*User's Guide*

# *BQ77207 Evaluation Module*


**ABSTRACT**

The BQ77207EVM evaluation module (EVM) is a complete evaluation system for the BQ77207, a 3-series to 7-series cell Li-Ion battery protection integrated circuit. The EVM consists of a BQ77207 circuit module which is used for simple evaluation of the BQ77207 protection function. The circuit module includes one BQ77207 integrated circuit (IC), thermistor, and all other onboard components necessary to signal the condition from overcharge, overdischarge, and overtemperature in a 7-series cell Li-Ion or Li-Polymer battery pack. The circuit module connects directly across the cells in a battery, or can be connected with a power supply and the included cell simulator resistors.


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# 1 Features

- Complete evaluation system for the BQ77207 3-series to 7-series cell Li-Ion and Phosphate battery protector
- Populated circuit module for 7-cell configuration for quick setup
- Resistor cell simulator for quick setup with only a power supply

## 1.1 Kit Contents

- BQ77207 circuit module

## 1.2 Ordering Information

For complete ordering information, refer to the product folder at www.ti.com/tool/BQ77207EVM.

**Table 1-1. Ordering Information**

| EVM Part Number | Chemistry | Configuration | Capacity |
|---|---|---|---|
| BQ77207EVM | Li-Ion | 7 cells | Any |

**Note**

Capacity is shown as *Any* since the board does not control current. If making additional connections monitor board currents and temperatures to operate within the limits of the components and laboratory environment. Refer to the physical construction section for board details.

## 1.3 BQ77207 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the BQ77207 circuit module in its default 7-series cell configuration.

Typical voltage depends on the number of cells configured. The board does not control current. If populating additional components limit currents to appropriate levels.

**Table 1-2. Performance Specification Summary**

| Specification | Min | Typ | Max | Unit |
|---|---|---|---|---|
| Input voltage BATT+ with respect to BATT– | 5 | – | 35 | V |
| Continuous current | 0 | - | 1 | A |
| Operating temperature range | 20 | 25 | 30 | °C |

## 1.4 Required Equipment

The following equipment is required to operate the BQ77207 EVM in a simple demonstration:

- DC power supply, 0 V to 32 V at 250 mA
- DC voltmeter
- Test leads to connect equipment

Additional equipment may be desired to operate the BQ77207 with a more extensive demonstration.



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# 2 BQ77207 EVM Getting Started Guide

## 2.1 Before You Begin

The following warnings and cautions are noted for the safety of anyone using or working close to the BQ77207EVM. Observe all safety precautions.

## 2.2 Warnings and Cautions

**CAUTION**

The BQ77207 does not limit performance to the ratings of the EVM. Set equipment appropriately to limit voltage and current for safe operation.

**CAUTION**

The circuit module has signal traces, components, and component leads on the bottom of the board. This may result in exposed voltages, warm surfaces, or sharp edges. Do not reach under the board during operation.

## 2.3 Quick Start

The BQ77207 installed on the board will output DOUT and/or COUT high during faults as described in the BQ77207 data sheet.

The BQ77207 is configured for cell count by the connections on the board. By default the board is set up for seven cells and this quick start is for all seven cells. When fewer cells are used, refer to Section 3 and adjust the supply voltage appropriately.

These steps describe quick connection of the BQ77207 EVM to demonstrate operation of the protector function of the EVM. For more detailed descriptions, refer to other sections of the user guide.

Refer to Figure 2-1 for the following steps:

1. Install the cell simulator shunts on J4 and the power supply shunt on J3.
2. Connect a 0-V DC power supply capable of approximately 250 mA between the “*BAT-*” and "*BAT+*" terminals and adjust to approximately 22 V.
3. Connect a meter to a VSS test point and monitor the COUT or DOUT test points, or the corresponding signals at J2 terminals 2 or 3.
4. With nominal conditions observe that both COUT (J2 pin 2) and DOUT (J2 pin 3) are low, approximately 0 V.
5. Demonstrate an open-wire condition:
   a. Remove the cell simulator shunt for cell 2, J4 pins 11 and 12.
   b. Observe the COUT and DOUT signals go to approximately 7 V after 4.5 seconds.
   c. Install the cell 2 cell simulator shunt at J4 pins 11 and 12.
6. Demonstrate an overvoltage condition:
   a. Adjust the supply voltage to approximately 32 V.
   b. Observe the COUT transitions to approximately 7 V after 1 second.
   c. Confirm DOUT is low if desired.
   d. Adjust the supply voltage to approximately 22 V.
7. Demonstrate an undervoltage condition:
   a. Adjust the supply voltage to approximately 12 V.
   b. Observe DOUT transitions to approximately 7 V after 1 second.
   c. Observe COUT is low if desired.
   d. Adjust the supply voltage to approximately 22 V.
8. Make other adjustments as desired for evaluation. See other sections of this user guide for details of operation.
9. When complete with this quick start demonstration, turn off the power supply.

