User's Guide
SLUUA25A–October 2012–Revised November 2012

bq51050BEVM-764, Integrated Wireless Power Li-Ion Charger Receiver

The bq51050BEVM (HPA764-002) wireless power receiver evaluation kit from TI is a high-performance, easy-to-use development kit for the design of wireless power solutions. It helps designers to evaluate the operation and performance of the bq51050B (WCSP package), a direct Li-Ion charge controller for wireless power transfer. The bq51050B device provides the AC/DC power conversion, integrates the digital controller required to comply with the Qi v1.1 communication protocol, and Li-Ion charge controller. The kit speeds up the development of end-use applications.

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1 Introduction

The bq5105x is an advanced, secondary-side direct Li-Ion charge-controller device for wireless power transfer in portable applications. The bq5105x device provides the AC/DC power conversion, integrates the digital controller required to comply with the Qi v1.1 communication protocol, and Li-Ion charge controller. Together with the bq500210 primary-side controller, the bq5105x enables a complete contact-free power transfer system for a wireless direct battery charger solution. By utilizing near-field inductive power transfer, the secondary coil embedded in the portable device can pick up the power transmitted by the primary coil. The AC signal from the secondary coil is then rectified and conditioned to apply power directly to the battery. Global feedback is established from the secondary to the primary in order to stabilize the power transfer process. This feedback is established by utilizing the Qi v1.1 communication protocol.

The bq5105x devices integrate a low-impedance synchronous rectifier, low-dropout regulator, digital control, Li-Ion charger controller, and accurate voltage and current loops. The entire power stage (rectifier and LDO) utilize low-resistive NMOS FET's (100-mΩ typical RDS(on)) ensuring high efficiency and low power dissipation.

2 Considerations with this EVM

The bq51050BEVM-764 evaluation module (HPA764-002) demonstrates the receiver portion of the bqTESLA™ wireless power system. This receiver EVM is a complete receiver-side solution that charges single-cell Li-Ion batteries with up to 1-A charge current.

- The bqTESLA receiver is used in any number of low-power battery portable devices as a direct battery charger. With contact-free charging capability, no connections to the device are needed.
- Regulation voltage of 4.2 V, up to 1-A charge current
- Low-profile, external pick-up coil
- Frame is configured to provide correct receiver-to-transmitter spacing
- Room above coil for testing with battery – key for tuning
- Option to adjust the charge current using variable resistor R16
- Adjustable resistor R13 is used to set termination current.
- Temperature sensing can be adjusted using R3

3 Modifications

Refer to the datasheet when changing components. To aid in such customization of the EVM, the board was designed with devices having 0603 or larger footprints. A real implementation likely occupies less total board space.

Note that changing components can improve or degrade EVM performance.

4 Recommended Operation Condition

Table 1 provides a summary of the bq51050BEVM-764 performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. bq51050BEVM-764 Electrical Performance Specifications

PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
V_{IN}	Input voltage range		4.0		10.0	V
I_{COMM-C}	Current limit during communication		330	390	420	mA
I_{IN}	Input current range				1.5	A
I_{OUT}	Output current range	Current limit programming range			1.5	A
$V_{OUT(REG)}$	Regulation output voltage	I_{LOAD} = 1000 mA	4.16	4.2	4.22	V
F_s	Switching frequency		110		205	kHz
Efficiency	AC-DC efficiency	1-A fast charge current, V_{BAT} = 4.2 V		93%		

5 Equipment and EVM setup

5.1 Schematic

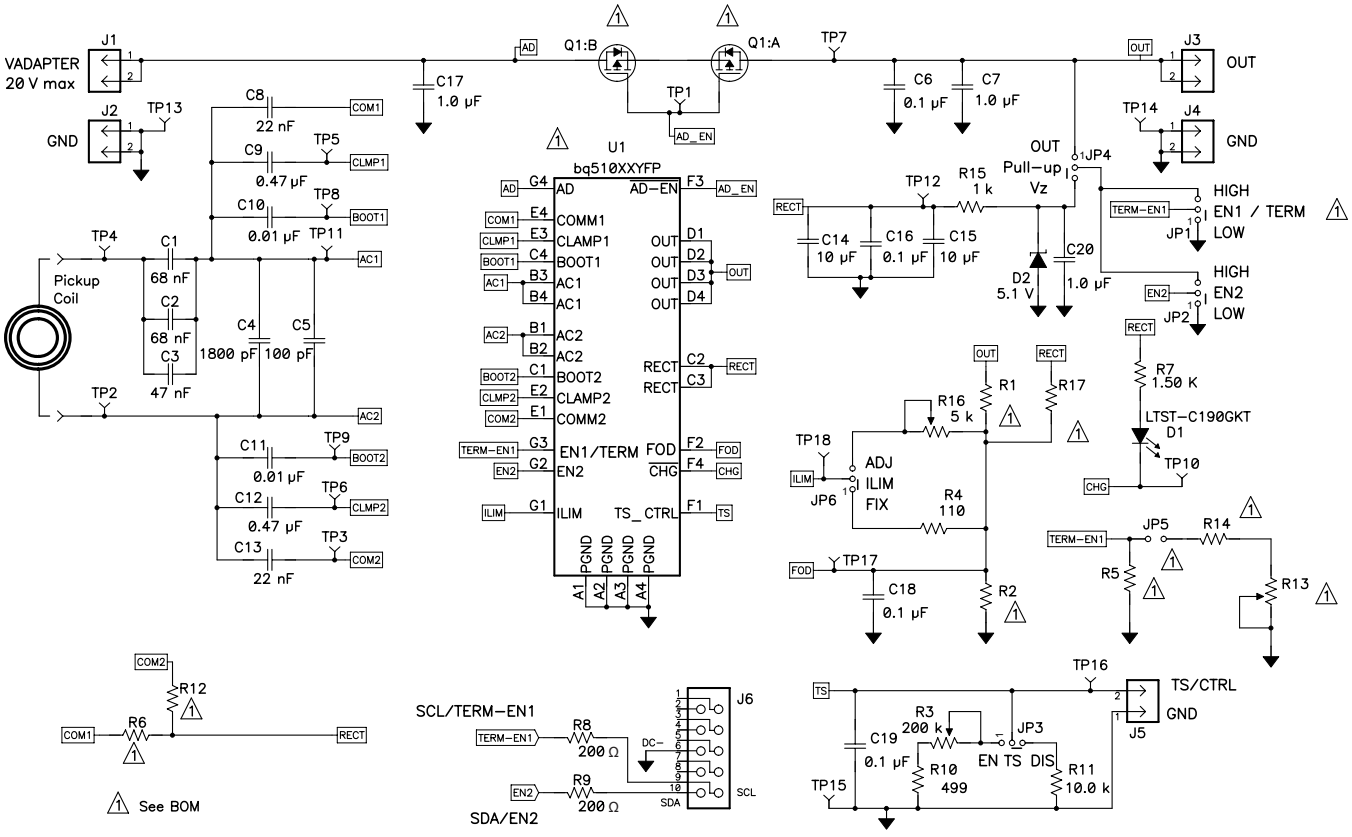

Figure 1. HPA764-Revision B Schematic

5.2 Connector and Test Point Descriptions

The connection points are described in the following paragraphs.

