

## CSD95377Q4M 同步降压 NexFET™ 功率级

### 1 特性

- 电流为 15A 时的效率约为 94%
- 最大额定持续电流 35A
- 高频运行（高达 2MHz）
- 高密度 3.5mm × 4.5mm SON 封装
- 超低电感封装
- 系统优化的 PCB 封装
- 兼容 3.3V 和 5V PWM 信号
- 支持强制连续传导模式 (FCCM) 的二极管仿真模式
- 输入电压最高可达 16V
- 三态 PWM 输入
- 集成型自举二极管
- 击穿保护
- 符合 RoHS 环保标准-无铅引脚镀层
- 无卤素

### 2 应用

- 服务器、网络互联和电信系统中的负载点同步降压
- 多相 Vcore、双倍数据速率 (DDR) 和图形解决方案

### 3 说明

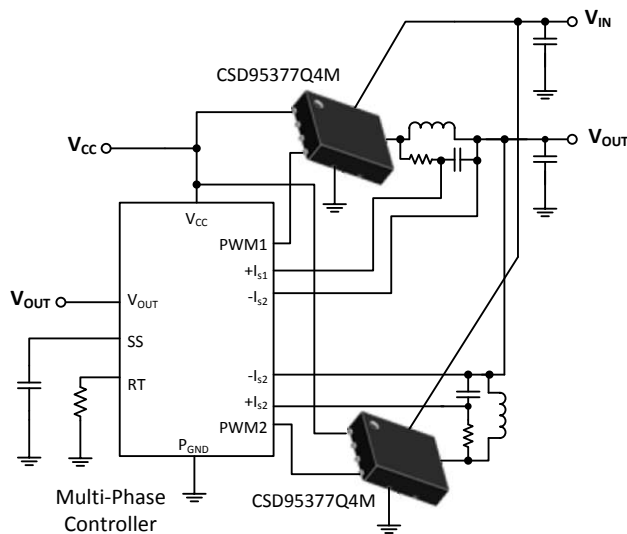
CSD95377Q4M NexFET™ 功率级的设计针对高功率、高密度同步降压转换器应用进行了高度优化。此产品集成了驱动器 IC 和功率 MOSFET，从而可以实现功率级开关功能。此驱动器 IC 具有内置可选二极管仿真功能，该功能支持非连续导通模式 (DCM) 运行，从而提高轻负载效率。该组合在小型 3.5mm x 4.5mm 外形尺寸封装中提供高电流、高效率和高速开关功能。此外，PCB 封装已经过优化，可帮助减少设计时间并简化总体系统设计。

#### 器件信息<sup>(1)</sup>

器件	包装介质	数量	封装	发货
CSD95377Q4M	13 英寸卷带	2500	3.50mm × 4.50mm SON 塑料封装	卷带封装
CSD95377Q4MT	7 英寸卷带	250		

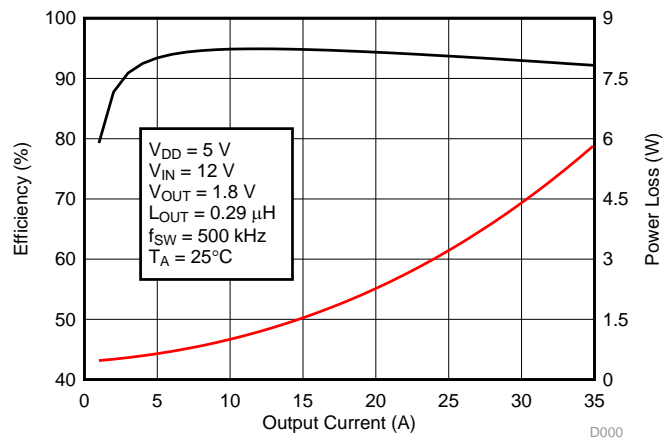
(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。

应用图表



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典型功率级效率与功率损耗



D000



## 目录

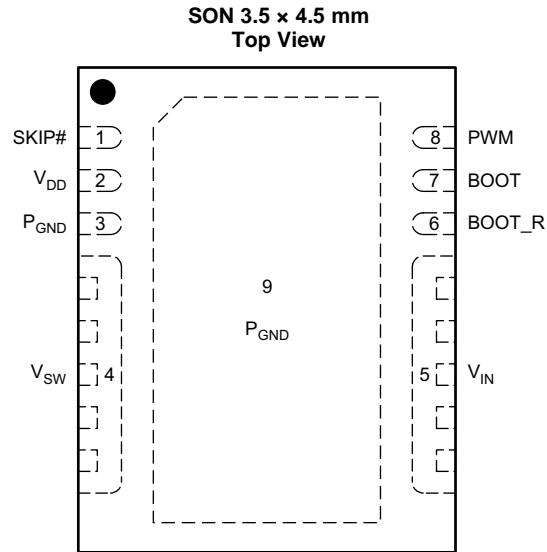
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## 4 修订历史记录

Changes from Revision A (January 2017) to Revision B	Page
• 将特性从“最大额定持续电流 30A”改为“最大额定持续电流 35A” .....	1
• 更新了典型功率级效率和功率损耗图以反映 35A 最大电流。 .....	1
• Changed the $I_{OUT}$ Continuous output current MAX value From: 30 A To: 35 A in the <i>Recommended Operating Conditions</i> table. ....	4
• Updated <a href="#">Figure 4</a> , <a href="#">Figure 5</a> , <a href="#">Figure 6</a> , <a href="#">Figure 7</a> , <a href="#">Figure 8</a> , <a href="#">Figure 9</a> , <a href="#">Figure 10</a> , <a href="#">Figure 11</a> , and <a href="#">Figure 15</a> to reflect 35 A maximum current. ....	10
• Changed the calculating values in the <i>Design Example</i> to reflect 35 A maximum current. ....	13

Changes from Original (December 2015) to Revision A	Page
• Changed unit for Hysteresis parameter from mV : to V in the <i>Electrical Characteristics</i> table .....	5
• 已添加 接收文档更新通知部分至器件和文档支持部分 .....	15

## 5 Pin Configuration and Functions



### Pin Functions

PIN		DESCRIPTION
NO.	NAME	
1	SKIP#	This pin enables the diode emulation function. When this pin is held low, Diode Emulation Mode is enabled for the sync FET. When SKIP# is high, the CSD95377Q4M operates in Forced Continuous Conduction Mode. A tri-state voltage on SKIP# puts the driver into a very-low power state.
2	V <sub>DD</sub>	Supply voltage to gate drivers and internal circuitry.
3	P <sub>GND</sub>	Power ground, needs to be connected to pin 9 and PCB.
4	V <sub>SW</sub>	Voltage switching node – pin connection to the output inductor.
5	V <sub>IN</sub>	Input voltage pin. Connect input capacitors close to this pin.
6	BOOT_R	Bootstrap capacitor connection. Connect a minimum 0.1-μF, 16-V, X5R ceramic capacitor from BOOT to BOOT_R pins. The bootstrap capacitor provides the charge to turn on the control FET. The bootstrap diode is integrated. Boot_R is internally connected to V <sub>SW</sub> .
7	BOOT	
8	PWM	Pulse width modulated tri-state input from external controller. Logic low sets control FET gate low and sync FET gate high. Logic high sets control FET gate high and sync FET gate low. Open or Hi-Z sets both MOSFET gates low if greater than the tri-state shutdown hold-off time (t <sub>3HT</sub> ).
9	P <sub>GND</sub>	Power ground.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

