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## FLS3217 / FLS3247

# 具有集成功率MOSFET的单级功率因数校正的原边反馈离线式 LED 驱动控制器

### 特性

- 无输入大电容和反馈电路的高性价比解决方案
- 功率因数校正 (PFC)
- 集成功率MOSFET
- 不依赖在线电压、输出电压及电感变化的精确恒定电流 (CC) 控制
- 提高效率的线性频率控制
- 开路/短路LED保护
- 逐周期限流
- 过温保护 (带自动重启)
- 低启动电流: 20  $\mu$  A
- 低工作电流: 5 mA
- $V_{DD}$  过压保护 (OVP)
- $V_{DD}$  欠压锁定 (UVLO)
- 应用电压范围: 80V<sub>AC</sub> ~ 308 V<sub>AC</sub>

### 应用

- LED 照明系统

### 说明

FLS3217 / FLS3247 为高度集成的脉宽调制控制器及功率 MOSFET, 具有多种功能, 可以提高低功率反激式转换器的性能。该专有拓扑使 LED 照明应用的电路设计得以简化。

通过使单级PFC的原边反馈拓扑, LED 照明电路板能采用更少的外部元件实现, 从而将成本降至最低, 无需大容量输入电容或反馈电路。为了实现较好的功率因数和较低的总谐波失真度, 采用一个连接至 COM1 引脚的外部电容进行恒定导通时间控制。

与输入输出电压的变化相比, 精确的恒定电流控制可精确控制输出电流。工作频率与输出电压成比例调节, 以保证 DCM 能够更加高效低运行, 其设计也更为简单。

FLS3217 和 FLS3247 具有保护功能, 例如 LED 开路保护、LED 短路保护和过温保护。电流限制电平自动降低以将输出电流降至最低, 在短路LED情况下保护外部器件。

### 订购信息

器件编号	工作温度范围	封装	包装方法
FLS3217M	-40° C至 +125° C	7 引脚小外形封装 (小外形集成电路, S01C)	卷带和卷盘
FLS3217N		7 引脚小外形封装 (双列直插式封装, DIP)	塑料管
FLS3247N			