5.2.1 J1 – AD External Adapter Input, J2-GND

Power can not be provided to simulate an external adapter applied to the receiver in this bq51050BEVM-764 (HPA764-002).

5.2.2 J3 – Output Voltage, J4-GND

Output voltage regulation is 4.2 V in wireless power mode up to 1 A; the adapter option is not supported in this HPA764-002.

5.2.3 J5 – TS and Return Connector

External connection for temperature sense resistor, see the datasheet for additional information.

5.2.4 J6 – Programming Connector

This connector is populated and is only useful at the factory level for programming the IC.

5.3 Jumpers and Switches

The control jumpers are described in the following paragraphs.

5.3.1 JP1 – EN1 Enable 1

Not populated in this EVM (HPA764-002).

5.3.2 JP2 – EN2 Enable 2

Enable signal input that allows the system to assert wireless charging. If EN2 is set to low, wireless charging is enabled unless AD voltage > 3.6 V. If EN2 is set to High, AD mode disabled, wireless charging always enabled. Used when OTG plus wireless charging is active.

5.3.3 JP3 – TS Enable or Disable

This jumper enables the TS adjustment feature using R3. The disable position sets voltage at the TS pin to a safe value. The default shorting jumper setting is disabled.

5.3.4 JP4 – Pull-Up to Out or Vz

EN2 pull-up can be powered from OUT or RECT. Vz is derived from RECT through a resistor and Zener diode D2.

5.3.5 JP5 – Termination

This jumper, along with R14 and R13, sets the termination current. See the bq51050B datasheet for additional information. The default shorting jumper setting is installed.

5.3.6 JP6 – ILIM Fix or ADJ

Max output current is set by ILIM pin. In the FIX position, the current is set to a fixed value. In the ADJ position the current is set by R16.

5.4 Test Point Descriptions

The test points are described in the following paragraphs.

5.4.1 TP1 – AD-EN

This push-pull driver for the external PFET connects the adapter and the output from the bq5101x. This is not useful for the bq5105x.

5.4.2 TP2 – AC Input 2

This is the test point for measuring AC voltage applied to the EVM from the receiver coil.

5.4.3 TP3 – COM2 Communication 2 Drive

Communication driver signal, open-drain output connected to communication capacitor.

5.4.4 TP4 – AC Input 1

This is the test point for measuring AC voltage applied to the EVM from the receiver coil.

5.4.5 TP5 – CLMP 1

Overvoltage clamp driver signal, open-drain output is connected to OVP capacitor.

5.4.6 TP6 – CLMP 2

Overvoltage clamp drive signal, open-drain output is connected to OVP capacitor.

5.4.7 TP7 – OUT Output Voltage

This test point is the output voltage from the bq51050B.

5.4.8 TP8 – Boot-1 Boot Capacitor

This bootstrap capacitor 1 drive connects to the integrated circuit (IC).

5.4.9 TP9 – Boot-2 Boot Capacitor

This bootstrap capacitor 2 drive connects to the IC.

5.4.10 TP10 – CHG Charge

This output signal indicates that the output current is being delivered to OUT, the open-drain output.

5.4.11 TP11 – AC1 IC input

This is the AC input to the IC from series capacitors.

5.4.12 TP12 – Rectified Voltage

The input AC voltage is rectified into unregulated DC voltage; additional capacitance is used to filter the voltage before the regulator.

5.4.13 TP13, TP14, TP15 – GND

These are the ground test points.

5.4.14 TP16 – TS Temp Sensor

This is the connection point for external thermistor; see the data sheet for additional information.

5.4.15 TP17 – FET Open Detection (FOD)

Input for rectified power measurement, pin F2 of the IC. FOD for the bq51050B.

5.4.16 TP18– ILIM

Programming pin for over current limit, pin G1 of the IC.

5.5 Pin Description of the IC

Table 2. Pin Description

PIN Number (WCSP)	bq51050B
A1, A2, A3, A4	PGND
B1, B2	AC2, AC2
B3, B4	AC1, AC1
C1	BOOT2
C2, C3	RECT
C4	BOOT1
D1, D2, D3, D4	BAT
E1	COM2
E2	CLMP2
E3	CLMP1
E4	COM1
F1	TS_CTRL
F2	FOD
F3	AD-EN
F4	CHG
G1	ILIM
G2	EN2
G3	TERM
G4	AD

6 Test Procedure

This procedure describes test configuration of the bq51050B evaluation board (HPA764-002) for bench evaluation.

6.1 Definition

The following naming conventions are used:

VXXX : External voltage supply name (VADP, VBT, VSBT)

LOADW: External load name (LOADR, LOADI)

V(TPyy): Voltage at internal test point TPyy. For example, V(TP02) means the voltage at TP02.

V(Jxx): Voltage at header Jxx

V(TP(XXX)): Voltage at test point XXX. For example, V(ACDET) means the voltage at the test point which is marked as ACDET.

V(XXX, YYY): Voltage across point XXX and YYY.

I(JXX(YYY)): Current going out from the YYY terminal of header

JXX. Jxx(BBB): Terminal or pin BBB of header xx.

JPx ON : Internal jumper Jxx terminals are shorted. JPx OFF: Internal jumper Jxx terminals are open.

JPx (-YY-) ON: Internal jumper Jxx adjacent terminals marked as YY are shorted.

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

6.2 Recommended Test Equipment

The following equipment is needed to complete this test procedure.

6.2.1 Power Supplies

Two power supplies

- Power supply #1 (PS #1) capable of supplying 19 V at 1 A is required
- Power supply #2 (PS #2) capable of supplying up to 6 V at 5 A is required to power the battery emulator.

6.2.2 Battery Emulator PR1010-002

Use the battery emulator shown in Figure 3 as a battery to test the charger.

6.2.3 Meters

Two DC voltmeters, one multimeter (Ohmmeter), and two DC ammeters are required.

