

bqTESLA Wireless Power Transmitter Manager EVM

The bqTESLA™ wireless power evaluation kit from Texas Instruments is a high-performance, easy-to-use development kit for the design of wireless power solutions. Consisting of a single-channel transmitter and power supply side receiver and associated magnetics, the kit enables designers to speed the development of their end-applications. The bq500210EVM evaluation module (EVM) provides all basic functions of WPC 1.0-compliant wireless charger pad. The EVM is intended to be used with bq51013EVM or any other WPC 1.0-compliant receiver.

Contents

1	Applications	2
2	bq500210EVM-689 Electrical Performance Specifications	2
3	Modifications	2
4	Connector and Test Point Descriptions	2
	4.1 Input/Output Connections	2
	4.2 Jumpers/Switches	3
	4.3 Test Point Descriptions	3
5	Schematic and Bill of Materials	5
6	Test Setup	10
	6.1 Equipment	10
	6.2 Equipment Setup	10
7	bq500210EVM-689 Assembly Drawings and Layout	12
8	Reference	16

List of Figures

1	HPA689EVM Schematic (Page 1 of 3).....	5
2	HPA689EVM Schematic (Page 2 of 3).....	6
3	HPA689EVM Schematic (Page 3 of 3).....	7
4	Equipment Setup	11
5	Efficiency v Power, HPA689 Transmitter and HPA725 Reciver.....	12
6	Assembly Top.....	13
7	Top Silk	13
8	Top Layer.....	14
9	Layer 2.....	14
10	Layer 3.....	15
11	Bottom Layer.....	15

List of Tables

1	bq500210EVM-688 Electrical Performance Specifications.....	2
2	Bill of Materials	8

1 Applications

The bq500210EVM-689 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 bq500210EVM requires single 19-V at 0.5 A power supply to operate and combines on the single printed-circuit board the transmitter electronics, input power socket, LED indicators, and the transmitting coil. The open design allows easy access to key points of the electrical schematic. The board has installed connectors for optional JTAG and serial interfaces that can be helpful to advanced users. This EVM has the following features.

- WPC-certified transmitter
- Transmitter mounting pad to provide correct receiver interface
- Receiver output voltage of 5 V up to 1 A
- Standard A1-type transmitter coil
- LED indicates power transfer state and buzzer indicates start of power transfer.

2 bq500210EVM-689 Electrical Performance Specifications

Table 1 provides a summary of the bq500210EVM-689 performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. bq500210EVM-688 Electrical Performance Specifications

Parameter		Notes and Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
V_{IN}	Input Voltage		18.5	19	19.5	V
I_{IN}	Input Current	$V_{IN} = \text{Nom}$, $I_{OUT} = \text{Max}$		0.3	0.5	A
	Input No Load Current	$V_{IN} = \text{Nom}$, $I_{OUT} = 0 \text{ A}$		20	50	mA
OUTPUT CHARACTERISTICS						
V_{OUT}	Output Voltage	$V_{IN} = \text{Nom}$, $I_{OUT} = \text{Nom}$	4.5	5	5.1	V
	Output Ripple	$V_{IN} = \text{Nom}$, $I_{OUT} = \text{Max}$			<u>200</u>	mV _{pp}
I_{OUT}	$V_{IN} = \text{Min to Max}$	$V_{IN} = \text{Min to Max}$	0		1	A
	Output Over Current	$V_{IN} = \text{Nom}$, $V_{OUT} = V_{OUT1} - 5\%$	1		1.1	A
SYSTEMS CHARACTERISTICS						
F_s	Switching Frequency		110	<u>145</u>	200	kHz
η_{pk}	Peak Efficiency	$V_{IN} = \text{Nom}$; Porx = 2.5		72%		
η	Full-Load Efficiency	$V_{IN} = \text{Nom}$, $I_{OUT} = \text{Max}$		70%		

3 Modifications

See the data sheet ([SLUSAL8](#)) 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.

4 Connector and Test Point Descriptions

4.1 Input/Output Connections

The connection points are described in the following paragraphs.

4.1.1 J1 – Vin

Input power 19 V ±500 mV; connected to J2 also.

4.1.2 J2 – GND

Input power return for input power; connected to J2 also.

4.1.3 J3 – I2C interface

Factory use only

4.1.4 J4 – JTAG (Not Installed)

Factory use only

4.1.5 J5 – Metal Object Detection Threshold

Connection point for external resistor to set trip point for Metal Object Detection. See the bq500210 data sheet for more information ([SLUSAL8](#)).

4.1.6 J6 – Select LED Mode

Connection point for external resistor to select LED mode. See the bq500210 data sheet for more information.

4.1.7 J7 – Vin

Input power 19 V \pm 500 mV; connected to J2 also.

4.1.8 JP1 – NTC

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

4.2 Jumpers/Switches

The control jumpers are described in the following paragraphs.

4.2.1 R23 – LED Scheme

LED indication scheme set resistor; default 42.2 k Ω . For a detailed function description, see the bq500210 data sheet

4.2.2 R51 – MOD-THR

MOD threshold set resistor; default 100 k Ω . For a detailed function description, see the bq500210 data sheet.

4.3 Test Point Descriptions

The test points are described in the following paragraphs.

4.3.1 TP1 – Coil Monitor 1

Test point for measuring ac voltage applied to TX coil.