Refer to other sections of this user guide for additional details.



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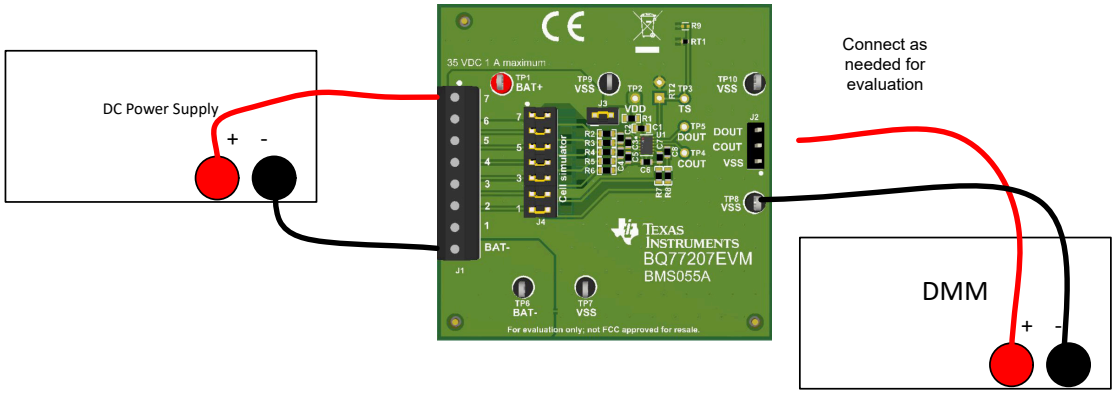


**Figure 2-1. EVM Connection for Basic Operation**


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# 3 BQ77207 Circuit Module Use

The BQ77207 circuit module contains the BQ77207 IC and related circuitry to demonstrate the features of the IC. The board does not control current, the COUT and DOUT signals pass directly to the J2 connector. J2 has no current limit or ESD protection on the signals, provide any necessary protection during evaluation external to the EVM. J3 provides a method to separate the supply feed from the input terminal block to measure current or to apply a voltage for customer test mode. A thermistor provides temperature sensing on the board. Other components provide support for the IC and connections to the board. Basic operation is described in the BQ77207 EVM Getting Started Guide section. For details of the circuit, refer to the BQ77207EVM Circuit Module Physical Construction section.

## 3.1 Cell Simulator

The EVM includes a resistive cell simulator made up of 499-Ω series resistors. The taps of the resistor network are connected to the cell inputs using shunts on the J4 header. BAT- is always connected to the resistor divider network. Install a shunt on the top cell location to connect BAT+ to the resistor divider to provide simulated voltages for the other cell inputs. With the top shunt installed the resistor divider is connected and shunts on the lower cell positions connect the inputs to the simulated voltages. With the top shunt removed all lower inputs with installed shunts are pulled to VSS. There is no indication of the cell simulator connection, the user must be aware of the shunt installation. The 499-Ω resistors provide a load of 2 mA per volt on each cell.

## 3.2 Reducing the Cell Count

The BQ77207 cell count is reduced by shorting unused cells, normally from the top down but cells between the top and bottom may be shorted. The inputs are usually shorted at the IC as shown in the data sheet. The bottom cell must be used for proper operation. Power for the IC comes from the BAT+ terminal so it must be connected when using the EVM. While not recommended the inputs of the EVM can typically be shorted at the terminal block for quick evaluation. For the best transient environment and to match the data sheet example, short the VCx pins at the capacitor and remove the unused input resistor. When using the cell simulator, shorting the unused cell at the terminal block is still required to eliminate the simulated cell voltage. Shorting the cell inputs at the terminal block screw terminals is also suggested since it should be apparent if the board is reused for a different cell count. While different connections are possible, Table 3-1 shows configuration recommendations for five cells.

