

## ***WCSP-Packaged bq24272/273 Evaluation Modules***

The bq24272/273 evaluation module is a complete charger module for evaluating compact, flexible, high-efficiency, 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 bq2427x IC Features

The bq24272/273 integrates a synchronous PWM controller, power MOSFETs, input-current sensing, high-accuracy current and voltage regulation, charge termination and power-path management into a small WCSP package. The charge parameters are programmable through an I<sup>2</sup>C interface. Key IC features include:

- High-efficiency, fully integrated, NMOS-NMOS, synchronous buck charger with 1.5-MHz frequency
- Integrated power FETs for up to a 2.5-A charge rate
- Power-path management between battery and system voltages

For details, see the bq24272/273 data sheets ([SLUSB09](#)/[SLUSB08](#)).

### 1.2 bq24272/273 EVM Features

The bq24272/273 evaluation module (EVM) is a complete charger module for evaluating compact, flexible, high-efficiency, switch-mode battery charge and power-path management solution for single-cell, Li-ion and Li-polymer battery-powered systems used in a wide range of portable applications. Key EVM features include:

- 76.2-mm × 76.2-mm × 1.2-mm footprint for entire solution
- Input power connector for AC adapter
- Programmable battery voltage, charge current, input current, and status via I<sup>2</sup>C™ interface
- IN operating range of 4.2 V – 10 V
- LED indication for status signals
- Test points for key signals available for testing purposes. Easy probe hook-up.

## 1.3 Schematic

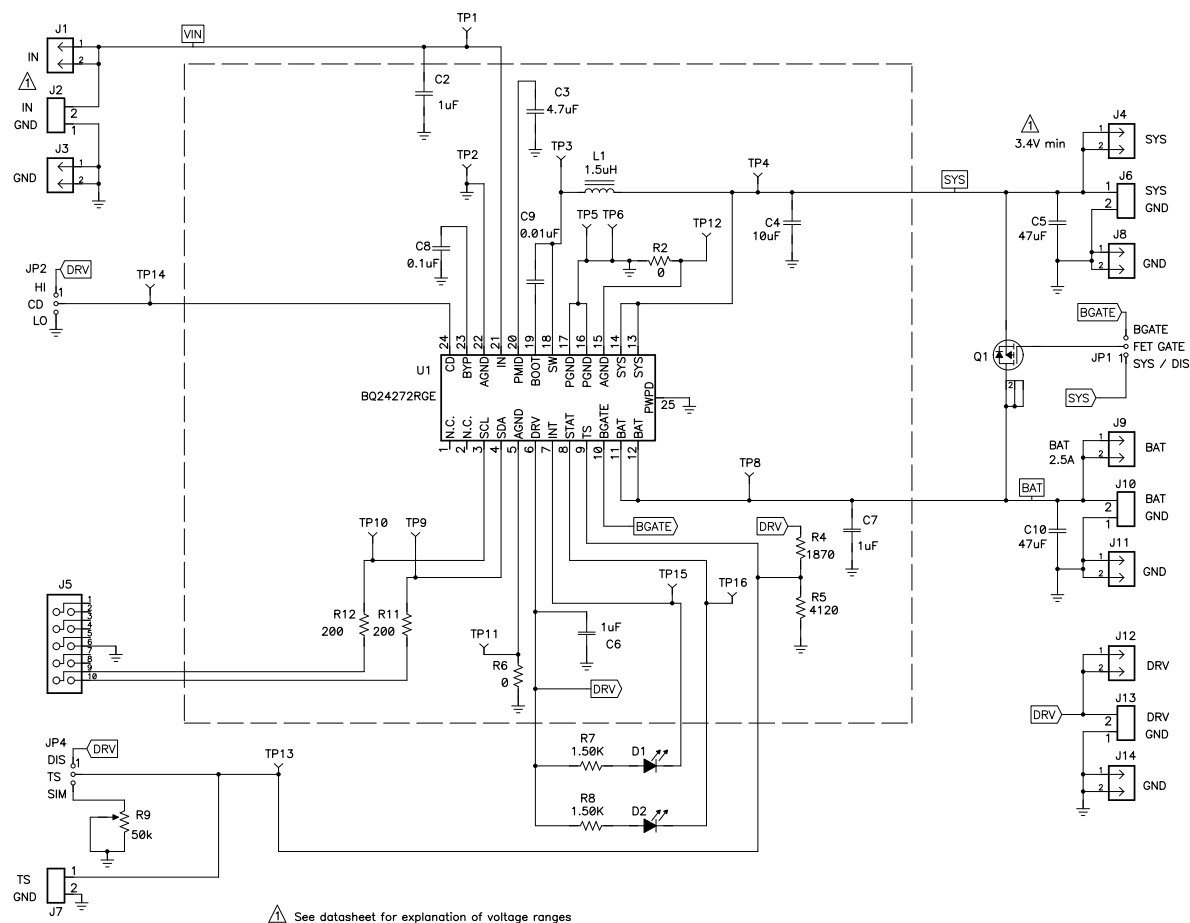
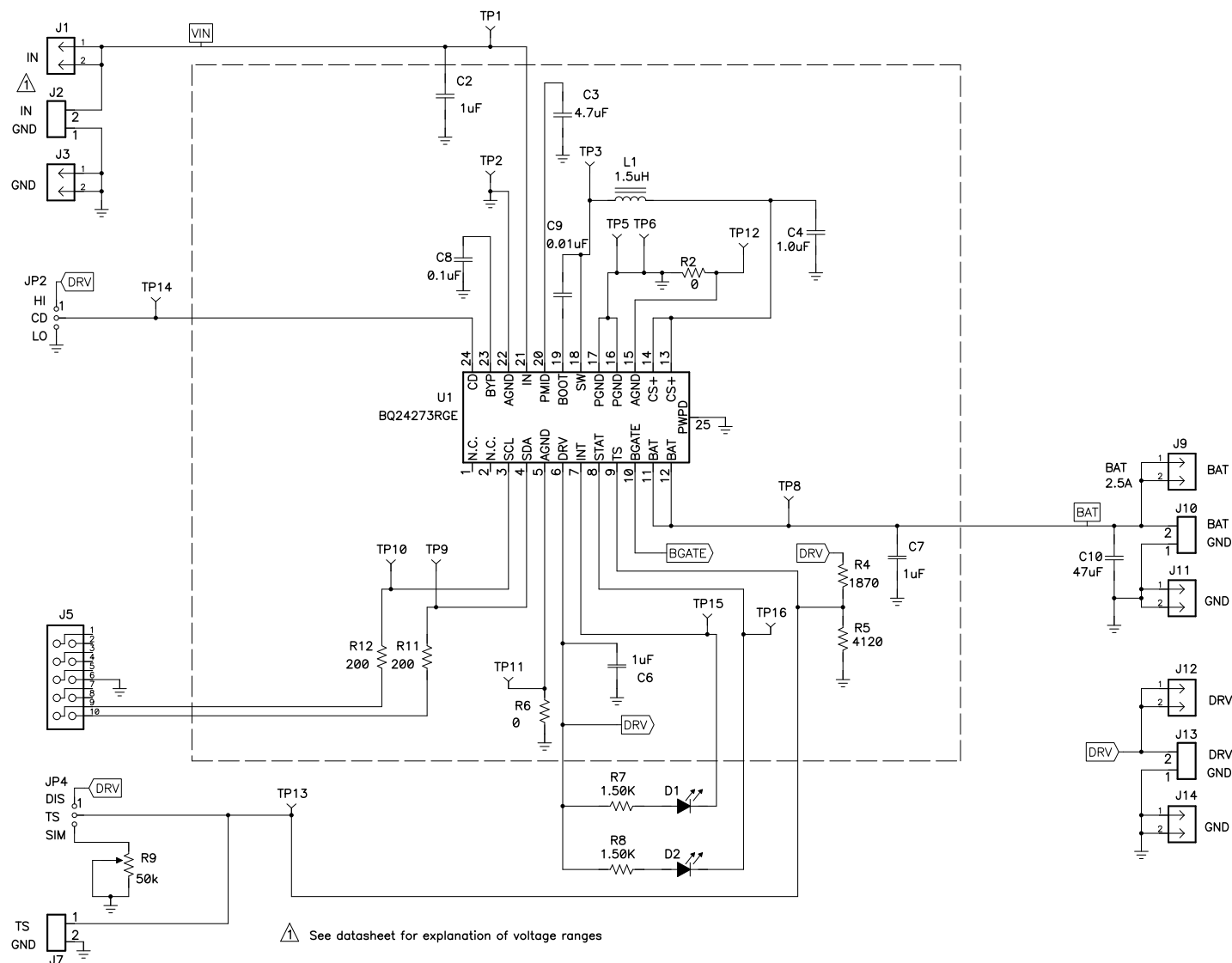


