

# Design Example Report

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标题	基于 PN8371 的 4.5W 灯丝灯 LED 应用方案 150V30mA
规格	输入电压：85~265V 全电压 输出功率：4.5W 输出电压：150V 输出电流：30mA±5%
应用范围	LED 灯丝灯内置电源
文件编号	DER-8371-14-P039
编写时间	2014-08-08
编写部门	应用二部
版本号	V1.0

## 特性概述：

- 双面板工艺，单面贴片元器件，面积：Φ20mm；
- 输入电压：85~265Vac 电压范围；
- 输出功率：4.5W；
- 拥有 LED 灯开路、短路、过温调节等功能；
- 拥有电流采样电阻短路保护；
- LED 开路或短路时输入功率小于 0.3W；
- 启动时间小于 100mS；

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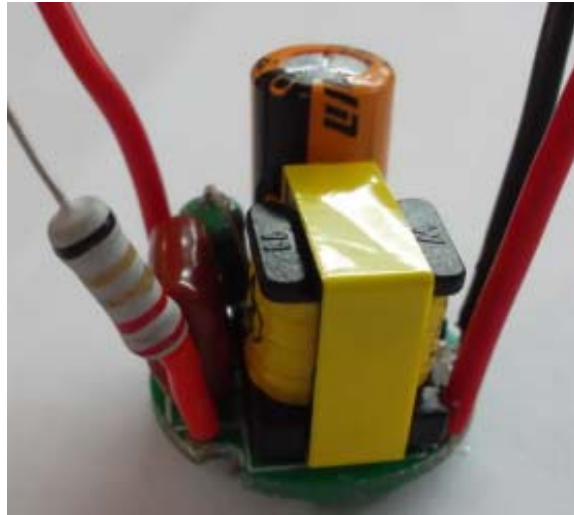
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## 1. 电源介绍

该报告提供了一种基于 PN8371 的 150V/30mA 输出的 LED 驱动电源。芯片集成度高，BOM 器件个数少，具有 LED 灯开路、短路、过温调节以及电流采用电阻短路保护等功能

该报告包含原理图，电源输入输出规格，BOM 表，变压器参数，EMI 测试，PCB LAYOUT 等数据。

以下为该电源的实物图片：



## 2. 电源规格明细

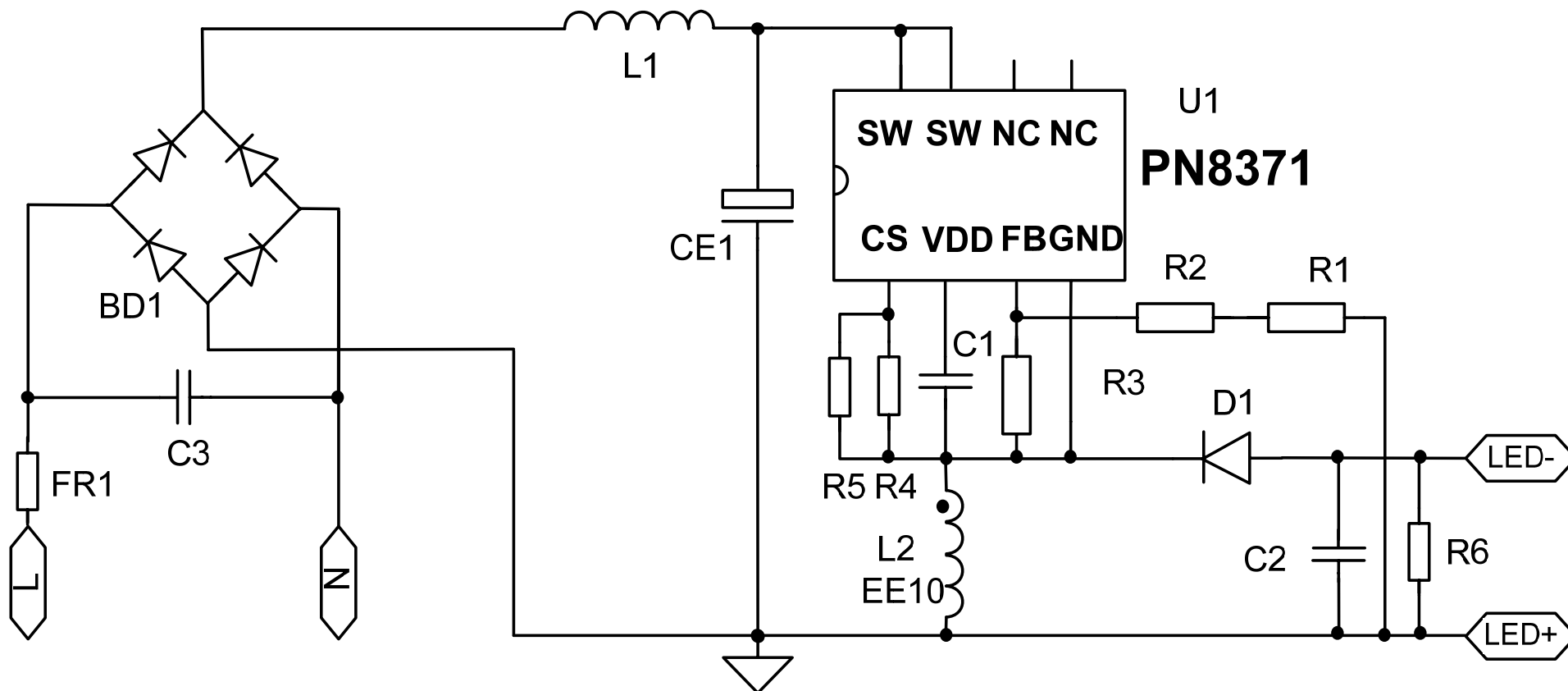
最大输入输出电气特性：

项目描述	标号	Min	Typ	Max	Unit	备注
输入电压	Vin	85	115/230	265	V	50/60Hz
输出电压	Vout		150		V	
输出电流	Iout		30		mA	
输出功率	Pout		4.5		W	
效率	$\eta$	85			%	
工作环境	Tamb	-30	25	75	°C	外部环境

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## 3. 电源原理图



Note: 具体参数以 BOM 为准

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## 4. 电路描述

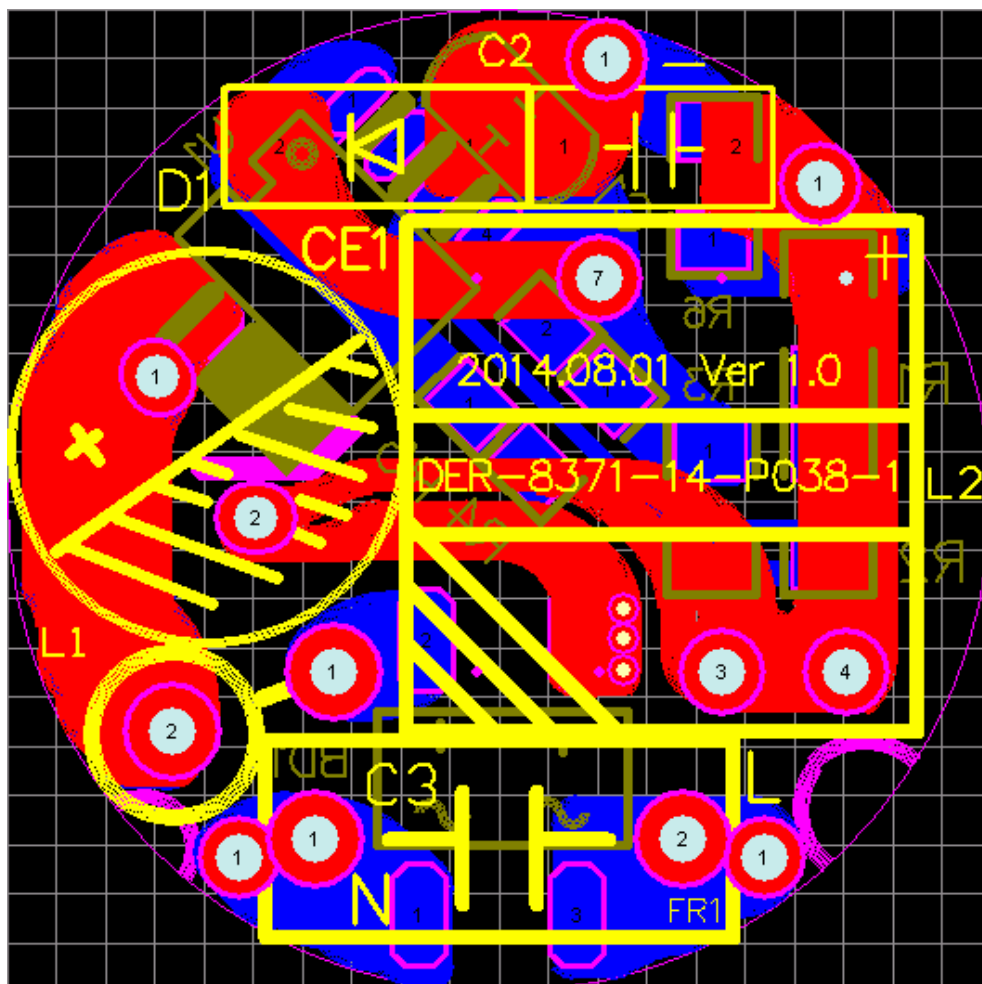
电路图中R1、R2、R3为反馈分压电阻，可间接采样出的电压，LED开路时，输出电压会很高，调整R1、R2和R3的比例，可调节LED开路时的输出电压；并且等比例调节R1、R2和R3可改善Io的输入线电压调整率；