**Table 3-1. Reducing Cell Count**

| Unused Cell (Numbered from Bottom Cell 1) | Short Cell Input Terminals | Input Resistor to Remove | Replace Capacitor with 0 Ω | IC Inputs Shorted |
|---|---|---|---|---|
| Cell 7 | BAT+ to CELL6 | R2 | C2 | VC7 to VC6 |
| Cell 6 | CELL6 to CELL5 | R3 | C3 | VC6 to VC5 |

## 3.3 Connecting Cells

The EVM is constructed with a single connection to the top and bottom of the cell stack. Cell voltage for these cells is sensed on the board. The board is not configured to control current into or out of the cells.

The cell simulator provides resistors between the cell inputs. When the cell simulator shunts are installed, these resistors will load the cells and divide the voltage to any unconnected inputs as cells are connected. The shunts must be removed or the cells will be discharged by the constant drain of the cell simulator resistors.

BAT- is the reference voltage for the IC and should be connected first. After BAT-, cells may be connected in any order. Cell connection from the bottom up minimizes the voltage step size applied to the board. The recommended connection sequence for the EVM when connecting cells is bottom up:

1. Connect BAT–
2. Connect cells bottom up; CELL1, CELL2, CELL3 ...
3. Ensure the cell simulator shunts are removed



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## 3.4 Hardware Configuration

### 3.4.1 Unused Components

The EVM contains a few component patterns which are not used. RT1 is installed as the thermistor. If RT1 is removed, an alternate may be installed at the R9 pattern or a through-hole thermistor may be installed at RT2. With an appropriate part a suitable PTC could be installed at either pattern. See the schematic in Figure 4-7.


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# 4 BQ77207EVM Circuit Module Physical Construction

This section contains the PCB layout, bill of materials, and schematic of the BQ77207EVM circuit module.

The BQ77207EVM consists of one circuit module assembly, BMS055.

## 4.1 Board Layout

The BQ77207EVM circuit module is a 2.2-inch × 2.2-inch 2-layer circuit card assembly. It is designed for easy assembly with cell connections on the left edge to a terminal block. Output terminals are on the right edge using a header. The EVM layout and construction allows easy understanding of the connections and access to the test points for evaluation.

See additional information in the configuration and operation sections of this document. Figure 4-1 to Figure 4-6 show the board layout.

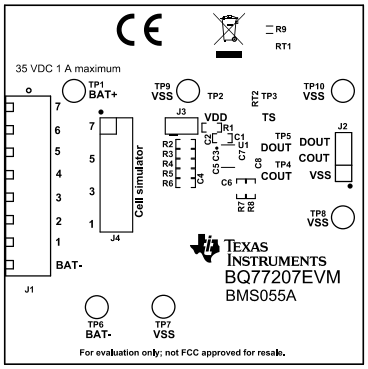


**Figure 4-1. Top Silk Screen**

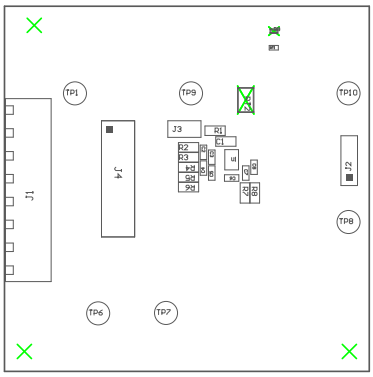

**Figure 4-2. Top Assembly**

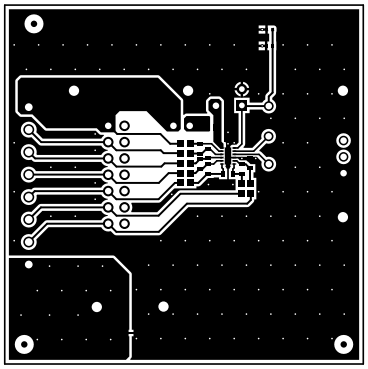

**Figure 4-3. Top Layer**



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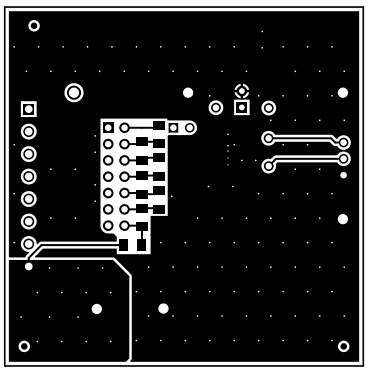

