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为多个1W LED组成的MR16代替灯减少零件数量、实现紧密的参考设计

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引言

MR16 灯属于多面向反射器灯的一种，通常以卤素灯丝囊作为光源。它们适用于很多零售和消费性应用，藉着独特的尺寸、可配置性、聚光能力和美观性，发挥实用性和创意。不过，低效率、热量产生和卤素囊处理问题往往成为了这种技术的缺点。MR16 灯一般采用 12V DC 或 12V AC 通用电磁式变压器下操作。

LED 是一个替代卤素灯的理想选择，因为它具有更高效能及无热辐射。

这款参考设计可以装设于 MR16 型 LED 射灯的标准连接器空间。它经过了优化，在零件数量以至热性能方面，都更臻完善。这款设计一般可在镜面部分配合 3 个 1W LED 使用，更可以作出调整，满足照明系统设计人员的要求。

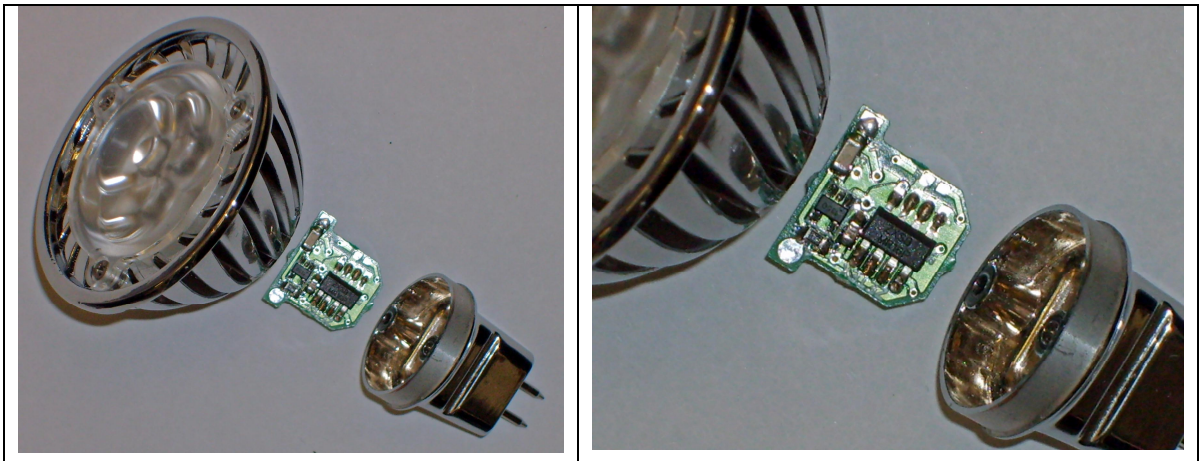


图 1：采用 ZXLD1350 的 MR16 应用

规格书

建议用户在使用此设计手册的同时，也参考 ZXLD1350 的规格书。请浏览：

http://www.zetex.com/3.0/pdf/ZXLD1350.pdf

描述

