

CSD16321Q5 25V N 沟道 NexFET™ 功率 MOSFET

1 特性

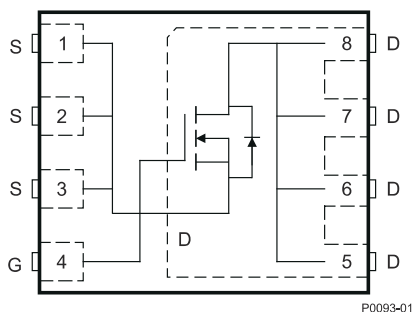
- 针对 5V 栅极驱动器进行了优化
- 超低 Q_g 和 Q_{gd}
- 低热阻
- 雪崩级
- 无铅引脚镀层
- 符合 RoHS 标准
- 5mm × 6mm SON 塑料封装

2 应用

- 用于网络互联，电信和计算系统的负载点同步降压转换器
- 已针对同步场效应晶体管 (FET) 应用进行优化

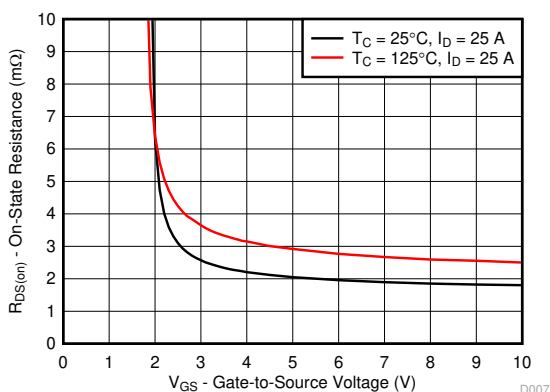
3 说明

这款 25V、1.9mΩ、5mm × 6mm SON NexFET™ 功率 MOSFET 旨在更大限度减小功率转换应用中的损耗，并针对 5V 栅极驱动应用进行了优化。

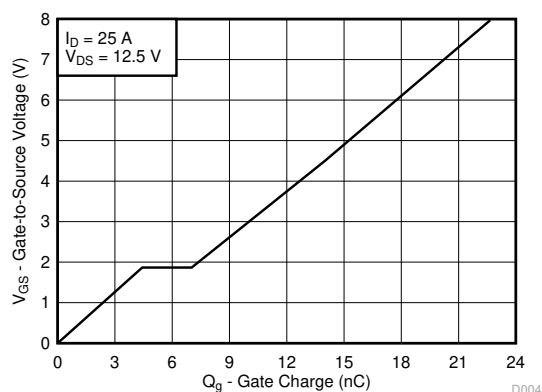


P0093-01

顶视图



D007

 $R_{DS(on)}$ 与 V_{GS} 间的关系

D004

栅极电荷

产品概要

$T_A = 25^\circ\text{C}$		典型值	单位
V_{DS}	漏源极电压	25	V
Q_g	栅极电荷总量 (4.5V)	14	nC
Q_{gd}	栅极电荷 (栅极到漏极)	2.5	nC
$R_{DS(on)}$	漏源导通电阻	$V_{GS}=3\text{V}$	2.8
		$V_{GS}=4.5\text{V}$	2.1
		$V_{GS}=8\text{V}$	1.9
$V_{GS(th)}$	阈值电压	1.1	V

器件信息(1)

器件	介质	数量	封装	出货
CSD16321Q5	13 英寸卷带	2500	SON 5.00mm × 6.00mm 塑料封装	卷带包装
CSD16321Q5T	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。

绝对最大额定值

$T_A = 25^\circ\text{C}$		值	单位
V_{DS}	漏源极电压	25	V
V_{GS}	栅源电压	+10 / -8	V
I_D	持续漏极电流 (受封装限制)	100	A)
	持续漏极电流 (受芯片限制), $T_C = 25^\circ\text{C}$ 时测得	177	
	持续漏极电流(1)	29	
I_{DM}	脉冲漏极电流(2)	400	A
P_D	功率耗散(1)	3.1	W
	功率耗散, $T_C = 25^\circ\text{C}$	113	
T_J , T_{stg}	工作结温、 贮存温度	-55 至 150	$^\circ\text{C}$
E_{AS}	雪崩能量, 单脉冲 $I_D = 66\text{A}$, $L = 0.1\text{mH}$, $R_G = 25\Omega$	218	mJ

(1) $R_{\theta JA} = 40^\circ\text{C/W}$ ，这是在 0.06 英寸厚 FR4 PCB 上的 1 平方英寸、2oz 铜焊盘上测得的典型值。

(2) 最大 $R_{\theta JC} = 1.1^\circ\text{C/W}$ ，脉冲持续时间 $\leq 100 \mu\text{s}$ ，占空比 $\leq 1\%$ 。



Table of Contents

1 特性	1	5.2 支持资源	7
2 应用	1	5.3 Trademarks	7
3 说明	1	5.4 静电放电警告	7
4 Specifications	3	5.5 术语表	7
4.1 Electrical Characteristics.....	3	6 Revision History	7
4.2 Thermal Information.....	3	7 Mechanical, Packaging, and Orderable Information	9
4.3 Typical MOSFET Characteristics.....	4	7.1 Package Option Addendum.....	10
5 Device and Documentation Support	7	7.2 Tape and Reel Information.....	11
5.1 接收文档更新通知.....	7		

