

bq2980 Low Power Protector With Integrated High-Side Driver For Fast Charging Single Cell Evaluation Module

This engineering evaluation module (EVM) is a complete evaluation system for the bq2980 voltage, current, temperature protector with integrated high-side NFET drivers with external FETs shutdown control for single lithium-ion and lithium polymer cell. The EVM includes one bq2980 and dual FETs to control current in a configuration typical for switching currents to turn ON or OFF the charging and discharging power path for battery cell protection. The EVM module includes one bq2980 integrated circuit (IC), a 1-m Ω sense resistor, EFC8811R FETs, and all other onboard components necessary to switch charge and discharge current. The evaluation module connects between a "battery" source and a "pack" load or charger. In addition to the voltage and current protection, bq2980 also supports overtemperature protection that can be tested on this EVM.

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Trademarks

All trademarks are the property of their respective owners.

1 Features

This EVM has the following features:

- Complete evaluation system for the bq2980 fast charging single cell, integrated high-side driver low power protector IC
- Populated evaluation module bq2980EVM-PWR883 for quick setup and basic testing with load currents up to 8 A

1.1 Kit Contents

This EVM kit contains the following piece:

- bq2980EVM-PWR883 evaluation module

1.2 Ordering Information

The EVM orderable part number is bq2980EVM-883. For complete ordering information, see the [bq2980EVM](#) product page.

1.3 Documentation

See the bq2980 data sheet ([SLUSCS3](#)) on [www.ti.com](#) for information on device hardware.

1.4 bq2980 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq2980EVM.

Table 1. bq2980 Configuration on PWR883

Specification	Minimum	Typical	Maximum	Unit
Input voltage BATT+ to BATT–	0	3.6	5.5	V
Input voltage PACK+ to PACK–	0	3.8	12	V
Charge current	0	+1	+8	A
Discharge current	–0.1	–1	–8	A
Ambient operating temperature	15	25	35	°C
Surface temperature of EVM with 8 A of load current		50	80	°C
OCD threshold set on the PWR883		+8		mV
OCC threshold set on the PWR883		–8		mV
SCD threshold set on the PWR883		20		mV
Overvoltage delay set on the PWR883		1.25		s
Undervoltage delay set on the PWR883		144		ms
Overvoltage set on the PWR883		4.475		V
Undervoltage set on the PWR883		2.6		V
Overcurrent (OCC, OCD) detection delay		8		ms
Short-circuit discharge detection delay		250		μs
Internal overtemperature threshold		80		°C
Overtemperature detection delay		4.5		s
CTR	-	Enabled	-	

NOTE: The PWR883 board is constructed and rated to withstand an absolute maximum of 10 A. Using a 1-mΩ sense resistor and OCC and OCD threshold of +8 mV (the bq2980 is pre-programmed from the factory), OCC, OCD testing can be performed at 8 A. If performing SCD testing (SCD threshold set to 20 mV), the sense resistor must be scaled up and the necessary wattage resistor must be installed.

2 bq2980EVM Quick Start Guide

This section provides the step-by-step procedures required to use a new bq2980 EVM and configure it for operation in a engineering laboratory environment.

2.1 Before You Begin

The following warnings and cautions are noted for the safety of anyone using or working close to the bq2980 EVM. Observe all safety precautions.

WARNING

The circuit module has signal traces 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. Do not operate the EVM on a conductive surface.

CAUTION

The circuit module may be damaged by overtemperature. To avoid damage, monitor the temperature during evaluation and provide cooling, as needed, for your system environment.

CAUTION

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

WARNING

The circuit module is not a finished product or electrical appliance. It must be used by qualified personnel with additional equipment for evaluation only. Do not leave EVM powered when unattended.

2.2 Items Needed for EVM Quick Start Evaluation

- bq2980 EVM module
- For the BAT+, BAT– connection terminal: One adjustable DC power supply to act as a 'cell connection' with capability to provide 1 V to 5.5 V and 0.25 A to 8 A maximum, with current source and sink to simulate a charging and discharging event.
- For the PACK+, PACK– connection terminal: One adjustable power supply to act as 'charger' with current source capability.
- An electronic load with current sink capability of 0.100 A to 8 A. (Note: electronic load is highly recommended as many models of the power supplies cannot sink high currents)

- A high impedance (greater than 10-M Ω input) digital multimeter or measurement to check voltage on the driver test points. DMM leads or scope probes connected on the CHG or DSG (CHG/DSG) line, increases the charge pump loading of the bq2980 at the expense of the device current consumption on VDD. Device power consumption returns to normal when the scope probes and leads are disconnected from the CHG/DSG line.
- Shielded high current cables for connection for battery connection and pack connection of the electronic load

2.3 EVM Connections

This section covers the hardware connections for the bq2980EVM-PWR883 (see [Figure 1](#)).

