bq500212A bqTESLA Wireless Power TX EVM

The bqTESLA™ wireless power transmitter evaluation module from Texas Instruments is a high-performance, easy-to-use development module for the design of wireless power solutions. The single-channel transmitter enables designers to speed the development of their end-applications. The bq500212A EVM evaluation module (EVM) provides all the basic functions of a Qi-compliant, wireless charger pad. The EVM is intended to be used with bq51013BEVM-764 or any other Qi-compliant receiver. The EVM supports both the WPC 1.0 and WPC 1.1 receivers. The transmitter EVM is a 5-V input design which powers a standard WPC low-power 5-W receiver.

Contents

List of Figures

List of Tables

1 Applications

The bq500212AEVM-550 evaluation module demonstrates the transmitter portion of the bqTESLA™ wireless power system. This transmitter EVM is a complete transmitter-side solution that powers a bqTESLA™ receiver. The EVM requires a single 5-V power supply capable of up to 2 A to operate and combines the transmitter electronics, input power socket, LED indicators, and the transmitting coil on the single printed-circuit board (PCB). The open design allows easy access to key points of the electrical schematic.

This EVM has the following features:

- WPC 1.1 Foreign Object Detection (FOD) and WPC 1.0 Parasitic Metal Object Detection (PMOD)
- Dynamic Power Limiting™ (DPL) allows operation from a 5-V supply with limited current capability (for example, a USB port)
- 5-V input power which is really available
- Transmitter-coil mounting pad providing the correct receiver interface
- Compact power section design using the CSD97376 NexFET power stage
- Standard WPC A11-type transmitter coil with no magnet
- LED indicates power transfer or power fault state

2 bq500212AEVM-550 Electrical Performance Specifications

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

Table 1. bq500212AEVM-550 Electrical Performance Specifications

Parameter		Notes and Conditions	Min	Typ	Max	Unit
Input Characteristics						
V_{IN}	Input voltage		4.50	5.0	5.50	V
I_{IN}	Input current	V_{IN} = Nom, I_{OUT} = Max		1.50	2.0	A
	Input no-load current	V_{IN} = Nom, I_{OUT} = 0 A		200		mA
	Input stand-by current	V_{IN} = Nom		20		mA
Output Characteristics – Receiver bq51013BEVM-764						
V_{OUT}	Output voltage	V_{IN} = Nom, I_{OUT} = Nom	4.5	5	5.1	V
	Output ripple	V_{IN} = Nom, I_{OUT} = Max			200	mV_{PP}
I_{OUT}	V_{IN} = Min to Max	V_{IN} = Min to Max	0		1	A
	Output overcurrent	V_{IN} = Nom	1		1.1	A
Systems Characteristics						
F_S	Switching frequency	Switching frequency varies with load	110		205	kHz
ηpk	Peak efficiency	V_{IN} = Nom, P Out RX = 2.5 W		72		%
η	Full-load efficiency	V_{IN} = Nom, I_{OUT} = Max		70		%

3 Modifications

See the datasheet (SLUSBD6) when changing components.

Use LED Mode – Resistor R23 to change the behavior of the status LED, D5, D7 and D9. The standard value is 42.2 kΩ for control option 1, see the datasheet for additional settings.

LED Mode 2 will also change Sleep & Snooze mode timing from external to internal. While LED Mode 9 will change Sleep mode only timing to internal.

NTC – Connector JP1 provides the option for connecting a negative temperature coefficient (NTC) sensor for thermal protection, see the datasheet for additional settings.

L1 and L3 – Common Mode Choke for additional input power filtering or output TX Coil.

L1 – DLW5BTN101SQ2L – 6 A, 9 mΩ, muRata

L3 – DLW5BTN102SQ2L – 2 A, 24 mΩ, muRata

PWR_UP function will flash an LED pattern at first power up, external ckt required. If not used, Pin 45 should be pulled high (3.3V).

4 Connector and Test Point Descriptions

4.1 Input/Output Connections

The connection points are described in Section 4.1.1 through Section 4.1.7.

4.1.1 J1 – V_{IN}

Input power 5 V ±100 mV, return at J2.

4.1.2 J2 – GND

Return for input power, input at J1.

J3 –JTAG

Factory use only.

4.1.3 J4 – Serial Interface

Factory use only.

4.1.4 J5 - Micro USB

Input power connector.

4.1.5 JP1 – NTC

The connection point for the external temperature sensor. See the datasheet for more information.

4.1.6 JP2 – LED Mode

External connection for LED MODE resistor, if R23 is removed.

4.1.7 JP3 – FOD / PMOD Enable (Not Used)

If LOSS_THR resistor (Pin 43 to Gnd) is used, JP3 can be used to Enable or Disable FOD / PMOD. See the datasheet (SLUSBD6) for additional details.

4.2 Test Point Descriptions

The test points are described in Section 4.2.1 through Section 4.2.15.

4.2.1 TP1 – Coil Monitor L / C

Coil signal at junction between coil and capacitors.

4.2.2 TP2 – DPWM Signal

Digital output signal from bq500212A to H-Bridge drive for U3.

4.2.3 TP3 – DPWM Signal

Digital output signal from bq500212A to H-Bridge drive for U2.

4.2.4 TP4 – Analog GND

Low-noise GND

4.2.5 TP5 – Not Used

Not used.

4.2.6 TP6 – Not Used

Not used.

4.2.7 TP7 – Not Used

Not used.

4.2.8 TP8 – Not Used

Not used.

4.2.9 TP9 – 3.3-VDC

Voltage for low-power circuits, switched ON/OFF using U5 EN.

4.2.10 TP10 - Filtered 3.3 V

3.3-V output with additional filtering for A-to-D converters.

4.2.11 TP11 – Not Used

Not used.

4.2.12 TP12 – Not Used

Not used.

4.2.13 TP13 – Demodulation Comm + Output

Primary communications channel, input to bq500212A, U1 from demodulation circuit.

4.2.14 TP14 – Snooze

Output from bq500212A, U1 starts Snooze timer circuit.

TP15 – Not Used

Not used.

TP16 – Not Used

Not used.

TP17 – Not Used

Not used.

TP18 – Spare Pin

Unused output from bq500212A.

TP19 – I_Sense

Input current-sense voltage, scale 1 V = 1 A.

4.2.15 TP20 -- Sleep

Output from bq212A, U1 starts Sleep timer circuit.

5 Schematic and Bill of Materials

This section includes the schematics and bill of materials for the EVM.

Figure 1 through Figure 3 illustrate the schematics for this EVM.

