

bq500211 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 bq500211EVM evaluation module (EVM) provides all basic functions of a Qi-compliant, wireless charger pad. The EVM is intended to be used with bq51013AEVM-764, -765 or any other Qi-compliant receiver. The transmitter EVM is a 5-V input design which powers a standard WPC low-power 5-W receiver. The bq500211EVM-045 will support bq500211 device.

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1 Applications

The bq500211EVM-045 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 bq500211EVM 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. The board has an installed serial interface connector for more advanced operation. This EVM has the following features.

- Dynamic Power Limiting™ (DPL) allows operation from a 5-V supply with limited current capability (for example, a USB port).
- Transmitter-coil mounting pad providing the correct receiver interface
- Input power is really available 5 V
- Standard WPC A5-type transmitter coil
- LED indicates power transfer or power fault state
- Audio indication of start-of-power transfer though a board-mounted buzzer

2 bq500211EVM-045 Electrical Performance Specifications

[Table 1](#) provides a summary of the bq500211EVM-045 performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. bq500211EVM-045 Electrical Performance Specifications

Parameter		Notes and Conditions	Min	Typ	Max	Unit
Input Characteristics						
V _{IN}	Input voltage		4.90	5.0	5.10	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 bq51013AEVM-764 or 765						
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
η _{pk}	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 data sheet ([SLUSAO2](#)) when changing components. The board is laid out so that a shield can be placed over the active circuit area; Laird Technology BMIS-207 can be used.

Use LED Mode – Resistor R23 to change the behavior of the status LED, D4. The standard value is 42.2 kΩ for control option 1, see the data sheet for additional settings.

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

EMI Shield – The board is laid out so that a shield can be placed over the active circuit area, Laird Technology BMIS-207 can be used

4 Connector and Test Point Descriptions

4.1 Input/Output Connections

The connection points are described in the following paragraphs.

4.1.1 J1 – V_{IN}

Input power 5 V $\pm$ 100 mV, return at J2.

4.1.2 J2 – GND

Return for input power, input at J1.

4.1.3 J3 –JTAG

Factory use only

4.1.4 J4 – Serial Interface

Factory use only

4.1.5 JP2 – LED Mode

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

4.1.6 JP4 – Select for Normal or Power Limiting

Shorting this header enables the Dynamic Power Limiting feature and the input current is limited to 500 mA. With this connector open, operation is normal, there is no restriction on input power.

4.1.7 JP3 – PMOD Enable (Future Use)

Not used for the bq500211 device, should be open.

4.1.8 JP1 – NTC

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

4.2 Test Point Descriptions

The test points are described in the following paragraphs.

4.2.1 TP1 – Coil Drive Q1 / Q2

H-Bridge drive signal.

4.2.2 TP2 – Coil Monitor L / C

Coil signal at junction between coil and capacitors.

4.2.3 TP3 – PWR GND

Ground for switch circuits.

4.2.4 TP4 – Analog GND

Low-noise GND

4.2.5 TP5 – Analog GND

Low-noise GND

4.2.6 TP6 – Analog GND

Low-noise GND

4.2.7 TP7 – Analog GND

Low-noise GND

4.2.8 TP8 – DC Buzzer Output

The connection point for an external DC buzzer; logic high for 500 ms at the start of power transfer to receiver unit.

4.2.9 TP9 – 3.3-VDC

Voltage for low-power circuits, 3.3-V output from U5, TPS62237, U5.

4.2.10 TP10 - Filtered 3.3 V

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

4.2.11 TP11 – Input voltage

Input voltage from J1.

4.2.12 TP12 – MSP430 3.3 V

Filtered 3.3 V for MSP430, U4.

4.2.13 TP13 – Demodulation Comm 1 Output

Primary communications channel, input to bq500211, U1 from demodulation circuit.

4.2.14 TP14 – Sleep

Output from bq500211, U1 to sleep timer circuit.

4.2.15 TP15 – Coil Drive Q3 and Q4 Side

H-Bridge drive signal Q3 and Q4.

4.2.16 TP16 – DPWM Signal

Digital output signal from bq500211 to H-Bridge drive for Q1 and Q2.

4.2.17 TP17 – DPWM Signal

Digital output signal from bq500211 to H-Bridge drive for Q3 and Q4.

4.2.18 TP18 – Spare Pin

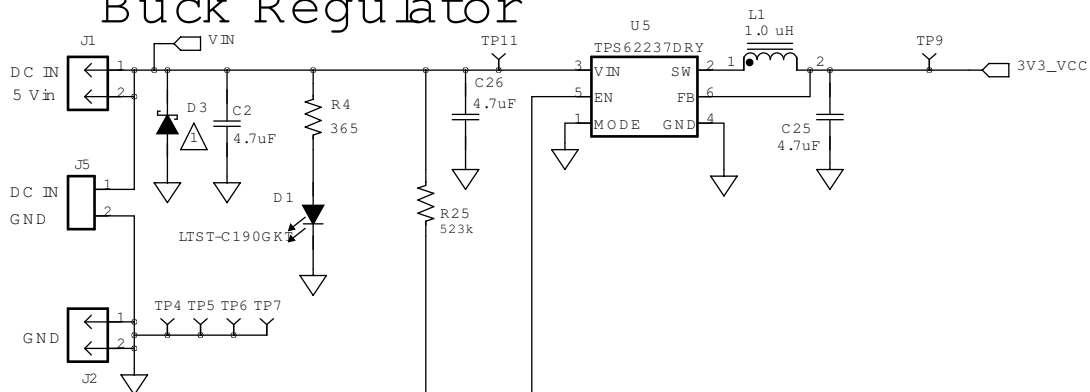
Unused output from bq500211.

