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2012年6月

# FAN5346
# 带PWM调光接口的串联升压LED驱动器

## 特性

- 异步升压转换器
- 驱动串联LED:
  - FAN5346S20X：20V输出
  - FAN5346S30X：30V输出
- 输入电压范围：2.5V—5.5V
- PWM 调光，用于LED亮度控制
- 5kHz 至 100kHz PWM 调光频率范围
- 1.2MHz 固定开关频率
- 软启动
- 输入欠压闭锁(UVLO)
- 输出过压保护 (OVP)
- 短路检测
- 热关闭保护（TSD）
- 小尺寸6 引脚SSOT23封装

### 应用

- 移动电话
- 移动互联网设备
- 便携式媒体播放器
- PDA、DSC、MP3 播放器

## 说明

FAN5346是驱动串联LED的异步恒定电流LED驱动器，可确保所有LED具有相同的亮度。FAN5346S20X具有20V的输出电压，最多可驱动5个串联LED。FAN5346S30X具有30V的输出电压和最多8个串联LED。为小外形应用而优化的1.2MHz固定开关频率允许使用小电感和小电容。

FAN5346使用PWM照明控制接口来设置LED亮度等级。EN引脚上施加了一个5kHz至100kHz的PWM信号。

为安全起见，该器件集成了过压、过流、短路检测和热关断保护等功能。此外，如果电池电压过低，则会触发输入欠压闭锁保护。

6引线SSOT23封装中有FAN5346。该器件符合“绿色”和RoHS标准。*（有关飞兆半导体绿色的定义，请参考http://www.fairchildsemi.com/company/green/index.html*。

## 订购信息

| 器件编号 | 输出电压选择 | 温度范围 | 封装 |
|---|---|---|---|
| FAN5346S20X | 20V | -40至85° C | 6引脚、SuperSOT™-6、JEDEC MO-193、1.6mm宽(MA06A) |
| FAN5346S30X | 30V | | |

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## 典型应用图

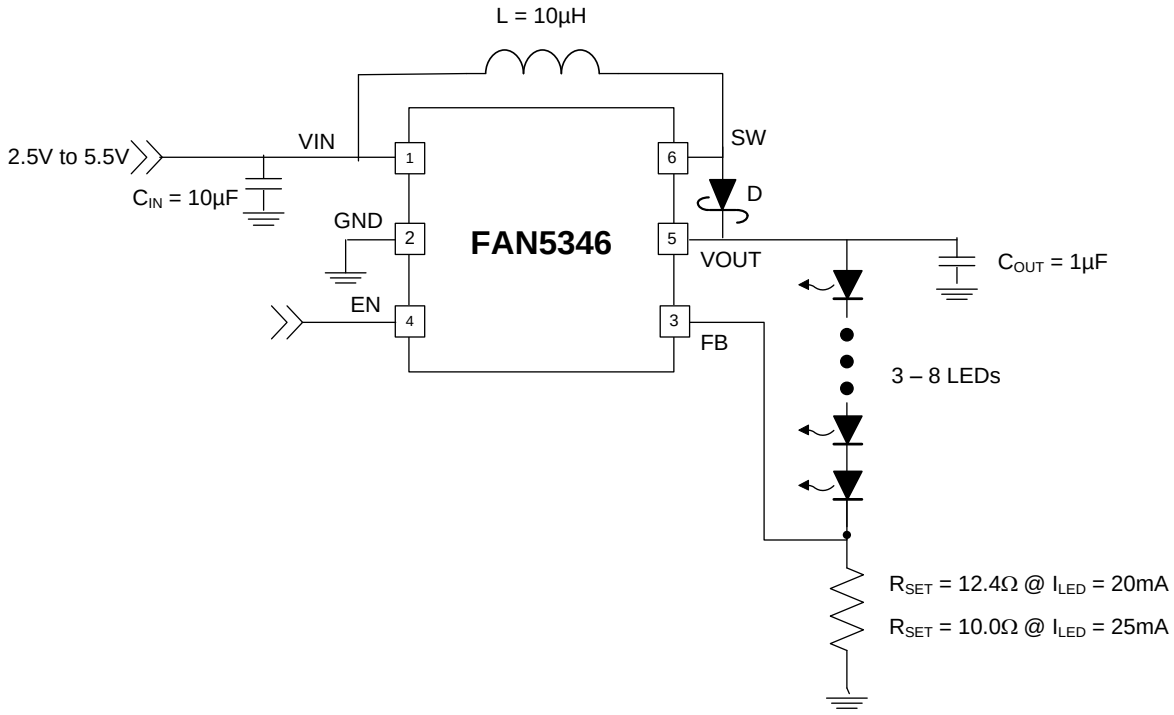


**图1。典型应用**

## 框图

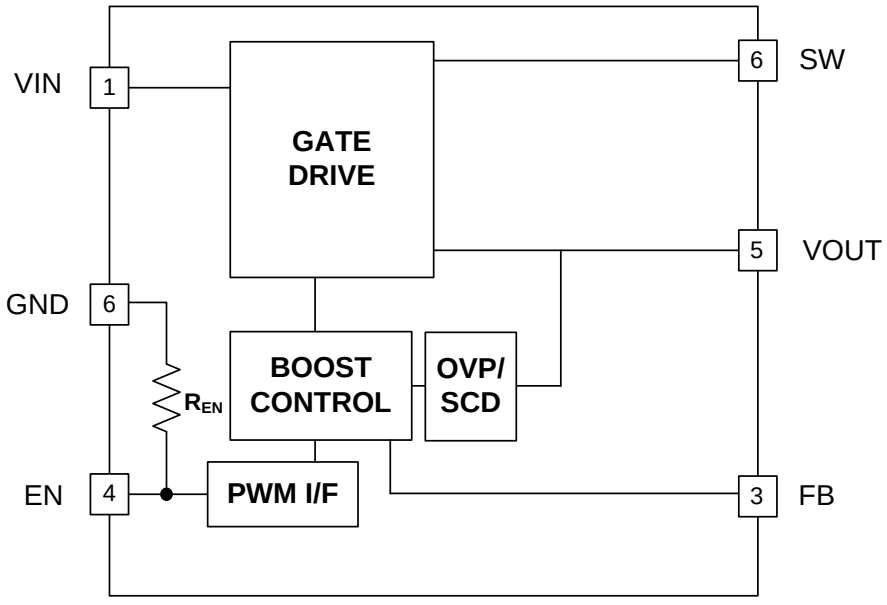


**图2。功能框图**

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## 引脚布局

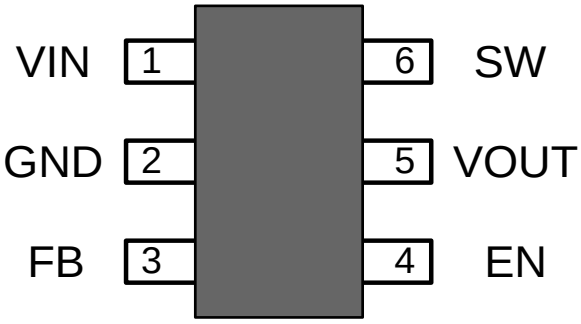


**图3。引脚分配俯视图**

## 引脚说明

| 引脚号 | 名称 | 说明 |
|---|---|---|
| 5 | VOUT | **升压输出电压**。升压稳压器的输出。LED连接到该引脚。连接 $C_{OUT}$（输出电容）至GND。 |
| 1 | VIN | **输入电压**。接入电源，并连接退耦$C_{IN}$至地。 |
| 4 | EN | **启用亮度控制**。采用PWM信号驱动该引脚可编制调光等级。 |
| 3 | FB | **温度反馈**。升压稳压器可将该引脚的电压调至0.250V，以控制LED的串行电流。将该引脚连接GND和LED串阴极之间的电流设置电阻（$R_{SET}$）。 |
| 6 | SW | **开关节点**。将电感L1由VIN引脚连接至SW引脚。 |
| 2 | GND | **接地**。直接连至GND平面。 |