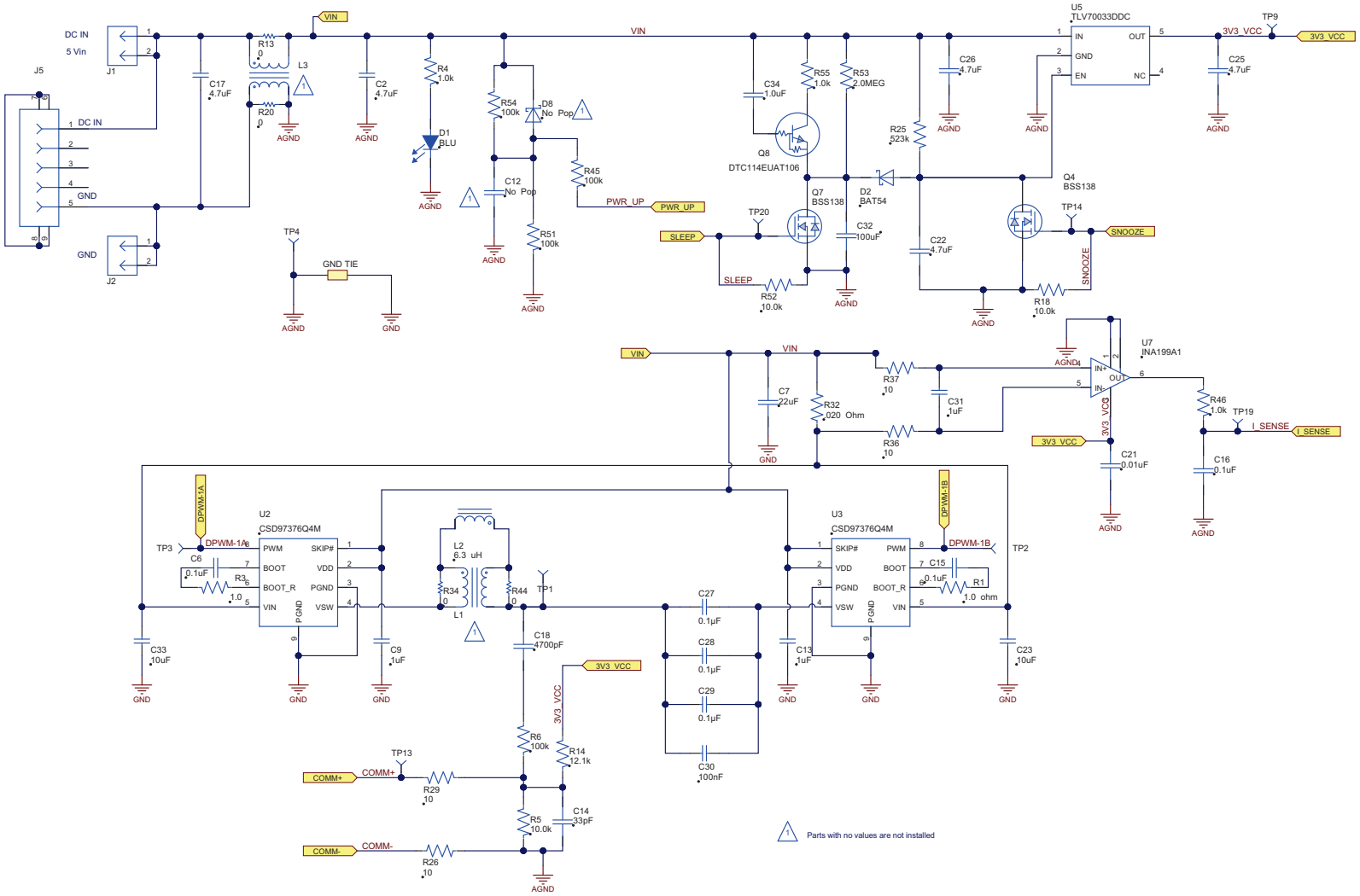

Figure 1. bq500212AEVM-550 Schematic, Page 1 of 3

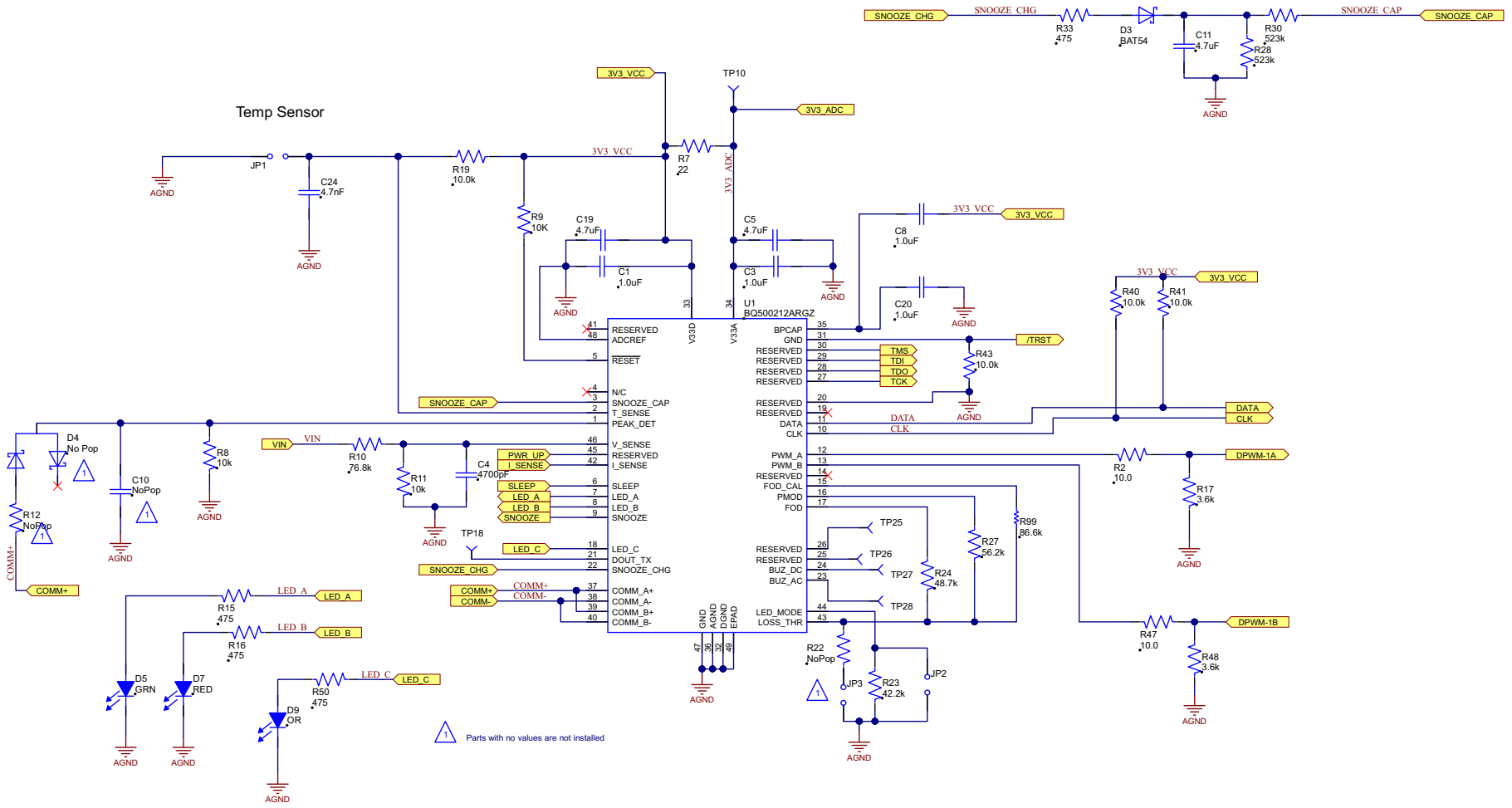

Figure 2. bq500212AEVM-550 Schematic, Page 2 of 3

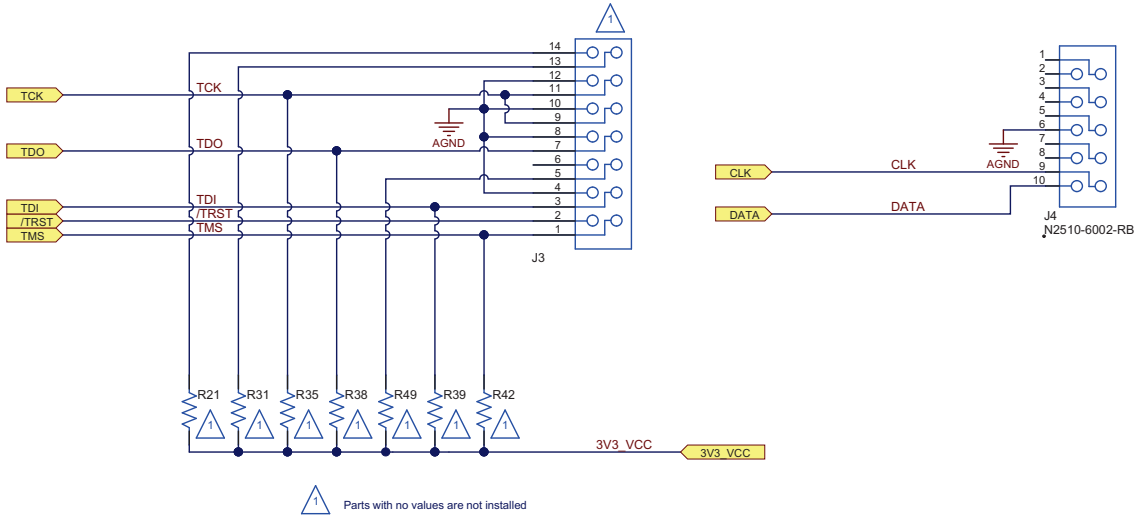

Figure 3. bq500212AEVM-550 Schematic, Page 3 of 3

Table 2 contains the BOM for this EVM.

Table 2. Bill of Materials

Designator	Qty	Description	Manufacturer	Part Number	Alternate Manufacturer	Alternate PartNumber
C1, C3, C20, C34	4	Capacitor, Ceramic, 1UF 16V 10% X7R 0603	TDK	C1608X7R1C105K080AC		
C2, C17	2	CAP, CERM, 4.7uF, 10V, +/-10%, X5R, 0805	AVX	0805ZD475KAT2A		
C4	1	Capacitor, Ceramic, 4700PF 50V 5% NP0 0603	TDK	C1608C0G1H472J080AA	Digi-Key	445-7400-2-ND
C5	1	Capacitor, Ceramic, 4.7uF, 10V, X7R, 20%	TDK	CGB3B1X5R1A475M055AC		
C6, C15, C16, C31	4	Capacitor, Ceramic, 0.1UF 50V 10% X7R 0603	TDK	C1608X7R1H104K080AA	TDK	C1608X7R1H104K080AA
C7	1	Capacitor, Ceramic, 22UF 25V 10% X5R 1210	Murata	GRM32ER61E226KE15L	Digi-Key	490-3889-1
C8	1	Capacitor, Ceramic, 2.2UF 10V 10% X7R 0603	TDK	C1608X7R1A225K080AC	Digi-Key	445-5958-1
C9, C13	2	CAP, CERM, 1uF, 16V, +/-10%, X5R, 0603	Kemet	C0603C105K4PACTU		
C11, C25	2	Capacitor, Ceramic, 4.7UF 10V 20% X5R 0603	TDK	CGB3B1X5R1A475M055AC		
C12	0	No-Pop	TDK	C3216X7R1C225K/1.60	Digi-Key	445-1384-1
C14	1	Capacitor, Ceramic, 33PF 50V 5% NP0 0603	TDK	C1608C0G1H330J080AA	Digi-Key	445-1275-1
C18	1	Capacitor, Ceramic, 4700pF, 50V, X7R, 10%	TDK	C1608C0G1H472J080AA	Digi-Key	445-7400-2-ND
C19, C26	2	Capacitor, Ceramic, 4.7UF 10V 20% X5R 0603	TDK	CGB3B1X5R1A475M055AC		
C21	1	Capacitor, Ceramic, 0.01uF, 50V, X7R, 10%	TDK	C1608X7R1H103K080AA	Digi-Key	445-1311-1
C22	1	Capacitor, Ceramic, 4.7UF 10V 20% X5R 060	TDK	CGB3B1X5R1A475M055AC		
C23, C33	2	CAP, CERM, 10uF, 10V, +/-10%, X5R, 1210	Kemet	C1210C106K8PACTU		