Figure 1. bq24272/273EVM (HPA759) Schematic (Sheet 1 of 2)



**Figure 2. bq24272/273EVM (HPA759) Schematic (Sheet 2 of 2)**

NOTE: EVMs with a printed-circuit board label that contain the suffix -X may have been assembled with incorrectly marked ICs. Regardless of the IC's marking, the EVM was assembled with the correct part number as specified in the EVM bill of material.

## 1.4 I/O Description

Header/Terminal Block	Description
J1-IN	Adapter positive header
J2-IN	Adapter positive terminal
J2-GND	Adapter negative terminal
J3-GND	Adapter negative header
J4-SYS	System output positive header (bq24272 only)
J5	USB-TO-GPIO box connector
J6-SYS	System output positive terminal (bq24272 only)
J6-GND	System output negative terminal (bq24272 only)
J7-TS	External thermistor positive terminal
J7-GND	Ground terminal for external thermistor
J8-GND	System output negative header (bq24272 only)
J9-BAT	Battery positive header
J10-BAT	Battery positive terminal
J10-GND	Battery negative terminal
J11-GND	Battery negative header
J12-DRV	DRV reference voltage positive header
J13-DRV	DRV reference voltage positive terminal
J13-GND	DRV reference voltage negative terminal
J14-GND	DRV reference voltage negative header

## 1.5 Test Points

Test Point	Description
TP1	Kelvin to VIN
TP2	AGND
TP3	SW
TP4	Kelvin to SYS (bq24272 only)
TP5	PGND
TP6	PGND
TP8	Kelvin to BAT
TP9	SDA
TP10	SCL
TP11	AGND
TP12	AGND
TP13	TS
TP14	CD
TP15	INT
TP16	STAT

## 1.6 Control and Key Parameters Setting

Jumper	Description	Default Factory Setting
JP1	bq24272 only 1-2 (FET GATE = SYS): External PFET's gate tied to SYS and therefore disabled. 2-3 (FET GATE = BGATE): External PFET's gate tied to BGATE pin and therefore controlled by IC.	2-3 (FET GATE = BGATE)
JP2	1-2 (CD = HI): Charge disable high to disable charge and enter Hi-Z mode 2-3 (CD = LO): Charge disable low for normal operation	2-3 (CD = LO)
JP4	1-2 (TS = DIS): Connects TS high to DRV and disables the temperature sense function on the IC 2 (JP4 Open): Connects a potentiometer to the TS so that the potentiometer can emulate a thermistor. The potentiometer has been preset to approximately 3.4 kΩ so that the TS voltage is 0.5 x V (DRV). 2-3 (TS = SIM): Connects the TS pin to an external thermistor. The resistor divider formed by R1 and R3 has been sized to accommodate a 10-kΩ thermistor. If a different thermistor is used, R1 and R3 must be resized.	2-3 (TS = SIM)