应用框图

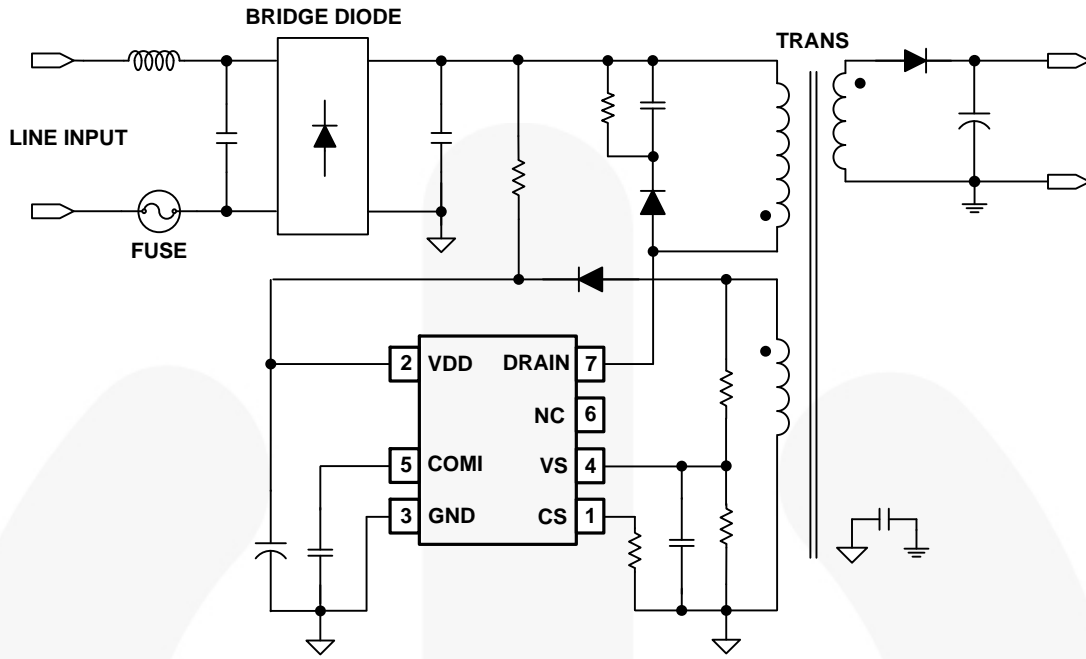


图1. 典型应用

内部框图

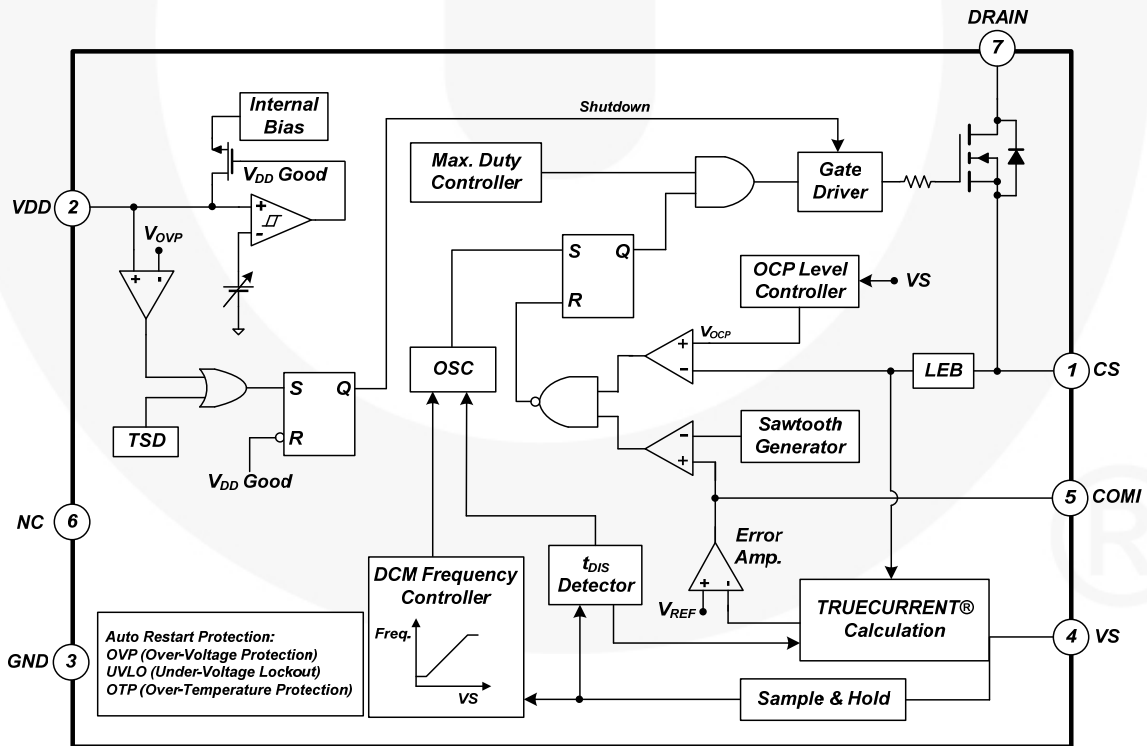


图2. 功能框图

## 标识信息

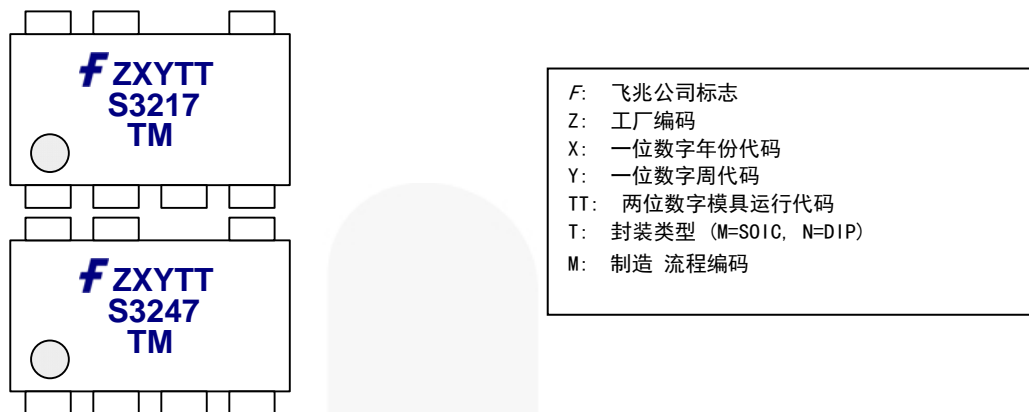


图3. 顶标

## 引脚布局

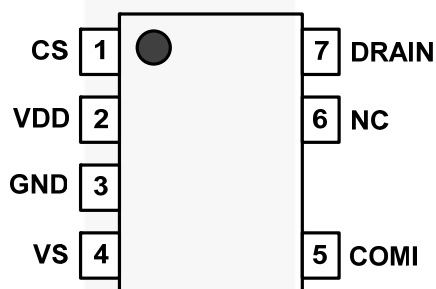


图4. 引脚布局

## 引脚定义

引脚号	名称	说明
1	CS	<b>电流检测。</b> 此引脚连接电流检测电阻，用来检测 MOSFET 电流，进行恒流调节中的输出电流调节。
2	VDD	<b>电源。</b> 集成电路工作电流和 MOSFET 驱动电流通过此引脚提供。
3	GND	<b>接地</b>
4	VS	<b>电压检测。</b> 此引脚检测输出电压信息，以及最大频率控制和恒流调节的放电时间。此引脚通过分压器电阻与变压器辅助绕组相连。
5	COMI	<b>恒流环路补偿。</b> 此引脚与 COMI 和 GND 之间的电容器相连，实现补偿电流回路增益。
6	NC	未连接
7	DRAIN	<b>功率 MOSFET 漏极。</b> 此引脚是高压功率 MOSFET 漏极。

## 绝对最大额定值

应力超过绝对最大额定值，可能会损坏器件。在超出推荐的工作条件的情况下，该器件可能无法正常工作，所以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应力规格值。

符号	参数		最小值	最大值	单位
V <sub>VDD</sub>	直流电源电压 <sup>(1,2)</sup>			30	V
V <sub>VS</sub>	VS 引脚输入电压		-0.3	7.0	V
V <sub>CS</sub>	CS 引脚输入电压		-0.3	7.0	V
V <sub>COM1</sub>	COM1 引脚输入电压		-0.3	7.0	V
I <sub>D</sub>	连续漏极电流	T <sub>A</sub> =25° C, FLS3217M/N		1	A
		T <sub>A</sub> =25° C, FLS3247N		4	
I <sub>DM</sub>	脉冲漏极电流	FLS3217M/N		4	A
		FLS3247N		16	
I <sub>AR</sub>	雪崩电流	FLS3217M/N	-	1	A
		FLS3247N		4	
P <sub>D</sub>	功耗	S01C, T <sub>A</sub> <50° C		660	mW
		DIP, T <sub>A</sub> <50° C		1	W
Θ <sub>JA</sub>	热阻 (结到空气)	S01C, T <sub>A</sub> <50° C		150	° C/W
		DIP, T <sub>A</sub> <50° C		95	
Θ <sub>JC</sub>	热阻 (结到外壳)	S01C, T <sub>A</sub> <50° C		40	° C/W
		DIP, T <sub>A</sub> <50° C		25	
T <sub>J</sub>	最大结温			+150	° C
T <sub>STG</sub>	存储温度范围		-55	+150	° C
T <sub>L</sub>	焊接温度 (焊接 10 秒)			+260	° C
ESD	静电放电能力, 人体放电模型			5	V
	静电放电能力, 组件充电模式			2	