4.3.2 TP2 – Coil Monitor 2

Test point for measuring ac voltage applied to TX coil.

4.3.3 TP3 – PWR GND

Ground for Switch circuits.

4.3.4 TP4 – Analog GND

Low noise GND

4.3.5 TP5 – Analog GND

Low noise GND

4.3.6 TP6 – Analog GND

Low noise GND

4.3.7 TP7 – Analog GND

Low noise GND

4.3.8 TP8 – DC Buzzer Output

Connection point for external dc buzzer; logic high for 500 ms at start of power transfer to receiver unit.

4.3.9 TP9 – 3.3V Input DC Current

3.3V output from U5 used for low power circuit.

4.3.10 TP10 - Filtered 3.3V

3.3V output with additional filtering for A to D convereters.

4.3.11 TP11 – Gate Drive Voltage

Input voltage to U2, gate driver for power switches.

4.3.12 TP12 – MSP430 3.3V

Filtered 3.3V for MSP430, U4.

4.3.13 TP13 – Demodulation Comm 1 Output

Primary communications channel, input to bq500210 from demodulation circuit.

4.3.14 TP14 – Sleep

Output from bq500210 to 500 ms timer circuit.

5 Schematic and Bill of Materials

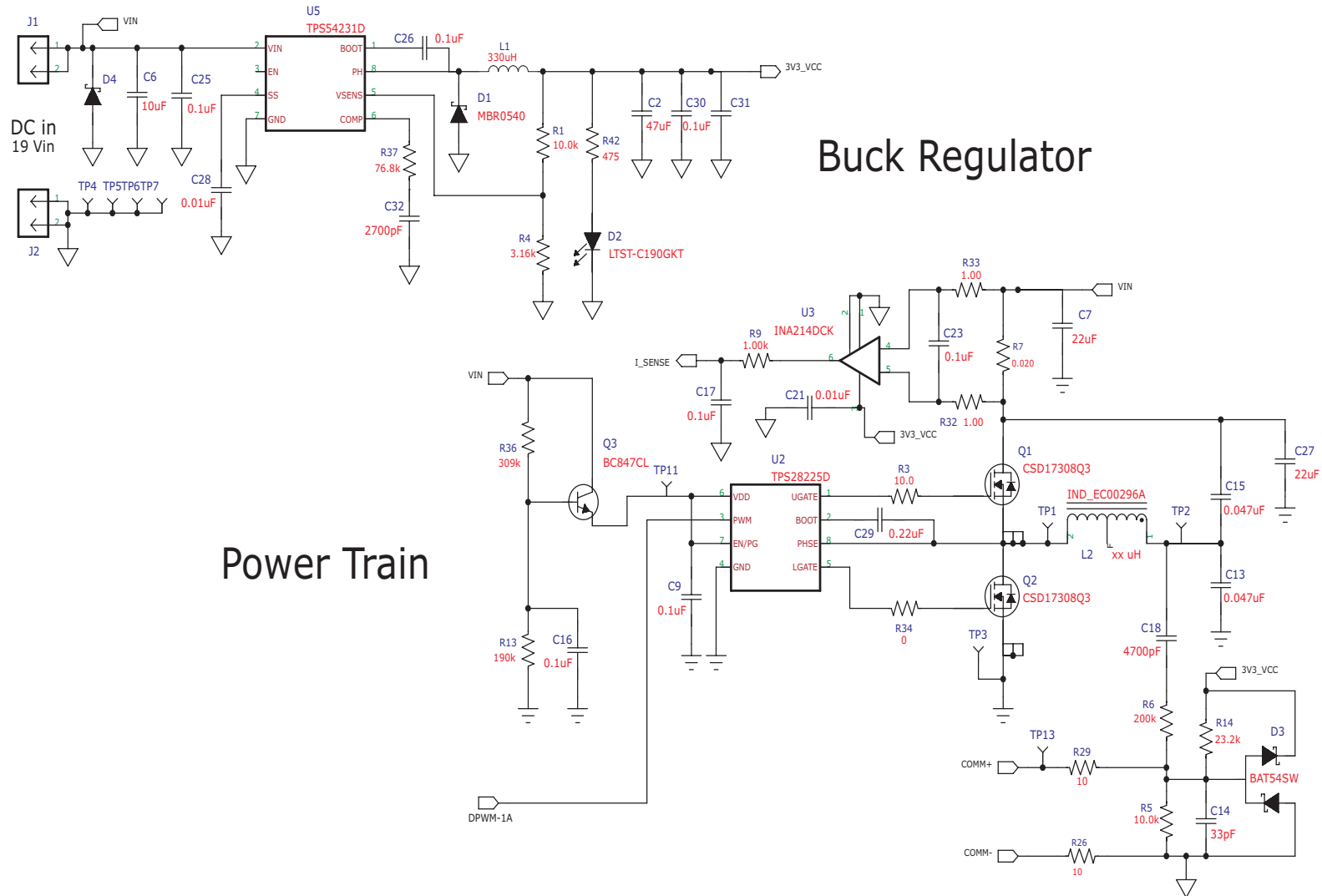
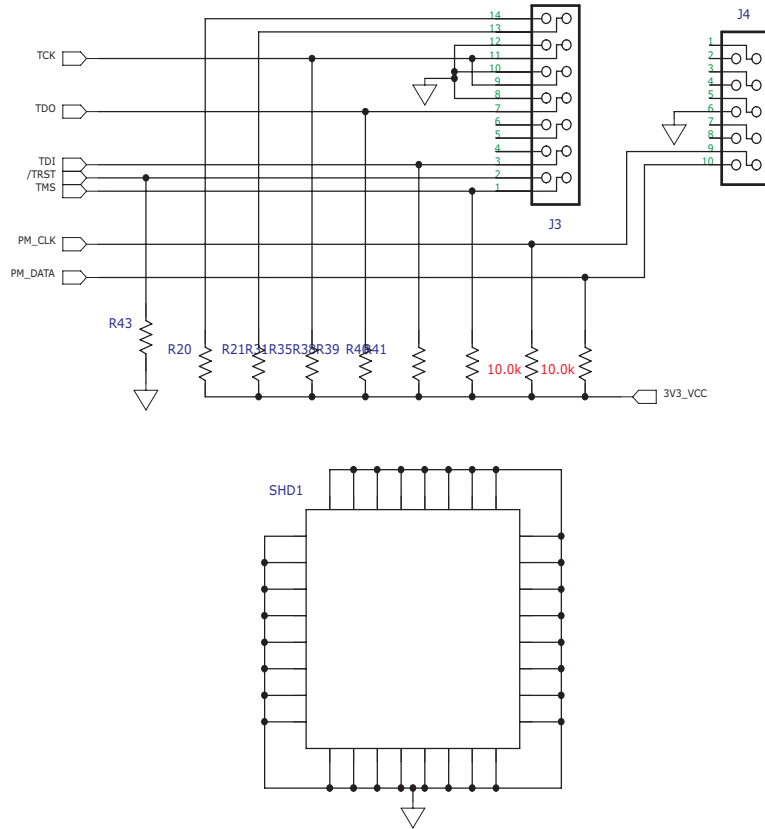