## 1.7 Recommended Operating Conditions

		Min	Typ	Max	Unit
Supply voltage, $V_{IN}$	Input voltage from ac adapter	4.2		10	V
System voltage, $V_{SYS}$	Voltage output at SYS terminal (bq24272 only; depends on VBAT voltage and status of $V_{INDPM}$ )	3.4		VBATR EG+4.17 %	V
Battery voltage, $V_{BAT}$	Voltage output at VBAT terminal (registers set via I2C communication)	3.4	4.2	4.44	V
Supply current, $I_{IN(MAX)}$	Maximum input current from ac adapter input (registers set via I2C communication)	1.5		2.5	A
Fast charge current, $I_{CHRG(MAX)}$	Battery charge current (registers set via I2C communication)	0.550		2.5	A
Operating junction temperature range, $T_J$		-40		125	°C

## 2 Test Summary

This procedure describes one test configuration of the HPA759 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 (LOADR, LOADI)
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. Power supply #1 (PS #1) capable of supplying 6 V at 3 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 4 A is required to power the circuit shown in Figure 3.

### 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 3 can simulate a battery when connected to a power supply.

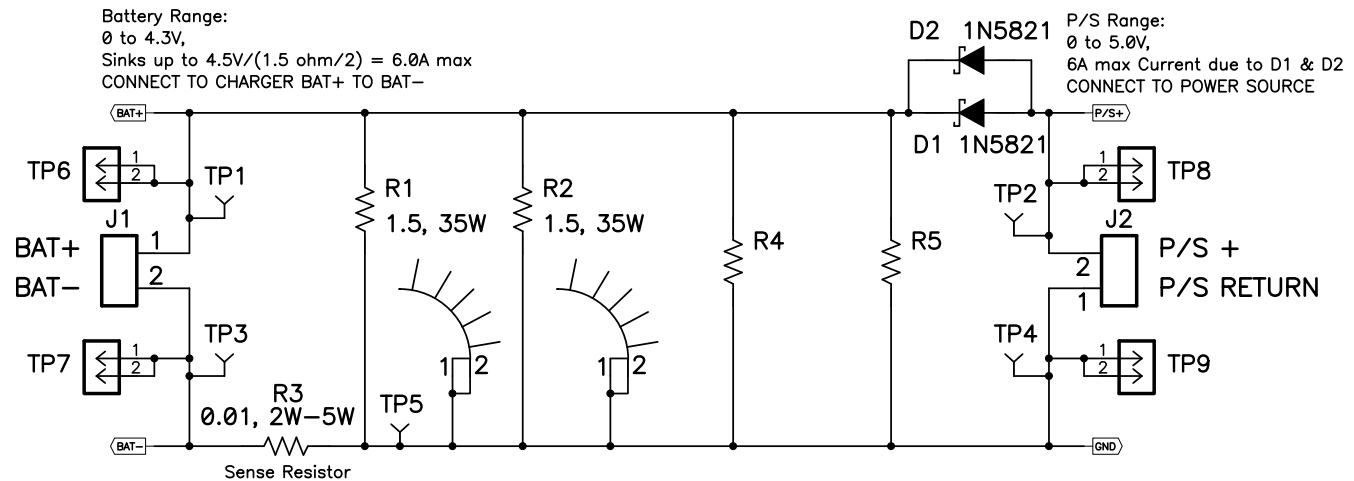


Figure 3. BAT\_Load (PR1010) Schematic

### 2.2.3 Load #2 Between SYS and GND

Although not required, a resistive load capable of sinking up to 3 A can be used.

### 2.2.4 Meters

Four equivalent voltage meters (VM #) and two equivalent current meters (CM #) are required. The current meters must be able to measure 4-A current.

### 2.2.5 Computer

A computer with at least one USB port and a USB cable is required. The bq2427x evaluation software must be properly installed.

### 2.2.6 HPA172 Communication Kit (USB TO GPIO)

An HPA172 USB-to-I<sup>2</sup>C communication kit is required.



## 2.2.7 Software

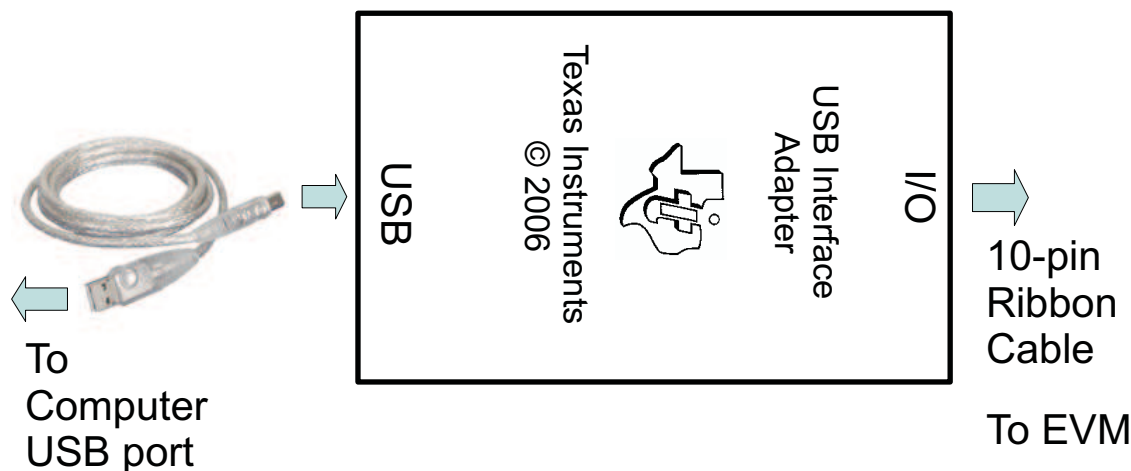
Download bq2427xSW.zip from the charger's product folder, unzip the file, and double-click on the SETUP.EXE file. Follow the installation steps.