4 Specifications

4.1 Electrical Characteristics

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

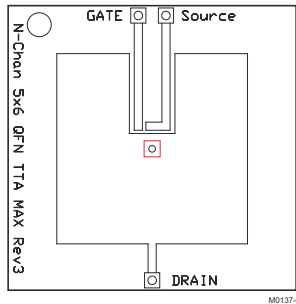
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
STATIC CHARACTERISTICS						
BV _{DSS}	Drain-to-source voltage	V _{GS} = 0 V, I _D = 250 μ A	25			V
I _{DSS}	Drain-to-source leakage current	V _{GS} = 0 V, V _{DS} = 20 V			1	μ A
I _{GSS}	Gate-to-source leakage current	V _{DS} = 0 V, V _{GS} = +10 / - 8 V			100	nA
V _{GS(th)}	Gate-to-source threshold voltage	V _{DS} = V _{GS} , I _D = 250 μ A	0.9	1.1	1.4	V
R _{DS(on)}	Drain-to-source on resistance	V _{GS} = 3 V, I _D = 25 A		2.8	3.8	mΩ
		V _{GS} = 4.5 V, I _D = 25 A		2.1	2.6	
		V _{GS} = 8 V, I _D = 25 A		1.9	2.4	
g _{fs}	Transconductance	V _{DS} = 12.5 V, I _D = 25 A		150		S
DYNAMIC CHARACTERISTICS						
C _{iss}	Input capacitance	V _{GS} = 0 V, V _{DS} = 12.5 V, f = 1 MHz		2360	3100	pF
C _{oss}	Output capacitance			1700	2200	pF
C _{rss}	Reverse transfer capacitance			115	150	pF
R _G	Series gate resistance			1.5	3	Ω
Q _g	Gate charge total (4.5 V)	V _{DS} = 12.5 V, I _D = 25 A		14	19	nC
Q _{gd}	Gate charge gate-to-drain			2.5		nC
Q _{gs}	Gate charge gate-to-source			4		nC
Q _{g(th)}	Gate charge at V _{th}			2.1		nC
Q _{oss}	Output charge	V _{DS} = 15 V, V _{GS} = 0 V		36		nC
t _{d(on)}	Turnon delay time	V _{DS} = 12.5 V, V _{GS} = 4.5 V, I _D = 25 A, R _G = 2 Ω		9		ns
t _r	Rise time			15		ns
t _{d(off)}	Turnoff delay time			27		ns
t _f	Fall time			17		ns
DIODE CHARACTERISTICS						
V _{SD}	Diode forward voltage	I _{SD} = 25 A, V _{GS} = 0 V		0.8	1	V
Q _{rr}	Reverse recovery charge	V _{DD} = 13 V, I _F = 25 A, di/dt = 300 A/ μ s		33		nC
t _{rr}	Reverse recovery time	V _{DD} = 13 V, I _F = 25 A, di/dt = 300 A/ μ s		32		ns

4.2 Thermal Information

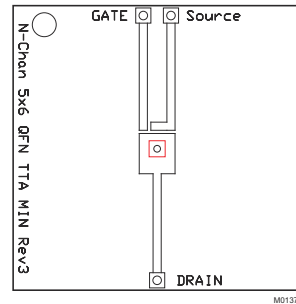
$T_A = 25^\circ\text{C}$ (unless otherwise stated)

PARAMETER		MIN	TYP	MAX	UNIT
$R_{\theta JC}$	Junction-to-case thermal resistance ⁽¹⁾			1.1	$^\circ\text{C}/\text{W}$
$R_{\theta JA}$	Junction-to-ambient thermal resistance ^{(1) (2)}			50	$^\circ\text{C}/\text{W}$

- (1) $R_{\theta JC}$ is determined with the device mounted on a 1-in², 2-oz Cu pad on a 1.5-in $\times$ 1.5-in, 0.06-in thick FR4 board. $R_{\theta JC}$ is specified by design while $R_{\theta JA}$ is determined by the user's board design.
- (2) Device mounted on FR4 Material with 1 in² of 2-oz Cu.



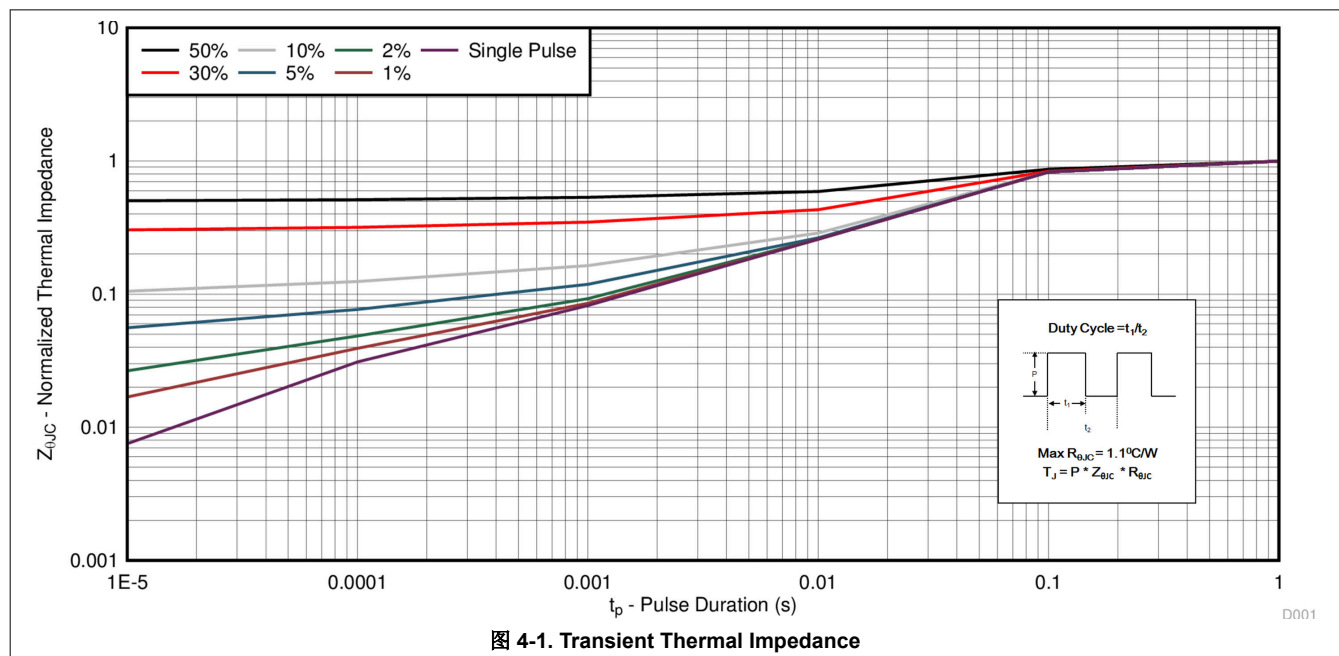
Max $R_{\theta JA} = 50^{\circ}\text{C/W}$ when
mounted on 1 in² of 2-oz Cu.



Max $R_{\theta JA} = 125^{\circ}\text{C/W}$ when
mounted on minimum pad
area of 2-oz Cu.