Figure 1. HPA689EVM Schematic (Page 1 of 3)

I2C and JTAG Connector--Factory Use Only



EMI Shield

Low Power Supervisor

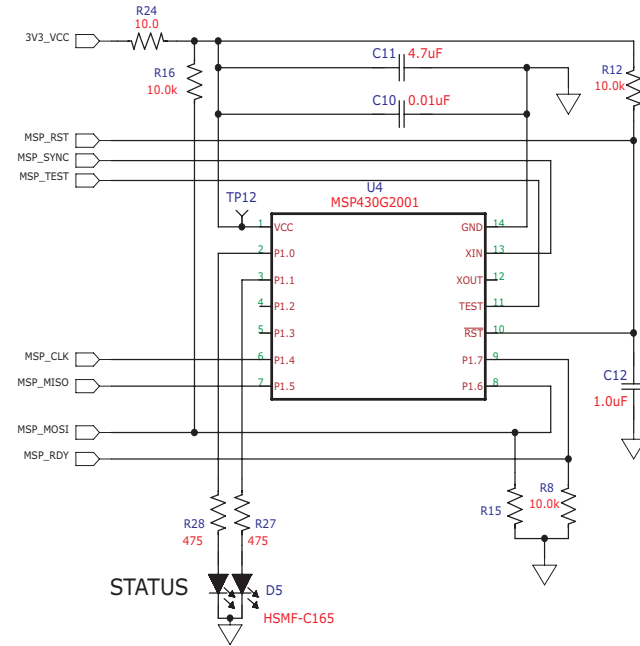


Figure 3. HPA689EVM Schematic (Page 3 of 3)

Table 2. Bill of Materials

COUNT	RefDes	Value	Description	Size	Part Number	MFR
1	BUZ	Buzzer	Piezoelectronic, 12 mm	12 mm	PS1240P02CT3	TDK
4	C1 C3 C12 C20	1.0uF	Capacitor, Ceramic, 16V, X7R, 20%	0603	STD	STD
4	C5 C11 C19 C22	4.7uF	Capacitor, Ceramic, 10V, X7R, 20%	0603	STD	STD
1	C14	33pF	Capacitor, Ceramic, 50V, C0G, 5%	0603	STD	STD
2	C15 C13	0.047uF	Capacitor, Ceramic, 100V, C0G, 5%	1210	Std	STD
7	C17 C9 C23 C16 C25-26 C30	0.1uF	Capacitor, Ceramic, 50V, X7R, 10%	0603	STD	STD
1	C2	47uF	Capacitor, Ceramic, 6.3V, X5R, 20%	1206	STD	STD
1	C29	0.22uF	Capacitor, Ceramic, 50V, X7R, 20%	0603	STD	STD
0	C31	Open	Capacitor, Ceramic,	1206	STD	STD
1	C32	2700pF	Capacitor, Ceramic, 50V, C0G, 5%	0603	STD	STD
3	C4 C18 C24	4700pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	STD	STD
1	C6	10uF	Capacitor, Ceramic, 35V, X5R, 20%	1206	STD	STD
2	C7 C27	22uF	Capacitor, Ceramic, 25V, X5R, 20%	1210	Std	STD
4	C8 C10 C21 C28	0.01uF	Capacitor, Ceramic, 50V, X7R, 10%	0603	STD	STD
1	D1	MBR0540	Diode, Schottky, 0.5A, 40V	SOD-123	MBR0540T1G	On Semi
2	D2 D6	LTST-C190GKT	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	0603	LTST-C190GKT	Lite On
1	D3	BAT54SW	Diode, Dual Schottky, 200mA, 30V	SOT523	BAT54SWT1G	On Semi
0	D4	Open	Diode, Schottky, 0.5A, 30V	SOD-123	MMSZ5251BT1G	On Semi
1	D5	HSMF-C165	Diode, Bi-Color LED, [GRN/RED] 20mA, 52 mW Max.	0603	HSMF-C165	Avago
1	L1	330uH	Inductor, SMT, 155mA, 1.8ohm	0.189 x 0.189 inch	LPS5030-334MLB	Coilcraft
1	L2	TX Coil	WPC Compliant TX Coil Set with Ferrite Shield	See note 1	EC00296A	Elytone
		TX Coil	WPC Compliant TX Coil Set with Ferrite Shield		Y31-60014F	E & E Magnetic
		TX Coil	WPC Compliant TX Coil Set with Ferrite Shield		X1387	Toko
2	Q1-2	CSD17308Q3	MOSFET, NChan, 30V, 13A, 9.4 milliOhm	QFN3.3x3.3 mm	CSD17308Q3	TI
1	Q3	BC847CL	TRANSISTOR, NPN, HIGH-PERFORMANCE, 500mA	SOT-23	BC847CLT1G	ON Semi
1	Q4	BSS138	MOSFET, Nch, 50V, 0.22A, 3.5 Ohm	SOT23	BSS138	Fairchild
10	R1 R5 R8 R12 R16-18 R40 R41 R45	10.0k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
5	R2, R3, R24, R26, R29	10	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R4	3.16k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R6	200k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R7	0.02	Resistor, Chip, 1/10W, 1%	0805	Std	Std

