

bq2435x DSG EVM for Li-Ion Charger Front-End Protection IC

This user's guide describes the features, setup, and operation of the bq2435xEVM evaluation module. Included are the bill of materials, board layout, and schematic.

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1 Introduction

1.1 General Description

The bq2435x evaluation module (EVM) is a complete charger module for evaluating a charger front-end protection and charger solution using the bq2435x and bq2057C devices. It is designed to deliver up to 560 mA of charge current to Li-ion or Li-polymer applications. The charger front-end protection current is designed to 1.2 A.

The bq2435x protects the charging system against three types of failures: input overvoltage when the ac adapter fails to regulate its voltage, load overcurrent when failures such as a short circuit occur in the charging system, and battery overcharge.

For details, see the bq2435x data sheet ([SLUS943](#)).

1.2 EVM Features

- Evaluation module for bq2435x DSG
- Evaluation module for bq2057C charger integrated circuit (IC)
- Input operating range for bq2435x 4.5 V–26 V
- Input operating range for bq24080 4.5 V–6.5 V
- Input overvoltage protection.
- Input overcurrent protection.
- Battery overvoltage protection.
- LED Indication for status signals.
- Test points for key signals available for testing purpose. Easy probe hook-up
- Jumpers available. Easy to change connections

1.3 I/O Description

| Jack | Description |
|-----------|--|
| J1-DC+ | AC adapter, positive output |
| J1-DC- | AC adapter, negative output, ground |
| J2-FAULT | bq24355 $\overline{\text{FAULT}}$ pin |
| J2-VBAT | bq2435x VBAT pin |
| J2-GATDRV | bq2435x GATDRV pin |
| J2-CHGIN | bq2435x CHGIN pin |
| J3-BATEN | bq24355 $\overline{\text{BATEN}}$ pin |
| J3-OUT | bq2435x OUT pin |
| J3-BAT+ | Battery positive output |
| J3-GND | Ground |
| J4-BAT+ | Connect to battery positive output |
| J4-BAT- | Connect to battery negative output, ground |

1.4 Controls and Key Parameters Setting

| Jack ⁽¹⁾ | Description | Factory Setting |
|---------------------|---|--|
| JP1 | If on, high-side current sensing resistor is disabled | Jumper on |
| JP2 | bq24355 $\overline{\text{BATEN}}$ pin logic input, pull low to enable | Jumper ($\overline{\text{BATEN}}$, GND) on |
| JP3 | bq2435x GATDRV pin | Jumper off |
| JP4 | bq2057C BAT pin connection to bq2435x | Jumper on |

⁽¹⁾ Short JP1, JP4, JP5, and JP6, and disconnect JP7 to use on board bq2057C as charger; to use external charger to control bq2435x, disconnect JP1, JP4, JP5, and JP6 and short JP7.

| Jack ⁽¹⁾ | Description | Factory Setting |
|---------------------|--|-----------------|
| JP5 | bq2057C VCC pin connection to bq2435x | Jumper on |
| JP6 | bq2057C CC pin connection to bq2435x | Jumper on |
| JP7 | If on, low-side current sensing resistor is disabled | Jumper off |

1.5 Recommended Operating Conditions

| Symbol | Description | Minimum | Typical | Maximum | Unit |
|---|---|---------|---------|---------|------|
| Supply voltage, V_{IN} | Input voltage from ac adapter input | 4.5 | 5 | 26 | V |
| Battery voltage, V_{BAT} | Voltage applied at VBAT terminal of J4 | 0 | 3–4.2 | 5 | V |
| Supply current, I_{AC} | Maximum input current from ac adapter input | 0 | | 1.5 | A |
| Charge current, I_{chrg} | Battery charge current | 0.05 | 0.56 | 1 | A |
| Operating junction temperature range, T_J | | 0 | | 125 | °C |

2 Test Summary

2.1 Definitions

This procedure details how to configure the evaluation board. On the test procedure, the following naming conventions are followed. See the schematic for details.