当PN8371 本体温度太高时，其内置的 OTC 保护功能会及时动作，以保护整个系统；

当LED 发生短路或开路时，系统将进入打嗝模式直到异常状态消除。

## 5. PCB LAYOUT

PCB 为普通双面板工艺，双面元器件，铜厚 1OZ，基材为 FR-4。PCB 直径为 20mm，厚 1mm。污染等级符合 CLASS2。



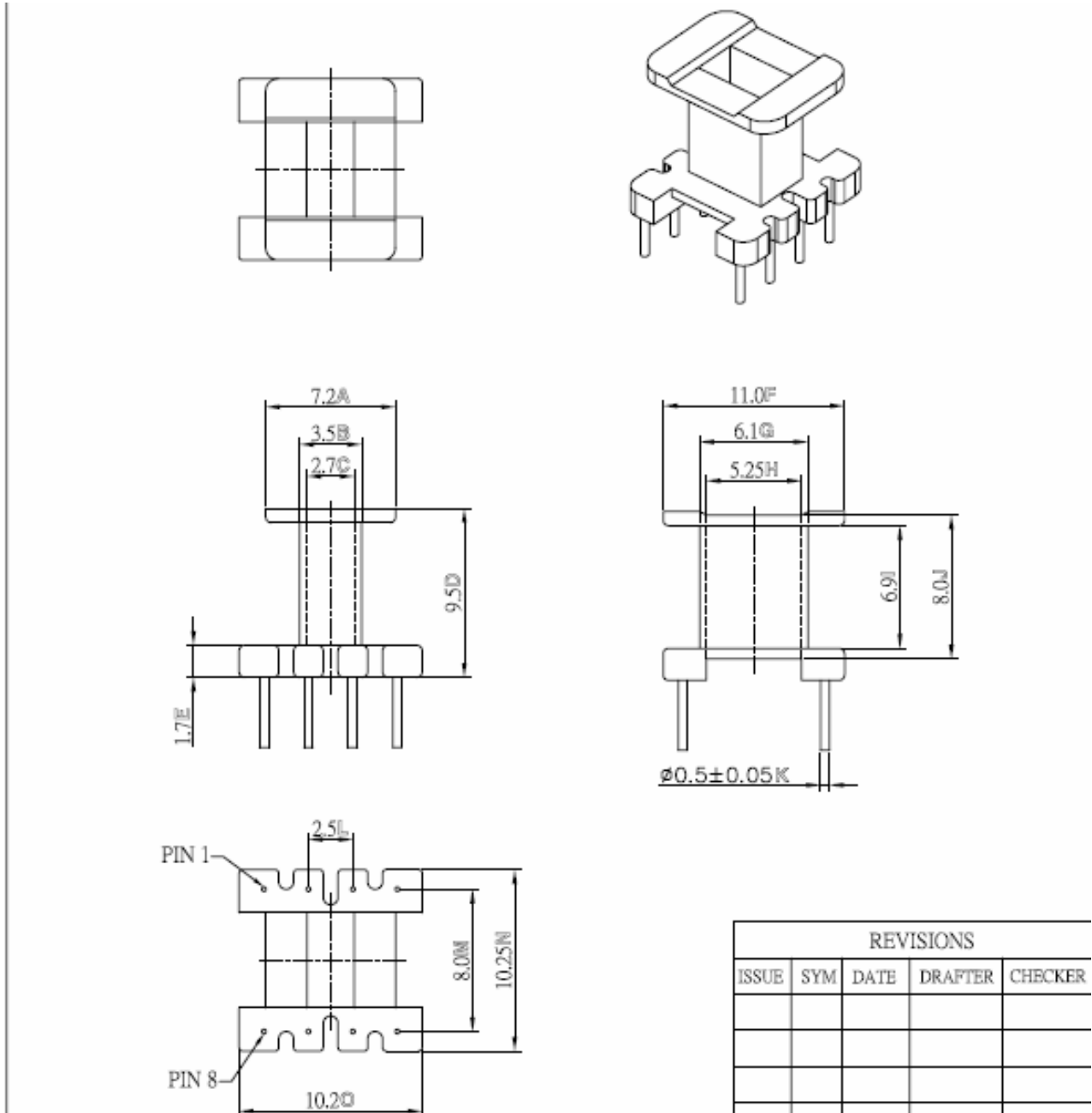


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## 7. 变压器规格 (EE10 立式)

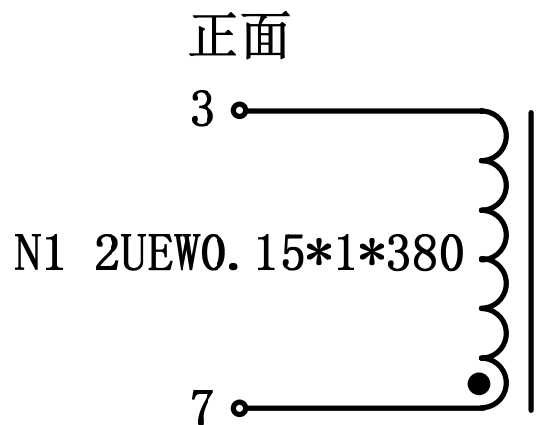
### 7.1 骨架尺寸:



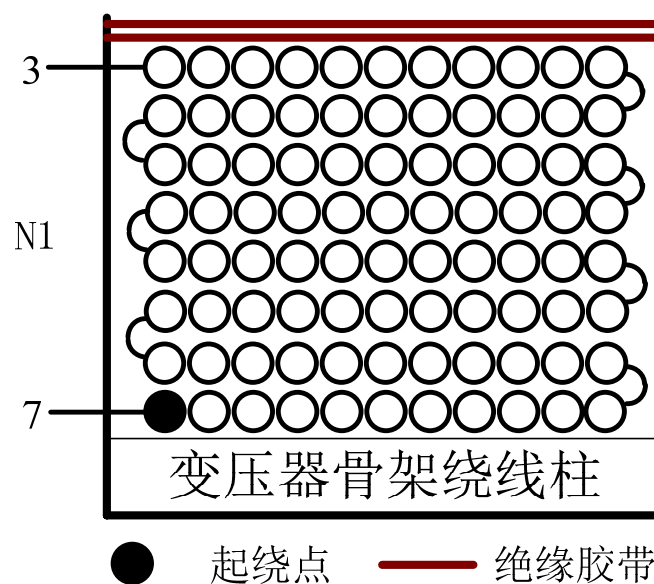
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## 7.2 线路图:



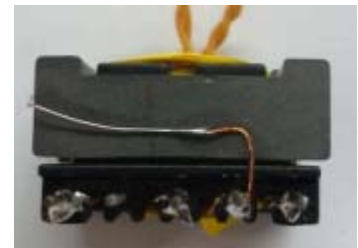
## 7.3 绕法示意图:



## 7.4 绕组结构:

Winding No. 组别	Margin Tape 挡墙	Pin 脚位	Wire&Wire Copper 线径&股数	Turns 圈数	Tape Layer 胶带层数	Tube 套管	Winding Tape 绕线方式
N1	N.A.	7~3	2UEW0.15*1	380	2	Add	密绕

- 备注:
1. 剪掉 Pin1, 2, 5, 6, 8;
  2. 电感的调整需磨磁芯中柱, 不能垫磁芯两边;
  3. 磁性采用  $\Phi 0.15$  的漆包线连接到 Pin3, 在外包胶带固定如右图所示;
  4. 含浸;



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## 7.5 电气特性:

Test Item 测试项目	Test Location 测试位置	Test Condition 测试条件	Test Spec. 测试规格
Primart Inductance 电感	7~3	10KHz, 1V	7.00mH

## 8. 电源输入输出特性和工作波形

备注：效率测试：需室温满载持续工作20Min以上，稳定后再测试；

负载分别采用电子负载和LED测试；同时满载热机

波形测试：输出负载采用LED 灯丝灯，灯串电压约152V；

负载为电子负载测试结果如下

Vin	Vo (V)	Io (mA)	Pin (W)	Po (W)	$\eta$
85V/63Hz	150	29.70	5.179	4.455	86.02%
	140	30.10	4.870	4.214	86.53%
	130	30.00	4.513	3.900	86.42%
	120	30.00	4.144	3.600	86.88%
150V/60Hz	150	29.90	5.092	4.485	88.08%
	140	29.90	4.732	4.186	88.47%
	130	30.10	4.425	3.913	88.43%
	120	30.00	4.086	3.600	88.10%
230V/50Hz	150	29.40	5.042	4.410	87.46%
	140	29.70	4.770	4.158	87.18%
	130	29.50	4.357	3.835	88.02%
	120	29.70	4.103	3.564	86.86%
265V/47Hz	150	29.20	5.049	4.380	86.76%
	140	29.30	4.776	4.102	85.88%
	130	29.10	4.376	3.783	86.44%
	120	29.20	4.078	3.504	85.92%

负载为LED测试结果如下

Vin (Vac)	85V/63Hz	115V/60Hz	230V/50Hz	265V/47Hz
Vo (V)	151.7	152.0	152.0	151.8
Io (mA)	29.90	30.40	30.30	30.00
Pin (W)	5.371	5.363	5.303	5.279
Po (W)	4.536	4.621	4.606	4.554
$\eta$	84.45%	86.16%	86.85%	86.27%



