

MIK36XX Applications in General Lighting MIK36XX 在普通照明灯中的应用方案

1. Introduction

简介

LED light will undoubtedly be a superstar in SSL (Solid State Lighting). As a special diode, HB LED can only be driven by a DC voltage or current. Therefore all LED lights require a DC power supply that converts AC main power to DC voltages.

LED 照明无疑会成为固态照明中的一个超级明星。高亮度发光二极管本身只能用直流电压或电流来驱动。所以所有的 LED 灯具内部都有一个直流电源把交流电转化为直流电压。

The light output (luminous flux) of a LED is proportional to the LED DC current. So as the heat dissipation of the LED, which has a direct, negative impact on the lifetime of the LED itself. Therefore, to maintain a constant LED driving current at elevated temperature is crucial to the performance and longevity of any LED lights.

LED 的输出光通量和发热量与通过的直流电流的大小成正比。而 LED 的发热和工作温度直接影响到 LED 的寿命。所以在较高的环境温度下保持恒定的 LED 驱动电流是关乎 LED 灯具性能及寿命的关键。

This applications note summarizes power supply solutions to LED lights using MikPower's MIK36XX Constant Current Regulators.

本应用说明总结了采用 MikPower 公司的 MIK36XX 系列恒流驱动芯片在不同灯具中的应用方案。

2. MIK36XX

MIK36XX is MikPower's high voltage, constant current driver IC product family designed for HV/AC (High Voltage/AC) LED lighting applications. The series has fixed current models and adjustable current models. The fixed models, MIK3622/3623/3624/3626/3628/3609/3610, generate a predetermined constant current up to 100 mA within the range of its operation voltages. For the adjustable models, the output current can be determined using an external setting resistor. MIK36XX operates in voltage range 7~200V, during which the IC outputs a rated constant current. With different LED configurations, MIK36XX can be used in 100/120/240 VAC environment. If desired, two or more pieces of MIK36XX can be used in parallel to deliver larger currents.

MIK36XX 是美国 MikPower 公司为交流 LED 照明应用量身定做的高压恒流驱动芯片产品系列。该组产品有两种工作模式：固定电流方式或可调方式。在固定电流方式工作时，该组芯片在其正常工作电压范围内输出一个恒定的、出厂设定的电流。可调方式则由外部电阻来设定输出恒定电流值。MIK36XX 的工作电压范围是 7~200V。通过改变 LED 的串并组合，MIK36XX 可在 100/120/240VAC 环境中使用。并且多颗 MIK36XX 可并联使用，输出更大电流。

MIK36XX is a linear regulator device. Compared with switching regulator, it has the following benefits:

- Simple, compact, low-cost application circuit that delivers higher reliability;
- Capacitor failure will not cause complete failure of the light;
- Very low EMI.

MIK36XX 是一颗线性整流器件。与开关整流器件相比，它有下列的优势：

- 应用电路简洁、体积小、成本低、可靠度高；
- 即使电容失效不会导致整灯不亮；
- 电磁干扰系数极低。

MIK36XX has two levels of thermal protection: thermal regulation and OTP (over temperature protection). For more details, please refer to Section 8 and 9.

MIK36XX 有两级温度保护机制：温度控制及过温保护。详情请见第 8、9 节。

Benefiting from wide working voltage range, simple applications circuit and high efficiency, MIK36XX is best for AC LED applications in low to mid power range, including

- LED light bulb (E26/27, MR16);
- LED light tube (T8/T5);
- LED panel light;
- LED down light.

基于其大范围的工作电压、简单的应用电路以及较高的转换效率等优势，MIK36XX 最适合应用中低功率的 LED 灯具中，包括：

- LED 球炮灯(E26/27 或 MR16);
- LED 灯管(T8/T5);
- LED 平面灯;
- LED 筒灯。

MIK36XX can be in TO-220, TO-252, TO-263 package, all providing very good performance in heat dissipation. MIK36XX family has the following models commercially available. Please contact MikPower Inc. for product datasheets.

