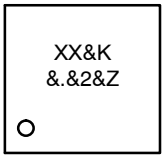
2.5 MHz、固定输出同步 TINYBOOST®稳压器

FAN48610

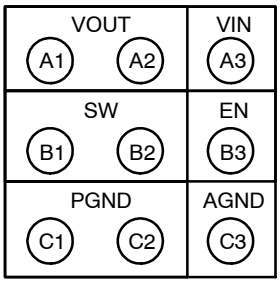
WLCSP9
CASE 567QW

MARKING DIAGRAM



XX	= KA / KF / KN
&K	= Lot Code
&.	= Alphabetical Year Code
&2	= Numeric Date Code
&Z	= Assembly Plant Code

PIN ASSIGNMENT



(Top View)

ORDERING INFORMATION

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

说明

FAN48610是一款低功耗设计的升压调节器，专门设计为可从标准单节锂离子电池和高级电池化学提供最低的电压调节轨。即使低于最小系统电池电压，器件也能保持最小输出负载电流1.0 A的输出电压调节。内置功率晶体管、同步整流以及低源电流的完美融合，使FAN48610成为电池供电应用的理想之选。

FAN48610可提供9凸块、0.4 mm间距的晶圆级芯片尺寸封装(WLCSP)。

特性

- 输入电压范围：2.5 V 至 4.8 V
- 输出电压范围：3.0 V 至 5.0 V
- $I_{OUT} \geq 1$ A (V_{OUT} = 5.0 V, $V_{IN} \geq 2.5$ V)
- $I_{OUT} \geq 1.5$ A (V_{OUT} = 5.0 V, $V_{IN} \geq 3.0$ V)
- 能效高达 94%
- 内部同步整流器
- 负载真正断开的软启动
- 短路保护
- 9 焊球、1.215 mm × 1.215 mm、0.4 mm 间距的 WLCSP
- 三个外部元件：2016 0.47 μH 电感、0603 外壳大小的输入/输出电容
- 总应用电路板解决方案尺寸：< 11 mm^2

应用

- D 类音频放大器和 USB OTG 电源
- 针对低压锂离子电池升压
- 智能手机、平板电脑、便携设备、可穿戴电子

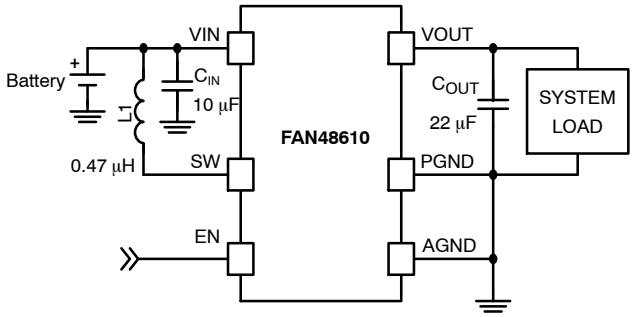


图 1. 典型应用

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表 1. 订购信息

部件编号	V_{OUT}	工作温度	封装	封装†	器件标记
FAN48610UC50X	5.0 V	–40°C 至 85°C	WLCSP, 0.4 mm 间距	卷带	KF
FAN48610BUC50X (Note 1)					
FAN48610BUC45X (Note 1)	4.5 V				KA
FAN48610BUC33X (Note 1)	3.3 V				KN

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

1. 包括背面层压。

框图

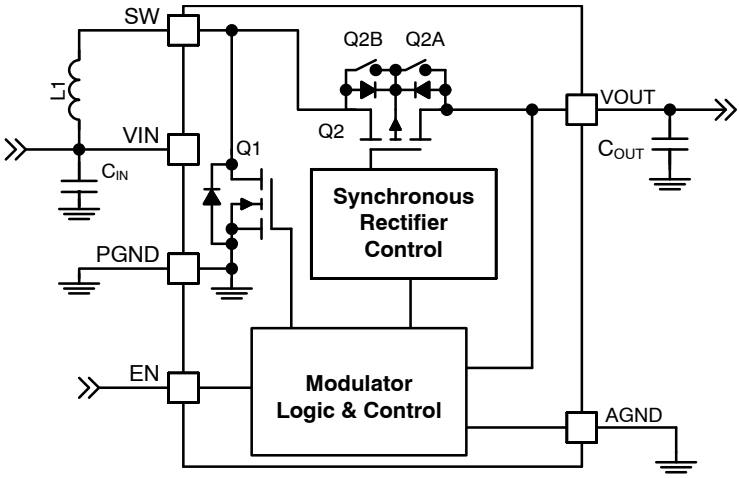

图 2. IC 模块图

表 2. 推荐元件

元件	说明	厂商	参数	典型值	单位
L1	0.47 µH, 30%, 2016	Toko: DFE201612C DFR201612C Cyntec: PIFE20161B	L	0.47	µH
			DCR (系列 R)	40	mΩ
C_{IN}	10 µF, 10%, 6.3 V, X5R, 0603	Murata: GRM188R60J106K TDK: C1608X5R0J106K	C	10	µF
C_{OUT}	22 µF, 20%, 6.3 V, X5R, 0603	TDK: C1608X5R0J226M	C	22	µF

