设计范例报告

标题	***使用LYTSwitch™-4 LYT4311E设计的5.8 W高功率因数、非隔离、降压-升压式、可控硅调光的LED驱动器***
规格	90 VAC – 132 VAC输入； 48V$_{TYP}$,120mA输出
应用	A19 LED驱动器
作者	应用工程部
文档编号	DER-407
日期	2014年5月16日
修订版本	1.0

特色概述

- 单级功率因数校正(PFC)与精确恒流(CC)输出相结合
- 低元件数的高度紧凑型设计
- 可控硅调光
  - 可兼容各种可控硅调光器（300 W至1200 W）
  - 快速启动时间(<200 ms) – 无可见延迟
- 集成的保护及可靠性能
  - 输出短路保护，带自动恢复功能
  - 带更大迟滞的自动恢复热关断
  - 在AC电压跌落期间不会造成任何损坏
- 在120 VAC下，PF > 0.9
- 满足振铃波、差模输入浪涌和EN55015传导EMI要求

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目录

重要说明：虽然本电路板的设计满足安全隔离要求，但工程原型尚未获得机构认证。因此，必须使用隔离变压器向原型板提供AC输入，以执行所有测试。

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1 简介

本文档介绍的是一款非隔离、高功率因数(PF)、可控硅调光的LED驱动器，它可以在90 VAC至132 VAC（典型值为60Hz）的输入电压范围内为LED灯串提供额定电压48V、额定电流120 mA的驱动。该LED驱动器采用了LYTSwitch-4系列IC中的LYT4311E器件。

所采用的拓扑结构是单级、非隔离、降压-升压式拓扑结构，可满足本设计的高功率因数、恒流调整和调光要求。

本文档包含LED驱动器规格、电路原理图、PCB设计细节、物料清单、变压器规格文件和典型性能特征。

2 装配后的PCB板

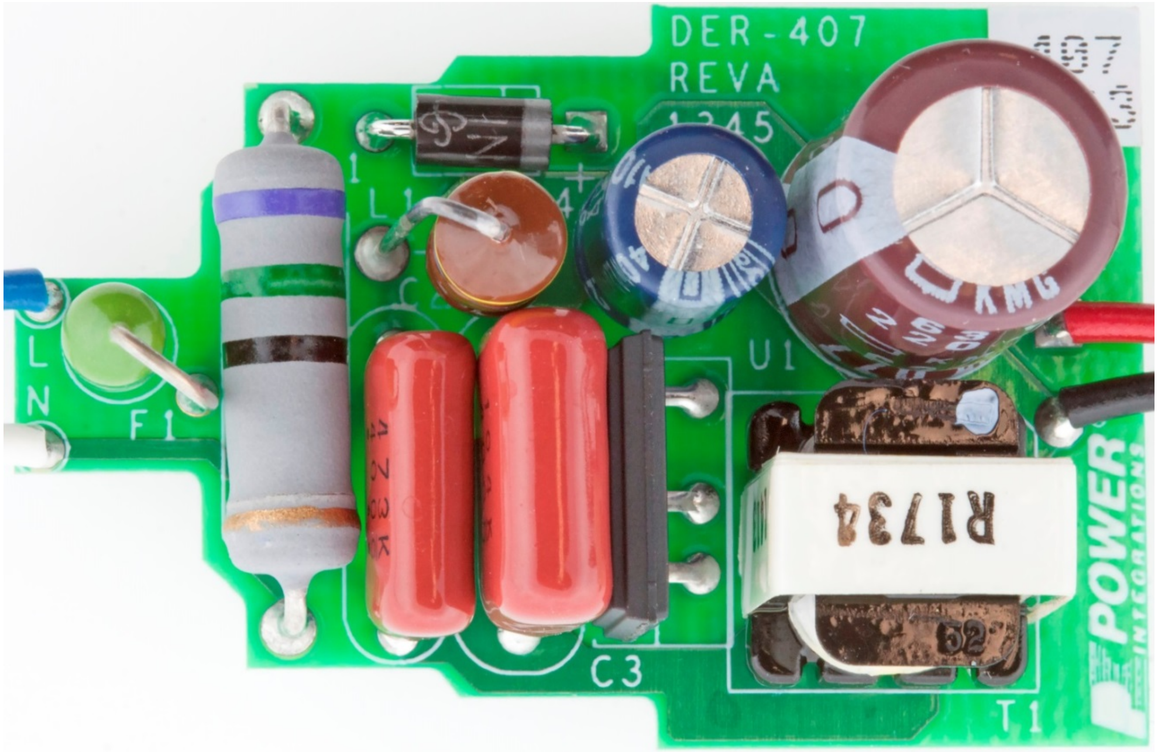

Figure 1 – Populated Circuit Board, Top View.

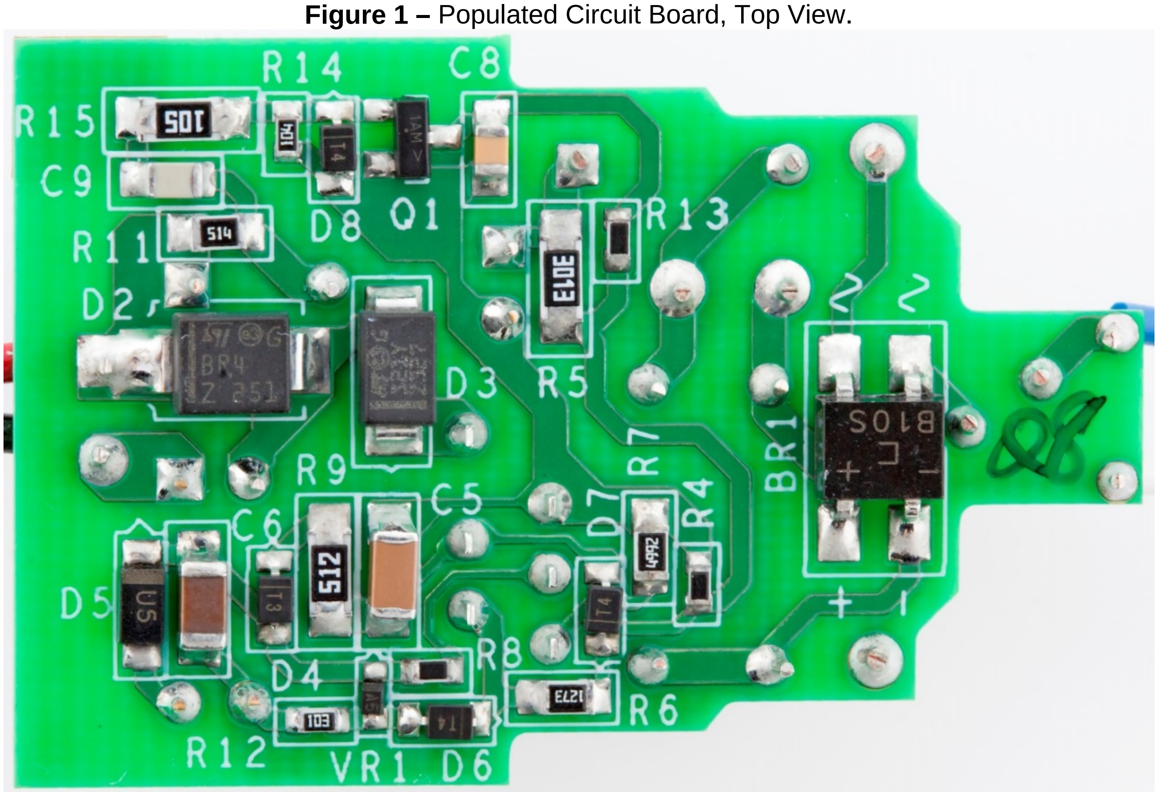

Figure 2 – Populated Circuit Board, Bottom View.

3 电源规格

下表所列为设计的最低可接受性能。实际性能可参考测量结果部分。

说明	符号	最小值	典型值	最大值	单位	备注
输入						
电压	V_{IN}	90	120	132	VAC	双导线 – 无P.E.
频率	f_{LINE}		60		Hz	
输出						
输出电压	V_{OUT}		48		V	
输出电流	I_{OUT}		120		mA	V_{OUT} = 48V, V_{IN} = 120 VAC, 25°C
总输出功率						
连续输出功率	P_{OUT}		5.76		W	
效率						
满载	η		83		%	在P_{OUT} 25°C、无调光器、120VAC的条件下测得
环境						
传导EMI		CISPR 15B / EN55015B				
安全		非隔离				
振铃波(100 kHz)						
差模(L1-L2)			2.5		kV	
差模浪涌			500		V	
功率因数			0.9			在$V_{OUT(TYP)}$、$I_{OUT(TYP)}$以及120 VAC、50Hz条件下测得
环境温度	T_{AMB}		50		°C	敞开式，120 VAC

4 电路原理图

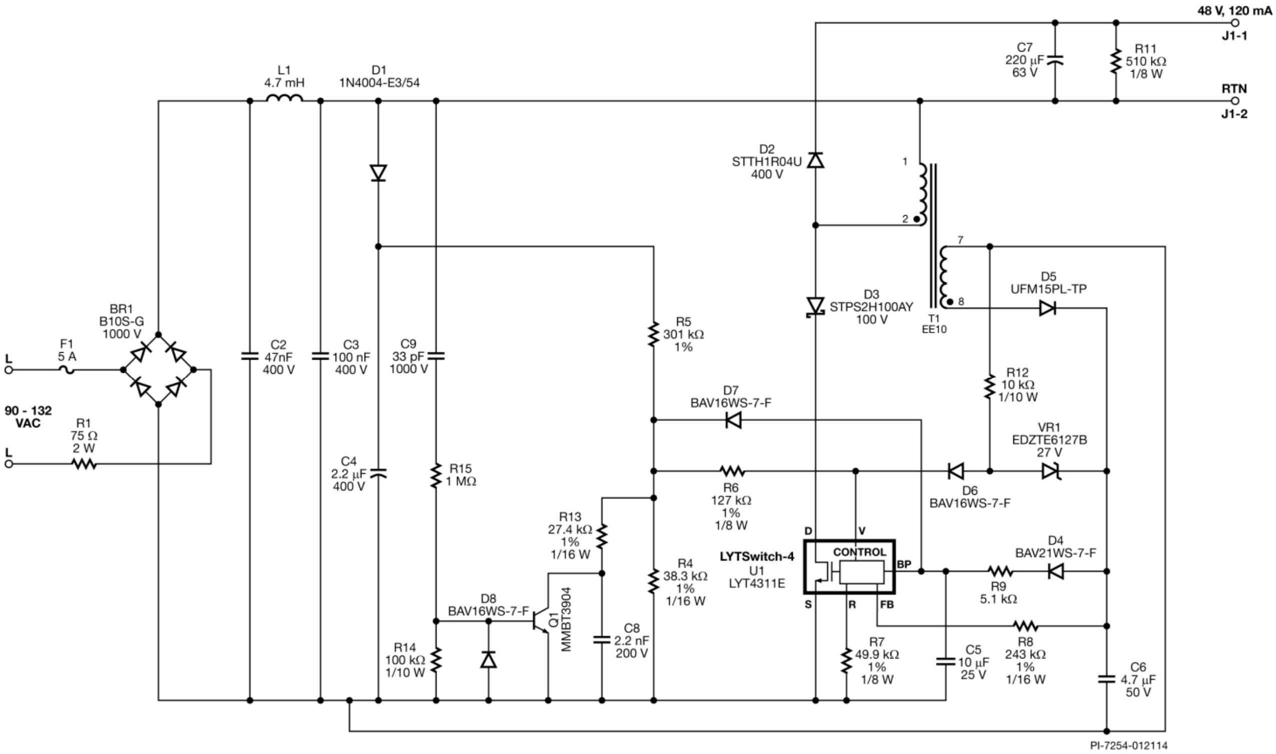

Figure 3 – Schematic Diagram.

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5 电路描述

LYTSwitch-4 LYT4311E器件是一种将控制器和725 V功率MOSFET集成在一起的器件，用于LED驱动器应用。LYTSwitch-4产品系列可用于单级、降压-升压式拓扑结构，提供调节的恒流隔离输出，同时保持高功率因数。

5.1 输入EMI滤波

保险丝F1在异常工作情况下提供元件故障保护。二极管桥堆BR1对AC线电压进行整流，电容C3为初级开关电流提供低阻抗通路（去耦）。为使功率因数保持在0.9以上，需要确保较低的输入电容（C2与C3之和）值。EMI滤波由电感L1以及电容C2和C3提供。

5.2 功率电路

本设计所采用的拓扑结构为低压端降压-升压式配置，可在90 VAC至132 VAC的输入电压范围内提供高功率因数和恒流输出。

输出二极管D2每当U1关断时就会导通，将能量传输至负载。在C3上的电压（整流后的输入AC）降到输出电压以下时，需要使用二极管D3来防止反向电流流经U1。

为向U1提供峰值输入电压信息，经整流AC的输入峰值经由D1对C4充电。然后该电流经过R5和R6，注入U1的电压监测(V)引脚。电阻R4、R5和R6所选取的值可以在120VAC输入下提供~100 µA的I_V（来自PIXls设计表格）。

输入过压关断功能（通过V引脚电流检测）可使整流后的线电压承受能力（在浪涌和线电压陡升期间）达到内部功率MOSFET的额定725 BV_{DSS}。

电容C5对U1的BP引脚进行局部去耦，该引脚是内部控制器的供电引脚。在启动期间，C10从与U1的D引脚相连的内部高压电流源被充电至约6 V。

U1的参考引脚通过49.9 kΩ电阻R7接地（源极）。

5.3 输出反馈

反馈信号来自由二极管D5和电容C6组成的网络所整流和滤波的偏置绕组。从电容C6产生的输出电压信息被电阻R8转换为反馈电流。该电流被LYT4311E用来调节转换器的输出电流。

5.4 可控硅相位调光控制兼容性

对于用低成本的可控硅前沿及后沿相控调光器提供输出调光的要求，我们需要在设计时进行一些折中。

由于LED照明的功耗非常低，灯吸收的电流要小于大部分应用中可控硅的维持电流。这样会产生调光范围受限和/或闪烁等不良情况。由于LED灯的阻抗相对较大，因此在可控硅导通时，浪涌电流会对输入电容进行充电，产生很严重的振铃。这种效应还会造成上述不良情况，因为振荡会使可控硅电流降至零并关断。

要克服这些问题，需增加无源衰减电路和无损耗的有源泄放电路。

电阻R1用于在可控硅接通时衰减输入网络。

额外的衰减通过在AC输入周期的前沿部分增大处理功率来提供。这种方法是在仿真无源RC泄放电路的行为，但不会产生相关的损耗和其他调光缺点。

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6 PCB布局

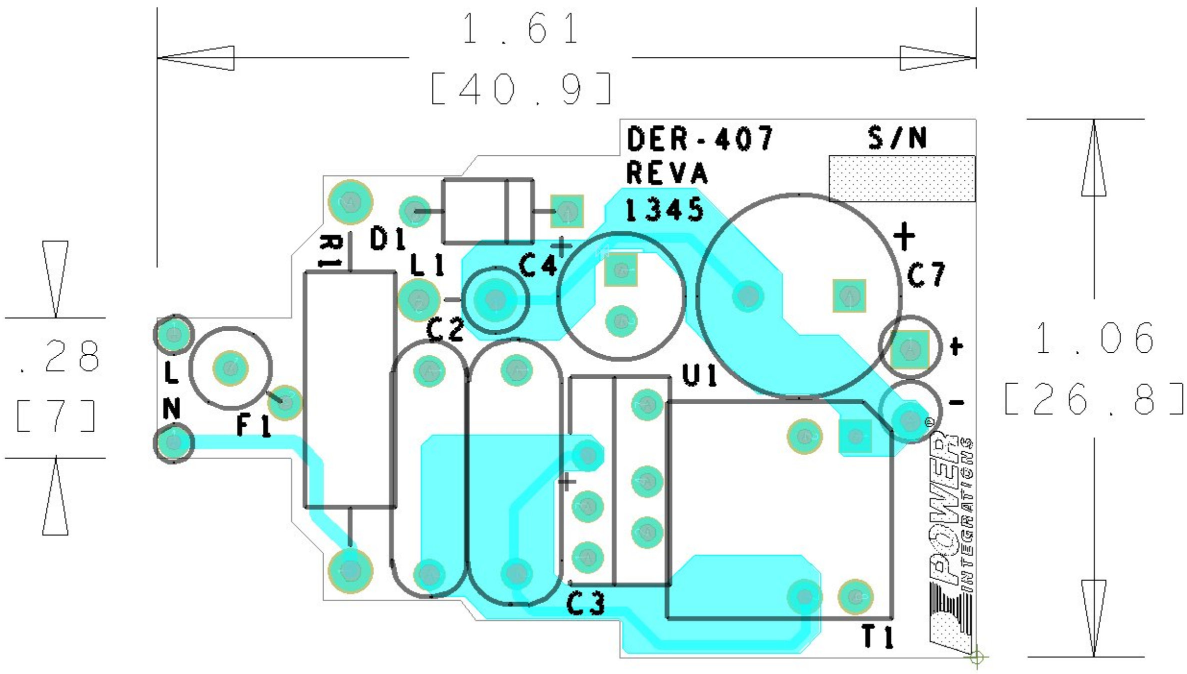

Figure 4– Top Side.