Table 2. Bill of Materials (continued)

COUNT	RefDes	Value	Description	Size	Part Number	MFR
1	R9	1.00k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R10	15.4k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R11 R19	2.00k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R13	191k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R14	23.2k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R15 R20-21 R31 R35 R38 R39 R43	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R22	100k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R23	42.2k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
3	R28 R27 R42 R44	475	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R30	22	Resistor, Chip, 1/10W, 1%	0805	Std	Std
2	R32-33	1	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R34	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R25	280k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R36	309k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R37	76.8k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	SHD1	Open	Shield, Copper	44.4x44.4 mm	BMI-S-207-F	Laird Tech
1	U1	BQ500210RGZ	IC, Qi Compliant Wireless Power Transmitter Manager	VQFN	BQ500210RGZ	TI
1	U2	TPS28225D	IC, High Frequency 4-Amp Sink Synchronous Buck MOSFET Driver	SO8	TPS28225D	TI
1	U3	INA214DCK	IC, Voltage Output, High or Low Side Measurement, Bi-Directional Zero-Drift Series	SC-70	INA214AIDCKT	TI
1	U4	MSP430G2001	IC, Mixed Signal Microcontroller	TSSOP	MSP430G2001IPW 14	TI
1	U5	TPS54231D	IC, 2A, 28V Input, Step Down Swift DC/DC Converter W/ eco-Mode	SO8	TPS54231D	TI
Notes:	1A. Elytone Electronics Co., Ltd.: Sales Exec Annie Jya Tel (Taiwan) : www.elytone.com.tw 1B. E&E Magnetic Products, Ltd.: www.eleceltek.com 1C. TOKO: www.tokoam.com					

6 Test Setup

6.1 Equipment

6.1.1 bqTESLA™ Receiver

Use bq51013EVM-725 (BQ51013EVM) or WPC Gen 1.0-compliant receiver to work with this EVM.

6.1.2 Voltage Source

Input voltage source must provide regulated dc voltage of 19 V and be able to deliver at least 0.5-A continuous load current, current limit should be set to 1A.

6.1.3 Meters

Output voltage can be monitor at bq51013EVM-725 TP7 with a voltmeter. Input current into the load must be monitored with an appropriate ammeter. Transmitter input current and voltage can be monitored also, but the meter must use averaging function for reducing error due to communications packets.

6.1.4 Loads

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

6.1.5 Oscilloscope

A dual-channel oscilloscope with appropriate probes is used to observe the COMM_DRV signal at bq51013EVM-725 TP3 and other signals. .

6.1.6 Recommended Wire Gauge

For proper operation, 22 AWG wire is recommended when connecting the bq500210EVM-689 to input supply and bq51013EVM-725 to load.

6.2 Equipment Setup

- With power supply OFF, connect supply to bqTESLA™ transmitter.
- Connect Vin positive power source to J1 and negative terminal of the Vin source connected to J2.
- Do not place bqTESLA™ receiver on transmitter. Connect load to J3 with return to J4, monitor current through load with ammeter, and monitor current to 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.

