



# CSD87335Q3D 同期整流降圧型NexFET™ パワー・ブロック

## 1 特長

- ・ ハーフ・ブリッジ・パワー・ブロック
- ・ 最高27Vの $V_{IN}$
- ・ 15A時に93.5%のシステム効率
- ・ 最大25Aで動作
- ・ 高周波数での動作(最高1.5MHz)
- ・ 高密度SON、占有面積3.3mm×3.3mm
- ・ 5Vゲートの駆動に最適化
- ・ 低いスイッチング損失
- ・ インダクタンスが非常に低いパッケージ
- ・ RoHS準拠
- ・ ハロゲン不使用
- ・ 鉛フリーの端子メッキ処理

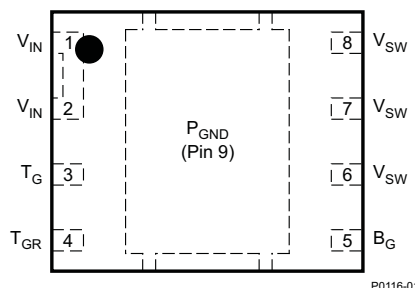
## 2 アプリケーション

- ・ 同期整流降圧コンバータ
  - 高周波数のアプリケーション
  - 大電流、低いデューティ・サイクルのアプリケーション
- ・ マルチフェーズの同期整流降圧コンバータ
- ・ POL DC/DCコンバータ
- ・ IMVP、VRM、VRDアプリケーション

## 3 概要

CSD87335Q3D NexFET™ パワー・ブロックは、同期整流降圧アプリケーション向けに最適化された設計で、大電流、高効率、高周波数の能力を小さな3.3mm×3.3mmの外形に収めています。この製品は5Vのゲート駆動アプリケーション用に最適化されており、外部のコントローラまたはドライバからの任意の5Vゲート・ドライブと組み合わせ、高密度の電源を実現できます。

上面図

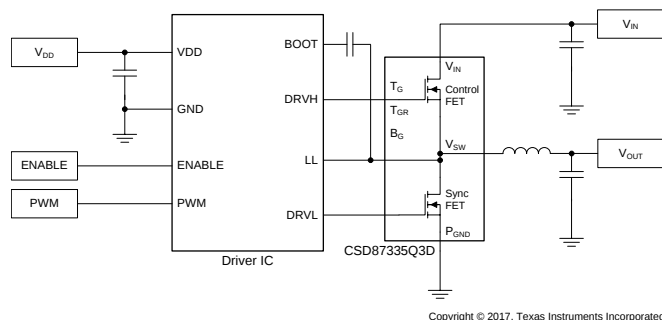


製品情報<sup>(1)</sup>

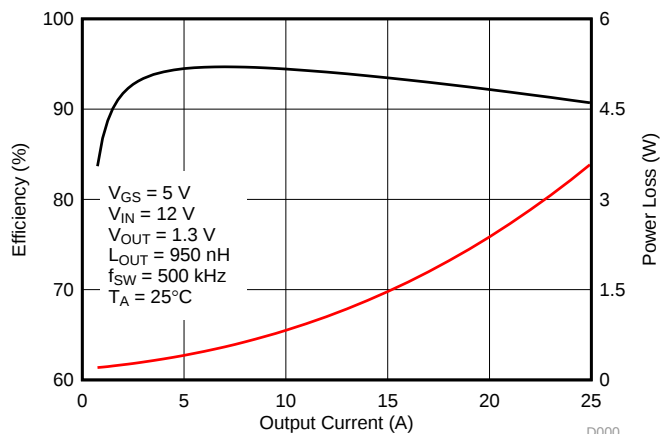
| デバイス         | メディア      | 数量   | パッケージ                | 出荷                  |
|--------------|-----------|------|----------------------|---------------------|
| CSD87335Q3D  | 13インチ・リール | 2500 | SON<br>3.30mm×3.30mm | テー<br>ブ・アン<br>ド・リール |
| CSD87335Q3DT | 7インチ・リール  | 250  | プラスチック・パッケージ         |                     |

(1) 提供されているすべてのパッケージについては、巻末の注文情報を参照してください。

回路例



標準的な電力ブロックの効率と電力損失との関係



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## 4 改訂履歴

### Revision A (October 2017) から Revision B に変更 Page

- Updated [Figure 33](#) top layer showing pins 1 and 2 connected. .... **16**

### 2016年2月発行のものから更新 Page

- Corrected X & Y axis labels on [Figure 29](#) ..... **11**
- Corrected X & Y axis labels on [Figure 30](#) ..... **11**

## 5 Specifications

### 5.1 Absolute Maximum Ratings

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

|                                                               |                                                        | MIN | MAX | UNIT             |
|---------------------------------------------------------------|--------------------------------------------------------|-----|-----|------------------|
| Voltage                                                       | $V_{IN}$ to $P_{GND}$                                  |     | 30  | V                |
|                                                               | $V_{SW}$ to $P_{GND}$                                  |     | 30  |                  |
|                                                               | $V_{SW}$ to $P_{GND}$ (10 ns)                          |     | 32  |                  |
|                                                               | $T_G$ to $T_{GR}$                                      | –8  | 10  |                  |
|                                                               | $B_G$ to $P_{GND}$                                     | –8  | 10  |                  |
| Pulsed current rating, $I_{DM}$ <sup>(2)</sup>                |                                                        |     | 70  | A                |
| Power dissipation, $P_D$                                      |                                                        |     | 6   | W                |
| Avalanche energy, $E_{AS}$                                    | Sync FET, $I_D = 51\text{ A}$ , $L = 0.1\text{ mH}$    |     | 130 | mJ               |
|                                                               | Control FET, $I_D = 33\text{ A}$ , $L = 0.1\text{ mH}$ |     | 54  |                  |
| Operating junction and storage temperature, $T_J$ , $T_{STG}$ |                                                        | –55 | 150 | $^\circ\text{C}$ |

(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.

(2) Pulse duration  $\leq 50\text{ }\mu\text{s}$ , duty cycle  $\leq 1\%$ .

### 5.2 Recommended Operating Conditions

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

|          |                       |                                          | MIN | MAX  | UNIT             |
|----------|-----------------------|------------------------------------------|-----|------|------------------|
| $V_{GS}$ | Gate drive voltage    |                                          | 4.5 | 8    | V                |
| $V_{IN}$ | Input supply voltage  |                                          |     | 27   | V                |
| $f_{SW}$ | Switching frequency   | $C_{BST} = 0.1\text{ }\mu\text{F}$ (min) |     | 1500 | kHz              |
|          | Operating current     |                                          |     | 25   | A                |
| $T_J$    | Operating temperature |                                          |     | 125  | $^\circ\text{C}$ |

### 5.3 Thermal Information

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

| THERMAL METRIC  |                                                                     | MIN | TYP | MAX | UNIT               |
|-----------------|---------------------------------------------------------------------|-----|-----|-----|--------------------|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance (min Cu) <sup>(1)</sup>      |     |     | 135 | $^\circ\text{C/W}$ |
|                 | Junction-to-ambient thermal resistance (max Cu) <sup>(1)(2)</sup>   |     |     | 73  |                    |
| $R_{\theta JC}$ | Junction-to-case thermal resistance (top of package) <sup>(1)</sup> |     |     | 29  | $^\circ\text{C/W}$ |
|                 | Junction-to-case thermal resistance ( $P_{GND}$ pin) <sup>(1)</sup> |     |     | 2.5 |                    |

(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  $\times$  1.5-in (3.81-cm  $\times$  3.81-cm), 0.06-in (1.52-mm) 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-in<sup>2</sup> (6.45-cm<sup>2</sup>) Cu.

### 5.4 Power Block Performance<sup>(1)</sup>

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

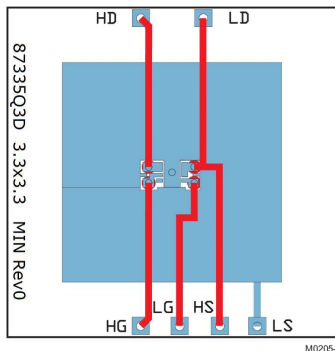
| PARAMETER                             | TEST CONDITIONS                                                                                                                                                                              | MIN | TYP | MAX | UNIT          |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|---------------|
| $P_{LOSS}$ Power loss <sup>(1)</sup>  | $V_{IN} = 12\text{ V}$ , $V_{GS} = 5\text{ V}$ , $V_{OUT} = 1.3\text{ V}$ ,<br>$I_{OUT} = 15\text{ A}$ , $f_{SW} = 500\text{ kHz}$ ,<br>$L_{OUT} = 950\text{ nH}$ , $T_J = 25^\circ\text{C}$ |     | 1.5 |     | W             |
| $I_{QVIN}$ $V_{IN}$ quiescent current | $T_G$ to $T_{GR} = 0\text{ V}$ , $B_G$ to $P_{GND} = 0\text{ V}$                                                                                                                             |     | 10  |     | $\mu\text{A}$ |

(1) Measurement made with six 10- $\mu\text{F}$  (TDK C3216X5R1C106KT or equivalent) ceramic capacitors placed across  $V_{IN}$  to  $P_{GND}$  pins and using a high-current 5-V driver IC.