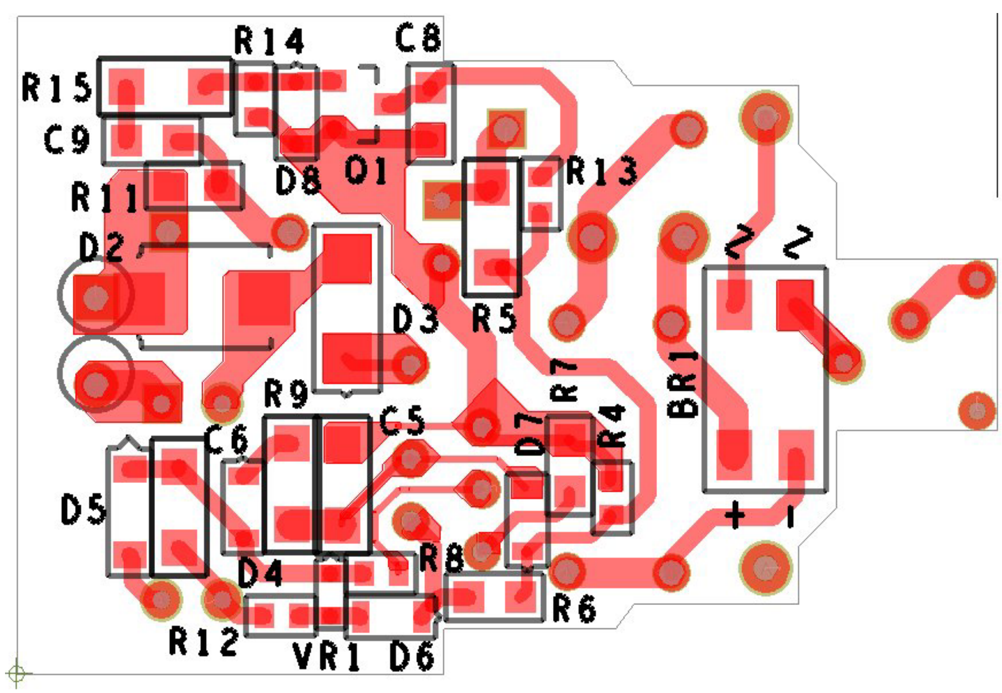

Figure 5– Bottom Side.

7 物料清单(BOM)

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	1000 V, 0.8 A, Bridge Rectifier, SMD, MBS-1, 4-SOIC	B10S-G	Comchip
2	1	C2	47 nF, 400 V, Film	ECQ-E4473KF	Panasonic
3	1	C3	100 nF, 400 V, Film	ECQ-E4104KF	Panasonic
4	1	C4	2.2 μF, 400 V, Electrolytic, (6.3 x 11)	TAB2GM2R2E110	Ltec
5	1	C5	10 μF, 25 V, Ceramic, X7R, 1206	C3216X7R1E106M	TDK Corp
6	1	C6	4.7 μF, 50 V, Ceramic, X7R, 1206	UMK316AB7475KL-T	Taiyo Yuden
7	1	C7	220 μF, 63 V, Electrolytic, (10 x 16)	EKMG630ELL221MJ16S	United Chemi-con
8	1	C8	2.2 nF, 200 V, Ceramic, X7R, 0805	08052C222KAT2A	AVX
9	1	C9	33 pF, 1000 V, Ceramic, COG, 0805	0805AA330KAT1A	AVX
10	1	D1	400 V, 1 A, Rectifier, DO-41	1N4004-E3/54	Vishay
11	1	D2	400 V, 1 A, Ultrafast Recovery, 500 ns, DO-214AA, SMB	STTH1R04U	ST Micro
12	1	D3	100 V, 2 A, Schottky, SMA	STPS2H100AY	ST Micro
13	1	D4	250 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV21WS-7-F	Diodes, Inc.
14	1	D5	600 V, 1 A, Ultrafast Recovery, 75 ns, SOD-123	UFM15PL-TP	MCC
15	1	D6	75 V, 0.15 A, Switching, SOD-323	BAV16WS-7-F	Diodes, Inc.
16	1	D7	75 V, 0.15 A, Switching, SOD-323	BAV16WS-7-F	Diodes, Inc.
17	1	D8	75 V, 0.15 A, Switching, SOD-323	BAV16WS-7-F	Diodes, Inc.
18	1	F1	5 A, 250 V, Fast, Microfuse, Axial	0263005.MXL	Littlefuse
19	1	L1	4.7 mH, 90 mA, 20 Ohm, RF Inductor	B82144A2475J	Epcos
20	1	Q1	NPN, Small Signal BJT, 40 V, 0.2 A, SOT-23	MMBT3904LT1G	On Semi
21	1	R1	75 Ω, 5%, 2 W, Metal Oxide	RSF200JB-75R	Yageo
22	1	R4	38.3 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF3832V	Panasonic
23	1	R5	301 kΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF3013V	Panasonic
24	1	R6	127 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1273V	Panasonic
25	1	R7	49.9 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF4992V	Panasonic
26	1	R8	243 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF2433V	Panasonic
27	1	R9	5.1 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ512V	Panasonic
28	1	R11	510 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ514V	Panasonic
29	1	R12	10 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ103V	Panasonic
30	1	R13	27.4 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF2742V	Panasonic
31	1	R14	100 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ104V	Panasonic
32	1	R15	1 MΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ105V	Panasonic
33	1	T1	Bobbin, EE10, Vertical, 8 pins Transformer	101 SNX-R1734	Hical Magnetics Santronics
34	1	U1	LYTSwitch-4, eSIP-7C	LYT4311E	Power Integrations
35	1	VR1	27 V, 5%, 150 mW, SOD 523	EDZTE6127B	Rohm Semi

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8 电感设计表格

ACDC_LYTSwitch-4_101813; Rev.1.3; Copyright Power Integrations 2013	INPUT	INFO	OUTPUT	UNIT	LYTSwitch-4_101813: Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					
Dimming required	**YES**		YES		Select 'YES' option if dimming is required. Otherwise select 'NO'.
VACMIN			90	V	Minimum AC Input Voltage
VACMAX			132	V	Maximum AC input voltage
fL	60		50	Hz	AC Mains Frequency
VO	48.00		48	V	Typical output voltage of LED string at full load
VO_MAX			52.80	V	Maximum expected LED string Voltage.
VO_MIN			43.20	V	Minimum expected LED string Voltage.
V_OVP			58.08	V	Over-voltage protection setpoint
IO	0.12		0.12	A	Typical full load LED current
PO			5.8	W	Output Power
n	0.82		0.82		Estimated efficiency of operation
VB	23		23	V	Bias Voltage
ENTER LYTSwitch-4 VARIABLES					
LYTSwitch-4	**Auto**		**LYT4311**		Selected LYTSwitch-4
Current Limit Mode	**RED**		**RED**		Select "RED" for reduced Current Limit mode or "FULL" for Full current limit mode
ILIMITMIN			0.75	A	Minimum current limit
ILIMITMAX			0.85	A	Maximum current limit
fS			132000	Hz	Switching Frequency
fSmin			124000	Hz	Minimum Switching Frequency
fSmax			140000	Hz	Maximum Switching Frequency
IV			96.7	uA	V pin current
RV	1.65		1.65	M-ohms	Upper V pin resistor
RV2			1000000000000	M-ohms	Lower V pin resistor
IFB	100.00		100.0	uA	FB pin current (85 uA< IFB < 210 uA)
RFB1			200.0	k-ohms	FB pin resistor
VDS			10	V	LYTSwitch on-state Drain to Source Voltage
VD			0.50	V	Output Winding Diode Forward Voltage Drop (0.5 V for Schottky and 0.8 V for PN diode)
VDB			0.70	V	Bias Winding Diode Forward Voltage Drop
Key Design Parameters					
KP	1.00		1.00		Ripple to Peak Current Ratio (For PF > 0.9, 0.4 < KP < 0.9)
LP			468	uH	Primary Inductance
VOR	48.50		48.5	V	Reflected Output Voltage.
Expected IO (average)			0.12	A	Expected Average Output Current
KP_VACMAX			1.09		Expected ripple current ratio at VACMAX
TON_MIN			1.08	us	Minimum on time at maximum AC input voltage
PCLAMP			0.05	W	Estimated dissipation in primary clamp

ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	**EE13**		**EE13**		Core Size
Custom Core					Enter custom core part number
AE			0.171	cm^2	Core Effective Cross Sectional Area
LE			3.02	cm	Core Effective Path Length
AL			1130	nH/T^2	Ungapped Core Effective Inductance
BW			7.4	mm	Bobbin Physical Winding Width
M			0	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L			3		Number of Primary Layers
NS	93		93		Number of Secondary Turns
DC INPUT VOLTAGE PARAMETERS					
VMIN			127	V	Peak input voltage at VACMIN
VMAX			187	V	Peak input voltage at VACMAX
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.29		Minimum duty cycle at peak of VACMIN
IAVG			0.08	A	Average Primary Current
IP			0.63	A	Peak Primary Current (calculated at minimum input voltage VACMIN)
IRMS			0.16	A	Primary RMS Current (calculated at minimum input voltage VACMIN)
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP			468	uH	Primary Inductance
LP_TOL			10		Tolerance of primary inductance
NP			93		Primary Winding Number of Turns
NB			45		Bias Winding Number of Turns
ALG			54	nH/T^2	Gapped Core Effective Inductance
BM			1844	Gauss	Maximum Flux Density at PO, VMIN (BM<3100)
BP			2504	Gauss	Peak Flux Density (BP<3700)
BAC			922	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			1588		Relative Permeability of Ungapped Core
LG			0.38	mm	Gap Length (Lg> 0.1 mm)
BWE			22.2	mm	Effective Bobbin Width
OD			0.24	mm	Maximum Primary Wire Diameter including insulation
INS			0.05	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.19	mm	Bare conductor diameter
AWG			33	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			51	Cmils	Bare conductor effective area in circular mils
CMA			317	Cmils/Amp	Primary Winding Current Capacity (200 < CMA < 600)
TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT EQUIVALENT)					
Lumped parameters					
ISP			0.63	A	Peak Secondary Current
ISRMS			0.23	A	Secondary RMS Current
IRIPPLE			0.20	A	Output Capacitor RMS Ripple Current

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CMS			47	Cmils	Secondary Bare Conductor minimum circular mils
AWGS			33	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS			0.18	mm	Secondary Minimum Bare Conductor Diameter
ODS			0.08	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
VOLTAGE STRESS PARAMETERS					
VDRAIN			297	V	Estimated Maximum Drain Voltage assuming maximum LED string voltage (Includes Effect of Leakage Inductance)
PIVS			245	V	Output Rectifier Maximum Peak Inverse Voltage (calculated at VOVP, excludes leakage inductance spike)
PIVB			119	V	Bias Rectifier Maximum Peak Inverse Voltage (calculated at VOVP, excludes leakage inductance spike)
FINE TUNING (Enter measured values from prototype)					
V pin Resistor Fine Tuning					
RV1			1.65	M-ohms	Upper V Pin Resistor Value
RV2			1000000000000	M-ohms	Lower V Pin Resistor Value
VAC1			115.0	V	Test Input Voltage Condition1
VAC2			230.0	V	Test Input Voltage Condition2
IO_VAC1			0.12	A	Measured Output Current at VAC1
IO_VAC2			0.12	A	Measured Output Current at VAC2
RV1 (new)			1.65	M-ohms	New RV1
RV2 (new)			8626.05	M-ohms	New RV2
V_OV			133.4	V	Typical AC input voltage at which OV shutdown will be triggered
V_UV			28.9	V	Typical AC input voltage beyond which power supply can startup
FB pin resistor Fine Tuning					
RFB1			200	k-ohms	Upper FB Pin Resistor Value
RFB2			1000000000000	k-ohms	Lower FB Pin Resistor Value
VB1			20.7	V	Test Bias Voltage Condition1
VB2			25.3	V	Test Bias Voltage Condition2
IO1			0.12	A	Measured Output Current at Vb1
IO2			0.12	A	Measured Output Current at Vb2
RFB1 (new)			200.0	k-ohms	New RFB1
RFB2(new)			1000000000000.0000	k-ohms	New RFB2
Input Current Harmonic Analysis					
Harmonic		Max Current	Limit		
1st Harmonic		65.10	N/A	mA	
3rd Harmonic		16.30	N/A	mA	N/A
5th Harmonic		8.47	N/A	mA	N/A
7th Harmonic		5.09	N/A	mA	N/A
9th Harmonic		3.54	N/A	mA	N/A
11th Harmonic		2.63	N/A	mA	N/A
13th Harmonic		1.97	N/A	mA	N/A
15th Harmonic		1.58	N/A	mA	N/A
THD		29.2	%		Estimated total Harmonic Distortion (THD)

9 电感规格

9.1 电气原理图

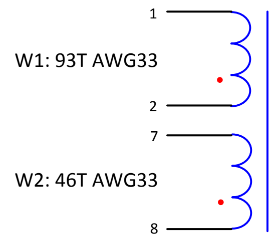

Figure 6 – Inductor Electrical Diagram.

9.2 电气规格

Primary Inductance	Pins 1-2, all other windings open, measured at 100kHz, 0.4 RMS. AL= 54.432nH/n^2	470µH ±5%
Resonant Frequency	Pins 1-2, all other windings open.	1 MHz (Min.)

9.3 材料

Item	Description
[1]	Core: TDK PC40EE10/11-Z.
[2]	Bobbin: B-EE10-V-8pins-(4/4)
[3]	Magnet Wire: #33 AWG.
[4]	Tape: 3M 1298 Polyester Film, 6.5 mm wide.
[5]	Dolph BC-359 or equivalent

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9.4 电感结构图

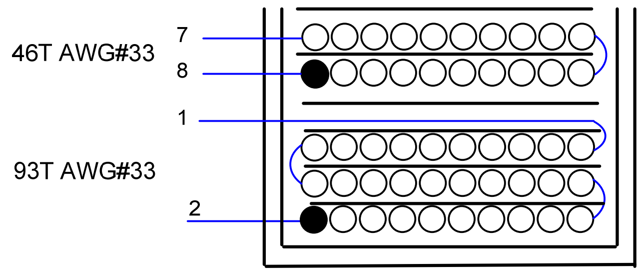

Figure 7– Inductor Build Diagram.

9.5 电感构造

Bobbin Preparation	Place the bobbin item [2] on the mandrel with pin side on the left and winding direction is clockwise direction.
Winding1	Use wire item [3], start at pin 2 wind 93 turns in ~ 3 layers and at the last turn terminate the wire at pin 1. Apply 1 layer of tape item [4] between layers
Winding2	Use wire item [3], start at pin 8 wind 46 turns in ~ 2 layers, and at the last turn terminate the wire at pin 7. Apply 1 layer of tape item [4] between layers
Finish	Grind core to get 470 μH inductance, secure the core with tape. Dip impregnate using varnish item[5]
Pins	Cut pins 3, 4, 5, 6.

10 性能数据

All measurements were performed at room temperature using an LED load.The following data was taken usinga customLED load of ~48V output voltage. Refer to the table in Section 9.4 for the complete data set.

