

# ***bq24171EVM JEITA Compliant and bq24172EVM Stand-Alone Synchronous, Switch-Mode, Battery-Charge With Integrated N-MOSFETs and Power Path Selector***

This user's guide describes the features and operation of the bq24171 and bq24172 Evaluation Module (EVM). The EVM assists users in evaluating the bq24171 and bq24172 synchronous battery charger. The EVM is also called the HPA706. The manual includes the bq24171 and bq24172EVM bill of materials, board layout, and schematic.

## **Contents**

1	Introduction .....	2
	1.1 EVM Features .....	2
	1.2 General Description .....	2
	1.3 I/O Description .....	2
	1.4 Control and Key Parameters Settings .....	3
	1.5 Recommended Operating Conditions .....	3
2	Test Summary .....	5
	2.1 Definitions .....	5
	2.2 Safety .....	5
	2.3 Quality .....	5
	2.4 Safety Apparel .....	5
	2.5 Equipment .....	5
	2.6 Equipment Setup .....	6
	2.7 Procedure .....	7
3	PCB Layout Guideline .....	8
4	Bill of Materials, Board Layout, and Schematic .....	9
	4.1 Bill of Materials .....	9
	4.2 Board Layout .....	12
	4.3 Schematic .....	18

## **List of Figures**

1	Original Test Setup for HPA706 Evaluation Board ( bq24171EVM and bq24172EVM) .....	6
2	Top Assembly .....	12
3	Top Layer .....	13
4	Second Layer .....	14
5	Third Layer .....	15
6	Bottom Layer .....	16
7	Bottom Assembly .....	17
8	bq24171EVM and bq24172EVM Schematic .....	18

## **List of Tables**

1	I/O Description .....	2
2	Control and Key Parameters Settings .....	3
3	Recommended Operating Conditions .....	3
4	Bill of Materials .....	9

## 1 Introduction

### 1.1 EVM Features

- Evaluation module for bq24171 and bq24172
- Stand-alone synchronous switch-mode, battery-charge
- Integrated N-MOSFETs and power path selector
- Resistor-programmable up to 12.6-V battery voltage
- Input operating range: 4.5 V–16 V
- LED indication for charge status
- Test points for key signals available for testing purposes; easy probe hook-up.
- Jumpers available; easy-to-change setting

### 1.2 General Description

The bq24171 and bq24172 are highly integrated stand-alone Li-ion and Li-polymer switch-mode, battery-charge with two integrated N-channel power MOSFETs and power path selector gate driver. They offer a constant-frequency synchronous PWM controller with high-accuracy regulation of input current, charge current and voltage. They also provide battery detection, preconditioning, charge termination, and charge status monitoring. Additionally, the bq24171 monitors the battery pack temperature and allows change only in a JEITA profile compatible window with lower charge current at a low temperature and a lower charge voltage at a high temperature.

The bq24171 and bq24172 automatically enter a low-quiescent-current sleep mode when the input voltage falls below the battery voltage. The bq24171 and bq24172 are adjustable for up to three series Li+ cells, supporting up to a 4-A charge current. The bq24171 and bq24172 are available in a 24-pin, 3.5-mm x 5.5-mm<sup>2</sup>, thin QFN package.

For details, see the bq24171 data sheet ([SLUSAF2](#)). , and the bq24172 data sheet ([SLUSAD2](#)).

### 1.3 I/O Description

**Table 1. I/O Description**

Jack	Description
J1–VIN	Positive input
J1–PGND	Negative input
J2–VSYS	Connected to system
J2–VBAT	Connected to charger output
J2–PGND	Ground
J2–TS_EXT	Temperature qualification voltage Input

## 1.4 Control and Key Parameters Settings

**Table 2. Control and Key Parameters Settings**

Jack	Description	Factory Setting
JP1	Select external TS input or internal valid TS setting 1-2 : External TS input 2-3 : Internal valid TS setting	Jumper ON 1-2 (external TS)
JP2	The pullup power source supplies the LEDs when JP2 is ON. LED has no power source when JP2 is OFF.	Jumper ON (LED power available)
JP3	TTC setting 2-3 : Connect TTC to VREF to enable termination and disable timer 1-2 : Connect TTC to GND to disable termination and disable timer OPEN : Enable timer and termination	Jumper OPEN (enable timer and termination)
JP4	Charger enable/disable setting. ISET is pulled to GND and the charger is disabled when JP4 OPEN; charger is enabled when JP4 is ON.	Jumper OPEN (disable charger)

## 1.5 Recommended Operating Conditions

**Table 3. Recommended Operating Conditions**

Symbol	Description	Min	Typ	Max	Unit	Notes
Supply voltage, $V_{BUS}$	Input voltage	4.5		8	V	001
Supply voltage, $V_{BUS}$	Input voltage	6		18	V	002 / 003
Battery voltage, $V_{BAT}$	Voltage applied at VBAT terminal of J2	2.1		4.2	V	001
Battery voltage, $V_{BAT}$	Voltage applied at VBAT terminal of J2	2.1		12.6	V	002 / 003
Supply current	Maximum input current	0		5	A	
Charge current, $I_{chrg}$	Battery charge current	0	2	4	A	
Operating junction temperature range, $T_J$		0		125	°C	

The bq24171 and bq24172EVM boards requires a regulated supply approximately 1 V minimum above the regulated voltage of the battery pack to a maximum input voltage of 16 Vdc. The bq24171 and bq24172 use resistor voltage divider for voltage feedback and regulate to internal 2.1-V voltage reference. Use the following equation for the regulation voltage for bq24171 and bq24172:

$$V_{BAT} = 2.1 \text{ V} \times \left( 1 + \frac{R_{34}}{R_{35}} \right) \quad (1)$$

For Note 001, the BAT voltage is set to 4.2 V and for Note 002 / 003, the BAT voltage is set to 12.6 V.

The ISET input sets the maximum charging current. Battery current is sensed by current sensing resistor RSR connected between SRP and SRN. The full-scale differential voltage between SRP and SRN is 40 mV maximum. The equation for charge current is:

$$I_{CHARGE} = \frac{V_{ISET}}{20 \times R_{15}} \quad (2)$$

In the bq24171 and bq24172, once the voltage on OVPSET is above the 1.6-V ACOV threshold or below the 0.5-V ACUV threshold, charge is disabled, and battery is switched to system instead of adapter.

$$I_{PRECHARGE} = \frac{V_{ISET}}{200 \times R_{15}} \quad (3)$$

The default setting is 2 Adc for fast-charge current and 0.2 Adc for precharge current.

