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FAN6961

临界模式 PFC 控制器

特性

- 临界模式 PFC 控制器
- 低输入电流 THD
- 受控导通时间 PWM
- 零电流检测
- 逐周期限流
- 前沿消隐取代 RC 滤波
- 低启动电流：10 μ A（典型值）
- 低工作电流：4.5 mA（典型值）
- 反馈开环保护
- 可编程最大导通时间 (MOT)
- 输出过压箝位保护
- 箝位栅极驱动输出电压 16.5 V

应用

- 电灯镇流器
- AC-DC 开关电源转换器
- 开架式电源和电源适配器
- 反激式电源转换器，带 ZCS/ZVS

说明

FAN6961 是一款用于控制 PFC 预调节器的 8 引脚、临界模式、PFC 控制器 IC。FAN6961 提供受控导通时间来调节输出 DC 电压，实现自然功率因数校正。外部开关的最大导通时间可编程设定，以确保 AC 欠压期间的安全运行。内置创新的多向量误差放大器，以提供快速瞬态响应和精确的输出电压箝位。如果输出反馈环路断开，则内置电路会禁用控制器。启动电流低于 20 μ A，工作电流已降至 6 mA 以下。电源电压最高可达 25 V，最大限度地提高应用灵活性。

订购信息

器件编号	工作温度范围	封装	包装方法
FAN6961SZ	-40°C 至 +125°C	8-引脚小尺寸封装 (SOP) ⁽¹⁾	卷带和卷盘
FAN6961DZ	-40°C 至 +125°C	8 引脚双列直插封装 (DIP)	塑料管
FAN6961SY	-40°C 至 +125°C	8-引脚小尺寸封装 (SOP) ⁽¹⁾	卷带和卷盘

注：

1. SZ & SY 封装标记表示符合绿色标准，请访问 <https://www.fairchildsemi.com/products/power-management/power-factor-correction/critical-boundary-conduction-mode-crcm/FAN6961.html> 有关更多信息。

