

绿色模式飞兆电源开关

FSL206MR

说明

FSL206MR 集成脉宽调制解调器 (PWM) 和 SENSEFET[®]，专为采用最少外部元件的高性能离线式开关电源 (SMPS) 而设计。此器件集成了高压功率调节器，合并了雪崩耐用 SENSEFET 和电流模式 PWM 控制模块。

集成的 PWM 控制器包括：无需辅助偏置绕组的 7.8 V 调节器、欠压锁定 (UVLO) 保护、前沿消隐 (LEB)、一个优化的栅极导通/关断驱动器、EMI 衰减器、热关断 (TSD) 保护、针对环路补偿的温度补偿精确电流源、启动期间的软启动，及故障保护电路，例如过载保护 (OLP)、过压保护 (OVP)、异常过流保护 (AOCP) 和线路欠压保护 (LUVF)。

内部高压启动开关和间歇模式运行使用极低的工作电流降低了待机模式下的功耗。因此，当输入电压为 265 Vac 时，若无偏置绕组，可以实现 150 mW 的空载功耗，若有偏置绕组时，可以实现 25 mW (对于 FSL206MR) 或 30 mW (对于 FSL206MRBN) 的空载功耗。

特性

- 耐雪崩的内部 SENSEFET：650 V
- 精确的固定工作频率：67 kHz
- 265 Vac 且不带有辅助偏压绕组时，空载功耗 < 150 mW；
FSL206MR 带有偏置绕组时，功耗 < 25 mW；
FSL206MRBN 带有偏置绕组时，功耗 < 30 mW
- 无需辅助偏压绕组
- 提供频率调制功能，可衰减电磁干扰 (EMI) 辐射
- 线路欠压保护 (LUVF)
- 逐脉冲限流
- 低欠压锁定 (UVLO)
- 超低工作电流：300 μ A
- 内置软启动和启动电路
- 提供各种保护：过载保护 (OLP)、过压保护 (OVP)、热关断 (TSD)、异常过流保护 (AOCP)，
自动重启模式针对所有保护功能

应用

- STB、DVD、DVCD 播放器的开关电源
- 用作辅助电源的开关电源

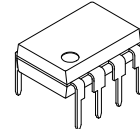
相关资源

- <https://www.onsemi.com/PowerSolutions/home.do>
- [AN-4137](#) — 采用 FPS 的离线反激式转换器设计指南
- [AN-4141](#) — 飞兆电源开关 (FPS) 反激式应用的排错与设计技巧
- [AN-4150](#) — 采用 FSQ 系列飞兆电源开关 (FPS) 的反激式转换器设计指南

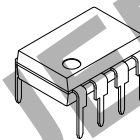


ON Semiconductor[®]

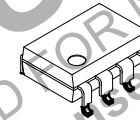
www.onsemi.cn



PDIP8 9.42x6.38, 2.54P
CASE 646CM



PDIP8 9.59x6.6, 2.54P
CASE 646CN



PDIP8 GW
CASE 709AJ

MARKING DIAGRAM

\$Y&E&Z&2&K
FSL206MR



\$Y	= ON Semiconductor Logo
&E	= Designated Space
&Z	= Assembly Plant Code
&2	= 2-Digit Date code format
&K	= 2-Digits Lot Run Traceability Code
FSL206MR	= Specific Device Code Data

\$Y&Z&2&K
L206MRB



\$Y	= ON Semiconductor Logo
&Z	= Assembly Plant Code
&2	= 2-Digit Date code format
&K	= 2-Digits Lot Run Traceability Code
L206MRB	= Specific Device Code Data

ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

FSL206MR

订购信息

器件编号	工作温度	顶标	PKG	包装方法	输出功率表(Note 1)			
					限流	R _{DS(ON),MAX}	230 Vac ±15% (Note 2)	85 ~265 Vac
							开架式 (Note 3)	开架式 (Note 3)
FSL206MRN	-40 ~ 115°C	FSL206MR	8-DIP	电轨	0.6 A	19 Ω	12 W	7 W
FSL206MRBN		L206MRB						
FSL206MRL		FSL206MR	8-LSOP	电轨				
FSL206MRLX				Tape & Reel				

1. 结温可以限制最大输出功率。
2. 230 Vac，或者带有倍频器时为 100/115 Vac。CCM 运行模式下的最大功率。
3. 50°C 环境温度下开架式设计中的最大实际持续功率。