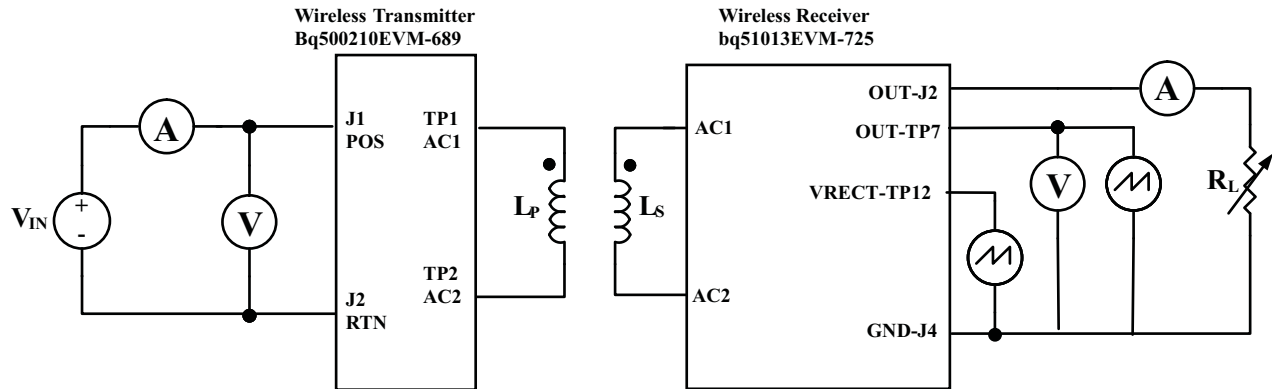


Figure 4. Equipment Setup

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 RX

Turn on V_{IN} , and observe that the Green Power LED D2 illuminates. Status LED D5 will be off until power transfer starts.

Apply the scope probe to the test point TP1 and observe a single pulse bursts approximately every 0.5 s. This is Analog Ping probing environment for the presence of a receiver placed on the Tx coil.

6.2.2.2 APPLY RX

Place bq51013EVM-725 EVM on the top of the transmitting coil. Align centers of the receiving and transmitting coils across each other. In the next few seconds, observe Status LED D5 illuminates green, indicating that communication between transmitter and receiver is established and power transfer has began.

- Buzzer will sound at the start of power transfer. Status LED D5 flashes green light during power transfer.
- Typical output voltage is 5 V, and the output current range is 0 mA to 1A.
- Observe continuous sine-wave on the test point TP1 when power transfer is active, frequency will be between 110kHz and 205kHz.
- Make tests and measurements applicable to a normal 5V 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. It is recommended to average the input current, the comm pulses will modulate the input current distorting the reading. See [Figure 5](#) for efficiency.

6.2.2.4 PARASITIC METAL OBJECT DETECTION

To test the Metal Object Detection (MOD) function. In addition to loading on the output of bq51013EVM-725, apply an electronic load in constant power mode between secondary GND (J4) and TP12 – the output of the secondary side rectifier. Increasing load power from 0 W to over 0.5 W, observe LED D5 of bq500210EVM turning red and the power transfer stopped in approximately 20 s after the MOD threshold was exceeded.

6.2.2.5 THERMAL PROTECTION, NTC

Thermal protection is provided by an NTC resistor connected to JP1. At 1.00V on the sense side (U1-2) thermal fault will be set and unit is shutdown, Status LED D5 will illuminate red. Typical resistor value for fault is 850 ohms. System will try to restart in 5 minutes.

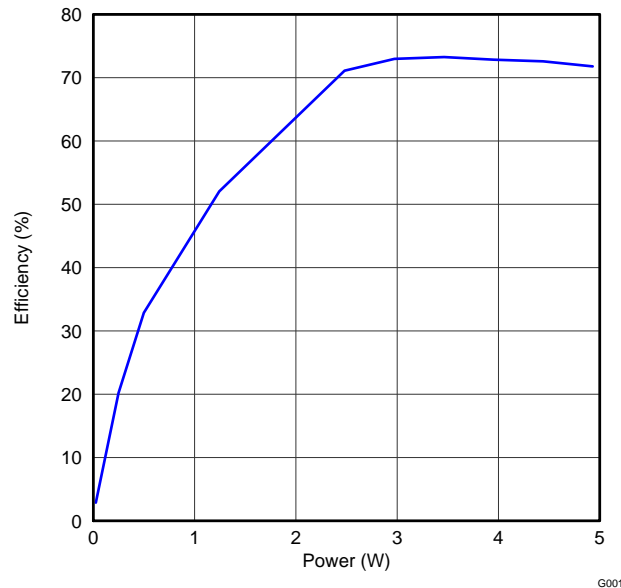


Figure 5. Efficiency v Power, HPA689 Transmitter and HPA725 Receiver

7 bq500210EVM-689 Assembly Drawings and Layout

The following figures show the design of the bq500210EVM printed-circuit board (PCB). The EVM has been designed using a 4-layer, 2-oz, copper-clad circuit board 13.2 cm x 7.24 cm with all components in a 4.5-cm x 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 bq500210 control IC in a practical application. Moving components to both sides of the PCB or using additional internal layers can offer additional size reduction for space-constrained systems.