| | |
|----------------|--|
| VXXX | External voltage supply name (V_{IN} , V_{BAT} , V_{OUT}) |
| LOADW: | External load name (LOADR, LOADI) |
| V(TPyyy) : | Voltage at internal test point TPyyy. For example, V(TP1) means the voltage at TP1. |
| V(Jxx): | Voltage at jack terminal Jxx. |
| V(TP(XXXXX)): | Voltage at test point “XXXXX”. For example, V(ACDET) means the voltage at the test point which is marked as “ACDET”. |
| V(XXX, YYY): | Voltage across point XXX and YYY. |
| I(JXX(YYY)): | Current going out from the YYY terminal of jack XX. |
| Jxx(BBB): | Terminal or pin BBB of jack xx |
| Jxx ON : | Internal jumper Jxx terminals are shorted |
| Jxx OFF: | Internal jumper Jxx terminals are open |
| Jxx (-YY-) ON: | Internal jumper Jxx adjacent terminals marked as “YY” are shorted |
| Measure:→ A,B | Check specified parameters A, B. If measured values are not within specified limits the unit under test has failed. |
| Observe → A,B | Observe if A, B occur. If they do not occur, the unit under test has failed. |

Assembly drawings have location for jumpers, test points and individual components

2.2 Equipment

2.2.1 Power Supplies

Power Supply 1 (PS 1): a power supply capable of supplying 10 V at 2 A is required.

2.2.2 Load 1

A 10-V (or above), 2-A (or above) electronic load that can operate at constant current mode.

2.2.3 Load 2

A 10-V (or above), 2-A (or above) electronic load that can operate at constant voltage mode.

2.2.4 Meters

Four Fluke 75 multimeters (equivalent or better)

Or:

Three equivalent voltage meters and one equivalent current meter

The current meter must be capable of measuring 2-A+ current.

2.2.5 Wire Gauge

All wires connected to the EVM input power supply and output load must use at least AWG 22. The maximum current is up to 1 A.

2.3 Equipment Setup

1. Set the PS 1 for 0 V \pm 100 mVdc, 2 \pm 0.1 A current limit, and then disable the output.
2. Connect the output of PS 1 to J1 (DC+, DC-).
3. Connect a voltage meter across J1 (DC+, DC-).
4. Connect the output of the Load 1 in series with a current meter (multimeter) to J2 (CHGIN) and J3 (GND). Turn on the power of the Load 1. Set the load current to 1.5 A \pm 50 mA but disable the output.
5. Connect output of the Load 2 in series with a current meter (multimeter) to J4 (BAT+, BAT-).
6. Connect a voltage meter across J4 (BAT+, BAT-).
7. Set the voltage of Load 2 to 3.6 V \pm 0.1 V, and disable output of Load 2.
8. JP1: ON, JP2 (BATEN, GND): ON, JP3: OFF, JP4: ON, JP5: ON, JP6: ON, JP7: OFF.

After the preceding steps have been taken, the test setup for HPA398 (bq2435x DSG EVM) appears as is shown in [Figure 1](#).