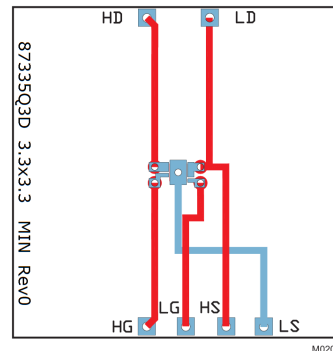
## 5.5 Electrical Characteristics

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

| PARAMETER               |                                  | TEST CONDITIONS                                                                                                                                                 | Q1 Control FET |     |     | Q2 Sync FET |     |     | UNIT        |
|-------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----|-----|-------------|-----|-----|-------------|
|                         |                                  |                                                                                                                                                                 | MIN            | TYP | MAX | MIN         | TYP | MAX |             |
| STATIC CHARACTERISTICS  |                                  |                                                                                                                                                                 |                |     |     |             |     |     |             |
| BV <sub>DSS</sub>       | Drain-to-source voltage          | V <sub>GS</sub> = 0 V, I <sub>DS</sub> = 250 μA                                                                                                                 | 30             |     |     | 30          |     |     | V           |
| I <sub>DSS</sub>        | Drain-to-source leakage current  | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 24 V                                                                                                                   | 1              |     |     | 1           |     |     | μA          |
| I <sub>GSS</sub>        | Gate-to-source leakage current   | V <sub>DS</sub> = 0 V,<br>V <sub>GS</sub> = +10 V / −8 V                                                                                                        | 100            |     |     | 100         |     |     | nA          |
| V <sub>GS(th)</sub>     | Gate-to-source threshold voltage | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>DS</sub> = 250 μA                                                                                                    | 1.0            |     |     | 1.9         |     |     | 0.75 1.20 V |
| Z <sub>DS(on)</sub>     | Effective AC on-impedance        | V <sub>IN</sub> = 12 V, V <sub>GS</sub> = 5 V,<br>V <sub>OUT</sub> = 1.3 V, I <sub>OUT</sub> = 15 A,<br>f <sub>SW</sub> = 500 kHz,<br>L <sub>OUT</sub> = 950 nH | 6.7            |     |     | 1.9         |     |     | mΩ          |
| g <sub>fs</sub>         | Transconductance                 | V <sub>DS</sub> = 3 V, I <sub>DS</sub> = 15 A                                                                                                                   | 59             |     |     | 107         |     |     | S           |
| DYNAMIC CHARACTERISTICS |                                  |                                                                                                                                                                 |                |     |     |             |     |     |             |
| C <sub>ISS</sub>        | Input capacitance                | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 15 V,<br>f = 1 MHz                                                                                                     | 805 1050       |     |     | 1620 2100   |     |     | pF          |
| C <sub>OSS</sub>        | Output capacitance               |                                                                                                                                                                 | 412 536        |     |     | 783 1020    |     |     | pF          |
| C <sub>RSS</sub>        | Reverse transfer capacitance     |                                                                                                                                                                 | 15 20          |     |     | 28 36       |     |     | pF          |
| R <sub>G</sub>          | Series gate resistance           |                                                                                                                                                                 | 1.2 2.4        |     |     | 0.6 1.2     |     |     | Ω           |
| Q <sub>g</sub>          | Gate charge total (4.5 V)        | V <sub>DS</sub> = 15 V,<br>I <sub>DS</sub> = 15 A                                                                                                               | 5.7 7.4        |     |     | 10.7 14.0   |     |     | nC          |
| Q <sub>gd</sub>         | Gate charge – gate-to-drain      |                                                                                                                                                                 | 1.1            |     |     | 1.7         |     |     | nC          |
| Q <sub>gs</sub>         | Gate charge – gate-to-source     |                                                                                                                                                                 | 2.1            |     |     | 2.8         |     |     | nC          |
| Q <sub>g(th)</sub>      | Gate charge at V <sub>th</sub>   |                                                                                                                                                                 | 1.1            |     |     | 1.4         |     |     | nC          |
| Q <sub>OSS</sub>        | Output charge                    |                                                                                                                                                                 | 11             |     |     | 19          |     |     | nC          |
| t <sub>d(on)</sub>      | Turnon delay time                | V <sub>DS</sub> = 15 V, V <sub>GS</sub> = 4.5 V,<br>I <sub>DS</sub> = 15 A, R <sub>G</sub> = 2 Ω                                                                | 8              |     |     | 8           |     |     | ns          |
| t <sub>r</sub>          | Rise time                        |                                                                                                                                                                 | 29             |     |     | 27          |     |     | ns          |
| t <sub>d(off)</sub>     | Turnoff delay time               |                                                                                                                                                                 | 13             |     |     | 17          |     |     | ns          |
| t <sub>f</sub>          | Fall time                        |                                                                                                                                                                 | 4              |     |     | 5           |     |     | ns          |
| DIODE CHARACTERISTICS   |                                  |                                                                                                                                                                 |                |     |     |             |     |     |             |
| V <sub>SD</sub>         | Diode forward voltage            | I <sub>DS</sub> = 15 A, V <sub>GS</sub> = 0 V                                                                                                                   | 0.8 1.0        |     |     | 0.8 1.0     |     |     | V           |
| Q <sub>rr</sub>         | Reverse recovery charge          | V <sub>DS</sub> = 15 V, I <sub>F</sub> = 15 A,                                                                                                                  | 24             |     |     | 40          |     |     | nC          |
| t <sub>rr</sub>         | Reverse recovery time            | di/dt = 300 A/μs                                                                                                                                                | 17             |     |     | 22          |     |     | ns          |



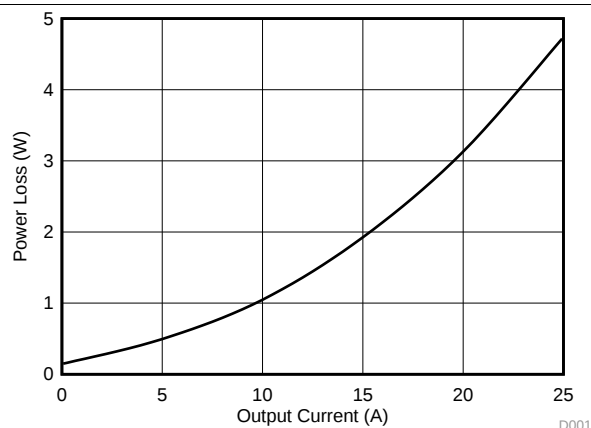
Max  $R_{\theta JA} = 73^\circ\text{C/W}$   
when mounted on 1 in<sup>2</sup>  
(6.45 cm<sup>2</sup>) of 2-oz  
(0.071-mm) thick Cu.



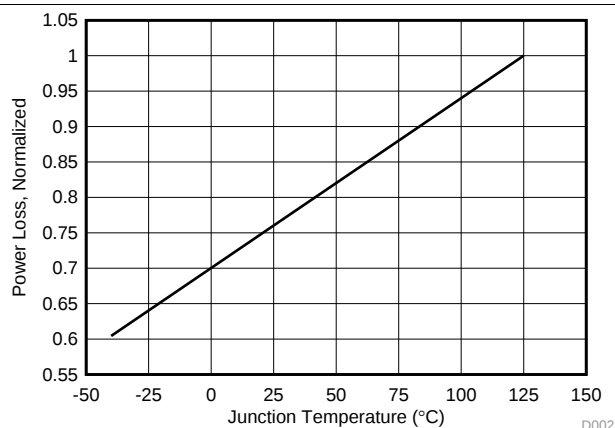
Max  $R_{\theta JA} = 135^\circ\text{C/W}$   
when mounted on  
minimum pad area of  
2-oz. (0.071-mm) thick  
Cu.

## 5.6 Typical Power Block Device Characteristics

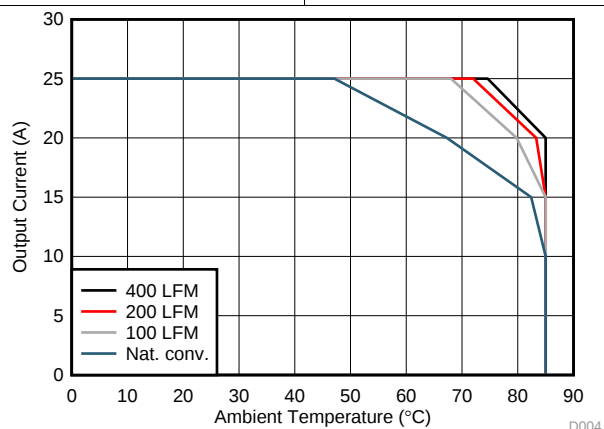
Test conditions:  $V_{IN} = 12\text{ V}$ ,  $V_{DD} = 5\text{ V}$ ,  $f_{SW} = 500\text{ kHz}$ ,  $V_{OUT} = 1.3\text{ V}$ ,  $L_{OUT} = 950\text{ nH}$ ,  $I_{OUT} = 25\text{ A}$ ,  $T_J = 125^\circ\text{C}$ , unless stated otherwise.



**Figure 1. Power Loss vs Output Current**



**Figure 2. Power Loss vs Temperature**



**Figure 3. Safe Operating Area – PCB Horizontal Mount<sup>(1)</sup>**

- (1) The Typical Power Block 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 (H) and 6 copper layers of 1-oz copper thickness. See [Applications and Implementation](#) section for detailed explanation.

## Typical Power Block Device Characteristics (continued)

Test conditions:  $V_{IN} = 12\text{ V}$ ,  $V_{DD} = 5\text{ V}$ ,  $f_{SW} = 500\text{ kHz}$ ,  $V_{OUT} = 1.3\text{ V}$ ,  $L_{OUT} = 950\text{ nH}$ ,  $I_{OUT} = 25\text{ A}$ ,  $T_J = 125^\circ\text{C}$ , unless stated otherwise.