引脚配置

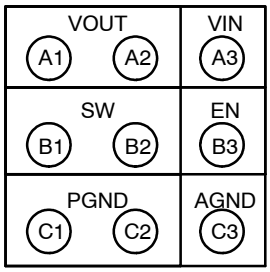

图 3. 俯视图

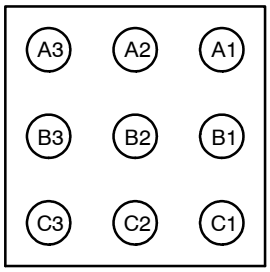

图 4. 底视图

表 3. 引脚定义

引脚号	名称	说明
A1, A2	VOUT	输出电压。此引脚是输出电压端子；直接连接到C_{OUT}。
A3	VIN	输入电压。连接到锂离子输入电源和栅极驱动器的偏压电源。
B1, B2	SW	开关节点。连接至电感。
B3	EN	使能。该引脚为高电平时，使能该电路。
C1, C2	PGND	电源地。这是IC的电源返回。C_{OUT}电容应使用可能的最短路径返回到这些引脚。
C3	AGND	模拟地。这是用于IC的信号接地参考。关于此引脚，测量了所有电压电平—在单个点连接到PGND。

表 4. 绝对最大额定值

符号	参数		最小值	最大值	单位
V_{IN}	VIN 引脚上的电压		–0.3	6.0	V
V_{OUT}	VOUT 引脚上的电压		–0.3	6.0	V
SW	SW 节点	DC	–0.3	6.0	V
		瞬态：10 ns，3 MHz	–1.0	8.0	
V_{CC}	其它引脚上的电压		–0.3	6.0 (Note 2)	V
ESD	静电放电防护等级	人体模型满足 JESD22–A114	2		kV
		充电器件模型 JESD22–C101	1		
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

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。

2. 选取6.0 V与V_{IN} + 0.3 V中的较小值。

表 5. 推荐工作条件

符号	参数	最小值	最大值	单位
V_{IN}	电源电压	2.5	4.8	V
I_{OUT}	最大输出电流	1000		mA
T_A	环境温度	–40	+85	°C
T_J	结温	–40	+125	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.
(参考译文)
高于推荐工作范围表格中所列电压时，不保证能够正常运行。长时间在推荐工作范围表格中规定范围以外的电压下运行，可能会影响器件的可靠性。

表 6. 热性能

符号	参数	典型值	单位
θ_{JA}	结至环境热阻	50	°C/W

结–环境之间热阻与具体应用和电路板布局有关。该数据由带过孔的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$T_{J(max)}$。

表 7. 电气特性
(否则每图1个电路为推荐的工作条件，V_{OUT} = 3.0 V至5.0 V，V_{IN} = 2.5 V至4.5 V，T_A = –40°C至85°C。典型值针对V_{IN} = 3.6 V 且 T_A = 25°C的情况给出，除非另有说明。)

符号	参数	工作条件	最小值	典型值	最大值	单位
电源						
I_Q	V_{IN}静态电流	V_{IN} = 3.6 V, I_{OUT} = 0 A, EN = V_{IN}		85	125	µA
		关断：EN = 0, V_{IN} = 3.6 V		3	10	
V_{UVLO}	欠压锁定	V_{IN} 上升		2.2	2.3	V
V_{UVLO_HYS}	欠压锁定滞环宽度			150		mV
输入						
V_{IH}	启用HIGH电压		1.05			V
V_{IL}	启用LOW电压				0.4	V
I_{PD}	下拉吸电流	EN引脚，逻辑高电平		100		nA
R_{LOW}	Low-State有源下拉电流	EN引脚，逻辑低电平	200	300	400	kΩ
输出						
V_{REG}	输出电压精度DC (Note 3)	以V_{OUT}为基准， 2.5 V ≤ V_{IN} ≤ V_{OUT} –150 mV	–2		4	%
I_{LK_OUT}	VIN至VOUT漏电流	V_{OUT} = 0, EN = 0, V_{IN} = 4.2 V			1	µA
I_{LK}	VOUT至VIN反向漏电流	V_{OUT} = 5.0 V, EN = 0, V_{IN} = 2.5 V			3.5	µA
V_{TRSP}	输出电压精度瞬态(Note 4)	以V_{OUT}为基准，50–500 mA负载阶跃	–5		5	%
计时						
f_{SW}	开关频率	V_{IN} = 3.6 V, V_{OUT} = 5.0 V, 负载 = 1000 mA	2.0	2.5	3.0	MHz
t_{SS}	软启动EN高电平至稳压(Note 4)	50 Ω负载，V_{OUT} = 5.0 V		600		µA
t_{RST}	故障重启计时器(Note 4)			20		ms

