User's Guide
SLUU464–November 2010

bq24450EVM

This user's guide describes the features and operation of the bq24450EVM Evaluation Module (EVM). This EVM assists users in evaluating the bq24450 linear battery charger. The manual includes the bq24450EVM bill of materials, board layout, and schematic.

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1.1 EVM Features

- Evaluation module for bq24450 (HPA691)
- Charge controller for lead-acid batteries
- Constant current and constant voltage modes
- Accommodates external transistor in DPAK or TO-220 package
- Programmable charge current
- Pre-Charge for deeply discharged batteries

1.2 General Description

The bq24450 contains all the necessary circuitry to optimally control the charging of lead-acid batteries. The IC controls the charging current as well as the charging voltage to safely and efficiently charge the battery, maximizing battery capacity and life. Depending on the application, the IC can be configured as a simple constant-voltage float charge controller or a dual-voltage float-cum-boost charge controller.

The built-in precision voltage reference is especially temperature-compensated to track the characteristics of lead-acid cells, and maintains optimum charging voltage over an extended temperature range without using any external components. The low current consumption of the IC allows for accurate temperature monitoring by minimizing self-heating effects.

The IC can support a wide range of battery capacities and charging currents, limited only by the selection of the external pass transistor. The versatile driver for the external pass transistor provides at least 25mA of base drive.

In addition to the voltage- and current-regulating amplifiers, the IC features comparators that monitor the charging voltage and current. These comparators feed into an internal state machine that sequences the charge cycle. Some of these comparator outputs are made available as status signals at external pins of the IC. These status and control pins can be connected to a processor, or they can be connected up in flexible ways for standalone applications.

1.3 I/O Description and Jumper Functions

Table 1. I/O Description

Header	Description
J1 – Vin	Power Supply Positive
J2 – GND	Power Supply Negative
J3 – GND	Ground
J4 – Vout	Connected to Battery/System Load
J5 – GND	Ground

Jumper	**Description** **See Functions and Features section for more information.**
JP1	Connects I_{SNSM} for current sense for I_{TAPER}. It can connect I_{SNSM} to either side of the sense resistor, R4.
JP2	Connects I_{FB} for current sense for $I_{MAX.}$ It can connect I_{FB} to either side of the sense resistor, R4.
JP3	Selects the topology for the external transistor. The external transistor can be configured for either Common-Emitter topology or Quasi-Darlington topology.

1.4 Recommended Operating Conditions

Table 2. Recommended Operating Conditions

Symbol	Description	Min	Typ	Max	Unit
Vin, J1	Supply Voltage	9.5	10.0	10.5	V
Vout, J4	Battery Voltage (3-cell lead-acid battery)	4		7.5	V
Iin	Supply Current	0		0.5	A
Iout	Charge Current	0		0.5	A

2 Equipment

2.1 Power Supplies

Power Supply #1 (PS#1): Adjustable from 0 to ≥ 10 VDC at ≥ 1A; used for input J1.

Power Supply #2 (PS#2): Adjustable from 0 to ≥ 10 VDC at ≥ 1.5A; used for Battery Load Board.

2.2 Loads

Load #1: Battery Load Circuit Board, PR1010-2, as shown in Figure 2.

2.3 Meters

Three Fluke 75 DMMs (equivalent or better).

3 Equipment Setup

The original test setup of HPA691 is shown in Figure 1.

1. Set the PS #1 for 10V, 1A current limit and then turn off supply. Connect PS#1 across J1, J2 (VIN, GND).
2. Connect a voltage meter (VM #1) across J1, J2 (VIN, GND)
3. Set PS#2 to 5.2V and then turn off supply. Connect to the Battery Load Circuit Board (P/S+, P/S–)
4. Connect Load #1 (BAT+, BAT–) across J4, J5 (VOUT, GND).
5. Connect a voltage meter (VM#2) across J4, J5 (VOUT, GND).
6. Connect a voltage meter (VM#3) across sense resistor on Load #1.
7. Verify the jumpers are placed correctly as per, Figure 1.

