

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

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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 <sup>(1)</sup>	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

<sup>(1)</sup> 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 <sup>(1)</sup>	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](#).

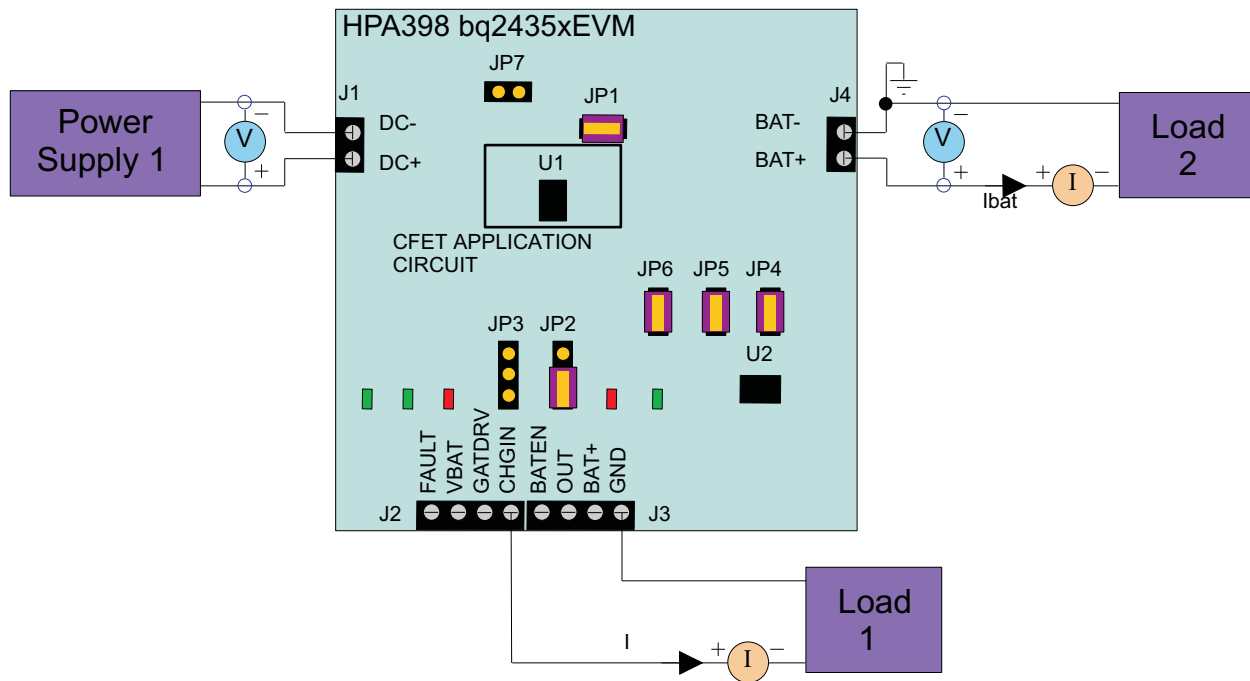


Figure 1. Original Test Setup for HPA398 (bq2435x DSG EVM)

## 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  $\rightarrow \text{D2 on, D3 on, D6 off, D7 on.}$

### 2.4.2 CFET Input Overvoltage Protection

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

### 2.4.3 CFET Load Overcurrent Protection

1. Enable the output of the Load 1.  
Observe  $\rightarrow \text{D2 on, D3 off, D6 off, D7 off.}$
2. Disable the output of the Load 1.  
Observe  $\rightarrow \text{D2 on, D3 on, D6 off, D7 on.}$
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**

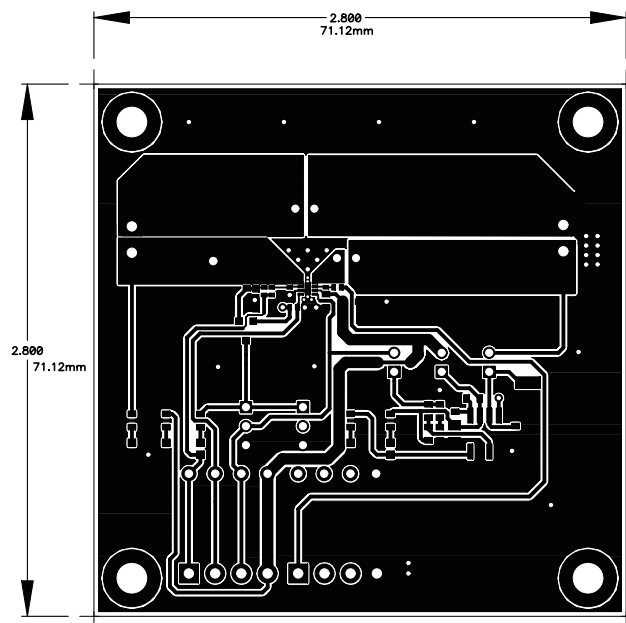
bq24350-001	bq24352-002	bq24355-003	RefDes	Value	Description	Size	Part Number	MFR
1	1	1	C1	1uF	Capacitor, Ceramic, 35V, X5R, 10%	603	Std	Std
3	3	3	C2, C3, C5	1uF	Capacitor, Ceramic, 10V, X7R, 10%	603	Std	Std
1	1	1	C4	0.1uF	Capacitor, Ceramic, 16V, X7R, 10%	805	Std	Std
1	1	1	C6	0.1uF	Capacitor, Ceramic, 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**

