User's Guide

BQ77216 Evaluation Module

Willy Massoth

ABSTRACT

The BQ77216EVM evaluation module (EVM) is a complete evaluation system for the BQ77216, a 3-cell to 16-cell Li-Ion battery protection integrated circuit. The EVM consists of a BQ77216 circuit module which is used for simple evaluation of the BQ77216 protection function. The circuit module includes one BQ77216 integrated circuit (IC), thermistor, and all other onboard components necessary to signal the condition from overcharge, overdischarge, and overtemperature in a 16-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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Trademarks

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1 Features

- Complete evaluation system for the BQ77216 3-cell to 16-cell Li-Ion and Phosphate battery protector
- Populated circuit module for 16-cell configuration for quick setup
- Resistor cell simulator for quick setup with only a power supply

1.1 Kit Contents

- BQ77216 circuit module

1.2 Ordering Information

For complete ordering information, refer to the product folder at www.ti.com/tool/BQ77216EVM.

Table 1-1. Ordering Information

EVM Part Number	Chemistry	Configuration	Capacity
BQ77216EVM	Li-Ion	16 cells	Any

Note

Capacity is shown as *Any* since the board does not control current as delivered. If using available component patterns 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 BQ77216 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the BQ77216 circuit module in its default 16-cell series FET 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	–	71	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 BQ77216 EVM in a simple demonstration:

- DC power supply, 0–71 V at 1 A
- DC voltmeter
- Test leads to connect equipment

Additional equipment may be desired to operate the BQ77216 with a more extensive demonstration.

2 BQ77216 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 BQ77216 EVM. Observe all safety precautions.

2.2 Warnings and Cautions

Warning

The BQ77216EVM is not rated as a high voltage EVM, has smaller clearances than normally used on high voltage boards and does not have an isolation boundary. If you apply high voltage to this board, all terminals should be considered high voltage. Electric shock is possible when connecting the board to live wire. The board should be handled with care by a professional. For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

Caution

Do not leave the EVM powered when unattended.

CAUTION

The BQ77216 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, hot surfaces or sharp edges. Do not reach under the board during operation.

CAUTION

The circuit module may be damaged by over temperature. To avoid damage, monitor the temperature during evaluation and provide cooling, as needed, for your system environment. Do not operate beyond the current and voltage limits in the Sepcification Table.

CAUTION

Some power supplies can be damaged by application of external voltages. If using more than 1 power supply, check your equipment requirements and use blocking diodes or other isolation techniques, as needed, to prevent damage to your equipment.

CAUTION

Connections for rated current must be made at the terminal block. Test points are not rated for the board current.

2.3 Quick Start

The BQ77216 is configured for cell count by the connections on the board. By default the board is set up for 16 cells and this quick start is for all 16 cells. When fewer cells are used, refer to Section 3 and adjust the supply voltage appropriately.

These steps describe quick connection of the BQ77216 EVM to demonstrate operation of the protector function 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.

2. Connect a 0-V DC power supply capable of 250 mA minimum between the "*BAT-*" and "*BAT+*" terminals and adjust to approximately 45 V.
3. Connect a meter to a VSS test point and monitor the COUT or DOUT test points, or the corresponding signals at J4 terminals 4 or 5.
4. Observe that both the COUT (J4 pin 4) and DOUT (J4 pin 5) are low, approximately 0 V.
5. Remove the cell simulator shunt for cell 2, J6 pins 17 and 18.
6. Observe the COUT and DOUT signals are low.
7. Install the cell 2 cell simulator shunt at J6 pins 17 and 18.
8. Adjust the supply voltage to approximately 71 V. Observe the COUT transitions to approximately 7 V after 4 seconds. Confirm DOUT remains low if desired.
9. Adjust the supply voltage to approximately 31 V. Observe DOUT is approximately 7 V after 4 seconds as the part transitions to UV mode. Observe COUT is low if desired.
10. Make other adjustments as desired for evaluation. See other sections of this user guide for details of operation.
11. When complete with this quick start demonstration, turn off the power supply.