 $T_A = 25^\circ\text{C}$  (unless otherwise noted)<sup>(1)</sup>

	MIN	MAX	UNIT
$V_{IN}$ to $P_{GND}$	−0.3	20	V
$V_{SW}$ to $P_{GND}$ , $V_{IN}$ to $V_{SW}$	−0.3	20	V
$V_{SW}$ to $P_{GND}$ , $V_{IN}$ to $V_{SW}$ (<10 ns)	−7	23	V
$V_{DD}$ to $P_{GND}$	−0.3	6	V
PWM, SKIP# to $P_{GND}$	−0.3	6	V
BOOT to $P_{GND}$	−0.3	25	V
BOOT to $P_{GND}$ (<10 ns)	−2	28	V
BOOT to BOOT_R	−0.3	6	V
BOOT to BOOT_R (duty cycle < 0.2%)		8	V
$P_D$ Power dissipation		8	W
$T_J$ Operating temperature	−40	150	°C
$T_{stg}$ Storage temperature	−55	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 6.2 ESD Ratings

	VALUE	UNIT
$V_{(ESD)}$ Electrostatic discharge	Human-body model (HBM) <sup>(1)</sup> Charged-device model (CDM) <sup>(2)</sup>	±1000 ±500
		V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

 $T_A = 25^\circ\text{C}$  (unless otherwise noted)

	MIN	MAX	UNIT
$V_{DD}$ Gate drive voltage	4.5	5.5	V
$V_{IN}$ Input supply voltage <sup>(1)</sup>		16	V
$I_{OUT}$ Continuous output current		35	A
$I_{OUT-PK}$ Peak output current <sup>(2)(3)</sup>		70	A
$f_{SW}$ Switching frequency		2000	kHz
On-time duty cycle		85%	
Minimum PWM On-time	40		ns
Operating temperature	−40	125	°C

(1) Operating at high  $V_{IN}$  can create excessive AC voltage overshoots on the switch node ( $V_{SW}$ ) during MOSFET switching transients. For reliable operation, the switch node ( $V_{SW}$ ) to ground voltage must remain at or below the *Absolute Maximum Ratings*.

(2) Peak output current is applied for  $t_p = 10$  ms, duty cycle  $\leq 1\%$ .

(3) Measurement made with six 10- $\mu\text{F}$  (TDK C3216X5R1C106KT or equivalent) ceramic capacitors placed across  $V_{IN}$  to  $P_{GND}$  pins.

### 6.4 Thermal Information

 $T_A = 25^\circ\text{C}$  (unless otherwise noted)

THERMAL METRIC	MIN	TYP	MAX	UNIT
$R_{\theta JC(top)}$ Thermal resistance junction-to-case (top of package) <sup>(1)</sup>		22.8		°C/W
$R_{\theta JB}$ Junction-to-board thermal resistance <sup>(2)</sup>		2.5		°C/W

(1)  $R_{\theta JC}$  is determined with the device mounted on a 1-in<sup>2</sup> (6.45-cm<sup>2</sup>), 2-oz (0.071-mm) thick Cu pad on a 1.5-in × 1.5-in, 0.06-in (1.52-mm) thick FR4 board.

(2)  $R_{\theta JB}$  value based on hottest board temperature within 1 mm of the package.

## 6.5 Electrical Characteristics

$T_A = 25^\circ\text{C}$ ,  $V_{DD} = \text{POR to } 5.5\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>P<sub>LOSS</sub></b>						
	Power loss <sup>(1)</sup>	$V_{IN} = 12\text{ V}$ , $V_{DD} = 5\text{ V}$ , $V_{OUT} = 1.8\text{ V}$ , $I_{OUT} = 15\text{ A}$ , $f_{SW} = 500\text{ kHz}$ , $L_{OUT} = 0.29\text{ }\mu\text{H}$ , $T_J = 25^\circ\text{C}$		1.6		W
	Power loss <sup>(1)</sup>	$V_{IN} = 12\text{ V}$ , $V_{DD} = 5\text{ V}$ , $V_{OUT} = 1.8\text{ V}$ , $I_{OUT} = 15\text{ A}$ , $f_{SW} = 500\text{ kHz}$ , $L_{OUT} = 0.29\text{ }\mu\text{H}$ , $T_J = 125^\circ\text{C}$		1.8		W
<b>V<sub>IN</sub></b>						
$I_Q$	$V_{IN}$ quiescent current	PWM = float			1	$\mu\text{A}$
<b>V<sub>DD</sub></b>						
$I_{DD}$	Standby supply current	PWM = float, $V_{SKIP\#} = V_{DD}$ or 0 V		130		$\mu\text{A}$
		$V_{SKIP\#} = \text{float}$		8		
$I_{DD}$	Operating supply current	PWM = 50% duty cycle, $f_{SW} = 500\text{ kHz}$		8.6		mA
<b>POWER-ON RESET AND UNDERVOLTAGE LOCKOUT</b>						
$V_{DD}$ rising	Power-on reset				4.15	V
$V_{DD}$ falling	UVLO		3.7			V
	Hysteresis			0.2		V
<b>PWM AND SKIP# I/O SPECIFICATIONS</b>						
$R_I$	Input impedance	Pullup to $V_{DD}$		1700		$k\Omega$
		Pulldown (to GND)		800		$k\Omega$
$V_{IH}$	Logic level high		2.65			V
$V_{IL}$	Logic level low			0.6		V
$V_{IHH}$	Hysteresis			0.2		V
$V_{TS}$	Tri-state voltage		1.3		2	V
$t_{THOLD(off1)}$	Tri-state activation time (falling) PWM			60		ns
$t_{THOLD(off2)}$	Tri-state activation time (rising) PWM			60		ns
$t_{TSKF}$	Tri-state activation time (falling) SKIP#			1		ns
$t_{TSKR}$	Tri-state activation time (rising) SKIP#			1		$\mu\text{s}$
$t_{3RD(PWM)}$	Tri-state exit time PWM <sup>(2)</sup>			100		ns
$t_{3RD(SKIP\#)}$	Tri-state exit time SKIP# <sup>(2)</sup>			50		$\mu\text{s}$
<b>BOOTSTRAP SWITCH</b>						
$V_{FBST}$	Forward voltage	$I_F = 10\text{ mA}$		120	240	mV
$I_{RLEAK}$	Reverse leakage <sup>(2)</sup>	$V_{BOOT} - V_{DD} = 25\text{ V}$			2	$\mu\text{A}$

(1) Measurement made with six 10- $\mu\text{F}$  (TDK C3216X5R1C106KT or equivalent) ceramic capacitors placed across  $V_{IN}$  to  $P_{GND}$  pins.