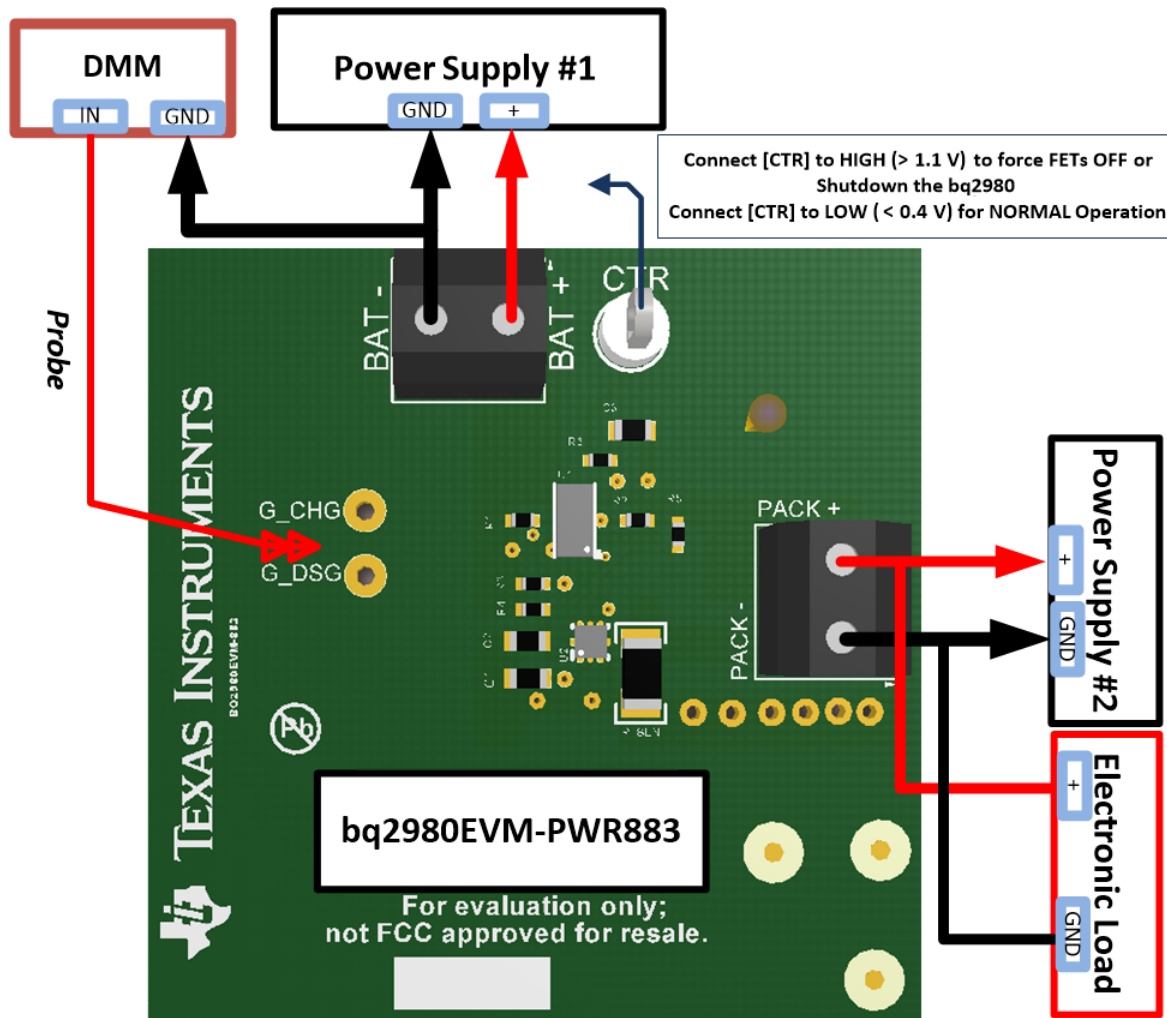


Figure 1. bq2980EVM-PWR883 Connection for Basic Operations

- On the bq2980 EVM-PWR883, BAT+ and BAT– are the positive and negative terminal of the power supply #1 - (VBAT).
- On the bq2980 EVM-PWR883, PACK+ and PACK– are the positive and negative terminal of the power supply #2 - (VPACK).

When using a power supply for evaluation, be sure the power supply can accept or is protected from any reverse current such as with a blocking diode if another supply is used in the system.

The PACK+ and PACK– terminals are for attachment of the load or charger. If using a power supply to simulate a charger, be sure it can accept or is protected from any reverse current.

2.4 Quick Start Testing Sequence

These steps describe a simple demonstration or check of the operation of the bq2980EVM in a 1S configuration.

1. Connect adjustable power supply #1 - (VBAT) as cell connection between the BAT+ and BAT- terminals as in [Figure 1](#).
2. Connect adjustable power supply #2 - (VPACK) as the charger between the PACK+ and PACK- terminals as in [Figure 1](#). The bq2980 will power up (starts up) at SHUTDOWN mode assuming undervoltage fault. If approximately 2 V is on PACK+, the device comes out of the SHUTDOWN assuming zero-voltage charging, hence the CHG FET will be ON. However, the DSG FET will still be OFF because the device assumes undervoltage fault.
3. Connect electronic load between the PACK+ and PACK- terminals, as required, refer to [Figure 1](#).
4. Set power supply #1 to 3.6 V with the ability to sink or source 100 mA–200 mA, enable the supply.
5. Set power supply #2 to 4.0 V with the ability sink or source 100 mA–200 mA, enable the supply and disable supply. Observe bq2980 to transition from SHUTDOWN to NORMAL mode. The bq2980 device can also enter NORMAL mode, if the VDD pin is SHORTED to the PACK pin. Also note in NORMAL mode, both drivers (charge and discharge FETs are ON) are to be operating at greater than 9.5 V, as detailed in [Figure 2](#).
6. If complete, power down BAT+ and PACK+. Disconnect setup, if complete.