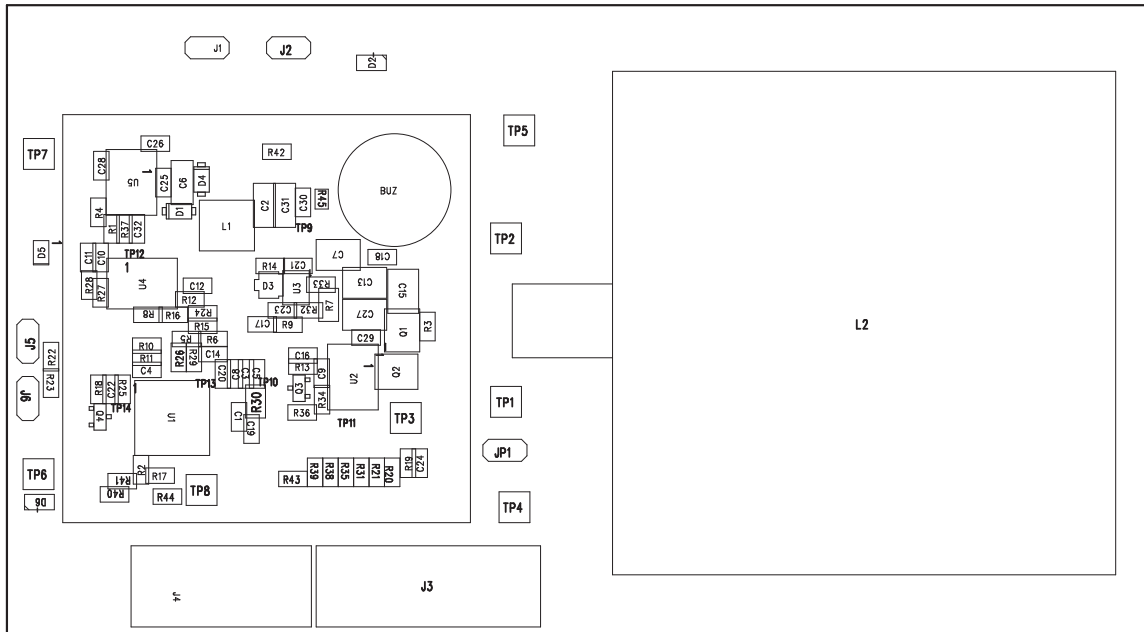
Coil Grounding – A ground plane area under the coil is recommended to reduce noise coupling into the receiver. Ground plane for the EVM is slightly larger than coil footprint and grounded at one point back to the circuit area.

Coil Stack Up and Mounting – The EVM mounting stack-up is as follows:

1. Transmitter coil thickness – 6 mm
2. Sil pad – 0.5 mm
3. Al shim – 1.5 mm

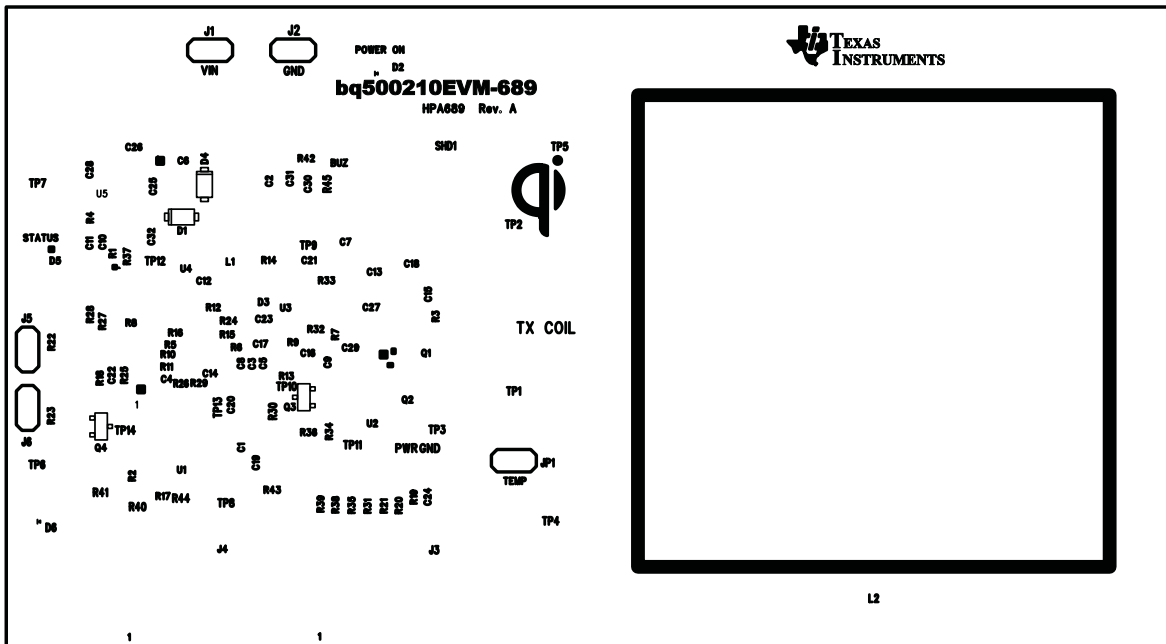
The overall stack-up is under compression from the cover plate. The AL shim and sil pad is optional for a customer solution optimized for size.

Note: The cover thickness is 0.93 inch, or 2.4 mm is the z-gap thickness for the transmitter.



