设计范例报告

标题	***使用LYTSwitch™-4 LYT4317E设计的20 W隔离反激式，可控硅调光，带功率因数校正(>0.98)的LED驱动器***
规格	90 VAC – 132 VAC输入；36 V，550 mA输出
应用	PAR38 LED驱动器
作者	应用工程部
文档编号	DER-350
日期	2013年5月20日
修订版本	2.1

特色概述

- 在120 VAC输入下，效率极高(≥85%)
- 具有非常宽的调光器兼容性（满足NEMA SSL6调光曲线要求），可兼容广泛的美国可控硅调光器
- 增强的用户体验
  - 无闪烁的单向调光
  - 快速单向启动(<200 ms) – 无可见延迟
  - 以几乎相同的调光角度导通和关断 – 不存在突然变亮现象
- 成本低
  - 单级集成式PFC与精确初级侧调节的恒流输出
  - 单面PCB；元件数量少
- 集成的保护及可靠性能
  - 输出开路/输出短路保护，带自动恢复功能
  - 快速反应的输入过压关断可扩展输入故障时的电压耐受范围
    - 无金属氧化物压敏电阻(MOV)，可耐受±2500 V振铃波和±500 V差模浪涌
  - 更大迟滞的自动恢复热关断可同时保护元件和印刷电路板
- 满足IEC 61000-4-5振铃波、IEC 61000-3-2 C THD和IEC CISPR 15 / EN55015 B传导EMI要求

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专利信息

此处介绍的产品和应用（包括产品之外的变压器结构和电路）可能包含一项或多项美国及国外专利，或正在申请的美国或国外专利。有关Power Integrations专利的完整列表，请参见www.powerint.com。Power Integrations按照在<http://www.powerint.com/ip.htm>中所述规定，向客户授予特定专利权利的许可。

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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。

1　简介

本文档介绍的是一款隔离式高功率因数(PF)、可控硅调光的LED驱动器，它可以在90 VAC至132 VAC的输入电压范围内为LED灯串提供额定电压36 V、额定电流550 mA的驱动。该LED驱动器采用了LYTSwitch-4系列IC中的LYT4317E器件。

所采用的拓扑结构为单级、带功率因数校正的反激式拓扑结构，可提供高隔离效率、高功率因数、高功率因数、低THD以及低元件数。

LYTSwitch-4 IC还可提供各种复杂的保护功能，包括环路开环或输出短路条件下自动重启动等，利用该器件可实现高功率因数和低THD。输入过压关断可提供增强的抗输入故障和浪涌能力，精确的迟滞热关断可确保在所有条件下平均PCB温度都处于安全范围内。

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

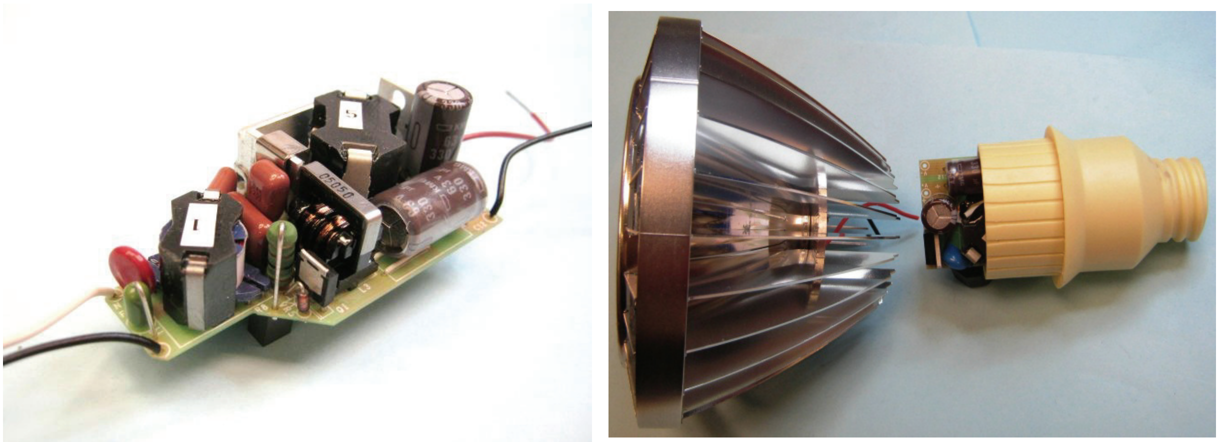

Figure 1 – Populated Circuit Board Photograph (Left) and Placed Inside a CREE PAR38 Lamp (Right).

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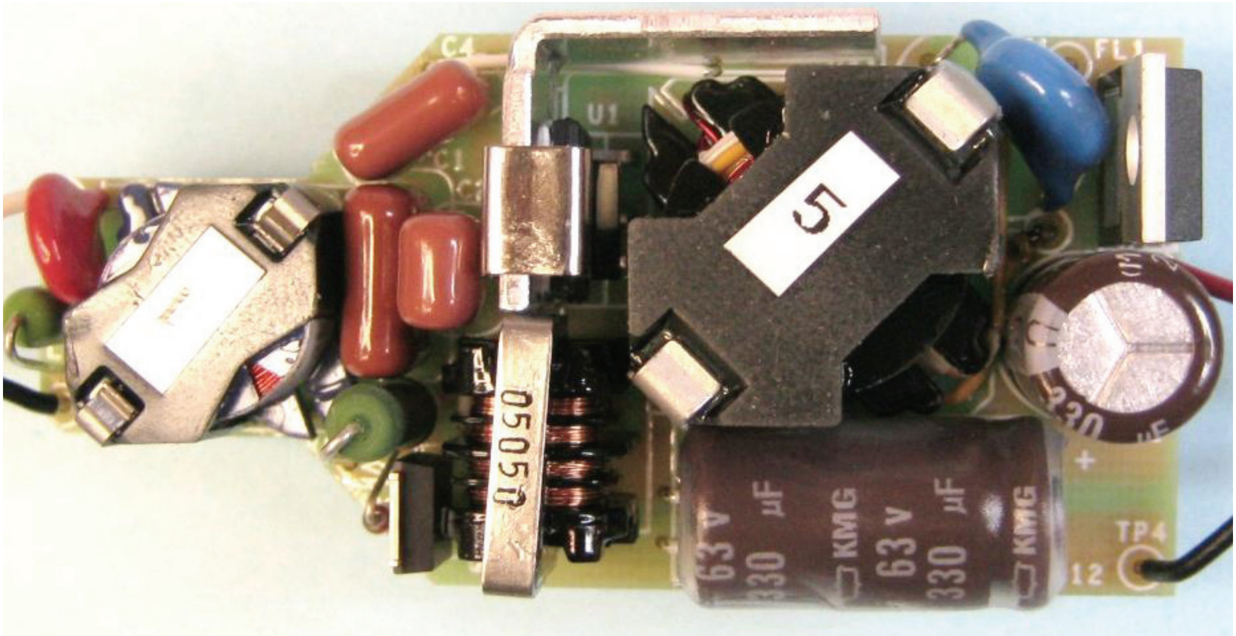

Figure 2 – Populated Circuit Board Photograph (Top View).

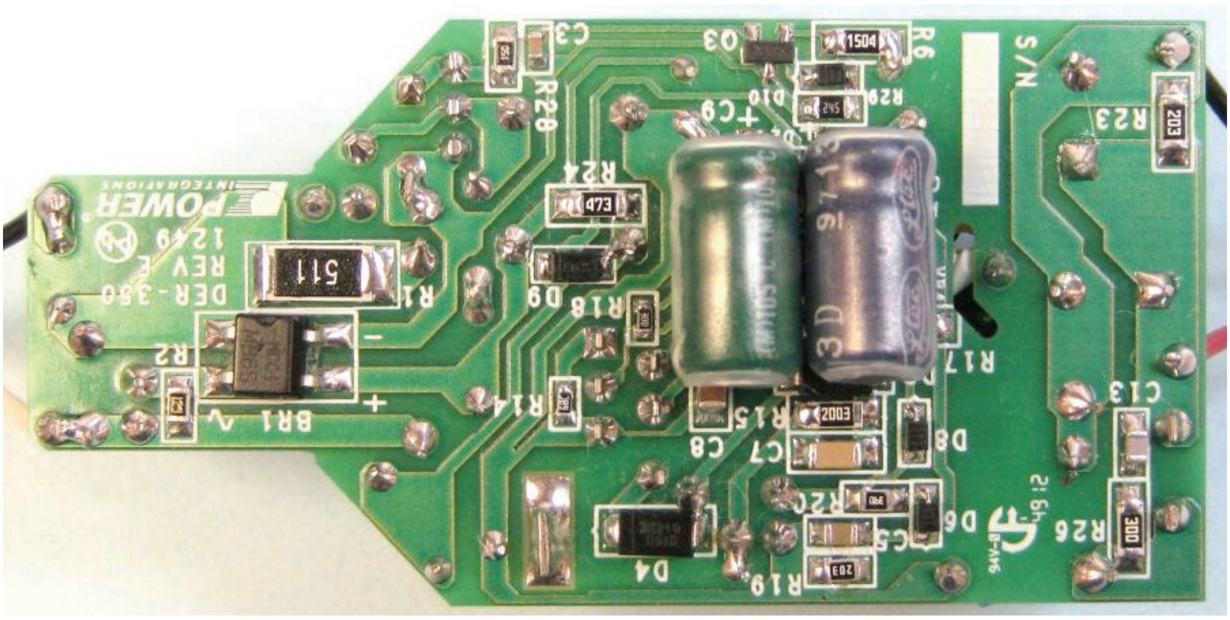

Figure 3 – Populated Circuit Board Photograph (Bottom View).

2 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	
频率	f_{LINE}		60		Hz	
输出						
输出电压	V_{OUT}	33	36	39	V	
输出电流	I_{OUT}		550		mA	
总输出功率						
连续输出功率	P_{OUT}		20		W	
效率						
满载	η		85		%	V_{OUT} = 36，V_{IN} = 120 VAC，25 °C 环境温度
环境						
传导EMI		CISPR 15B / EN55015B				
安全		隔离式				
振铃波(100 kHz)						
差模(L1-L2)			2.5		kV	
共模（L1/L2-PE）						
差模浪涌(1.2 / 50 μs)			500		V	
功率因数			0.97			在$V_{OUT(TYP)}$、$I_{OUT(TYP)}$以及120 VAC、60 Hz条件下测得
谐波电流		EN 61000-3-2 Class D (C)				当 P_{IN} <25 W，Class C指定Class D限值
环境温度	T_{AMB}		45		°C	自然对流，海平面

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3 电路原理图

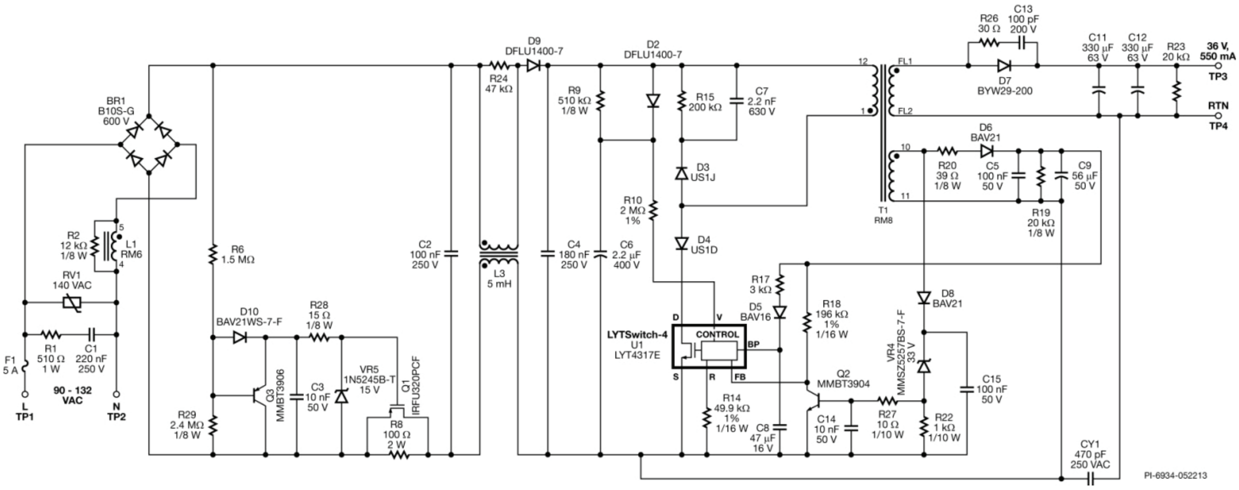

Figure 4 – Schematic.

4 电路描述

LYTSwitch-4器件是一种将控制器和650 V功率MOSFET集成在一起的器件，用于LED驱动器应用。LYTSwitch-4可用于单级反激式拓扑结构，提供初级侧调节的恒流隔离输出，同时使AC输入保持高功率因数。

4.1 输入滤波

保险丝F1提供元件故障保护。本电路选用了相对较高的电流额定值，以防止在差模(1.2 μs / 50 μs)输入浪涌期间出现故障。LYTSwitch-4的快速反应输入过压检测与D2和C6峰值检测电容一起提供箝位功能，用以限制在IC的MOSFET上出现最大电压应力。可选MOV（金属氧化物压敏电阻）RV1用来满足>500 V的差模输入电压浪涌要求。RV1的额定电压为140 VAC，略高于最大指定工作电压132 VAC。二极管桥堆BR1对AC线电压进行整流，电容C4为初级开关电流提供低阻抗通路（去耦）。

EMI滤波由电感L1以及电容C2、C4和CY1提供。L1和L3上的电阻R2和R24可分别抑制由滤波元件和AC输入阻抗所产生的任何共振，不然会导致传导EMI测量值增大。

4.2 LYTSwitch-4初级

变压器(T1)一端连接到DC总线，另一端经过阻断二极管D4连接到LinkSwitch-4器件的漏极(D)引脚。在功率MOSFET的导通时间内，初级绕组中的电流升高，存储的能量随后在功率MOSFET关断时间内传送到输出。

为向U1提供峰值输入电压信息，经整流AC的输入峰值经由D2对C6充电。然后电流经过R10，注入U1的电压监测(V)引脚。电阻R9为C6提供放电通路，时间常数远大于经整流AC的放电时间，以防止V引脚电流被线电压频率所调制（这会降低功率因数）。

输入过压关断功能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650 BV_{DSS}。

V引脚电流和反馈(FB)引脚电流在内部用来控制LED平均输出电流。对于相位角调光应用，可在参考(R)引脚(R14)和V引脚上分别使用49.9 kΩ电阻和2 MΩ (R10)电阻，使输入电压和输出电流保持线性关系。这样可在配合可控硅调光器使用时扩大调光范围。

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在功率MOSFET的关断时间内，由于漏感的影响，D3、R15和C7将漏极电压箝位到一个安全水平。在C4上的电压（整流后的输入AC）降到反射输出电压（在设计表格中为参数V_{OR}）以下时，需要使用二极管D4来防止反向电流流经U1。

二极管D6、C5、C9、R20和R19对U1进行初级偏置供电，能量来自变压器的辅助绕组。电阻R20提供滤波，以使偏置电压密切跟踪输出电压，从而使输出电流在LED电压发生变化时保持恒定。电阻R19用于在输出短路条件下对C9放电。

电容C8对U1的旁路(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，C8从与D引脚相连的内部高压电流源被充电至约6 V。充电完成后，U1开始开关，器件的供电电流再由偏置供电经过R17提供。

建议使用外部偏置供电（通过D5和R17）以实现最低的器件功耗，并在深度调光情况下向U1提供足够的电源。

电容C8同时用来选择输出功率模式，选择47 μF（低功率模式）可以将器件功耗减至最低，降低对散热片的要求。

4.3 反馈

偏置绕组电压用来间接地反映输出电压的高低，而无需使用次级侧反馈元件。偏置绕组上的电压与输出电压成比例（由偏置绕组与次级绕组之间的匝数比决定）的。电阻R18将偏置电压转换为电流，馈入U1的FB引脚。U1中的内部引擎综合FB引脚电流、V测引脚电流和内部漏极电流信息，提供恒定的输出电流，同时保持较高的输入功率因数。

4.4 负载断开保护

如果出现开路（断开）负载故障，齐纳二极管VR4将导通晶体管Q2。晶体管Q2然后拉低FB引脚，强制IC进入自动重启动模式。在软启动结束后，一旦FB引脚电流低于$I_{FB(AR)}$阈值，控制器立即报告摄短路和开路故障。为了降低此故障情况下的功耗，关断/自动重启动电路将通常以DC_{AR}的自动重启动占空比对电源进行接通（与软启动持续时间相同）和关断操作，直到故障排除为止。如果故障在自动重启动关断期间消除，电源将保持自动重启动，直到整个关断时间计时结束。

4.5 输出整流

变压器次级绕组由D7进行整流，由电容C11和C12进行滤波。对于要求采用低纹波的设计，可提高输出电容值。

4.6 可控硅相位调光控制兼容性

对于用低成本的可控硅前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全面权衡。

由于LED照明的功耗非常低，灯具所消耗的电流要小于调光器内可控硅的维持电流。这样会因为可控硅触发不一致而产生某些不良情况，比如灯具在调光器控制范围结束时关闭和/或闪烁。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。这同样会造成类似的不良情况，因为振铃会使可控硅电流降至零。

要克服这些问题，需要增加有源衰减电路和无源泄放电路。这些电路的缺点是会增大功耗，进而降低电源的效率。对于非调光应用，可以省略这些元件。

有源衰减电路由元件R6、R28、R29、D10、Q1、Q3、C3、VR5以及R8共同组成。该电路可以限制可控硅导通时流入输入电容C2和C4并对其充电的浪涌电流，实现方式是在导通前~0.5ms内将电阻R8串联。在大约0.5 ms后，Q1导通并将电阻R8短路。这样可使R8的功耗保持在低水平，在限流时可以使用更大的值。电阻R6、R29和电阻C3在可控硅导通后提供0.5 ms延迟。晶体管Q3在可控硅不导通时对电容C3进行放电，VR5将Q1的栅极电压箝位在15 V，R28用于防止MOSFET发生振荡。

无源泄放电路由C1和R1构成。这样可以使输入电流始终大于可控硅的维持电流，而驱动器的输入电流将在每个AC半周期内增大，防止每个导通期间的起始阶段出现可控硅开关振荡。

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5 PCB布局

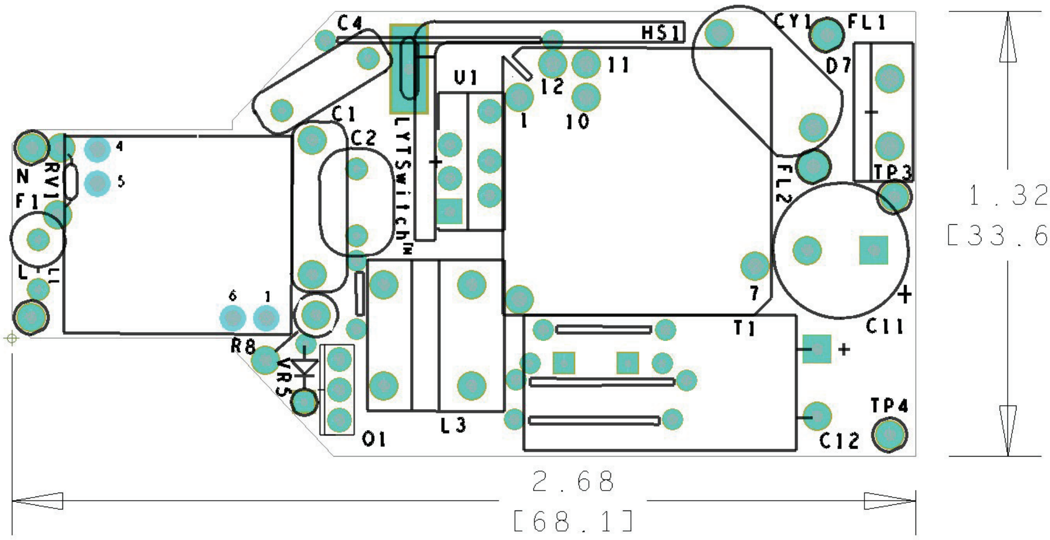

Figure 5 – Top Side.

