SLM5600
5V2ASynchronous Step-up Converter

DESCRIPTION

The SLM5600 devices provide a power supplysolution for products powered by eithera one-cell Li-Ion orLi-polymerbattery. The converter generates a stable output voltage that is either adjusted byan external resistor divider orfixed internallyon thechip. It provides high efficient power conversionand iscapable of delivering output currents up to 2.1A at 5.3V at a supplyvoltage down to 2.9V. The maximumpeak current in the step-up switch is limited to a value of 6A. TheSLM5600 operates at 800KHz switching frequencyand enters pulse-skip-mode (PSM) operation at light load currentsto maintain high efficiency over the entire load current range. The PSM mode extends the batterylife by reducing the quiescent current to 80μA (typ) during lightload operation. A low-EMI mode is implemented to reduce ringing and, in effect, lowerradiated electromagnetic energy when the converter enters the discontinuous conduction mode. The converter can be disabled to minimize battery drain. During shutdown, the load is completelydisconnected from the battery.

FEATURES

- 95% Efficient Synchronus Step-up Converter with 2A OutputCurrent From 2.9V Input
- Wide VBAT Range From 2.5V to5.5V
- Fixed and Adjustable Output Voltage
- Built-in Output Over-voltage Protection
- Light-Load Pulse Skip Mode with 80μA Quiescent Current
- Low Battery Comparator
- Low EMI-Converter (Integrated Anti-ringing Switch)
- Load Disconnect During Shutdown
- ThermalShutdown and Overload Protection
- Available in a Small3mmx 3mm QFN-16

APPLICATIONS

- Tablet PCand Notebook
- PowerBank
- USB Charging Port (5V)
- DC/DC MicroModules

Figure1. SLM5600 Typical Operating Circuit

SLM5600

5V2ASynchronous Step-up Converter

Ordering Information

Part No.	Marking	Temp. Range	Package	Remark
SLM5600	SLM5600 xxxxx	-40°C ~+85°C	QFN16L 3x3	

PinConfiguration

PinDescription

NAME	PIN NO.	DESCRIPTION
EN	11	Enable input. (1: VBAT enabled, 0: GND disabled)
FB	14	Voltage feedback of adjustable versions. Connect FB to GND and set fixed 5.125V output voltage.
GND	13	Analog Ground pin. Connect GND toPGND underEP.
LBI	9	0.5V Threshold Low batterycomparatorinput (comparatorenabled with EN)
LBO	12	Lowbattery comparatoroutput (open drain)
NC	2	Not connected
MODE	10	Enable/disable pulse skipmode (1: VBATdisabled, 0: GND enabled)
SW	3，4	Step-up and rectifying switch input
PGND	5，6，7	Power Ground pin.
VBAT	8	Input Supplyvoltage
VOUT	1，15，16	Step-up convert output
EP		Exposed pad must be soldered to achieve appropriate power dissipation. Connect EP to GND.

AbsoluteMaximum Rating(1)

SupplyVoltage(VBAT) ....-0.3Vto+6V

Output Voltage (VOUT) ....-0.3Vto +6V

InputVoltage (LBI, LBO,SW) .... -0.3V to +6V

InputVoltage (MODE, EN,FB)........-0.3Vto+6V

Peak outputcurrent .... Internallylimited

Lead Temperature ....260°C

Junctiontemperature range, TJ ......-40°C ~+135°C

Storage temperature range, Tstg ......-55°C~+155°C

Thermalinformation

Maximum Power Dissipation(TA=+25°C)......2.2W

Thermal resistance(θJA)...............................45°C/W

RecommendOperatingConditions(2)

InputVoltage (VBAT)......................+2.5V to+5.5V

Output Voltage (VOUT) ....+2.5Vto +5.5V

Operating Temperature Range ......-40°C to+85°C

Note(1): Stressbeyond thoselisted under "AbsoluteMaximum Ratings" may damage the device.

Note(2): The deviceisnotguaranteed to function outside the recommended operatingconditions.