应用框图

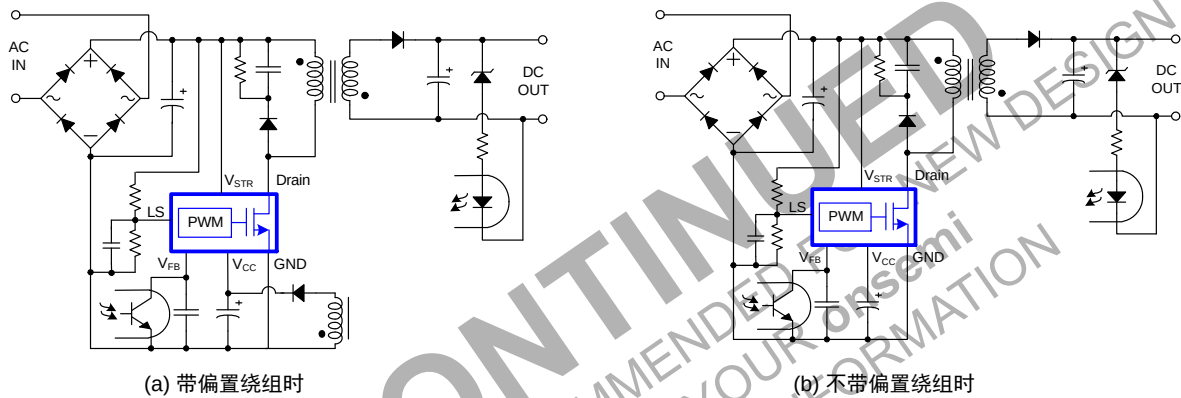


图 1. 典型应用

内部框图

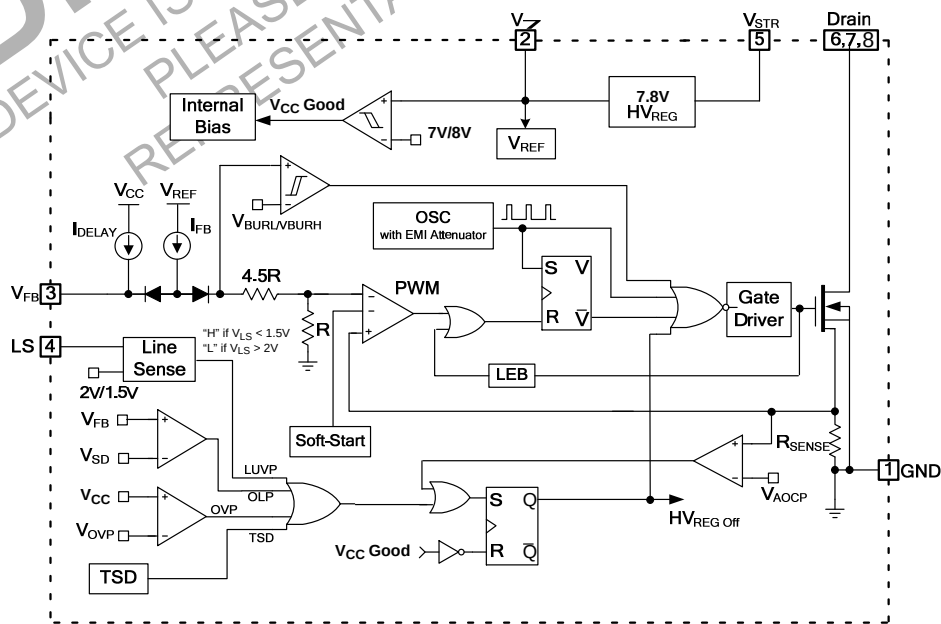


图 2. 内部框图

FSL206MR

引脚布局

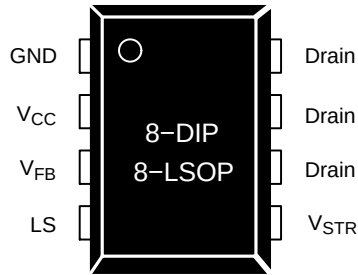


图 3. 引脚布局

引脚定义

引脚号	名称	说明
1	GND	接地。初级端和内部控制地上的 SENSEFET 源极端子。
2	V _{CC}	电源电压正输入。尽管连接至变压器辅助绕组，在启动期间，电流仍是通过内部开关从引脚 5 (V _{STR}) 提供 (参见内部框图部分)。直到 V _{CC} 达到 UVLO 上阀限 (8 V)，内部启动开关才会打开，并且器件电源通过变压器辅助绕组提供。
3	V _{FB}	反馈电压。PWM 比较器的同相输入，包含一个内部连接的 0.11 mA 电流源并且通常外部连接一个电容和光电耦合器。在采用内部 2.7 μ A 的电流源向外部电容 C _{FB} 从 2.4 V 充电至 5 V 时，存在一个延时。该延时可防止瞬态情况下的错误触发，但允许保护机制在真正过载状况下工作。
4	LS	线路感测引脚。当输入电压低于额定输入电压范围时，该引脚用来保护器件。如果未使用该引脚，连接至地。
5	V _{STR}	启动。连接至经过整流的交流线路电压源。启动时，内部开关提供内部偏压，并对放置在 V _{CC} 引脚和地之间的外部存储电容器充电。一旦 V _{CC} 达到 8 V，所有内部模块都被激活。然后，内部高压调节器 (HV REG) 不定期导通和关断，以使 V _{CC} 维持在 7.8 V。
6, 7, 8	漏极	漏极。设计用于直连到变压器的初级引脚，最大能够实现 650 V 开关。最大限度地缩短连接这些引脚到变压器的引线长度，能够减小漏电感。

绝对最大额定值 ($T_A = 25^\circ\text{C}$, 除非另有说明)

符号	参数	最小值	最大值	单位
V_{STR}	V_{STR} 引脚电压	-0.3	650	V
V_{DS}	漏极引脚电压	-0.3	650	V
V_{CC}	电源电压	-	26	V
V_{LS}	LS 引脚电压	-	内部箝位电压 (Note 4)	V
V_{FB}	反馈电压范围	-0.3	内部箝位电压 (Note 4)	V
I_{DM}	漏极电流脉冲 (Note 5)	-	1.5	A
E_{AS}	单脉冲雪崩能量 (Note 6)	-	11	mJ
P_D	总功耗	-	1.3	W
T_J	工作结温	-40	+150	$^\circ\text{C}$
T_A	工作环境温度	-40	+125	$^\circ\text{C}$
T_{STG}	存储温度	-55	+150	$^\circ\text{C}$
ESD	人体模式, JESD22-A114	-	4	kV
	元件充电模式, JESD22-C101	-	2	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

(参考译文)

如果电压超过最大额定值表中列出的值范围, 器件可能会损坏。如果超过任何这些限值, 将无法保证器件功能, 可能会导致器件损坏, 影响可靠性。

4. V_{FB} 由内部箝位二极管进行箝位 ($13\text{ V } I_{CLAMP_MAX}$ 低于 $100\text{ }\mu\text{A}$)。关断后, V_{CC} 达到 V_{STOP} 前, $V_{SD} < V_{FB} < V_{CC}$ 。

5. 重复额定值: 脉冲宽度受限于最大结温。

6. $L = 21\text{ mH}$, 开始 $T_J = 25^\circ\text{C}$ 。

热阻测试 ($T_A = 25^\circ\text{C}$, 除非另有说明)

符号	参数	数值	单位
θ_{JA}	结至环境热阻 (Note 7)	93	$^\circ\text{C/W}$

7. JEDEC 推荐环境, JESD51-2 和测试板 JESD51-10 具有针对 8DIP 的最小焊盘布局, 且 JESD51-3 具有针对 8LSOP 的最小焊盘布局。

电气特征 ($T_A = 25^\circ\text{C}$, 除非另有说明)

符号	参数	条件	最小值	典型值	最大值	单位
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SENSEFET 部分

BV_{DSS}	漏极-源极击穿电压	$V_{CC} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$	650	-	-	V
I_{DSS}	零栅极电压漏极电流	$V_{DS} = 650\text{ V}, V_{GS} = 0\text{ V}$	-	-	50	μA
		$V_{DS} = 520\text{ V}, V_{GS} = 0\text{ V}, T_A = 125^\circ\text{C}$ (Note 8)	-	-	250	μA
$R_{DS(ON)}$	漏源极导通电阻 (Note 9)	$V_{GS} = 10\text{ V}, I_D = 0.3\text{ A}$	-	14	19	Ω
C_{ISS}	输入电容	$V_{GS} = 0\text{ V}, V_{DS} = 25\text{ V}, f = 1\text{ MHz}$	-	162	-	pF
C_{OSS}	输出电容	$V_{GS} = 0\text{ V}, V_{DS} = 25\text{ V}, f = 1\text{ MHz}$	-	14.9	-	pF
C_{RSS}	反向传输电容	$V_{GS} = 0\text{ V}, V_{DS} = 25\text{ V}, f = 1\text{ MHz}$	-	2.7	-	pF
t_r	上升时间	$V_{DS} = 325\text{ V}, I_D = 0.5\text{ A}, R_G = 25\text{ }\Omega$	-	6.1	-	ns
t_f	下降时间	$V_{DS} = 325\text{ V}, I_D = 0.5\text{ A}, R_G = 25\text{ }\Omega$	-	43.6	-	ns