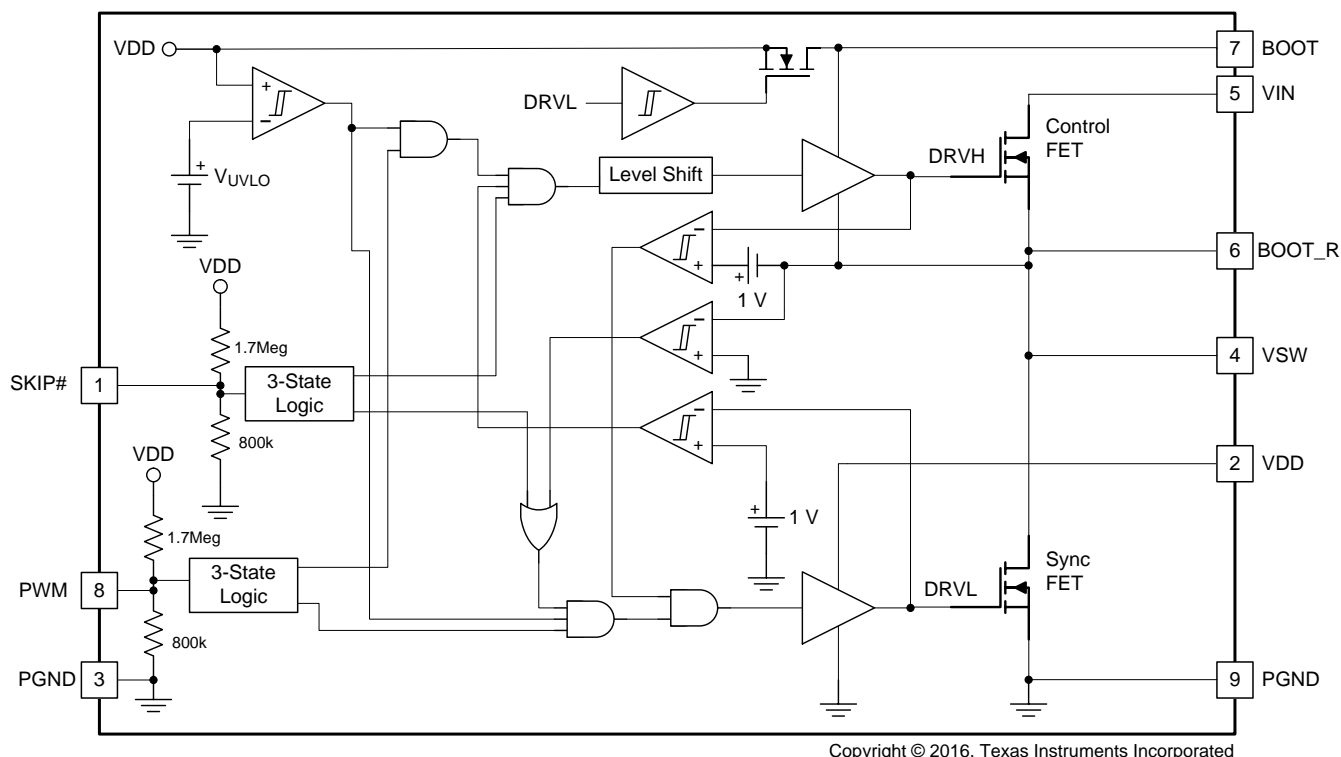
(2) Specified by design.

## 7 Detailed Description

### 7.1 Overview

The CSD95377Q4M™ power stage is a highly-optimized design for use in a high-power, high-density synchronous buck converter.

### 7.2 Functional Block Diagram



### 7.3 Feature Description

#### 7.3.1 Powering CSD95377Q4M and Gate Drivers

An external  $V_{DD}$  voltage is required to supply the integrated gate driver IC and provide the necessary gate drive power for the MOSFETs. TI recommends a 1- $\mu$ F, 10-V, X5R or higher ceramic capacitor to bypass  $V_{DD}$  pin to  $P_{GND}$ . A bootstrap circuit to provide gate drive power for the control FET is also included. The bootstrap supply to drive the control FET is generated by connecting a 100-nF, 16-V, X5R ceramic capacitor between BOOT and BOOT\_R pins. An optional  $R_{BOOT}$  resistor can be used to slow down the turnon speed of the control FET and reduce voltage spikes on the  $V_{SW}$  node. A typical 1- $\Omega$  to 4.7- $\Omega$  value is a compromise between switching loss and  $V_{SW}$  spike amplitude.

#### 7.3.2 Undervoltage Lockout (UVLO) Protection

The UVLO comparator evaluates the  $V_{DD}$  voltage level. As  $V_{DD}$  rises, both the control FET and sync FET gates hold actively low at all times until  $V_{DD}$  reaches the higher UVLO threshold ( $V_{UVLO\_H}$ ). Then the driver becomes operational and responds to PWM and SKIP# commands. If  $V_{DD}$  falls below the lower UVLO threshold ( $V_{UVLO\_L} = V_{UVLO\_H} - \text{hysteresis}$ ), the device disables the driver and drives the outputs of the control FET and Sync FET gates actively low. Figure 1 shows this function.

#### CAUTION

Do not start the driver in the very-low power mode (SKIP# = Tri-state).

## Feature Description (continued)

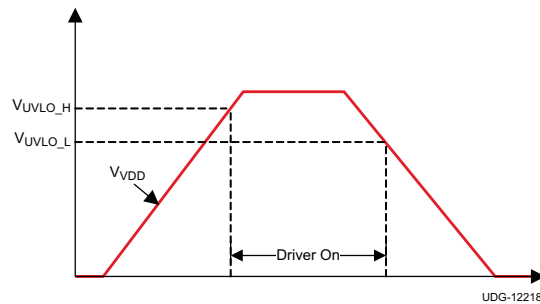


Figure 1. UVLO Operation

### 7.3.3 PWM Pin

The PWM pin incorporates an input tri-state function. The device forces the gate driver outputs to low when PWM is driven into the tri-state window and the driver enters a low-power state with zero exit latency. The pin incorporates a weak pullup to maintain the voltage within the tri-state window during low-power modes. Operation into and out of tri-state mode follows the timing diagram outlined in Figure 2.

When VDD reaches the UVLO\_H level, a tri-state voltage range (window) is set for the PWM input voltage. The window is defined as the PWM voltage range between PWM logic high ( $V_{IH}$ ) and logic low ( $V_{IL}$ ) thresholds. The device sets high-level input voltage and low-level input voltage threshold levels to accommodate both 3.3-V (typical) and 5-V (typical) PWM drive signals.

When the PWM exits tri-state, the driver enters CCM for a period of 4  $\mu$ s, regardless of the state of the SKIP# pin. Normal operation requires this time period for the auto-zero comparator to resume.