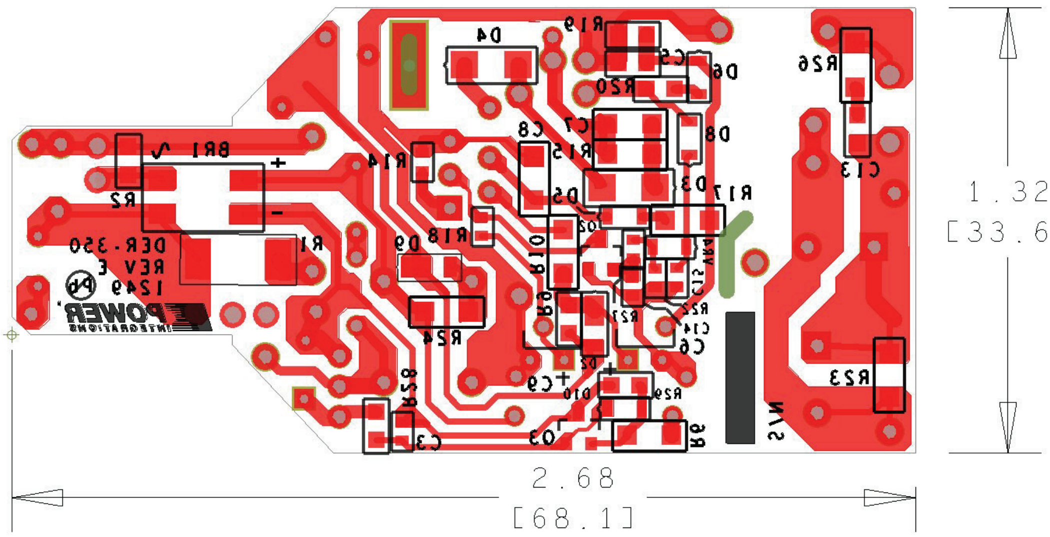

Figure 6 – Bottom Side.

6 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	C1	220 nF, 250 V, Film	ECQ-E2224KF	Panasonic
3	1	C2	100 nF, 250 V, Film	ECQ-E2104KB	Panasonic
4	2	C3 C14	10 nF 50 V, Ceramic, X7R, 0603	C0603C103K5RACTU	Kemet
5	1	C4	180 nF, 250 V, Film	ECQ-E2184KB	Panasonic
6	1	C5	100 nF, 50 V, Ceramic, X7R, 0805	CC0805KRX7R9BB104	Yageo
7	1	C6	2.2 μF, 400 V, Electrolytic, (6.3 x 11)	TAB2GM2R2E110	Ltec
8	1	C7	2.2 nF, 630 V, Ceramic, X7R, 1206	C3216X7R2J222K	TDK
9	1	C8	47 μF, 16 V, X5R, 1206	3216X5R1C476M	TDK
10	1	C9	56 μF, 50 V, Electrolytic, Very Low ESR, 140 mΩ, (6.3 x 11)	EKZE500ELL560MF11D	Nippon Chemi-Con
11	2	C11 C12	330 μF, 63 V, Electrolytic, (10 x 20)	EKMG630ELL331MJ20S	United Chemi-con
12	1	C13	100 pF, 200 V, Ceramic, COG, 0805	08052A101JAT2A	AVX
13	1	C15	100 nF 50 V, Ceramic, X7R, 0603	C1608X7R1H104K	TDK
14	1	CY1	470 pF, 250 VAC, Film, X1Y1	CD95-B2GA471KYNS	TDK
15	2	D2 D9	400 V, 1 A, DIODE SUP FAST 1 A PWRDI 123	DFLU1400-7	Diodes, Inc.
16	1	D3	DIODE ULTRA FAST, SW 600 V, 1 A, SMA	US1J-13-F	Diodes, Inc.
17	1	D4	DIODE ULTRA FAST, SW, 200 V, 1 A, SMA	US1D-13-F	Diodes, Inc.
18	1	D5	75 V, 0.15 A, Switching, SOD-323	BAV16WS-7-F	Diodes, Inc.
19	3	D6 D8 D10	250 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV21WS-7-F	Diodes, Inc.
20	1	D7	200 V, 8 A, Ultrafast Recovery, 25 ns, TO-220AC	BYW29-200G	On Semi
21	1	F1	5 A, 250 V, Fast, Microfuse, Axial	0263005.MXL	Littlefuse
22	1	L1	Bobbin, RM6, Vertical, 6 pins Inductor	B65808-N1006-D1 SNX-R1684	Epcos Santronics-USA
23	1	L3	5 mH, 0.5 A, Common Mode Choke Vertical	SU9VF-05050	Tokin
24	1	Q1	400 V, 3.1 A, N-Channel, TO-251AA	IRFU320PBF	Vishay/Siliconix
25	1	Q2	NPN, Small Signal BJT, 40 V, 0.2 A, SOT-23	MMBT3904LT1G	On Semi
26	1	Q3	PNP, Small Signal BJT, 40 V, 0.2 A, SOT-23	MMBT3906LT1G	On Semi
27	1	R1	510 Ω, 5%, 1 W, Thick Film, 2512	ERJ-1TYJ511U	Panasonic
28	1	R2	12 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ123V	Panasonic
29	1	R6	1.5 MΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ155V	Panasonic
30	1	R8	100 Ω, 5%, 2 W, Metal Oxide	RSMF2JT100R	Stackpole
31	1	R9	510 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ514V	Panasonic
32	1	R10	2.00 MΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF2004V	Panasonic
33	1	R14	49.9 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF4992V	Panasonic
34	1	R15	200 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ204V	Panasonic
35	1	R17	3 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ302V	Panasonic
36	1	R18	196 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1963V	Panasonic
37	1	R19	20 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ203V	Panasonic
38	1	R20	39 Ω, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ390V	Panasonic
39	1	R22	1 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ102V	Panasonic
40	1	R23	20 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ203V	Panasonic
41	1	R24	47 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ473V	Panasonic

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42	1	R26	30 Ω, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ300V	Panasonic
43	1	R27	10 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ100V	Panasonic
44	1	R28	15 Ω, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ150V	Panasonic
45	1	R29	2.4 MΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ245V	Panasonic
46	1	RV1	140 V, 12 J, 7 mm, RADIAL	V140LA2P	Littlefuse
47	1	T1	Bobbin, RM8, Vertical, 12 pins Transformer	RM8/12/1 SNX-R1670	Schwartzpunkt Santronics-USA
48	1	U1	LYTSwitch-4, eSIP-7C	LYT4317E	Power Integrations
49	1	VR4	33 V, 5%, 200 mW, SOD-323	MMSZ5257BS-7-F	Diodes, Inc.
50	1	VR5	15 V, 5%, 500 mW, DO-35	1N5245B-T	Diodes, Inc.

7 变压器规格

7.1 电气原理图

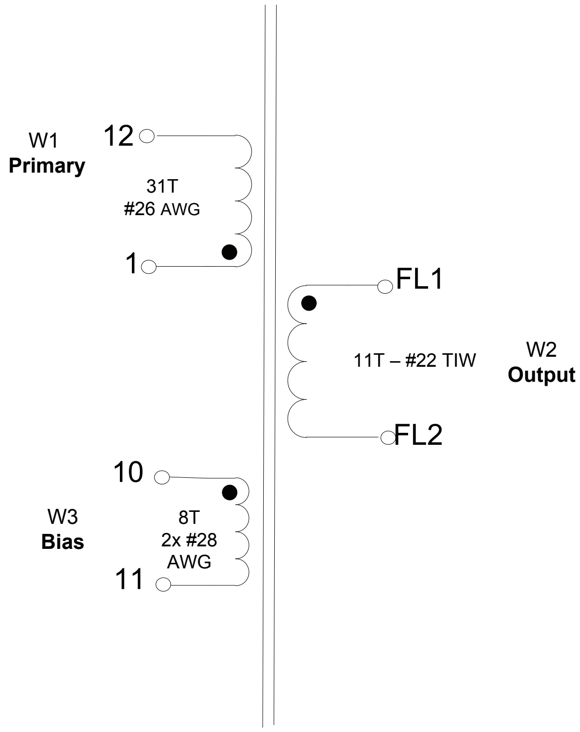

Figure 7 – Transformer Electrical Diagram.

7.2 电气规格

Electrical Strength	1 second, 60 Hz, from pins 1, 10, 11, 12 to FL1, FL2.	3000 VAC
Primary Inductance	Pins 1 and 12, all other windings open, measured at 10 kHz, 0.4 $V_{RMS.}$	387 µH +7%
Resonant Frequency	Pins 1 -12, all other windings open.	750 kHz (Min.)
Primary Leakage Inductance	Pins 1-12, with FL1-FL2 shorted, measured at 132 kHz, 0.4 $V_{RMS.}$	<10 µH

7.3 材料

Item	Description
[1]	Core: RM8/I, 3F3.
[2]	Bobbin, 12 pin vertical, CSV-RM8-1S-12P from Philips or equivalent. With mounting clip, CLI/P-RM8.
[3]	Tape, Polyester film, 3M 1350F-1 or equivalent, 9 mm wide.
[4]	Wire: Magnet, #26 AWG, solderable double coated.
[5]	Wire: Magnet, #28 AWG, solderable double coated.
[6]	Wire, Triple Insulated, Furukawa TEX-E or Equivalent, #22 TIW.
[7]	Transformer Varnish, Dolph BC-359 or equivalent.

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7.4 变压器结构图

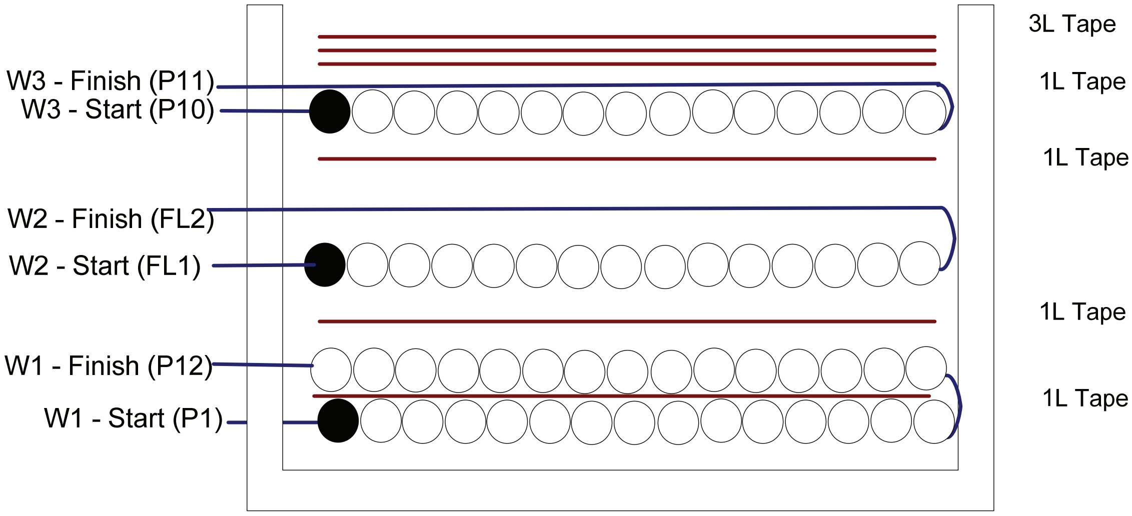

Figure 8 – Transformer Build Diagram.

7.5 变压器构造

Bobbin Preparation	Place the bobbin item [2] on the mandrel such that pin side on the left side. Winding direction is the clockwise direction.
WDG 1 (Primary)	Starting at pin 1, wind 31 turns of wire item [4] in two layers. Apply one layer of tape item [3] between 1st and 2nd layer (spread the winding evenly). Finish at pin 12.
Insulation	Apply one layer of tape item [3].
WDG 2 (Secondary)	Leave about 1” of wire item [6], use small tape to mark as FL1, enter into slot of secondary side of bobbin, wind 11 turns in one layer. At the last turn exit the same slot, leave about 1”, and mark as FL2.
Insulation	Apply one layer of tape item [3].
WDG 3 (Bias)	Starting at pin 10, wind bifilar 8 turns of wire item [5], spreading the wire, and finish at pin 11.
Finish Wrap	Apply three layers of tape item [3] for finish wrap.
Final Assembly	Cut FL1 and FL2 to 0.75”. Grind core to get 387 µH inductance. Assemble and secure core halves. Dip impregnate using varnish item [7].

8　变压器设计表格

ACDC_LYTSwitch_101712; Rev.1.0; Copyright Power Integrations 2012	INPUT	INFO	OUTPUT	UNIT	LYTSwitch_101712: 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	Hz	AC Mains Frequency
VO	36.00		36	V	Typical output voltage of LED string at full load
VO_MAX	39.00		39.00	V	Maximum expected LED string Voltage.
VO_MIN	33.00		33.00	V	Minimum expected LED string Voltage.
V_OVP			42.90	V	Over-voltage protection setpoint
IO	0.55		0.55	A	Typical full load LED current
PO			19.8	W	Output Power
n	0.85		0.85		Estimated efficiency of operation
VB			25	V	Bias Voltage
ENTER LYTSwitch VARIABLES					
LYTSwitch	**LYT4317**		**LYT4317**		Selected LYTSwitch
Current Limit Mode	**RED**		**RED**		Select "RED" for reduced Current Limit mode or "FULL" for Full current limit mode
ILIMITMIN			2.35	A	Minimum current limit
ILIMITMAX			2.73	A	Maximum current limit
fS			132000	Hz	Switching Frequency
fSmin			124000	Hz	Minimum Switching Frequency
fSmax			140000	Hz	Maximum Switching Frequency
IV			79.8	uA	V pin current
RV			2	M-ohms	Upper V pin resistor
RV2			1E+012	M-ohms	Lower V pin resistor
IFB	133.00		133.0	uA	FB pin current (85 uA < IFB < 210 uA)
RFB1			165.4	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	0.97		0.97		Ripple to Peak Current Ratio (For PF > 0.9, 0.4 < KP < 0.9)
LP			389	uH	Primary Inductance
VOR	102.00		102	V	Reflected Output Voltage.
Expected IO (average)			0.55	A	Expected Average Output Current
KP_VACMAX			1.08		Expected ripple current ratio at VACMAX
TON_MIN			1.83	us	Minimum on time at maximum AC input voltage
PCLAMP			0.16	W	Estimated dissipation in primary clamp
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	**RM8/I**		**RM8/I**		
Bobbin		RM8/I_BOBBIN		P/N:	*
AE			0.63	cm^2	Core Effective Cross Sectional Area
LE			3.84	cm	Core Effective Path Length

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AL		3000	nH/T^2	Ungapped Core Effective Inductance
BW		8.6	mm	Bobbin Physical Winding Width
M		0	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L	1.50	1.5		Number of Primary Layers
NS	11	11		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		0.47		Minimum duty cycle at peak of VACMIN
IAVG		0.25	A	Average Primary Current
IP		1.29	A	Peak Primary Current (calculated at minimum input voltage VACMIN)
IRMS		0.39	A	Primary RMS Current (calculated at minimum input voltage VACMIN)
TRANSFORMER PRIMARY DESIGN PARAMETERS				
LP		389	uH	Primary Inductance
LP_TOL		10		Tolerance of primary inductance
NP		31		Primary Winding Number of Turns
NB		8		Bias Winding Number of Turns
ALG		412	nH/T^2	Gapped Core Effective Inductance
BM		2586	Gauss	Maximum Flux Density at PO, VMIN (BM<3100)
BP		3081	Gauss	Peak Flux Density (BP<3700)
BAC		1254	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur		1455		Relative Permeability of Ungapped Core
LG		0.17	mm	Gap Length (Lg > 0.1 mm)
BWE		12.9	mm	Effective Bobbin Width
OD		0.42	mm	Maximum Primary Wire Diameter including insulation
INS		0.06	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA		0.36	mm	Bare conductor diameter
AWG		28	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM		161	Cmils	Bare conductor effective area in circular mils
CMA		416	Cmils/Amp	Primary Winding Current Capacity (200 < CMA < 600)
TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT EQUIVALENT)				
Lumped parameters				
ISP		3.59	A	Peak Secondary Current
ISRMS		1.07	A	Secondary RMS Current
IRIPPLE		0.92	A	Output Capacitor RMS Ripple Current
CMS		214	Cmils	Secondary Bare Conductor minimum circular mils
AWGS		26	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS		0.41	mm	Secondary Minimum Bare Conductor Diameter
ODS		0.78	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
VOLTAGE STRESS PARAMETERS				
VDRAIN		394	V	Estimated Maximum Drain Voltage assuming maximum LED string voltage (Includes Effect of Leakage Inductance)
PIVS		110	V	Output Rectifier Maximum Peak Inverse Voltage (calculated at VOVP, excludes

			leakage inductance spike)
PIVB	77	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	2.00	M-ohms	Upper V Pin Resistor Value
RV2	1E+012	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	0.55	A	Measured Output Current at VAC1
IO_VAC2	0.55	A	Measured Output Current at VAC2
RV1 (new)	2.00	M-ohms	New RV1
RV2 (new)	10455.82	M-ohms	New RV2
V_OV	161.1	V	Typical AC input voltage at which OV shutdown will be triggered
V_UV	34.5	V	Typical AC input voltage beyond which power supply can startup
FB pin resistor Fine Tuning			
RFB1	165	k-ohms	Upper FB Pin Resistor Value
RFB2	1E+012	k-ohms	Lower FB Pin Resistor Value
VB1	22.9	V	Test Bias Voltage Condition1
VB2	27.1	V	Test Bias Voltage Condition2
IO1	0.55	A	Measured Output Current at Vb1
IO2	0.55	A	Measured Output Current at Vb2
RFB1 (new)	165.4	k-ohms	New RFB1
RFB2(new)	1.00E+12	k-ohms	New RFB2

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9 L1电感规格

9.1 电气原理图

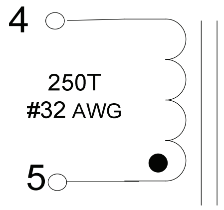

Figure 9 – Inductor Electrical Diagram.