控制部分

f_{OSC}	开关频率	$V_{FB} = 4\text{ V}, V_{CC} = 10\text{ V}$	61	67	73	KHz
Δf_{OSC}	开关频率变化	$-25^\circ\text{C} < T_J < 85^\circ\text{C}$	-	± 5	± 10	%
f_M	频率调制 (Note 8)		-	± 3	-	KHz
D_{MAX}	最大占空比	$V_{FB} = 4\text{ V}, V_{CC} = 10\text{ V}$	66	72	78	%

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电气特征 ($T_A = 25^\circ\text{C}$, 除非另有说明) (continued)

符号	参数	条件	最小值	典型值	最大值	单位
D_{MIN}	最小占空比	$V_{\text{FB}} = 0\text{ V}$, $V_{\text{CC}} = 10\text{ V}$	0	0	0	%
V_{START}	UVLO 阈值电压	$V_{\text{FB}} = 0\text{ V}$, V_{CC} 扫描	7	8	9	V
V_{STOP}		导通后	6	7	8	V
I_{FB}	反馈源电流	$V_{\text{FB}} = 0$, $V_{\text{CC}} = 10\text{ V}$	90	110	130	μA
$t_{\text{S/S}}$	内部软启动时间	$V_{\text{FB}} = 4\text{ V}$, $V_{\text{CC}} = 10\text{ V}$	10	15	20	ms

间歇模式部分

V_{BURH}	间歇模式高阈值电压	$V_{\text{CC}} = 10\text{ V}$ 时, V_{FB} 增大	FSL206MR	0.66	0.83	1.00	V
			FSL206MRB	0.40	0.50	0.60	V
V_{BURL}	间歇模式低阈值电压	$V_{\text{CC}} = 10\text{ V}$ 时, V_{FB} 减小	FSL206MR	0.59	0.74	0.89	V
			FSL206MRB	0.28	0.35	0.42	V
HYS_{BUR}	间歇模式滞回		FSL206MR	—	90	—	mV
			FSL206MRB	—	150	—	mV

保护部分

I_{LIM}	峰值电流限制	$V_{\text{FB}} = 4\text{ V}$, $di/dt = 300\text{ mA}/\mu\text{s}$, $V_{\text{CC}} = 10\text{ V}$	0.54	0.60	0.66	A
t_{CLD}	电流限制延迟 (Note 8)		—	100	—	ns
V_{SD}	关断反馈电压	$V_{\text{CC}} = 10\text{ V}$	4.5	5.0	5.5	V
I_{DELAY}	关断延迟电流	$V_{\text{FB}} = 4\text{ V}$	2.1	2.7	3.3	μA
t_{LEB}	前沿消隐时间 (Note 8)		250	—	—	ns
V_{AOCP}	异常过流保护 (Note 8)		—	0.7	—	V
V_{OVP}	过压保护	$V_{\text{FB}} = 4\text{ V}$ 时, V_{CC} 增大	23.0	24.5	26.0	V
$V_{\text{LS_OFF}}$	线路感测保护从开到关	$V_{\text{FB}} = 3\text{ V}$, $V_{\text{CC}} = 10\text{ V}$ 时, V_{LS} 减小	1.9	2.0	2.1	V
$V_{\text{LS_ON}}$	线路感测保护从关到开	$V_{\text{FB}} = 3\text{ V}$, $V_{\text{CC}} = 10\text{ V}$ 时, V_{LS} 增大	1.4	1.5	1.6	V
T_{SD}	热关断温度 (Note 8)		125	135	150	$^\circ\text{C}$
HYS_{TSD}	TSD 滞回温度 (Note 8)		—	60	—	$^\circ\text{C}$

高压调节器部分

H_{HVR}	高压调节器电压	$V_{\text{FB}} = 0\text{ V}$, $V_{\text{STR}} = 40\text{ V}$	—	7.8	—	V
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整机部分

I_{OP1}	工作电源电流 (仅控制部分, 无开关过程)	$V_{\text{CC}} = 15\text{ V}$, $0\text{ V} < V_{\text{FB}} < V_{\text{BURL}}$	—	0.3	0.5	mA
I_{OP2}	工作电源电流 (仅控制部分, 无开关过程)	$V_{\text{CC}} = 8\text{ V}$, $0\text{ V} < V_{\text{FB}} < V_{\text{BURL}}$	—	0.25	0.45	mA
I_{OP3}	工作电源电流 (Note 8) (开关过程中)	$V_{\text{CC}} = 15\text{ V}$, $V_{\text{BURL}} < V_{\text{FB}} < V_{\text{SD}}$	—	—	1.3	mA
I_{CH}	启动充电电流	$V_{\text{CC}} = 0\text{ V}$, $V_{\text{STR}} > 40\text{ V}$	1.6	1.9	2.4	mA
I_{START}	启动电流	$V_{\text{CC}} = \text{Before } V_{\text{START}}$, $V_{\text{FB}} = 0\text{ V}$	—	100	150	μA
V_{STR}	最小电源电压 V_{STR}	$V_{\text{CC}} = V_{\text{FB}} = 0\text{ V}$ 时, V_{STR} 增大	—	26	—	V

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

(参考译文)

