



# **bq24312 Overvoltage and Overcurrent Protection IC and Li+ Charger Front-End Protection IC**

## **1 Features**

- Provides Protection for Three Variables:
  - Input Overvoltage Protection
  - User-Programmable Overcurrent with Current Limiting
  - Battery Overvoltage
- Maximum Input Voltage of 30 V
- Supports up to 1.5-A Input Current
- Robust Against False Triggering Due to Current Transients
- Thermal Shutdown
- Enable Input
- Status Indication – Fault Condition
- Available in Space-Saving Small 8 Lead 2 × 2 WSON

## **2 Applications**

- Mobile Phones and Smart Phones
- PDAs
- MP3 Players
- Low-Power Handheld Devices
- Bluetooth™ Headsets

## **3 Description**

The bq24312 device is a highly integrated circuit (IC) designed to provide protection to Li-ion batteries from failures of the charging circuit. The device continuously monitors the input voltage, the input current, and the battery voltage. In case of an input overvoltage condition, the device immediately removes power from the charging circuit by turning off an internal switch. In the case of an overcurrent condition, it limits the system current at the threshold value, and if the overcurrent persists, switches the pass element OFF after a blanking period. Additionally, the device also monitors its own die temperature and switches off if it exceeds 140°C. The input overcurrent threshold is user-programmable.

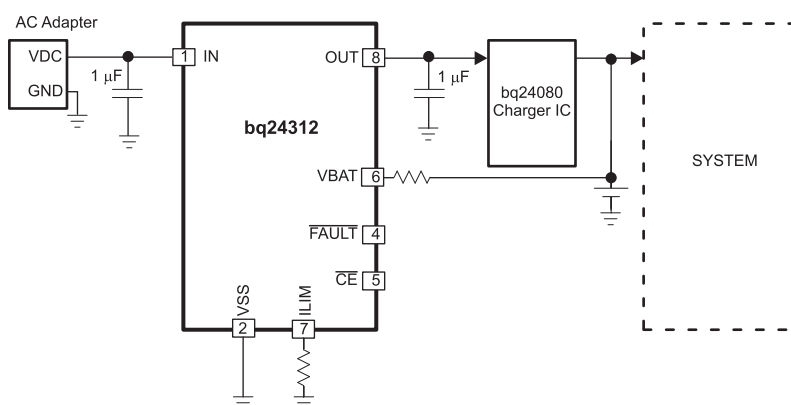
The device can be controlled by a processor and also provides status information about fault conditions to the host.

### **Device Information<sup>(1)</sup>**

| PART NUMBER | PACKAGE  | BODY SIZE (NOM)   |
|-------------|----------|-------------------|
| bq24312     | WSON (8) | 2.00 mm × 2.00 mm |

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

### **Simplified Schematic**



## Table of Contents

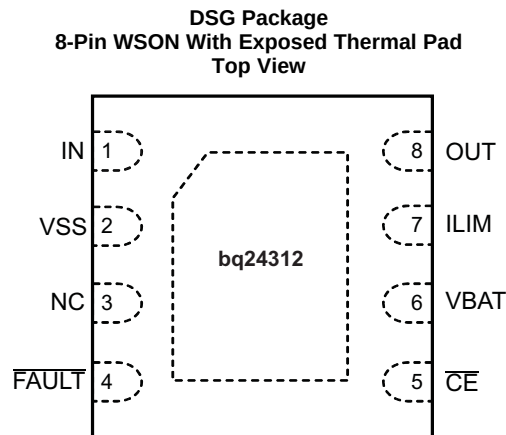
|                                                |          |                                                                  |           |
|------------------------------------------------|----------|------------------------------------------------------------------|-----------|
| <b>1 Features</b> .....                        | <b>1</b> | 7.3 Feature Description.....                                     | <b>9</b>  |
| <b>2 Applications</b> .....                    | <b>1</b> | 7.4 Device Functional Modes.....                                 | <b>10</b> |
| <b>3 Description</b> .....                     | <b>1</b> | <b>8 Application and Implementation</b> .....                    | <b>12</b> |
| <b>4 Revision History</b> .....                | <b>2</b> | 8.1 Application Information.....                                 | <b>12</b> |
| <b>5 Pin Configuration and Functions</b> ..... | <b>3</b> | 8.2 Typical Application .....                                    | <b>13</b> |
| <b>6 Specifications</b> .....                  | <b>4</b> | <b>9 Power Supply Recommendations</b> .....                      | <b>17</b> |
| 6.1 Absolute Maximum Ratings .....             | <b>4</b> | <b>10 Layout</b> .....                                           | <b>17</b> |
| 6.2 ESD Ratings.....                           | <b>4</b> | 10.1 Layout Guidelines .....                                     | <b>17</b> |
| 6.3 Recommended Operating Conditions.....      | <b>4</b> | 10.2 Layout Example .....                                        | <b>17</b> |
| 6.4 Thermal Information .....                  | <b>4</b> | <b>11 Device and Documentation Support</b> .....                 | <b>18</b> |
| 6.5 Electrical Characteristics.....            | <b>5</b> | 11.1 Community Resources.....                                    | <b>18</b> |
| 6.6 Typical Characteristics .....              | <b>6</b> | 11.2 Trademarks .....                                            | <b>18</b> |
| <b>7 Detailed Description</b> .....            | <b>8</b> | 11.3 Electrostatic Discharge Caution.....                        | <b>18</b> |
| 7.1 Overview .....                             | <b>8</b> | 11.4 Glossary .....                                              | <b>18</b> |
| 7.2 Functional Block Diagram .....             | <b>8</b> | <b>12 Mechanical, Packaging, and Orderable Information</b> ..... | <b>18</b> |

## 4 Revision History

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

| Changes from Original (August 2009) to Revision A                                                                                                                                                                                                                                                                                                    | Page      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| • Added <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section ..... | <b>1</b>  |
| • Changed SON to WSON throughout document.....                                                                                                                                                                                                                                                                                                       | <b>1</b>  |
| • Changed $R_{ILIM}$ from 25k to 24.9k throughout document.....                                                                                                                                                                                                                                                                                      | <b>5</b>  |
| • Moved Figures 1 through 10 from <i>Typical Characteristics</i> to <i>Application Curves</i> section .....                                                                                                                                                                                                                                          | <b>15</b> |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN                       |     | I/O | DESCRIPTION                                                                                                                                                                                                                                                                                                                                 |
|---------------------------|-----|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME                      | NO. |     |                                                                                                                                                                                                                                                                                                                                             |
| $\overline{\text{CE}}$    | 5   | I   | Chip enable input. Active low. When $\overline{\text{CE}}$ = High, the input FET is off. Internally pulled down.                                                                                                                                                                                                                            |
| $\overline{\text{FAULT}}$ | 4   | O   | Open-drain output, device status. $\overline{\text{FAULT}}$ = Low indicates that the input FET Q1 has been turned off due to input overvoltage, input overcurrent, battery overvoltage, or thermal shutdown.                                                                                                                                |
| ILIM                      | 7   | I/O | Input overcurrent threshold programming. Connect a resistor to VSS to set the overcurrent threshold.                                                                                                                                                                                                                                        |
| IN                        | 1   | I   | Input power, connect to external DC supply. Connect external 1 $\mu\text{F}$ ceramic capacitor (minimum) to VSS.                                                                                                                                                                                                                            |
| NC                        | 3   |     | These pins may have internal circuits used for test purposes. Do not make any external connections at these pins for normal operation.                                                                                                                                                                                                      |
| OUT                       | 8   | O   | Output terminal to the charging system. Connect external 1 $\mu\text{F}$ ceramic capacitor (minimum) to VSS.                                                                                                                                                                                                                                |
| VBAT                      | 6   | I   | Battery voltage sense input. Connect to pack positive terminal through a resistor.                                                                                                                                                                                                                                                          |
| VSS                       | 2   | —   | Ground terminal                                                                                                                                                                                                                                                                                                                             |
| Thermal PAD               | —   | —   | There is an internal electrical connection between the exposed thermal pad and the VSS pin of the device. The thermal pad must be connected to the same potential as the VSS pin on the printed circuit board. Do not use the thermal pad as the primary ground input for the device. The VSS pin must be connected to ground at all times. |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                  |                      |                                                                                       | MIN                 | MAX | UNIT |
|------------------|----------------------|---------------------------------------------------------------------------------------|---------------------|-----|------|
| V <sub>I</sub>   | Input voltage        | IN (with respect to VSS)                                                              | −0.3                | 30  | V    |
|                  |                      | OUT (with respect to VSS)                                                             | −0.3                | 12  |      |
|                  |                      | ILIM, $\overline{\text{FAULT}}$ , $\overline{\text{CE}}$ , VBAT (with respect to VSS) | −0.3                | 7   |      |
| I <sub>I</sub>   | Input current        | IN                                                                                    | −1.8 <sup>(2)</sup> | 2   | A    |
| I <sub>O</sub>   | Output current       | OUT                                                                                   |                     | 2   | A    |
|                  | Output sink current  | $\overline{\text{FAULT}}$                                                             |                     | 15  | mA   |
| T <sub>J</sub>   | Junction temperature |                                                                                       | −40                 | 150 | °C   |
| T <sub>stg</sub> | Storage temperature  |                                                                                       | −65                 | 150 | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Negative current is specified for a maximum of 50 hours at T<sub>J</sub> = 175°C.