ElectricalCharacteristics

TA= +25°C, 2.5V ≤ VBAT ≤ 5.5V, unlessotherwisenoted.
Typical valuesare atVBAT= VEN =3.6V andVOUT=5V.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input voltagerangeVBAT				2.5		5.5	V
Input Under voltagelockout threshold		VBATvoltagedecreasing			2.2		V
OutputvoltageadjustablerangeVOUT				2.5		5.5	V
		FB=GND	TA= +25°C	4.90	5.00	5.10	V
			TA= –40°C to+85°C	4.85		5.15	
Feedbackvoltage VFB		TA =+25°C		490	500	510	mV
Oscillator frequencyfOSC					800		KHz
NCH SwitchCurrentLimit		VOUT=5V			5.5		A
NCH Switchon resistance		VOUT=5V			60		mΩ
PCH Switch onresistance		VOUT=5V			60		mΩ
Shutdown Current		VEN = 0V,VBAT = 3.6V			0.1	1	μA
	VBAT	VFB = 0.55V			80		μA
	VOUT	VFB = 0.55V, VOUT = 5V			5		
LowBatteryLBI voltagethreshold		VLBI voltagedecreasing		485	500	515	mV
LBI inputhysteresis					10		mV
LBI inputBias Current		LBI =VBAT or GND		-0.1		0.1	μA
LBO output lowvoltage		VOUT=5V andVLBI=0V,sink 100μA			0.04	0.4	V
LBO output leakagecurrent		VLBI=0.6V and VLBO= 5V				0.1	μA
EN, MODE logic lowvoltage						0.4	V
EN, MODE logic high voltage				1.4			V

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
EN, MODE leakagecurrent	Clampedon GND or VBAT	-1		1	μA
Thermal Shutdown			150		℃
Thermal ShutdownHysteresis			20		℃