4.3 Typical MOSFET Characteristics

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



4.3 Typical MOSFET Characteristics

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

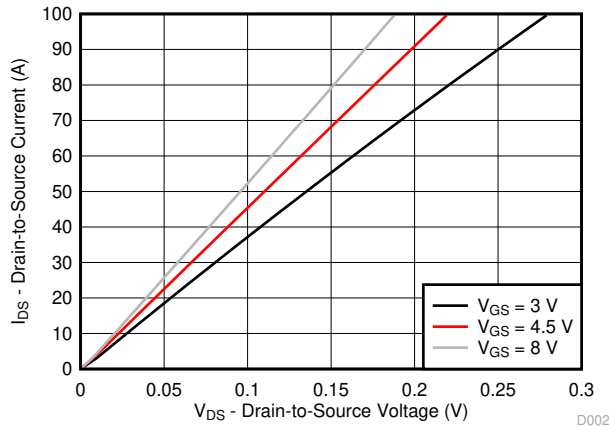


图 4-2. Saturation Characteristics

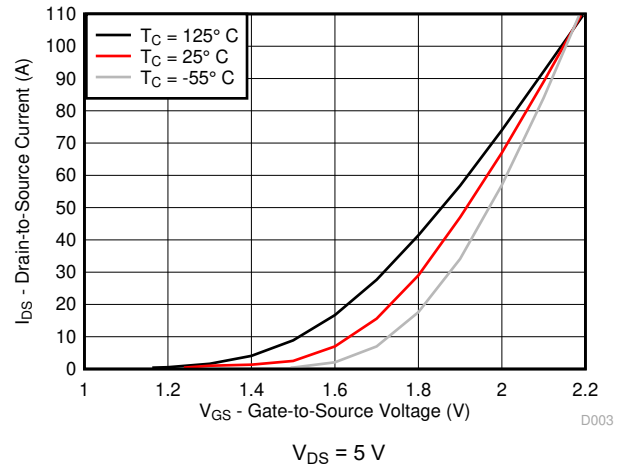


图 4-3. Transfer Characteristics

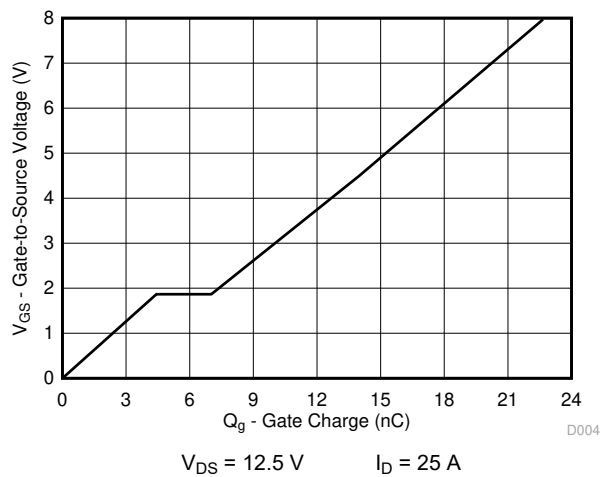


图 4-4. Gate Charge

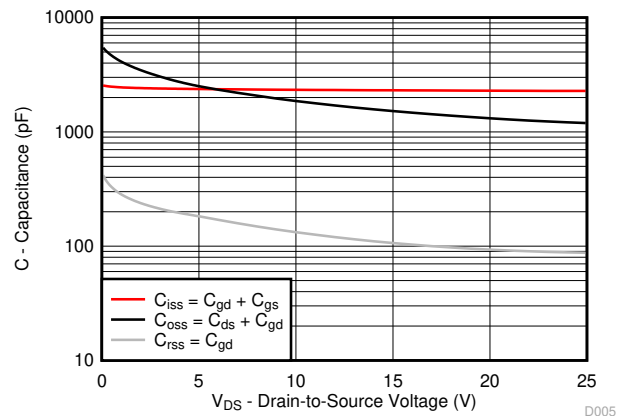


图 4-5. Capacitance

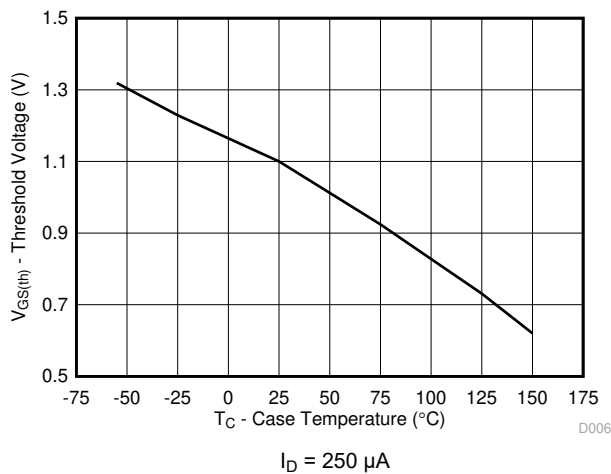


图 4-6. Threshold Voltage vs Temperature

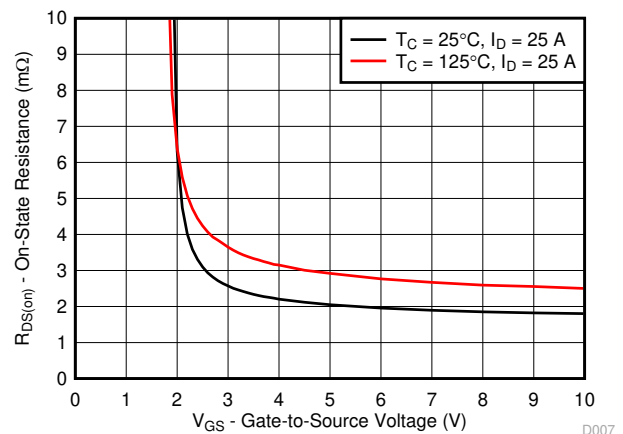


图 4-7. On Resistance vs Gate Voltage

4.3 Typical MOSFET Characteristics (continued)

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

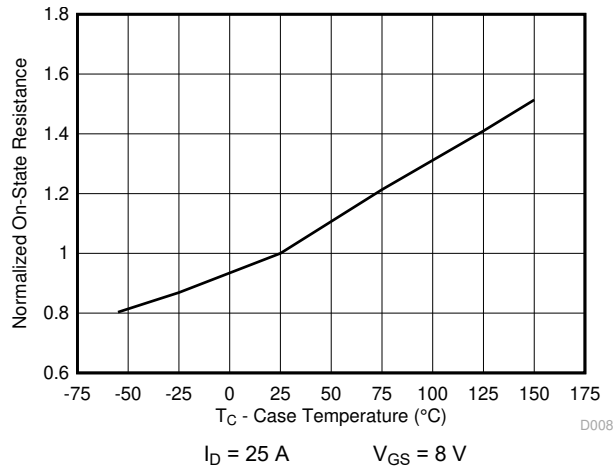


图 4-8. On Resistance vs Temperature

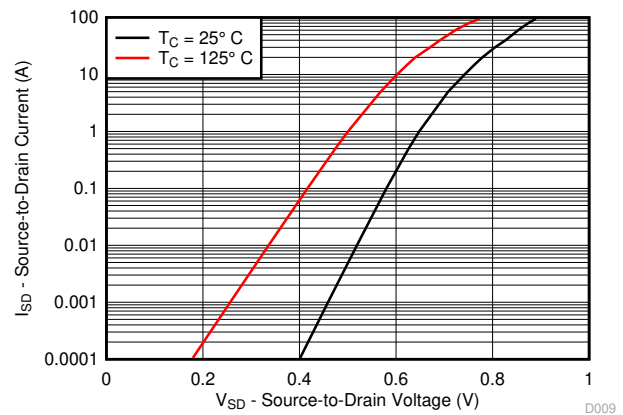


图 4-9. Typical Diode Forward Voltage

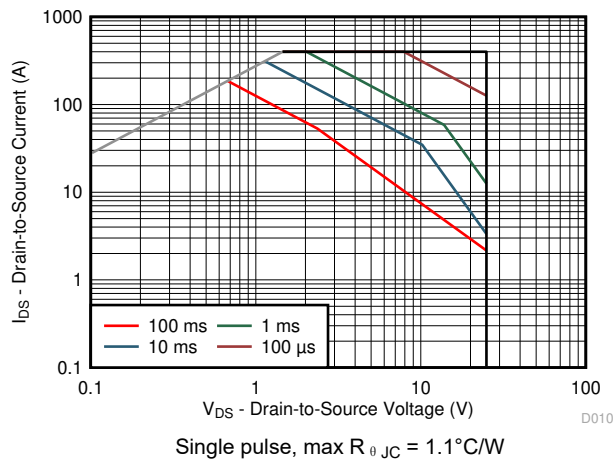


图 4-10. Maximum Safe Operating Area

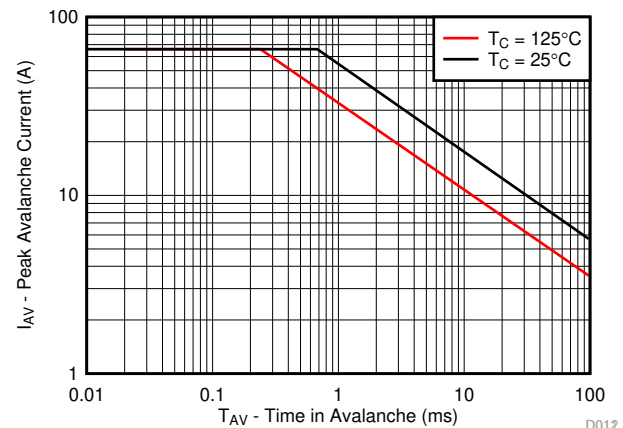


图 4-11. Single Pulse Unclamped Inductive Switching

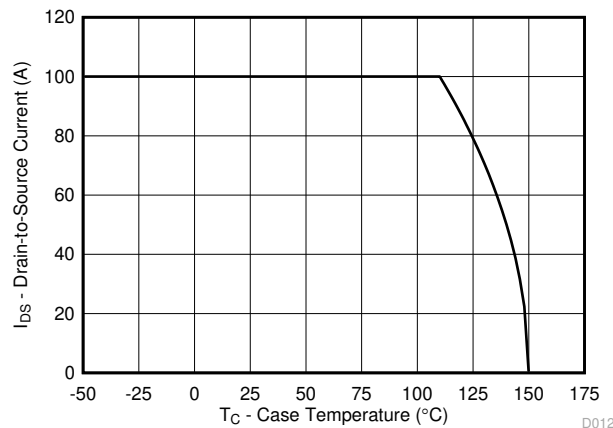


图 4-12. Maximum Drain Current vs Temperature

5 Device and Documentation Support

5.1 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击 [通知](#) 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。

5.2 支持资源

TI E2E™ 中文支持论坛 是工程师的重要参考资料，可直接从专家处获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题，获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的 [使用条款](#)。