### 6.2 ESD Ratings

|                    |                         |                                                                                |               | VALUE  | UNIT |
|--------------------|-------------------------|--------------------------------------------------------------------------------|---------------|--------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              |               | ±2000  | V    |
|                    |                         | Charged device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> |               | ±500   |      |
|                    |                         | IN(IEC 61000-4-2) <sup>(3)</sup>                                               | Air Discharge | ±15000 |      |
|                    |                         |                                                                                | Contact       | ±8000  |      |

- (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.
- (3) With IN bypassed to the VSS with a 1-μF low-ESR ceramic capacitor

### 6.3 Recommended Operating Conditions

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

|                   |                          | MIN | NOM | MAX | UNIT |
|-------------------|--------------------------|-----|-----|-----|------|
| V <sub>IN</sub>   | Input voltage range      | 3   |     | 30  | V    |
| I <sub>IN</sub>   | Input current, IN pin    |     |     | 1.5 | A    |
| I <sub>OUT</sub>  | Output current, OUT pin  |     |     | 1.5 | A    |
| R <sub>ILIM</sub> | OCF Programming resistor | 15  |     | 90  | kΩ   |
| T <sub>J</sub>    | Junction temperature     | –40 |     | 125 | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | bq24312   | UNIT |
|-------------------------------|----------------------------------------------|-----------|------|
|                               |                                              | DSG (WSN) |      |
|                               |                                              | 8 PINS    |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 64        | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 84.1      | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 33.9      | °C/W |
| ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 1.9       | °C/W |
| ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 34.3      | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | 5.6       | °C/W |

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

## 6.5 Electrical Characteristics

over junction temperature range  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  and recommended supply voltage (unless otherwise noted)

| PARAMETER                                                |                                                       | TEST CONDITIONS                                                                                                                                                 | MIN  | TYP  | MAX  | UNIT               |
|----------------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|--------------------|
| <b>IN</b>                                                |                                                       |                                                                                                                                                                 |      |      |      |                    |
| UVLO                                                     | Undervoltage lock-out, input power detected threshold | $\overline{\text{CE}} = \text{Low}$ , $V_{\text{IN}}$ increasing from 0 V to 3 V                                                                                | 2.6  | 2.7  | 2.8  | V                  |
| $V_{\text{hys}}(\text{UVLO})$                            | Hysteresis on UVLO                                    | $\overline{\text{CE}} = \text{Low}$ , $V_{\text{IN}}$ decreasing from 3 V to 0 V                                                                                | 200  | 260  | 300  | mV                 |
| $T_{\text{DGL}}(\text{PGOOD})$                           | Deglintch time, input power detected status           | $\overline{\text{CE}} = \text{Low}$ . Time measured from $V_{\text{IN}}$ 0 V $\rightarrow$ 5 V 1 $\mu\text{s}$ rise-time, to output turning ON                  |      | 8    |      | ms                 |
| $I_{\text{DD}}$                                          | Operating current                                     | $\overline{\text{CE}} = \text{Low}$ , No load on OUT pin, $V_{\text{IN}} = 5 \text{ V}$ , $R_{\text{ILIM}} = 24.9 \text{ k}\Omega$                              |      | 400  | 600  | $\mu\text{A}$      |
| $I_{\text{STDBY}}$                                       | Standby current                                       | $\overline{\text{CE}} = \text{High}$ , $V_{\text{IN}} = 5 \text{ V}$                                                                                            |      | 65   | 95   | $\mu\text{A}$      |
| <b>INPUT TO OUTPUT CHARACTERISTICS</b>                   |                                                       |                                                                                                                                                                 |      |      |      |                    |
| VDO                                                      | Drop-out voltage IN to OUT                            | $\overline{\text{CE}} = \text{Low}$ , $V_{\text{IN}} = 5 \text{ V}$ , $I_{\text{OUT}} = 1 \text{ A}$                                                            |      | 170  | 280  | mV                 |
| <b>INPUT OVERVOLTAGE PROTECTION</b>                      |                                                       |                                                                                                                                                                 |      |      |      |                    |
| $V_{\text{OVP}}$                                         | Input overvoltage protection threshold                | $\overline{\text{CE}} = \text{Low}$ , $V_{\text{IN}}$ increasing from 5 V to 7.5 V                                                                              | 5.71 | 5.85 | 6.00 | V                  |
| $V_{\text{hys}}(\text{OVP})$                             | Hysteresis on OVP                                     | $\overline{\text{CE}} = \text{Low}$ , $V_{\text{IN}}$ decreasing from 7.5 V to 5 V                                                                              | 20   | 60   | 110  | mV                 |
| $t_{\text{BLANK}}(\text{OVP})$                           | Blanking time on OVP                                  | $\overline{\text{CE}} = \text{Low}$ , Time measured from $V_{\text{IN}}$ 5 V $\rightarrow$ 7.5 V, 1 $\mu\text{s}$ fall-time to output turning OFF               |      | 64   |      | $\mu\text{s}$      |
| $t_{\text{ON}}(\text{OVP})$                              | Recovery time from input overvoltage condition        | $\overline{\text{CE}} = \text{Low}$ , Time measured from $V_{\text{IN}}$ 7.5 V $\rightarrow$ 5 V, 1 $\mu\text{s}$ fall-time                                     |      | 8    |      | ms                 |
| <b>INPUT OVERCURRENT PROTECTION</b>                      |                                                       |                                                                                                                                                                 |      |      |      |                    |
| $I_{\text{OCP}}$                                         | Input overcurrent protection threshold range          |                                                                                                                                                                 | 300  |      | 1500 | mA                 |
| $I_{\text{OCP}}$                                         | Input overcurrent protection threshold                | $\overline{\text{CE}} = \text{Low}$ , $R_{\text{ILIM}} = 24.9 \text{ k}\Omega$ , $3 \text{ V} \leq V_{\text{IN}} < V_{\text{OVP}} - V_{\text{hys}}(\text{OVP})$ | 900  | 1000 | 1100 | mA                 |
| $K_{\text{ILIM}}$                                        | Programmable current limit factor                     |                                                                                                                                                                 |      | 25   |      | Ak $\Omega$        |
| $t_{\text{BLANK}}(\text{OCP})$                           | Blanking time, input overcurrent detected             |                                                                                                                                                                 |      | 176  |      | $\mu\text{s}$      |
| $t_{\text{REC}}(\text{OCP})$                             | Recovery time from input overcurrent condition        |                                                                                                                                                                 |      | 64   |      | ms                 |
| <b>BATTERY OVERVOLTAGE PROTECTION</b>                    |                                                       |                                                                                                                                                                 |      |      |      |                    |
| $BV_{\text{OVP}}$                                        | Battery overvoltage protection threshold              | $\overline{\text{CE}} = \text{Low}$ , $V_{\text{IN}} > 4.4 \text{ V}$                                                                                           | 4.30 | 4.35 | 4.4  | V                  |
| $V_{\text{hys}}(\text{Bovp})$                            | Hysteresis on $BV_{\text{OVP}}$                       | $\overline{\text{CE}} = \text{Low}$ , $V_{\text{IN}} > 4.4 \text{ V}$                                                                                           | 200  | 275  | 320  | mV                 |
| $I_{\text{VBAT}}$                                        | Input bias current on VBAT pin                        | $V_{\text{BAT}} = 4.4 \text{ V}$ , $T_{\text{J}} = 25^{\circ}\text{C}$                                                                                          |      |      | 10   | nA                 |
| $T_{\text{DGL}}(\text{Bovp})$                            | Deglintch time, battery overvoltage detected          | $\overline{\text{CE}} = \text{Low}$ , $V_{\text{IN}} > 4.4 \text{ V}$ . Time measured from $V_{\text{VBAT}}$ rising from 4.1 V to 4.4 V to FAULT going low.     |      | 176  |      | $\mu\text{s}$      |
| <b>THERMAL PROTECTION</b>                                |                                                       |                                                                                                                                                                 |      |      |      |                    |
| $T_{\text{J}}(\text{OFF})$                               | Thermal shutdown temperature                          |                                                                                                                                                                 |      | 140  | 150  | $^{\circ}\text{C}$ |
| $T_{\text{J}}(\text{OFF-HYS})$                           | Thermal shutdown hysteresis                           |                                                                                                                                                                 |      | 20   |      | $^{\circ}\text{C}$ |
| <b>LOGIC LEVELS ON <math>\overline{\text{CE}}</math></b> |                                                       |                                                                                                                                                                 |      |      |      |                    |
| $V_{\text{IL}}$                                          | Low-level input voltage                               |                                                                                                                                                                 | 0    |      | 0.4  | V                  |
| $V_{\text{IH}}$                                          | High-level input voltage                              |                                                                                                                                                                 | 1.4  |      |      | V                  |
| $I_{\text{IL}}$                                          | Low-level input current                               | $V_{\text{CE}} = 0 \text{ V}$                                                                                                                                   |      |      | 1    | $\mu\text{A}$      |
| $I_{\text{IH}}$                                          | High-level input current                              | $V_{\text{CE}} = 1.8 \text{ V}$                                                                                                                                 |      |      | 15   | $\mu\text{A}$      |
| <b>LOGIC LEVELS ON FAULT</b>                             |                                                       |                                                                                                                                                                 |      |      |      |                    |
| $V_{\text{OL}}$                                          | Output low voltage                                    | $I_{\text{SINK}} = 5 \text{ mA}$                                                                                                                                |      |      | 0.2  | V                  |
| $I_{\text{HI-Z}}$                                        | Leakage current, FAULT pin HI-Z                       | $V_{\text{FAULT}} = 5 \text{ V}$                                                                                                                                |      |      | 10   | $\mu\text{A}$      |

## 6.6 Typical Characteristics

Test conditions (unless otherwise noted) for typical operating performance:  $V_{IN} = 5\text{ V}$ ,  $C_{IN} = 1\text{ }\mu\text{F}$ ,  $C_{OUT} = 1\text{ }\mu\text{F}$ ,  $R_{ILIM} = 24.9\text{ k}\Omega$ ,  $R_{BAT} = 100\text{ k}\Omega$ ,  $T_A = 25^\circ\text{C}$ ,  $V_{PU} = 3.3\text{ V}$  (see Figure 12 for the Typical Application Circuit)