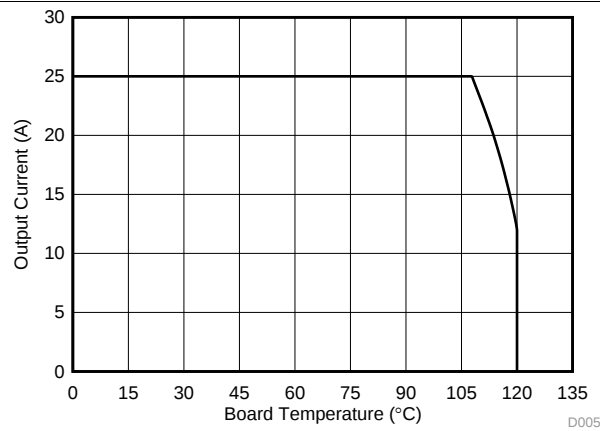


Figure 4. Typical Safe Operating Area<sup>(1)</sup>

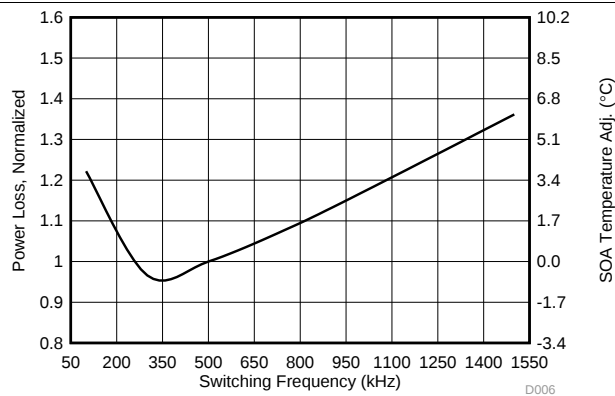


Figure 5. Normalized Power Loss vs Switching Frequency

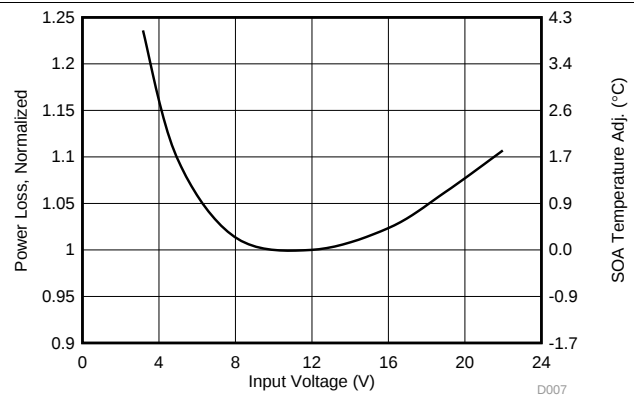


Figure 6. Normalized Power Loss vs Input Voltage

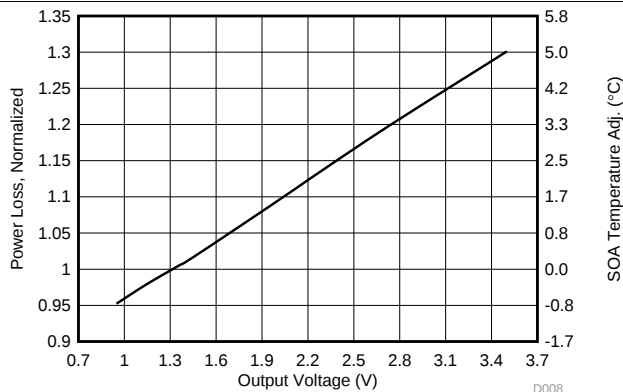


Figure 7. Normalized Power Loss vs Output Voltage

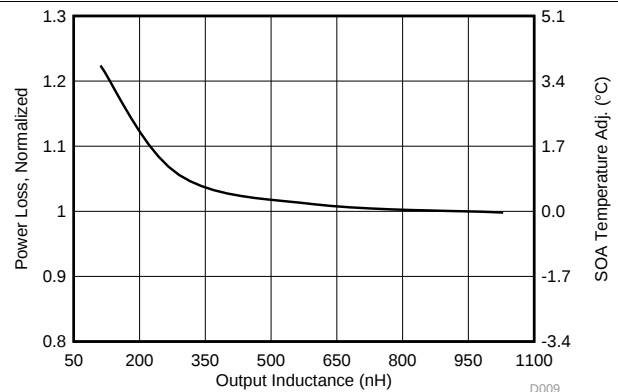


Figure 8. Normalized Power Loss vs Output Inductance

## 5.7 Typical Power Block MOSFET Characteristics

$T_A = 25^\circ\text{C}$ , unless stated otherwise.

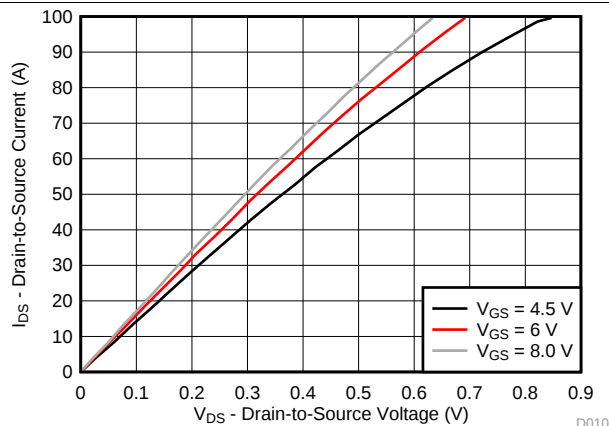


Figure 9. Control MOSFET Saturation

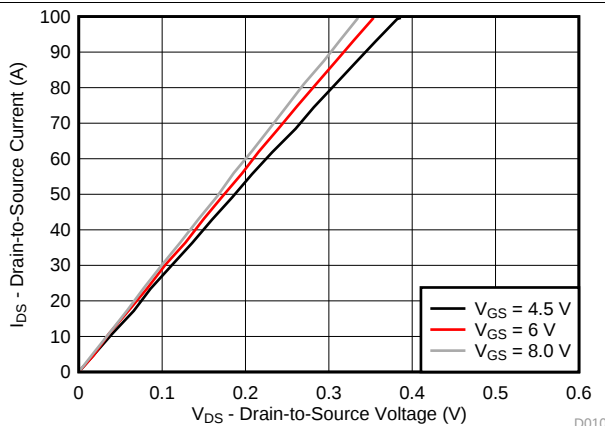


Figure 10. Sync MOSFET Saturation

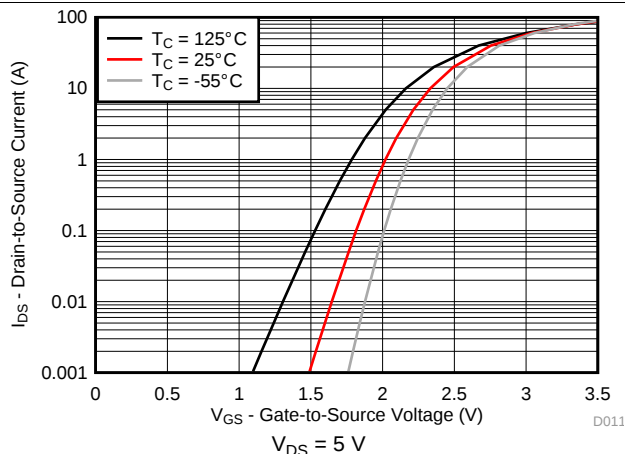


Figure 11. Control MOSFET Transfer

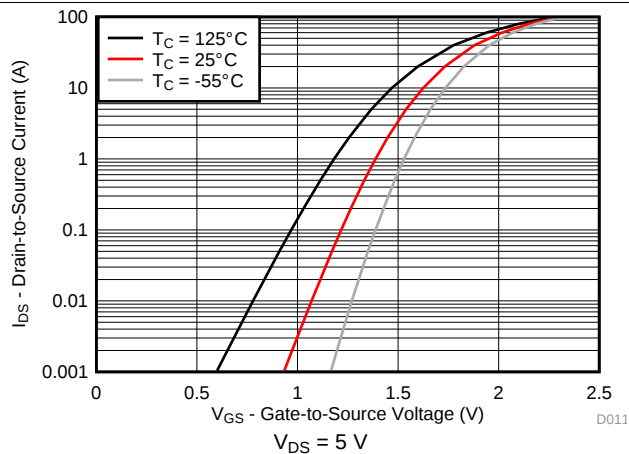


Figure 12. Sync MOSFET Transfer

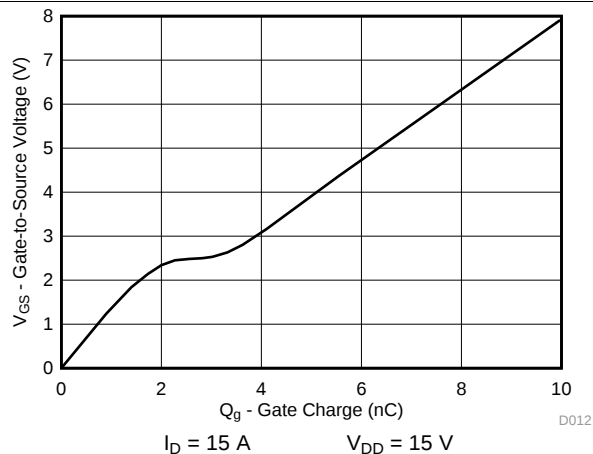


Figure 13. Control MOSFET Gate Charge

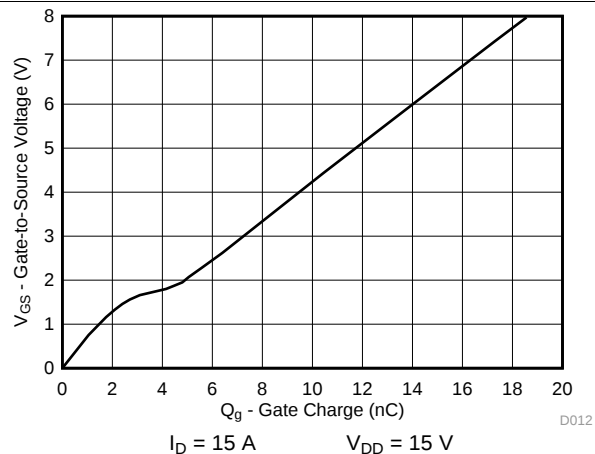


Figure 14. Sync MOSFET Gate Charge

## Typical Power Block MOSFET Characteristics (continued)

$T_A = 25^\circ\text{C}$ , unless stated otherwise.