9.2 电气规格

Primary Inductance	Pins 4-5, all other windings open, measured at 100 kHz, 0.4 $V_{RMS.}$	2 mH ±5%
Resonant Frequency	Pins 4-5, all other windings open.	750 kHz (Min.)

9.3 材料

Item	Description
[1]	Core: RM6, TDK - PC40. ALG=32nH/n^2.
[2]	Bobbin: RM6-V 6 pins (3/3), PI#: 25-00039-00.
[3]	Clip: AllStar Magnetic, #: CLI-RM6/I; or equivalent.
[4]	Tape: Polyester film, 3M 1350F-1; or equivalent, 6.4 mm wide.
[5]	Wire: Magnet, #32 AWG, solderable double coated.
[6]	Varnish: Dolph BC-359 or equivalent.

9.4 电感结构图

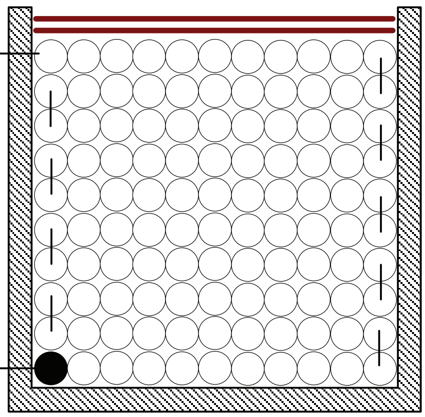

Figure 10 – Inductor Build Diagram.

9.5 电感构造

Bobbin Preparation	Place bobbin item [2] on the mandrel such that pin side is on the left side. Winding direction is the clockwise direction. <u>Note:</u> pin 1 side has V notch on the top of bobbin.
Winding	Start pin 5, wind 250 turns of wire item [5] from left to right then form right to left in 10 layers, at the last turn finish at pin 4.
Finish	Apply 1 layer of tape item [4] to secure the winding. Grind both core halves to get 2.0 mH and assemble with clip item [3]. Cut pins: 2 and 3. Varnish item [6].

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10 U1散热片装配

10.1 U1散热片加工图

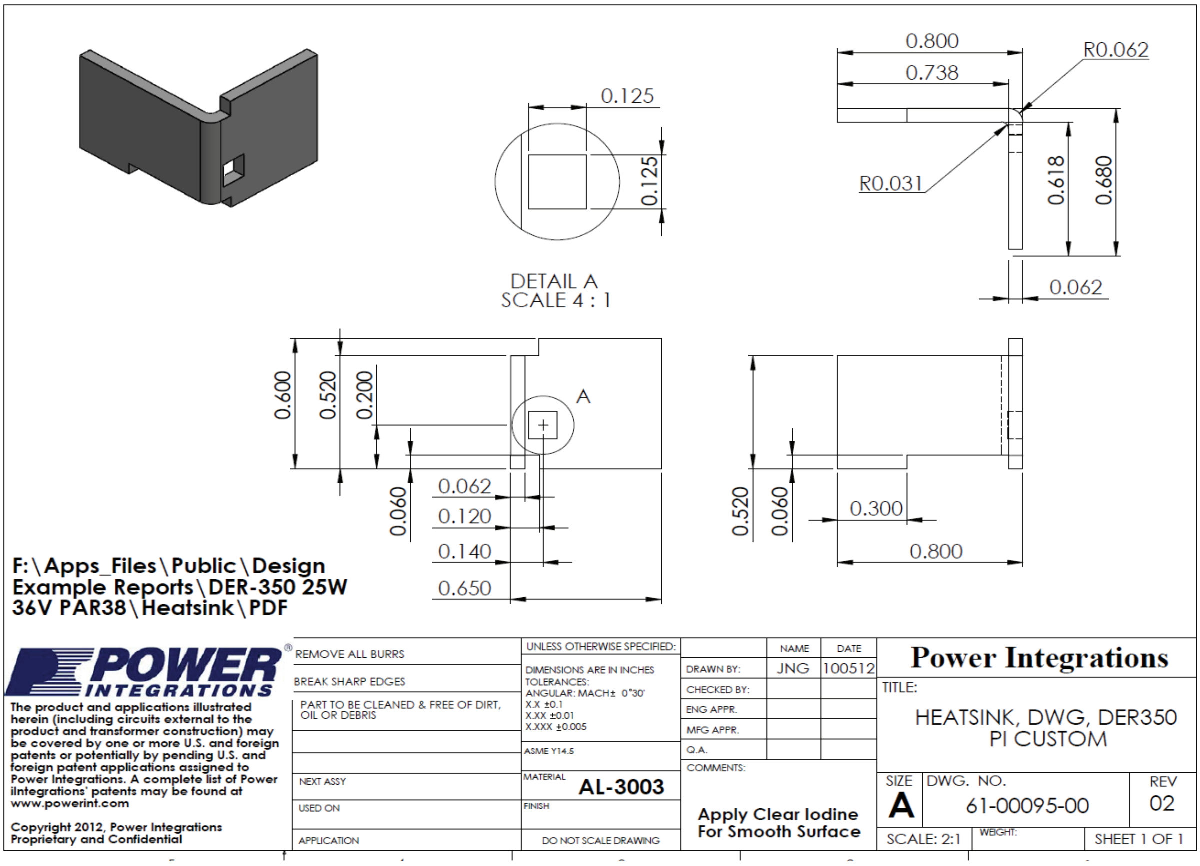

Figure 11 – Heat Sink Fabrication Drawing.

10.2 U1散热片装配图

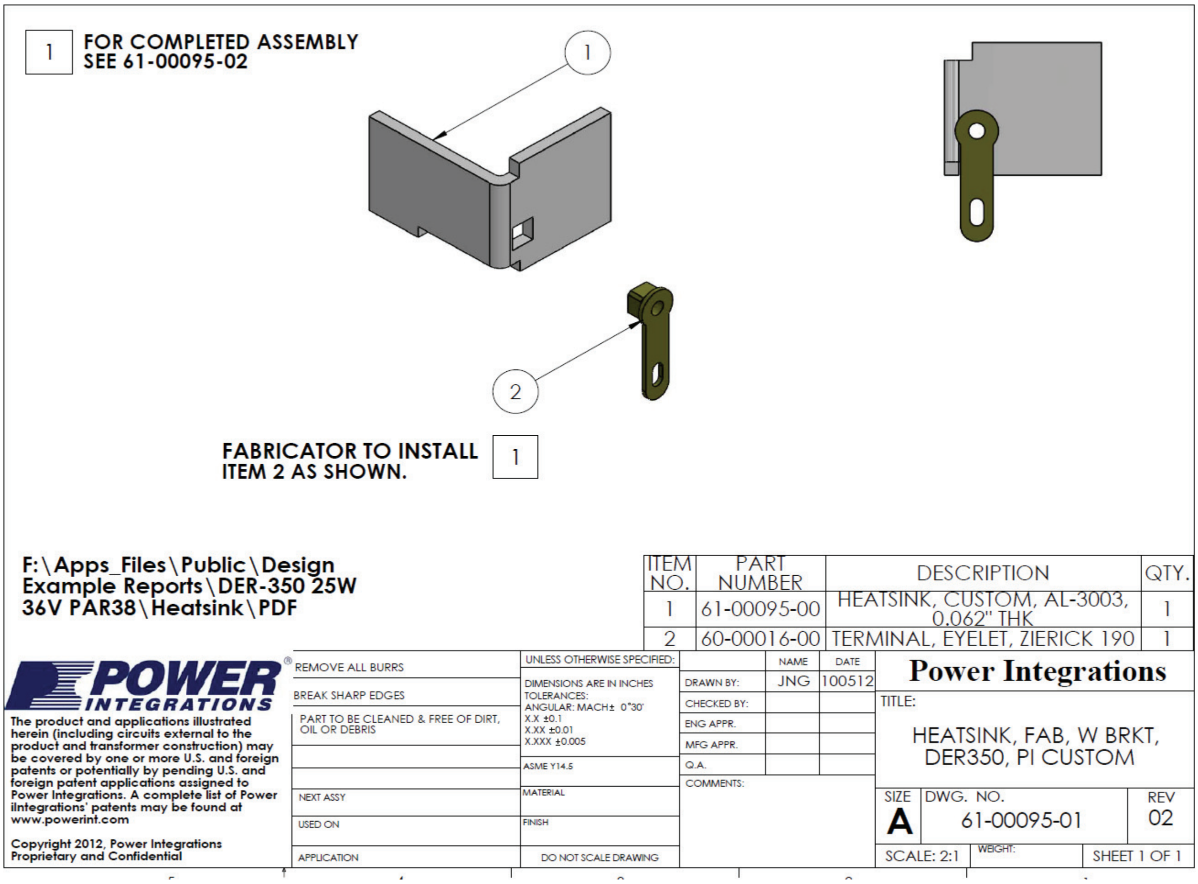

Figure 12 – U1 Heat Sink Assembly Drawing.

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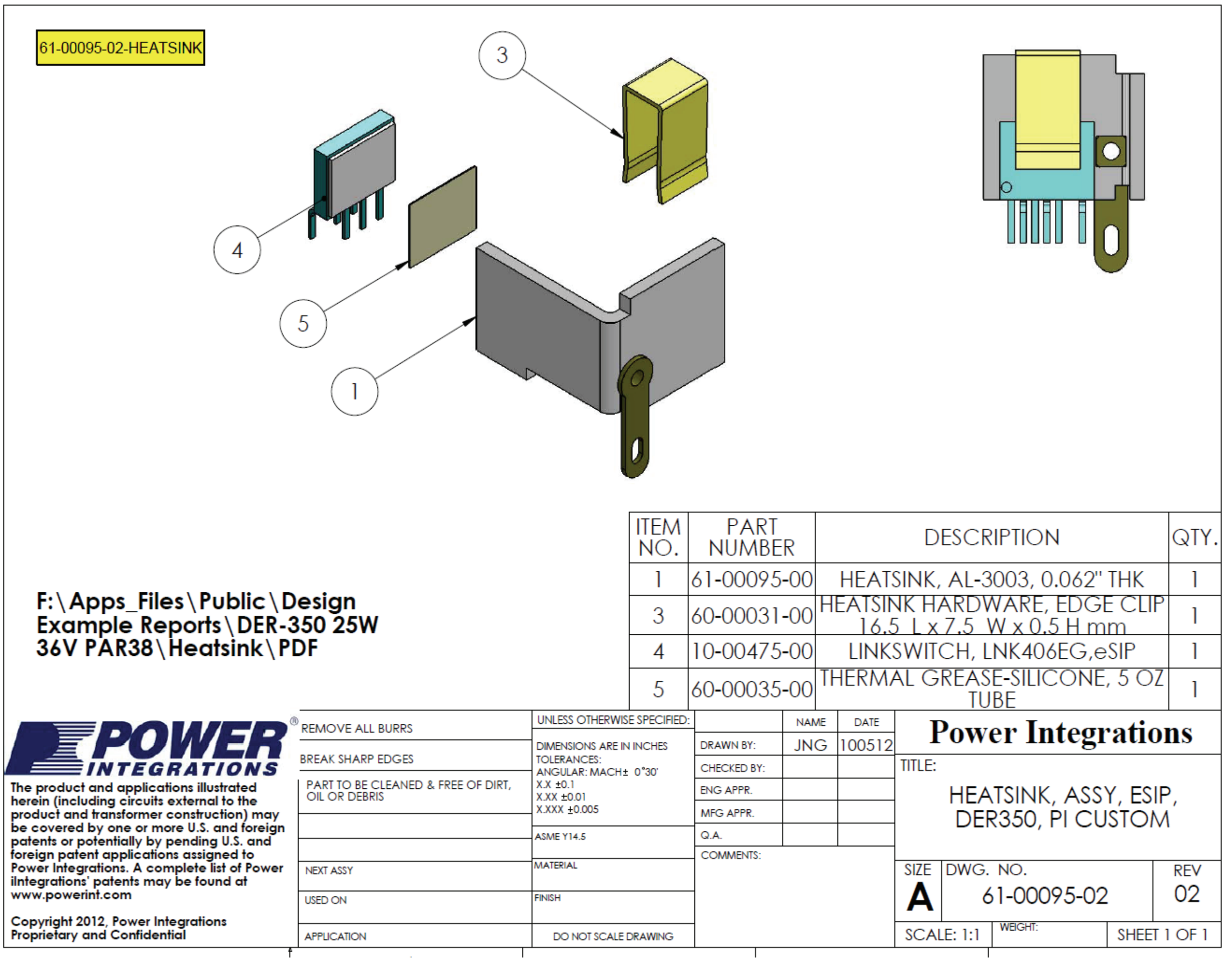
10.3 U1和散热片装配图



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	61-00095-00	HEATSINK, AL-3003, 0.062" THK	1
3	60-00031-00	HEATSINK HARDWARE, EDGE CLIP 16.5 L x 7.5 W x 0.5 H mm	1
4	10-00475-00	LINKSWITCH, LNK406EG,eSIP	1
5	60-00035-00	THERMAL GREASE-SILICONE, 5 OZ TUBE	1

Figure 13 – U1 and Heat Sink Assembly Drawing.

11 性能数据

All measurements performed at room temperature using an LED load. The table in Section 11.6 shows complete test data values.

11.1 效率

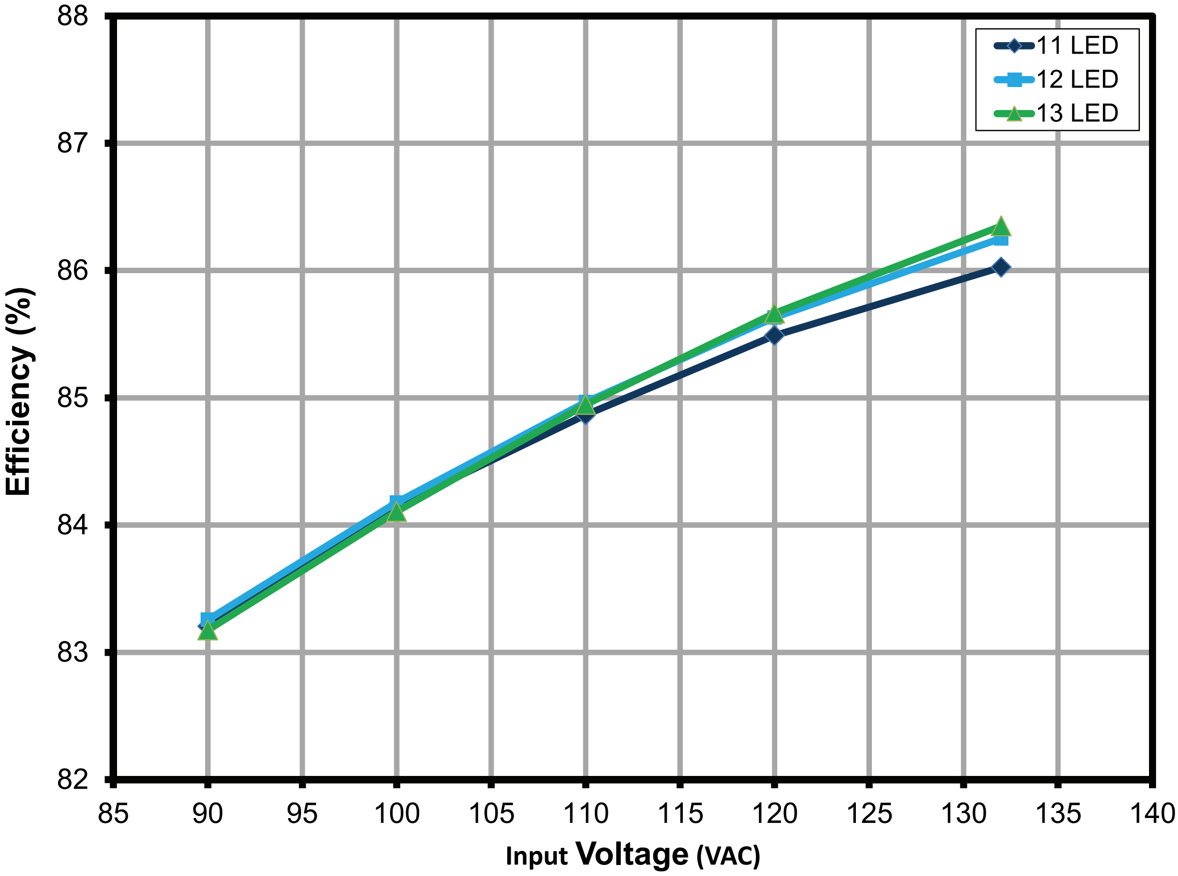


Figure 14 – Efficiency vs. Line.