应用框图

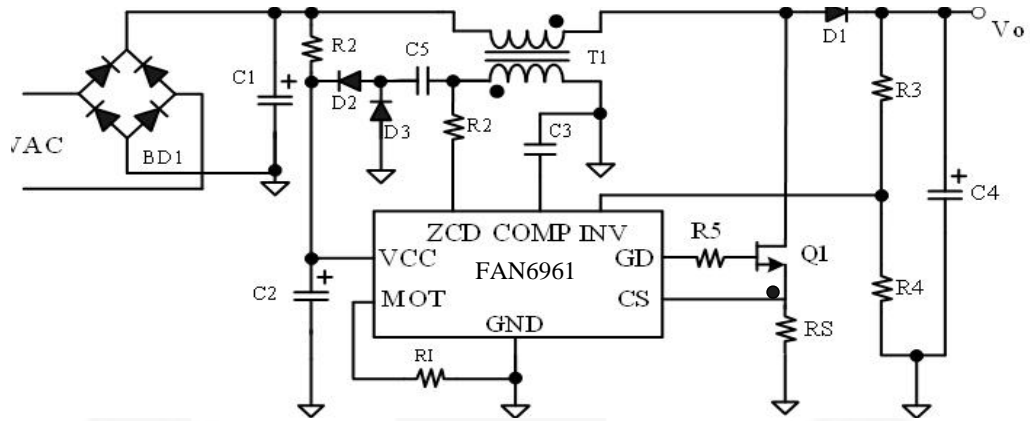


图 1. 典型应用

框图

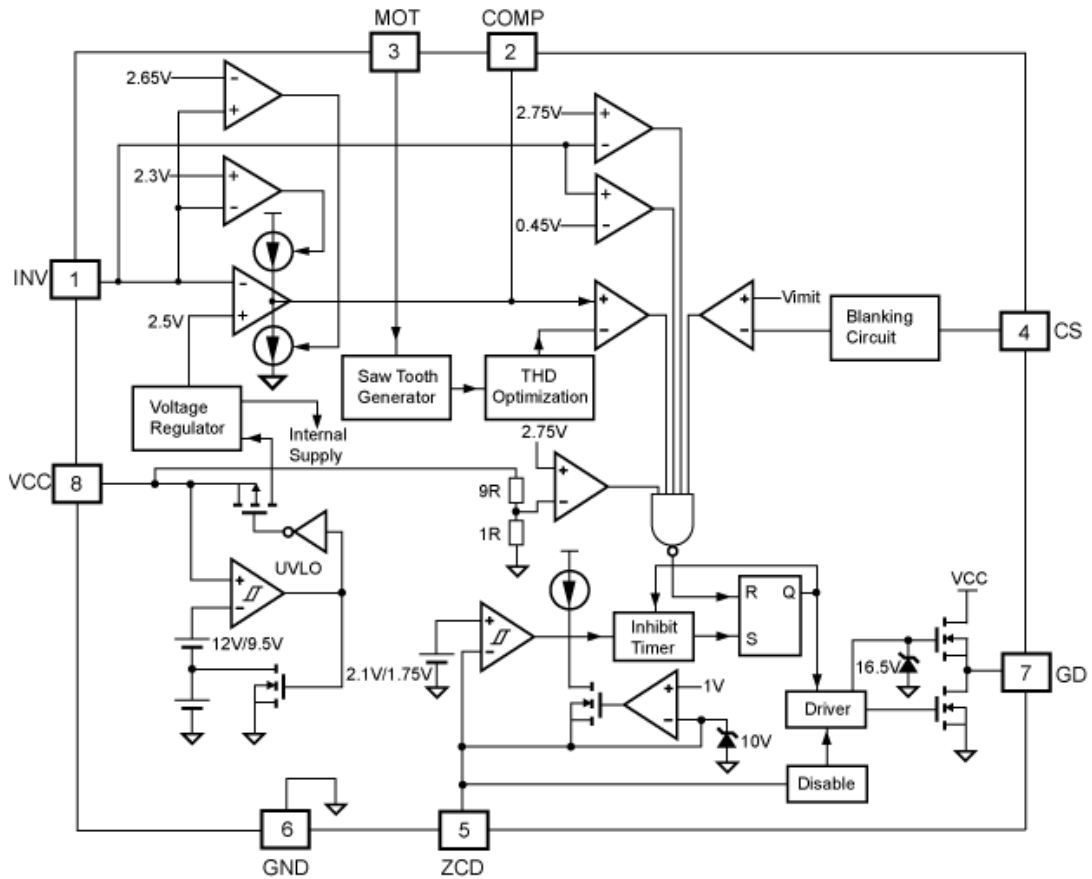
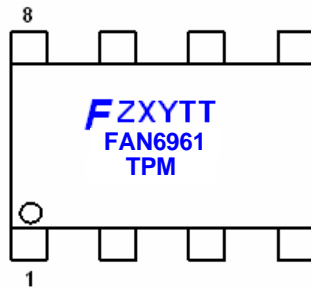


图 2. 功能框图

标识信息



F- 飞兆标志
 Z- 工厂编码
 X- 年份编码
 Y- 星期编码
 TT: 晶圆编码
 T: 封装类型 (S=SOP, D=DIP)
 P: Z: 无铅 Y: 绿色复合材料
 M: 制造流程编码

图 3. 标识信息

引脚配置

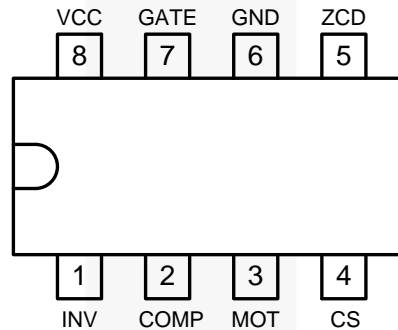


图 4. DIP 和 SOP 引脚配置 (顶视图)

引脚定义

引脚号	名称	说明
1	INV	误差放大器的反相输入。 INV 通过分压电阻连接至转换器输出。该引脚还用于过压箝位和开环反馈保护。
2	COMP	误差放大器的输出。 为了创建精确的箝位保护，建议在该引脚与 GND 之间建立补偿电路。
3	MOT	最大导通时间。 MOT 至 GND 之间的电阻用于确定外部功率 MOSFET 的最大导通时间。转换器的最大输出功率是最大导通时间的函数。
4	CS	电流检测。 过流保护比较器输入。当检测电阻两端的检测电压达到内部阈值 (0.8 V) 时，开关关闭，以激活逐周期限流。
5	ZCD	零电流检测。 该引脚通过电阻连接至辅助绕组，以检测开关电流过零。当检测到过零时，开始一个新的开关周期。如果该引脚连接至 GND，器件被禁用。
6	GND	接地。 功率地和信号地。推荐在 VCC 和 GND 之间放置一个 0.1 μ F 的去耦电容。
7	栅极	驱动器输出。 驱动外部功率 MOSFET 的图腾柱驱动器输出 箝位栅极输出电压为 16.5 V。
8	VCC	电源。 驱动器和控制电路电源电压。

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，长期在高于推荐的工作条件下工作，会影响器件的可靠性。绝对最大额定值仅是应力规格值。测得的所有电压，除差模电压之外，都参照 GND 引脚。

符号	参数	最小值	最大值	单位
V_{VCC}	电源电压 (DC)		30	V
V_{HIGH}	栅极驱动器	-0.3	30.0	V
V_{LOW}	其它 (INV、COMP、MOT、CS)	-0.3	7.0	V
V_{ZCD}	ZCD 引脚上的输入电压	-0.3	12.0	V
P_D	功耗	SOP	400	mW
		DIP	800	
T_J	工作结温	-40	+125	°C
θ_{JA}	热阻 (结到空气)	SOP	150	°C/W
		DIP	113	
T_{STG}	存储温度范围	-65	+150	°C
T_L	引脚温度 (波峰焊接或 IR, 10 秒)	SOP	+230	°C
		DIP	+260	
ESD	人体模型: JESD22-A114		2.5	KV
	元件充电模型: JESD22-A115		200	V

推荐工作条件

推荐的操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	典型值	最大值	单位
T_A	工作环境温度	-40		+125	°C