除非另有说明, “电气特性” 表格中列出的是所列测试条件下的产品性能参数。如果在不同条件下运行, 产品性能可能与 “电气特性” 表格中所列性能参数不一致。

8. 虽然有设计保证, 但未经 100% 产品测试。

9. 脉冲测试: 脉冲宽度 = 300 ms, 占空比 = 2%。

典型性能特征

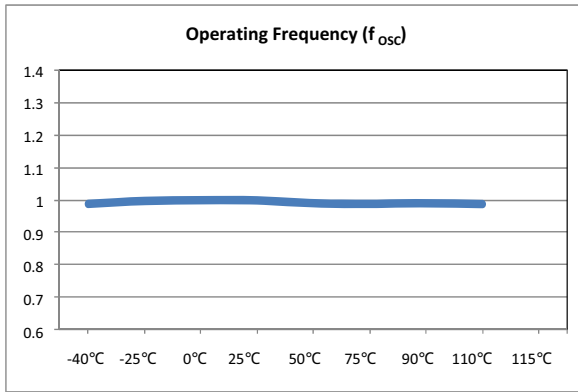


图 4. 工作频率与温度的关系

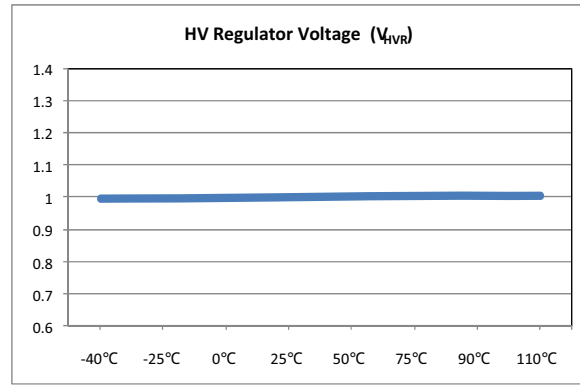


图 5. 高压调节器电压与温度的关系

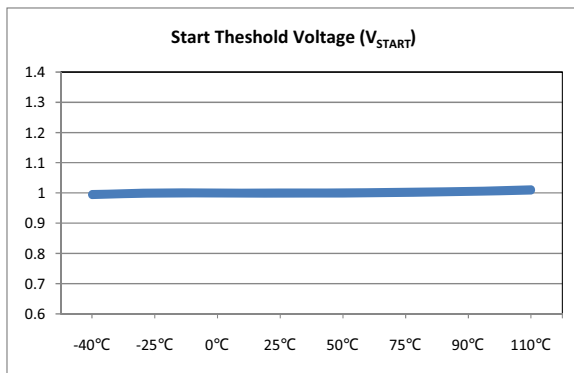


图 6. 开始阈值电压与温度的关系

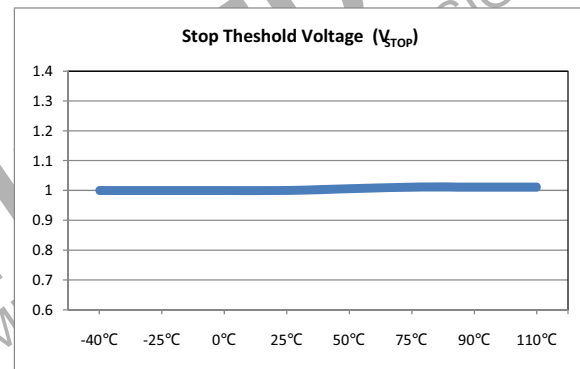


图 7. 停止阈值电压与温度的关系

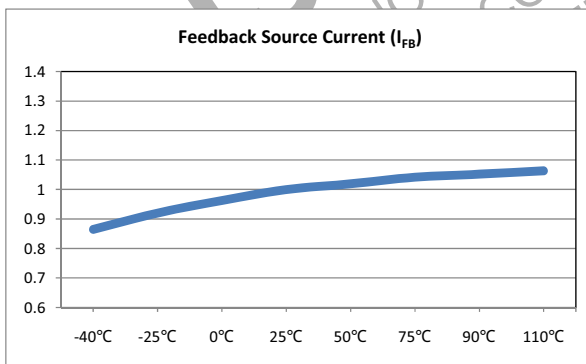


图 8. 反馈源电流与温度的关系

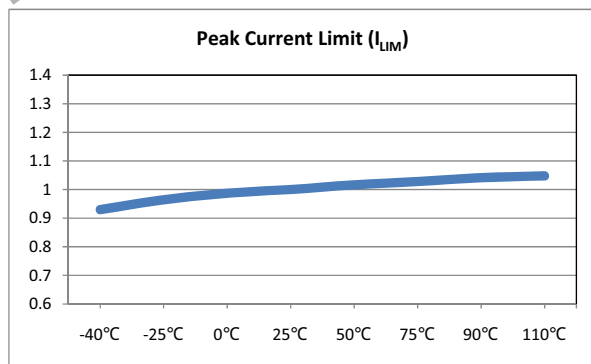


图 9. 峰值电流限值与温度的关系

典型性能特征 (接上页)