FunctionalBlockDiagram

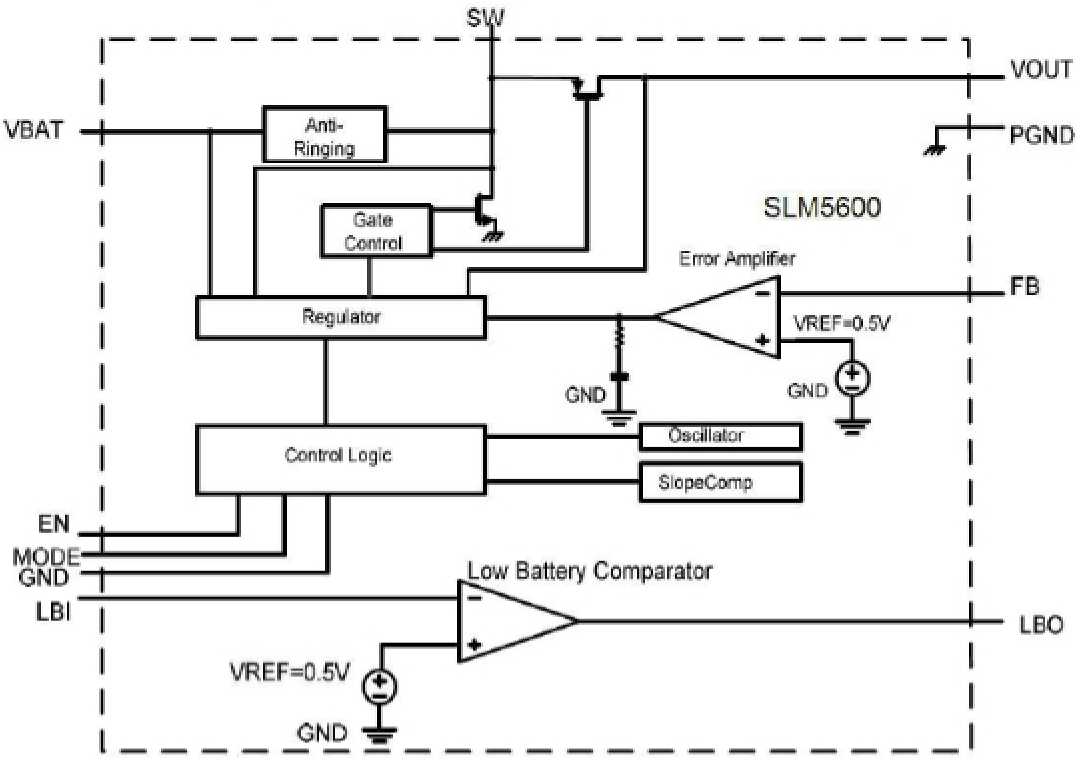


Figure2.SLM5600 Functional BlockDiagram

Detailed Description

The SLM5600 isbased ona fixedfrequencycurrent mode pulsewidthmodulationtopology.The peak currentof theNMOS switch issensedtolimit themaximumcurrent flowingthroughtheswitchandtheinductor.Thetypical peakcurrentlimit isset to6A. An internal temperature sensorpreventsthedevicefromgetting overheatedincase ofexcessive power dissipation.

The MODE pin can beusedtoselect different operationmodes. Set MODE pinlowto enablepulseskip mode andimprove efficiency at light load. In pulse skip mode,theconverter onlyoperateswhen theoutput voltage tripsbelowa setthreshold voltage. It ramps uptheoutput voltagewith oneor severalpulsesandreturns pulseskip mode once theoutput voltageexceeds thesetthreshold voltage. This pulseskip mode canbedisabledbysettingthe MODE toVBAT.

The low-batterydetector circuit LBI/LBO istypically used tosupervise thebattery voltageand togenerate an errorflagwhenthebatteryvoltagedropsbelowauser-set thresholdvoltage. Thefunctionis onlyactivewhenthe deviceis enabled(EN=Hi).Whenthedeviceisdisabled, the LBOpinis high-impedance. The LBI trip thresholdis 500 mV.Duringnormal operation,LBO stays at highimpedance whenthevoltage, appliedat LBI,isabovethe threshold.It is active lowwhen the voltageat LBI goesbelow500mV.The lowbatteryvoltagecanbe programmedwith aresistive divider connected to theLBI pin.

The deviceintegratesa circuit that removes theringing thattypicallyappearsontheSW node when the converter entersdiscontinuouscurrent mode. Inthis case,thecurrent throughthe inductor ramps tozero andtherectifying PMOS switchisturned off toprevent areverse current flowingfrom theoutput capacitorsback tothebattery. Due tothe remainingenergy thatis storedinparasitic componentsof thesemiconductor andtheinductor,a ringingon theSW pin isinduced. Theintegrated anti-ringingswitchclampsthis voltagetoVBATandthereforedampensringing.

Application Information

Becauseofthehighintegration of SLM5600, the applicationcircuit issimple. Onlyinput capacitor C1, output capacitorC2, C3, inductor L, outputfeedback resistors R3, R4, LBI Batteryvoltagedivider R1,R2,LBO pull-upresistor R6needto beselectedfor thetargeted applications specifications.

Settingthe OutputVoltage

TheSLM5600output voltagecanbeadjustedwith an external resistor divider (SeeFigure1 SLM5600Typical OperatingCircuit). The typical value ofthe voltageon the FB pinis500mV.Themaximumallowed valuefor the outputvoltageis5.5V.Choose thebottom resistor R4 in the 100kΩ~500kΩ rangetoset thedivider current at 1μA or higher. Thevalueofresistor R3, dependingonthe needed outputvoltage VOUT, canbe calculatedusing Equation 1:

Settingthe LBI/LBO Threshold Voltage

Therecommendedvaluefor R2is thereforeinthe rangeof 500kΩ. Fromthat,thevalue ofresistor R1, dependingonthedesiredminimumbatteryvoltage VBAT, canbe calculated usingEquation2:

Theoutput ofthelowbattery supervisor isasimple open-drainoutput thatgoesactive lowif thededicated batteryvoltagedropsbelowthe programmedthreshold voltageonLBI. The LBOoutput requiresapull-up resistor with arecommendedvalueof 1MegΩ.Themaximum voltagewhichisused to pullup theLBOoutputs shouldnot exceedthe SLM5600output voltage. If notused, theLBO pincanbeleftfloatingor tiedto GND.