图 2 是利用 ZXLD1350 和 ZXSBMR16T8 实现的 MR16 灯解决方案的系统接线图，表 1 则提供了物料清单。

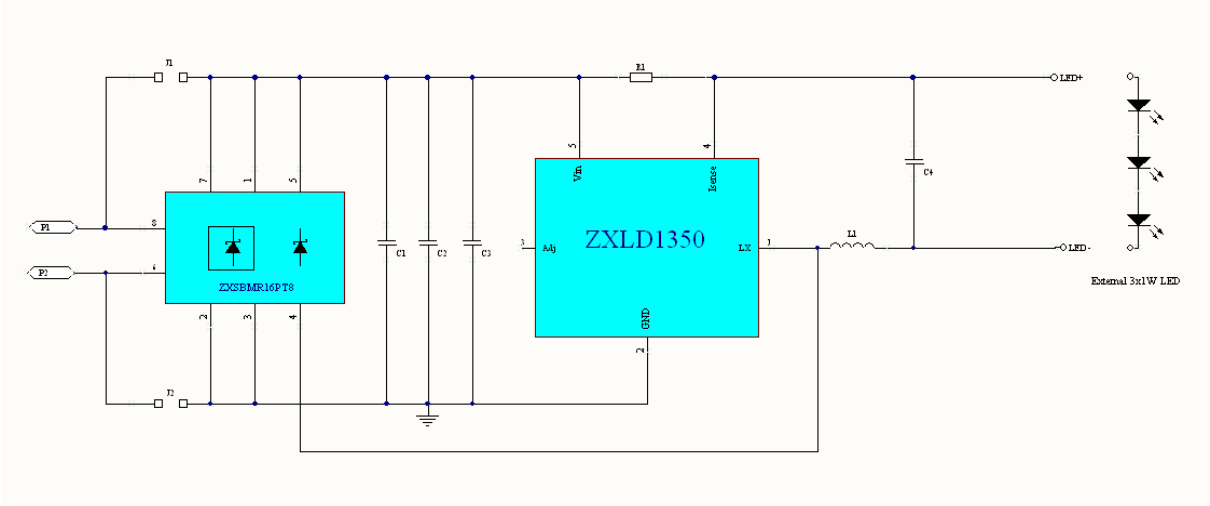


图 2 – ZXLD1350 MR16 灯解决方案的系统接线图

ZXLD1350 是为 350mA 或以下的 LED 电流驱动应用而设计。这款单片式 NMOSFET 大小适中，提供具有成本效益的芯片尺寸，额定电流为 400mA，在迟滞操作模式下 (电流波形从标称电流设定点约升降 +/-15%)提供足够的裕度。ZXLD1350 的主要特点包括：

- 高至 380mA 的输出电流
- 宽阔的输入电压范围：7V 至 30V
- 内部 30V 400mA NDMOS 开关
- 高效率 (高于 90%)
- 高至 1MHz 的开关频率

ZXSBMR16T8 是一款能够节省空间又具有热效率，并且特别为满足 MR16 应用的关键要求设计的器件。它包含一个全桥和一个空转二极管，以低泄漏的 1A、40V 肖特基二极管来实现标称 12V AC 输入操作。相比于采用一体式设计的标准硅式二极管，这种肖特基桥与嵌入式续流二极管的组合有助于提升系统的效率。参考设计中具备旁路焊接点，可以省略桥式整流器，最终的电灯设计亦适用于纯 DC 操作。

由于 ZXLD1350 采用了迟滞式转换电路拓朴，因此转换效率取决于几项因素 – 输入电压、目标电流和 LED 数量。当中还设有以 Excel 为基础的计算器，用于系统的初始评测和决定零件选择。

