bq500410A bqTESLA™ Wireless Power Transmitter EVM

The bq500410AEVM-085 (EVM) wireless power transmitter evaluation module from Texas Instrument is a high-performance, easy-to-use development tool for wireless power solutions. The transmitter module is a complete solution allowing the designer to speed the development of their end-product. The bq500410AEVM-085 evaluation module (EVM) provides all basic functions for evaluation of the bq500410A IC in a fully functional wireless transmitter configuration, WPC A6 type. The bq500410A supports a three coil array for increased free positioning area. Any Qi-compliant receiver or bq51013AEVM-764, -765 receiver EVM's can be used for evaluation. The bq500410AEVM-085 is a 12-V input design with an optional boost converter for operation from 5 V.

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1 Applications

The bq500410AEVM-085 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. All transmitter-side electronics and transmitter coils are on a single 4-layer printed circuit board (PCB). The open design allows easy access to key points of the electrical schematic:

- WPC certified transmitter
- WPC A6-type transmitter coil, 70 mm × 25 mm free positioning area
- Input voltage 12 V
- Optional boost converter to allow operation from 5 V
- Transmitter-coil mounting pad providing correct receiver interface
- LED indicates power transfer or fault state, and buzzer indicates start of power transfer

2 bq500410AEVM-085 Electrical Performance Specifications

Table 1 provides a summary of the bq500410AEVM-045 performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. bq500410AEVM-045 Electrical Performance Specifications

Parameter		Notes and Conditions	Min	Typ	Max	Unit
Input Characteristics						
V_{IN}	Input voltage		0.6	12.0	0.6	V
I_{IN}	Input current	V_{IN} = Nom, I_{OUT} = 1 A at 5 V		570		mA
	Input no-load current	V_{IN} = Nom, I_{OUT} = 0 A		75		mA
	Input stand-by current	Vin = Nom		10		mA
Output Characteristics – Receiver bq51013AEVM-764, -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}	VIN = 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		74.2		%
η	Full-load efficiency	V_{IN} = Nom, I_{OUT} = Max		73.6		%

3 Modifications

See the data sheet (SLUSB96) when changing components.

- LED Mode--Resistor R39 can be used to change behavior of status LED D4. Standard value is 42.2 kΩ for control option 1, see data sheet for additional settings.
- NTC--Connector J6 provides the option for connecting a negative temperature coefficient (NTC) sensor for thermal protection, see data sheet for additional settings
- PMOD--Resistor R40 is used to set the loss threshold, standard value is 56.2 kΩ. Removing jumper JP1 disables PMOD. Resistor value can be changed to adjust the threshold, see data sheet for additional settings.

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4 Connector and Test Point Descriptions

4.1 Input/Output Connections

The connection points are described in Section 4.1.1 – Section 4.1.8.

4.1.1 J1: Vin--12V

Input power 12 V ±600 mV, return at J2.

4.1.2 J2: GND

Return for input power, input at J1.

4.1.3 J3: Vin--5V

Input power 5 V return at J2.

4.1.4 J4: PMBus interface

Factory use only

4.1.5 J5: JTAG interface

Factory use only

4.1.6 J6: NTC

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

4.1.7 JP1: Loss Threshold

With the jumper open, PMOD function is disabled. With shorting jumper installed, PMOD is enabled and resistor R40 sets the PMOD threshold, see data sheet for more information.

4.1.8 JP2: Select LED Mode

The connection point for an external resistor to select the LED mode. See the bq500410A data sheet for more information.

4.2 Test Point Descriptions

The test points are described in Section 4.2.1 – Section 4.2.8.

