

BQ2945xy Overvoltage Protection For 2-Series and 3-Series Cell Li-Ion Batteries

1 Features

- 2-series and 3-series cell overvoltage monitor for secondary protection
- Fixed programmable delay timer
- Fixed OVP threshold
 - Available range from 3.85 V to 4.6 V
- Fixed OVP delay option: 4 s or 6.5 s
- High-accuracy overvoltage protection: ± 10 mV
- Low power consumption $I_{CC} \approx 1 \mu\text{A}$ ($V_{\text{CELL(ALL)}} < V_{\text{PROTECT}}$)
- Low leakage current per cell input < 100 nA
- Small package footprint
 - 6-pin SON

2 Applications

- Second-level protection in Li-ion battery packs in:
 - Tablets
 - Slates
 - Power tools
 - Notebook computers
 - Portable equipment and instrumentation

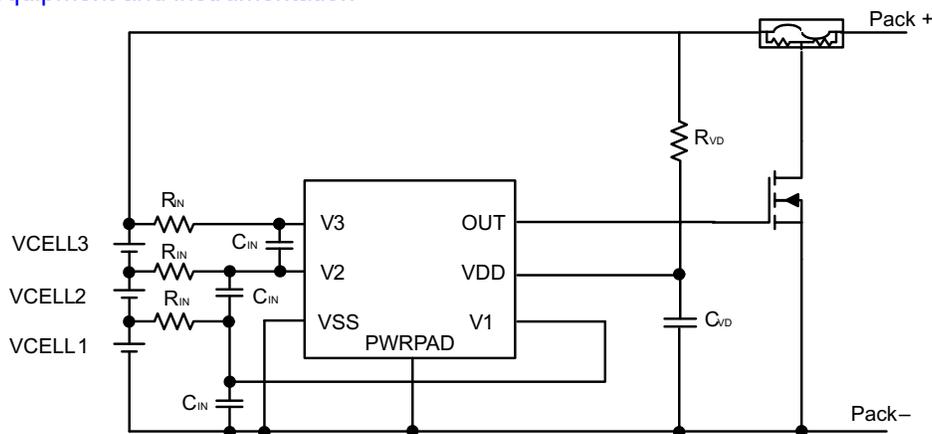
3 Description

The BQ2945xy family of products is a secondary-level voltage monitor and protector for Li-ion battery pack systems. Each cell is monitored independently for an overvoltage condition. Based on the configuration, an output is triggered after a fixed delay if any of the two or three cells has an overvoltage condition. This output is triggered into a high state after an overvoltage condition satisfies the specified delay timer.

Device Information

| PART NUMBER ⁽¹⁾ | PACKAGE | BODY SIZE (NOM) |
|----------------------------|---------|-------------------|
| BQ2945xy | SON (6) | 2.00 mm × 2.00 mm |

- (1) For all available packages, see the orderable addendum at the end of the data sheet.



Copyright © 2017, Texas Instruments Incorporated

Simplified Schematic



Table of Contents

| | | | |
|--|---|--|----|
| 1 Features | 1 | 9 Application and Implementation | 10 |
| 2 Applications | 1 | 9.1 Application Information..... | 10 |
| 3 Description | 1 | 9.2 Typical Application..... | 10 |
| 4 Revision History | 2 | 9.3 System Examples..... | 11 |
| 5 Device Comparison Table | 3 | 10 Power Supply Recommendations | 12 |
| 6 Pin Configuration and Functions | 3 | 11 Layout | 12 |
| 7 Specifications | 4 | 11.1 Layout Guidelines..... | 12 |
| 7.1 Absolute Maximum Ratings..... | 4 | 11.2 Layout Example..... | 12 |
| 7.2 ESD Ratings..... | 4 | 12 Device and Documentation Support | 13 |
| 7.3 Recommended Operating Conditions..... | 4 | 12.1 Device Support..... | 13 |
| 7.4 Thermal Information..... | 4 | 12.2 Related Documentation..... | 13 |
| 7.5 Electrical Characteristics..... | 5 | 12.3 Receiving Notification of Documentation Updates.. | 13 |
| 7.6 Typical Characteristics..... | 6 | 12.4 Support Resources..... | 13 |
| 8 Detailed Description | 7 | 12.5 Trademarks..... | 13 |
| 8.1 Overview..... | 7 | 12.6 Electrostatic Discharge Caution..... | 13 |
| 8.2 Functional Block Diagram..... | 7 | 12.7 Glossary..... | 13 |
| 8.3 Feature Description..... | 7 | 13 Mechanical, Packaging, and Orderable Information | 13 |
| 8.4 Device Functional Modes..... | 8 | | |

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| | |
|---|-------------|
| Changes from Revision J (June 2022) to Revision K (August 2022) | Page |
| • Changed the BQ294534 device to Production Data..... | 3 |
| • Changed the BQ294534 device to Production Data in the <i>Electrical Characteristics</i> | 5 |
| Changes from Revision I (May 2021) to Revision J (June 2022) | Page |
| • Added the PRODUCT PREVIEW BQ294534 device..... | 3 |
| • Added the PRODUCT PREVIEW BQ294534 device to the <i>Electrical Characteristics</i> | 5 |
| Changes from Revision H (December 2017) to Revision I (May 2021) | Page |
| • Changed the BQ294506 device to Production Data..... | 3 |
| Changes from Revision G (November 2017) to Revision H (December 2017) | Page |
| • Added the BQ294506 device..... | 3 |
| • Added the BQ294506 device to the <i>Electrical Characteristics</i> | 5 |

5 Device Comparison Table

| T _A | PART NUMBER | OVP (V) | DELAY TIME (s) |
|-----------------|-------------|---------|----------------|
| -40°C to +110°C | BQ294502 | 4.35 | 4 |
| | BQ294504 | 4.35 | 6.5 |
| | BQ294506 | 4.38 | 4 |
| | BQ294512 | 4.4 | 4 |
| | BQ294522 | 4.45 | 4 |
| | BQ294524 | 4.45 | 6.5 |
| | BQ294532 | 4.5 | 4 |
| | BQ294533 | 4.5 | 6.5 |
| | BQ294534 | 4.55 | 4 |
| | BQ294582 | 4.225 | 4 |
| BQ294592 | 4.3 | 4 | |