详情可浏览 http://www.zetex.com/3.0/otherdocs/zxld1350calc.xls

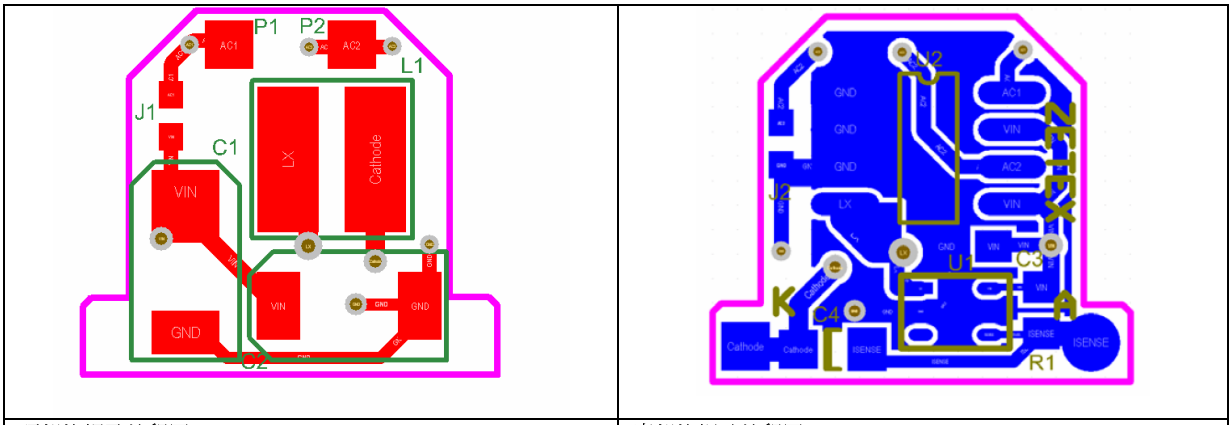
系统效率和 LED 电流测量皆包含在设计中， ADJ 管脚保持浮动，以测量器件中的电流额定值。ADJ 管脚的阻抗输入较高 (200K)，容易受到其他来源的泄漏电流所影响。任何从这个管脚载下的电流，都会减低输出电流。为了避免出现任何电磁耦合情况，管脚的周遭设有保护线轨。

数量	零件参考	价值	描述	来源
1	R1	0.33Ω	电阻器，1%，0805	不同来源
1	C1,C2	150µF/20V	D 类 SMD 钽电容器	Kemet
1	C3	0.1µF/25V	SMD 0805 X7R	NIC 元件
1	C4	1µF/25V	SMD 1210 X7R	NIC 元件
1	L1	100µH	MSS6132-104	Coilcraft
1	U1	ZXLD1350	LED 驱动器 IC	ZETEX
1	U2	ZXSBMR16PT8	肖特基桥式整流器矛及续流二极管	ZETEX

表1 – 物料清单

从图 2 中的电路原理图可见，只需要使用 0Ω 电阻器，便可运用跳线连接，实现纯 DC 操作。
由于系统并没有反极性保护，所以用户要特别小心。

图 3 为电路设计，说明了节省空间和紧凑设计的优点。底层及顶层皆清楚显示，高效器件布置清晰可见。



顶部的铜及丝印层　　底部的铜及丝印层

图 3：电路设计

主层设计建议如下：

- 所有薄器件设于同一边
- 以星形联结作为接地线轨
- 以接地环保护 ADJ 管脚
- 请检查：
  - 把 R1 连接至 ZXLD1350 愈短愈好 (感应线轨)
  - 滤波电容器 C3 应连接至最接近 V_{in} 管脚的地方
  - 续流电流路径愈短愈好，以保障系统的精密度和效率