MIK36XX 有几种封装形式：TO-220、TO-252 及 TO-263。这几种封装都提供了非常好的散热性能。MIK36XX 系列有以下的产品，具体产品规格请另行向 MikPower 公司索取。

Model	Descriptions
MIK3622	High voltage, constant current source, fixed 20 mA. 高电压恒定电流 20 毫安
MIK3623	High voltage, constant current source, fixed 30 mA. 高电压恒定电流 30 毫安
MIK3624	High voltage, constant current source, fixed 40 mA. 高电压恒定电流 40 毫安
MIK3605	High voltage, constant current source, fixed 50 mA. 高电压恒定电流 50 毫安
MIK3625	High voltage, constant current source, programmable from 20 mA up to 40 mA. 高电压恒定电流 20-40 毫安可调。
MIK3626	High voltage, constant current source, fixed 60 mA. 高电压恒定电流 60 毫安
MIK3628	High voltage, constant current source, fixed 80 mA. 高电压恒定电流 80 毫安
MIK3609	High voltage, constant current source, fixed 90 mA. 高电压恒定电流 90 毫安
MIK3610	High voltage, constant current source, fixed 100 mA. 高电压恒定电流 100 毫安
MIK3629	High voltage, constant current source, programmable from 60 mA up to 80 mA 高电压恒定电流 60-80 毫安可调

3. Design Objectives of LED Light Power Supplies

LED 灯驱动电源应用电路的设计目标

DC power supplies have three main categories: switching regulated, linear regulated and unregulated. Each has its own pros and cons. A quick comparison is shown Table 1.

直流电源基本分三类：开关控制、线形控制及无控制的。每类都各有其优缺点。其比较见表一。

To achieve a high lumens per dollar (lm/\$) ratio and long life that LED lights promise, the LED is required to be driven with a constant current that matches the LED's rated forward current under varying AC input voltages.

为了使 LED 灯的设计达到较高的亮度（流明）成本比以及尽量长的寿命，LED 就必须由恒定电流来驱动。此恒定电流还必须在变动的交流电输入时，稳定在 LED 的标称前向电流值上。

Design objectives of a LED power supply:

- Constant current in varying AC environment
- Compact size
- Well designed heat dissipation
- High power factor
- High efficiency
- Low EMI
- Low cost
- High reliability

LED 灯驱动电源的设计目标有以下这些:

- 在变化的交流电环境中保持恒流输出
- 体积尽量小
- 散热良好
- 功率因素高
- 转换效率高
- 电磁干扰低
- 成本低廉
- 高可靠性

Table 1: LED DC Power Supply Comparisons

表一：LED 直流电源种类的比较

	Switching Regulated	Traditional Linear Regulated	RC Voltage Splitter	MikPower Linear Regulated
Circuit Design	complex	simple	simple	simple
Part Count	high	low	low	low
Cost	high	low	low	low
Line Regulation	good	good	directly proportional to AC input change	good
Ripple (RMS)	high	low	high	low
Efficiency	70-85%	40-60%	90-95%	70-85%
EMI	medium	very low	very low	very low
Size	medium	big	small	small
Weight	light	heavy	light	light
Power Factor	0.6 - 0.7 no PFC >0.95 with PFC	0.6 - 0.7	0.6 - 0.7	>0.9 (no cap or with PFC)
Heat	small	medium	small	medium
Input Voltage Range	90 - 264 VAC	105 - 125 VAC and/or 210 - 250 VAC	0 - 125 VAC 0 - 250 VAC Output directly proportional to input	110±25% VAC or 220±25% VAC

