bq24735/725A Battery Charger Evaluation Module

This user's guide describes the features and operation of the bq24725A/735EVM Evaluation Module.

Contents

1 Introduction 2
1.1 EVM Features 2
1.2 General Description 2
1.3 Input/Output Jack Description 2
1.4 Control and Key Parameters Setting 3
1.5 Recommended Operating Conditions 3
2 Test Summary 3
2.1 Definitions 3
2.2 Equipment 3
2.3 Equipment Setup 4
2.4 Procedure 6
3 Printed-Circuit-Board Layout Guideline 8
4 Bill of Materials, Board Layout, and Schematics 10
4.1 Board Layouts 12
4.2 Schematics 18

List of Figures

1 EV2300 Kit Connections 5
2 Original Test Setup for HPA710 5
3 Main Window of bq24725A/735 Evaluation Software 6
4 Test Setup for HPA710 7
5 Top Assembly 12
6 Top Layer 13
7 Second Layer 14
8 Third Layer 15
9 Bottom Layer 16
10 Bottom Assembly 17
11 Schematic 18

List of Tables

1 EV2300 and bq24725A/735EVM Connections 5
2 Bill of Materials 10

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1 Introduction

1.1 EVM Features

- Evaluation module for bq24725A/735
- bq24735 adapter and battery together provide power to system to support Intel™ CPU Turbo Boost mode
- High-efficiency NMOS-NMOS synchronous buck charger with 750-kHz frequency
- High-efficiency and low-cost NMOS power path selector and integrated gate driver
- User-selectable 1-cell, 2-cell, 3-cell, or 4-cell Li-ion battery voltage
- Programmable battery voltage, charge current, and ac adapter current via SMBus interface
- Flexible Chargeoption() register control via SMBus interface
- AC adapter operating range 4.5 V–24 V
- Test points for key signals available for testing purposes. Easy probe hook-up
- Jumpers available. Easy-to-change connections

1.2 General Description

The bq24725A/735 evaluation module (EVM) is a complete charger module for evaluating a multicell synchronous notebook turbo boost charge using the bq24725A/735 devices. It is designed to deliver up to 4 A of charge current to Li-ion or Li-polymer applications. The charge current is programmable by SMBus interface through the EV2300 interface board.

The bq24725A/735EVM does not include the EV2300 interface board. In order to evaluate the bq24725A/735EVM, a user must order the EV2300 interface board separately.

The bq24725A/735 is a high-efficiency, synchronous battery charger, offering low component count for space-constraint, multichemistry battery charging applications.

The bq24735 supports the Turbo Boost mode by allowing the battery to discharge energy to the system when system power demand is temporarily higher than adapter maximum power level so that the adapter does not crash.

The bq24725A/735 uses two charge pumps to separately drive n-channel MOSFETs (ACFET, RBFET, and BATFET) for automatic system power source selection.

SMBus-controlled input current, charge current, and charge voltage DACs allow for high regulation accuracies that can be easily programmed by the system power management microcontroller.

To throttle down PWM modulation and reduce the charge current, the bq24725A/735 uses the internal input current register or the external ILIM pin .

The bq24725A/735 charges one, two, three, or four series Li+ cells and is available in a 20-pin, 3.5 x 3.5 mm^2 QFN package. For details, see the bq24725A/735 data sheet (SLUSAK9).

1.3 Input/Output Jack Description

Jack	Description
J1–DCIN	AC adapter, positive output
J1–GND	AC adapter, negative output
J2-SYS	Connected to system
J2-BAT	Connected to battery pack
J2-GND	Ground
J3-ACOK	ACOK pin
J3-IOUT	IOUT pin
J3-3.3V	External voltage supply, 3.3 V
J4–SCL	SCL pin output, SMBus clock line
J4–SDA	SDA pin output, SMBus data line

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Jack	Description
J4– GND	External power supply, negative output

1.4 Control and Key Parameters Setting

Jack	Description	Factory Setting
JMP1	Connect battery voltage to VCC pin	Jumper installed

1.5 Recommended Operating Conditions

		Min	Typ	Max	Unit	Notes
Supply voltage, V_{IN}	Input voltage from ac adapter input	18	19-20	22	V	
Battery voltage, V_{BAT}	Voltage applied at VBAT terminal	0	3-16.8	20	V	
Supply current, I_{AC}	Maximum input current from ac adapter input	0		4.5	A	
Charge current, I_{chrg}	Battery charge current	1	3	4	A	
Operating junction temperature range, T_J		0		125	°C	

2 Test Summary

2.1 Definitions

This procedure details how to configure the HPA710 evaluation board. On the test procedure, the following naming conventions are followed. See the HPA710 schematic for details.

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 jack terminal 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 jack XX.
Jxx(BBB)	Terminal or pin BBB of jack xx
Jxx ON	Internal jumper Jxx terminals are shorted.
Jxx OFF	Internal jumper Jxx terminals are open.
Jxx (-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 location for jumpers, test points, and individual components.

2.2 Equipment

Power Supplies

Power Supply #1 (PS#1): a power supply capable of supplying 20 V at 5 A is required.
Power Supply #2 (PS#2): a power supply capable of supplying 5 V at 1 A is required.
Power Supply #3 (PS#3): a power supply capable of supplying 20 V at 5 A is required.

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Load #1

A 30-V (or above), 5-A (or above) electronic load that can operate at constant current mode

Load #2

A HP 6060B 3-V to 60-V/0-A to 60-A, 300-W system dc electronic load or equivalent

Meters

Seven Fluke 75 multimeters, (equivalent or better)
Or four equivalent voltage meters and three equivalent current meters.
The current meters must be capable of measuring 5-A+ current.

Computer

A computer with at least one USB port and a USB cable. The EV2300 USB driver and the bq24725A/735 SMB evaluation software must be properly installed.

EV2300 SMBus Communication Kit

An EV2300 SMBUS communication kit

Software

Install the EV2300 driver before installing the bq24725A/735 software.

Driver (USB EV2300) Installer XP2K – Last updated Jan28-04.zip or later: This is the EV2300 USB driver. Save and unzip to c:\temp (or other local directory). Double-click on the setup.exe file. Perform the following installation steps.