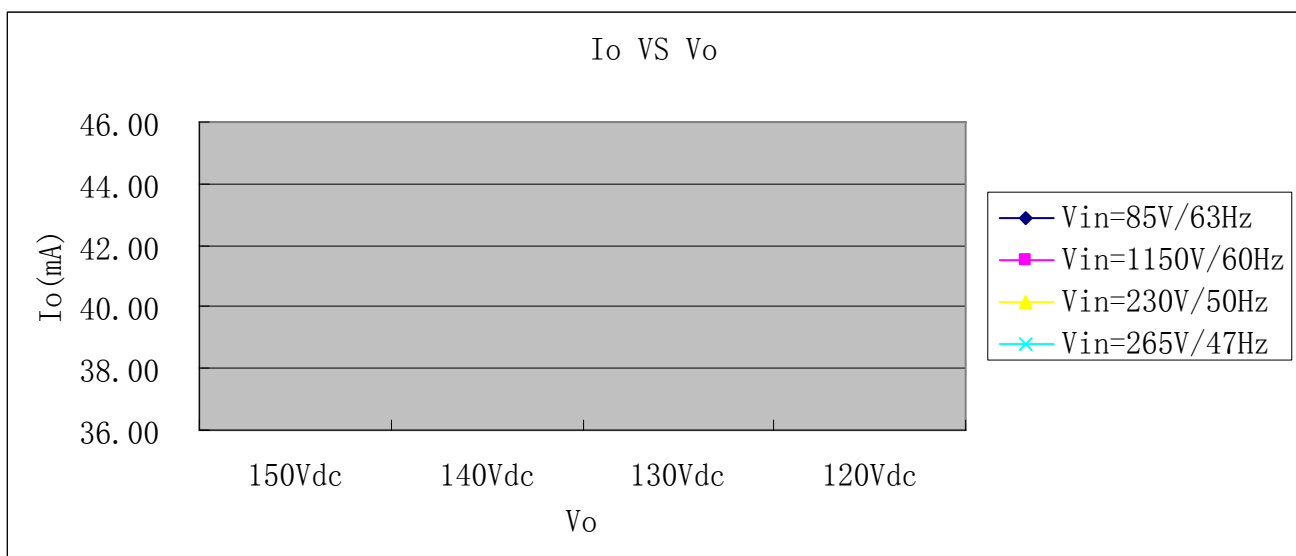
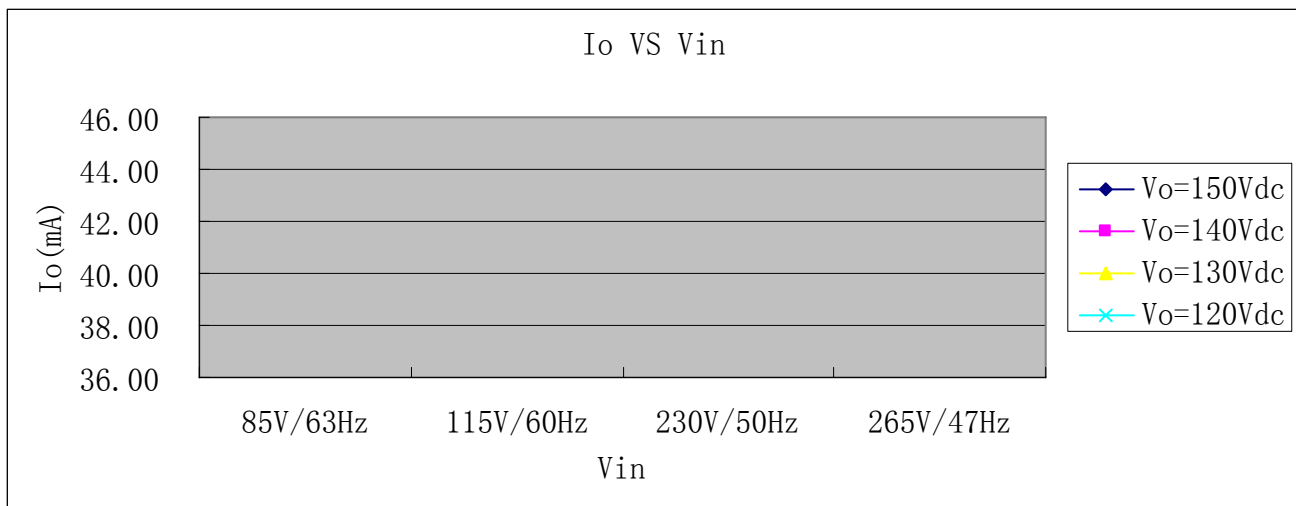
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## 1) 调整率

负载 (Vo)	输出电流(mA)				Max.-Min.	线性调整率
	85V/63Hz	115V/60Hz	230V/50Hz	265V/47Hz		
150Vdc	29.70	29.90	29.40	29.20	0.70	±1.18%
140Vdc	30.10	29.90	29.70	29.30	0.80	±1.34%
130Vdc	30.00	30.10	29.50	29.10	1.00	±1.68%
120Vdc	<b>30.00</b>	30.00	29.70	29.20	0.80	±1.34%
Max.-Min.	0.40	0.20	0.30	0.20		
负载调整率	±0.66%	±0.33%	±0.50%	±0.34%		

系统线性调整率和负载调整率均小于±2%;



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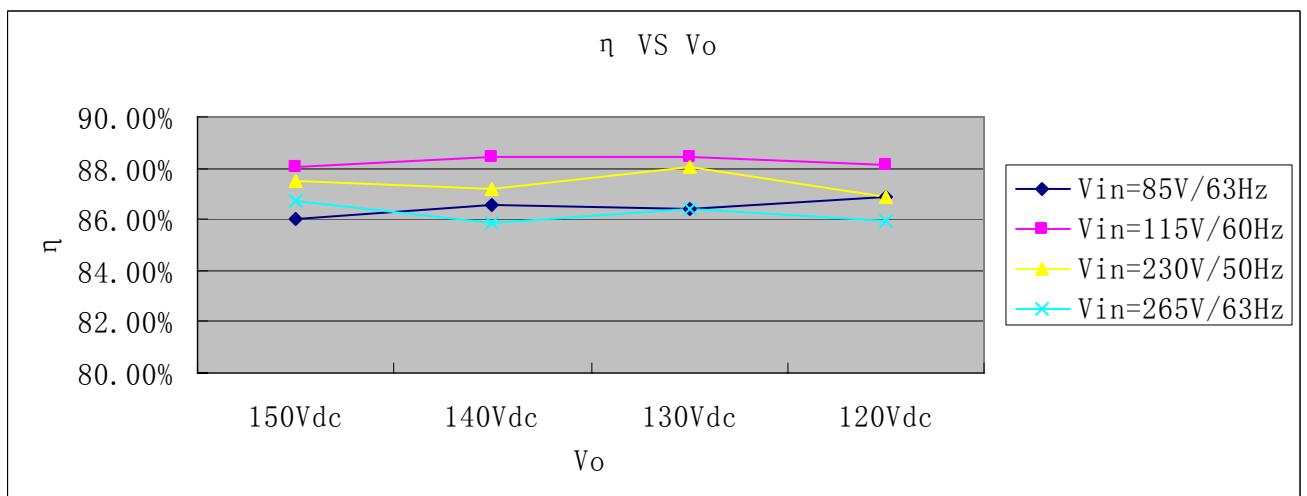
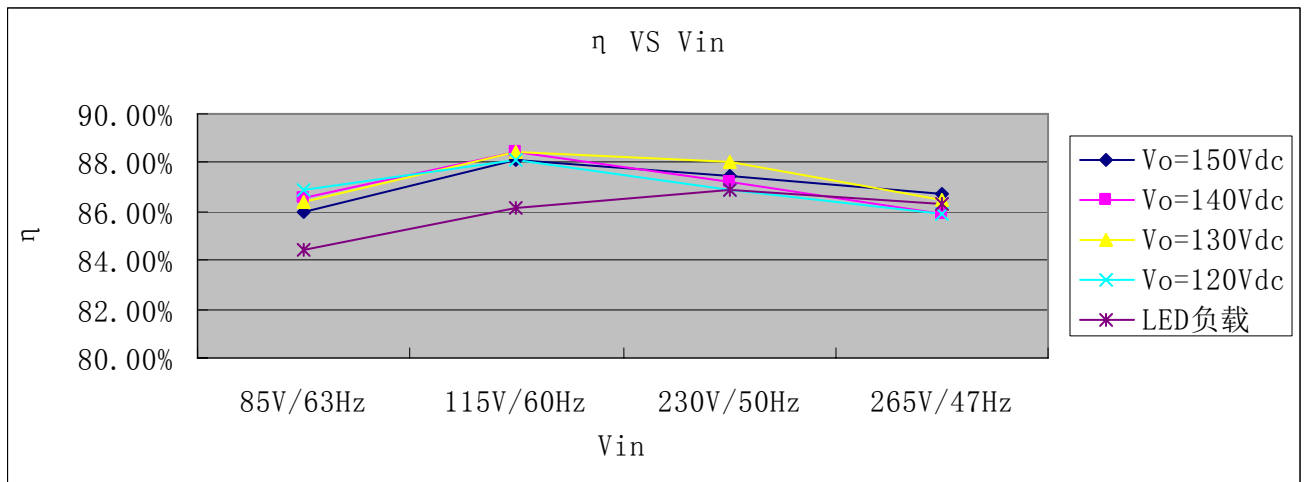
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## 2) Efficiency

Note: 用电子负载CV模式模拟LED负载

负载 (Vo)	$\eta$ 效率			
	85V/63Hz	115V/60Hz	230V/50Hz	265V/47Hz
150Vdc	86.02%	88.08%	87.46%	86.76%
140Vdc	86.53%	88.47%	87.18%	85.88%
130Vdc	86.42%	88.43%	88.02%	86.44%
120Vdc	86.88%	88.10%	86.86%	85.92%
灯丝灯	84.45%	86.16%	86.85%	86.27%

备注: 可以看出采用LED做负载和比采用电子负载效率低约1~2%，特别是低压输入时差异较大；同时效率会随输入电压升高而升高；



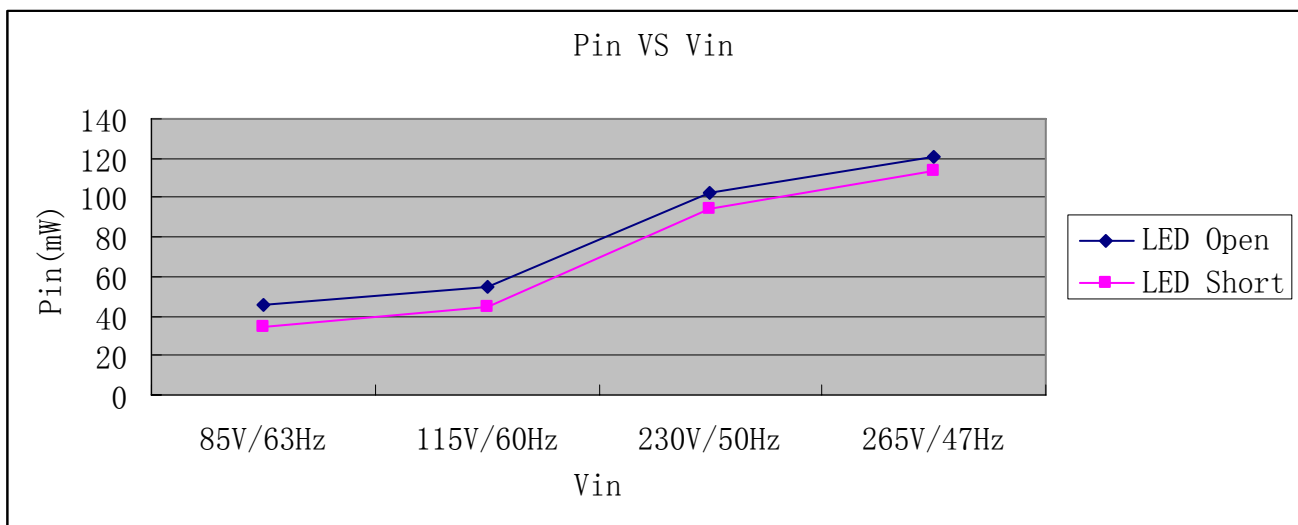
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## 3) Input power when LED open Or Short

Vin	LED Open		LED Short
	Pin(mW)	Vo_max(V)	Pin(mW)
85V/60Hz	55	209	31
100V/60Hz	65	203	41
110V/60Hz	66	221	38
135V/60Hz	70	205	60

