OVERVOLTAGE AND OVERCURRENT PROTECTION IC AND Li+ CHARGER FRONT-END PROTECTION IC

FEATURES

- **Provides Protection for Three Variables:**
  - **Input Overvoltage, with Rapid Response in < 1 μs**
  - **User-Programmable Overcurrent with Current Limiting**
  - **Battery Overvoltage**
- **30V Maximum Input Voltage**
- **Supports up to 1.5A 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 SON**

APPLICATIONS

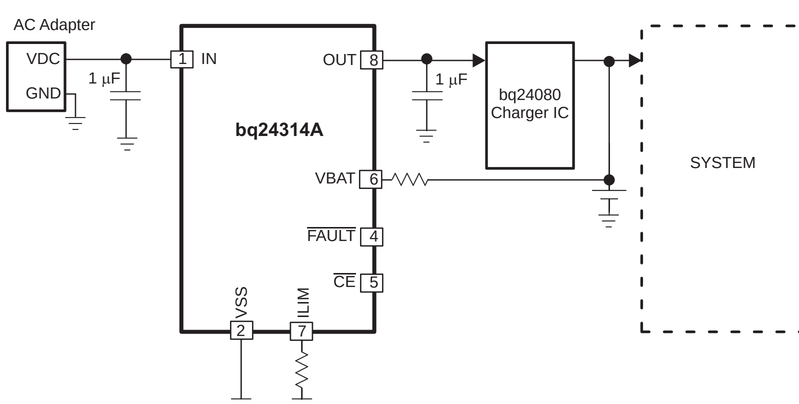
- **Mobile Phones and Smart Phones**
- **PDAs**
- **MP3 Players**
- **Low-Power Handheld Devices**
- **Bluetooth™ Headsets**

DESCRIPTION

The bq24314A is a highly integrated circuit designed to provide protection to Li-ion batteries from failures of the charging circuit. The IC continuously monitors the input voltage, the input current, and the battery voltage. In case of an input overvoltage condition, the IC 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 IC also monitors its own die temperature and switches off if it exceeds 140°C. The input overcurrent threshold is user-programmable.