Inductor Selection

The inductor DC current rating should be greater (by some margin) than the maximum input average current. The highest peak current through the inductor and the switch depends on the output load, converter efficiency η, the input voltage (VBAT), and the output voltage (VOUT). Estimation of the maximum average inductor current can be done using Equation 3:

For example, for an output current of 2A at 5V with 85% efficiency, at least 4.7A of average current flows through the inductor at a minimum input voltage of 2.5V.

The SLM5600 step-up converters have been optimized to operate with an effective inductance in the range of 1μH to 3.3μH and with output capacitors in the range of 20μF to 200μF. The internal compensation is optimized for an output filter of L = 1.2μH and COUT = 100μF. Larger or smaller inductor values can be used to optimize the performance of the device for specific operating conditions.

Input Capacitor

Place at least a 10μF input ceramic capacitor close to the IC is to improve transient behavior of the regulator and EMI behavior of the total power supply circuit.

Output Capacitor

For the output capacitor, it is recommended to use X7R ceramic capacitors placed as close as possible to the VOUT and PGND pins of the IC. A recommended output capacitance value is around 20~200μF. Note that high capacitance ceramic capacitors have a DC Bias effect, which will have a strong influence on the final effective capacitance. A 10V rated 0805 capacitor with 10μF can have an effective capacitance of less 5μF at an output voltage of 5V.

Layout consideration

Use wide and short traces for the main current path and for the power ground tracks. The input capacitor, output capacitor, and the inductor should be placed as close as possible to the IC. Use a common ground node for power ground and a different one for analog ground to minimize the effects of ground noise. Connect these ground nodes at any place close to the ground pins of the IC.

Thermal information

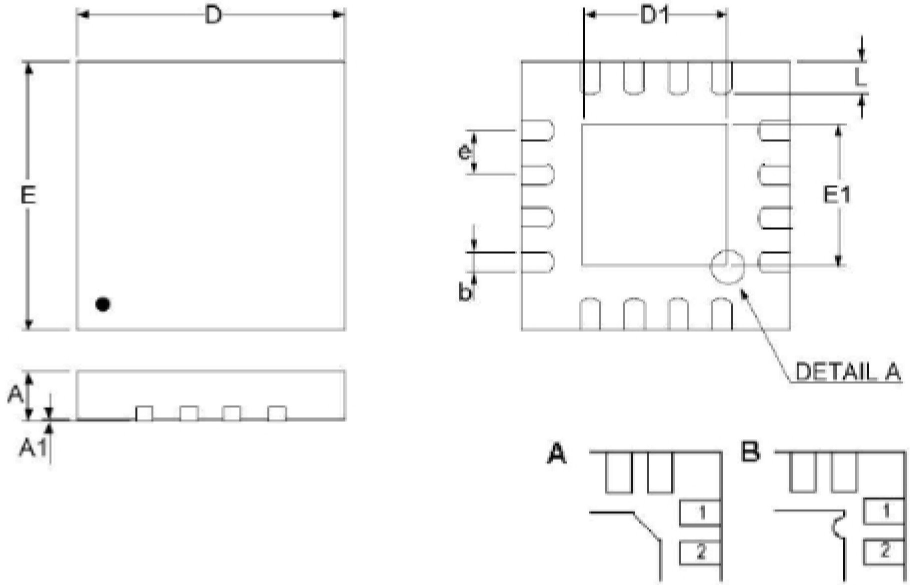
Implementation of integrated circuits in low-profile and fine-pitch surface-mount packages typically requires special attention to power dissipation. Many system-dependent issues such as thermal coupling, airflow, added heat sinks and convection surfaces, and the presence of other heat-generating components affect the power-dissipation limits of a given component.

Three basic approaches for enhancing thermal performance are listed below:

- Improve the power dissipation capability of the PCB design
- Improve the thermal coupling of the component to the PCB
- Introducing airflow in the system

The maximum junction temperature (TJ) of the SLM5600 devices is 125℃. The thermal resistance of the 16-pin QFN package is θ JA = 45℃/W, if the Exposed PAD is soldered. Specified regulator operation is assured to a maximum ambient temperature TA of +50℃. Therefore, the maximum power dissipation for the 16-pin QFN package it is about 1.67W. More power can be dissipated if the maximum ambient temperature of the application is lower.