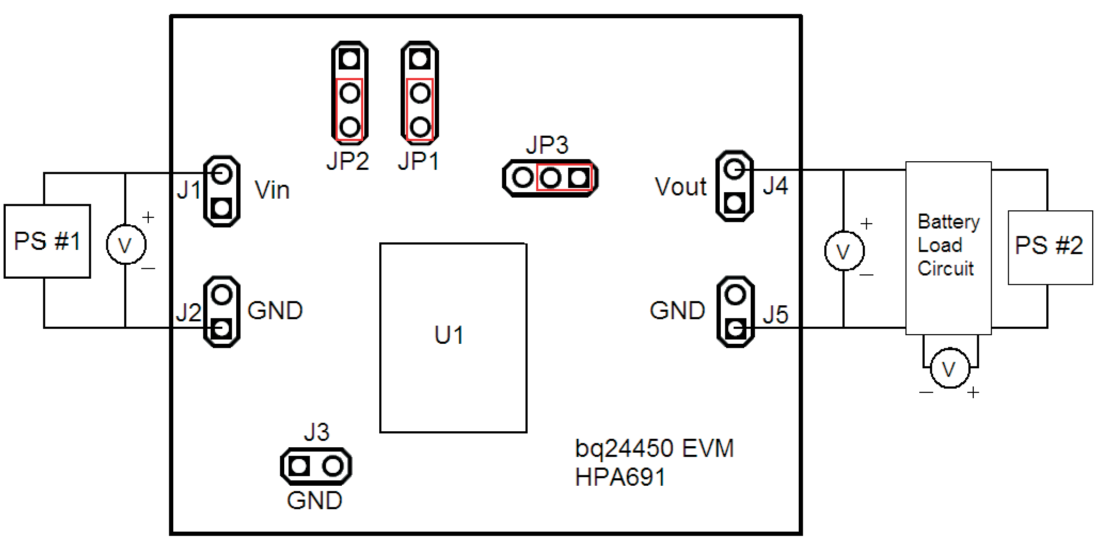

Figure 1. Original Test Setup for HPA691 (bq24450 EVM)

Replacement circuit for a 3-cell lead acid battery. BAT+ to BAT– voltage tracks the power supply input voltage, minus 1 diode drop

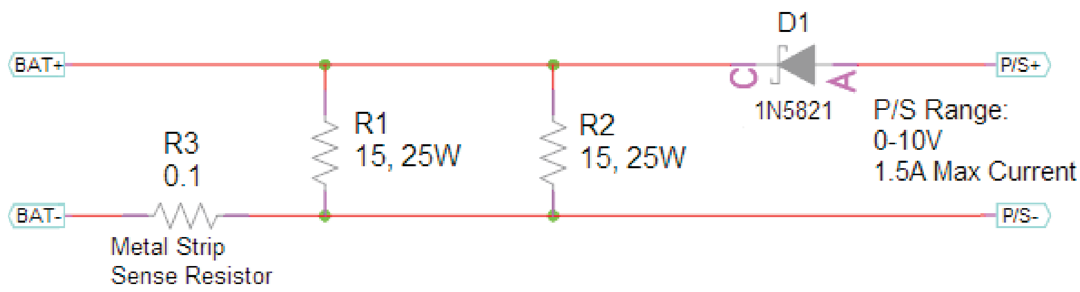

Figure 2. Battery Load Circuit – PR1010-2

4 Procedure

4.1 Pre-charge

Turn on PS #1, preset to 10 VDC. Verify voltage on VM #1.

Turn on PS #2, preset to 5.2 VDC.

Adjust PS #2 such that VM #2 shows 5 VDC.

Using VM #3, measure the voltage across the current sense resistor on Load #1. Multiply this value by a conversion factor of 10A/V. This is the pre-charge current.

4.2 Max Charge

Adjust PS #2 such that VM #2 shows 6 VDC.

Using VM #3, measure the voltage across the current sense resistor on Load #1. Multiply this value by a conversion factor of 10A/V. This is the max charge current.

4.3 Charge Termination

Adjust PS #2 such that VM #2 shows 7.5 VDC.