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

APPLICATION SCHEMATIC



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ELECTRICAL CHARACTERISTICS

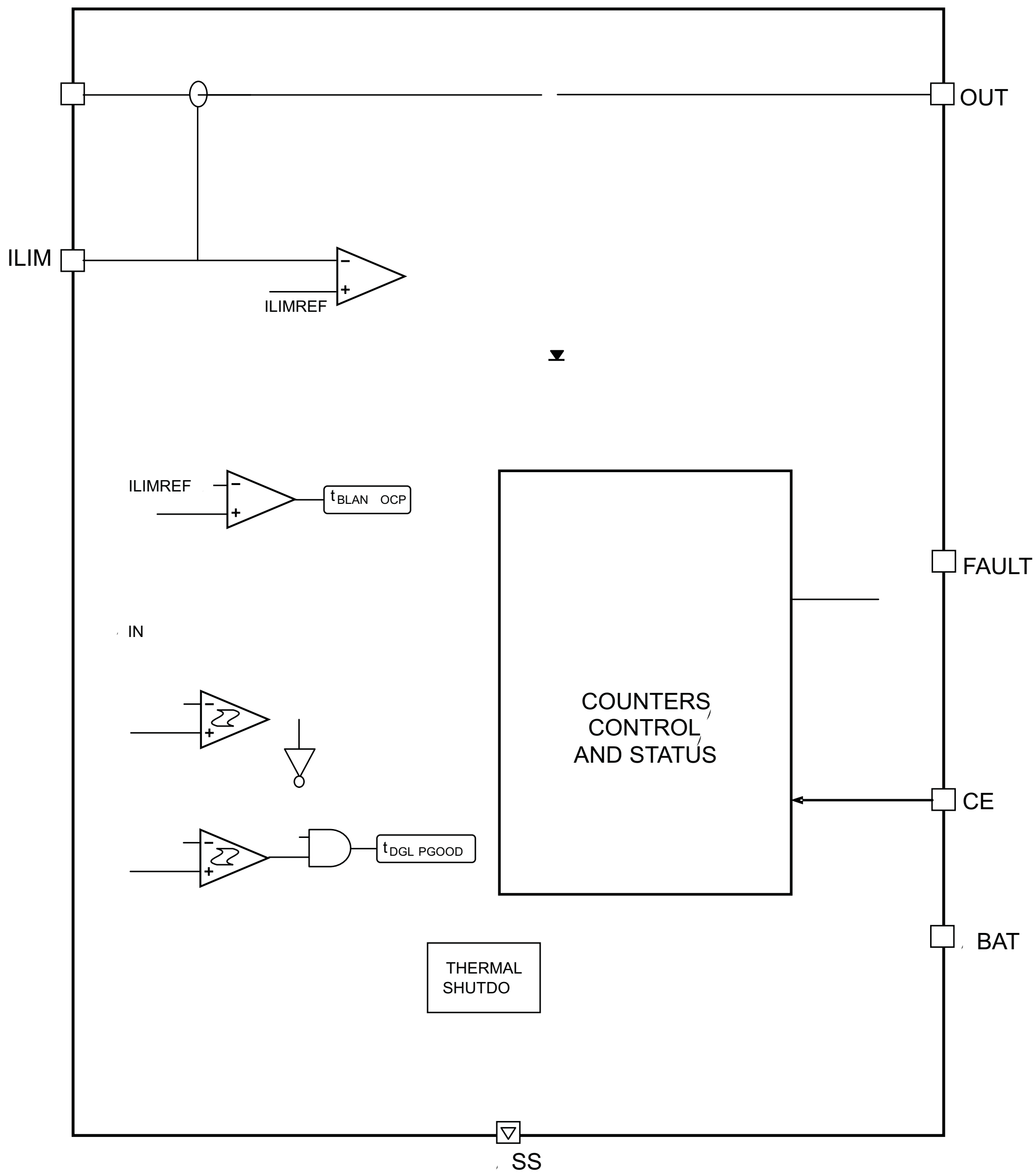


Figure 1. Simplified Block Diagram

TYPICAL OPERATING PERFORMANCE

Test conditions (unless otherwise noted) for typical operating performance: V_{IN} = 5 V, C_{IN} = 1 µF, C_{OUT} = 1 µF, R_{ILIM} = 25 k , R_{BAT} = 100 k , T_A = 25°C, V_{PU} = 3.3V (see Figure 20 for the Typical Application Circuit)

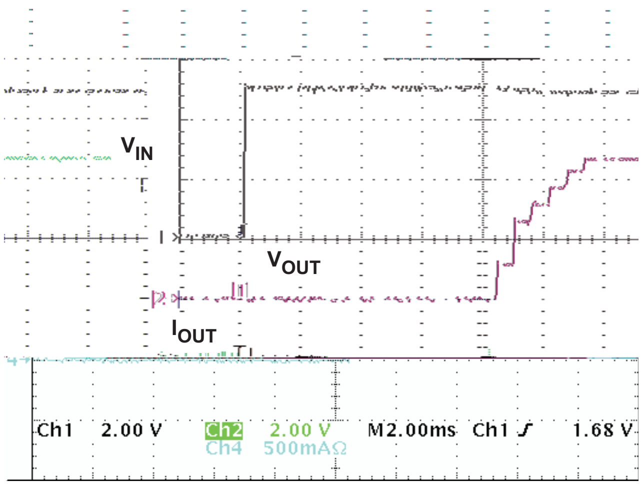


Figure 2. Normal Power-On Showing Soft-Start, R_{OUT} = 6.6

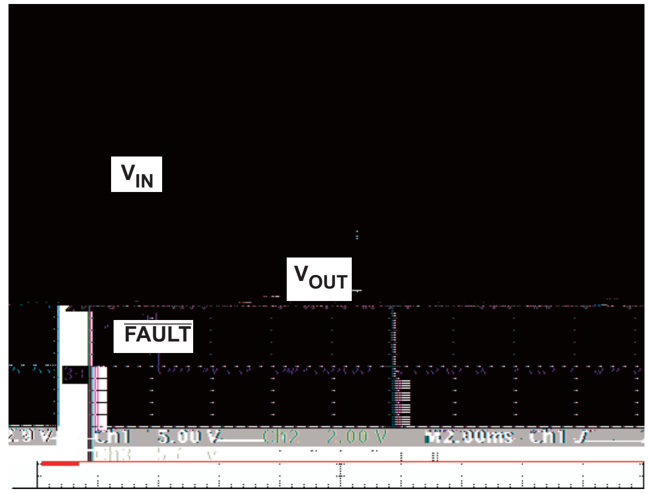


Figure 3. OVP at Power-On, V_{IN} = 0V to 9V, t_r = 50µs

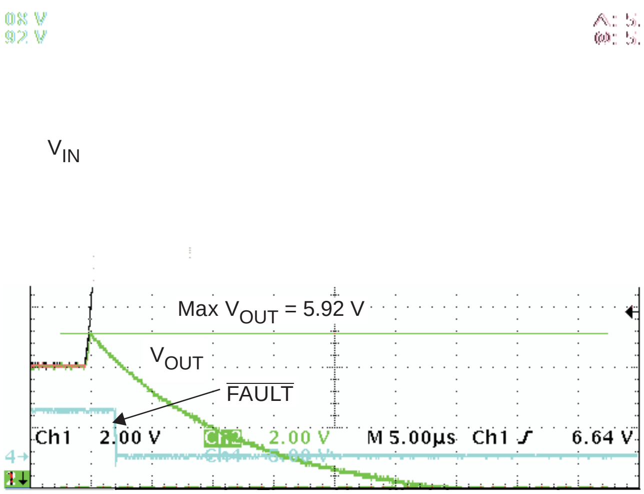


Figure 4. OVP Response for Input Step, V_{IN} = 5V to 12V, t_r = 1µs

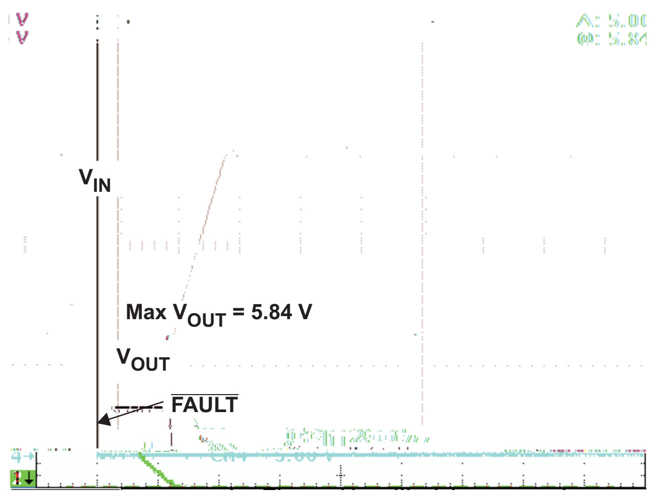


Figure 5. OVP Response for Input Step, V_{IN} = 5V to 12V, t_r = 20µs

TYPICAL OPERATING PERFORMANCE (continued)