### 注意:

1. 若压力超过绝对最大额定值中所列的数值，可能会给器件造成不可修复的损坏。
2. 测得的所有电压，除差模电压之外，都参照GND引脚。

## 推荐工作条件

推荐的工作条件表明了器件的真实工作条件。指定推荐的工作条件，以确保器件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
T <sub>A</sub>	操作环境温度	-40	125	° C

## 电气特性

除另有规定外,  $V_{DD}=15\text{ V}$  且  $T_A=25^\circ\text{ C}$ 。

符号	参数	条件	最小值	典型值	最大值	单位	
<b>MOSFET 部分</b>							
$BV_{DSS}$	漏极-源极击穿电压	$I_D=250\ \mu\text{A}$ , $V_{GS}=0\text{ V}$	700			V	
$R_{DS(ON)}$	静态漏源通态电阻	FLS3217M	$I_D=0.5\text{ A}$ , $V_{GS}=10\text{ V}$		13	16	$\Omega$
		FLS3217N			8.8	11.0	$\Omega$
		FLS3247N	$I_D=1\text{ A}$ , $V_{GS}=10\text{ V}$		2.4	2.8	$\Omega$
$C_{ISS}$	输入电容	FLS3217M	$V_{DS}=0\text{ V}$ , $V_{GS}=25\text{ V}$ , $f_s=1\text{ MHz}$		175	200	pF
		FLS3217N			250		pF
		FLS3247N			435		pF
$C_{OSS}$	输出电容	FLS3217M	$V_{GS}=0\text{V}$ , $V_{DS}=25\text{V}$ , $f_s=1\text{MHz}$		23	25	pF
		FLS3217N			25		pF
		FLS3247N			51		pF
<b><math>V_{DD}</math>部分</b>							
$V_{DD-ON}$	启动阈值电压		14.5	16.0	17.5	V	
$V_{DD-OFF}$	断开阈值电压		6.75	7.75	8.75	V	
$I_{DD-OP}$	工作电流	$V_S=2.4\text{ V}$ , $C_L=\text{MOSFET } C_{ISS}$	2.85	4.00	5.00	mA	
$I_{DD-ST}$	启动电流	$V_{DD}=V_{DD-ON} - 0.16\text{ V}$		2	20	$\mu\text{ A}$	
$V_{OVP}$	$V_{DD}$ 过压保护水平		22.0	23.5	25.0	V	
<b>振荡器部分</b>							
$f_{MAX-CC}$	恒流最大频率	$V_{DD}=10\text{ V}$ , $20\text{ V}$	60	65	70	kHz	
$f_{MIN-CC}$	恒流最小频率	$V_{DD}=10\text{ V}$ , $20\text{ V}$	21.0	23.5	26.0	kHz	
$V_{S_{MAX-CC}}$	恒流最大频率时 $V_S$ 电压	频率=最大频率-2 kHz	2.25	2.35	2.45	V	
$V_{S_{MIN-CC}}$	恒流最小频率时 $V_S$ 电压	频率=最大频率+1 kHz	0.55	0.85	1.15	V	
$t_{ON(MAX)}$	最大开启时间		12	14	16	$\mu\text{s}$	
<b>电流检测部分</b>							
$V_{RV}$	参考电压		2.475	2.500	2.525	V	
$V_{CCR}$	CS 引脚电压变化测试, 用以恒流调节	$V_{CS}=0.24\text{ V}$	2.38	2.43	2.48	V	
$t_{LEB}$	前沿消隐时间			300		ns	
$t_{MIN}$	恒流模式下的最小导通时间	$V_{VS}=-0.5\text{ V}$ , $V_{GS}=1.5\text{ V}$		600		ns	
$t_{PD}$	GATE 输出传播延迟		50	100	150	ns	
$D_{SAW}$	SAW 限制器占空比			40		%	
$t_{DIS-BNK}$	$t_{DIS}$ VS电压消隐时间			1.5		$\mu\text{s}$	
$I_{VS-BNK}$	VS电压检测消隐时VS脚电流			100		$\mu\text{A}$	

接下页

**电气特性 (续)**除另有规定外,  $V_{DD}=15V$  且  $T_A=25^\circ C$ 。

符号	参数	条件	最小值	典型值	最大值	单位
<b>电流误差放大器部分</b>						
$G_m$	跨导			85		$\mu mho$
$I_{COM1-SINK}$	COM1 灌电流	$V_{EAI}=3 V, V_{COM1}=5 V$	25		38	$\mu A$
$I_{COM1-SOURCE}$	COM1 拉电流	$V_{EAI}=2 V, V_{COM1}=0 V$	25		38	$\mu A$
$V_{COM1-HGH}$	COM1 高压	$V_{EAI}=2 V$	4.7			V
$V_{COM1-LOW}$	COM1 低压	$V_{EAI}=3 V$			0.1	V
<b>过流保护部分</b>						
$V_{OCP}$	$V_{CS}$ 过流保护阈值电压		0.60	0.67	0.74	V
$V_{LowOCP}$	$V_{CS}$ 低过流保护阈值电压		0.13	0.18	0.23	V
$V_{LowOCP-EN}$	启用低过流保护的 $V_S$ 阈值电压			0.40		V
$V_{LowOCP-DIS}$	禁用低过流保护的 $V_S$ 阈值电压			0.60		V
<b>过温保护部分</b>						
$T_{OTP}$	过温保护阈值温度 <sup>(3)</sup>		140	150	160	$^\circ C$
$T_{OTP-HYS}$	重新启动结温滞回			10		$^\circ C$