10.1 效率

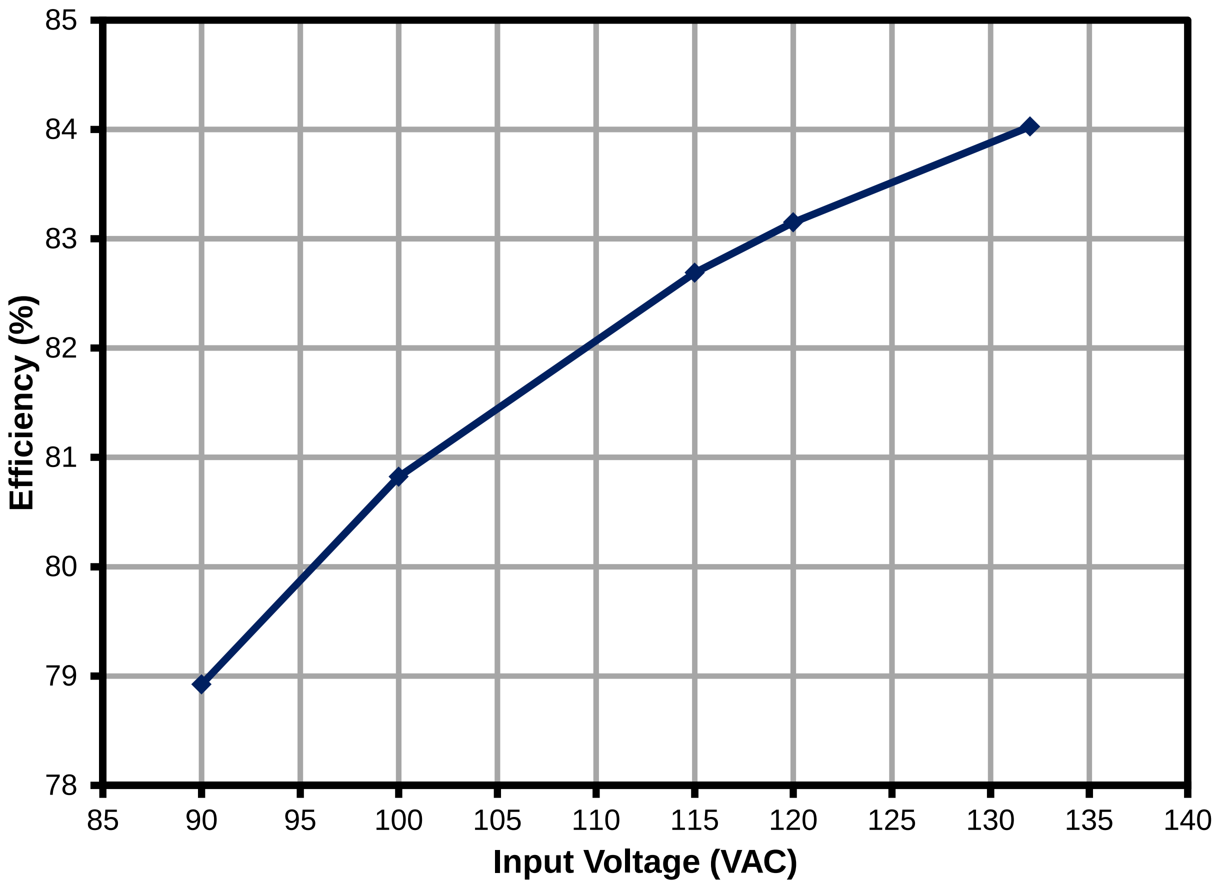

Figure 8 – Efficiency vs. Line.

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10.2 线电压调整

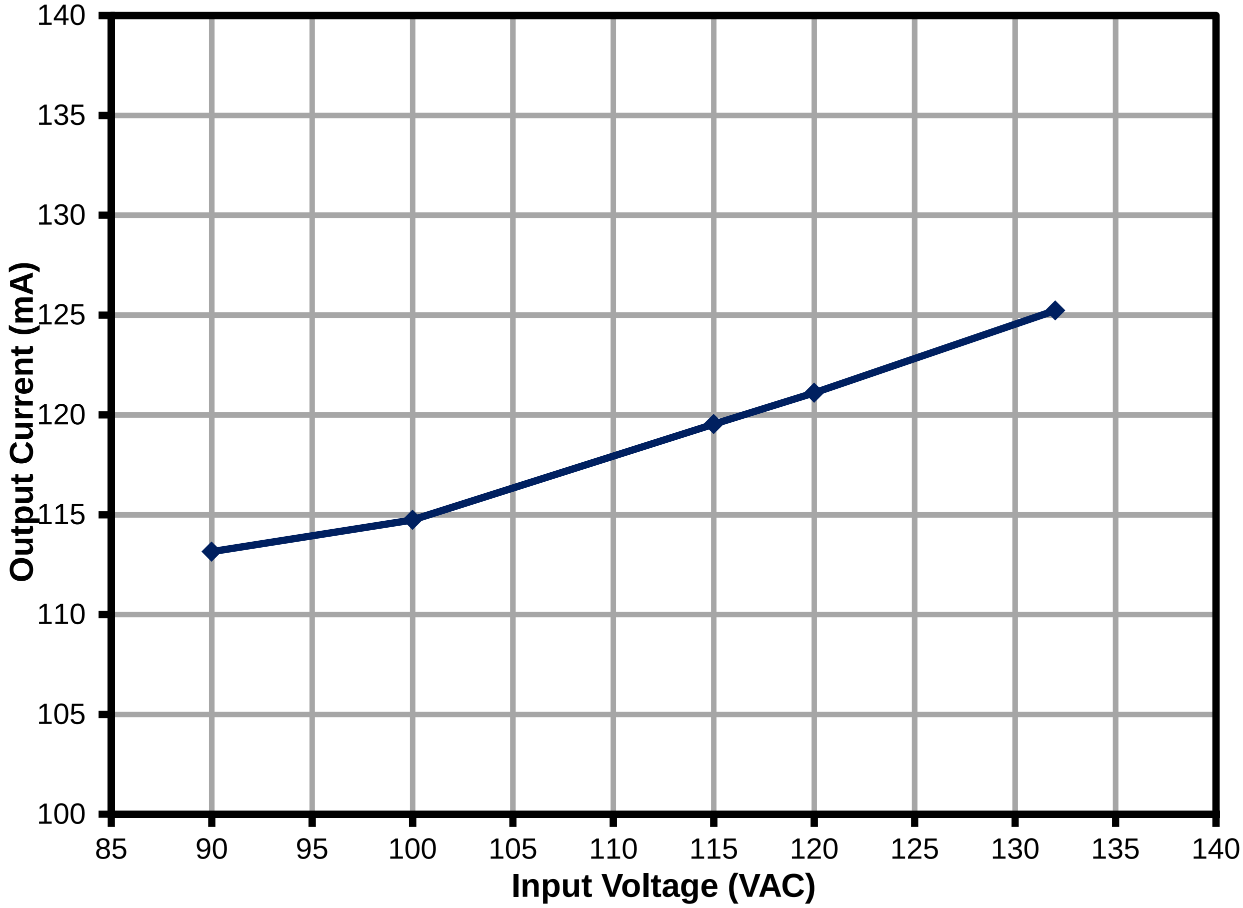

Figure 9 – Regulation vs. Line.

10.3 功率因数

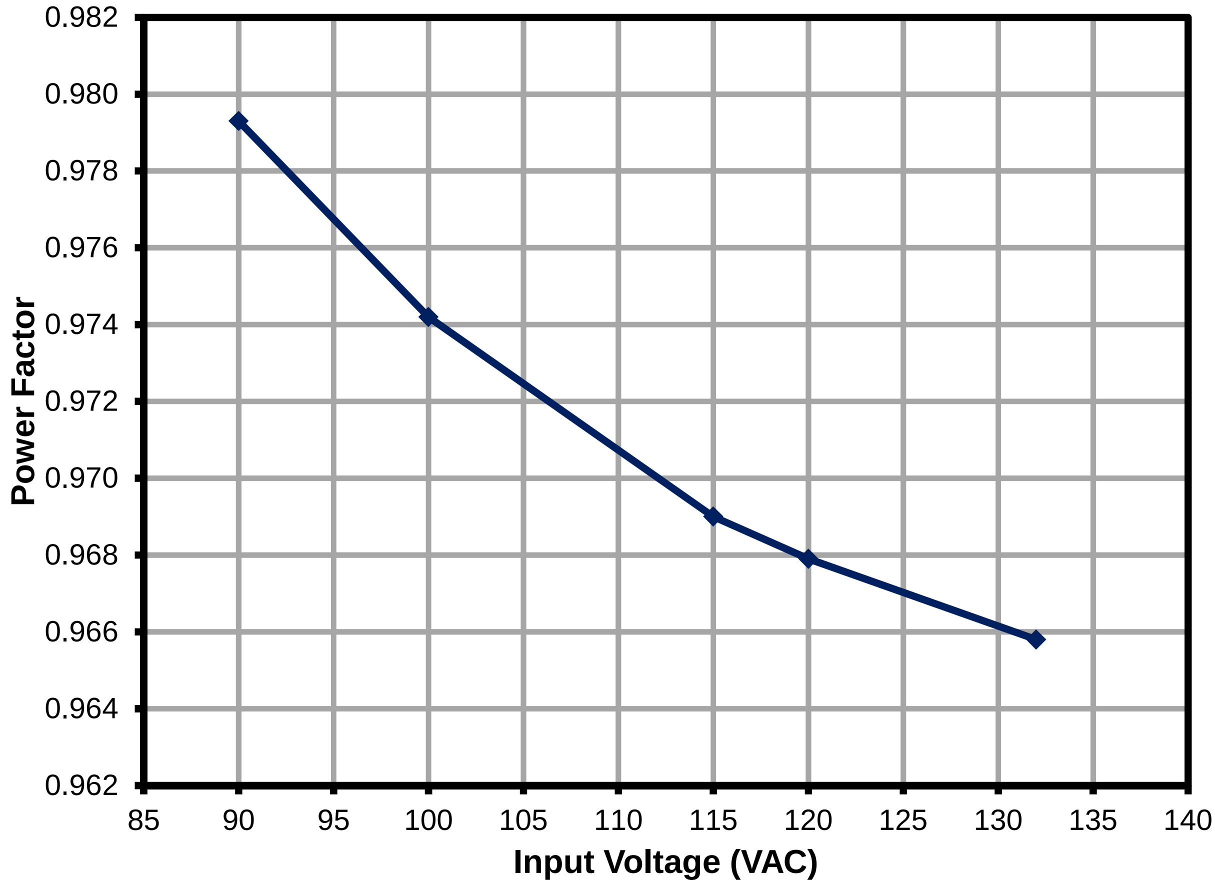

Figure 10 – Power Factor vs. Line.

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10.4 测试数据

All measurements were taken with the board mounted open frame, 25 ºC ambient, 60Hz line frequency, and with an LED load.

Input Measurement					Load Measurement			Calculation		
V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	%ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	P_{CAL} (W)	Efficiency (%)	Loss (W)
90.06	80.76	7.123	0.979	20.09	49.5970	113.150	5.622	5.61	78.92	1.50
100.03	72.39	7.055	0.974	22.24	49.6110	114.740	5.702	5.69	80.82	1.35
115.07	64.51	7.193	0.969	24	49.6730	119.540	5.948	5.94	82.69	1.25
120.06	62.38	7.249	0.968	24.18	49.6840	121.110	6.028	6.02	83.15	1.22
132.09	58.20	7.425	0.966	24.29	49.7320	125.230	6.239	6.23	84.03	1.19

11 调光性能数据

TRIAC dimming results were taken with input voltage of 120VAC, 60Hz line frequency, room temperature, and nominal ~48V LED load.

11.1 调光曲线

Taken using a programmable AC source providing the leading edge chopped AC input.

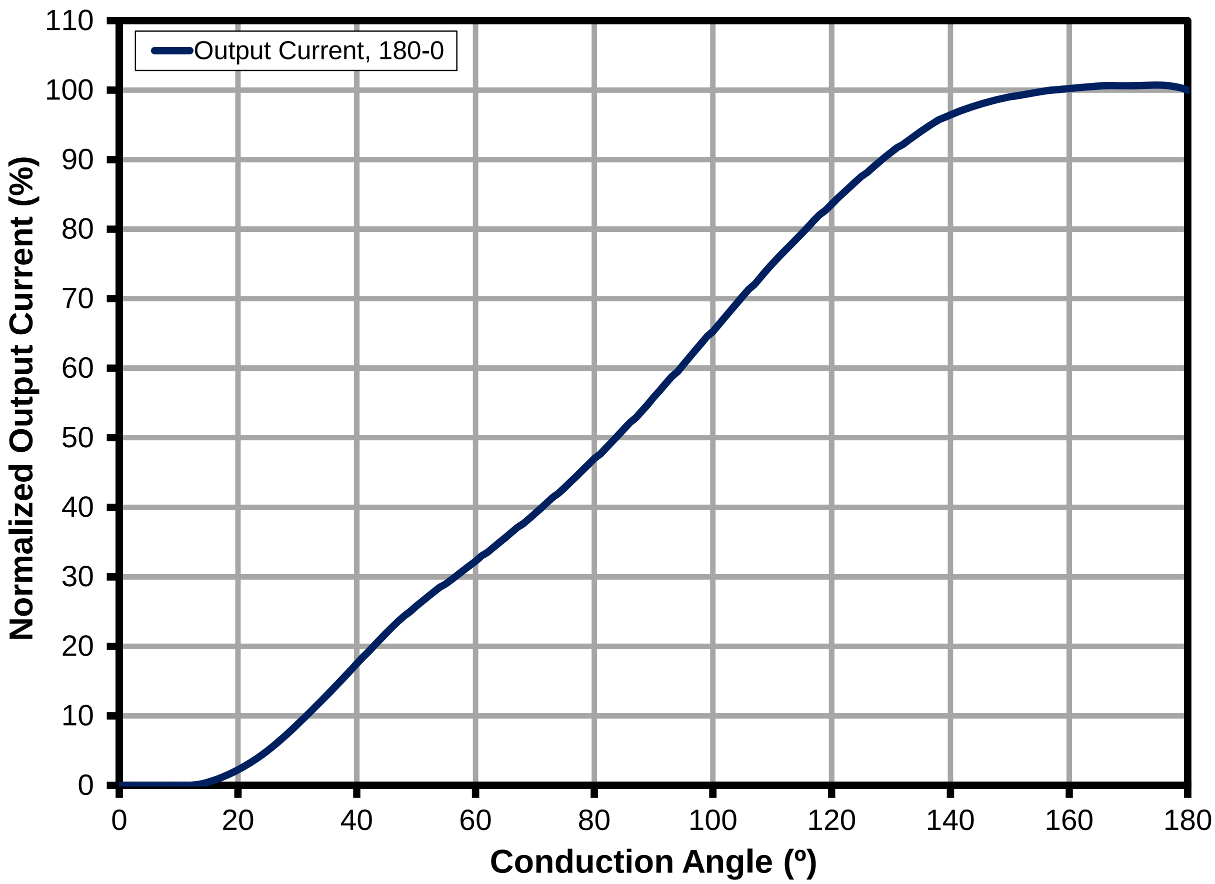

Figure 11 – Leading Edge Dimming Characteristics.

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11.2 调光效率

Measured using a programmable AC source providing the leading edge chopped AC input.

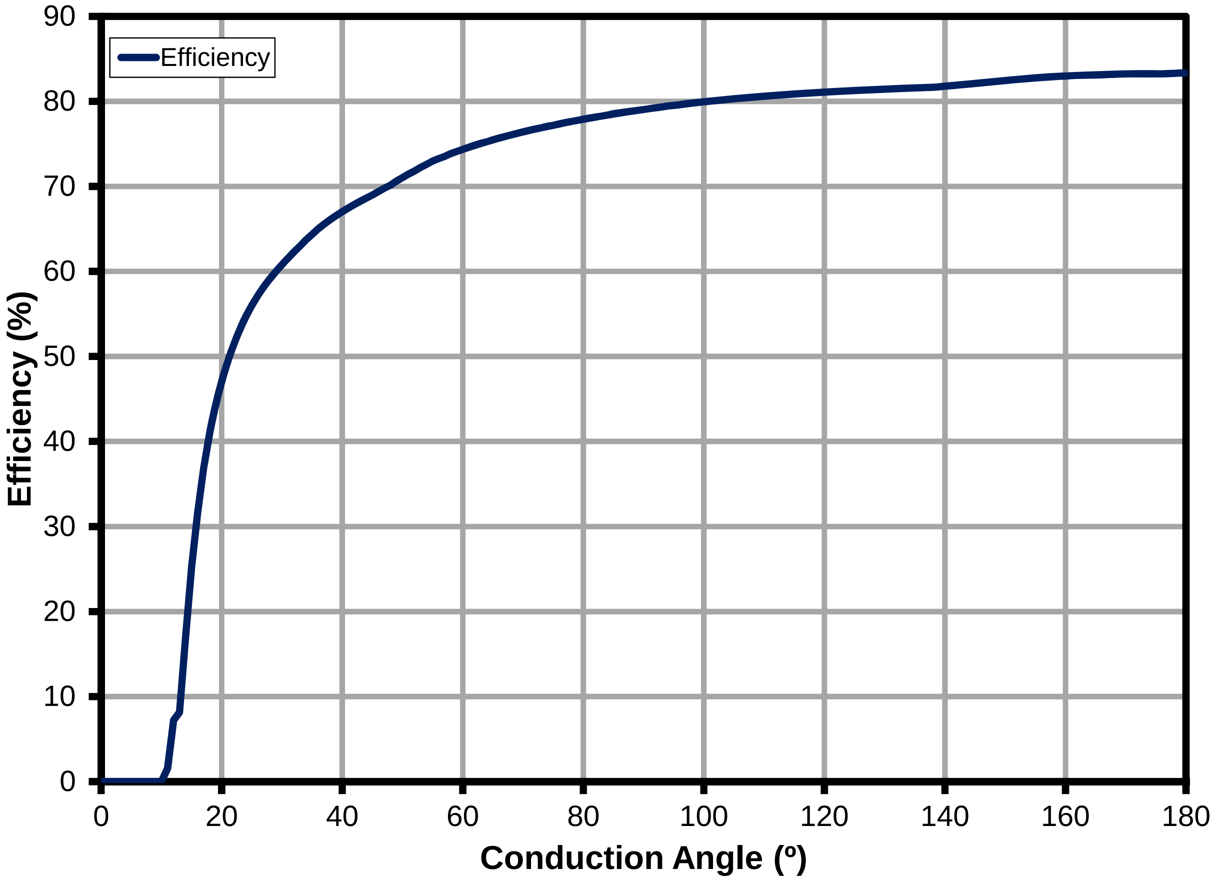

Figure 12 – Driver Efficiency as a Function of Conduction Angle.