电气特性

VDD=12V, T_J=-40°C~125°C, 除非另有说明。流入器件的电流定义为正, 流出器件的电流定义为负。

符号	参数	工作条件	最小值	典型值	最大值	单位
V_{CC} 部分						
V _{CC-OP}	连续工作电压				24.5	V
V _{CC-ON}	导通阈值电压		11.5	12.5	13.5	V
V _{CC-OFF}	关断阈值电压		8.5	9.5	10.5	V
I _{CC-ST}	启动电流	V _{CC} =V _{CC-ON} - 0.16 V		10	20	μA
I _{CC-OP}	工作电源电流	V _{CC} =12 V, V _{CS} =0 V, C _L =3 nF, f _{SW} =60 KHz		4.5	6	mA
V _{CC-OVP}	V _{DD} 过压保护水平		26.8	27.8	28.8	V
t _{D-VCCOVP}	V _{DD} 过压保护延迟			30		μs
误差放大器部分						
V _{REF}	参考电压		2.475	2.500	2.525	V
G _m	跨导			125		μmho
V _{INVH}	箝位高电平反馈电压			2.65	2.70	V
V _{INVL}	箝位低电平反馈电压		2.25	2.30		V
V _{OUT HIGH}	输出高电平		4.8			V
V _{OZ}	零占空比输出电压		1.15	1.25	1.35	V
V _{INV-OVP}	INV 输入的过压保护		2.70	2.75	2.80	V
V _{INV-UVP}	INV 输入的欠压保护		0.40	0.45	0.50	V
I _{COMP}	源电流	V _{INV} =2.35 V, V _{COMP} =1.5 V	10	20		μA
	灌电流	V _{INV} =1.5 V, V _{COMP} =5 V	550	800		
电流检测部分						
V _{PK}	峰值电流逐周期限制阈值电压		0.77	0.82	0.87	V
t _{PD}	传播延时				200	ns
t _{LEB}	前沿消隐时间	R _{MOT} =24 kΩ, V _{COMP} =5 V		400	500	ns
		R _{MOT} =24 kΩ, V _{COMP} =V _{OZ} +50 mV		270	350	
栅极部分						
V _{Z-OUT}	最大输出电压 (箝位)	V _{CC} =25 V	14.5	16.0	17.5	V
V _{OL}	输出低电平	V _{CC} =15 V, I _O =100 mA			1.4	V
V _{OH}	输出高电平	V _{CC} =14 V, I _O =100 mA	8			V
t _R	上升时间	V _{CC} =12 V, C _L =3 nF, 20~80%		80		ns
t _F	下降时间	V _{CC} =12 V, C _L =3 nF, 80~20%		40		ns

接下页

电气特性

除非另有说明， $V_{CC}=15\text{ V}$ 且 $T_J=-40^\circ\text{C}$ 至 150°C 。电流流入器件定义为正向，且流出器件为负向。

符号	参数	工作条件	最小值	典型值	最大值	单位
零电流检测部分						
V_{ZCD}	上升沿电压输入阈值	VZCD 升高	1.9	2.1	2.3	V
H_{ys} of V_{ZCD}	阈值滞回电压	VZCD 降低		0.35		V
$V_{ZCD-HIGH}$	箝位电压上限	$I_{ZCD}=3\text{ mA}$			12	V
$V_{ZCD-LOW}$	箝位电压下限	$I_{ZCD}=-1.5\text{ mA}$	0.3			V
t_{DEAD}	最大延时，ZCD 至输出导通	$V_{COMP}=5\text{ V}$, $f_{SW}=60\text{ KHz}$	100		400	ns
$t_{RESTART}$	重启时间	ZCD 关断输出	300	500	700	μs
t_{INHIB}	禁止时间（最大开关频率限制）	$R_{MOT}=24\text{ k}\Omega$		2.8		μs
V_{DIS}	禁用阈值电压		130	200	250	mV
$t_{ZCD-DIS}$	禁用功能延迟时间	$R_{MOT}=24\text{ k}\Omega$, $V_{ZCD}=100\text{ mV}$	800			μs
最大导通时间部分						
V_{MOT}	最大导通时间电压		1.25	1.30	1.35	V
t_{ON-MAX}	最大导通时间编程（基于电阻）	$R_{MOT}=24\text{ k}\Omega$, $V_{CS}=0\text{ V}$, $V_{COMP}=5\text{ V}$		25		μs