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## 绝对最大额定值

应力超过绝对最大额定值，可能会损坏设备。在超出推荐的工作条件的情况下，该器件可能无法正常运行或操作，且不建议让器件在这些条件下长期工作。此外，过度暴露在高于推荐的工作条件下，会影响器件的可靠性。绝对最大额定值仅是额定应力值。

| 符号 | 参数 | | 最小值 | 最大值 | 单位 |
|---|---|---|---|---|---|
| $V_{IN}$ | VIN 引脚 | | -0.3 | 6.0 | V |
| $V_{FB}$, $V_{EN}$ | FB、EN引脚 | | -0.3 | $V_{IN}$ + 0.3 | V |
| $V_{SW}$ | SW 引脚 | FAN5346S20X | -0.3 | 22.0 | V |
| | | FAN5346S30X | -0.3 | 33.0 | V |
| $V_{OUT}$ | VOUT 引脚 | FAN5346S20X | -0.3 | 22.0 | V |
| | | FAN5346S30X | -0.3 | 33.0 | V |
| ESD | 静电放电防护 | 人体模型满足JESD22-A114 | 1.5 | | kV |
| | | 充电器件模型 JESD22-C101 | 1.5 | | |
| $T_J$ | 结温 | | -40 | +150 | °C |
| $T_{STG}$ | 存储温度 | | -65 | +150 | °C |
| $T_L$ | 引脚焊接温度，10秒 | | | +260 | °C |

## 推荐工作条件

推荐的操作条件表定义了器件的真实工作条件。指定推荐的工作条件，以确保设备的最佳性能达到数据表中的规格。飞兆半导体建议不要超过推荐工作条件，也不能按照绝对最大额定值进行设计。

| 符号 | 参数 | | 最小值 | 最大值 | 单位 |
|---|---|---|---|---|---|
| $V_{IN}$ | $V_{IN}$ 电源电压 | | 2.5 | 5.5 | V |
| $V_{OUT}$ | $V_{OUT}$ 电压[1] | FAN5346S20X | 6.2 | 18.5 | V |
| | | FAN5346S30X | 6.2 | 28.5 | |
| $I_{OUT}$ | $V_{OUT}$ 负载电流 | | 5 | 25 | mA |
| $T_A$ | 环境温度 | | -40 | +85 | °C |
| $T_J$ | 结温 | | -40 | +125 | °C |

**注意：**

1. 应用必须确保最大和最小占空比在20-85%之间，方可满足指定范围。

## 热性能

结-环境之间热阻与具体应用和电路板布局有关。该数据由2s2p四层板测得，符合JESD51-JEDEC标准。特别注意的是，不要超过给定环境温度$T_A$时的结温 $T_{J(max)}$ 。

| 符号 | 参数 | 典型值 | 单位 |
|---|---|---|---|
| $\theta_{JA}$ | 结-环境之间热阻，SSOT23-6 封装 | 151 | °C/W |

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## 电气规格

$V_{IN}$ = 2.7V 至 5.5V, $T_A$= -40° C至 +85° C，除非另有说明。 典型值测量条件为 $T_A$ +25° C 且 $V_{IN}$= 3.6V。

| 符号 | 参数 | 工作条件 | 最小值 | 典型值 | 最大值 | 单位 |
|---|---|---|---|---|---|---|
| **电源** | | | | | | |
| $I_{SD}$ | 停机电源电流 | EN = GND | | 0.30 | 0.90 | μA |
| $I_{Q(ACTIVE)}$ | 静态电流 $I_{LOAD}$ = 0mA | 器件未开关，无负载 | | 300 | | μA |
| $V_{UVLO}$ | 欠压闭锁阈值 | $V_{IN}$ 升 | 2.10 | 2.35 | 2.60 | V |
| | | $V_{IN}$ 降 | 1.80 | 2.05 | 2.30 | |
| $V_{UVHYST}$ | 欠压锁定滞环宽度 | | | 250 | | mV |
| **EN: 使能引脚** | | | | | | |
| $V_{IH}$ | 高电平输入电压 | | 1.2 | | | V |
| $V_{IL}$ | 低电平输入电压 | | | | 0.4 | V |
| $R_{EN}$ | EN 下拉电阻 | | 200 | 300 | 400 | kΩ |
| $f_{PWM}$ | PWM调光频率 (3) | | 5 | | 100 | kHz |
| $t_{SD}$ | EN 低电平， 关断脉宽 | $V_{IN}$ = 3.6V; 自EN的下降沿 | | | 1 | ms |
| **反馈和参考** | | | | | | |
| $V_{FB}$ | 反馈电压 | $I_{LED}$ = 20mA（-40° C至+85° C），2.5V ≤ $V_{IN}$ ≤ 5.5V | 230 | 250 | 270 | mV |
| $I_{FB}$ | 反馈输入电流 | $V_{FB}$ = 250mV | | 0.1 | 1.0 | μA |
| **电源输出** | | | | | | |
| $R_{DS(ON)\_Q1}$ | 升压开关接通电阻 | $V_{IN}$ = 3.6V, $I_{SW}$ = 100mA | | 600 | | mΩ |
| | | $V_{IN}$ = 2.5V, $I_{SW}$ = 100mA | | 650 | | |
| $I_{SW(OFF)}$ | SW 节点漏电流 (2) | EN = 0, $V_{IN}$ = $V_{SW}$ = $V_{OUT}$ = 5.5V, $V_{LED}$ = 0V | | 0.1 | 2.0 | μA |
| $I_{LIM-PK}$ | 升压开关峰值电流限值 | FAN5346S20X: $V_{IN}$= 3.2V 至 4.3V, $T_A$ =-20° C 至 +60° C, $V_F$ = 3.4V, 4 LEDs | 200 | 300 | 400 | mA |
| | | FAN5346S30X | 500 | 750 | 1000 | |
| **振荡器** | | | | | | |
| $f_{SW}$ | 升压稳压器开关频率 | | 0.95 | 1.15 | 1.35 | MHz |
| **输出和保护** | | | | | | |
| $V_{OVP}$ | 升压输出过压保护 (OVP) | FAN5346S20X | 18.0 | 20.0 | 21.5 | V |
| | | FAN5346S30X | 27.5 | 30.0 | 32.5 | |
| | OVP 滞环 | FAN5346S20X | | 0.8 | | |
| | | FAN5346S30X | | 1.0 | | |
| $V_{TLSC}$ | $V_{OUT}$ 短路检测阈值 | $V_{OUT}$ 下降 | | $V_{IN}$ - 1.4 | | V |
| $V_{THSC}$ | $V_{OUT}$ 短路检测阈值 | $V_{OUT}$ 升 | | $V_{IN}$ - 1.2 | | V |
| $D_{MAX}$ | 最大升压占空比 (3,4) | | 85 | | | % |
| $D_{MIN}$ | 最小升压占空比 (3,4) | | | | 20 | |
| $T_{TSD}$ | 热关断 | | | 150 | | ° C |
| $T_{HYS}$ | 热关闭滞环宽度 | | | 35 | | ° C |