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11.2 输入电压调整率和负载调整率

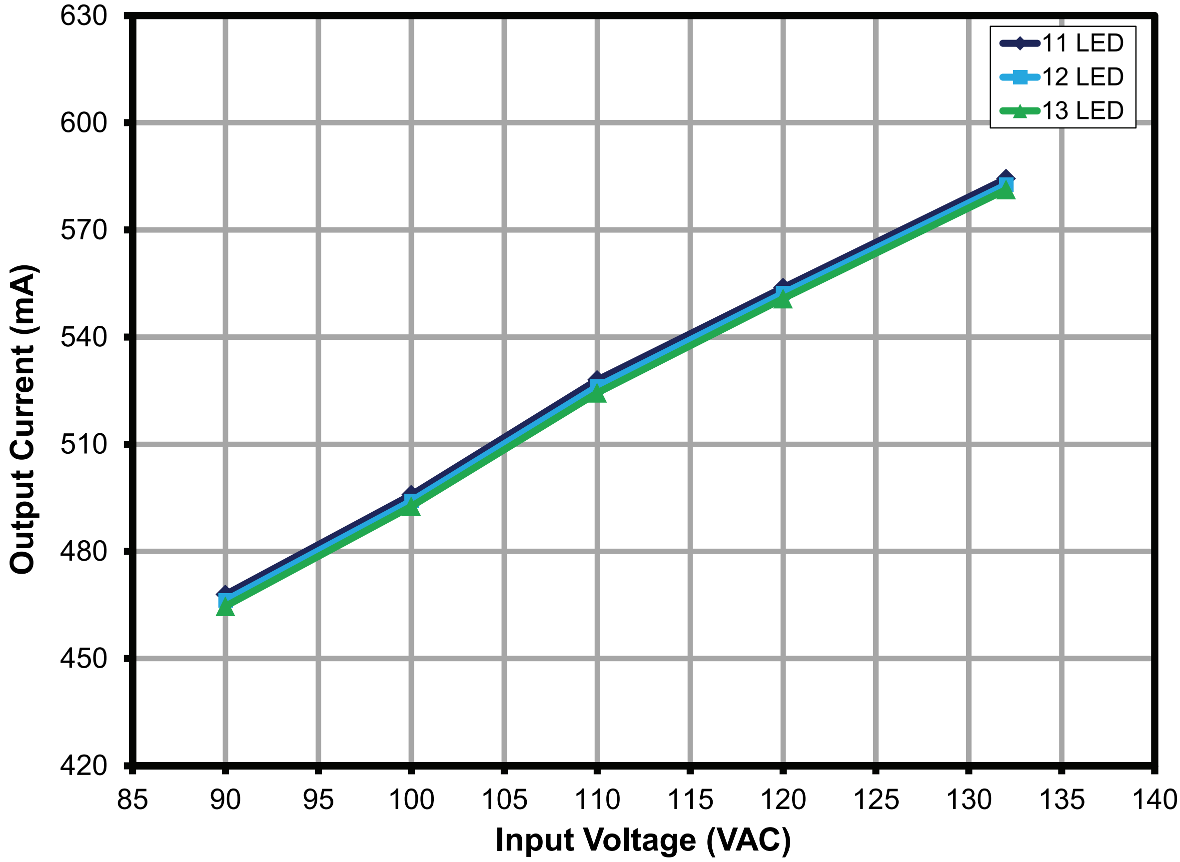

Figure 15 – Regulation vs. Line and Load.

11.3 功率因数

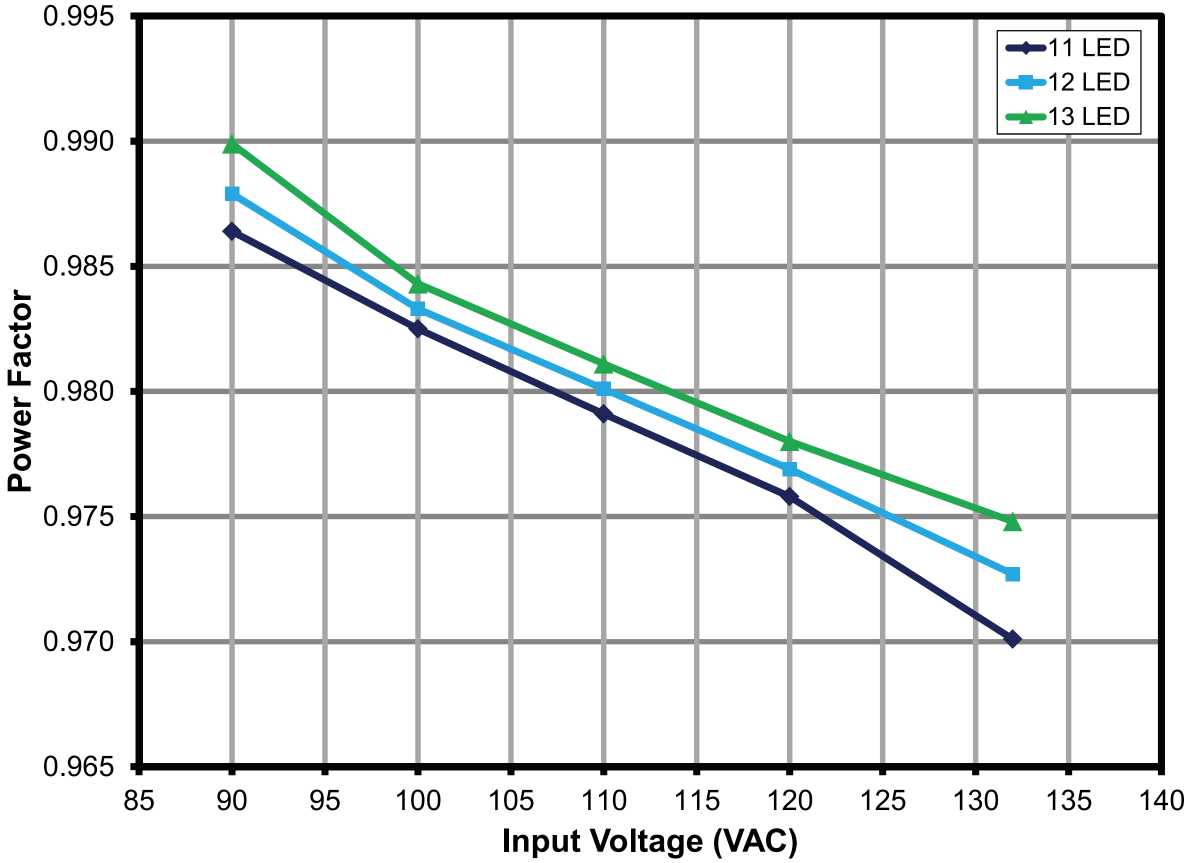

Figure 16 – Power Factor vs. Line and Load.

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11.4 A-THD

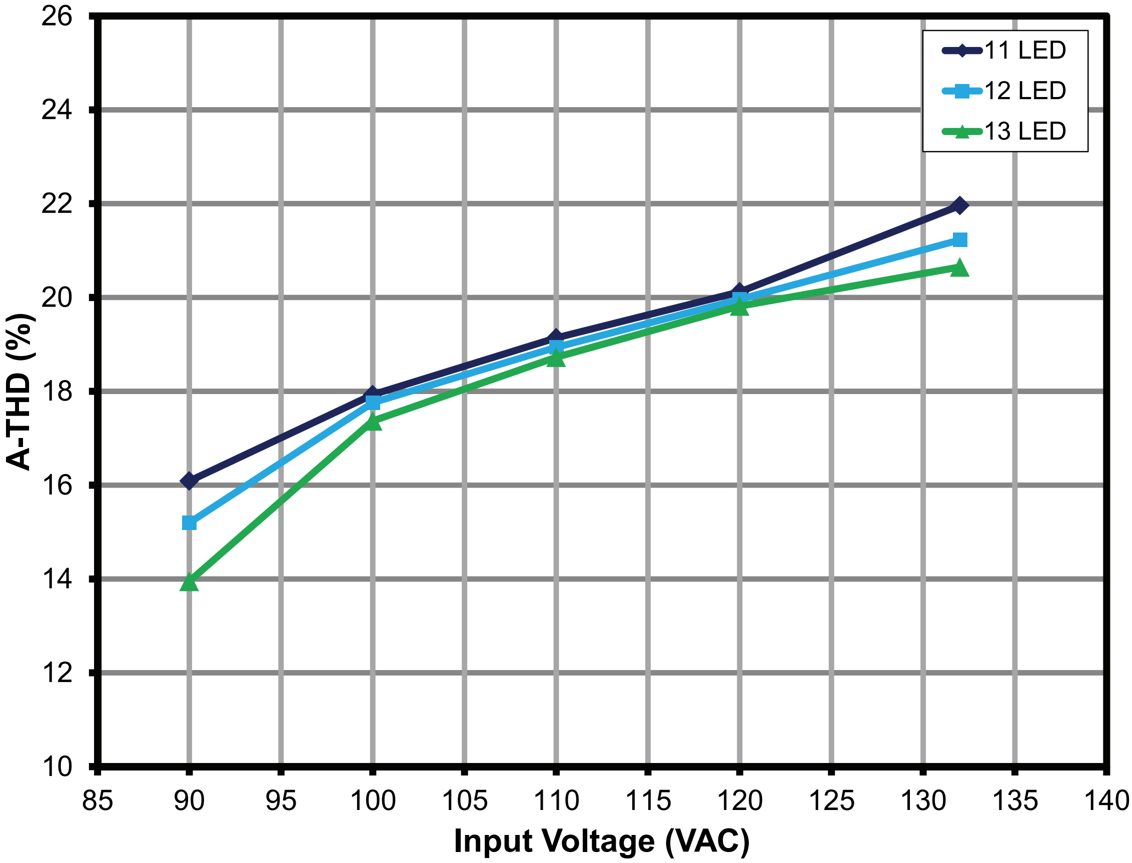

Figure 17 – A-THD vs. Line and Load.

11.5 谐波电流

The design met the IEC61000-3-2 Limits for Class C equipment (section 7.3-a) for an Active input power of >25 W, which states that the harmonic currents shall not exceed the related limits given in Table 2 - Limits for Class C equipment.

11.5.1 11 LED负载

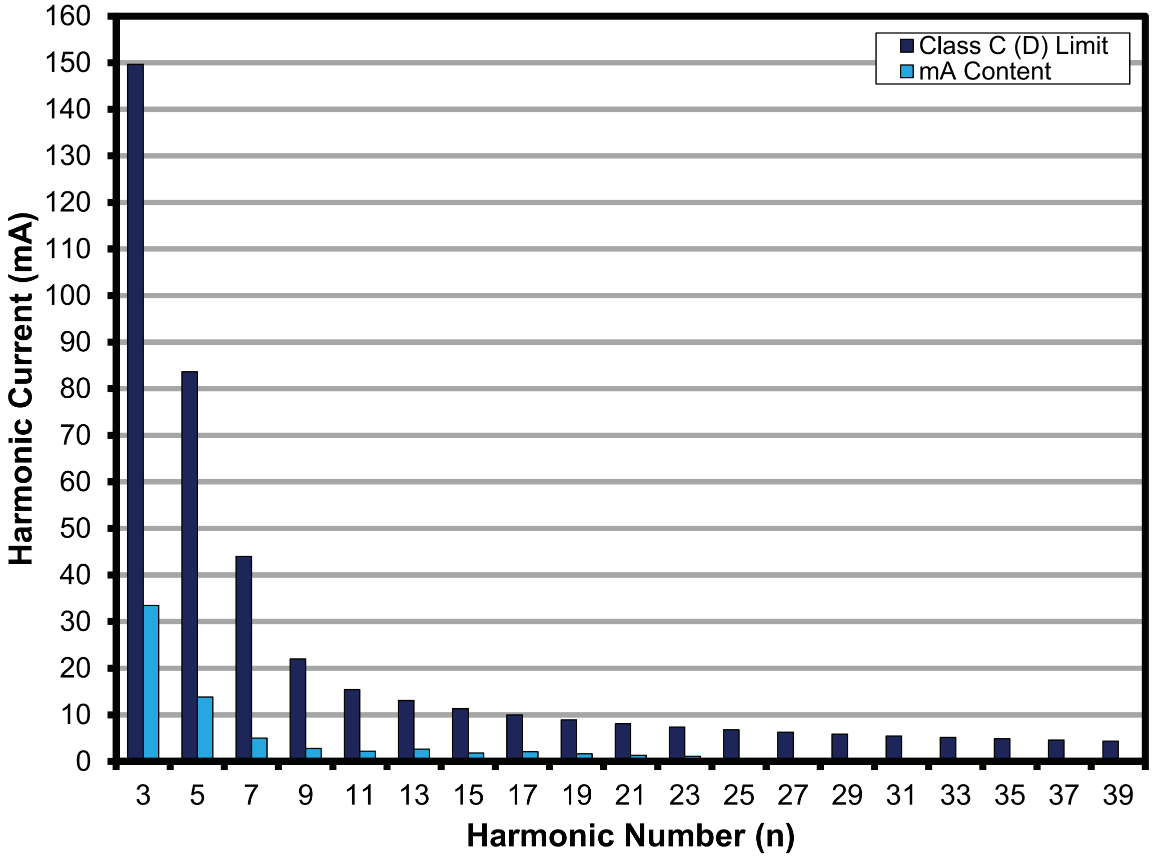

Figure 18 – 11 LED Load Input Current Harmonics (IEC61000-3-2) at 120 VAC, 60 Hz.

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11.5.2 12 LED负载

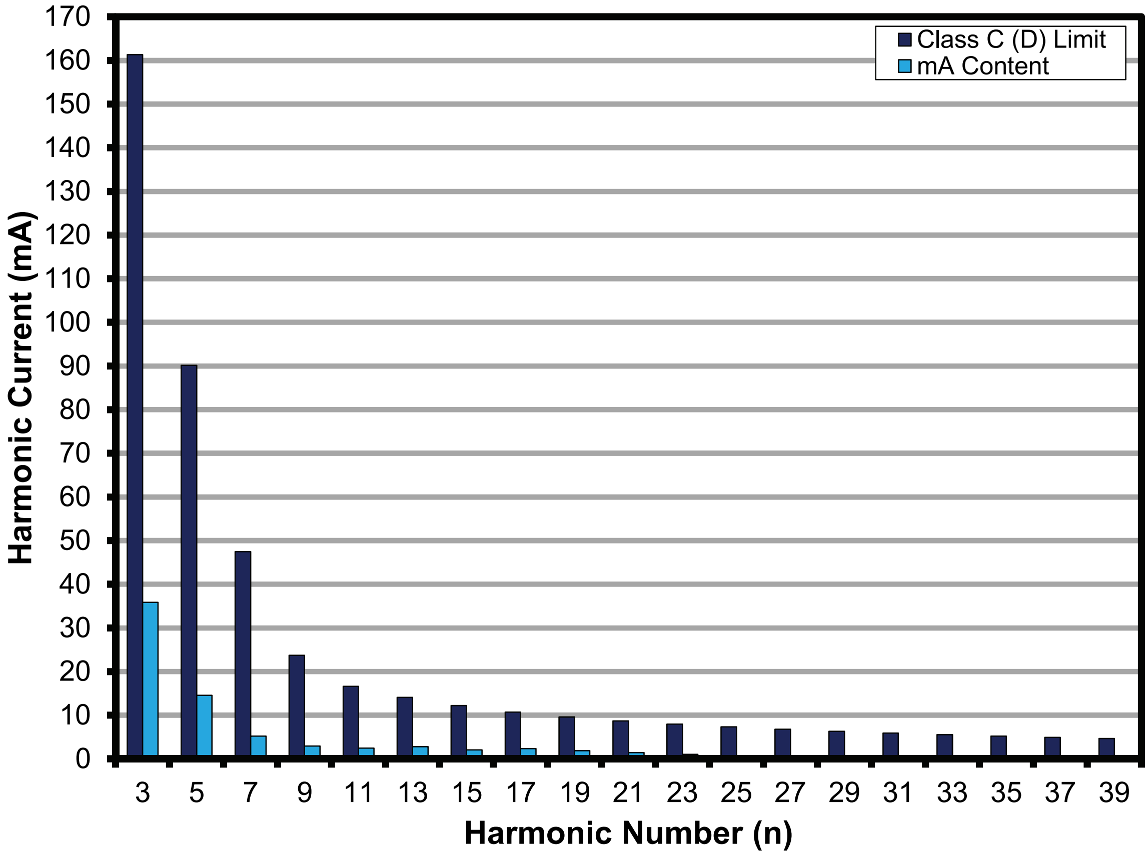

Figure 19 – 12 LED Load Input Current Harmonics case (IEC61000-3-2) at 120 VAC, 60 Hz.

11.5.3 13 LED负载

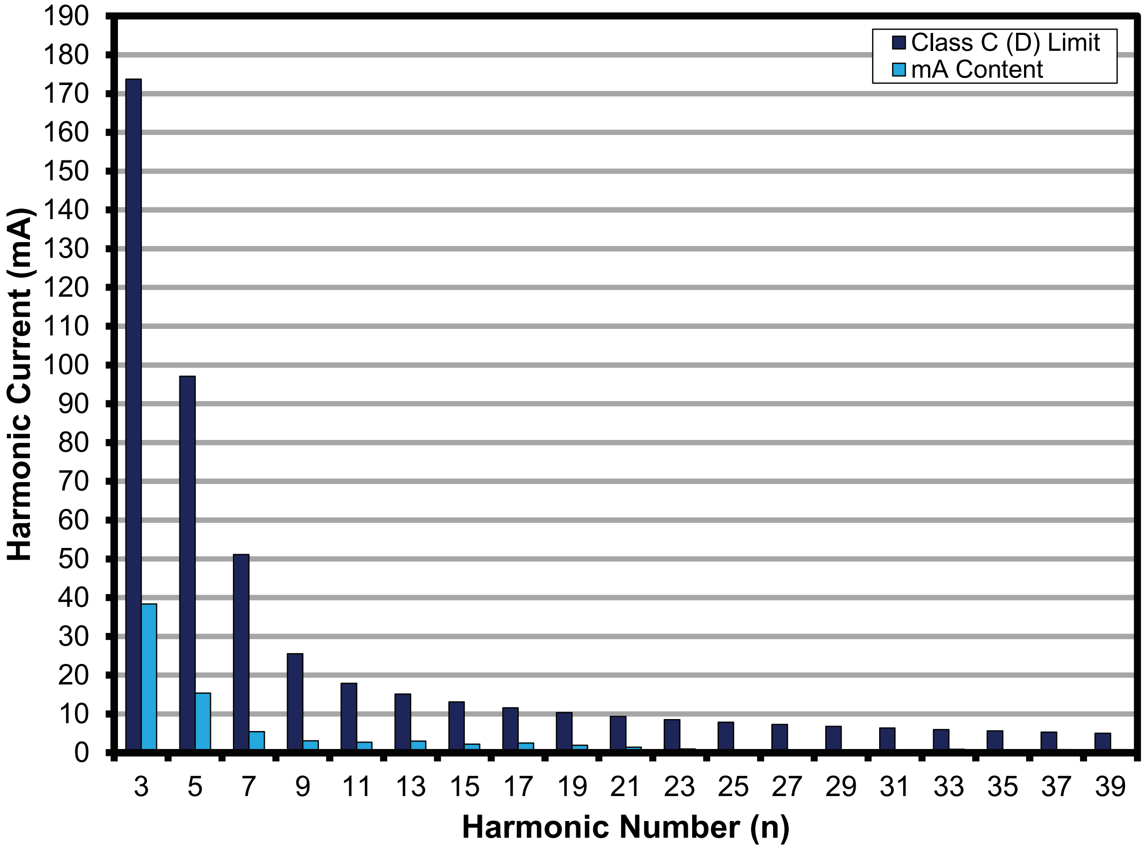

Figure 20 – 13 LED Load Input Current Harmonics (IEC61000-3-2) at 120 VAC, 60 Hz.