2.5 Undervoltage(UV) Testing

1. Adjust the power supply #1 voltage to simulate an undervoltage condition.
2. Observe the DSG FET and CHG FET being disabled after the UV fault delay.
3. Refer to the EVM883 scope capture in [Figure 2](#).
4. Allow recovery from the undervoltage condition by removing the load from the PACK terminal and increase the power supply #1 voltage - (VBAT) > ($V_{uvp} + V_{uvp_hys}$) [or perform the next step].
5. Connect the power supply #2 - (VPACK) to act as the charger, with (VPACK – VBAT) > 700 mV for charger detection and increase the power supply #1 - (VBAT) voltage to greater than V_{uvp} threshold voltage as indicated in the data sheet.

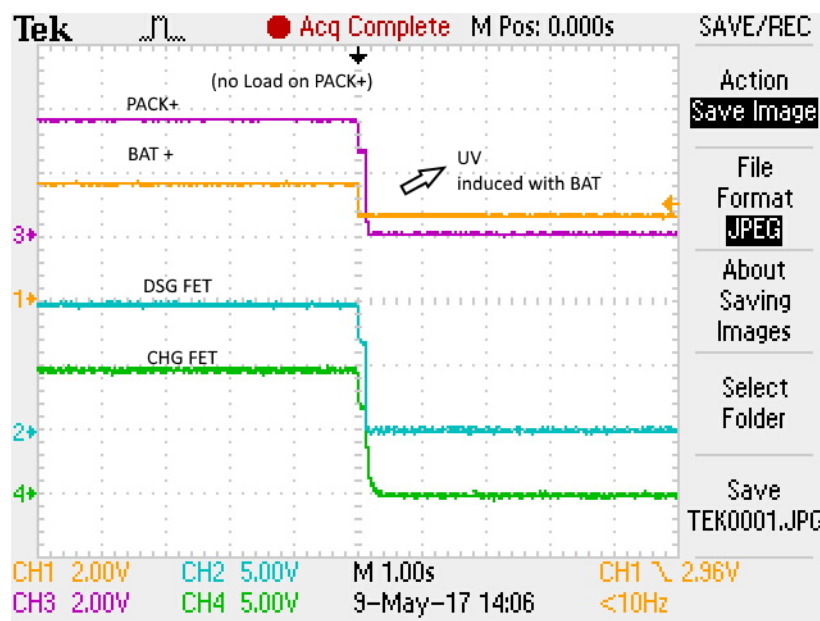


Figure 2. bq2980EVM-PWR883 Demonstration of Undervoltage

2.6 Overvoltage (OV) Testing

1. Adjust the power supply #1 voltage - (VBAT) to simulate an overvoltage condition.
2. Observe the CHG FET being disabled after the OV fault delay. Refer to the EVM scope capture in Figure 3.
3. Allow recovery from the overvoltage condition by removing the charger and decreasing the power supply #1 voltage (VBAT) < (Vovp - Vovp_hys), **or** when the power supply #1 voltage - (VBAT) < (Vovp) and the load resistor is in place and being detected.
4. For load detection, the bq2980 needs the condition of (VBAT - VPACK) > 400 mV.
5. If complete, power down BAT+ and PACK+, disconnect setup, if complete.