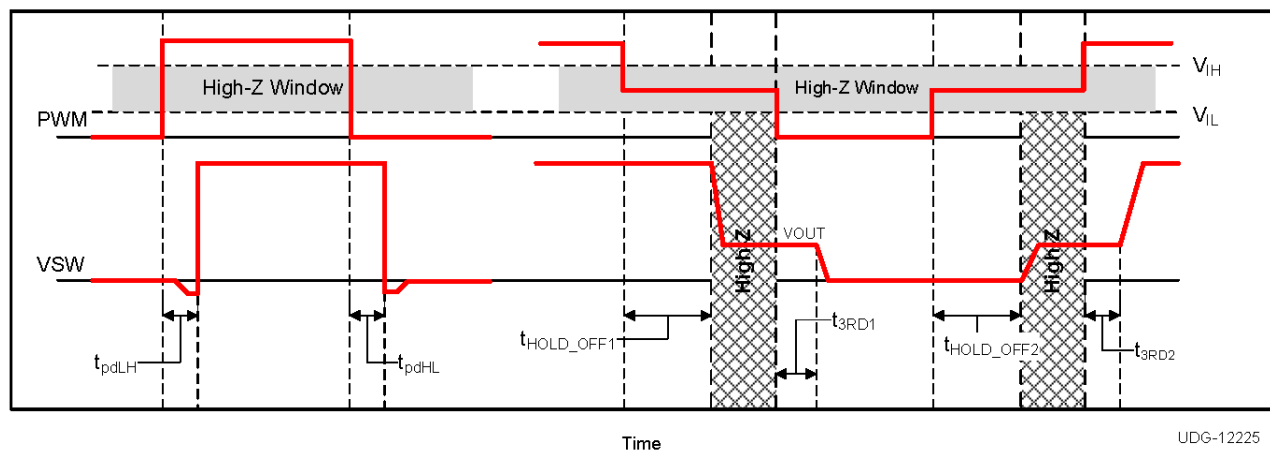


Figure 2. PWM Tri-State Timing Diagram

### 7.3.4 SKIP# Pin

The SKIP# pin incorporates the input tri-state buffer as PWM. The function is somewhat different. When SKIP# is low, the zero crossing (ZX) detection comparator is enabled, and DCM operation occurs if the load current is less than the critical current. When SKIP# is high, the ZX comparator disables, and the converter enters FCCM mode. When both SKIP# and PWM are tri-stated, normal operation forces the gate driver outputs low and the driver enters a low-power state. In the low-power state, the UVLO comparator remains off to reduce quiescent current. When SKIP# is pulled low, the driver wakes up and is able to accept PWM pulses in less than 50  $\mu$ s.

## Feature Description (continued)

Table 1 shows the logic functions of UVLO, PWM, SKIP#, the control FET gate, and the sync FET gate.

**Table 1. Logic Functions of the Driver IC**

UVLO	PWM	SKIP#	SYNC FET GATE	CONTROL FET GATE	MODE
Active	—	—	Low	Low	Disabled
Inactive	Low	Low	High <sup>(1)</sup>	Low	DCM <sup>(1)</sup>
Inactive	Low	High	High	Low	FCCM
Inactive	High	H or L	Low	High	
Inactive	Tri-state	H or L	Low	Low	LQ <sup>(2)</sup>
Inactive	—	Tri-state	Low	Low	ULQ <sup>(3)</sup>

(1) Until zero crossing protection occurs.

(2) Low-quiescent current (LQ).

(3) Ultra-low quiescent current (ULQ).

### 7.3.4.1 Zero Crossing (ZX) Operation

The zero crossing comparator is adaptive for improved accuracy. As the output current decreases from a heavy load condition, the inductor current also reduces and eventually arrives at a *valley*, where it touches zero current, which is the boundary between continuous conduction and discontinuous conduction modes. The SW pin detects the zero-current condition. When this zero inductor current condition occurs, the ZX comparator turns off the rectifying MOSFET.

### 7.3.5 Integrated Boost-Switch

To maintain a BST-SW voltage close to VDD (to get lower conduction losses on the high-side FET), the conventional diode between the VDD pin and the BST pin is replaced by a FET which is gated by the DRV1 signal.

## 7.4 Device Functional Modes

Table 1 shows the different functional modes of CSD95377. The diode emulation mode is enabled with SKIP# pulled low, which improves light load efficiency. With PWM in tri-state, the power stage enters LQ mode and the quiescent current is reduced to 130  $\mu$ A. When SKIP# is held in tri-state, ULQ mode is enabled and the current is decreased to 8  $\mu$ A.



## 8 Application and Implementation

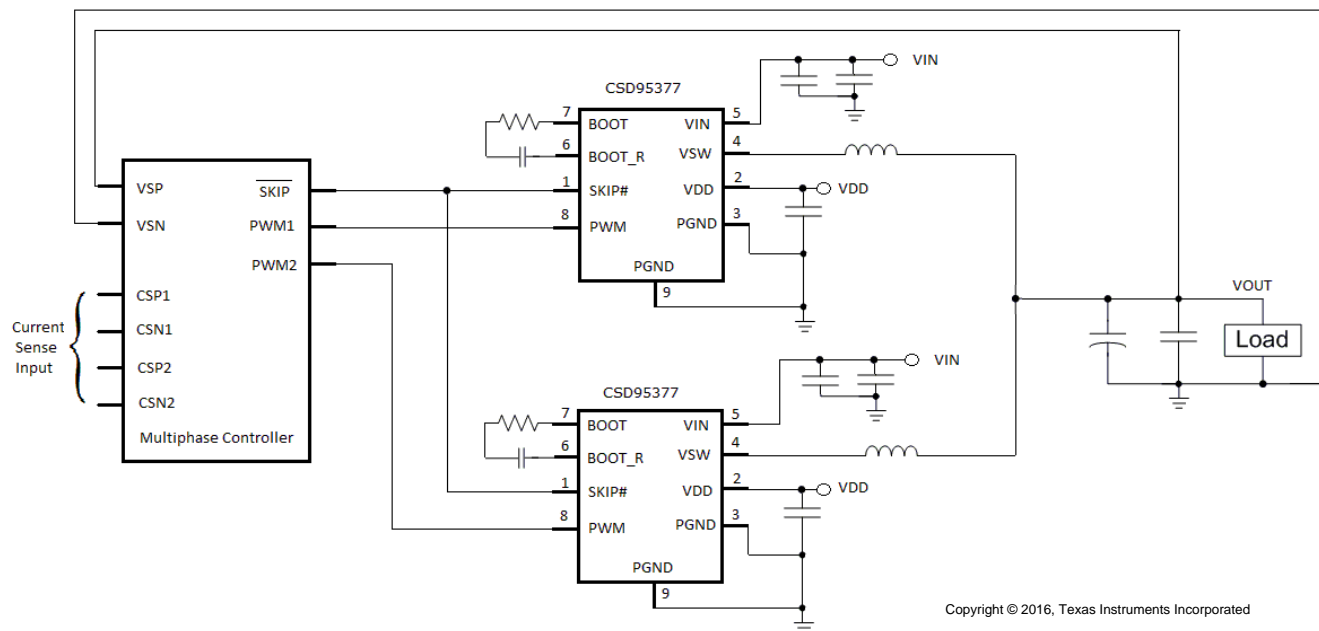
### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Application Information

The power stage CSD95377Q4M is a highly-optimized design for synchronous buck applications using NexFET devices with a 5-V gate drive. The control FET and sync FET silicon are parametrically tuned to yield the lowest power loss and highest system efficiency. As a result, a rating method is used that is tailored toward a more systems-centric environment. The high-performance gate driver IC integrated in the package helps minimize the parasitics and results in extremely fast switching of the power MOSFETs. System-level performance curves such as power loss, SOA, and normalized graphs allow engineers to predict the product performance in the actual application.

### 8.2 Typical Application



**Figure 3. Application Schematic**

## Typical Application (continued)

### 8.2.1 Application Curves

$T_J = 125^\circ\text{C}$ , unless stated otherwise.