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11.6 测试数据

All measurements were taken with the board at open frame, 25 °C ambient, and 60 Hz line frequency.

11.6.1 测试数据，11 LED负载

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)
90.04	213.30	18.944	0.986	16.09	33.56	467.90	15.76	15.70	83.20	3.18
100.01	202.56	19.904	0.983	17.93	33.65	495.89	16.75	16.69	84.15	3.16
110.07	195.64	21.086	0.979	19.14	33.76	528.03	17.90	17.82	84.87	3.19
120.05	187.84	22.004	0.976	20.12	33.83	553.86	18.81	18.74	85.49	3.19
132.08	180.56	23.136	0.970	21.96	33.92	584.33	19.90	19.82	86.03	3.23

11.6.2 测试数据，12 LED负载

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)
90.03	229.36	20.401	0.988	15.20	36.30	466.32	16.99	16.93	83.26	3.42
100.01	218.20	21.456	0.983	17.76	36.43	494.09	18.06	18.00	84.18	3.40
110.07	210.62	22.723	0.980	18.94	36.56	526.19	19.31	19.24	84.97	3.42
120.05	202.30	23.726	0.977	19.96	36.65	552.30	20.32	20.24	85.63	3.41
132.08	194.00	24.923	0.973	21.23	36.76	582.69	21.50	21.42	86.25	3.43

11.6.3 测试数据，13 LED负载

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)
90.03	246.50	21.967	0.990	13.95	39.21	464.64	18.27	18.22	83.17	3.70
100.00	234.86	23.117	0.984	17.37	39.36	492.59	19.44	19.39	84.11	3.67
110.06	226.53	24.460	0.981	18.73	39.50	524.39	20.78	20.72	84.95	3.68
120.04	217.61	25.547	0.978	19.82	39.61	550.75	21.89	21.82	85.67	3.66
132.07	208.34	26.822	0.975	20.65	39.72	581.26	23.16	23.09	86.35	3.66

11.6.4 120 VAC 60 Hz，11 LED负载谐波数据

Current Harmonics Limits for IEC61000-3-2

V	Freq	I (mA)	P	PF	%THD
120	60.00	187.84	22.0040	0.9758	20.12
nth Order	**mA Content**	**% Content**	**Limit <25 W**	**Limit >25 W**	**Remarks**
1	183.99				
2	0.04	0.02%		2.00%	
3	33.44	18.17%	149.6272	29.27%	Pass
5	13.81	7.51%	83.6152	10.00%	Pass
7	4.99	2.71%	44.0080	7.00%	Pass
9	2.76	1.50%	22.0040	5.00%	Pass
11	2.19	1.19%	15.4028	3.00%	Pass
13	2.63	1.43%	13.0331	3.00%	Pass
15	1.82	0.99%	11.2954	3.00%	Pass
17	2.08	1.13%	9.9665	3.00%	Pass
19	1.62	0.88%	8.9174	3.00%	Pass
21	1.30	0.71%	8.0681	3.00%	Pass
23	1.06	0.58%	7.3666	3.00%	Pass
25	0.28	0.15%	6.7772	3.00%	Pass
27	0.12	0.07%	6.2752	3.00%	Pass
29	0.54	0.29%	5.8424	3.00%	Pass
31	0.56	0.30%	5.4655	3.00%	Pass
33	0.67	0.36%	5.1343	3.00%	Pass
35	0.61	0.33%	4.8409	3.00%	Pass
37	0.28	0.15%	4.5792	3.00%	Pass
39	0.28	0.15%	4.3444	3.00%	Pass
41	0.34	0.18%			
43	0.33	0.18%			
45	0.40	0.22%			
47	0.34	0.18%			
49	0.19	0.10%			

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11.6.5 120 VAC 60 Hz，12 LED负载谐波数据

Current Harmonics Limits for IEC61000-3-2

V	Freq	I (mA)	P	PF	%THD
120	60.00	202.30	23.7260	0.9769	19.96
nth Order	**mA Content**	**% Content**	**Limit <25 W**	**Limit >25 W**	**Remarks**
1	198.22				
2	0.03	0.02%		2.00%	
3	35.84	18.08%	161.3368	29.31%	Pass
5	14.56	7.35%	90.1588	10.00%	Pass
7	5.20	2.62%	47.4520	7.00%	Pass
9	2.94	1.48%	23.7260	5.00%	Pass
11	2.44	1.23%	16.6082	3.00%	Pass
13	2.81	1.42%	14.0531	3.00%	Pass
15	2.06	1.04%	12.1793	3.00%	Pass
17	2.35	1.19%	10.7465	3.00%	Pass
19	1.86	0.94%	9.6153	3.00%	Pass
21	1.43	0.72%	8.6995	3.00%	Pass
23	1.03	0.52%	7.9431	3.00%	Pass
25	0.12	0.06%	7.3076	3.00%	Pass
27	0.14	0.07%	6.7663	3.00%	Pass
29	0.71	0.36%	6.2997	3.00%	Pass
31	0.62	0.31%	5.8932	3.00%	Pass
33	0.71	0.36%	5.5361	3.00%	Pass
35	0.62	0.31%	5.2197	3.00%	Pass
37	0.27	0.14%	4.9376	3.00%	Pass
39	0.28	0.14%	4.6844	3.00%	Pass
41	0.35	0.18%			
43	0.36	0.18%			
45	0.49	0.25%			
47	0.43	0.22%			
49	0.27	0.14%			

11.6.6 120 VAC 60 Hz，13 LED负载谐波数据

Current Harmonics Limits for IEC61000-3-2

V	Freq	I (mA)	P	PF	%THD
120	60.00	202.30	23.7260	0.9769	19.96
nth Order	**mA Content**	**% Content**	**Limit <25 W**	**Limit >25 W**	**Remarks**
1	198.22				
2	0.03	0.02%		2.00%	
3	35.84	18.08%	161.3368	29.31%	Pass
5	14.56	7.35%	90.1588	10.00%	Pass
7	5.20	2.62%	47.4520	7.00%	Pass
9	2.94	1.48%	23.7260	5.00%	Pass
11	2.44	1.23%	16.6082	3.00%	Pass
13	2.81	1.42%	14.0531	3.00%	Pass
15	2.06	1.04%	12.1793	3.00%	Pass
17	2.35	1.19%	10.7465	3.00%	Pass
19	1.86	0.94%	9.6153	3.00%	Pass
21	1.43	0.72%	8.6995	3.00%	Pass
23	1.03	0.52%	7.9431	3.00%	Pass
25	0.12	0.06%	7.3076	3.00%	Pass
27	0.14	0.07%	6.7663	3.00%	Pass
29	0.71	0.36%	6.2997	3.00%	Pass
31	0.62	0.31%	5.8932	3.00%	Pass
33	0.71	0.36%	5.5361	3.00%	Pass
35	0.62	0.31%	5.2197	3.00%	Pass
37	0.27	0.14%	4.9376	3.00%	Pass
39	0.28	0.14%	4.6844	3.00%	Pass
41	0.35	0.18%			
43	0.36	0.18%			
45	0.49	0.25%			
47	0.43	0.22%			
49	0.27	0.14%			

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12 调光性能数据

TRIAC dimming results were taken at an input voltage of 120 VAC, 60 Hz line frequency, room temperature, and a nominal 36 V LED load.

The output current High Limit I_{OUT} (Max) and Low Limit I_{OUT} (Min) were incorporated based on the USA NEMA publication SSL6-2010 section 4 page 9 for dimming performance system requirements for reference. The standard however refers to 120 VAC operating input voltage and pertains to the limits as relative light output. The limits incorporated on the succeeding graphs assumes that 100% relative light output falls on the maximum operating output current of 550 mA and 0 mA as 0% light output, and input line of 120 VAC, 60 Hz.

12.1 模拟（使用Agilent 6812B交流电源供应器）前沿调光器的调光曲线

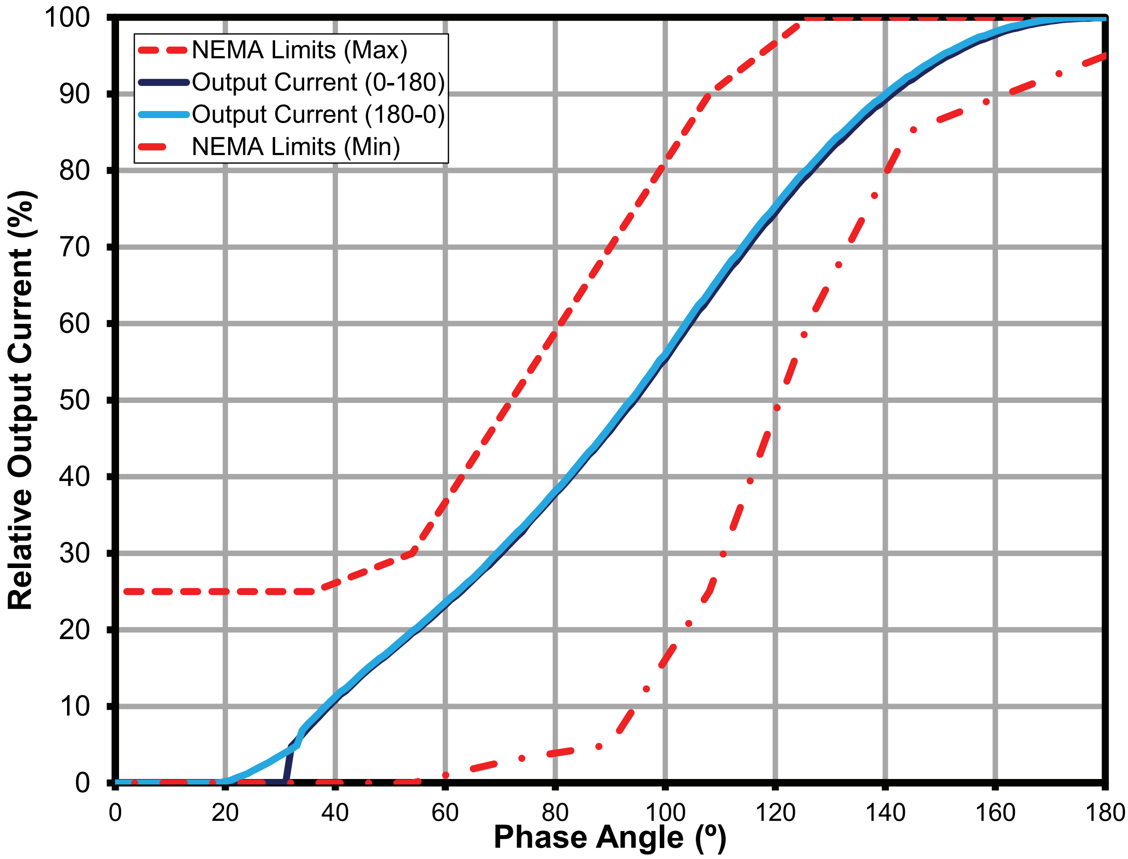

Figure 21 – Dimming Curve at 120 VAC, 60 Hz Input.

12.2 快速启动(<200 ms) – 采用可控硅调光器

Using a TRIAC-based U.S. dimmer model S-600P-WH (Lutron) with thumb-wheel adjust set to minimum turn-on (i.e. <30 degrees) which guarantees the LED driver is off when it is switched to ON position. The test was made by turning/sliding the dimmer knob as quickly as possible from minimum to maximum position then measuring the time from the point the dimmer started conducting to the point the output current started rising.

Input voltage: 120 VAC / 60 Hz

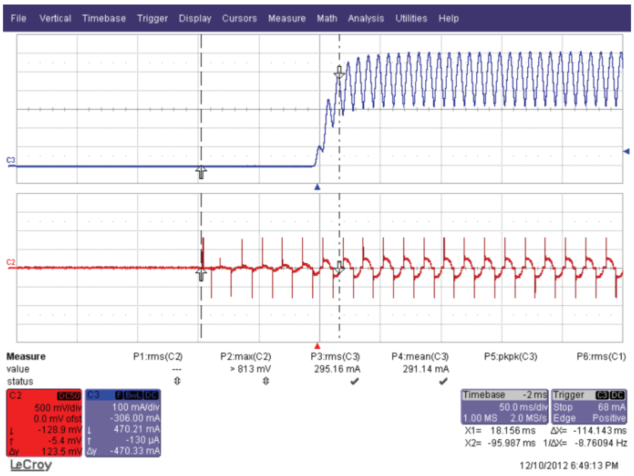

Figure 22 – Measured Start-up Time 114 ms. Flicking the Switch ON, Dimmer at Full Conduction.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 500 mA, 50 ms / div.

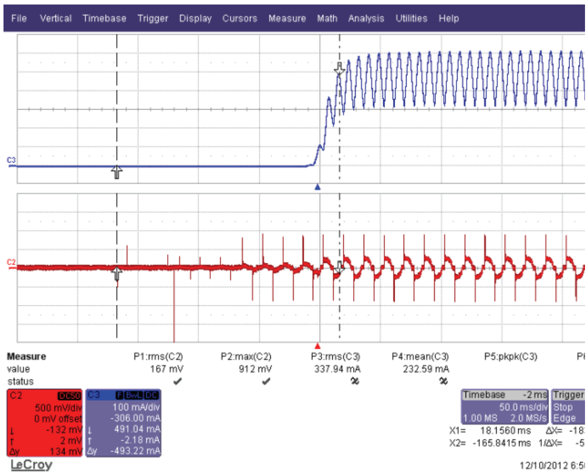

Figure 23 – Measured Start-up Time 184 ms. Quickly Sliding the Knob from Minimum to Full Conduction.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 500 mA, 50 ms / div.

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12.3 可控硅调光器的突然变亮点

Pop-on per NEMA SSL-6 definition is lowest dimmer setting above minimum at which the lamp transitions from off to dimmed.

This particular test was conducted using 120 V / 60 Hz TRIAC dimmer model S-600P-WH (Lutron U.S. dimmer).

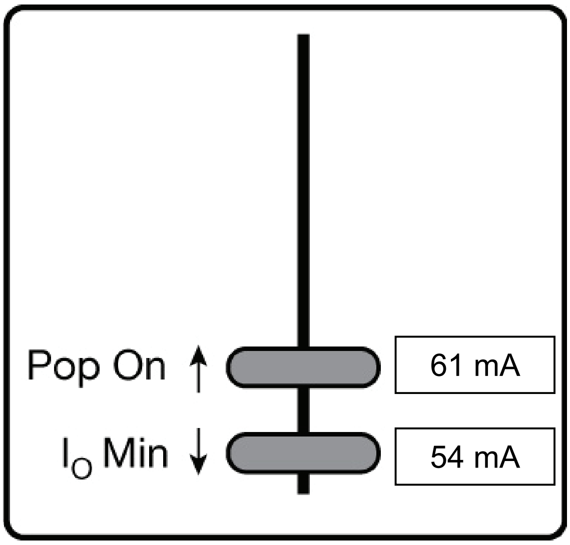

Figure 24 – 35º Conduction Angle was Measured at Pop-on Point.

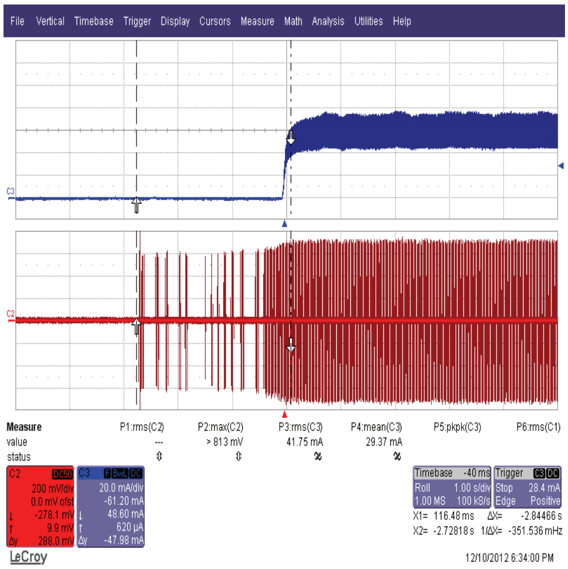

Figure 25 – 35º Conduction Angle at Pop-on Point.
Upper: I_{OUT}, 20 mA / div.
Middle: V_{OUT}, 200 V / div.
Lower: I_{IN}, 0.2 A / div., 1 s / div.