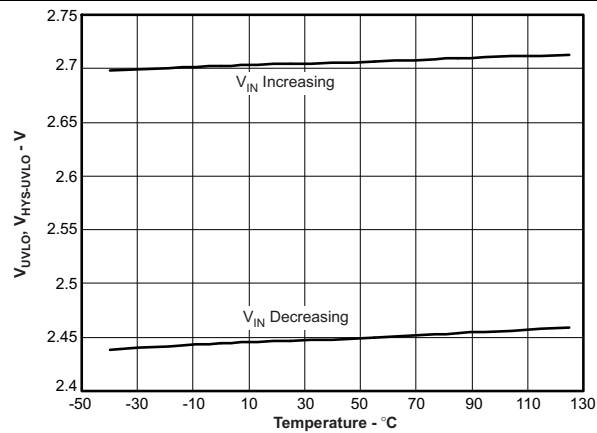


Figure 1. Undervoltage Lockout vs Free-Air Temperature

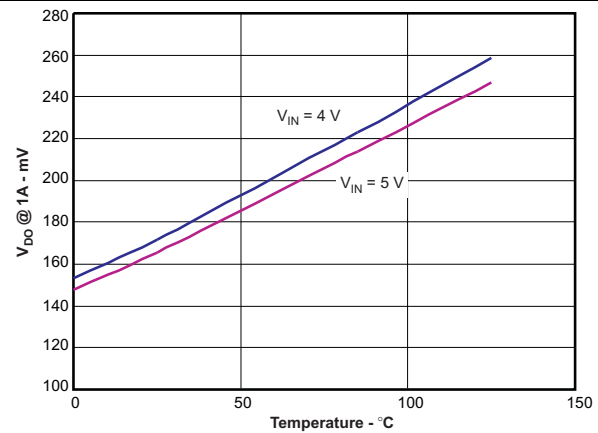


Figure 2. Dropout Voltage (IN to OUT) vs Free-Air Temperature

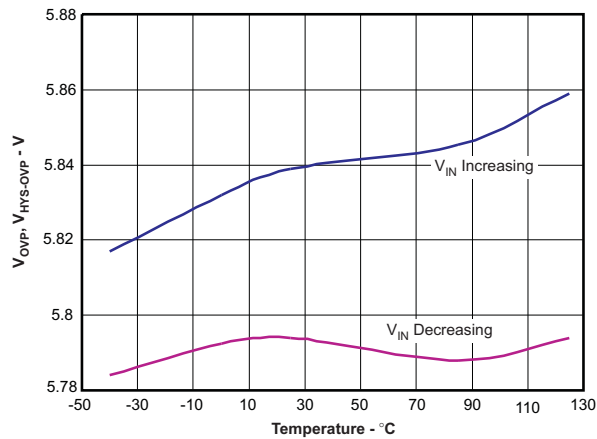


Figure 3. Overvoltage Threshold Protection vs Free-Air Temperature

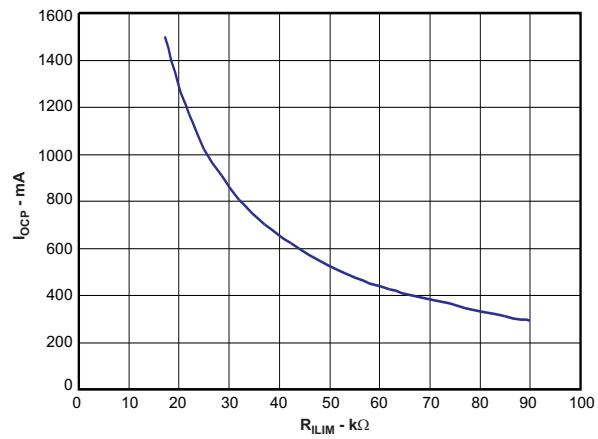


Figure 4. Input Overcurrent Protection vs ILIM Resistance

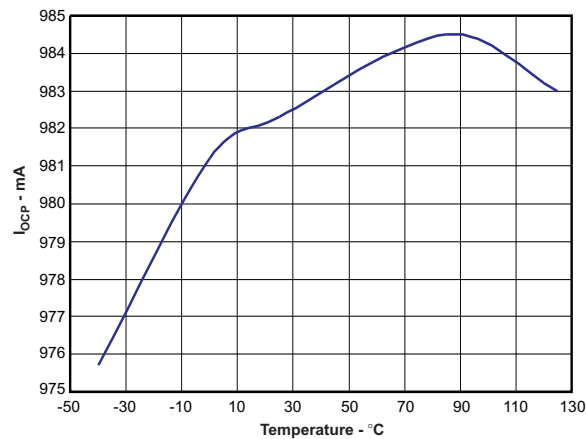


Figure 5. Input Overcurrent Protection vs Free-Air Temperature

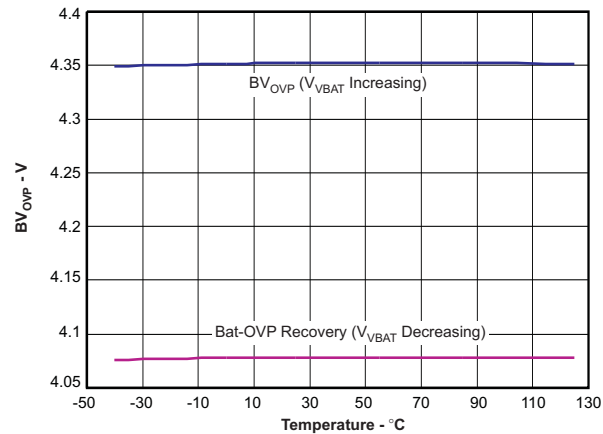
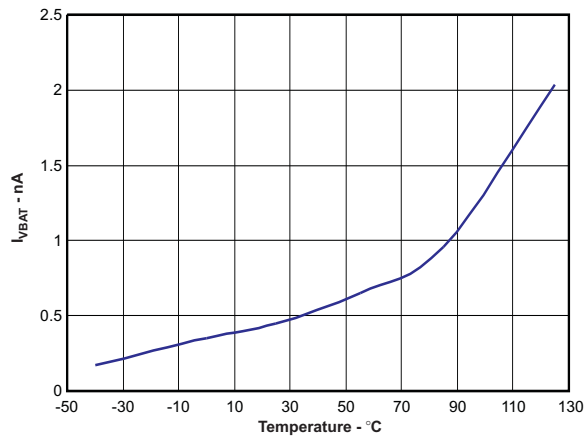


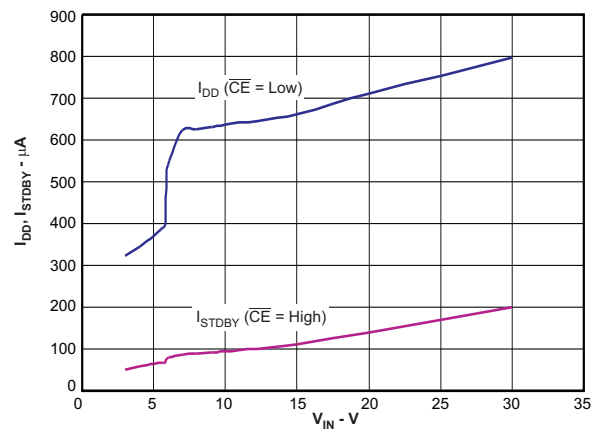
Figure 6. Battery Overvoltage Protection vs Free-Air Temperature

## Typical Characteristics (continued)

Test conditions (unless otherwise noted) for typical operating performance:  $V_{IN} = 5\text{ V}$ ,  $C_{IN} = 1\text{ }\mu\text{F}$ ,  $C_{OUT} = 1\text{ }\mu\text{F}$ ,  $R_{ILIM} = 24.9\text{ k}\Omega$ ,  $R_{BAT} = 100\text{ k}\Omega$ ,  $T_A = 25^\circ\text{C}$ ,  $V_{PU} = 3.3\text{ V}$  (see Figure 12 for the Typical Application Circuit)



**Figure 7. Leakage Current (VBAT Pin) vs Free-Air Temperature**



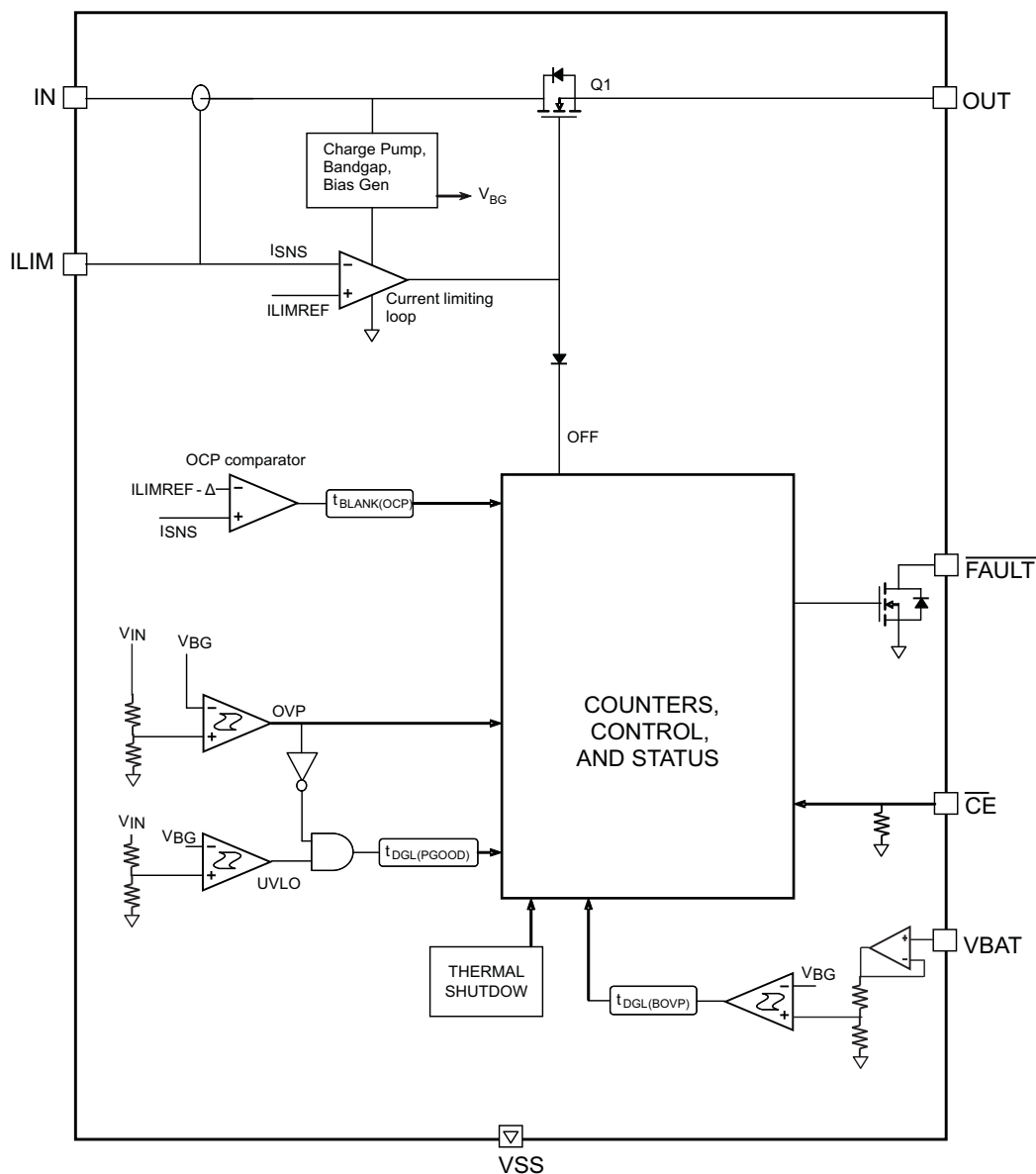
**Figure 8. Supply Current vs INPUT Voltage**