表 7. 电气特性 (continued)
(否则每图1个电路为推荐的工作条件，V_{OUT} = 3.0 V至5.0 V，V_{IN} = 2.5 V至4.5 V，T_A = –40°C至85°C。典型值针对V_{IN} = 3.6 V 且 T_A = 25°C的情况给出，除非另有说明。)

符号	参数	工作条件	最小值	典型值	最大值	单位
功率级						
$R_{DS(ON)N}$	N沟道升压开关$R_{DS(ON)}$	V_{IN} = 3.6 V, V_{OUT} = 5.0 V		80	130	mΩ
$R_{DS(ON)P}$	P沟道同步整流器$R_{DS(ON)}$	V_{IN} = 3.6 V, V_{OUT} = 5.0 V		65	115	mΩ
I_{V_LIM}	升压谷底电流限值	V_{OUT} = 5.0 V		3.00	3.85	A
$I_{V_LIM_SS}$	升压软启动谷底限流	V_{IN} < V_{OUT} < V_{OUT_TARGET}, SS模式		1.7		A
$V_{MIN_1.0A}$	最小V_{IN}，针对1000 mA负载(Note 4)	V_{OUT} = 5.0 V		2.5		V
$V_{MIN_1.5A}$	最小V_{IN}，针对1500 mA负载(Note 4)	V_{OUT} = 5.0 V		3.0		V
T_{150T}	过温保护(OTP)			150		°C
T_{150H}	OTP滞后			20		°C

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。

3. DC I_{LOAD}从0至1 A。V_{OUT}从输出电压纹波的中点测量。C_{OUT}的有效电容 ≥ 3 μF。
4. 由设计和特性保证；未经产品测试。

典型特性

(否则 V_{IN} = 3.6 V、V_{OUT} = 5.0 V、T_A = 25°C，电路和组件依据图1，除非另有规定。)