In the bq24171 and bq24172, once the voltage on OVPSET is above the 1.6-V ACOV threshold or below the 0.5-V ACUV threshold, the charge is disabled, and the battery is switched to the system instead of the adapter.

$$V_{ACUV} = 0.5 \text{ V} \times \left( 1 + \frac{R6}{R9} \right) \quad (4)$$

For Note 001, ACUV = 2.51 V; for Note 002 / 003, ACUV = 5.87 V.

$$V_{ACOV} = 1.6 \text{ V} \times \left( 1 + \frac{R6}{R9} \right) \quad (5)$$

For Note 001, ACOV = 8.03 V; for Note 002 / 003, ACOV = 18.8 V.

Similar to setting battery regulation current, adapter current is set by the voltage on ACSET pin using the following equation:

$$I_{DPM} = \frac{V_{ACSET}}{20 \times R2} \quad (6)$$

The default setting on the EVM is 2 Adc (Note 001), 4 Adc (Note 002 / 003) for adapter current regulation.

## 2 Test Summary

### 2.1 Definitions

This procedure details how to configure the HPA706 evaluation board. The following naming conventions are followed on the test procedure.

VXXX :	External voltage supply name (VIN, VBAT, VTS)
LOADW:	External load name (LOADR, LOADL)
V(TPyyy):	Voltage at internal test point TPyyy. For example, V(TP1) means the voltage at TP1.
V(Jxx):	Voltage at jack terminal Jxx.
V(TP(XXX)):	Voltage at test point XXX. For example, V(ACSET) means the voltage at the test point which is marked as ACSET.
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 Safety

1. Safety glasses are to be worn.
2. This test must be performed by qualified personnel who are trained in electronics theory and understand the risks and hazards of the assembly to be tested.
3. ESD precautions must be followed while handling electronic assemblies and performing this test.
4. Precautions must be observed to avoid touching areas of the assembly that may get hot or present a shock hazard during testing.

### 2.3 Quality

1. Test data can be made available on request to Texas Instruments.

### 2.4 Safety Apparel

1. Electrostatic smock
2. Electrostatic gloves or finger cots
3. Safety glasses
4. Ground ESD wrist strap.

### 2.5 Equipment

#### 2.5.1 Power Supplies

Power Supply #1 (PS#1): a power supply capable of supplying 30 V at 5 A is required.

### 2.5.2 Loads

LOAD#1 A 30-V (or greater), 5-A (or greater) electronic load that can operate at constant current and constant voltage mode.

LOAD#2: An HP 6060B 3-V to 60-V/0-A to 60-A, 300-W system dc electronic load or equivalent.

### 2.5.3 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.

## 2.6 Equipment Setup

1. Set the power supply #1 (PS#1) for 6-V  $\pm 200$ -mVdc (001), or 16-V  $\pm 0.200$ -mVdc (002 / 003), 4.5-A  $\pm 0.1$ -A current limit, and then turn off supply.
2. Connect the output of PS#1 in series with a current meter (multimeter) to J1 (VIN, PGND).
3. Connect a voltage meter across J1 (VIN, PGND).
4. Connect Load#1 in series with a current meter to J2 (VBAT, PGND). Turn off Load#1.
5. Connect Load#2 in series with a current meter to J2 (VSYS, PGND). Turn off Load#2.
6. Connect a voltage meter across J2 (VBAT, PGND).
7. Connect a voltage meter across J2 (VSYS, PGND).
8. Check all jumper shunts. JP1: connect 2-3 (External TS); JP2: ON; JP3: OPEN; JP4: OPEN.

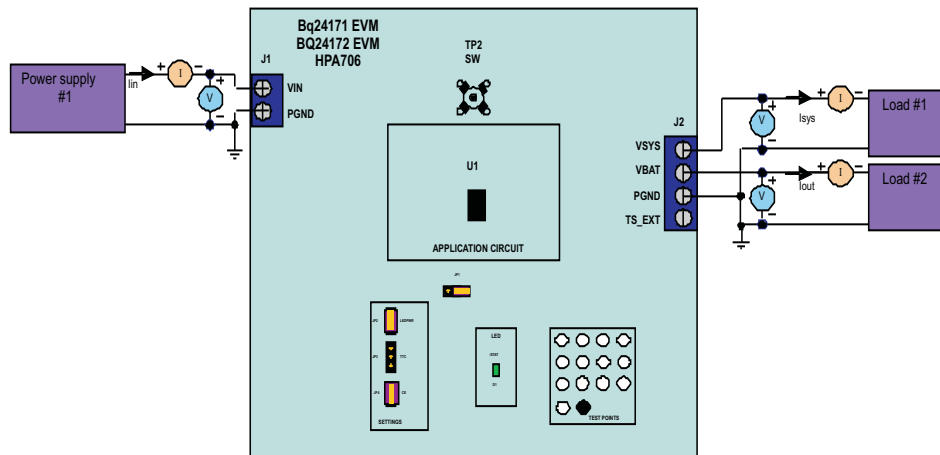


Figure 1. Original Test Setup for HPA706 Evaluation Board ( bq24171EVM and bq24712EVM)

## 2.7 Procedure

Disconnect the load and power supply. Use diode-function of multimeter to check the resistance between J1-VIN and J2-VSYS. Pass only if both OPEN for bi-direction (positive J1-VIN and negative on J2-VSYS; negative J1-VIN and positive on J2-VSYS).

### 2.7.1 Power Supply and VREF

Ensure that [Section 2.6](#) steps are followed.

Disconnect LOAD#1#2. Turn on PS#1 (6 V for 001 and 16 V for 002 / 003).

*Measure* →  $V(J2(VSYS)) = 6\text{ V} \pm 500\text{ mV}$  (001)

$V(J2(VSYS)) = 16\text{ V} \pm 500\text{ mV}$  (002 / 003)

*Measure* →  $V(J2(VBAT)) = 0.5\text{ V} \pm 500\text{ mV}$

*Measure* →  $V(TP(VREF)) = 3.3\text{ V} \pm 200\text{ mV}$

*Measure* →  $V(TP(REGN)) = 0.5\text{ V} \pm 500\text{ mV}$

### 2.7.2 Charger Enable and Battery Detection

Connect 2-3 of JP1 (Internal TS); short JP4 (Charger Enable)

*Measure* →  $V(TP(VREF)) = 3.3\text{ V} \pm 200\text{ mV}$

*Measure* →  $V(TP(REGN)) = 6\text{ V} \pm 200\text{ mV}$

*Observe* →  $V(J2(VBAT)) = 4.2\text{ V} \pm 200\text{ mV}$  (001)

$V(J2(VBAT)) = 12.6\text{ V} \pm 200\text{ mV}$  (002 / 003)

*Observe* → D1 (/STAT) BLINK

### 2.7.3 Charge Current/Voltage Regulation and Battery Temperature Qualification

Reconnect LOAD#2, and turn on. Use the constant voltage mode. Set the output voltage to 2.5 V for 001 and 8 V for 002.

