

bq500110EVM-688 Evaluation Module

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 bq500110EVM evaluation module (EVM) provides all basic functions of WPC 1.0-compliant wireless charger pad. The EVM is intended to be used with bq25046EVM or any other WPC 1.0-compliant receiver.

Contents

1	Applications	2
2	bq500110EVM-688 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	bq500110EVM-688 Assembly Drawings and Layout	12
8	Reference	16

List of Figures

1	HPA688EVM Schematic, Sheet 1 of 3	5
2	HPA688EVM Schematic, Sheet 2 of 3	6
3	HPA688EVM Schematic, Sheet 3 of 3	7
4	Equipment Setup	11
5	Top Assembly	12
6	Bottom Silk	13
7	Top Layer	13
8	Layer 2	14
9	Layer 3	14
10	Bottom Layer	15
11	Silk Screen	15

List of Tables

1	bq500110EVM-688 Electrical Performance Specifications	2
2	Bill of Materials	8

1 Applications

The bq500110EVM-688 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 bq500110EVM 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
- Option to configure an external buzzer

2 bq500110EVM-688 Electrical Performance Specifications

Table 1 provides a summary of the bq500110EVM-688 performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. bq500110EVM-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	VIN = Nom, IOU = Max		0.3	0.5	A
	Input No Load Current	VIN = Nom, IOU = 0 A		20	50	mA
OUTPUT CHARACTERISTICS						
V _{OUT}	Output Voltage	VIN = Nom, IOU = Nom	4.5	5	5.1	V
	Output Ripple	VIN = Nom, IOU = Max			200	mV _{pp}
I _{OUT}	VIN = Min to Max	VIN = Min to Max	0		1	A
	Output Over Current	VIN = Nom, VOUT = VOUT1-5%	1		1.1	A
SYSTEMS CHARACTERISTICS						
F _s	Switching Frequency		110	145	200	kHz
η _{pk}	Peak Efficiency	VIN = Nom; Porx = 2.5		72%		
η	Full-Load Efficiency	VIN = Nom, IOU = Max		70%		

3 Modifications

See the data sheet ([SLUSAE0](#)) 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 – SPI (Not Installed)

Optional programming input/output (I/O).

4.1.2 J2 – Input Voltage and GND

Input voltage, same connections as J6 and J7. Input must be 19 V ±500 mV.

4.1.3 J3 – SPI EN (Not Installed)

Optional diagnostic output

4.1.4 J4 – JTAG (Not Installed)

Optional programming I/O

4.1.5 J5 – NTC

Connection for external NTC temperature sensor. Leave open if not used.

4.1.6 J6 – GND

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

4.1.7 J7 – Vin

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

4.1.8 X1, X2 – Coil Connection

Connection for transmitter coil

4.2 Jumpers/Switches

The control jumpers are described in the following paragraphs.

4.2.1 R50 – LED Scheme

LED indication scheme set resistor; default 64.9 k Ω . For a detailed function description, see the bq500110 data sheet.

4.2.2 R51 – MOD (Not Installed)

MOD threshold set resistor. For a detailed function description, see the bq500110 data sheet.

4.3 Test Point Descriptions

The test points are described in the following paragraphs.

4.3.1 TPX1 – Coil Monitor 1

Test point for measuring ac voltage applied to TX coil.

4.3.2 TPX2 – Coil Monitor 2

Test point for measuring ac voltage applied to TX coil.

4.3.3 TP1 – DC Buzzer Output

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

4.3.4 TP2 – Not Used

Not used

4.3.5 TP3 – Output to External Watchdog

See data sheet for additional information.

4.3.6 TP4 – Low Power Kill/Master in Slave Out

See data sheet for additional information.

4.3.7 TP5 – AC Buzzer Output

Connection point for ac buzzer; 4 kHz for 200 ms at start of power transfer to receiver unit.

4.3.8 TP6 – Coil PWM Output

PWM logic signal out of bq500100 to gate driver IC.

4.3.9 TP7 – Input DC Current

Transmitter input current

4.3.10 TP8 - LED Drive Output 1/Serial Clock Output

LED D2 (red) drive signal

4.3.11 TP9 – LED Drive Output 1/Slave Select Output

Optional LED drive, not used

4.3.12 TP10 – Coil Current Monitor

Coil current input

4.3.13 TP11 – GND

Large ground terminal for meter or probe connection

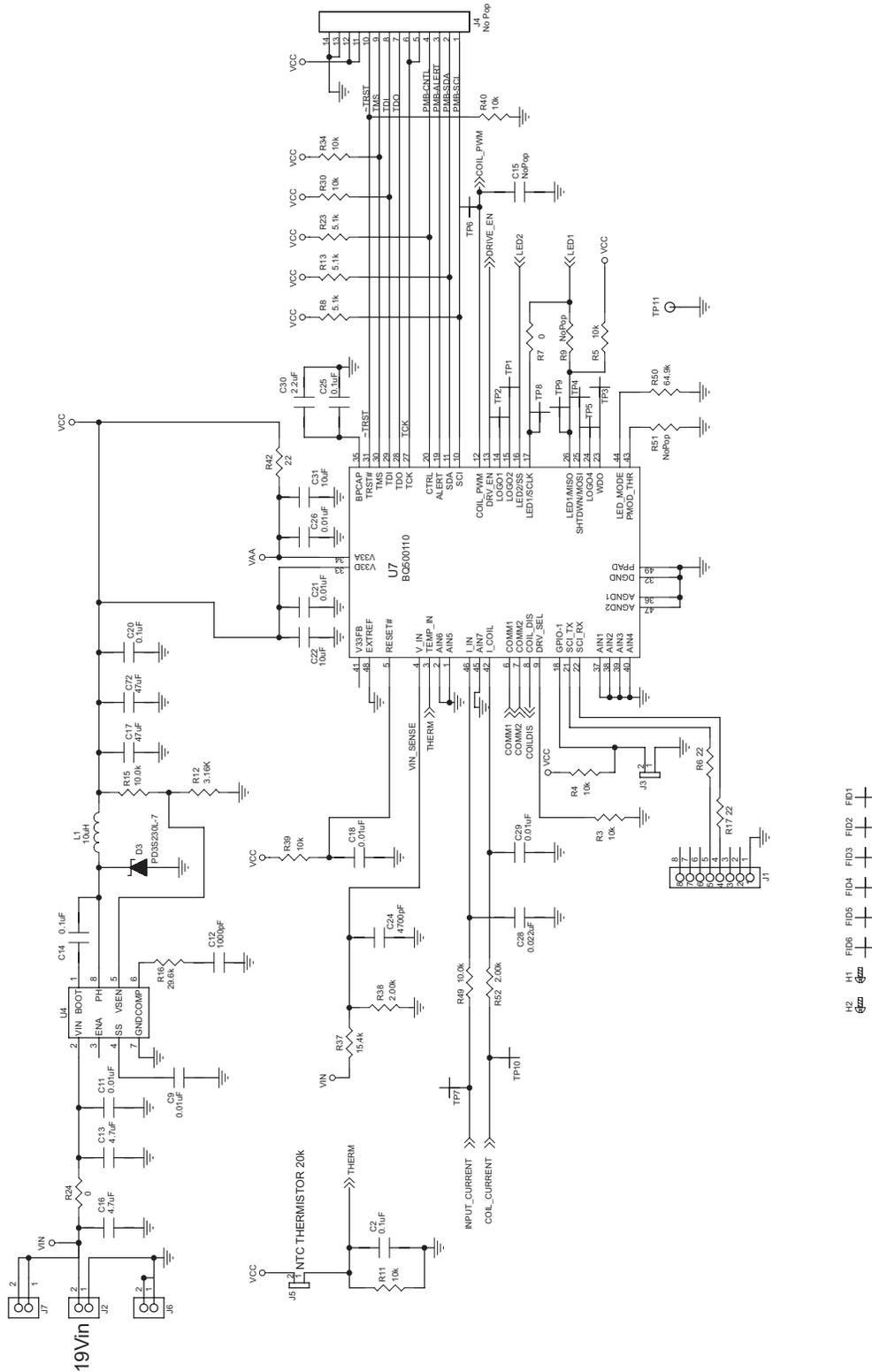
4.3.14 TP12 – Demodulation Comm 1 Output