SLM5600 QFN 16L 3mmx3mm PACKAGE OUTLINE DIMENSIONS



DETAIL A

Thermal Pad Option

SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
b	0.18	0.3	0.007	0.012
E	2.90	3.10	0.114	0.122
D	2.90	3.10	0.114	0.122
D1	1.70		0.067	
E1	1.70		0.067	
e	0.50		0.020	
L	0.30	0.50	0.012	0.020

SLM5600
800KHz 同步升压转换器
2A

概述

SLM5600 是一款针对由单节锂电池或者锂聚合物电池供电的产品提供 2A 同步升压 PWM 控制器。它可以通过外部分压电阻网络或者内部固定电阻产生稳定的输出电压。当输入电压低至 2.9V 时，输出端仍能工作在 5.1V/2.1A。

SLM5600 的工作频率为 800KHz，能够提供高效的电源转换效率，升压开关的最大峰值电流被限制在 6A。当器件进入 PSM 模式，在轻载条件下能够保持较高的效率，而且芯片在轻载时的静态电流被降低到 80uA，从而可以延长电池的使用时间。当器件进入不连续工作模式后通过减少开关处振铃，来降低电磁能量辐射。

SLM5600 可以通过关断来减少电池的放电，在芯片关断期间负载完全从电池断开。

特性

- 输出 5V/2A 时，效率高达 95%
- 2.5V~5.5V 宽范围工作电压
- 固定或者可调的输出电压
- 内置输出过压保护
- PSM 轻载时静态电流低至 80uA
- 低电量比较器
- 低电磁辐射干扰
- 关断期间负载断开
- 热关断和过流保护
- 采用 3mm x3mm QFN-16 封装

最大额定值

供电电压 (VIN)：	-0.3V to+6V
VOUT ：	-0.3V to+6V
LBI，LBO，SW：	-0.3V to+6V
MODE，EN，FB：	-0.3V to+6V
最大输出峰值电流：	6.0A
焊接温度：	260℃
最大结温：	135℃
工作环境温度范围：	-40℃~85℃
贮存温度范围：	-55℃~+155℃
最大功率损耗（TA=+25℃）：	2.2W
热阻(θJA)：	45℃/W

应用

- 台式电脑和便携式笔记本
- 移动电源
- USB 充电端口 (5V)
- DC/DC 微处理模块

SLM5600

2A 800KHz 同步升压转换器

典型应用

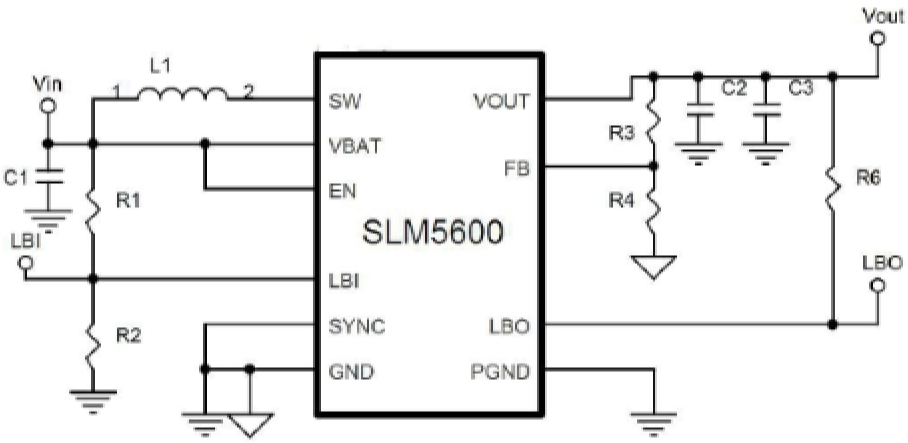
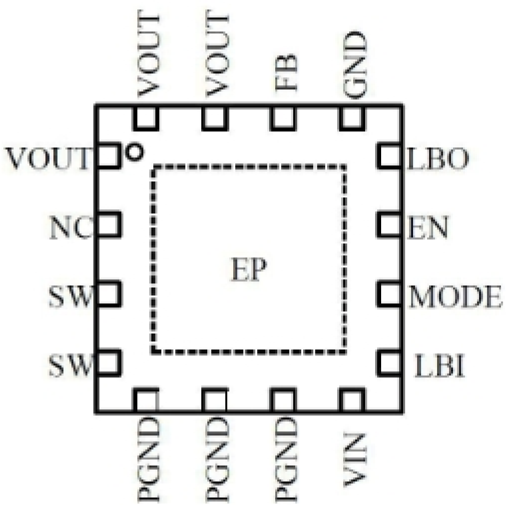