*Measure* →  $I(J2(VBAT)) = 0.2\text{ A} \pm 100\text{ mA}$

*Observe* → D1 (/STAT) ON

Increase the voltage of LOAD#2 to 3.5 V for 001 and 10.5 V for 002 / 003.

*Measure* →  $I(J2(VBAT)) = 2\text{ A} \pm 200\text{ mA}$

*Observe* → D1 (/STAT) ON

Open 2-3 of JP1 (External TS)

*Measure* →  $I(J2(VBAT)) = 0\text{ A} \pm 100\text{ mA}$

*Observe* → D1 (/STAT) BLINK

Connect 2-3 of JP1 (Internal TS)

*Measure* →  $I(J2(VBAT)) = 2\text{ A} \pm 200\text{ mA}$

*Observe* → D1 (/STAT) BLINK

## 2.7.4 Charger Termination and Recharge

Increase the voltage of LOAD#2 slowly to approximately 4.2 V for 001 and 12.6 V for 002 / 003.

*Observe* →  $I(J2(VBAT))$  decreases from 2 A while  $V(J2(VBAT))$  becomes constant.

*Observe* →  $I(J2(VBAT))$  drops to zero when LOAD#2 current is less than 0.2 A.

Decrease the voltage of LOAD#2 slowly to approximately 3.5 V for 001 and 10.5 V for 002 / 003.

*Measure* →  $I(J2(VBAT)) = 2\text{ A} \pm 200\text{ mA}$ .

*Observe* → D1 (/STAT) ON.

## 2.7.5 OVP - Input Overvoltage Protection

Increase the voltage of PS#1 to 9 V for 001 or 20 V for 002 / 003.

*Measure* →  $I(J2(VBAT)) = 0\text{ A} \pm 200\text{ mA}$ .

*Observe* → D1 (/STAT) BLINK.

## 2.7.6 DPM - Input Current Regulation

Connect the output of the Load#1 in series with a current meter (multimeter) to J2 (SYS, PGND). Ensure that a voltage meter is connected across J2 (SYS, PGND). Resume other status as in [Section 2.7.3](#).

Turn on the power of Load#1. Set the load current to 0.1 A (001) or 1.5 A (002 / 003). Increase the load current until  $I(J1(VIN)) = 2\text{ A}$  (001) or 4 A (002 / 003).

*Observe* →  $I(J2(VBAT))$  decreases from 2 A to 0 A and  $I(J1(VIN))$  and keeps 2 A (001) or 4 A (002 / 003) unchanged.

## 2.7.7 Test Complete

Turn off the power supply, and remove all connections from the unit under test.

# 3 PCB Layout Guideline

1. It is critical that the exposed thermal pad on the backside of the bq24171 and bq24172 package be soldered to the PCB ground. Ensure that sufficient thermal vias are right underneath the IC, connecting to the ground plane on the other layers.
2. The control stage and the power stage must be routed separately. At each layer, the signal ground and the power ground are connected only at the thermal pad.
3. Charge current sense resistor must be connected to SRP and SRN with a Kelvin contact. The area of this loop must be minimized. The decoupling capacitors for these pins must be placed as close to the IC as possible.
4. Decoupling capacitors for VREF, AVCC, and REGN must make the interconnections to the IC as short as possible.
5. Decoupling capacitors for BAT must be placed close to the corresponding IC pins, and make the interconnections to the IC as short as possible.
6. Decoupling capacitor(s) for the charger input must be placed close to the Q1A drain and Q1B source.
7. Take the EVM layout for design reference.



## 4 Bill of Materials, Board Layout, and Schematic

### 4.1 Bill of Materials

Table 4. Bill of Materials

COUNT			RefDes	Value	Description	SIZE	PART NUMBER	MFR
-001	-002	-003						
4	4	4	C1, C7, C14, C15	10uF	Capacitor, Ceramic, 25V, X7R, 10%	1206	STD	STD
0	0	0	C2	Open				
1	1	1	C3	2.2uF	Capacitor, Ceramic, 25V, X7R, 10%	0805	STD	STD
1	1	1	C4	330pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	STD	STD
2	2	2	C5, C18	0.1uF	Capacitor, Ceramic, 16V, X7R, 10%	0603	STD	STD
2	2	2	C6, C13	0.047uF	Capacitor, Ceramic, 50V, X7R, 10%	0603	STD	STD
3	3	3	C8, C16, C17	1.0uF	Capacitor, Ceramic, 25V, X7R, 10%	0805	STD	STD
1	1	1	C9	4700pF	Capacitor, Ceramic, 25V, X7R, 10%	0603	STD	STD
4	4	4	C10, C20, C24, C25	0.1uF	Capacitor, Ceramic, 50V, X7R, 10%	0603	STD	STD
0	0	0	C11, C12, C21, C23	Open				
2	2	2	C22, C19	1.0uF	Capacitor, Ceramic, 16V, X7R, 20%	0805	STD	STD
1	1	1	C26	22pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	STD	STD
1	1	1	D1	LTST-C190GKT	Diode, LED, Green, 2.1V, 20mA, 6mcd	0603	LTST-C190GKT	Lite On
1	1	1	D2	B220A-13-F	Diode, Schottky, 2A, 20V	SMA	B220A-13-F	Diodes Inc
0	1	1	D3	BAT54C	Diode, Dual Schottky, 200-mA, 30-V	SOT23	BAT54C-V-G	Vishay
1	1	1	J1	ED120/2DS	Terminal Block, 2 pin, 15A, 5.1mm	0.40 x 0.35 inch	ED120/2DS	OST
1	1	1	J2	ED120/4DS	Terminal Block, 4 pin, 15A, 5.1mm	0.80 x 0.35 inch	ED120/4DS	OST
2	2	2	JP1, JP3	PEC03SAAN	Header, 3 pin, 100mil spacing	0.100 inch x 3	PEC03SAAN	Sullins
2	2	2	JP2, JP4	PEC02SAAN	Header, 2 pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
1	1	1	L1	3.3uH	Inductor, SMT, 5A, 55milliohm	0.204 x 0.216 inch	IHLP2020CZER3R3M01	Vishay
1	1	1	Q1	BSS138W	MOSFET, Nch, 30V, 0.5A, 700 milliohms	SOT323	BSS138W-7-F	Vishay
2	2	2	Q2, Q3	CSD17313Q2	Trans, Nch, 30V, 5A, 26milliohm	SON-6	CSD17313Q2	TI
1	1	1	Q4	CSD25401Q3	MOSFET, PChan, -20V, 60A, 8.7 milliohm	QFN3.3X3.3mm	CSD25401Q3	TI
1	1	1	Q5	2N7002	MOSFET, N-ch, 60V, 115mA, 1.2Ohms	SOT23	2N7002-7-F	Diodes Inc
1	1	1	R1	1.00M	Resistor, Chip, 1/16W, 5%	0603	STD	STD
1	0	0	R2	0.02 Ohm	Resistor, Metal Film, ½ watt, 1%	2010	WSL2010R0200FEA	Vishay
0	1	1		0.01 Ohm	Resistor, Metal Film, ½ watt, 1%	2010	WSL2010R0100FEA	Vishay