C24	1	Capacitor, Ceramic, 4.7nF, 50V, X7R, 10%	TDK	CGA3E2X7R1H472K080AD	Digi-Key	445-8828-1
C27, C28, C29	3	CAP, CERM, 0.1uF, 100V, +10/%, X7R, 1206	TDK	C3216X7R2A104K		
C30	1	CAP CER 0.1UF 50V 10% NP0 1210	TDK Corporation	C3225C0G1H104K250AA		
C32	1	Capacitor, Ceramic Chip, 100UF 6.3V 20% X5R 1206	TDK	C3216X5R0J107M160AB	TDK	445-6008-1
D1	1	Diode. LED 2X1.2MM 470NM BL WTR CLR SMD	Kingbright Corp	APT2012QBC/D	Digi-Key	754-1437-1-ND
D2, D3	2	Diode, Schottky, 200-mA, 30-V	Vishay-Liteon	BAT54		
D4	0	Diode, Dual Schottky, ---No Pop	On Semi	BAT54SWT1G		
D5	1	Diode. LED 2X1.2MM 568NM GN WTR CLR SMD	Kingbright Corp	APT2012SGC	Digi-Key	754-1131-1
D7	1	Diode. LED 2X1.2MM 640NM RD WTR CLR SMD	Kingbright Corp	APT2012SRCPRV	Digi-Key	754-1132-1-ND
D9	1	Diode. LED 2X1.2MM 601NM OR WTR CLR SMD	Kingbright Corp	APT2012SECK	Digi-Key	754-1130-1
L2	1	TX Coil	Wurth Elektronik	760-308-111		
Q4, Q7	2	MOSFET, Nch, 50V, 0.22A, 3.5 Ohm	Fairchild	BSS138		
Q8	1	Transistor, Digital NPN, 50 V, 100 mA	Rohm	DTC114EUA		
R1, R3, R37	3	Resistor, Chip, 1.0 OHM 1/10W 5% 0603 SMD	Yageo, Yageo, Yareo	RC0603JR-071RL	Digi-Key	311-1.0GRCT
R2, R47	2	Resistor, Chip, 10 OHM 1/10W 5% 0603 SMD	Yageo	RC0603JR-0710RL	Digi-Key	311-10GR
R4, R46, R55	3	Resistor, Chip, 1.00K OHM 1/10W 1% 0603 SMD	Std, Yageo, Yageo	RC0603FR-071KL	[NoValue], Digi-Key, Digi-Key	[NoValue], 311-1.00KH, 311-1.00KH
R5, R8, R9, R11, R18, R19, R40, R41, R43, R52	10	RES 10.0K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0710KL		
R6, R54, R45, R51	2	Resistor, Chip, 100K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-07100KL	Digi-Key	311-100KHRTR
R7	1	Resistor, Chip, 22 OHM 1/8W 5% 0805 SMD	Yageo	RC0805JR-0722RL	Digi-Key	311-22ARCT
R10	1	Resistor, Chip, 76.8K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0776K8L	Digi-Key	311-76.8KHRCT