11.3 调光期间的驱动器功耗

Measured using a programmable AC source providing the trailing edge chopped AC input.

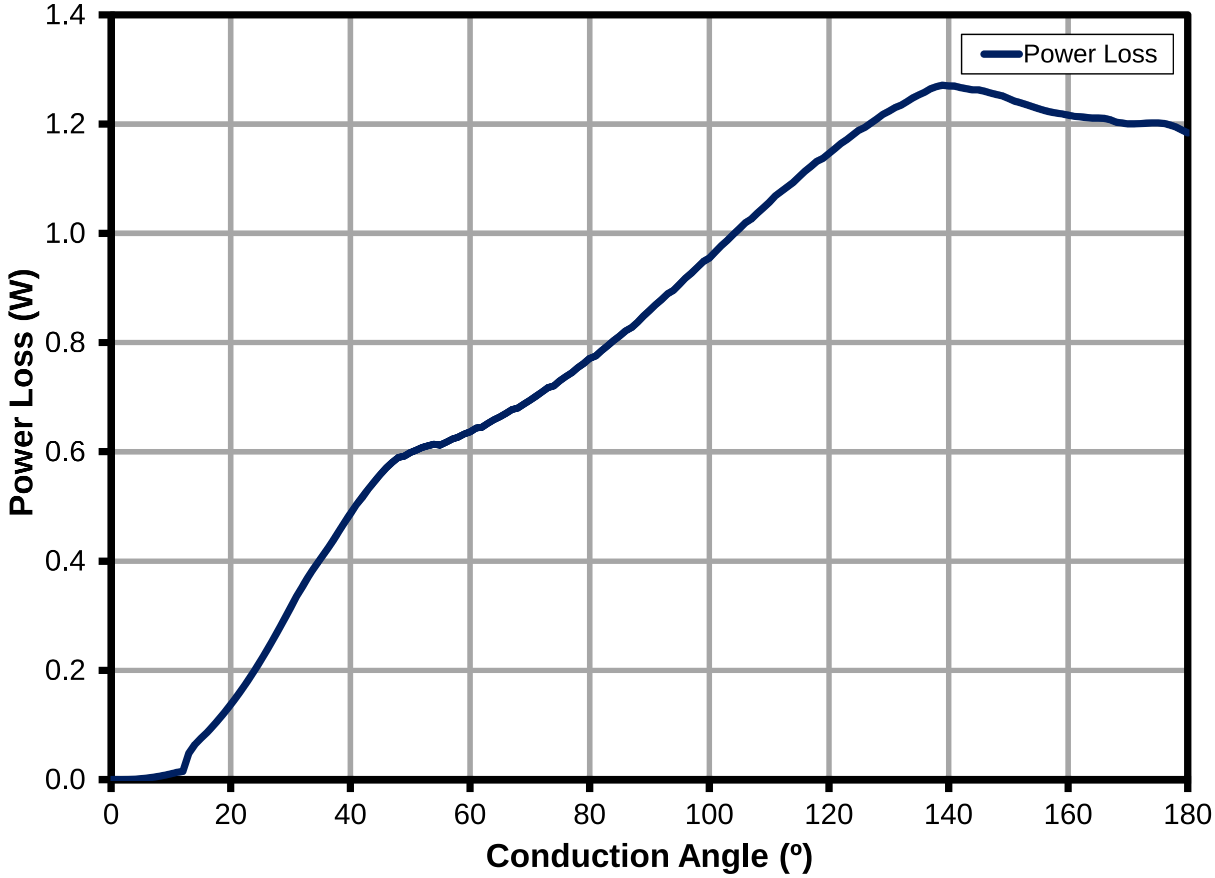

Figure 13 – Driver Power Loss as a Function of Conduction Angle.

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11.4 调光器兼容性列表

The unit was tested with the following high-line dimmers at 120VAC, 60 Hz input and ~48V LED load.

List of Dimmers	Type	Part Number	Min,mA	Max, mA	DR
LUTRON LG600PH-LA	L	LG-600PH-WH	14	115	8.21
LUTRON S603P	L	S-603P-WH	12	116	9.67
LUTRON SLV600P	T	SLV600P-WH	20	116	5.80
LUTRON S600	L	S-600-WH	18	118	6.56
LUTRON S-600PH-WH	L	S-600PH-WH	11	115	10.45
LUTRON DVCL153P	L	DVWCL-153-PLH-WH	13	114	8.77
LUTRON DV603P	L	DV-603P-WH	14	115	8.21
LUTRON DV600P	L	DV-600P-WH	13	115	8.85
LUTRON TG600PH-IV	L	TG-600PH-WH	29	117	4.03
LUTRON AY600P	T	AY-600P-WH	31	95	3.06
LUTRON GL600P-WH	L	GL-600P-WH	17	116	6.82
LEVITON 6633PLI	L	R62-06633-1LW	13	119	9.15
LEVITON 6631-LI	L	R62-06631-1LW	5	117	23.40
LEVITON IPI06	L	R60-IPI06-1LM	31	118	3.81
LEVITON 6161-I	E	R52-06161-00W	24	116	4.83
LEVITON RP106	L	R52-RPI06-1LW	17	119	7.00
LEVITON 6681	L	R60-06681-0IW	10	119	11.90
LEVITON 6684	L	R60-06684-1IW	3	118	39.33
LEVITON 6683	L	6683	5	119	23.80
LEVITON 6613	L	R02-06613-PLW	10	119	11.90
COOPER SLC03	L	SLC03P-W-K-L	7	117	16.71
LUTRON GL600-WH	L	GL-600-WH	19	119	6.26
LUTRON DVPDC-203P-WH	L	DVPDC-203P-WH	50	118	2.36
LUTRON LX600PL	L	LX-600PL-wh	21	118	5.62
LUTRON D600P	L	D-600P-WH	10	113	11.30
LUTRON CTCL-153PDH	L		10	115	11.50
LUTRON S-600P	L	S-600P	10	115	11.50
LUTRON TGLV-600P	L	TGLV-600P	25	117	4.68
LUTRON TGLV-600PR	L	TGLV-600PR	23	116	5.04
LUTRON TT-300NLH-WH	L	TT-300NLH-WH	18	118	6.56
LUTRON TT-300H-WH	L	TT-300H-WH	12	118	9.83
LUTRON NLV-1000-WH	L	NLV-1000-WH	14	117	8.36
Lutron	E	MAELV-600	20	106	5.30
Lutron	L	S-600P-WH	14	115	8.21
Lutron	E	MIR-600	12	110	9.17
Lutron	L	S-600-WH	11	119	10.82
Cooper	L	S106P	22	119	5.41
Lutron	L	S-103P-WH	23	116	5.04
Lutron	L	S-10P-WH	18	115	6.39
Lutron	L	S-600PNLH-WH	18.5	117	6.32
Lutron	L	S-603PNL-WH	21	116	5.52
Lutron	L	SLV-603P-WH	25	116	4.64
Lutron	L	S-603PGH-WH	12	100	8.33

Lutron	L	AYLV-600P-WH	25	116	4.64
Lutron	L	AYLV-603P-WH	26	116	4.46
Lutron	L	AY-103PNL-WH	20	117	5.85
Lutron	L	AY-10PNL-WH	17	119	7.00
Lutron	L	AY-10P-WH	14	116	8.29
Lutron	L	AY-603PNL-WH	25	115	4.60
Lutron	L	AY-603PG-WH	25	97	3.88
Lutron	L	AY-603P-WH	31	115	3.71
Lutron	L	AY-600PNL-WH	26	117	4.50
Lutron	T	DVELV-300P-WH	16	102	6.38
Lutron	L	DVLV-10P-WH	27	115	4.26
Lutron	L	DVLV-103P-WH	25	115	4.60
Lutron	L	DVLV-603P-WH	24	115	4.79
Lutron	L	S-1000-WH	19	118	6.21
Lutron	T	SELV-300P-WH	15	100	6.67
Lutron	L	S-600P-WH	11	115	10.45
Lutron	L	S-103PNL-WH	24	115	4.79
Lutron	E	SPSLV-1000-WH	23	119	5.17
Lutron	E	SPSLV-600-WH	23	119	5.17
Lutron	E	SPSELV-600-WH	20	106	5.30
Lutron	L	GLV-600-WH	13	119	9.15
Lutron	L	LG-603PGH-WH	16	96.5	6.03
Lutron	L	DVW-603PGH-WH	17	96	5.65
Lutron	L	TG-10PR-WH	25	116	4.64
Lutron	L	NT-600	13	117	9.00
Lutron	L	NT-1000	13	117	9.00
Lutron	L	LGCL-153PLH-WH	18	111	6.17
Lutron	L	CTCL-153PDH-WH	24	111	4.63
Lutron	L	TGCL-153PH-WH	18	113	6.28
Lutron	L	DVWCL-153PH-LA	26	112	4.31
Leviton	L	81000-W	27	117	4.33
Lutron	L	TTCL-100LH-WH	26	111	4.27

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12 热性能

The following readings were taken with the power supply configured for open frame and room temperature ambient conditions.

12.1 120 VAC，60 Hz，未连接调光器

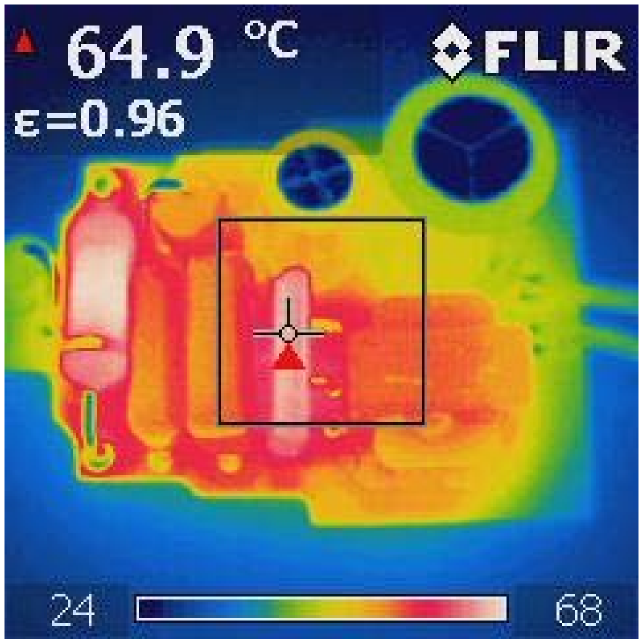

Figure 14 – U1: LYT4311E.

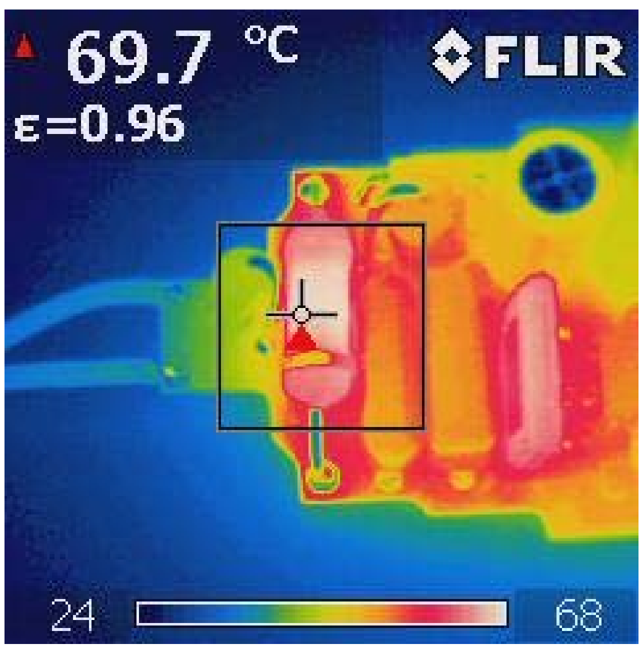

Figure 15 – R1: Damper Resistor.

12.2 120 VAC，60 Hz，连接调光器，90º导通角

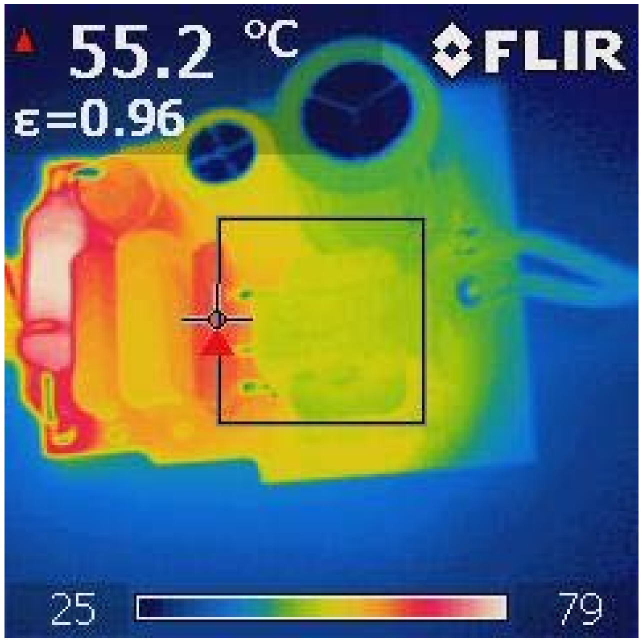

Figure 16 – U1: LYT4311E.

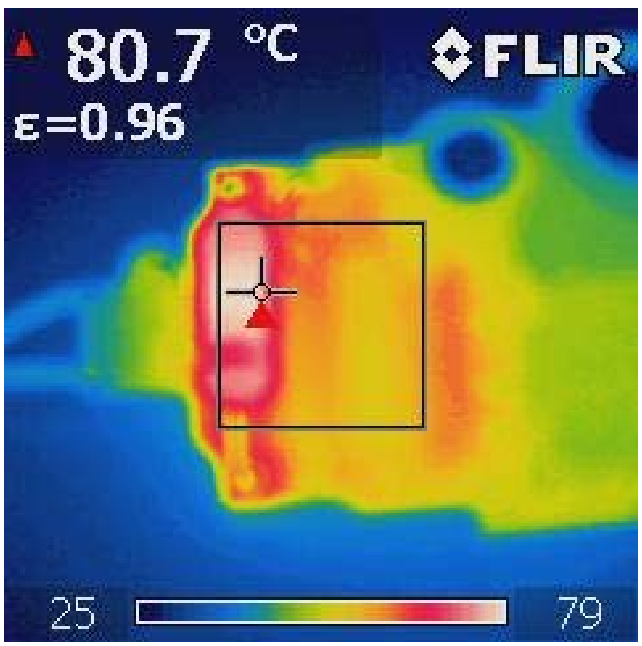

Figure 17 – R1: Damper Resistor.