## 7 Detailed Description

### 7.1 Overview

The bq24312 device is a highly integrated circuit designed to provide protection to Li-ion batteries from failures of the charging circuit. The device continuously monitors the input voltage, the input current, and the battery voltage. In case of an input overvoltage condition, the device immediately removes power from the charging circuit by turning off an internal switch. In the case of an overcurrent condition, it limits the system current at the threshold value, and if the overcurrent persists, switches the pass element OFF after a blanking period. If the battery voltage rises to an unsafe level, the device disconnects power from the charging circuit until the battery voltage returns to an acceptable value. Additionally, the device also monitors its own die temperature and switches off if it exceeds 140°C. The input overcurrent threshold is user-programmable. The device can be controlled by a processor and also provides status information about fault conditions to the host.

### 7.2 Functional Block Diagram





## 7.3 Feature Description

### 7.3.1 Input Overvoltage Protection

The bq24312 device integrates an input overvoltage protection feature to protect downstream devices from faulty input sources. As long as the input voltage is less than  $V_{O(REG)}$ , the output voltage tracks the input voltage (less the drop caused by  $R_{DS(ON)}$  of Q1). If the input voltage is greater than  $V_{O(REG)}$  (plus the  $R_{DS(ON)}$  drop) and less than  $V_{OVP}$ , the device acts like a series linear regulator, with the output voltage regulated to  $V_{O(REG)}$ . If the input voltage rises above  $V_{OVP}$ , the output voltage is clamped to  $V_{O(REG)}$  for a blanking duration  $t_{BLANK(OVP)}$ . If the input voltage returns below  $V_{OVP}$  within  $t_{BLANK(OVP)}$ , the device continues normal operation (See Figure 15). This provides protection against turning power off due to transient overvoltage spikes while still protecting the system. However, if the input voltage remains above  $V_{OVP}$  for more than  $t_{BLANK(OVP)}$ , the internal FET is turned off, removing power from the circuit (see Figure 16). When the input voltage comes back to a safe value the device waits for  $t_{ON(OVP)}$ , then switches on Q1 and goes through the soft-start routine (see Figure 17).

### 7.3.2 Input Overcurrent Protection

The overcurrent threshold is programmed by a resistor  $R_{ILIM}$  connected from the ILIM pin to VSS. Figure 4 shows the OCP threshold as a function of  $R_{ILIM}$ , and may be approximated by the following equation:

$$I_{OCP} = 25 \div R_{ILIM} \text{ (current in A, resistance in k}\Omega\text{)},$$

where

- $R_{ILIM}$  must be between 15 k $\Omega$  and 90 k $\Omega$  (1)

If the load current tries to exceed the  $I_{OCP}$  threshold, the device limits the current for a blanking duration of  $t_{BLANK(OCP)}$ . If the load current returns to less than  $I_{OCP}$  before  $t_{BLANK(OCP)}$  times out, the device continues to operate. However, if the overcurrent situation persists for  $t_{BLANK(OCP)}$ , the FET Q1 is turned off for a duration of  $t_{REC(OCP)}$ , and the FAULT pin is driven low. The FET is then turned on again after  $t_{REC(OCP)}$  and the current is monitored all over again. Each time an OCP fault occurs, an internal counter is incremented. If 15 OCP faults occur in one charge cycle, the FET is turned off permanently. The counter is cleared either by removing and re-applying input power, or by disabling and re-enabling the device with the  $\overline{CE}$  pin. Figure 18 to Figure 20 show what happens in an overcurrent fault.

To prevent the input voltage from spiking up due to the inductance of the input cable, Q1 is turned off slowly, resulting in a *soft-stop*, as shown in Figure 20.

### 7.3.3 Battery Overvoltage Protection

The battery overvoltage threshold  $BV_{OVP}$  is internally set to 4.35 V. If the battery voltage exceeds the  $BV_{OVP}$  threshold, the FET Q1 is turned off, and the FAULT pin is driven low. The FET is turned back on once the battery voltage drops to  $BV_{OVP} - V_{hys(Bovp)}$  (see Figure 21 and Figure 22). Each time a battery overvoltage fault occurs, an internal counter is incremented. If 15 such faults occur in one charge cycle, the FET is turned off permanently. The counter is cleared either by removing and re-applying input power, or by disabling and re-enabling the device with the  $\overline{CE}$  pin. In the case of a battery overvoltage fault, Q1 is switched OFF gradually (see Figure 21).

### 7.3.4 Thermal Protection

If the junction temperature of the device exceeds  $T_{J(OFF)}$ , the FET Q1 is turned off, and the FAULT pin is driven low. The FET is turned back on when the junction temperature falls below  $T_{J(OFF)} - T_{J(OFF-HYS)}$ .

### 7.3.5 Enable Function

The device has an enable pin which can be used to enable or disable the device. When the  $\overline{CE}$  pin is driven high, the internal FET is turned off. When the  $\overline{CE}$  pin is low, the FET is turned on if other conditions are safe. The OCP counter and the Bat-OVP counter are both reset when the device is disabled and re-enabled. The  $\overline{CE}$  pin has an internal pulldown resistor and can be left floating. Note that the FAULT pin functionality is also disabled when the  $\overline{CE}$  pin is high.

## Feature Description (continued)

### 7.3.6 Fault Indication

The  $\overline{\text{FAULT}}$  pin is an active-low open-drain output. It is in a high-impedance state when operating conditions are safe, or when the device is disabled by setting  $\overline{\text{CE}}$  high. With  $\overline{\text{CE}}$  low, the  $\overline{\text{FAULT}}$  pin goes low whenever any of these events occurs:

- Input overvoltage
- Input overcurrent
- Battery overvoltage
- IC overtemperature

## 7.4 Device Functional Modes

### 7.4.1 OPERATION Mode

The device continuously monitors the input voltage, the input current, and the battery voltage. As long as the input voltage is less than VOVP, the output voltage tracks the input voltage (less the drop caused by RDSON of Q1). During fault conditions, the internal FET is turned off and the output is isolated from the input source.

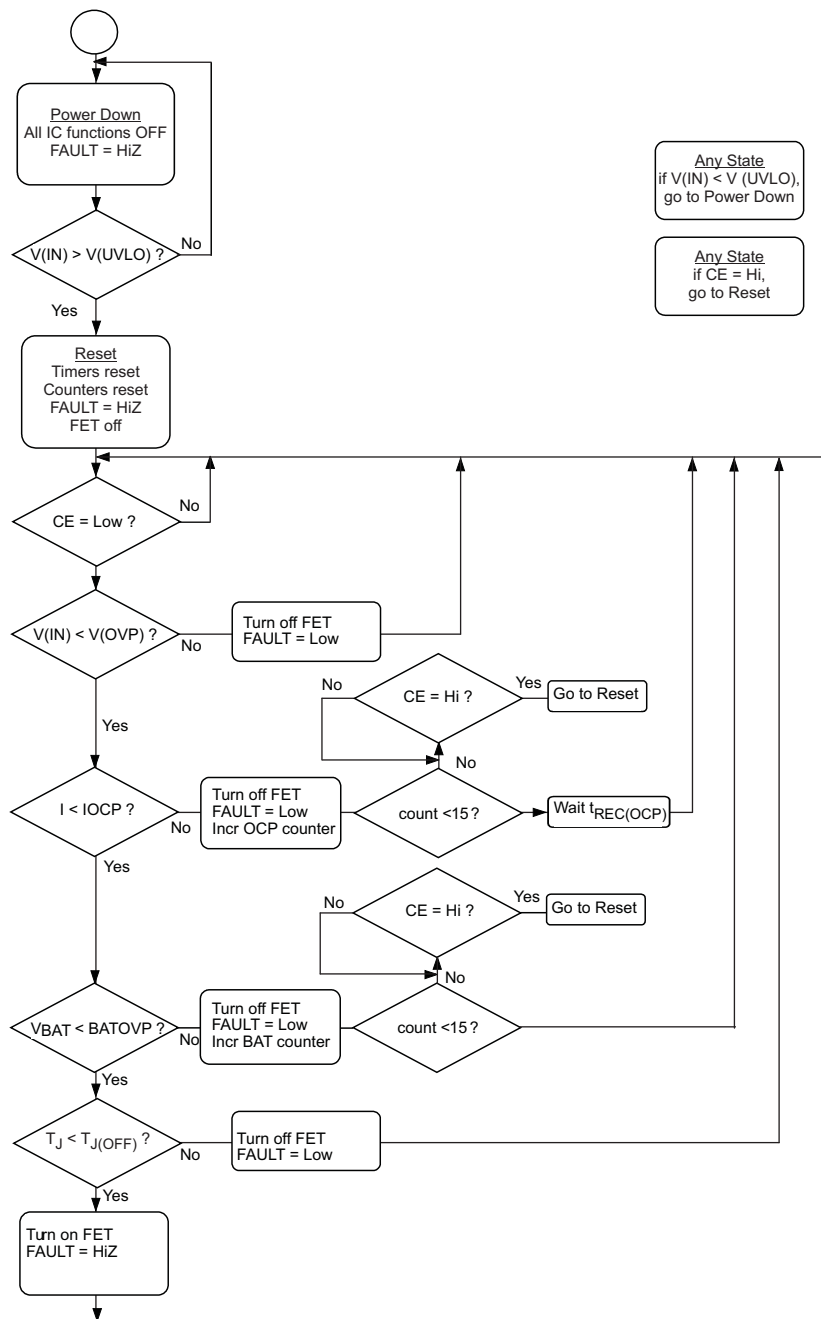
### 7.4.2 POWER-DOWN Mode

The device remains in POWER-DOWN mode when the input voltage at the IN pin is below the undervoltage threshold UVLO. The FET Q1 connected between IN and OUT pins is off, and the status output,  $\overline{\text{FAULT}}$ , is set to Hi-Z. See [Figure 9](#).