1. This software needs to be installed after the EV2300 USB driver.
   - bq2473x EVSW setup.zip (SLUC258): This is the bq24725A/735 SMB evaluation software. Save and unzip to c:\temp (or other local directory). Double-click on the setup.exe file. Perform the following steps.
   - Note that on first insertion of EV2300 into the USB port of personal computer (PC), the user needs to follow the instructions of the Found New Hardware wizard.
   - Allow the Windows™ operating system to connect to Windows Update to search for software. Then click *Next*.
   - Select *Install software automatically (Recommended)*. Then click *Next*.
   - If a window pops up informing that the TI USB Firmware Updater has not passed Windows Logo testing, click *Continue Anyway*.
   - If a target file already exists and is newer, do not overwrite the newer file.
   - Click *Finish.*

2.3 Equipment Setup

1. Set the power supply #1 for 0 V ± 100 mVdc, with the current limit set to > 5 A, and then turn off supply.
2. Connect the output of power supply #1 in series with a current meter (multimeter) to J1 (DCIN, GND).
3. Connect a voltage meter across J1 (DCIN, GND).
4. Set the power supply #2 for 3.3 V ± 100 mVdc, 0.2-A ± 0.1-A current limit, and then turn off supply.
5. Connect the output of the power supply #2 to J3 (3.3 V) and J4 (GND).
6. Connect a voltage meter across J2 (BAT, GND).
7. Connect a voltage meter across J2 (SYS, GND).
8. Connect J4 (SDA, SCL) and J4 (GND) to the EV2300 kit SMB port. See Table 1 for a connection reference. Connect the USB port of the EV2300 kit to the USB port of the computer. The connections are shown in Figure 1.

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Table 1. EV2300 and bq24725A/735EVM Connections

bq24725A/735EVM-710	EV2300
GND (J4)	GND (1)
SCL (J4)	SMBC (2)
SDA (J4)	SMBD (3)

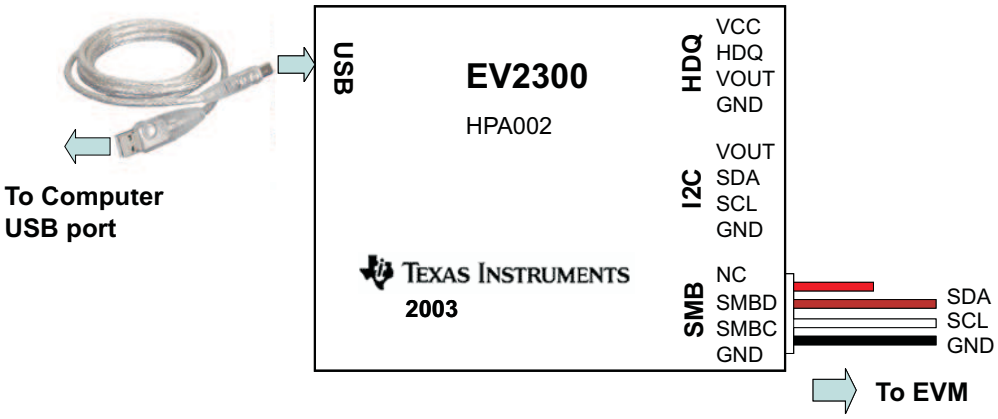


Figure 1. EV2300 Kit Connections

9. If JP1 is not installed, install the jumper.
10. After performing the preceding steps, the test setup for HPA710 is configures as is shown in Figure 2.

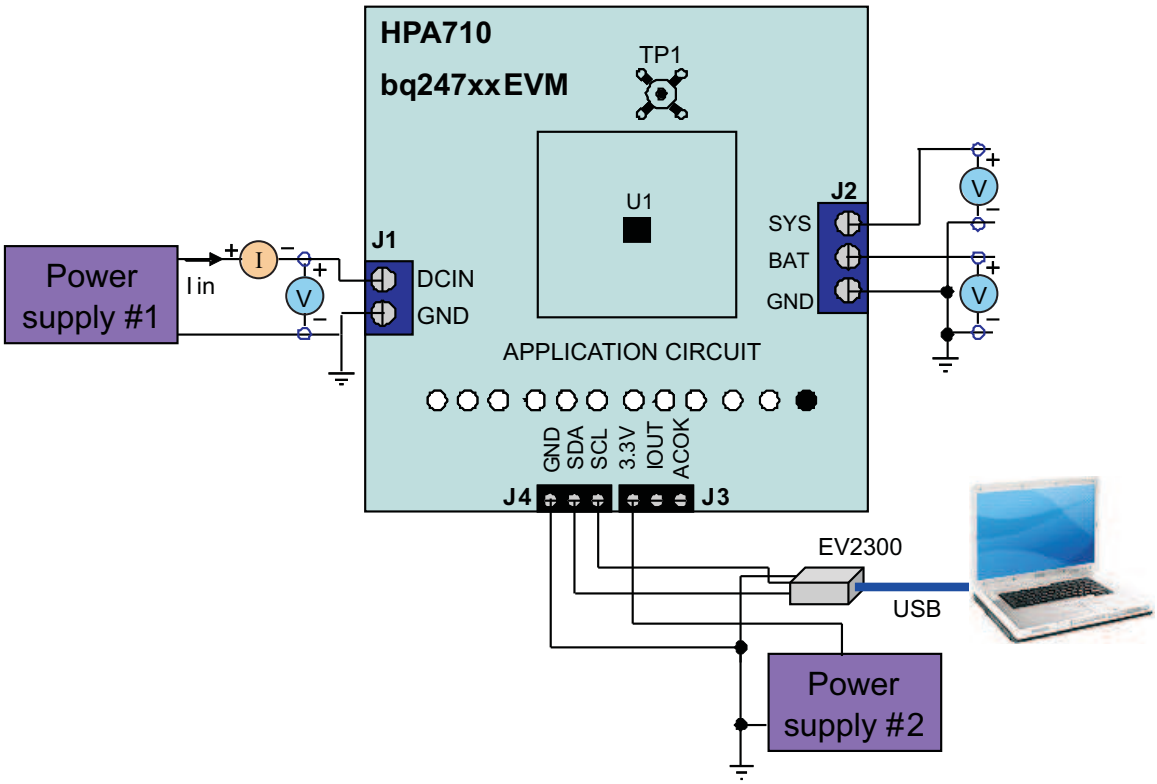


Figure 2. Original Test Setup for HPA710

11. Turn on the computer. Open the bq24725A/735 evaluation software. The main window of the software appears as is shown in Figure 3.