4.2.1 Ground Test Point

TP1: Analog Ground

TP29: Analog Ground

4.2.2 TPS54231 U3 Signal

TP30: Test point used for loop stability test of U3

TP31: 3V3_VCC 3.3 V out of DC to DC converter

4.2.3 INA199A1 U4 Signal

TP3: I_SENSE – Signal representing input current to coil drive circuit

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4.2.4 bq500410A U9 Signals

TP14: U9 Pin 1 COMM+ peak detect input

TP17: DPWM output

TP2: COMM+ Signal output from MUX

TP4: COMM- Signal output from MUX

4.2.5 Coil L1 Signals

TP5: COMM select signal for Coil 1

TP6: Capacitor Side Drive signal to Coil 1

TP9: Switch Transistor Side Drive signal to Coil 1

TP10: PWR GND Coil 1

4.2.6 Coil L2 Signals

TP11: COMM Select signal for Coil 2

TP12: Capacitor Side Drive signal to Coil 2

TP16: Switch Transistor Side Drive signal to Coil 2

TP23: PWR GND Coil 2

4.2.7 Coil L3 Signals

TP25: COMM Select signal for Coil 3

TP26: Capacitor Side Drive signal to Coil 3

TP27: Switch Transistor Side Drive signal to Coil 3

TP28: PWR GND Coil 3

4.2.8 Unused Pins

TP7: U6 Pin 4, not used

TP8: U6 Pin 5, not used

TP13: U9 Pin 41, not used

TP15: U9 Pin 6, not used

TP18: U9 Pin 13, not used

TP19: U9 Pin 24, not used

TP20: U9 Pin 19, not used

TP21: U9 Pin 20, not used

TP22: U9 Pin 22, not used

TP24: U9 Pin 21, not used

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5 Schematic and Bill of Materials