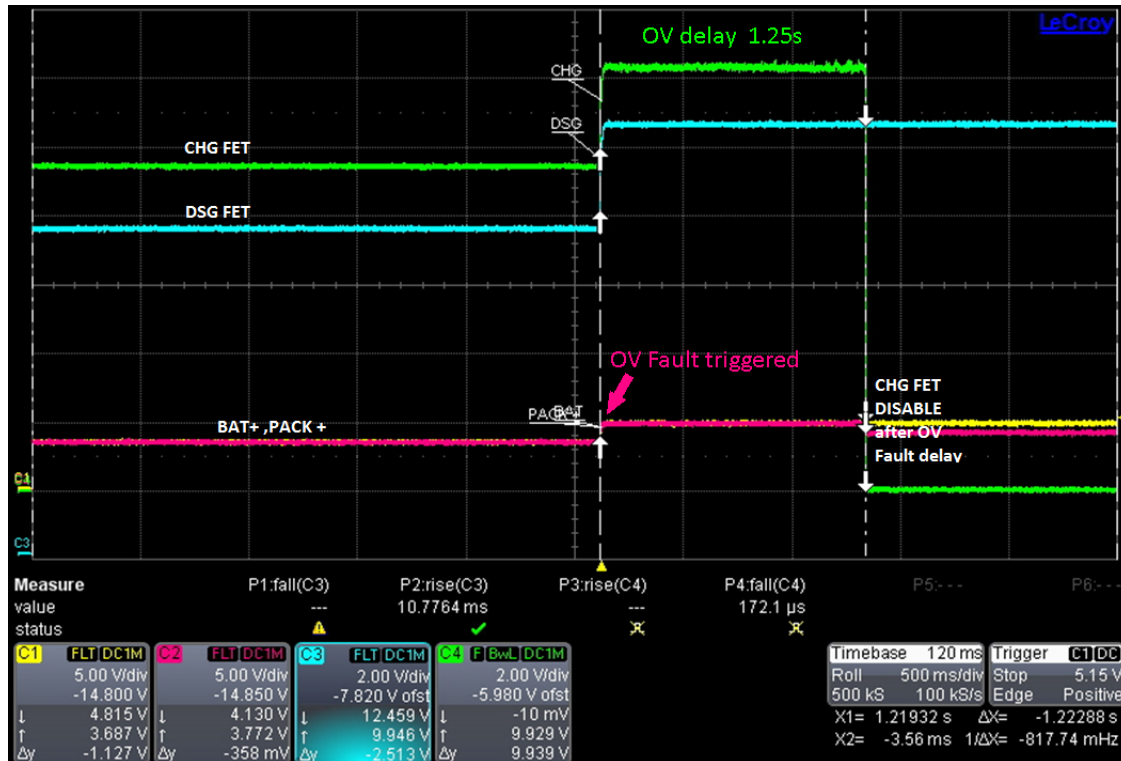


Figure 3. bq2980EVM-PWR883 Demonstration of Overvoltage

2.7 FET Override Testing With Control (CTR) Pin

1. Set power supply #1 to 3.6 V with the ability to sink or source 100 mA–200 mA, enable the supply.
2. Set power supply #2 to 4.0 V with the ability sink or source 100 mA–200 mA, enable the supply and disable supply. Observe that the bq2980 transitions from SHUTDOWN to NORMAL mode.
3. Connect CTR to LOW (< 400 mV) for NORMAL operation.
4. Note in NORMAL mode, both drivers (charge and discharge FETs are ON) are to be operating at greater than 9.5 V.
5. Connect CTR to HIGH (> 1.1 V).
6. Observe FETs are forced to shutoff as shown in Figure 4.

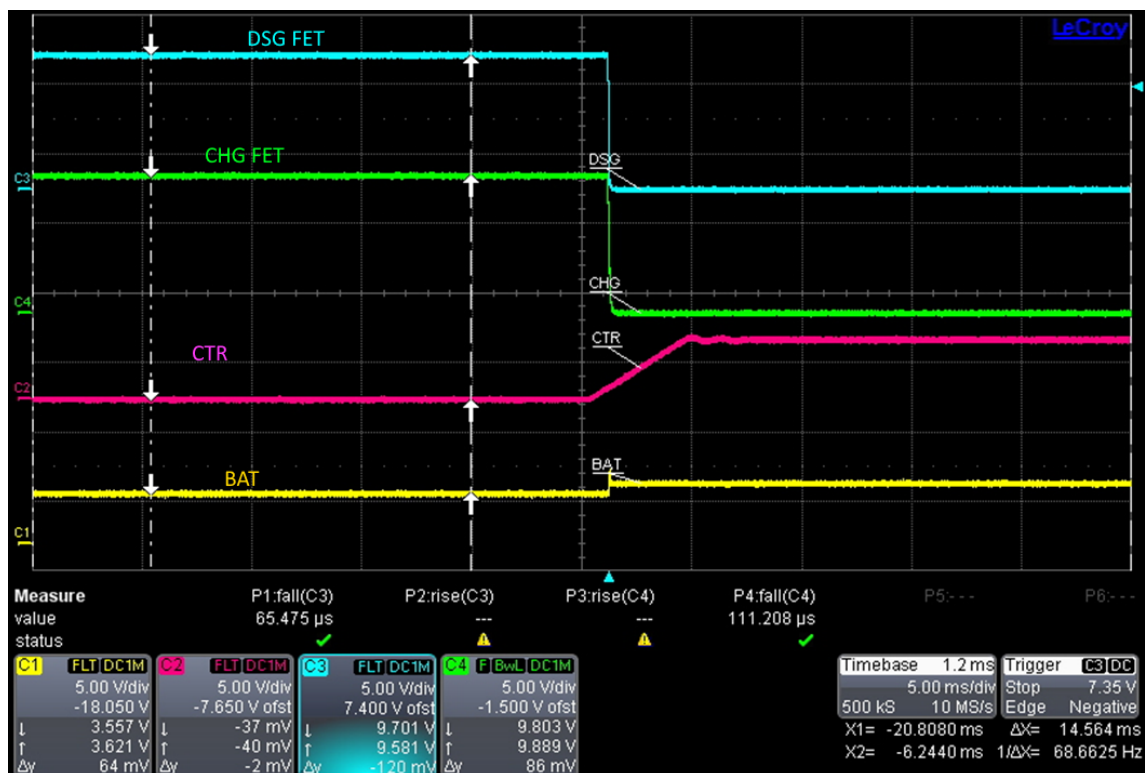


Figure 4. bq2980EVM-PWR883 Demonstration FET Override With Control Pin (CTR)

3 Additional Evaluation Setups

CAUTION

The bq2980EVM-PWR883 does not contain capacitors on the input or output current paths to dampen transients. Be sure to use appropriate transient suppression scheme to avoid damage to the board from cable or equipment transient responses during evaluation.