Primary communications channel, input to bq500110 from demodulation circuit.

4.3.15 TP13 – Demodulation Comm 2 Output

Alternate communications channel, input to bq500110 from demodulation circuit.

5 Schematic and Bill of Materials



NOTE: For Reference Only, See Table 2 for Specific Values

Figure 1. HPA688EVM Schematic, Sheet 1 of 3

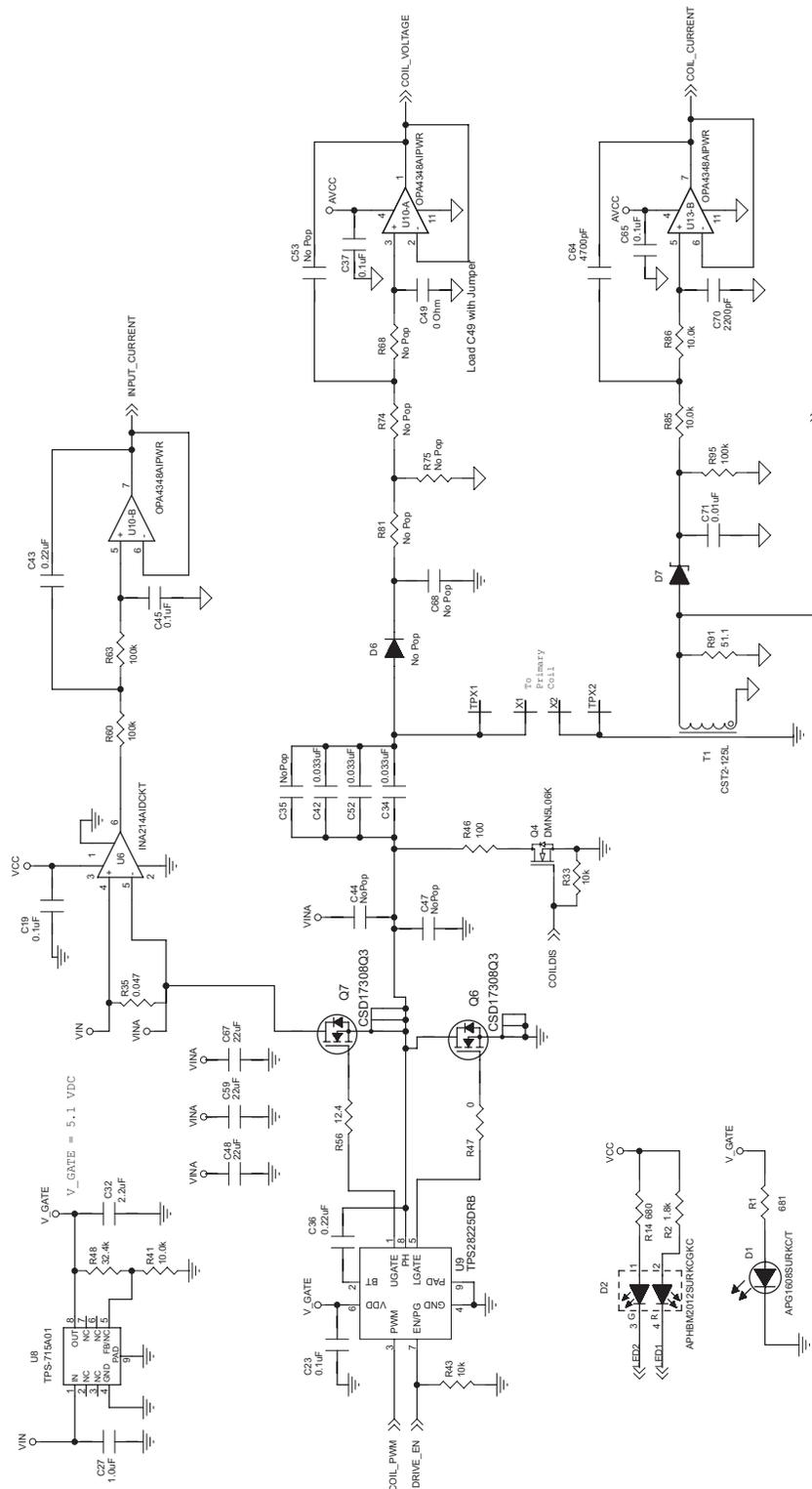


Figure 2. HPA688EVM Schematic, Sheet 2 of 3

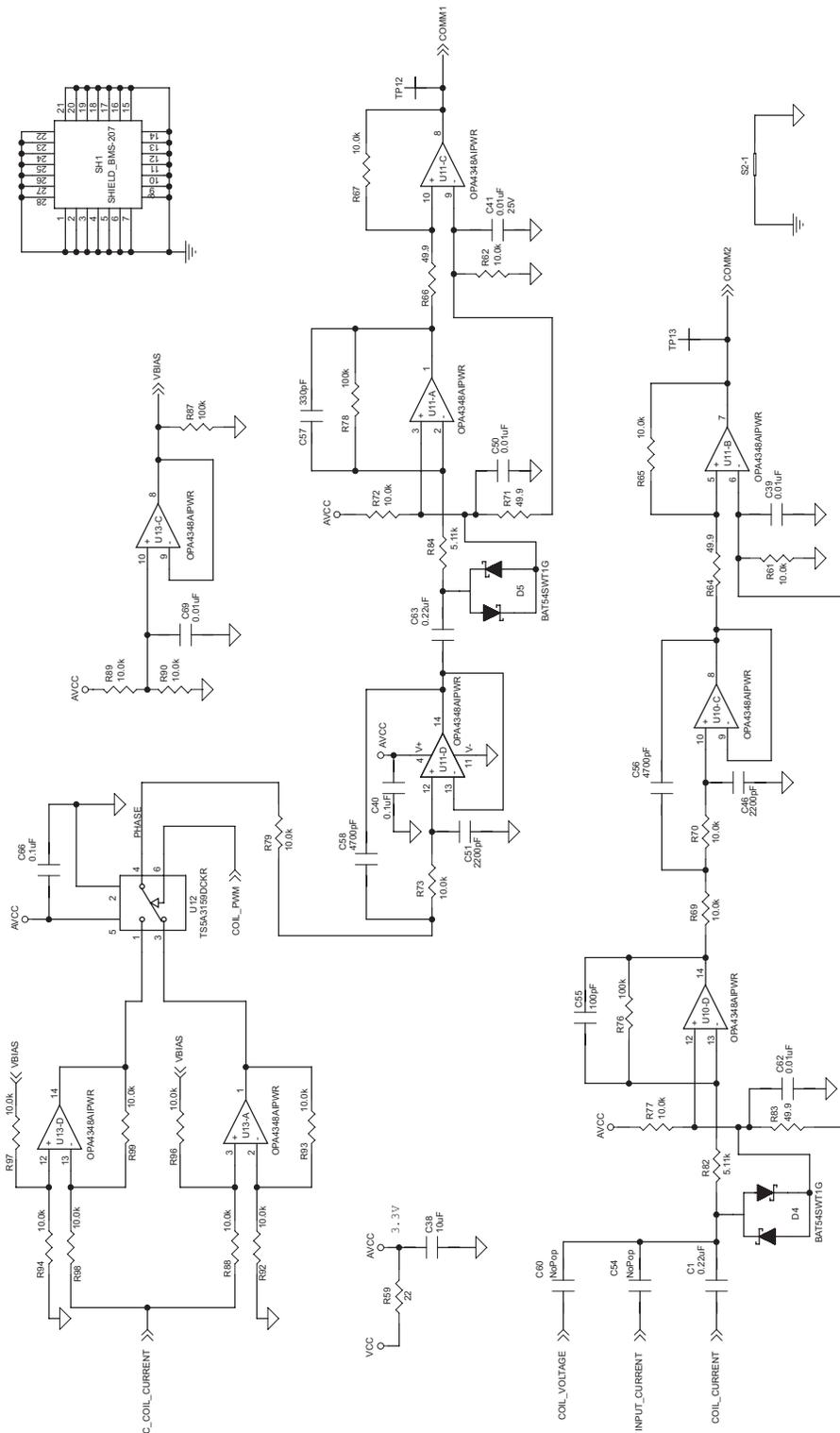


Figure 3. HPA688EVM Schematic, Sheet 3 of 3

Table 2. Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
4	C1 C36 C43 C63	0.22 µF	Cap - Ceramic, 10%, 16V, X7R	0402	GRM155R71C224KA12D	Murata Erie
11	C9 C18 C21 C26 C29 C39 C41 C50 C62 C69 C71	0.01 µF	Cap - Ceramic, 10%, 25V, X7R	0402	C0402C103K3RACTU	Kemet
1	C11	0.01 µF	Cap - Ceramic, 10%, 50V, X7R	0805	C0805C103K5RACTU	Kemet
1	C28	0.022 µF	Cap - Ceramic, 10%, 10V, X7R	0402	C0402C223K8PACTU	Kemet
3	C34 C42 C52	0.033 µF	Cap - Ceramic, 5%, 250V, C0G	1812	C4532C0G2E333J	TDK
1	C14	0.1 µF	Cap - Ceramic, 10%, 50V, X7R	0603	GRM188R71H104KA93D	Murata Erie
10	C2, C19-20 C23 C25 C37 C40 C45 C65-66	0.1 µF	Cap - Ceramic, 10%, 10V, X5R	0402	GRM155R61A104KA01D	Murata Erie
1	C27	1.0 µF	Cap - Ceramic, 10%, 25V, X5R	0603	C1608X5R1E105K	TDK
1	C55	100 pF	Cap - Ceramic, 10%, 25V, NPO	0402	C0402C101J3GACTU	Kemet
3	C22 C31 C38	10 µF	Cap - Ceramic, 20%, 6.3V, X5R	0603	ECJ-1VB0J106M	Panasonic
2	C30 C32	2.2 µF	Cap - Ceramic, 10%, 16V, X5R	0603	C1608X5R1C225K	TDK
3	C46 C51 C70	2200 pF	Cap - Ceramic, 10%, 50V, X7R	0402	GRM155R71H222KA01D	Murata Erie
3	C48 C59 C67	22 µF	Cap - Ceramic, 20%, 25V, X7R	1812	C4532X7R1E226M	TDK
1	C12	1000 pF	Cap - Ceramic, 10%, 50V, X7R	0402	GRM155R71H102KA01D	Murata Erie
1	C57	330 pF	Cap - Ceramic, 10%, 50V, X7R	0402	C0402C331K5RACTU	Kemet
2	C13 C16	4.7 µF	Cap - Ceramic, 10%, 25V, X5R	0805	C2012X5R1E475K	TDK
4	C24 C56 C58 C64	4700 pF	Cap - Ceramic, 10%, 50V, X7R	0402	GRM155R71H472KA01D	Murata Erie
2	C17 C72	47 µF	Cap - Ceramic, 20%, 6.3V, X5R	1206	C1206C476M9PACTU	Kemet
0	C15, C35, C44, C47, C53, C54, C60, C68	Open	Cap - Ceramic TBD		TBD	TBD