Because the watchdog timer is enabled, 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. Periodically click the **READ** button to find the IC's instantaneous status. Alternatively, the **AutoRead** function can be activated, periodically updating 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 6-V, 3-A current limit and then turn the supply off.
3. If BAT\_Load as shown in Figure 1 is used, connect PS #2 set to approximately 3.1 V to the input side (PS #2) of BAT\_Load, then turn off PS #2.
4. Connect the output side of the battery or BAT\_Load in series with CM #2 to J9 and J11 or J10 (BAT, GND). Ensure that a voltage meter is connected across J9 or TP8 and J11 (BAT, GND).
5. bq24272 only: Connect the electronic load or resistor decade box in series with a current meter (multimeter) to J6(SYS, GND). Ensure the electronic load is in current mode and set to 0 A or the resistor decade box is set to the maximum resistance.
6. bq24272 only: Connect VM #3 across J4 or TP4 and J8 (SYS, GND).
7. Connect VM #4 across J12 and J14 (DRV, GND).
8. Connect J5 to the HPA172 kit 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 4.



**Figure 4. Connections of HPA172 Kit**

9. Ensure jumpers are at the default factory settings per Section 1.6

10. After the preceding steps have been performed, the test setup for HPA759 is configured as shown in Figure 5

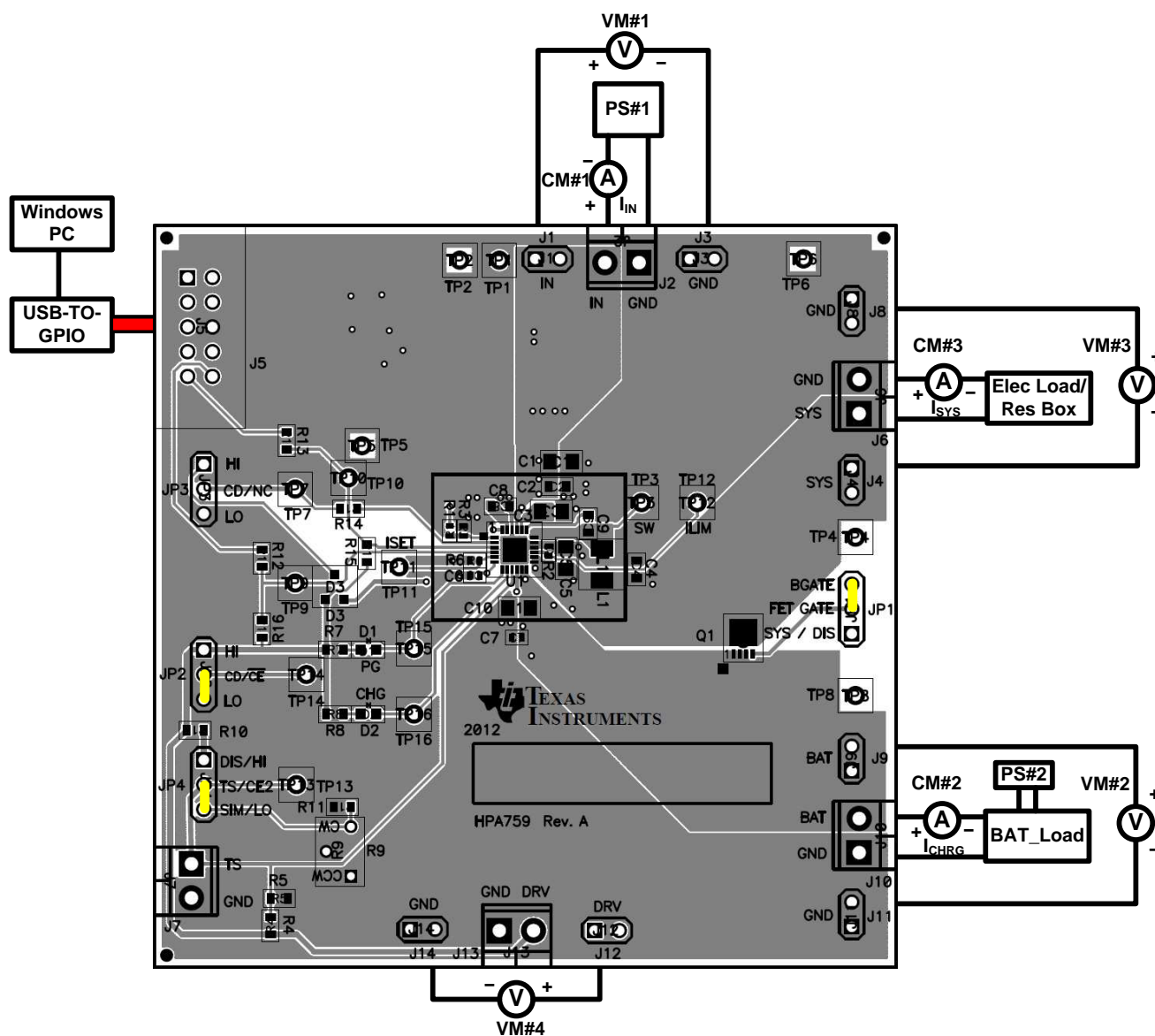


Figure 5. Original Test Setup for bq24272/273EVM (HPA759)

- Turn on the computer. Open the bq2427x evaluation software and click "IN DEVICE" when prompted at start-up. The main window of the software is shown in Figure 6.