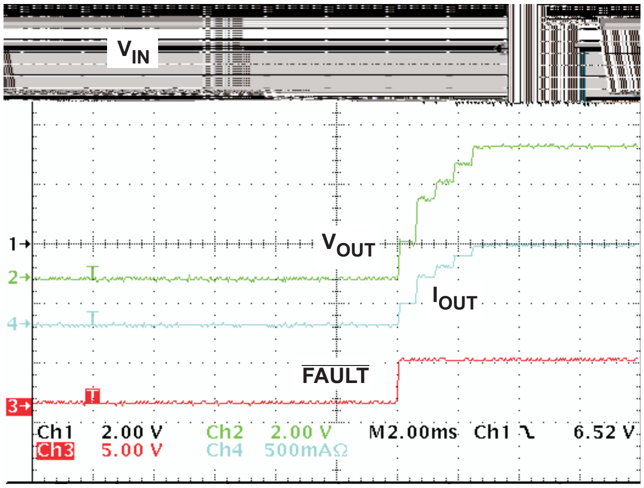


Figure 6. Recovery from OVP, V_{IN} = 7.5V to 5V, t_f = 400µs

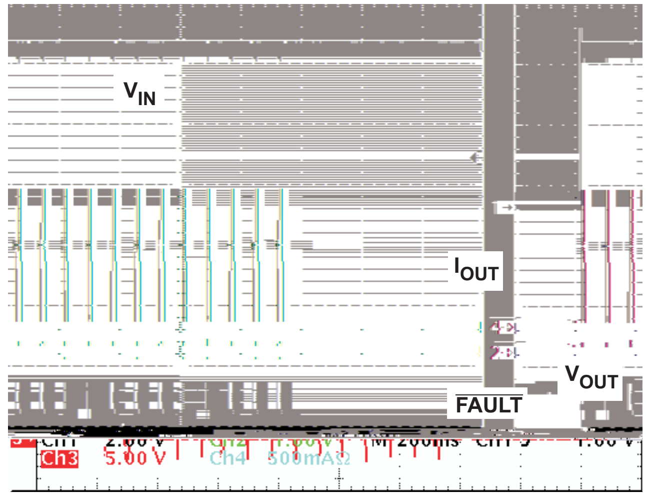


Figure 7. OCP, Powering Up into a Short Circuit on OUT Pin, OCP Counter Counts to 15 Before Switching OFF the Device

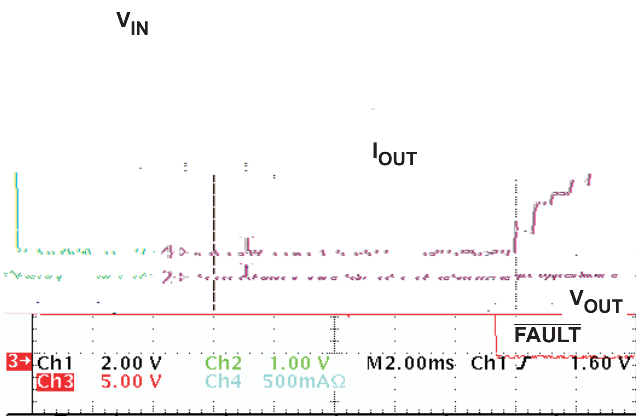


Figure 8. OCP, Zoom-in on the First Cycle of Figure 7

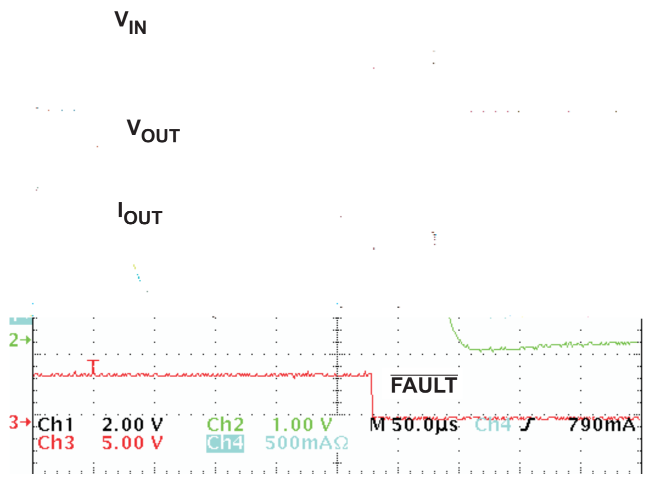


Figure 9. OCP, R_{OUT} Switches from 6.6 to 3.3 , Shows Current Limiting and Soft-Stop

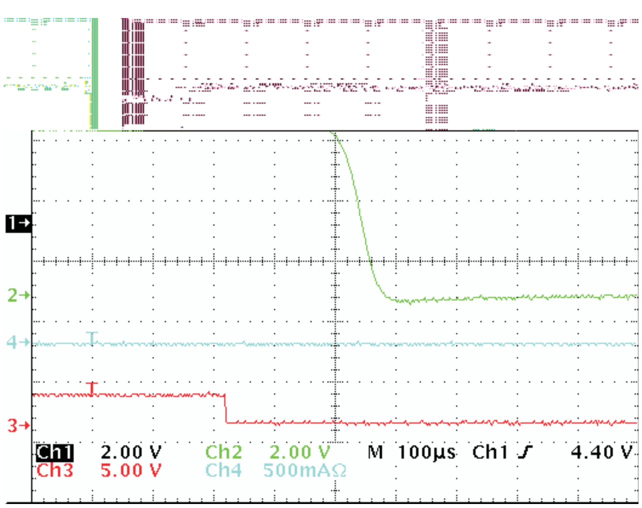


Figure 10. BAT-OVP, V_{VBAT} Steps from 4.2V to 4.4V, Shows $t_{DGL(BAT-OVP)}$ and Soft-Stop