3.1 bq2980EVM-PWR883 Operation With Charge and Discharge Currents

Charge and discharge current operation can also be demonstrated with conventional supplies and loads.

Connect and operate the equipment within its performance limits. By design, the bq2980EVM-PWR883 can operate at 6 A–8 A with high reliability. If high current power supplies are available, current control can be demonstrated through the board in both directions (charge and discharge). Note OCD generation as detailed in [Figure 5](#).

Connect the electronic load to the PACK+, PACK– terminal.

Adjust the electronic load to the desired load current. (Note the load current is delivered from the battery power supply #1.)

Enable the electronic load.

Observe that the BAT+ and PACK+ voltage dip as the load current as detailed in [Figure 5](#) is increased and the power supply #1 - (VBAT) voltage may need to be increased. Compensation for the lossy cables between the power supply #1 and BAT+ and BAT– terminals may be required.

NOTE: When turning ON the load, the power supply #1 - (VBAT) can droop (due to extra IR drops) to levels that inadvertently can trigger an undervoltage fault. Likewise, when the load current is OFF, the power supply #1 (VBAT) voltage will bounce back to the set voltage limit of the power supply to inadvertently trigger an overvoltage event or exceed ABS maximum of VDD specification of the bq2980.

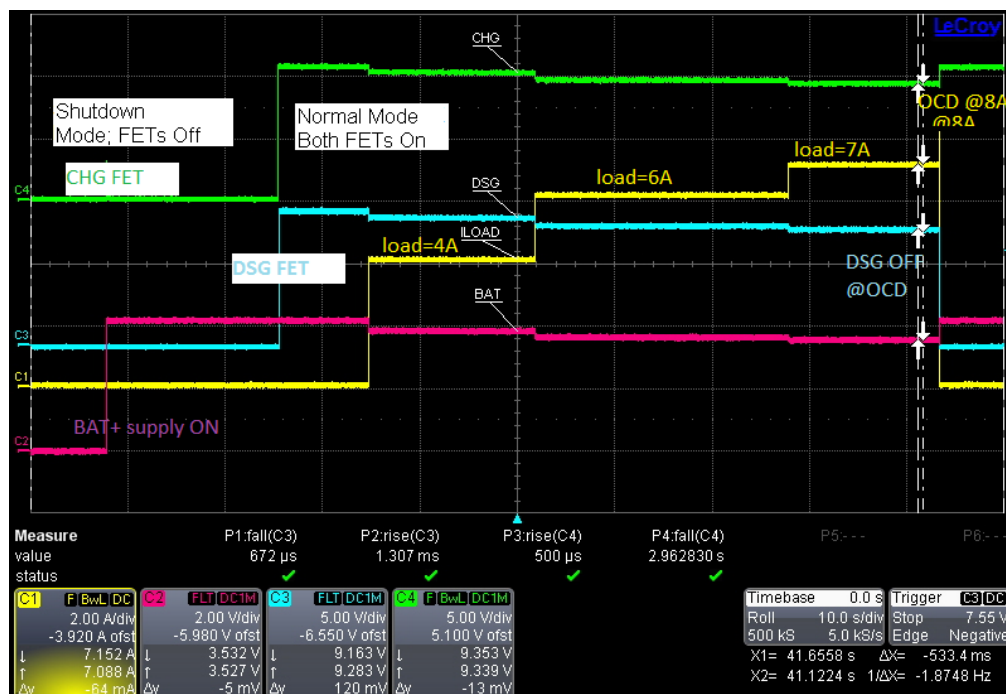


Figure 5. bq2980EVM-PWR883 Demonstration of Overcurrent Discharge Fault at 8 A

3.2 Troubleshooting

Table 2 is a good procedure to check the basic electrical integrity of the board, if SHUTDOWN or NORMAL mode currents being violated as described in the bq2980 data sheet ([SLUSCS3](#)).

- If the bq2980 does not appear to be operating after applying the wake pulse signal on the PACK+ pin, check the VDD voltage at the battery connection and PACK+ connectors.
- Check that the battery input voltages are within the operating range of the part. If a fault has been induced, check that the UV recovery condition has been met. Check the status of the CTR pin. If CTR is HIGH, the bq2980 will be in SHUTDOWN mode.
- After disconnecting the power supply #2 and the electronic load from the PACK+ terminal, in NORMAL mode (both FETs are ON), the voltage on the PACK+ voltage should almost be the same as that of BAT+.
- To ensure the voltage on BAT± is not below undervoltage due to $I \times R$ losses, check the BAT± voltage at the EVM terminal.