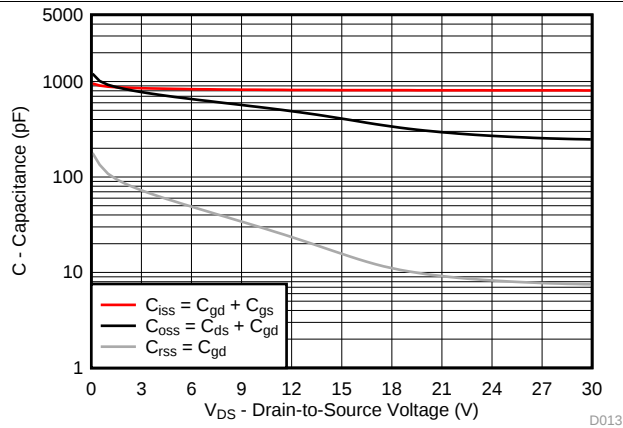


Figure 15. Control MOSFET Capacitance

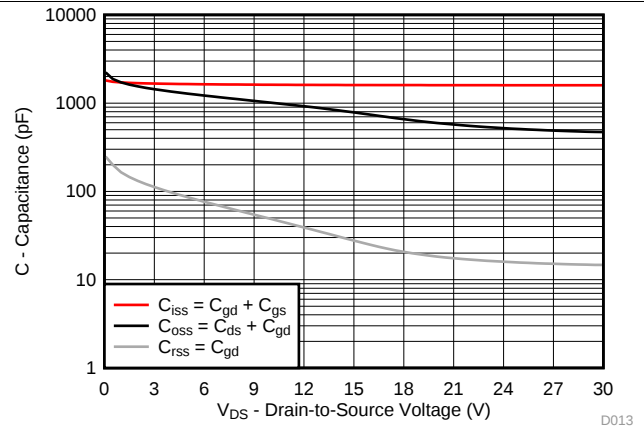


Figure 16. Sync MOSFET Capacitance

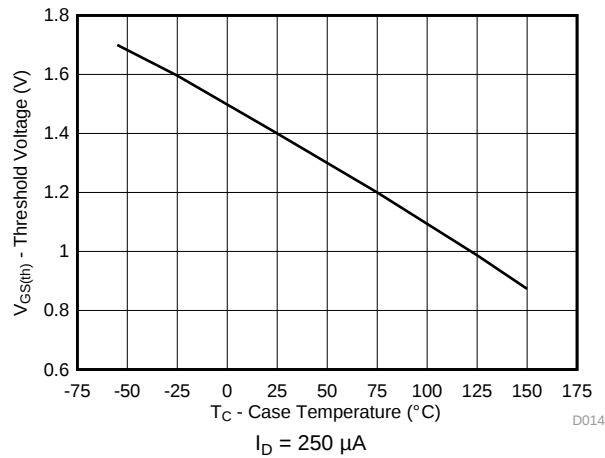


Figure 17. Control MOSFET  $V_{GS(th)}$

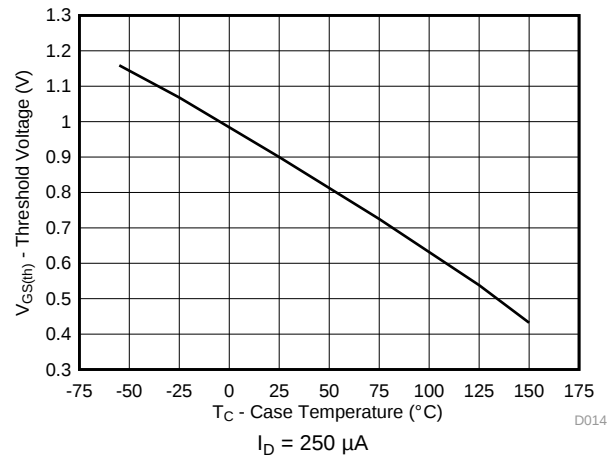


Figure 18. Sync MOSFET  $V_{GS(th)}$

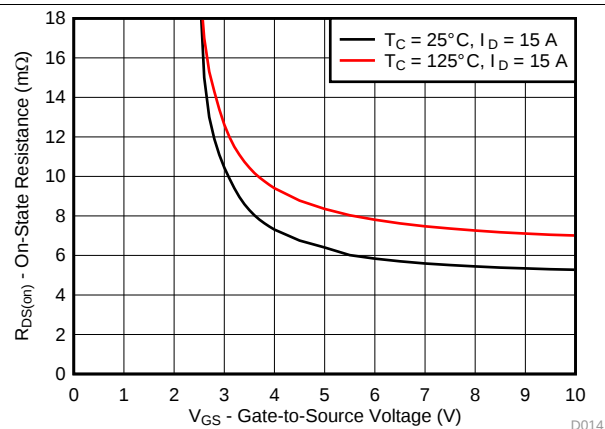


Figure 19. Control MOSFET  $R_{DS(on)}$  vs  $V_{GS}$

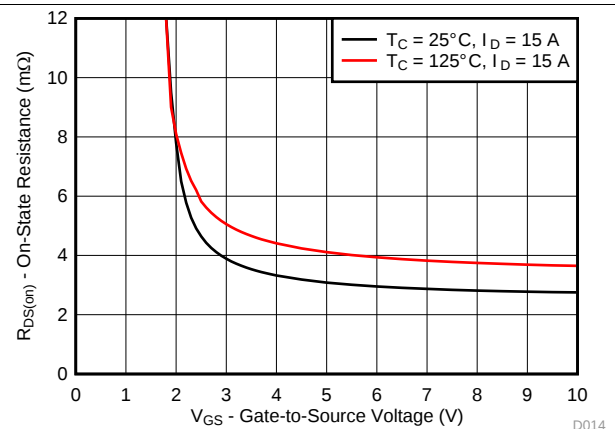


Figure 20. Sync MOSFET  $R_{DS(on)}$  vs  $V_{GS}$

## Typical Power Block MOSFET Characteristics (continued)

$T_A = 25^\circ\text{C}$ , unless stated otherwise.

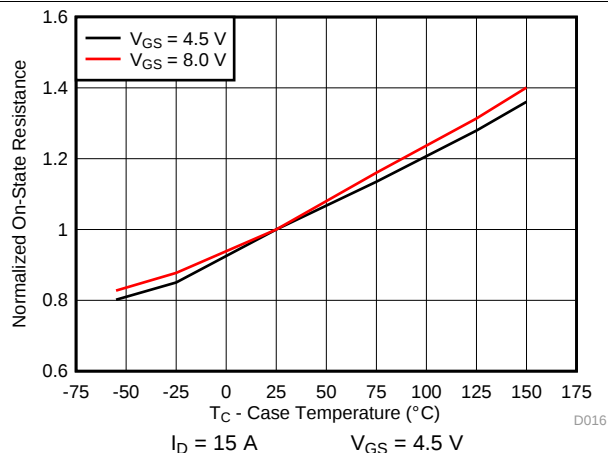


Figure 21. Control MOSFET Normalized  $R_{DS(on)}$

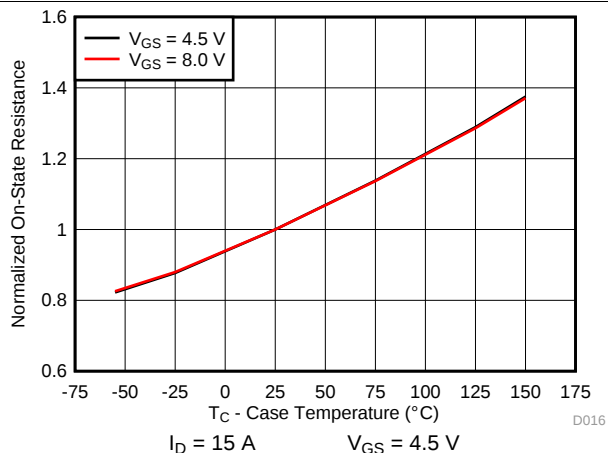


Figure 22. Sync MOSFET Normalized  $R_{DS(on)}$

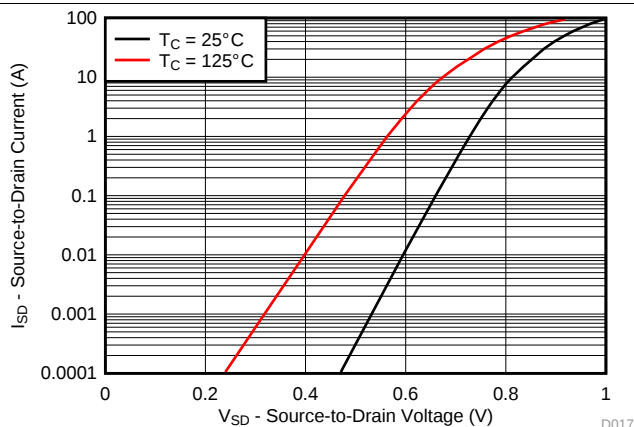


Figure 23. Control MOSFET Body Diode

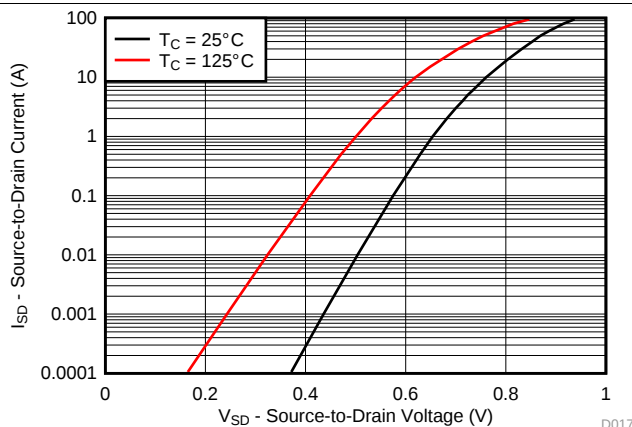


Figure 24. Sync MOSFET Body Diode

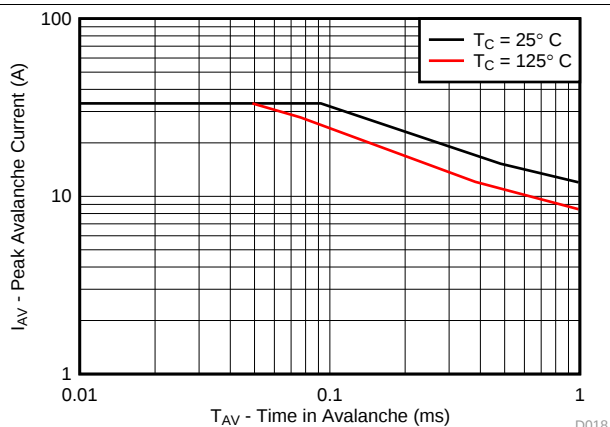


Figure 25. Control MOSFET Unclamped Inductive Switching

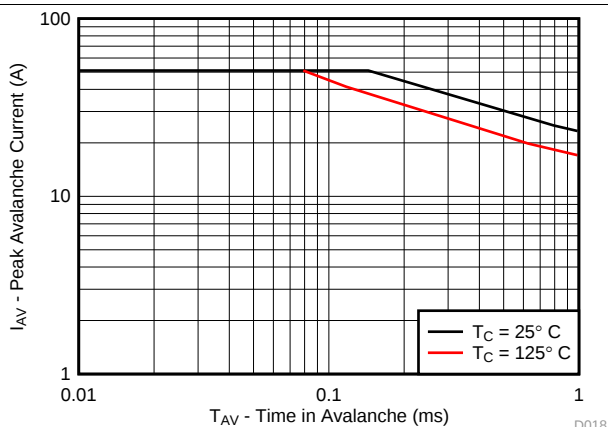


Figure 26. Sync MOSFET Unclamped Inductive Switching

## 6 Applications and Implementation

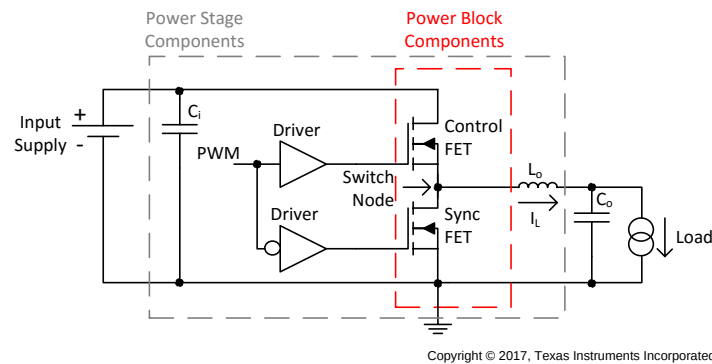
### NOTE

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.