### 7.4.3 POWER-ON RESET Mode

The device resets when the input voltage at the IN pin exceeds the UVLO threshold. All internal counters and other circuit blocks are reset. The device then waits for duration  $t_{\text{DGL(PGOOD)}}$  for the input voltage to stabilize. If, after  $t_{\text{DGL(PGOOD)}}$ , the input voltage and battery voltage are safe, FET Q1 is turned ON. The device has a soft-start feature to control the inrush current. The soft-start minimizes the ringing at the input (the ringing occurs because the parasitic inductance of the adapter cable and the input bypass capacitor form a resonant circuit). [Figure 13](#) shows the power-up behavior of the device. Because of the deglitch time at power-on, if the input voltage rises rapidly to beyond the OVP threshold, the device will not switch on at all, instead it will go into PROTECTION mode and indicate a fault on the  $\overline{\text{FAULT}}$  pin, as shown in [Figure 14](#).

## Device Functional Modes (continued)



**Figure 9. Flow Diagram**

## 8 Application and Implementation

### NOTE

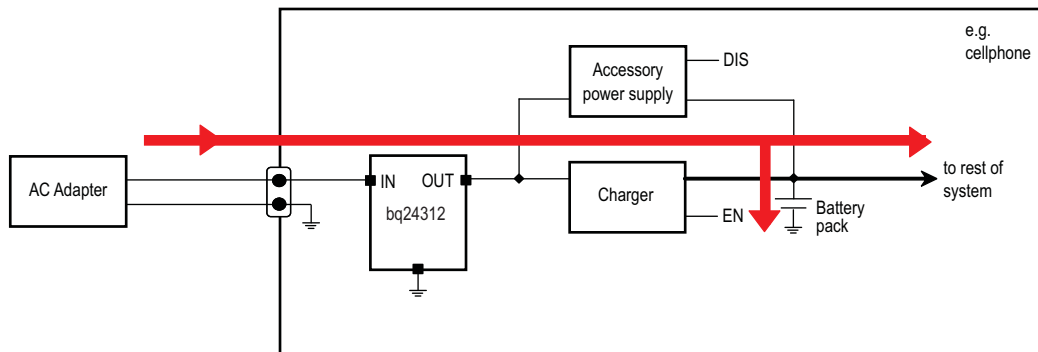
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation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

### 8.1 Application Information

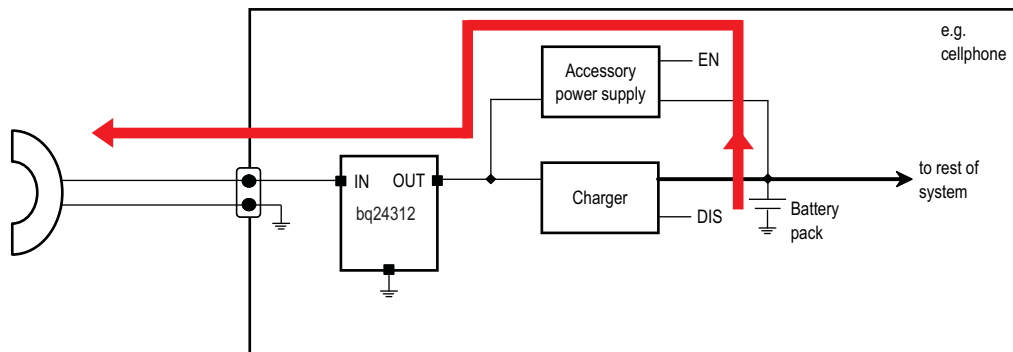
The bq24312 device protects against overvoltage, overcurrent, and battery overvoltage events that occur due to a faulty adapter or other input sources. If any of these faults occur, the bq24312 device isolates the downstream devices from the input source and alerts the host controller with the FAULT open-drain output.

#### 8.1.1 Powering Accessories

In some applications, the equipment that the protection IC resides in may be required to provide power to an accessory (for example, a cellphone may power a headset or an external memory card) through the same connector pins that are used by the adapter for charging. Figure 10 and Figure 11 illustrate typical charging and accessory-powering scenarios:



**Figure 10. Charging - Red Arrows Show Direction of Current Flow**



**Figure 11. Powering an Accessory - Red Arrows Show Direction of Current Flow**

In the second case, when power is being delivered to an accessory, the bq24312 device is required to support current flow from the OUT pin to the IN pin.

If  $V_{OUT} > UVLO + 0.7\text{ V}$ , FET Q1 is turned on, and the reverse current does not flow through the diode but through Q1. Q1 will then remain ON as long as  $V_{OUT} > UVLO - V_{hys}(UVLO) + R_{DS(on)} \times I_{ACCESSORY}$ . Within this voltage range, the reverse current capability is the same as the forward capability, 1.5 A. It should be noted that there is no overcurrent protection in this direction.

## 8.2 Typical Application

The typical values for an application are  $V_{OVP} = 5.85\text{ V}$ ,  $I_{OCP} = 1000\text{ mA}$ ,  $BV_{OVP} = 4.35\text{ V}$  (Terminal numbers shown are for the  $2 \times 2$  DSG package)

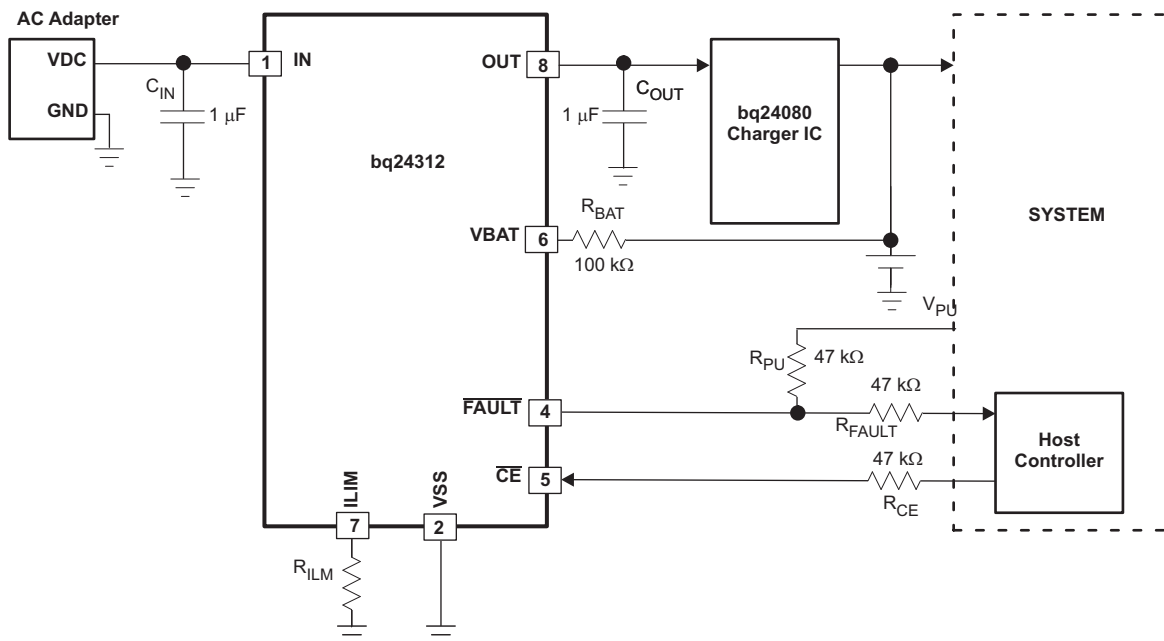


Figure 12. Typical Application Circuit

### 8.2.1 Design Requirements

For this design example, use the parameters listed in [Table 1](#).

Table 1. Design Parameters

| DESIGN PARAMETER | EXAMPLE VALUE |
|------------------|---------------|
| Supply Voltage   | 5 V           |
| INILIM           | 1 A           |

### 8.2.2 Detailed Design Procedure

#### 8.2.2.1 Selection Of $R_{BAT}$

It is strongly recommended that the battery not be tied directly to the VBAT pin of the device, as under some failure modes of the device, the voltage at the IN pin may appear on the VBAT pin. This voltage can be as high as 30 V, and applying 30 V to the battery in case of the failure of the bq24312 device can be hazardous. Connecting the VBAT pin through  $R_{BAT}$  prevents a large current from flowing into the battery in case of a failure of the device. In the interests of safety,  $R_{BAT}$  should have a very high value. The problem with a large  $R_{BAT}$  is that the voltage drop across this resistor because of the VBAT bias current  $I_{VBAT}$  causes an error in the  $BV_{OVP}$  threshold. This error is over and above the tolerance on the nominal 4.35 V  $BV_{OVP}$  threshold.

Choosing  $R_{BAT}$  in the range from 100 kΩ to 470 kΩ is a good compromise. In the case of an device failure, with  $R_{BAT}$  equal to 100 kΩ, the maximum current flowing into the battery would be  $(30\text{ V} - 3\text{ V}) \div 100\text{ k}\Omega = 246\text{ }\mu\text{A}$ , which is low enough to be absorbed by the bias currents of the system components.  $R_{BAT}$  equal to 100 kΩ would result in a worst-case voltage drop of  $R_{BAT} \times I_{VBAT} = 1\text{ mV}$ . This is negligible to compared to the internal tolerance of 50 mV on  $BV_{OVP}$  threshold.

If the Bat-OVP function is not required, the VBAT pin should be connected to VSS.

### 8.2.2.2 Selection Of $R_{CE}$ , $R_{FAULT}$ , And $R_{PU}$

The  $\overline{CE}$  pin can be used to enable and disable the IC. If host control is not required, the  $\overline{CE}$  pin can be tied to ground or left unconnected, permanently enabling the device.