**Table 4. Bill of Materials (continued)**

COUNT			RefDes	Value	Description	SIZE	PART NUMBER	MFR
-001	-002	-003						
5	5	5	R3, R16, R20, R29, R33	0	Resistor, Chip, 1/16W	0603	STD	STD
2	2	2	R4, R5	3.9	Resistor, Chip, 1/4W, 5%	1206	STD	STD
1	1	1	R6	402k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	1	1	R7	499k	Resistor, Chip, 1/8W, 5%	0603	STD	STD
1	0	0	R8	100k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	0	0	R9	100k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
0	1	1		37.4k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	0	0	R10	10k	Resistor, Chip, 1/16W, 5%	0603	STD	STD
0	1	1		1M	Resistor, Chip, 1/16W, 5%	0603	STD	STD
1	1	1	R11	1.00k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
0	0	0	R12	Open			STD	STD
2	2	2	R13, R14	4.02k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	1	1	R15	0.01	Resistor, Metal Film, 1/4 watt, 1%	1206	WSL1206R0100FEA	Vishay
1	1	1	R17	10	Resistor, Chip, 1/16W, 5%	0805	STD	STD
1	0	0	R19	10	Resistor, Chip, 1/16W, 5%	0805	STD	STD
1	1	0	R21	5.23k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
0	0	1		2.2k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	0	0	R22	0	Resistor, Chip, 1/16W, 5%	0603	STD	STD
1	1	1	R23	100	Resistor, Chip, 1/16W, 5%	0603	STD	STD
1	1	0	R24	30.1k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
0	0	1		6.8k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	1	1	R25	3.01M	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	1	1	R26	10k	Resistor, Chip, 1/16W, 5%	0603	STD	STD
1	1	1	R27	4.99k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
2	2	2	R28, R31	100k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	1	1	R30	232k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
2	2	2	R32, R18	32.4k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	0	0	R34	100k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
0	1	1		499k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
1	1	1	R35	100k	Resistor, Chip, 1/16W, 1%	0603	STD	STD
0	0	0	TP1, TP3 - TP6	TP-SMALL	Test Point, 0.020 Hole	0.100 x 0.100 inch	N/A	N/A

Table 4. Bill of Materials (continued)

COUNT			RefDes	Value	Description	SIZE	PART NUMBER	MFR
-001	-002	-003						
1	1	1	TP2	131-5031-00	Adaptor, 3.5-mm probe clip	0.200 inch	131-4244-00 or 131-5031-00	Tektronix
13	13	13	TP7 - TP19	5002	Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone
1	1	1	TP20	5001	Test Point, Black, Thru Hole Color Keyed	0.100 x 0.100 inch	5001	Keystone
1	1	0	U1	BQ24172RHL	IC, Power Path Selector Stand-alone Charger	VQFN	BQ24172RHL	TI
0	0	1		BQ24171RHL	IC, Power Path Selector Stand-alone Charger	VQFN	BQ24171RHL	TI
1	1	1	–		PCB, 2.65 In x 3.00 In x 0.062 In		HPA706	Any
4	4	4			Bumper foot (install after final wash)	0.440 x 0.2	SJ-5303	3M
4	4	4			Shunt, 100-mil, Black	0.100	929950-00	3M
1	1	1	–		Label (See Note 5)	1.25 x 0.25 inch	THT-13-457-10	Brady

- 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.  
Use of no clean flux is not acceptable.
3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
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 5.

Table 5	
Assembly Number	Text
HPA706-001	BQ24172EVM-706-5V
HPA706-002	BQ24172EVM-706-15V
HPA076-003	BQ24171EVM-706-15V