5.3 Trademarks

NexFET™ and TI E2E™ are trademarks of Texas Instruments.

所有商标均为其各自所有者的财产。

5.4 静电放电警告



静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

5.5 术语表

TI 术语表 本术语表列出并解释了术语、首字母缩略词和定义。

6 Revision History

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision D (May 2017) to Revision E (December 2023)	Page
• 更新了整个文档中的表格、图和交叉参考的编号格式.....	1
Changes from Revision C (December 2016) to Revision D (May 2017)	Page
• 更改了 3V、4.5V、8V 时的 $R_{DS(ON)}$ 值以及 说明 ，以匹配 电气特性 表中的值.....	1
Changes from Revision B (May 2010) to Revision C (December 2016)	Page
• 更改了 说明 文本.....	1
• 向 绝对最大额定值 表中添加了受器件限制的持续漏极电流.....	1
• 向 绝对最大额定值 表中添加了 $T_C = 25^\circ\text{C}$ 时的最大功率耗散.....	1
• 更改了 绝对最大额定值 表中的注释 2.....	1
• Changed $R_{\theta JA}$ max from 48°C/W : to 50°C/W	3
• Changed the SOA in 图 4-10 to reflect measured data.....	4
• Changed MECHANICAL DATA section to <i>Mechanical, Packaging, and Orderable Information</i> section.....	9
Changes from Revision A (January 2010) to Revision B (May 2010)	Page
• Changed $R_{DS(on)} - V_{GS} = 3\text{ V}, I_D = 25\text{ A MAX}$ value From: 3.5 To: 3.8.....	3
Changes from Revision * (August 2009) to Revision A (January 2010)	Page
• 更改了顶视图引脚排列图上的标签.....	1
• 将 绝对最大额定值 的注释 1 从 “ $R_{\theta JA} = 39^\circ\text{C/W}$ ” 更改为 “典型 $R_{\theta JA} = 39^\circ\text{C/W}$ ”	1
• Changed 图 4-1 text From: $R_{\theta JA} = 92^\circ\text{C/W}$ To: Typical $R_{\theta JA} = 93^\circ\text{C/W}$	4