典型性能特征

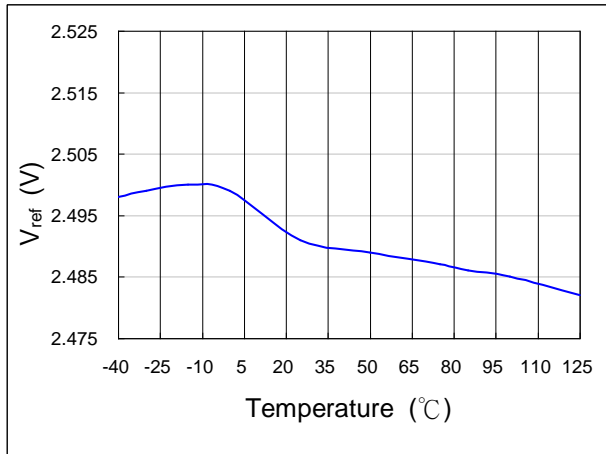


图 5. V_{REF} 与 T_A 的关系

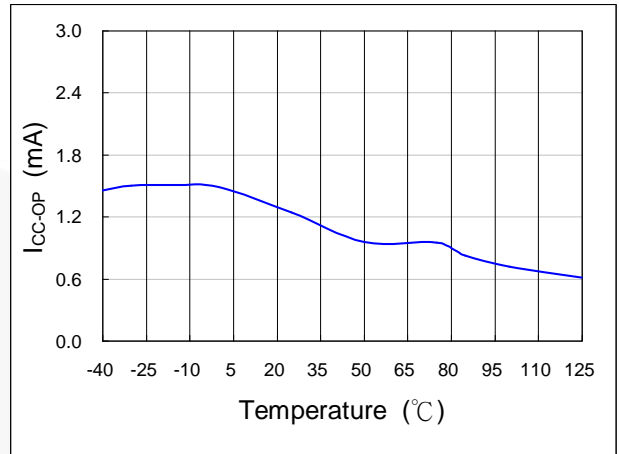


图 6. I_{CC-OP} 与 T_A 的关系

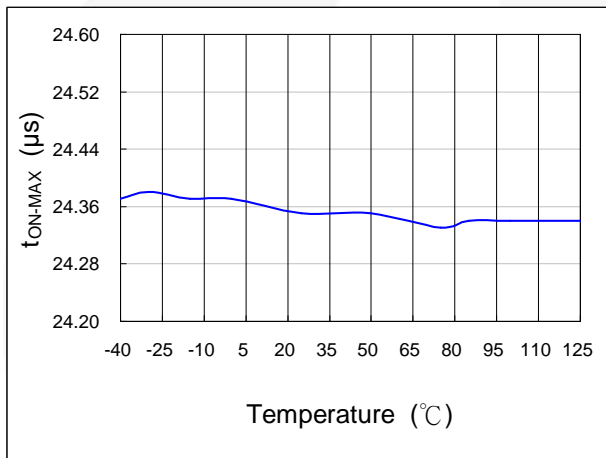


图 7. t_{ON-MAX} 与 T_A 的关系

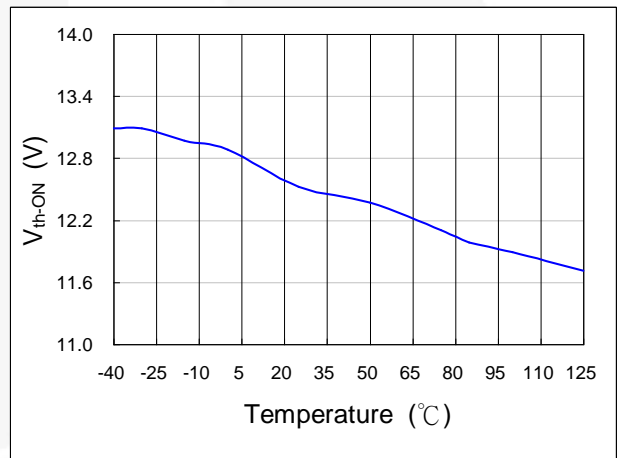


图 8. V_{th-ON} 与 T_A 的关系

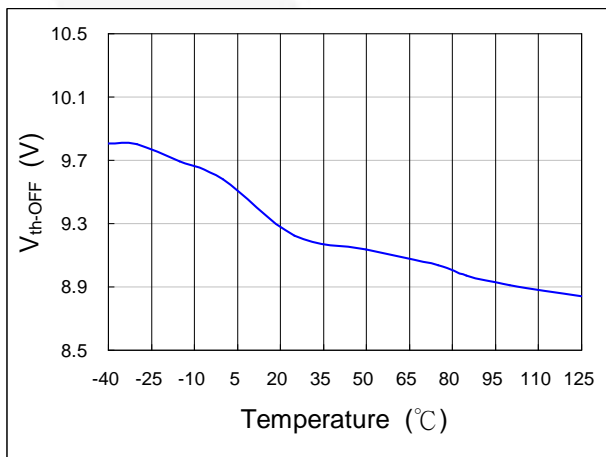


图 9. V_{th-OFF} 与 T_A 的关系

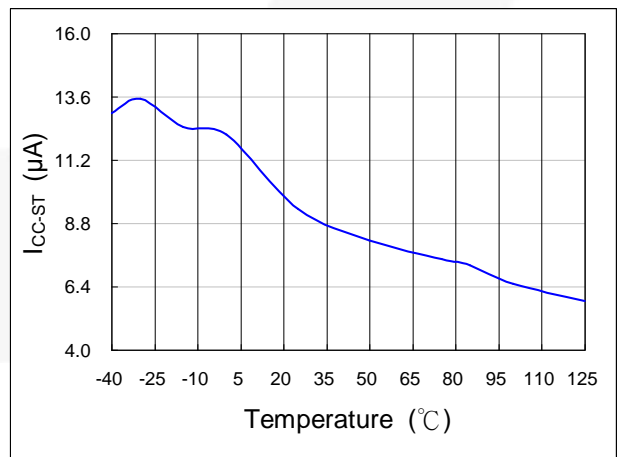


图 10. I_{CC-ST} 与 T_A 的关系

典型性能特征 (续)