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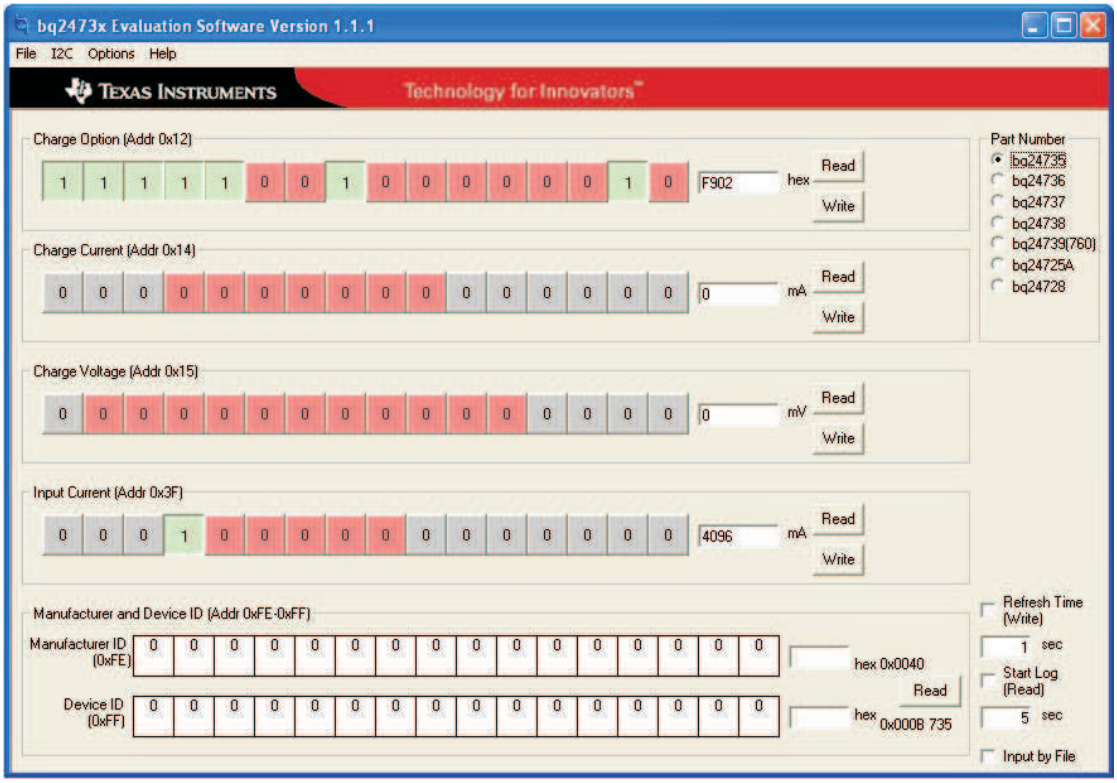


Figure 3. Main Window of bq24725A/735 Evaluation Software

2.4 Procedure

2.4.1 AC Adapter Detection Threshold

1. Ensure that Section 2.3 steps are followed. Turn on PS#2.
   Note: Load #1 and Load #2 are not connected during this step.
2. Turn on PS#1.
3. Increase the output voltage of PS#1 to 19.5 V.
   Measure → V(TP(ACDET)) = 2.6 V ± 0.1 V
   Measure → V(TP(ACOK)) = 3.3 V ± 0.1 V
   Measure → V(J2(SYS)) = 19.5 V ± 0.5 V
   Measure → V(TP(REGN)) = 6 V ± 0.5 V
   Measure → V(TP(ACDRV, CMSRC)) = 6 V ± 0.5 V
   Measure → V(J2(BAT, GND)) = 2 V ± 2 V

2.4.2 Charger Parameters Setting

1. In the software main window, click all the Read buttons. Ensure that no error information is generated.
2. If the error information window pops up and you see *USB Error. Insure USB cable is connected and Driver is working.*, do the following steps.
   a) Click *OK*. Then, close main window, as shown in Figure 3, and disconnect USB cable.
   b) Check 3.3-V power supply (PS#2) and power supply #1 (PS#1) voltage on the EVM board.

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c) Disconnect any other unsure SMBus connection. Plug USB cable back to the original EVM2300 installation USB port.

d) Open the bq24725A/735 evaluation software. The main window of the software is shown in Figure 3.

3. In the software main window, click all the Read buttons.

a) Type in *512* (mA) in the Charge Current DAC, and click *Write*. This sets the battery charge current regulation threshold.

b) Type in *12592* (mV) in the Charge Voltage DAC, and click *Write*. This sets the battery voltage regulation threshold.

c) Measure → V(J2(BAT)) = 12.6 V ± 200 mV

2.4.3 Charge Current and ac Current Regulation, DPM

1. Type in *7801* in the Charge Option, and click *Write*; this disable charging.
2. Connect the Load #2 in series with a current meter (multimeter) to J2 (BAT, GND). Ensure that a voltage meter is connected across J2 (BAT, GND). Turn on the Load #2. Use the constant voltage mode. Set the output voltage to 10.5 V.
3. Connect the output of the Load #1 in series with a current meter (multimeter) to J2 (SYS, GND). Ensure that a voltage meter is connected across J2 (SYS, GND). Turn on the power of the Load #1. Set the load current to 3 A ± 50 mA but disable the output. The setup is now like Figure 4 for HPA710. Ensure that Ibat = 0 A ± 10 mA and Isys = 0 A ± 10 mA.