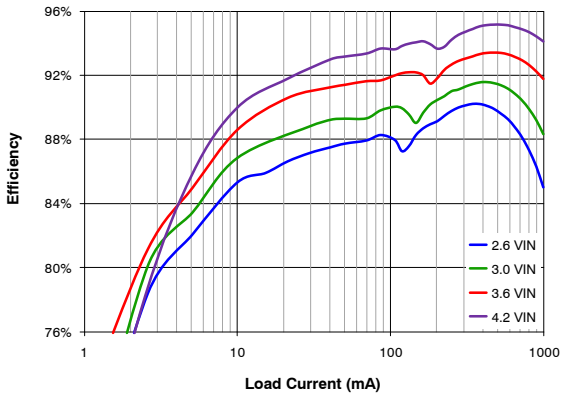

图 5. 效率与负载电流和输入电压的关系

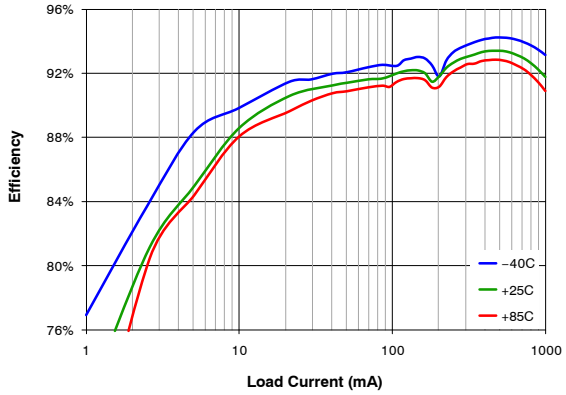

图 6. 效率与负载电流和温度的关系

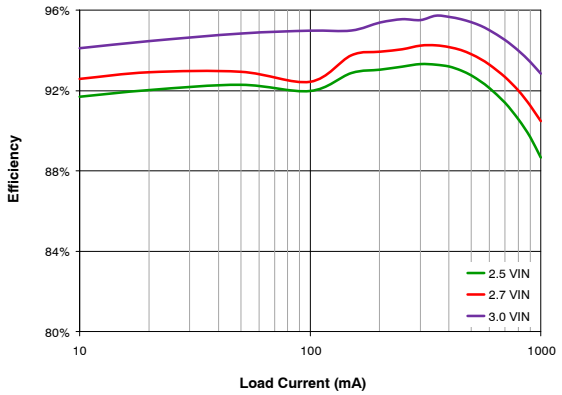

图 7. 效率与负载电流和输入电压的关系，V_{OUT} = 3.3 V

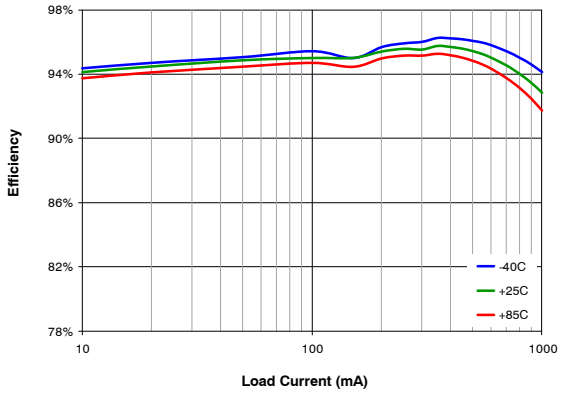

图 8. 效率与负载电流和温度的关系，V_{IN} = 3.0 V, V_{OUT} = 3.3 V

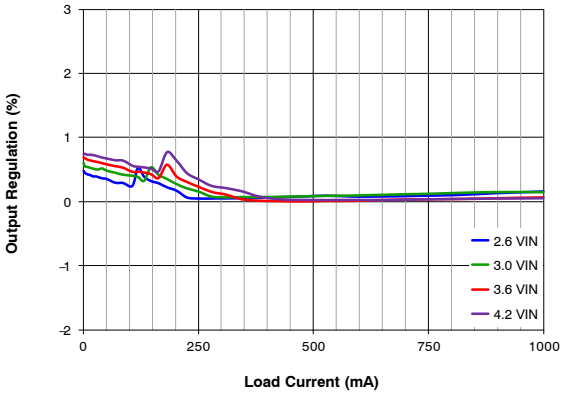

图 9. 输出调节与负载电流和输入电压的关系(正规化为3.6 V_{IN}、500 mA负载)

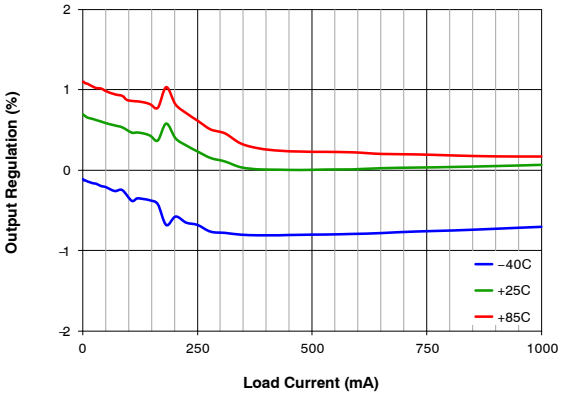

图 10. 输出调节与负载电流和温度的关系(正规化为3.6 V_{IN}、500 mA 负载、T_A = 25°C)

典型特性

(否则 V_{IN} = 3.6 V、V_{OUT} = 5.0 V、T_A = 25°C，电路和组件依据图1，除非另有规定。)