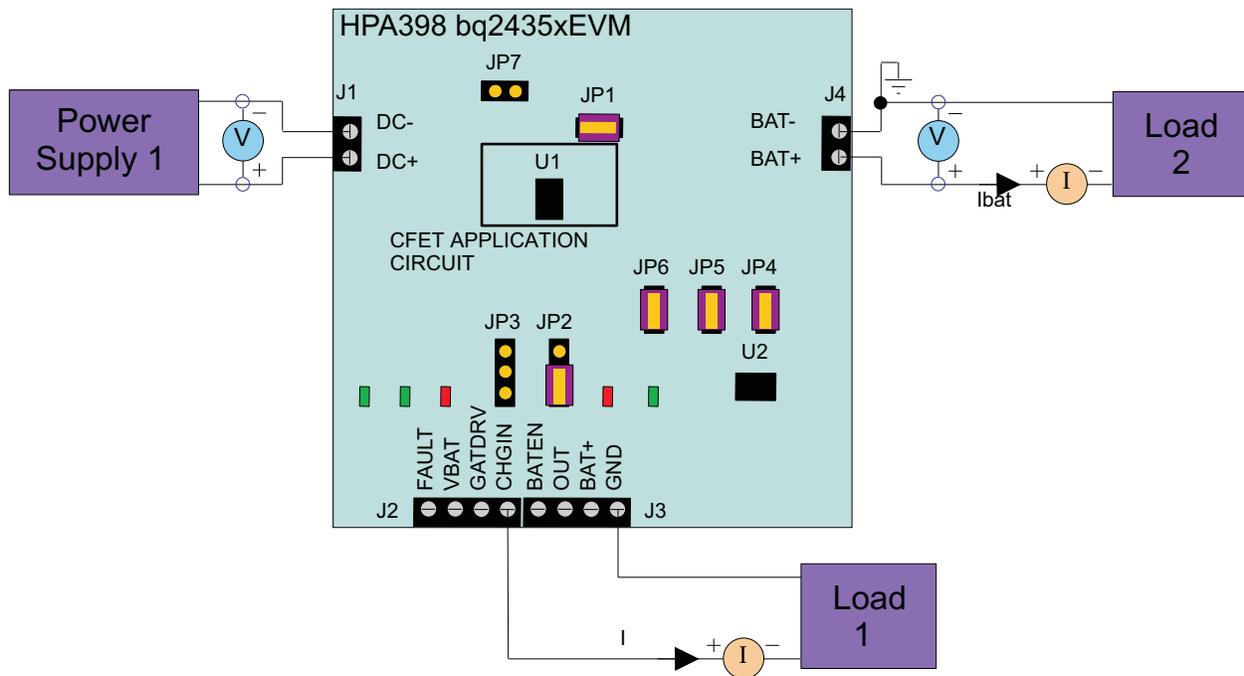


Figure 1. Original Test Setup for HPA398 (bq2435x DSG EVM)

2.4 Procedure

2.4.1 Charger Current and Voltage Regulation

1. Ensure that steps in [Section 2.3](#) are followed.
2. Enable output of PS 1.
3. Increase the output voltage of PS 1 to $5\text{ V} \pm 0.1\text{ V}$.
4. Enable output of Load 2.

Measure $\rightarrow V(\text{J2}(\text{OUT})) = 3.6\text{ V} \pm 200\text{ mV}$

Measure $\rightarrow I_{\text{bat}} = 560\text{ mA} \pm 70\text{ mA}$

Observe \rightarrow D2 on, D3 on, D6 off, D7 on.

2.4.2 CFET Input Overvoltage Protection

1. Increase the voltage of PS 1 to $8\text{ V} \pm 0.1\text{ V}$.
Observe \rightarrow D2 on, D3 off, D6 off, D7 off.
2. Decrease the voltage of PS 1 to $5\text{ V} \pm 0.1\text{ V}$.
Observe \rightarrow D2 on, D3 on, D6 off, D7 on.

2.4.3 CFET Load Overcurrent Protection

1. Enable the output of the Load 1.
Observe \rightarrow D2 on, D3 off, D6 off, D7 off.
2. Disable the output of the Load 1.
Observe \rightarrow D2 on, D3 on, D6 off, D7 on.
3. Decrease the voltage of PS 1 to $0\text{ V} \pm 0.1\text{ V}$.

3 PCB Layout Guideline

1. It is critical that the exposed power pad on the backside of the bq2435x package be soldered to the printed-circuit board (PCB) ground. Ensure that sufficient thermal vias are located underneath the IC, connecting to the ground plane on the other layers.
2. The high-current charge paths into ACIN and from CHGIN, OUT pins must be sized appropriately for the maximum charge current in order to avoid voltage drops in these traces.
3. Decoupling capacitors for ACIN, CHGIN must be placed and make the interconnections to the IC as short as possible.
4. Resistors for VBAT pin must be placed close to the corresponding IC pins and make the interconnections to the IC as short as possible.