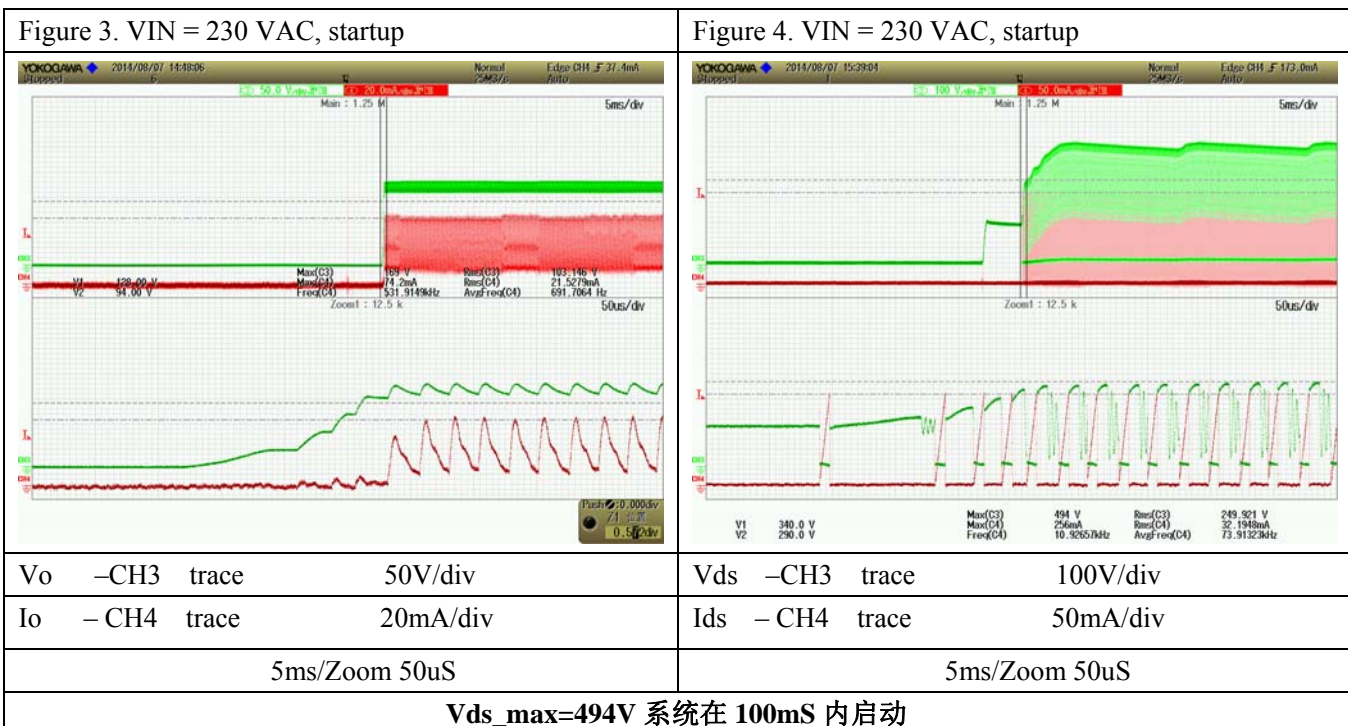
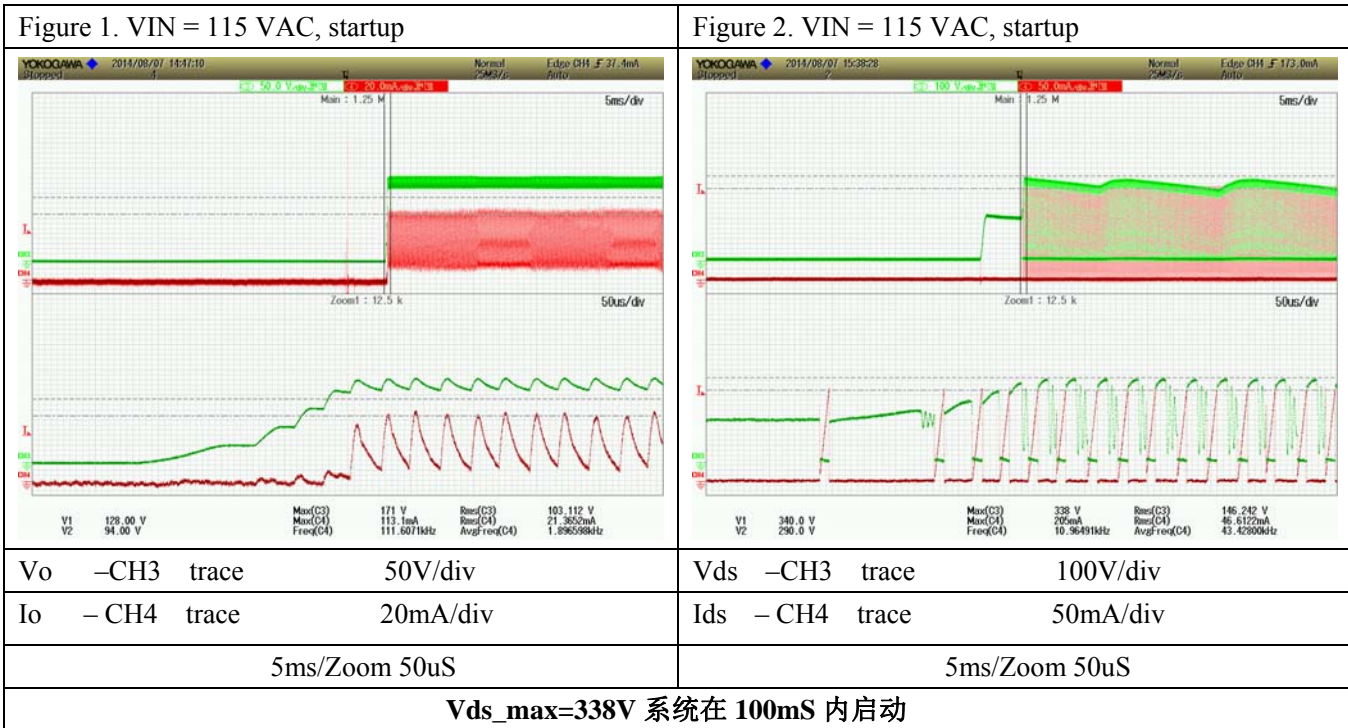
LED 开路电压为尖峰电压(见后续工作波形图 7)，实际采用万用表测试时电压有效值不到 100V；



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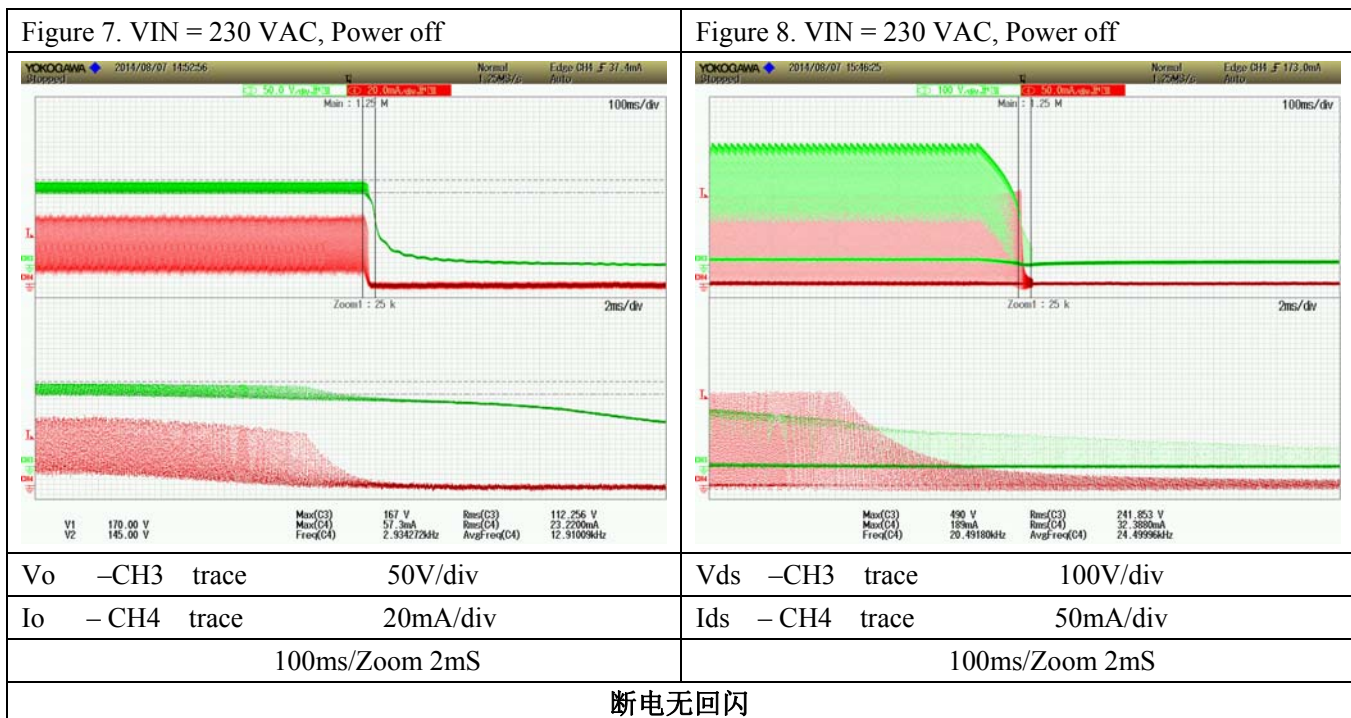
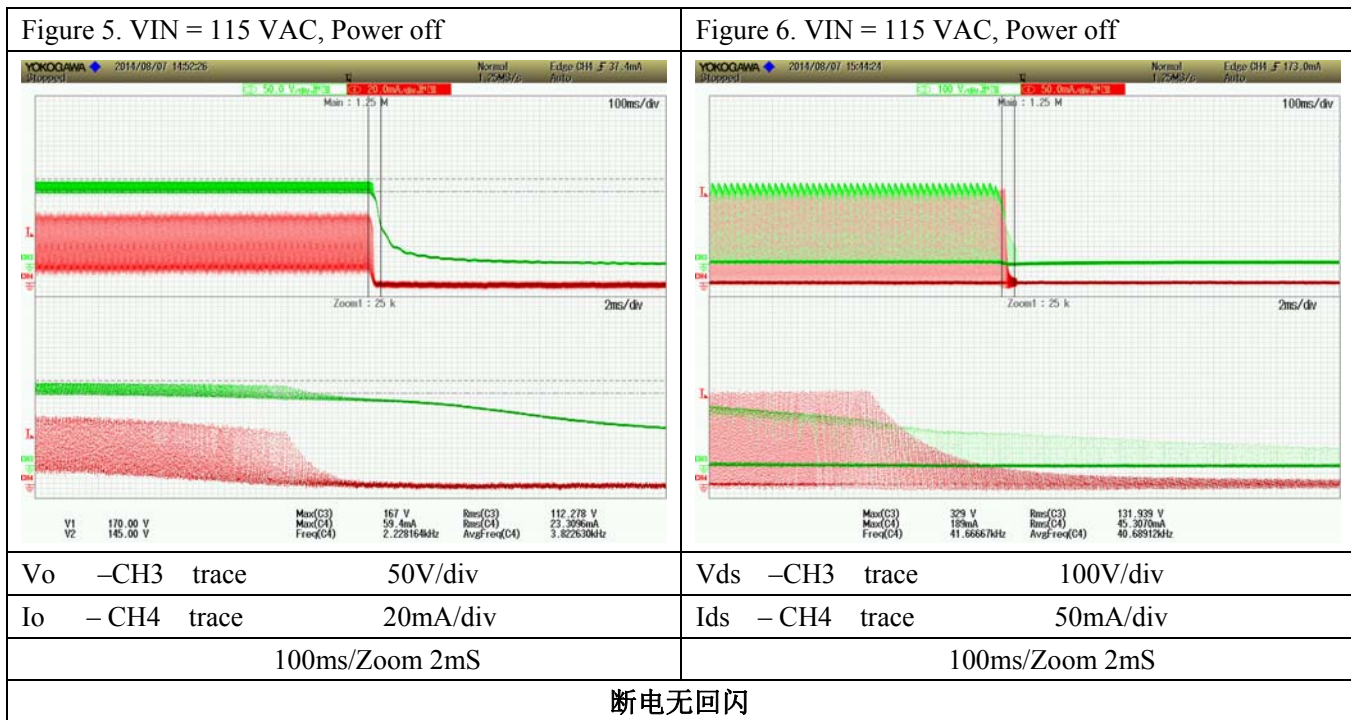
## 5) Startup (负载灯丝灯)