**注意：**

2. SW漏电流包括包括两个内部开关的漏电流；SW 至 GND 与 SW 至 $V_{OUT}$。
3. 未经产品测试；由设计保证。
4. 应用必须确保最大和最小占空比在20-85%之间，方可满足指定范围。

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## 典型特性

$V_{IN}$ = 3.6V，$T_A$ = 25°C，$I_{LED}$ = 25mA，L = 10µH，$C_{OUT}$ = 1.0µF，以及$C_{IN}$ = 10.0µF。

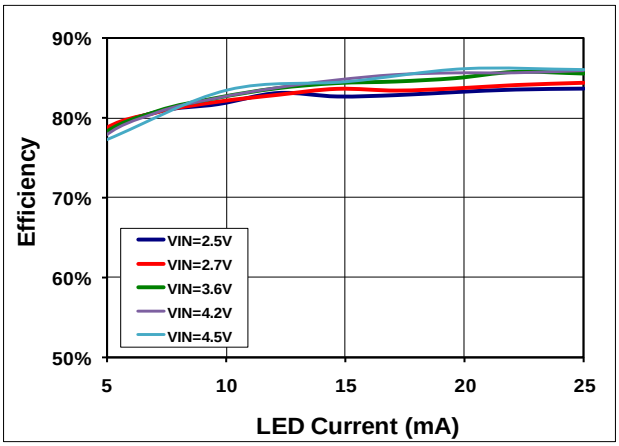


图4。 3 LED： 效率与 LED电流 和 输入电压的关系

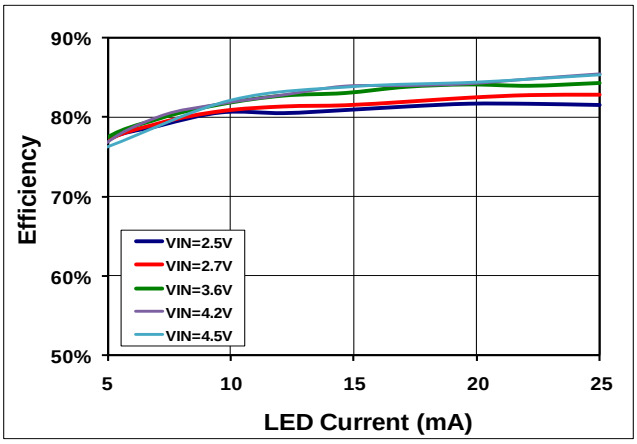


图5。 4个LED： 效率与 LED电流 和 输入电压的关系

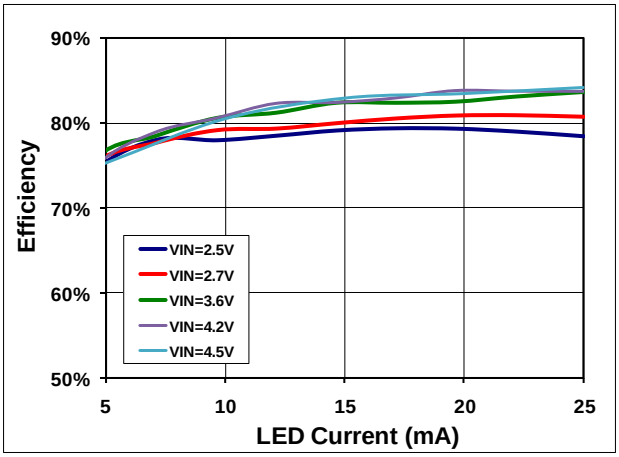


图6。 5个LED： 效率与 LED电流 和 输入电压的关系

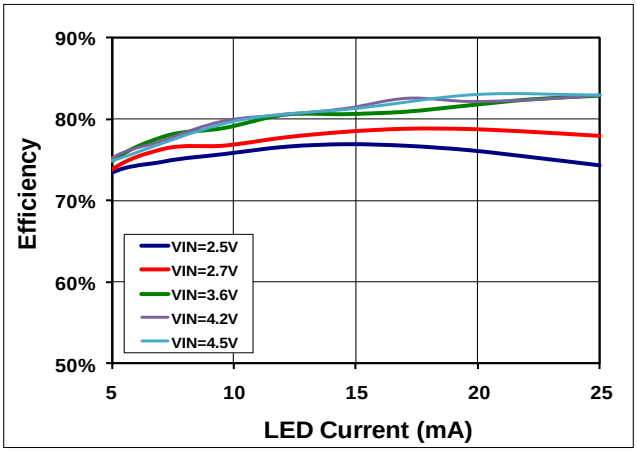


图7。 6个LED： 效率与 LED电流 和 输入电压的关系

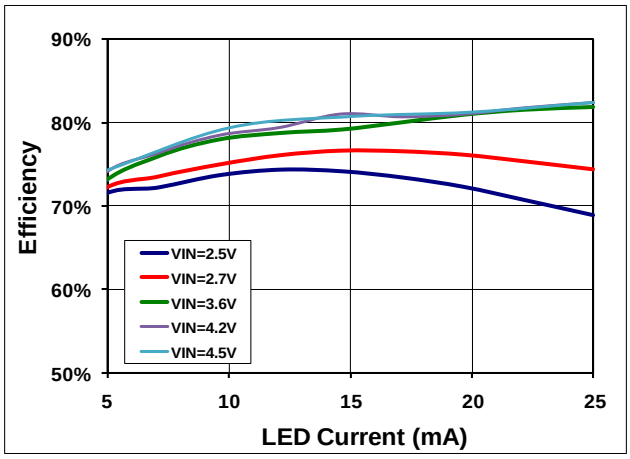


图8。 7个LED： 效率与 LED电流 和 输入电压的关系

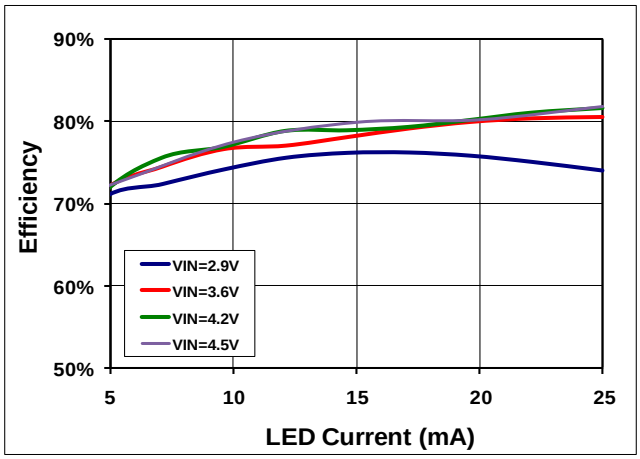


图9。 8个LED： 效率与 LED电流 和 输入电压的关系

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## 典型特性

$V_{IN}$ = 3.6V，$T_A$ = 25°C，$I_{LED}$ = 25mA，L = 10µH，$C_{OUT}$ = 1.0µF，以及$C_{IN}$ = 10.0µF。