- Changed [图 4-10](#) text From: $R_{\theta JA} = 92^{\circ}\text{C/W}$ To: Typical $R_{\theta JA} = 93^{\circ}\text{C/W}$ 4
 - Changed [图 4-11](#) X-axis values.....4
-

7 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

7.1 Package Option Addendum

Packaging Information

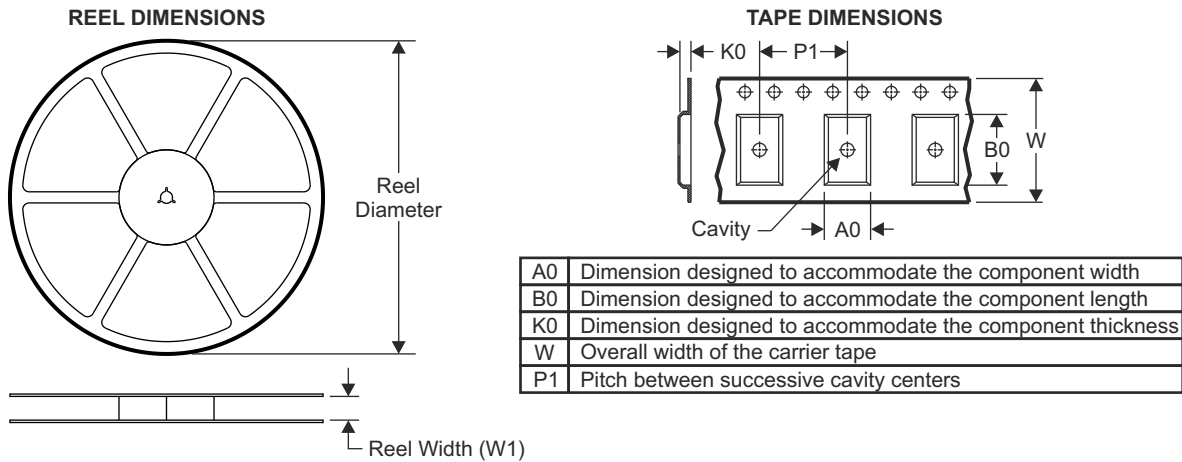
Orderable Device	Status	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish ⁽⁶⁾	MSL Peak Temp ⁽³⁾	Op Temp (°C)	Device Marking ^{(4) (5)}
CSD16321Q5	ACTIVE ⁽¹⁾	VSON-CLIP	DQH	8	2500	RoHS-Exempt & Green	SN	Level-1-260C-UNLIM	-55 to 150	CSD16321
CSD16321Q5T	ACTIVE	VSON-CLIP	DQH	8	250	RoHS-Exempt & Green	SN	Level-1-260C-UNLIM	-55 to 150	CSD16321

- (1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PRE_PROD Unannounced device, not in production, not available for mass market, nor on the web, samples not available.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.
- (2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material).
- (3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.
- (4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.
- (5) Multiple Device markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.
- (6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

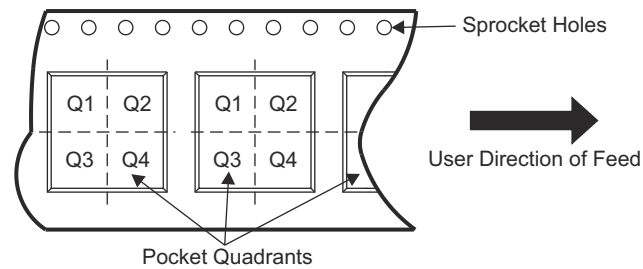
Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

7.2 Tape and Reel Information

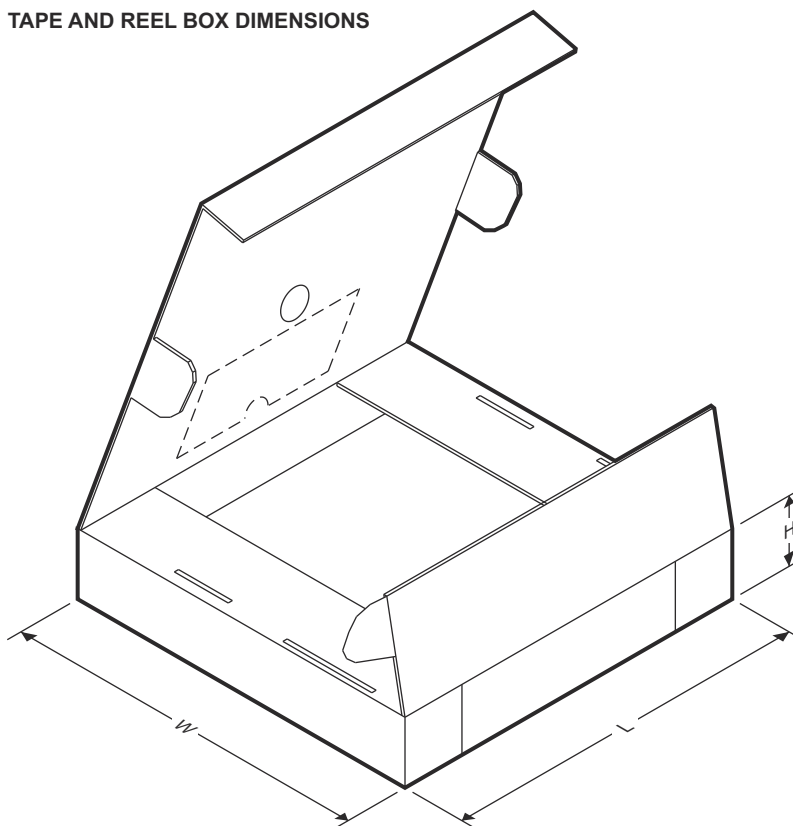


QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CSD16321Q5T	VSON-CLIP	DQH	8	250	178.0	12.4	6.3	5.3	1.2	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CSD16321Q5T	VSON-CLIP	DQH	8	250	180.0	180.0	79.0