### 6.1 Application Information

#### 6.1.1 Equivalent System Performance

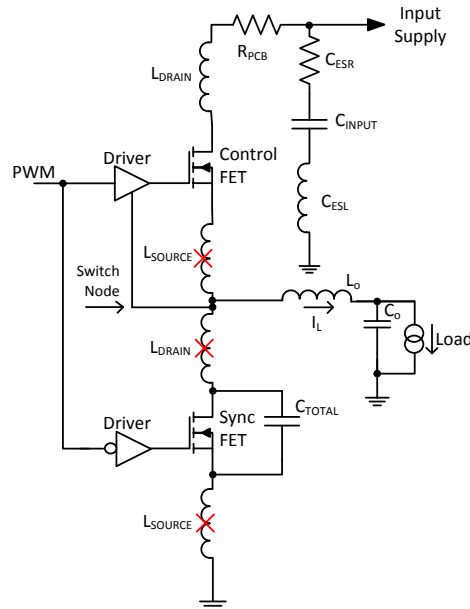
Many of today's high-performance computing systems require low-power consumption in an effort to reduce system operating temperatures and improve overall system efficiency. This has created a major emphasis on improving the conversion efficiency of today's synchronous buck topology. In particular, there has been an emphasis in improving the performance of the critical power semiconductor in the power stage of this application (see Figure 27). As such, optimization of the power semiconductors in these applications, needs to go beyond simply reducing  $R_{DS(ON)}$ .



**Figure 27. Equivalent System Schematic**

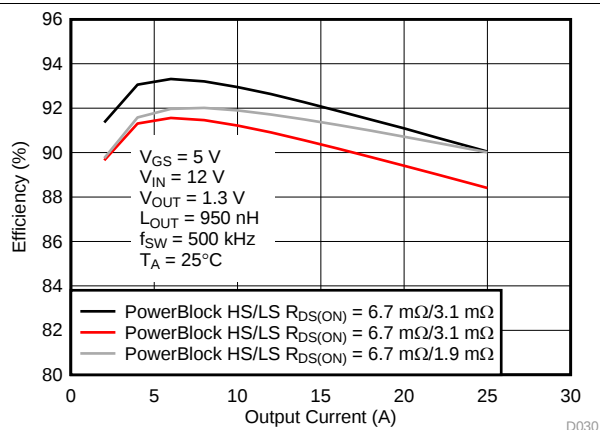
The CSD87335Q3D is part of TI's power block product family which is a highly optimized product for use in a synchronous buck topology requiring high current, high efficiency, and high frequency. It incorporates TI's latest generation silicon which has been optimized for switching performance, as well as minimizing losses associated with  $Q_{GD}$ ,  $Q_{GS}$ , and  $Q_{RR}$ . Furthermore, TI's patented packaging technology has minimized losses by nearly eliminating parasitic elements between the control FET and sync FET connections (see Figure 28). A key challenge solved by TI's patented packaging technology is the system level impact of Common Source Inductance (CSI). CSI greatly impedes the switching characteristics of any MOSFET which in turn increases switching losses and reduces system efficiency. As a result, the effects of CSI need to be considered during the MOSFET selection process. In addition, standard MOSFET switching loss equations used to predict system efficiency need to be modified in order to account for the effects of CSI. Further details behind the effects of CSI and modification of switching loss equations are outlined in [Power Loss Calculation With Common Source Inductance Consideration for Synchronous Buck Converters](#) (SLPA009).

## Application Information (continued)

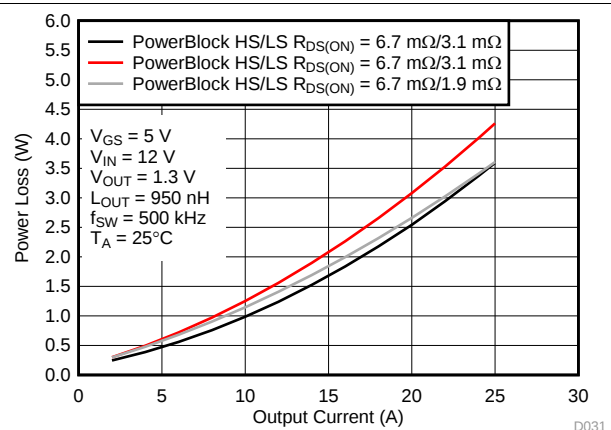


**Figure 28. Elimination of Parasitic Inductances**

The combination of TI's latest generation silicon and optimized packaging technology has created a benchmarking solution that outperforms industry standard MOSFET chipsets of similar  $R_{DS(ON)}$  and MOSFET chipsets with lower  $R_{DS(ON)}$ . Figure 29 and Figure 30 compare the efficiency and power loss performance of the CSD87335Q3D versus industry standard MOSFET chipsets commonly used in this type of application. This comparison purely focuses on the efficiency and generated loss of the power semiconductors only. The performance of CSD87335Q3D clearly highlights the importance of considering the effective AC on-impedance ( $Z_{DS(ON)}$ ) during the MOSFET selection process of any new design. Simply normalizing to traditional MOSFET  $R_{DS(ON)}$  specifications is not an indicator of the actual in-circuit performance when using TI's power block technology.



**Figure 29. Efficiency**



**Figure 30. Power Loss**

## Application Information (continued)

**Table 1** compares the traditional DC measured  $R_{DS(ON)}$  of CSD87335Q3D versus its  $Z_{DS(ON)}$ . This comparison takes into account the improved efficiency associated with TI's patented packaging technology. As such, when comparing TI's power block products to individually packaged discrete MOSFETs or dual MOSFETs in a standard package, the in-circuit switching performance of the solution must be considered. In this example, individually packaged discrete MOSFETs or dual MOSFETs in a standard package would need to have DC measured  $R_{DS(ON)}$  values that are equivalent to CSD87335Q3D's  $Z_{DS(ON)}$  value in order to have the same efficiency performance at full load. Mid to light-load efficiency will still be lower with individually packaged discrete MOSFETs or dual MOSFETs in a standard package.

**Table 1. Comparison of  $R_{DS(ON)}$  vs.  $Z_{DS(ON)}$**

| PARAMETER                                                        | HS  |     | LS  |     |
|------------------------------------------------------------------|-----|-----|-----|-----|
|                                                                  | TYP | MAX | TYP | MAX |
| Effective AC on-impedance $Z_{DS(ON)}$ ( $V_{GS} = 5\text{ V}$ ) | 6.7 | —   | 1.9 | —   |
| DC measured $R_{DS(ON)}$ ( $V_{GS} = 4.5\text{ V}$ )             | 6.7 | 8.1 | 3.1 | 3.9 |

The CSD87335Q3D NexFET™ power block is an optimized design for synchronous buck applications using 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 new rating method is needed which is tailored towards a more systems-centric environment. System-level performance curves such as power loss, Safe Operating Area (SOA), and normalized graphs allow engineers to predict the product performance in the actual application.

### 6.2 Power Loss Curves

MOSFET centric parameters such as  $R_{DS(ON)}$  and  $Q_{gd}$  are needed 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 1** plots the power loss of the CSD87335Q3D as a function of load current. This curve is measured by configuring and running the CSD87335Q3D as it would be in the final application (see **Figure 31**). The measured power loss is the CSD87335Q3D loss and consists of both input conversion loss and gate drive loss. **Equation 1** is used to generate the power loss curve.

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

The power loss curve in **Figure 1** is measured at the maximum recommended junction temperatures of 125°C under isothermal test conditions.

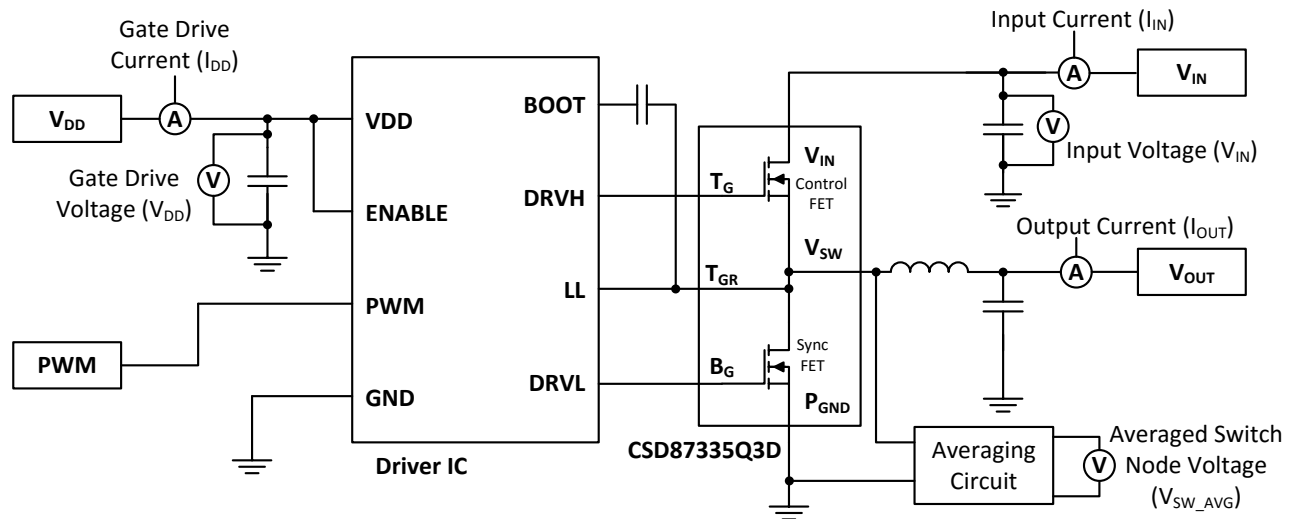
### 6.3 Safe Operating Curves (SOA)

The SOA curves in the CSD87335Q3D data sheet provides guidance on the temperature boundaries within an operating system by incorporating the thermal resistance and system power loss. **Figure 4** 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) × 3.5 in (L) × 0.062 in (T) and 6 copper layers of 1-oz copper thickness.