4.2.19 TP19 – I_Sense

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

5 Schematic and Bill of Materials

Buck Regulator



Power Train

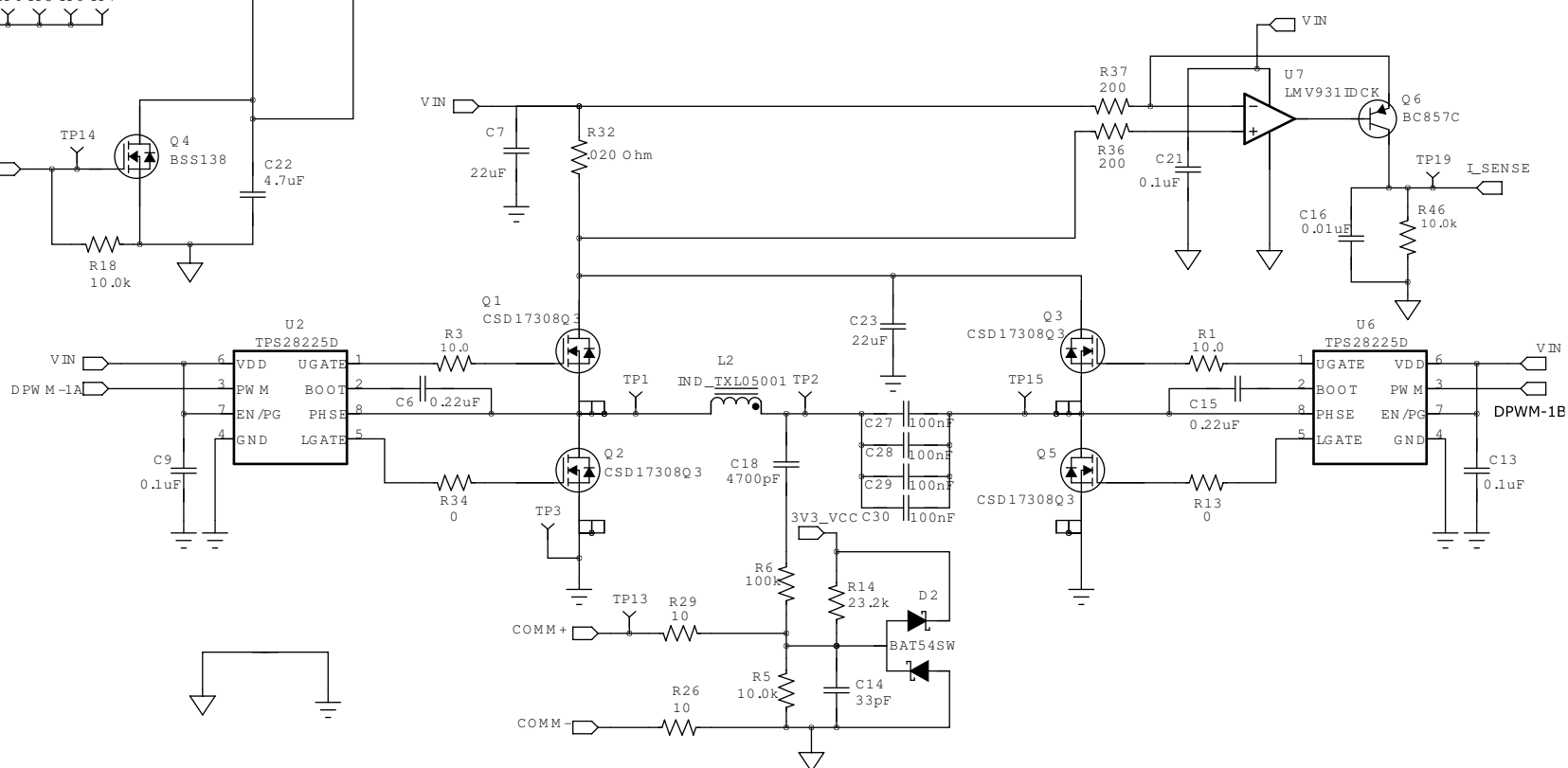


Figure 1. bq500211EVM-045 Schematic, Page 1 of 3

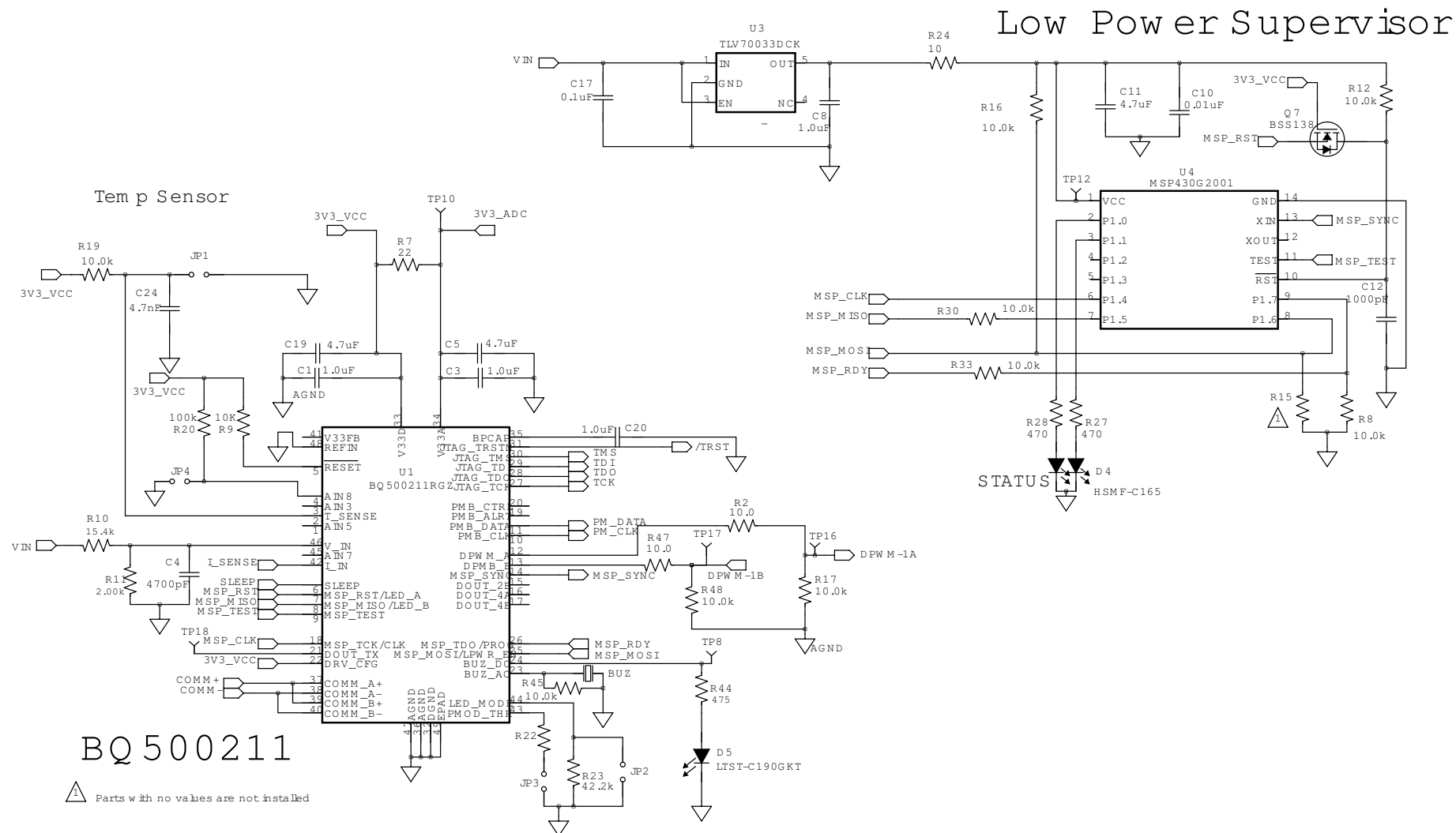


Figure 2. bq500211EVM-045 Schematic, Page 2 of 3

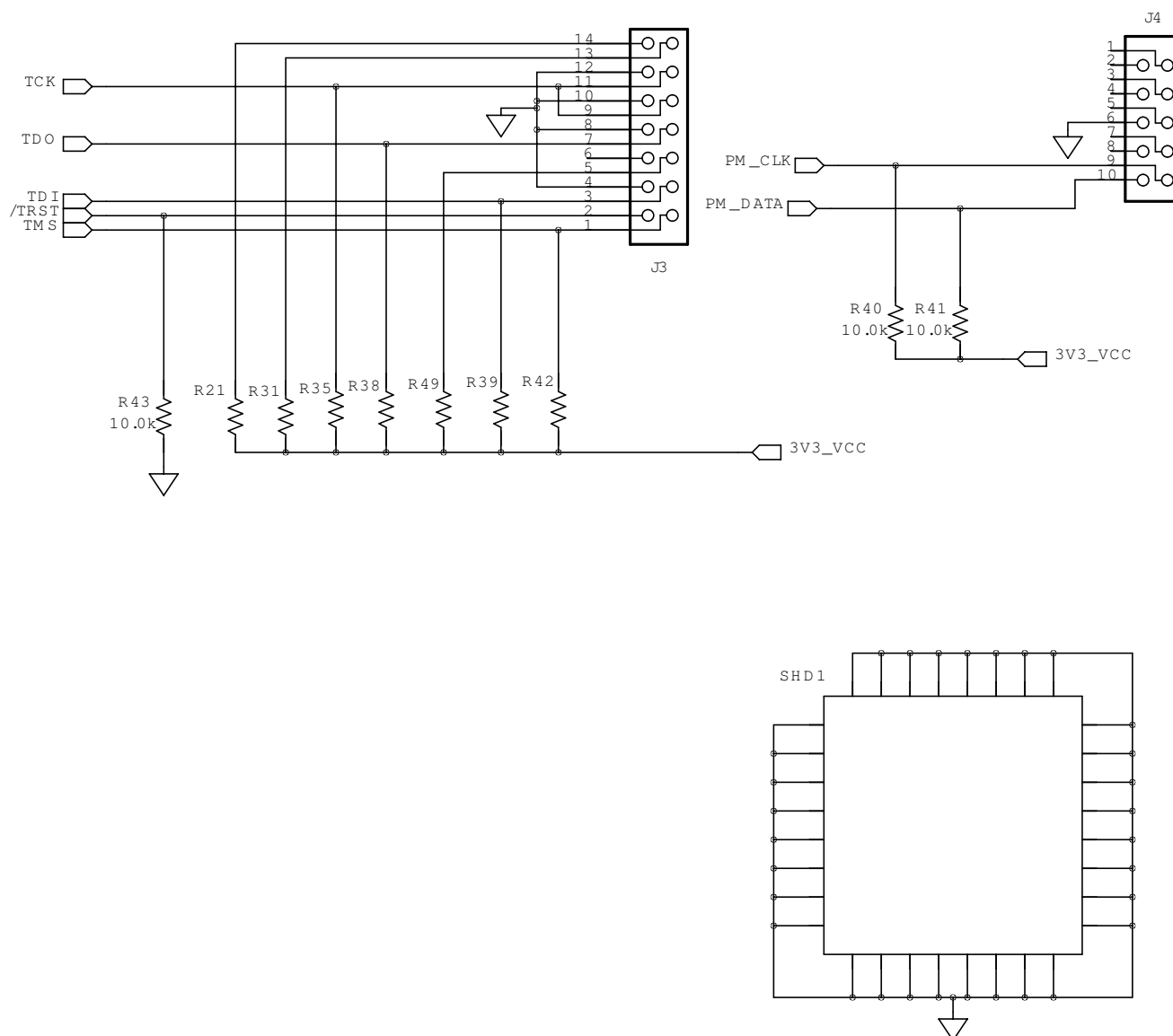


Figure 3. bq500211EVM-045 Schematic, Page 3 of 3

Table 2. Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
1	BUZ	Buzzer	Piezoelectronic, 12 mm	12 mm	PS1240P02CT3	TDK
1	C14	33pF	Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std
1	C12	1000pF	Capacitor, Ceramic, 10V, COG, 5%	0603	Std	Std
2	C4, C18, C24	4700pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
2	C16, C10	0.01uF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
4	C13, C21, C17, C9	0.1uF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
4	C27, C28, C29, C30	100nF	Capacitor, Ceramic, COG, 50V, 5%	1812	C4532COG1H104J	TDK
2	C15, C6	0.22uF	Capacitor, Ceramic, 50V, X7R, 20%	0603	Std	Std
4	C1, C3, C8, C20	1.0uF	Capacitor, Ceramic, 16V, X7R, 20%	0603	Std	Std
7	C22, C25, C5, C11, C19, C26, C2	4.7uF	Capacitor, Ceramic, 10V, X5R, 20%	0603	Std	Std
2	C23, C7	22uF	Capacitor, Ceramic, 25V, X5R, 20%	1210	Std	Std
2	D1, D5	LTST-C190GKT	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	0603	LTST-C190GKT	Lite On
1	D2	BAT54SW	Diode, Dual Schottky, 200mA, 30V	SOT523	BAT54SWT1G	On Semi