## 4.2 Board Layout

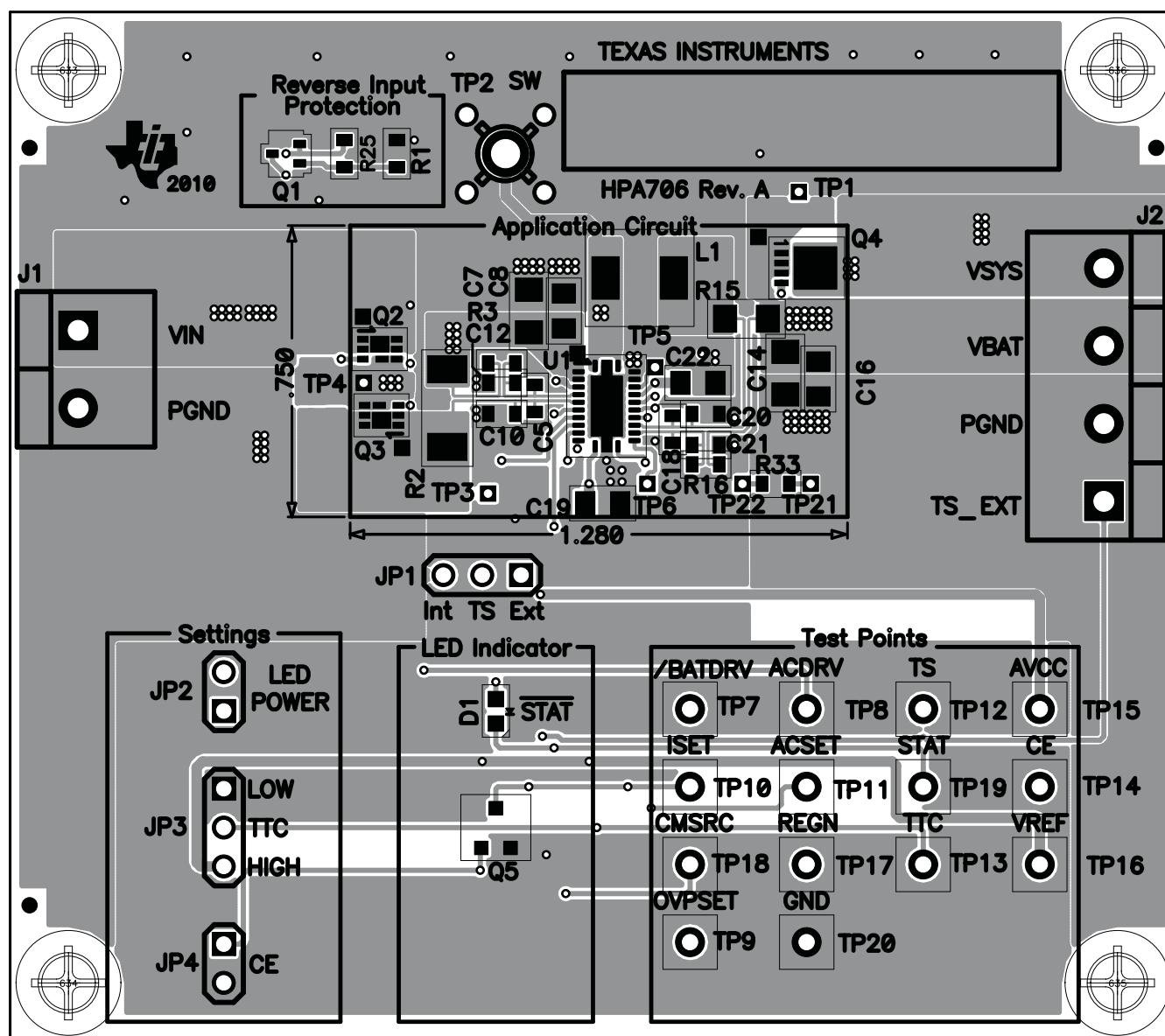