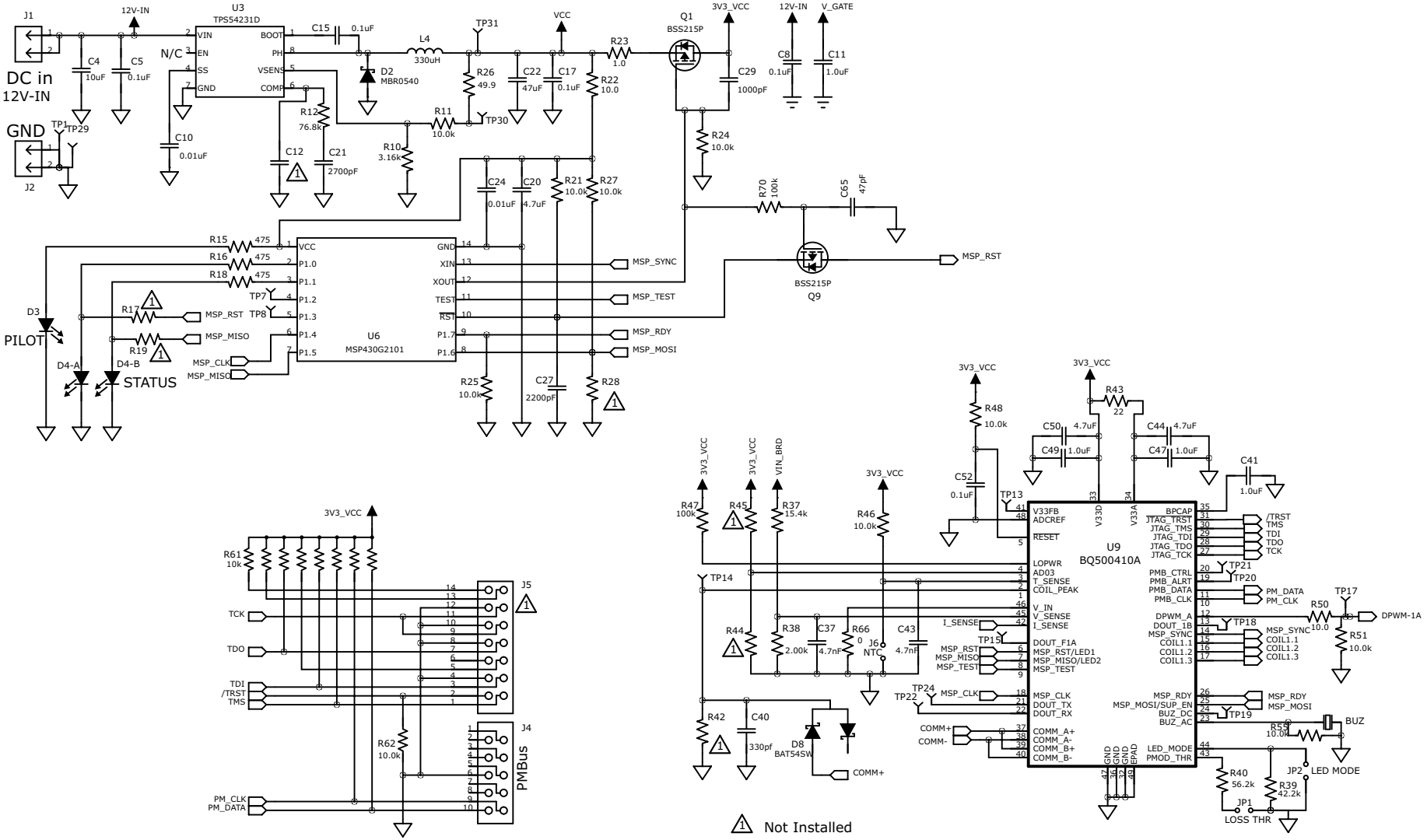


Figure 1. bq500410AEVM-085EVM Schematic, Page 1 of 3

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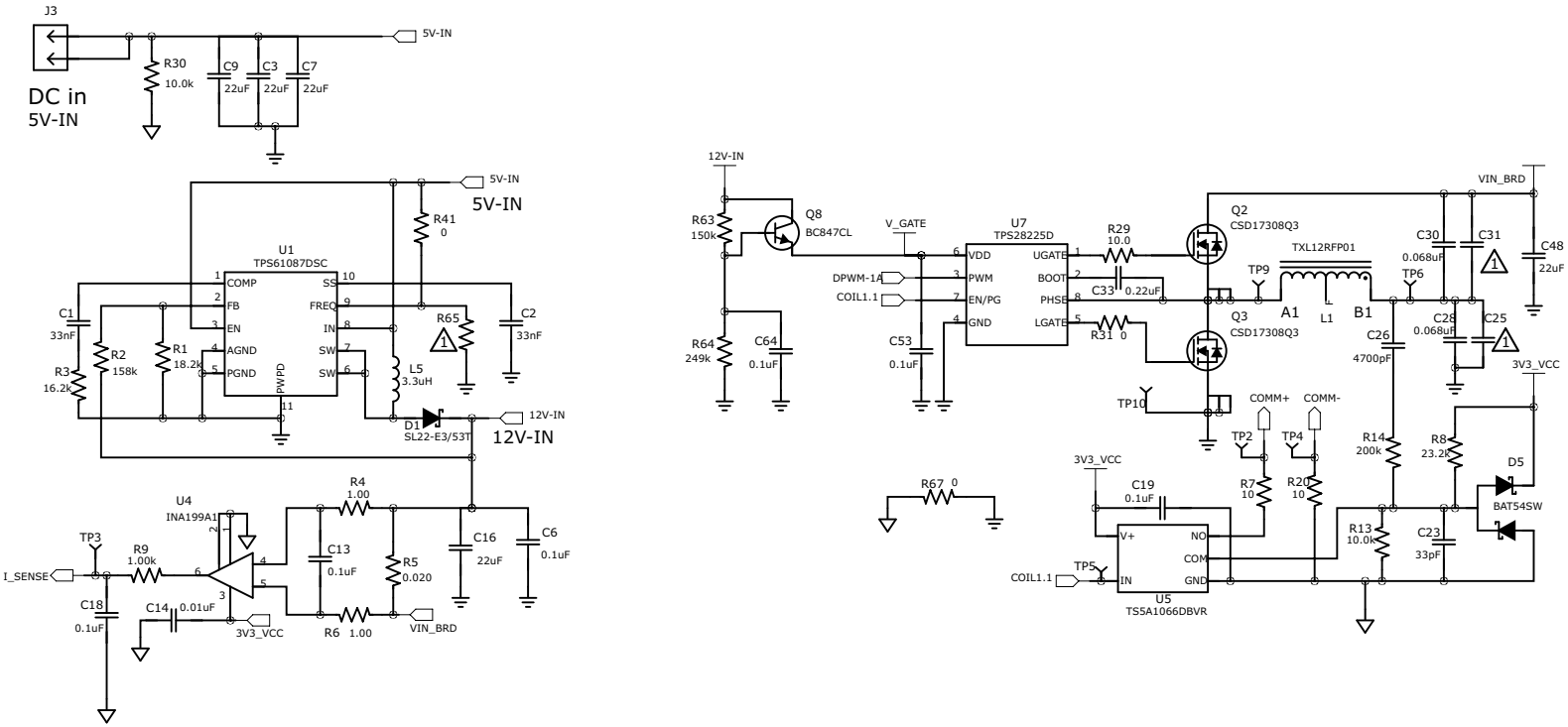