6.2.4 Oscilloscopes

Not required. But can replace the multimeters

6.2.5 bqTesla Transmitter

Power for the bq510xxxEVM-764 receiver EVM is supplied through a bqTESLA transmitter (bq500210EVM-689) or WPC-certified transmitter. The input AC voltage is applied to the receiver through the coil located in the receiver bottom.

6.3 Equipment Setup

6.3.1 Test Set Up

The final assembly is tested using a bqTesla transmitter provided (bq5100210EVM-HPA689). Input voltage to the transmitter is set to 19 V_{DC} ±200 mV with a current limit of 1.0 A. Set the power supply to OFF. Connect input power supply to HPA689 V_{IN} (J1) and GND (J2) as shown on Figure 2. Place UUT on transmitter coil. Unit under test will be placed in the center of HPA689 TX coil.

Other bqTesla transmitter base units are also acceptable for this test.

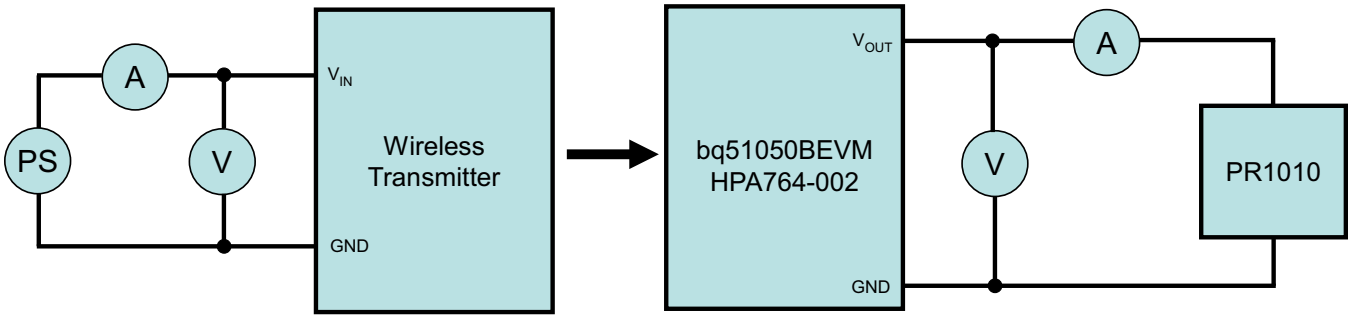

Figure 2. Test Set up

6.3.2 Battery Emulator

Adjust PS#2 to approximately 3.6 V and 3.5-A current limit to the input side (PS #2+/–) of the battery emulator (Figure 3), then turn PS #2 off.

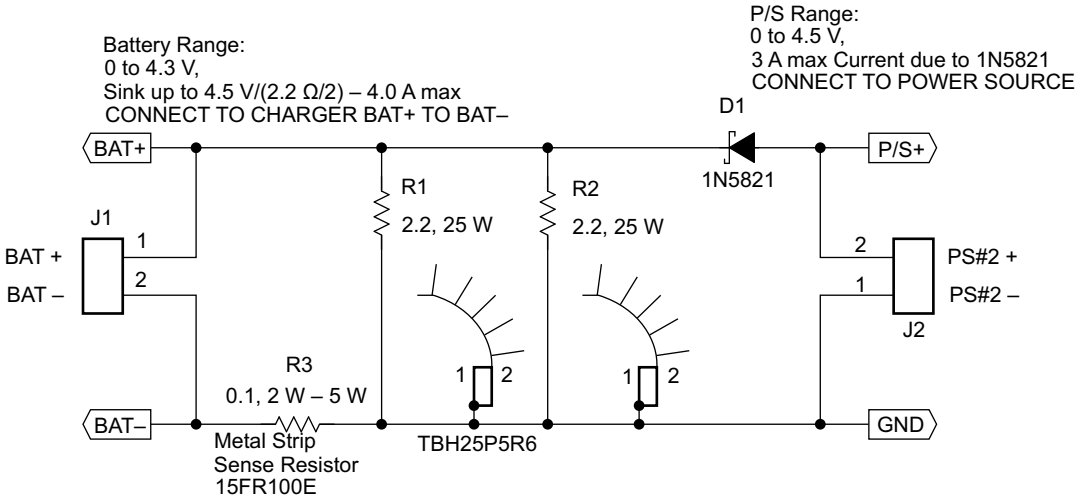

Figure 3. Battery Emulator

6.3.3 Jumper Settings

JP2 → EN2 and LOW shorted
JP3 → TS and EN shorted
JP4 → Pullup and Vz shorted
JP5 → Install
JP6 → ILIM and ADJ shorted

6.3.4 Voltage and Current Meters

- Connect ammeter to measure input current to transmitter
- Connect voltmeter to monitor input voltage of TX unit
- On UUT (receiver) a voltmeter is used to measure output voltage (battery voltage) at J3 (OUT) with ground at J4 (GND).
- On UUT (receiver), connect ammeter to measure charge current.

6.3.5 TS: R3 Set Up

Connect ohmmeter across J5. Connect shorting jumper JP3 from TS to EN. Adjust R3 for a 10 kΩ ±200-Ω reading on the ohmmeter. (This allows the temperature sensing to operate in charge allowable region). Make sure: JP3 → TS and EN shorted.

6.3.6 ILIM : R16 Set Up

Connect ohmmeter between JP6-ADJ and J2 (GND). Adjust R16 for 300 Ω ±20-Ω reading on the ohmmeter. (This allows the fast charge current to 1 A). Make sure: JP6 → ILIM and ADJ shorted.

6.3.7 ITERM : R13 Set Up

Connect ohmmeter between JP5 (end that is connected to R13 and R14) and J2 (GND). Adjust R13 for 5 kΩ ±200-Ω reading on the ohmmeter. (This adjusts termination current to around 20% of fast charge current, for 1-A fast charge current, termination current should be 200 mA). Make sure JP5 → Shorted.