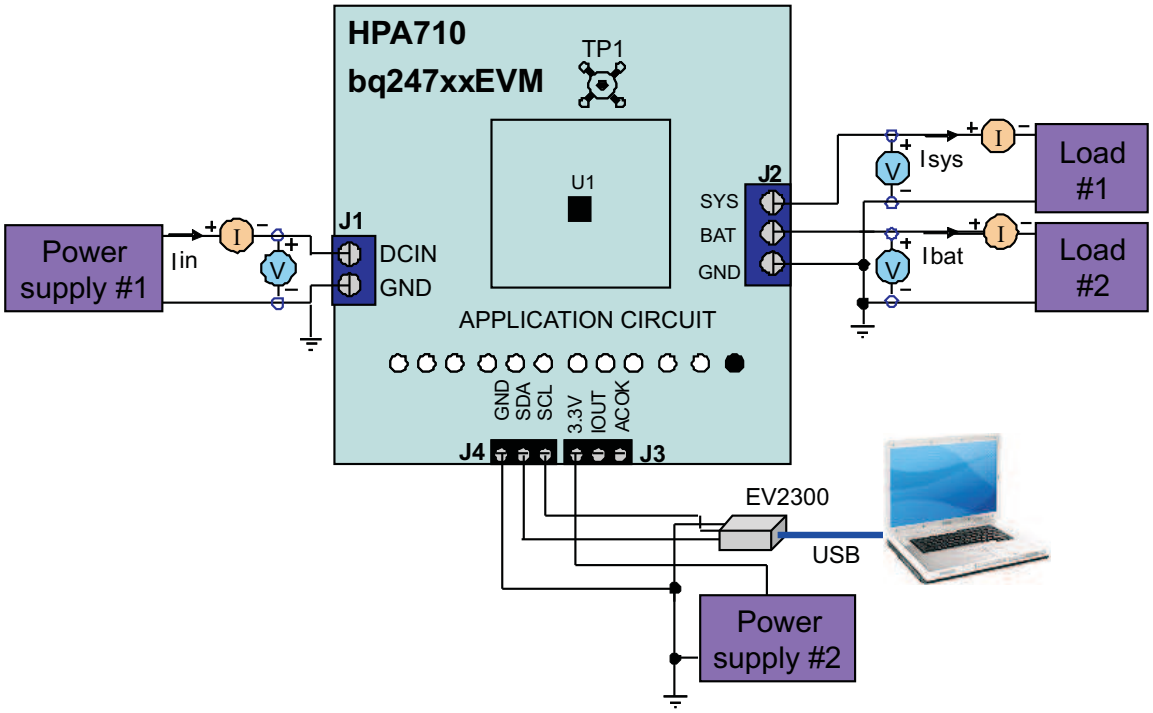


Figure 4. Test Setup for HPA710

4. Type in *7800* in the Charge Option, and click *Write*, this enable charging.
   Measure → Ibat = 500 mA ± 100 mA

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5. Type in *2944* (mA) in the Charge Current DAC and click *Write*. This sets the battery charge current regulation threshold to 2.944A.

   Measure → Ibat = 3000 mA ± 300 mA
   Measure → V(TP(IOUT)) = 340 mV ± 40 mV

6. Enable the output of the Load #1.

   Measure → Isys = 3000 mA ± 300 mA, Ibat = 1600 mA ± 300 mA, Iin = 4100 mA ± 400 mA
   Measure → V(TP(IOUT)) = 820 mV ± 100 mV

7. Turn off the Load #1.

   Measure → Isys = 0 ± 100 mA, Ibat = 3000 mA ± 300 mA.

2.4.4 Boost Mode – bq24735EVM Only

1. Set ChargeOption() bit [3] to 1, and click *Write*; this enables turbo boost function.
2. Replace Load #2 with PS#3. Ensure that a voltage meter is connected across J2 (BAT, GND).
3. Enable the output of the PS #3. Ensure that the output voltage is 10 V ± 500 mV.
4. Set the Load#1 load current to 5 A ± 50 mA. Enter boost mode

   Measure → I_{SYS} = 5000 mA ± 500 mA, I_{BAT} = -2000 mA ± 300 mA, I_{IN} = 4100 mA ± 400 mA

5. Set the Load#1 load current to 3 A ± 50 mA. Exit boost mode.

   Measure → I_{SYS} = 3000 mA ± 500 mA, I_{BAT} = 1600 mA ± 300 mA, I_{IN} = 4100 mA ± 400 mA

2.4.5 Power Path Selection

1. Type in *7801* in the Charge Option, and click *Write*; this disable charging.

   Measure → V(J2(SYS)) = 19.5 V ± 1 V (adapter connected to system)

2. Turn off PS#1. (PS#3 setting per Section 2.4.4, Step 2 and Step 3.

   Measure → V(J2(SYS)) = 10 V ± 1 V (battery connected to system)
   Measure → V(J2(BAT)) = 10 V ± 1 V (battery connected to system)

3 Printed-Circuit-Board Layout Guideline

The switching node rise and fall times must be minimized for minimum switching loss. Proper layout of the components to minimize high-frequency, current-path loop is important to prevent electrical and magnetic field radiation and high-frequency resonant problems. The following is a printed-circuit-board (PCB) layout priority list for proper layout. Layout of the PCB according to this specific order is essential.

1. Place input capacitor as close as possible to switching MOSFET's supply and ground connections, and use the shortest copper trace connection. These parts must be placed on the same layer of the PCB instead of on different layers and using vias to make this connection.
2. The integrated circuit (IC) must be placed close to the switching MOSFET's gate terminals and the gate drive signal traces kept short for a clean MOSFET drive. The IC can be placed on the other side of the PCB of switching MOSFETs.
3. Place the inductor input terminal as close as possible to the switching MOSFET's output terminal . Minimize the copper area of this trace in order to lower electrical and magnetic field radiation, but make the trace wide enough to carry the charging current. Do not use multiple layers in parallel for this connection. Minimize parasitic capacitance from this area to any other trace or plane.
4. The charging current-sensing resistor must be placed right next to the inductor output. Route the sense leads connected across the sensing resistor back to the IC in the same layer, close to each other (minimize loop area), and do not route the sense leads through a high-current path. Place decoupling capacitor on these traces next to the IC.
5. Place output capacitor next to the sensing resistor output and ground.

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6. The output capacitor ground connections need to be tied to the same copper that connects to the input capacitor ground before connecting to the system ground.
7. Use single ground connection to tie the charger power ground to the charger analog ground. Just beneath the IC, use analog ground copper pour, but avoid the power pins in order to reduce inductive and capacitive noise coupling.
8. Route the analog ground separately from the power ground. Connect the analog ground, and then connect the power ground separately. Connect analog ground and power ground together using power pad as the single ground connection point. Or use a 0-Ω resistor to tie analog ground to the power ground. (The power pad must tie to the analog ground in this case, if possible).
9. Place the decoupling capacitors next to the IC pins, and make the trace connection as short as possible.
10. It is critical that the exposed power pad on the backside of the IC package be soldered to the PCB ground. Ensure that sufficient thermal vias are located directly under the IC, connecting to the ground plane on the other layers.