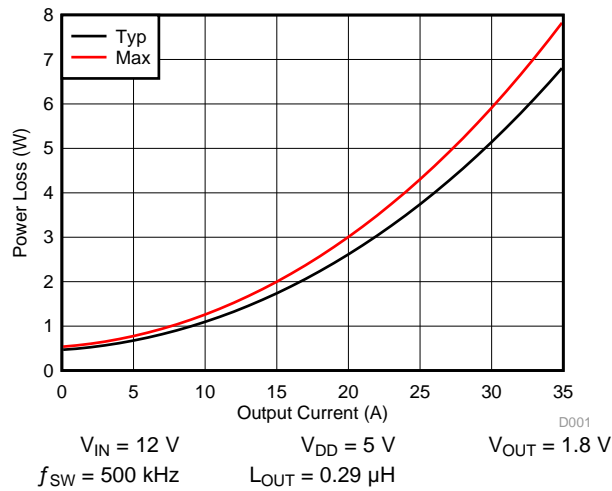


Figure 4. Power Loss vs Output Current

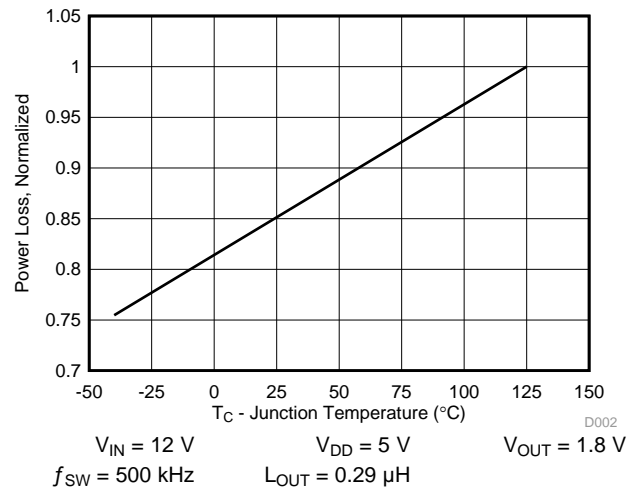


Figure 5. Power Loss vs Temperature

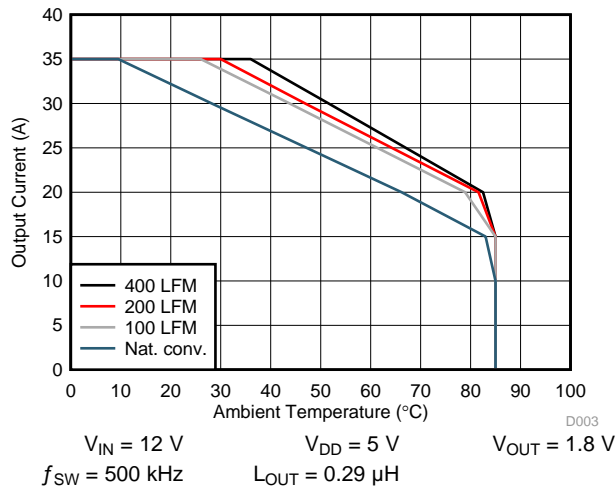


Figure 6. Safe Operating Area – PCB Horizontal Mount <sup>(1)</sup>

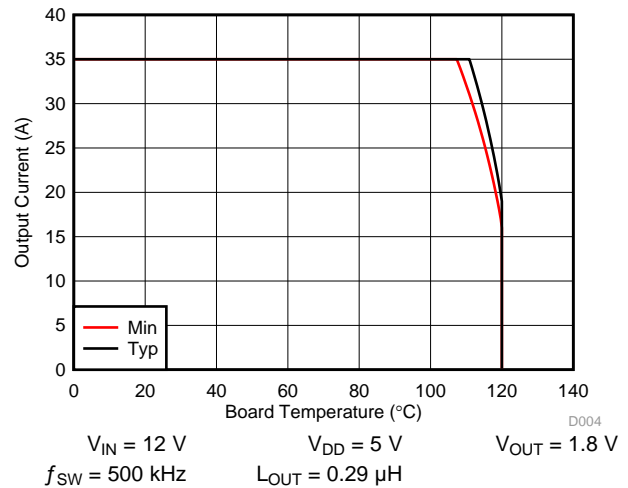
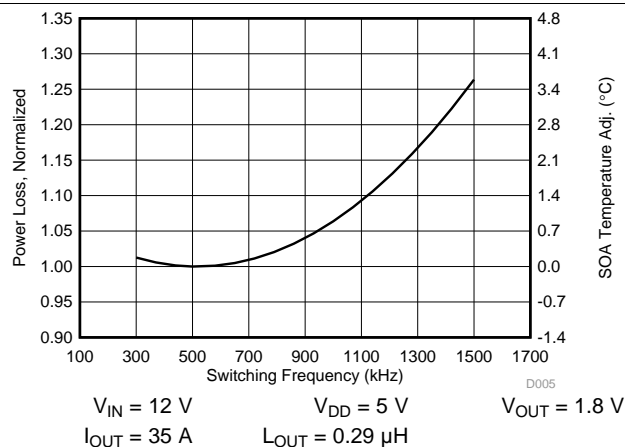


Figure 7. Typical Safe Operating Area <sup>(1)</sup>

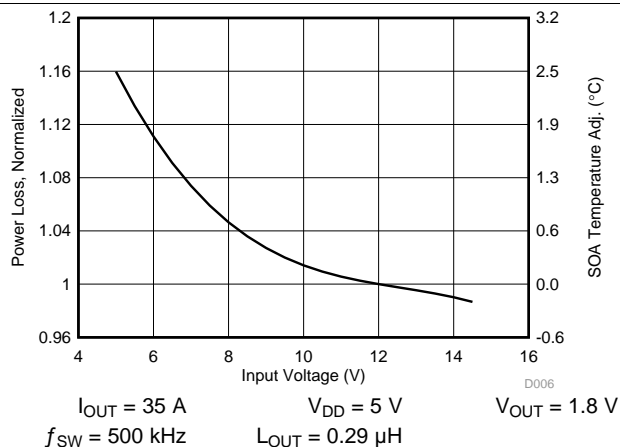
1. The typical CSD95377Q4M system characteristic curves are based on measurements made on a PCB design with dimensions of 4 in (W) × 3.5 in (L) × 0.062 in (T) and 6 copper layers of 1-oz copper thickness. See [System Example](#) for detailed explanation.

## Typical Application (continued)

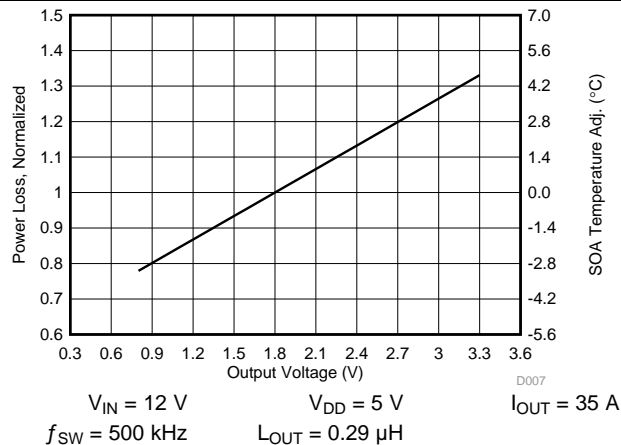
$T_J = 125^\circ\text{C}$ , unless stated otherwise.