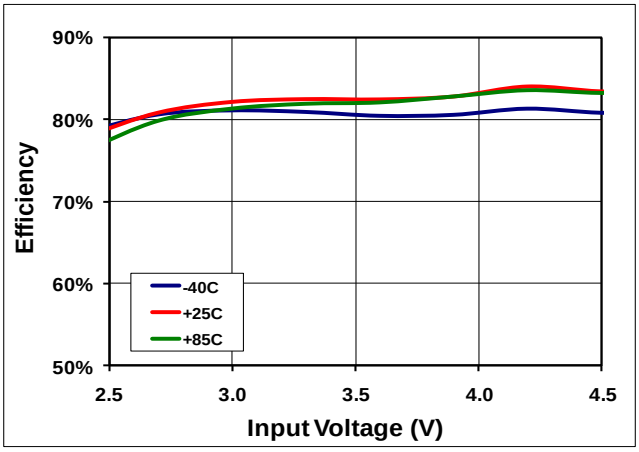


图10。 效率与 输入电压和 温度（5个串联LED）的关系

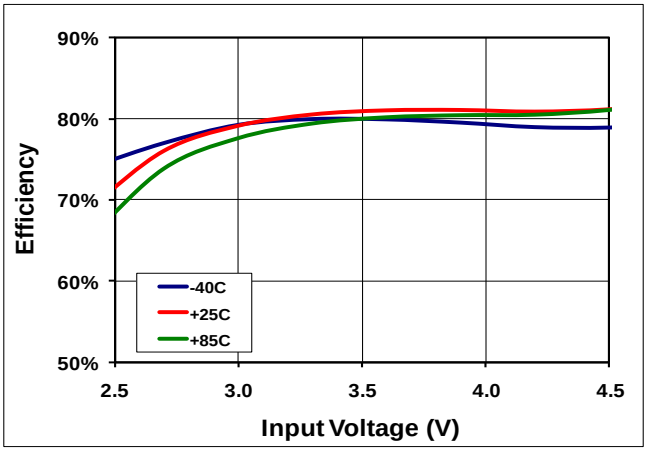


图11。 效率与 输入电压和 温度（7个串联LED）的关系

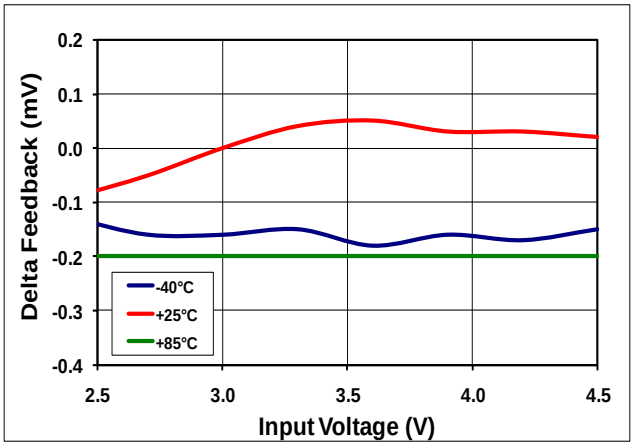


图12。 $V_{FB}$随输入电压和温度的变化，7 LED，L=10µH且$C_{OUT}$=1.0µF

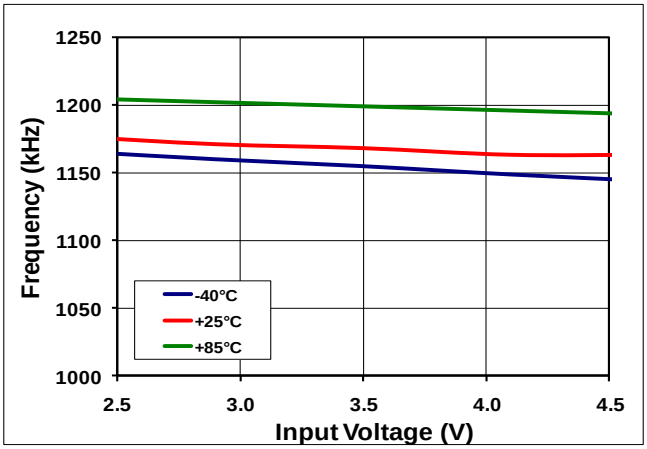


图13。 频率 vs. 输入电压vs. 温度

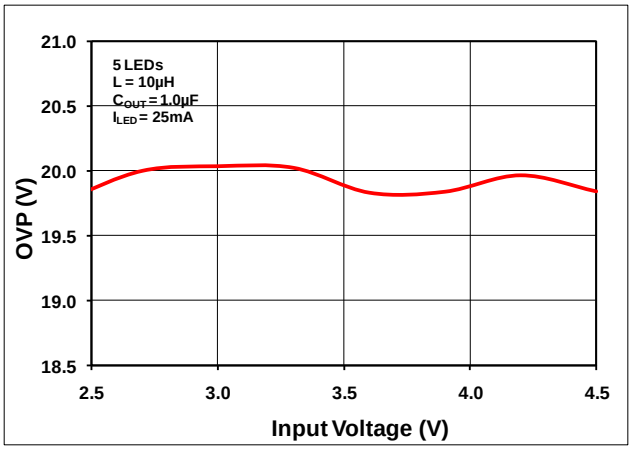


图14。 OVP vs. 输入电压：FAN5346S20X

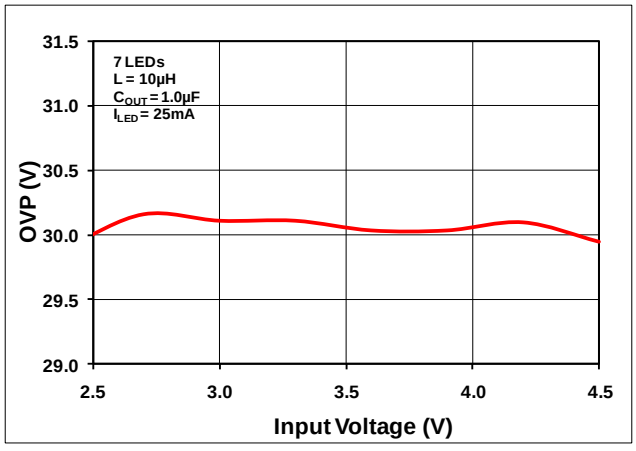


图15。 OVP vs. 输入电压：FAN5346S30X

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## 典型特性

$V_{IN}$ = 3.6V，$T_A$ = 25°C，$I_{LED}$ = 25mA，L = 10µH，$C_{OUT}$ = 1.0µF，以及$C_{IN}$ = 10.0µF。