6 Pin Configuration and Functions

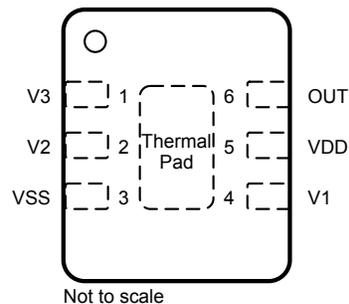


Figure 6-1. DRV Package 6-Pin SON Top View

Table 6-1. Pin Functions

| NUMBER | NAME | TYPE ⁽¹⁾ | DESCRIPTION |
|--------|--------|---------------------|--|
| 1 | V3 | IA | Sense input for positive voltage of the third cell from the bottom of the stack. |
| 2 | V2 | IA | Sense input for positive voltage of the second cell from the bottom of the stack. |
| 3 | VSS | P | Electrically connected to IC ground and negative terminal of the lowest cell in the stack. |
| 4 | V1 | IA | Sense input for positive voltage of the lowest cell in the stack. |
| 5 | VDD | P | Power supply |
| 6 | OUT | OA ¹ | Output drive for external N-channel FET. |
| — | PWRPAD | — | VSS pin to be connected to the PWRPAD on the printed-circuit-board (PCB) for proper operation. |

(1) IA = Input Analog, OA = Output Analog, P = Power Connection

7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)^{(1) (2)}

| | | MIN | MAX | UNIT |
|---|-----------------------------|-----------------------------------|-----|------|
| Supply voltage | VDD–VSS | –0.3 | 30 | V |
| Input voltage | V1–VSS or V2–VSS or V3–VSS+ | –0.3 | 30 | V |
| | V3–V2 or V2–V1 | –0.3 | 8 | V |
| Output voltage | OUT–VSS | –0.3 | 30 | V |
| Continuous total power dissipation, P _{TOT} | | See Section 7.4 . | | |
| Lead temperature (soldering, 10 s), T _{SOLDER} | | | 300 | °C |
| Storage temperature, T _{stg} | | –65 | 150 | °C |

- (1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- (2) See [Figure 8-3](#).

7.2 ESD Ratings

| | | VALUE | UNIT |
|--|--|-------|------|
| V _(ESD) Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±2000 | V |
| | Charged device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾ | ±500 | |

- (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.

7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|---|--------------------------|-----|-----|------|
| Supply voltage, V _{DD} | ⁽¹⁾ | 3 | 25 | V |
| Input voltage | V3–V2 or V2–V1 or V1–VSS | 0 | 5 | V |
| Operating ambient temperature, T _A | | –40 | 110 | °C |

- (1) See [Section 9.2](#).

7.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | BQ2945xy | UNIT |
|-------------------------------|--|-----------|------|
| | | DRV (SON) | |
| | | 6 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 186.4 | °C/W |
| R _{θJC(top)} | Junction-to-case(top) thermal resistance | 90.4 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 110.7 | °C/W |
| Ψ _{JT} | Junction-to-top characterization parameter | 96.7 | °C/W |
| Ψ _{JB} | Junction-to-board characterization parameter | 90 | °C/W |
| R _{θJC(bot)} | Junction-to-case(bottom) thermal resistance | N/A | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics Application Report](#).

7.5 Electrical Characteristics

Typical values stated where $T_A = 25^\circ\text{C}$ and $V_{DD} = 10.8\text{ V}$, MIN/MAX values stated where $T_A = -40^\circ\text{C}$ to $+110^\circ\text{C}$ and $V_{DD} = 3\text{ V}$ to 15 V (unless otherwise noted).

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT | |
|---|--|--|------|----------------|------|---------------|
| VOLTAGE PROTECTION THRESHOLD VCx | | | | | | |
| V_{OV} | $V_{(PROTECT)} -$ Overvoltage Detection | BQ294502, fixed delay 4 s | | 4.35 | V | |
| | | BQ294504, fixed delay 6.5 s | | 4.35 | | |
| | | BQ294506, fixed delay 4 s | | 4.38 | | |
| | | BQ294512, fixed delay 4 s | | 4.4 | | |
| | | BQ294522, fixed delay 4 s | | 4.45 | | |
| | | BQ294524, fixed delay 6.5 s | | 4.45 | | |
| | | BQ294532, fixed delay 4 s | | 4.5 | | |
| | | BQ294533, fixed delay 6.5 s | | 4.5 | | |
| | | BQ294534, fixed delay 4 s | | 4.55 | | |
| | | BQ294582, fixed delay 4 s | | 4.225 | | |
| BQ294592, fixed delay 4 s | | 4.3 | | | | |
| V_{HYS} | Overvoltage Detection Hysteresis | V_{HYS} | 250 | 300 | 400 | mV |
| V_{OA} | OV Detection Accuracy | $T_A = 25^\circ\text{C}$, BQ2945xy | -10 | | 10 | mV |
| | | $T_A = 25^\circ\text{C}$, BQ294506 only | -7 | | 7 | mV |
| $V_{OA-DRIFT}$ | OV Detection Accuracy due to Temperature | $T_A = -40^\circ\text{C}$ | -40 | | 44 | mV |
| | | $T_A = 0^\circ\text{C}$ | -20 | | 20 | |
| | | $T_A = 60^\circ\text{C}$ | -24 | | 24 | |
| | | $T_A = 110^\circ\text{C}$ | -54 | | 54 | |
| | | $T_A = 10^\circ\text{C}$ to 45°C , BQ294506 only | -15 | | 15 | mV |
| SUPPLY AND LEAKAGE CURRENT | | | | | | |
| I_{CC} | Supply Current | $(V3-V2) = (V2-V1) = (V1-VSS) = 4\text{ V}$ (See Figure 8-3 for reference.) | | 1 | 2 | μA |
| | | $(V3-V2) = (V2-V1) = (V1-VSS) = 2.8\text{ V}$ with $T_A = -40^\circ\text{C}$ to 60°C | | | 1.25 | |
| I_{IN} | Input Current at Vx Pins | Measured at V3, V2, and V1 = 4 V $(V2-V1) = (V1-VSS) = 4\text{ V}$ $T_A = 0^\circ\text{C}$ to 60°C (See Figure 8-3 for reference.) | -0.1 | | 0.1 | μA |
| OUTPUT DRIVE OUT | | | | | | |
| V_{OUT} | Output Drive Voltage | $(V3-V2)$ or $(V2-V1)$ or $(V1-VSS) > V_{OV}$ $V_{DD} = 7.2\text{ V}$, $I_{OH} = 100\ \mu\text{A}$, $T_A = -40^\circ\text{C}$ to $+110^\circ\text{C}$ | 6 | | | V |
| | | Two of the three cells are short circuit and only one cell is powered $(V3-V2)$ or $(V2-V1)$ or $(V1-VSS) > V_{OV}$ $V_{DD} = V_x$ (Cell voltage), $I_{OH} = 100\ \mu\text{A}$, $T_A = -40^\circ\text{C}$ to $+110^\circ\text{C}$ | | $V_{DD} - 0.2$ | | V |
| | | $(V3-V2)$, $(V2-V1)$, and $(V1-VSS) < V_{OV}$, $I_{OL} = 100\ \mu\text{A}$, $T_A = 25^\circ\text{C}$ $T_A = -40^\circ\text{C}$ to $+110^\circ\text{C}$ | | 250 | 400 | mV |
| $I_{OUT(Short)}$ | OUT Short Circuit Current | $OUT = 0\text{ V}$ ($V3-V2$) or $(V2-V1)$ or $(V1-VSS) > V_{OV}$ | | | 4.5 | mA |
| t_R | Output Rise Time | $CL = 1\text{ nF}$, $V_{OH(OUT)} = 0\text{ V}$ to $5\text{ V}^{(1)}$ | | 5 | | μs |
| Z_O | Output Impedance | | | 2 | 5 | k Ω |
| FIXED DELAY TIMER | | | | | | |
| t_{DELAY} | Fault Detection Delay Time | Fixed Delay, BQ2945xy with delay set to 4s typ | 3.2 | 4 | 4.8 | s |
| | | Fixed Delay, BQ2945xy with delay set to 6.5 s | 5.2 | 6.5 | 7.8 | |