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

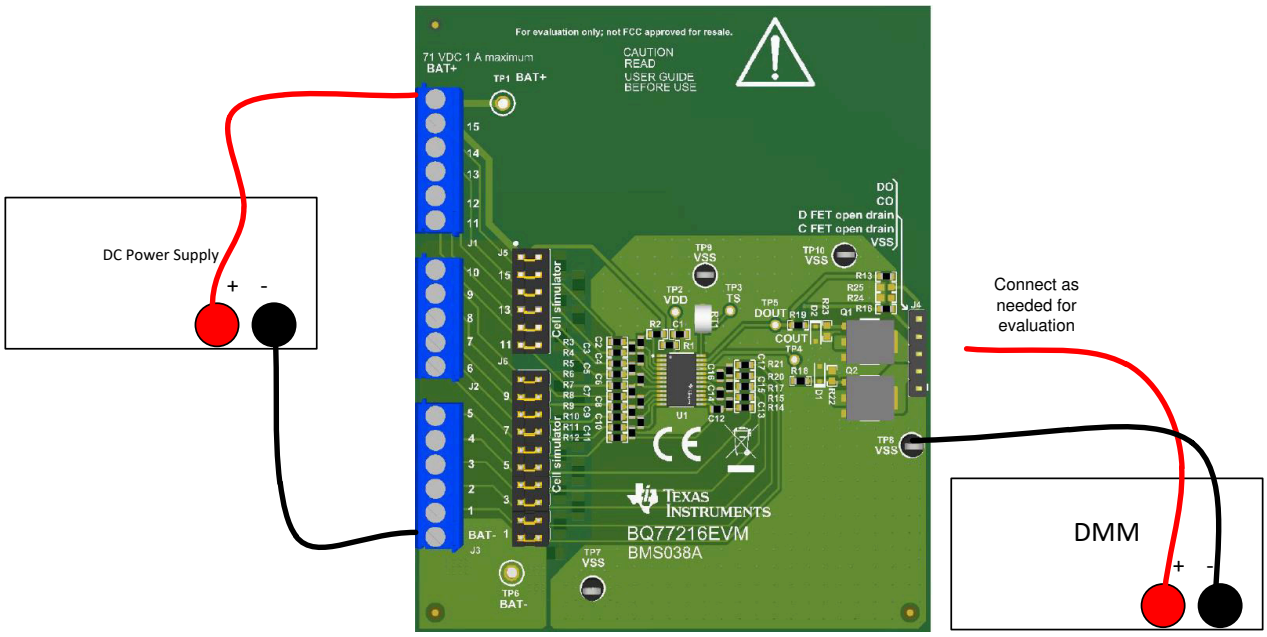

Figure 2-1. EVM Connection for Basic Operation

3 BQ77216 Circuit Module Use

The BQ77216 circuit module contains the BQ77216 IC and related circuitry to demonstrate the features of the IC. The board does not control current, the COUT and DOUT signals pass through 100 ohm resistors and are available on the J4 connector. COUT and DOUT are also used to control the gate of N-channel FETs, the open drain outputs are also available on J4. 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 BQ77216 EVM Getting Started Guide section. For details of the circuit, refer to the BQ77216EVM 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 J5 and J6 headers. BAT- is always connected to the resistor divider network. Install a shunt on the top cell location to connect the 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 will 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 BQ77216 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 re-used for a different cell count. While different connections are possible, Table 3-1 shows configuration recommendations for 14 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 ohm	IC Inputs Shorted
Cell 16	BAT+ to CELL15	R2	C2	VC16 to VC15
Cell 15	CELL15 to CELL14	R3	C3	VC15 to VC14

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. Recommended connection sequence for the EVM when connecting cells is bottom up:

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

3.4 Hardware Configuration

3.4.1 Unused Components

The EVM contains several component patterns which are not used. Components could be populated to divide the voltage to the J4 output connector or limit the voltage to the signal FETs. Adjustments to installed resistors may be needed to divide voltages. If using these patterns for evaluation monitor the temperature of the board and limit current as needed. See the schematic in Figure 4-7.

4 BQ77216EVM Circuit Module Physical Construction

This section contains the PCB layout, bill of materials, and schematic of the BQ77216EVM circuit module.

The BQ77216EVM consists of one circuit module assembly, BMS038.

4.1 Board Layout

The BQ77216EVM circuit module is a 3.0-inch × 3.6-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.