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## 6) Power off (负载灯丝灯)

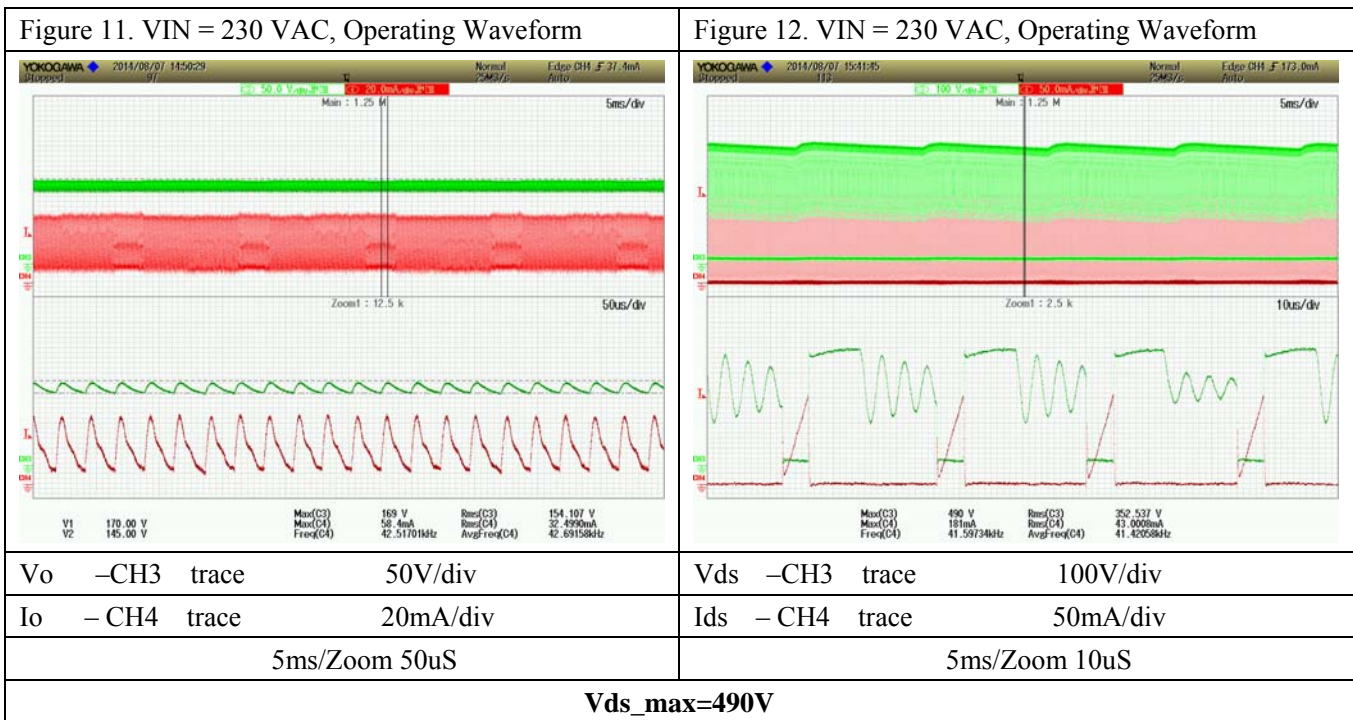
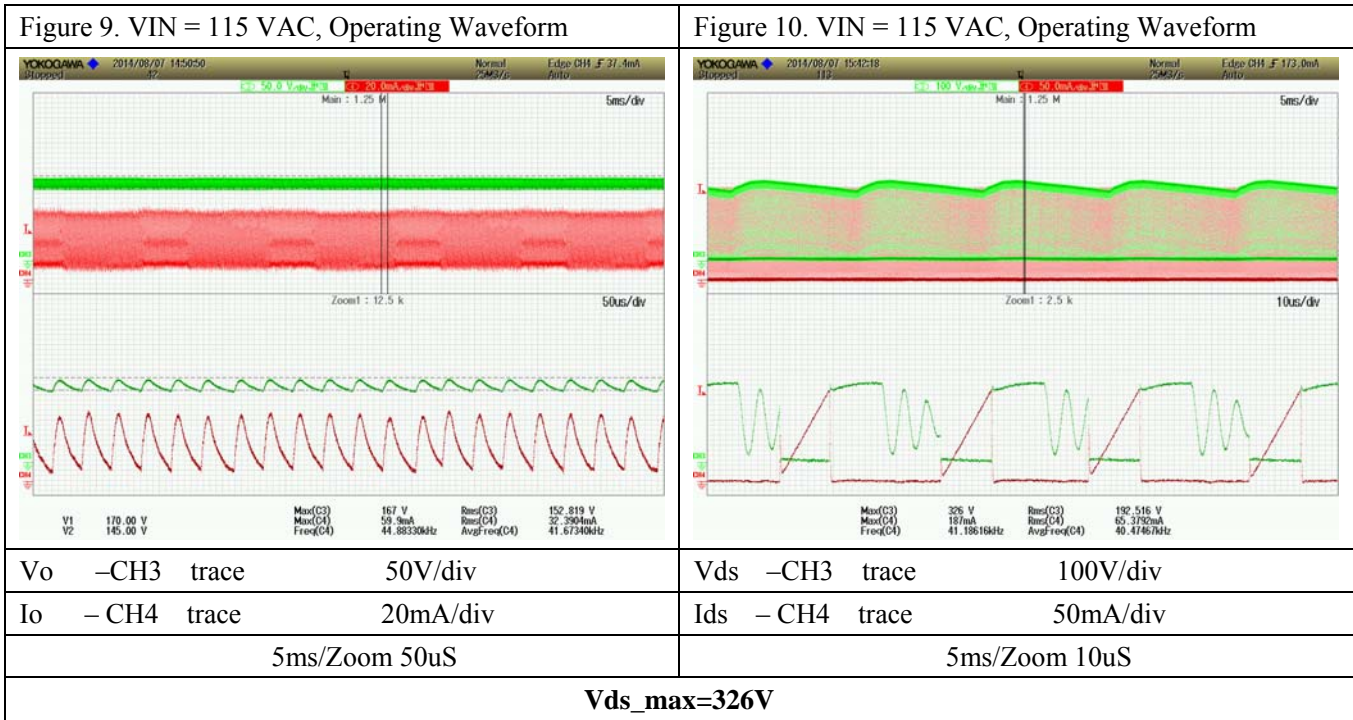