Figure 2. bq500410AEVM-085 Schematic, Page 2 of 3

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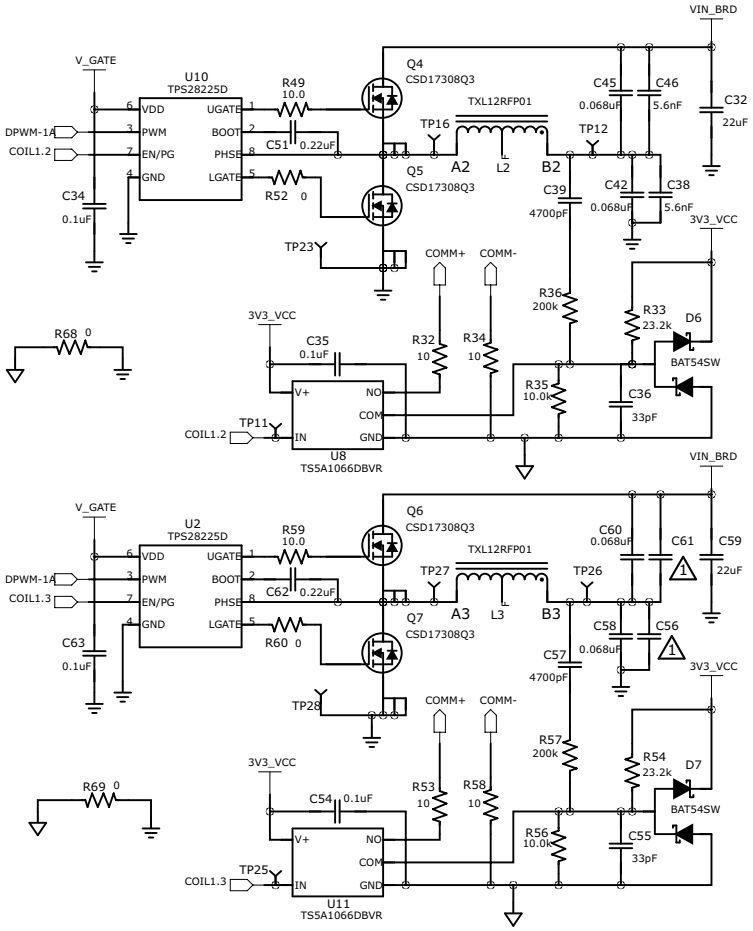


