bq24187 Evaluation Module User's Guide

The bq24187 evaluation module is a complete charger module for evaluating compact, flexible, high-efficiency, USB-friendly, switch-mode charge management solution for single-cell, Li-ion and Li-polymer batteries used in a wide range of portable applications.

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1 Introduction

1.1 BQ24187 IC Features

The BQ24187 family integrates a synchronous PWM controller, power MOSFETs, input-current sensing, high-accuracy current and voltage regulation and charge termination into a small WCSP package. The charge parameters can be programmed through an I^2C interface. Key IC features include:

- High-efficiency, fully integrated, NMOS-NMOS, synchronous buck charger with 1.5-MHz frequency
- Charge time optimizer
- Integrated power FETs for up to 2-A charge rate
- 5-V, 1-A on-the-go (OTG) VBUS supply

For details, see the bq24187 data sheet (SLUSBM0).

1.2 bq24187EVM Features

The bq24187 evaluation module (EVM) provides a complete charger module for evaluating compact, flexible, high-efficiency, USB-friendly, switch-mode battery charge solutions for single-cell, Li-ion and Li-polymer battery-powered systems used in a wide range of portable applications. Key EVM features include:

- Terminal blocks and standard headers for IN, BAT, TS; USB connector for IN
- Programmable battery voltage, charge current, input current, and status via I^2C interface
- IN operating up to 6.0 V
- LED indication for status signals
- Test points for key signals available for testing purposes. Easy probe hook-up

1.3 Schematic

Figure 1 illustrates the bq2418x EVM schematic.

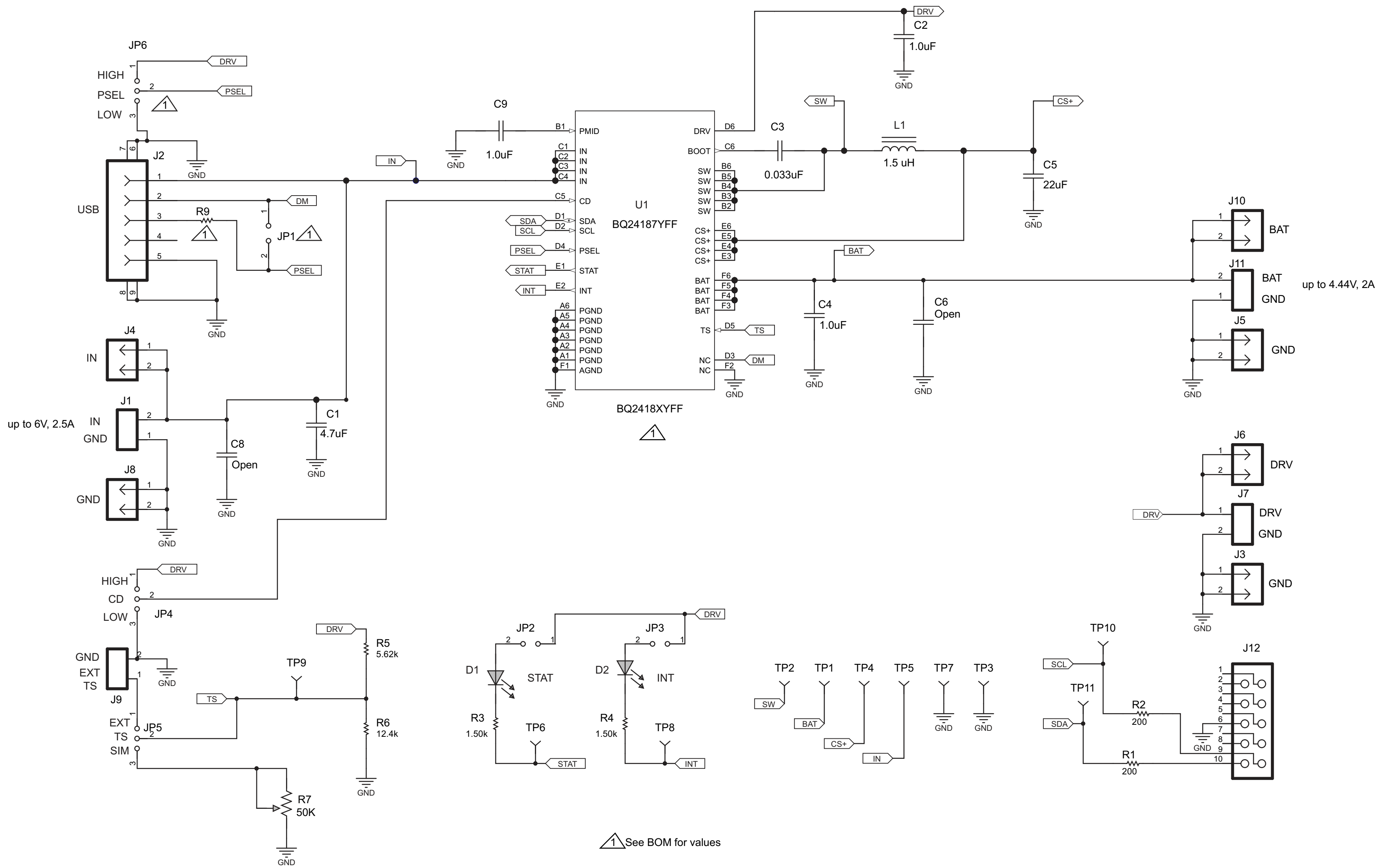

Figure 1. bq2418xEVM Schematic

1.4 I/O Description

Header/Terminal Block	Description
J1– IN/GND	Input power positive and negative terminal
J2 – USB	USB miniconnector
J3 - GND	DRV linear regulator negative header
J4 - IN	Input power positive header
J5 - GND	Battery negative header
J6 - DRV	DRV linear regulator positive output
J7 - DRV/GND	DRV linear regulator positive and negative terminals
J8 - GND	Input power negative header
J9 - EXT TS/GND	External thermistor terminal
J10 - GND	Battery positive header
J11 - BAT/GND	Battery positive and negative terminal
J12 - USB-TO-GPIO	USB-TO-GPIO box keyed connector