Table 2. Unpowered bq2980EVM-PWR883 Troubleshooting Guide

Resistance on bq2980EVM-PWR883 (Without the Power on the EVM)	Values (Typical)
G_DSG-GND	Open
GND-G_DSG	3.4 MΩ
BAT+ to G_DSG	Open
G_DSG to PACK+	Open
GND to PACK+	5.5 MΩ
PACK+ to GND	Open

3.3 Changing Configuration or Conditions

If the board is modified to change the IC or other components or is operated at an expanded temperature range, be sure to check component temperatures and other operating characteristics to be sure the board does not provide a hazard in evaluation. The bq2980 device (depending on the OCD, OCC thresholds) may allow more current flow through the FETs with higher surface temperatures.

4 bq2980EVM Specifics for Varying Conditions

This section contains information on EVM specifics in adapting to varying applications and conditions

4.1 Third Party Power MOSFETs

The bq2980EVM-PWR883 has on-semi EFC8811R, dual N-channel power MOSFET in CSP6 chip-scale footprint options. Alternate FETs and configurations, depending on the gate capacitance and gate charges, may require a change to the gate resistor to provide an appropriate rise and fall switching time.

4.2 BAT± Transient Pattern

To suppress transients currents, a 10-μF to 100-μF electrolytic capacitor across the battery input (±) terminals, may be desired during switching of high load- current (> 4 A) testing.

4.3 Other Uninstalled Components

The bq2980EVM contains specific variance in BOM configuration. Refer to the schematic diagram ([Figure 6](#)) for additional information. R1 and R2 resistors are not needed as they will load the CHG and DSG drivers and expend current from the charge pump of the device; therefore, they are not populated.

5 Circuit Module Physical Layouts

This section contains the schematics, the printed-circuit board (PCB) layout, and assembly drawings for the bq2980 circuit module.

5.1 Schematic

Figure 6 shows the bq2980EVM schematic.

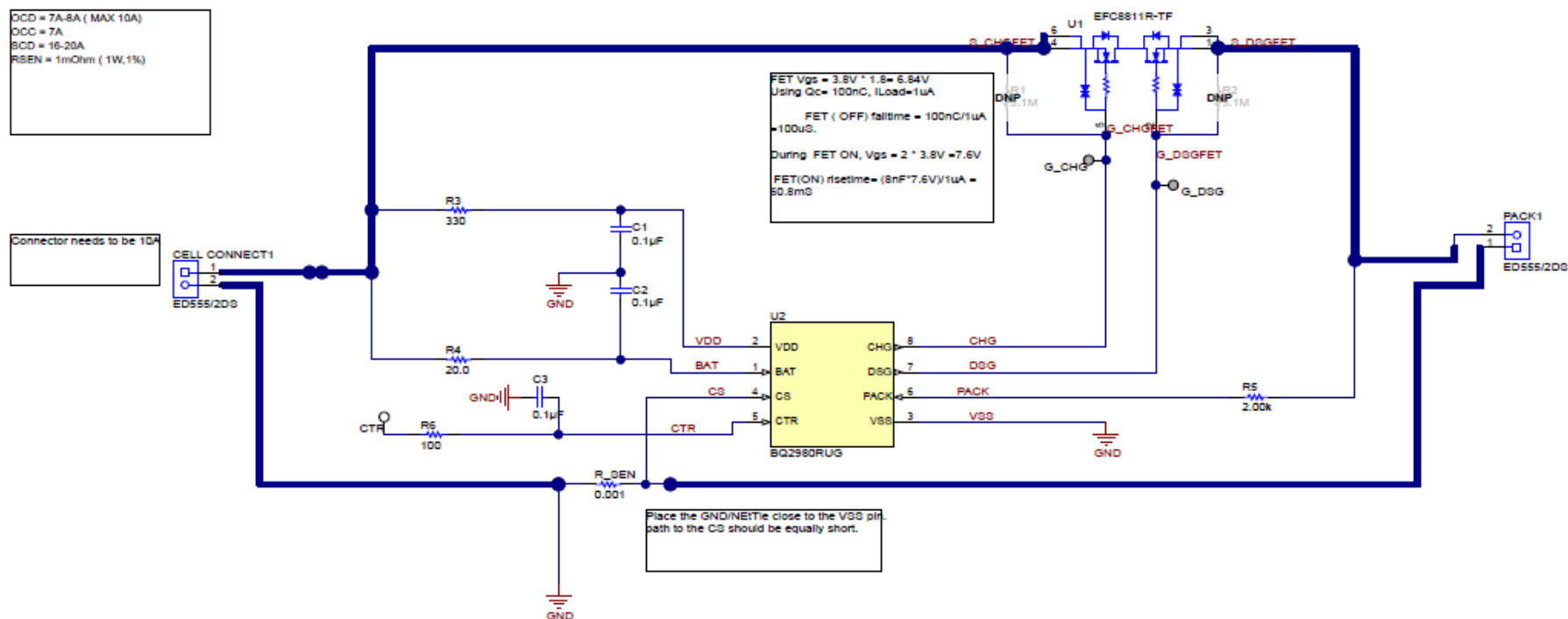


Figure 6. bq2980EVM Schematic

5.2 Board Layout

This section shows the PCB layers and assembly drawing for the bq2980 module (see [Figure 7](#) through [Figure 10](#)). The board is a 2-layer, 2-oz copper clad, single-sided assembly board. There are no components placed on the bottom of the EVM.