1	C49	0	Res - 1/10W 5% SMD	0402	CRCW04020000Z0ED	Vishay/Dale
1	D1	Blue	LED - Blue, High Brightness	0603	LNJ926W8CRA	Panasonic
1	D2	Red-green	LED - Miniature Bicolor Chip LED, GREEN & RED	0805	APHBM2012SURKCGKC	Kingbright
2	D3 D7	B0540W-7-F	DIODE - Schottky, 40V 500mA,	SOD-123	B0540W-7-F	Diodes Inc.
2	D4 D5	BAT54SW-7-F	DIODE - Dual Schottky, 30V 200mW,	SC-70	BAT54SW-7-F	Diodes Inc.
0	D6	Open	DIODE	SOT323	Open	Open
1	L1	10 µH	Inductor - 20%, 1.4A, 0.60 Ω, LPS5030, SMT	5030	LPS5030-103M	Coilcraft
2	Q6-Q7	CSD17308Q3	MOSFET - 30V N-Channel NexFET	SON8	CSD17308Q3	Texas Instruments
1	Q4	DMN5L06K-7	MOSFET - N-Ch, 50V, 0.3A, 3 Ω	SOT23	DMN5L06K-7	Diodes Inc.
2	R1, R2	1.8k	Res - 1.8kΩ 1/16W 5%	0402	CRCW04021K80JNED	Vishay/Dale
35	R3-R5 R11 R15 R30 R33-R34 R39-R41 R43 R49 R61-R62 R65 R67 R69-R70 R72-R73 R77 R79 R85-R86 R88-R90 R92-R94 R96-R99	10.0k	Res - 1/16W 1%	0402	CRCW040210K0FKED	Vishay/Dale
4	R6 R17 R42 R59	22	Res - 1/16W 5%	0402	CRCW040222R0JNED	Vishay/Dale
2	R7 R24	0	Res - 1/10W 5%	0402	CRCW04020000Z0ED	Vishay/Dale
3	R8 R13 R23	5.1k	Res - 1/16W 5%	0402	CRCW04025K10JNED	Vishay/Dale
1	R12	3.16k	Res - 1/16W 1%	0402	CRCW04023K16FKED	Vishay/Dale
1	R14	680	Res - 1/16W 5%	0402	CRCW0402680RJNED	Vishay/Dale
1	R16	29.4k	Res - 1/16W 1%	0402	CRCW040276K8FKED	Vishay/Dale
1	R35	0.047	Res - 1/10W 1% Current Shunt	0603	ERJ-L03KF47MV	Panasonic
1	R37	15.4k	Res - 1/16W 1%	0402	CRCW040215K4FKED	Vishay/Dale
2	R38 R52	2.00k	Res - 1/16W 1%	0402	CRCW04022K00FKED	Vishay/Dale
1	R46	100	Res - 1/10W 5%	0603	CRCW0603100RJNEA	Vishay/Dale
1	R47	0	Res - 1/10W 5%	0603	CRCW06030000Z0EA	Vishay/Dale
1	R48	32.4k	Res - 1/16W 1%	0402	CRCW040232K4FKED	Vishay/Dale
1	R50	64.9k	Res - 1/16W 1%	0805	CRCW080564K9FKEA	Vishay/Dale
1	R56	12.4	Res - 1/10W 5%	0603	CRCW060324R9FKEA	Vishay/Dale
6	R60 R63 R76 R78 R87 R95	100k	Res - 1/16W 1%	0402	CRCW0402100KFKED	Vishay/Dale
4	R64 R66 R71 R83	49.9	Res - 1/16W 1%	0402	CRCW040249R9FKED	Vishay/Dale
0		200	Res - 1/16W 1%	0402	RCW0402200RFKED	Vishay/Dale
2	R82 R84	5.11k	Res - 1/16W 1%	0402	CRCW04025K11FKED	Vishay/Dale