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13 非调光（未连接调光器）波形

13.1 输入电压和输入电流波形

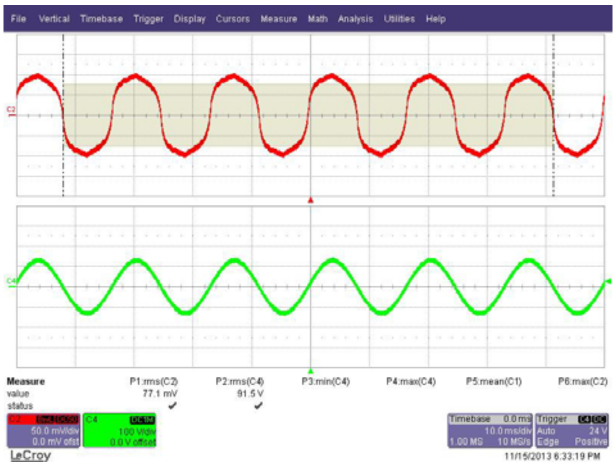

Figure 18 – 90 VAC, Full Load.
Upper: I_{IN}, 50mA / div.
Lower: V_{IN}, 100 V, 10 ms / div.

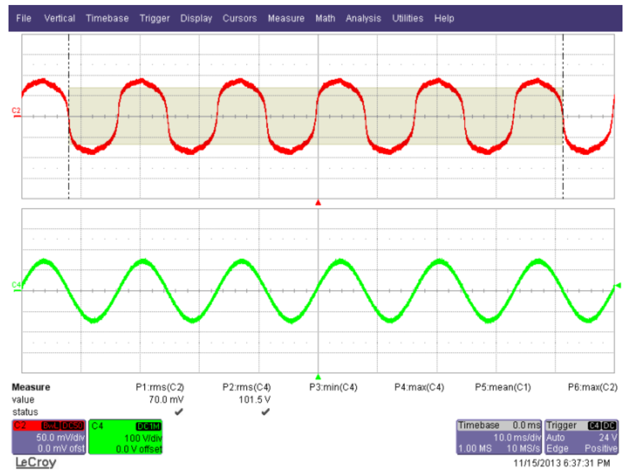

Figure 19 – 100 VAC, Full Load.
Upper: I_{IN}, 50mA / div.
Lower: V_{IN}, 100 V, 10 ms / div.

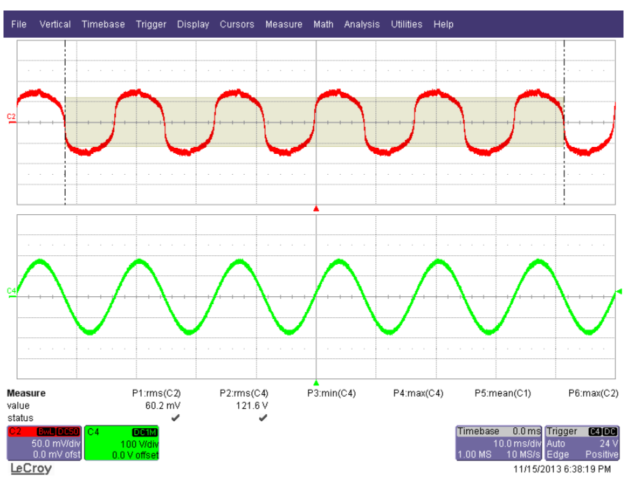

Figure 20 – 120 VAC, Full Load.
Upper: I_{IN}, 50mA / div.
Lower: V_{IN}, 100 V, 10 ms / div.

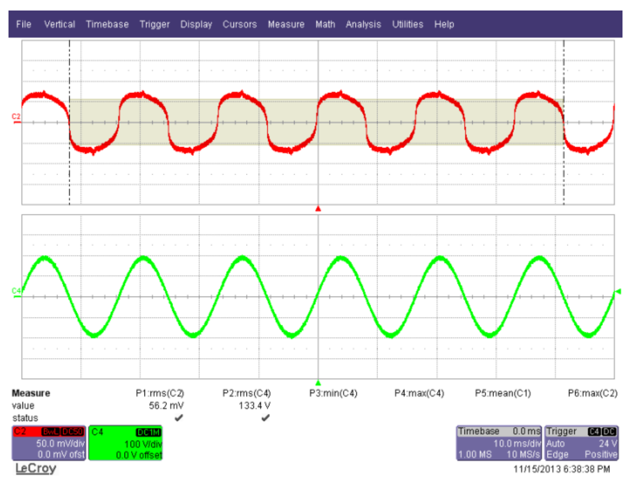

Figure 21 – 132 VAC, Full Load.
Upper: I_{IN}, 50mA / div.
Lower: V_{IN}, 100 V, 10 ms / div.

13.2 正常工作时的输出电流和输出电压

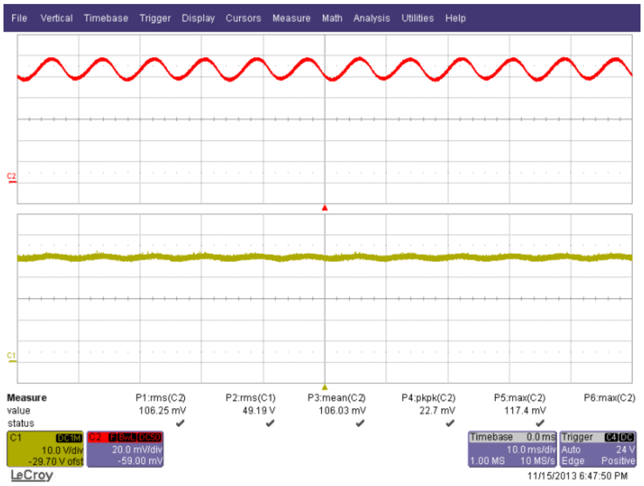

Figure 22 – 90 VAC, 60Hz Full Load.
Upper: I_{OUT}, 20mA / div.
Lower: V_{OUT}, 10 V, 10 ms / div.

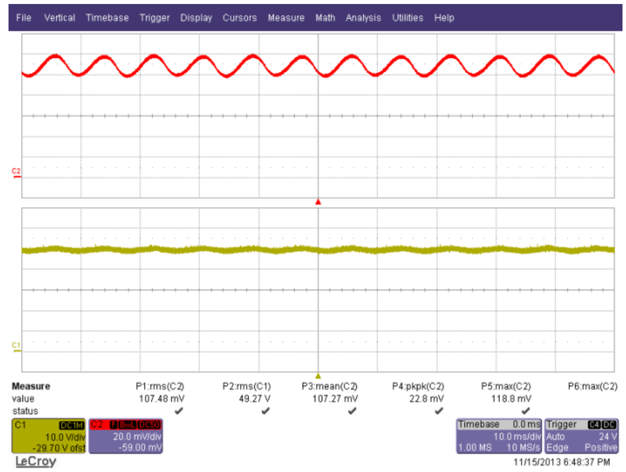

Figure 23 – 100 VAC, 60Hz Full Load.
Upper: I_{OUT}, 20mA / div.
Lower: V_{OUT}, 10 V, 10 ms / div.

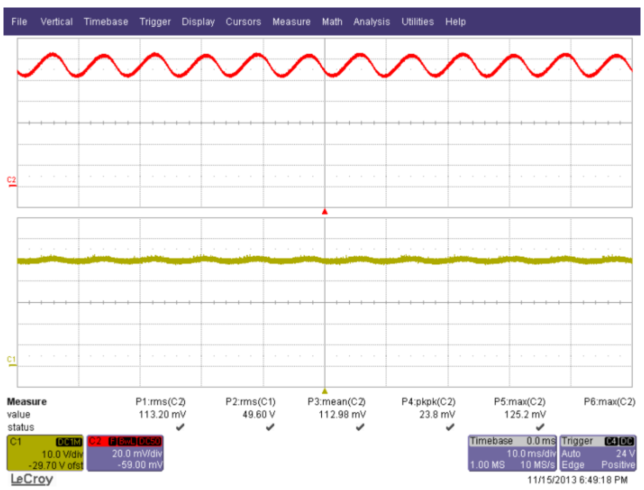

Figure 24 – 120 VAC, 60Hz Full Load.
Upper: I_{OUT}, 20mA / div.
Lower: V_{OUT}, 10 V, 10 ms / div.

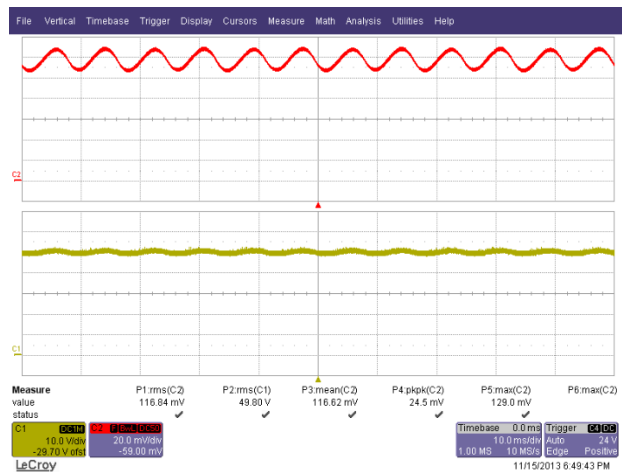

Figure 25 – 132 VAC, 60Hz Full Load.
Upper: I_{OUT}, 20mA / div.
Lower: V_{OUT}, 10 V, 10 ms / div.

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13.3 输出电流的升降

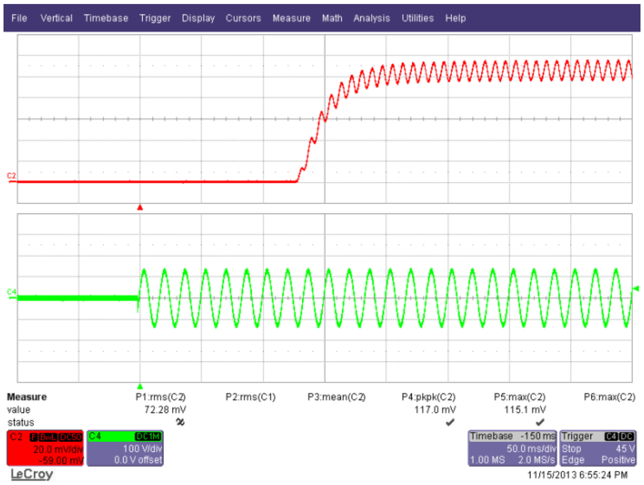

Figure 26 – 90 VAC Output Rise.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 200 V, 100 ms / div.

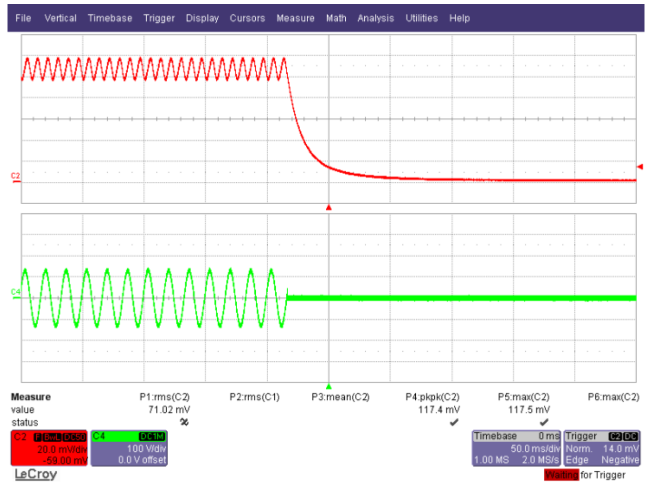

Figure 27 – 90 VAC Output Fall.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 200 V, 100 ms / div.

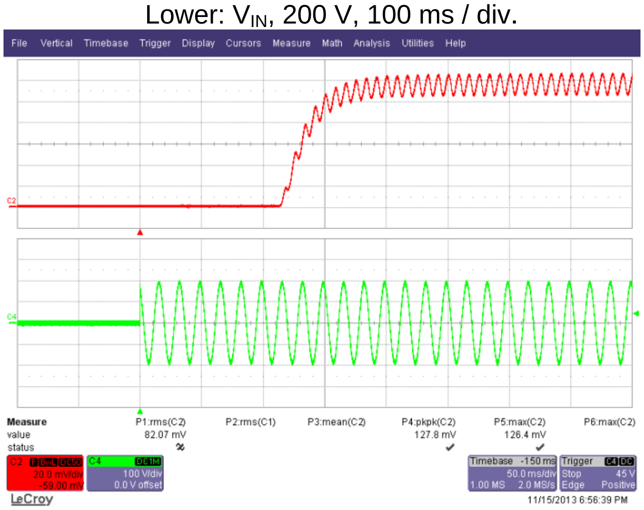

Figure 28 – 132 VAC Output Rise.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 200 V, 100 ms / div.

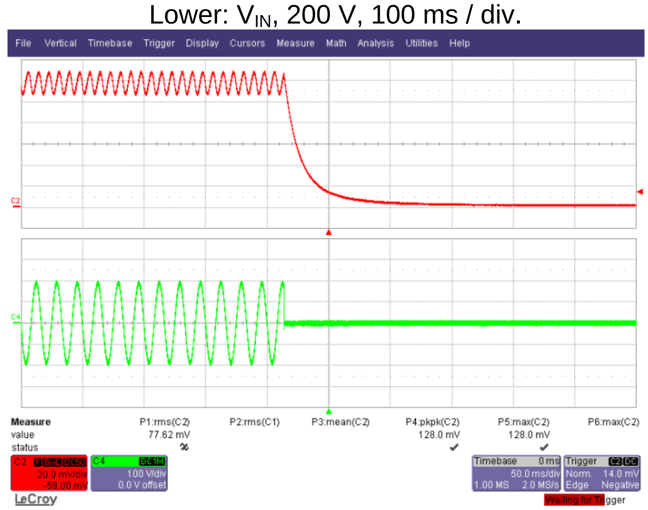

Figure 29 – 132 VAC Output Fall.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 200 V, 100 ms / div.

13.4 正常工作时的漏极电压和电流

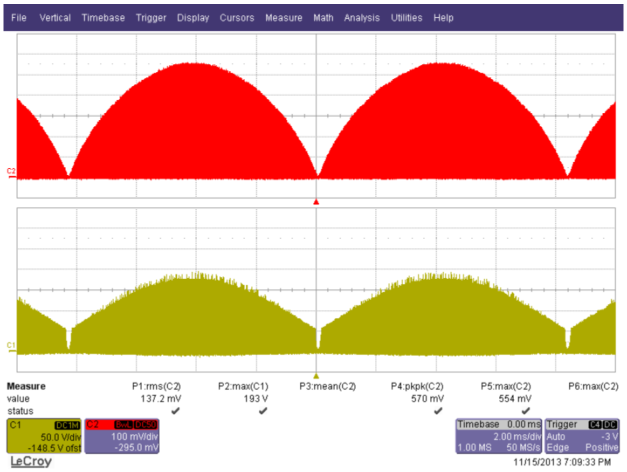

Figure 30 – 90 VAC, 60Hz.
Upper: I_{DRAIN}, 0.1 A / div.
Lower: V_{DRAIN}, 50 V,2ms / div.

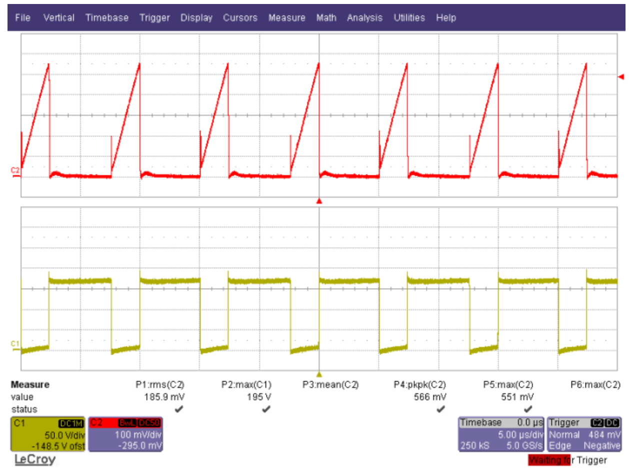

Figure 31 – 90 VAC, 60Hz.
Upper: I_{DRAIN}, 0.1 A / div.
Lower: V_{DRAIN}, 50 V / div., 5μs / div.