Table 2. Bill of Materials (continued)

Designator	Qty	Description	Manufacturer	Part Number	Alternate Manufacturer	Alternate PartNumber
R13, R20, R34, R44	4	RES, 0 ohm, 5%, 0.25W, 1206	Vishay-Dale	CRCW12060000Z0EA		
R14	1	Resistor, Chip, 12.1K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0712K1L	Digi-Key	311-12.1KHRCT
R15, R16, R33	3	Resistor, Chip, 475 OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-07475RL	Digi-Key	311-475HRCT, 311-475HRCT, 311-475HRC
R17	1	Resistor, Chip, 3.60K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-073K6L	Digi-Key	311-3.60KHR
R22	1	Resistor, Chip, 56.2K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0756K2L	Digi-Key	311-56.2KHRCT
R23	1	Resistor, Chip, 42.2K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-0742K2L	Yageo	311-42.2KHRCT
R25, R28, R30	3	Resistor, Chip, 523K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-07523KL	Digi-Key	311-523KHRCT
R26, R29	2	Resistor, Chip, 10 OHM 1/10W 5% 0603 SMD	Yageo	RC0603JR-0710RL	Digi-Key	311-10GR, 311-10GRCT
R32	1	Resistor, Chip, 0.02 OHM 1/2W 1% 0805 SMD	Panasonic Electronic Components	ERJ-6BWFR020V		
R36	1	Resistor, Chip, 1.0 OHM 1/10W 5% 0603 SMD	Yareo	RC0603JR-071RL	Digi-Key	311-1.0GRCT
D8	0	Diode, Schottky, No-Pop	Vishay-Liteon	BAT54		
R48	1	Resistor, Chip, 3.60K OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-073K6L	Digi-Key	311-3.60KHRCT
R50	1	Resistor, Chip, 475 OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-07475RL	Digi-Key	311-475HRCT
	0	Resistor, Chip, 1.00M OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-071ML	Digi-Key	311-1.00MHRCT
R53	1	Resistor, Chip, 2.00M OHM 1/10W 1% 0603 SMD	Yageo	RC0603FR-072ML	Digi-Key	311-2.00MHRCT
R99	1	RES, 86.6k ohm, 1%, 0.1W, 0603	Yageo America	RC0603FR-0786K6L		
U1	1	IC, Qi Compliant Wireless Power Transmitter Manager	TI	BQ500212ARGZ	None	
U2, U3	2	IC, Synchronous Buck NexFETPower Stage	TI	CSD97376CQ4M	None	
U5	1	IC REG LDO 3.3V 200mA SOT-23-5	TI	TLV70033DDC	Digi-Key	
U7	1	IC, Current Monitor, High or Low Side Measurement, Bi-Directional Zerø-Drift Series	TI	INA199A1DCKR	None	
C10	0	Capacitor, Ceramic, 50V, C0G, 5%	TDK	C1608C0G1H330J080AA		
L1, L3	0	Inductor, Toroid, yyA, zzmilliohm	muRata	DLW5BSNxxxSQ2		
R12, R21, R31, R35, R38, R39, R42, R49	0	Resistor, Chip, 1/16W, 1%	N/A	Open		
R24	0	Resistor, Chip, 1/16W, 1%	Yageo	RC0603FR-0748K7L	DigiKey	311-48.7KHRCT-ND
R27	0	Resistor, Chip, 56.2K OHM 1/10W 1%	Yageo	RC0603FR-0756K2L		

6 Test Setup

6.1 Equipment

6.1.1 bqTESLA™ Receiver

Use the bq51013BEVM-764 or a Qi-compliant receiver to work with this EVM.

6.1.2 Voltage Source

The input voltage source must provide a regulated DC voltage of 5 V and deliver at least 2-A continuous load current; current limit must be set to 3 A.

CAUTION

To help assure safety integrity of the system and minimize risk of electrical shock hazard, always use a power supply providing suitable isolation and supplemental insulation (double insulated). Compliance to IEC 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use, Part 1, General Requirements, or its equivalent is strongly suggested, including any required regional regulatory compliance certification approvals. Always select a power source that is suitably rated for use with this EVM as referenced in this user manual.

External Power Supply Requirements:
Nom Voltage: 5.0 VDC
Max Current: 3.0 A
Efficiency Level V

External Power Supply Regulatory Compliance Certifications: Recommend selection and use of an external a power supply which meets TI's required minimum electrical ratings in addition to complying with applicable regional product regulatory/safety certification requirements such as (by example) UL, CSA, VDE, CCC, PSE, and so forth.