电路板一览

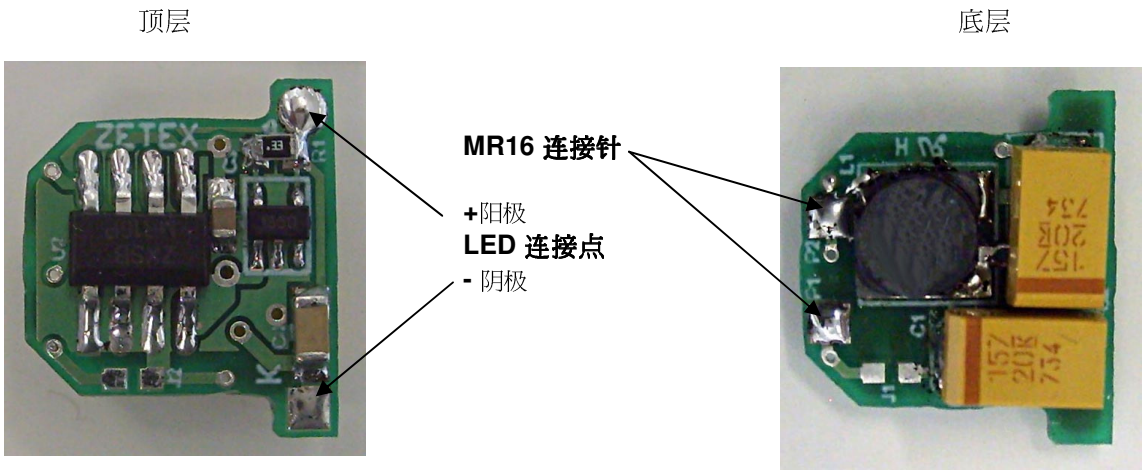


图 4：电路板一览

电感器的选择和开关电路佈线设计

电路中选用了 100 µH 的屏蔽式电感器，把标称频率设定于约 250kHz 的水平，同时把辐射电磁干扰减至最少。任何开关稳压器的设计，对减低辐射电磁干扰都相当重要。这款参考设计可以把关键的线轨长度减至最低，而关键性区域四周的接地面积则扩至最大。

电路的性能表现

电路的性能表现根据两项主要的参数进行评测，包括系统效率和电流精度。

参考电路的电流设定于 300mA 的标称值，但只须根据以下公式改变感应电阻器 R_{sense}，电流便可调整至 350mA 或下的水平。

$$I_{ref} = 0.1 / R1 \quad [A]$$

当使用 $R1 = 0.33\Omega \rightarrow I_{ref} = 300mA$

表 2 列出了 12V 至 15V DC 供应电压系统的相关资料，有关测试采用了肖特基二极管桥。最重要的参数包括系统效率及额定 LED 电流 (300mA) 和实际 LED 电流之间的误差。在 DC 环境下，频率介于 150kHz 和 300kHz 之间，视输入电压而定。不论输入电压多少，效率皆高于 87%，误差少于 2%。

输入电压 [V]	输入电流 [A]	输出电压 [V]	输出电流 [A]	效率	电流准确度
12.000	0.275	9.80	0.296	87.9%	1.3%
13.000	0.252	9.78	0.294	87.7%	2.0%
14.000	0.232	9.76	0.294	87.6%	2.0%
15.000	0.220	9.75	0.294	87.4%	2.0%

表 2 - DC 输入电压

表 3 列出了以一个采用 SMD 钽电容器及AC 电磁变压器供电系统的相关资料。系统以节省空间为设计目标，同时避免使用体积更大、可靠性更低的电解电容器。对于体积、可靠性、成本及平均LED电流都有取舍，一般标定 12V AC 的变压器输出电压会变化＋／－10%，三个 LED 的压降约 10V，在图8 可以看到，如电容值少於200 µF ，AC 输入的波形扭歪了。当整流后电压没有被有效地平滑，谷低电压有可能低於 LED 电压，在这情况下，开关电路停止运作， LED 平均电流下降，最后 LED 输出流明也下降。

C1 [µF]	输入电压 [V]	输入电流 [A]	输出电压 [V]	输出电流 [A]	效率	电流准确度
100	12.70	0.303	9.28	0.225	54%	25%
150	12.60	0.394	9.50	0.271	52%	10%
200	12.53	0.432	9.55	0.293	52%	2%
300	12.50	0.386	9.70	0.295	60%	2%

表 3 - AC 输入电压

图5至图8显示由输入电容Cin=C1+C2+C3所影响的输入电压纹波及LX电压。输入电容愈大，输出电流愈準确，亦令平均输出流明愈高。当输入电容达300uF时，整体表现，包括效率及电流準确度都最好。相反，当输入电容降低，输出电流準确度降低多达25%，但效率总高於50%。