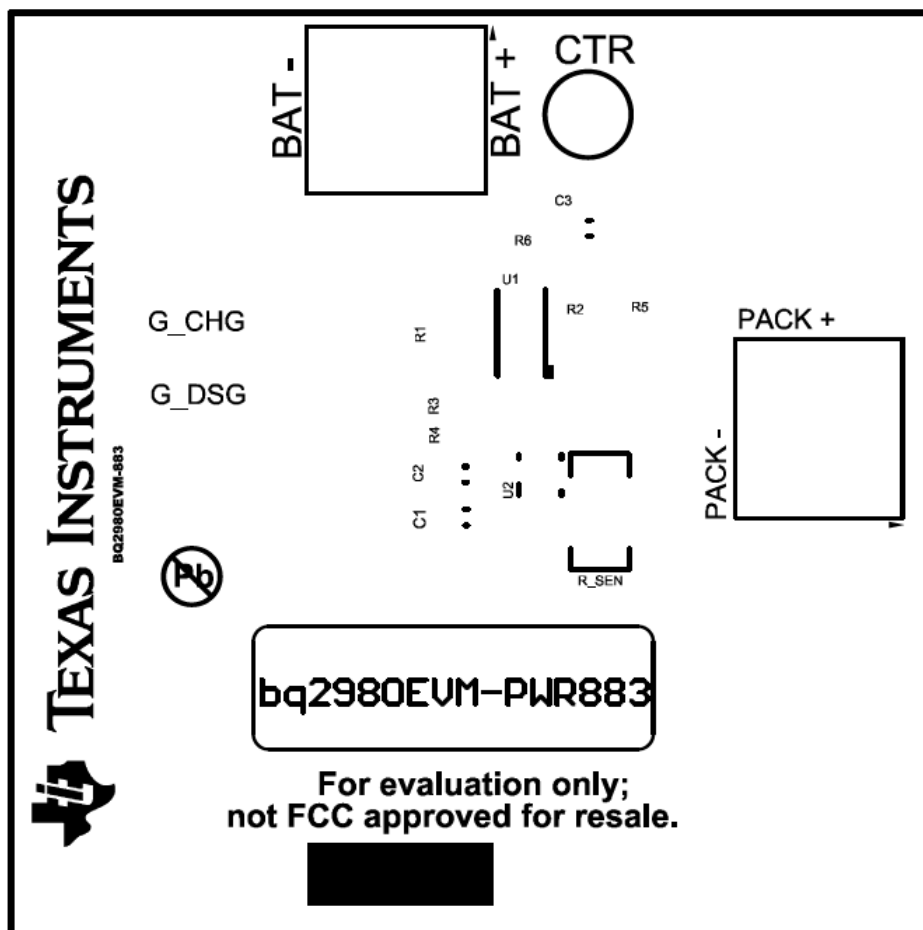


Figure 7. Top Silk Screen

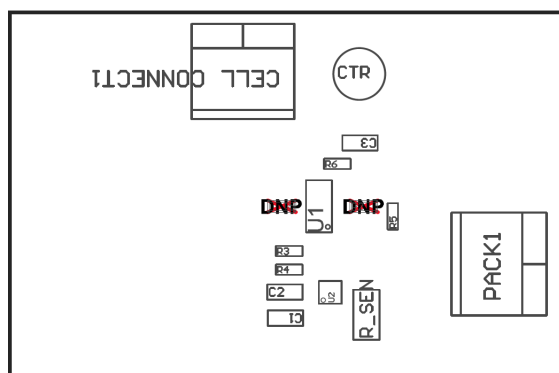


Figure 8. Top Assembly

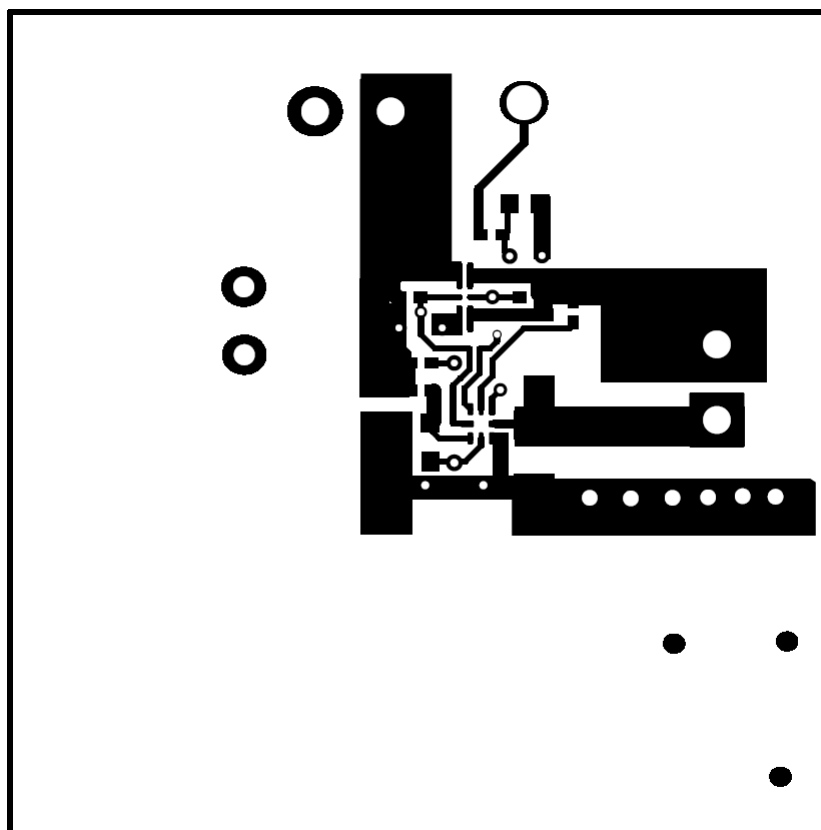


Figure 9. Top Layer

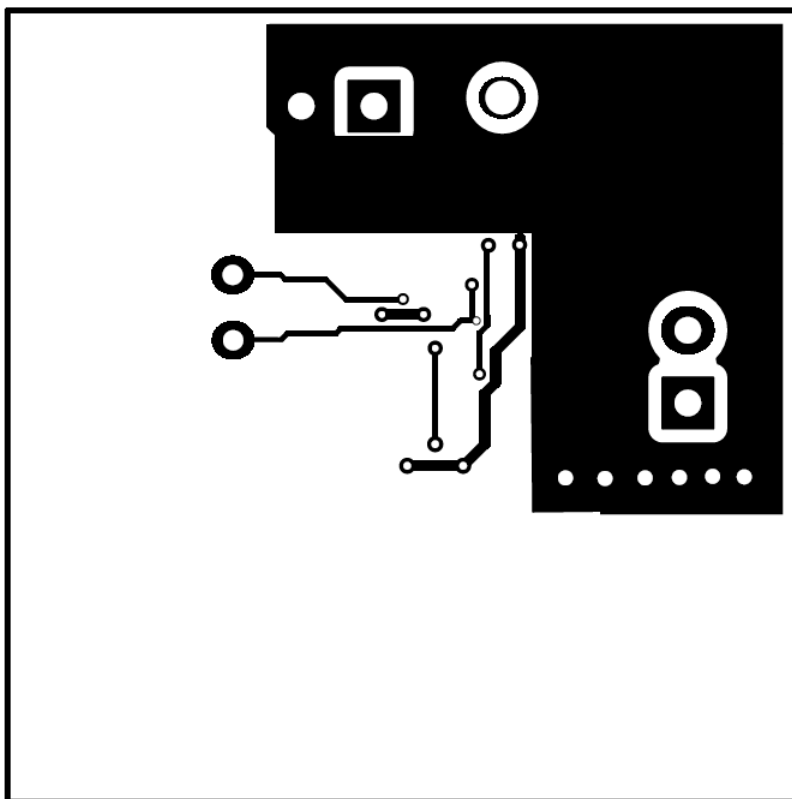


Figure 10. Bottom Layer

6 Bill of Materials

Table 3 lists the bq2980EVM-PWR883 bill of materials.

Table 3. bq2980EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		PWR883	Any
C1, C2, C3	3	0.1uF	CAP, CERM, 0.1 μ F, 50 V, \pm 10%, X7R, 0603	0603	GRM188R71H104KA93D	Murata
CELL CONNECT1, PACK1	2		Terminal Block, 3.5mm Pitch, 2x1, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology
CTR	1		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone
H9, H10, H11, H12	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
R3	1	330	RES, 330, 5%, 0.063 W, 0402	0402	CRCW0402330RJNED	Vishay-Dale
R4	1	20.0	RES, 20.0, 1%, 0.063 W, 0402	0402	CRCW040220R0FKED	Vishay-Dale
R5	1	2.00k	RES, 2.00 k, 1%, 0.063 W, 0402	0402	CRCW04022K00FKED	Vishay-Dale
R6	1	100	RES, 100, 1%, 0.063 W, 0402	0402	CRCW0402100RFKED	Vishay-Dale
R_SEN	1	0.001	RES, 0.001, 1%, 1 W, AEC-Q200 Grade 0, 1206	1206	CSNL1206FT1L00	Stackpole Electronics Inc
U1	1		Power MOSFET for 1 Cell Lithium-ion Battery Protection 12V, 3.2mOhm, 27A, Dual N-Channel, SMD	1.77x3.54mm	EFC8811R-TF	ON Semiconductor
U2	1		1S High-Side Protector with External Shutdown Control, RUG0008A (X2QFN-8)	RUG0008A	BQ2980RUG	Texas Instruments
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R1, R2	0	5.1Meg	RES, 5.1 M, 5%, 0.063 W, 0402	0402	CRCW04025M10JNED	Vishay-Dale

7 Related Documentation from Texas Instruments

- bq2980 Voltage, Current, Temperature Protector with Integrated High Side NFET Driver for Fast/Flash Charging Single-Cell Li-ion and Li-Polymer Batteries ([SLUSCS3](#))

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 semiconductor 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.

- 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/lstds/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/lstds/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。

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上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/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/lstds/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.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

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9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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