6.1.3 Meters

Monitor the output voltage at the bq51013BEVM-764 test point TP7 with a voltmeter. Monitor the input current into the load with an appropriate ammeter. You can also monitor the transmitter input current and voltage, but the meter must use the averaging function for reducing error, due to communications packets.

6.1.4 Loads

A single load is required at 5 V with a maximum current of 1 A. The load can be resistive or electronic.

6.1.5 Oscilloscope

Use a dual-channel oscilloscope with appropriate probes to observe the COMM_DRV signal at bq51013BEVM-764 TP3 and other signals.

6.1.6 Recommended Wire Gauge

For proper operation, use 22-AWG wire when connecting the EVM to the input supply and the bq51013BEVM-764 to the load.

6.2 Equipment Setup

- With the power supply OFF, connect the supply to the bqTESLA™ transmitter.
- Connect the V_{IN} positive power source to J1, and connect the negative terminal of the V_{IN} source to J2.
- Do not place the bqTESLA™ receiver on the transmitter. Connect a load to J3 with a return to J4, monitor current through the load with the ammeter, and monitor the current to the load at TP7. All voltmeters must be Kelvin connected (at the pin) to the point of interest.

6.2.1 Equipment Setup Diagram

The diagram in Figure 4 shows the test setup.

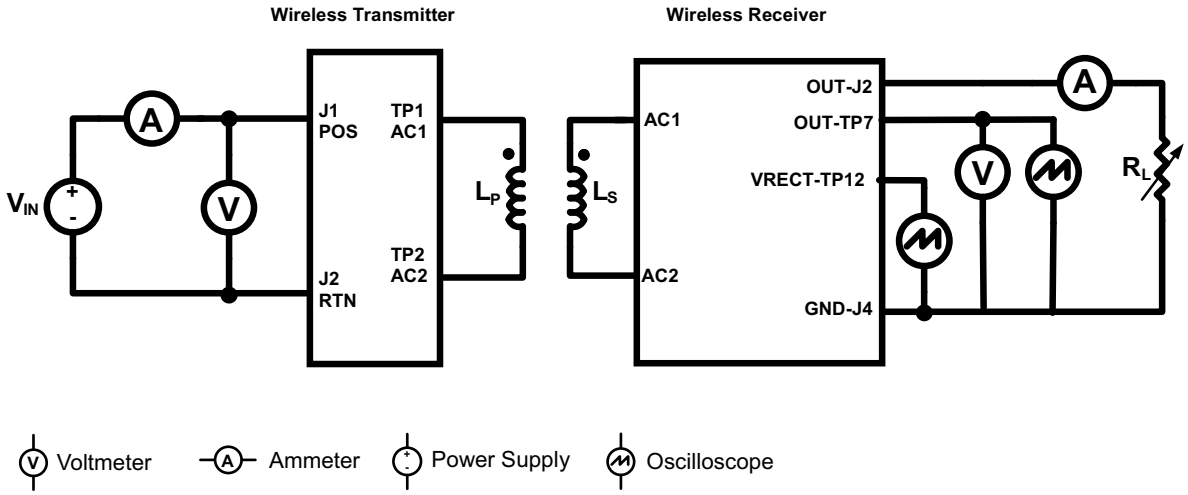

Figure 4. Equipment Setup

6.2.2 EVM Procedures

This section guides the user through a few general test procedures to exercise the functionality of the presented hardware. Some key notes follow.

6.2.2.1 Start-Up No Receiver

Turn on V_{IN}, and observe that the blue power LED, D1, illuminates. Status LEDs D7, D9 and D5 are OFF until the power transfer starts.

Apply the scope probe to the test point, TP1, and observe single-pulse bursts approximately every 500 ms. This is a Digital Ping to begin communications with a receiver placed on the TX coil.

6.2.2.2 Apply Receivers

Place the bq51013BEVM-764 EVM on the top of the transmitting coil. Align the centers of the receiving and transmitting coils across each other. In the next few seconds, observe that the status LED, D5, flashes green, indicating that communication between the transmitter and the receiver is established and that power transfer has started.

- The status LED, D5, flashes a green light during power transfer.
- Typical output voltage is 5 V, and the output current range is 0 mA to 1 A.
- Observe a continuous sine-wave on the test point TP1 when power transfer is active; the frequency is between 110 kHz and 205 kHz.
- Make tests and measurements applicable to a normal 5-V power supply.

6.2.2.3 Efficiency

To measure system efficiency, measure the output voltage, the output current, input voltage, and input current and calculate efficiency as the ratio of the output power to the input power. Connect voltage meters at the input and output of TX and RX (see Figure 4). Average the input current; the comm pulses modulate the input current, distorting the reading. See Figure 5 for efficiency. Figure 5 shows efficiency with standard EVM (C30-COG but C29, C28, and C27 - X7R).

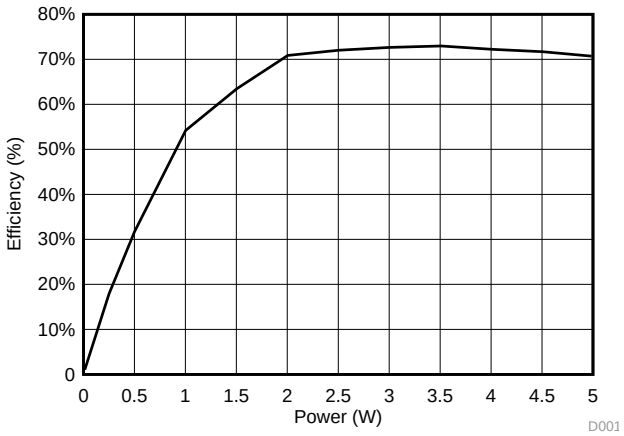

Figure 5. Efficiency versus Power, bq500212AEVM-550 Transmitter and HPA764 Receiver

6.2.2.4 Efficiency Improvements

Efficiency improvements can be made with component changes. The EVM uses an integrated power stage device that combines both the driver and two MOSFETs into one package, CSD97376. Similar devices with lower RDSon MOSFETs are available. The CSD97374 reduces RDSon by about 50% and improves efficiency by 2% to 4%. This device is pin-to-pin compatible and is a drop in replacement.

To reduce cost, the EVM uses a mix on COG and X7R capacitors for the resonant capacitors, C28, C29, C30, and C27. X7R is lower cost but has higher ESR resulting in higher loss. COG capacitors are lower loss but present problems for FOD calibration and Qi certification. If certification is required, do not use an all-COG configuration.

Note that changing the efficiency of the unit and reducing loss (or increasing loss) changes the FOD performance and may require re-calibration. This would require FOD_CAL resistor, R99 to change along with FOD_Threshold resistor, R24. FOD Calibration procedure would need to be repeated.