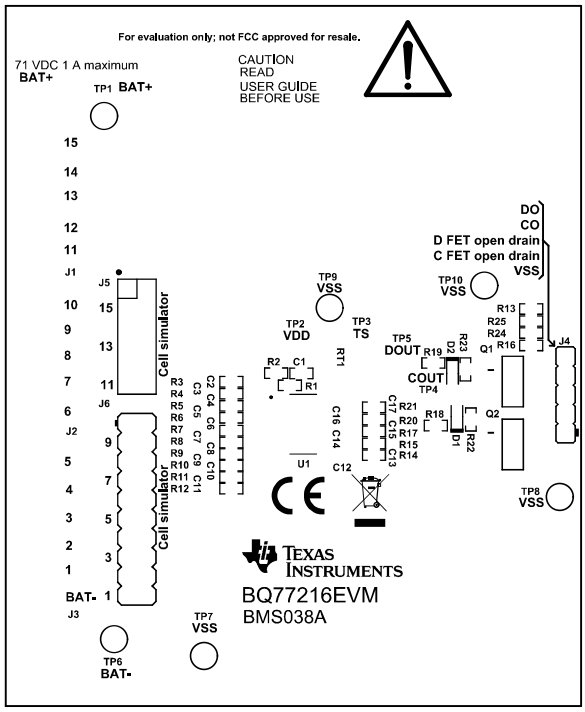

Figure 4-1. Top Silk Screen

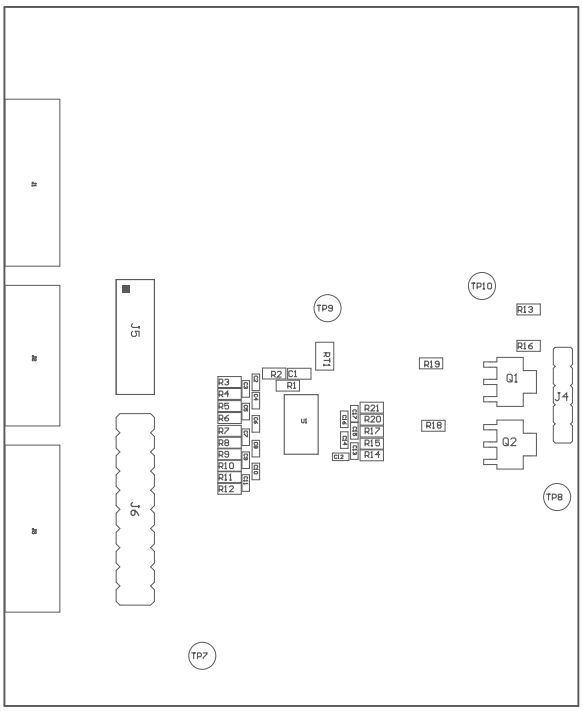

Figure 4-2. Top Assembly

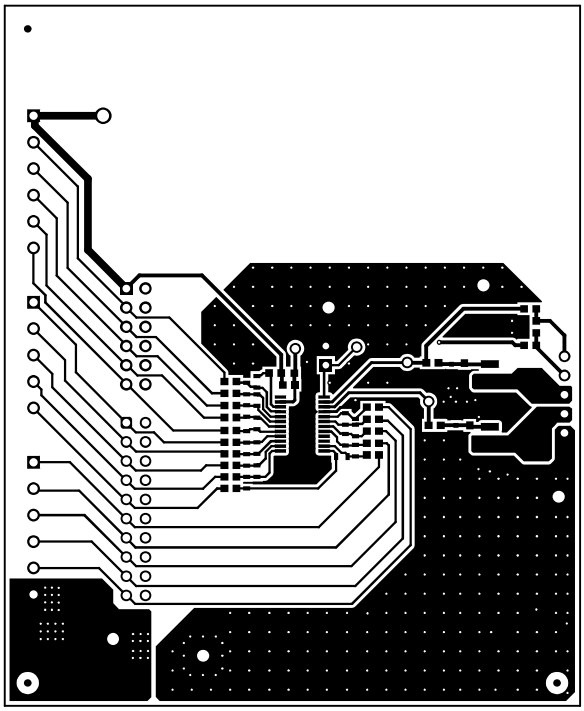

Figure 4-3. Top Layer

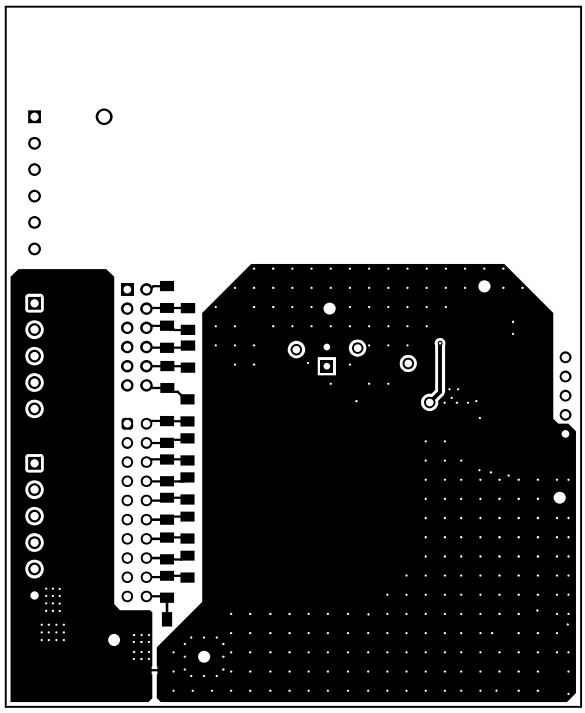