12.4 使用调光器时的输出电流和输入电流波形

Input: 120 VAC, 60 Hz Utility Line
Output: 36 V LED Load
Dimmer: LUTRON GL-600WH

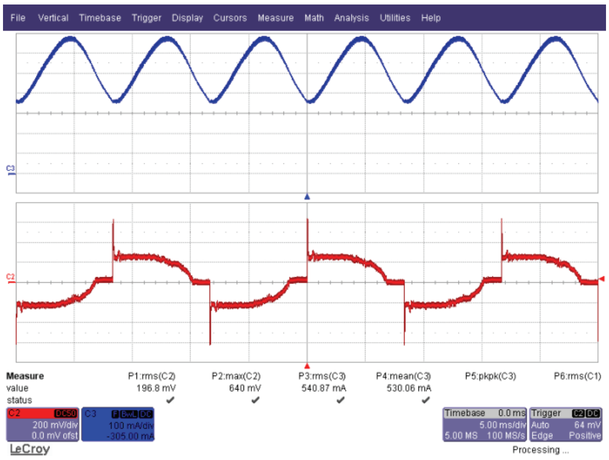

Figure 26 – 147º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 200 mA, 5 ms / div.

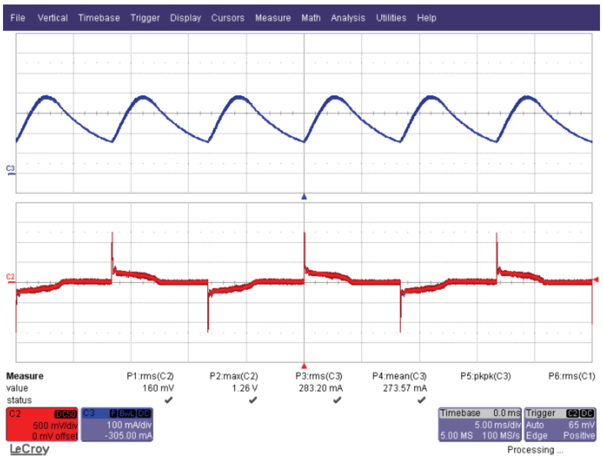

Figure 27 – 90º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 500 mA, 5 ms / div.

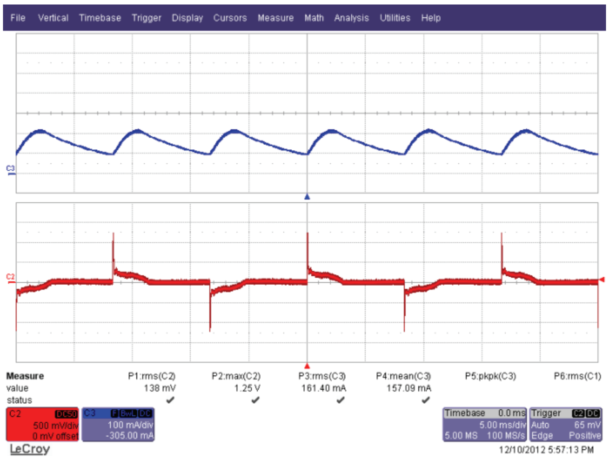

Figure 28 – 60º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 500 mA, 5 ms / div.

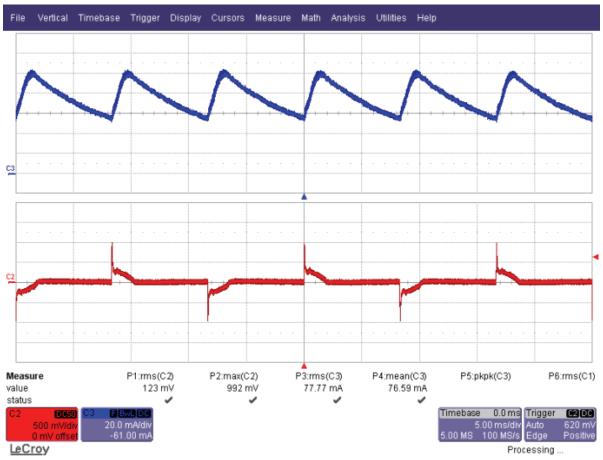

Figure 29 – 40º Conduction Angle.
Upper: I_{OUT}, 20 mA / div.
Lower: I_{IN}, 500 mA, 5 ms / div.

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12.5 兼容性列表

The following U.S. TRIAC-based dimmers were tested with utility line input (~120 VAC, 60 Hz) and 36 V LED load.

Dimmer Brand	Type	Part Number	$V_{RMS(MIN)}$	I_{MIN} (mA)	$V_{RMS(MAX)}$	I_{MAX} (mA)	Dim Ratio
Lutron	L	LG-600PH-WH	24	41	115.5	492	12
Lutron	L	S-603P-WH	24.5	43	116.0	497	12
Lutron	L	SLV600P-WH	29	62	116.7	505	8
Lutron	L	S-600-WH	27.5	57	118.5	530	9
Lutron	L	S-600PH-WH	23	40	116.1	501	13
Lutron	L	DVWCL-153-PLH-WH	21.8	32	114.0	484	15
Lutron	L	DV-603P-WH	25	48	115.6	498	10
Lutron	L	DV-600P-WH	24	42	115.8	498	12
Lutron	L	TG-600PH-WH	40	87	117.0	513	6
Lutron	L	Q-600P-WH aka FA-600	19.6	18	115.0	494	28
Lutron	L	AY-600P-WH	42.2	91	116.5	508	6
Lutron	L	GL-600P-WH	28.5	61	116.0	502	8
Leviton	L	R62-06633-1LW	24	42	119.8	549	13
Leviton	L	R62-06631-1LW	13	4	117.6	520	130
Leviton	L	R60-IPI06-1LM	43	95	119.2	542	6
Leviton	E	R52-06161-00W	33	60	116.3	507	8
Leviton	L	R52-RPI06-1LW	32	50	119.9	555	11
Leviton	L	TGM10-1LW	16.8	12	115.0	493	41
Leviton	L	R02-06613-PLW	21	28	120.0	550	20
Cooper	L	SLC03P-W-K-L	16	10	117.4	519	51
Lutron	L	GL-600-WH	31	66	118.4	533	8
Lutron	L	DVPDC-203P-WH	65	166	118.0	527	3
Lutron	L	LX-600PL-wh	29	60	118.0	525	9
Lutron	L	CTCL-153PDH	20	21	114.7	488	23
Lutron	L	S-600P	22	36	116.0	503	14
Lutron	L	TGLV-600P	33	70	117.0	517	7
Lutron	L	TGLV-600PR	32	67	117.0	512	8
Lutron	L	TT-300NLH-WH	40	84	119.0	540	6
Lutron	L	NLV-1000-WH	25	45	117.4	519	12
Lutron	T		30.7	52	115.5	495	10
Lutron	L		24	41	118.2	532	13
Cooper	L		32	70	118.0	528	8
Lutron	L	S-103P-WH	32	68	116.0	503	7
Lutron	L	S-10P-WH	27	56	115.0	496	9
Lutron	L	S-600PNLH-WH	29	63	116.2	511	8
Lutron	L	S-603PNL-WH	31	68	116.0	508	7
Lutron	L	SLV-603P-WH	33	71	116.0	506	7
Lutron	L	AYLV-600P-WH	33	71	117.0	514	7
Lutron	L	AYLV-603P-WH	33.5	73	115.0	497	7
Lutron	L	AY-103PNL-WH	31	65	117.6	523	8

Lutron	L	AY-103P-WH	31	60	118.0	526	9
Lutron	L	AY-10PNL-WH	29	63	119.8	551	9
Lutron	L	AY-10P-WH	24.5	44	117.8	528	12
Lutron	L	AY-603PNL-WH	34	73	114.6	493	7
Lutron	L	AY-603PG-WH	37	77	103.7	395	5
Lutron	L	AY-603P-WH	41	90	115.1	497	6
Lutron	L	AY-600PNL-WH	37	76	116.6	512	7
Lutron	T	DVELV-300P-WH	25	33	112.3	458	14
Lutron	L	DVLV-10P-WH	34	72	115.8	493	7
Lutron	L	DVLV-103P-WH	33	70	115.9	498	7
Lutron	L	DVLV-603P-WH	32	68	116.0	500	7
Lutron	L	S-1000-WH	32	67	118.6	531	8
Lutron	T	SELV-300P-WH	25	34	111.0	452	13
Lutron	L	S-600P-WH	24	41	115.6	501	12
Lutron	L	S-103PNL-WH	33.5	66	115.3	498	8
Lutron		SPSLV-1000-WH	30	64	117.0	518	8
Lutron		SPSLV-600-WH	30	64	116.7	517	8
Lutron		SPSELV-600-WH	30	52	115.7	496	10
Lutron	L	GLV-600-WH	24	43	118.5	533	12
Lutron	L	LG-603PGH-WH	27	54.0	106.0	408.0	8
Lutron	L	DVW-603PGH-WH	29	61.0	106.1	409.0	7
Leviton	L	VPI06	26	51.0	116.9	510.0	10
Lutron	L	TG-10PR-WH	39.7	85.0	118.0	523.0	6
Lutron	L	NT-600	22.5	32.0	118.7	532.0	17
Lutron	L	NT-1000	23	38.0	118.7	534.0	14
Lutron	L	LGCL-153PLH-WH	27	56.0	114.2	486.0	9
Lutron	L	CTCL-153PDH-WH	37	75.0	115.0	491.0	7
Lutron	L	TGCL-153PH-WH	27	56.0	114.5	491.0	9
Lutron	L	DVWCL-153PH-LA	38.7	81.0	114.7	492.0	6
Leviton	L	81000-W	38	79.0	119.3	538.0	7
Lutron	L	TTCL-100LH-WH	37	76.0	114.4	486.0	6

Figure 30 – U.S. TRIAC-Based Dimmers Compatibility List.

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13 热性能

13.1 PAR38灯的热测量

The UUT was placed inside a PAR38 with MT-G2 lamp provided by CREE and the lamp was screwed into a conical metal housing oriented in upside down position for worse case position. Type-T thermo-couple wire was attached on the body of each device under test. Temperature readings were recorded when it stabilizes after running more than one hour with 36 V LED (MT-G2) load at the specified input voltage and load current. The probe location for the ambient was shown on the figure below.

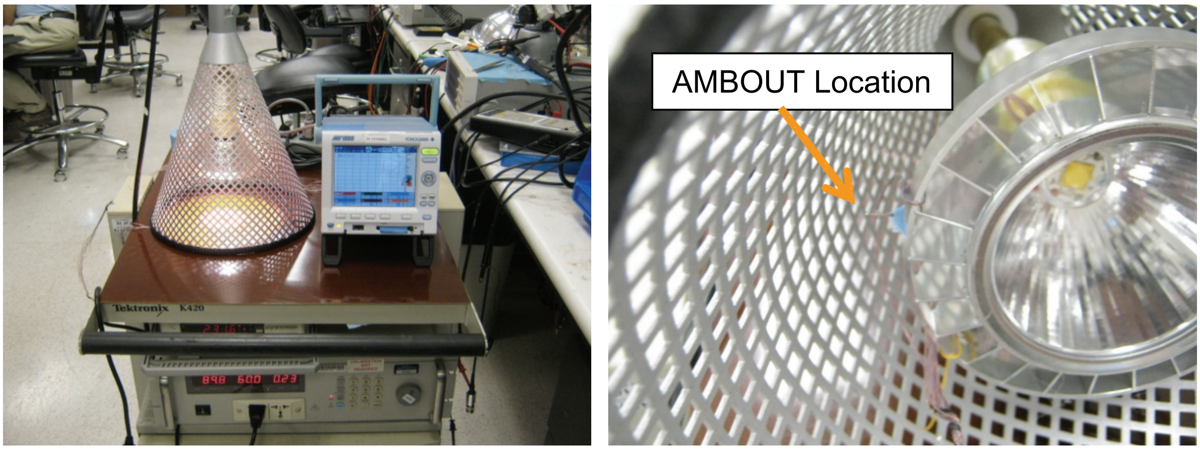

Figure 31 – Thermal Set-up.

13.2 90 VAC，非调光

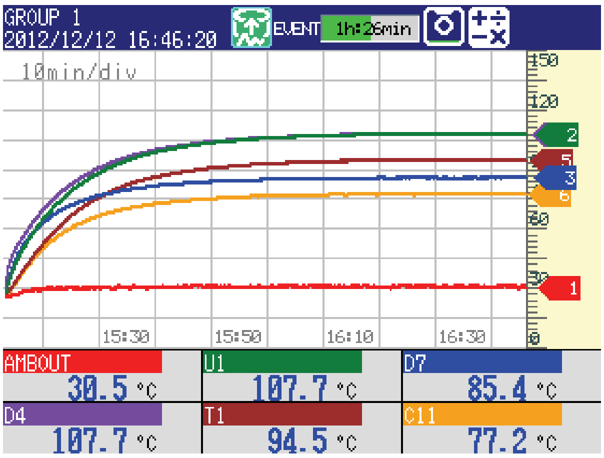

Figure 32 – 90 VAC.
AMBOUT, U1, D7, D4, T1, C11.

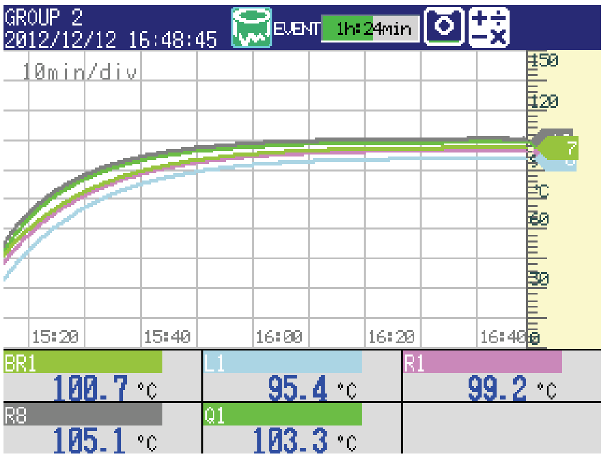

Figure 33 – 90 VAC Conduction Angle.
BR1, L1, R1, R8, Q1.

13.3 132 VAC，非调光

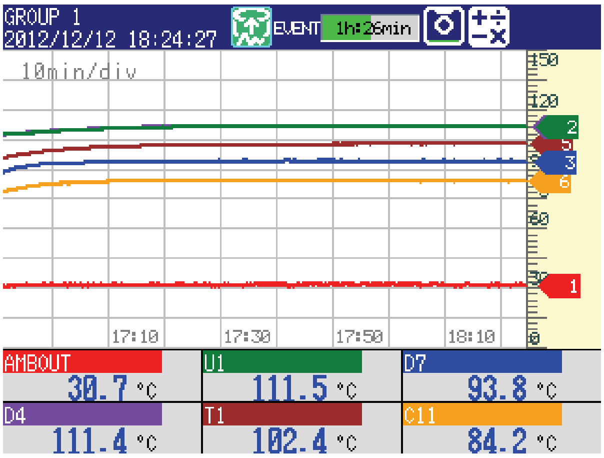

Figure 34 – 132 VAC.
AMBOUT, U1, D7, D4, T1, C11.

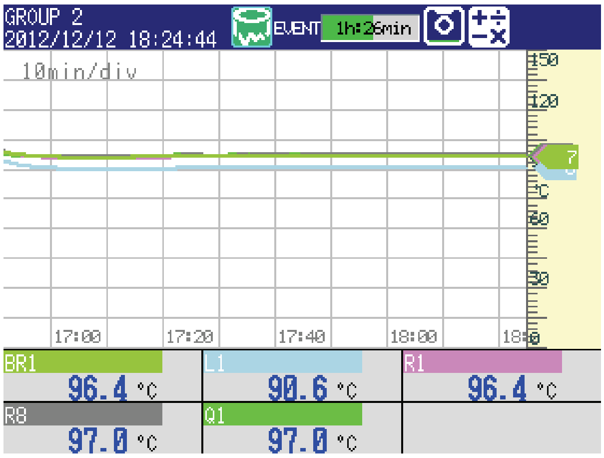

Figure 35 – 132 VAC.
BR1, L1, R1, R8, Q1.

13.4 120 VAC，90°导通角

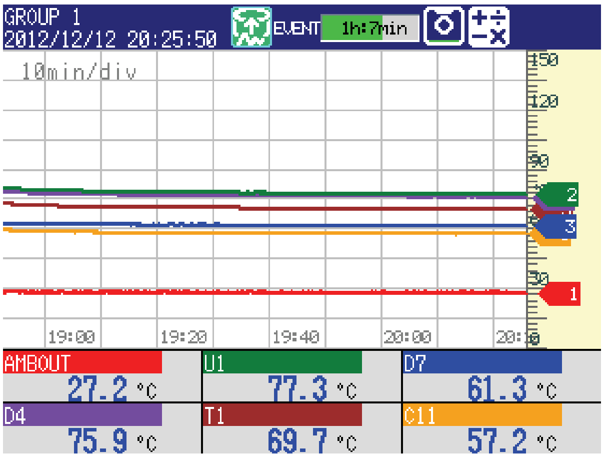

Figure 36 – 120 VAC, 90 ° Conduction Angle.
AMBOUT, U1, D7, D4, T1, C11.

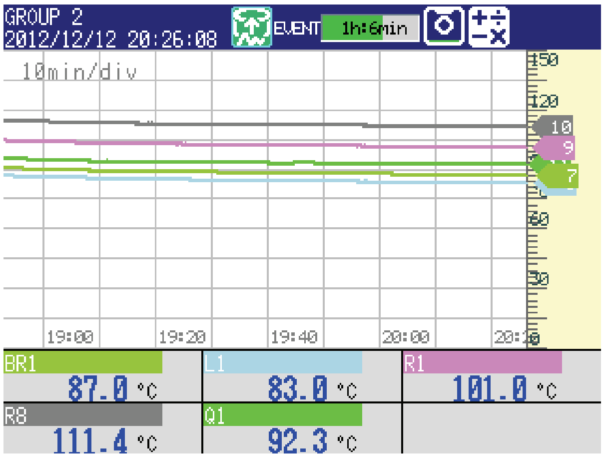

Figure 37 – 120 VAC, 90° Conduction Angle.
BR1, L1, R1, R8, Q1.

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14 非调光波形

14.1 输出电流和输入电流波形

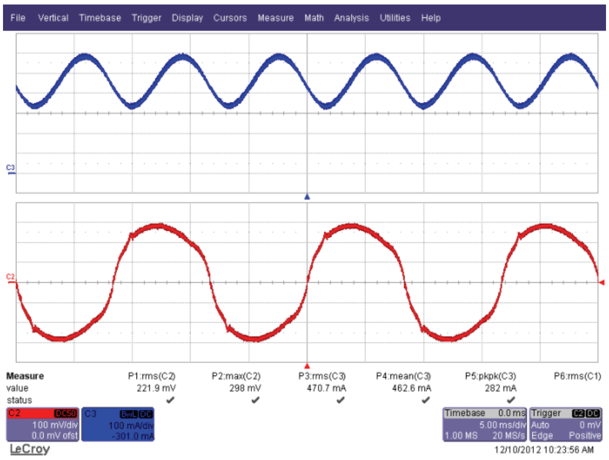

Figure 38 – 90 VAC, 36 V LED Load.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 100 mA, 5 ms / div.