6.4 Procedure

6.4.1 Turn ON Operation

- Turn ON transmitter PS#1 (19 V)
- Transmitter – verify LED D2 is *ON*
- Turn *ON* emulator PS#2 (3.6 V)
- Put the receiver EVM on the transmitter coil and align them correctly
- After 5 s, verify that:
  1. Transmitter – status LED D5 is flashing green ~ 1 s
  2. You should hear a beep from the transmitter
  3. Transmitter – LED D2 still *ON*
  4. Receiver – LED D1 is *ON*

6.4.2 Pre-Charge Operation

- Adjust PS#2 to read 2.5 V across J3 and J4 (battery voltage)
- Verify the charging current is 200 mA ±20 mA

6.4.3 Fast-Charge Operation

- Adjust PS#2 to read 3.6 V across J3 and J4 (battery voltage).
- Verify the charging current is 1000 mA ±100 mA

6.4.4 Constant Voltage Charge Operation and Termination

- Adjust PS#2 to read 4.2 V ±50 mV across J3 and J4 (Battery Voltage)
- Keep increasing the voltage on PS#2 and observe the charging current decreases (constant voltage phase)
- Keep increasing the voltage on PS#2 until you reach and observe the charging current approximately 200 mA ± 20 mA (constant voltage phase)
- The charge should terminate after you reach the 200 mA ±200mA level

6.4.5 Efficiency Test

- Adjust PS#2 to read 3.6 V ±50 mV across J3 and J4 (Battery Voltage)
- Remove the receiver and reinstall it
- Verify the charging current is 1000 mA ±100 mA
- Verify that input current to TX is less than 350 mA ±30 mA with input voltage at 19 V_{DC}

7 Test Results

7.1 Start up to Fast-Charge Mode

With the power supply off, connect supply to the bqTESLA transmitter.

- Place the bqTESLA receiver on the transmitter
- Connect battery emulator to J3 with GND J4
- Power TX with 19 V
- Trigger scope sweep on I-BAT

The test results shown in Figure 4 are taken under 19-V input, 3.7-V battery and 1000-mA fast charge current.

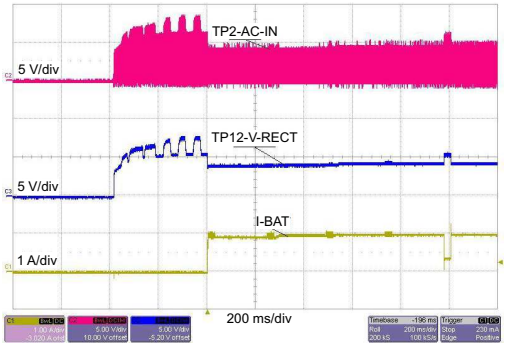

Figure 4. Start-Up to Fast-Charge Mode

7.2 Start up to Pre-Charge Mode

With the power supply off, connect the supply to the bqTESLA transmitter.

- Place the bqTESLA receiver on the transmitter
- Connect the battery emulator to J3 with GND J4
- Power TX with 19 V
- Trigger scope sweep on I-BAT

The test results shown in Figure 5 are taken under 19-V input, 2-V battery and 200-mA pre-charge current.

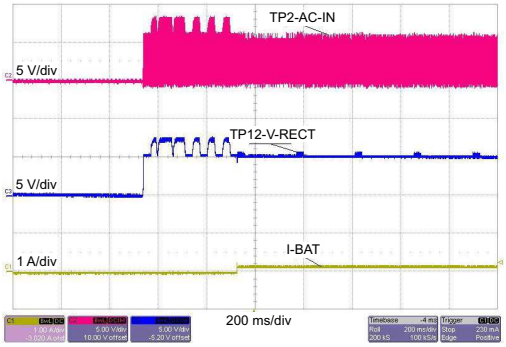

Figure 5. Start-Up to Pre-charge Mode

7.3 Pre-charge to Fast-Charge Transition

With the power supply off, connect the supply to the bqTESLA transmitter.

- Place the bqTESLA receiver on the transmitter
- Connect the battery emulator to J3 with GND J4
- Power TX with 19 V
- Adjust the battery emulator voltage to 2 V (pre-charge mode)
- Increase the battery emulator voltage until exiting the pre-charge mode (200 mA) and enter fast-charge mode (1000 mA)
- Trigger scope sweep on I-BAT

The test results shown in Figure 6 shows pre-charge to fast-charge mode transition

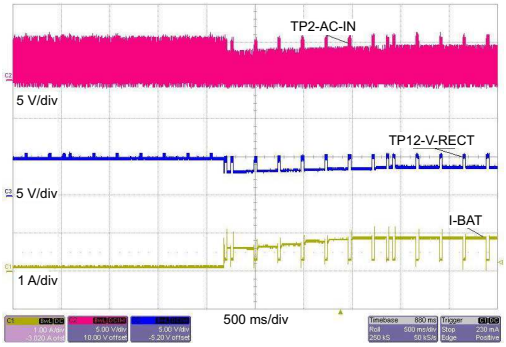

Figure 6. Pre-charge to Fast-Charge Transition

7.4 Fast Charge to Taper and Termination Transition

With the power supply off, connect the supply to the bqTESLA transmitter.

- Place the bqTESLA receiver on the transmitter
- Connect the battery emulator to J3 with GND J4
- Power TX with 19 V
- Adjust the battery emulator voltage to 4.2 V (fast-charge mode, 1000 mA)
- Decrease the battery emulator voltage until exiting the fast-charge mode to taper and then termination 200 mA
- Trigger scope sweep on I-BAT

The test results shown in Figure 7 shows fast-charge to taper and termination modes transition.

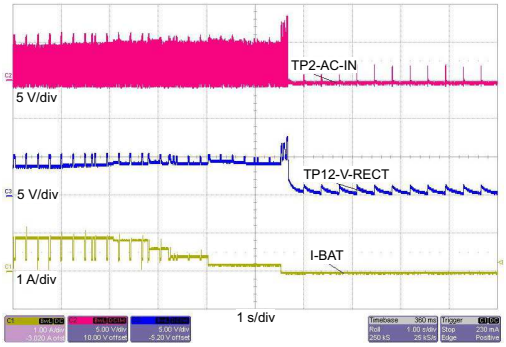

Figure 7. Fast Charge to Taper and Termination Transition

7.5 Efficiency Data

7.5.1 Efficiency Versus Output Power (AC-DC)

Figure 8 illustrates the efficiency of the bq51050BEVM-764 during the full charge cycle. The regulation voltage is 4.2 V, fast charge current is set to 1 A, and termination is set to 100 mA.

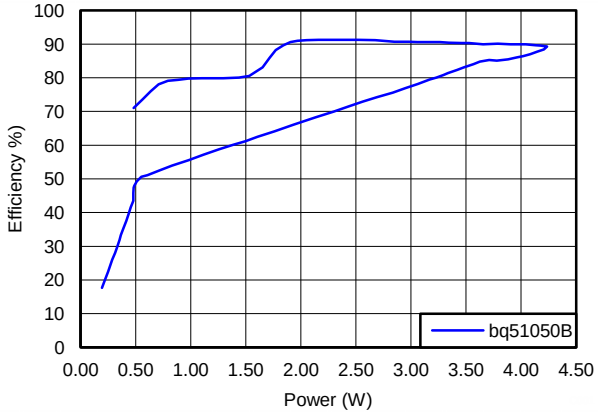

Figure 8. Efficiency Versus Output Power (AC Input to DC Output)

7.5.2 Efficiency Versus Fast Charge Current (AC-DC)

Figure 9 illustrates the efficiency of the bq51050BEVM-764 for different fast charging current levels. The regulation voltage is 4.2 V, fast charge current is varied from 200 mA to 1 A, and the battery emulator voltage is set to approximately 4.1 V.