**注:**

3. 当过温保护 (OTP) 激活后, 电源系统进入自动恢复模式并禁止输出。

### 典型性能特征

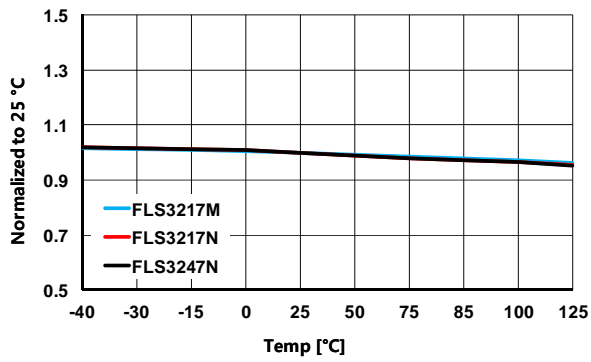


图5.  $V_{DD-ON}$  与温度的关系

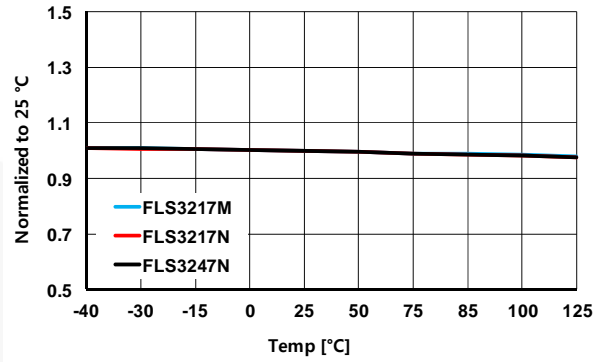


图6.  $V_{DD-OFF}$  与温度的关系

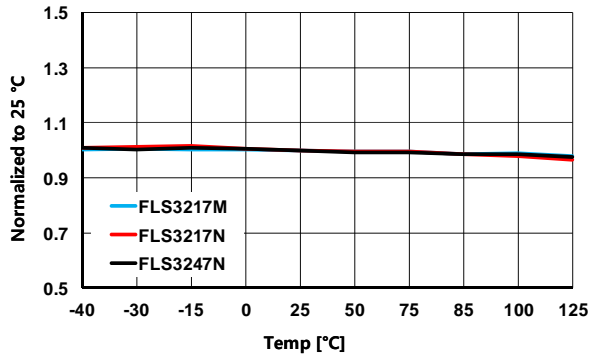


图7.  $I_{DD-OP}$  与温度的关系

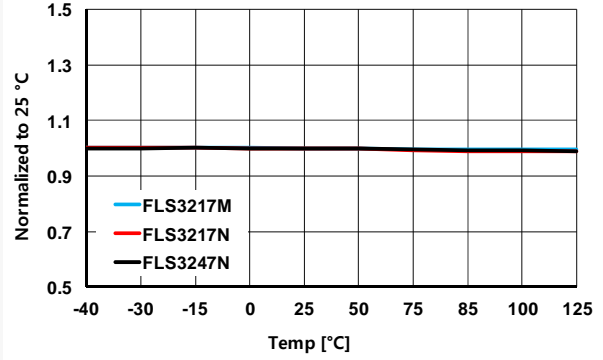


图8.  $V_{ADCP}$  与温度的关系

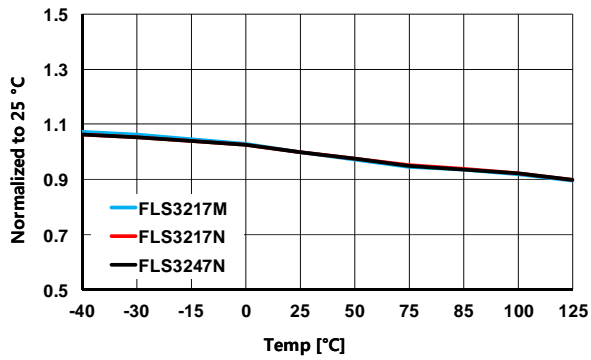


图9.  $f_{MAX\_GG}$  与温度的关系

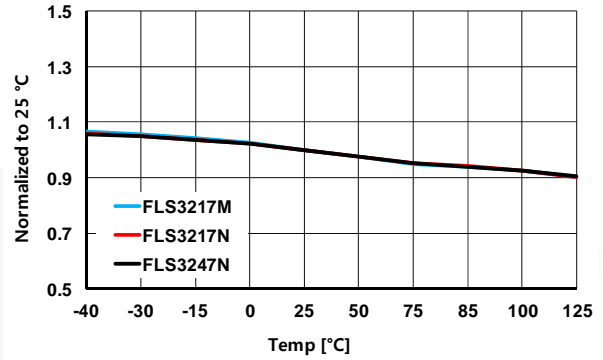


图10.  $f_{MIN\_GG}$  与温度的关系



典型性能特征 (续)