1	R91	51.1	Res - 1/4W 1%	1206	CRCW120651R1FKEA	Vishay/Dale

Table 2. Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
0	R9, R51, R68, R74, R75, R81	Open	Res		TBD	TBD
0	SH1	Open	EMI Shield		Open	
1	T1	CST2-125L	Xfmr - Current Sense, 1:125, 6mΩ Pri.		CST2-125LC	Coilcraft
0	TP1-10, TP12, TP13	Open	Test Point - 0.035" Through Hole, Red		5005	Keystone Electronics
1	TP11		Test Point - 0.062" Through Hole, Black		5011	Keystone Electronics
2	TPX1, TPX2		Test Point - 0.062" Through Hole, White		5012	Keystone Electronics
1	U4	TPS54231D	IC - TPS54231 Step-Down Converter	8-SOIC	TPS54231D	Texas Instruments
1	U6	INA214AIDCKT	IC - Voltage Output Current Shunt Monitor	SC-70-6	INA214AIDCKT	Texas Instruments
1	U7	BQ500110	IC - Wireless Power TX Controller	QFN-48	BQ500110-W100RGZ	Texas Instruments
1	U8	TPS715A01DRBT	IC - LDO, Hi Vin, 50MA, Adjustable	SON8	TPS715A01DRBT	Texas Instruments
1	U9	TPS28225DRBR	IC - FET Driver, 4A, Sync MOSFET Driver	SON8	TPS28225DRBR	Texas Instruments
3	U10, U11, U13	OPA4348AIPWR	IC - Quad Op Amp, 2.1V, 45μA, RRIO	TSSOP14	OPA4348AIPWR	Texas Instruments
1	U12	SN74LVC1G3157DCK	IC - SPDT Analog Switch	SC70-6	SN74LVC1G3157DCKR	Texas Instruments
1	LX		WPC Compliant TX Coil Set with Ferrite Shield and Magnet	See note 5, 7	EC00296A	Elytone Electronic
1	-		PCB		HPA688	Any
1	-		Cover, Plastic Polycarbonate, 2.75" Square, 0.93 thick		MCH002	Any
	-		Plate, aluminum 2.0" x 2.0" x 0.062"		MCH003	Any
1	Note 6		Sil-Pad Cut to Size 2.0" Square		GP1500-0.020-00-0816 GP1500-0.020-00-0404	Bergquist
4	-		Standoff, Nylon, Female to Male, 4-40		4800	Keystone
4	-		Nut #4-40 Hex Nylon		Standard	Standard
4	-		Screw steel zinc, flathead 4-40 machine, 0.250		Standard	Standard
6	-		Mounting Feet, 0.25" tall		2563	Voltrex
4	J2, J5, J6, J7	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
0	J1	PEC08SAAN	Header, Male 8-pin, 2.0mm spacing		Standard	Standard
0	J4	OPEN	Conn Header 14pos 1.25MM STR TIN		53047-1410	Molex
0	-		Shunt, 100-mil, Black	0.100	929950-00	3M
0	J3	OPEN				
-	-	SA-1000	Adhesive, Thermally Conductive Silicon	See Note 9	SA-1000	Bergquist