**Figure 4-4. Bottom Layer**

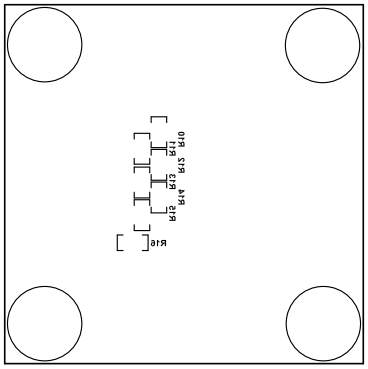

**Figure 4-5. Bottom Silk Screen**

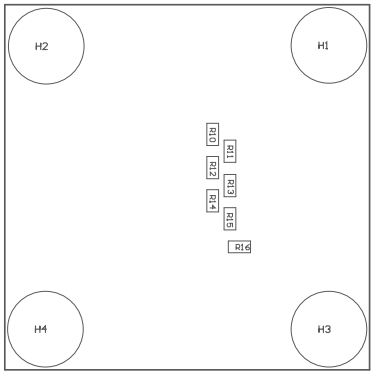


**Figure 4-6. Bottom Assembly**


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## 4.2 Bill of Materials

The bill of materials for the circuit module is shown in Table 4-1. Substitute parts may be used in the manufacturing of the assembly.

**Table 4-1. BQ77207 Circuit Module Bill of Materials**

| Designator | Quantity | Value | Part Number | Manufacturer | Description | Package Reference |
|---|---|---|---|---|---|---|
| !PCB1 | 1 | | BMS055 | Any | Printed Circuit Board | |
| C1 | 1 | 0.1uF | CAP, CERM, 0.1 uF, 100 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603 | 603 | GCJ188R72A104KA01D | MuRata |
| C2, C3, C4, C5, C6, C7, C8 | 7 | 0.1uF | CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603 | 603 | 8.85012E+11 | Wurth Elektronik |
| H1, H2, H3, H4 | 4 | | Bumpon, Hemisphere, 0.44 X 0.20, Clear | Transparent Bumpon | SJ-5303 (CLEAR) | 3M |
| J1 | 1 | | Terminal Block, 8x1, 3.5mm, TH | 8x1 Terminal Block | OSTTE080161 | On-Shore Technology |
| J2 | 1 | | Header, 100mil, 3x1, Tin, TH | Header, 3 PIN, 100mil, Tin | PEC03SAAN | Sullins Connector Solutions |
| J3 | 1 | | Header, 100mil, 2x1, Tin, TH | Header, 2 PIN, 100mil, Tin | PEC02SAAN | Sullins Connector Solutions |
| J4 | 1 | | Header, 100mil, 7x2, Tin, TH | Header, 7x2, 100mil, Tin | PEC07DAAN | Sullins Connector Solutions |
| R1 | 1 | 300 | RES, 300, 5%, 0.1 W, AEC-Q200 Grade 0, 0603 | 603 | CRCW0603300RJNEA | Vishay-Dale |
| R2, R3, R4, R5, R6, R7, R8 | 7 | 1.0k | RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603 | 603 | CRCW06031K00JNEA | Vishay-Dale |
| R10, R11, R12, R13, R14, R15, R16 | 7 | 499 | RES, 499, 1%, 0.25 W, AEC-Q200 Grade 0, 1206 | 1206 | ERJ-8ENF4990V | Panasonic |
| RT1 | 1 | 10k | Thermistor NTC, 10.0k ohm, 1%, 0402 | 402 | NCP15XH103F03RC | MuRata |
| SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8 | 8 | 1x2 | Shunt, 100mil, Gold plated, Black | Shunt | SNT-100-BK-G | Samtec |
| TP1 | 1 | | Test Point, Multipurpose, Red, TH | Red Multipurpose Testpoint | 5010 | Keystone |
| TP6, TP7, TP8, TP9, TP10 | 5 | | Test Point, Multipurpose, Black, TH | Black Multipurpose Testpoint | 5011 | Keystone |



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**Table 4-1. BQ77207 Circuit Module Bill of Materials (continued)**

| Designator | Quantity | Value | Part Number | Manufacturer | Description | Package Reference |
|---|---|---|---|---|---|---|
| U1 | 1 | | Voltage and Temperature Protection for 3-Series to 7-Series Cell Li-Ion Batteries with Internal Delay Timer | WSON12 | BQ7720700DSSR | Texas Instruments |
| FID1, FID2, FID3 | 0 | | Fiducial mark. There is nothing to buy or mount. | N/A | N/A | N/A |
| R9 | 0 | 1kΩ | THERMISTOR PTC 1K OHM 5% 0402 | 402 | PRF15AR102RB6RC | Murata |
| RT2 | 0 | 10k | Thermistor NTC, 10.0k ohm, 1%, Disc, 5x8.4 mm | Disc, 5x8.4 mm | 103AT-2 | SEMITEC Corporation |

## 4.3 Schematics

Figure 4-7 and Figure 4-8 illustrate the schematics.