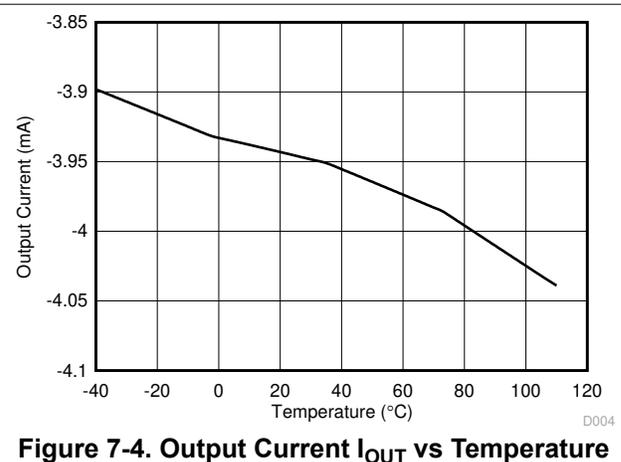
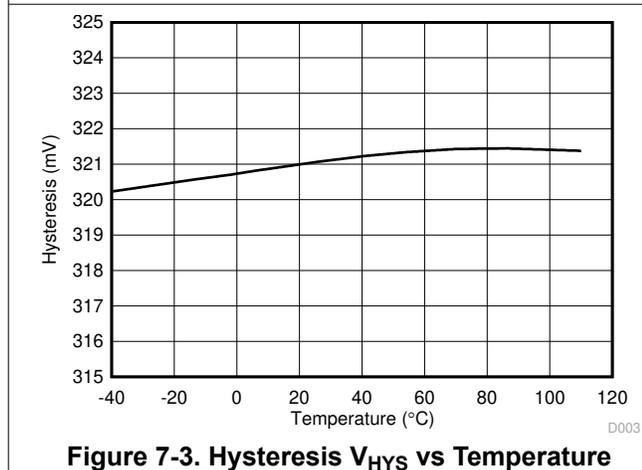
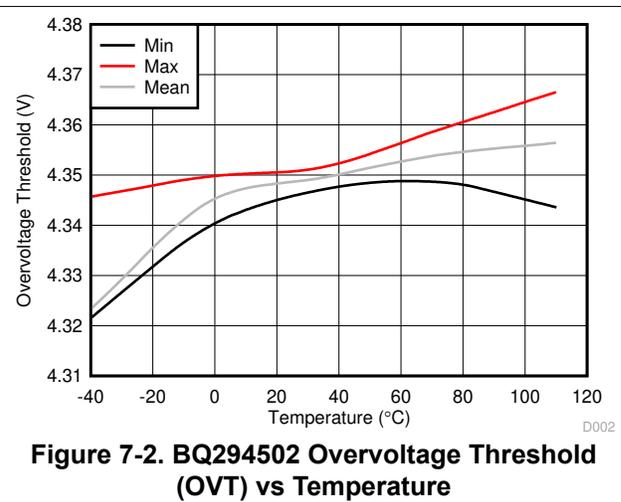
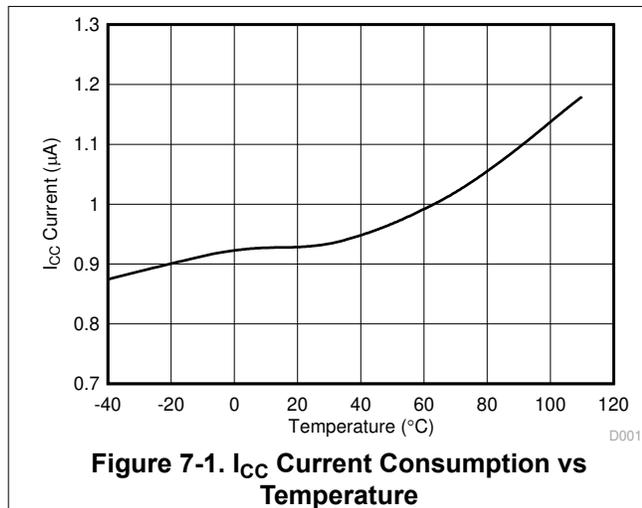
7.5 Electrical Characteristics (continued)

Typical values stated where $T_A = 25^\circ\text{C}$ and $V_{DD} = 10.8\text{ V}$, MIN/MAX values stated where $T_A = -40^\circ\text{C}$ to $+110^\circ\text{C}$ and $V_{DD} = 3\text{ V}$ to 15 V (unless otherwise noted).

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---------------------------------|-----|-----|-----|------|
| $t_{\text{DELAY_CTM}}$ Fault Detection Delay Time in Test Mode | Fixed Delay (Internal settings) | | 15 | | ms |

(1) Specified by design. It is not 100% tested in production.