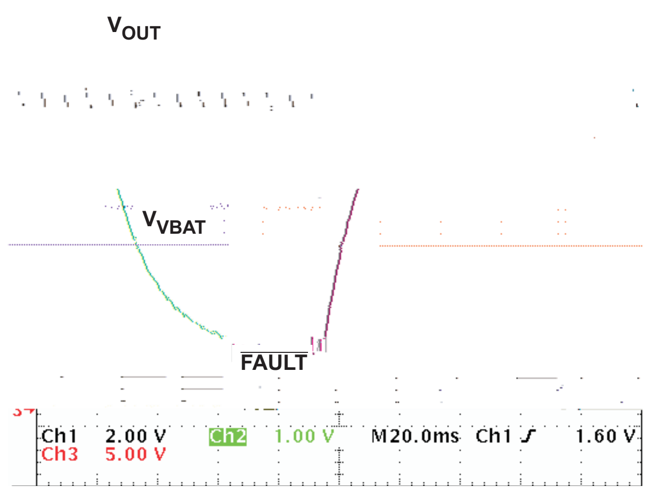
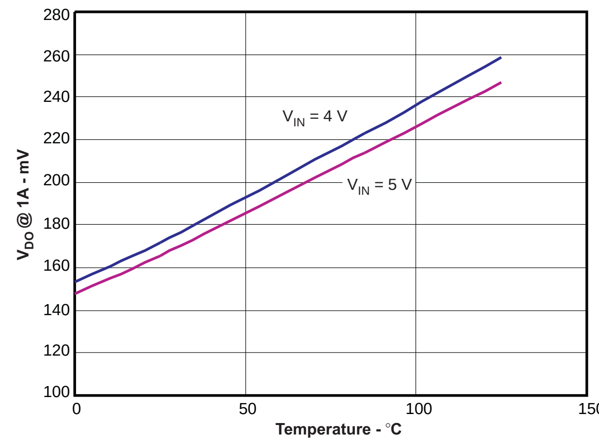


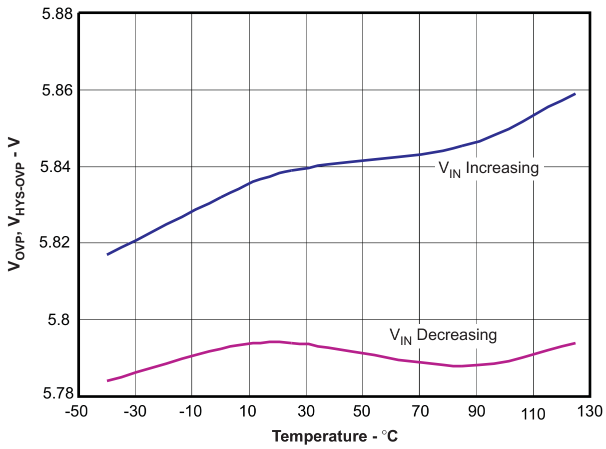
Figure 11. BAT-OVP, V_{VBAT} Cycles Between 4.1V and 4.4V, Shows BAT-OVP Counter

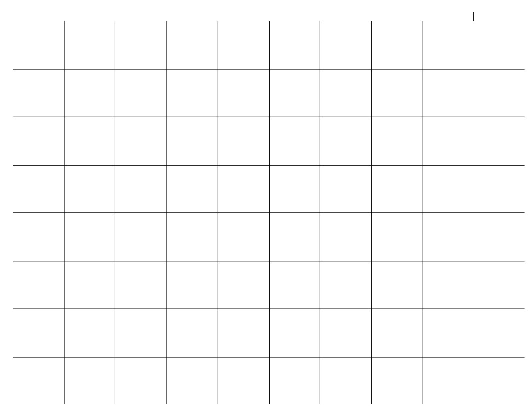
TYPICAL OPERATING PERFORMANCE (continued)

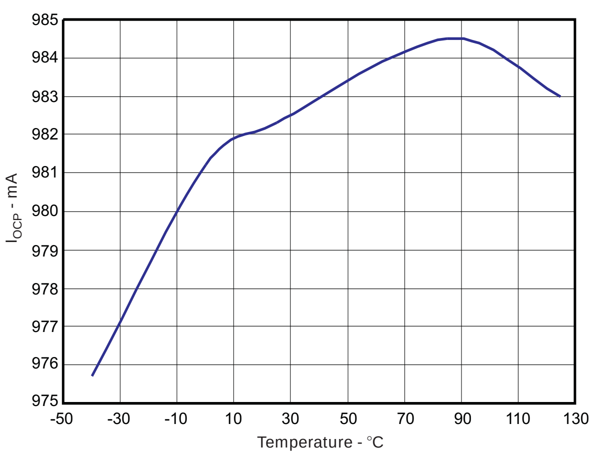
UNDERVOLTAGE LOCKOUT
vs

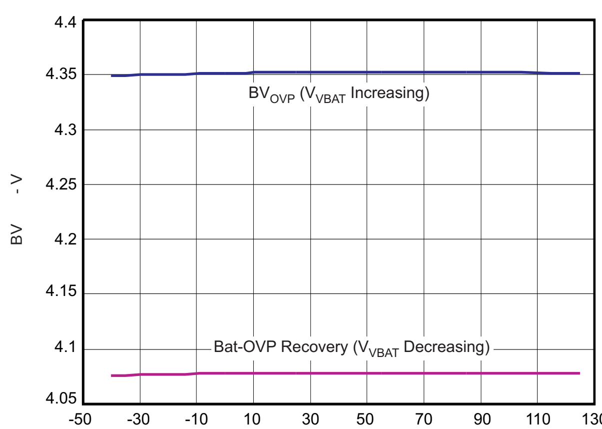
DROPOUT VOLTAGE (IN to OUT)
vs











TYPICAL OPERATING PERFORMANCE (continued)