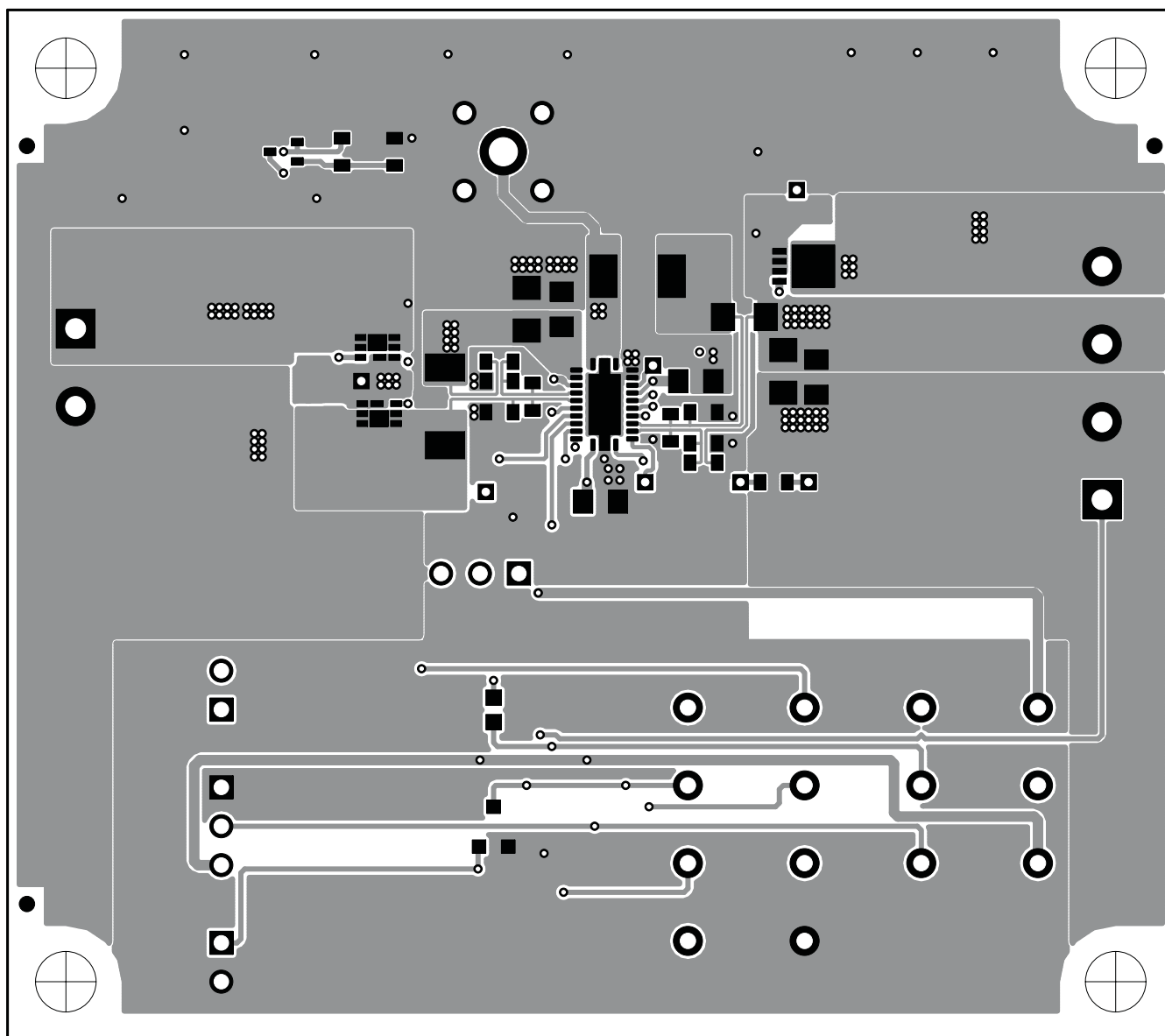
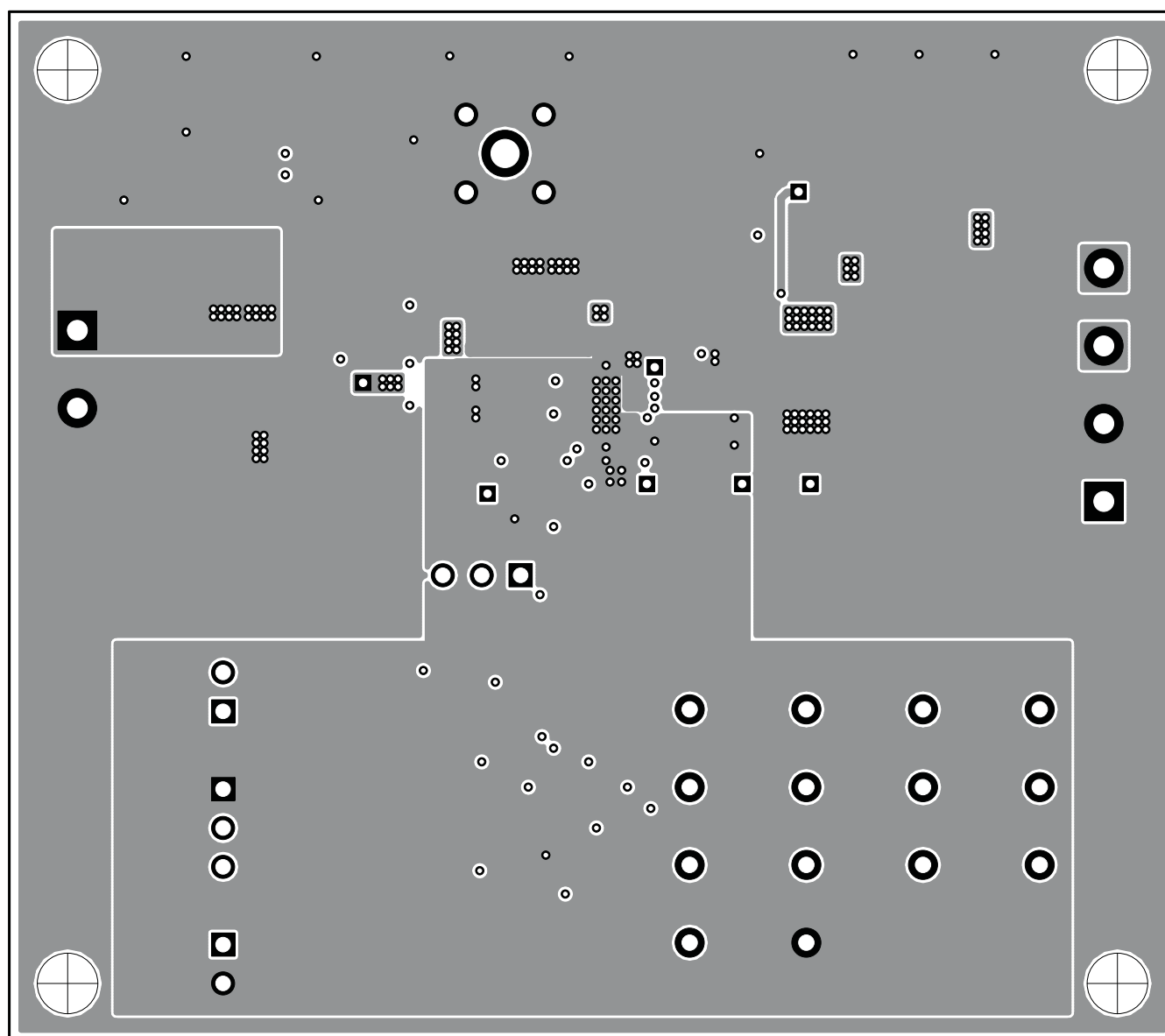