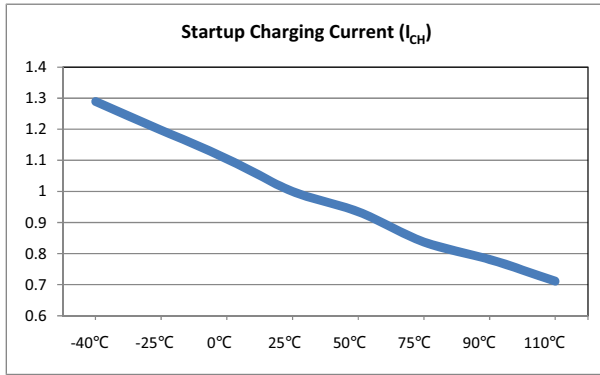


图 10. 启动充电电流与温度的关系

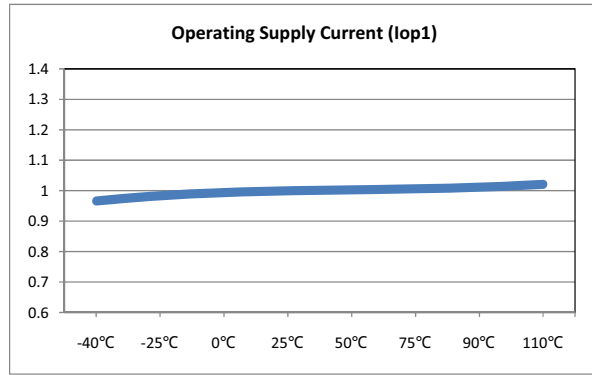


图 11. 工作电源电流 1 与温度的关系

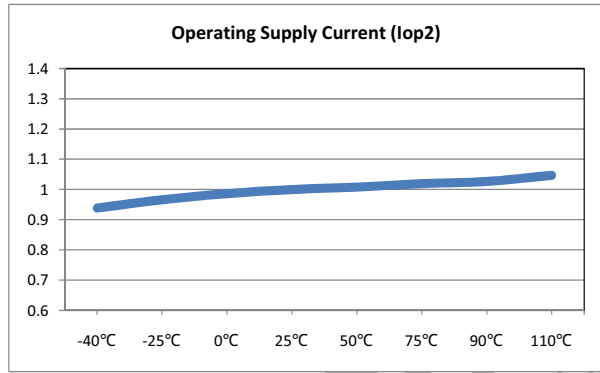


图 12. 工作电源电流 2 与温度的关系

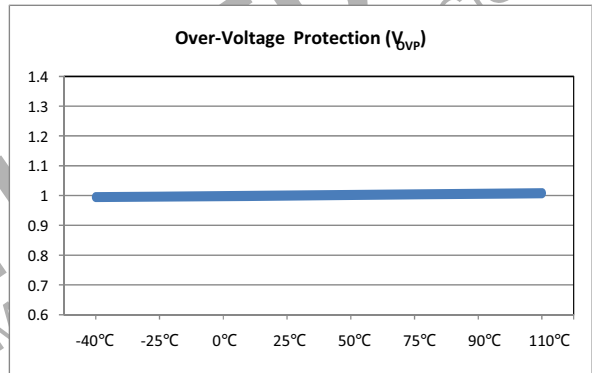


图 13. 过压保护电压与温度的关系

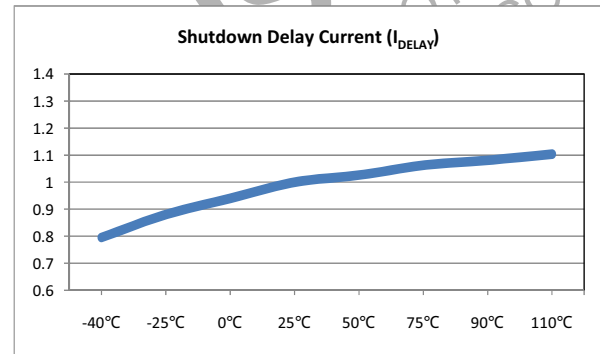


图 14. 关断延迟电流与温度的关系

功能说明

启动

在启动时，内部高压电流源提供内部偏压并对连接到 V_{CC} 引脚的外部电容 (C_A) 充电，如图 15 所示。位于 V_{STR} 和 V_{CC} 引脚之间的内部高压调节器 (HV REG) 将 V_{CC} 调节为 7.8 V，并提供工作电流。因此，FSL206MR 无需辅助偏置绕组。

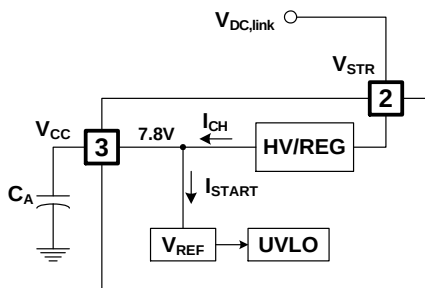


图 15. 启动框图

振荡器模块

振荡器频率在内部设定，FPS 具有随机频率波动功能。开关频率的波动将能量分布在比 EMI 测试设备测得的带宽还要宽的频率范围内，因而能够减少 EMI。EMI 的减少量与频率变化有直接的关系。频率变化范围内部固定；然而，频率范围的选择由外部反馈电压和内部自激振荡器共同随机决定。随机选择的开关频率将 EMI 噪声有效地分布在开关频率附近，并允许使用具有成本效益的电感器，而不是交流输入线路滤波器，来满足全球 EMI 要求。

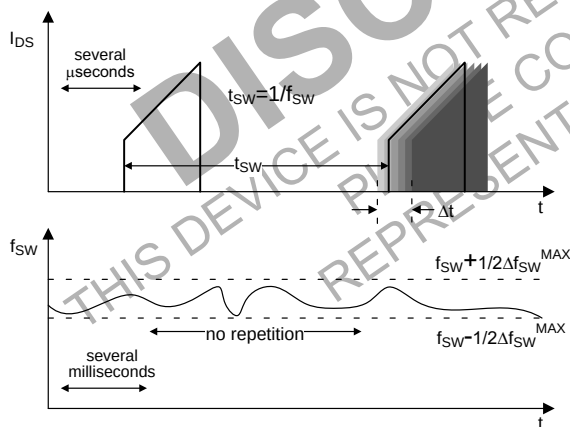


图 16. 频率波动波形

反馈控制

FSL206MR 采用电流模式控制，如图 17 所示。通常用光电耦合器 (如 FOD817A) 和电压调节器 (如 KA431) 来实现反馈网络。通过比较反馈电压与 R_{SENSE} 电阻两端的电压，可实现开关占空比的控制。当电压调节器参考引脚电压超过内部参考电压 2.5 V 时，光电耦合器 LED 电流会增大，反馈电压 V_{FB} 被拉低，并且占空比减小。这种情况通常在输入电压提高或输出负载降低时发生。

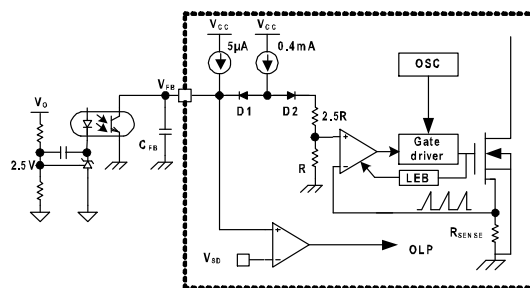


图 17. 脉宽调制 (PWM) 电路

前沿消隐时间 (LEB)

内部 SENSEFET 导通瞬间, 初级端电容放电和次级端整流二极管反向恢复通常会导致 SENSEFET 上通过一个高电流尖峰。R_{SENSE} 电阻两端的过大电压会导致电流模式 PWM 控制中出现不正确的反馈运行状况。为了抵消这种效应, FPS 采用了前沿消隐 (LEB) 电路 (见图 17)。SENSEFET 导通后, 此电路将在短时间 (t_{LEB}) 内抑制 PWM 比较器。

保护电路

保护功能包括过载保护 (OLP)、过压保护 (OVP)、欠压锁定 (UVLO)、线路欠压保护 (LUVLP)、异常过流保护 (AOCP) 以及热关断 (TSD)。由于这些保护电路都完全集成在 IC 中, 无需任何外部器件, 因此能够在不增加成本的情况下提高可靠性。如果出现故障情况, 开关将终止, 且 SENSEFET 保持关断。这会导致 V_{CC} 开始下降。当 V_{CC} 达到 UVLO 停止电压 V_{STOP} (7 V) 时, 保护功能被重置, 并且内部高压电流源通过 V_{STR} 引脚为 V_{CC} 电容器充电。当 V_{CC} 达到 UVLO 开始电压 V_{START} (8 V) 时, FPS 恢复正常运行。通过这种方式, 自动重启功能可以交替使能和禁用功率 SENSEFET 的开关过程, 直到消除故障条件。