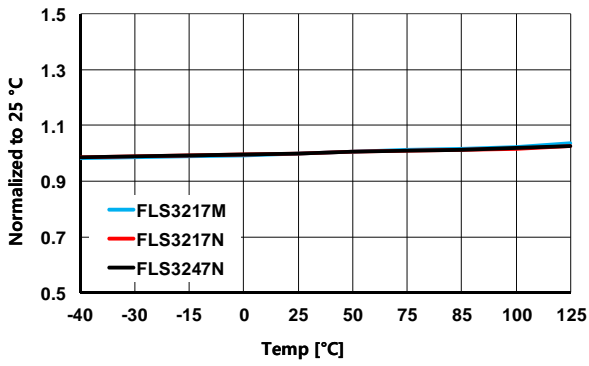


图11.  $V_{OCR}$ 与温度的关系

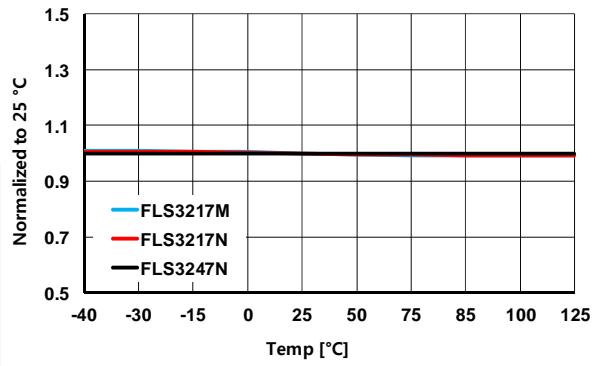


图12.  $V_{OCR}$ 与温度的关系

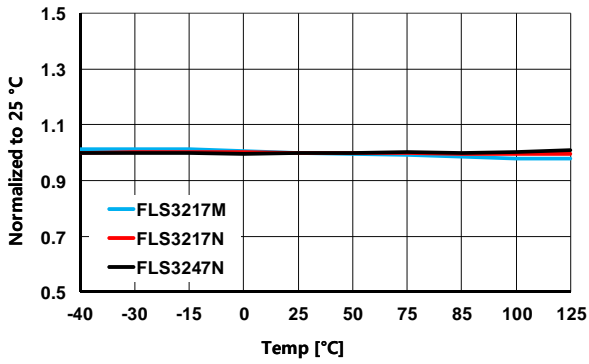


图13.  $V_{OCP}$ 与温度的关系

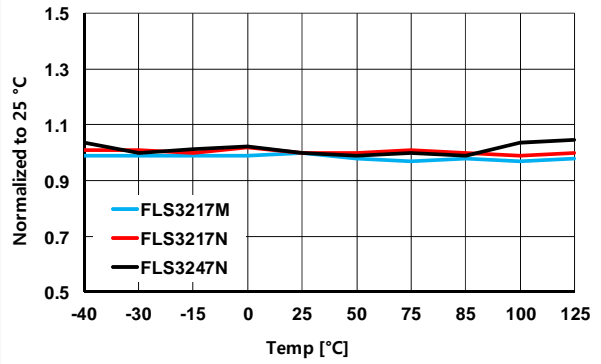


图14.  $V_{OCP\_Low}$ 与温度对比

## 功能说明

FLS3217 / FLS3247 是一种交流-直流脉宽调制控制器，用于 LED 照明应用。TRUECURRENT® 技术能够精确控制 LED 电流，不依赖于输入电压、输出电压和电感量变化。振荡器中的线性频率控制能够减少导通损耗，保持 DCM 模式在宽范围输出电压下运行，在单级反激式拓扑结构下实现高功率因数校正。诸如 LED 开路/短路保护、过温保护、逐周期限流等一系列保护措施，能够使系统稳定运行，保护外部元件。

## 启动

由于功率因数校正转换器中的反馈回路带宽较低，因此启动阶段的供能较为缓慢。为了加快启动阶段的供能，内部振荡器计时 12 ms 作为启动模式。在启动模式中，导通时间取决于电流模式控制，限制 0.2 V 电压。跨导增强 14 倍，如图所示图15。启动模式后，接通时间由电压模式控制，即 COM1 电压决定。误差放大器跨导减小到 85  $\mu\text{mho}$ 。

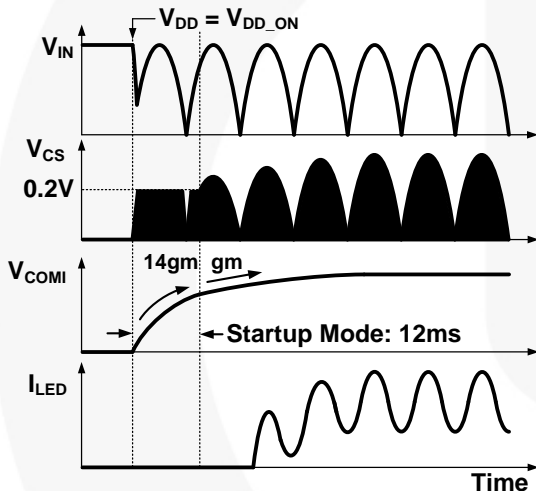


图15. 启动顺序

## 恒流调节

由于输出电流与稳定状态时二极管电流的平均值相等，因此可以通过峰值漏极电流和电感电流放电时间来估计输出电流。漏极电流峰值取决于 CS 引脚，电感放电时间 ( $t_{DIS}$ ) 由  $t_{DIS}$  探测器检测。通过使用三种数据（峰值漏极电流、电感放电时间和工作周期），TRUECURRENT 综合计算预估输出电流。TRUECURRENT 计算结果与内部精确基准进行比较，能够生成误差电压  $V_{COM1}$ ，它可以决定电压模式控制中的导通时间。凭借飞兆公司的创新技术，恒流输出可以实现精确控制。

## 功率因数校正 (PFC) 和 总体谐波失真 (THD)

在传统升压变换器中，临界导通模式 (BCM) 通常用于保持输入电流与输入电压同相，以控制功率因数 (PF) 和总体谐波失真 (THD)。在反激式/升降压拓扑中，恒定导通时间和恒定频率 | 不连续导通模式 (DCM) 可以实现高功率因数和低总谐波失真度，如图 16 所示。恒定导通时间由内部误差放大器以及 COM1 引脚较大的外部电容（通常超过 1  $\mu\text{F}$ ）维持。恒定频率和 DCM 运行由线性频率控制来管理。