1.5 Test Points to IC Pins

Test Point	Description
TP1	BAT
TP2	SW
TP3	GND
TP4	CS+
TP5	GND
TP6	STAT
TP7	GND
TP8	INT
TP9	TS
TP10	SCL
TP11	SDA

1.6 Control and Key Parameters Setting

Jumper	Description	Default Factory Setting
JP1	N/A	Not installed
JP2	Shorting jumper to connect DRV to annode of D1 STAT LED	SHORTED
JP3	Shorting jumper to connect DRV to annode of D1 INT LED	SHORTED
JP4	CD = LO: Charge disable low for normal operation CD = HI: Charge disable high to disable the buck converter and enter Hi-Z mode	CD = LO
JP5	TS = SIM: Connects a potentiometer to the TS pin so that the potentiometer can simulator a thermistor. The potentiometer is preset per R5 and R6 so that the TS voltage is 0.5 x V (DRV). TS = EXT: Connects the TS pin to an external thermistor through J9. The resistor divider formed by R5 and R6 is sized to accommodate a 10-kΩ thermistor. If a different thermistor is used, R5 and R6 must be resized.	TS=SIM
JP6	PSEL = LOW: Input current limit is set to 1.5 A until changed by I2C. PSEL = HIGH: Default mode input current limit is set to 100 mA until changed by I2C. Default mode input current limit is set to 1.5 A until changed by I2C.	PSEL = LOW

1.7 Recommended Operating Conditions

		Min	Typ	Max	Unit
Supply voltage, V_{IN}	Input voltage from ac adapter (bq24262)	4.2		6.0	V
Battery voltage, V_{BAT}	Voltage output at VBAT terminal (registers set via I2C communication)	3.5	4.2	4.44	V
Supply current, $I_{IN(MAX)}$	Maximum input current from ac adapter input (registers set via I2C communication)	0.1		2.0	A
Fast charge current, $I_{CHRG(MAX)}$	Battery charge current (registers set via I2C communication)	0.500		2.0	A
Operating junction temperature range, T_J		-40		125	°C

2 Test Summary

This procedure describes one test configuration of the HPA721 evaluation board for bench evaluation.

2.1 Definitions

The following naming conventions are followed.

VXXX :	External voltage supply name (VADP, VBT, VSBT)
LOADW:	External load name (LOAD1, LOAD2)
V(TPyyy):	Voltage at internal test point TPyyy. For example, V(TP12) means the voltage at TP12.
V(Jxx):	Voltage at header Jxx
V(TP(XXX)):	Voltage at test point XXX. For example, V(ACDET) means the voltage at the test point which is marked as ACDET.
V(XXX, YYY):	Voltage across point XXX and YYY
I(JXX(YYY)):	Current going out from the YYY terminal of header XX
Jxx(BBB):	Terminal or pin BBB of header xx
JPx ON :	Internal jumper Jxx terminals are shorted
JPx OFF:	Internal jumper Jxx terminals are open
JPx (-YY-) ON:	Internal jumper Jxx adjacent terminals marked as YY are shorted
Measure: → A,B	Check specified parameters A, B. If measured values are not within specified limits, the unit under test has failed.
Observe → A,B	Observe if A, B occur. If they do not occur, the unit under test has failed.

Assembly drawings have locations for jumpers, test points, and individual components.

2.2 Recommended Test Equipment

2.2.1 Power Supplies

1. A power supply #1 (PS #1) capable of supplying 5 V at 2.5 A, is required.
2. If not using a battery as the load, then power supply #2 (PS #2) capable of supplying up to 5 V at 5 A is required to power the circuit shown in Figure 2.

2.2.2 Load #1 Between BAT and GND

Testing with an actual battery is the best way to verify operation in the system. If a battery is not available, then a circuit similar to the one shown in Figure 2 can simulate a battery when connected to a power supply. Alternatively, a sourcemeter, capable of sourcing and sinking current can be used to simulate a battery.

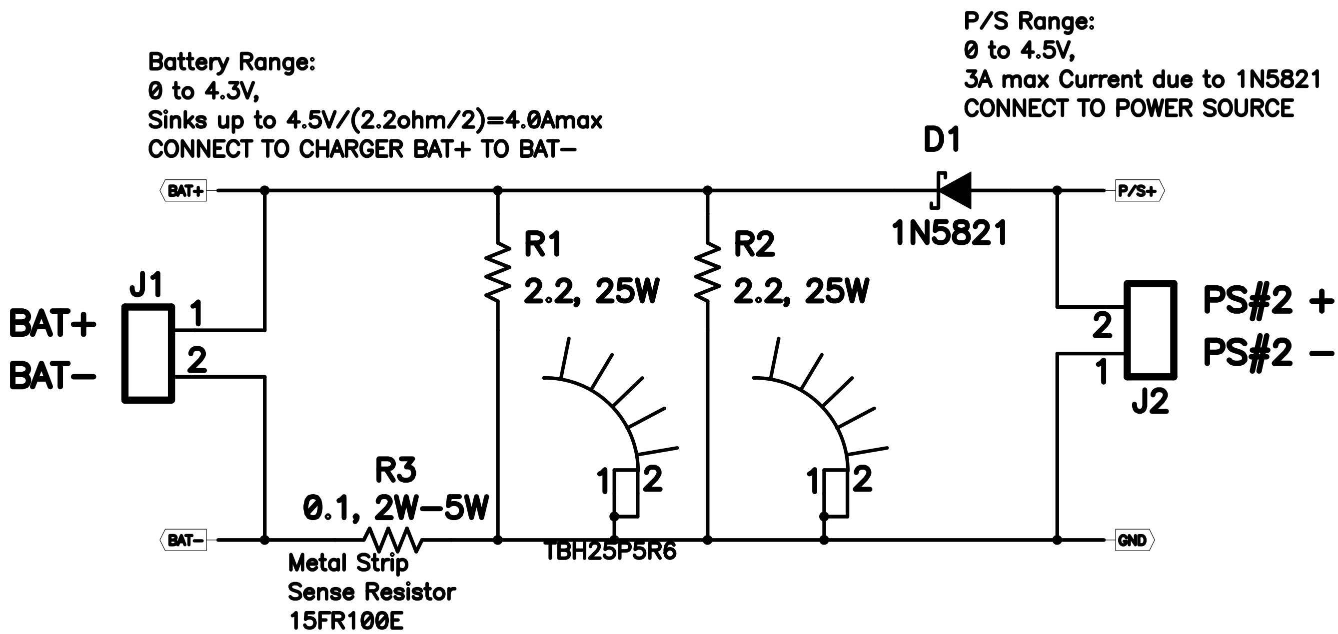

Figure 2. BAT_Load (PR1010) Schematic

2.2.3 Meters

Four equivalent voltage meters (VM #) and two equivalent current meters (CM #) are required. The current meters must be able to measure 3-A current.