Figure 4-4. Bottom Layer

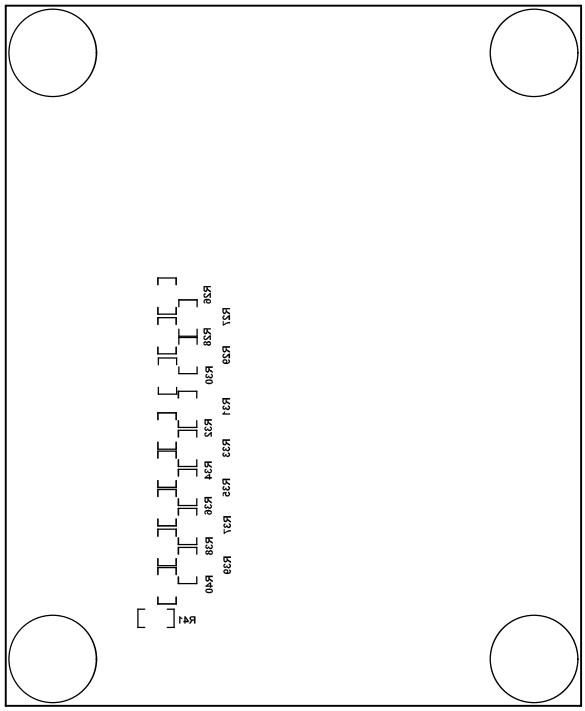

Figure 4-5. Bottom Silk Screen

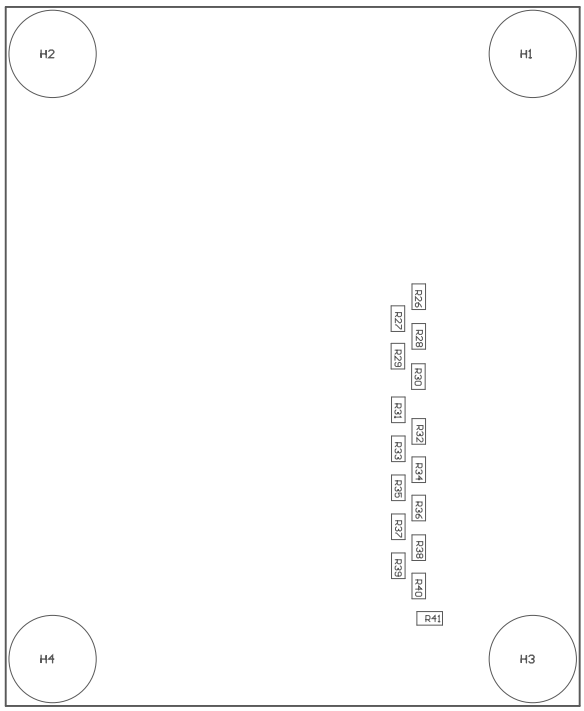

Figure 4-6. Bottom Assembly

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. BQ77216 Circuit Module Bill of Materials

Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReference
!PCB1	1		BMS038	Any	Printed Circuit Board	
C1	1	0.1uF	GCJ188R72A104KA01D	MuRata	CAP, CERM, 0.1 uF, 100 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	603
C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17	16	0.1uF	885012206095	Wurth Elektronik	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	603
H1, H2, H3, H4	4		SJ-5303 (CLEAR)	3M	Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon
J1, J3	2		OSTTE060161	On Shore Technology	TERM BLOCK 3.5MM VERT 6POS PCB	HDR6
J2	1		OSTTE050161	On Shore Technology	TERM BLOCK 3.5MM VERT 5POS PCB	HDR5
J4	1		PEC05SAAN	Sullins Connector Solutions	Header, 2.54mm, 5x1, Tin, TH	Header, 2.54mm, 5x1, TH
J5	1		PEC06DAAN	Sullins Connector Solutions	Header, 100mil, 6x2, Tin, TH	Header, 6x2, 100mil, Tin
J6	1		PEC10DAAN	Sullins Connector Solutions	Header, 2.54mm, 10x2, Tin, TH	Header, 10x2, 2.54mm, TH
Q1, Q2	2	100V	FDT86113LZ	Fairchild Semiconductor	MOSFET, N-CH, 100 V, 3.3 A, SOT-223	SOT-223
R1	1	300	CRCW0603300RJNEA	Vishay-Dale	RES, 300, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603
R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R14, R15, R17, R20, R21	16	1.0k	CRCW06031K00JNEA	Vishay-Dale	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603
R13, R16, R18, R19	4	100	CRCW0603100RJNEA	Vishay-Dale	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603
R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R37, R38, R39, R40, R41	16	499	ERJ-8ENF4990V	Panasonic	RES, 499, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206
RT1	1	10k	103AT-2	SEMITEC Corporation	Thermistor NTC, 10.0k ohm, 1%, Disc, 5x8.4 mm	Disc, 5x8.4 mm

Table 4-1. BQ77216 Circuit Module Bill of Materials (continued)

Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReference
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11, SH-J12, SH-J13, SH-J14, SH-J15, SH-J16	16	1x2	SNT-100-BK-G	Samtec	Shunt, 100mil, Gold plated, Black	Shunt
TP7, TP8, TP9, TP10	4		5006	Keystone	Test Point, Compact, Black, TH	Black Compact Testpoint
U1	1		BQ7721602PWR	Texas Instruments	Voltage and Temperature Protection for 3-Series to 16-Series Cell Li-Ion Batteries with Internal Delay Timer	TSSOP24