### 6.4 Normalized Curves

The normalized curves in the CSD87335Q3D data sheet provides 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.

## Normalized Curves (continued)



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Figure 31. Typical Application

## 6.5 Calculating Power Loss and SOA

The user can estimate product loss and SOA boundaries by arithmetic means (see [Design Example](#) section). 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 the user should take to predict product performance for any set of system conditions.

### 6.5.1 Design Example

Operating conditions:

- Output current = 15 A
- Input voltage = 14 V
- Output voltage = 1.4 V
- Switching frequency = 750 kHz
- Inductor = 600 nH

### 6.5.2 Calculating Power Loss

- Power loss at 15 A = 1.92 W ([Figure 1](#))
- Normalized power loss for input voltage  $\approx 1.01$  ([Figure 6](#))
- Normalized power loss for output voltage  $\approx 1.01$  ([Figure 7](#))
- Normalized power loss for switching frequency  $\approx 1.08$  ([Figure 5](#))
- Normalized power loss for output inductor  $\approx 1.01$  ([Figure 8](#))
- **Final calculated power loss =  $1.92 \text{ W} \times 1.01 \times 1.01 \times 1.08 \times 1.01 \approx 2.14 \text{ W}$**

### 6.5.3 Calculating SOA Adjustments

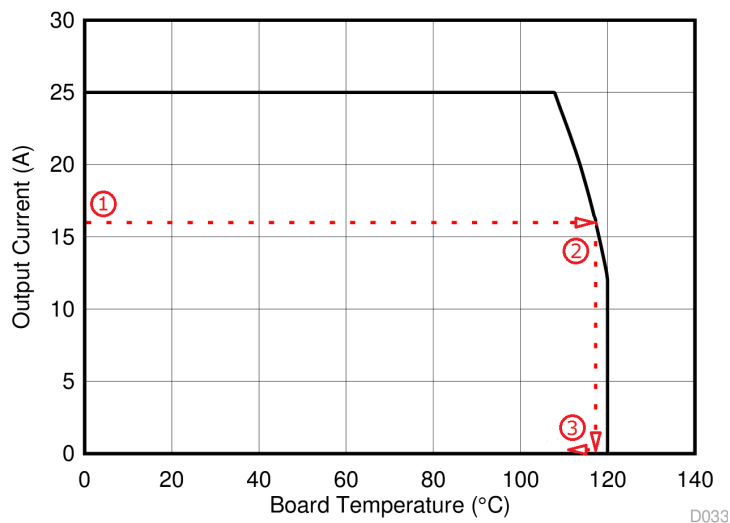
- SOA adjustment for input voltage  $\approx 0.14^\circ\text{C}$  ([Figure 6](#))
- SOA adjustment for output voltage  $\approx 0.17^\circ\text{C}$  ([Figure 7](#))
- SOA adjustment for switching frequency  $\approx 1.32^\circ\text{C}$  ([Figure 5](#))
- SOA adjustment for output inductor  $\approx 0.18^\circ\text{C}$  ([Figure 8](#))
- **Final calculated SOA adjustment =  $0.14 + 0.17 + 1.32 + 0.18 \approx 1.81^\circ\text{C}$**

## Calculating Power Loss and SOA (continued)

In the design example above, the estimated power loss of the CSD87335Q3D would increase to 2.14 W. In addition, the maximum allowable board and/or ambient temperature would have to decrease by 1.81°C. [Figure 32](#) 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 1.81°C. In the event the adjustment value is a negative number, subtracting the negative number would yield an increase in allowable board/ambient temperature.



**Figure 32. Power Block SOA**

## 7 Recommended PCB Design Overview

There are two key system-level parameters that can be addressed with a proper PCB design: electrical and thermal performance. Properly optimizing the PCB layout will yield maximum performance in both areas. A brief description on how to address each parameter is provided.

### 7.1 Electrical Performance

The power block has the ability to switch voltages at rates greater than 10 kV/μs. Special care must be then taken with the PCB layout design and placement of the input capacitors, driver IC, and output inductor.

- The placement of the input capacitors relative to the power block's VIN and PGND pins 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 VIN and PGND pins (see [Figure 33](#)). The example in [Figure 33](#) uses 6 × 10-μF ceramic capacitors (TDK Part # 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 block, C5, C7, C19, and C8 should follow in order.
- The driver IC should be placed relatively close to the power block gate pins. T<sub>G</sub> and B<sub>G</sub> should connect to the outputs of the driver IC. The T<sub>GR</sub> pin serves as the return path of the high-side gate drive circuitry and should be connected to the phase pin of the IC (sometimes called LX, LL, SW, PH, etc.). The bootstrap capacitor for the driver IC will also connect to this pin.
- The switching node of the output inductor should be placed relatively close to the power block VSW pins. Minimizing the node length between these two components will reduce the PCB conduction losses and actually reduce the switching noise level. In the event the switch node waveform exhibits ringing that reaches undesirable levels, the use of a boost resistor or RC snubber can be an effective way to easily reduce the peak ring level. The recommended boost resistor value will range between 1 Ω to 4.7 Ω depending on the output characteristics of driver IC used in conjunction with the power block. The RC snubber values can range from 0.5 Ω to 2.2 Ω for the R and 330 pF to 2200 pF for the C. Please refer to [Snubber Circuits: Theory, Design and Application](#) (SLUP100) for more details on how to properly tune the RC snubber values. The RC snubber should be placed as close as possible to the Vsw node and PGND (see [Figure 33](#)). <sup>(1)</sup>

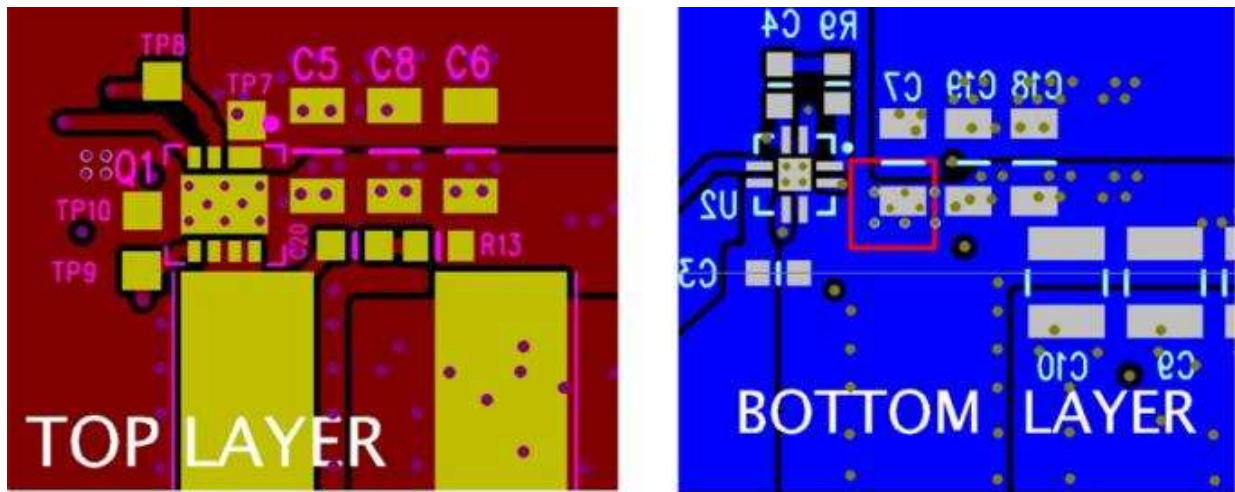
(1) Keong W. Kam, David Pommerenke, "EMI Analysis Methods for Synchronous Buck Converter EMI Root Cause Analysis", University of Missouri – Rolla

## 7.2 Thermal Performance

The power block has the ability to utilize the 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 33](#) uses vias with a 10-mil drill hole and a 16-mil capture pad.
- Tent the opposite side of the via with solder-mask.

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



**Figure 33. Recommended PCB Layout (Top Down)**

## 8 デバイスおよびドキュメントのサポート

### 8.1 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、[ti.com](http://ti.com)のデバイス製品フォルダを開いてください。右上の隅にある「通知を受け取る」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

### 8.2 コミュニティ・リソース

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

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**設計サポート** TIの設計サポート役に立つE2Eフォーラムや、設計サポート・ツールをすばやく見つけることができます。技術サポート用の連絡先情報も参照できます。

### 8.3 商標

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### 8.4 静電気放電に関する注意事項



これらのデバイスは、限定的なESD (静電破壊) 保護機能を内蔵しています。保存時または取り扱い時は、MOSゲートに対する静電破壊を防止するために、リード線同士をショートさせておくか、デバイスを導電フォームに入れる必要があります。

### 8.5 Glossary

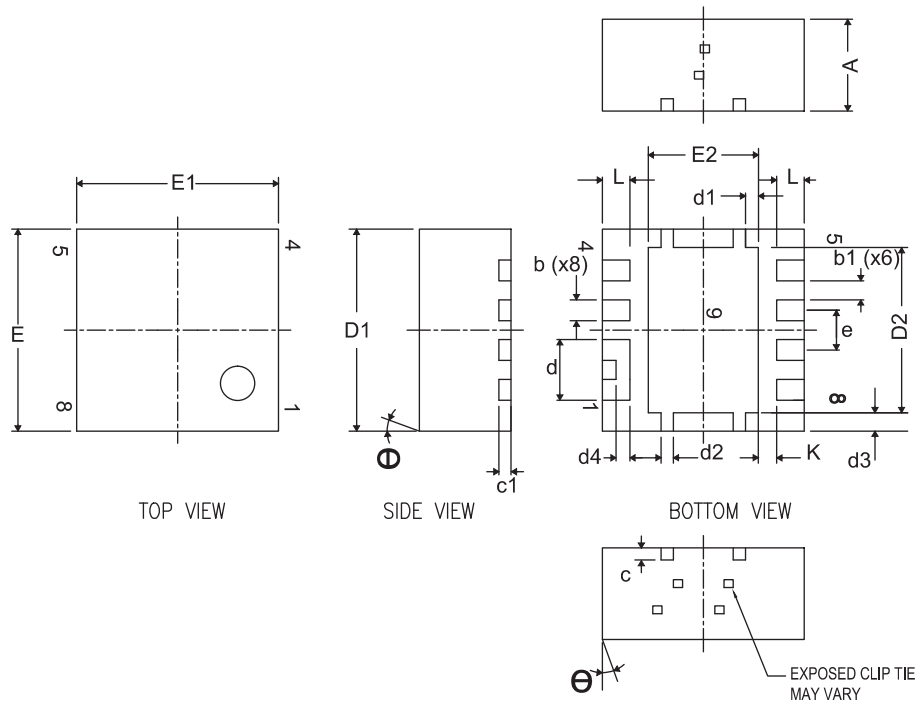
**SLYZ022** — *TI Glossary*.