In applications where external control is required, the  $\overline{CE}$  pin can be controlled by a host processor. As in the case of the VBAT pin (see above), the  $\overline{CE}$  pin should be connected to the host GPIO pin through as large a resistor as possible. The limitation on the resistor value is that the minimum  $V_{OH}$  of the host GPIO pin less the drop across the resistor should be greater than  $V_{IH}$  of the bq24312 device's  $\overline{CE}$  pin. The drop across the resistor is given by  $R_{CE} \times I_{IH}$ .

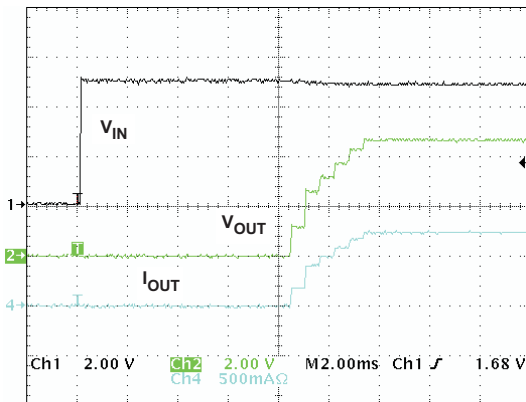
The  $\overline{FAULT}$  pin is an open-drain output that goes low during OV, OC, battery-OV, and OT events. If the application does not require monitoring of the  $\overline{FAULT}$  pin, it can be left unconnected. But if the  $\overline{FAULT}$  pin has to be monitored, it should be pulled high externally through  $R_{PU}$ , and connected to the host through  $R_{FAULT}$ .  $R_{FAULT}$  prevents damage to the host controller if the bq24312 device fails (see above). The resistors should be of high value, in practice values between 22 k $\Omega$  and 100 k $\Omega$  should be sufficient.

### 8.2.2.3 Selection Of Input And Output Bypass Capacitors

The input capacitor  $C_{IN}$  in [Figure 12](#) is for decoupling, and serves an important purpose. Whenever there is a step change downwards in the system load current, the inductance of the input cable causes the input voltage to spike up.  $C_{IN}$  prevents the input voltage from overshooting to dangerous levels. It is strongly recommended that a ceramic capacitor of at least 1  $\mu F$  be used at the input of the device. It should be located in close proximity to the IN pin.

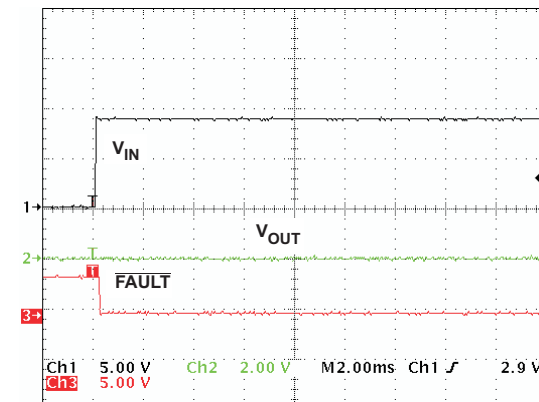
$C_{OUT}$  in [Figure 12](#) is also important: If a very fast (< 1  $\mu s$  rise time) overvoltage transient occurs at the input, the current that charges  $C_{OUT}$  causes the device's current-limiting loop to kick in, reducing the gate-drive to FET Q1. This results in improved performance for input overvoltage protection.  $C_{OUT}$  should also be a ceramic capacitor of at least 1  $\mu F$ , located close to the OUT pin.  $C_{OUT}$  also serves as the input decoupling capacitor for the charging circuit downstream of the protection IC.

## 8.2.3 Application Curves



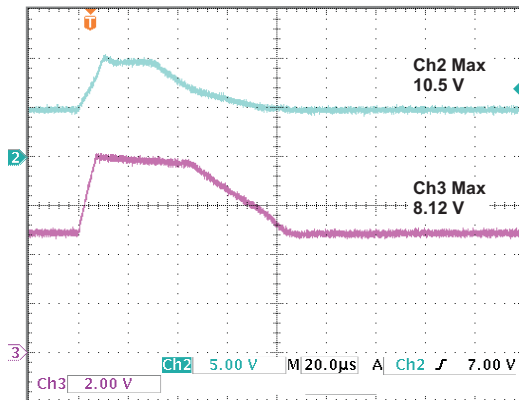
$R_{OUT} = 6.6 \Omega$

Figure 13. Normal Power-On Showing Soft-Start



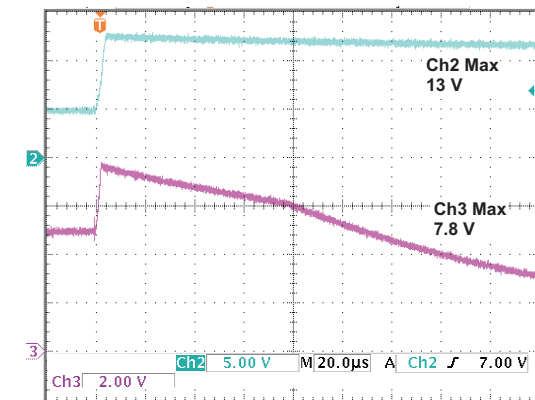
$V_{IN} = 0 \text{ V to } 9 \text{ V}$   
 $t_r = 50 \mu\text{s}$

Figure 14. OVP at Power-On



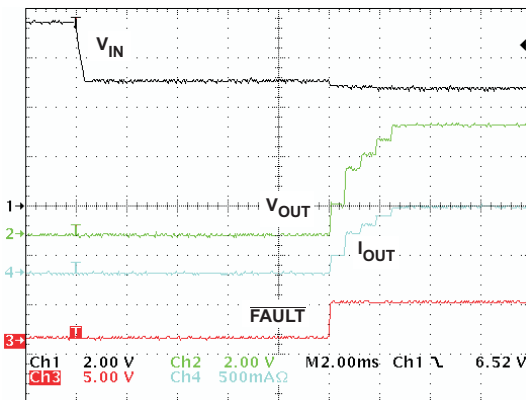
$V_{IN} = 5 \text{ V to } 10 \text{ V back to } 5 \text{ V}$   
 $t_r = 10 \mu\text{s}$

Figure 15. OVP Response for Brief Input Step



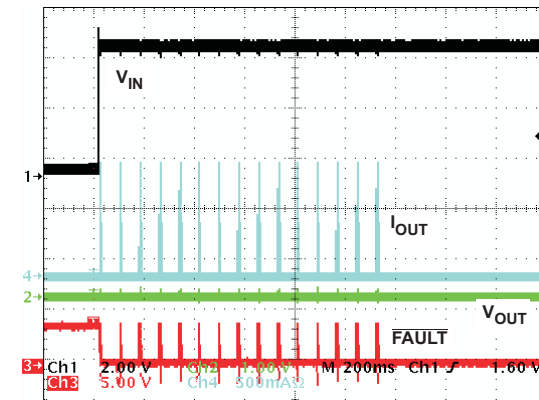
$V_{IN} = 5 \text{ V to } 12 \text{ V}$   
 $t_r = 4 \mu\text{s}$

Figure 16. OVP Response for Extended Input Step



$V_{IN} = 7.5 \text{ V to } 5 \text{ V}$   
 $t_r = 400 \mu\text{s}$

Figure 17. Recovery from OVP



OCP Counter Counts to 15 Before  
Switching OFF Device

Figure 18. Powering Up into a Short Circuit on OUT Pin

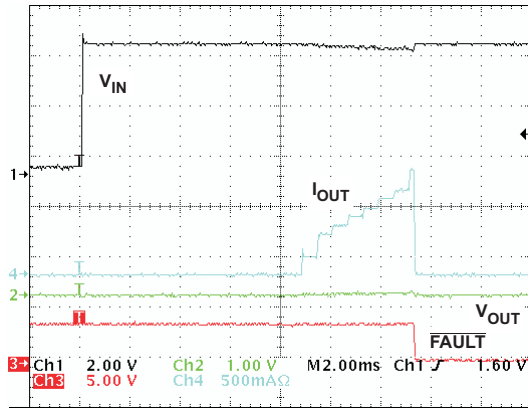


Figure 19. OCP, Zoom-in on the First Cycle of Figure 18

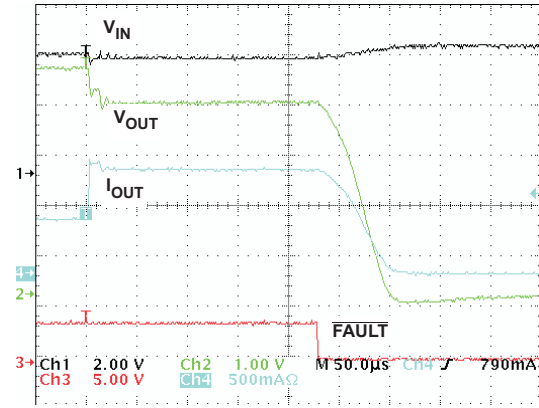

 $R_{OUT}$  Switches from 6.6  $\Omega$  to 3.3  $\Omega$ 

Figure 20. OCP, Current Limiting and Soft-Stop

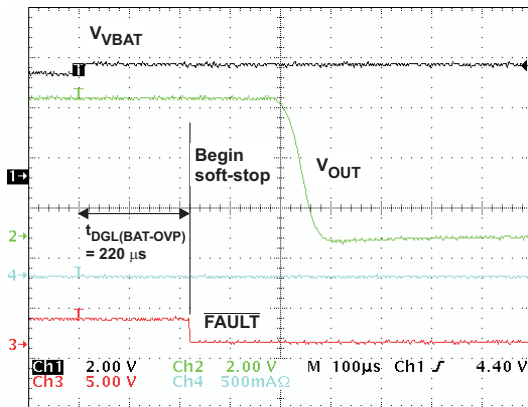

 $V_{BAT}$  Steps from 4.2 V to 4.4 V

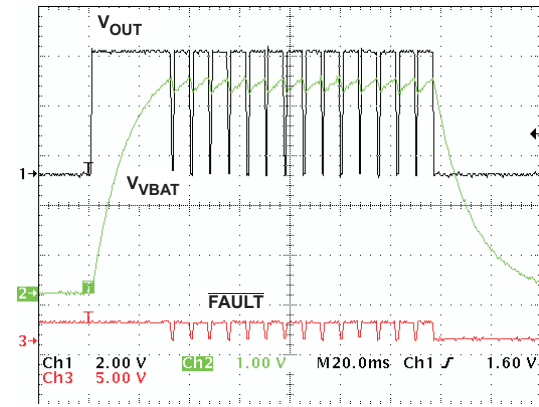
Figure 21. BAT-OVP,  $t_{DGL(BAT-OVP)}$  and Soft-Stop

 $V_{BAT}$  Cycles Between 4.1 V and 4.4 V

Figure 22. BAT-OVP, BAT-OVP Counter



## 9 Power Supply Recommendations

The intention is for the bq24312 device to operate with 5-V adapters with a maximum current rating of 1.5 A. The device operates from sources from 3 V to 5.7 V. Outside of this range, the output is disconnected due to either UVLO or the OVP function.