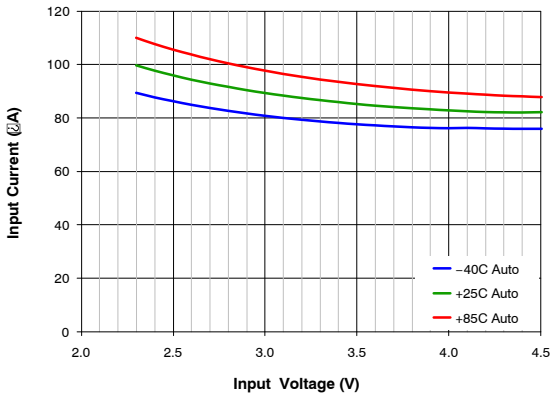

图 11. 静态电流与输入电压和温度的关系

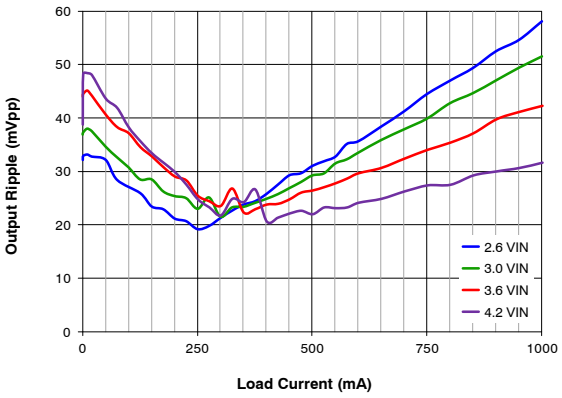

图 12. 输出纹波与负载电流和输入电压的关系

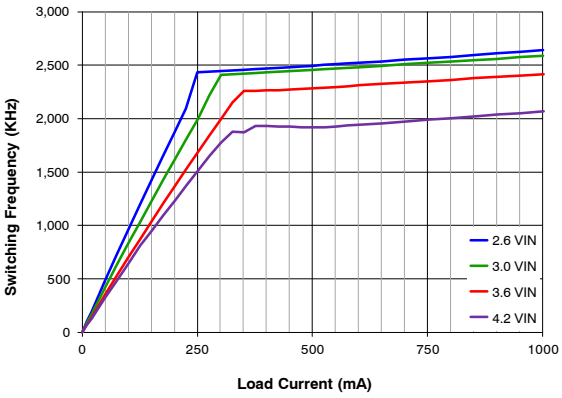

图 13. 输出纹波与负载电流和输入电压的关系

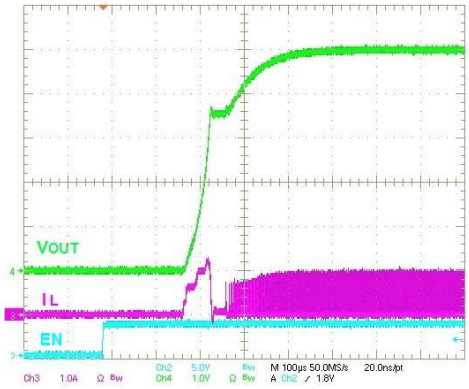

图 14. 启动，50 Ω 负载

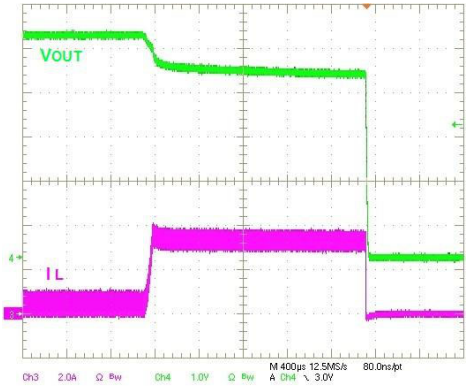

图 15. 过载保护

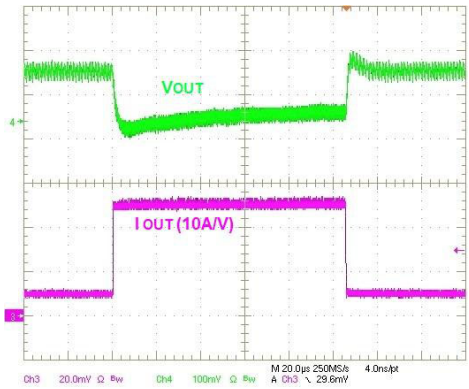

图 16. 负载瞬态，100–500 mA，100 ns 边沿

典型特性

(否则 V_{IN} = 3.6 V、V_{OUT} = 5.0 V、T_A = 25°C，电路和组件依据图1，除非另有规定。)