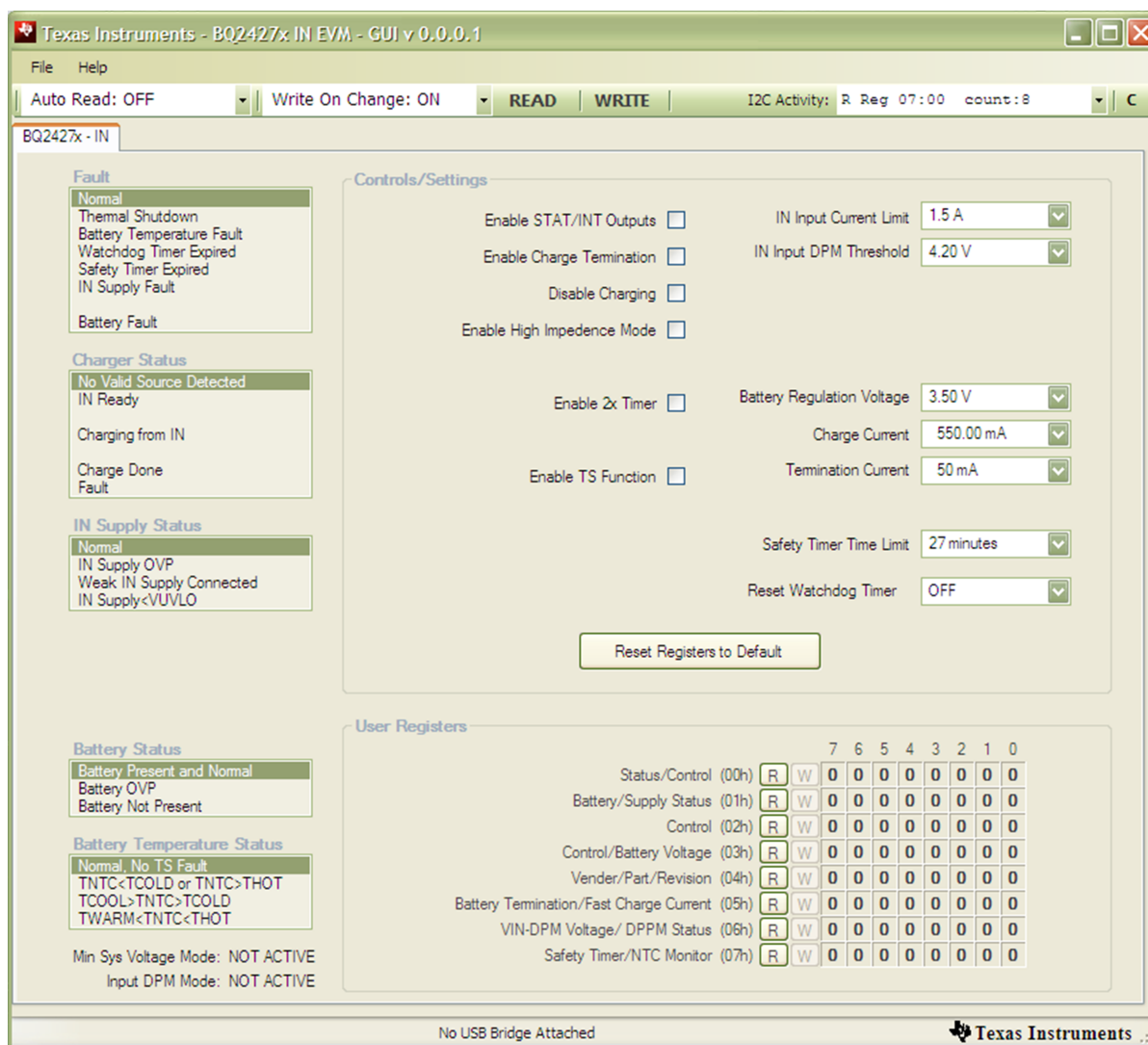


Figure 6. Main Window of bq2427xSW Evaluation Software

## 2.4 Recommended Test Procedure

The following test procedure is 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 is needed.

### 2.4.1 System Voltage and Output Current (bq24272 only)

1. Ensure that the [Section 2.3](#) steps are followed.
2. Connect the output of PS #1 in series with CM #1 to J2 (IN, GND).
3. Connect voltage meter 1 (VM #1) across J1 or TP1 and J3 (IN, GND).
4. With PS #2 disabled, turn on PS #1.
5. Ensure the electronic load is on current mode and set the current to 1 A or turn down the resistor decade box until CM #3 measures  $1000 \pm 100$  mA.
6. Measure:  
*Measure on VM #3*  $\rightarrow V(J4(SYS), J8(GND)) = 3.7 \pm 150$  mV.  
*Observe*  $\rightarrow$  D1 and D2 are on.
7. Move JP2 (CD) = HI.
8. *Measure on VM #3*  $\rightarrow V(J4(SYS), J8(GND)) = 0$  V.
9. Disable PS #1 and disconnect electronic load or resistor box and CM #3 from the HPA759 board.

### 2.4.2 Charge Voltage and Current Regulation of IN

1. Ensure that the [Section 2.3](#) steps are followed.
2. Connect the output of PS #1 in series with current meter (multimeter) #1 (CM #1) to J1 and J3 or J2 (IN, GND).
3. Connect voltage meter 1 (VM #1) across J1 or TP1 and J3 (IN, GND).
4. Move JP2 to HI.
5. Turn on PS #1 and PS #2 if used.
6. Return JP2 to LO.
7. Software setup:
  - Press the **READ** button to obtain the current settings.
  - Set **Write On Change** to ON if not already set.
  - 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 **USB Input Current Limit** to 2.5 A.
  - Set **Charge Current** to 1000 mA.
  - Click the **READ** button at the top of the window, and confirm that the previous settings remain.
8. Adjust PS #2 so that the voltage measured by VM #2, across BAT and GND, measures  $3.2$  V  $\pm 50$  mV.
9. Adjust the power supply so that VM #1 still reads  $6$  V  $\pm 100$  mV if necessary then  
*Measure on CM #2*  $\rightarrow I_{CHRG} = 1000$  mA  $\pm 100$  mA  
*Measure on CM #1*  $\rightarrow I_{IN} < 850$  mA  
*Observe*  $\rightarrow$  D1 and D2 are on.
10. Turn off PS #1 and PS #2.