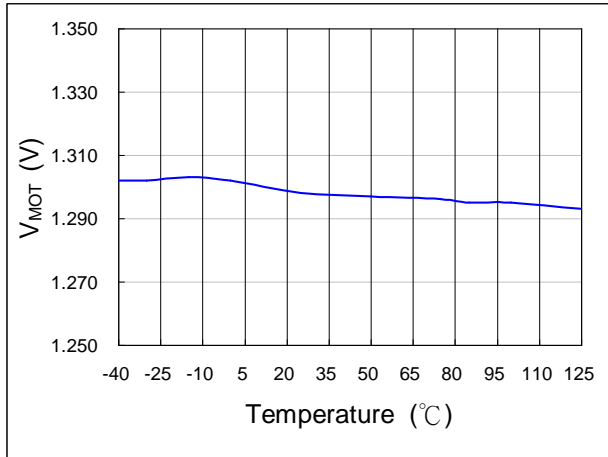


图 11. V_{MOT} 与的关系 T_A

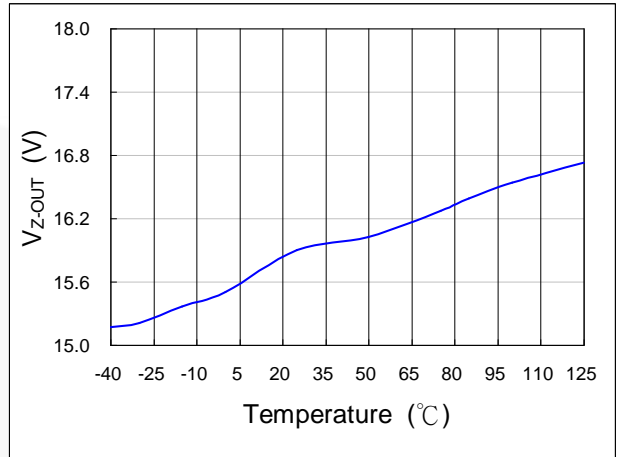


图 12. V_{Z-OUT} 与的关系 T_A

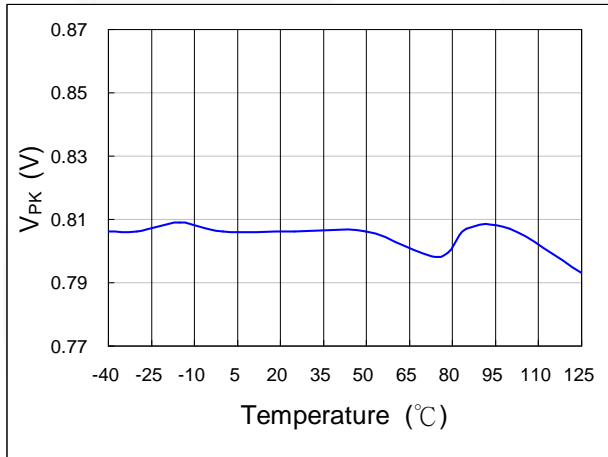


图 13. V_{PK} 与 T_A 的关系

功能说明

误差放大器

误差放大器的反相输入以 INV 作为基准。误差放大器的输出以 COMP 作为基准。同相输入内部连接到固定的 2.5 V ±2% 电压。误差放大器的输出用于确定 PWM 输出的导通时间并调节输出电压。为了实现较低的输入电流总谐波失真度，单个交流输入周期内的导通时间变化应该非常小。内置多向量误差放大器，以提供快速瞬态响应和精确的输出电压箝位。

建议在 COMP 和 GND 之间连接一个电容，如 1 μF。误差放大器是能够以 125 μmho 将电压转换为电流的跨导放大器。

启动电流

典型的启动电流低于 20 μA。该超低启动电流允许使用高阻值和低功率启动电阻。例如，推荐将 1 MΩ/0.25 W 的启动电阻和 10 μF/25 V (V_{CC} 保持) 的电容用于输入范围较宽 85-265 V_{AC} 的交流-直流电源适配器。

工作电流

工作电流通常为 4.5 mA。较低的工作电流有助于提高效率、减小所需 V_{CC} 电容容量。

最大导通时间运行

给定固定电感值和最大输出功率情况下，导通时间和线电压之间的关系是：

$$t_{on} = \frac{2 \cdot L \cdot P_o}{V_{rms}^2 \cdot \eta} \quad (1)$$

如果线电压过低或电感值过高，t_{ON} 会过长。为了避免降低工作频率并实现欠压保护，t_{ON} 通过 MOT 和 GND 之间连接的电阻 R_I 实现控制导通时间。24 kΩ 的电阻 R_I 对应 25 μs 的最大导通时间：

$$t_{on(max)} = R_I(k\Omega) \cdot \frac{25}{24}(\mu s) \quad (2)$$

最大导通时间范围是 10 ~ 50 μs。

峰值电流限流

开关电流由一个电阻检测。信号馈入 CS 引脚和比较器的一个输入端子。若 CS 引脚为高电压，开关周期将立即终止，并实现逐周期限流。设计的保护点阈值为 0.82 V。