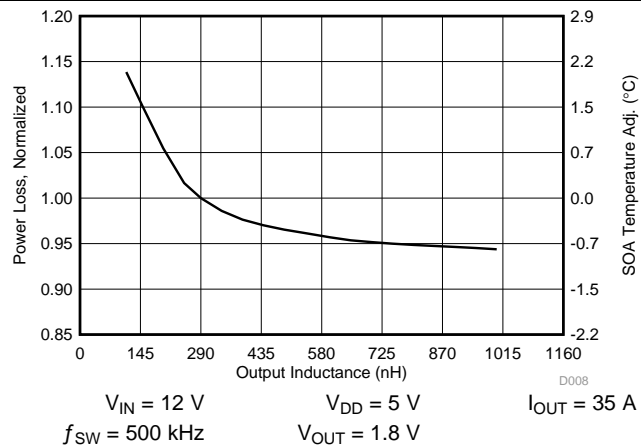
**Figure 8. Normalized Power Loss vs Frequency**



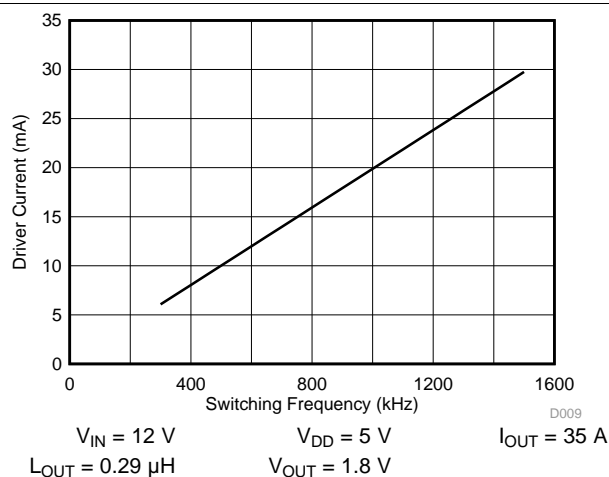
**Figure 9. Normalized Power Loss vs Input Voltage**



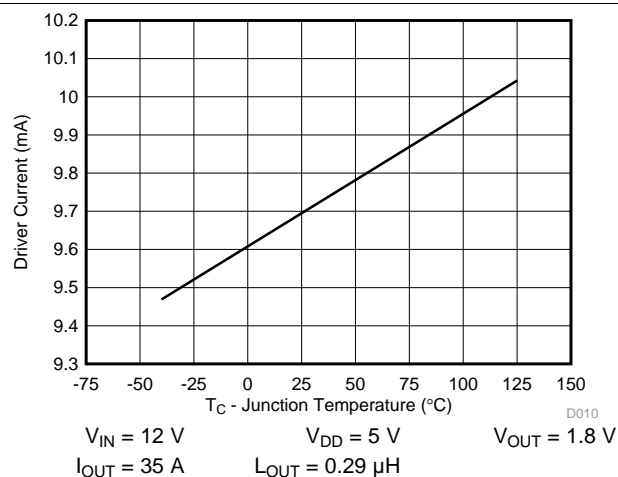
**Figure 10. Normalized Power Loss vs Output Voltage**



**Figure 11. Normalized Power Loss vs Output Inductance**



**Figure 12. Driver Current vs Frequency**



**Figure 13. Driver Current vs Temperature**

## 8.3 System Example

### 8.3.1 Power Loss Curves

MOSFET-centric parameters such as  $R_{DS(ON)}$  and  $Q_{gd}$  are primarily needed by engineers to estimate the loss generated by the devices. In an effort to simplify the design process for engineers, Texas Instruments has provided measured power loss performance curves. Figure 4 plots the power loss of the CSD95377Q4M as a function of load current. This curve is measured by configuring and running the CSD95377Q4M as it would be in the final application (see Figure 14). The measured power loss is the CSD95377Q4M device power loss which consists of both input conversion loss and gate drive loss. Equation 1 is used to generate the power loss curve.

$$\text{Power loss} = (V_{IN} \times I_{IN}) + (V_{DD} \times I_{DD}) - (V_{SW\_AVG} \times I_{OUT}) \quad (1)$$

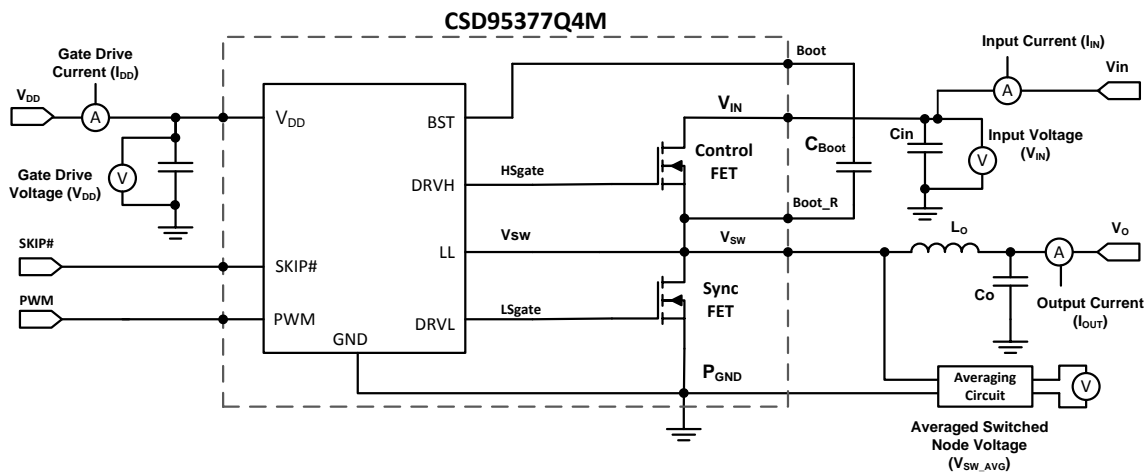
The power loss curve in Figure 4 is measured at the maximum recommended junction temperature of  $T_J = 125^\circ\text{C}$  under isothermal test conditions.

### 8.3.2 Safe Operating Area (SOA) Curves

The SOA curves in the CSD95377Q4M data sheet give engineers guidance on the temperature boundaries within an operating system by incorporating the thermal resistance and system power loss. Figure 6 and Figure 7 outline the temperature and airflow conditions required for a given load current. The area under the curve dictates the safe operating area. All the curves are based on measurements made on a PCB design with dimensions of 4 in (W)  $\times$  3.5 in (L)  $\times$  0.062 in (T) and 6 copper layers of 1-oz copper thickness.

### 8.3.3 Normalized Curves

The normalized curves in the CSD95377Q4M data sheet give engineers guidance on the power loss and SOA adjustments based on their application specific needs. These curves show how the power loss and SOA boundaries will adjust for a given set of systems conditions. The primary Y-axis is the normalized change in power loss and the secondary Y-axis is the change in system temperature required in order to comply with the SOA curve. The change in power loss is a multiplier for the power loss curve and the change in temperature is subtracted from the SOA curve.