- 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. Using unclean flux is unacceptable.
3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
4. Reference designators marked with an asterisk (***) cannot be substituted. All other components can be substituted with equivalent MFG's components.
5. Elytone Electronics Co., Ltd.: Sales Exec Annie Jya Tel (Taiwan) : +886-2-2671-2071 Ext 301 Cell : +886-972-190- 990 Fax : +886-2-2672-3775 www.elytone.com.tw
6. If part number GP1500-0.020-00-0404 is used, the Sil-Pads need to be cut into 2-inch squares.
7. Solder coil leads to plated-through hole X1 and X2 , TX Coil
8. C49 – Load this spot with 0-Ω resistor
9. Apply thin layer of SA-1000 between aluminum plate MCH003 and PCB during installation.

6 Test Setup

6.1 Equipment

6.1.1 bqTESLA™ Receiver

Use HPA687EVM (BQ25046EVM) 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.

6.1.3 Meters

Output voltage can be monitor at TP6 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 TPS10 and other signals. .

6.1.6 Recommended Wire Gauge

For proper operation, 22 AWG wire is recommended when connecting the bq500110EVM-688 to input supply and bq25046EVM-687 to load.

6.2 Equipment Setup

- With power supply OFF, connect supply to bqTESLA™ transmitter.
- Place bqTESLA™ receiver on transmitter.
- Connect load to J2 with return to J5, monitor current through load with ammeter, and monitor current to load at TP6.
- Typical output voltage is 5 V, and the output current range is 0 mA to 750 mA.

6.2.1 Equipment Setup Diagram

The diagram in [Figure 4](#) shows the test setup.

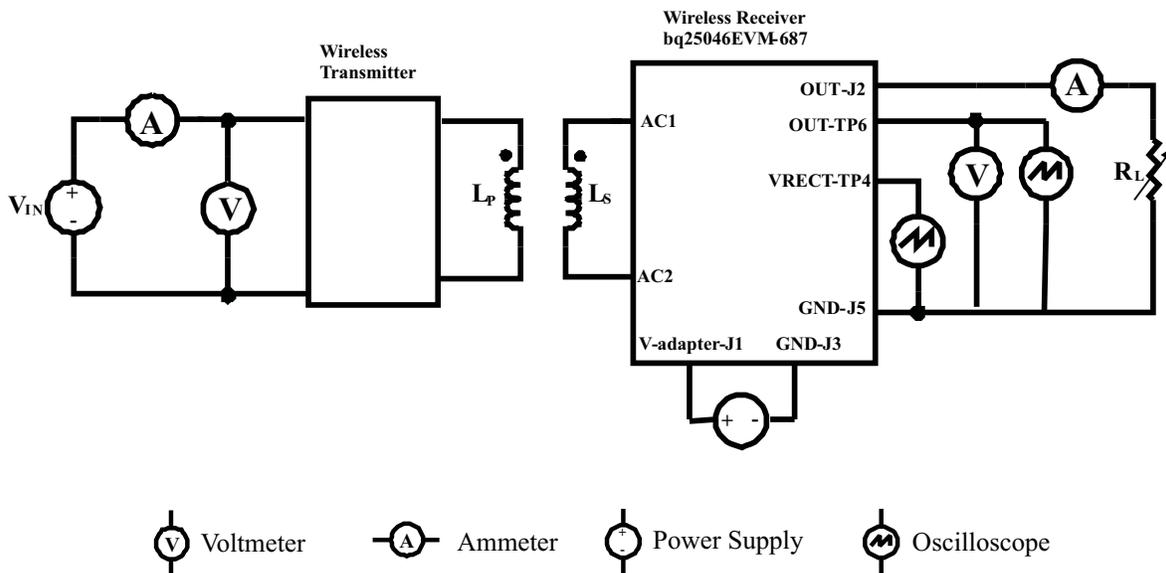


Figure 4. Equipment Setup

6.2.2 EVM Setup Procedures

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

- Working at an ESD workstation, ensure that any wrist straps, bootstraps, or mats are connected referencing the user to earth ground before power is applied to the EVM. Wearing electrostatic smock and safety glasses are also recommended.
- Prior to connecting the dc input source, V_{IN} , it is advisable to limit the source current from V_{IN} to 1 A maximum. Ensure that V_{IN} is initially set to 19 V.
- Connect V_{in} power source to J6, J7 with positive terminal of the power source attached to J7 and negative terminal of the V_{in} source connected to J6.
- Turn on V_{in} , and observe that the blue LED illuminates. Depending on the LED indication scheme set by the resistor R50, LED D2 may produce amber, green, or red light. The default value of 64.9k programs D2 to produce amber light in this stand-by state. All voltmeters must be Kelvin connected (at the pin) to the point of interest.
- Apply the scope probe to the test point TPX1 and observe three-pulse bursts of 100 kHz every 0.5 s. This is Analog Ping probing environment for testing the presence of the receiver placed on the Tx coil. The output load is recommended to be a variable power resistor.
- Place HPA687 EVM (bq25046EVM) on the top of the transmitting coil. Align centers of the receiving and transmitting coils across each other. In the next few seconds, observe two green LEDs D7 and D8 illuminating, indicating that communication between secondary and primary is established and power transfer has began. Measure output voltage between TP6 and J6, being 5 V.
- LED D2 on bq500110EVM flashes green light when the power transfer is initiated.
- Observe waveform close to the sine-wave on the test point TPX1 when power transfer is active.
- Apply load to HPA687 EVM (bq25046EVM).
- Observe the waveform on TPX1 changing frequency from high (~150 kHz) to low (~120 kHz) when the load changes from low to high.
- Observe demodulated communication waveforms COMM1 and COMM2 on test points TP12 and TP13, respectively.
- Make tests and measurements applicable to HPA687 EVM (bq25046EVM) output as you normally test power supplies.
- 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.

- To test the MOD function, install resistor R51 = 42.2 kΩ. In addition to loading on the output of HPA687 EVM (bq25046EVM), apply an electronic load in constant power mode between secondary GND (J6) and TP4 – the output of the secondary side rectifier. Increasing load power from 0 W to over 0.5 W, observe LED D2 of bq500110EVM turning red and the power transfer stopped in approximately 20 s after the MOD threshold was exceeded.