图 1. SLM5600 典型应用电路

引脚功能表



引脚	名称	说明
11	EN	输入使能端 (1: VIN 使能, 0: GND 关断)
14	FB	反馈基准电压。 FB 连接到 GND，固定输出 5.125V 输出电压
13	GND	模拟地。通过底部散热片连接模拟地和电源地
9	LBI	低电量比较器输入(比较器通过 EN 脚使能)
12	LBO	低电量比较器输出
2	NC	不连接
10	MODE	使能/关断 PSM 模式(1: VIN 关断, 0: GND 使能)
3，4	SW	升压整流开关输入
5，6，7	PGND	功率地
8	VIN	输入电源端
1，15，16	VOUT	升压转换器输出端
	EP	底部焊盘必须很好的焊接来保证可靠的功率耗散 连接底部焊盘到地

直流电特性

TA=+25°C，2.5V≤VIN≤5.5V。除非特别说明，典型测试条件 $V_{IN}=V_{EN}=3.6V$，VOUT=5V。

参数		测试条件		最小	典型	最大	单位
输入 VIN 电压范围				2.5		5.5	V
输入欠压锁定阈值		VIN 电压逐渐降低			2.2		V
输出电压 VOUT 可调范围				2.5		5.5	V
固定输出电压		FB=GND	TA=+25°C	4.95	5.05	5.15	V
			TA=-40°C to +85°C	4.9		5.2	
反馈电压 VFB		TA=+25°C		490	500	510	mV
振荡器频率 FOSC					800		KHz
NCH 开关电流限制		VOUT=5V			5.5		A
NCH 开关导通电阻		VOUT=5V			60		mΩ
PCH 开关导通电阻		VOUT=5V			60		mΩ
关断电流		VEN=0V，VBAT=3.6V			0.1	1	uA
静态电流	VIN	VFB=0.55V			80		
	VOUT	VFB=0.55V，VOUT=5V			5		uA
低电量输入 LBI 电压阈值		VLBI 电压逐渐降低		485	500	515	mV
LBI 输入迟滞					10		mV

LBI 输入基准电流	LBI=VBATorGND	-0.1		0.1	uA
LBO 输出低电压	VOUT=5V，VLBI=0V，抽 100µA 电流		0.04	0.4	V
LBO 输出漏电电流	VLBI=0.6V and VLBO=5V			0.1	uA
EN, MODE 逻辑低电压				0.4	V
EN, MODE 逻辑高电压		1.4			V
EN, MODE 漏电流	接 GND 或者 VIN	-1		1	uA
热保护关断			150		°C
热保护关断迟滞			20		°C

功能框图

图 2. SLM5600 功能框图

SLM5600
2A 800KHz 同步升压转换器

功能描述

SLM5600 是一个固定开关频率，PWM 模式的电流升压转换器。通过检测流过 NMOS 开关的峰值电流来限制流过开关和电感的最大电流，典型的峰值电流被限制在 6A。内部的温度检测器能够防止器件因为过度的功率损耗而过热。

MODE 引脚用来选择不同的工作模式，将 MODE 引脚设置为低电平确保工作在 PSM 模式下，从而提高轻载下的效率。在 PSM 模式下，转换器仅在输出电压低于设置的阈值电压时才会工作。它通过一个或者几个脉冲来增加输出电压，一旦输出电压高于设置的阈值电压后就跳出 PSM 模式。可以通过将 MODE 脚连接到 VIN 来禁用 PSM 模式。