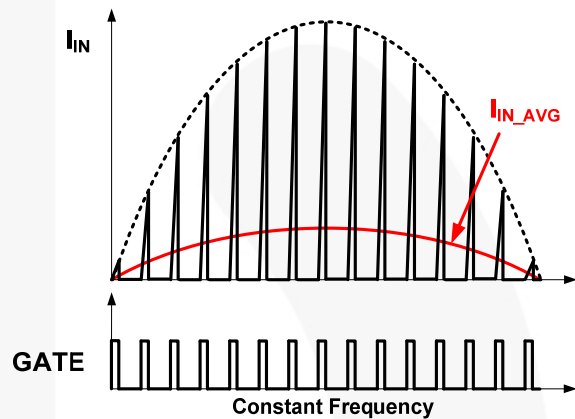


图16. 输入电流和切换

## 线性频率控制

在反激式拓扑中，应当确保工作于 DCM 模式以保证达到高功率因数。为了保持在宽范围输出电压下，线性频率控制中的频率应根据输出电压而发生线性变化。输出电压由辅助线圈和连接 VS 引脚的分压电阻检测，如图所示。图17

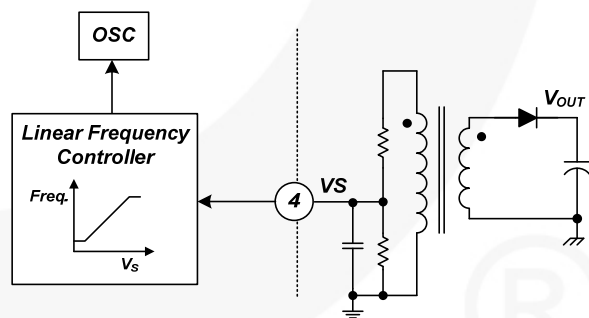


图17. 线性频率控制

当输出电压降低时，次级二极管传导时间增加，线性频率控制会延长切换周期。这可以保持在 DCM 在宽范围输出电压下运行，如图所示图18。在满载条件下，频率控制还会调低电流有效值，获得更高效率。

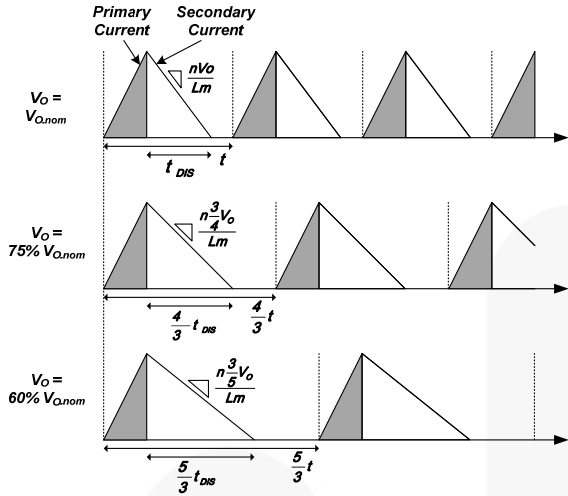


图18. 初级电流和次级电流

### BCM 控制

次级二极管导通时间末尾可能超过线性频率控制设定的开关周期。在这种情况下，FLS3217 和 FLS3247 不会允许 CCM，工作模式会从 DCM 转为 BCM。因此，FLS3217 和 FLS3247 可以消除 CCM 中的次谐波失真。

### 短路LED保护

当发生 LED 短路时，开关 MOSFET 和次级二极管通常会经受高强度电流。然而，FLS3217 和 FLS3247 会在 LED 短路时改变过流保护点。当  $V_s$  低于 0.4 V 时，过流保护点会从 0.7 V 降至 0.2 V，如图所示图17。功率受到限制，外部元件电流应力得到减轻。

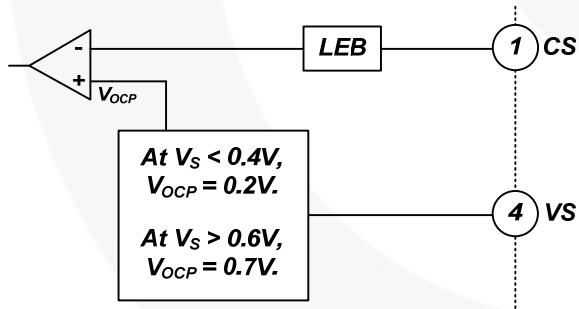


图19. 内部过流保护模块

图20图中显示了 LED 短路时的工作波形。发生 LED 短路时，输出电压迅速降至 0 V。然后反射辅助电压同样变为 0 V，使得  $V_s$  小于 0.4 V。0.2 V 的过流保护点限制了初级端电流， $V_{DD}$  在欠压锁定滞回范围内上下波动。

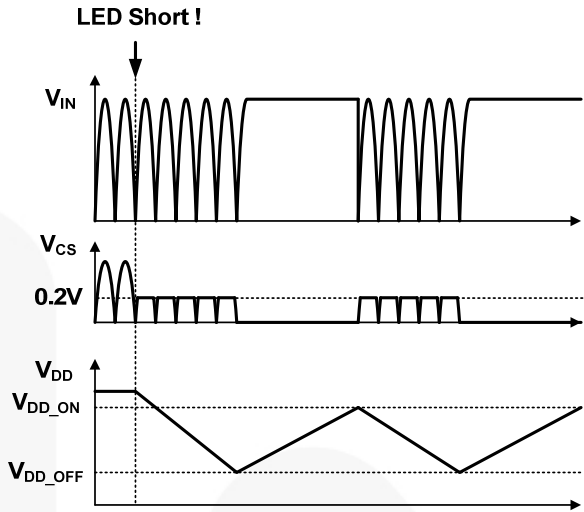


图20. LED 短路时的波形

### LED 开路保护

当发生 LED 开路时，FLS3217 和 FLS3247 可以保护次级端外部元件，例如二极管和电容。开关关闭期间， $V_{DD}$  电容充电至辅助绕组电压，反映了输出电压。由于  $V_{DD}$  电压具有输出电压信息， $V_{DD}$  引脚的内部电压比较器可以触发输出过压保护 (OVP)，如图图21所示。当至少一个 LED 发生开路时，输出负载阻抗会变得非常高，输出电容快速充电至  $V_{OVP} \times N_s / N_p$ 。随后开关关闭， $V_{DD}$  模块进入“打嗝模式”，直至 LED 开路情况解除，如图图22所示。