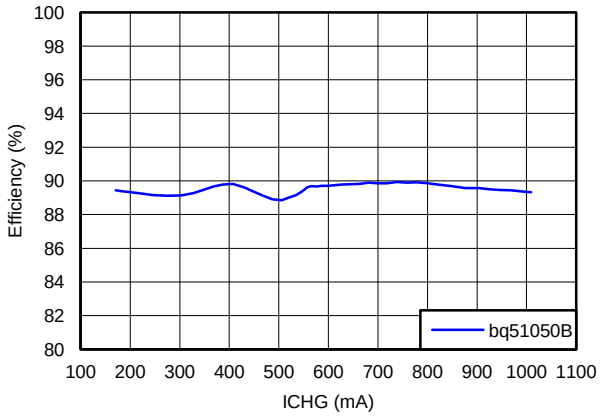

Figure 9. Efficiency Versus Fast Charge Current (AC Input to DC Output)

7.6 Thermal Performance

This section shows a thermal image of the bq51050BEVM-764 in fast-charge mode. A 4.0-V battery is used at a charging rate of 1000 mA. There is no air flow and the ambient temperature is 25°C. The peak temperature of the IC (57.5°C) is well below the maximum recommended operating condition listed in the data sheet.

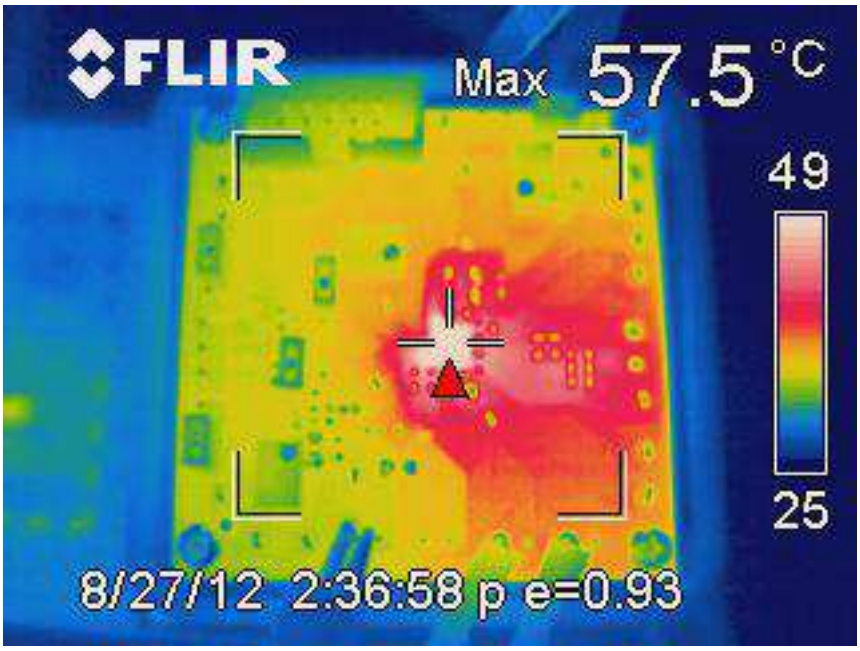

Figure 10. Thermal Image

8 Layout and Bill of Material

8.1 Layout

8.1.1 Printed-Circuit Board Layout Guideline

The primary concerns when laying out a custom receiver PCB are:

- AC1 and AC2 trace resistance
- OUT trace resistance
- RECT trace resistance
- GND connection
- Copper weight ≥ 2 oz

For a 1-A fast charge current application, the current rating for each net is as follows:

- AC1 = AC2 = 1.2 A
- BOOT1 = BOOT2 = 10 mA
- RECT = 1 A
- OUT = 1 A
- COM1 = COM2 = 300 mA
- CLAMP1 = CLAMP2 = 500 mA
- ILIM = 10 mA
- AD = AD-EN = TS-CTRL = EN1 = EN2 = TERM = FOD = 1 mA
- CHG = 10 mA

It is also recommended to have the following capacitance on RECT and OUT:

- RECT ≥ ±10 µF
- OUT ≥ 1 µF

It is always a good practice to place high-frequency bypass capacitors of 0.1 µF next to RECT and OUT. Figure 11 illustrates an example of a WCSP layout:

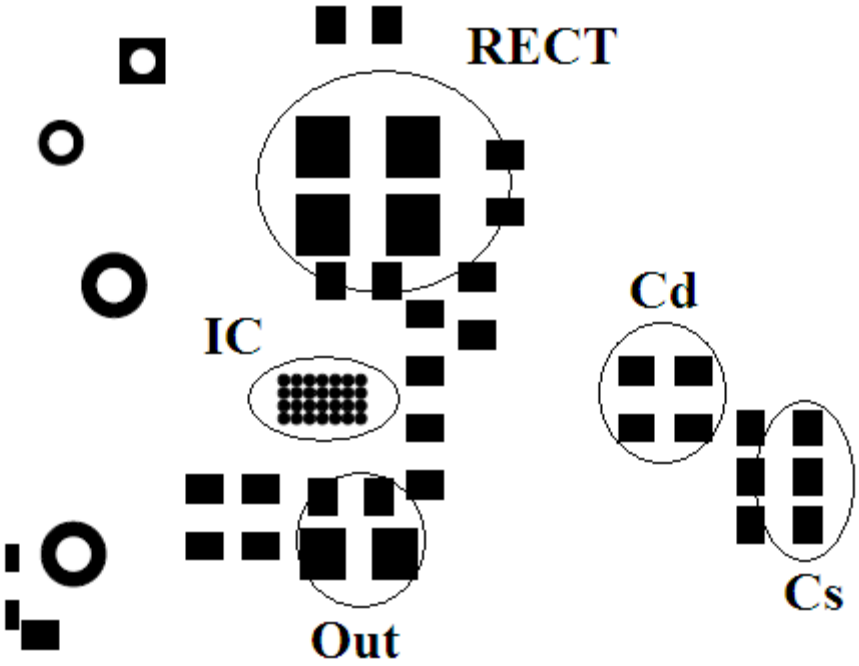

Figure 11. bq51050BEVM Layout Example

8.1.2 Layout

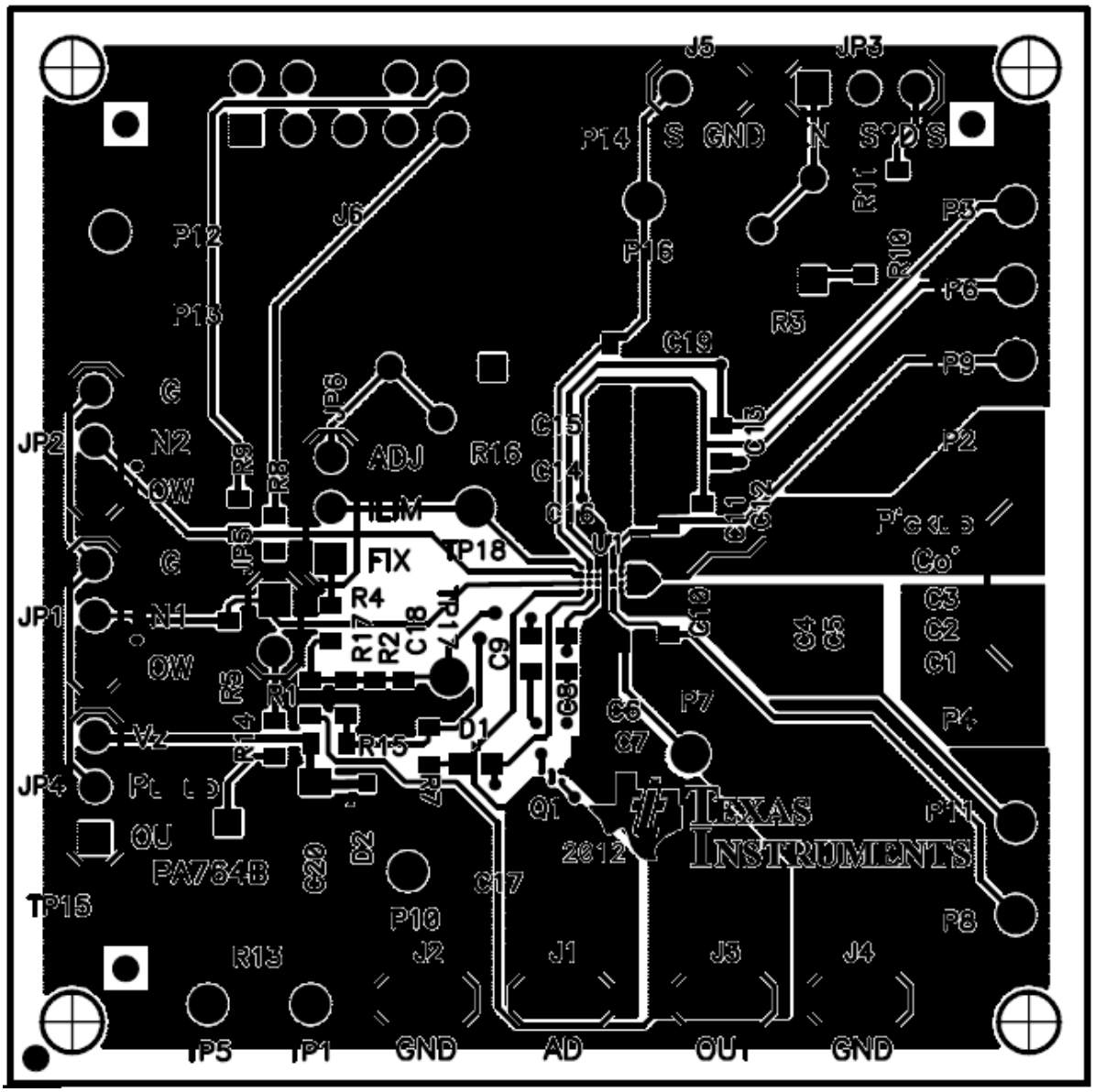

Figure 12. bq51050BEVM-764 Top Assembly

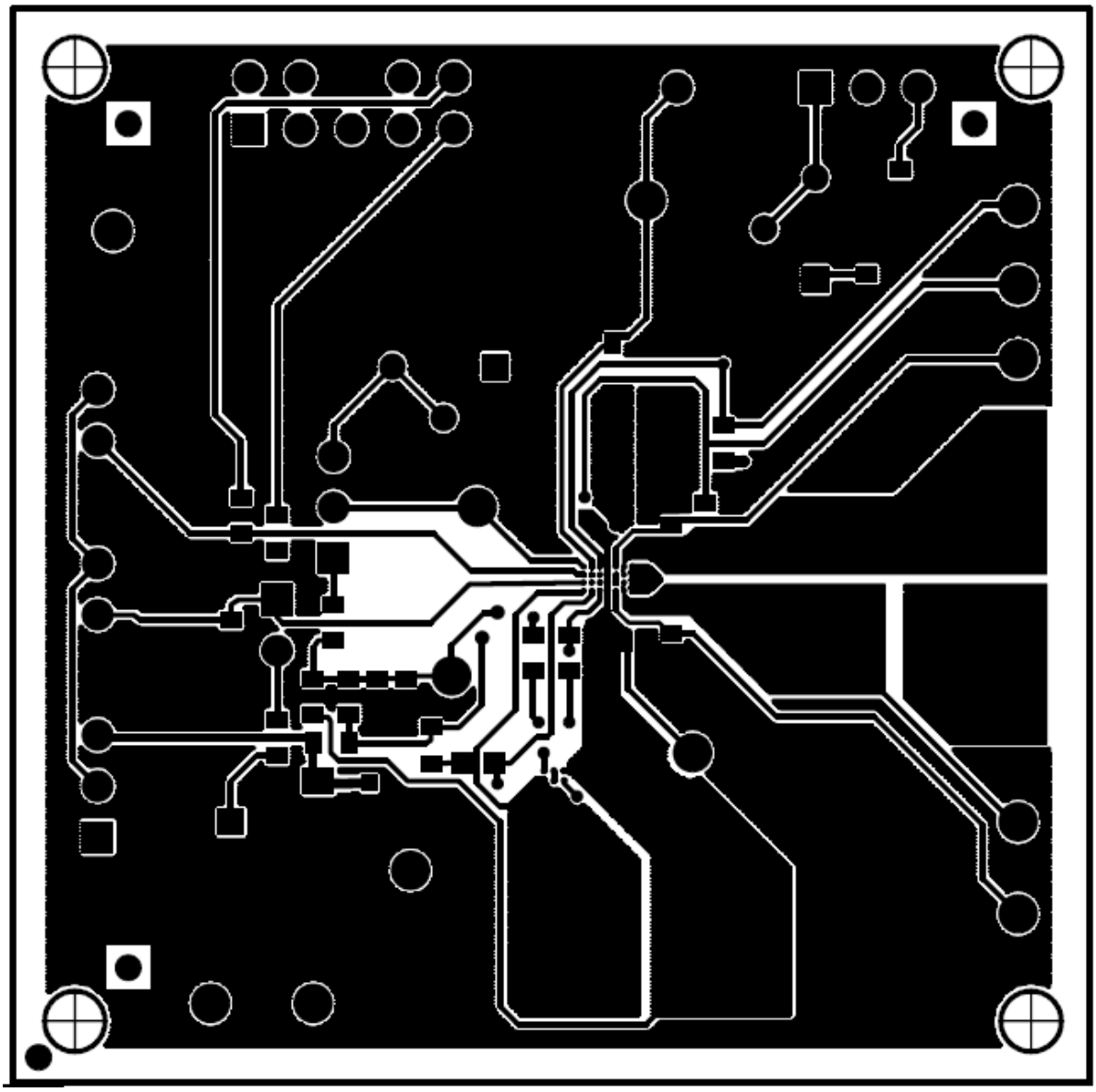

Figure 13. bq51050BEVM-764 Top Layer

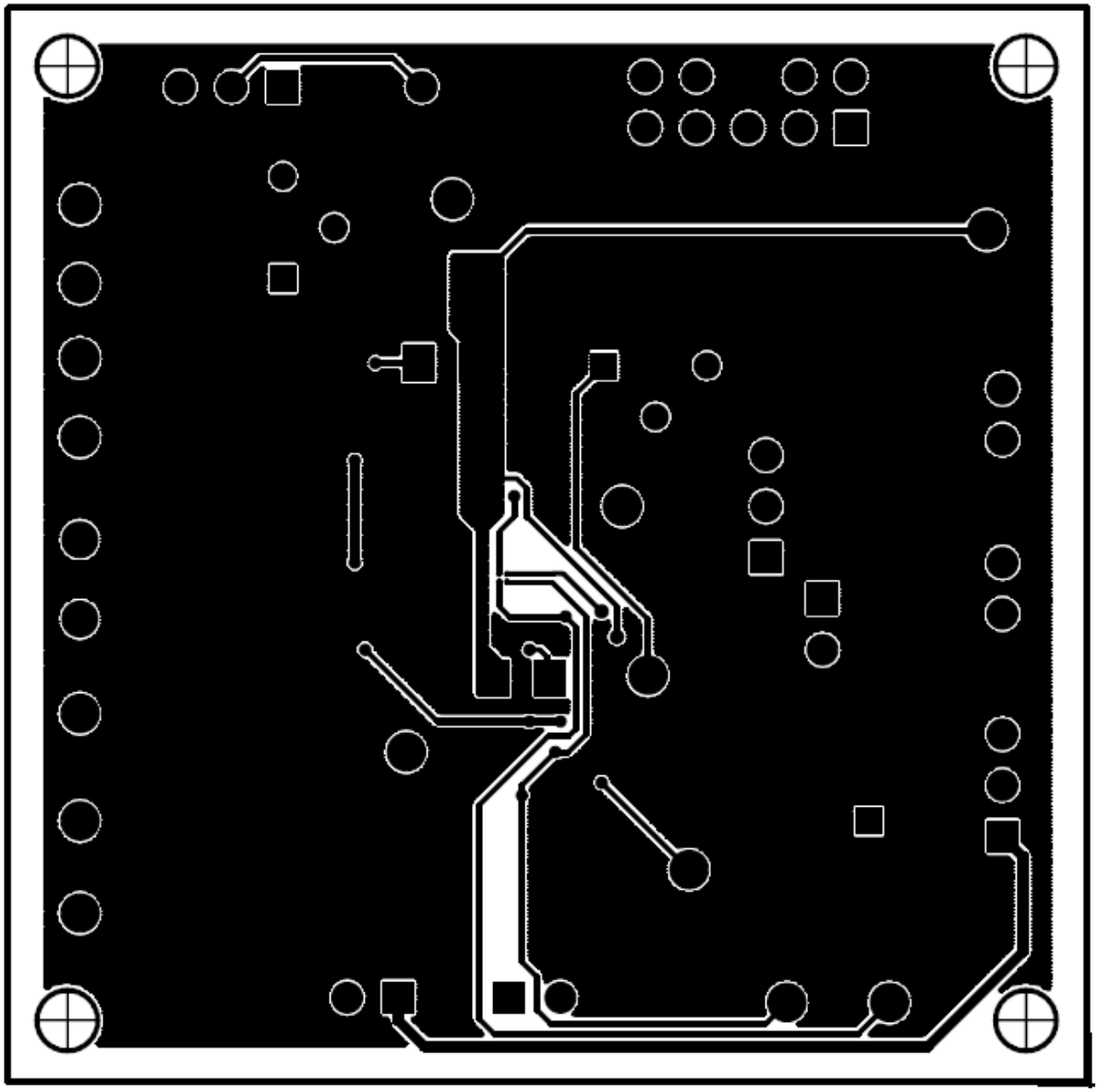

Figure 14. bq51050BEVM-764 Bottom Copper Layer

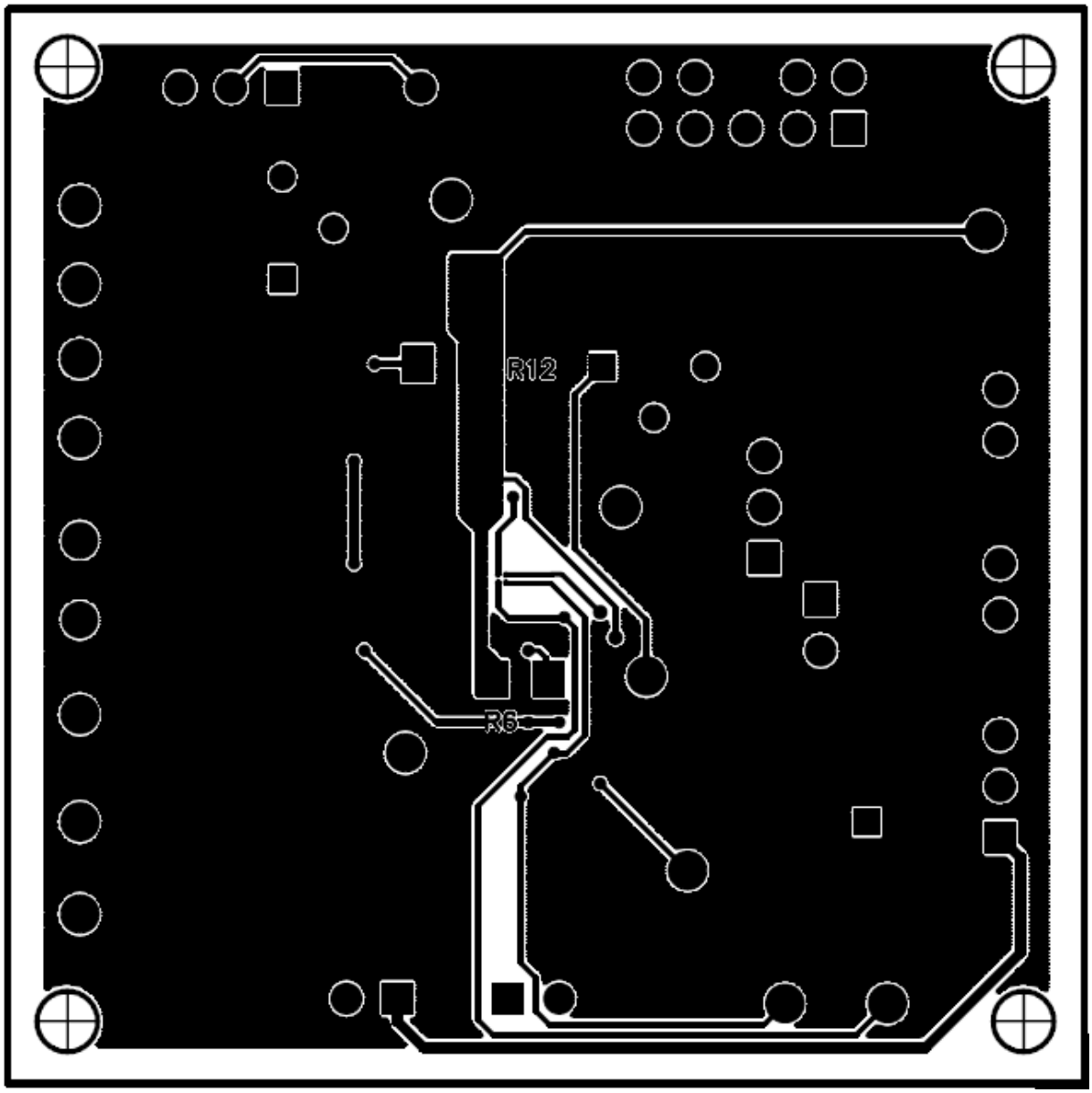

Figure 15. bq51050BEVM-764 Bottom Assembly

8.2 Bill of Materials (BOM)

Table 3. bq51050BEVM-764 Bill of Materials

Count 002	RefDes	Value	Description	Size	Part Number	MFR
2	C1, C2	68nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C3	47nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C4	1800pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C5	100pF	Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std
4	C6, C16, C18, C19	0.1uF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
3	C7, C17, C20	1.0uF	Capacitor, Ceramic, 50V, X5R, 10%	0805	Std	Std
2	C8, C13	22nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
2	C9, C12	0.47uF	Capacitor, Ceramic, 25V, X5R, 10%	0603	Std	Std
2	C10, C11	0.01uF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
2	C14, C15	10uF	Capacitor, Ceramic, 25V, X5R, 10%	1206	Std	Std
1	D1	LTST-C190GKT	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	0603	LTST-C190GKT	Lite On
1	D2	5.1V	Diode, Zener, 5.1V, 300mW	SOD-523	BZT52C5V1T-7	Diodes, Inc.
5	J1– J5	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
1	J6	N2510-6002-RB	Connector, Male Straight 2x5 pin, 100mil spacing, 4 Wall	0.338 x 0.788 inch	N2510-6002-RB	3M
4	JP2–JP4, JP6	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