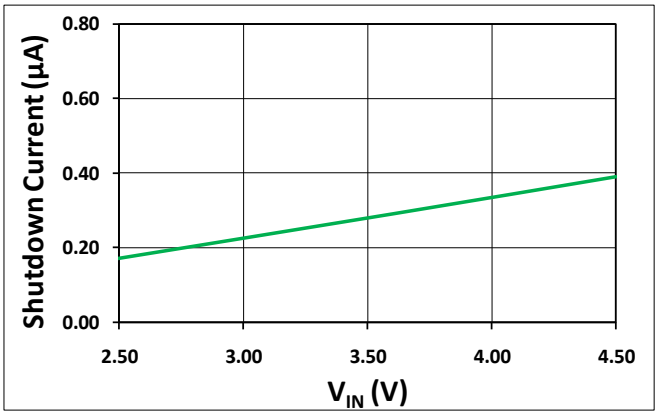


图16。 关断电流与 输入电压的关系

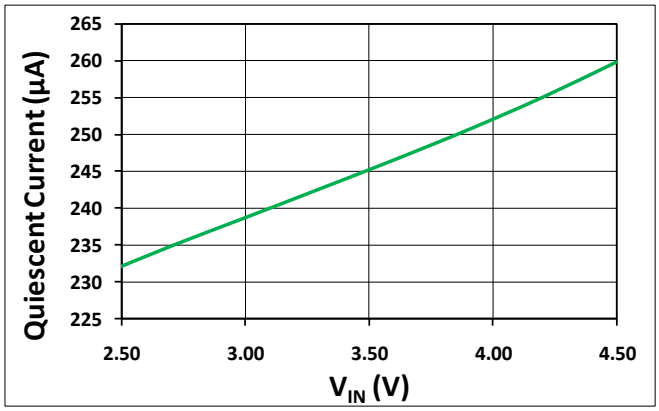


图17。 静态电流与输入电压的关系

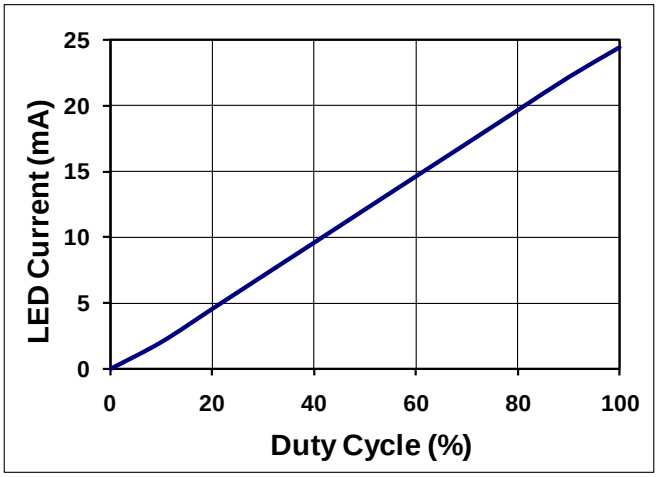


图18。 LED电流与 占空比，$f_{PWM}$ = 20kHz的关系

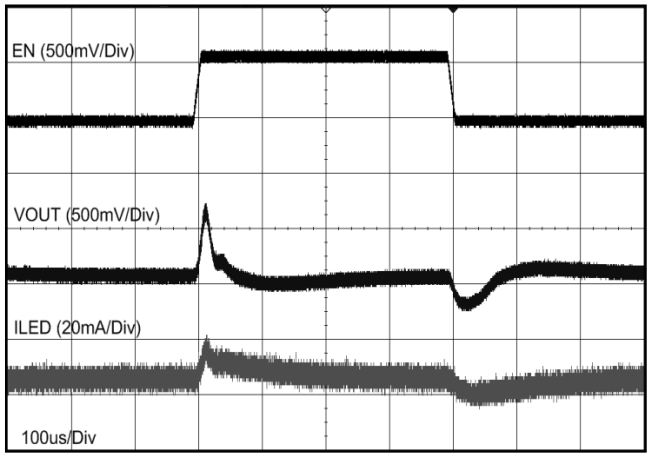


图19。 5 LED 的线性瞬态响应

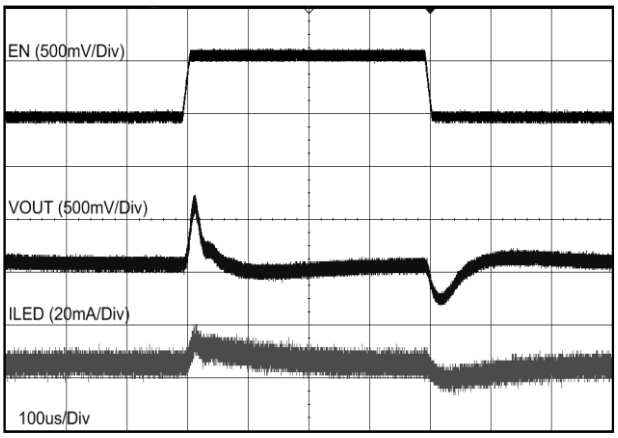


图20。 6 LED 的线性瞬态响应

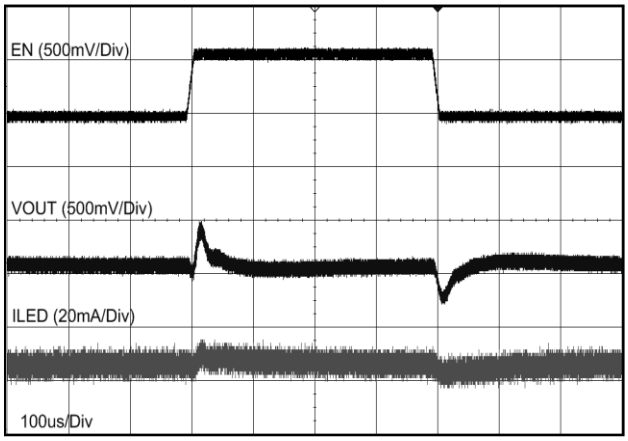


图21。 7个LED的线路瞬态响应

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## 典型特性

$V_{IN}$ = 3.6V，$T_A$ = 25°C，$I_{LED}$ = 25mA，L = 10µH，$C_{OUT}$ = 1.0µF，以及$C_{IN}$ = 10.0µF。