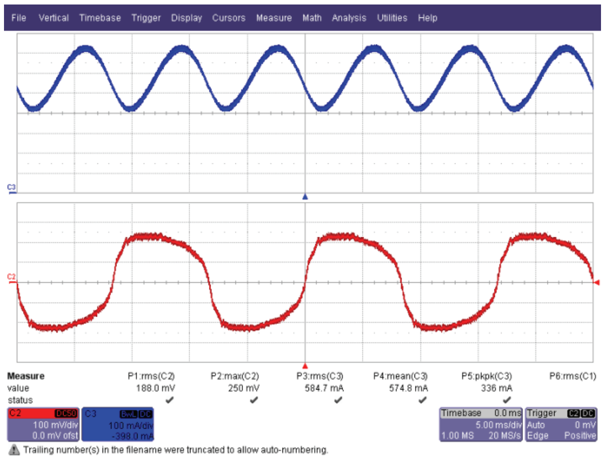

Figure 39 – 132 VAC, 36 V LED Load.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 100 mA, 5 ms / div.

14.2 正常工作时的输出电流和输出电压波形

Input Condition	I_{OUT}, Mean (mA)	I_{OUT}, Peak to Peak (mA)	I_{OUT} Ripple (%)
90 VAC, 60 Hz	457	256	±28
120 VAC, 60 Hz	540	291	±27
132 VAC, 60 Hz	572	315	±28

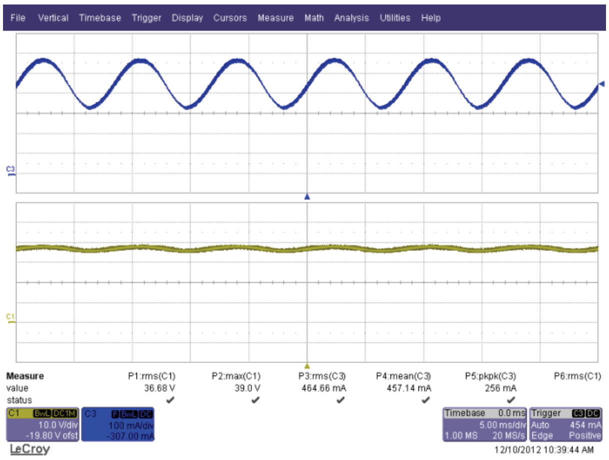

Figure 40 – 90 VAC, 60 Hz Full Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 10 V, 5 ms / div.

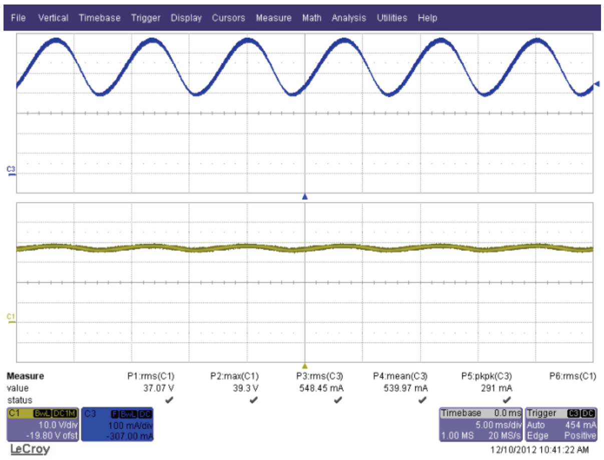

Figure 41 – 120 VAC, 60 Hz Full Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 10 V, 5 ms / div.

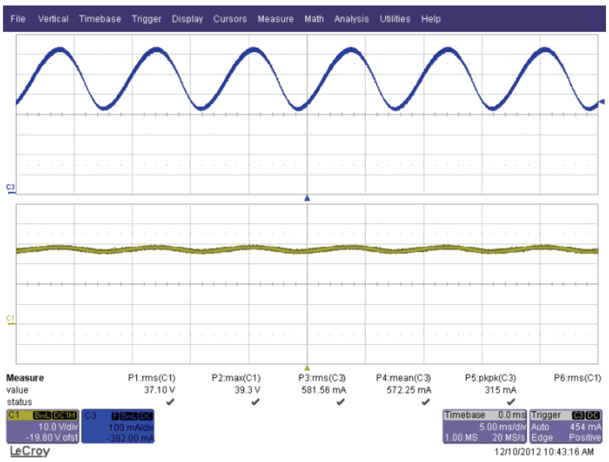

Figure 42 – 132 VAC, 60 Hz Full Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 10 V, 5 ms / div.

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14.3 启动时的输入电压和输出电流波形

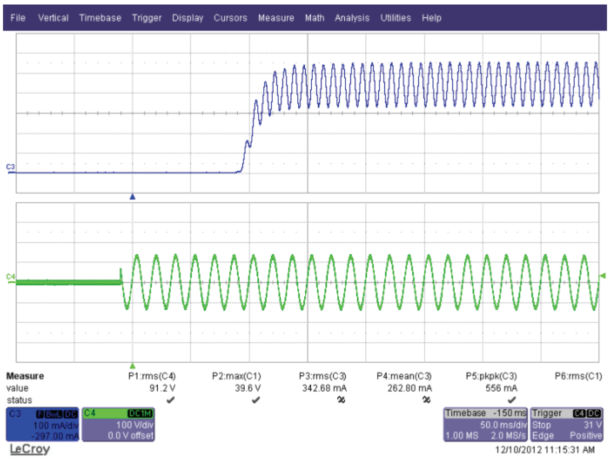

Figure 43 – 90 VAC, 60 Hz.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 100 V, 50 ms / div.

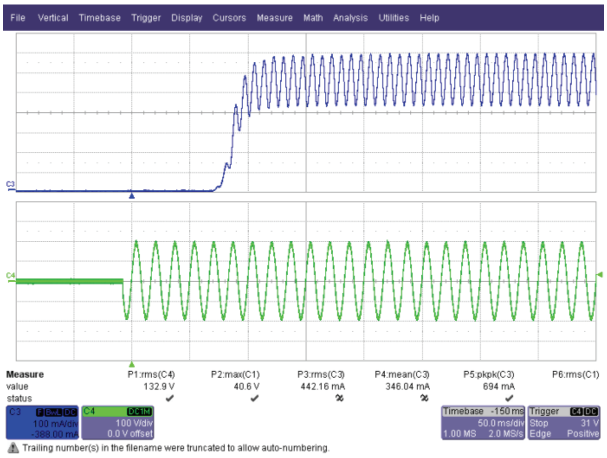

Figure 44 – 132 VAC, 60 Hz.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 100 V, 50 ms / div.

14.4 启动时的输出电压和输出电流波形

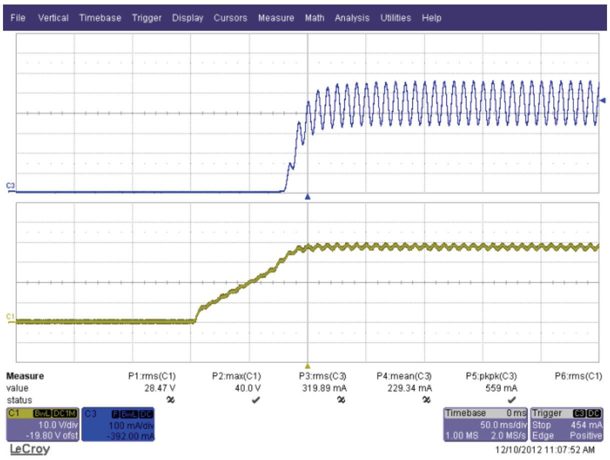

Figure 45 – 90 VAC, 60 Hz.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 10 V, 50 ms / div.

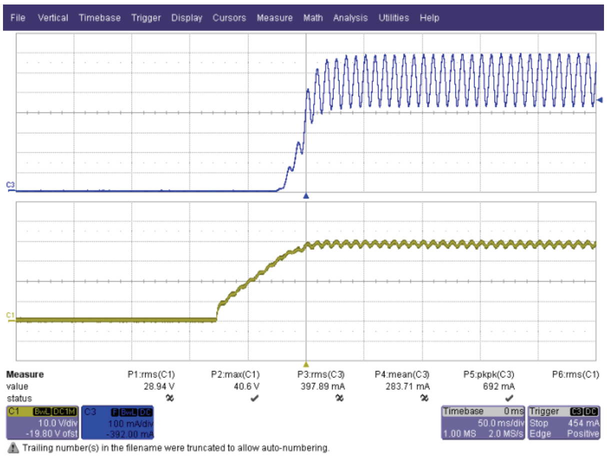

Figure 46 – 132 VAC, 60 Hz.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 10 V, 50 ms / div.

14.5 正常工作时的漏极电压和电流

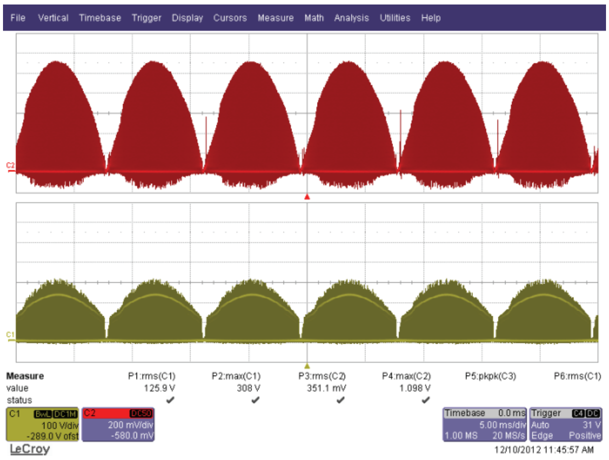

Figure 47 – 90 VAC, 60 Hz.
Upper: I_{DRAIN}, 0.2 A / div.
Lower: V_{DRAIN}, 100 V, 5 ms / div.

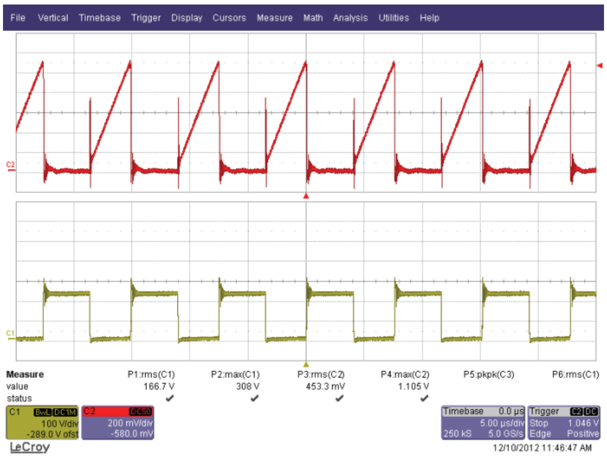

Figure 48 – 90 VAC, 60 Hz.
Upper: I_{DRAIN}, 0.2 A / div.
Lower: V_{DRAIN}, 100 V / div., 5 μs / div.

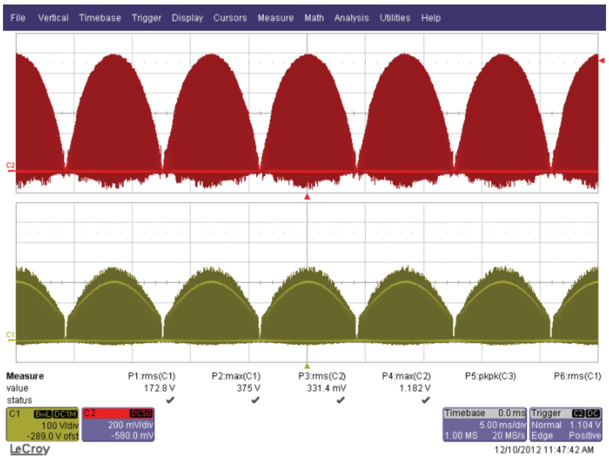

Figure 49 – 132 VAC, 60 Hz.
Upper: I_{DRAIN}, 0.2 A / div.
Lower: V_{DRAIN}, 100 V, 5 ms / div.

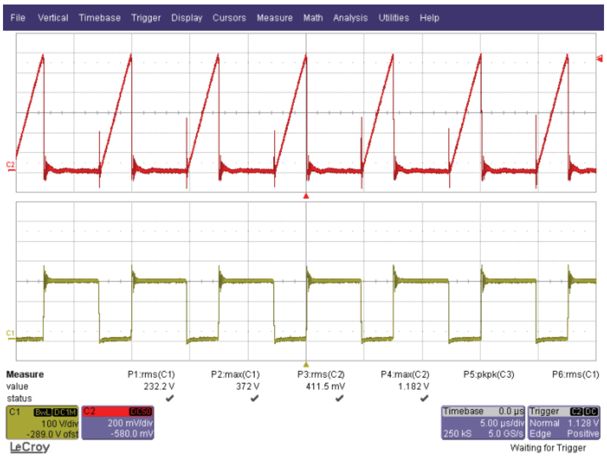

Figure 50 – 132 VAC, 60 Hz.
Upper: I_{DRAIN}, 0.2 A / div.
Lower: V_{DRAIN}, 100 V / div., 5 μs / div.

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14.6 启动时的漏极电压和电流

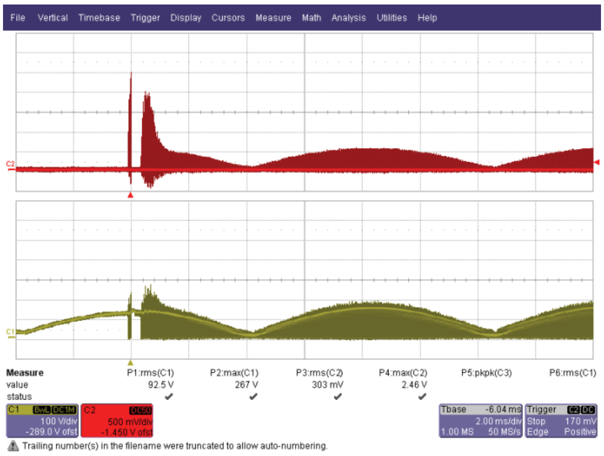

Figure 51 – 90 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500 mA / div.
Lower: V_{DRAIN}, 100 V, 2 ms / div.

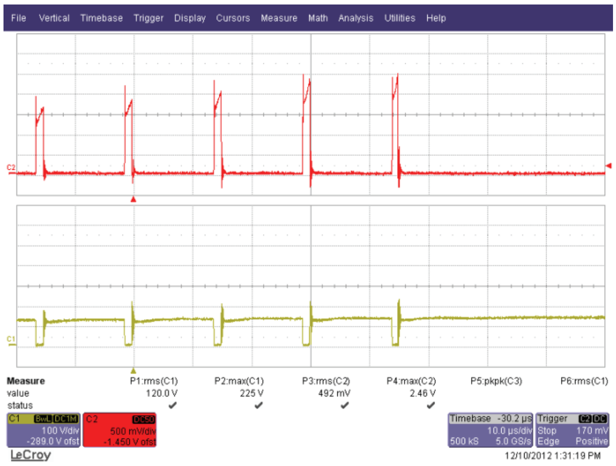

Figure 52 – 90 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500 mA / div.
Lower: V_{DRAIN}, 100 V, 10 μs / div.

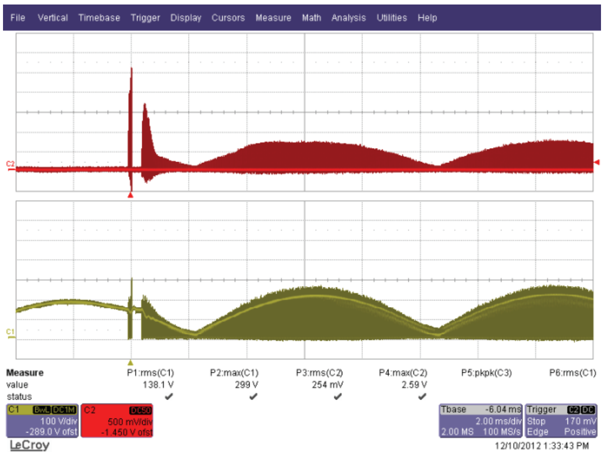

Figure 53 – 132 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500 mA / div.
Lower: V_{DRAIN}, 100 V, 2 ms / div.

Figure 54 – 132 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500 mA / div.
Lower: V_{DRAIN}, 100 V, 10 μs / div.

14.7 输出短路条件下的漏极电压和电流

During output short condition, the I_{FB} current falls below the $I_{FB(AR)}$ threshold and enters the auto-restart condition. During this condition, to minimize power dissipation on the power components, the auto-restart circuit turns the power supply on and off at an auto-restart duty cycle of typically DC_{AR} for as long as the fault condition persists.

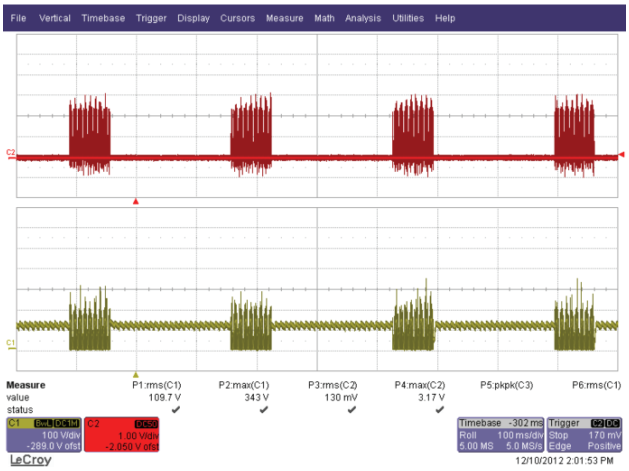

Figure 55 – 90 VAC, 60 Hz Output Short Condition.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V, 100 ms / div.