7.6 Typical Characteristics



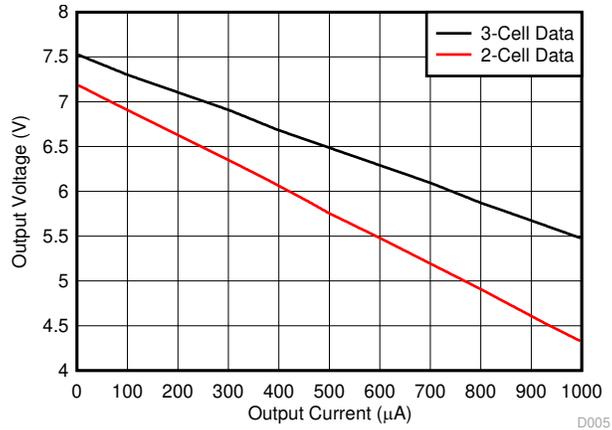


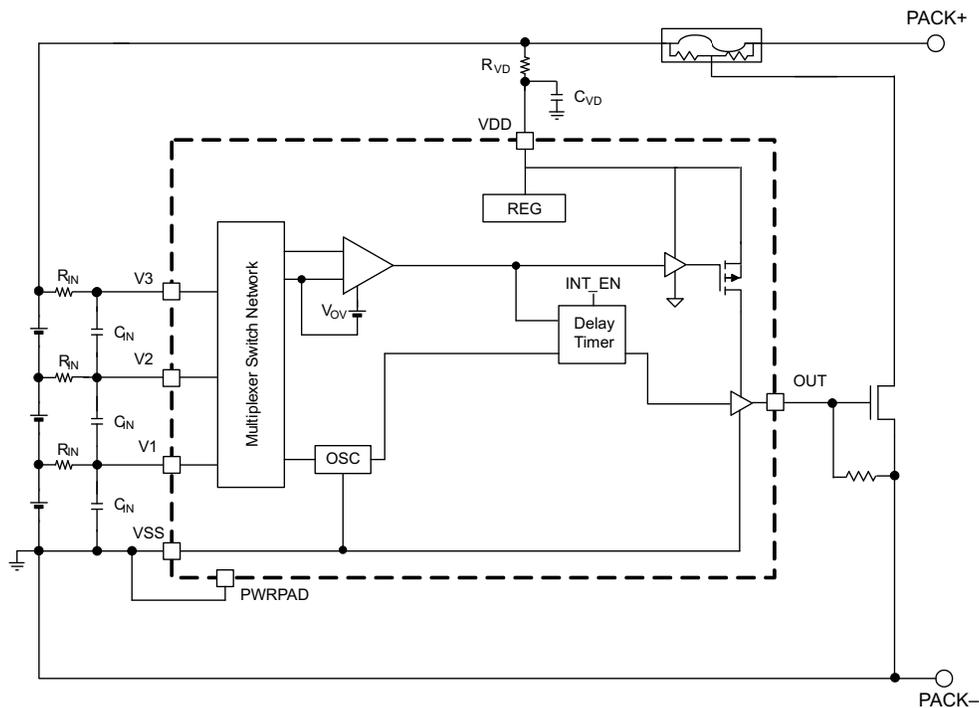
Figure 7-5. Output Voltage vs Output Current

8 Detailed Description

8.1 Overview

The BQ2945xy is a second-level overvoltage (OV) protector. Each cell is monitored independently by comparing the actual cell voltage to a protection voltage threshold, V_{OV} . The protection threshold is preprogrammed at the factory with a range from 3.85 V to 4.65 V.

8.2 Functional Block Diagram



Copyright © 2017, Texas Instruments Incorporated

8.3 Feature Description

The voltage sensing for each cell is done independently using a multiplexer. The method of overvoltage detection is comparing the voltage to an overvoltage protection voltage V_{OV} . Once the voltage exceeds the programmed fixed value, the delay timer circuit is activated. This delay (t_{DELAY}) is fixed for either a 4-s or 6.5-s delay. When these conditions are satisfied, the OUT terminal is transitioned to a high level. This output (OUT) is released to a low condition if *all* of the cell inputs (V_x) are below the OVP threshold minus the V_{hys} .

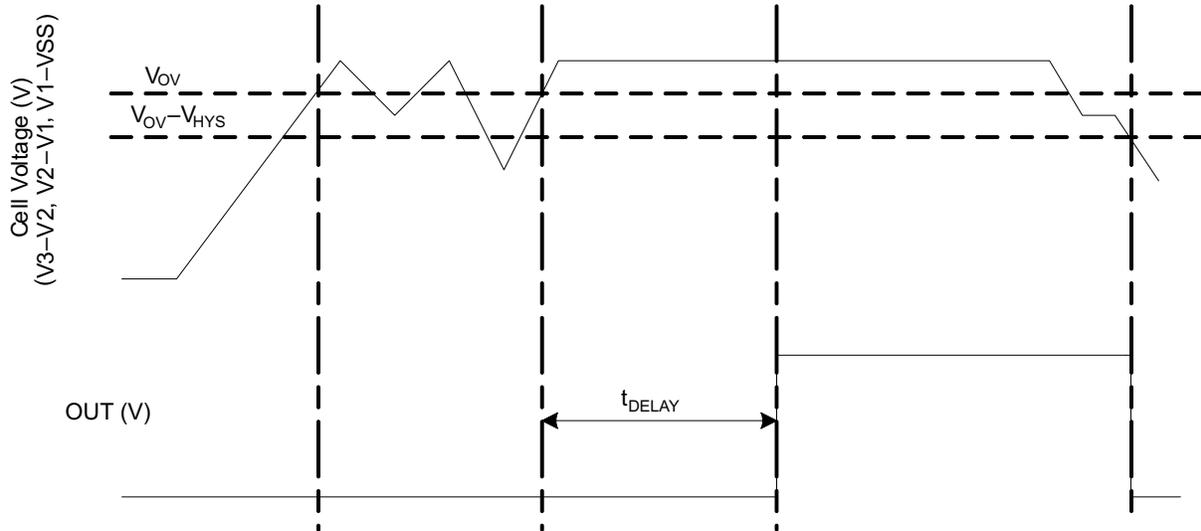


Figure 8-1. Timing for Overvoltage Sensing

8.3.1 Sense Positive Input for VX

This is an input to sense each single battery cell voltage. A series resistor and a capacitor across the cell for each input is required for noise filtering and stable voltage monitoring.

8.3.2 Output Drive, OUT

The gate of an external N-channel MOSFET is connected to this terminal. This output transitions to a high level when an overvoltage condition is detected and after the programmed delay timer. OUT resets to a low level if the cell voltage falls below the V_{OV} threshold before the fixed delay timer expires.

8.3.3 Supply Input, VDD

This terminal is the unregulated input power source for the IC. A series resistor is connected to limit the current, and a capacitor is connected to ground for noise filtering.

8.3.4 Thermal Pad, PWRPAD

For correct operation, the power pad (PWRPAD) is connected to the V_{SS} terminal on the PCB.

8.4 Device Functional Modes

8.4.1 NORMAL Mode

When all of the cell voltages are below the overvoltage threshold, V_{OV} , the device operates in NORMAL mode. The device monitors the differential cell voltages connected across ($V1-VSS$), ($V2-V1$) and ($V3-V2$). The OUT pin is inactive in this mode.