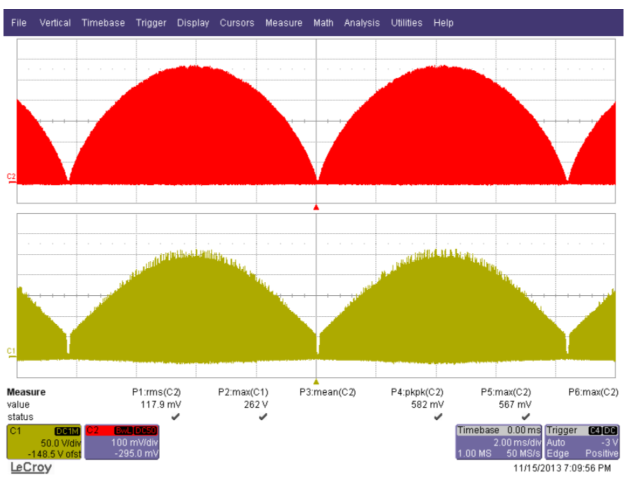

Figure 32 – 132 VAC, 60Hz.
Upper: I_{DRAIN}, 0.1 A / div.
Lower: V_{DRAIN}, 50 V,2ms / div.

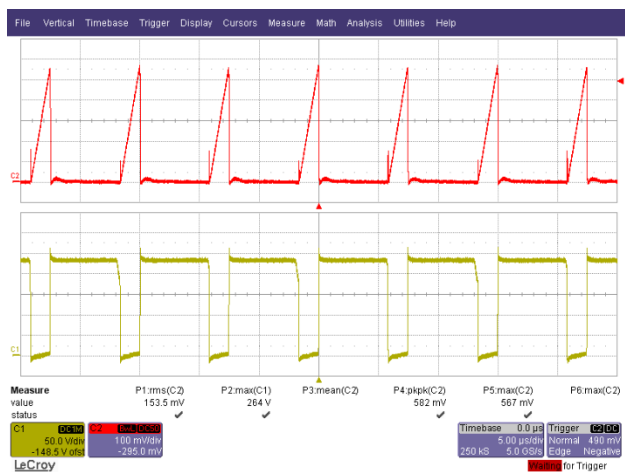

Figure 33 – 132 VAC, 600Hz.
Upper: I_{DRAIN}, 0.1 A / div.
Lower: V_{DRAIN}, 50 V / div., 5μs / div.

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13.5 启动时的漏极电压和电流

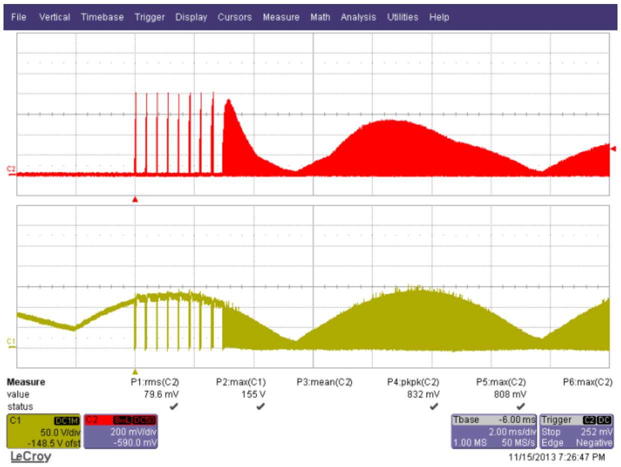

Figure 34 – 90 VAC, 60Hz Start-up.
Upper: I_{DRAIN}, 500mA / div.
Lower: V_{DRAIN},100 V, 2 ms / div.

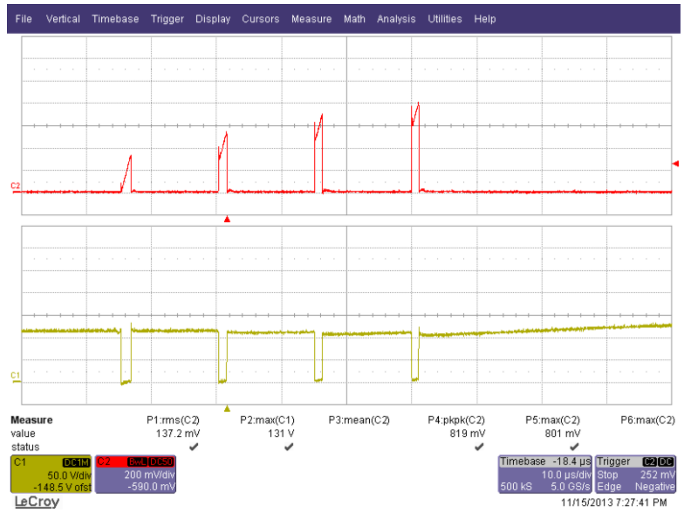

Figure 35 – 90 VAC, 60Hz Start-up.
Upper: I_{DRAIN}, 500mA / div.
Lower: V_{DRAIN},100 V, 5µs / div.

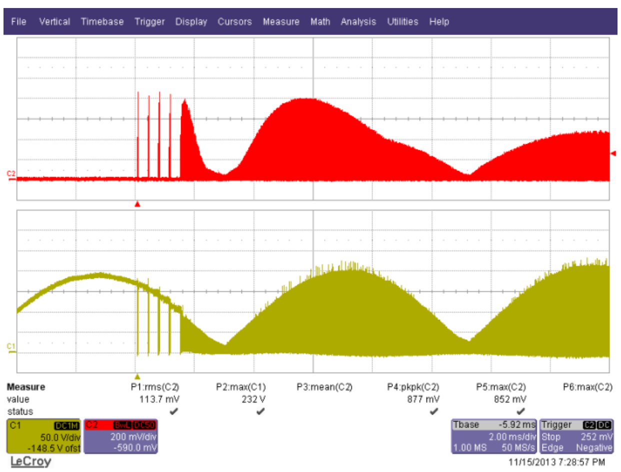

Figure 36 – 132 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500mA / div.
Lower: V_{DRAIN},100 V, 2 ms / div.

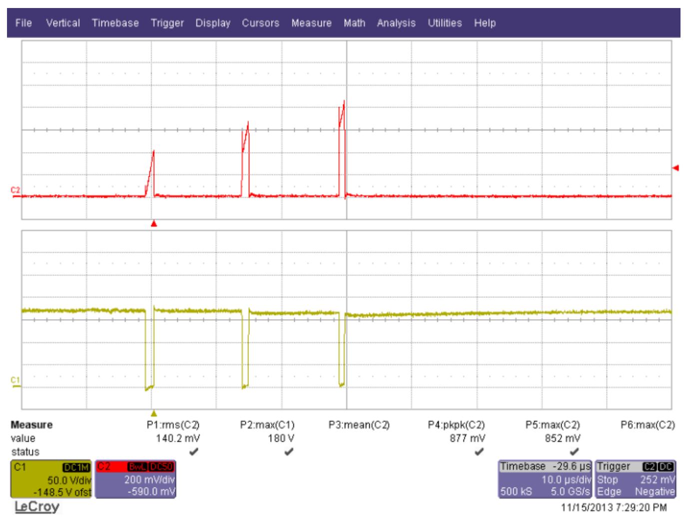

Figure 37 – 132 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500mA / div.
Lower: V_{DRAIN},100 V, 5µs / div.

13.6 输出短路时的漏极电流和漏极电压

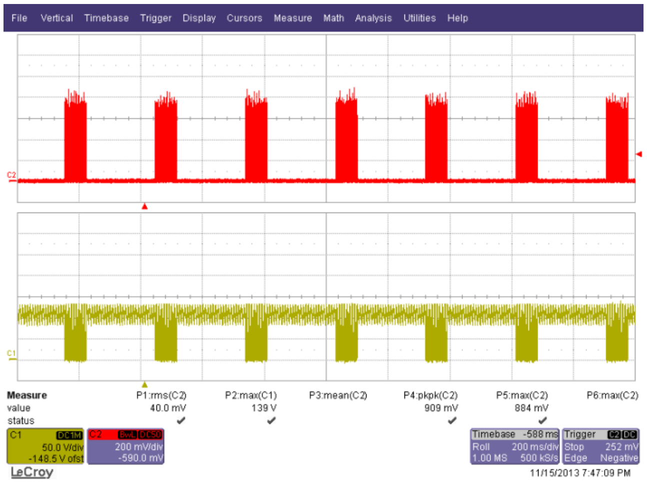

Figure 38 – 90 VAC, 60Hz Output Short Condition.
Upper: I_{DRAIN}, 500mA / div.
Lower: V_{DRAIN},100 V, 200ms / div.

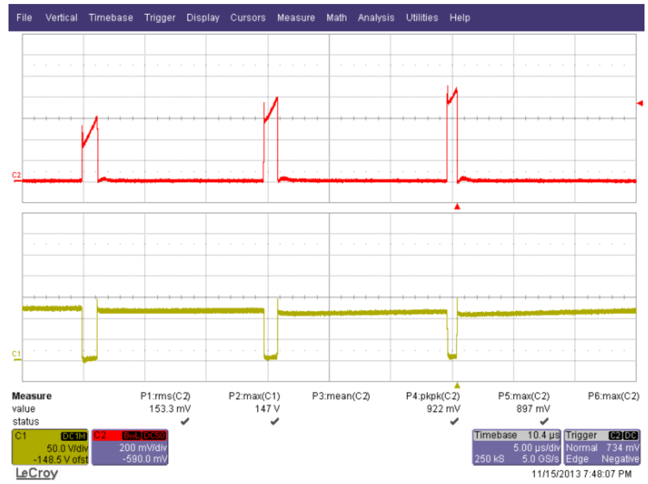

Figure 39 – 90 VAC, 60Hz Output Short Condition.
Upper: I_{DRAIN}, 500 mA / div.
Lower: V_{DRAIN}, 100 V, 0.5µs / div.

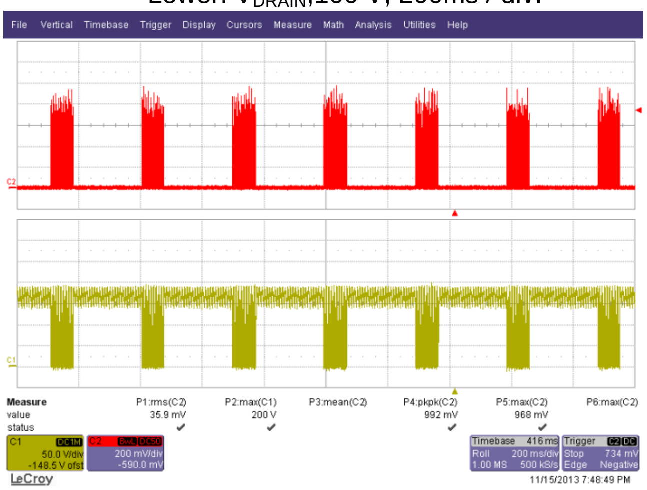

Figure 40 – 132 VAC, 60Hz Output Short Condition.
Upper: I_{DRAIN}, 500 mA / div.
Lower: $V_{DRAIN,}$ 100 V, 5ms / div.

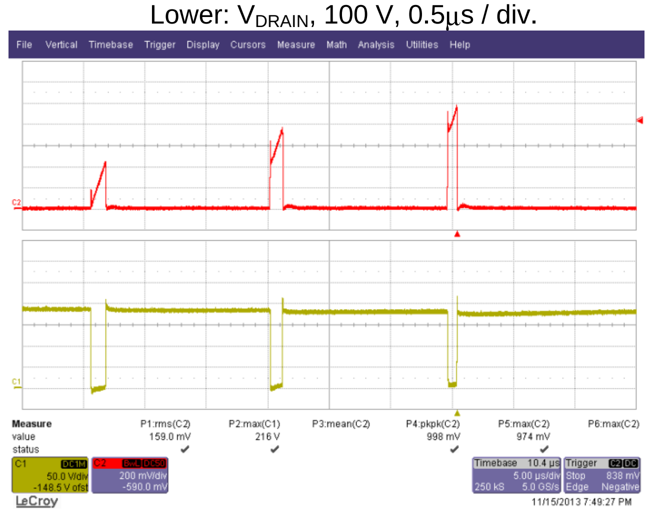

Figure 41 – 132 VAC, 60Hz Output Short Condition.
Upper: I_{DRAIN}, 500 mA / div.
Lower: $V_{DRAIN,}$ 100 V, 1µs / div.

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13.7 *开路负载特性*

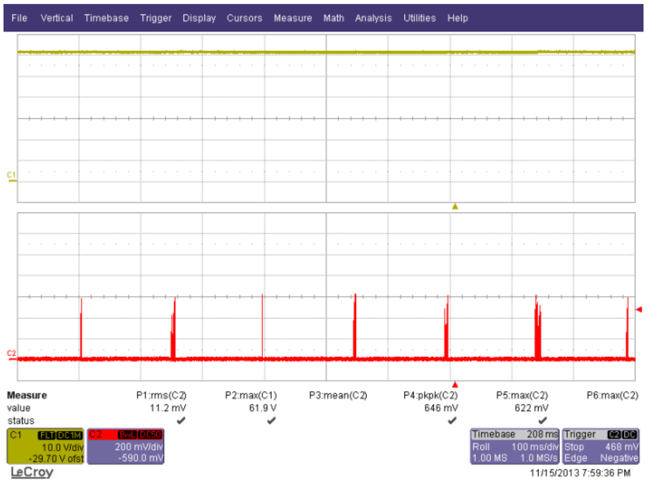

Figure 42 – 90 VAC, 60Hz Output Short Condition.
Upper: V_{OUT}, 10 V / div.
Lower: I_{DRAIN}, 200 mA, 200ms / div.

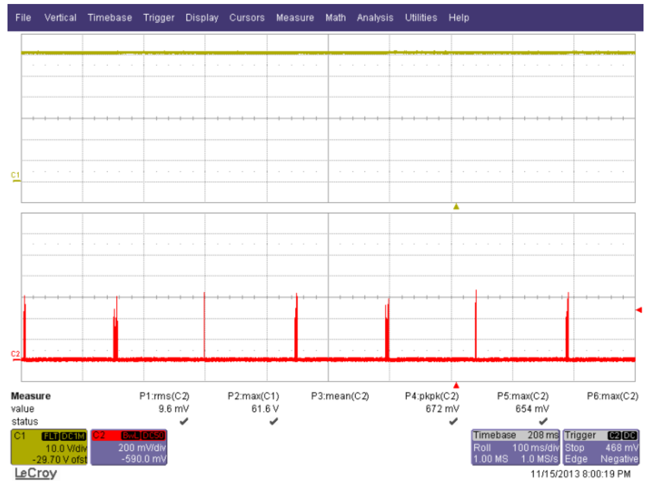

Figure 43 – 132 VAC, 60Hz Output Short Condition.
Upper: V_{OUT}, 10 V / div.
Lower: I_{DRAIN}, 200 mA, 200ms / div.

13.8 *电压跌落/缓升*

No failure of any component during brownout test of 0.5 V / sec AC cut-in and cut-off.

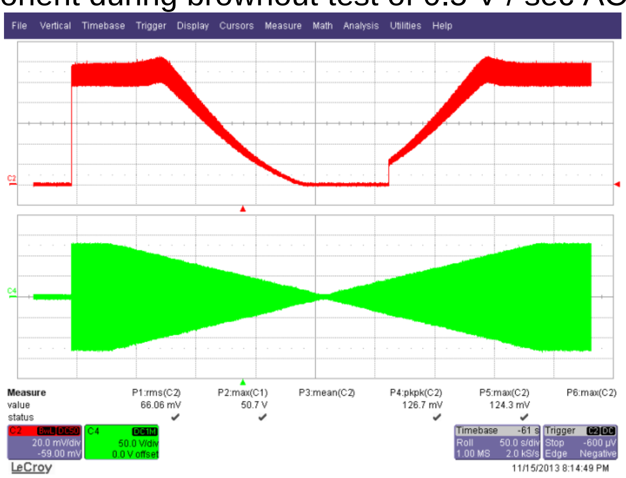

Figure 44 – Brown-out Test at 0.5V / s. The Unit is Able to Operate Normally Without Any Failure and Without Flicker.
Ch4: V_{IN}; 50V / div.
Ch2: I_{OUT}; 20mA / div.
Time Scale:50s / div.