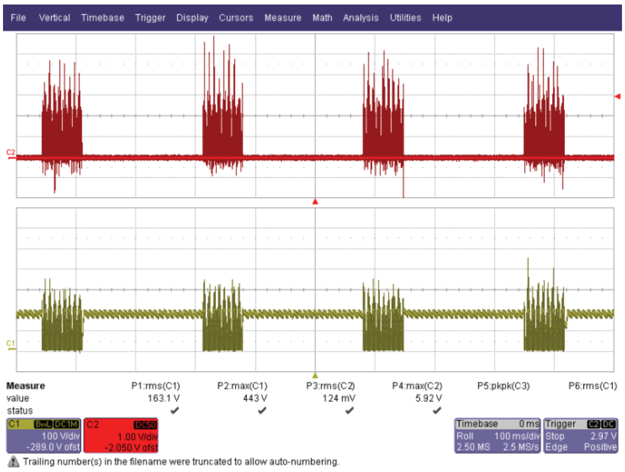

Figure 56 – 132 VAC, 60 Hz Output Short Condition.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V, 100 ms / div.

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14.8 开路负载条件

The LED load was disconnected from the driver.

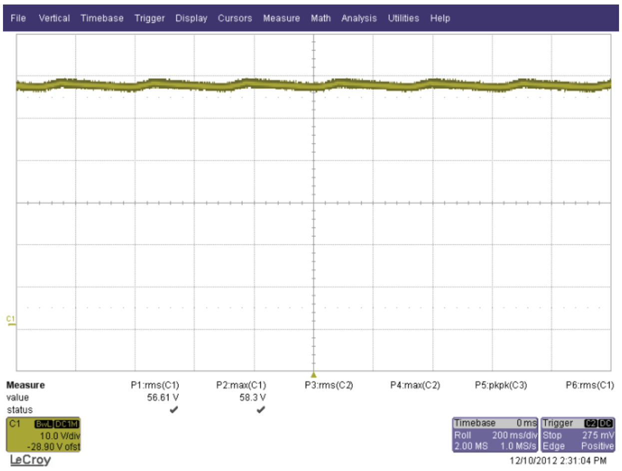

Figure 57 – 90 VAC, 60 Hz Output Open Load. CH4: V_{OUT}, 10 V, 200 ms / div.

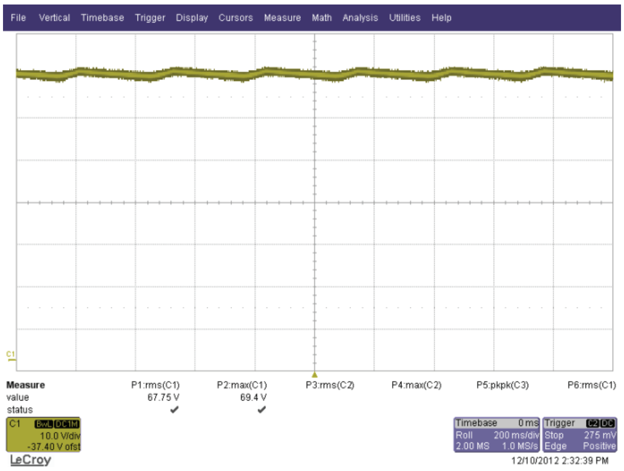

Figure 58 – 132 VAC, 60 Hz Output Open Load. CH4: V_{OUT}, 10 V, 200 ms / div.

14.9 正常工作时的输出二极管电压和电流波形

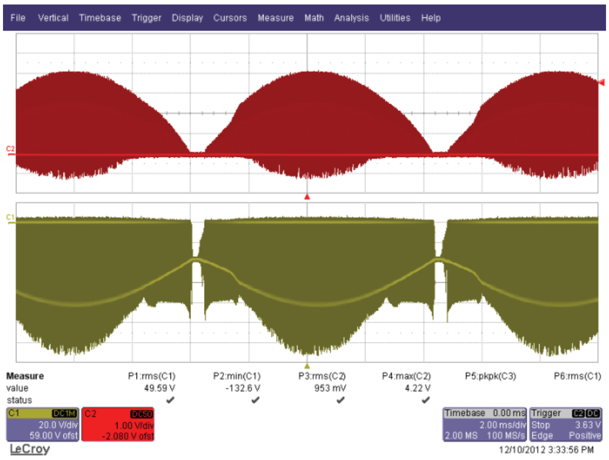

Figure 59 – 90 VAC, 60 Hz.
Upper: I_{D7}, 1A / div.
Lower: V_{D7}, 10 V, 2 ms / div.

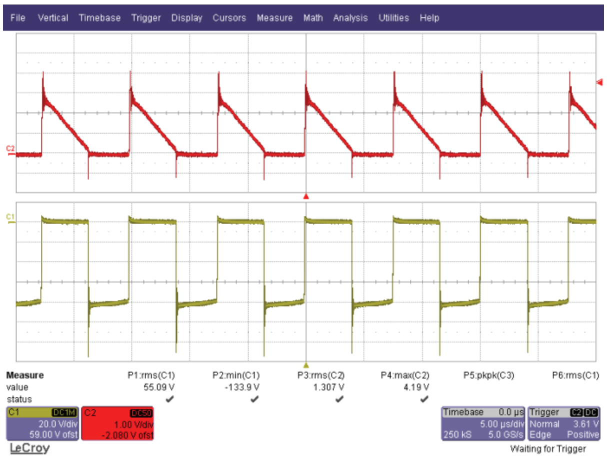

Figure 60 – 90 VAC, 60 Hz.
Upper: I_{D7}, 1 A / div.
Lower: V_{D7}, 20 V / div., 5 μs / div.

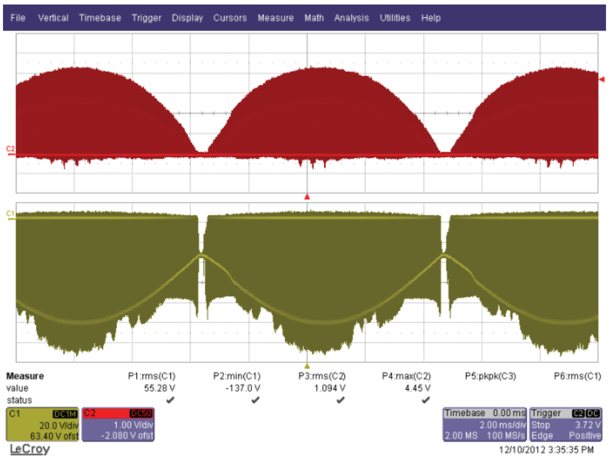

Figure 61 – 132 VAC, 60 Hz.
Upper: I_{D7}, 1 A / div.
Lower: V_{D7}, 20 V, 2 ms / div.

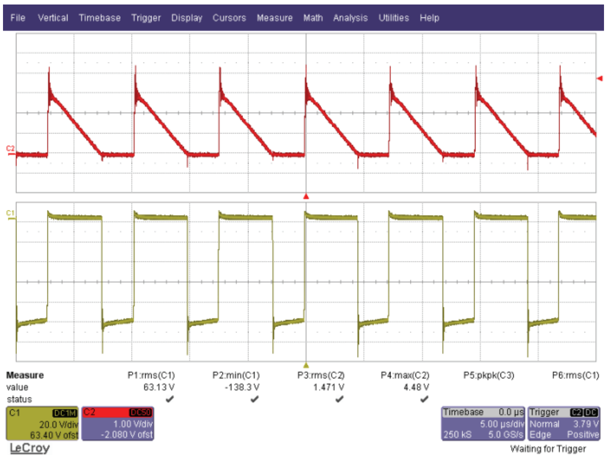

Figure 62 – 132 VAC, 60 Hz.
Upper: I_{D7}, 1 A / div.
Lower: V_{D7}, 20 V / div., 5 μs / div.

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15 传导EMI

The design met the limits for conducted electromagnetic emission (EMI) with frequency range of 9 kHz to 30 MHz as per described in the CISPR 15 / IEC: 2005 Standard.

15.1 测试设置

The UUT was placed inside a PAR38 with MT-G2 lamp provided by CREE at input voltage of 120 VAC, 60 Hz at room temperature. The unit was placed inside a conical metal housing as shown in Figure 63.

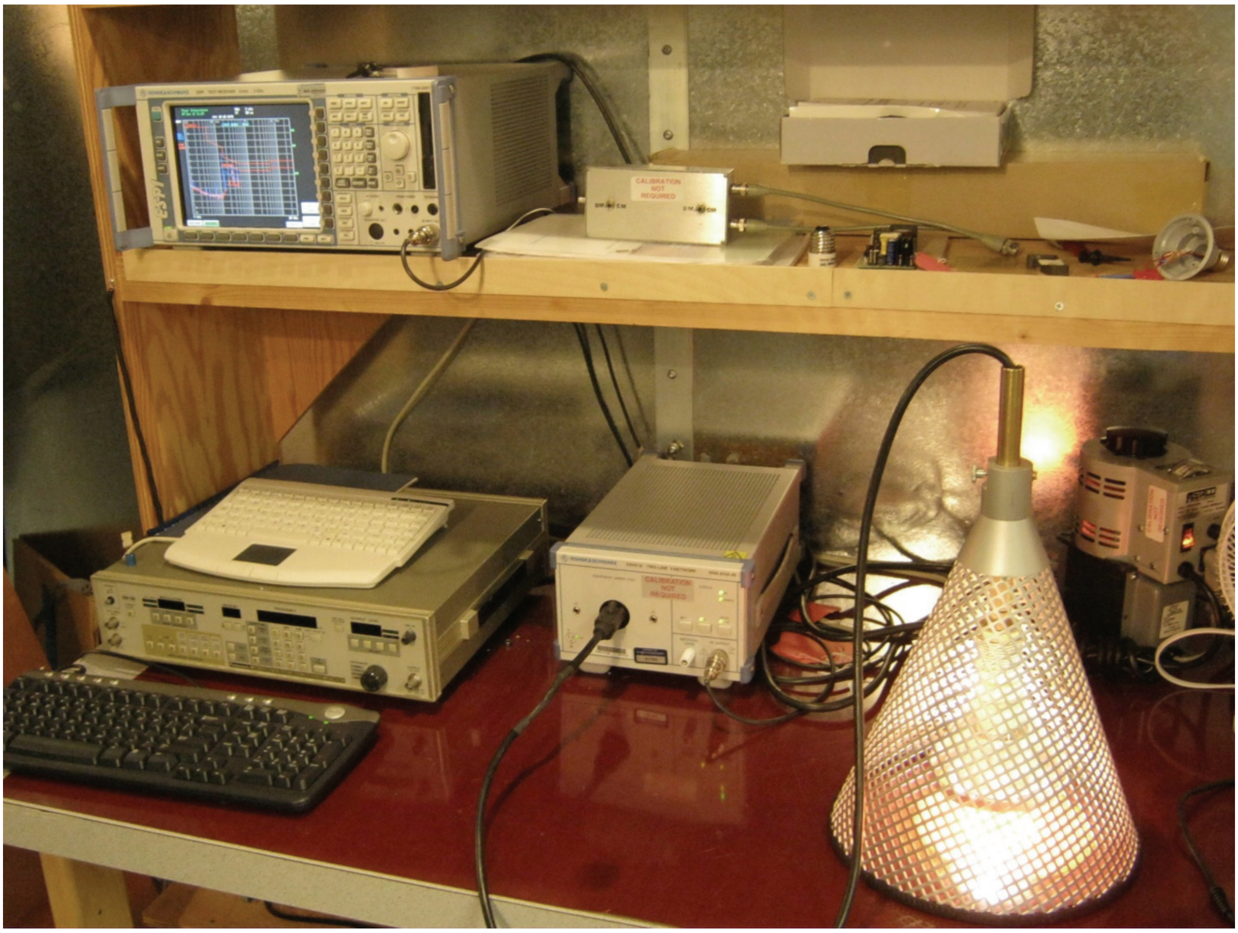
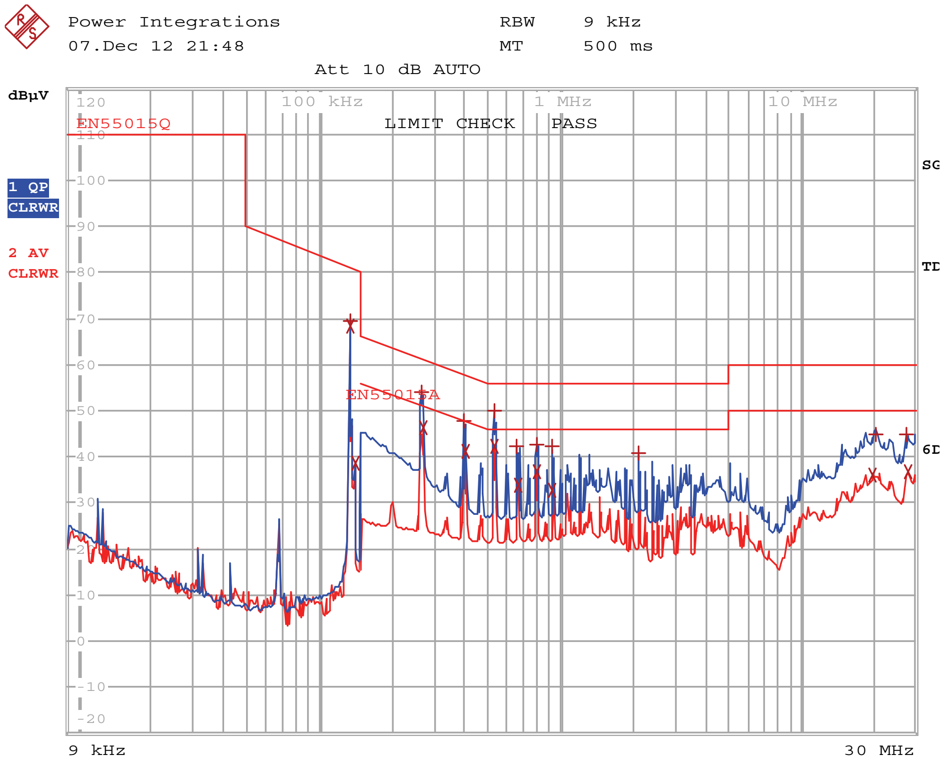


Figure 63 – EMI Test Set-up with the Unit and LED Load Placed Inside a Conical Metal Housing as Described in CISPR 15 / IEC: 2005 Standard.

15.2 测试结果



EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55015Q
Trace2: EN55015A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV		DELTA LIMIT dB
1	Quasi Peak	133.454986145 kHz	69.43	L1 gnd	-11.62
2	Average	133.454986145 kHz	68.36	N gnd	
2	Average	140.262531674 kHz	38.70	L1 gnd	
1	Quasi Peak	264.49018761 kHz	54.05	L1 gnd	-7.23
2	Average	267.135089486 kHz	46.46	L1 gnd	-4.73
1	Quasi Peak	397.727746704 kHz	47.97	L1 gnd	-9.92
2	Average	401.705024172 kHz	41.31	L1 gnd	-6.50
1	Quasi Peak	530.769219795 kHz	49.87	L1 gnd	-6.12
2	Average	530.769219795 kHz	42.20	L1 gnd	-3.79
1	Quasi Peak	660.656865747 kHz	42.26	L1 gnd	-13.73
2	Average	667.263434405 kHz	33.72	L1 gnd	-12.27
1	Quasi Peak	798.145472681 kHz	42.47	L1 gnd	-13.52
2	Average	798.145472681 kHz	36.78	L1 gnd	-9.21
1	Quasi Peak	926.622115652 kHz	42.24	L1 gnd	-13.75
2	Average	926.622115652 kHz	32.58	L1 gnd	-13.41
1	Quasi Peak	2.11629733595 MHz	40.80	L1 gnd	-15.19
2	Average	19.8557266951 MHz	36.09	L1 gnd	-13.90
1	Quasi Peak	20.4573750697 MHz	44.92	L1 gnd	-15.07
1	Quasi Peak	27.5734507982 MHz	44.75	L1 gnd	-15.24
2	Average	27.8491853062 MHz	36.93	L1 gnd	-13.06

Figure 64 – Conducted EMI, 36 V LED Load, 120 VAC, 60 Hz, and EN55015 B Limits.

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16 输入浪涌

The unit was subjected to ±2500 V 100 kHz ring wave and ±500 V differential surge at 120 VAC using 10 strikes at each condition. A test failure was defined as a non-recoverable interruption of output requiring supply repair or recycling of input voltage.

The unit tested passed both ±2500 V 100 kHz ring wave and ±500 V differential surge with and without MOV.

Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Type	Test Result (Pass/Fail)
+2500	120	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
-2500	120	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
+2500	120	L1, L2	90	100 kHz Ring Wave (500 A)	Pass
-2500	120	L1, L2	90	100 kHz Ring Wave (500 A)	Pass

Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Type	Test Result (Pass/Fail)
+500	120	L1, L2	0	Surge (2 Ω)	Pass
-500	120	L1, L2	0	Surge (2 Ω)	Pass
+500	120	L1, L2	90	Surge (2 Ω)	Pass
-500	120	L1, L2	90	Surge (2 Ω)	Pass

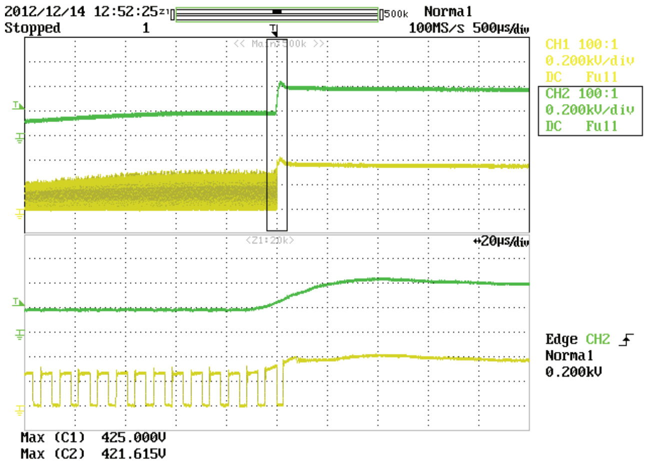

Figure 65 – CH1: 90º 500 V Differential Surge (No MOV).
CH1: U1 VDS.
CH2: C2 Voltage.

17 版本历史

Date	Author	Revision	Description and Changes	Reviewed
13-Nov-12	ME	1.0	Initial release	Apps & Mktg
15-Jan-13	CA	2.0	Design Updated with Inductor	Apps & Mktg
20-May-13	KM	2.1	Changed name to LYTSwitch-4	Apps & Mktg

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