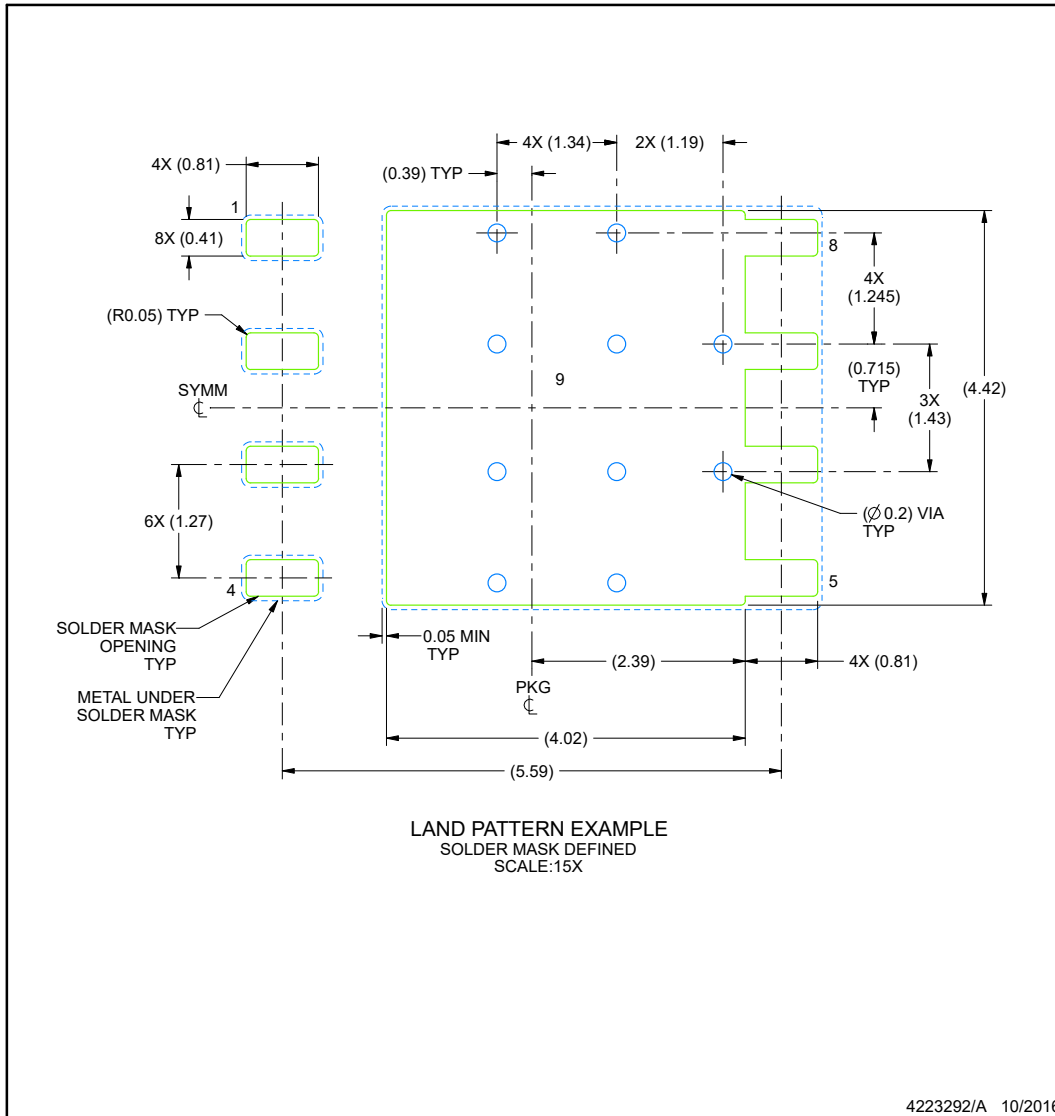
PLASTIC SMALL OUTLINE - NO LEAD



1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

DQH0008A**EXAMPLE BOARD LAYOUT****VSON-CLIP - 1.05 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



NOTES: (continued)

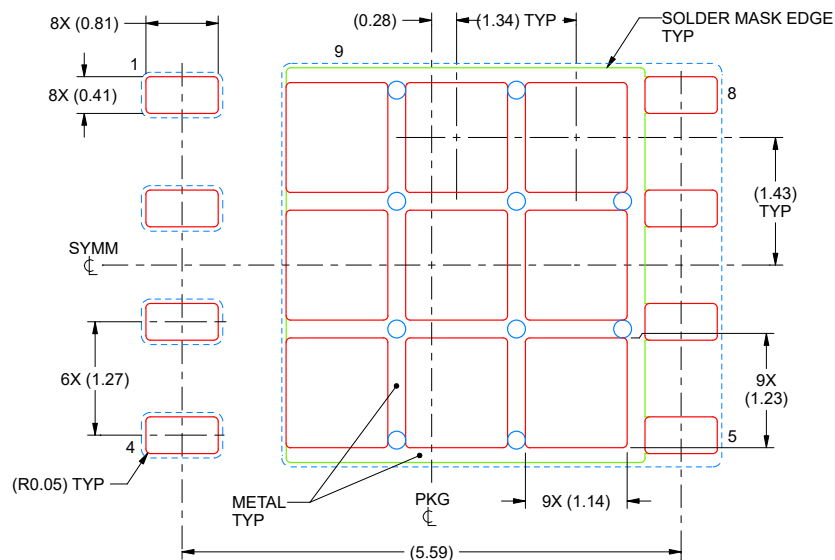
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).
5. Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.

EXAMPLE STENCIL DESIGN

DQH0008A

VSON-CLIP - 1.05 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



**SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL**

EXPOSED PAD 9:
71% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:15X

4223292/A 10/2016

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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)
CSD16321Q5	Active	Production	VSON-CLIP (DQH) 8	2500 LARGE T&R	ROHS Exempt	SN	Level-1-260C-UNLIM	-55 to 150	CSD16321
CSD16321Q5.B	Active	Production	VSON-CLIP (DQH) 8	2500 LARGE T&R	ROHS Exempt	SN	Level-1-260C-UNLIM	-55 to 150	CSD16321
CSD16321Q5T	Active	Production	VSON-CLIP (DQH) 8	250 SMALL T&R	ROHS Exempt	SN	Level-1-260C-UNLIM	-55 to 150	CSD16321
CSD16321Q5T.B	Active	Production	VSON-CLIP (DQH) 8	250 SMALL T&R	ROHS Exempt	SN	Level-1-260C-UNLIM	-55 to 150	CSD16321

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

⁽²⁾ **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.

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

⁽⁴⁾ **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.

⁽⁵⁾ **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.