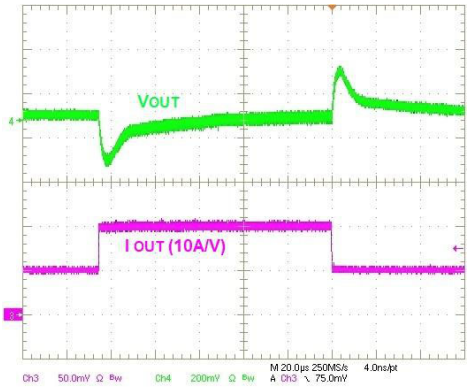

图 17. 负载瞬态，**500–1000 mA**，**100 ns** 边沿

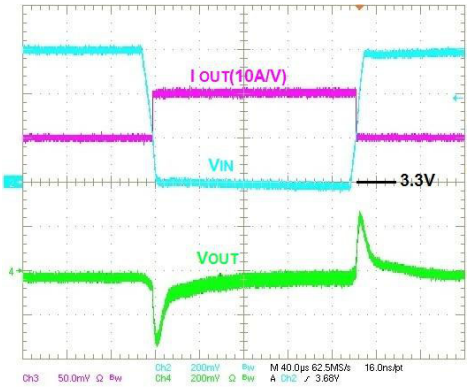

图 18. 同向线路/负载瞬态，**3.3–3.9 V_{IN}**，**10 µs**边沿，**500–1000 mA** 负载，**100 ns** 边沿

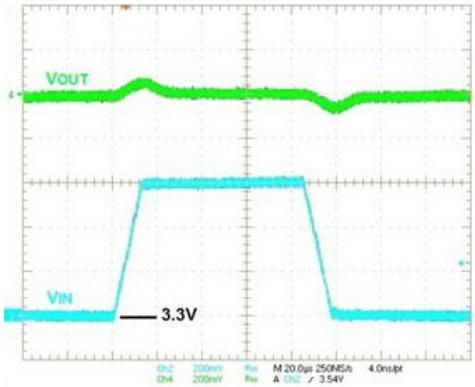

图 19. 线路瞬态，**3.3–3.9 V_{IN}**，**10 µs** 边沿，**500 mA** 负载

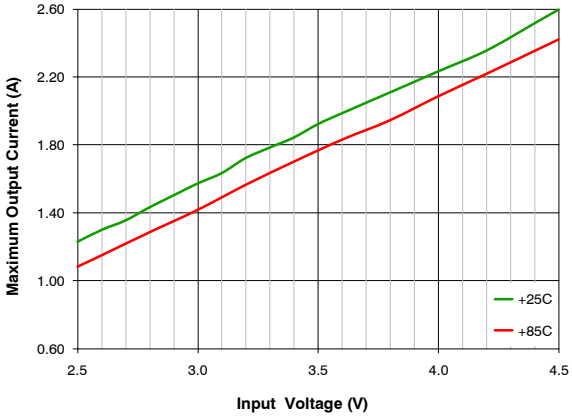

图 20. 典型最大输出电流与输入电压的关系

电路说明

FAN48610是同步升压稳压器，通常在连续导通模式(CCM)中以2.5 MHz的频率运行，其从中度至重载电流和低V_{IN}电压下发生。当V_{IN}在升压稳压器的设定点以上时，该稳压器的导通模式自动激活。

表 8. 工作模式

Mode	说明	调用时间点：
LIN	线性启动	$V_{IN} > V_{OUT}$
SS	升压软启动	$V_{IN} < V_{OUT} < V_{OUT(TARGET)}$
BST	升压操作模式	$V_{OUT} = V_{OUT(TARGET)}$
PT	导通模式	$V_{IN} > V_{OUT(TARGET)}$

升压模式调节

FAN48610使用电流模式调制器在CCM和DCM操作之间实现出色的瞬态响应和平滑转换。在CCM运行期间，器件保持约2.5 MHz的开关频率。在轻负载运行(DCM)中，将自然降低频率以保持高效率。

关断和启动

当EN为低电平时，所有偏置电路关闭并且稳压器处于关闭模式。在关断时，电流无法从VIN传至VOUT，也无法逆向从VOUT传至VIN。建议保持负载电流耗电量低于500 mA，直至器件成功执行启动。下表说明启动序列。

表 9. 升压启动顺序

启动模式	进入	退出	结束模式	超时 (µs)
LIN1	$V_{IN} > V_{UVLO}$, EN = 1	$V_{OUT} > V_{IN} - 300$ mV	SS	
		超时	LIN2	512
LIN2	LIN1 退出	$V_{OUT} > V_{IN} - 300$ mV	SS	
		超时	故障	1024
SS	LIN1 或 LIN2 退出	$V_{OUT} = V_{OUT(TARGET)}$	BST	
		过载超时	故障	64

LIN模式

当EN为高电平且$V_{IN} > V_{UVLO}$时，稳压器先尝试使用来自VIN (Q2)的内部固定电流源使V_{OUT}在V_{IN}的300 mV内。电流限制为LIN1设定点。

如果V_{OUT}在LIN1模式期间达到VIN−300 mV，将启动SS模式。否则，512 µs后LIN1将超时，并进入LIN2模式。

在LIN2模式中，电流源增大到1.6 A。如果V_{OUT}在1024 µs后未能达到V_{IN}−300 mV，将宣布故障状况，并且器件等待20 ms尝试自动重新启动。

软启动 (SS) 模式

成功完成LIN模式($V_{OUT} \geq V_{IN}$−300 mV)后，稳压器开始使用限制为标称电平50%的升压脉冲电流开关。

在SS模式期间，如果V_{OUT}在SS斜变序列中到达稳压的时间未超过64 µs，会宣布故障。如果使用大C_{OUT}，参考电压将自动减慢以避免过多消耗输入电流。

升压 (BST) 模式

这是稳压器的正常工作模式。

导通 (PT) 模式

在正常操作中，如果V_{IN}高于目标V_{OUT}，器件自动从升压模式转换为导通模式。在导通模式中，器件完全增强Q2以提供从V_{IN}至V_{OUT}的极低阻抗路径。在$V_{IN} > V_{OUT}$且在过去的5 µs中未发生开关操作的条件下，将触发进入导通模式。为缓和进入导通模式，Q2作为前5 µs的线性电流源驱动。当V_{OUT}达到目标V_{OUT}电压时，触发导通模式退出。在自动导通模式中，器件受电压比较器的短路保护，跟踪从V_{IN}至V_{OUT}的压降；如果压降超过300 mV，将宣布故障。