There should be no charge current in this condition.

4.4 Re-Charge

Adjust PS #2 such that VM #2 shows 6 VDC.

Using VM #3, measure the voltage across the current sense resistor on Load #1. Multiply this value by a conversion factor of 10A/V. This is the max charge current.

5 Functions and Features

5.1 Changing Output Voltage and Charge Current

This EVM is configured to charge a 3-Cell Lead Acid Battery with a maximum charge current of 450 mA. The EVM can be altered to charge lower or higher voltage batteries and can also be altered to have a lower or higher maximum charge current.

Power Dissipation
It is important to monitor the power dissipation in the external transistor, Q1.

> **WARNING**
>
> **Q1 and the surrounding area of the PCB may become hot.**

(Power Dissipation in Q1) = (Vin – Vout – 0.25 – 0.7) × Charge Current

With a large difference between Vin and Vbat, and/or a high charge current, there will be a significant amount of power dissipation in Q1. This causes both Q1 and the surrounding PCB to get hot. If any alterations are made to the EVM circuit, it is important to ensure a safe level of power dissipation in the external FET, Q1.

Changing Output Voltage
The output voltage may be altered by changing some on-board resistors (R7, R8, R9, R11, R12). See the bq24450 datasheet for information on how to size these resistors. If Vout is changed, Vin must also be changed. Vin should be high enough to allow for the necessary dropout (across R2, R4, Q1, and D1) and low enough to maintain a safe level of power dissipation.

Changing the Maximum Charge Current
The maximum charge current is set by sense resistor, R2. (Max Charge Current) = (0.25) / R2. Resistor R2 may be adjusted to set a different max charge current. However, more current will yield higher power dissipation in Q1. This may cause the board to become hot.

Changing Pre-Charge Current
Pre-Charge current is set by R10.

Pre-Charge Current = (Vin – 2 – Vout) / R10

Changing the value of Itaper

As populated, I_{TAPER} is 10% of $I_{Max\text{-}Chg}$. This is because V_{ILIM} is 250mV and V_{ISNS} is 25mV and both are being sensed across R2. If a different value of I_{TAPER} is desired, R4 can be populated (with a non-zero resistor) and JP1 and JP2 can be used to connect pins ISNSM and IFB to opposite sides of R4. See figure below.

$I_{MAX\text{-}CHG} = V_{ILIM} \div (R2 + R4)$
$I_{TAPER} = V_{ISNS} \div R2$

$I_{MAX\text{-}CHG} = V_{ILIM} \div R2$
$I_{TAPER} = V_{ISNS} \div (R2 + R4)$

Figure 3. Calculating the Value of I_{TAPER}

5.2 Options for External Transistor

Using a Transistor in a TO-220 package
The EVM is populated with a DPAK transistor for Q1. However, if desired, a TO-220 transistor can be used instead. Three holes have been placed in the PCB in parallel with the DPAK pad. Remove the DPAK transistor and replace it with a TO-220 transistor. The top hole is the base, the middle hole is the collector, and the bottom hole is the emitter.

Using a P-channel FET
The EVM is populated with a PNP transistor for Q1. However, if desired, a P-channel MOSFET may be used instead. In order to use a P-FET, a resistor must be populated on R5. Pin 16 of the BQ24450 will sink current through R5 and generate a negative gate to source voltage for the P-FET. By varying the sink current (and subsequently Vgs), the IC can accurately control the charge current. A 1kΩ resistor is suitable for R5.

Changing the topology
The EVM is configured with the Common-Emitter PNP topology. However, it can also be configured for the PNP in a Quasi-Darlington as described on page 13 of the datasheet. To make this change, the following steps should be taken:

1. Place jumper on JP3 such that it connects Pin 15 of the IC to the collector of Q1.
2. Remove R6 and replace with Rp as calculated on page 13 of the data sheet.

5.3 Other Options

Disabling Pre-Charge Mode
The EVM is populated to perform pre-charge on a deeply depleted battery. If pre-charge mode is not desired, it can be disabled by performing the steps below.