前沿消隐 (LEB)

当功率 MOSFET 导通时，CS 引脚上出现导通尖峰。在每个开关脉冲开始时，限流比较器被禁用约 400 ns，以避免误触发保护。栅极驱动输出在消隐时段不能被关断。不需要传统的 RC 滤波，因此能够最小化限流保护的传播延时。

欠压锁定 (UVLO)

导通和关断阈值电压在内部固定为 12 V/9.5 V。该滞回特性保证在适当的启动电阻和保持电容下一次性成功启动。采用 20 μA 的超低启动电流，一个 1 MΩ 的 R_{IN} 就足以实现低线电压 85 V_{rms} 的启动。即使在高线电压 (V_{AC} = 265 V_{rms}) 情况下，R_{IN} 上的功耗也低于 0.1 W。

输出驱动器

凭借低导通电阻和高电流驱动能力，输出驱动器能够驱动大于 3000 pF 的外部容性负载。避免重叠导通的出现最大限度地降低热损、增加效率并提高了可靠性。该输出驱动器由 16.5 V 的齐纳二极管进行内部箝位。

零电流检测 (ZCD)

电感的零电流检测通过辅助绕组实现。当电感中存储的能量完全释放到输出时，ZCD 电压下降并在触发 ZCD 后启动一个新的开关周期。功率 MOSFET 总是以零电感电流导通，以便最小化导通损耗和噪声。转换器以临界模式工作，并且峰值电感电流总是平均电流的两倍。以低带宽和导通时间调制实现自然功率因数校正功能。内置有固有的最大关断时间，以确保正确的启动运行。该 ZCD 引脚可用作同步输入。

抗噪性

电流检测或控制信号噪声可能导致明显的脉宽抖动，尤其是在临界模式下。斜坡补偿和内置保护延迟电路可以缓解该问题。因为 FL6961 有单个接地引脚，较高的输出灌电流不能从单独路径返回。应该遵循良好的高频或 RF 布局实践。避免长 PCB 引线 and 元件引线，将补偿和滤波元件放置在 FL6961 附近，以及增加功率 MOSFET 栅极电阻都能提高性能。