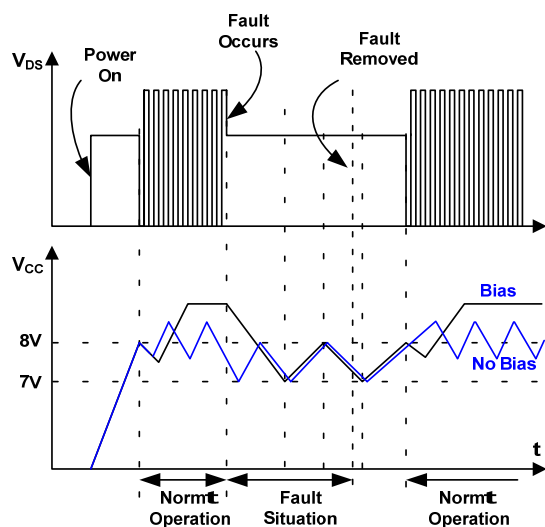


图 18. 自重启保护波形

过载保护 (OLP)

过载定义为负载电流因意外事件而超过预设值。这种情况下，应该激活保护电路，从而保护 SMPS。然而，即使 SMPS 正常工作，过载保护 (OLP) 电路也会在负载变化或启动期间被激活。为了避免出现这种不必要的工作状况，特定时间后激活 OLP 电路确定这是瞬态情况还是真正的过载情况。当达到最大 PWM 占空比时，电流模式反馈路径限制 SENSEFET 中的电流。如果输出消耗的功率超过最大功率，输出电压 (V_O) 降至低于该额定电压。这样会降低通过光电耦合器 LED 的电流，同时减少光电耦合器晶体管电流，进而增大反馈电压 (V_{FB})。如果 V_{FB} 超过 2.4 V，反馈输入二极管被阻断，2.7 μA 的电流源 (I_{DELAY}) 开始缓慢向 C_{FB} 充电。在这种情况下， V_{FB} 增大直至达到 5 V，此时开关操作终止，如图 19 所示。关断延时是指通过 2.7 μA 的电流源将 C_{FB} 从 2.4 V 充电至 5 V 所需的时间。

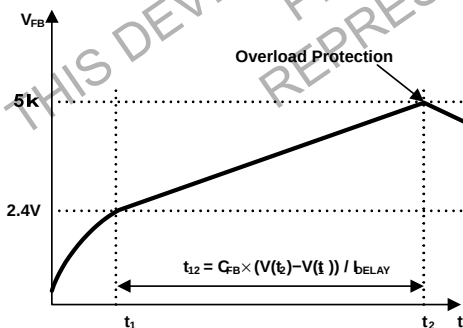


图 19. 过载保护 (OLP)

异常过流保护 (AOCP)

当次级整流二极管或变压器引脚短路时，具有极高 di/dt 的陡波电流可能在 LEB 时间内流过 SENSEFET。即使 FPS 具有过载保护功能，仍不足以在那种异常情况下保护 FPS，这是因为会对 SENSEFET 施加严重的电流应力，直至触发 OLP。FPS 包括内部异常过流保护 (AOCP) 电路，如图 20 所示。当栅极导通信号被用于功率感测时，AOCP 模块被启用并通过感测电阻监控电流。电阻两端的电压与预置 AOCP 电平进行比较。如果感测电阻电压大于 AOCP 电平，设置信号被施加到锁存，导致 SMPS 关断。

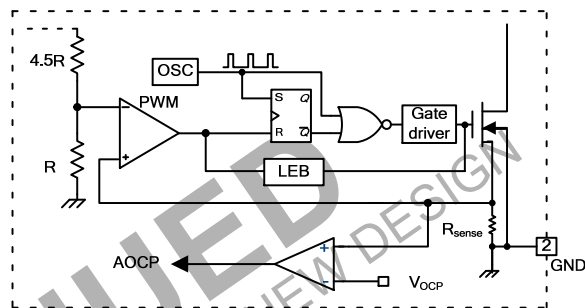


图 20. 异常过流保护

热关断 (TSD)

SENSEFET 和控制 IC 集成在一起，方便了 SENSEFET 温度的检测。当结温超过 $\sim 135^{\circ}C$ 时，激活热关断，当温度降低至 $60^{\circ}C$ 时，PFS 被重启。

过压保护 (OVP)

若次级端反馈电路出现功能故障或焊接故障导致反馈开环，通过光电耦合器晶体管的电流几乎变为零 (参见图17)。然后， V_{FB} 将以类似于过载情况的方式攀升，从而导致强制向 SMPS 提供预置最大电流，直到激活过载保护。由于向输出端提供了过大能量，在激活过载保护之前，输出电压可能就超出了额定电压，从而导致次级端器件击穿。为防止出现这种现象，采用了过压保护 (OVP) 电路。通常， V_{CC} 与输出电压成正比，FPS 采用 V_{CC} ，而不是直接监控输出电压。如果 V_{CC} 超过 24.5 V，过压保护电路被激活，导致开关操作终止。为避免在正常工作期间激活 OVP， V_{CC} 应该设计为低于 24.5 V。

线路欠压保护 (LUVP)

如果转换器输入电压低于最小工作电压，转换器输入电流会增大太多，导致元件故障。如果输入电压较低，转换器应该受到保护。在 FSL206MR 中，LUVP 电路采用 LS 引脚检测输入电压，如果该电压低于 1.5 V，会生成 LUVP 信号。比较器有 0.5 V 的滞回。如果生成了 LUVP 信号，输出驱动模块关断，输出电压反馈环路饱和。

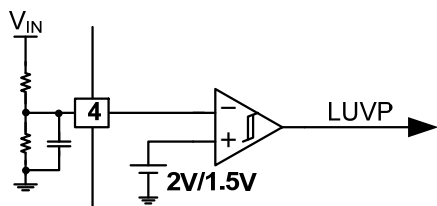


图 21. 线路 UVP 电路

软启动

FSL206MR 具有内部软启动电路，它启动后能够缓慢增大反馈电压以及 SENSEFET 电流。典型软启动时间为 15 ms，如图 22 所示，启动过程中允许 SENSEFET 电流逐渐递增。输入功率开关器件的脉宽逐渐增加，从而建立适合变压器、电感器和电容器的正确工作条件。输出电容器上的电压逐渐增加，旨在顺畅地建立所需的输出电压。软启动还有助于防止变压器饱和，并减少次级二极管上的应力。