### 2.4.3 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  $V_{INDPM}$  function, lower the current limit on PS #1.
3. To observe battery supplement mode, apply a resistive load across SYS and GND that is higher than the maximum charge current.

## 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 bq2427x.
2. Place a 4.7- $\mu$ F input capacitor as close as possible to the PMID pin and PGND pin to make the high-frequency current loop area as small as possible. Place 1- $\mu$ F input capacitor GNDs as close as possible to the respective PMID capacitor GND and PGND pins to minimize the ground difference between the input and PMID.
3. The local bypass capacitor from SYS for bq24272 (or CS+ for bq24273) to GND must be connected between the SYS (or 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) reducing 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. Having the components segregated minimizes coupling between signals.
6. The high-current charge paths into IN, BAT, SYS (or CS+), 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. Bill of Materials - HPA759A**

COUNT							
- 001	- 002	RefDes	Value	Description	Size	Part Number	MFR
0	0	C1	Open	Capacitor, ceramic, 25 V, X5R, 10%	0805	Std	Std
1	1	C2	1 $\mu$ F	Capacitor, ceramic, 25 V, X5R, 10%	0603	Std	Std
1	1	C3	4.7 $\mu$ F	Capacitor, ceramic, 25 V, X5R, 10%	0805	Std	Std
1	0	C4	10 $\mu$ F	Capacitor, ceramic, 6.3 V, X5R, 20%	0603	Std	Std
0	1	C4	1 $\mu$ F	Capacitor, ceramic, 6.3 V, X5R, 20%	0603	Std	Std
1	0	C5	47 $\mu$ F	Capacitor, ceramic, 6.3 V, X5R, 20%	0805	Std	Std
1	1	C10	47 $\mu$ F	Capacitor, ceramic, 6.3 V, X5R, 20%	0805	Std	Std
2	2	C6, C7	1 $\mu$ F	Capacitor, ceramic, 6.3 V, X5R, 10%	0402	Std	Std
1	1	C8	0.1 $\mu$ F	Capacitor, ceramic, 25 V, X7R, 10%	0603	Std	Std
1	1	C9	0.01 $\mu$ F	Capacitor, ceramic, 10 V, X5R, 10%	0603	Std	Std
2	2	D1, D2	Green	Diode, LED, green, 2.1 V, 20 mA, 6 mcd	0603	LTST-C190GKT	Liteon
6	6	J1, J3, J9, J11, J12, J14	PEC02SAAN	Header, 2-pin, 100-mil spacing	0.100 $\times$ 2	PEC02SAAN	Sullins
4	4	J2, J7, J10, J13	ED555/2DS	Terminal block, 2 pin, 6 A, 3.5 mm	0.27 $\times$ 0.25	ED555/2DS	OST
2	0	J4, J8	PEC02SAAN	Header, 2-pin, 100-mil spacing	0.100 $\times$ 2	PEC02SAAN	Sullins
1	1	J5	N2510-6002-RB	Connector, male straight 2 $\times$ 5 pin, 100-mil spacing, 4 wall	0.338 $\times$ 0.788 in	N2510-6002-RB	3M
1	0	J6	ED555/2DS	Terminal block, 2 pin, 6 A, 3.5 mm	0.27 $\times$ 0.25	ED555/2DS	OST
1	0	JP1	PEC03SAAN	Header, male, 3 pin, 100-mil spacing	0.100 in $\times$ 3	PEC03SAAN	Sullins
2	2	JP2, JP4	PEC03SAAN	Header, male, 3 pin, 100 mil spacing	0.100 in $\times$ 3	PEC03SAAN	Sullins
1	1	L1	1.5 $\mu$ H	Inductor, SMT, 3.5 A, 70 m $\Omega$	4.1 $\times$ 4.4 mm	SPM4012T-1R5M Alternate: FDSD0415-H-1R5M	TDK Alternate: Toko
1	0	Q1	CSD25401Q3	MOSFET, PChan, -20 V, 60 A, 8.7 m $\Omega$	QFN 3.3 $\times$ 3.3mm	CSD25401Q3	TI
1	1	R2	0 $\Omega$	Resistor, chip, 1/16W, 1%	0402	Std	Std
1	1	R4	1870 $\Omega$	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	1	R5	4120 $\Omega$	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	1	R6	0 $\Omega$	Resistor, chip, 1/16W, 1%	0402	Std	Std
2	2	R7, R8	1.50 k $\Omega$	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	1	R9	50 k $\Omega$	Potentiometer, 3/8 cermet, single-turn	0.25 $\times$ 0.17 in	3266W-1-503LF	Bourns