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4 Bill of Materials, Board Layout, and Schematics

Table 2. Bill of Materials

-001 bq24725A	-002 bq24735	RefDes	Value	Description	Size	Part Number	MFR
1	1	C1	2.2 µF	Capacitor, Ceramic, 25V, X7R, 10%	1210	Std	Std
6	6	C2, C3, C4, C5, C6, C7	10 µF	Capacitor, Ceramic, 25V, X7R, 10%	1206	Std	Std
6	6	C8, C14, C15, C16, C17, C19	0.1 µF	Capacitor, Ceramic, 25V, X7R, 10%	603	Std	Std
4	4	C9, C10, C20, C25	1 µF	Capacitor, Ceramic, 25V, X7R, 10%	603	Std	Std
3	3	C11, C12, C27	0.01 µF	Capacitor, Ceramic, 25V, X7R, 10%	603	Std	Std
0	0	C13, C18, C24	Open	Capacitor, Ceramic, 25V, X7R, 10%	603	Std	Std
1	1	C21	0.047 µF	Capacitor, Ceramic, 25V, X7R, 10%	603	Std	Std
1	1	C22	100 pF	Capacitor, Ceramic, 25V, X7R, 10%	603	Std	Std
1	1	C23	2200 pF	Capacitor, Ceramic, 25V, X7R, 10%	603	Std	Std
1	1	C26	1000 pF	Capacitor, Ceramic, 25V, X7R, 10%	603	Std	Std
1	1	D1	BAT54-V-G	Diode, Schottky, 200-mA, 30-V	SOT23	BAT54-V-G	Vishay-Liteon
1	1	D2	BAT54C-V-G	Diode, Dual Schottky, 200-mA, 30-V	SOT23	BAT54C-V-G	Vishay-Liteon
1	1	J1	ED120/2DS	Terminal Block, 2-pin, 15-A, 5.1mm	0.40 x 0.35 inch	ED120/2DS	OST
1	1	J2	ED120/3DS	Terminal Block, 3-pin, 15-A, 5.1mm	0.60 x 0.35 inch	ED120/3DS	OST
2	2	J3. J4	ED555/3DS	Terminal Block, 3-pin, 6-A, 3.5mm	0.41 x 0.25 inch	ED555/3DS	OST
1	1	JP1	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
1	1	SH1	929950-00	Shorting jumpers, 2-pin, 100mil spacing,		929950-00	3M/ESD
1	1	L1	4.7 µH	Inductor, SMT	0.255 x 0.270 inch	IHLP2525CZER4R7M01	Vishay
3	3	Q1, Q2, Q3	CSD17307Q5A	MOSFET, NChan, 30V, 14A, 9.5millohm	PWRPAK S0-8	CSD17307Q5A	Texas Instruments
2	2	Q4, Q5	CSD17308Q3A	MOSFET, NChan, 30V, 13A, 9.4millohm	PWRPAK 1212	CSD17308Q3A	Texas Instruments
1	1	Q6	BSS138W-7-F	MOSFET, Nch, 50V, 200mA,	SOT-323	BSS138W-7-F	Diodes
2	2	R1, R2	0.01	Resistor, Chip, 1/2W, 1% 150PPM Resistor, Chip, 1W, 1% 75 PPM	1206	PMR18EZPFU10L0 WSLP1206R0100FEA	Rohm Vishay/Dale
1	1	R3	0	Resistor, Chip, 1/16W, 5%	603	Std	Std
1	1	R5	20	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	R4	7.5	Resistor, Chip, 1/16W, 1%	603	Std	Std
2	2	R6, R7	3.9	Resistor, Chip, 0.5W, 5%	1210	Std	Std
3	3	R8, R9, R13	4.02k	Resistor, Chip, 1/10W, 1%	603	Std	Std
0	0	R10, R11	Open	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	R12	1.00M	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	R14	66.5k	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	R15	430k	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	R16	10.0	Resistor, Chip, 1/4W, 1%	1206	Std	Std
3	3	R17, R18, R19	10.0k	Resistor, Chip, 1/16W, 1%	603	Std	Std

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Table 2. Bill of Materials (continued)

-001 bq24725A	-002 bq24735	RefDes	Value	Description	Size	Part Number	MFR
1	1	R20	100k	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	R21	12.1k	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	R22	316k	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	R23	3.01M	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	R24	10	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	1	TP1	131-4244-00	Adaptor, 3.5-mm probe clip (or 131-5031-00)	0.200 inch	131-4244-00	Tektronix
11	11	TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12		Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone
1	1	TP13	GND	Test Point, Black, Thru Hole Color Keyed	0.100 x 0.100 inch	5001	Keystone
0	0	TP14, 15, 16, 17, 18					
4	4			6-32 NYL nuts		NY HN 632	Building Fasteners
4	4	ST1,ST2,ST3,ST4	4816	STANDOFF M/F HEX 6-32 NYL .500"	sf_thvt_325_rnd	4816	Keystone
1	0	U1	bq24725ARGR	IC, SMBus Charge Controller with NMOS Selector		bq24725ARGR	TI
0	1	U1	bq24735RGR	IC, SMBus Charge Controller with NMOS Selector		bq24735RGR	TI
1	1	—		Label	1.25 x 0.25 inch	THT-13-457-10	Brady
1	1	—	HPA710	2.5x2.5inch 4 layer 2oz. PCB	2.5x2.5inch	PCB	Any

Notes: 1. These assemblies are ESD sensitive, ESD precautions shall be observed.

2. These assemblies must be clean and free from flux and all contaminants.
3. Use of no clean flux is not acceptable.
4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.
5. Install label after final wash. Text shall be 8 pt font. Text shall be per Table 1.

Table 1.