	开关控制	传统线性控制	无控制(阻容降压)	MikPower 方案
电路设计	复杂	简单	简单	简单
元件数量	多	少	少	少
成本	高	低	低	低
输出对输入变动的抑制	好	好	输出直接和输入的变动成比例	好
输出纹波(RMS)	高	低	高	低
转换效率	70-85%	40-60%	90-95%	70-85%
EMI	中等	非常低	非常低	非常低
体积	中等	大	小	小
重量	轻	重	轻	轻
功率因素	0.6 - 0.7 (无功率因数修正) >0.95(带功率因数修正)	0.6 - 0.7	0.6 - 0.7	>0.9 (不用电容或带功率因数修正电路时)
热量	低	中	低	中
输入电压范围	90 - 264 VAC (带功率因数修正电路)	105 - 125 VAC 和 / 或 210 - 250 VAC	0 - 125 VAC 0 - 250 VAC 输出直接和输入的变动成比例	110±25% VAC 或 220±25% VAC

4. Symbols and Definitions

符号及定义

- a. I_F : LED forward current. This current is delivered by the constant current driver IC.
 I_F : LED 的前向电流。此电流由恒流驱动芯片输出。
- b. PF: Power Factor ($PF = \frac{\text{True Power}}{\text{Apparent Power}}$), measured directly on the oscilloscope.
 PF: 功率因数 $PF = (\text{实际功率 watt}) / (\text{显著功率 VA})$, 直接从带有 PF 量测的示波器上读取。
- c. Room temperature unless otherwise indicated.
 除非另外注明, 量测环境为室温。

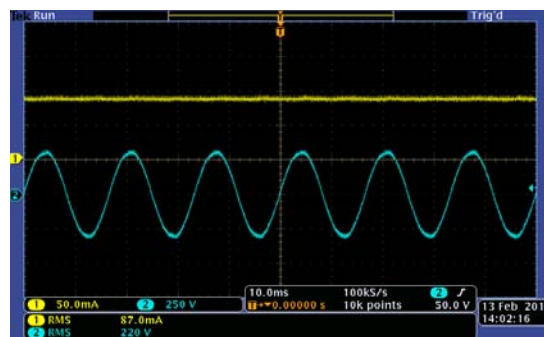


Figure 1: LED Current vs. AC Input. The LED current is delivered by a MIK3629 Constant Current Source.
 图 1: LED 电流及 AC 输入。LED 电流由 MIK3629 恒流源产生。

5. Applications 应用电路

MikPower's MIK36XX takes the high voltage, linear regulated approach to address general lighting applications. The following picture shows some general lighting products (shown in clockwise), using MIK36XX constant current source ICs:

- Light bulb;
- MR6;
- T8 light tubes, and
- Down light.

MikPower 的 MIK36XX 系列 IC 产品是把高电压、线性控制的方法用于 LED 普通照明。下面的照片展示了几种应用 MIK36XX 恒流源 IC 的 LED 灯：（顺时针方向为）球泡灯、MR6 射灯、筒灯及灯管。



Figure 2: Various lights using MIK36XX driver

图 2: 采用 MIK36XX 作为 LED 驱动的不同种类的灯

6. Typical Application Circuits 典型应用电路及比较

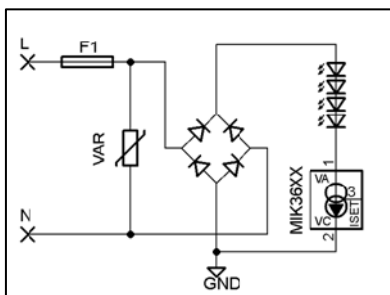
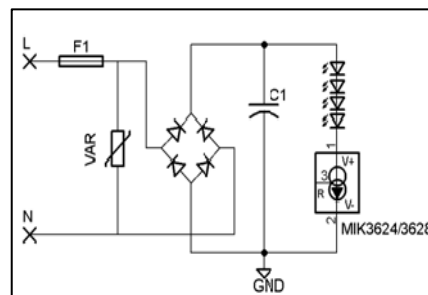