0	D3	Open	Diode, Schottky, 0.5A, 30V	SOD-123	MMSZ5251BT1G	On Semi
1	D4	HSMF-C165	Diode, Bi-Color LED, [GRN/RED] 20mA, 52 mW Max.	0603	HSMF-C165	Avago
1	L1	1.0 uH	Inductor, SMT, 800 mA, ±20%	0805	LQM21PN1R0MC0	Murata
	Alternate L1	1.0 uH	Inductor, SMT, 800 mA, ±20%	0805	74479775210	Würth
1	L2	6.3 uH	Inductor, WPC TX Coil	53 × 53 mm	TXL05001A (or B)	Mingstar
	Alternate L2	6.3 uH	Inductor, WPC TX Coil	52 X 53 mm	760-308-105	Würth
4	Q1, Q2, Q3, Q5	CSD17308Q3	MOSFET, NChan, 30V, 13A, 9.4 milliOhm	QFN3.3x3.3 mm	CSD17308Q3	TI
2	Q4, Q7	BSS138	MOSFET, Nch, 50V, 0.22A, 3.5 Ohm	SOT23	BSS138	Fairchild
1	Q6	BC857C	Trans, P-Chan GP, 65V, 100mA,	SOT-23	BC857	Philips
1	R10	15.4k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R11	2.00k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R13, R34	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R32	0.020 Ohm	Resistor, Chip, 1/4W, 1%, 200ppm	0805	ERJ-6BWFR020V	Panasonic
6	R1-3, R24, R26, R29	10	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R7	22	Resistor, Chip, 1/10W, 1%	0805	Std	Std
2	R36, R37	200	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R4	365	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R27, R28	470	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R38	475	Resistor, Chip, 1/16W, 1%	0603	Std	Std

Table 2. Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