2.2.4 Computer

A computer with at least one USB port and a USB cable is required. The BQ24187 evaluation software must be properly installed.

2.2.5 HPA172 Communication Kit (USB TO GPIO)

An HPA172 USB-to-I^{2}C communication kit is required.

2.2.6 Software

Download BQ24187SW.zip from the charger's product folder, unzip the file, and double-click on the SETUP.EXE file. Follow the installation steps.

Because the bq24187 has a watchdog timer, it is recommended that you set the software's **Reset Watchdog Timer** to reset every 5 seconds. Otherwise, after 30 seconds of operation, the IC enters Default mode. Note that the 27-minute safety timer is not reset by this function and eventually times out if charging does not complete, unless the **Safety Timer Time Limit** is expanded or disabled via the GUI. One way to reset the safety timer is to allow the 30-second watchdog timer to expire. See Figure 3 in the data sheet for more information about the timers.

Also, it is generally helpful to activate the **Write On Change** functions, in the upper left of the GUI window, to ON. The Write On Change function writes any changes to the GUI's check boxes, drop-down boxes, and registers to the IC. Otherwise, the user must click the **WRITE** button to write changes to the software. It is recommended that the user periodically click the **READ** button to find the IC's instantaneous status. Alternatively, the **AutoRead** function can be activated to periodically update the GUI with the IC's status.

2.3 Recommended Test Equipment Setup

1. For all power connections, use short, twisted-pair wires of appropriate gauge wire for the amount of the current.
2. Set PS #1 for 5-V, 2.5-A current limit and then turn off supply.
3. Connect the output of PS #1 in series with a current meter (CM #1) to J1 (IN).
4. Connect a voltmeter (VM #1) across J4 and J3 (IN and GND).
5. If BAT_Load as shown in Figure 1 is used, connect PS #2, set to approximately 3.7 V, to the input side (PS #2+/-) of BAT_Load, then turn off PS #2.
6. Connect the output side of the battery or BAT_Load in series with current meter (multimeter) #2 (CM #2) to J11 and J10 or J5 (BAT, GND). Ensure that a voltage meter (VM #2) is connected across J10 or TP1 and J5 or TP7 (BAT and GND).
7. Connect VM #3 across J6 and J8 (DRV and GND).
8. Connect the HPA172 kit to J12 by the 10-pin ribbon cable. Connect the USB port of the HPA172 kit to the USB port of the computer. The connections are shown in Figure 3.

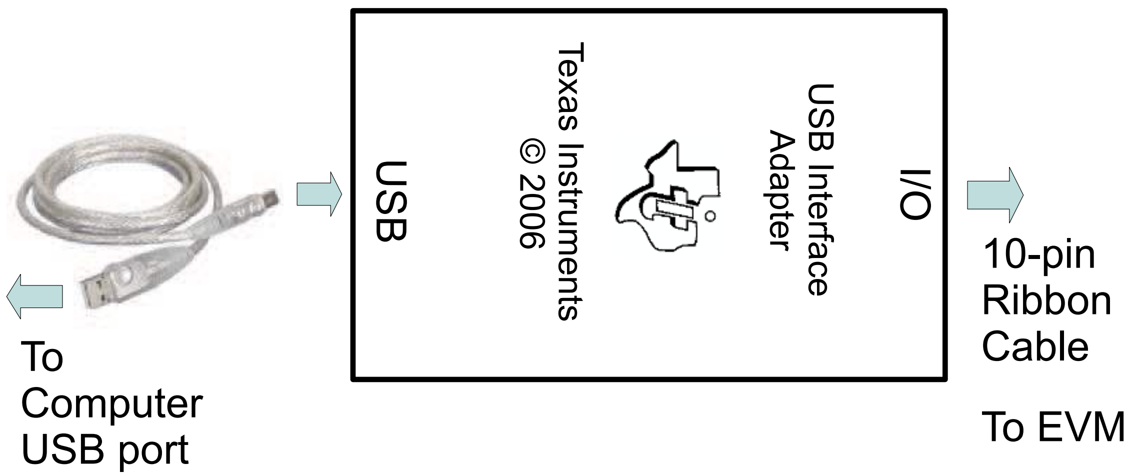

Figure 3. Connections of HPA172 Kit

9. Ensure jumpers are at the settings highlighted in yellow (except for JP1 which is not installed) per Section 1.6.

10. After the preceding steps have been performed, the test setup for bq24187EVM-625 is configured as is shown in Figure 4