LEAKAGE CURRENT (VBAT Pin) vs FREE-AIR TEMPERATURE

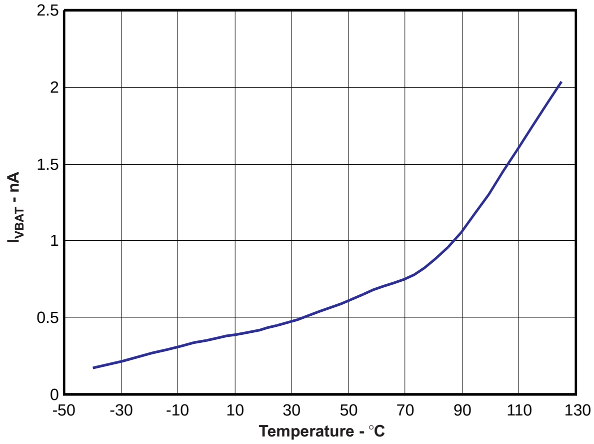


Figure 18.

SUPPLY CURRENT vs INPUT VOLTAGE

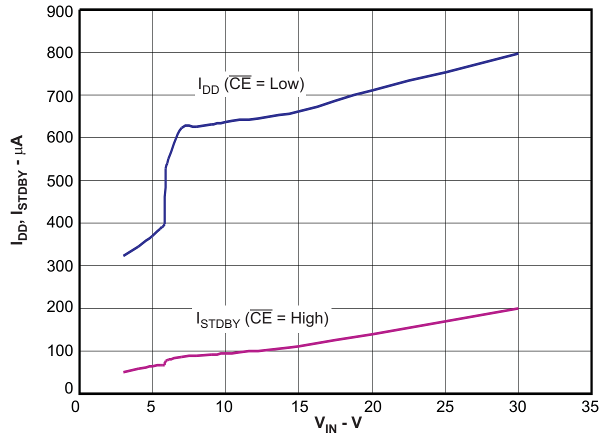


Figure 19.

TYPICAL APPLICATION CIRCUIT

V_{OVP} = 6.8V, I_{OCP} = 1000mA, BV_{OVP} = 4.35V (Terminal numbers shown are for the 2×2 DSG package)

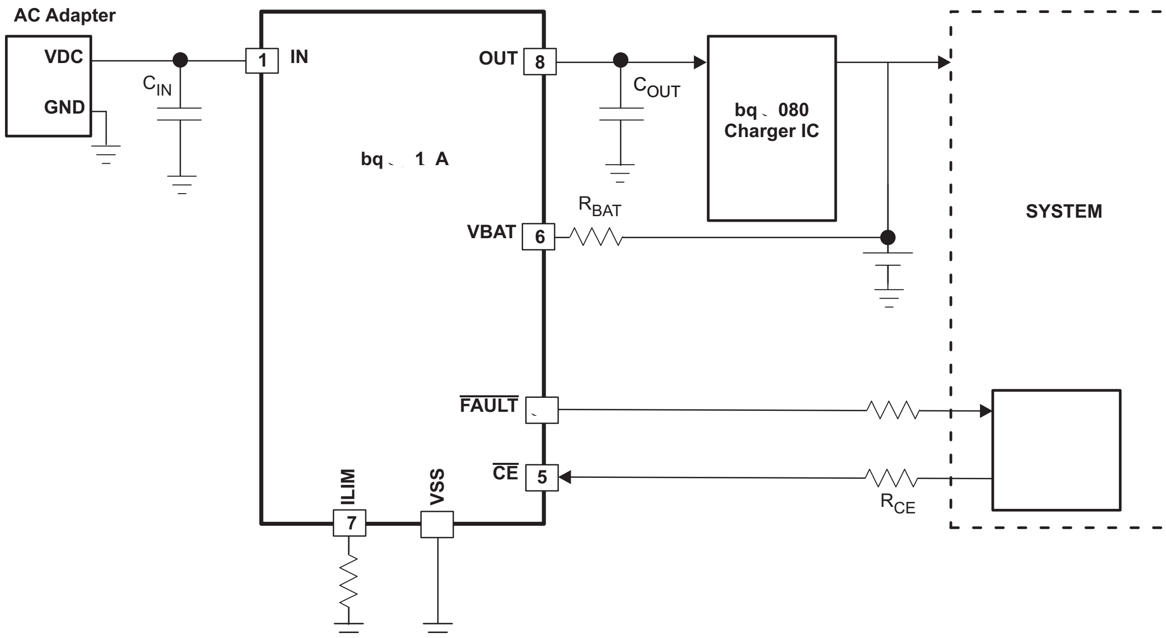


Figure 20.

DETAILED FUNCTIONAL DESCRIPTION

The bq24314A is a highly integrated circuit designed to provide protection to Li-ion batteries from failures of the charging circuit. The IC continuously monitors the input voltage, the input current and the battery voltage. In case of an input overvoltage condition, the IC 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 IC

POWER DOWN

POWER-ON RESET

OPERATION

The device continuously monitors the input voltage, the input current, and the battery voltage as described in detail in the following sections.