4 Bill of Materials, Board Layout, and Schematic

4.1 Bill of Materials

Table 1. Bill of Materials

| bq24350-001 | bq24352-002 | bq24355-003 | RefDes | Value | Description | Size | Part Number | MFR |
|-------------|-------------|-------------|-------------------------|------------|--|--------------------|----------------|---------------|
| 1 | 1 | 1 | C1 | 1uF | Capacitor, Ceramic, 35V, X5R, 10% | 603 | Std | Std |
| 3 | 3 | 3 | C2, C3, C5 | 1uF | Capacitor, Ceramic, 10V, X7R, 10% | 603 | Std | Std |
| 1 | 1 | 1 | C4 | 0.1uF | Capacitor, Ceramic, 16V, X7R, 10% | 805 | Std | Std |
| 1 | 1 | 1 | C6 | 0.1uF | Capacitor, Ceramic, 10V, X7R, 10% | 603 | Std | Std |
| 1 | 1 | 1 | C7 | 220uF | Capacitor, Electrolytic, 25V, 20% | 0.327 X 0.327 inch | UUD1E221MNL1GS | Nichicon |
| 1 | 1 | 1 | D1 | BZT52C6V8S | Diode, Zener, 200mW, 6.8V | SOD-323 | BZT52C6V8S | General |
| 3 | 3 | 3 | D2, D3, D6 | Green | Diode, LED, Green, 2.1-V, 20-mA, 6-mcd | 603 | LTST-C190GKT | Lite On |
| 2 | 2 | 2 | D4, D7 | Red | Diode, LED, Red, 2.1-V, 20-mA, 6-mcd | 603 | LTST-C190CKT | Lite On |
| 1 | 1 | 1 | D5 | BAT54C | Diode, Dual Schottky, 200-mA, 30-V | SOT23 | BAT54C | Vishay-Liteon |
| 2 | 2 | 2 | J1, J4 | ED1514/2DS | Terminal Block, 2-pin, 6-A, 3.5mm | 0.27 x 0.25 inch | ED1514/2DS | OST |
| 2 | 2 | 2 | J2, J3 | ED1516/4DS | Terminal Block, 4-pin, 6-A, 3.5mm | 0.55 x 0.25 inch | ED1516/4DS | OST |
| 5 | 5 | 5 | JP1, JP4, JP5, JP6, JP7 | PEC02SAAN | Header, 2-pin, 100mil spacing | 0.100 inch x 2 | PEC02SAAN | Sullins |
| 2 | 2 | 2 | JP2, JP3 | PTC03SAAN | Header, Male 3-pin, 100mil spacing, (36-pin strip) | 0.100 inch x 3 | PTC03SAAN | Sullins |
| 5 | 5 | 5 | JP1, JP2, JP4, JP5, JP6 | 929950-00 | Shorting jumpers, 2-pin, 100mil spacing, | | 929950-00 | 3M/ESD |
| 2 | 2 | 0 | R1, R2 | 0 | Resistor, Chip, 1/16W, 1% | 402 | Std | Std |
| 0 | 0 | 2 | R3, R4 | 0 | Resistor, Chip, 1/16W, 1% | 402 | Std | Std |
| 2 | 2 | 2 | R5, R6 | 200k | Resistor, Chip, 1/16W, 5% | 402 | Std | Std |
| 2 | 2 | 2 | R7, R8 | 200k | Resistor, Chip, 1/16-W, 5% | 603 | Std | Std |
| 2 | 2 | 2 | R9, R10 | 0.2 | Resistor, Metal Film, 1/4 watt, 1% | 1206 | Std | Std |
| 1 | 1 | 1 | R11 | 20k | Resistor, Chip, 1/16-W, 5% | 603 | Std | Std |
| 1 | 1 | 1 | R12 | 1k | Resistor, Chip, 1/16-W, 5% | 603 | Std | Std |
| 1 | 1 | 1 | R13 | 100 | Resistor, Chip, 1/16-W, 5% | 603 | Std | Std |
| 1 | 1 | 1 | R14 | 6.2k | Resistor, Chip, 1/16-W, 5% | 603 | Std | Std |
| 4 | 4 | 4 | R15, R16, R17, R18 | 1.5k | Resistor, Chip, 1/16-W, 5% | 603 | Std | Std |