故障状态

稳压器在以下任何条件下进入故障状态：

- V_{OUT} 未能实现从 LIN 模式进入 SS 模式所需的电压。
- V_{OUT} 未能实现从 SS 模式进入 BST 模式所需的电压。
- 升压限流在 BST 模式中触发 2 ms。
- $V_{IN} - V_{OUT} > 300$ mV；此故障仅在成功完成软启动序列后发生。
- $V_{IN} < V_{UVLO}$.

一旦触发故障，调节器将停止开关，且V_{IN}和V_{OUT}之间出现高阻抗路径。等待20 ms后，尝试自动重新启动。

过温

当芯片温度超过150°C时，调节器将关闭。当IC已冷却约20°C时会重新启动。

应用信息

输出电容 (C_{OUT})

当偏置电压增大时，小型高价值陶瓷电容器的有效电容(C_{EFF} (Note 6))会减小，如下图所示：

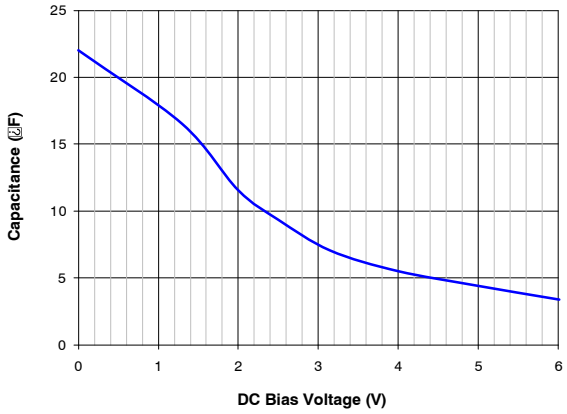

图 21. 22 µF、0603、X5R、6.3 V额定电容的 C_{EFF} (TDK C1608X5R0J226M)

FAN48610确保稳定运行，C_{EFF} ($C_{EFF(MIN)}$)最小值在表10中列出。

5. C_{EFF} varies by manufacturer, capacitor material, and case size.

表 10. 稳定运行所需的 C_{EFF} 最小值

工作条件			$C_{EFF(MIN)}$ (µF)
V_{OUT} (V)	V_{IN} (V)	I_{LOAD} (mA)	
5.0	2.5 至 4.5	0 至 1000	3.0

6. C_{EFF}视制造商、电容材料和外壳大小而异。

电感选型

推荐的标称电感值为0.47 µH。FAN48610采用谷底限流，因此峰值电感电流在过载条件下达到3.8 A持续一小段时间。饱和影响导致电感电流纹波在高负载下变得更高，因为仅控制电感电流纹波的谷底。

启动

输入限流功能将在软启动时开启，这将限制可用于为C_{OUT}以及处于V_{OUT}线路上的任何额外电容进行充电的电流。如果输出未能在上面软启动部分中所述的限制内达到标准，将发生故障，从而导致电路关闭。尝试重新启动之前，将等待约20 ms。如果总联合输出电容很高，电路一开始可能不会启动，而最终将在无负载的情况下实现调节。如果高电流负载和高电容在软启动期间都存在，电路可能无法达到标准，并且继续尝试软启动，仅在故障状态时由负载释放输出电容。

输出电压纹波

输出电压纹波与C_{OUT}成反比。在t_{ON}期间，升压开关导通时，C_{OUT}提供全负载电流。

$$V_{RIPPLE(P-P)} = t_{ON} \cdot \frac{I_{LOAD}}{C_{OUT}} \qquad \text{(eq. 1)}$$

和

$$t_{ON} = t_{SW} \cdot D = t_{SW} \cdot \left(1 - \frac{V_{IN}}{V_{OUT}}\right) \qquad \text{(eq. 2)}$$