Input Overvoltage Protection

If the input voltage rises above V_{OVP}, the internal FET Q1 is turned off, removing power from the circuit. As shown in Figure 4 to Figure 5, the response is very rapid, with the FET turning off in less than a microsecond. The $\overline{FAULT}$ pin is driven low. When the input voltage returns below $V_{OVP} – V_{hys(OVP)}$ (but is still above UVLO), the FET Q1 is turned on again after a deglitch time of $t_{ON(OVP)}$ to ensure that the input supply has stabilized. Figure 6 shows the recovery from input OVP.

Input Overcurrent Protection

The overcurrent threshold is programmed by a resistor R_{ILIM} connected from the ILIM pin to VSS. Figure 15 shows the OCP threshold as a function of R_{ILIM}, and may be approximated by the following equation: $I_{OCP} = 25 \div R_{ILIM}$ (current in A, resistance in k), where R_{ILIM} must be between 15 k and 90 k .

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 $\overline{FAULT}$ 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 7 to Figure 9 show what happens in an overcurrent fault.

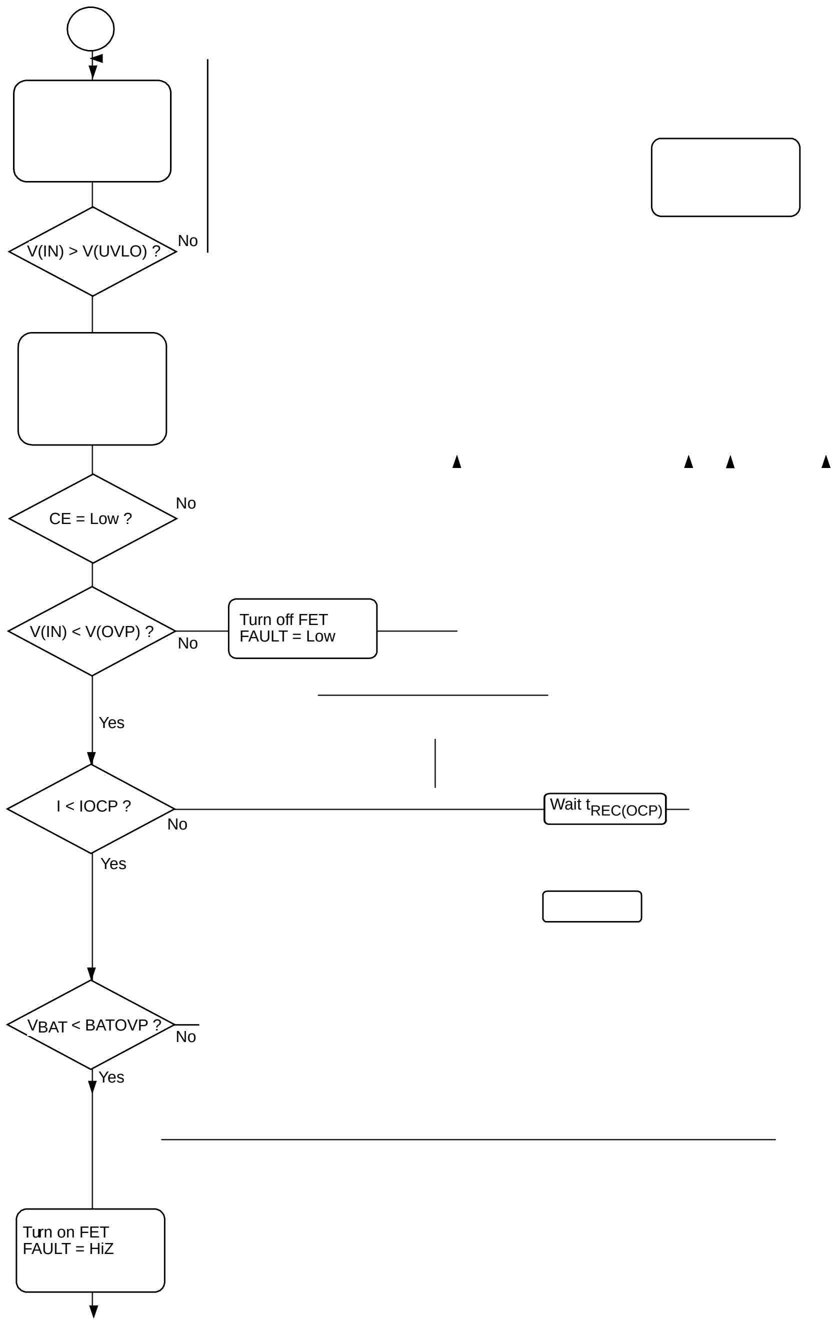
To prevent the input voltage from spiking up due to the inductance of the input cable, Q1 Q1

Battery Overvoltage Protection

Thermal Protection

Enable Function

Fault Indication


V(IN) > V(UVLO) ?
No
CE = Low ?
No
V(IN) < V(OVP) ?
No
Turn off FET
FAULT = Low
Yes
I < IOCP ?
No
Wait tREC(OCP)
Yes
VBAT < BATOVP ?
No
Yes
Turn on FET
FAULT = HiZ

APPLICATION INFORMATION (WITH REFERENCE TO FIGURE 20)

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 IC, the voltage at the IN pin may appear on the VBAT pin. This voltage can be as high as 30V, and applying 30V to the battery in case of the failure of the bq24314A 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 IC. 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 4.35V BV_{OVP} threshold.