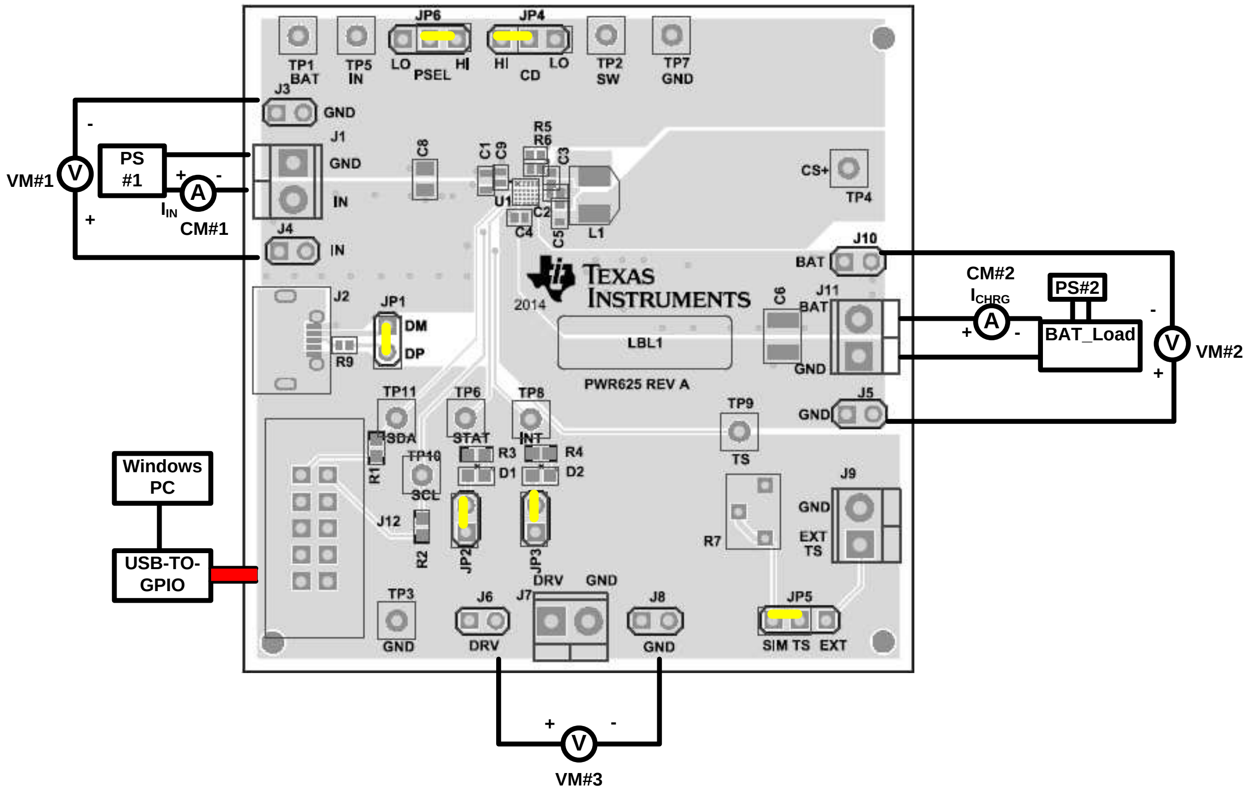

Figure 4. Recommended Initial Test Setup for bq24187EVM-625

11. Turn on the computer. Open the BQ24187 evaluation software. Figure 5 shows the main window of the software.

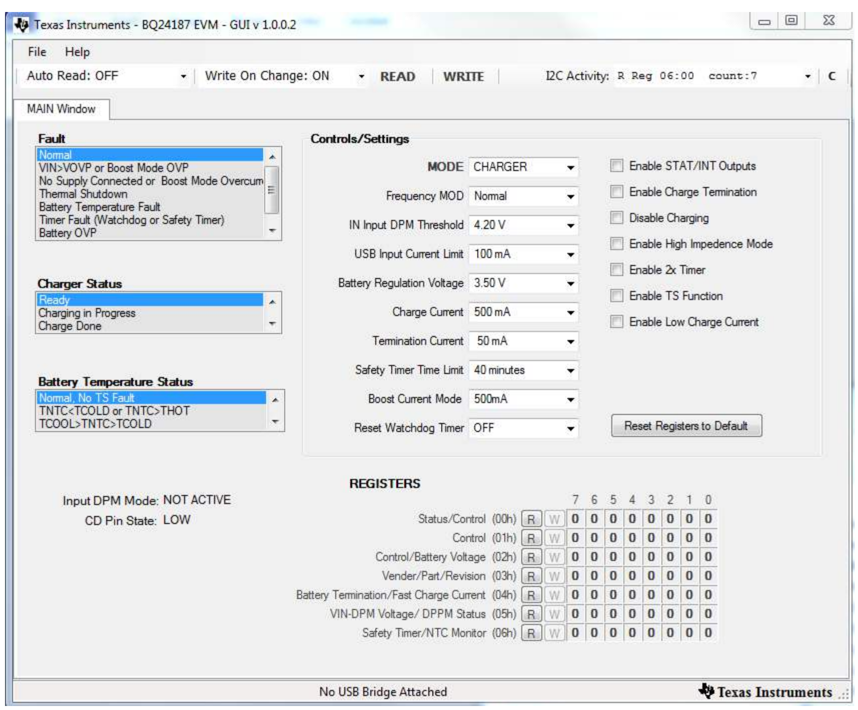

Figure 5. Main Window of BQ24187SW Evaluation Software

2.4 Recommended Test Procedure

The following test procedure may be useful for evaluating the charger IC outside of a real system, if no battery is available to connect to the output and a simulated battery, if needed.

2.4.1 Charge Voltage and Current Regulation of IN

1. Ensure that the steps in Section 2.3 are followed.
2. Move JP4 to LO.
3. Turn on PS #1.
4. Enable PS #2 and adjust PS #2 so that the voltage measured by VM #2, across BAT and GND, measures 3.2 V ±50 mV.
5. Adjust the power supply so that VM #1 still reads 5 V ±100 mV, if necessary, then

   Measure on CM #2 → I_{CHRG} < 120 mA

   Measure on CM #1 → I_{IN} = 90–100 mA
6. Software setup:
   - Press the **READ** button to obtain the current settings.
   - Set **Write On Change** to ON, if not already set.
   - Set **Safety Timer** to Disabled.
   - Set **Reset Watchdog Timer** to update every 5 seconds.
   - Uncheck **Disable Charging** if checked.
   - Check **Enable STAT/INT Outputs**.
   - Set **Battery Regulation Voltage** to 4.20 V.
   - Set **IN Input Current Limit** to 2.0 A.
   - Set **Charge Current** to 1000 mA.
   - Click the **READ** button at the top of the window and confirm that the previous settings remain.
7. Enable PS #2 and adjust PS #2 so that the voltage measured by VM #2, across BAT and GND, measures 3.8 V ±50 mV.
8. Adjust the power supply so that VM #1 still reads 5 V ±100 mV, if necessary, then

   Measure on CM #2 → I_{CHRG} = 1000 mA ±50 mA

   Measure on CM #1 → I_{IN} < 750 mA
9. Turn off PS #1 and PS #2.