Figure 3: Applications. A: No capacitor
图 3: 应用电路。A: 无电容



B: With bulk capacitor.
B: 带去耦电容

Table 2: Application Circuit Comparison

表 2: 应用电路比较

	No Capacitor (A)	With Bulk Capacitor (B)
Power Factor	> 92%	48~70%
Protection	LED open and short. Driver IC OTP (over temperature protection).	
Pros	<ul style="list-style-type: none"> • Low component count. • No capacitors 	<ul style="list-style-type: none"> • Flat LED current. • Even if the capacitor fails, the LED can be lit on with a duty cycle not visible to human eye. • Long life capacitors recommended.
Cons	The LED current has a duty cycle therefore the LED's are not turned on 100% of the time. It results a lower lm/\$. The light has an invisible flash at 100/120 Hz.	<ul style="list-style-type: none"> • The bulk capacitor needs more space, limiting applications in small light fixtures. • The bulk capacitor also has a limited life span especially in elevated temperature environment. Long life capacitors have a higher cost.
	A: 无电容	B: 带滤波电容
功率因数	> 92%	48~70%
保护	LED 开路、断路。驱动 IC 的过温保护。	
优点	<ul style="list-style-type: none"> • 外围元器件极少 • 无电容 	<ul style="list-style-type: none"> • LED 工作电流无占空比。无频闪。 • 即使电容失效，LED 还是能点亮。电容失效后产生的占空比或频闪肉眼觉察不到。 • 电容建议选用长寿命品牌
缺点	LED 工作电流有占空比。会有肉眼觉察不到的 100/120Hz 的频闪。LED 不是全时间点亮，其光效没有得到极大化。	<ul style="list-style-type: none"> • 加装电容体积增大，会限制在某些小型灯具上的应用。 • 普通电容寿命较短，特别是在较高的工作温度环境下。长寿电容成本较高。

7. Applications 应用案例

- 1) 5 W 110V E27 light bulb
5 瓦 110V E27 球灯泡

Configuration:	配置:
• Application type: B	• 应用电路 B
• 1 LED string total	• 共 1 串 LED
• LED string: 7 pieces of 6-die LEDs in 5050 package, $I_F = 30 \text{ mA}$	• 7 颗 5050 封装的 6 晶 LED 串联; LED 电流为 30mA
• C1 = 15 μF , 250V	• C1 电容为 250V 15 μF
• Driver IC: 1X MIK3623 (constant current 30 mA)	• 驱动芯片为单颗 MIK3623, 恒流输出电流为 30mA
• 450lm, 90lm/W	• 450 流明, 90 流明/瓦

2) 7 W 110V E27 light bulb
7 瓦 110V E27 球灯泡

Configuration:	配置:
• Application type: A	• 应用电路 A
• 2 LED strings total in parallel	• 共 2 串 LED, 12 颗
• LED string: 6 pieces of 6-die LEDs in 5050 package, $I_F = 50$ mA	• 每串 6 颗 5050 封装的 6 晶 LED 串联; LED 电流为 50mA
• No capacitor	• 无电容
• Driver IC: 1 X MIK3609 (constant current 90 mA)	• 驱动芯片: 单颗 MIK3609, 恒流输出电流为 90mA
• 600lm, 85lm/W	• 600 流明, 85 流明/瓦

3) 10 W 110V E27 light bulb
10 瓦 110V E27 球灯泡

Configuration:	配置:
• Application type: B	• 应用电路 B
• LED string: 7 pieces of 6-die LEDs in 5050 package, $I_F = 60$ mA	• 7 颗 5050 封装的 6 晶 LED 串联; LED 电流为 60mA
• 2 LED strings total in parallel	• 共 2 串 LED, 14 颗
• C1 capacitor = 22 μ F, 250V	• C1 电容 250V 22 μ F
• Driver IC: 1 X MIK3626 (constant current 60 mA)	• 驱动芯片为单颗 MIK3626, 恒流输出电流为 60mA
• 850lm, 85lm/W	• 850 流明, 85 流明/瓦

4) 7 W 220V 2 ft T5 Light Tube (Integration power supply)
7 瓦 220V 60 CM T5 灯管 (内置电源)