低电量检测电路 LBI/LBO 是用来监测电池电压的典型电路，当电池电压降低到用户设置的电压阈值时 LBO 将会产生一个误差标志位。只有当器件被使能的时候(EN=Hi)检测电路才工作。在器件关断期间，LBO 表现为高阻态。在正常工作期间，当 LBI 脚的电压高于阈值 500mV 时，LBO 保持为高阻态，当 LBI 脚的电压低于阈值 500mV 时，LBO 脚变为低电平。低电池电压值可以通过连在 LBI 脚的外部分压电阻来设置。

SLM5600 进入不连续电流模式后，通过内部集成电路来减少出现在 SW 节点的振铃。在这种情况下，电流通过电感降低到零，接着整流 PMOS 开关关闭来防止出现从输出电容流到电池的反向电流。由于在寄生的半导体器件和电感中还存储着能量，SW 脚的振荡还会持续。针对开关振铃集成的电路能够将电压钳位在 VIN，从而来抑制振荡。

由于 SLM5600 高集成度，它的应用电路很简单。在典型的应用规范中只需要输入电容 C1，输出电容 C2，C3，电感 L，输出反馈电阻 R3，R4，低电量输入电池电压分压电阻 R1，R2，低电量输出上拉电阻 R6。

设置输出电压

SLM5600 输出电压可以通过外部分压电阻来调整（见图 1 SLM5600 典型工作电路）。FB 脚的典型电压值是 500mV。允许的最大输出电压为 5.5V。底部分压电阻 R4 阻值建议在 100kΩ~500kΩ的范围内，可以使环路电流在 1uA 或者更高。R3 电阻的阻值取决于所需要被输出的电压 VOUT，它能够通过下面的公式 1 来计算得到：

$$R3 = R4\times\left(\frac{V_{OUT}}{V_{FB}}-1\right) = 200k\Omega\times\left(\frac{V_{OUT}}{500mV}-1\right) \quad \text{(Equation 1)}$$

设置 LBI/LBO 阈值电压

R2 电阻在 500KΩ范围内取值。因此，R1 电阻的取值取决于希望工作的最小电池电压 VBAT，R1 可以通过公式 2 来计算得到：

$$R1 = R2\times\left(\frac{V_{BAT}}{V_{LBI}}-1\right) = 500k\Omega\times\left(\frac{V_{BAT}}{500mV}-1\right) \quad \text{(Equation 2)}$$

低电量检测的输出端是一个简单的漏极开路电路，如果检测到电池电压降低到 LBI 端所设定的阈值电压以下时，LBO 端被下拉到低电平。一般 LBO 端接一个 1MΩ的上拉电阻。LBO 端的最大上拉电压不能超过 SLM5600 的输出电压。如果不使用检测电路，LBO 脚可以悬空或者下拉到 GND。

电感选择

电感的饱和电流率（留有余量）需要大于输入的最大平均电流。流过电感和开关的最大平均电流取决于最大输出负载，转换效率η，最小输入电压（VBAT）和输出电压(VOUT)。通过电感的最大平均电流可以通过公式 3 估算：

$$I_L = I_{OUT} \times \frac{V_{OUT}}{V_{BAT} \times \eta} \quad \text{(Equation 3)}$$

例如在输出 5V 电流 2A 效率达到 85%时，在最小输入电压 2.5V 条件下流过电感的平均电流至少是 4.7A。

在电感值取 1μH 到 3.3μH，输出电容为 20μF 到 200μF 时，SLM5600 升压转换器能够高效的工作。 内部补偿在输出滤波器为 L=1.2μH，COUT=100μF 的条件下是最优化的，在特定的工作条件下，更大或者更小的电感值被用来提高工作性能。

输入电容

为了更好的去除干扰，尽可能在靠近芯片 VIN 引脚和电源地 PGND 之间放置一个质量好的 0.1uF 电容，再至少并联一个 10uF 或更大的陶瓷电容 X5R 或 X7R 的旁路电容来提高器件的瞬态响应和降低整个电路的电磁辐射干扰。