7 bq500110EVM-688 Assembly Drawings and Layout

The following figures show the design of the bq500110EVM 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 bq500110 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 Connection to PCB terminal – The coil leads must be connected so that the coil top winding lead is connected to the TP2 terminal and the bottom winding is connected to the TP1 terminal. TP2 is the low-noise connection, and the top winding is closest to the receiver; this configuration provides the lowest noise configuration for the receiver.

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.

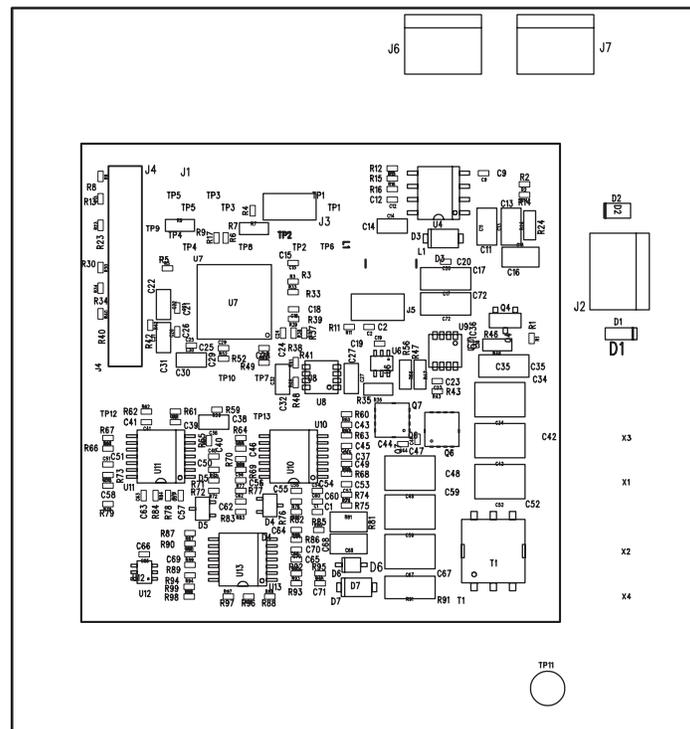


Figure 5. Top Assembly

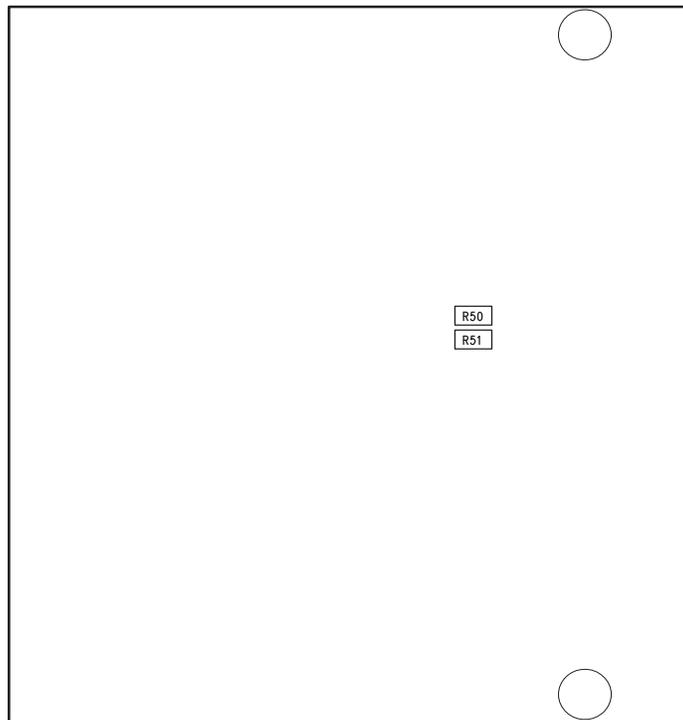


Figure 6. Bottom Silk

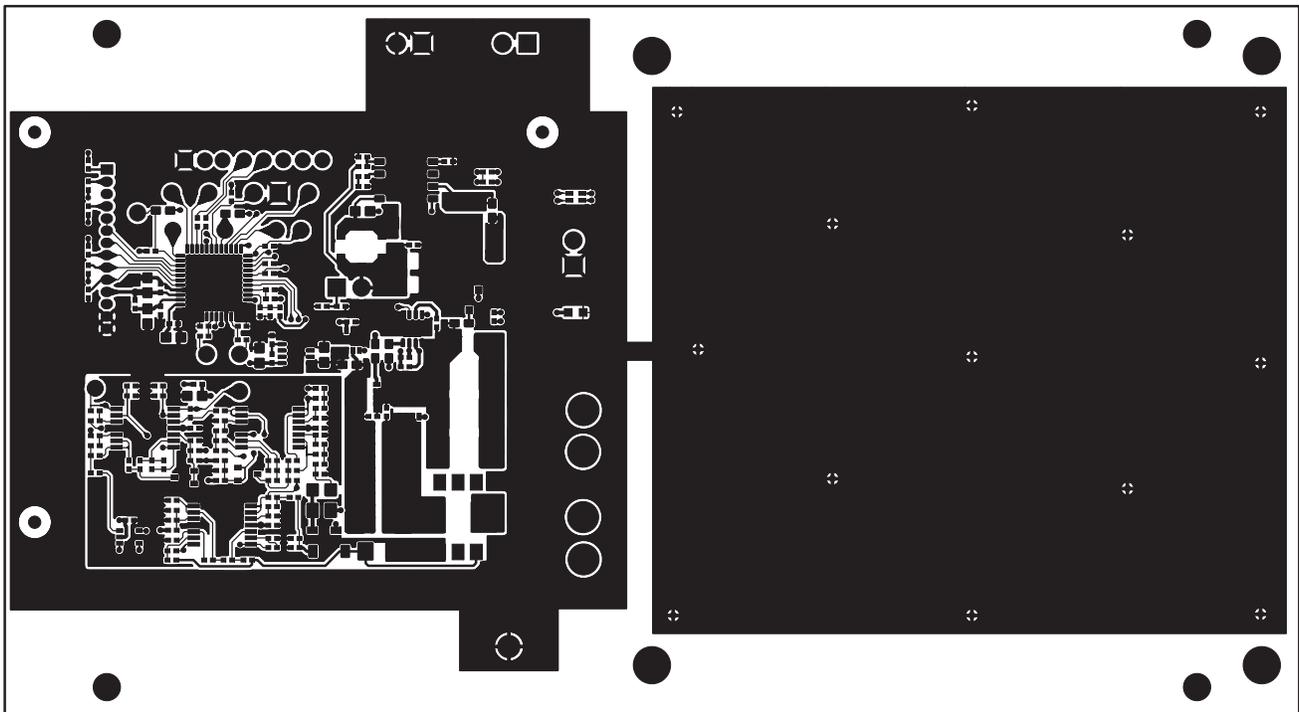


Figure 7. Top Layer

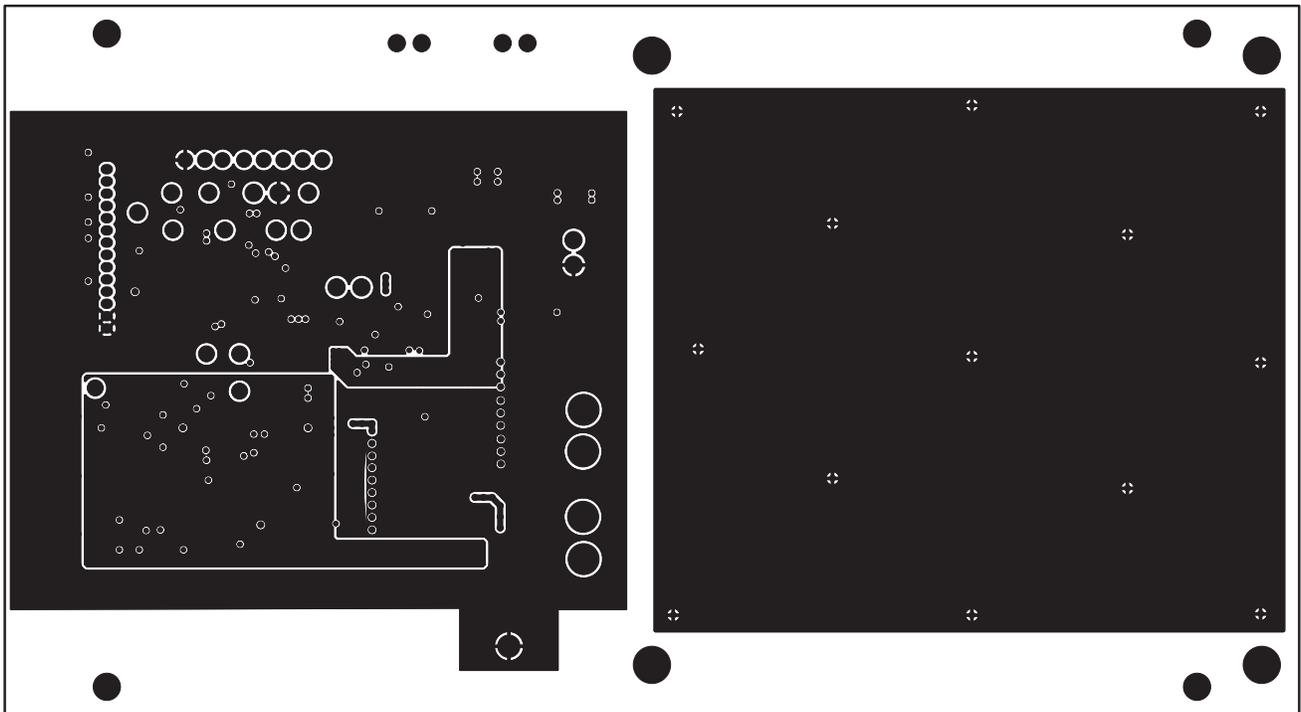