Configuration:	配置:
• Application type: A	• 应用电路 A
• LED string: 70 pieces of LEDs of 3014 package, $I_F = 50$ mA	• 70 颗 3014 封装的 LED 串联; LED 电流为 50mA
• 1 LED string	• 1 串 LED
• No capacitor	• 无电容
• Driver IC: 1 X MIK3605 (constant current 50 mA)	• 驱动芯片为单颗 MIK3605, 恒流输出电流为 50mA
• 600 lm, 85lm/W	• 600 流明, 85 流明/瓦

5) 10W 110V 2 ft T8 Light Tube
10 瓦 110V 60 CM T8 灯管

Configuration:	配置:
• Application type: B	• 应用电路 B
• LED string: 42 pieces of LEDs of 3014 package, $I_F = 30$ mA	• 42 颗 3014 封装的 LED 串联; LED 电流为 30mA
• 2 LED strings in parallel	• 2 串 LED 并联
• C1 = 22 μ F capacitor, 250V	• C1 电容为 250V 22 μ F
• Driver IC: 1 X MIK3626 (constant current 60 mA)	• 驱动芯片为单颗 MIK3626, 恒流输出电流为 60mA
• 800lm, 80 lm/W	• 800 流明, 80 流明/瓦

- 6) 14 W 220V 3 ft T5 Light Tube (with fixture and embedded power supply)
14 瓦 220V 0.9 米 T5 灯管 (含支架, 支架内置电源)

Configuration:	配置:
• Application type: B	• 应用电路 B
• LED string: 86 pieces of LEDs of 2835 package, $I_F = 50 \text{ mA}$	• 86 颗 2835 封装的 LED 串联; LED 电流为 50mA
• 1 LED string	• 1 串 LED
• C1 capacitor = 15 μF , 400V	• C1 电容 400V 15 μF
• Driver IC: 1 X MIK3605 (constant current 50 mA)	• 驱动芯片为单颗 MIK3605, 恒流输出电流为 50mA
• 1200 lm, 85lm/W	• 1200 流明, 85 流明/瓦

- 7) 18 W 110V 4 ft T5 Light Tube (Integrated power supply)
18 瓦 110V 1.2 米 T5 灯管 (一体电源)

Configuration:	配置:
• Application type: A	• 应用电路 A
• LED string: 35 pieces of LEDs of 3014 package, $I_F = 30 \text{ mA}$	• 35 颗 3014 封装的 LED 串联; LED 电流为 30mA
• Total 4 LED strings in parallel	• 共 4 串 LED 并联
• No capacitor	• 无电容
• Driver IC: 4 X MIK3626 (each constant current 60 mA)	• 驱动芯片为 4 颗 MIK3626, 每颗恒流输出电流为 60 mA
• 1680 lm, 93 lm/W	• 1680 流明, 93 流明/瓦
• PF = 93%	• PF = 93%
• CCK = 6700	• CCK = 6700
• RA > 70	• RA > 70

- 8) 18 W 110V 4 ft T5 Light Tube (Integrated power supply)
18 瓦 110V 1.2 米 T5 灯管 (一体电源)

Configuration:	配置:
• Application type: B	• 应用电路 B
• LED string: 35 pieces of LEDs of 3014 package, $I_F = 30 \text{ mA}$	• 35 颗 3014 封装的 LED 串联; LED 电流为 30mA
• Total 2 LED strings in parallel	• 共 2 串 LED 并联
• Bulk capacitor installed	• 有使用电解电容
• Driver IC: 2 X MIK3626 (each constant current 60 mA)	• 驱动芯片为 2 颗 MIK3626, 每颗恒流输出电流为 60 mA
• 1650 lm, 90 lm/W	• 1650 流明, 90 流明/瓦
• PF = 48%	• PF = 48%
• CCK = 6600	• CCK = 6600
• RA > 69	• RA > 69

- 9) 9 W 110V 2 ft T5 Light Tube (Integrated power supply)
9 瓦 110V 0.6 米 T5 灯管 (一体电源)