15	R5, R8, R9, R12, R16-19, R30, R31, R33, R35, R39, R40, R43	10.0k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R14	23.2k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R23	42.2k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R6, R20	100k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R20	100k	Resistor, Chip, 1/16W, 1%	0402	Std	Std
1	R25	523k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R15, R22, R21, R31, R35, R49, R39, R42	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	U1	BQ500211RGZ	IC, Qi Compliant Wireless Power Transmitter Manager	7X7 QFN	BQ500211RGZ (R/T)	TI
2	U2 U6	TPS28225D	IC, High Frequency 4-Amp Sink Synchronous Buck MOSFET Driver	SO8	TPS28225D	TI
1	U4	MSP430G2001	IC, Mixed Signal Microcontroller	TSSOP	MSP430G2001IPW14	TI
1	U5	TPS62237DRY	IC, 3MHz Ultra Small Step Down Converter, 3.3 V	USON	TPS62237DRY	TI
1	U7	LMV931IDCK	IC, Single Op-Amp R-R In/Out put	SC-70	LMV931IDCK	TI
1	U8	TLV70033DCK	IC, 150mA, Low IQ, LDO Regulator	SOT	TLV70033DCK	TI
0	SHD1	Open	Shield, Copper	44.4x44.4 mm	BMI-S-207-F	Laird Tech

6 Test Setup

6.1 Equipment

6.1.1 bqTESLA™ Receiver

Use the bq51013AEVM-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.

6.1.3 Meters

Monitor the output voltage at the bq51013AEVM-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 bq51013AEVM-764 TP3 and other signals.

6.1.6 Recommended Wire Gauge

For proper operation, use 22-AWG wire when connecting the bq500211EVM-045 to the input supply and the bq51013AEVM-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.