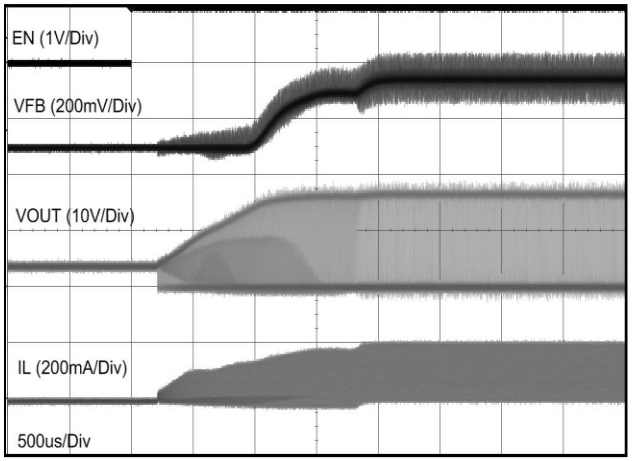


图22。 5只LED时的开关电压、电感电流、$V_{FB}$及EN 的启动波形

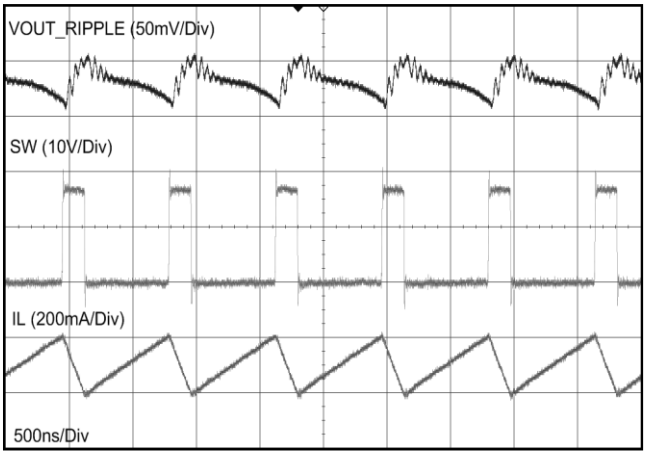


图23。 5 LED的 $V_{OUT}$，开关电压，电感电流的稳态波形

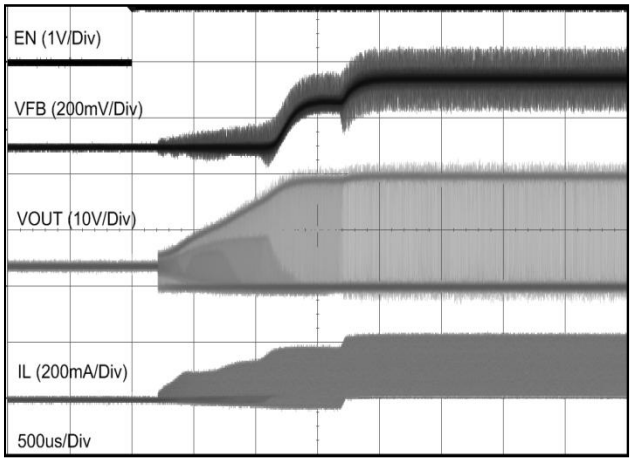


图24。 5只LED时的开关电压、电感电流、$V_{FB}$及 EN 的启动波形

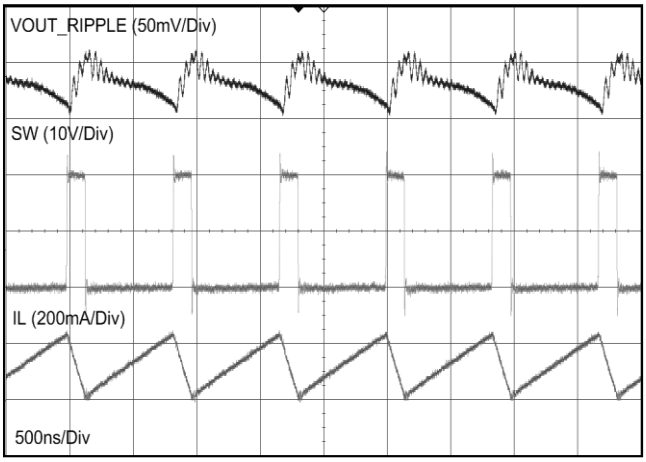


图25。 5 LED的$V_{OUT}$，开关电压，电感电流的稳态波形

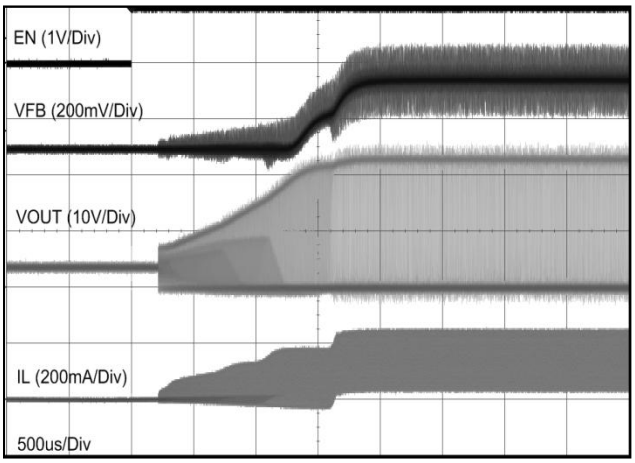


图26。 5只LED时的开关电压、电感电流$V_{FB}$及EN 的启动波形

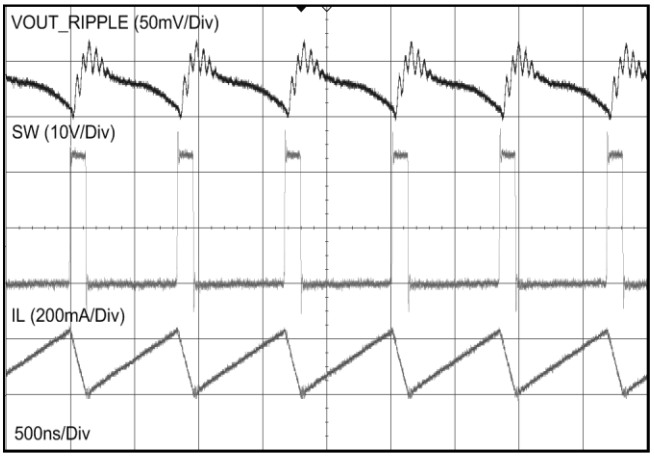


图27。 5 LED的$V_{OUT}$，
开关电压，电感电流的稳态波形

# 电路说明

## 概述

FAN5346是一种感应电流模式升压串联LED驱动器，通过保持电阻$R_{SET}$端电压为0.250V，实现LED电流调节。LED串的电流($I_{LED}$)的计算公式为：

$$I_{LED} = \frac{0.250}{R_{SET}} \quad (1)$$

输出电压$V_{OUT}$取决于每只LED的正向电压与$R_{SET}$端电压之和，端电压为恒值250mV。

## 驱动八只串联LED

FAN5346S30X可以驱动8只串联LED，但是输入电压($V_{IN}$)的最小值必须大于或等于2.9V，而白色LED的正向电压应该小于或等于3.2V，同时为了维持稳态运行，LED的最大电流不能超过20mA。