因此：

$$V_{RIPPLE(P-P)} = t_{SW} \cdot \left(1 - \frac{V_{IN}}{V_{OUT}}\right) \cdot \frac{I_{LOAD}}{C_{OUT}} \qquad \text{(eq. 3)}$$

$$t_{SW} = \frac{1}{f_{SW}} \qquad \text{(eq. 4)}$$

当V_{IN}为最小值且I_{LOAD}为最大值时，发生最大V_{RIPPLE}。为实现更好的纹波性能，可添加更多输出电容。

推荐布局

下面的推荐布局使用不同颜色突出各种顶部灌铜。

为最小化VOUT的尖峰，C_{OUT}必须尽可能放在靠近PGND和VOUT的位置，如下所示。

考虑到热的原因，建议除了SW之外，最大限度地提高所有其他平面的铜铺面积。尤其接地铜铺应该填满所有可用的PCB表面，并利用散热孔群集与内层连接起来。

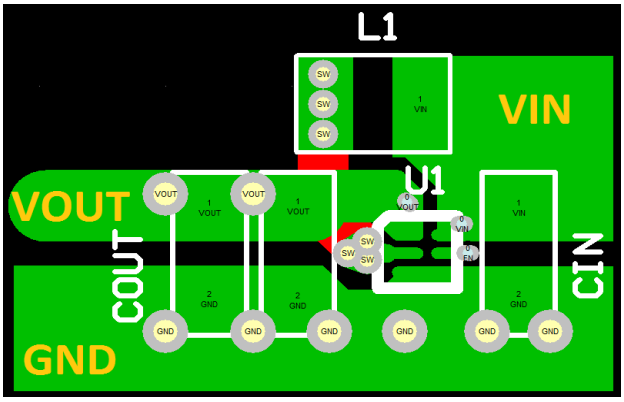

图 22. 推荐布局

特定产品尺寸 (该表属于下页上的封装信息。)

D	E	X	Y
1.215 ±0.030 mm	1.215 ±0.030 mm	0.2075 mm	0.2075 mm

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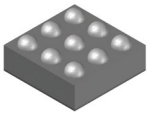

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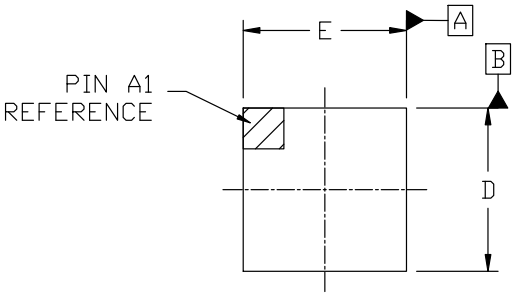
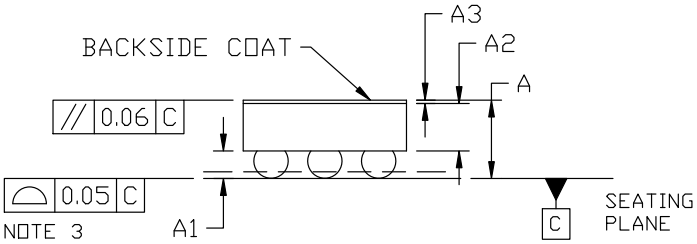
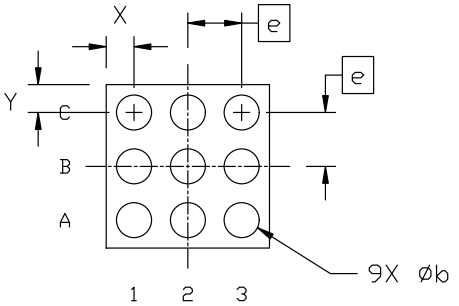


TOP VIEW



SIDE VIEW



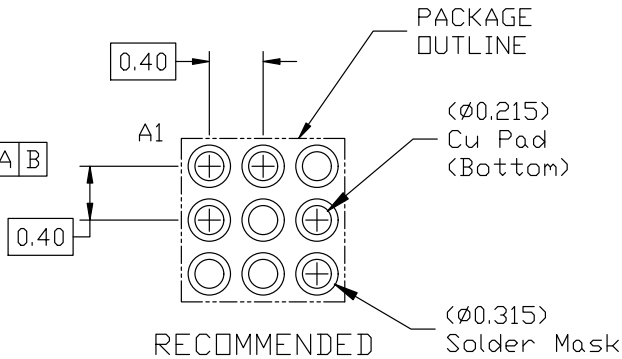
BOTTOM VIEW

0.005 Ⓜ C A B

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. COPLANARITY APPLIES TO THE SPHERICAL CROWNS OF THE SOLDER BALLS.
4. DATUM C, THE SEATING PLANE, IS DEFINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
5. DIMENSION b IS MEASURED AT THE MAXIMUM SOLDER BALL DIAMETER PARALLEL TO DATUM C.

DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	0.542	0.581	0.620
A1	0.183	0.203	0.223
A2	0.335	0.353	0.371
A3	0.022	0.025	0.027
b	0.24	0.26	0.28
D	1.185	1.215	1.245
E	1.185	1.215	1.245
e	0.400 BSC		
X	0.208 REF		
Y	0.208 REF		



RECOMMENDED
MOUNTING FOOTPRINT

* For additional information on our Pb-Free strategy and soldering details, please download the onsemi Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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