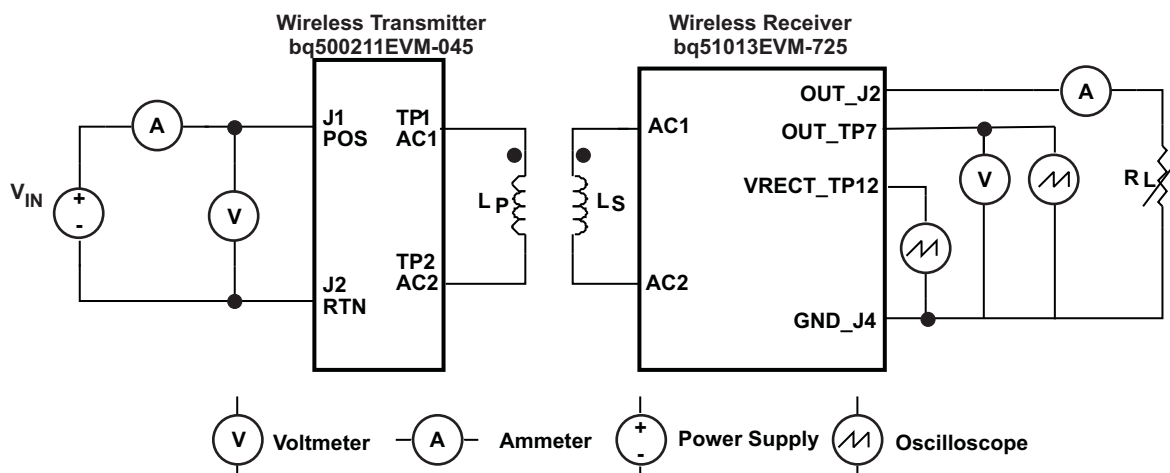


Figure 4. Equipment Setup

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 green power LED, D1, illuminates. Status LED D5 is off until the power transfer starts.

Apply the scope probe to the test point, TP1, and observe single-pulse bursts approximately every 400 ms. This is an analog ping probing environment for the presence of a receiver placed on the TX coil.

6.2.2.2 Apply Receivers

Place the bq51013AEVM-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 buzzer sounds at the start of power transfer. The status LED, D4, 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.

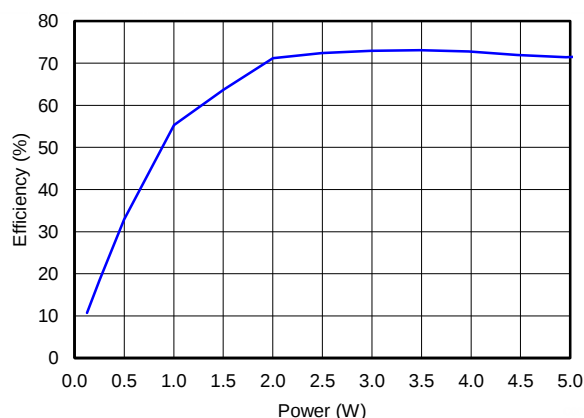


Figure 5. Efficiency versus Power, bq500211EVM-045 Transmitter and HPA764 Receiver

6.2.2.4 Dynamic Power Limiting™

Dynamic Power Limiting™ (DPL) allows operation from a 5-V supply with limited current capability. DPL is controlled by JP4, which pulls U1 pin 4 high or low. With the jumper open (pin 4 High) the IC monitors input voltage and when that voltage is observed drooping, the output power is limited to reduce the load and provide some operating margin relative to the supply's capability. With a shorting jumper installed (pin 4 Low), the IC restricts output power such that the input current remains below 500 mA, compatible with a USB port. See the data sheet for additional information on the DPL function

6.2.2.5 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.

7 bq500211EVM-045 Assembly Drawings and Layout

Figure 6 through Figure 11 show the design of the bq500211EVM PCB. The EVM has been designed using a 4-layer, 2-oz, copper-clad circuit board 13.2 cm $\times$ 7.24 cm with all components in a 4.5-cm $\times$ 4.5-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 bq500211 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 bq500211 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 is 0.93 in, or 2.4 mm is the z-gap thickness for the transmitter.