Figure 8. Layer 2

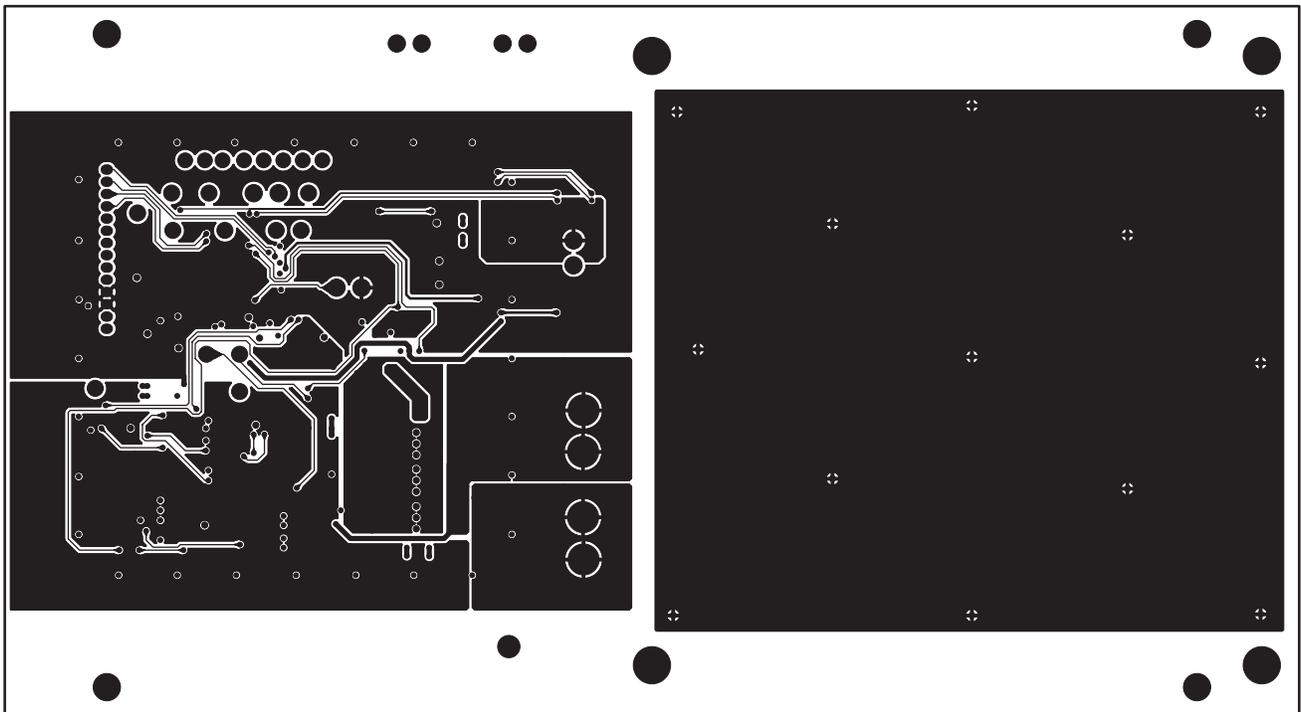


Figure 9. Layer 3

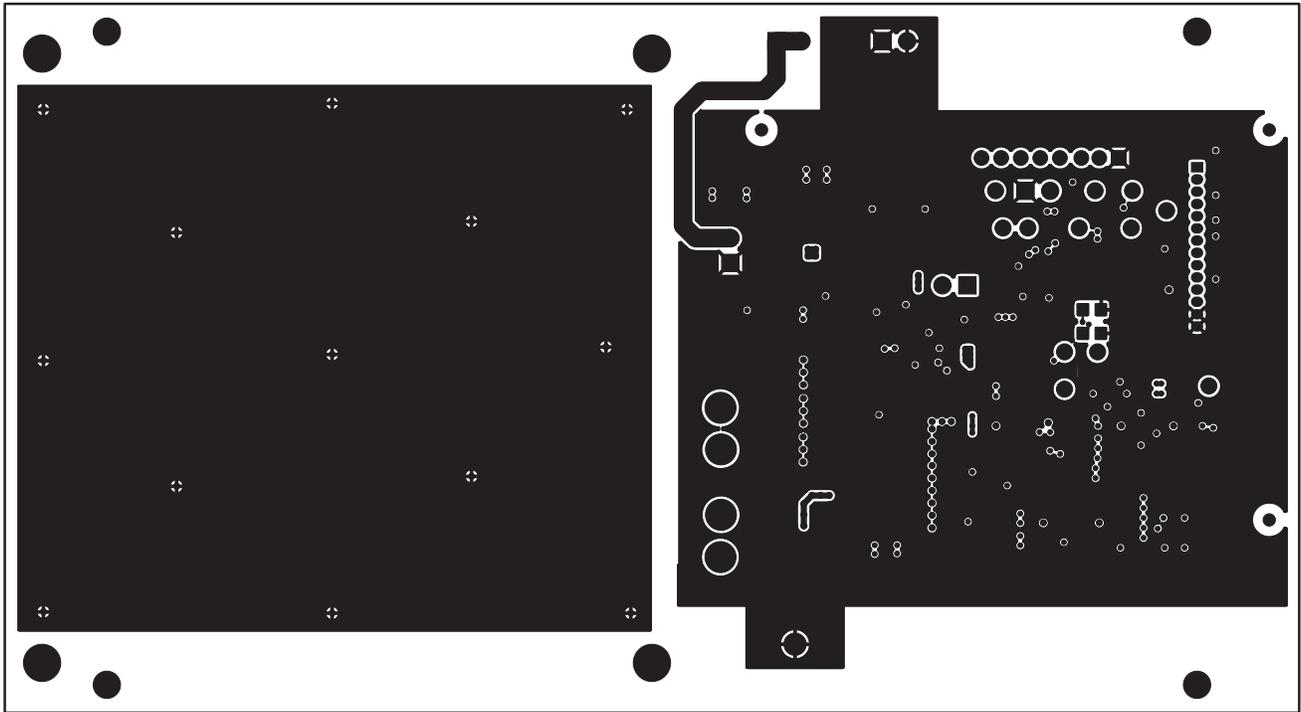


Figure 10. Bottom Layer

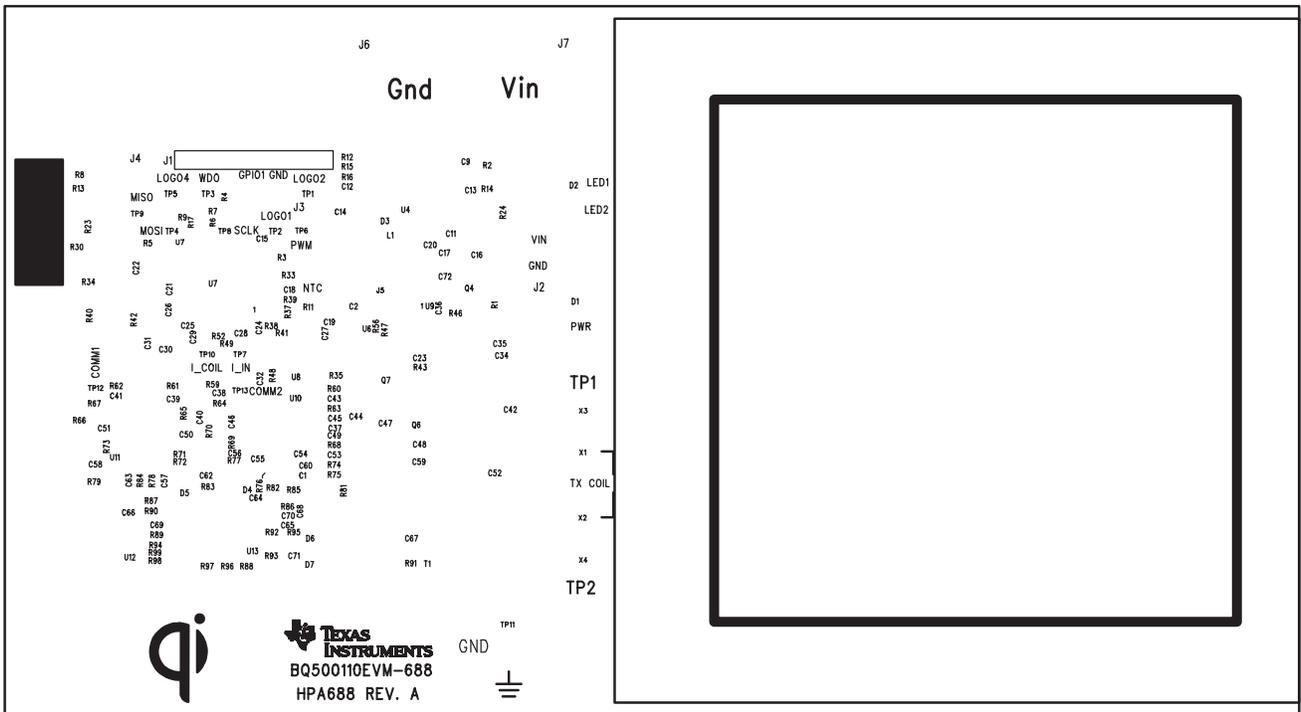


Figure 11. Silk Screen

8 Reference

For additional information about the bqTESLA100LP 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>.

Evaluation Board/Kit Important Notice

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