## UVLO 和软启动

假定$V_{IN}$高于UVLO阀值，如果EN处于低电平时间超过1ms，当EN上升时，IC开始“冷启动”的软启动。

## PWM 调光

FAN5346 使用 PWM 信号直接调节LED串的输出电流，从而改变LED的亮度。EN引脚高电平时，FB电压为250mV。在EN引脚上施加 PWM 信号时，电压降低，因而可令LED变暗。FB电压可根据下式得出：

$$V_{FB} = DutyCycle \times 250mV \quad (2)$$

其中 DutyCycle = PWM 信号的占空比，250mV为内部参考电压。

图 28显示 FAN5346 以PWM信号的占空比来划分内部 250mV 的参考电压。PWM 信号通过低通滤波器，然后再输入故障放大器，作为FB引脚的参考电压。

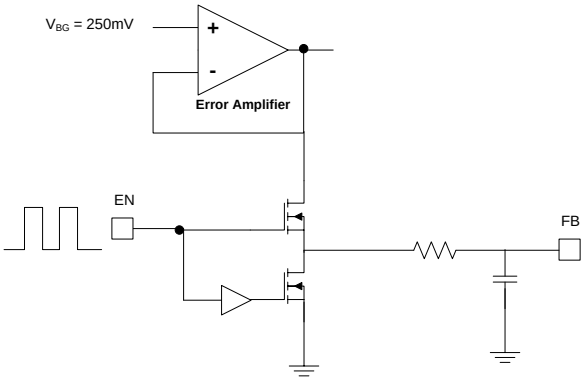


**图 28. PWM 调光的FB和EN电路框图**

## 过流和短路检测

对于FAN5346S20X
与FAN5346S30X，升压稳压器的逐周期电感电流峰值限制分别为300mA（典型值）与750mA（典型值）。

## 过压/开路保护

如果LED串开路，FB保持为0V，且当没有过压保护（OVP）电路时，输出电压持续增加。当输出电压$V_{OUT}$超过20V时，FAN5346S20X的过压保护（OVP）电路启动，保持稳压器升压调节关闭，直到$V_{OUT}$跌落低于19V为止。对于FAN5346S30X，过压保护值是30V，且当$V_{OUT}$低于29V时，该器件恢复正常状态。

## 热关断

晶圆温度超过150° C时，发生复位并保持，直至晶圆冷却至115 °C；此时允许电路开始软启动序列。

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## 应用信息

参考原理图如图 29中所示。在输入电压大于等于2.9V（$V_{IN}$ ≥ 2.9V）时，FAN5346可以驱动多达8只LED。但是，FAN5346可以使用的LED数量取决于正向电压。建议白色LED的正向电压（$V_F$）不高于3.2V，LED的最大电流为20mA。通过将$V_{OUT}$端直接与负载相连，FAN5345可以用作升压转换器。负载的回线也应该通过检测电阻（R1）返回到地。

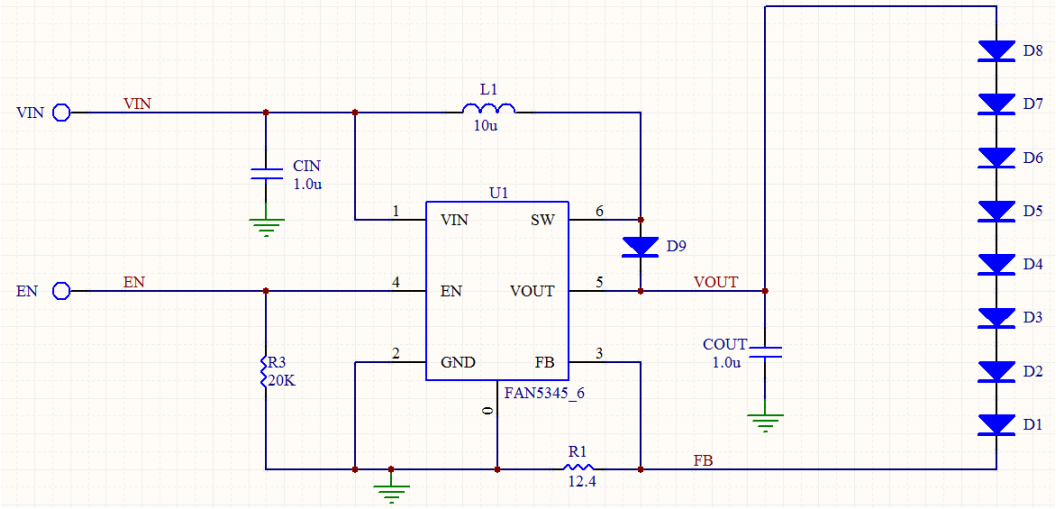


图 29. 参考应用原理图

## 推荐的器件和PCB布局

FAN5346可以升高输出电压，工作频率为1.2MHz。为了确保稳定输出并阻止噪声的产生，应当谨慎地考虑元器件的摆放与PCB布局。图30给出了FAN5346评估板的一部分。关键布局器件包括： L1，$C_{IN}$，$C_{IN}$ 回线，$C_{OUT}$，以及 $C_{OUT}$ 回线。

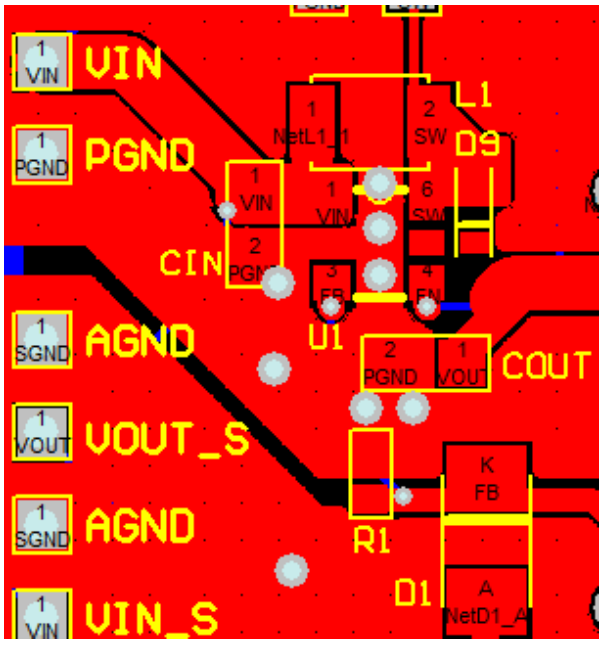


图 30. 参考用 PCB 布局

### 输入电容与回线

在降压或升压开关稳压器 PCB布局中，应优先考虑输入电容。一个稳定的输入电源（$V_{IN}$）可以使得开关型稳压器表现出最佳性能。稳压器运行时，其开关频率很高，这将引起$C_{IN}$的负载剧烈变化，因为这将使得输入电源按照相同的稳压器开关频率变化。为了确保稳定的输入电源，$C_{IN}$需要保持足够的能量，才能最小化稳压器输入引脚的变化。为了使 $C_{IN}$ 具有快速的充放电响应，$C_{IN}$与稳压器输入引脚之间布线以及$C_{IN}$与稳压器GND之间的回线应该尽可能的粗短，以此来最小化布线电阻、电感与电容。在运行过程中，开关过程会导致由$C_{IN}$流入、流经稳压器后从负载流出、并流回$C_{IN}$的电流含有高频波动。由于$I^2R$损耗的缘故，布线电阻可以降低总效率。更进一步地，即使是小布线电感也能有效地引起地电平的变化，给VOUT带来噪声。应该将输入电容就近放置在稳压器的VIN与GND引脚旁，并且布线应该越短越好。由于过孔在高频时具有很强的电感效应，因此应该避免在不同层间布置回线。如果不可避免的要布线到其他的PCB层，那么过孔应紧靠稳压器的VIN与GND引脚，以此来最小化布线距离。