Figure 3. bq500410AEVM-085 Schematic, Page 3 of 3

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Table 2. Bill of Materials

QTY	Ref Des	Value	Description	Size	Part Number	MFR
1	U1	TPS61087DSC	IC, 600 kHz/1.2 MHz Step-Up DC-DC Converter	SON-10	TPS61087DSC	TI
3	U2 U7 U10	TPS28225D	IC, High Frequency 4-Amp Sink Synchronous Buck MOSFET Driver	SO8	TPS28225D	TI
1	U3	TPS54231D	IC, 2-A, 28-V Input, Step-down Swift DC/DC Converter W/ eco-Mode	SO8	TPS54231D	TI
1	U4	INA199A1	IC, Current Monitor, High or Low Side Measurement, Bi-Directional Zero-Drift Series	SC-70	INA199A1DCKR	TI
3	U5 U8 U11	TS5A1066DBVR	IC, 10-Ω SPST Analog Switch	SOT23-5	TS5A1066DBVR	TI
1	U6	MSP430G2101	IC, Mixed Signal Microcontroller	TSSOP	MSP430G2101IPW14	TI
1	U9	bq500410ARGZ	IC, Qi Compliant Wireless Power Transmitter Manager	VQFN	bq500410ARGZ	TI
1	BUZ	Buzzer	Piezoelectronic, 12 mm	12 mm	PS1240P02CT3	TDK
2	C1-2	33 nF	Capacitor, ceramic, 50 V, X7R, 10%	0603	STD	STD
7	C3 C7 C9 C16 C32 C48 C59	22 µF	Capacitor, ceramic, 25 V, X5R, 20%	1210	Std	STD
1	C4	10 µF	Capacitor, ceramic, 35 V, X5R, 20%	1210	Std	STD
15	C5-6 C8 C13 C15 C17-19 C34-35 C52-54 C63-64	0.1 µF	Capacitor, ceramic, 50 V, X7R, 10%	0603	STD	STD
4	C11 C41 C47 C49	1.0 µF	Capacitor, ceramic, 16 V, X7R, 20%	0603	STD	STD
0	C12	Open	Capacitor, ceramic, 50 V, C0G, 5%	0603	STD	STD
3	C20 C44 C50	4.7 µF	Capacitor, ceramic, 10 V, X5R, 20%	0603	STD	STD
1	C21	2700 pF	Capacitor, ceramic, 50 V, C0G, 5%	0603	STD	STD
1	C22	47 µF	Capacitor, ceramic, 6.3 V, X5R, 20%	1206	STD	STD
3	C24 C10 C14	0.01 µF	Capacitor, ceramic, 50 V, X7R, 10%	0603	STD	STD
0	C25 C56 C31 C61	Open	Capacitor, ceramic, 100 V, C0G, 5%	1210	Std	STD
6	C28 C30 C42 C45 C58 C60	0.068 µF	Capacitor, ceramic, 100 V, C0G, 5%	1812	Std	Std
1	C29	1000 pF	Capacitor, ceramic, 16 V, X7R, 20%	0603	STD	STD
3	C36 C55 C23	33 pF	Capacitor, ceramic, 50 V, C0G, 5%	0603	STD	STD
1	C65	47 pF	Capacitor, ceramic, 50 V, COG, 5%	0603	STD	STD
1	C27	2200 pF	Capacitor, ceramic, 16V, X7R, 20%	0603	STD	STD
2	C38 C46	5.6 nF	Capacitor, ceramic, 100 V, C0G, 5%	1210	Std	STD
3	C39 C26 C57	4700 pF	Capacitor, ceramic, 50 V, X7R, 10%	0603	STD	STD
1	C40	330 pF	Capacitor, ceramic, 50 V, X7R, 10%	0603	STD	STD
2	C43 C37	4.7 nF	Capacitor, ceramic, 50 V, X7R, 10%	0603	STD	STD
3	C51 C33 C62	0.22 µF	Capacitor, ceramic, 50 V, X7R, 20%	0603	STD	STD
1	D1	SL22-E3/53T	Diode, Schottky, 2 A, 20 V	SMC	SL22-E3/53T	Vishay
1	D2	MBR0540	Diode, Schottky, 0.5 A, 40 V	SOD-123	MBR0540T1G	On Semi
1	D3	LTST-C190GKT	Diode, LED, Green, 2.1 V, 20 mA, 6 mcd	0603	LTST-C190GKT	Lite On
1	D4	LTST-C155KGJRKT	Diode, Dual LED, Water Clear, 80 mA, 35/25 mcd	0.126 × 0.106 in	LTST-C155KGJRKT	Lite On
4	D5-8	BAT54SW	Diode, Dual Schottky, 200 mA, 30 V	SOT523	BAT54SWT1G	On Semi
4	J1-3, J6	PEC02SAAN	Header, Male 2-pin, 100 mil spacing,	0.100 in × 2	PEC02SAAN	Sullins
1	J4	N2510-6002-RB	Connector, Male Straight 2 × 5 pin, 100 mil spacing, 4 wall	0.338 × 0.788 in	N2510-6002RB	3M
1	J5	N2514-6002-RB	Header, 2 × 7 pin, 100 mil spacing, straight, 4 wall	0.338 × 0.988 in	N2514-6002-RB	3M
2	JP1-2	PEC02SAAN	Header, Male 2-pin, 100 mil spacing,	0.100 in × 2	PEC02SAAN	Sullins
1	L1-3	TX Coil	WPC-Compliant A6 TX Coil Set	Note 1A	Y31-60037F	E&E
		TX Coil	WPC-Compliant A6 TX Coil Set	Note 1B	or 760308106	Wurth Elektronik