Assembly Number	Text
HPA710-001	bq24725AEVM-710
HPA710-002	bq24735EVM-710

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4.1 Board Layouts

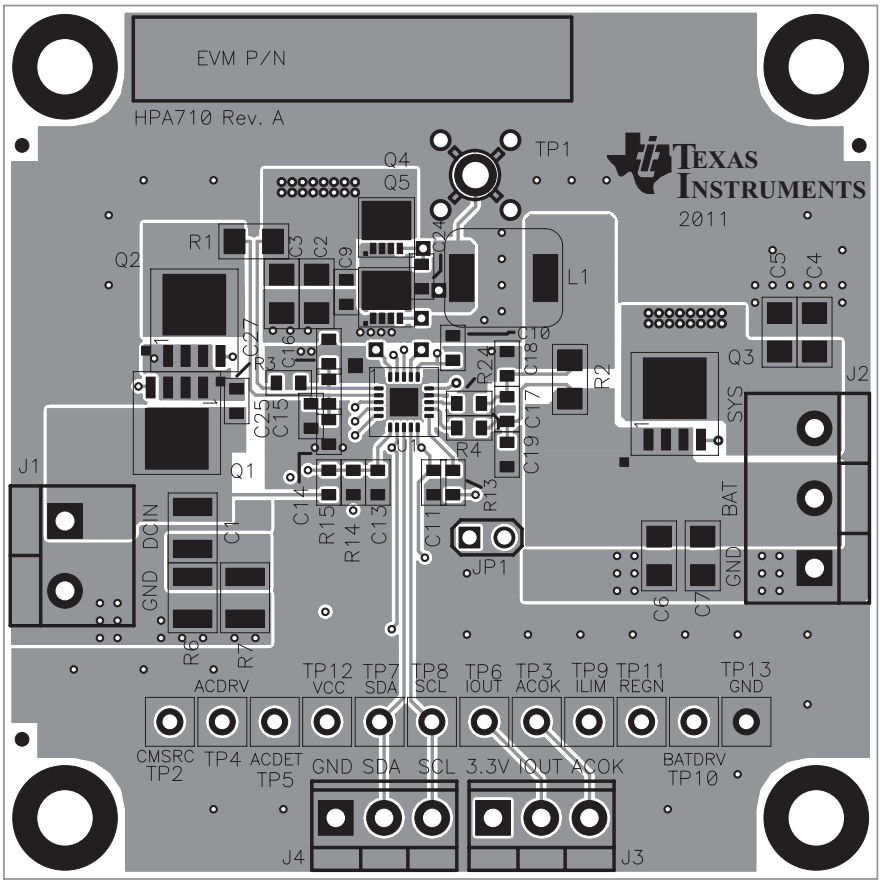


Figure 5. Top Assembly

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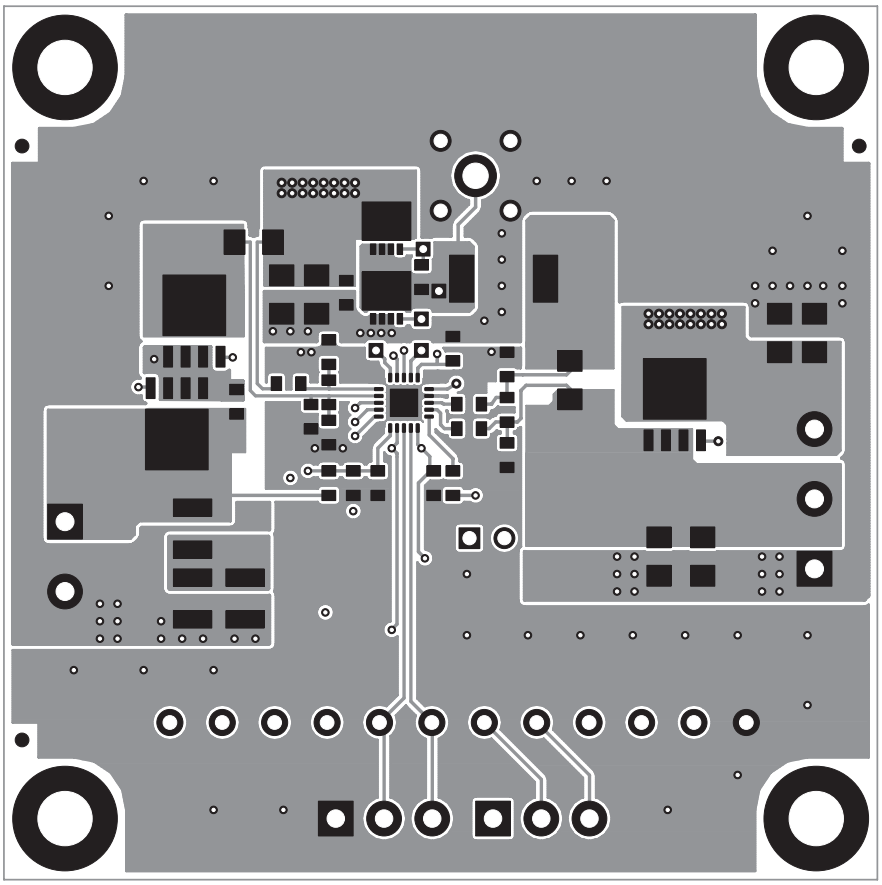


Figure 6. Top Layer

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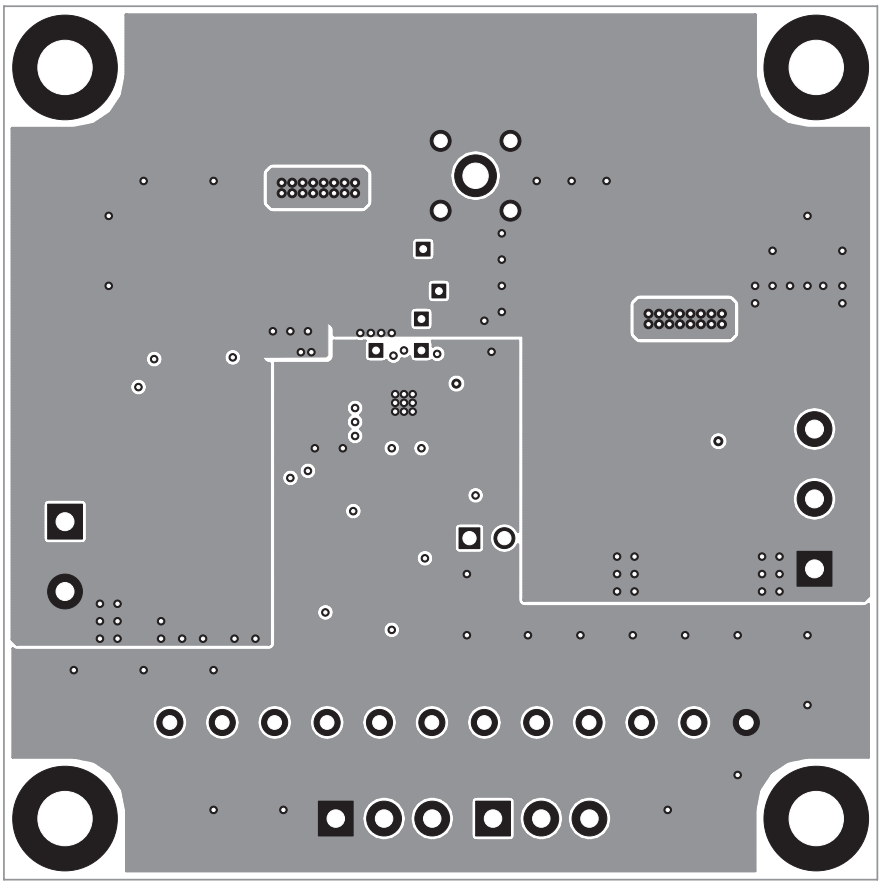