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

## 9 メカニカル、パッケージ、および注文情報

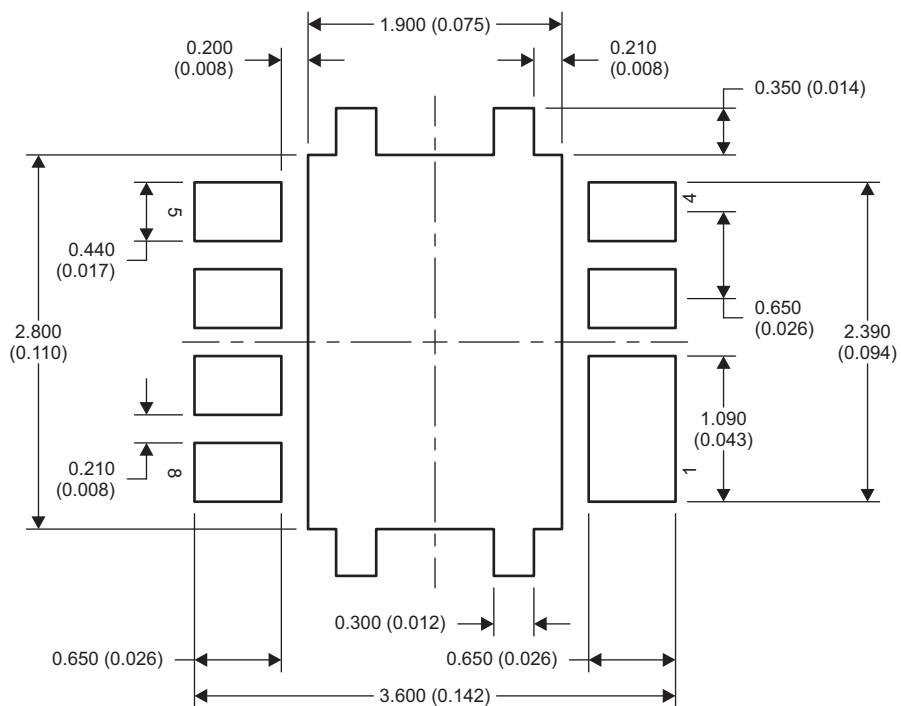
以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。この情報は、そのデバイスについて利用可能な最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。

### 9.1 Q3Dパッケージの寸法



| 寸法 | ミリメートル      |       | インチ         |       |
|----|-------------|-------|-------------|-------|
|    | 最小          | 最大    | 最小          | 最大    |
| A  | 1.400       | 1.500 | 0.055       | 0.059 |
| b  | 0.280       | 0.400 | 0.011       | 0.016 |
| b1 | 0.310 (公称値) |       | 0.012 (公称値) |       |
| c  | 0.150       | 0.250 | 0.006       | 0.010 |
| c1 | 0.150       | 0.250 | 0.006       | 0.010 |
| d  | 0.940       | 1.040 | 0.037       | 0.041 |
| d1 | 0.160       | 0.260 | 0.006       | 0.010 |
| d2 | 0.150       | 0.250 | 0.006       | 0.010 |
| d3 | 0.250       | 0.350 | 0.010       | 0.014 |
| d4 | 0.175       | 0.275 | 0.007       | 0.011 |
| D1 | 3.200       | 3.400 | 0.126       | 0.134 |
| D2 | 2.650       | 2.750 | 0.104       | 0.108 |
| E  | 3.200       | 3.400 | 0.126       | 0.134 |
| E1 | 3.200       | 3.400 | 0.126       | 0.134 |
| E2 | 1.750       | 1.850 | 0.069       | 0.073 |
| e  | 0.650 (標準値) |       | 0.026 (標準値) |       |
| L  | 0.400       | 0.500 | 0.016       | 0.020 |
| θ  | 0.00        | —     | —           | —     |
| K  | 0.300 (標準値) |       | 0.012 (標準値) |       |

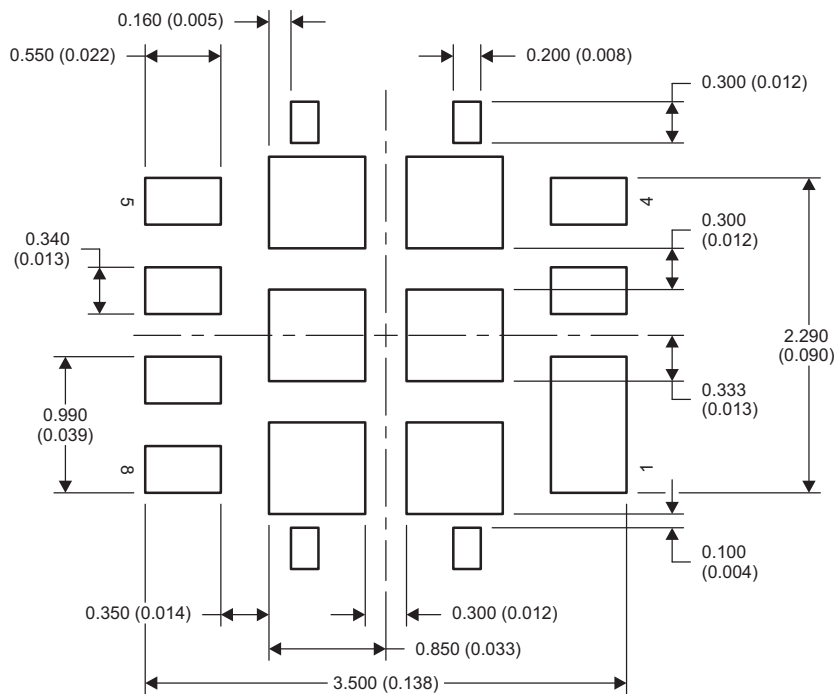
## 9.2 推奨ランド・パターン



M0193-01

NOTE: 寸法はmm (インチ)単位です。

### 9.3 推奨ステンシル

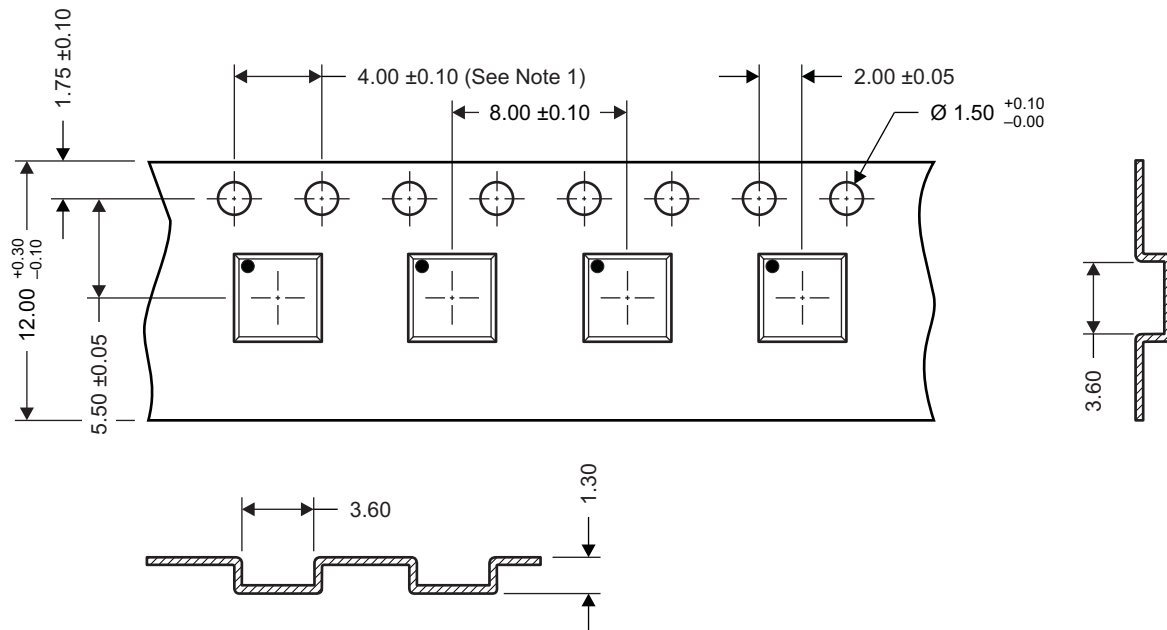


M0207-01

NOTE: 寸法はmm (インチ)単位です。

PCB設計の推奨回路レイアウトについては、『[PCBレイアウト技法によるリンギングの低減](#)』(SLPA005)を参照してください。

## 9.4 Q3Dのテープ・アンド・リール情報



M0144-01

- NOTES: 1. 10スプロケット・ホール・ピッチの累積許容誤差は $\pm 0.2$
2. キャンバーは100mm内に1mmを超えないこと(250mm以上では累積しない)。
3. 材質: 黒色の静電散逸性ポリスチレン。
4. すべての寸法は、特記されていない限りmm単位
5. 厚さ:  $0.3 \pm 0.05$ mm
6. MSL1 260°C (IRおよび対流方式) Pbフリフロー互換

## 9.5 ピン構成

| 位置  | 機能        |
|-----|-----------|
| ピン1 | $V_{IN}$  |
| ピン2 | $V_{IN}$  |
| ピン3 | $T_G$     |
| ピン4 | $T_{GR}$  |
| ピン5 | $B_G$     |
| ピン6 | $V_{SW}$  |
| ピン7 | $V_{SW}$  |
| ピン8 | $V_{SW}$  |
| ピン9 | $P_{GND}$ |