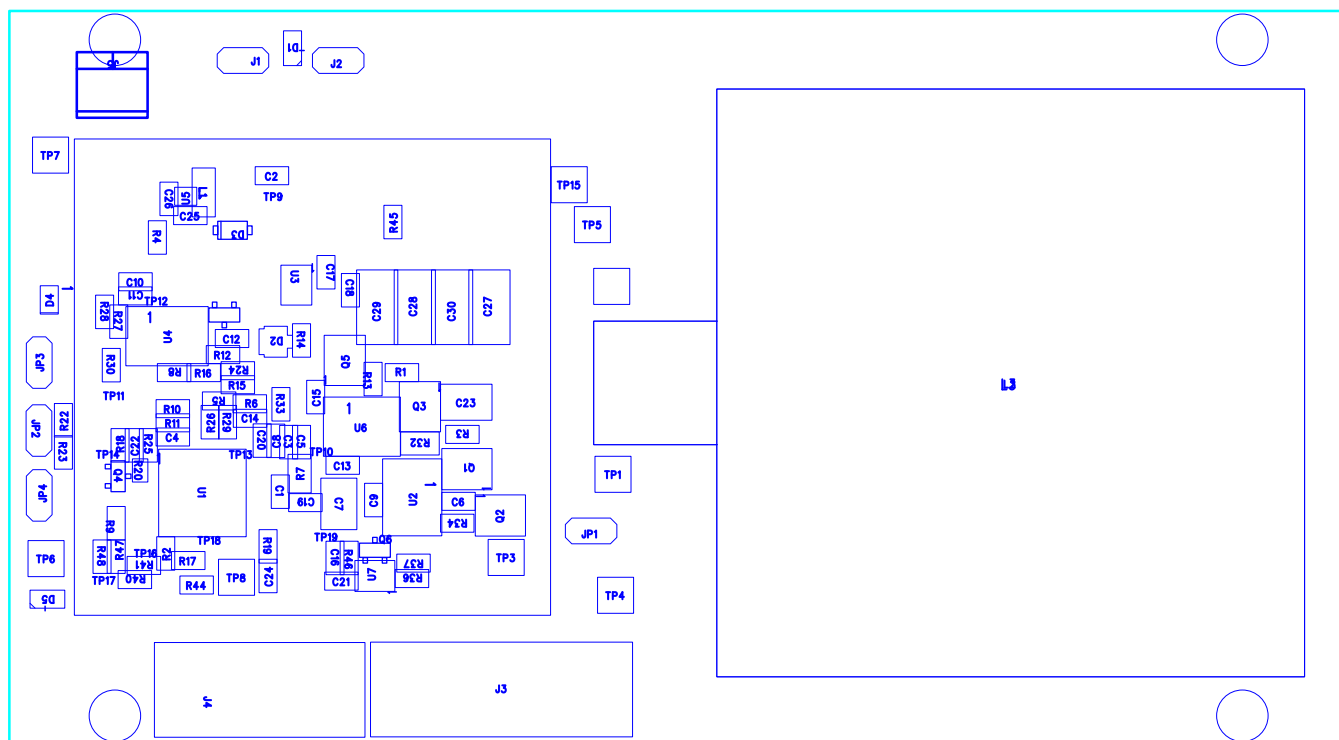


Figure 6. Assembly Top

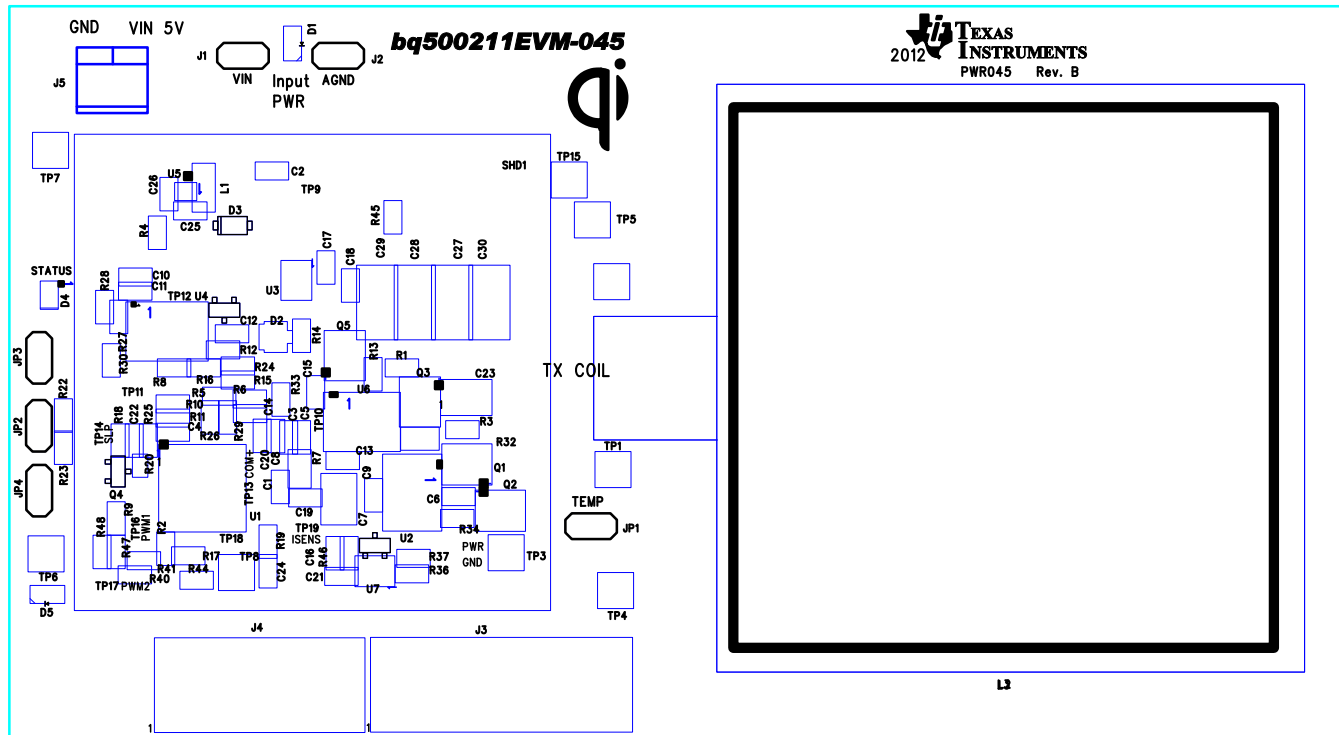


Figure 7. Top Silk

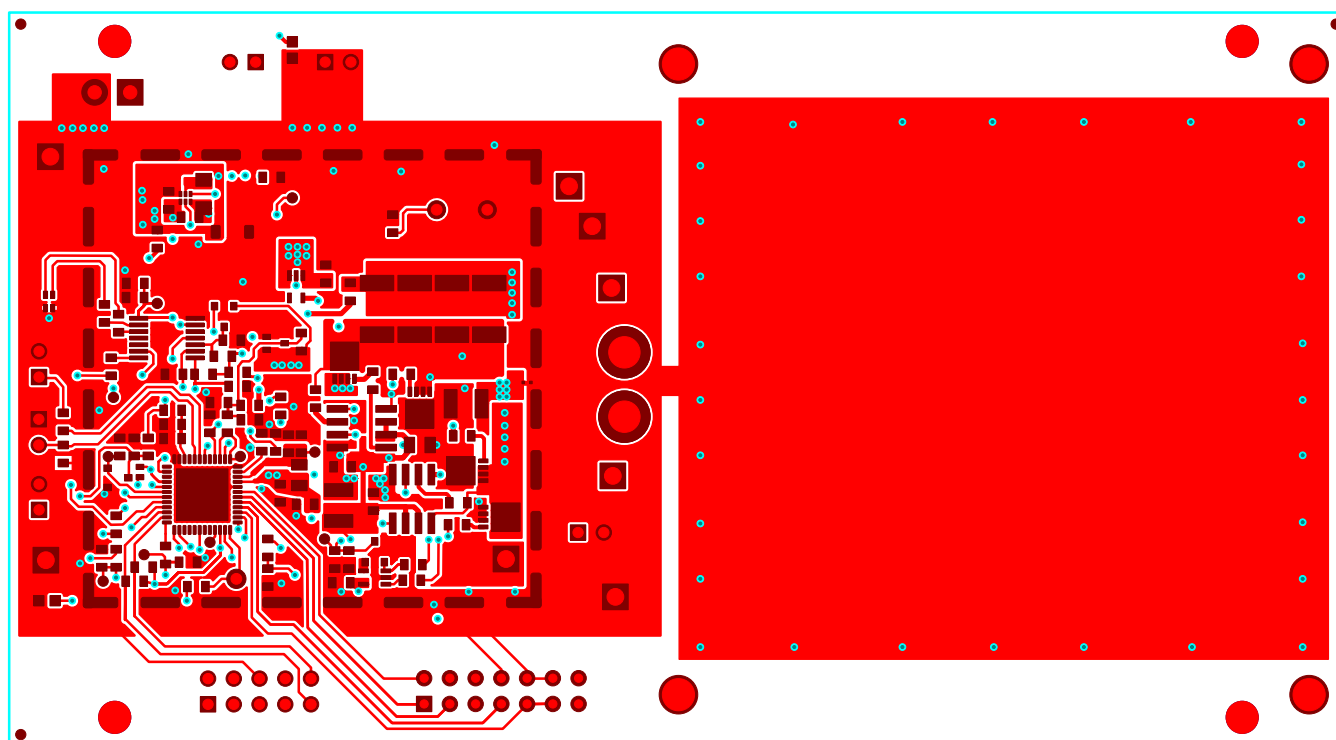


Figure 8. Top Layer

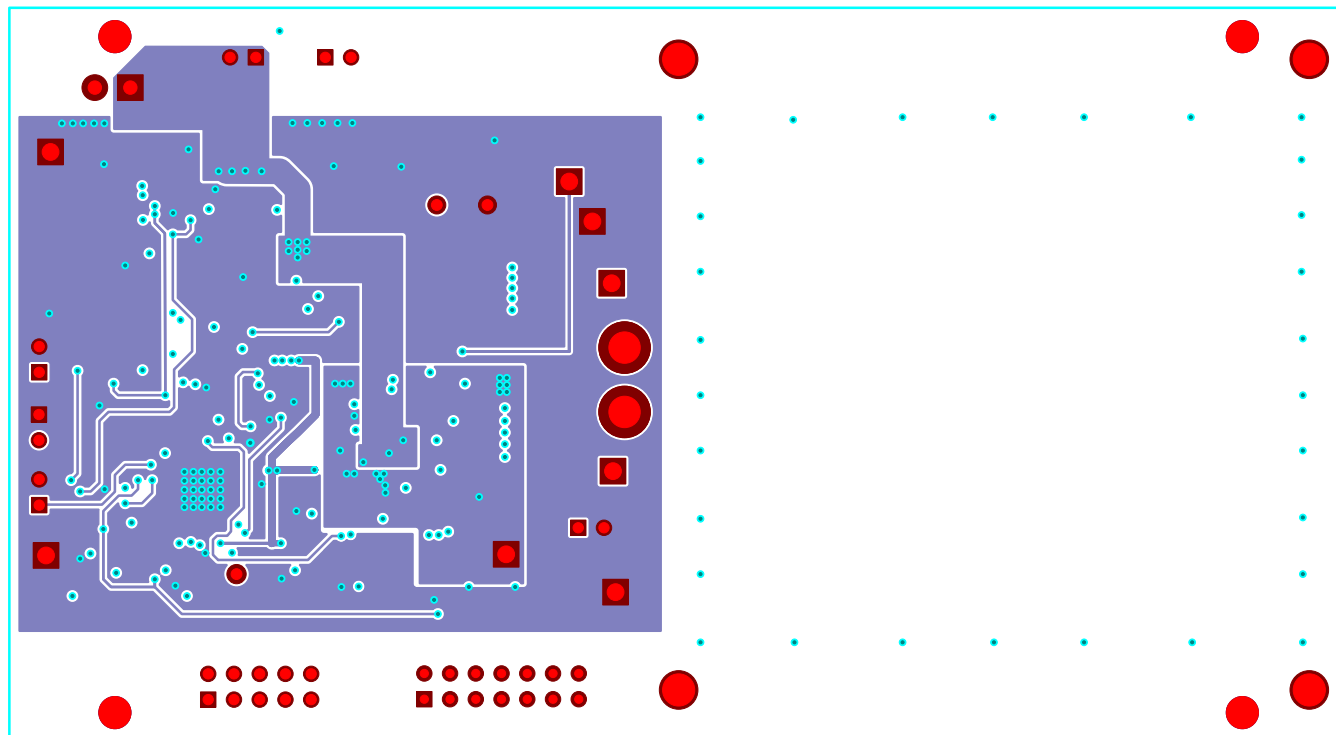


Figure 9. Layer 2

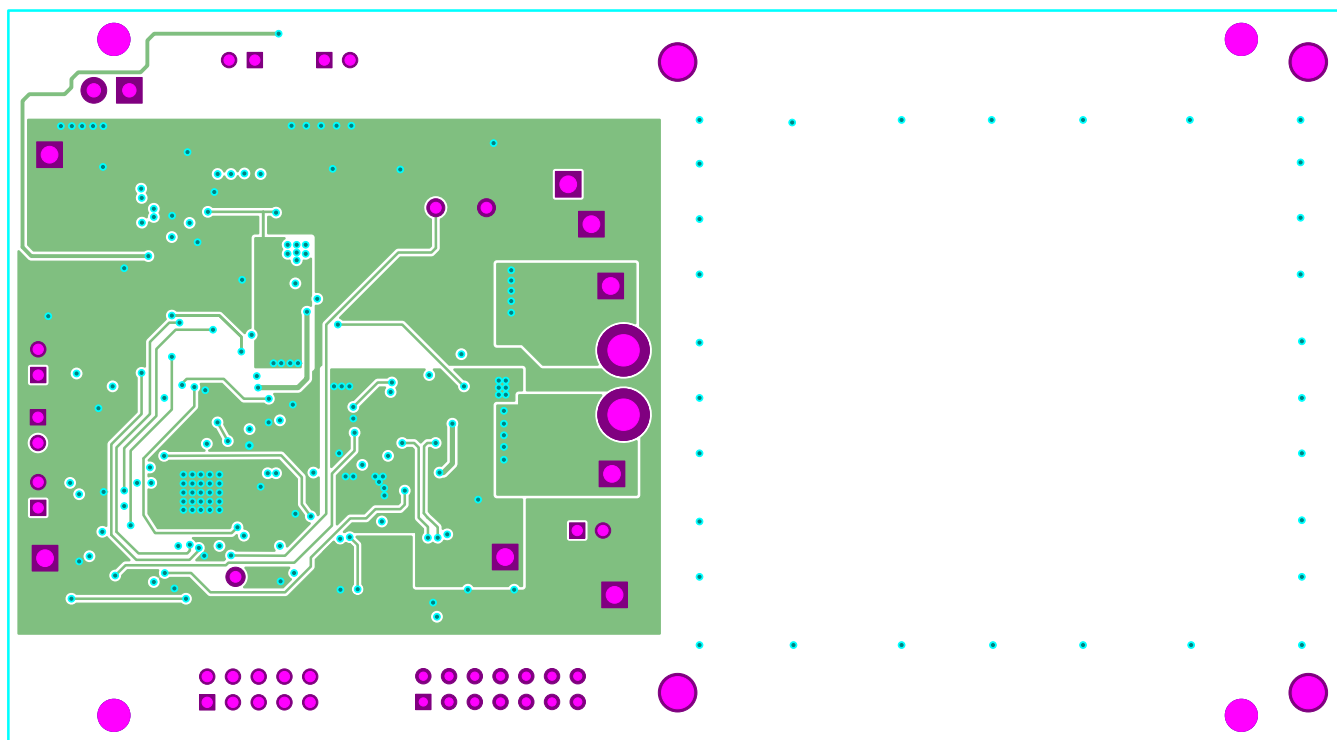


Figure 10. Layer 3

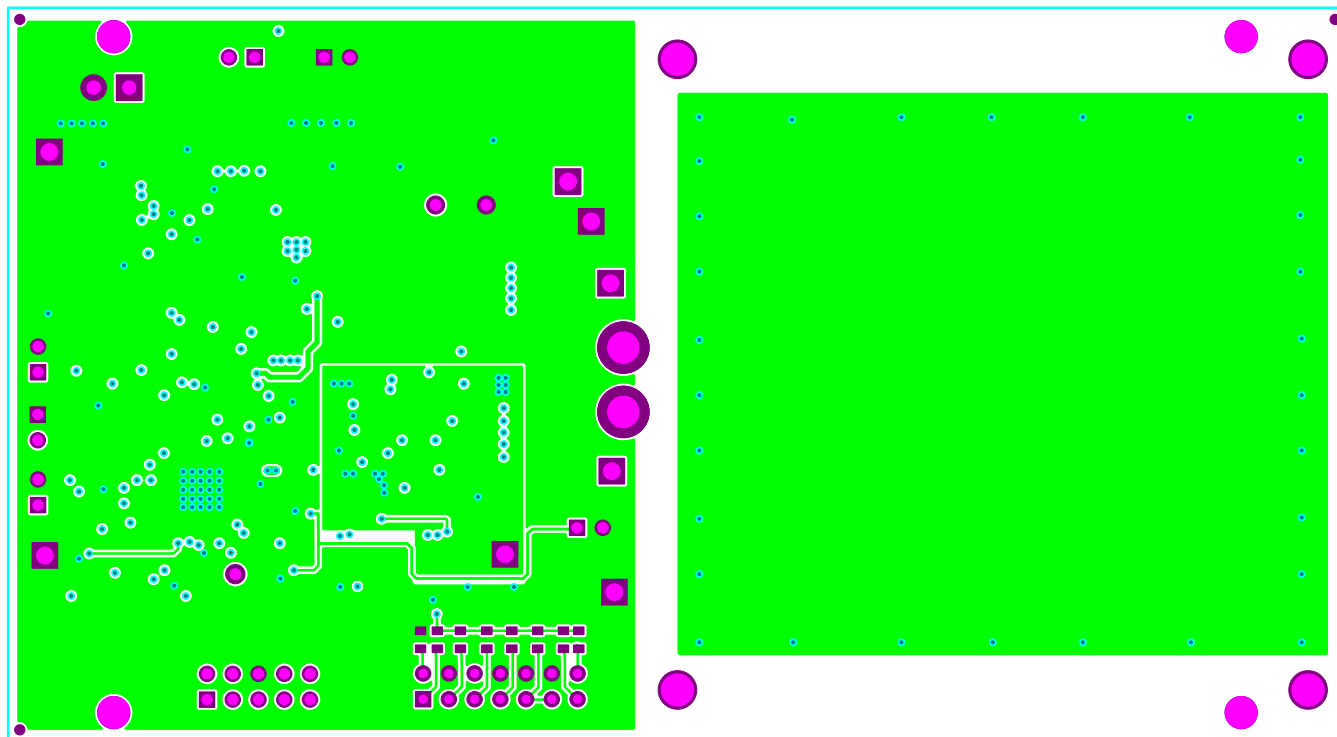


Figure 11. Bottom Layer

8 Reference

For additional information about the bq500211EVM-045 low-power, wireless, power evaluation kit from Texas Instruments, visit the product folder on the TI Web site at <http://focus.ti.com/docs/toolsw/folders/print/bq500211.html>.

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 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.

European Union CE Mark

This ISM device complies with Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC – the **EMC Directive**, tested to **EN55011: 2007, Industrial Scientific and Medical (ISM) radio-frequency equipment**.

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.

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