8.4.2 OVERVOLTAGE Mode

OVERVOLTAGE mode is detected if any of the cell voltages exceeds the overvoltage threshold, V_{OV} for the configured OV delay time, t_{DELAY} . The OUT pin pulls high internally. An external FET then turns on, shorting the fuse to ground, which enables the battery or charger power to blow the fuse. When all of the cell voltages fall below ($V_{OV}-V_{HYS}$), the device returns to NORMAL mode.

8.4.3 Customer Test Mode

Customer Test Mode (CTM) helps to reduce test time for checking the overvoltage delay timer parameter once the circuit is implemented in the battery pack. To enter CTM, set VDD to at least 10 V higher than V3 (see Figure 8-2). The delay timer is greater than 10 ms, but considerably shorter than the timer delay in normal operation. To exit CTM, remove the VDD to VC3 voltage differential of 10 V so that the decrease in this value automatically causes an exit.

CAUTION

Avoid exceeding any Absolute Maximum Voltages on any pins when placing the part into CTM. Also avoid exceeding Absolute Maximum Voltages for the individual cell voltages (V3–V2), (V2–V1), and (V1–VSS). Stressing the pins beyond the rated limits may cause permanent damage to the device.

Figure 8-2 shows the timing for CTM.

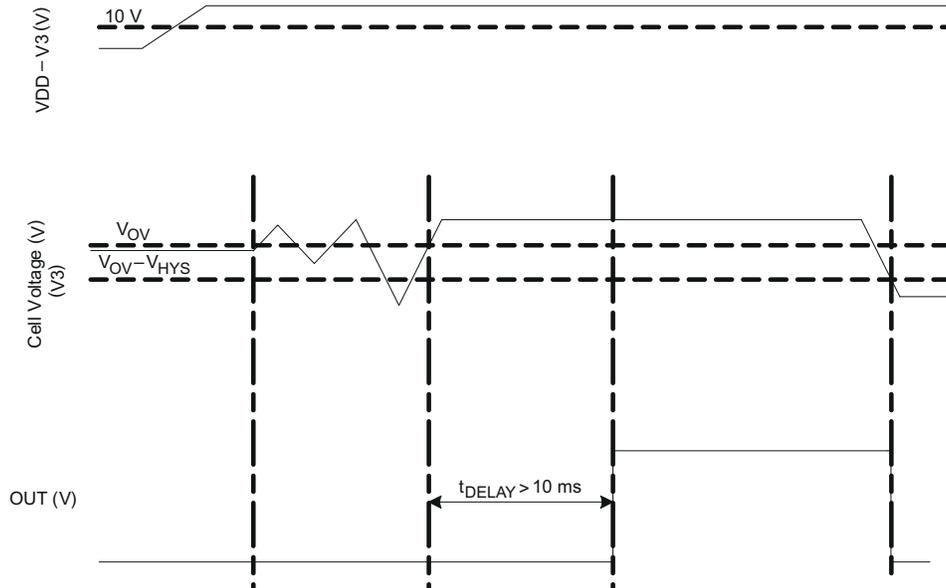


Figure 8-2. Timing for Customer Test Mode

Figure 8-3 shows the measurement for current consumption for the product for both VDD and Vx.

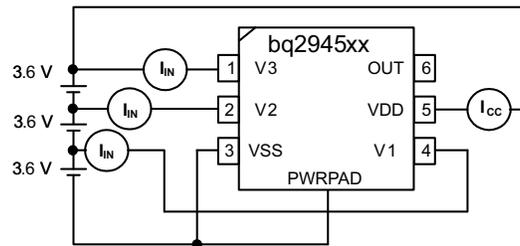


Figure 8-3. Configuration for IC Current Consumption Test

9 Application and Implementation

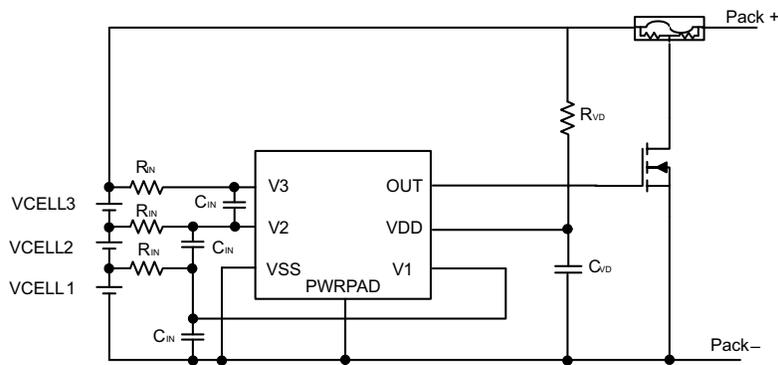
Note

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.

9.1 Application Information

The BQ2945xy devices are second-level protectors used for overvoltage protection for the battery pack in the application. The device, when configuring the OUT pin with active high, drives an NMOS FET that connects the fuse to ground in the event of a fault condition. This provides a shorted path to use the battery or charger power to blow the fuse and cut the power path.

9.2 Typical Application



Copyright © 2017, Texas Instruments Incorporated

Figure 9-1. Application Configuration Schematic

9.2.1 Design Requirements

Changes to the ranges stated in [Table 9-1](#) impact the accuracy of the cell measurements. [Figure 9-1](#) shows each external component.

Table 9-1. Parameters

| PARAMETER | EXTERNAL COMPONENT | MIN | TYP | MAX | UNIT |
|------------------------------------|--------------------|-----|------|------|------|
| Voltage monitor filter resistance | RIN | 100 | 1000 | 4700 | Ω |
| Voltage monitor filter capacitance | CIN | 0.1 | | 1 | μF |
| Supply voltage filter resistance | RVD | 100 | | 1K | Ω |
| Supply voltage filter capacitance | CVD | | 0.1 | | μF |

9.2.2 Detailed Design Procedure

1. Determine the overvoltage threshold and delay time. Select the proper device from the table in [Section 5](#) or contact TI for a different configuration.
2. Determine the number of cell in series. The device supports 2-series to 3-series cell configurations. For a 2-series configuration, the V3 pin is shorted to V2.
3. To connect to the device, follow the application configuration schematic (see [Figure 9-1](#)).