**Table 1. Bill of Materials - HPA759A (continued)**

0	0	R10	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	2	R11, R12	200 $\Omega$	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	0	TP4	5000	Test point, red, thru hole color keyed	0.100 × 0.100 in	5000	Keystone
6	6	TP1, TP2, TP3, TP7, TP8, TP15, TP16	5000	Test point, red, thru hole color keyed	0.100 × 0.100 in	5000	Keystone
2	2	TP5, TP6	5001	Test point, black, thru hole color keyed	0.100 × 0.100 in	5001	Keystone
1	1	TP9, TP10	5002	Test point, white, thru hole color keyed	0.100 × 0.100 in	5002	Keystone
4	4	TP11, TP12, TP13, TP14	5002	Test point, white, thru hole color keyed	0.100 × 0.100 in	5002	Keystone
1	0	U1	BQ24272RGE	IC, 2.5 A, single input, single cell switchmode Li-Ion battery charger with power-path management	QFN-24	BQ24272RGE	TI
0	1	U1	BQ24273RGE	IC, 2.5 A, single input, single cell switchmode Li-Ion battery charger with power-path management	QFN-24	BQ24273RGE	TI
3	2	–		Shunt, 100 mil, Black	0.100	929950-00	3M
1	1	–		PCB 3.00 in × 3.00 in × 0.062 in		HPA759	Any

## 4.2 Board Layout

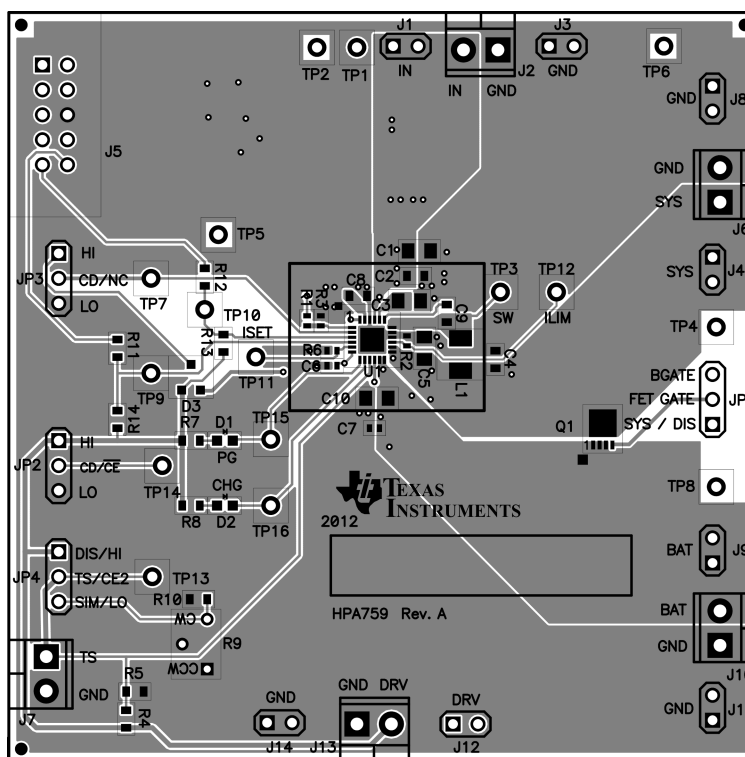


Figure 7. Top Assembly Layer

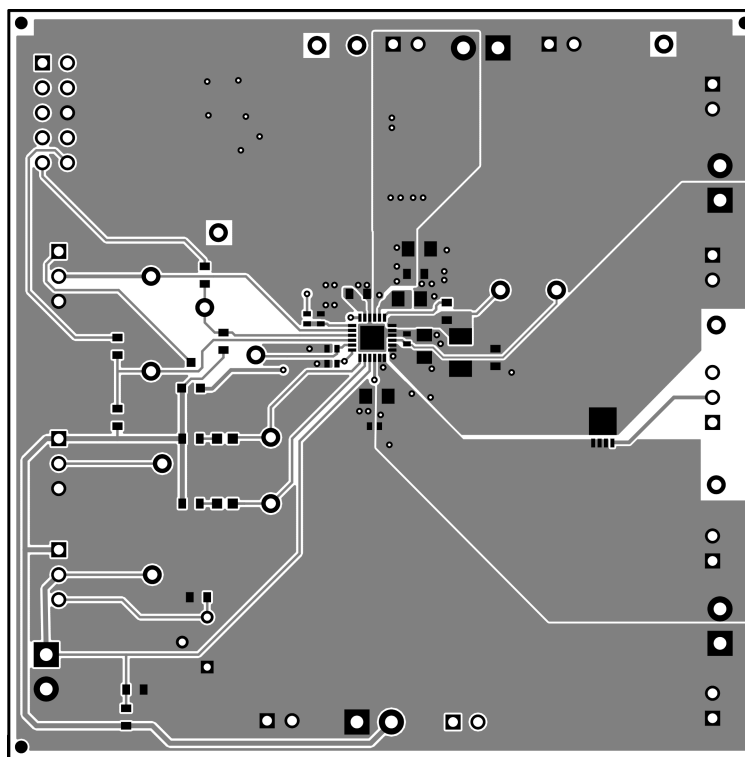
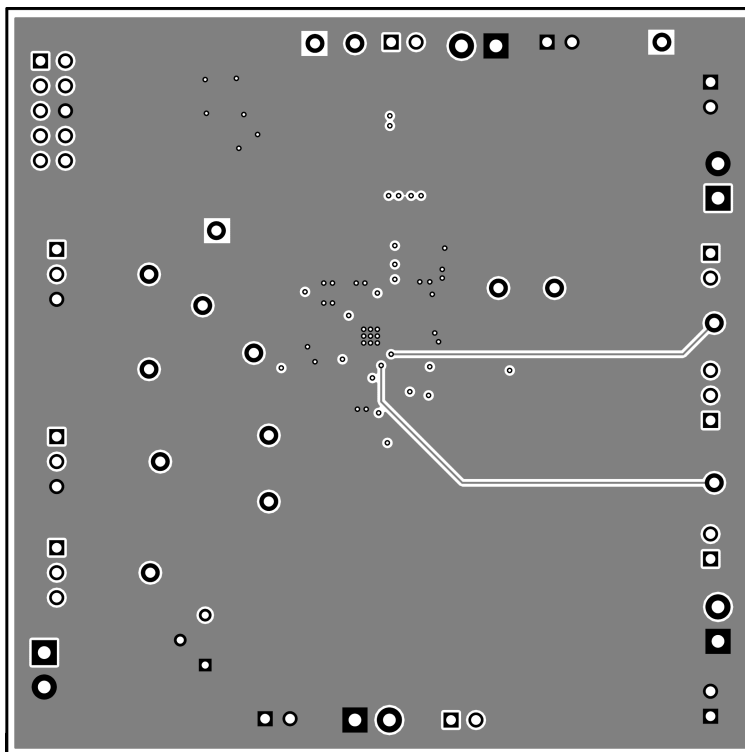
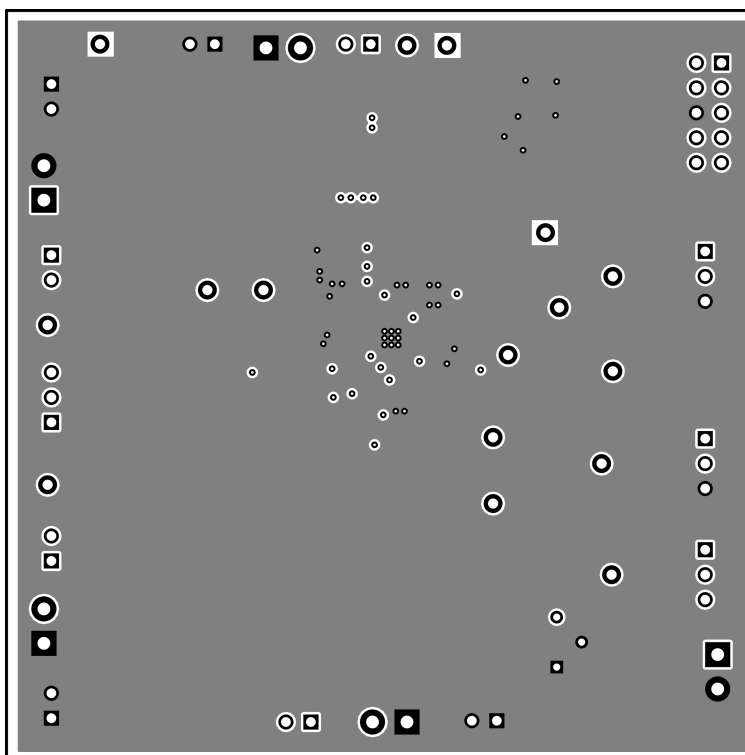