14 调光波形

14.1 输入电压及输入电流波形 - 前沿调光器

Input: 120VAC, 60Hz
Output: 48V LED Load
Dimmer: S-600-WH

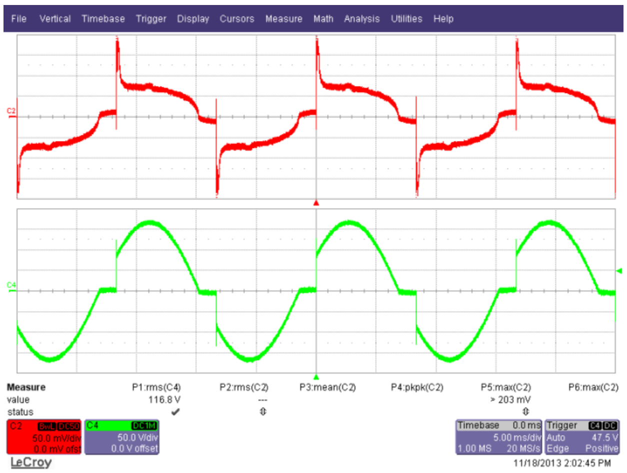

Figure 45 – 147ºConduction Angle.
Upper: I_{IN}, 50mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

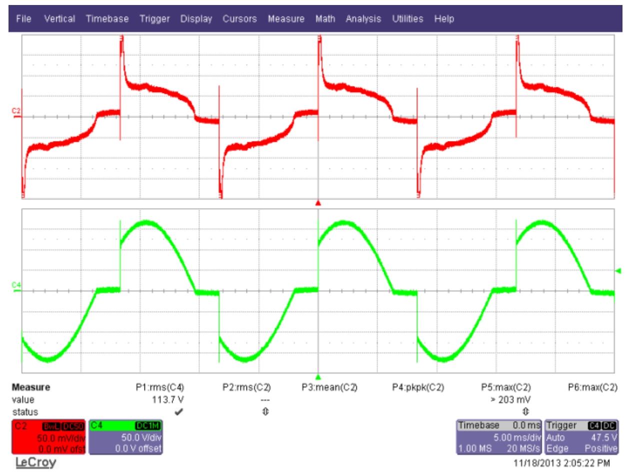

Figure 46 – 135ºConduction Angle.
Upper: I_{IN}, 50mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

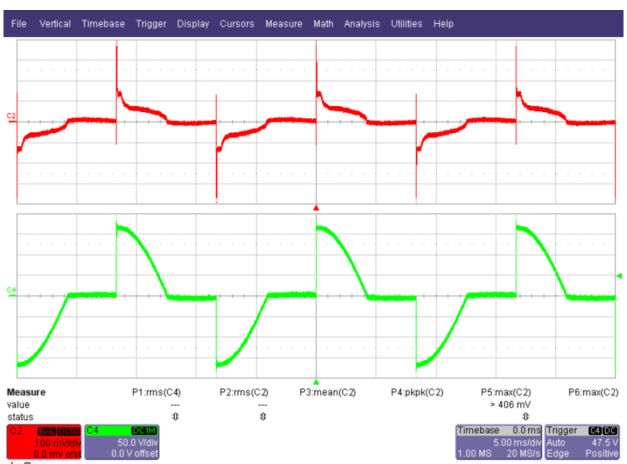

Figure 47 – 90ºConduction Angle.
Upper: I_{IN}, 100mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

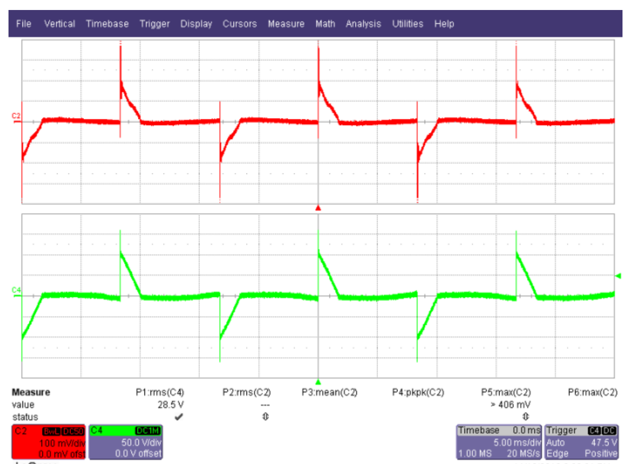

Figure 48 – 36ºConduction Angle.
Upper: I_{IN}, 100mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

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14.2 输出电流波形 – 前沿调光器

Input: 120 VAC, 60 Hz
Output: 48 V LED Load
Dimmer: S-600-WH

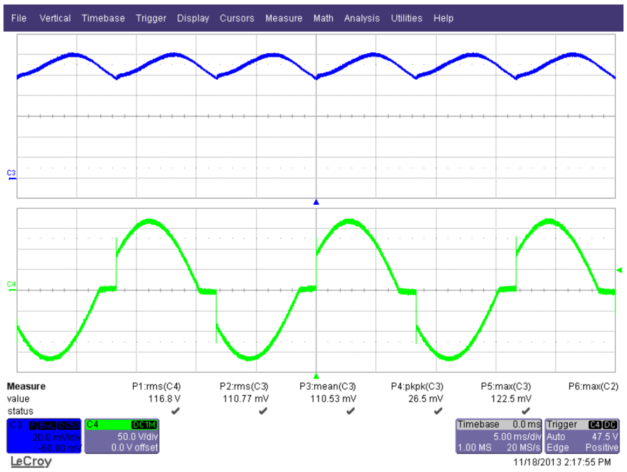

Figure 49 – 147ºConduction Angle.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

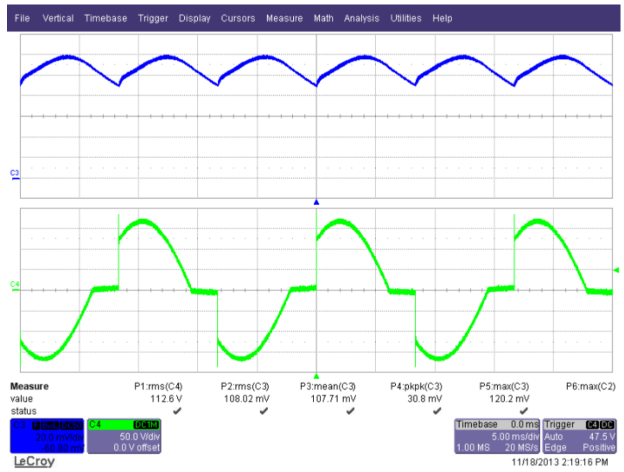

Figure 50 – 135ºConduction Angle.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

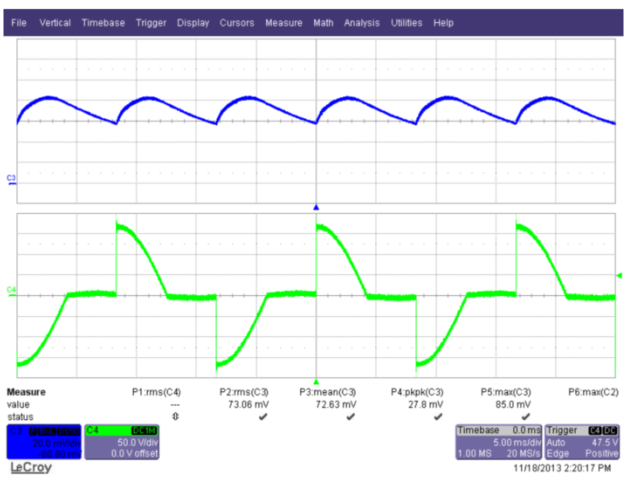

Figure 51 – 90ºConduction Angle.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

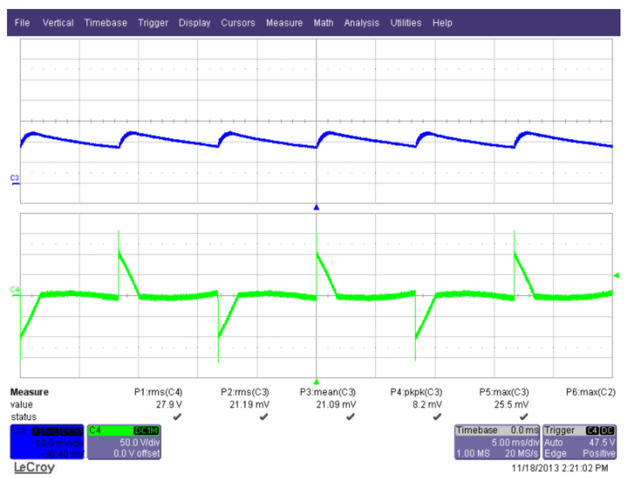

Figure 52 – 36ºConduction Angle.
Upper: I_{OUT}, 10mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

14.3 输入电压及输入电流波形 – 后沿调光器

Input: 120 VAC, 60 Hz
Output: 48 V LED Load
Dimmer: DVELV-300P-WH

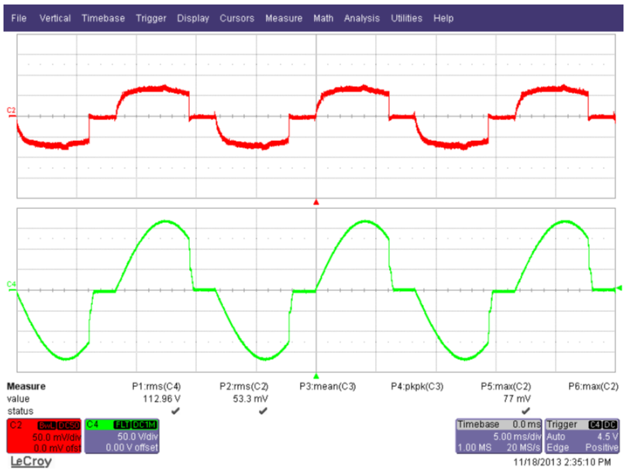

Figure 53 – 131ºConduction Angle.
Upper: I_{IN}, 50mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

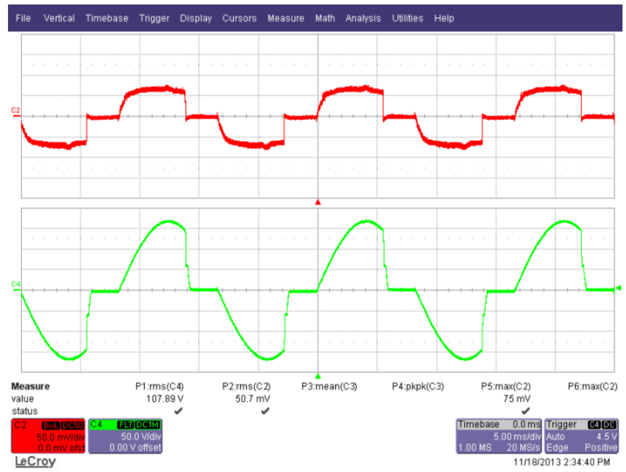

Figure 54 – 120ºConduction Angle.
Upper: I_{IN}, 50mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

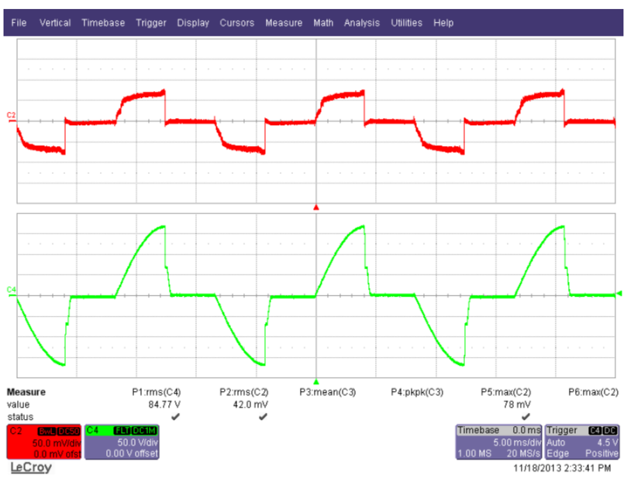

Figure 55 – 90ºConduction Angle.
Upper: I_{IN}, 50mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

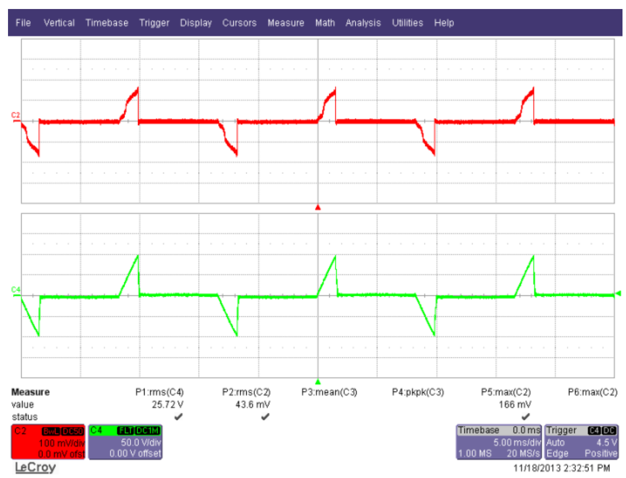

Figure 56 – 40ºConduction Angle.
Upper: I_{IN}, 100mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

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14.4 输出电流波形 – 后沿调光器

Input: 120 VAC, 60 Hz
Output: 48 V LED Load
Dimmer: DVELV-300P-WH

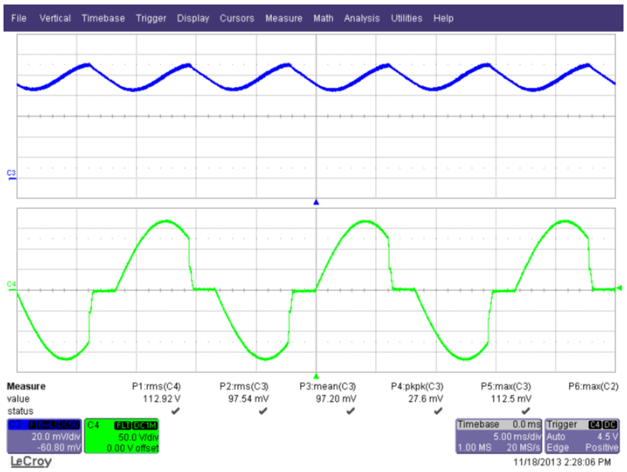

Figure 57 – 131ºConduction Angle.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

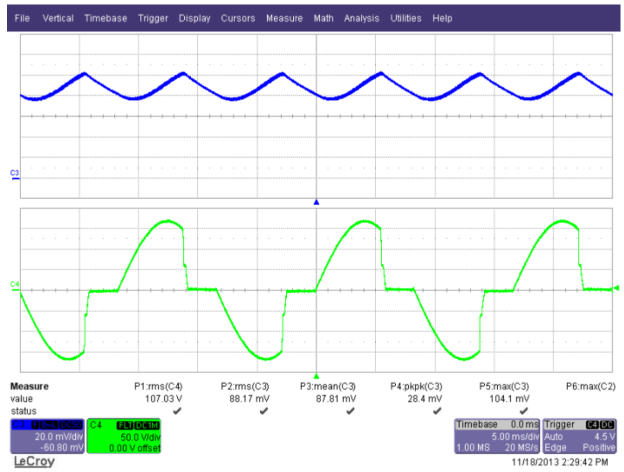

Figure 58 – 120ºConduction Angle.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

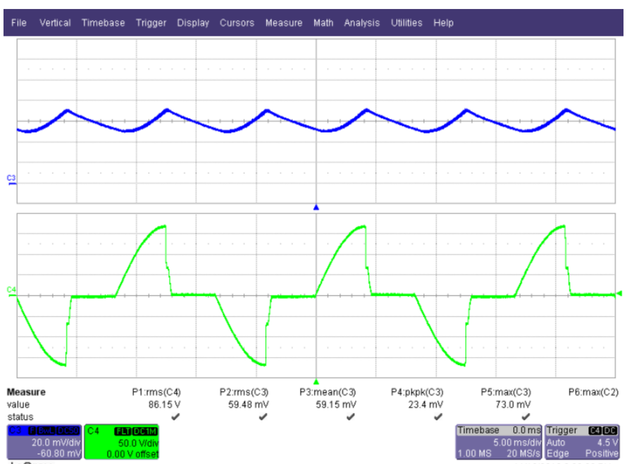

Figure 59 – 90ºConduction Angle.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

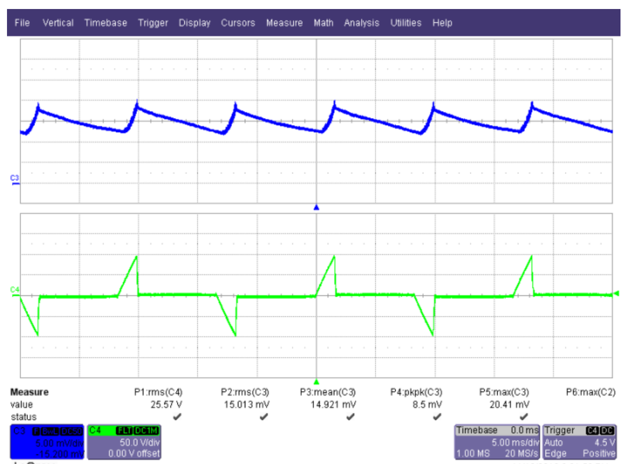

Figure 60 – 40ºConduction Angle.
Upper: I_{OUT}, 20mA / div.
Lower: V_{IN}, 50 V, 5 ms / div.