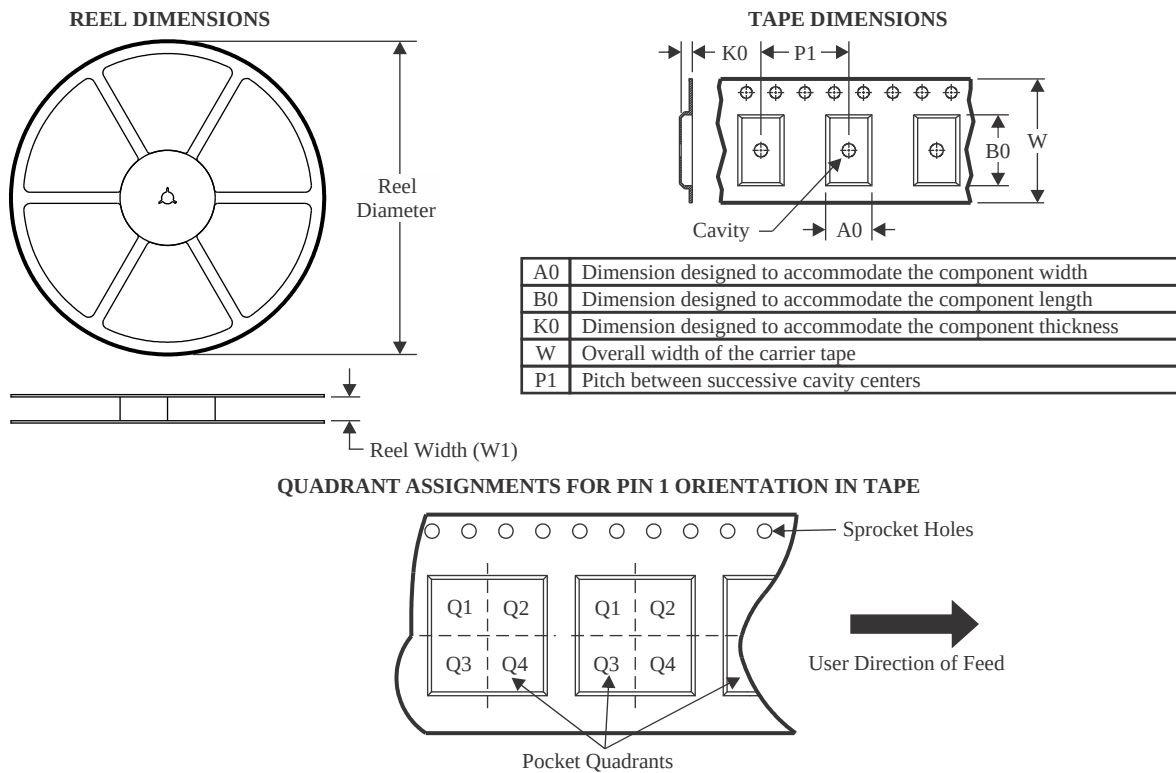
⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

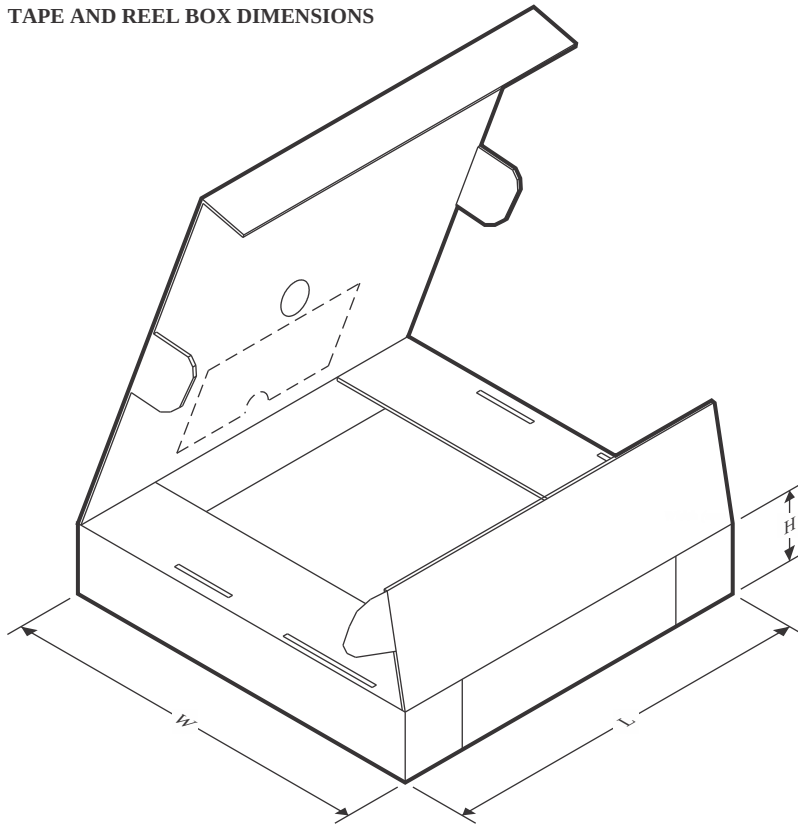
TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CSD16321Q5T	VSON-CLIP	DQH	8	250	178.0	12.4	6.3	5.3	1.2	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