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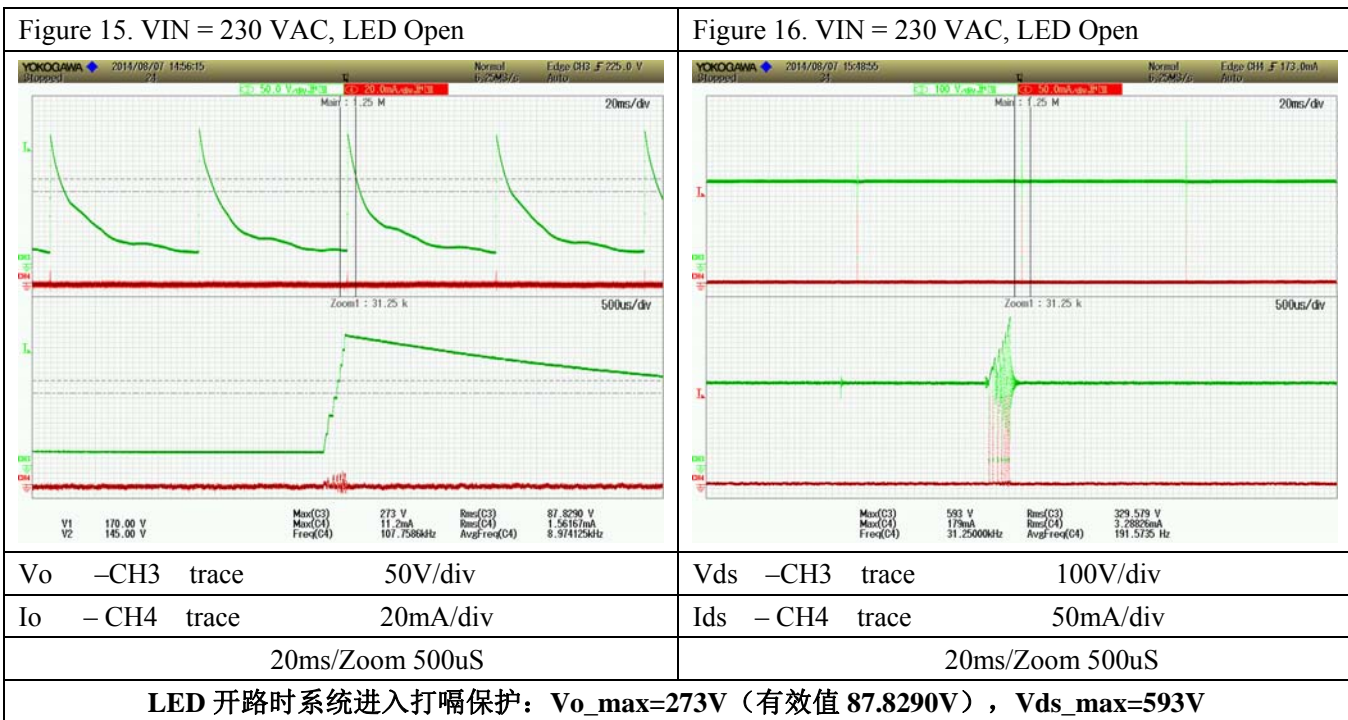
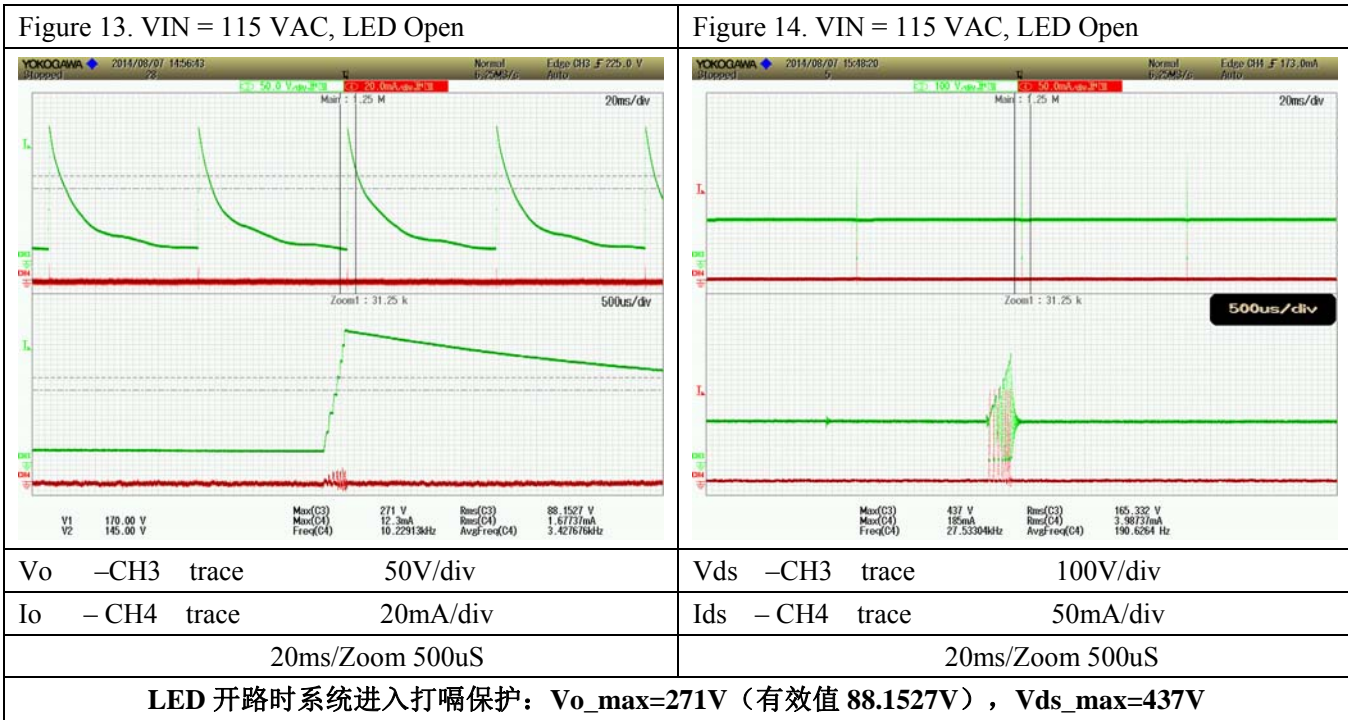
## 7) Operating waveforms (负载灯丝灯)



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## 8) LED Open Protection (负载灯丝灯)

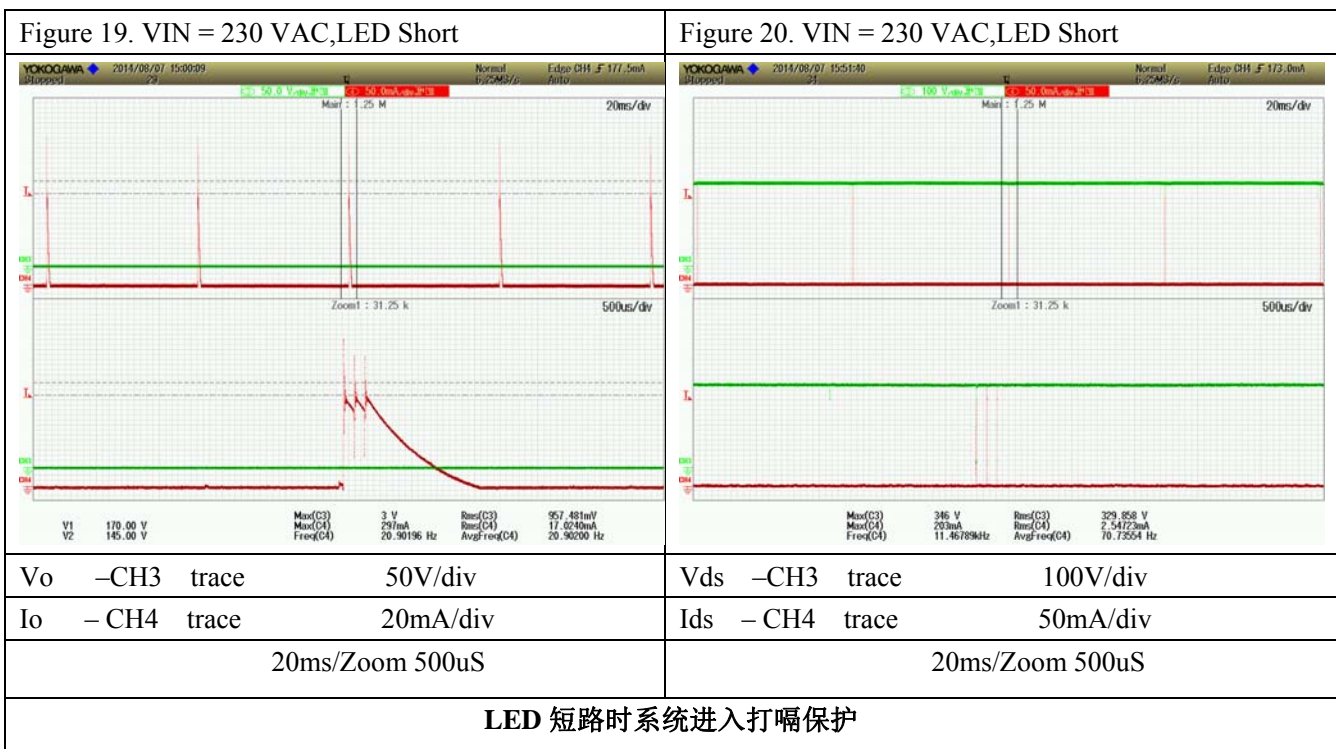
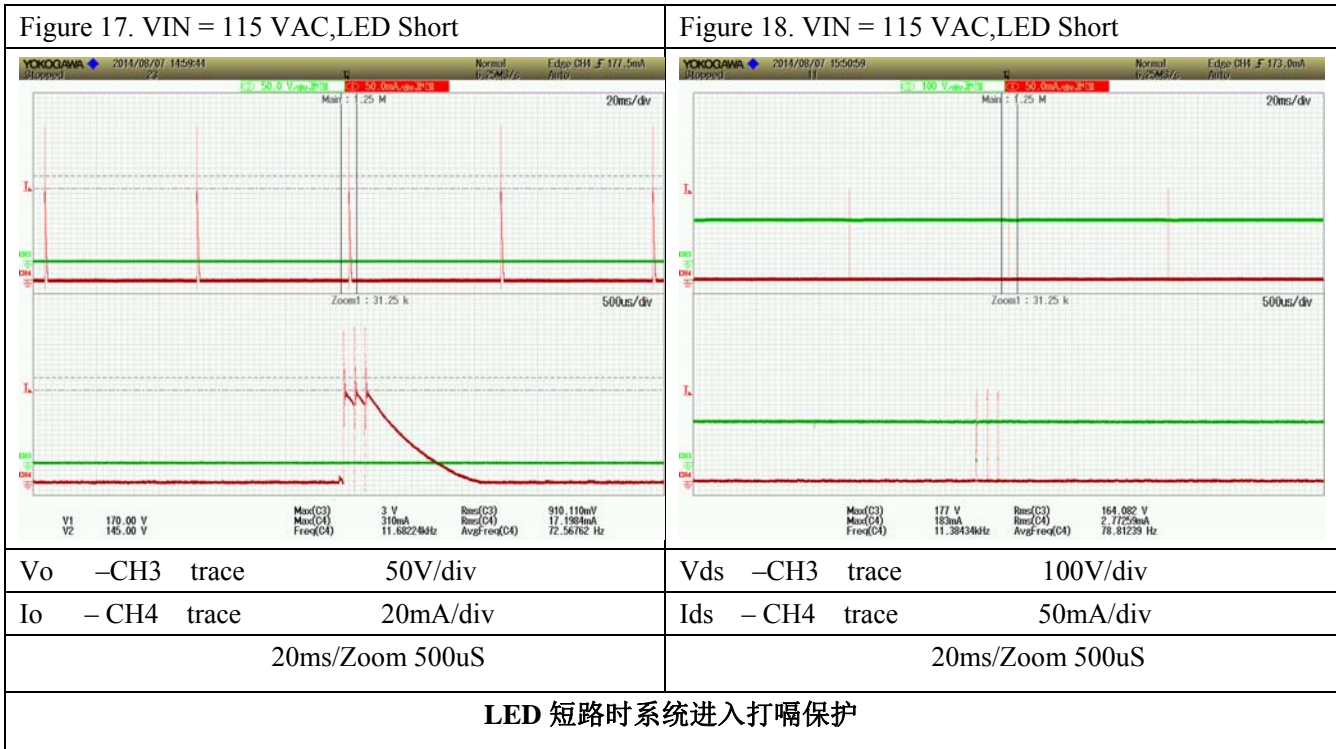