Figure 7. Second Layer

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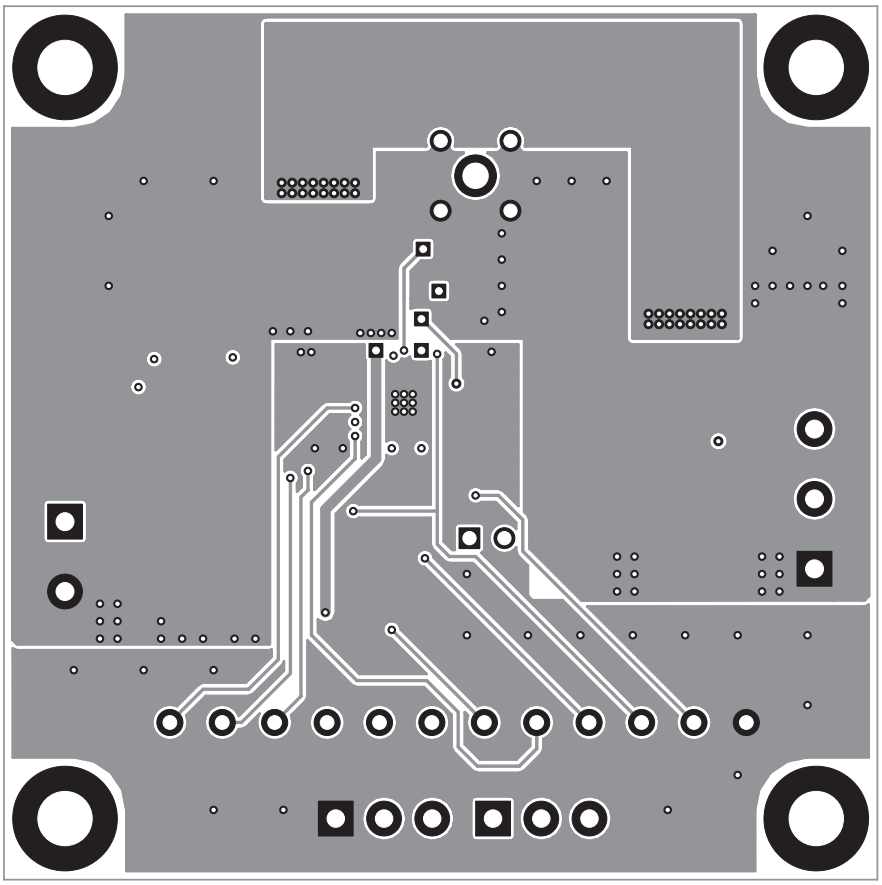


Figure 8. Third Layer

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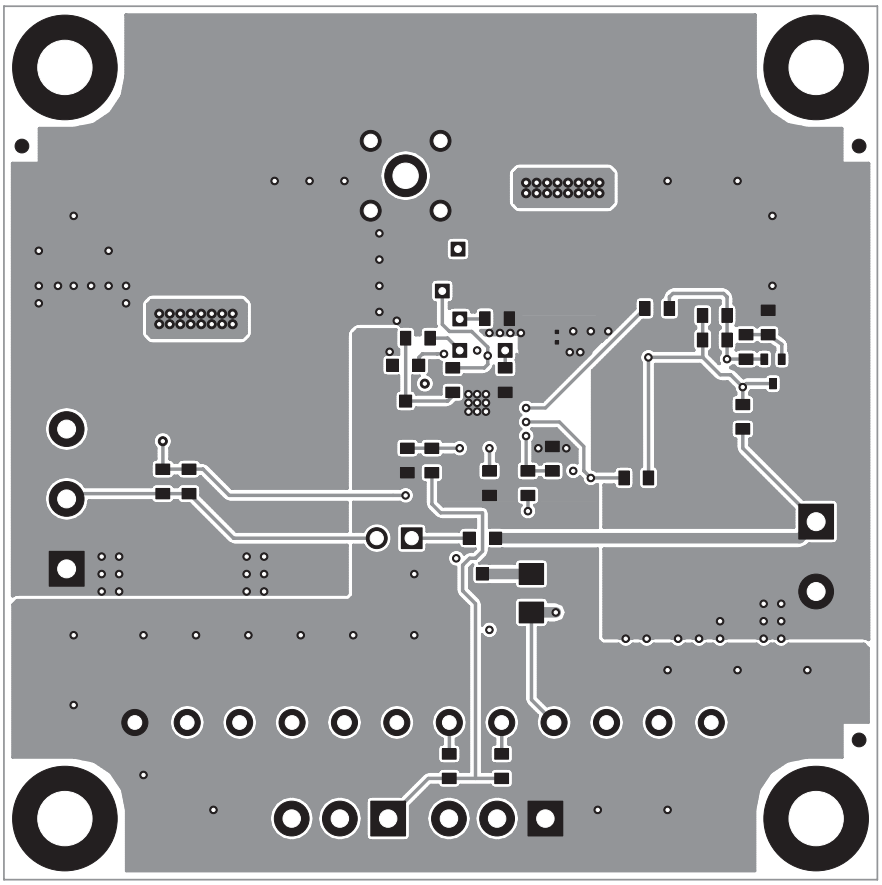