### 输出电容与回线

输出电容不仅与输入电容具有相同的作用，而且也能保证输出电压稳定。如上所述，电流流向负载并返回到$C_{OUT}$的GND端。$C_{OUT}$ 应该就近放置在VOUT引脚处。$C_{OUT}$到L1、VOUT间的布线以及由负载到$C_{OUT}$间的回线应尽可能的短粗，以此来最小化布线电阻与电感。为了最小化负载的耦合噪声，可以在VOUT与$C_{OUT}$间放置一低容值电容，这样，高频噪声在到达负载前即可回到地中。

### 电感
根据以上原因，电感（L1）应该尽可能近地放置在稳压器附近，以此来最小化布线电阻与电容。

### 检测电阻
根据检测电阻提供的反馈信号，稳压器控制输出电压。检测电阻到FB引脚的长布线向FB引脚耦合了噪声。如果FB引脚耦合了噪声，那么将会引起开关稳压器的不稳定运行，进而影响应用性能。检测电阻到FB引脚的回线应该简短，且远离一切高频开关信号线。没有必要将地平面放置在回线之下。如果回线下的地平面有噪声，但是与稳压器的地平面不同，该噪声就会通过PCB寄生电容耦合到FB引脚，产生噪声输出。

如在 中所示图 30，$C_{IN}$, $C_{OUT}$ 与 L1 均靠近稳压器放置。所有的布线都放在同一层，可以减小地平面电阻、电感。整个PCB面积为67.2mm2 $^{2}$(7.47mm x 8.99mm)不包括检测电阻。

**表1。建议使用的外部器件**

| 电感 (L) | 器件编号 | 生产厂商 |
|---|---|---|
| 10.0µH | LQH43MN100K03 | Murata |
| | NLCV32T-100K-PFR | TDK |
| | VLF3010AT-100MR49-1 | TDK |
| | DEM2810C 1224-AS-H-100M | TOKO |
| **最小 $C_{OUT}$** | | |
| 1.0µF | CV105X5R105K25AT | AVX/Kyocera |
| **最小 $C_{IN}$** | | |
| 10.0µF | GRM21BR71A106KE51L | Murata |
| **肖特基二极管** | | |
| N/A | RBS520S30 | 飞兆半导体 |
| N/A | RB520S-30 | Rohm |

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## 物理尺寸测试

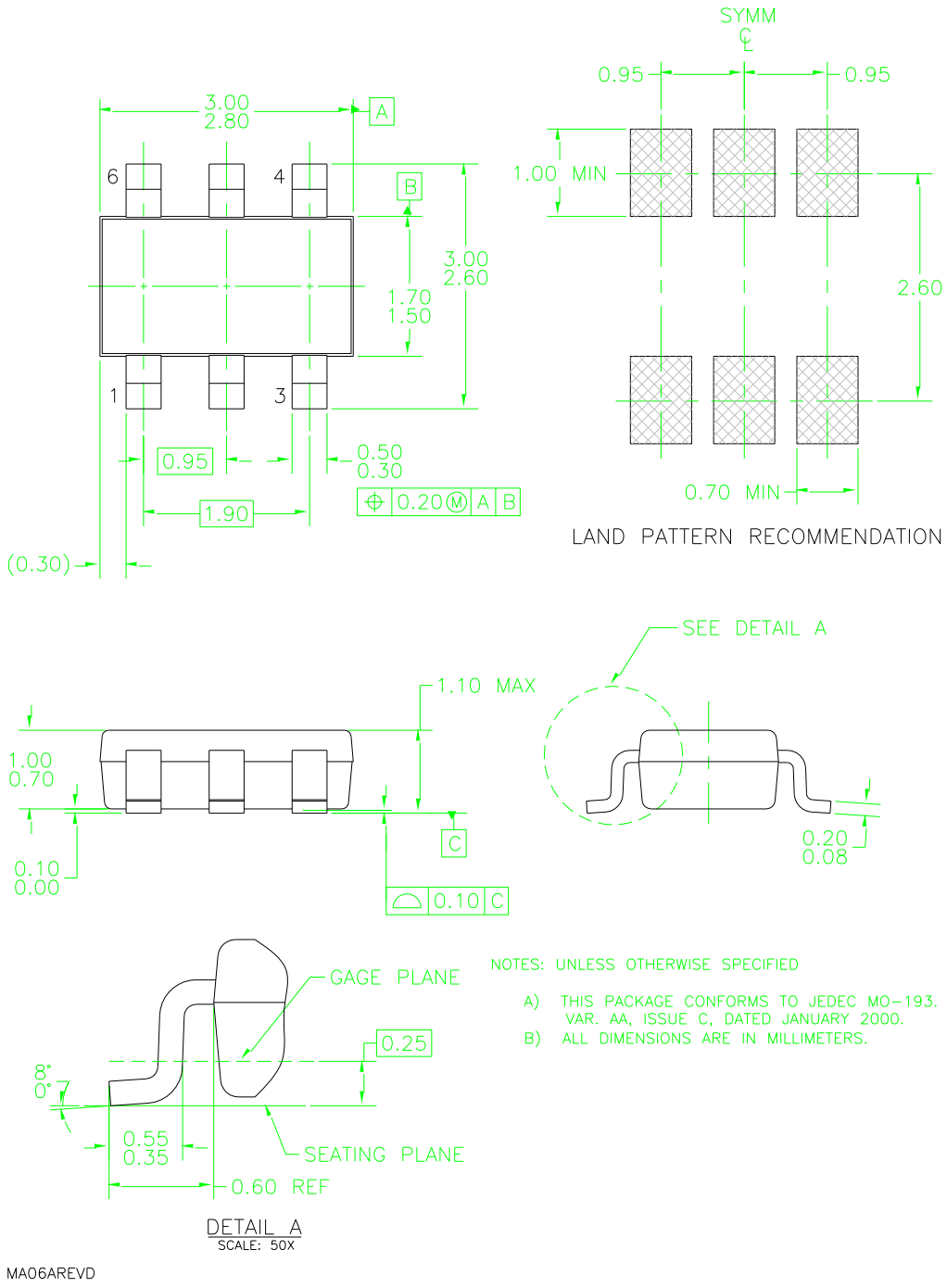


**图31。6引脚、SuperSOT™-6、JEDEC MO-193、1.6mm宽**

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