2.4.2 Helpful Hints

1. To observe the taper current as the battery voltage approaches the set regulation voltage, allow the battery to charge or, if using BAT_Load (PR1010), slowly increase the PS #2 voltage powering BAT_Load (PR1010). Use VM #2 across BAT and GND to measure the battery voltage seen by the IC.
2. To observe the VIN-DPM feature, lower the current limit on PS #1.

3 Printed-Circuit Board Layout Guideline

1. To obtain optimal performance, the power input capacitors, connected from the PMID input to PGND, must be placed as close as possible to the IC.
2. Place 4.7-µF input capacitor as close to PMID pin and PGND pin as possible to make the high-frequency current loop area as small as possible. Place 1-µF input capacitor GNDs as close to the respective PMID capacitor GND and PGND pins as possible to minimize the ground difference between the input and PMID.
3. The local bypass capacitor from CS+ to GND must be connected between the CS+ pin and PGND of the IC. The intent is to minimize the current path loop area from the SW pin through the LC filter and back to the PGND pin.
4. Place all decoupling capacitors close to their respective IC pins and as close as possible to PGND (do not place components such that routing interrupts power stage currents). All small control signals must be routed away from the high-current paths.
5. The PCB must have a ground plane (return) connected directly to the return of all components through vias (two vias per capacitor for power-stage capacitors, one via per capacitor for small-signal components). It is also recommended to put vias inside the PGND pads for the IC, if possible. A star ground design approach is typically used to keep circuit block currents isolated (high-power/low-power small-signal) which reduces noise-coupling and ground-bounce issues. A single ground plane for this design gives good results. With this small layout and a single ground plane, no ground-bounce issue exists, and having the components segregated minimizes coupling between signals.
6. The high-current charge paths into IN, USB, BAT, and from the SW pins must be sized appropriately for the maximum charge current in order to avoid voltage drops in these traces. The PGND pins must be connected to the ground plane to return current through the internal low-side FET.
7. For high-current applications, the balls for the power paths must be connected to as much copper in the board as possible. This allows better thermal performance because the board conducts heat away from the IC.

4 Bill of Materials and Board Layout

4.1 Bill of Materials

Table 1 lists the bq24187EVM-625 Rev A BOM.

Table 1. Bill of Materials - PWR625A

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB	1		Printed Circuit Board		PWR625	Any	-	-
C1	1	4.7uF	Capacitor, Ceramic Chip, 25V, X5R, ±20%	603	C1608X5R1E475M080AC	TDK		
C2, C4	2	1.0uF	Capacitor, Ceramic Chip, 6.3V, X5R, ±10%	402	C1005X5R0J105K050BB	TDK		
C3	1	0.033uF	Capacitor, Ceramic Chip, 25V, X5R, ±10%	402	C1005X5R1E333K050BA	TDK		
C5	1	22uF	Capacitor, Ceramic Chip, 10V, X5R, ±20%	603	C1608X5R1A226M080AC	TDK		
C9	1	1.0uF	Capacitor, Ceramic Chip, 25V, X5R, ±10%	402	C1005X5R0J105K050BB	TDK		
D1	1	LTST-C190GKT	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	603	LTST-C190GKT	Lite On		
D2	1	LTST-C190CKT	Diode, LED, Red, 2.1-V, 20-mA, 6-mcd	603	LTST-C190CKT	Lite On		
J1, J7, J9, J11	4	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25 inch	ED555/2DS	OST		
J2	1	ZX62D-AB-5P8	Connector, USB Micro, Type AB	0.315 X 0.200 inch	ZX62D-AB-5P8	Hirose		
J3, J4, J5, J6, J8, J10, JP2, JP3	8	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins		
J12	1	N2510-6002RB	Connector, Male Straight 2x5 pin, 100mil spacing, 4 Wall	0.338 x 0.788 inch	N2510-6002RB	3M		
JP4, JP5, JP6	3	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins		
L1	1	1.5 uH	Inductor, High Current, 3.5A, 70 milliohm	4.20x 4.20 mm	SPM4012T-1R5M	TDK	FDSD0415-H-1R5M	TOKO
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady	-	-
R1, R2	2	200	RES, 200 ohm, 1%, 0.1W, 0603	0603	CRCW0603200RFKEA	Vishay-Dale		
R3, R4	2	1.50k	RES, 1.50k ohm, 1%, 0.1W, 0603	0603	RC0603FR-071K5L	Yageo America		
R5	1	5.62k	RES, 5.62k ohm, 1%, 0.063W, 0402	0402	CRCW04025K62FKED	Vishay-Dale		
R6	1	12.4k	RES, 12.4k ohm, 1%, 0.063W, 0402	0402	CRCW040212K4FKED	Vishay-Dale		
R7	1	50K	Potentiometer, 3/8 Cermet, Single-Turn	0.25x0.17 inch	3266W-1-503LF	Bourns		
SH-JP2, SH-JP3, SH-JP4, SH-JP5, SH-JP6	5	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11	11	5002	Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone		
U1	1	BQ24187YFF	IC, 2a, 30v Host-Controlled Single Input, Single Cell Switche Mode	YFF0036ADAD	bq24187YFF	Texas Instruments		None
C6	0	Open	Capacitor, Ceramic Chip, xxV, ±10%	1210	STD	STD		
C8	0	Open	Capacitor, Ceramic Chip, xxV, ±10%	805	STD	STD		
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		
JP1	0	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins		
R9	0	0	RES, 0 ohm, 5%, 0.063W, 0402	0402	CRCW04020000Z0ED	Vishay-Dale		
SH-JP1	0	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec

4.2 Board Layout

Figure 6 through Figure 10 show the bq24187EVM-625 Rev A PCB layouts.