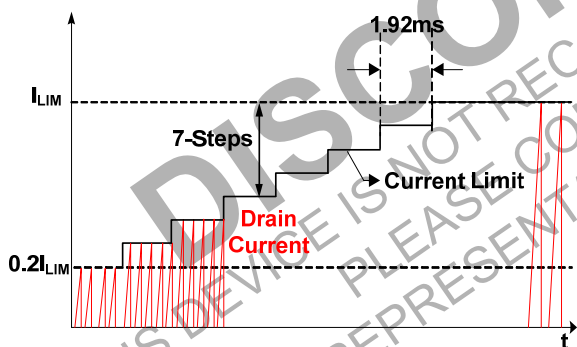


图 22. 内部软启动

间歇运行

为最大限度地降低待机模式下的功耗，FPS 会进入间歇模式。随着负载减小，反馈电压也随之减小。如图 23 所示，反馈电压降至 V_{BURL} 以下时，器件自动进入间歇运行模式。开关过程继续进行，直至反馈电压跌至低于 V_{BURL} 。此时，开关操作将停止，输出电压开始降低，降低的速率取决于待机电流负载。这会导致反馈电压上升。一旦此值超过 V_{BURH} ，开关操作将恢复。反馈电压则随之降低，此过程重复进行。间歇模式会交替使能和禁用 SENSEFET 的开关过程，并降低待机模式下的开关损耗。

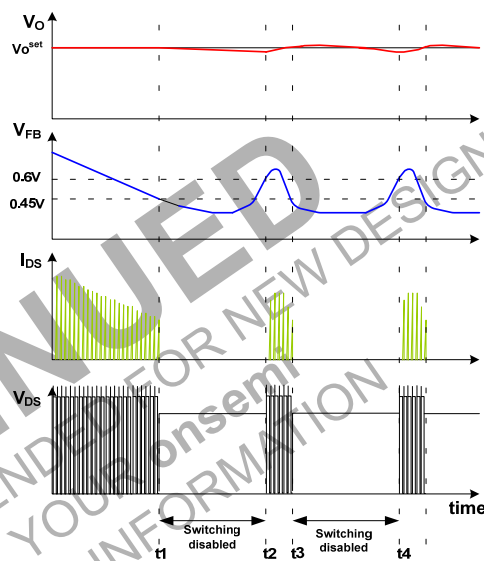
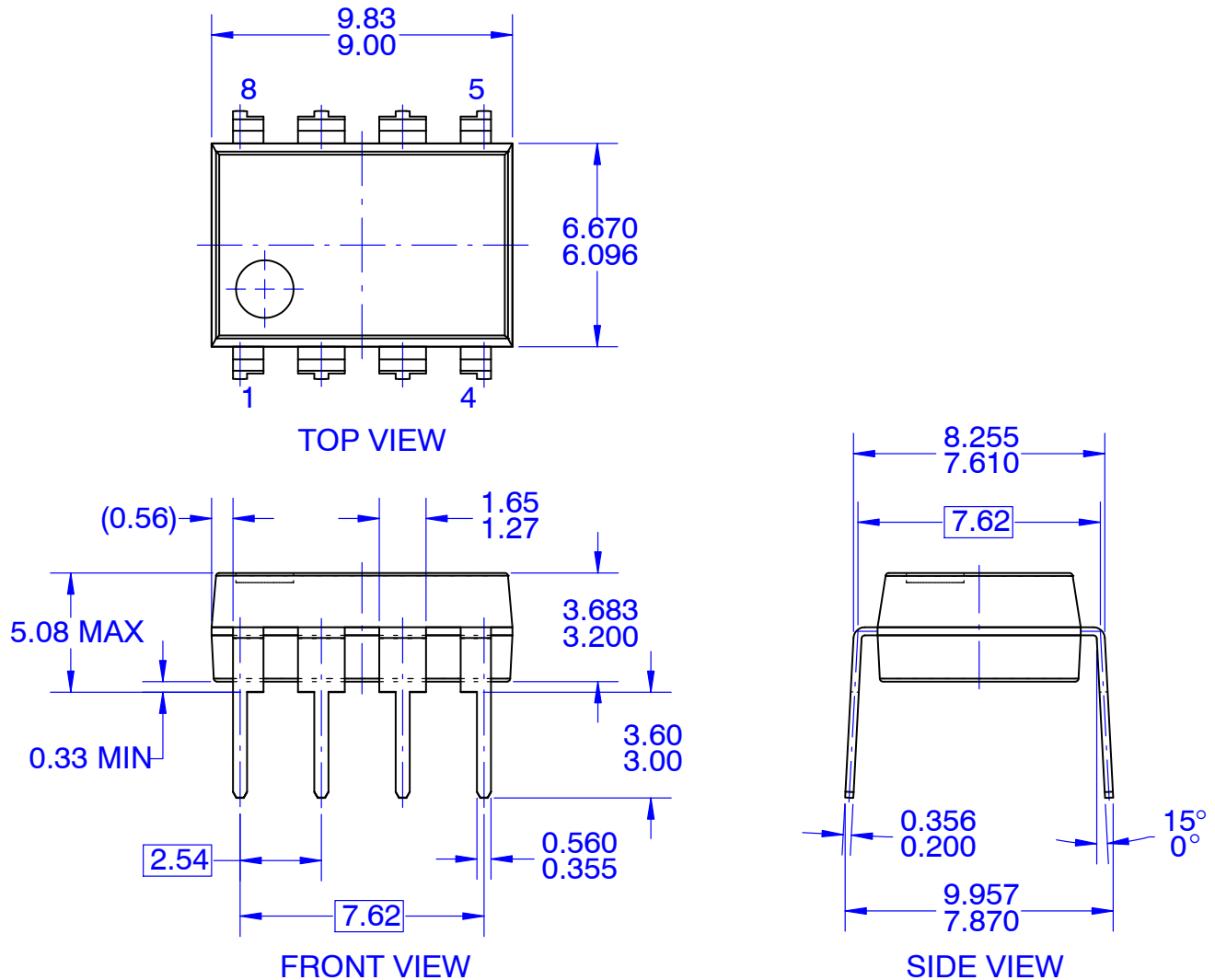