Figure 8. Top Layer

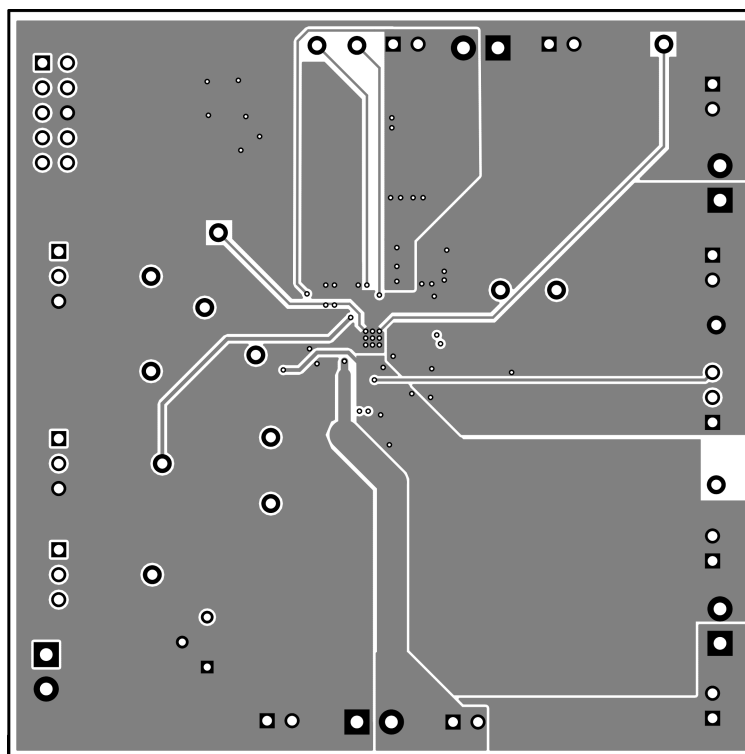




**Figure 9. First Internal Layer**



**Figure 10. Second Internal Layer**



**Figure 11. Bottom Layer**

## EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

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As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

### General Statement for EVMs including a radio

*User Power/Frequency Use Obligations:* This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

### 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

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**

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.

**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.

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.

## **【Important Notice for Users of this Product in Japan】**

**This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan**

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

**Texas Instruments Japan Limited**  
**(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan**

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本開発キットは技術基準適合証明を受けておりません。

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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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日本テキサス・インスツルメンツ株式会社

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## EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

**For Feasibility Evaluation Only, in Laboratory/Development Environments.** Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

**Certain Instructions.** It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

**Agreement to Defend, Indemnify and Hold Harmless.** You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

**Safety-Critical or Life-Critical Applications.** If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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## EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit [www.ti.com/esh](http://www.ti.com/esh) or contact TI.

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## REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

### General Statement for EVMs including a radio

*User Power/Frequency Use Obligations:* This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

### 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

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**

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.

### **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.

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.



## **【Important Notice for Users of this Product in Japan】**

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2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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## EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

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Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

**Certain Instructions.** It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

**Agreement to Defend, Indemnify and Hold Harmless.** You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

**Safety-Critical or Life-Critical Applications.** If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

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In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

### Products

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DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
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