 2. Over power, over current, over temperature, over voltage and reverse warning functions 3. Frequency response (Max. 200kHz)	
Specification	
LED Mode	
Range	0 – 300V or 0 – 500V
Voltage Measurement	
Range	0 – 500V
Resolution	10mV
Accuracy	0.025%+0.025%F.S.
Current Measurement	
Range	0 – 20A
Resolution	400μA
Accuracy	0.05%+0.05%F.S.
Others	
Operating Temperature	0°C – 40°C
Storage Temperature	-5°C – 60°C

Electrical Safety Analyzer	
Function	
1. Provides ACW/DCW/IR (Insulation Resistance)/GB (Ground Bond)/LC (Leakage Current) tests (optional). 2. AC 5kV, DC 6kV programmable output voltage. 3. 50GΩ/1000V DC insulation resistance. 4. Up to 40 grounding connection test. 5. Electrical Flashover detection function. 6. Comply with the EN50191 standard floating high voltage output design. 7. 500VA output capability.	
Specification	
ACW / DCW Mode	
Voltage Measurement	
Range	AC: 0.05~ 5kV ; DC: 0.05 ~ 6kV
Resolution	2V
Accuracy	±(2% of setting +0.1% of full scale)
Current Measurement	
Range	AC: 100 mA max. ; DC: 25 mA max.
Resolution	AC: 1μA ; DC: 0.1μA
Accuracy	±(2% of reading +0.5% of range)
IR Mode	
Voltage Measurement	
Range	DC: 0.05 ~ 1kV
Resolution	2V
Accuracy	±(2% of reading +0.5% of full scale)
Resistance Measurement	
Range	0.1MΩ~ 50GΩ
Resolution	0.1MΩ
Accuracy	5% typical
GB Mode	
Current Measurement	
Range	3 ~ 40A
Accuracy	±(2% of setting +0.1% of full scale)
Resistance Measurement	
Range	10mΩ~ 510mΩ
Resolution	0.1mΩ
Accuracy	±(2% of setting +0.1% of full scale)
Others	
Operating Temperature	0°C ~ 40°C

6. Reference Documents

Following documents are referenced in this test guide.

1. Chroma ATE Inc. *AN-63110A-00002-C_Buck Type LED Driver Test Application*, Taiwan.
2. Chroma ATE Inc. *AN-63110A-00004-C_LED Driver Output Voltage Range Testing Notices*. Taiwan.
3. Chroma ATE Inc. *AN-63110A-00005-C_LED LOAD Using Backlight Driver Application*. Taiwan.
4. Chroma ATE Inc. *FAQ-63110A-00001-C_63110A Parallel Application*. Taiwan.
5. Chroma ATE Inc. *LED Power Driver Test Solution*. Taiwan.
6. 巨祥生, “Brief analysis of driving power for LED lighting standards”, POWER-ONE SED CHINA JV.
7. IEC 62384:2006, “DC or AC supplied electronic control gear for LED modules – Performance requirements.”
8. IEC 61347-1:2007, “Part 1: General and safety requirements.”
9. IEC 61347-2-13:2006, “Part 2-13: Particular requirements for d.c. or a.c. supplied electronic control gear for LED modules.”
10. IEC 61000-3-2: “Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≦16A per phase).”
11. UL8750, “Light Emitting Diode (LED) Light Source for Use in Lighting Products.”
12. UL 1310 “Class 2 Power Units.”
13. UL 1012 “Power Units Other Than Class 2.”
14. UL 60950-1 “Safety of Information Technology Equipment.”
15. “http://www.ledinside.com.tw/led_pn_temp_issue_200812,” *LEDinside*.
16. IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES. “IPC-9592 Performance Parameters for Power Conversion Devices.”
17. A Server System Infrastructure (SSI) Specification Version 1.2. “Power Supply Design Guideline for 2008 Dual-Socket Servers and Workstations.”
18. Intel. “VRM 11.0.”
19. Next Generation Lighting Industry Alliance with the U. S. Department of Energy. “LED LUMINAIRE LIFETIME: Recommendations for Testing and Reporting.”
20. Energy Star. “ENERGY STAR® Program Requirements for Solid State Lighting Luminaires.”

Appendix A LED Driver Technical Specification

Example of LED driver technical specifications for voltage source		
Output Characteristics	Output voltage	12.0Vdc
	Max. output current	8.33A
	Ripple voltage	120mV
	Maximum output power	100W
	Efficiency	93%
Input Characteristics	AC input voltage range	90 – 305VAC
	Input frequency range	50/60Hz
	Input power factor	Up to 0.99
	Input power	107.5W
	Input inrush current (max.)	Cold start, 70A/230VAC
	Current harmonics	Compliant to IEC61000-3-2 Class C
Protection	Over power protection	Hiccup mode, auto recovery
	Over voltage protection	110% – 145% of rated output voltage
	Over current protection	>105% of rated output current
	Short circuit	Valid
Environmental	Operating temperature	-35 – 70°C
	Operating humidity	10% – 98%
	Storage temperature	-40 – 80°C
	Storage humidity	10% – 90%
	Temperature coefficient	100ppm
EMC and Safety	EMI standards	EN55015, EN61547, EN61000-3-2, EN61000-3-3, EN61000-4-2, 3, 4, 5, 6, 8, 11, GB17743
	Safety standards	UL8750, UL1310, UL1012, EN61347-1, EN61347-2-13
Others	Weight	350g
	Size	184×67×37 mm

Example of LED driver technical specifications for current source		
Output Characteristics	Output current	700mA
	Output voltage range	71.0 – 143.0Vdc
	Ripple current	105mA
	Maximum output power	100W
	Efficiency	92%
Input Characteristics	AC input voltage range	90 – 305VAC
	Input frequency range	50/60Hz
	Input power factor	Up to 0.99
	Input Power	107.5W
	Input inrush current (max.)	Cold start, 70A/230VAC
	Current harmonics	Compliant to IEC61000-3-2 Class C
Protection	Over power protection	Hiccup mode, auto recovery
	Over voltage protection	110% – 145% of rated output voltage
	Over current protection	>105% of rated output current
	Short circuit	Valid
Environmental	Operating temperature	-35 – 70°C
	Operating humidity	10% – 98%
	Storage temperature	-40 – 80°C
	Storage humidity	10% – 90%
	Temperature coefficient	100ppm
EMC and Safety	EMI standards	EN55015, EN61547, EN61000-3-2, EN61000-3-3, EN61000-4-2, 3, 4, 5, 6, 8, 11, GB17743
	Safety standards	UL8750, UL1310, UL1012, EN61347-1, EN61347-2-13
Others	Weight	350g
	Size	184×67×37 mm

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