Figure 9. Bottom Layer

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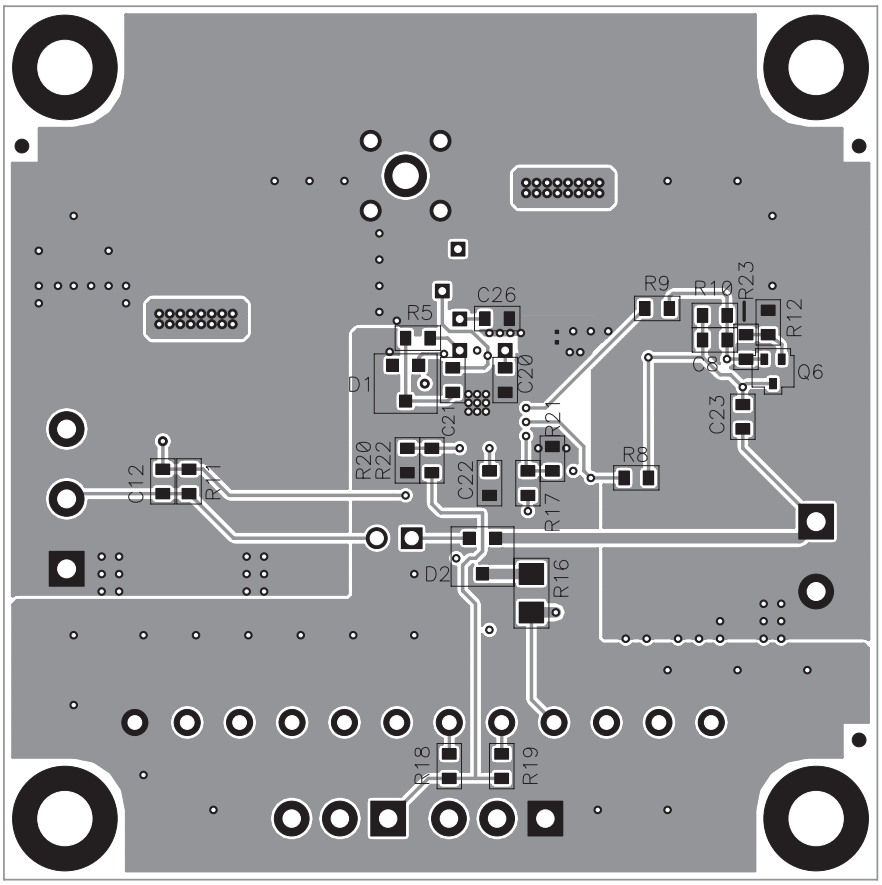


Figure 10. Bottom Assembly

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4.2 Schematics

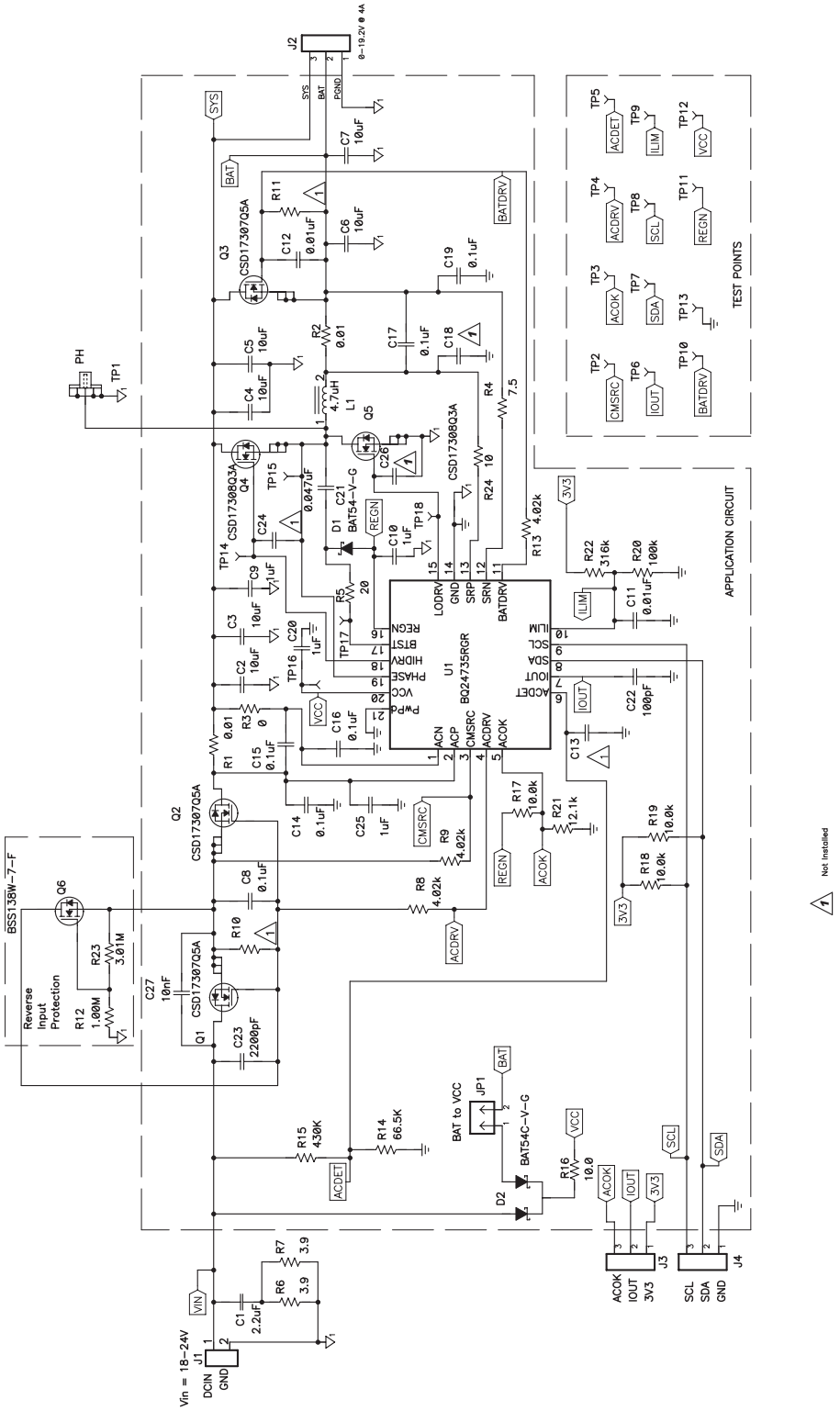


Figure 11. Schematic

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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 or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

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】

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

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。
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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東京都新宿区西新宿６丁目２４番１号
西新宿三井ビル
http://www.tij.co.jp

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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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions 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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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:*

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-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.

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

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

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

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required 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.

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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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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 WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (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 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.

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