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**Figure 14. Power Loss Test Circuit**

### 8.3.4 Calculating Power Loss and SOA

The user can estimate product loss and SOA boundaries by arithmetic means (see the Design Example). Though the power loss and SOA curves in this data sheet are taken for a specific set of test conditions, the following procedure will outline the steps engineers should take to predict product performance for any set of system conditions.

## System Example (continued)

### 8.3.4.1 Design Example

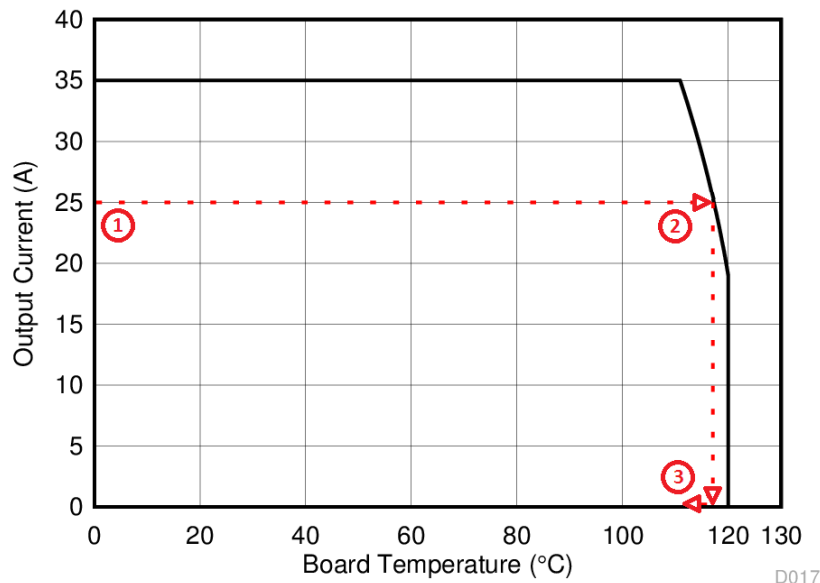
Operating conditions: Output current ( $I_{OUT}$ ) = 25 A, input voltage ( $V_{IN}$ ) = 7 V, output voltage ( $V_{OUT}$ ) = 2 V, switching frequency ( $f_{SW}$ ) = 800 kHz, output inductor ( $L_{OUT}$ ) = 0.2  $\mu$ H

### 8.3.4.2 Calculating Power Loss

- Typical power loss at 25 A = 3.74 W (Figure 4)
- Normalized power loss for switching frequency  $\approx 1.02$  (Figure 8)
- Normalized power loss for input voltage  $\approx 0.99$  (Figure 9)
- Normalized power loss for output voltage  $\approx 1.04$  (Figure 10)
- Normalized power loss for output inductor  $\approx 1.01$  (Figure 11)
- **Final calculated Power Loss =  $3.741 \text{ W} \times 1.02 \times 0.99 \times 1.04 \times 1.01 \approx 3.97 \text{ W}$**

### 8.3.4.3 Calculating SOA Adjustments

- SOA adjustment for switching frequency  $\approx 0.3^\circ\text{C}$  (Figure 8)
- SOA adjustment for input voltage  $\approx -0.12^\circ\text{C}$  (Figure 9)
- SOA adjustment for output voltage  $\approx 0.62^\circ\text{C}$  (Figure 10)
- SOA adjustment for output inductor  $\approx 0.25^\circ\text{C}$  (Figure 11)
- **Final calculated SOA adjustment =  $0.3 + (-0.12) + 0.62 + 0.25 \approx 1.05^\circ\text{C}$**



**Figure 15. Power Stage CSD95377Q4M SOA**

In the previous design example, the estimated power loss of the CSD95377Q4M would increase to 3.97 W. In addition, the maximum allowable board and/or ambient temperature would have to decrease by 1.05°C. Figure 15 graphically shows how the SOA curve would be adjusted accordingly.

1. Start by drawing a horizontal line from the application current to the SOA curve.
2. Draw a vertical line from the SOA curve intercept down to the board/ambient temperature.
3. Adjust the SOA board/ambient temperature by subtracting the temperature adjustment value.

In the design example, the SOA temperature adjustment yields a reduction in allowable board/ambient temperature of 1.05°C. In the event the adjustment value is a negative number, subtracting the negative number would yield an increase in allowable board and ambient temperature.

## 9 Layout

### 9.1 Layout Guidelines

#### 9.1.1 Recommended PCB Design Overview

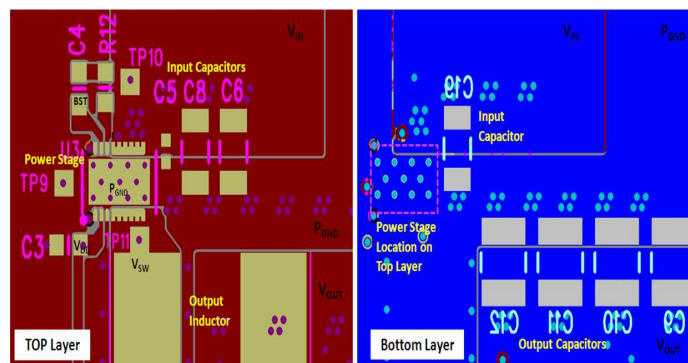
Two key system-level parameters can be addressed with a proper PCB design: electrical and thermal performance. Properly optimizing the PCB layout yields maximum performance in both areas. A brief description follows on how to address each parameter.

#### 9.1.2 Electrical Performance

The CSD95377Q4M has the ability to switch at voltage rates greater than 10 kV/μs. Take special care with the PCB layout design and placement of the input capacitors, inductor, and output capacitors.

- The placement of the input capacitors relative to  $V_{IN}$  and  $P_{GND}$  pins of the CSD95377Q4M device should have the highest priority during the component placement routine. It is critical to minimize these node lengths. As such, ceramic input capacitors need to be placed as close as possible to the  $V_{IN}$  and  $P_{GND}$  pins (see Figure 16). The example in Figure 16 uses 1 × 1-nF 0402, 25-V and 3 × 10-μF 1206, 25-V ceramic capacitors (TDK part number C3216X5R1C106KT or equivalent). Notice there are ceramic capacitors on both sides of the board with an appropriate amount of vias interconnecting both layers. In terms of priority of placement next to the power stage C5, C8, C6, and C19 should follow in order.
- The bootstrap capacitor  $C_{BOOT}$  0.1-μF 0603, 16-V ceramic capacitor should be closely connected between BOOT and BOOT\_R pins.
- The switching node of the output inductor should be placed relatively close to the power stage CSD95377Q4M  $V_{SW}$  pins. Minimizing the  $V_{SW}$  node length between these two components will reduce the PCB conduction losses and actually reduce the switching noise level. <sup>(1)</sup>

### 9.2 Layout Example



**Figure 16. Recommended PCB Layout (Top-Down View)**

### 9.3 Thermal Considerations

The CSD95377Q4M has the ability to use the  $P_{GND}$  planes as the primary thermal path. As such, the use of thermal vias is an effective way to pull away heat from the device and into the system board. Concerns of solder voids and manufacturability problems can be addressed by the use of three basic tactics to minimize the amount of solder attach that will wick down the via barrel:

- Intentionally space out the vias from each other to avoid a cluster of holes in a given area.
- Use the smallest drill size allowed in your design. The example in Figure 16 uses vias with a 10-mil drill hole and a 16-mil capture pad.
- Tent the opposite side of the via with solder-mask.