6.2.2.5 Dynamic Power Limiting

Dynamic Power Limiting (DPL) allows operation from a 5-V supply with limited current capability. Input voltage is monitored at Pin 46 though a voltage divider network. When input voltage decreases to 4.2 V, the operating point is adjusted to reduce load and increase input voltage to 4.5 V.

6.2.2.6 Thermal Protection, NTC

Thermal protection is provided by an NTC resistor connected to JP1. At 1 V on the sense side (U1-2), the thermal fault is set, and the unit is shut down, The status LED, D5, illuminates red. The typical resistor value for fault is 850 Ω. The system tries to restart in 5 minutes.

6.2.2.7 Foreign Object Detection

The bq500212A EVM incorporated Foreign Object Detection (FOD) call in WPC 1.1. Power loss is calculated by comparing the power sent to the receiver (RX) with the power the RX reported receiving, less know power loss. The transmitter determines the power sent to the RX by measuring input power and calculating internal losses. The RX measures the power it received and also calculates losses. The RX sends this information to the driver (TX) in a digital word, message packet. Unaccounted for power loss is presumed to be a foreign object on the charging pad. Should this lost power exceed the threshold set by R24, a FOD fault is set and power transfer is stopped.

Three key measurements for the TX FOD calculation:

- **Input Power** – Product of input voltage and current. Input voltage is measured at Pin 46 though R10 and R11. Input current is measured using sense resistor R32 and current sense amp U7. Both measurements need to be very accurate.
- **Power Loss in Transmitter** – This is an internal calculation based on the operating point of the transmitter. The calculation is adjusted using FOD_Cal resistor, R99. This calculation changes with external component changes in the power path such as MOSFETs, resonate capacitors, and TX coil. Recalculation of R99 and R24 will be required.
- **Receiver Reported Power** – The receiver calculates and reports power it receives in the message packet “Received Power Packet (0X04)”.

The FOD threshold on the EVM is set to 350 mW, R24 is set to 48.7 kΩ. Increasing R24 increases the threshold and reduces the sensitivity to foreign objects.

This loss threshold is determined after making a measurement of transmitter performance using a FOD Calibration Receiver similar to unit manufactured by Avid® Technology. Contact Texas Instruments for the Foreign Object Detection Calibration Procedure for bq500212A.

6.2.2.8 WPC Certification

The bq500212AEVM-550 was tested and certified to WPC version 1.1.1, July 2013.

7 bq500212AEVM-550 Assembly Drawings and Layout

Figure 6 through Figure 11 show the design of the bq500212AEVM PCB. The EVM has been designed using a 4-layer, 2-oz, copper-clad circuit board 13.2 cm × 7.24 cm with all components in a 4.0-cm x 5.0-cm active area on the top side and all active traces to the top and bottom layers to allow the user to easily view, probe, and evaluate the bq500212A control IC in a practical application. Moving components to both sides of the PCB or using additional internal layers offers additional size reduction for space-constrained systems. Gerber files are available for download from the EVM product folder.

A 4-layer PCB design is recommended to provide a good low-noise ground plane for all circuits. A 2-layer PCB presents a high risk of poor performance. Grounding between the bq500212A GND pin 47, 36, and 32 and filter capacitor returns C19, C1, C5, and C3 should be a good low-impedance path.

Coil Grounding – A ground plane area under the coil is recommended to reduce noise coupling into the receiver. The ground plane for the EVM is slightly larger than the coil footprint and grounded at one point back to the circuit area.

Note: The clear plastic cover thickness (0.93 in or 2.4 mm) is the z-gap thickness for the transmitter.