## PACKAGING INFORMATION

| Orderable part number        | Status<br>(1) | Material type<br>(2) | Package   Pins      | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|------------------------------|---------------|----------------------|---------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">CSD87335Q3D</a>  | Active        | Production           | LSON-CLIP (DQZ)   8 | 2500   LARGE T&R      | ROHS Exempt | NIPDAU   SN                          | Level-1-260C-UNLIM                | -55 to 150   | 87335D              |
| CSD87335Q3D.B                | Active        | Production           | LSON-CLIP (DQZ)   8 | 2500   LARGE T&R      | ROHS Exempt | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 150   | 87335D              |
| CSD87335Q3DG4                | Active        | Production           | LSON-CLIP (DQZ)   8 | 2500   LARGE T&R      | ROHS Exempt | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 150   | 87335D              |
| CSD87335Q3DG4.B              | Active        | Production           | LSON-CLIP (DQZ)   8 | 2500   LARGE T&R      | ROHS Exempt | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 150   | 87335D              |
| <a href="#">CSD87335Q3DT</a> | Active        | Production           | LSON-CLIP (DQZ)   8 | 250   SMALL T&R       | ROHS Exempt | NIPDAU   SN                          | Level-1-260C-UNLIM                | -55 to 150   | 87335D              |
| CSD87335Q3DT.B               | Active        | Production           | LSON-CLIP (DQZ)   8 | 250   SMALL T&R       | ROHS Exempt | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 150   | 87335D              |

<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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**LSON-CLIP - 1.55 mm max height**

The drawing illustrates the mechanical specifications of a microelectronic package through three views: top, side, and bottom.

**Top View:** Shows a square footprint with overall dimensions of 3.4 by 3.4. A shaded region in the top-left corner is designated as the "PIN 1 INDEX AREA". Reference markers A and B are located at the top and left corners, respectively. Dimension lines indicate 3.2 for the distance from the corners to the center.

**Side View:** Shows the package profile with a total height of 1.55. The distance from the base to the top of the main body is 1.45. A "SEATING PLANE" is indicated at the base. A detail callout for the seating plane shows a semi-circular feature with a radius of 0.08 and a depth of 0.05. The base thickness is 0.00.

**Bottom View:** Shows the underside of the package with a central square area labeled "9". The overall width is 1.8 ± 0.1. Key features include:
 

- Four mounting pads at the corners, each 0.2 wide (4X 0.2).
- Two central pads, each 0.98 wide (2X 0.98).
- Six side pads, each 0.65 wide (6X 0.65).
- Two central side pads, each 1.95 wide (2X 1.95).
- Eight small pads along the bottom edge (8X 0.5).
- Eight small pads along the right edge (8X 0.4).
- Dimensions of 0.32 and 0.12 for the bottom-left corner pads.
- A central square area labeled "9" with a width of 1.8 ± 0.1.
- A vertical dimension of 2.7 ± 0.1 for the right side.
- A horizontal dimension of 0.40 and 0.28 for the bottom-right corner pads.
- Reference markers A, B, and C are used for alignment.
- Feature callouts include "EXPOSED THERMAL PAD" and "SYMM" (symmetry).

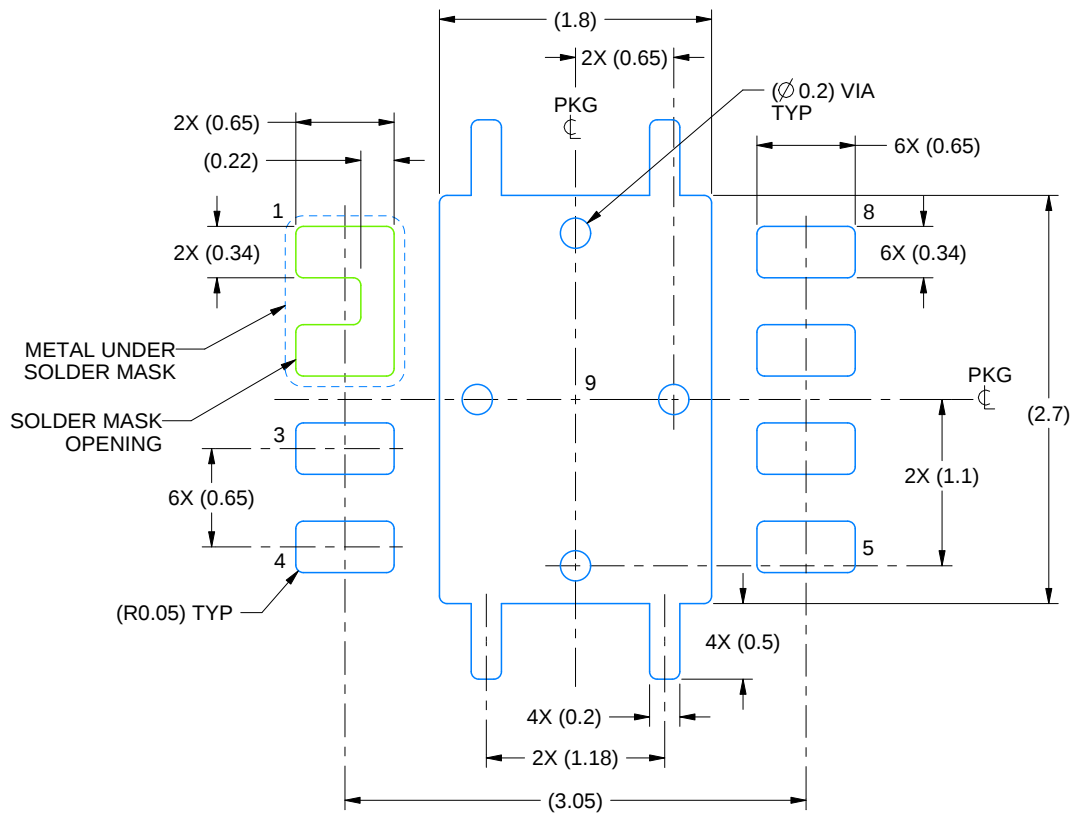
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

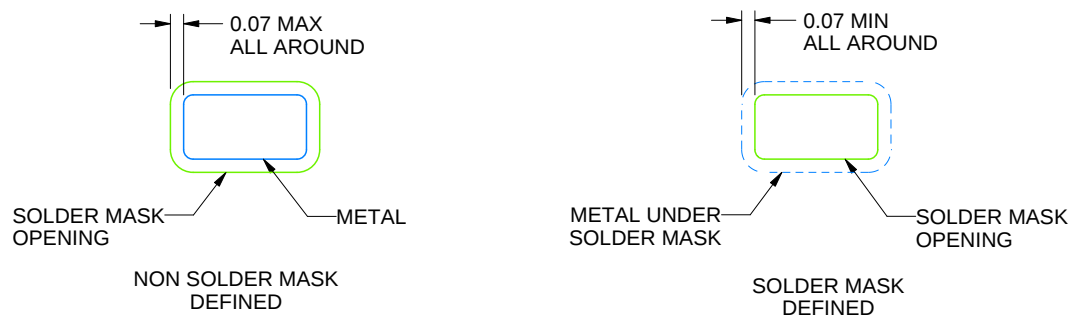
DQZ0008A

LSON-CLIP - 1.55 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:20X



SOLDER MASK DETAILS

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NOTES: (continued)

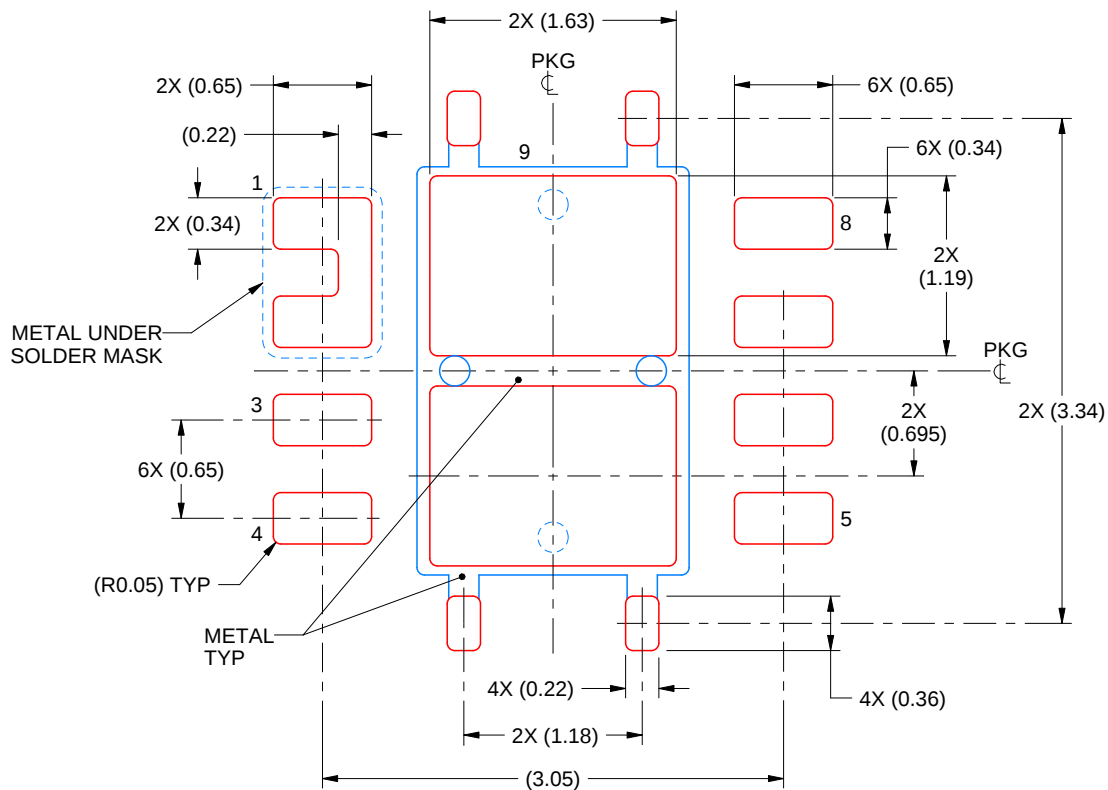
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If some or all are implemented,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

# EXAMPLE STENCIL DESIGN

DQZ0008A

LSON-CLIP - 1.55 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 9  
76% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:20X

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NOTES: (continued)

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

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