1. Populate R1 = 0 Ω
2. Remove R11 and R12
3. Populate R14 = R11 + R12 (For example: If R11 = 75kΩ and R12 = 16.9kΩ, R14 = 91.9kΩ)

PGOOD
As populated, the EVM uses PGOOD as part of the feedback divider (explained on page 11 of data sheet). If desired, PGOOD can be used to indicate the supply status on pin 5.

1. Remove R8 and place it on R15 pad.
2. Populate R13 with a pull-up resistor.

6 PCB Layout Guideline

It is important to pay special attention to the printed-circuit board (PCB) layout. The following provides some guidelines:

1. All low-current GND connections must be kept separate from the high-current charge or discharge paths from the battery. Use a single-point ground technique incorporating both the small signal ground path and the power ground path.

2. The high current charge paths into IN pin and from the OUT pin must be sized appropriately for the maximum charge current in order to avoid voltage drops in these traces.

7 Bill of Materials, Board Layouts and Schematic

7.1 Bill of Materials

Table 3. Bill of Materials

Reference Designator	Value	Description	Size	Part Number	MFR
C1, C4	Open	Capacitor, Ceramic	1206	Std	Std
C2, C5	1.0µF	Capacitor, Ceramic, 25V, X5R, 10%	603	Std	Std
C3	0.1µF	Capacitor, Ceramic, 25V, X7R, 10%	603	Std	Std
D1	ES2AA-13-F	Diode	SMA	ES2AA-13-F	Diodes, Inc.
Q1	MJD32CT4	Transistor, PNP	DPAK	MJD32CT4	ST
R1, R5, R13, R14, R15	Open	Resistor, Chip, 1/16W, 1%	603	Std	Std
R2	0.56Ω	Resistor, Chip, 1/2W, 1%	2010	STD	STD
R3, R6	0Ω	Resistor, Chip, 1/16W	603	Std	Std
R4	0Ω	Resistor, Chip, 1/2W	2010	CRCW20100000Z0EF	Vishay
R7	475kΩ	Resistor, Chip, 1/16W, 1%	603	Std	Std
R8	46.4kΩ	Resistor, Chip, 1/16W, 1%	603	Std	Std
R9	453Ω	Resistor, Chip, 1/16W, 1%	603	Std	Std
R10	187Ω	Resistor, Chip, 1/10W, 1%	603	Std	Std
R11	75.0kΩ	Resistor, Chip, 1/16W, 1%	603	Std	Std
R12	16.9kΩ	Resistor, Chip, 1/16W, 1%	603	Std	Std
R16	10.0kΩ	Resistor, Chip, 1/16W, 1%	603	Std	Std
U1	BQ24450D	IC, INTEGRATED CHARGE CONTROLLER FOR LEAD-ACID BATTERIES	SO-16	BQ24450D	TI