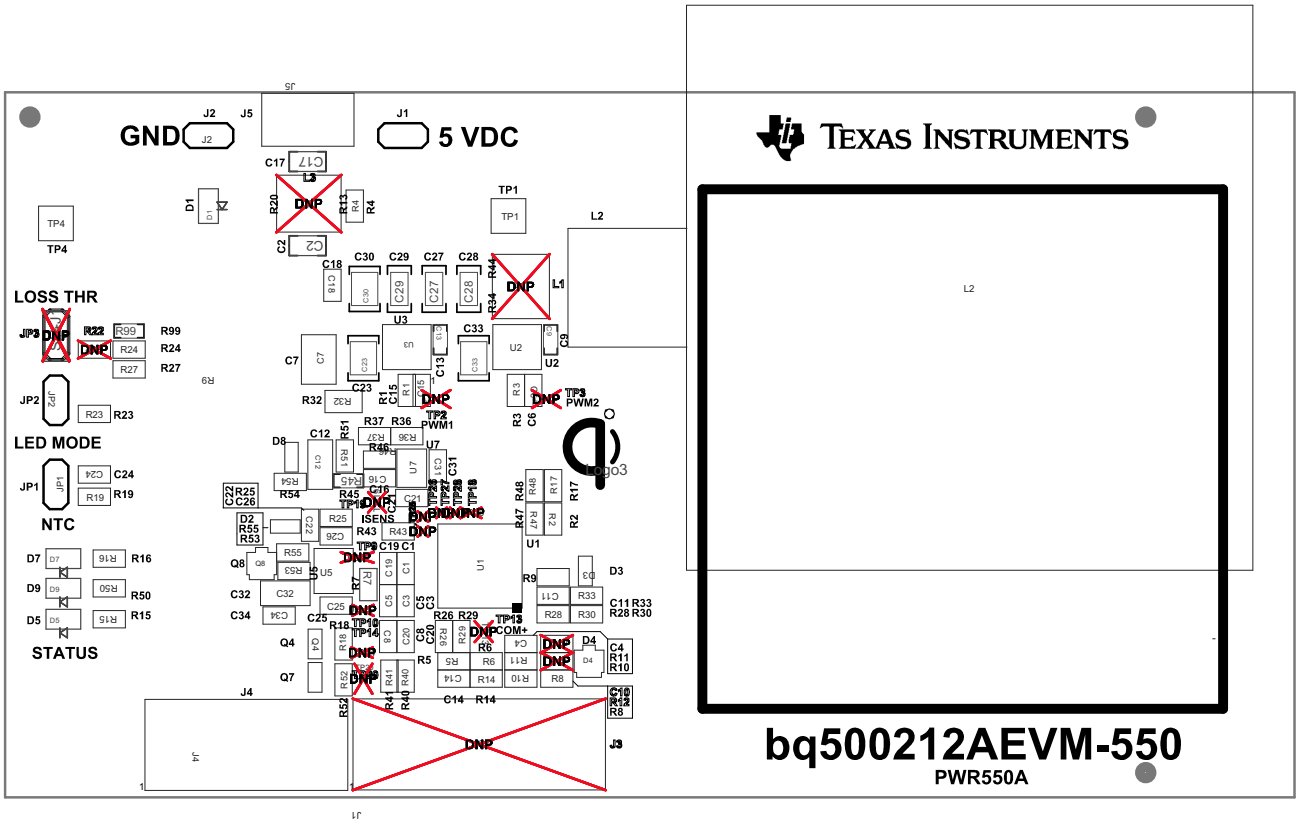

Figure 6. Assembly Top

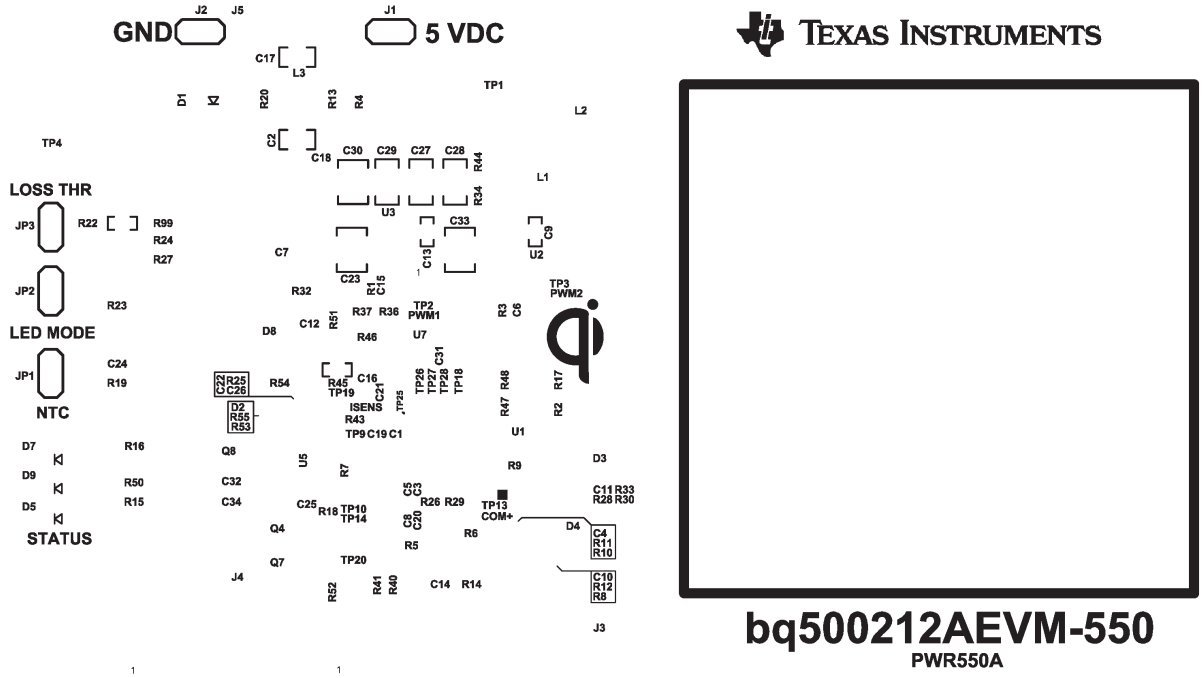

Figure 7. Top Silk

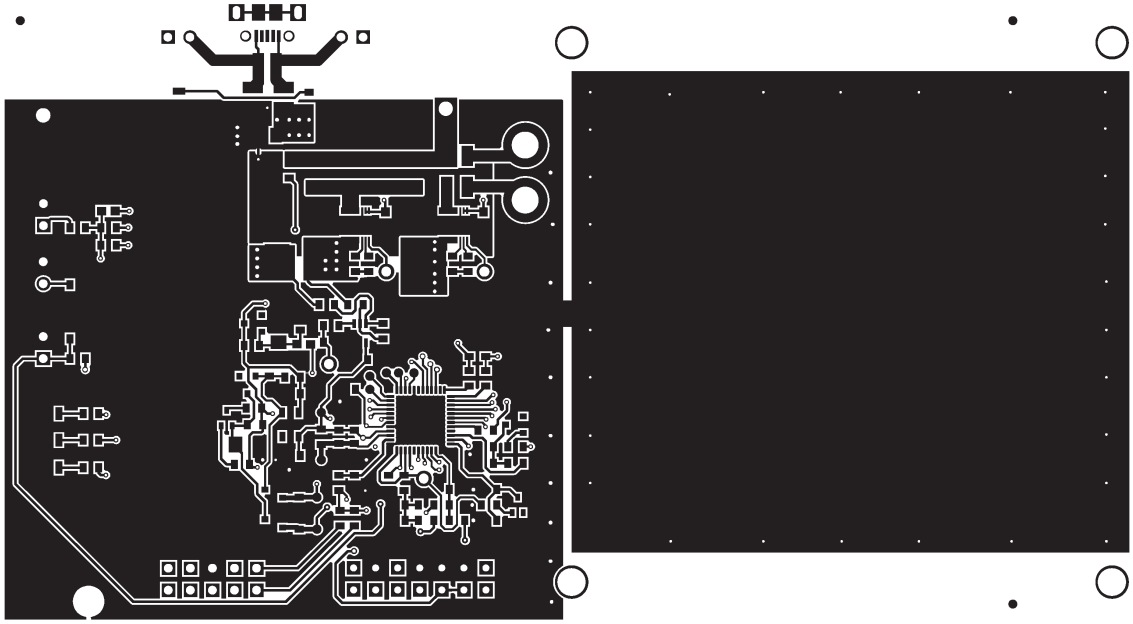

Figure 8. Top Layer

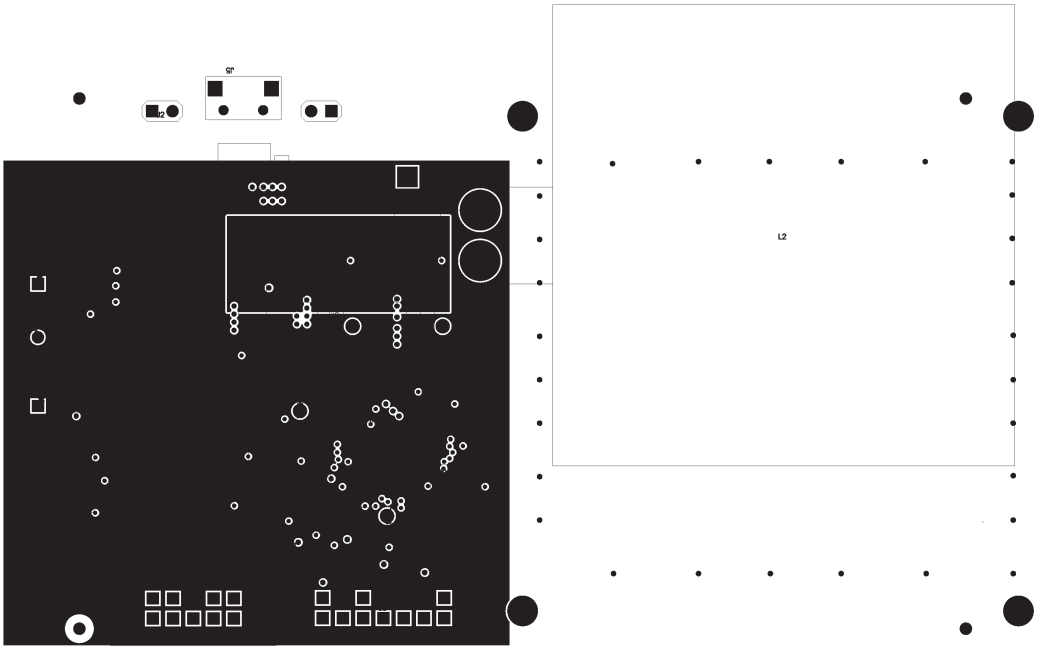

Figure 9. Layer 2

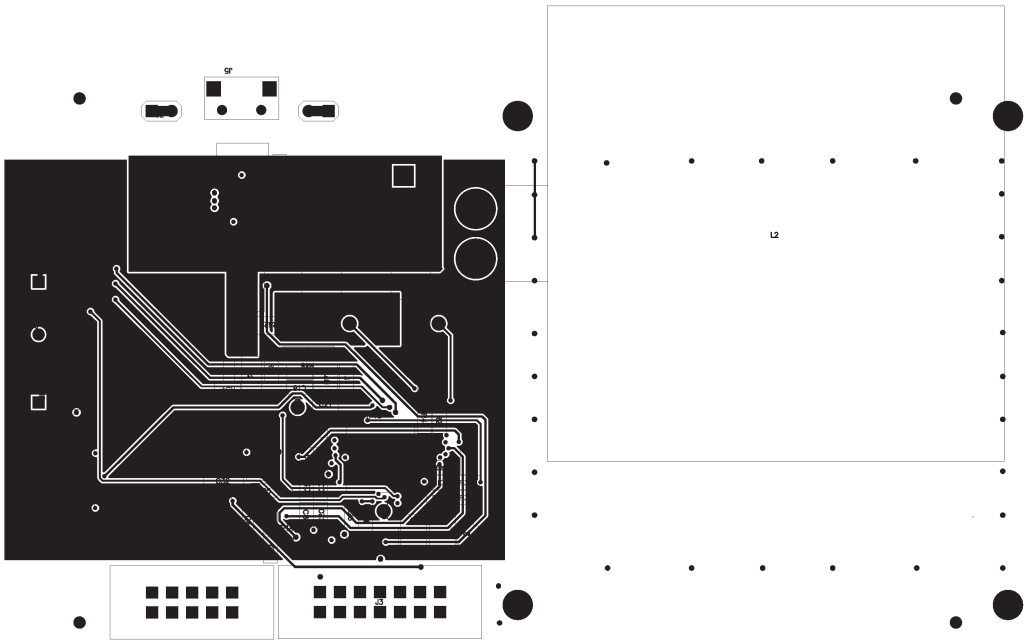

Figure 10. Layer 3

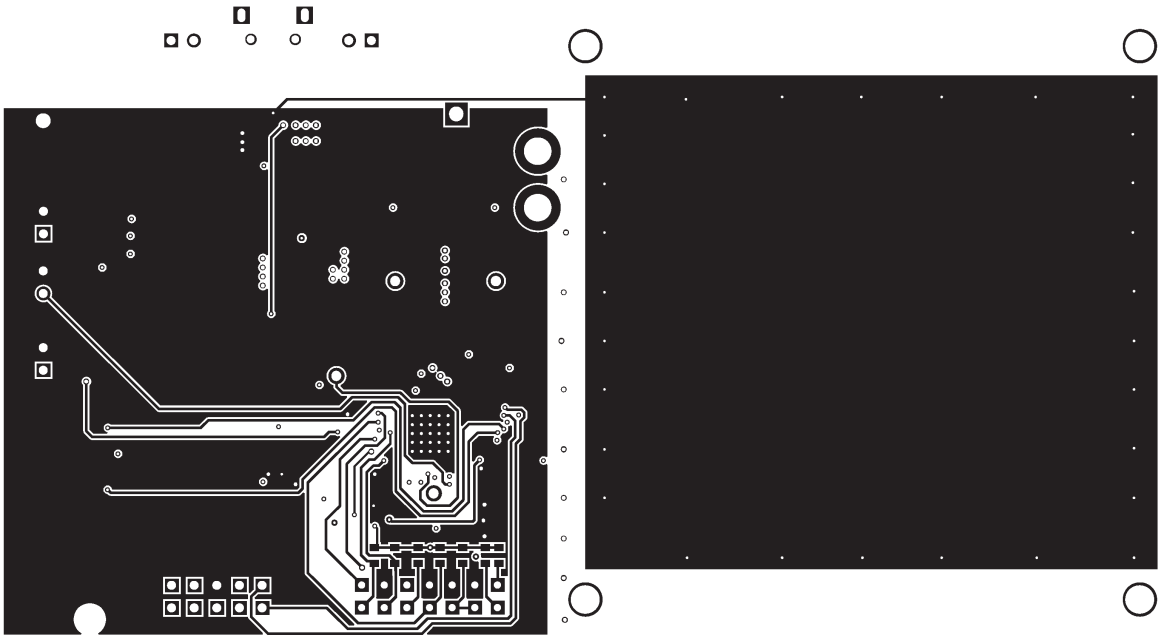

Figure 11. Bottom Layer

8 Reference

For additional information about the bq500212AEVM-550 low-power, wireless, power evaluation kit from Texas Instruments, visit the product folder on the TI Web site at http://www.ti.com/product/bq500212A.

FCC and IC Regulatory Compliance

REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM is subject to the Federal Communications Commission (FCC), Industry Canada (IC) and European Union CE Mark rules.

FCC – FEDERAL COMMUNICATIONS COMMISSION Part 18 Compliant

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 18 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.

Note: There is no required maintenance of this device from a FCC compliance perspective.

IC – INDUSTRY CANADA ICES-001 Compliant

This ISM device complies with Canadian ICES-001.

Cet appareil ISM est conforme à la norme NMB-001 du Canada.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from B Revision (March 2016) to C Revision	Page
• Deleted last sentence in the *Efficiency* section.	13
• Updated *Efficiency versus Power, bq500212AEVM-550 Transmitter and HPA764 Receiver* image.	13
• Updated information in the *Efficiency Improvements* section.	13

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   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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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.

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