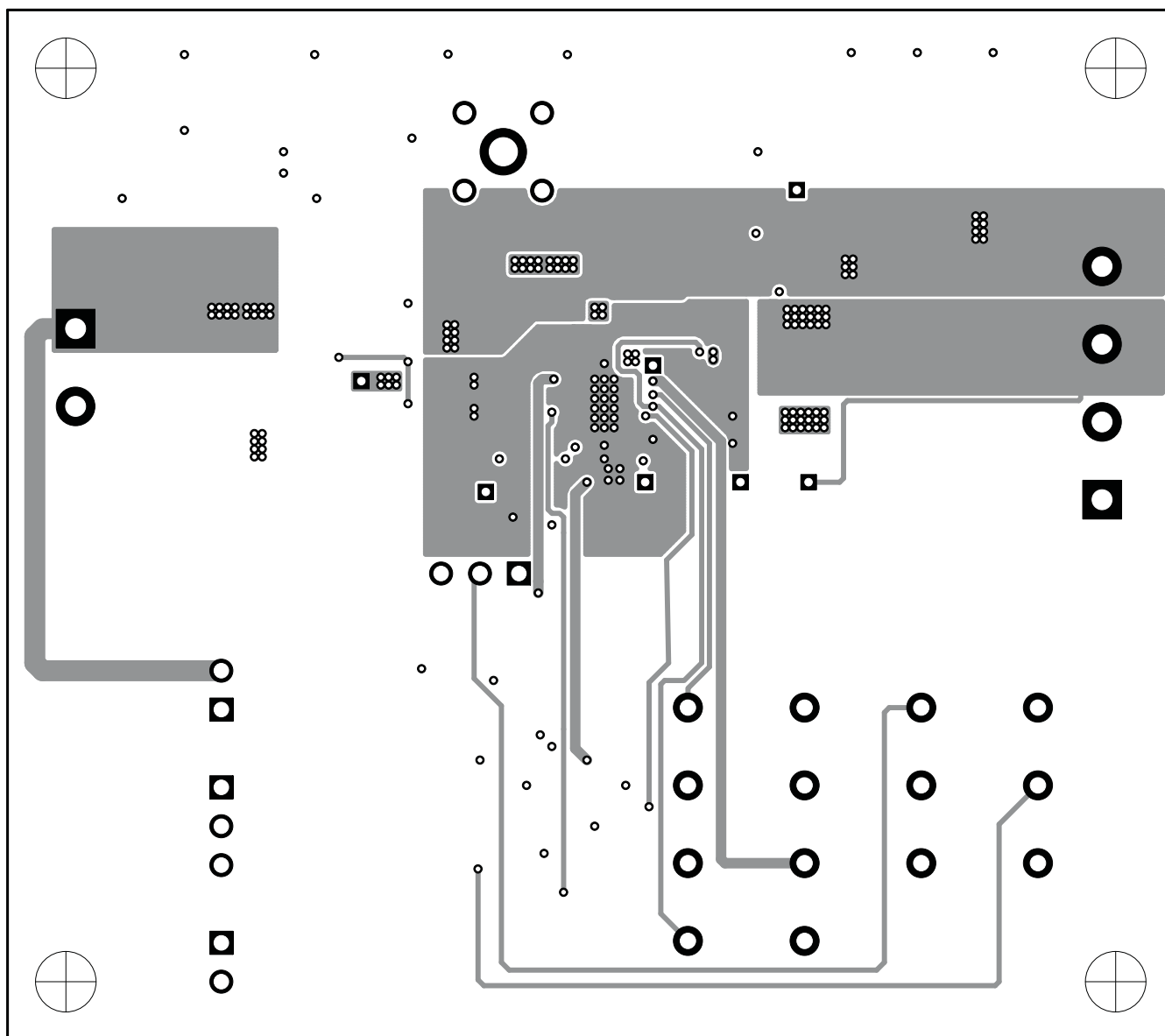
Figure 2. Top Assembly



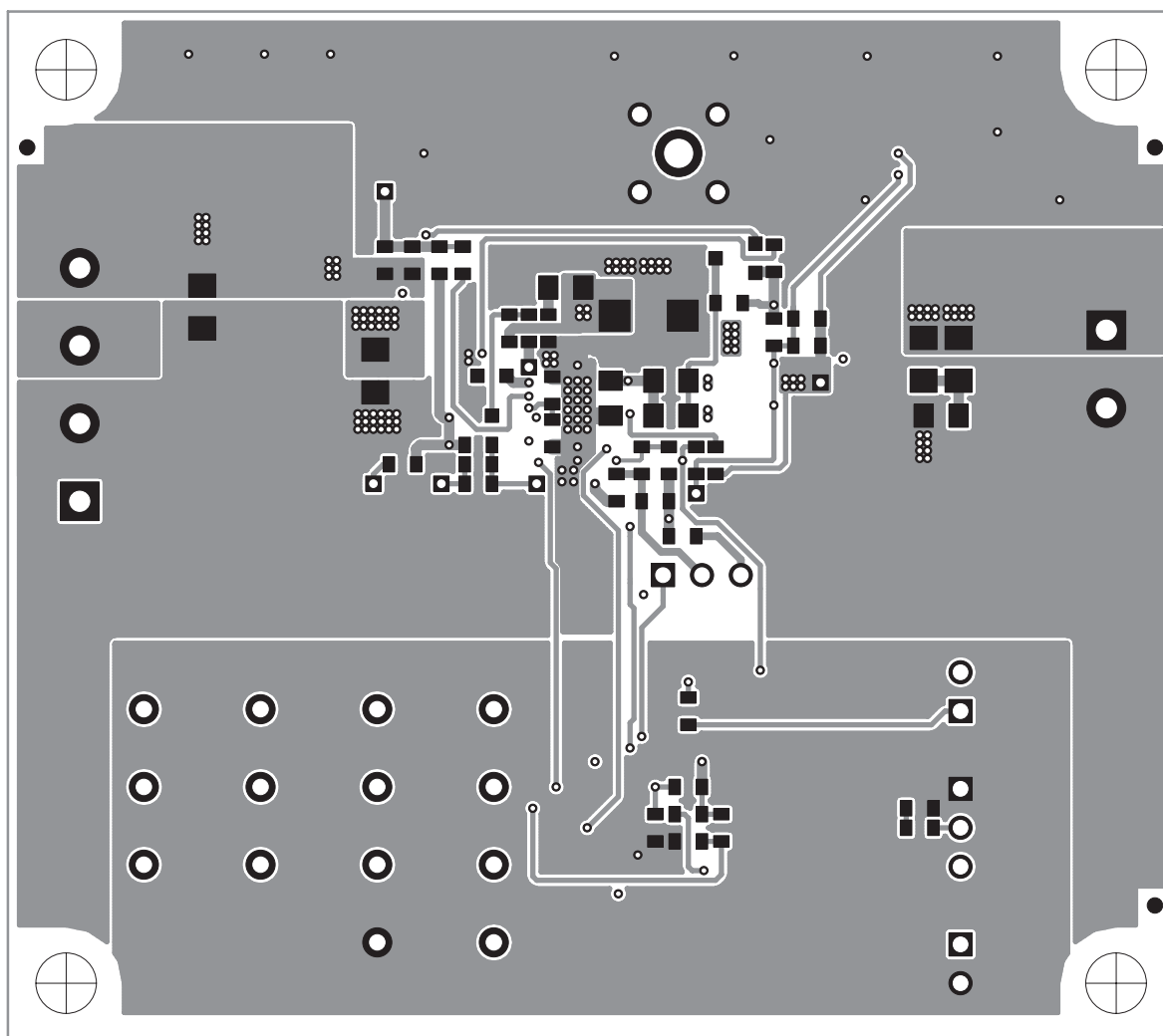
**Figure 3. Top Layer**



**Figure 4. Second Layer**

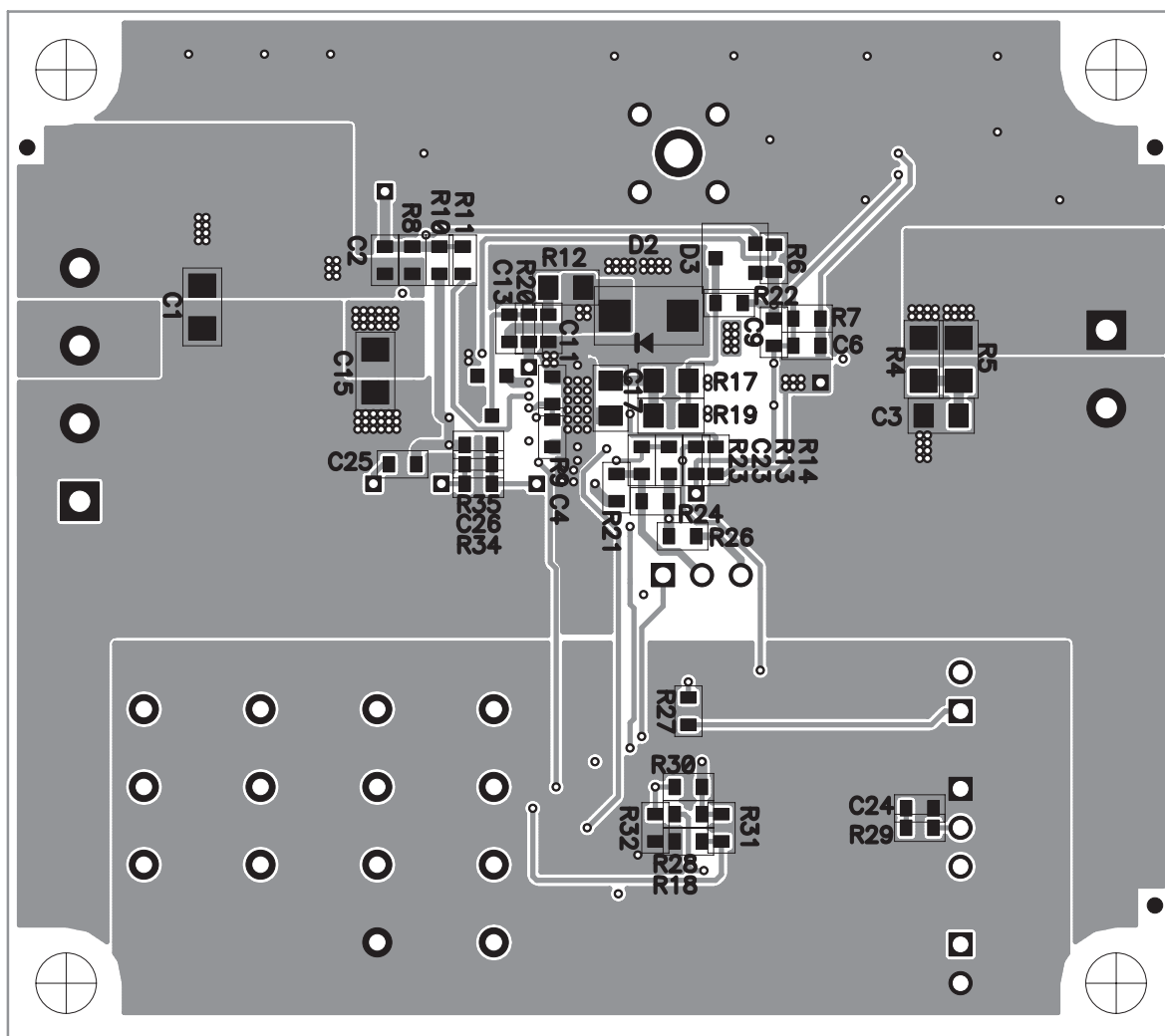


**Figure 5. Third Layer**



**Figure 6. Bottom Layer**





**Figure 7. Bottom Assembly**

## 4.3 Schematic

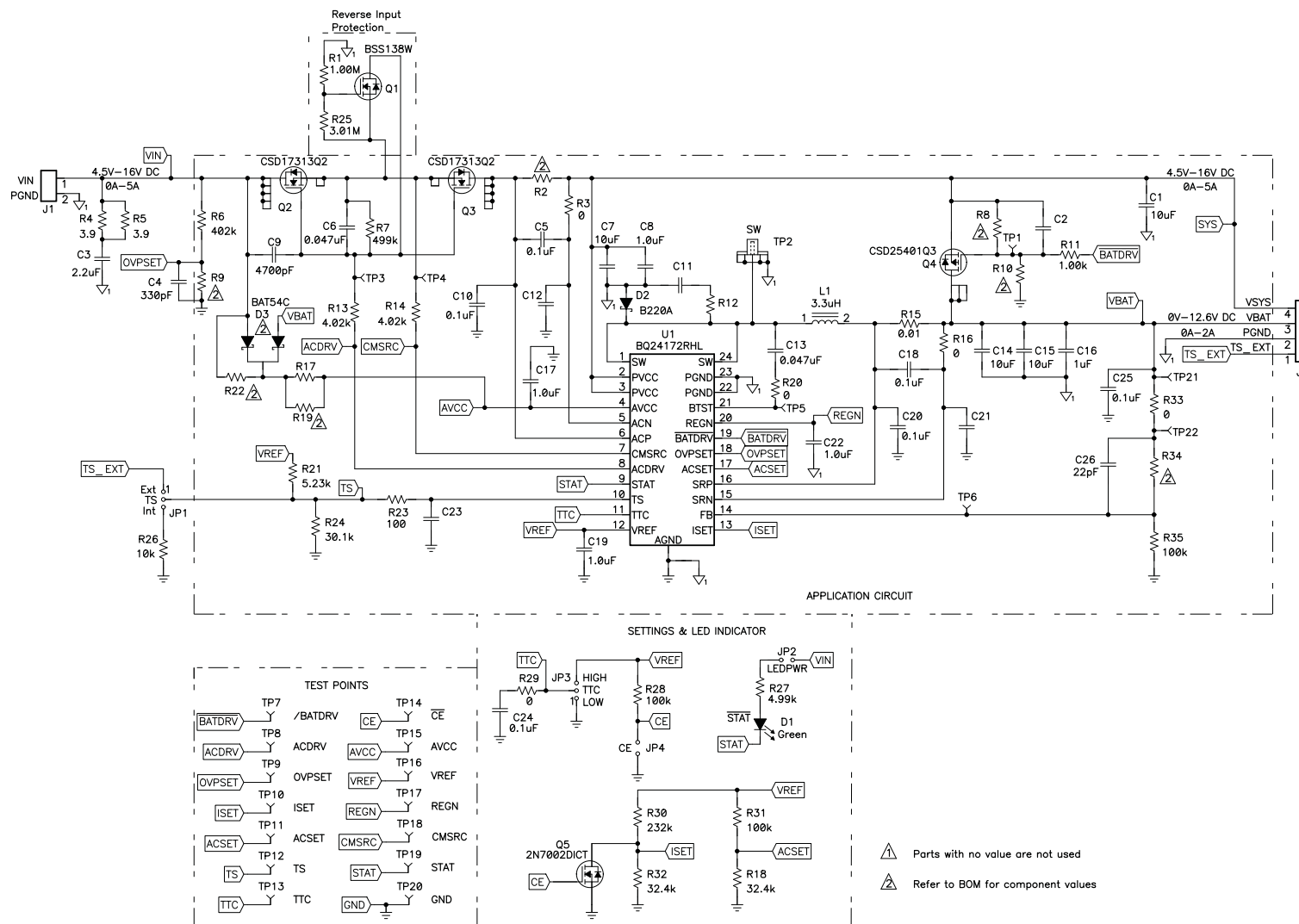


Figure 8. bq24171EVM and bq24172EVM Schematic

## Evaluation Board/Kit Important Notice

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit 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. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

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 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.**

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. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

**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.**

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.**

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 contact the TI application engineer or visit [www.ti.com/esh](http://www.ti.com/esh).

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.

## FCC Warning

This evaluation board/kit 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 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments 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.

## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 0 V to 20 V and the output voltage range of 0 V to 12.6 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. 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 85° C. The EVM is designed to operate properly with certain components above 85° C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated

## STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
  - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
  - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
  - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
  - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
  - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

### **WARNING**

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

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

**NOTE:**

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

### 3 Regulatory Notices:

#### 3.1 United States

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

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

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

#### **CAUTION**

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

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

#### **FCC Interference Statement for Class A EVM devices**

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

#### **FCC Interference Statement for Class B EVM devices**

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

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

#### 3.2 Canada

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

#### **Concerning EVMs Including Radio Transmitters:**

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

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

#### **Concernant les EVMs avec appareils radio:**

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

#### **Concerning EVMs Including Detachable Antennas:**

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

### Concernant les EVMs avec antennes détachables

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

#### 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/sds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/sds/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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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

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

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

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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

3.3.3 *Notice for EVMs for Power Line Communication:* Please see [http://www.tij.co.jp/sds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_02.page)

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

#### 3.4 European Union

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

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

---

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

6. *Disclaimers:*

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

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

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

8. *Limitations on Damages and Liability:*

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

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.
10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2023, Texas Instruments Incorporated



## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025