Configuration:	配置:
• Application type: A	• 应用电路 A
• LED string: 35 pieces of LEDs of 3014 package, $I_F = 30 \text{ mA}$	• 35 颗 3014 封装的 LED 串联; LED 电流为 30mA
• Total 2 LED strings in parallel	• 共 2 串 LED 并联

• No capacitor	• 无电容
• Driver IC: 2 X MIK3626 (each constant current 60 mA)	• 驱动芯片为 2 颗 MIK3626, 每颗恒流输出电流为 60mA
• 750 lm, 94 lm/W	• 750 流明, 94 流明/瓦
• PF = 93%	• PF = 93%
• CCK = 6700	• CCK = 6700
• RA > 70	• RA > 70

10) 18 W 220V Ceiling Light
18 瓦 220V 吸顶灯

Configuration:	配置:
• Application type: B	• 应用电路 B
• LED string: 84 pieces of LED's in 2835 package, $I_F = 60$ mA	• 84 颗 2835 封装 LED 串联, $I_F = 60$ mA
• C1 = 15 μ F capacitor, 400V	• C1 电容为 400V 15 μ F
• Driver IC: 1 X MIK3626 (constant current 60 mA)	• 驱动芯片为单颗 MIK3626, 恒流输出电流为 60mA
• 1500 lm	• 1500 流明

8. Applications in Extended Voltage Environment

Beyond typical 110VAC and 220 VAC environments, there are 100VAC environment, for example, Japanese market, and the regions where AC main voltage has huge upswings as high as 270-280 VAC. Applications in those environments require adjustments to the system configuration and/or additional application circuits.

除了欧亚大陆的 220VAC 及美洲大陆的 110VAC, 日本是 100VAC。除此之外, 有些地区的电网有很大的波动, 电压可高达 270 甚至 280VAC。在那些电网环境中, 应用方案需要作出调整, 或需要额外的应用电路。

For 100 VAC applications, LED strings with 30 pieces of 3.0 V_f or 3.1 V_f discrete LEDs provide the best configuration. However, LED COB (chip on board) modules that are designed for 110 VAC environments, e.g. Lustrous Pearl IX, which has a typical forward voltage of 135V, are not good candidates for 100 VAC environments. Changes have to be made in choosing LED dies in COB modules. For example, Lustrous has designed their new Jade product series to address the Japan market. The Jade series LED COB has a typical 120 V forward voltage and a higher Lumen/\$ ratio. 针对 100VAC 的应用, 30 颗 3.0V 或 3.1V 的单颗 LED 是最佳配置。但是像原本给 110VAC 应用的 LED COB 模组, 譬如 Lustrous 的 Pearl IX 模组产品, 其典型的前向电压是 135V, 并不适合于 110VAC 的应用环境。所以必须对 COB 模组的 LED 晶粒选择作出变动。例如, Lustrous 设计出新的 Jade 系列模组主打日本市场。Jade 系列 LED COB 模组的典型前向电压是 120V。利用 Jade 系列模组可以获得更高的流明成本比例。

For application environments with huge voltage swings, changing LED serial numbers will not completely address the issue. The excessive voltage drop on the LEDs and the power supply due to

the voltage upswings generates excessive heat, reduces efficacy, and even causes damages to the LED's and/or the power supply.

对于有些电网中存在的电压漂高现象，光增加或改变 LED 串联的数量不能完全解决问题。过高的交流输入造成在 LED 及电源上跨压过高，产生巨大热量，降低效率，甚至导致 LED 或驱动电源损坏。

To prevent such damages, MIK36XX has two levels of thermal protection mechanism. First, the thermal regulation feature rolls off the output current at about 0.6% per °C when the junction temperature reaches 110 °C. This keeps the power consumption relatively flat when input voltage swings upward. Second, if the IC junction temperature continues to rise to about 160 °C due to poor heat dissipation, the output current will shut down and reduce to about 1 mA. At this time, the LED light is almost turned off. The driver IC cools down. When its junction temperature goes down to about 130 °C, the driver resumes its output current and the LED light goes back on.