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

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

Selection of R_{CE}, R_{FAULT}, and R_{PU}

The CE pin can be used to enable and disableflowingBATflowingflowingand

Selection of Input and Output Bypass Capacitors

Powering Accessories

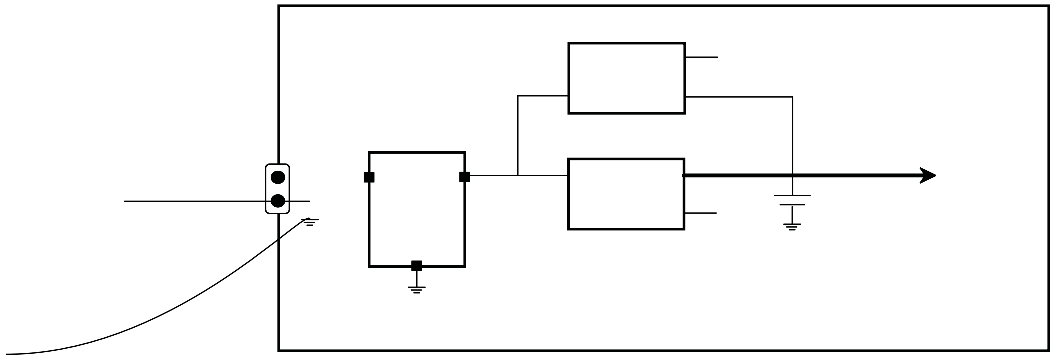


Figure 22. Charging - The Red Arrows Show the Direction of Current Flow

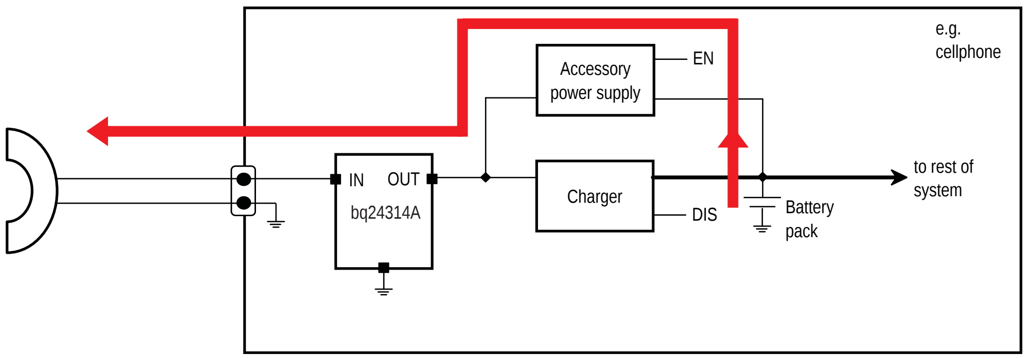


Figure 23. Powering an Accessory - The Red Arrows Show the Direction of Current Flow

In the second case, when power is being delivered to an accessory, the bq24314A device is required to support current flow from the OUT pin to the IN pin.

If V_{OUT} > UVLO + 0.7V, 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, 1.5A. It should be noted that there is no overcurrent protection in this direction.

PCB 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 ahhe

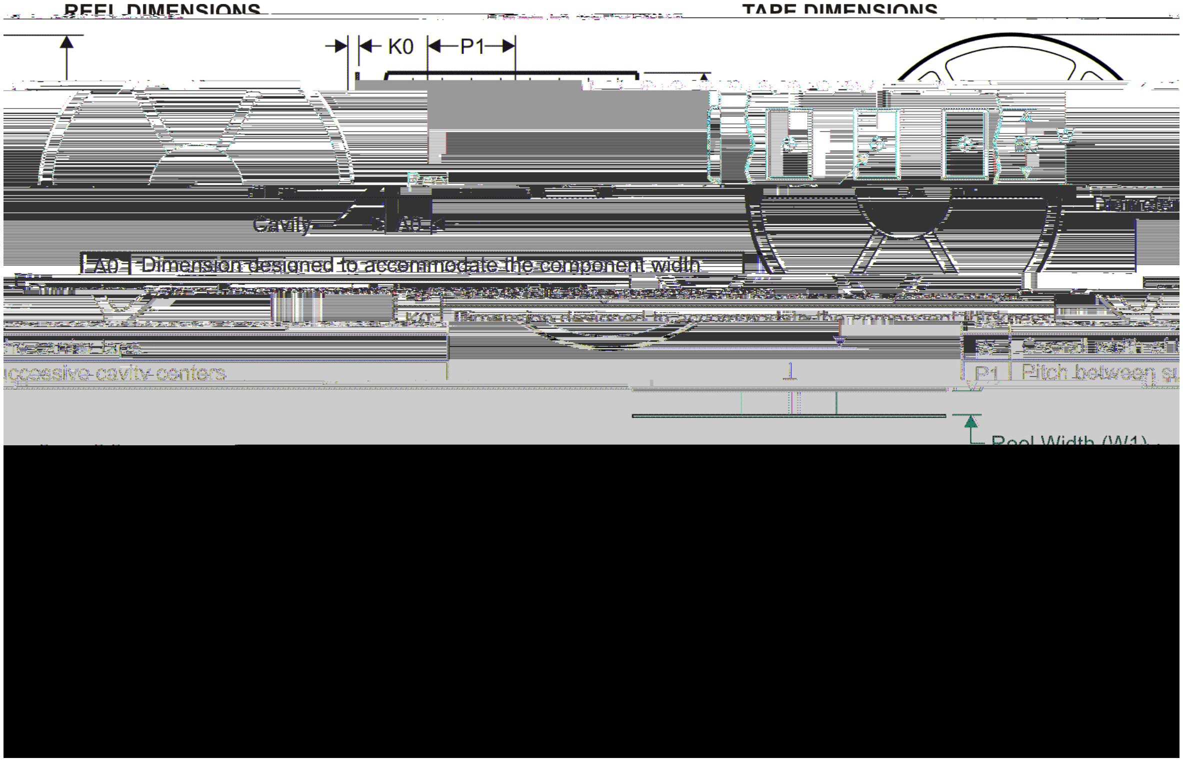
PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
BQ24314ADSGR	ACTIVE	WSON	DSG	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ24314ADSGRG4	ACTIVE	WSON	DSG	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ24314ADSGT	ACTIVE	WSON	DSG	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ24314ADSGTG4	ACTIVE	WSON	DSG	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