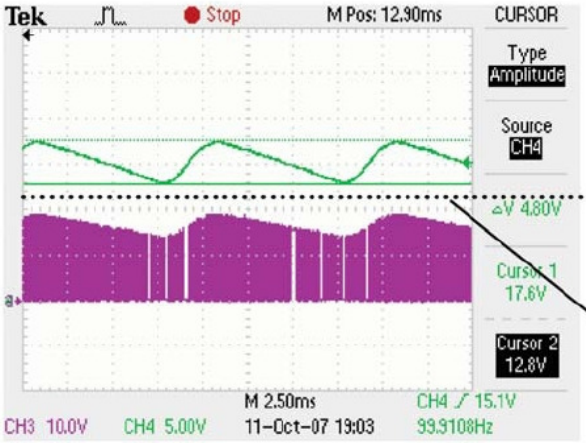


图 5 Cin=300µF

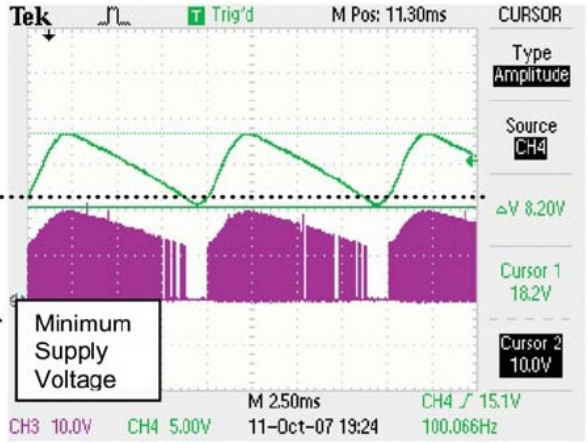


图 6 Cin=200µF

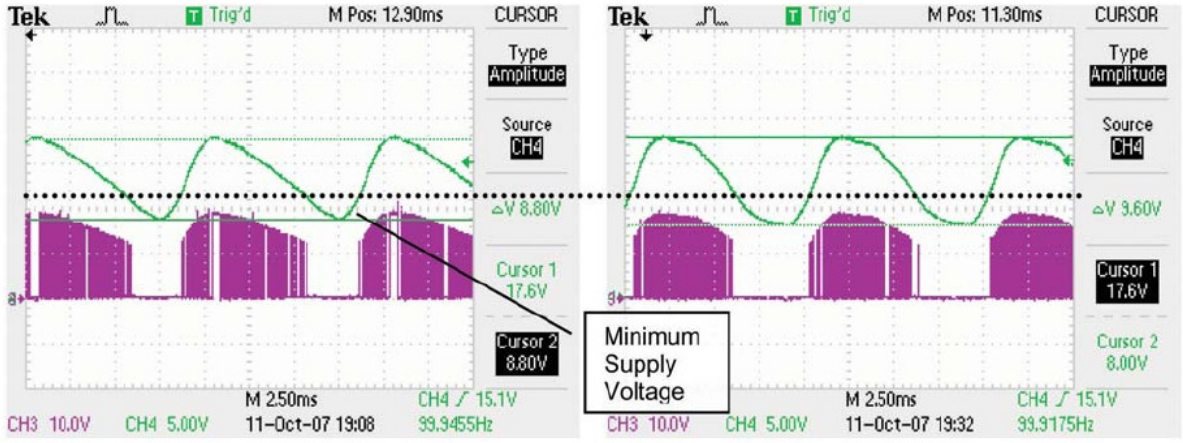


图 7 Cin=150µF

图 8 Cin=100µF

图 5 至 8：输入纹波及 LX 电压 (Ch3 为 LX 管脚电压，Ch4 为输入电压)

有关 Gerber Plot 及进一步协助， 可联络 Zetex 的本地销售代表。以下为各本地销售处的电邮地址。

europe.sales@zetex.com

usa.sales@zetex.com

asia.sales@zetex.com

结论

ZXLD1350 及 ZXSBMR16T8 配合其他被动元件，展现了一个细小、可靠、高效率及小元件数目的方案。这个超小设计可放进连接器的外壳，将这些对温度敏感的元件与发热的 LED 尽量分隔开。在最终的解决方案中，LED电流及电容器的大小都要有所取舍，以达致最理想的效率、准确度、尺寸及元件数量。

这是一系列不同 MR16 解决方案和选项参考设计中的第一份设计手册。

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