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## 9) LED Short Protection (负载灯丝灯)





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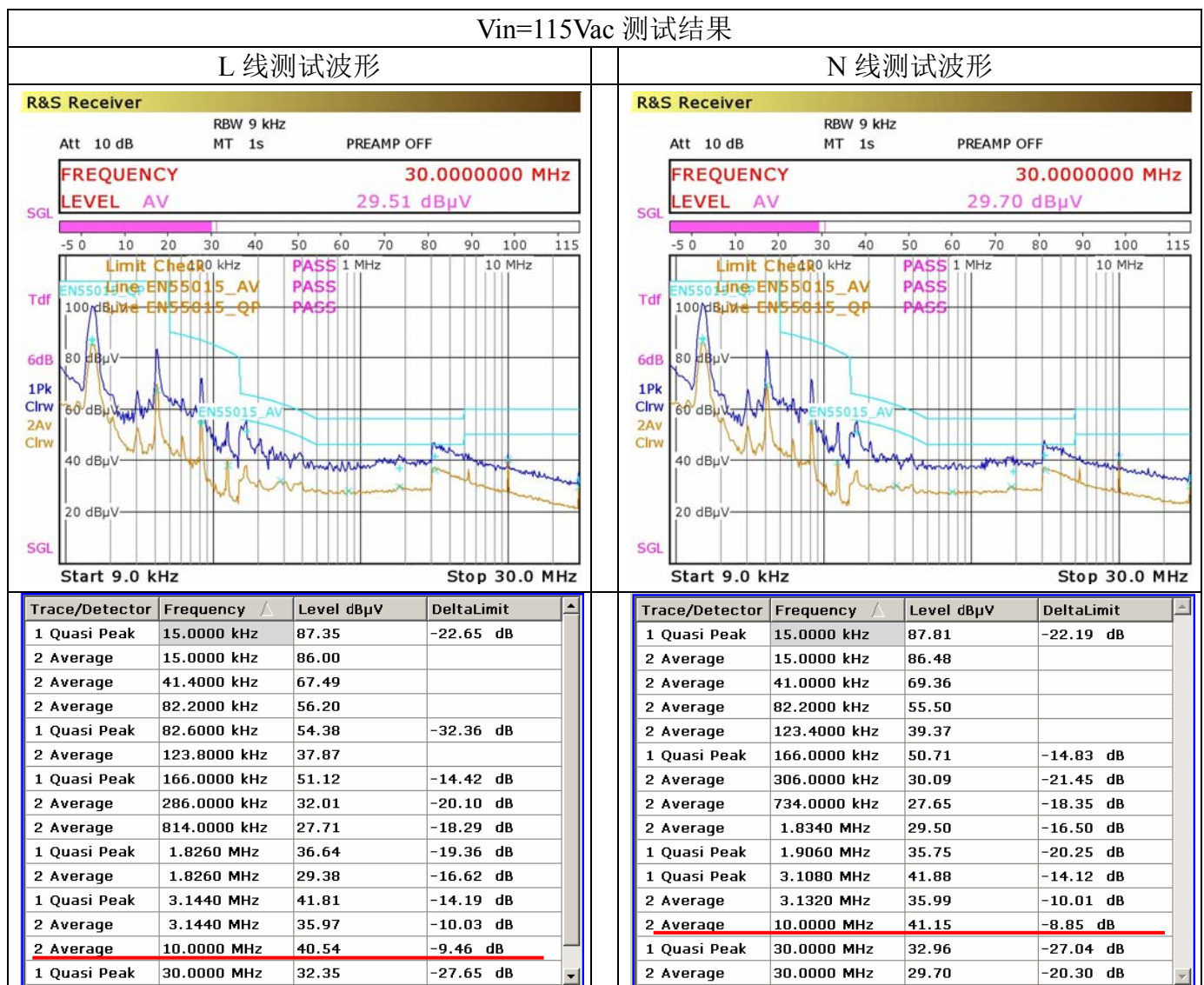
## 9. EMI 特性测试

### 9.1 传导测试

测试条件:  $V_{in}=115/230V_{ac}$ , 输出接 LED 灯丝灯, LED 压降约 150V

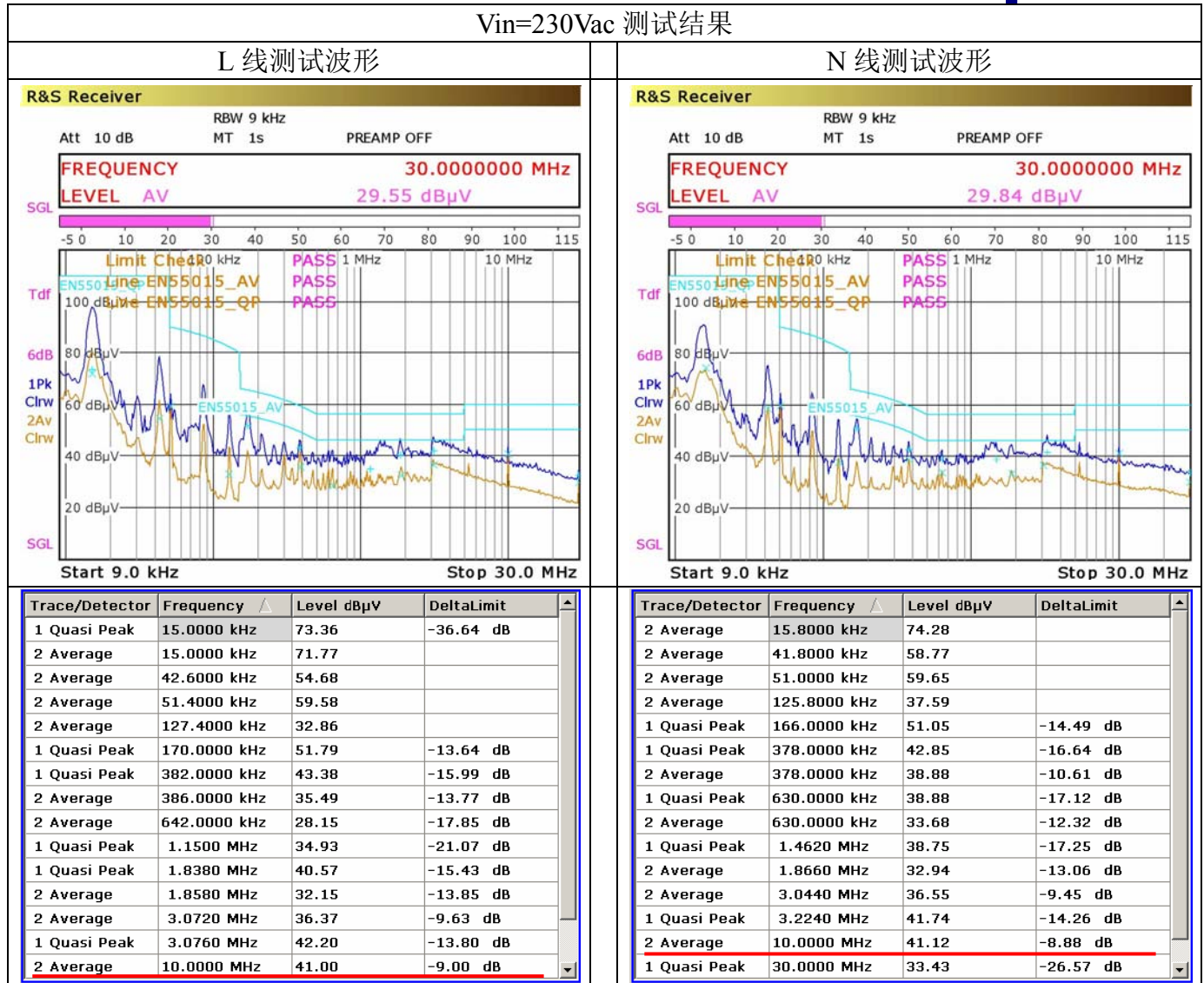
测试结果: 裕量大于-4dB;

输入电压	传导测试结果	
	L	N
115V/60Hz	-9.46dB	-8.85dB
230V/50Hz	-9.00dB	-8.88dB



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## 9.2 辐射测试

测试条件: Vin=115/230Vac, 输出接 LED 灯丝灯, LED 压降约 150V

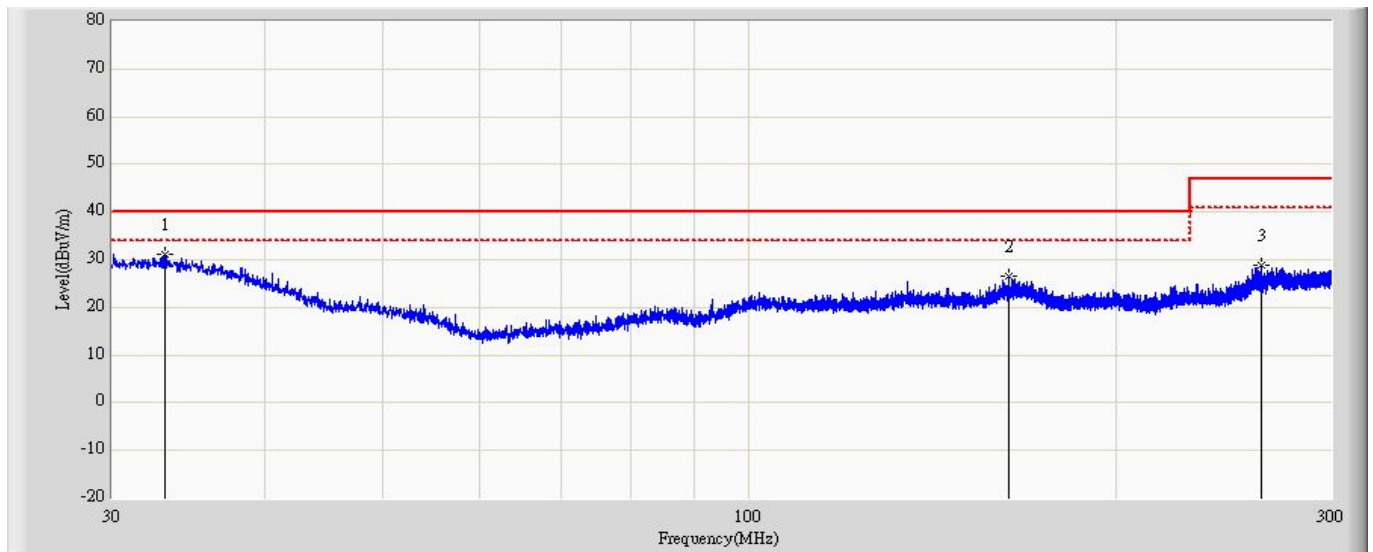
测试结果: 裕量大于-4dB;