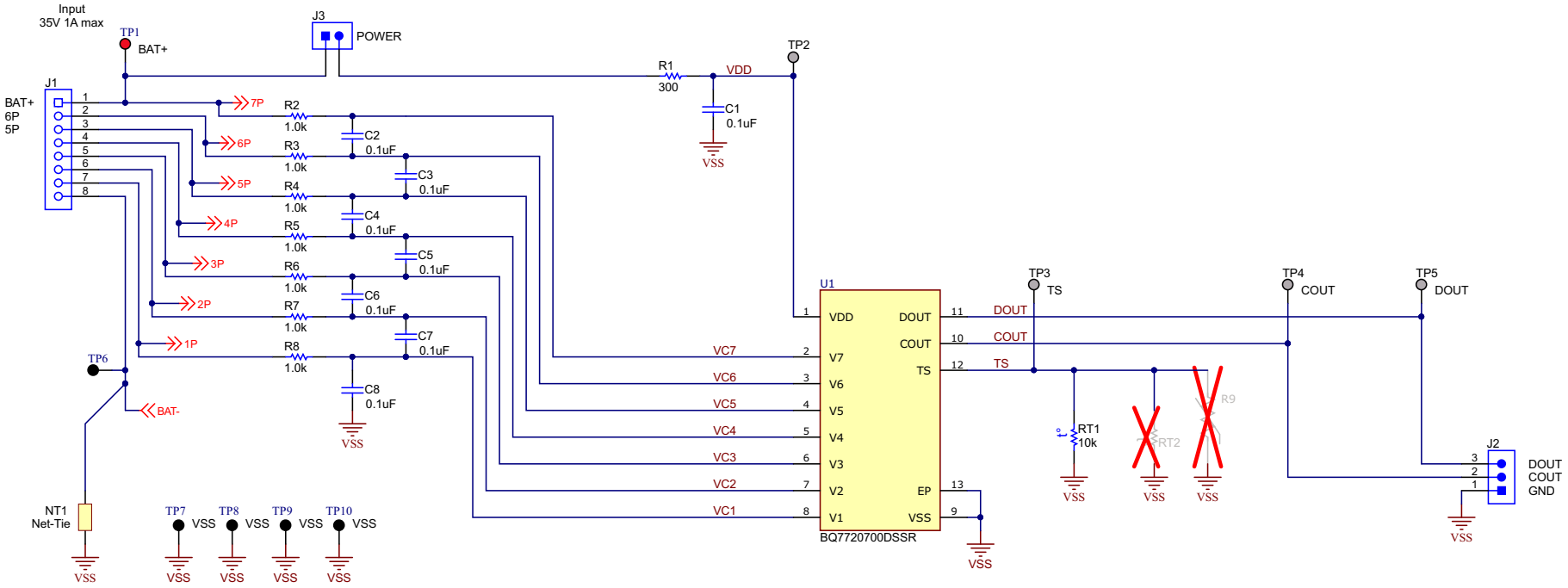


**Figure 4-7. Schematic Diagram**



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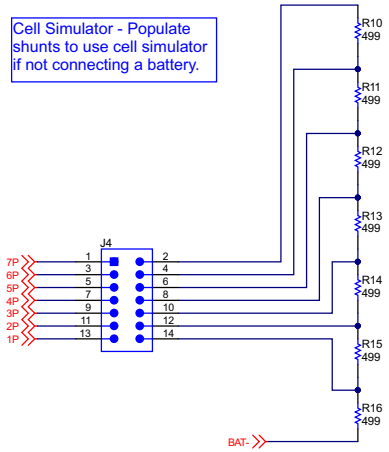


**Figure 4-8. Cell Simulator**



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## 5 Related Documents from Texas Instruments

- Texas Instruments, BQ77207 *Voltage and Temperature Protection for 3-Series to 7-Series Cell Li-Ion Batt w/ Int Delay Timer* data sheet

## 6 Revision History

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

| DATE | REVISION | NOTES |
|---|---|---|
| October 2021 | * | Initial Release |


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