4.3 Schematics

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

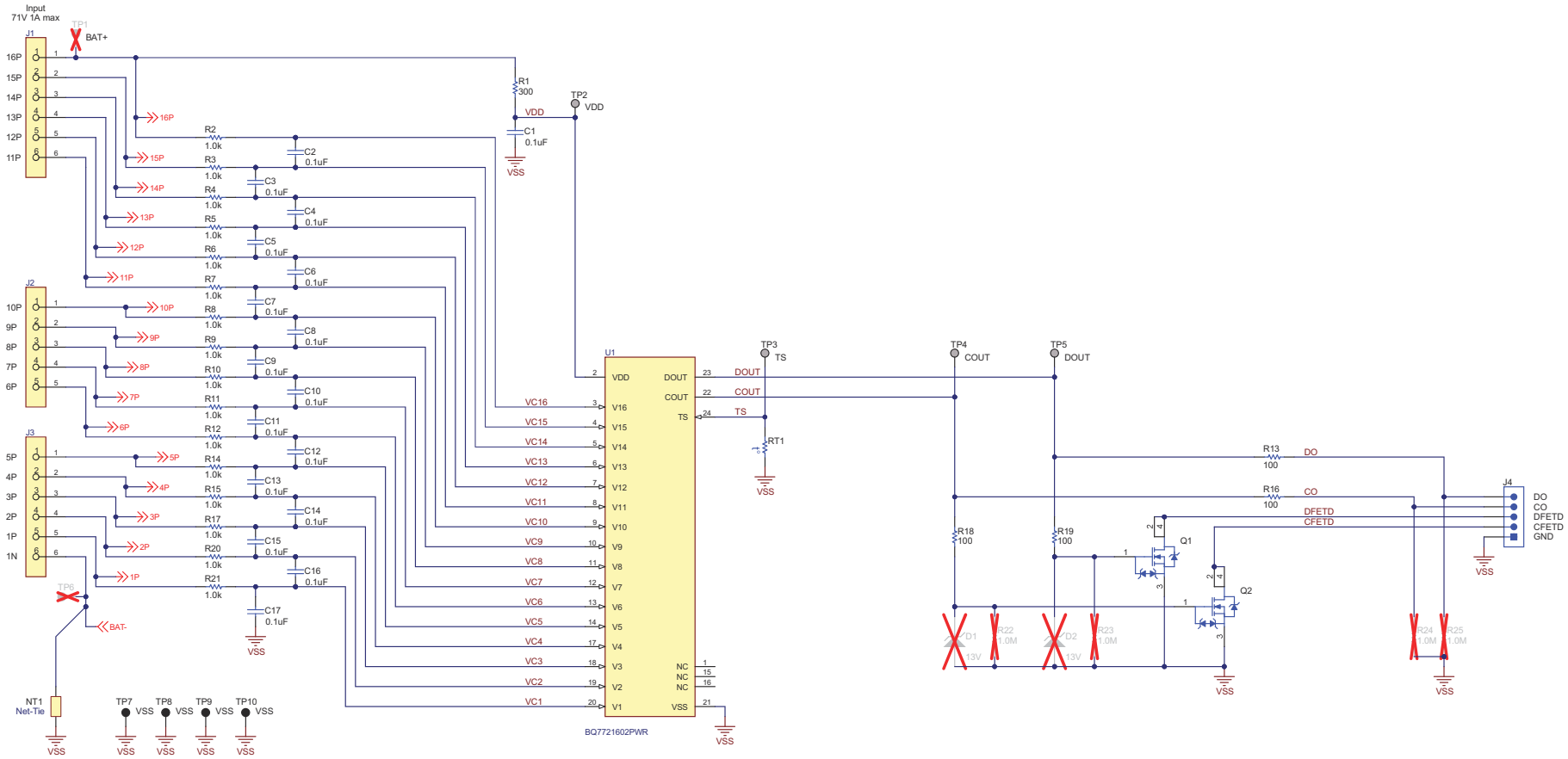

Figure 4-7. Schematic Diagram

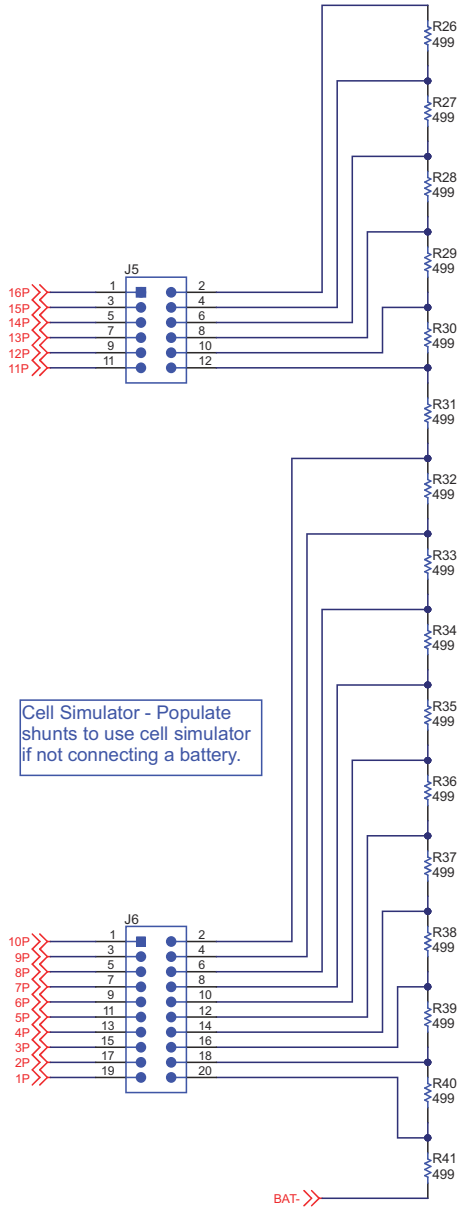

Figure 4-8. Cell Simulator

5 Related Documents from Texas Instruments

- Texas Instruments, BQ77216 *Voltage and Temperature Protection for 2 to 16-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.

Changes from Revision * (August 2020) to Revision A (November 2020)	Page
• Changed cell simulator component value and current. Changed reference designators throughout document for revision A of board	6
• Changed board size, layers	8
• Changed component and ref des in Bill of Materials	12
• Changed schematics	13

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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