输出电容

对于输出电容，最好使用 X7R 材质的陶瓷电容，且尽可能靠近 IC 的 VOUT 和 PGND 脚放置。输出电容值在 20μF 到 200μF 范围内选取。需要注意的是高容值的陶瓷电容有一个直流偏置效应，它会对最终的有效电容值产生影响。例如一个耐压值为 10V，0805 封装的 10μF 陶瓷电容在输出电压为 5V 时有效电容值可能会少于 5μF。

PCB 布板建议

对于主要的电流路径和电源地线建议使用宽而短的走线。输入电容，输出电容，电感应尽可能的靠近芯片放置。电源地和模拟地在芯片端单点接地，可以降低地线噪声带来的影响。尽可能的将地端靠近芯片放置。

热性能信息

低成本、细引脚贴片封装的集成电路技术对功耗有特别的要求。许多基于系统的热偶，对流，额外吸收的热量，表面对流以及产热器件的性能影响着该器件的功率损耗的极限。可以通过以下三种方式提高热性能:

提高 PCB 设计时功率耗散的能力

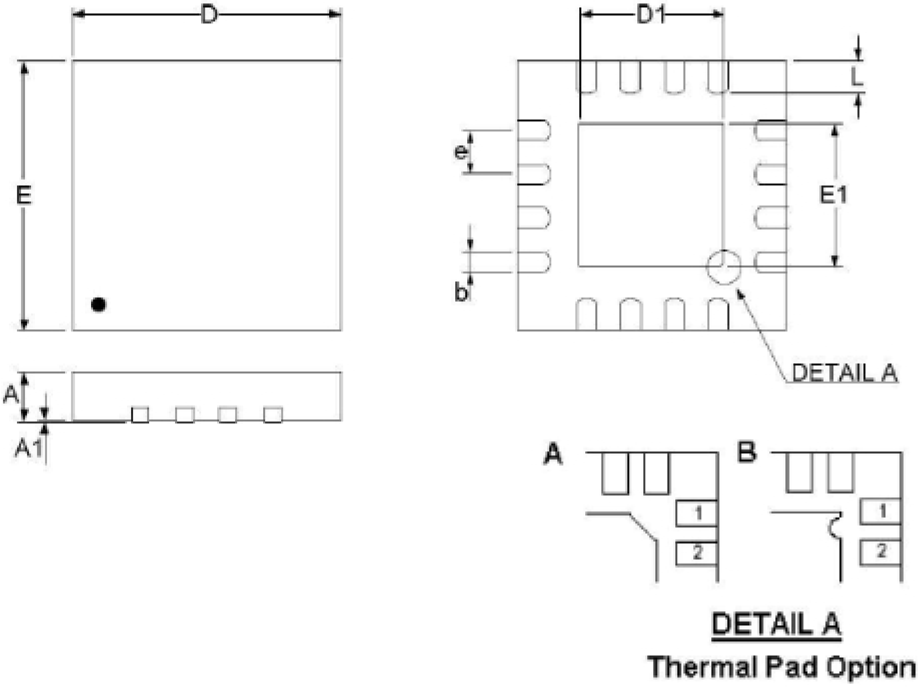
提高 PCB 和器件间的热传导

系统中形成空气对流

SLM5600 的最高结点温度是 125℃。如果底部散热焊盘有效焊接，那么 16 脚 QFN 封装的热阻抗是 θ_{JA} =45℃/W。在最高环境温度为+50℃的条件下，能够保证器件可靠工作。因此 16 脚 QFN 封装的最大耗散功率大约为 1.67W。工作的环境温度越低，功率损耗越大。

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{R_{\theta JA}} = \frac{125^\circ C\text{-}50^\circ C}{45^\circ C/W} = 1.67W$$

SLM5600 QFN16L3mmx3mm 封装外形尺寸



符号	毫米		英寸	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
b	0.18	0.3	0.007	0.012
E	2.90	3.10	0.114	0.122
D	2.90	3.10	0.114	0.122
D1	1.70		0.067	
E1	1.70		0.067	
e	0.50		0.020	
L	0.30	0.50	0.012	0.020