输入电压	传导测试结果	
	H	V
115V/60Hz	-8.9dB(PK)	-9.9dB(QP)
230V/50Hz	-9.3dB(PK)	-7.0dB(QP)

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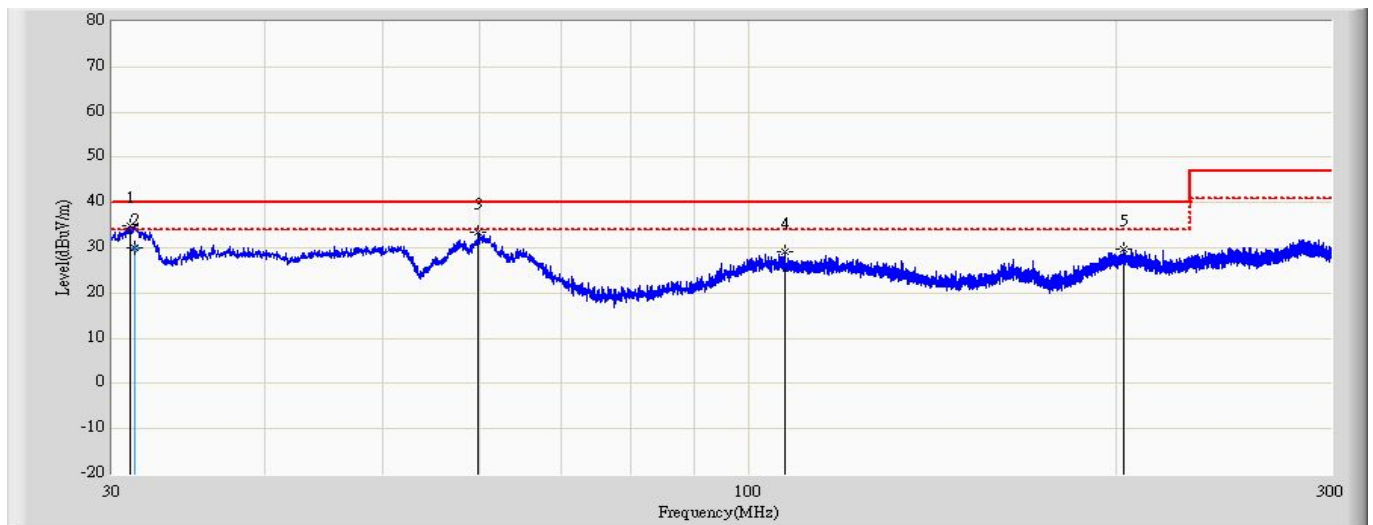
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110V 输入水平方向



No	Mark	Frequency (MHz)	Measure Level (dBuV/m)	Reading Level (dBuV)	Over Limit (dB)	Limit (dBuV/m)	Probe (dB/m)	Cable (dB)	Amp (dB)	Ant Pos (cm)	Table Pos (deg)	Type
1	*	33.139	31.022	5.456	-8.978	40.000	19.103	6.462	0.000	0	0	PK
2		163.076	26.642	7.821	-13.358	40.000	11.691	7.130	0.000	0	0	PK
3		262.909	28.879	8.213	-18.121	47.000	13.194	7.471	0.000	0	0	PK

110V 输入垂直水平方向

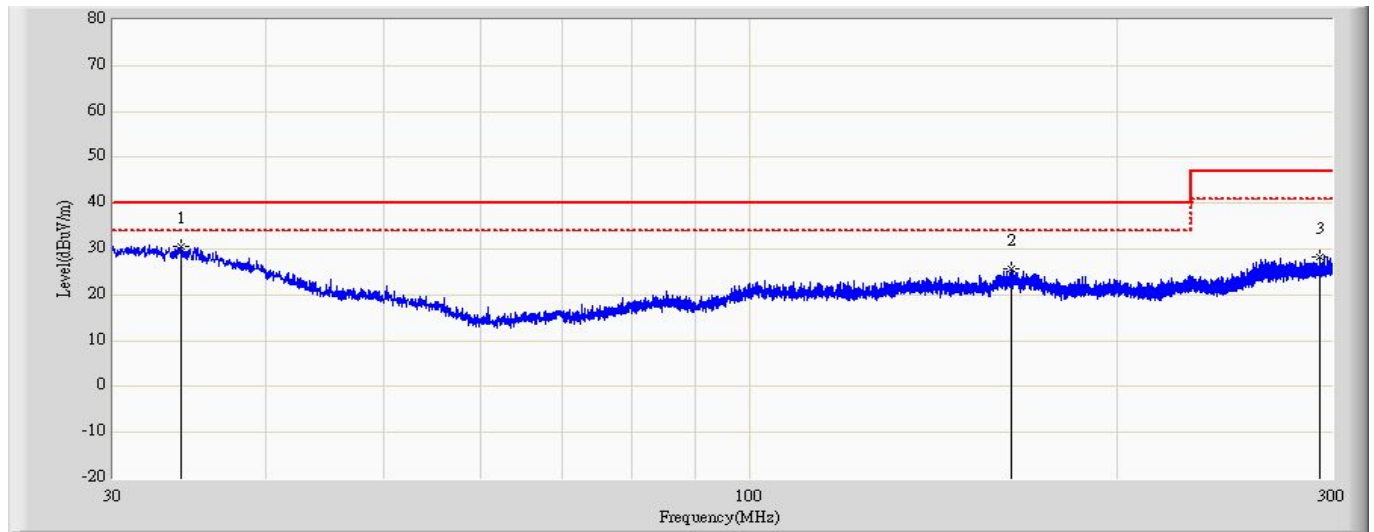


No	Mark	Frequency (MHz)	Measure Level (dBuV/m)	Reading Level (dBuV)	Over Limit (dB)	Limit (dBuV/m)	Probe (dB/m)	Cable (dB)	Amp (dB)	Ant Pos (cm)	Table Pos (deg)	Type
1	*	31.080	34.868	10.865	-5.132	40.000	17.552	6.451	0.000	0	0	PK
2		31.335	30.002	6.100	-9.998	40.000	17.448	6.454	0.000	100	359	QP
3		59.936	33.305	16.046	-6.695	40.000	10.619	6.640	0.000	0	0	PK
4		106.950	29.266	5.810	-10.734	40.000	16.560	6.897	0.000	0	0	PK
5		202.631	29.784	5.087	-10.216	40.000	17.427	7.270	0.000	0	0	PK

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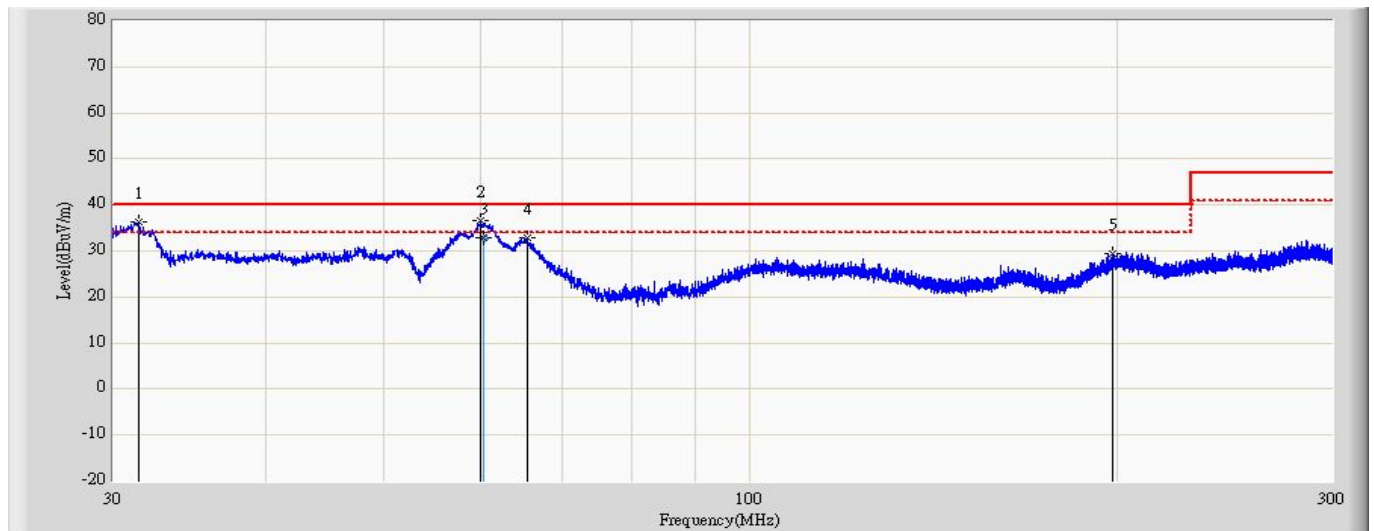
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230V 输入水平方向



No	Mark	Frequency (MHz)	Measure Level (dBuV/m)	Reading Level (dBuV)	Over Limit (dB)	Limit (dBuV/m)	Probe (dB/m)	Cable (dB)	Amp (dB)	Ant Pos (cm)	Table Pos (deg)	Type
1	*	34.084	30.658	5.100	-9.342	40.000	19.086	6.472	0.000	0	0	PK
2		163.583	25.772	6.912	-14.228	40.000	11.730	7.130	0.000	0	0	PK
3		293.554	28.375	5.885	-18.625	47.000	14.913	7.577	0.000	0	0	PK

230V 输入垂直方向



No	Mark	Frequency (MHz)	Measure Level (dBuV/m)	Reading Level (dBuV)	Over Limit (dB)	Limit (dBuV/m)	Probe (dB/m)	Cable (dB)	Amp (dB)	Ant Pos (cm)	Table Pos (deg)	Type
1		31.451	36.443	12.587	-3.557	40.000	17.401	6.455	0.000	0	0	PK
2	*	60.037	36.575	19.322	-3.425	40.000	10.613	6.640	0.000	0	0	PK
3		60.331	32.950	15.700	-7.050	40.000	10.608	6.643	0.000	100	0	QP
4		65.539	32.805	15.686	-7.195	40.000	10.443	6.676	0.000	0	0	PK
5		198.176	29.442	5.018	-10.558	40.000	17.160	7.264	0.000	0	0	PK

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### 10. 附件：IC 封装图

PN8371 封装和脚位配置图：