9.2.3 Application Curves

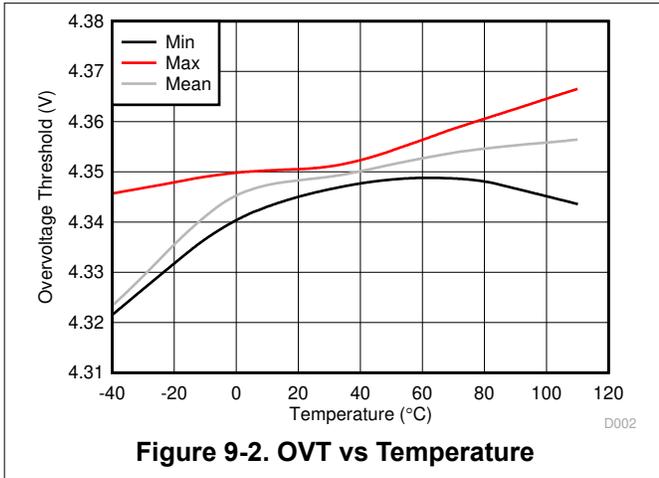


Figure 9-2. OVT vs Temperature

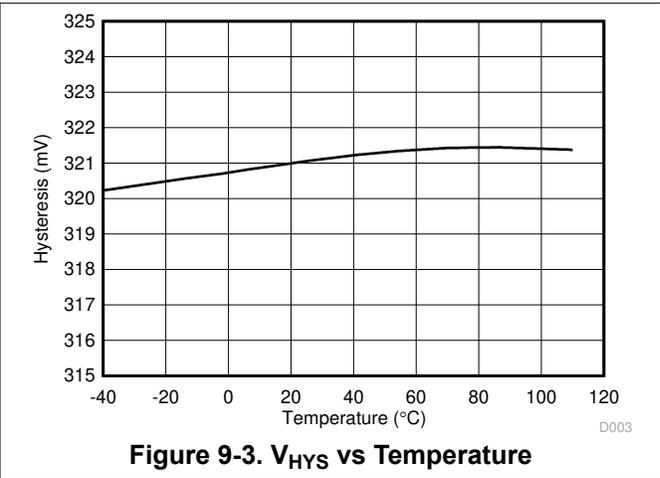


Figure 9-3. V_{HYS} vs Temperature

9.3 System Examples

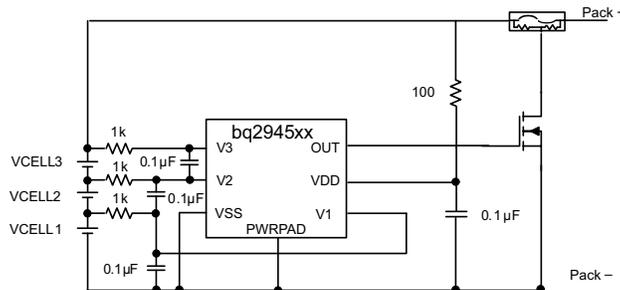


Figure 9-4. 3-Series Cell Configuration with Fixed Delay

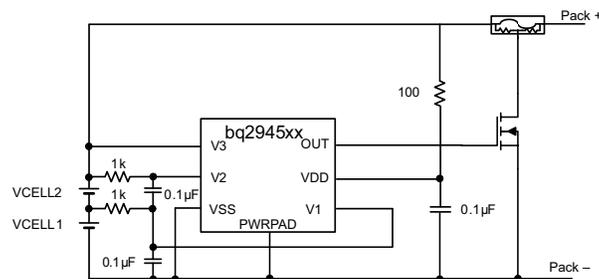


Figure 9-5. 2-Series Cell Configuration with Internal Fixed Delay

10 Power Supply Recommendations

The maximum power of this device is 25 V on VDD.

11 Layout

11.1 Layout Guidelines

- Ensure the RC filters for the V1 and VDD pins are placed as close as possible to the target terminal, reducing the tracing loop area.
- Route the VSS pin to the CELL– terminal.
- Ensure the trace connecting the fuse to the gate, source of the NFET to the Pack– is sufficient to withstand the current during a fuse blown event.

11.2 Layout Example

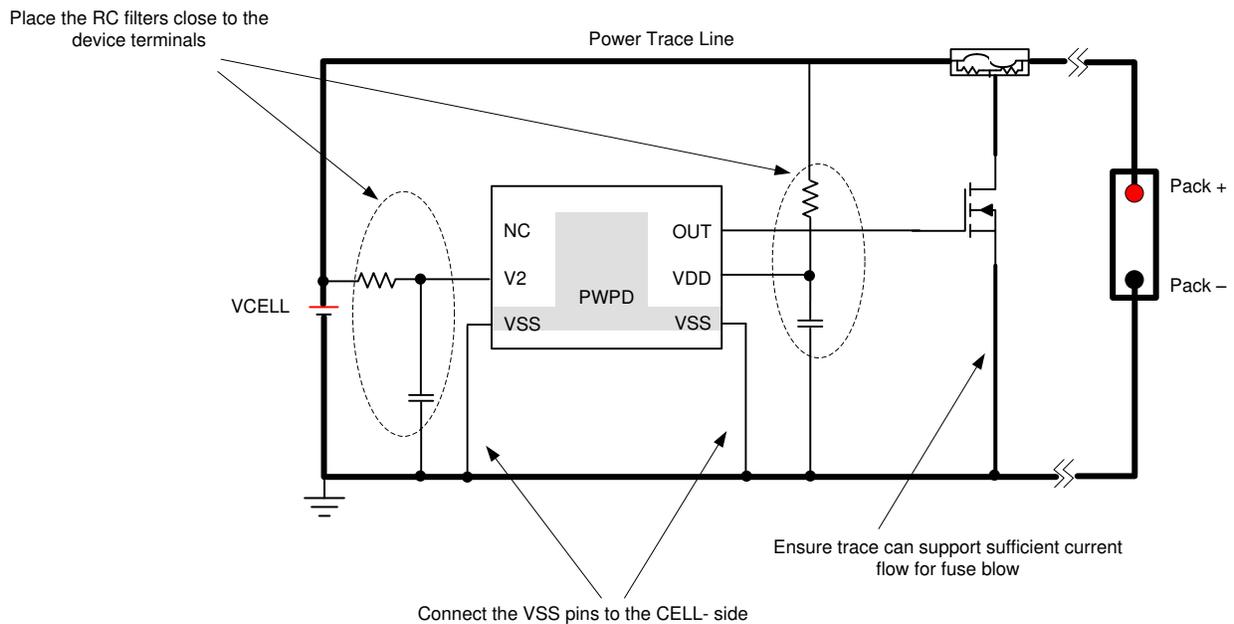


Figure 11-1. Layout Schematic

12 Device and Documentation Support

12.1 Device Support

12.1.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

12.2 Related Documentation

- [Semiconductor and IC Package Thermal Metrics Application Report](#)

12.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](#). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

12.4 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is 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](#).