7.2 Board Layout

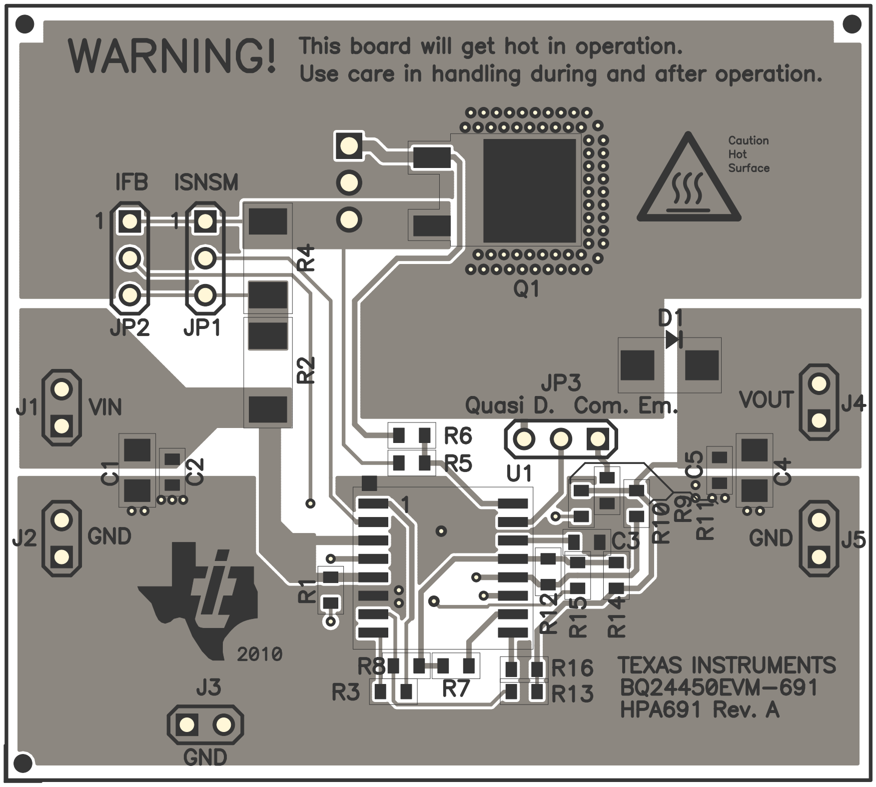

Figure 4. Top Assembly Layer

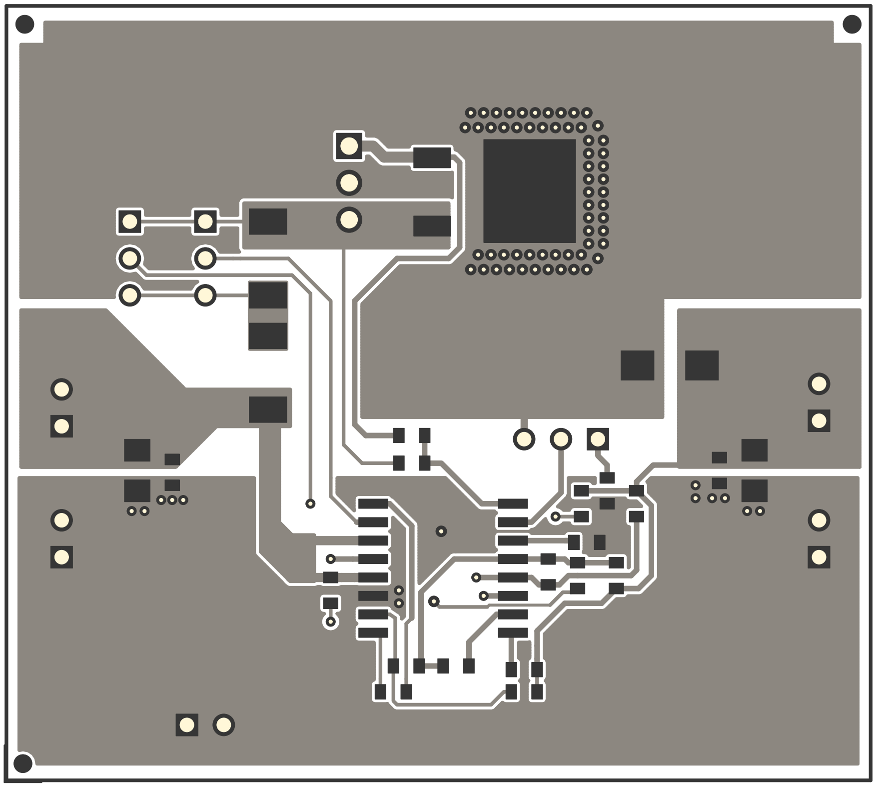

Figure 5. Top PCB Layer

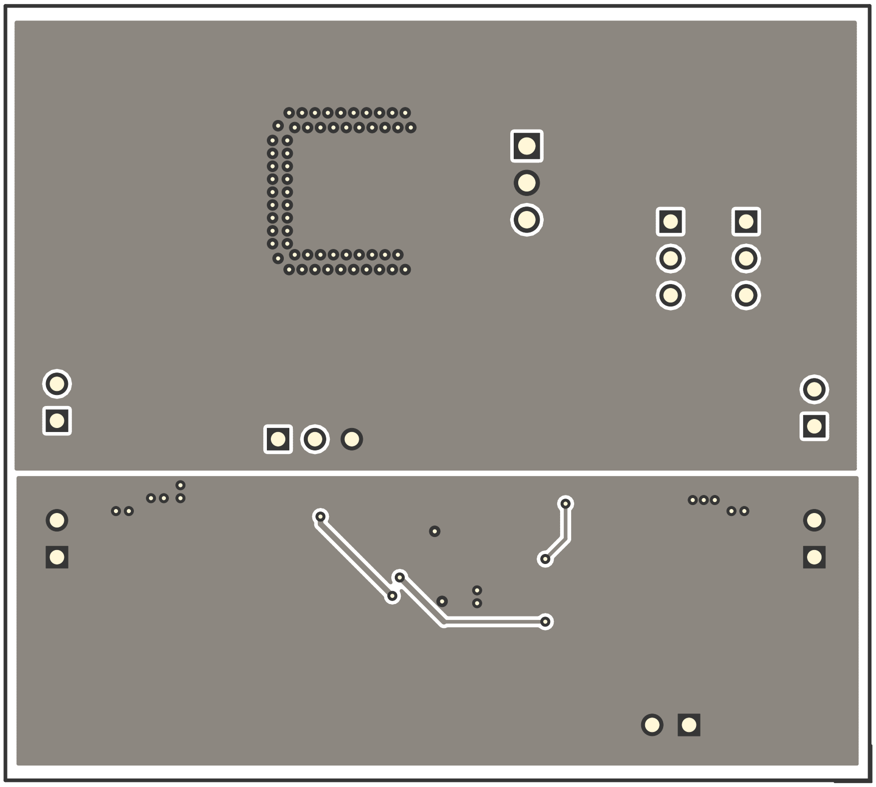

Figure 6. Bottom PCB Layer

7.3 Schematic

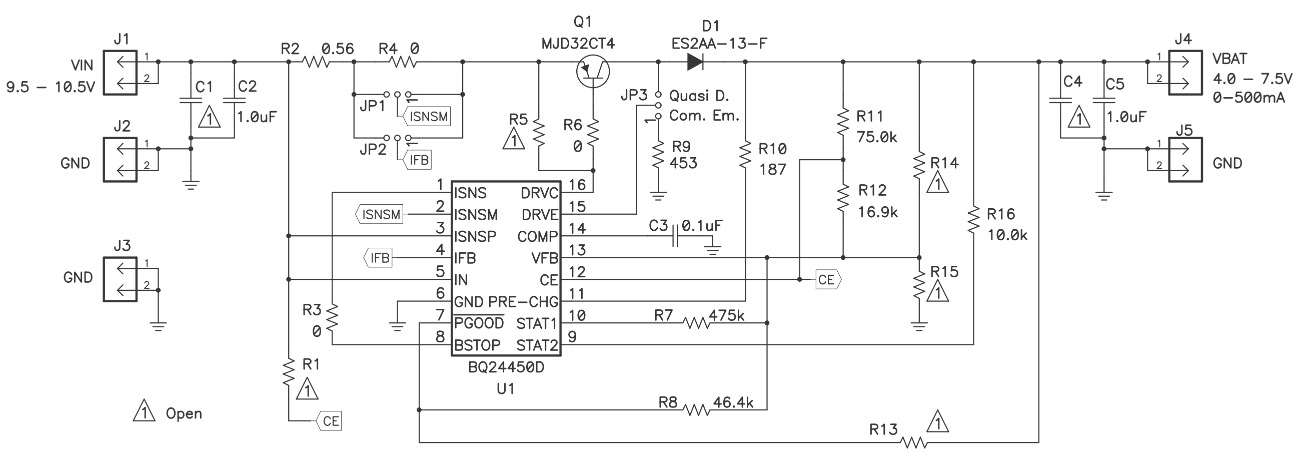

Figure 7. bq24450 EVM Schematic

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 9.5 V to 10.5 V and the output voltage range of 4 V to 7.5 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 75° C. The EVM is designed to operate properly with certain components above 75° 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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