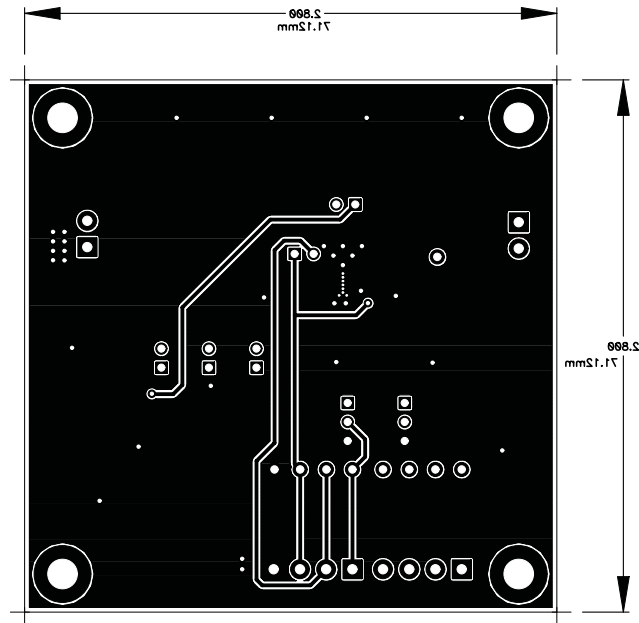


Figure 3. Bottom Layer

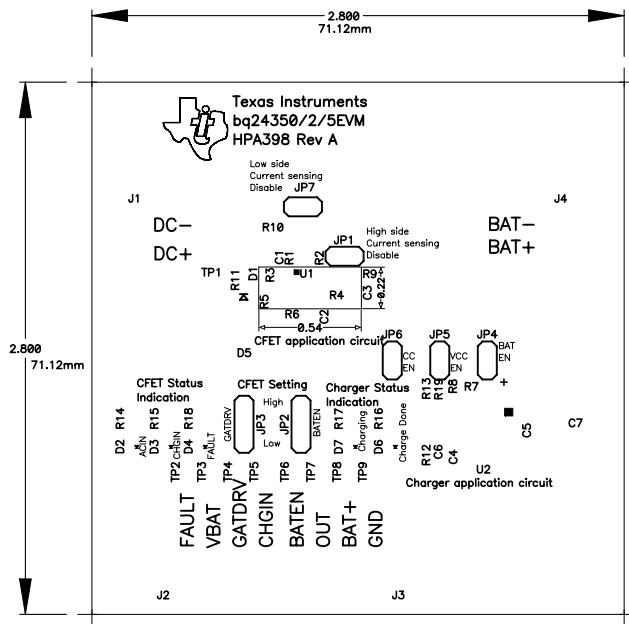


Figure 4. Top Silk Screen



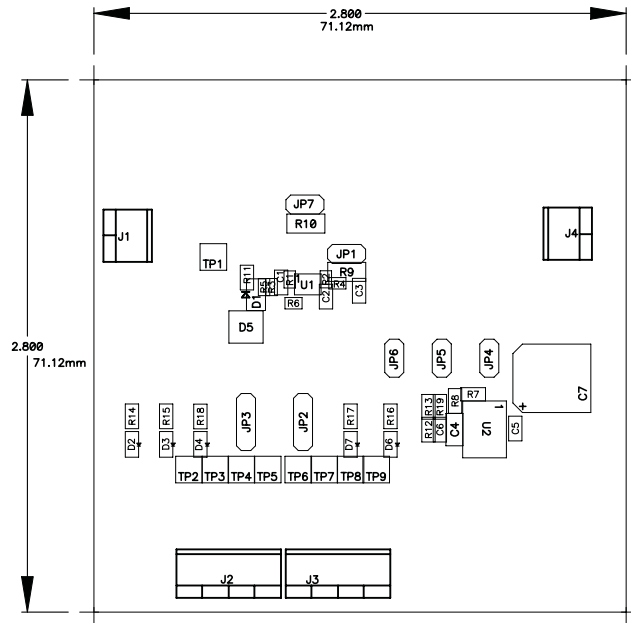


Figure 5. Top Assembly

4.3 Schematic

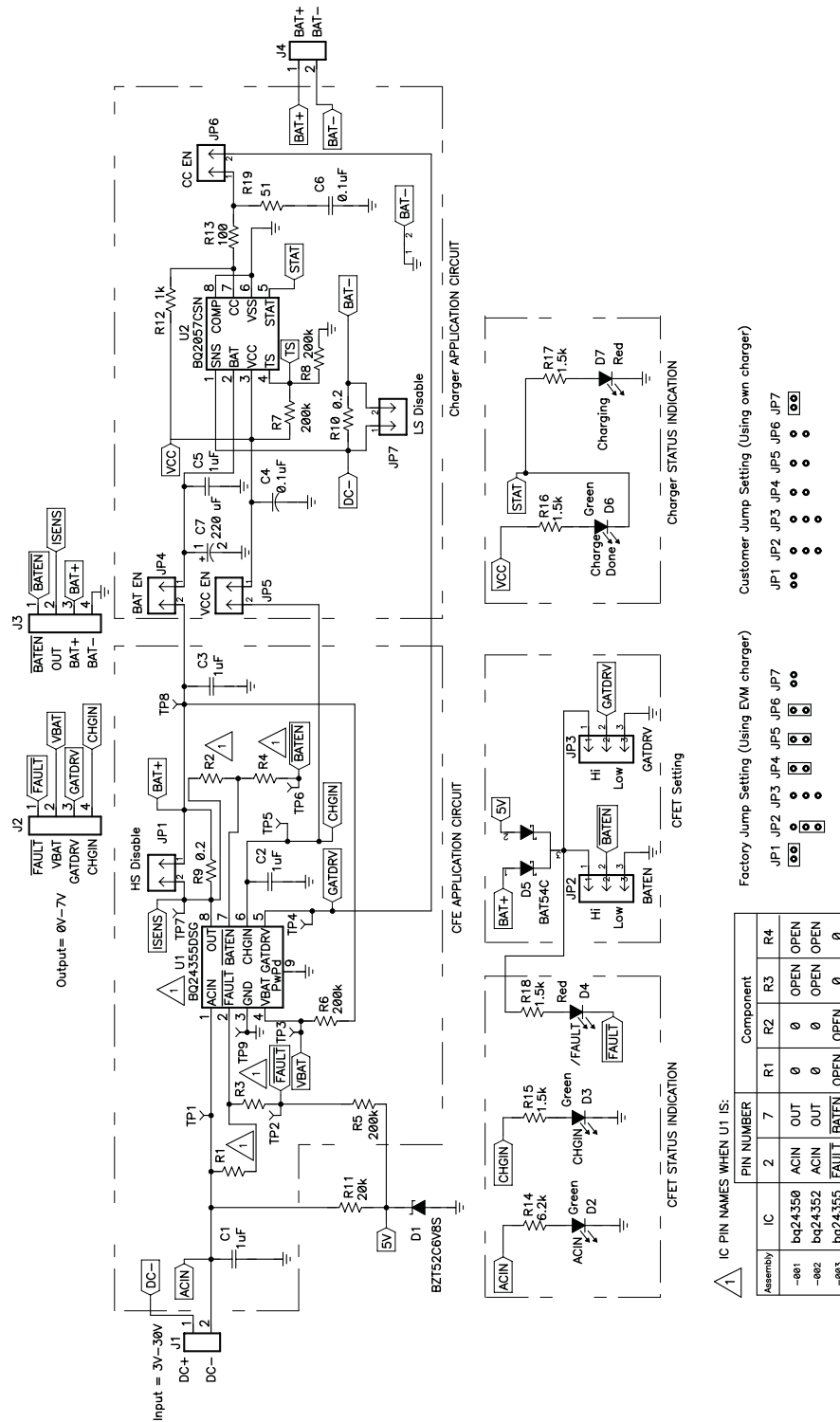


Figure 6. bq24355 Schematic

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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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RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

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Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
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