Table 1. Bill of Materials (continued)

| bq24350-001 | bq24352-002 | bq24355-003 | RefDes | Value | Description | Size | Part Number | MFR |
|-------------|-------------|-------------|---|------------|---|--------------------|-------------|--------------------|
| 1 | 1 | 1 | R19 | 51 | Resistor, Chip, 1/16-W, 5% | 603 | Std | Std |
| 4 | 4 | 4 | | | 6-32 NYL nuts | NY HN 632 | H620-ND | Building Fasteners |
| 4 | 4 | 4 | ST1,ST2,S T3,ST4 | 4816 | STANDOFF M/F HEX 6-32 NYL .500" | sf_thvt_325_rnd | 4816 | Keystone |
| 8 | 8 | 8 | TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8 | white | Test Point, White, Thru Hole Color Keyed | 0.100 x 0.100 inch | 5002 | Keystone |
| 1 | 1 | 1 | TP9 | white | Test Point, White, Thru Hole Color Keyed | 0.100 x 0.100 inch | 5001 | Keystone |
| 1 | 0 | 0 | U1 | bq24350DSG | IC, OVER-VOLTAGE AND OVER-CURRENT CHARGER FRONT-END | SON-8 | BQ24350DSG | TI |
| 0 | 1 | 0 | U1 | bq24352DSG | IC, OVER-VOLTAGE AND OVER-CURRENT CHARGER FRONT-END | SON-8 | BQ24352DSG | TI |
| 0 | 0 | 1 | U1 | bq24355DSG | IC, OVER-VOLTAGE AND OVER-CURRENT CHARGER FRONT-END | SON-8 | BQ24355DSG | TI |
| 1 | 1 | 1 | U2 | BQ2057CSN | IC, Charge Management, One or Two Cell Li-Ion or Li-Pol Charger | S0-8 | BQ2057CSN | TI |
| 1 | 1 | 1 | -- | HPA398 | PCB, 2.8 In x 2.8 In x 0.062 In | | PCB | Any |

Notes: 1. Number 0 in left side columns means do not use this component.
 2. OPEN in value column means do not use this component.
 3. Std in part number column means standard manufacturer's part number.
 4. Std in MFR column means standard manufacturer.