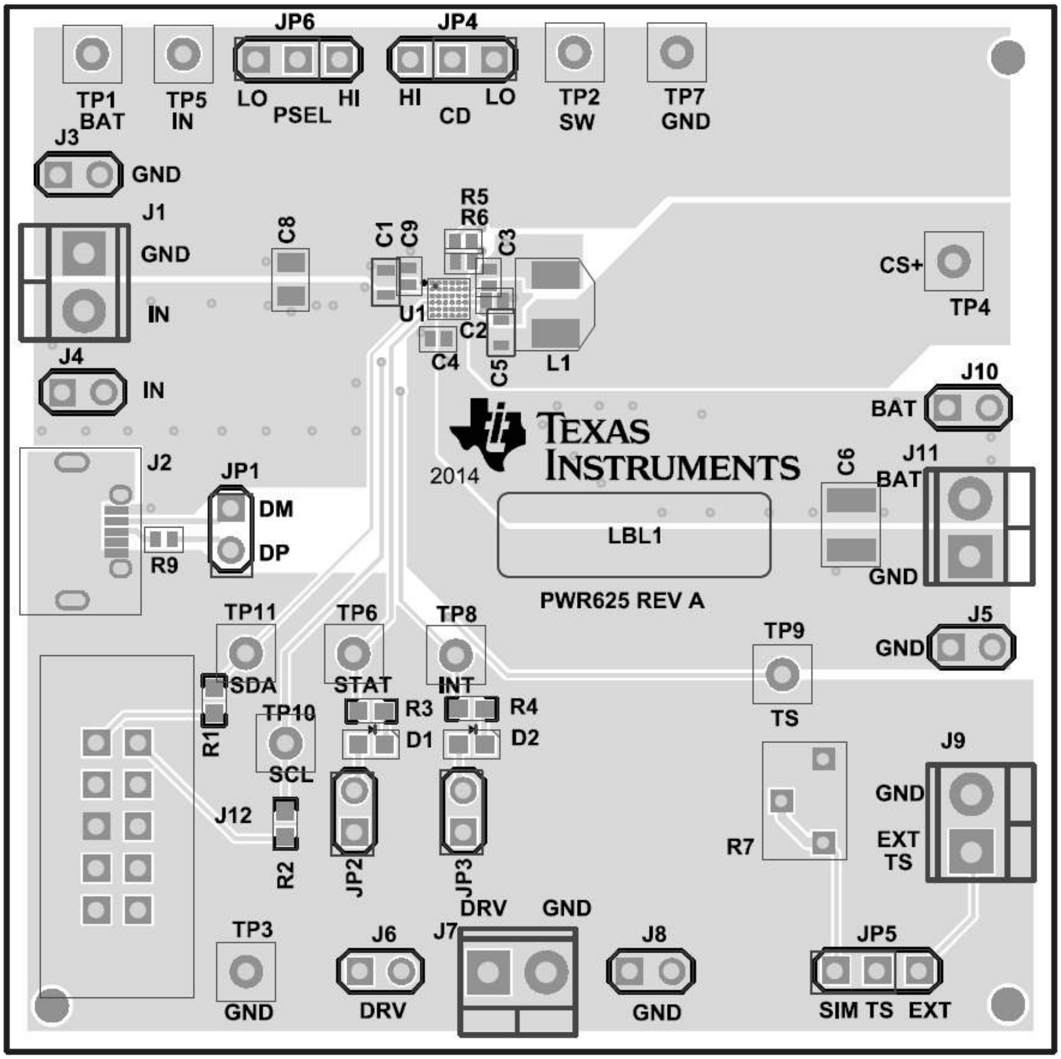

Figure 6. Top Assembly Layer

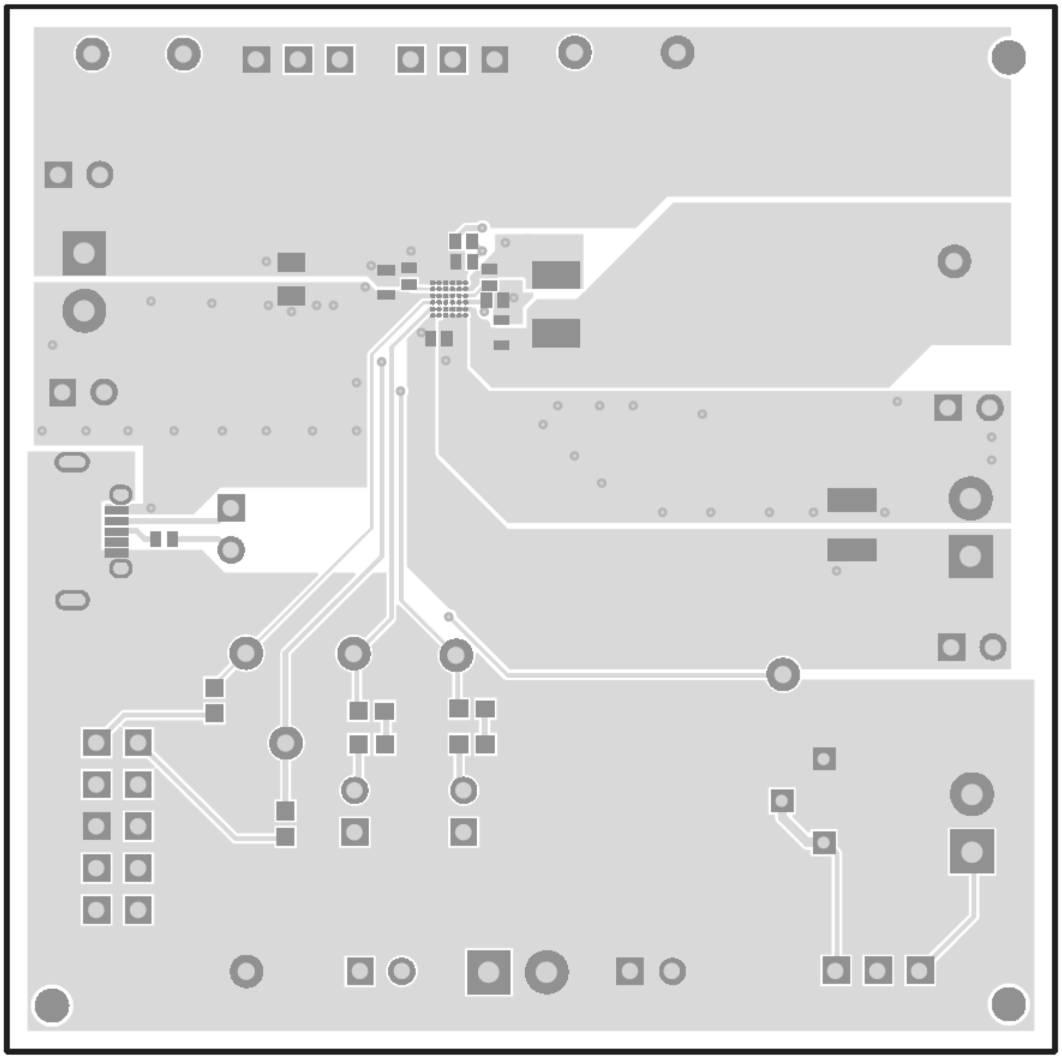

Figure 7. Top Layer

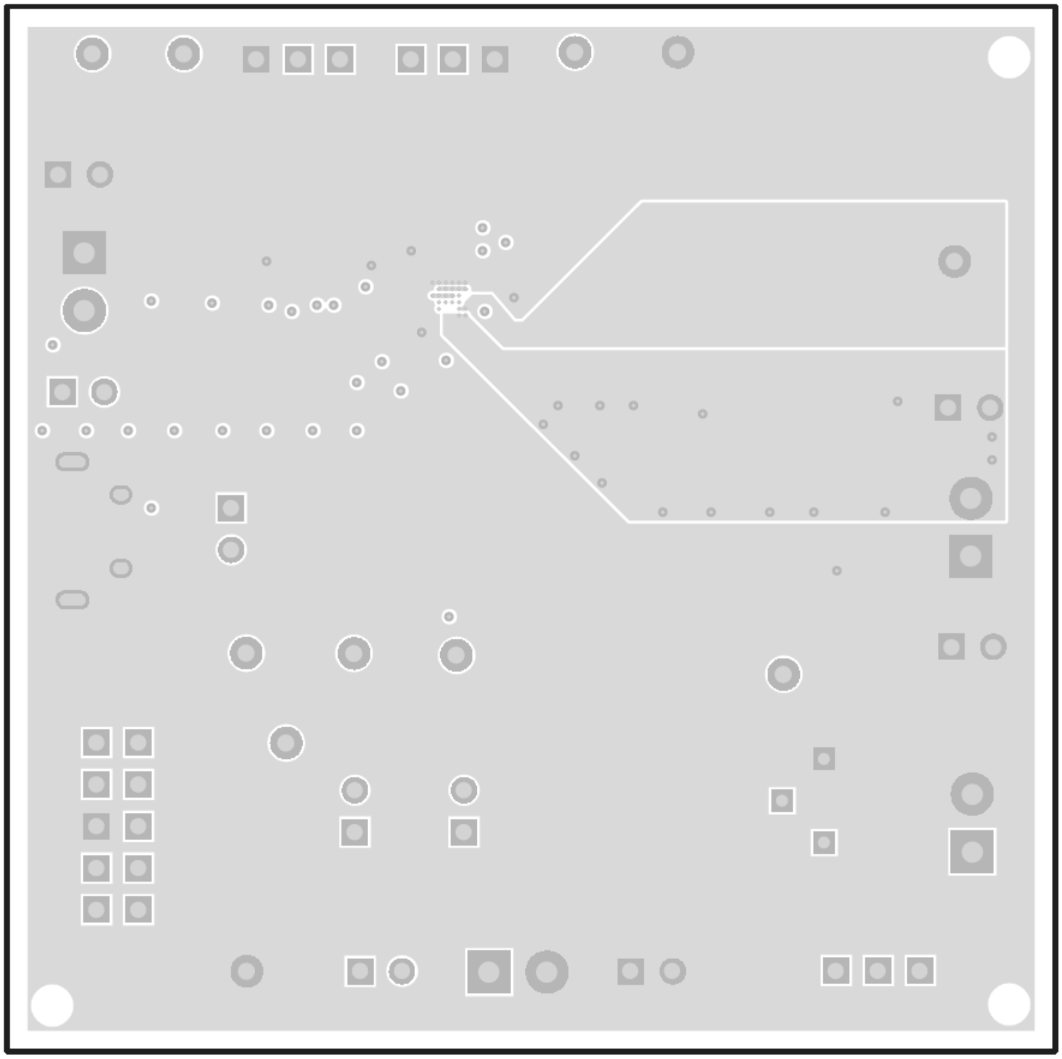

Figure 8. First Internal Layer

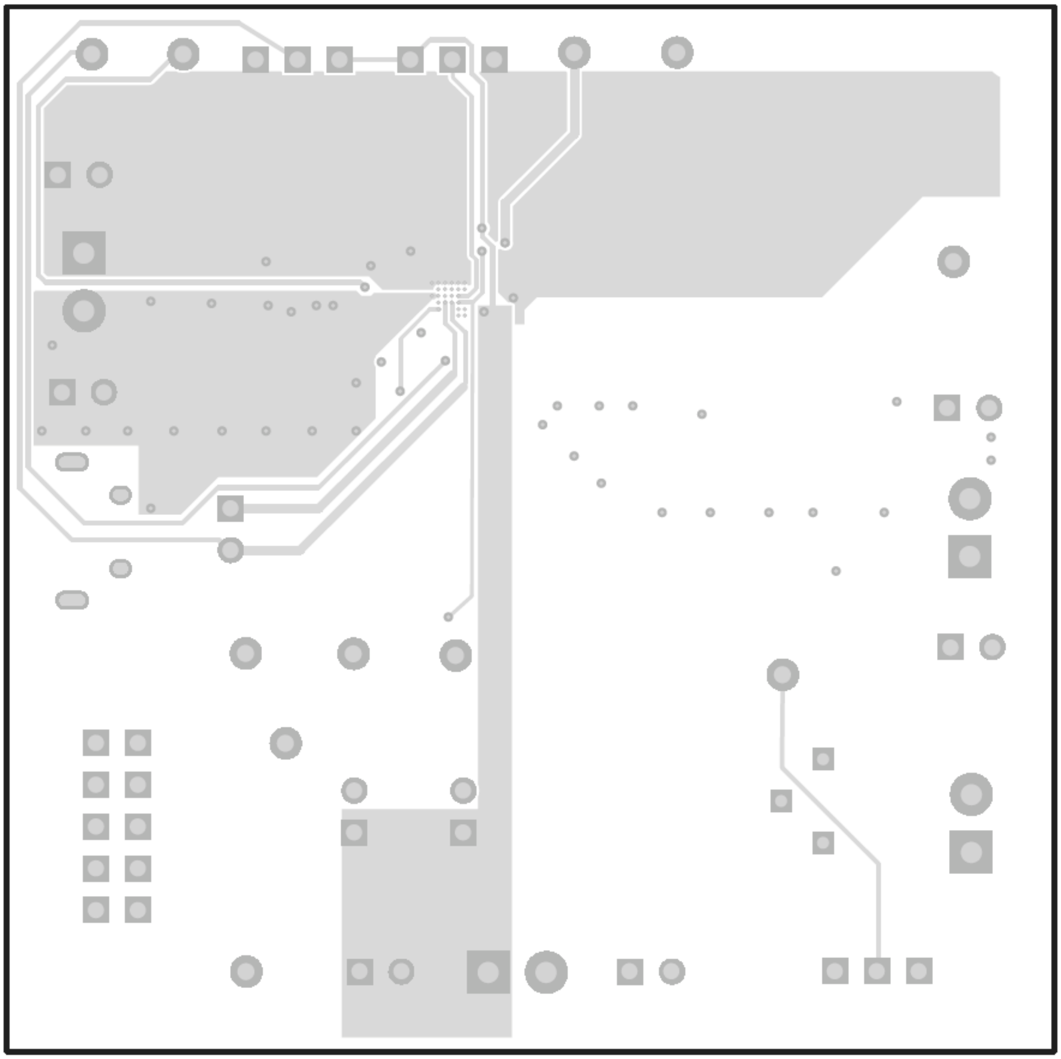

Figure 9. Second Internal Layer

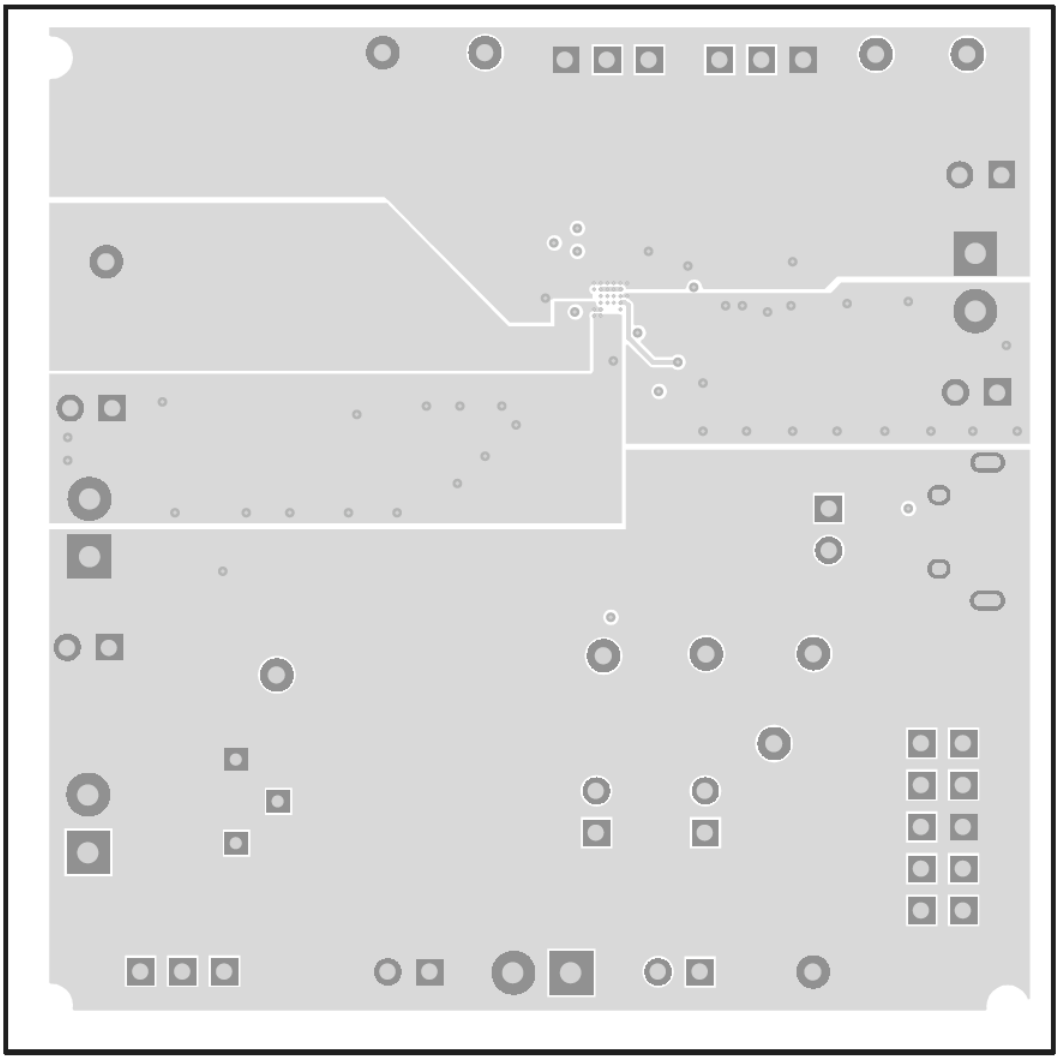

Figure 10. Bottom Layer

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U.S. Federal Communications Commission Compliance

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 could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

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 its own expense.

FCC Interference Statement for Class B EVM devices

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.

Industry Canada Compliance (English)

For EVMs Annotated as IC – INDUSTRY CANADA Compliant:

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs Including Radio Transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Canada Industry Canada Compliance (French)

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

Important Notice for Users of EVMs Considered "Radio Frequency Products" in Japan

EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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.

http://www.tij.co.jp

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2. 実験局の免許を取得後ご使用いただく。
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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

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。

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IMPORTANT NOTICE

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