12.5 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

12.6 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

12.7 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

13 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.

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) |
|------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| BQ294502DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4502 |
| BQ294502DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4502 |
| BQ294502DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4502 |
| BQ294502DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4502 |
| BQ294504DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4504 |
| BQ294504DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4504 |
| BQ294504DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4504 |
| BQ294504DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4504 |
| BQ294506DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4506 |
| BQ294506DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4506 |
| BQ294506DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4506 |
| BQ294506DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4506 |
| BQ294512DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 85 | 4512 |
| BQ294512DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 85 | 4512 |
| BQ294512DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4512 |
| BQ294512DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4512 |
| BQ294522DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 85 | 4522 |
| BQ294522DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 85 | 4522 |
| BQ294522DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4522 |
| BQ294522DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4522 |
| BQ294524DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4524 |
| BQ294524DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4524 |
| BQ294524DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4524 |
| BQ294524DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4524 |
| BQ294532DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | Call TI Nipdau | Level-1-260C-UNLIM | -40 to 85 | 4532 |
| BQ294532DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | Call TI | Level-1-260C-UNLIM | -40 to 85 | 4532 |
| BQ294532DRVRG4 | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4532 |
| BQ294532DRVRG4.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4532 |
| BQ294532DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4532 |

| 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) |
|------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| BQ294532DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4532 |
| BQ294533DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | 4533 |
| BQ294533DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | 4533 |
| BQ294533DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | 4533 |
| BQ294533DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 85 | 4533 |
| BQ294534DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 110 | 4534 |
| BQ294534DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 110 | 4534 |
| BQ294582DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4582 |
| BQ294582DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4582 |
| BQ294582DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4582 |
| BQ294582DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4582 |
| BQ294592DRVR | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4592 |
| BQ294592DRVR.A | Active | Production | WSON (DRV) 6 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4592 |
| BQ294592DRVT | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | 4592 |
| BQ294592DRVT.A | Active | Production | WSON (DRV) 6 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 4592 |

(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.

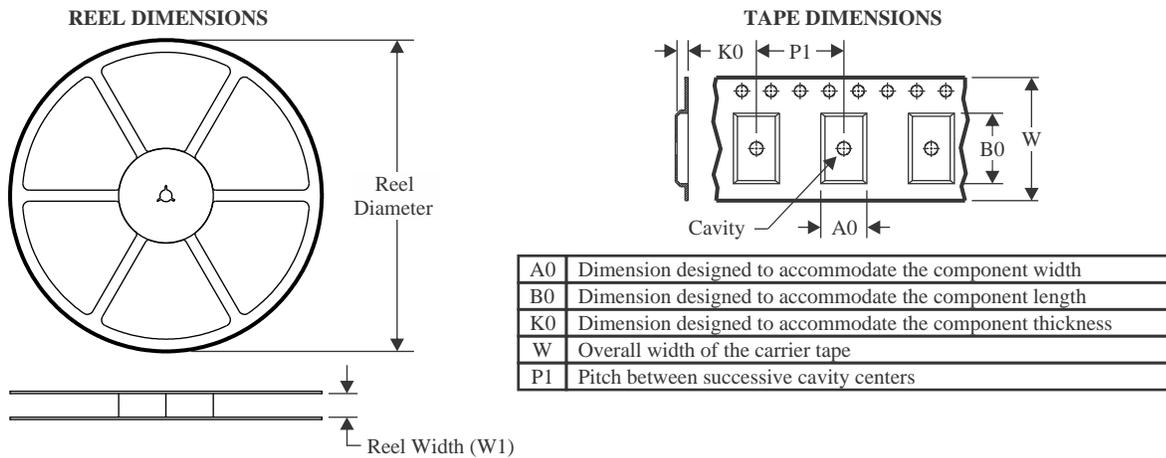
(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| BQ294502DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294502DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294502DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294504DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294504DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294504DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294504DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294506DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294506DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294506DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294512DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294512DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294522DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294522DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294524DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294524DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |

| 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 |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| BQ294524DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294532DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294532DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294532DRVRG4 | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294532DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294532DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294533DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294533DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294534DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294582DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294582DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294582DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294582DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294592DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294592DRVR | WSON | DRV | 6 | 3000 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294592DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |
| BQ294592DRVT | WSON | DRV | 6 | 250 | 180.0 | 8.4 | 2.3 | 2.3 | 1.15 | 4.0 | 8.0 | Q2 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| BQ294502DRVR | WSO | DRV | 6 | 3000 | 182.0 | 182.0 | 20.0 |
| BQ294502DRVT | WSO | DRV | 6 | 250 | 182.0 | 182.0 | 20.0 |
| BQ294502DRVT | WSO | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294504DRVR | WSO | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294504DRVR | WSO | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294504DRVT | WSO | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294504DRVT | WSO | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294506DRVR | WSO | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294506DRVR | WSO | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294506DRVT | WSO | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294512DRVR | WSO | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294512DRVT | WSO | DRV | 6 | 250 | 182.0 | 182.0 | 20.0 |
| BQ294522DRVR | WSO | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294522DRVT | WSO | DRV | 6 | 250 | 182.0 | 182.0 | 20.0 |
| BQ294524DRVR | WSO | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294524DRVT | WSO | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294524DRVT | WSO | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294532DRVR | WSO | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |

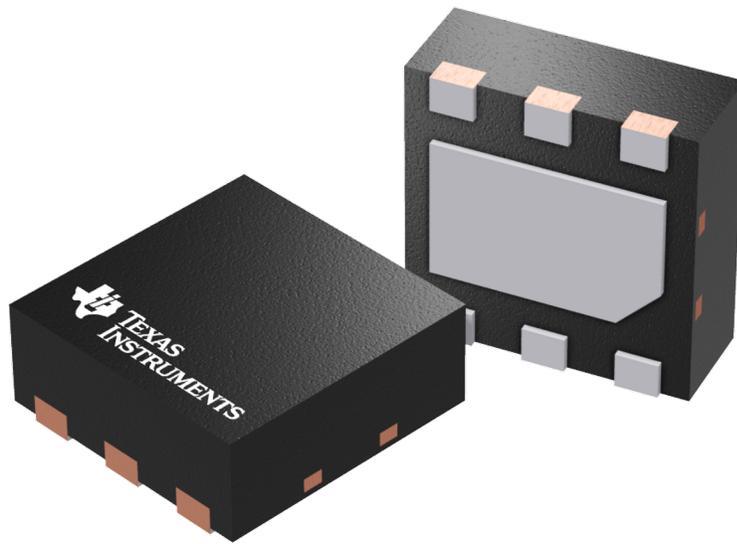
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| BQ294532DRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294532DRVRG4 | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294532DRVT | WSON | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294532DRVT | WSON | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294533DRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294533DRVT | WSON | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294534DRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294582DRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294582DRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294582DRVT | WSON | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294582DRVT | WSON | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294592DRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294592DRVR | WSON | DRV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| BQ294592DRVT | WSON | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| BQ294592DRVT | WSON | DRV | 6 | 250 | 210.0 | 185.0 | 35.0 |