0	JP1	Open	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
1	JP5	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
0	Q1	CSD75205W1015	MOSFET, Dual PChan, -20V, 1.2A, 190 milliOhm	CSP 1x1.5mm	CSD75205W1015	TI
0	R1	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R2	200	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R3	200k	Potentiometer, 1/4 in. Cermet, 12-Turn, Top-Adjust	0.25x0.17	3266W-1-204LF	Bourns
1	R4	110	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R5	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R6, R12	Open	Resistor, Metal Film, 1/4 watt, ± 1%	1206	CRCW120624R0FKEA	Vishay
1	R7	1.50K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R8, R9	200	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R10	499	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R11	10.0k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R14	1.0k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R15	1.0k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R13	20k	Potentiometer, 1/4 in. Cermet, 12-Turn, Top-Adjust	0.25x0.17	3266W-1-203LF	Bourns
1	R16	5k	Potentiometer, 1/4 in. Cermet, 12-Turn, Top-Adjust	0.25x0.17	3266W-1-502LF	Bourns
1	R17	42.2k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
15	TP1–TP12, TP16–TP18	5000	Test Point, Red, Thru Hole Color Keyed	0.100 x 0.100 inch	5000	Keystone
3	TP13, TP14, TP15	5001	Test Point, Black, Thru Hole Color Keyed	0.100 x 0.100 inch	5001	Keystone
1	U1	bq51050BYFP	IC, Wireless Secondary-Side Power Controller and Battery Charge	DSBGA	bq51050BYFP	TI
5	—		Shunt, 100-mil, Black		929950-00	3M
1	—		PCB, 2.1" x 2.1" x 0.031"		HPA764	Any
1			Case Modified Polycase LP-11B with 4 screws--**See note 7**		J-6838A	Polycase
1			Coil, RX with Attractor		IWAS-4832FF-50 WR-483250-15M2-G	Vishay TDK

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. Tape "Coil, RX" into bottom of case, centered, coil side down, lead wires passing through milled groove.
6. Used to secure RX coil to case. Cut tape section from 36 yard roll identified in part number field.
7. Install PCB in case using provided screws.

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.

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REGULATORY COMPLIANCE INFORMATION

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

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

General Statement for EVMs including a radio

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

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

Caution

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

For EVMs annotated as IC – INDUSTRY CANADA Compliant

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

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

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

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

Concernant les EVMs avec appareils radio

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

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

【Important Notice for Users of this Product in Japan】

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.

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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.

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