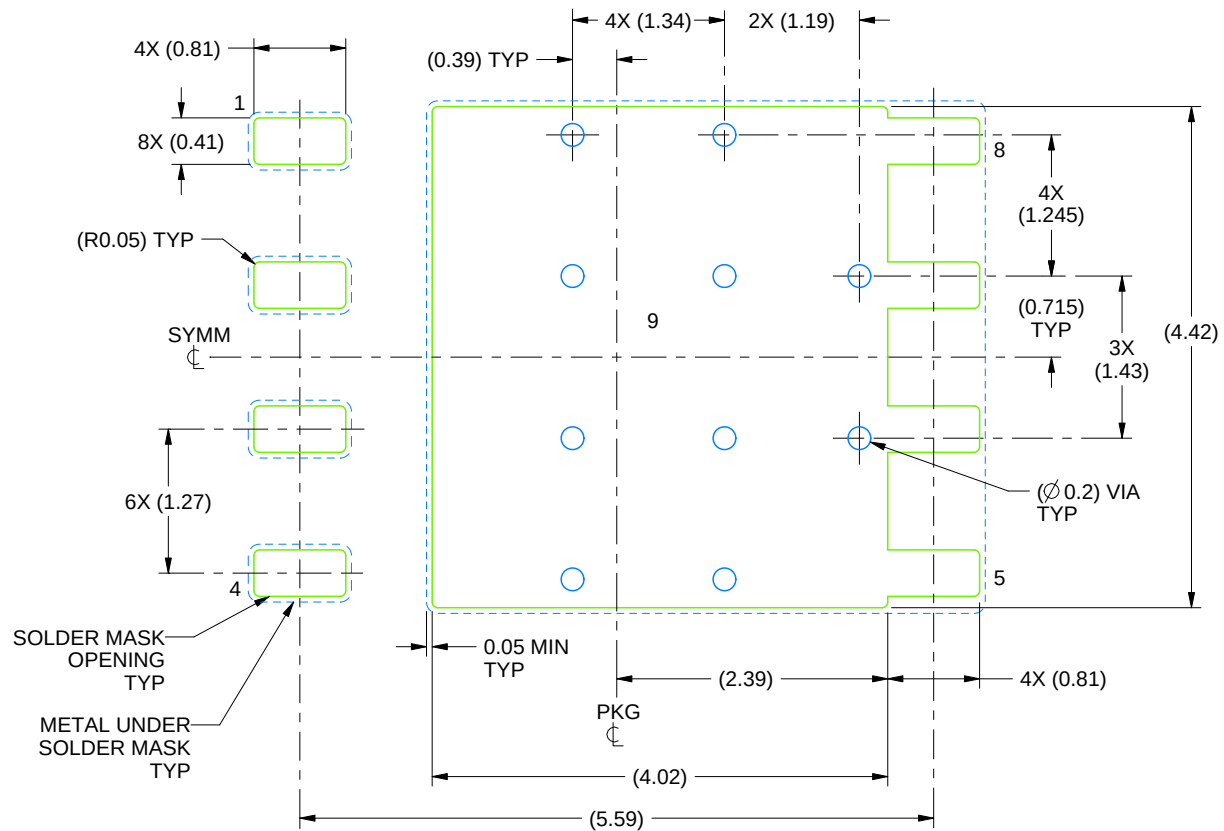
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CSD16321Q5T	VSON-CLIP	DQH	8	250	180.0	180.0	79.0

DQH0008A

VSON-CLIP - 1.05 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE
SOLDER MASK DEFINED
SCALE:15X

4223292/A 10/2016

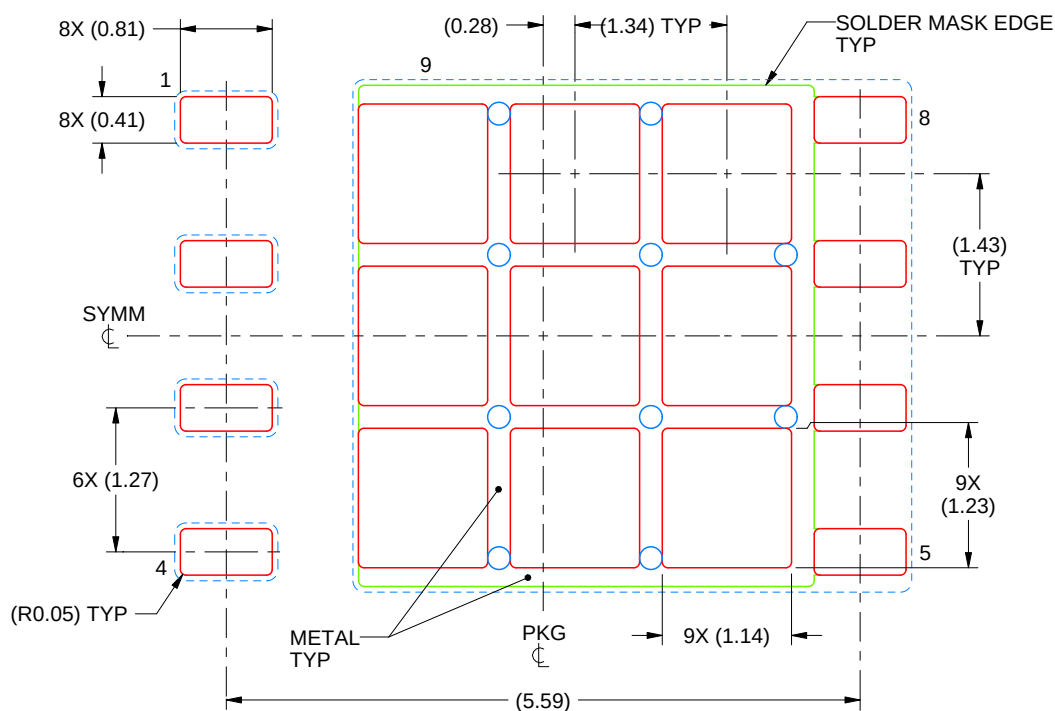
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.

DQH0008A

VSON-CLIP - 1.05 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 9:
71% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:15X

4223292/A 10/2016

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

重要通知和免责声明

TI“按原样”提供技术和可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证没有瑕疵且不做任何明示或暗示的担保，包括但不限于对适销性、与某特定用途的适用性或不侵犯任何第三方知识产权的暗示担保。

这些资源可供使用 TI 产品进行设计的熟练开发人员使用。您将自行承担以下全部责任：(1) 针对您的应用选择合适的 TI 产品，(2) 设计、验证并测试您的应用，(3) 确保您的应用满足相应标准以及任何其他安全、安保法规或其他要求。

这些资源如有变更，恕不另行通知。TI 授权您仅可将这些资源用于研发本资源所述的 TI 产品的相关应用。严禁以其他方式对这些资源进行复制或展示。您无权使用任何其他 TI 知识产权或任何第三方知识产权。对于因您对这些资源的使用而对 TI 及其代表造成的任何索赔、损害、成本、损失和债务，您将全额赔偿，TI 对此概不负责。

TI 提供的产品受 [TI 销售条款](#)、[TI 通用质量指南](#) 或 [ti.com](#) 上其他适用条款或 TI 产品随附的其他适用条款的约束。TI 提供这些资源并不会扩展或以其他方式更改 TI 针对 TI 产品发布的适用的担保或担保免责声明。除非德州仪器 (TI) 明确将某产品指定为定制产品或客户特定产品，否则其产品均为按确定价格收入目录的标准通用器件。

TI 反对并拒绝您可能提出的任何其他或不同的条款。

版权所有 © 2025，德州仪器 (TI) 公司

最后更新日期：2025 年 10 月