4.2 Board Layout

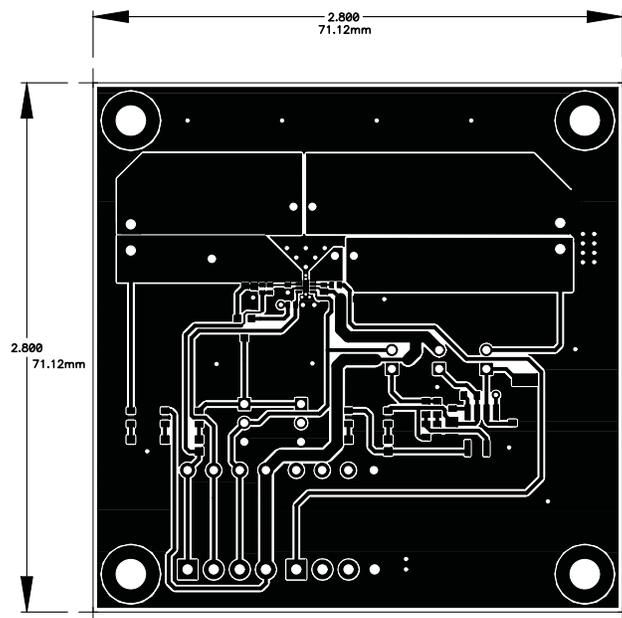


Figure 2. Top Layer

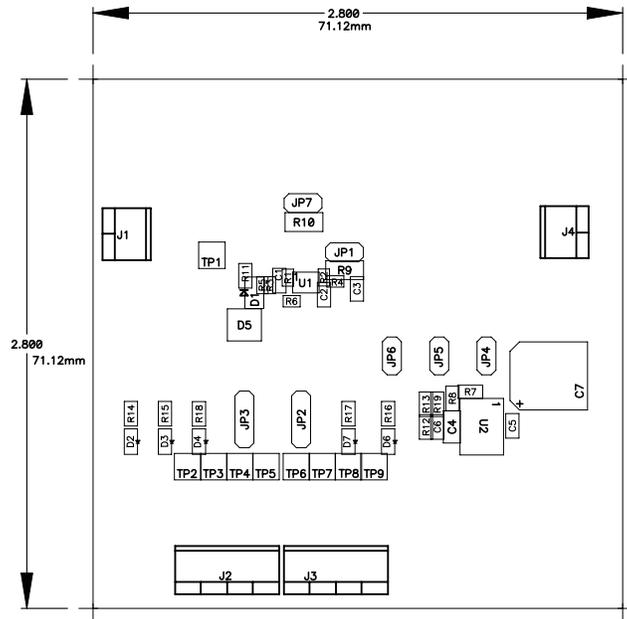


Figure 5. Top Assembly

4.3 Schematic

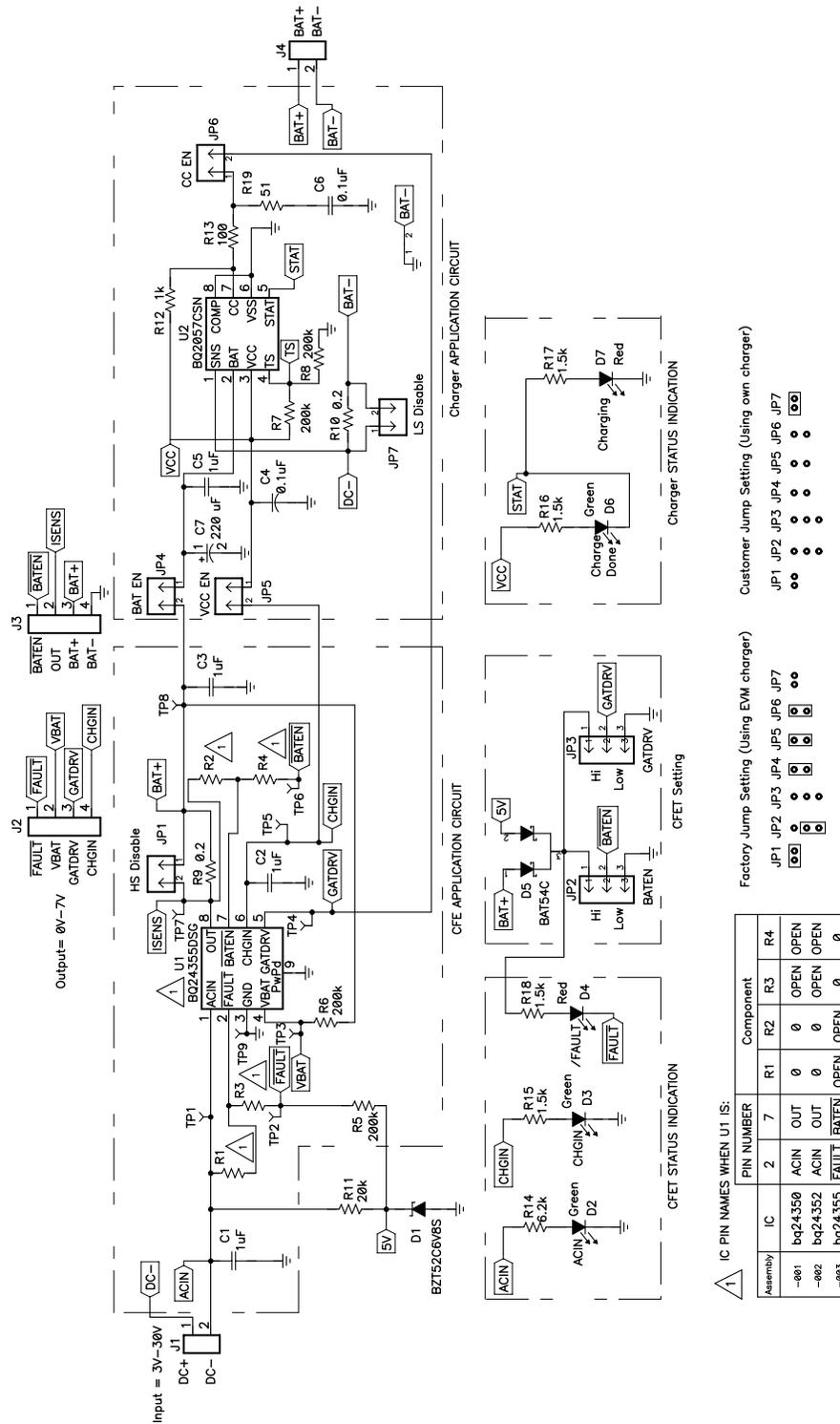


Figure 6. bq24355 Schematic

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 4.5 V to 26 V and the output voltage range of 0 V to 4.2 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 70°C. The EVM is designed to operate properly with certain components above 125°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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