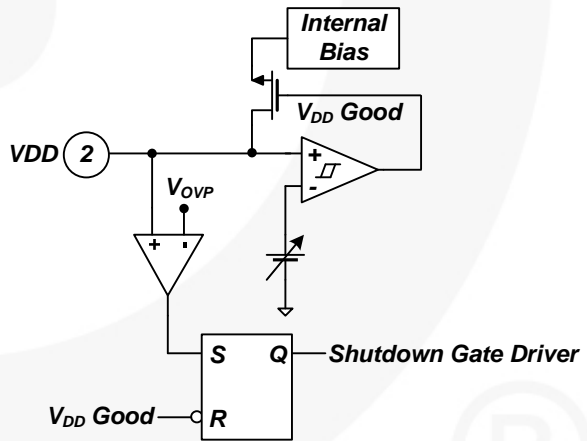


图21. 内部过压保护模块

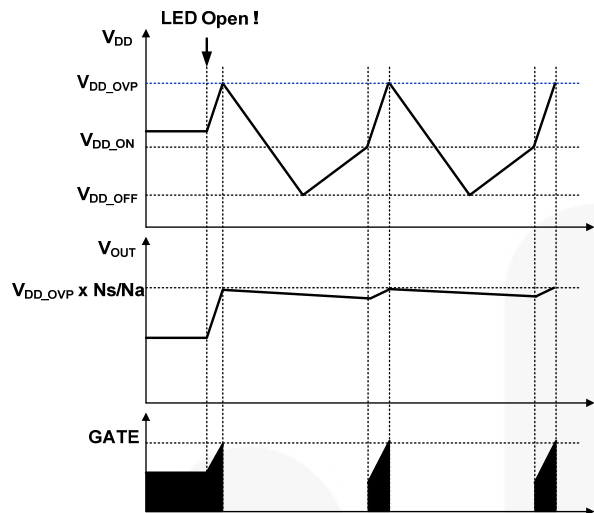


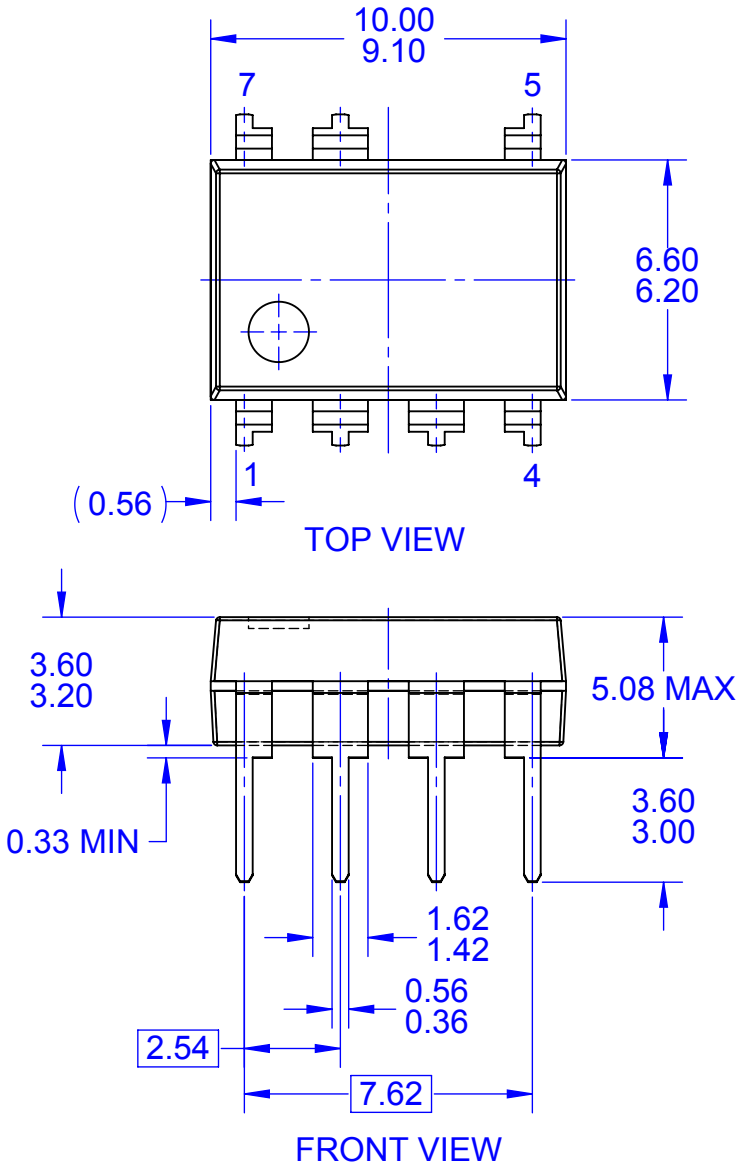
图22. LED 开路时的波形

### 欠压锁定 (UVLO)

接通和断开阈值分别内固定为 16 V 和 7.5 V。在启动阶段，VDD 电容必须通过启动电阻充电至 16 V，从而使 FLS32x7 能够工作。VDD 电容供应 VDD，直至能够从主变压器的辅助线圈供能。在启动阶段，VDD 不可低于 7.5 V。欠压锁定滞回窗口确保了 VDD 电容在启动阶段足以供应 VDD。