## 10 Layout

### 10.1 Layout Guidelines

- This device is a protection device, and is meant to protect down-stream circuitry from hazardous voltages. Potentially, high voltages may be applied to this device. It has to be ensured that the edge-to-edge clearances of PCB traces satisfy the design rules for high voltages.
- The device uses WSON packages with a thermal pad. For good thermal performance, the thermal pad must be thermally coupled with the PCB ground plane (GND). This requires a copper pad directly under the device. This copper pad must be connected to the ground plane with an array of thermal vias.
- Ensure that external  $C_{IN}$  and  $C_{OUT}$  are located close to the device. Other external components like  $R_{ILIM}$  and  $R_{BAT}$  must also be located close to the device

### 10.2 Layout Example

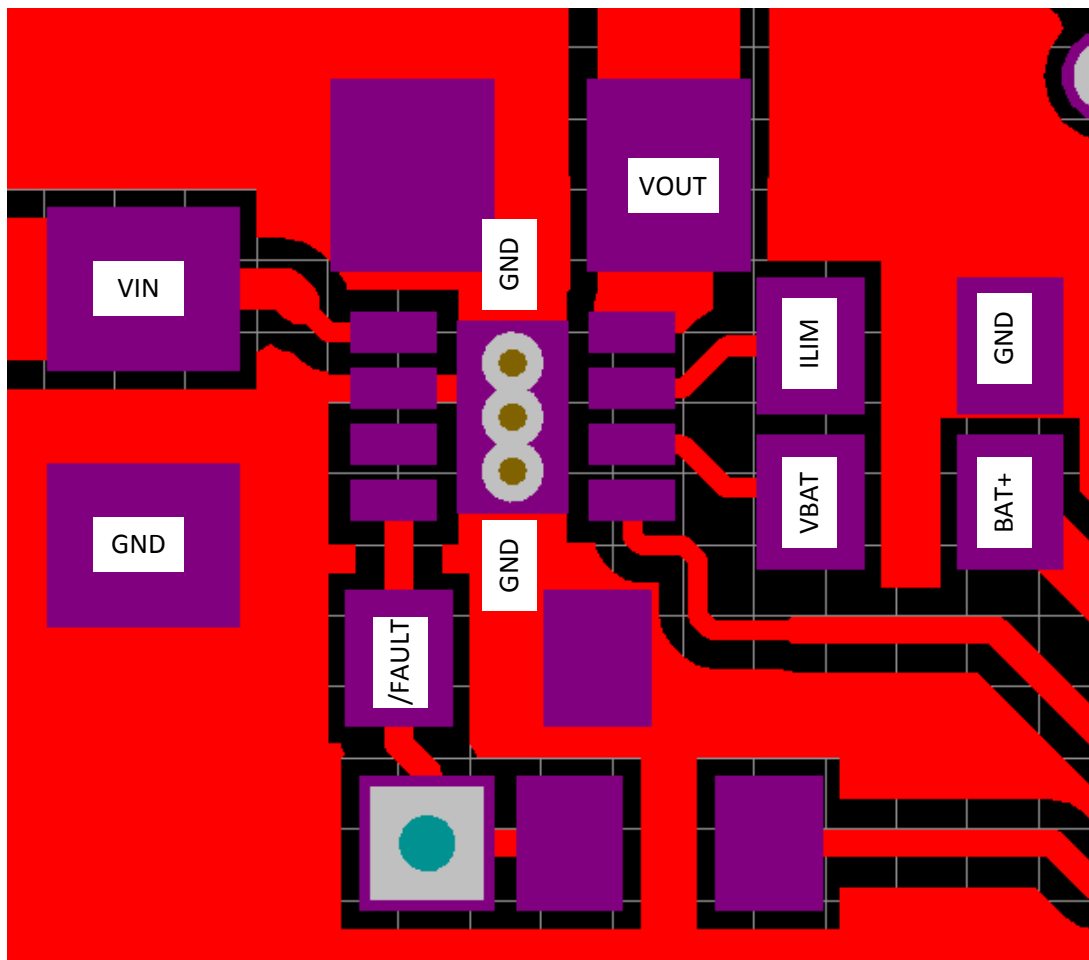


Figure 23. Layout Example

## 11 Device and Documentation Support

### 11.1 Community Resources

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](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 11.2 Trademarks

E2E is a trademark of Texas Instruments.  
Bluetooth is a trademark of Bluetooth SIG, Inc.  
All other trademarks are the property of their respective owners.

### 11.3 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 11.4 Glossary

[SLYZ022](#) — *TI Glossary*.

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

## 12 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 Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| BQ24312DSGR      | ACTIVE        | WSO          | DSG                | 8    | 3000           | RoHS & Green    | NIPDAU   NIPDAUAG                    | Level-2-260C-1 YEAR  | -40 to 125   | OEU                     | <a href="#">Samples</a> |
| BQ24312DSGT      | ACTIVE        | WSO          | DSG                | 8    | 250            | RoHS & Green    | NIPDAU   NIPDAUAG                    | Level-2-260C-1 YEAR  | -40 to 125   | OEU                     | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

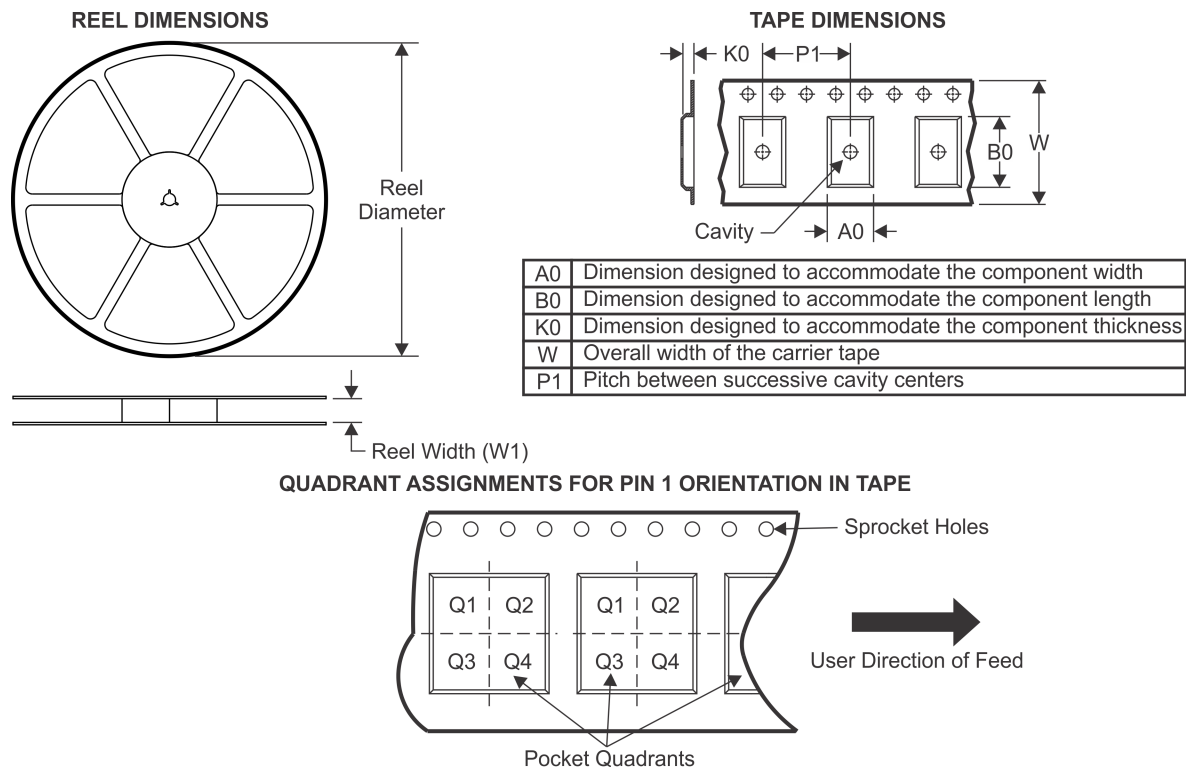
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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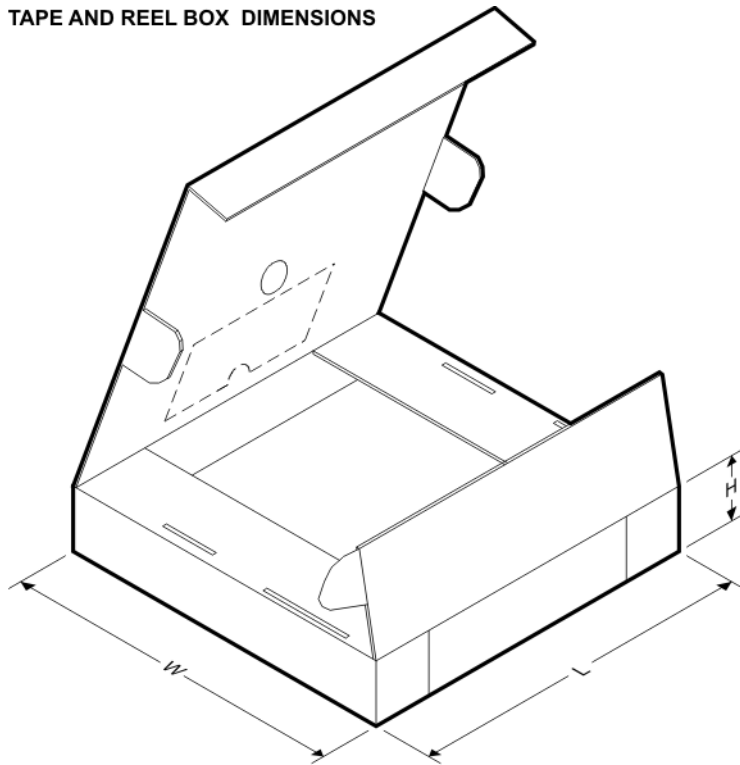