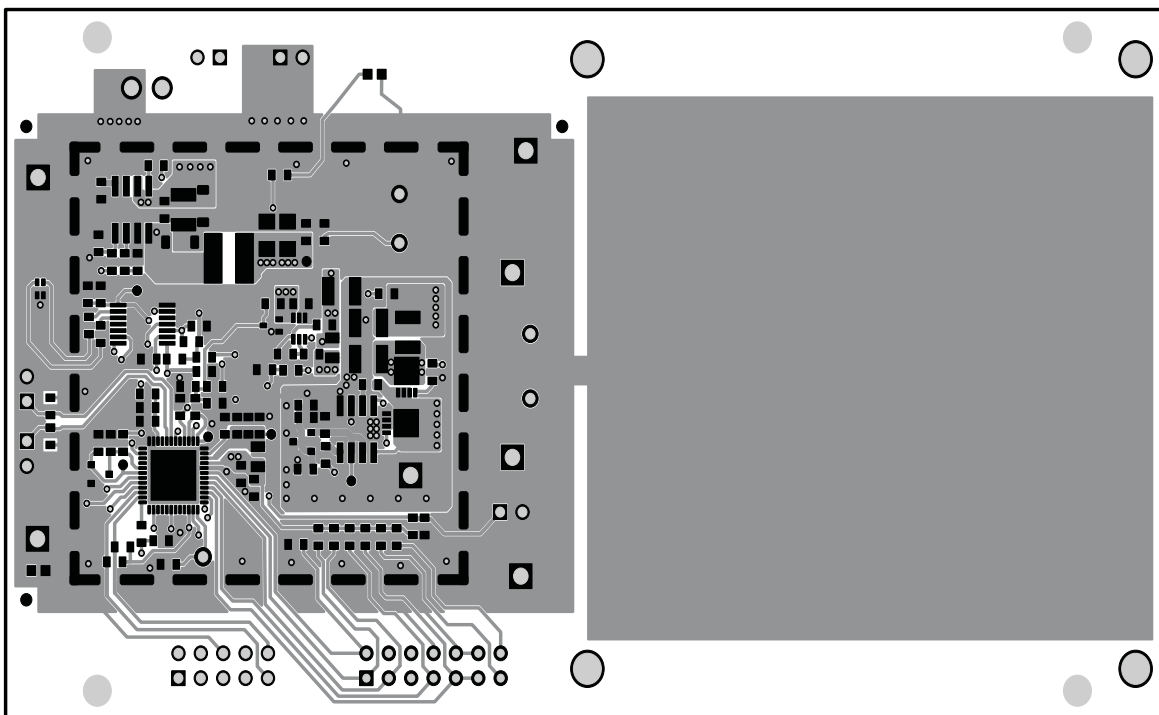
A1

Figure 6. Assembly Top



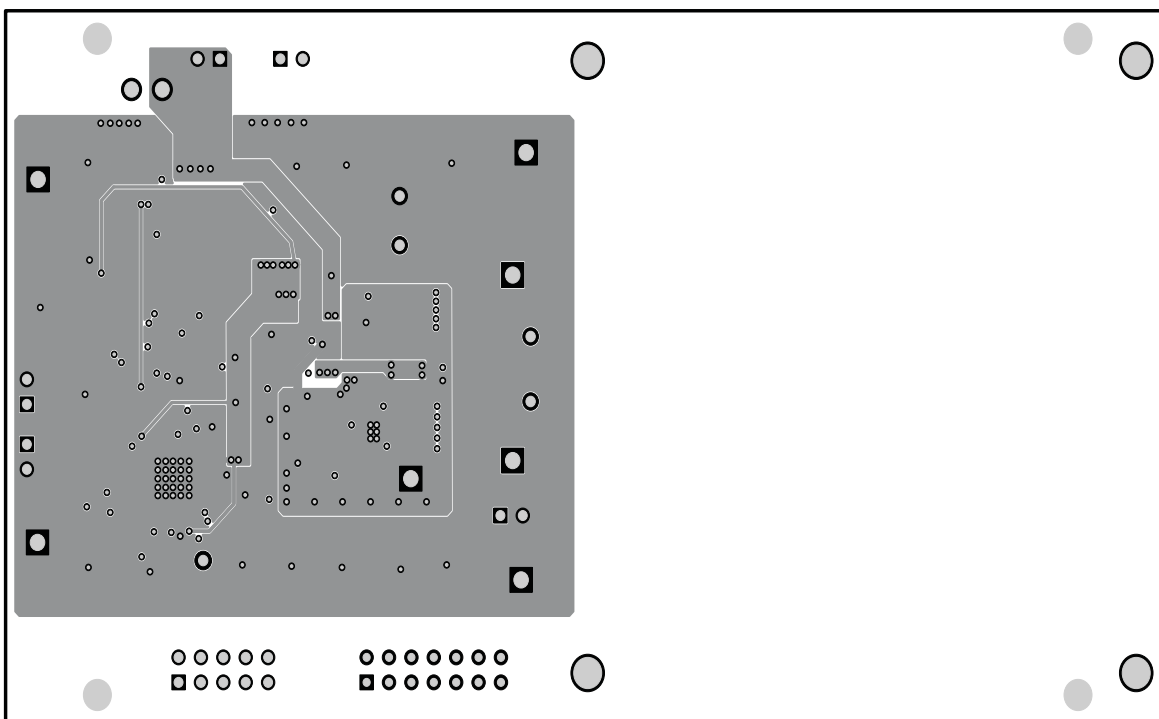
S1

Figure 7. Top Silk



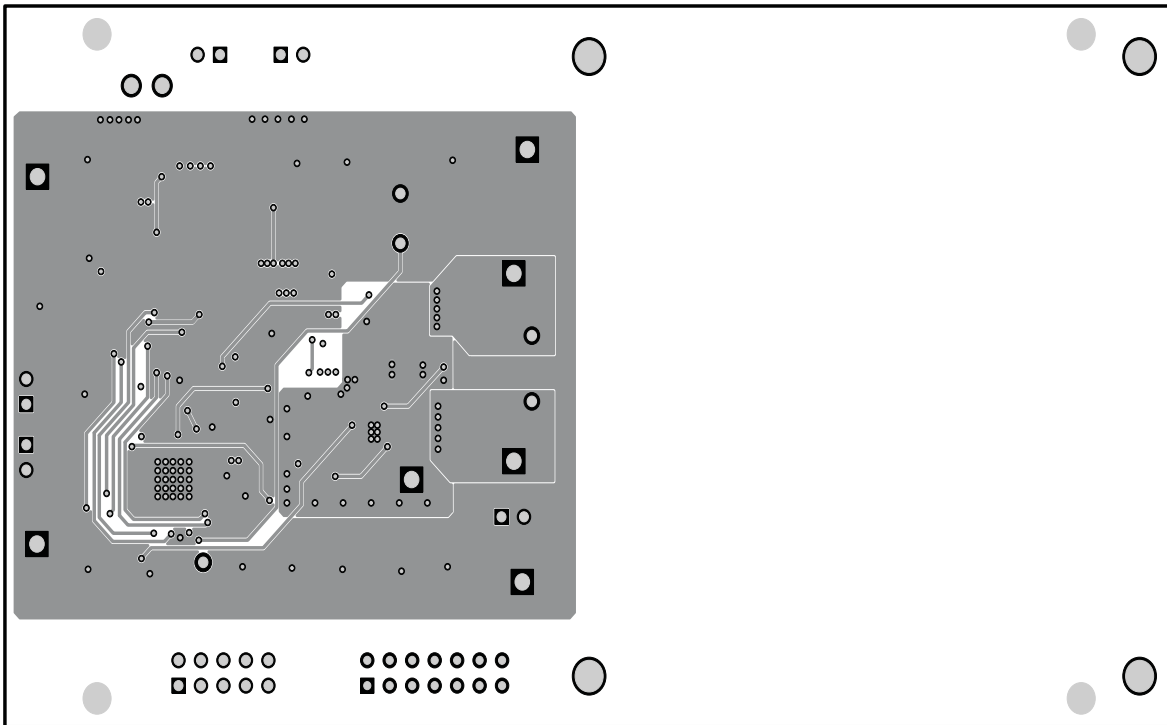
L1

Figure 8. Top Layer



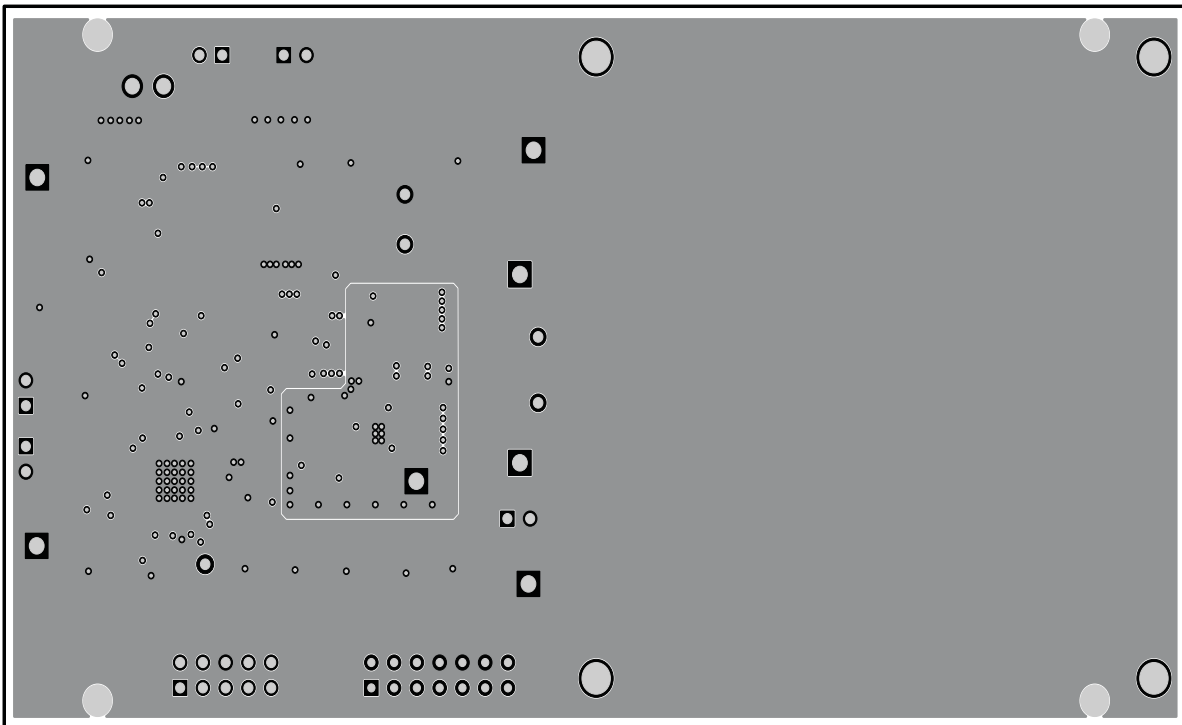
L2

Figure 9. Layer 2



L3

Figure 10. Layer 3



L4

Figure 11. Bottom Layer

8 Reference

For additional information about the bq500210EVM-689 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/bqtesla100lp.html>.

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 0 V to 20 V and the output voltage range of 0 V to 5 V .

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

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 65°C. The EVM is designed to operate properly with certain components above 65°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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