[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] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br):

TAPE AND REEL INFORMATION



*All dimensions are nominal

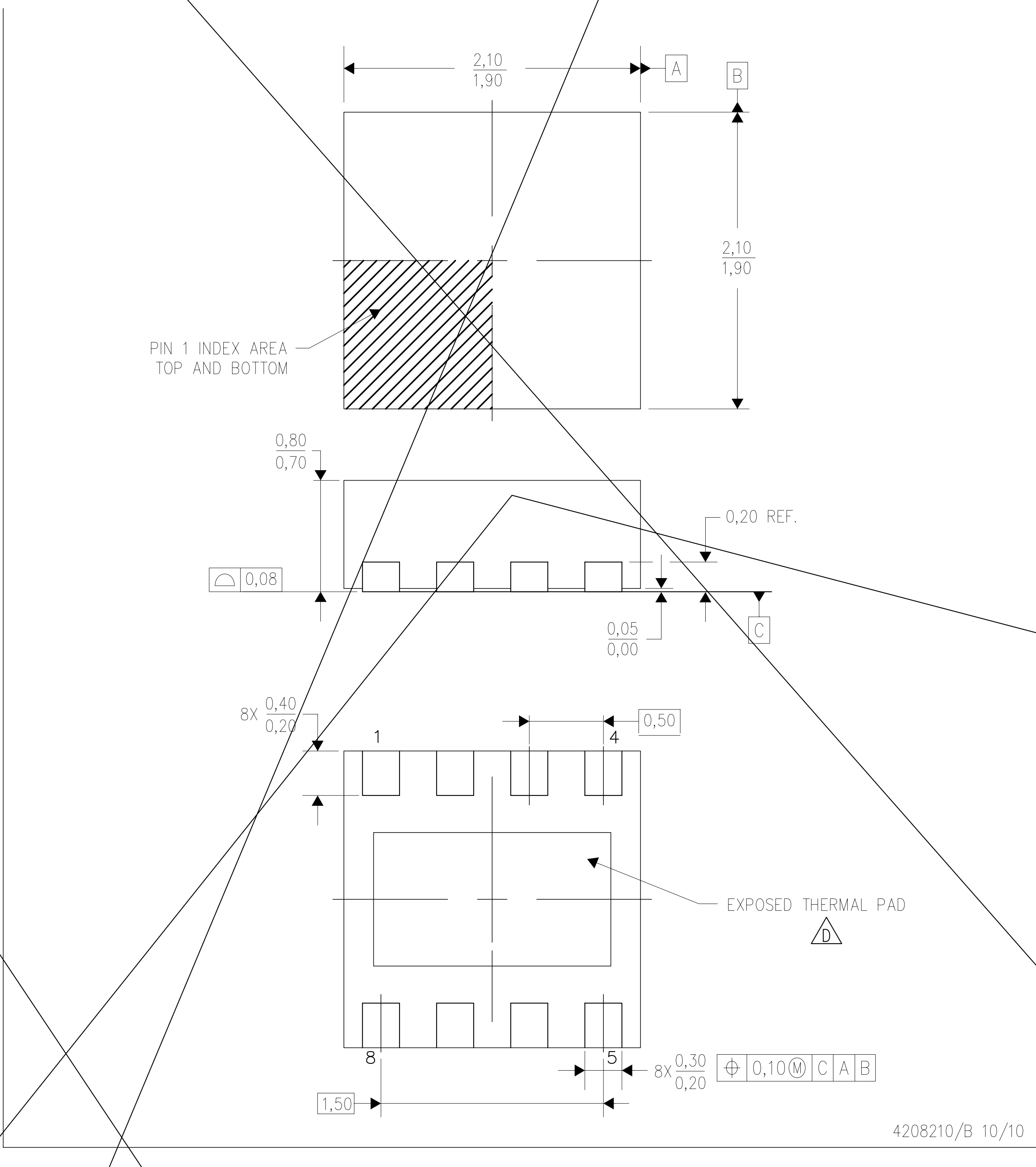
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
BQ24314ADSGR	WSON	DSG	8	3000	179.0	8.4	2.2	2.2	1.2	4.0	8.0	Q2
BQ24314ADSGT	WSON	DSG	8	250	179.0	8.4	2.2	2.2	1.2	4.0	8.0	Q2

[redacted]

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ24314ADSGR	WSON	DSG	8	3000	195.0	200.0	45.0
BQ24314ADSGT	WSON	DSG	8	250	195.0	200.0	45.0

-STIC SMALL OUTLINE NO-LEAD



B

C. Quad Flatpack, No–Leads (QFN) package configuration.

D. The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Prod c thermal pad dimensions.

E. Falls within JEDEC MO–229.

IMPORTANT NOTICE