**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

| Device      | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| BQ24312DSGR | WSO          | DSG             | 8    | 3000 | 180.0              | 8.4                | 2.3     | 2.3     | 1.15    | 4.0     | 8.0    | Q2            |
| BQ24312DSGT | WSO          | DSG             | 8    | 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) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| BQ24312DSGR | WSON         | DSG             | 8    | 3000 | 210.0       | 185.0      | 35.0        |
| BQ24312DSGT | WSON         | DSG             | 8    | 250  | 210.0       | 185.0      | 35.0        |

## GENERIC PACKAGE VIEW

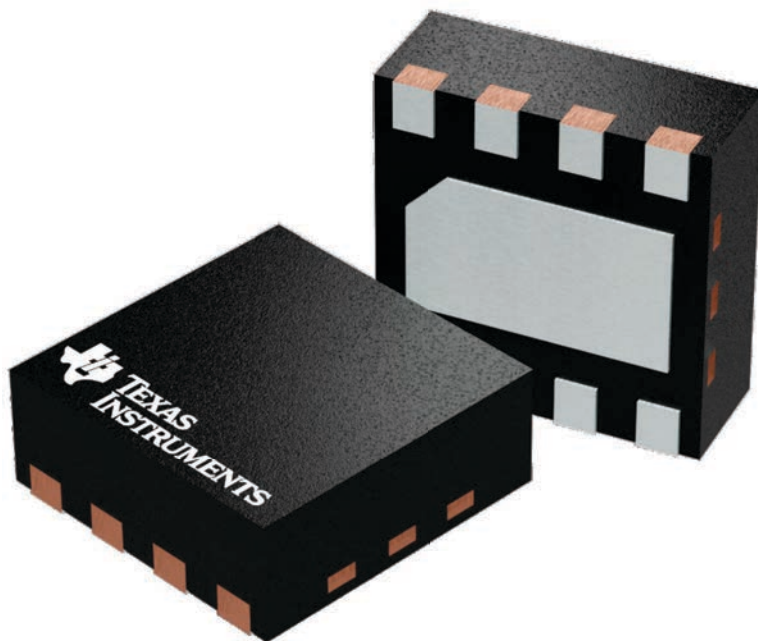
**DSG 8**

**WSON - 0.8 mm max height**

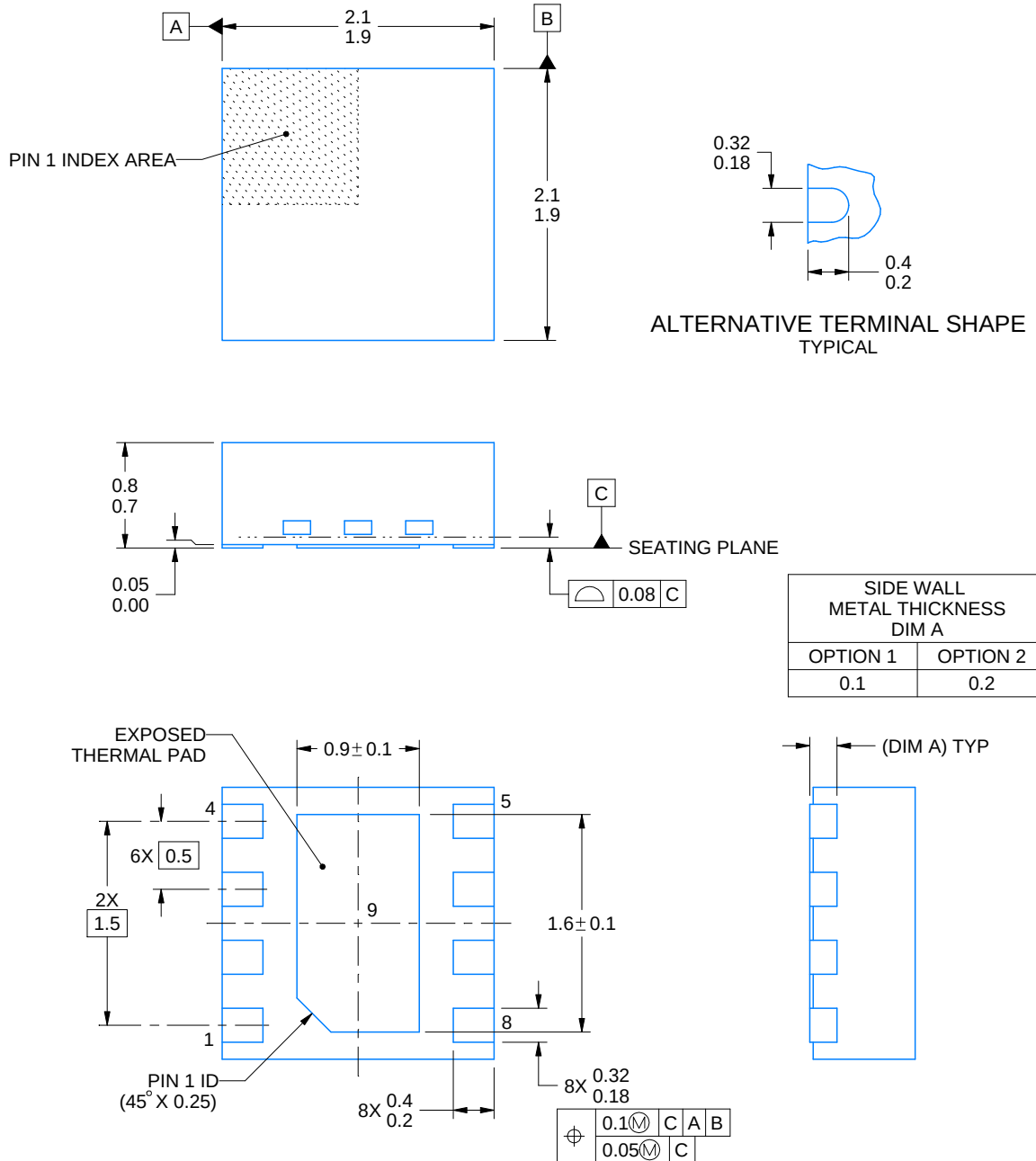
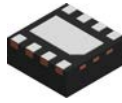
2 x 2, 0.5 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4224783/A



4218900/E 08/2022

## 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.

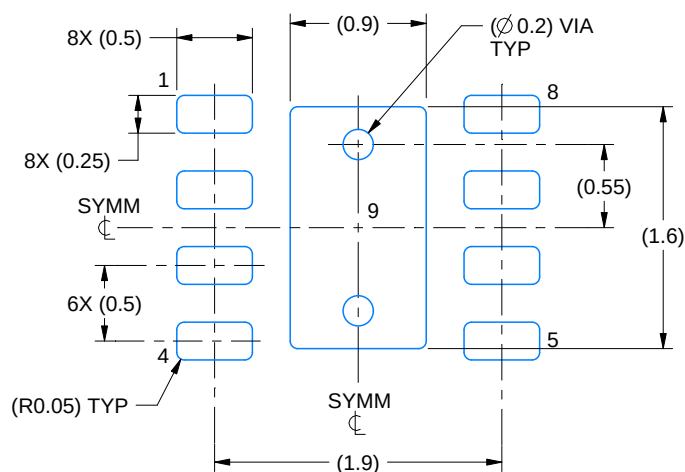


# EXAMPLE BOARD LAYOUT

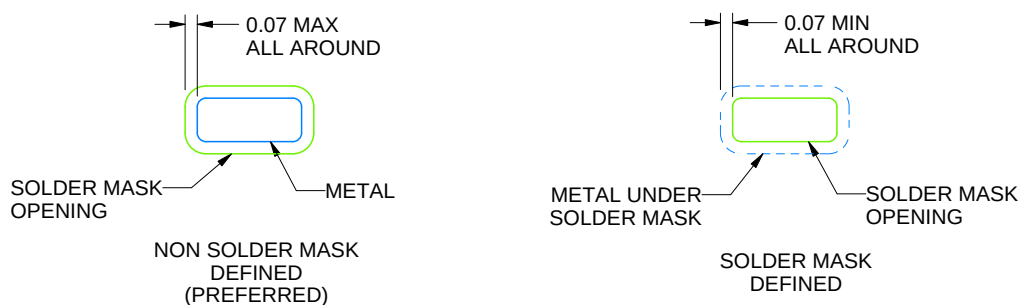
DSG0008A

WSN - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:20X



SOLDER MASK DETAILS

4218900/E 08/2022

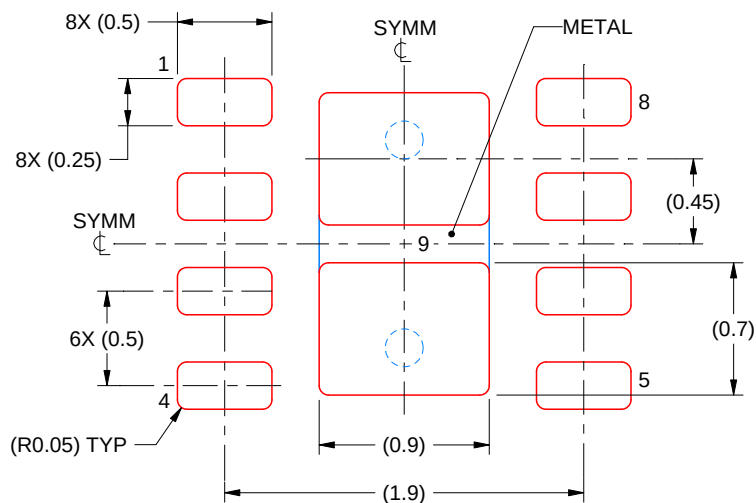
NOTES: (continued)

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/slue271](http://www.ti.com/lit/slue271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

**DSG0008A**

**WSON - 0.8 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



## SOLDER PASTE EXAMPLE BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 9:  
87% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:25X

4218900/E 08/2022

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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