14.5 漏极电流波形 – 前沿调光器

Input: 120V, 60 Hz
Output: 48 V LED Load
Dimmer: S-1000-WH

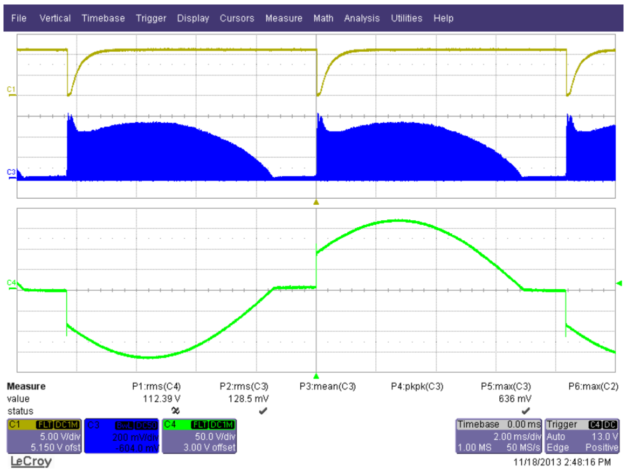

Figure 61 – 150ºConduction Angle.
Upper: U1 I_{DS}, 200mA / div.
Q1 V_{CE}, 5V/ div.
Lower: V_{IN}, 50 V, 2 ms / div.

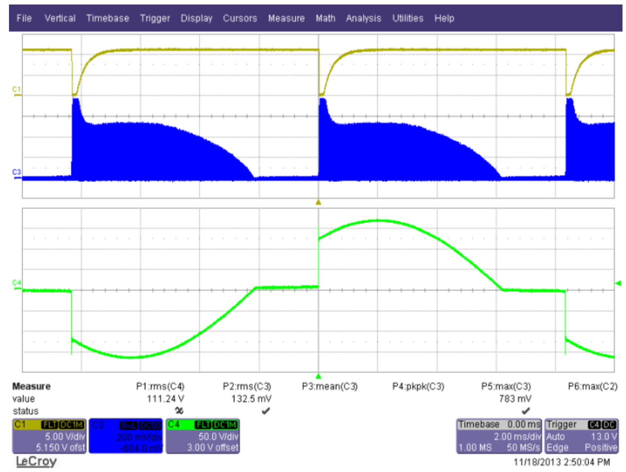

Figure 62 – 135ºConduction Angle.
Upper: U1 I_{DS}, 200mA / div.
Q1 V_{CE}, 5V/ div.
Lower: V_{IN}, 50 V, 2 ms / div.

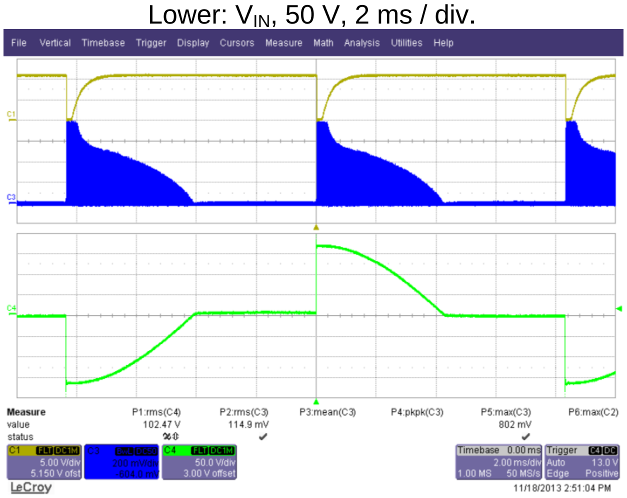

Figure 63 – 90ºConduction Angle.
Upper: U1 I_{DS}, 200mA / div.
Q1 V_{CE}, 5V/ div.
Lower: V_{IN}, 50 V, 2 ms / div.

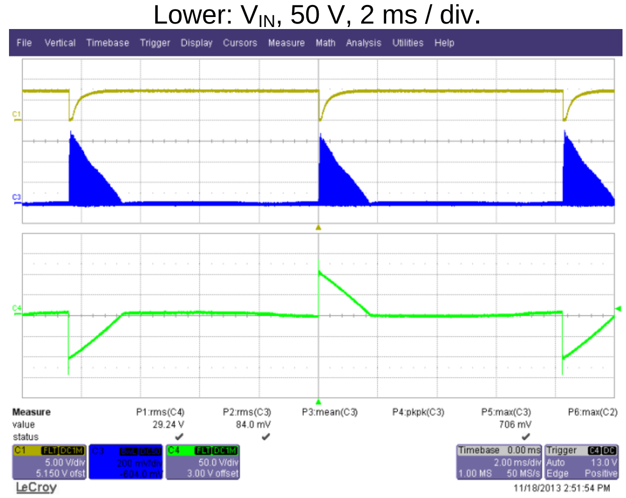

Figure 64 – 40ºConduction Angle.
Upper: U1 I_{DS}, 200mA / div.
Q1 V_{CE}, 5V/ div.
Lower: V_{IN}, 50 V, 2 ms / div.

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15 传导EMI

15.1 测试设置

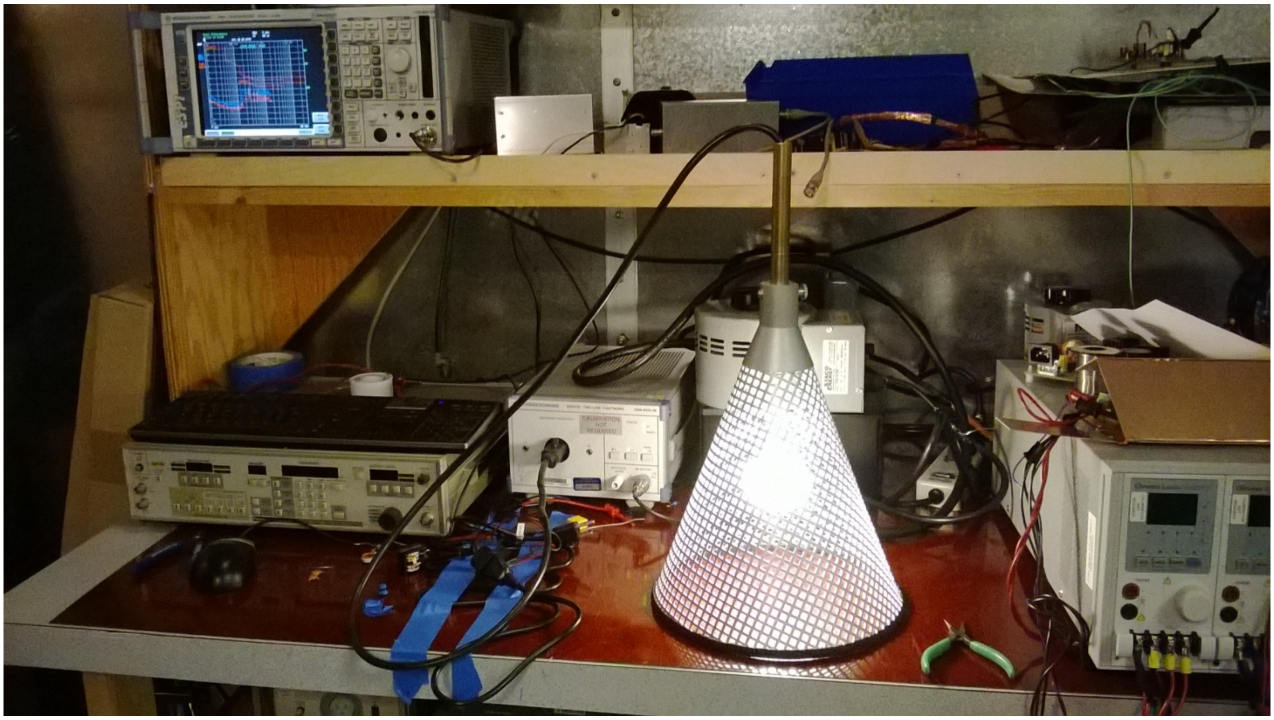

Figure 65 – Conducted EMI Test Set-up.

15.2 测试结果

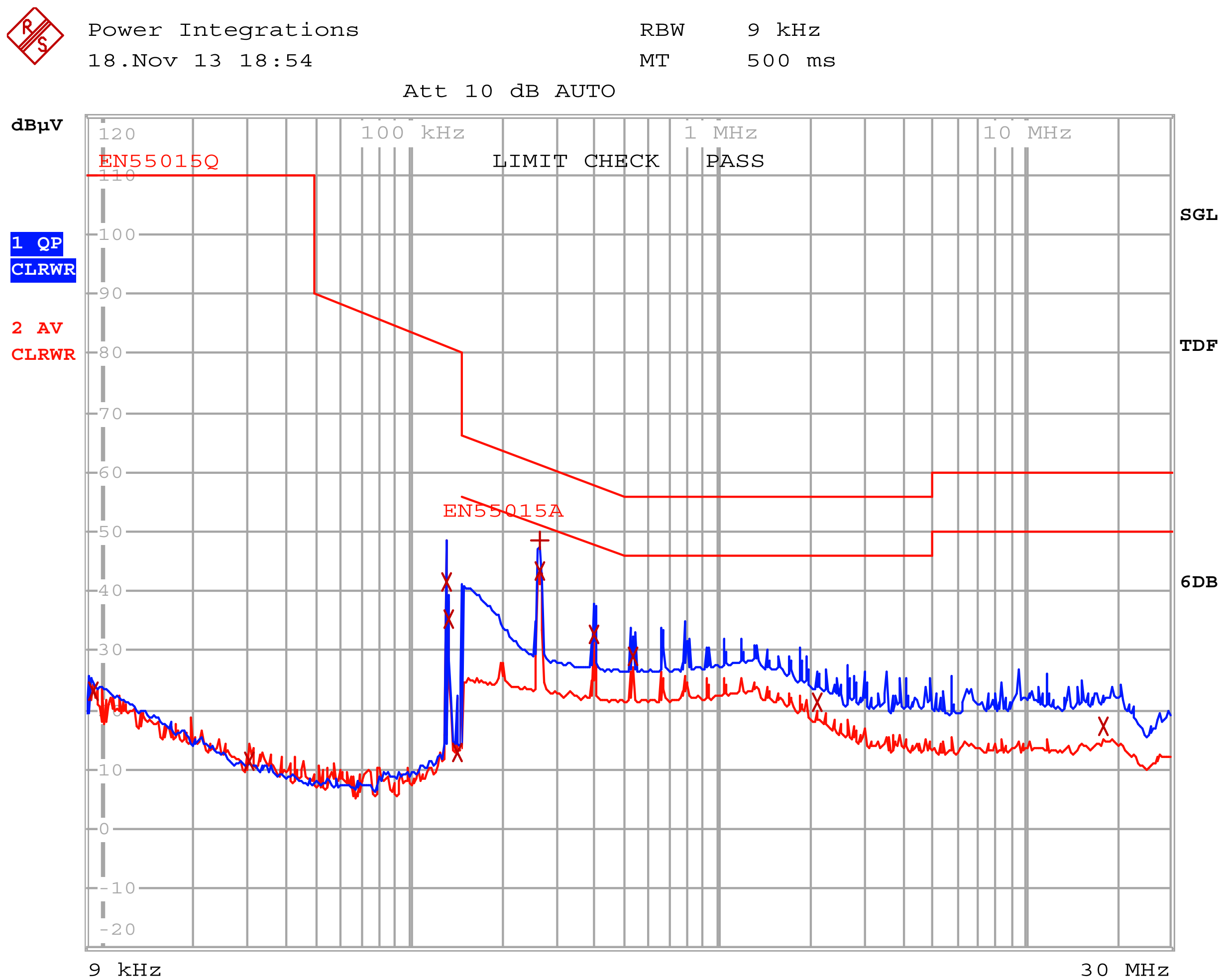

Figure 66 – Conducted EMI, ~48 V LED Load, 115 VAC, 60 Hz, and EN55015 B Limits.

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EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55015Q

Trace2: EN55015A

Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV		DELTA LIMIT dB
2	Average	9.36543609 kHz	23.00	L1 gnd	
2	Average	30.0005168717 kHz	11.39	N gnd	
2	Average	130.825395691 kHz	41.59	L1 gnd	
2	Average	133.454986145 kHz	35.44	N gnd	
2	Average	141.665156991 kHz	12.79	N gnd	
1	Quasi Peak	264.49018761 kHz	48.51	N gnd	-12.77
2	Average	264.49018761 kHz	43.33	N gnd	-7.95
2	Average	397.727746704 kHz	32.58	N gnd	-15.31
2	Average	530.769219795 kHz	29.10	N gnd	-16.90
2	Average	2.11629733595 MHz	21.43	N gnd	-24.57
2	Average	17.975130353 MHz	17.28	N gnd	-32.71

Figure 67 – Conducted EMI, Final Measurement Results.

16 输入浪涌

Differential input line 500 V surge testing was completed on a single test unit to IEC61000-4-5. Input voltage was set at 120 VAC / 60 Hz.

Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+500	120	L to N	90	Pass
-500	120	L to N	90	Pass
+500	120	L to N	0	Pass
-500	120	L to N	0	Pass

Unit passed under all test conditions.

Differential ring input line surge testing was completed on a single test unit to IEC61000-4-5. Input voltage was set at 120 VAC / 60 Hz. Output was loaded at full load and operation was verified following each surge event.

Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+2500	120	L to N	90	Pass
-2500	120	L to N	90	Pass
+2500	120	L to N	0	Pass
-2500	120	L to N	0	Pass

Unit passed under all test conditions.

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17 版本历史

Date	Author	Revision	Description andChanges	Reviewed
16-May-14	CA	1.0	Initial Release	Mktg & Apps

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Power Integrations 全球销售支持网络

全球总部
5245 Hellyer Avenue
San Jose, CA 95138, USA.
Main: +1-408-414-9200
Customer Service:
Phone: +1-408-414-9665
Fax: +1-408-414-9765
e-mail: usasales@powerint.com

德国
Lindwurmstrasse 114
80337, Munich
Germany
Phone: +49-895-527-39110
Fax: +49-895-527-39200
e-mail: eurosales@powerint.com

日本
Kosei Dai-3 Building
2-12-11, Shin-Yokohama,
Kohoku-ku, Yokohama-shi,
Kanagawa 222-0033
Japan
Phone: +81-45-471-1021
Fax: +81-45-471-3717
e-mail: japansales@powerint.com

台湾
5F, No. 318, Nei Hu Rd.,
Sec. 1
Nei Hu District
Taipei 11493, Taiwan R.O.C.
Phone: +886-2-2659-4570
Fax: +886-2-2659-4550
e-mail: taiwansales@powerint.com

中国（上海）
Rm 2410, Charity Plaza, No. 88,
North Caoxi Road,
Shanghai, PRC 200030
Phone: +86-21-6354-6323
Fax: +86-21-6354-6325
e-mail: chinasales@powerint.com

印度
#1, 14th Main Road
Vasanthanagar
Bangalore-560052
India
Phone: +91-80-4113-8020
Fax: +91-80-4113-8023
e-mail: indiasales@powerint.com

韩国
RM 602, 6FL
Korea City Air Terminal B/D,
159-6
Samsung-Dong, Kangnam-Gu,
Seoul, 135-728 Korea
Phone: +82-2-2016-6610
Fax: +82-2-2016-6630
e-mail: koreasales@powerint.com

欧洲总部
1st Floor, St. James's House
East Street, Farnham
Surrey GU9 7TJ
United Kingdom
Phone: +44 (0) 1252-730-141
Fax: +44 (0) 1252-727-689
e-mail: eurosales@powerint.com

中国（深圳）
3rd Floor, Block A,
Zhongtou International Business
Center, No. 1061, Xiang Mei Rd,
FuTian District, ShenZhen,
China, 518040
Phone: +86-755-8379-3243
Fax: +86-755-8379-5828
e-mail: chinasales@powerint.com

意大利
Via Milanese 20, 3rd. Fl.
20099 Sesto San Giovanni
(MI) Italy
Phone: +39-024-550-8701
Fax: +39-028-928-6009
e-mail: eurosales@powerint.com

新加坡
51 Newton Road,
#19-01/05 Goldhill Plaza
Singapore, 308900
Phone: +65-6358-2160
Fax: +65-6358-2015
e-mail: singaporesales@powerint.com

技术支持热线
World Wide +1-408-414-9660

技术支持传真
World Wide +1-408-414-9760