为防止这种损坏，MIK36XX 内部有两级温度保护。第一，当芯片内部节温超过 110 °C 后，节温每超过 1 °C，输出电流大概会下降 0.6%。此功能会在输入交流电压过高时，总功率消耗不致上升太多。第二，如果芯片的节温持续上升并达到 160 °C 左右，芯片会自动切断电流输出到大约 1 mA。此时，LED 灯会灭掉，芯片温度很快下降。当结温下降到下限 130 °C 左右时，芯片又会自动恢复电流输出。这样，会看到灯的明暗闪烁。

9. Heat Dissipation

散热处理

One of the challenges for linear drivers is to achieve good heat dissipation while satisfying safety regulation. MIK36XX's two-stage thermal protection prevents the IC from damages due to overheating; however, constant operation in high temperature will have significantly negative impact on the lifetime of the IC. So as a member of the power IC family, MIK36XX requires good heat dissipation solutions. The typical thermal solution are listed below:

- Metal Core PCB (aluminum based), ceramic base, FR4 or even CEM materials.
- When selecting TO252 or TO263 packages, designer should budget enough real estate for the heat sink copper (1 x 1" or larger).
- Use fasteners, thermal glue or grease to achieve good contact with the heat sink.

线性驱动方案的一个挑战就是在电气绝缘满足安规的前提下，解决好散热问题。虽然 MIK36XX 内建有两级温度保护机制，但是芯片长期在高温下工作，会缩短其寿命。所以，作为功率芯片家族里一员，MIK36XX 系列驱动芯片也需要有良好的散热。取决于线路板的材质，一般有以下几种散热处理的方法：

- 铝基板、陶瓷基板、FR4 甚至 CEM 材质的 PCB 板
- 当采用了 SMD 的 TO252 或 TO263 封装时，芯片的散热铺铜足够大（25x25mm 或更大）。
- 采用紧固件或散热硅脂保证 PCB 板与散热部件的紧密接触。

10. Conclusions

MIK36XX Constant Current Source family IC products are designed for general LED lighting solutions with low component count, ease to use, and low cost in mind. The solutions using MIK36XX well address the low to mid power lighting devices, such as E26/E27 light bulbs, MR16 light bulbs, T8 light tubes and down lights, to achieve compact size, reasonable power factor, output stability and high efficiency.

For more details, please contact us through email info@mikpowerinc.com.

Appendix A: Application Circuit BOM (Bill of Material)

附录 A: 应用电路参考元器件表

App A

Item	MIK P/N	QTY	ID	Manufacturer P/N	Descriptions
1		1	F1	SK18F1A	FUSE 250VAC 1A
2		1	VAR	V275LA20AP, Littlefuse	VARISTOR 275V 14mm
3		1	R1		RES 100K OHM 1/8W 5% 1206 SMD
4		1	B1	HY B6S	RECTIFIER 600V 0.8A
5		1	R7		RES 15K OHM 1/10W 1% 0603 SMD (current setting resistor)

App B

Item	MIK P/N	QTY	ID	Manufacturer P/N	Descriptions
1		1	F1	SK18F1A	FUSE 250VAC 1A
2		1	VAR	V275LA20AP, Littlefuse	VARISTOR 275V 14mm
3		1	R1		RES 50 OHM 2W 5% METAL FILM AX
4		1	R2		RES 100K OHM 1/8W 5% 1206 SMD (Bleeding resistor)
5		1	C1	EEU-EE2V100, Panasonic	CAP ALUM 10UF 350V 20% RADIAL
6		1	B1	HY B6S	RECTIFIER 600V 0.8A
7		1	R3		RES 15K OHM 1/10W 1% 0603 SMD (current setting resistor)

Note: BOM lists are for reference only, not official designs. 非正式设计，仅供参考。