The number and drill size of the thermal vias should align with the end user's PCB design rules and manufacturing capabilities.

(1) Keong W. Kam, David Pommerenke, "EMI Analysis Methods for Synchronous Buck Converter EMI Root Cause Analysis", University of Missouri – Rolla

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### 10.1 接收文档更新通知

要接收文档更新通知，请导航至 [TI.com](http://TI.com) 上的器件产品文件夹。单击右上角的 [通知我](#) 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

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### 10.5 Glossary

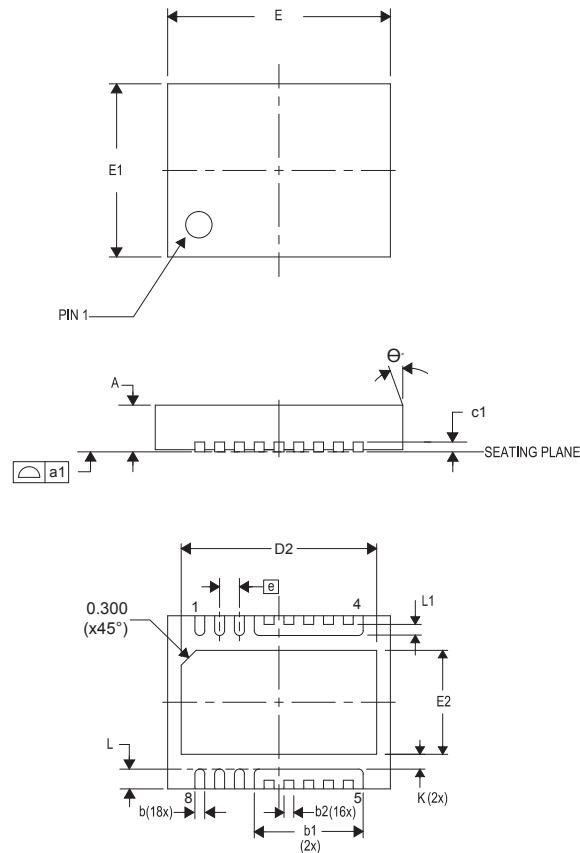
[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 11 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知和修订此文档。如欲获取此产品说明书的浏览器版本，请参阅左侧的导航。

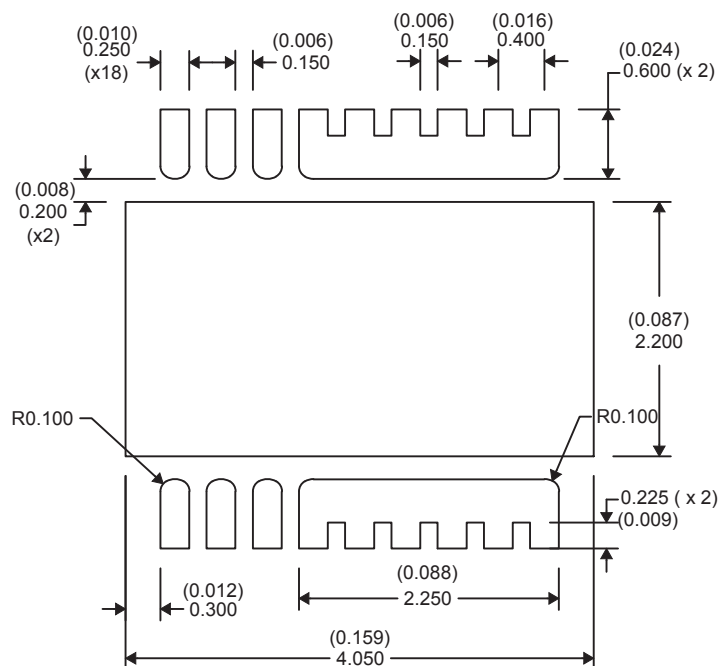
### 11.1 机械制图



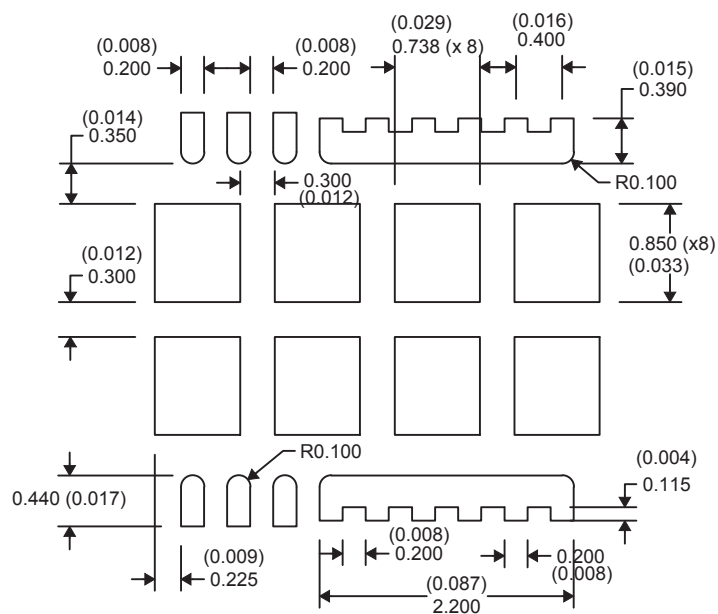
DIM	毫米			英寸		
	最小值	标称值	最大值	最小值	标称值	最大值
A	0.800	0.900	1.000	0.031	0.035	0.039
a1	0.000	0.000	0.080	0.000	0.000	0.003
b	0.150	0.200	0.250	0.006	0.008	0.010
b1	2.000	2.200	2.400	0.079	0.087	0.095
b2	0.150	0.200	0.250	0.006	0.008	0.010
c1	0.150	0.200	0.250	0.006	0.008	0.010
D2	3.850	3.950	4.050	0.152	0.156	0.160
E	4.400	4.500	4.600	0.173	0.177	0.181
E1	3.400	3.500	3.600	0.134	0.138	0.142
E2	2.000	2.100	2.200	0.079	0.083	0.087
e	0.400 典型值			0.016 典型值		
K	0.300 典型值			0.012 典型值		
L	0.300	0.400	0.500	0.012	0.016	0.020
L1	0.180	0.230	0.280	0.007	0.009	0.011
$\theta$	0.00	—	—	0.00	—	—



## 11.2 建议印刷电路板 (PCB) 焊盘图案



### 11.3 建议模版开口



NOTE: 尺寸单位为 mm (英寸)。

模版厚度为 100 $\mu$ m。

## PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">CSD95377Q4M</a>	Active	Production	VSON-CLIP (DPC)   8	2500   LARGE T&R	ROHS Exempt	NIPDAU   SN	Level-2-260C-1 YEAR	-40 to 150	95377M
<a href="#">CSD95377Q4MT</a>	Active	Production	VSON-CLIP (DPC)   8	250   SMALL T&R	ROHS Exempt	NIPDAU   SN	Level-2-260C-1 YEAR	-40 to 150	95377M

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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