参考电流

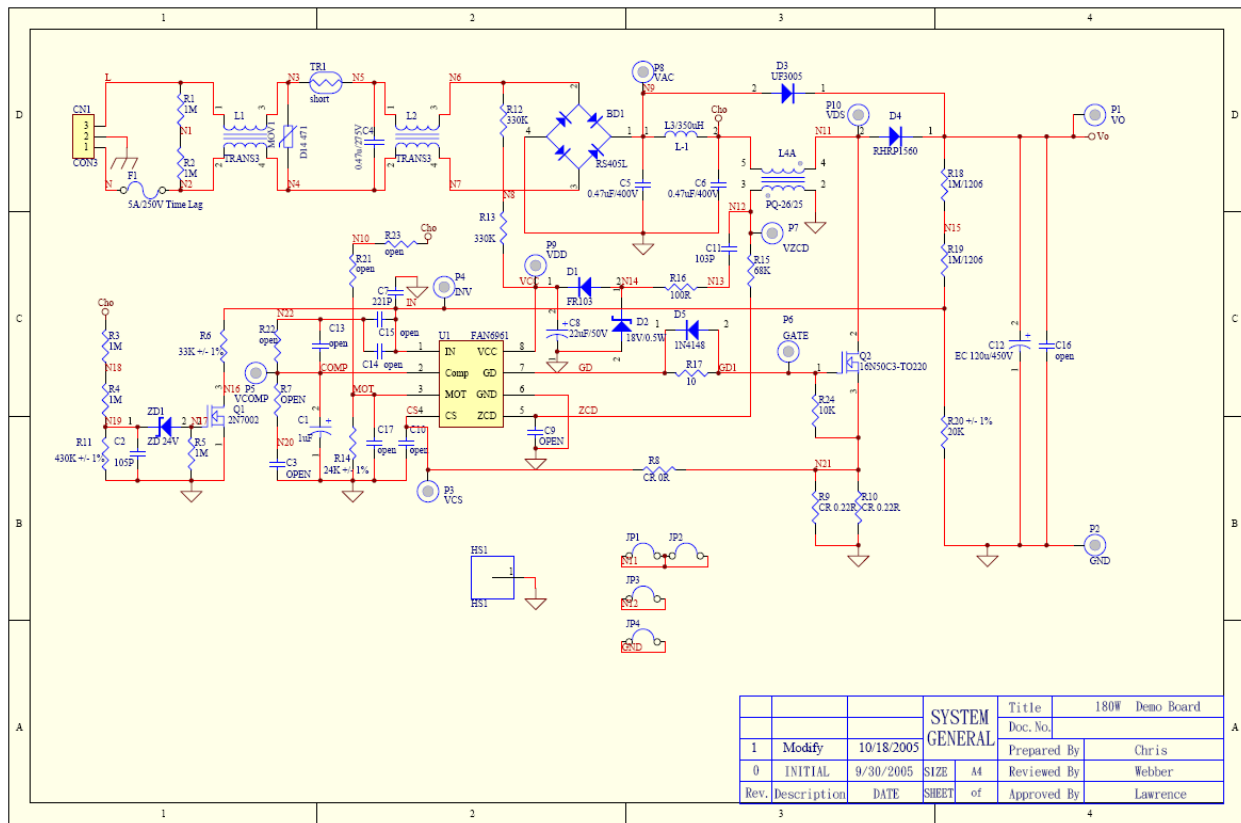
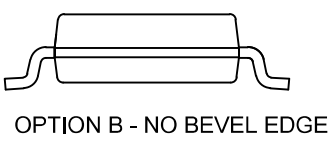
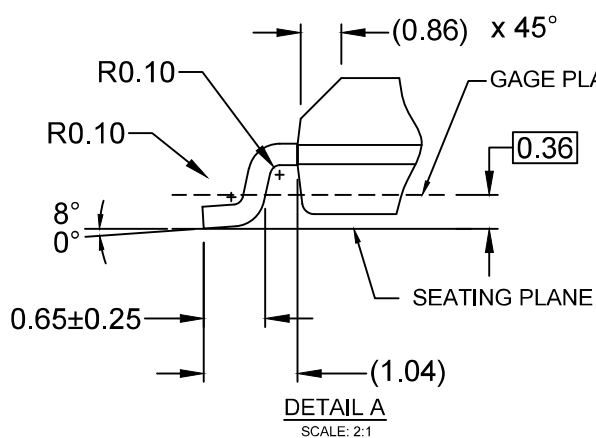
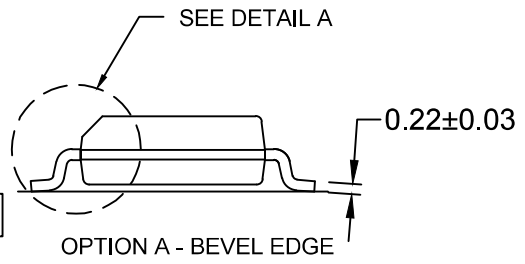
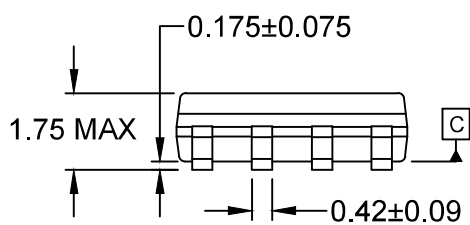
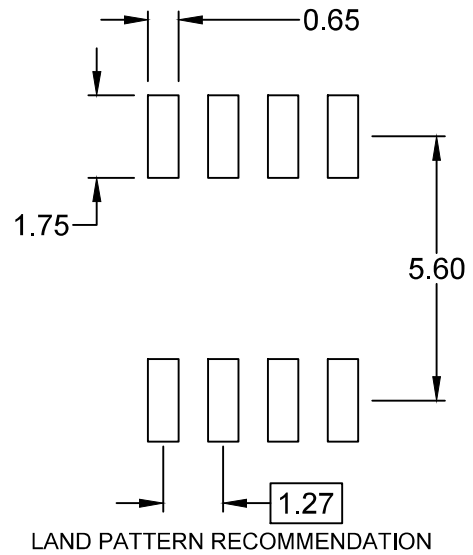
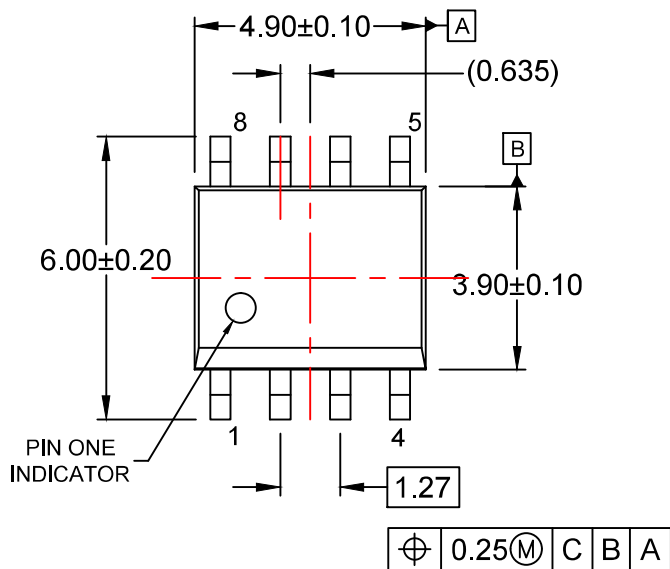
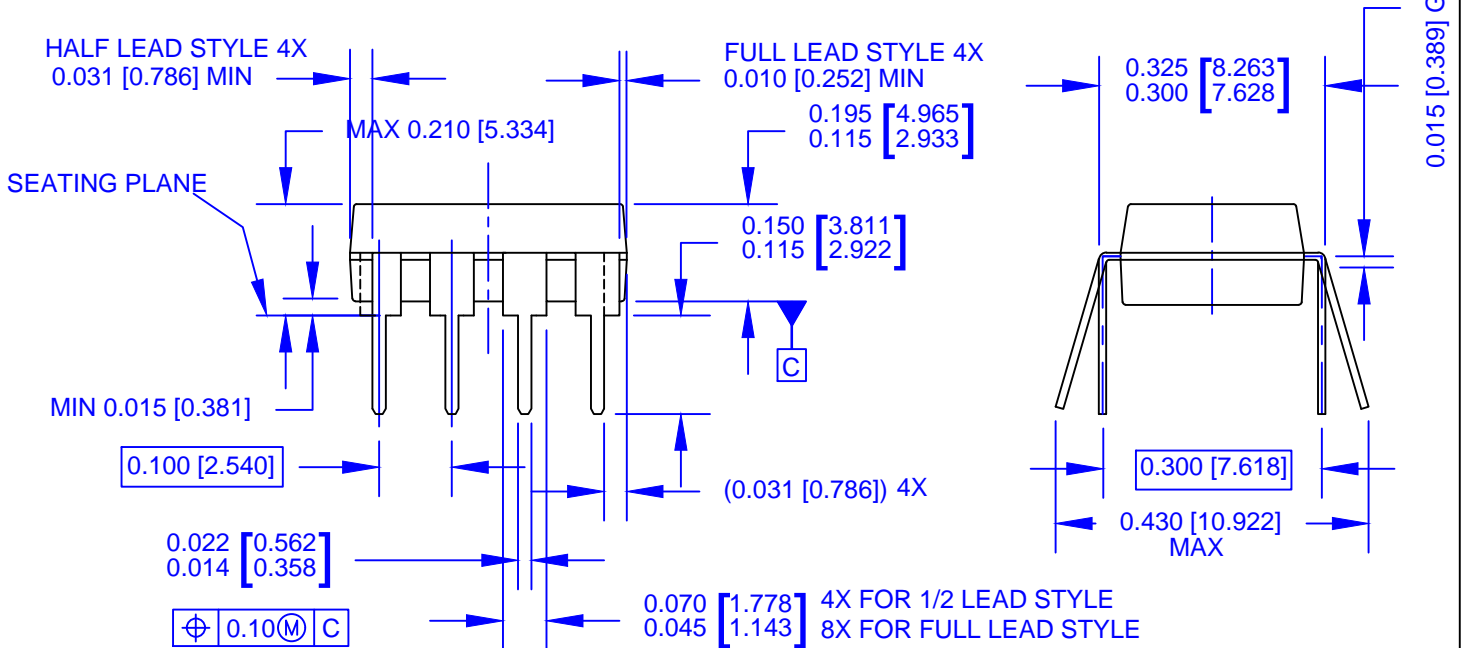
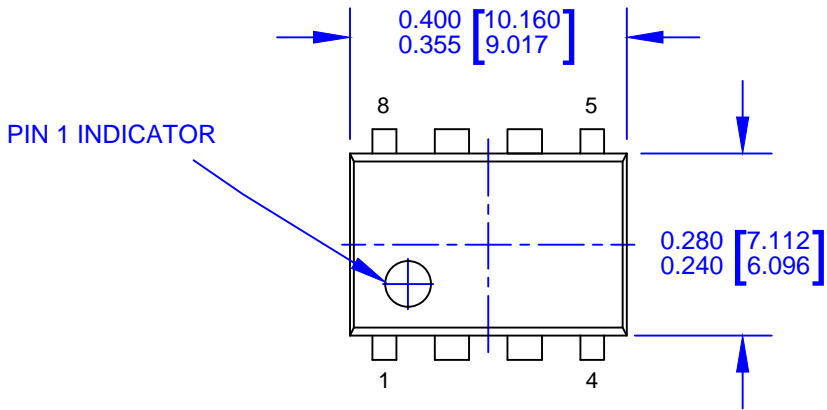


图 14. 参考电流



- NOTES:
- A) THIS PACKAGE CONFORMS TO JEDEC MS-012, VARIATION AA.
 - B) ALL DIMENSIONS ARE IN MILLIMETERS.
 - C) DIMENSIONS DO NOT INCLUDE MOLD FLASH OR BURRS.
 - D) LANDPATTERN STANDARD: SOIC127P600X175-8M
 - E) DRAWING FILENAME: M08Arev16





NOTES:

- A) THIS PACKAGE CONFORMS TO JEDEC MS-001 VARIATION BA WHICH DEFINES 2 VERSIONS OF THE PACKAGE TERMINAL STYLE WHICH ARE SHOWN HERE.
- B) CONTROLLING DIMS ARE IN INCHES
- C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.
- D) DIMENSIONS AND TOLERANCES PER ASME Y14.5M-2009
- E) DRAWING FILENAME AND REVISION: MKT-N08MREV2.



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