### 过温保护 (OTP)

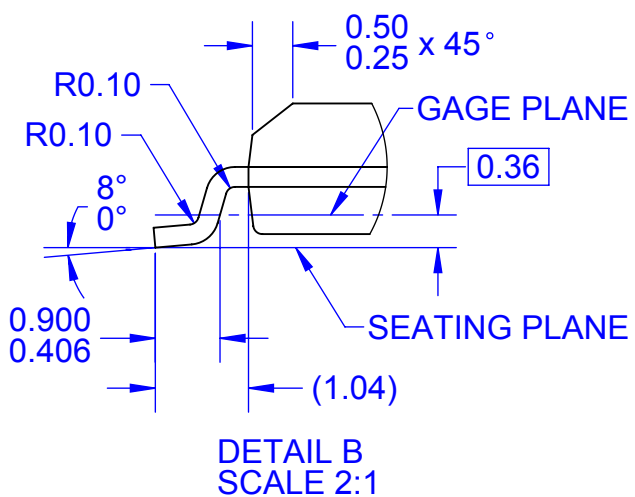
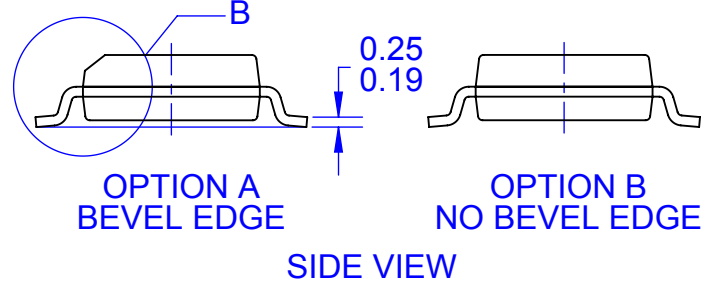
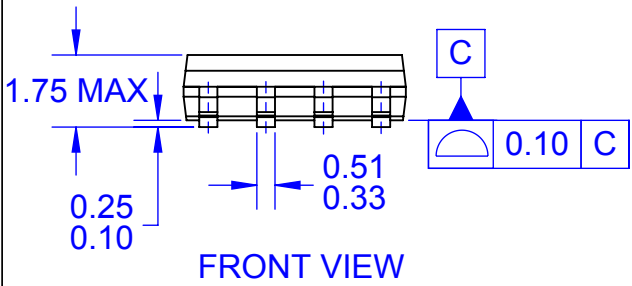
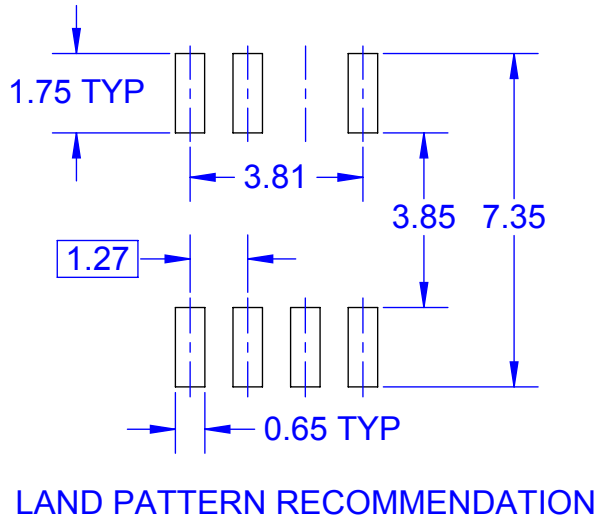
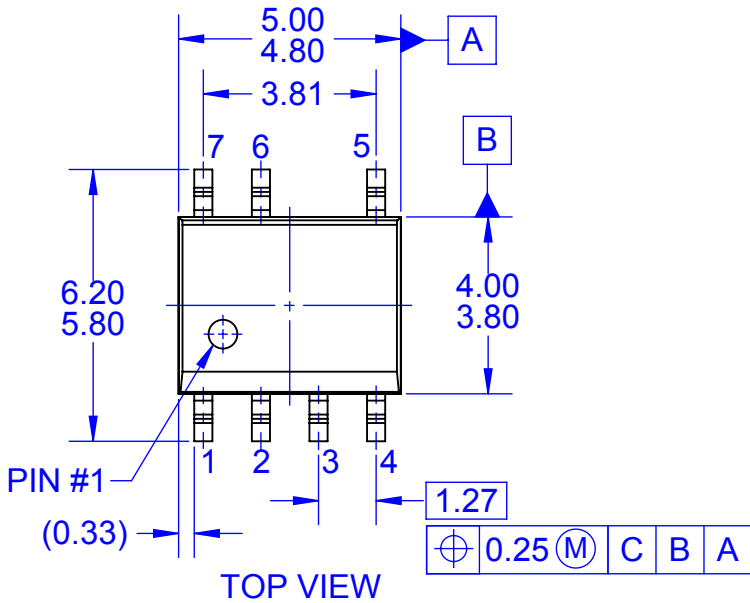
当结温超过 150° C 时，内置温度检测电路会关闭脉宽调制输出。当脉宽调制输出关闭时，VDD 会逐渐下降至欠压锁定电压。部分内部电路关闭，VDD 又逐渐升高。当 VDD 升至 16 V 时，所有内部电路开始工作。如果结温仍然高于 140° C，脉宽调制控制器会立即关闭。



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