图 23. 间歇模式运行

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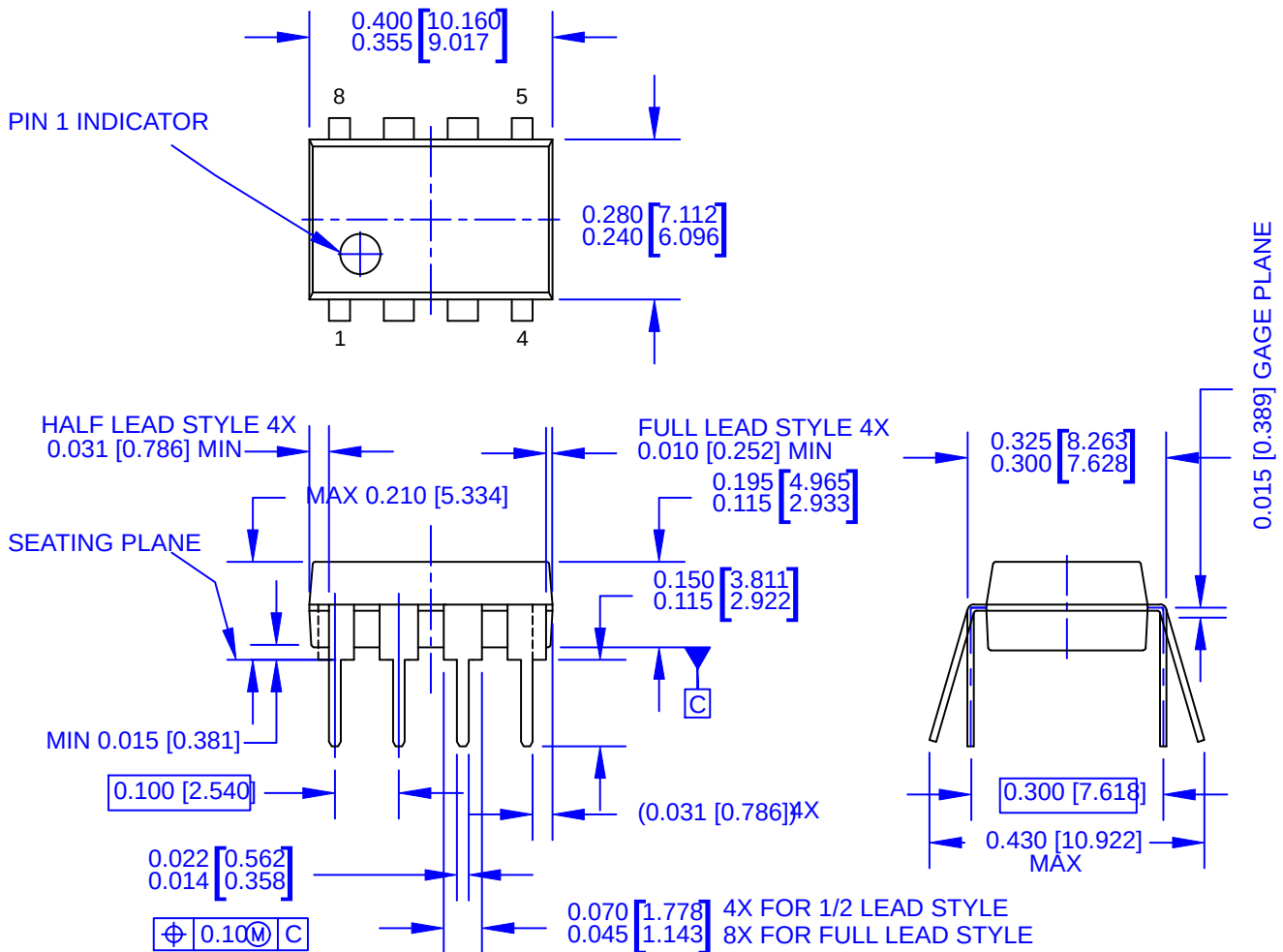
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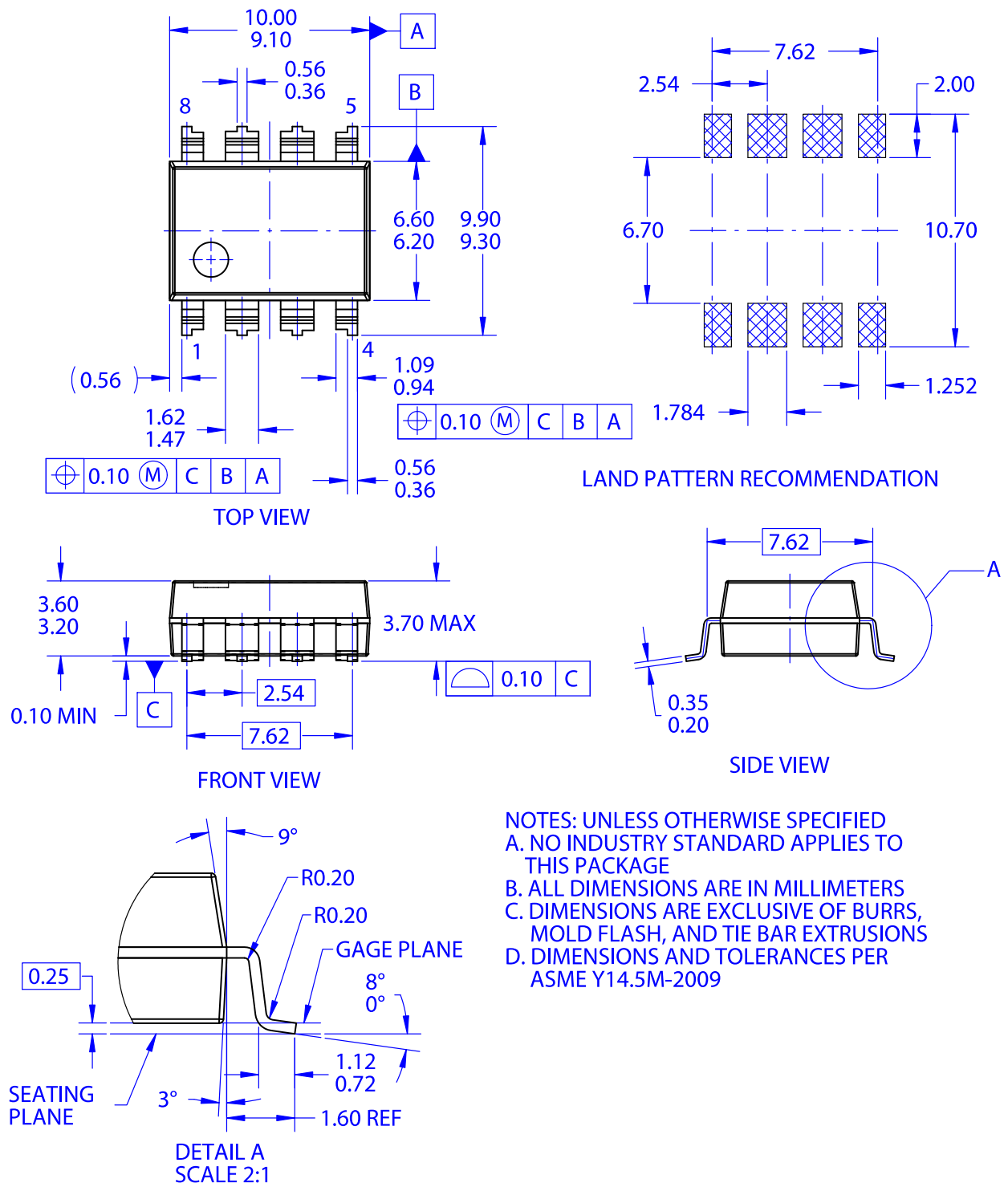
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