GENERIC PACKAGE VIEW

DRV 6

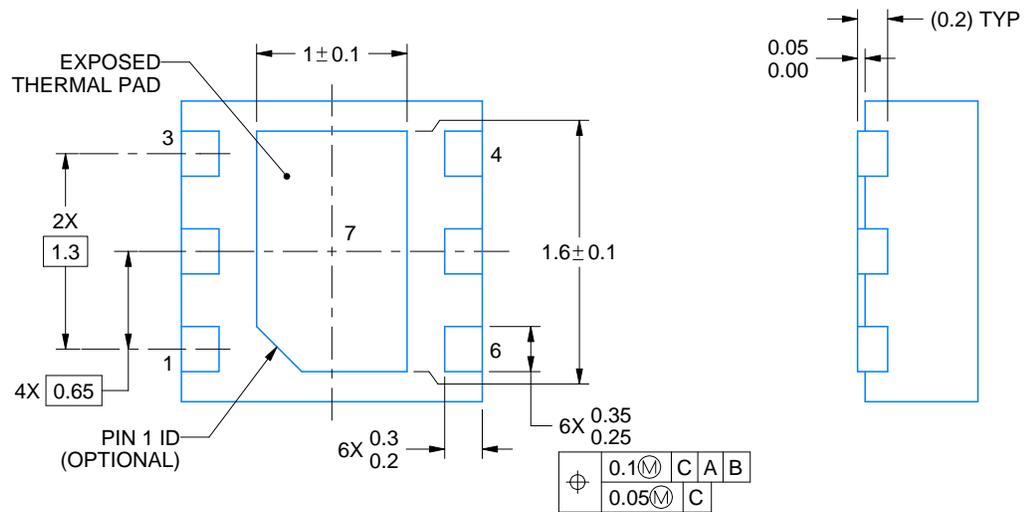
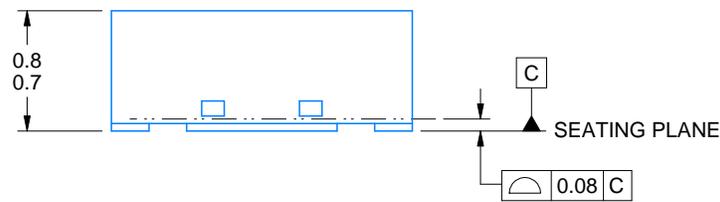
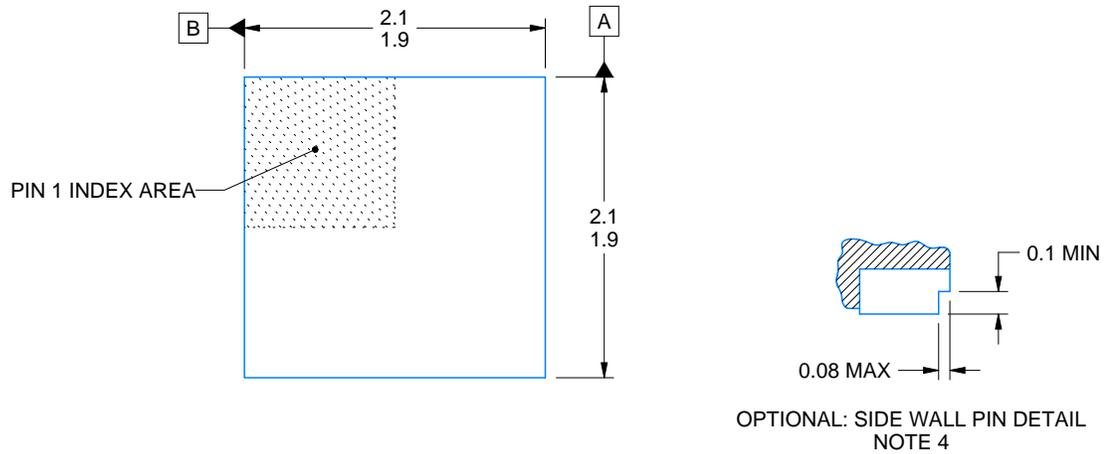
WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4206925/F



4222173/C 11/2025

NOTES:

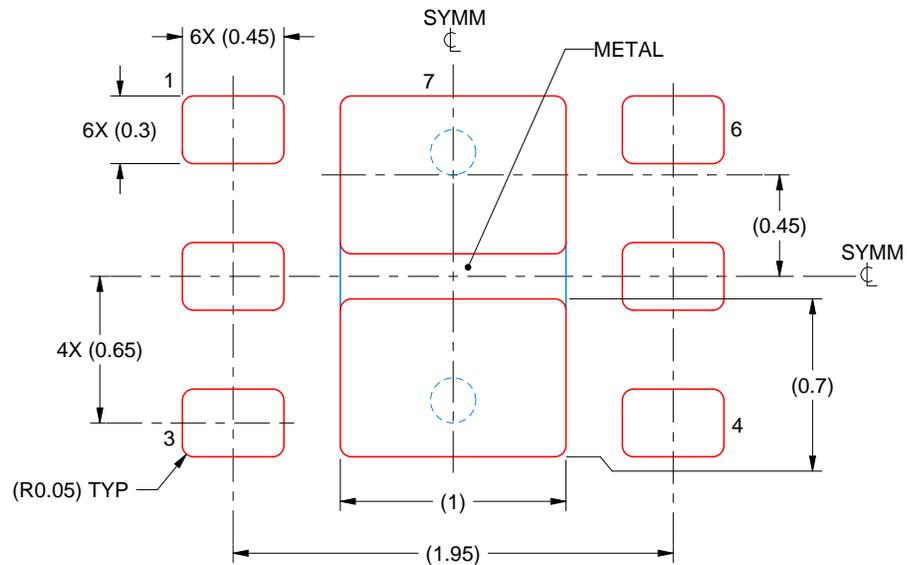
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.
4. Minimum 0.1 mm solder wetting on pin side wall. Available for wettable flank version only.

EXAMPLE STENCIL DESIGN

DRV0006A

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD #7
88% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:30X

4222173/C 11/2025

NOTES: (continued)

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

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025