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Table 2. Bill of Materials (continued)

QTY	Ref Des	Value	Description	Size	Part Number	MFR
1	L4	330uH	Inductor, SMT, 155 mA, 1.8 Ω	0.189 × 0.189 in	LPS5030-334MLB	Coilcraft
		330uH	Inductor, SMT, 170mA, 1.7 ohm	4.8mm x 4.8mm	or 744043331	Wurth Electronik
1	L5	3.3uH	Inductor, SMT, 3.3uH, 4.2A, 24 mΩ	7.3mm x 7.3mm	7447789003	Wurth Elektronik
2	Q1 Q9	BSS215P	MOSFET P-CH, 20 V, 1.5 A, SOT-23	SOT23	BSS215P	Infineon
6	Q2-7	CSD17308Q3	MOSFET, NChan, 30 V, 13 A, 9.4 mΩ	QFN3.3 × 3.3 mm	CSD17308Q3	TI
1	Q8	BC847CL	TRANSISTOR, NPN, HIGH-PERFORMANCE, 500 mA	SOT-23	BC847CLT1G	ON Semi
1	R1	18.2 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R2	158 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R3	16.2 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R5	0.02 Ω	Resistor, chip, 1/4W, 1%	0805	ERJ-6BWFR020V	Panasonic
1	R9	1.00 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R10	3.16 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R12	76.8 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
0	R17 R28 R19 R42 R44-45 R65	Open	Resistor, chip, 1/16W, 1%	0603	Std	Std
3	R18 R15-16	475 Ω	Resistor, chip, 1/16W, 1%	0603	Std	Std
3	R14 R36 R57	200 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
2	R23, R4 R6	1 Ω	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R26	49.9 Ω	Resistor, chip, 1/16W, 1%	0603	Std	Std
11	R29 R49-50 R22 R59, R7 R20 R32 R34 R53 R58	10 Ω	Resistor, chip, 1/16W, 1%	0603	Std	Std
3	R33 R8 R54	23.2 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R37	15.4 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R38	2.00 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R39	42.2 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R40	56.2 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R43	22 Ω	Resistor, chip, 1/10W, 1%	0805	STD	STD
1	R47	100 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
8	R52 R41 R60 R31 R66-69	0 Ω	Resistor, chip, 1/16W	0603	Std	Std
15	R55 R13 R21 R24 R25 R27 R30 R35 R46 R48 R51 R11 R56 R62 R70	10.0 kΩ	Resistor, chip, 1/16W, 1%	0603	STD	STD
1	R61	10 kΩ	Resistor, Network 9 Pin, 10 kΩ, 200 mW, 2%	SIP-9	4309R-101-103LF	Bourns
1	R63	150 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R64	249 kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
Notes:	1. E&E Magnetic Products, Ltd.: Sales 852-29543333 Tel (Hong Kong) www.eleceltek.com US Sales Contact Darren Simmons 408-727-4223 Cell 707-363-2448 darren_a_simmon@eleceltek.com					
	1B. Wurth Elektronik, Oliver Opitz, Oliver.Opitz@we-online.de					

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6 Test Setup

6.1 Equipment

6.1.1 bqTESLA™ Receiver

Use the bq51013AEVM-764, -765 or Qi-compliant receiver to work with this EVM.

6.1.2 Voltage Source

Input voltage source must provide regulated dc voltage of 12 V and be able to deliver at least 1.0 A continuous load current; the current limit must be set to 2.0 A.

CAUTION

Safety Considerations of Voltage Source: 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 for 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, 22-AWG wire is recommended when connecting the bq500410AEVM-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 Vin 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 load with an ammeter, and monitor the current to load at TP7. All voltmeters must be Kelvin connected (at the pin) to the point of interest.

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6.2.1 Equipment Setup Diagram

The diagram in Figure 4 shows the test setup.

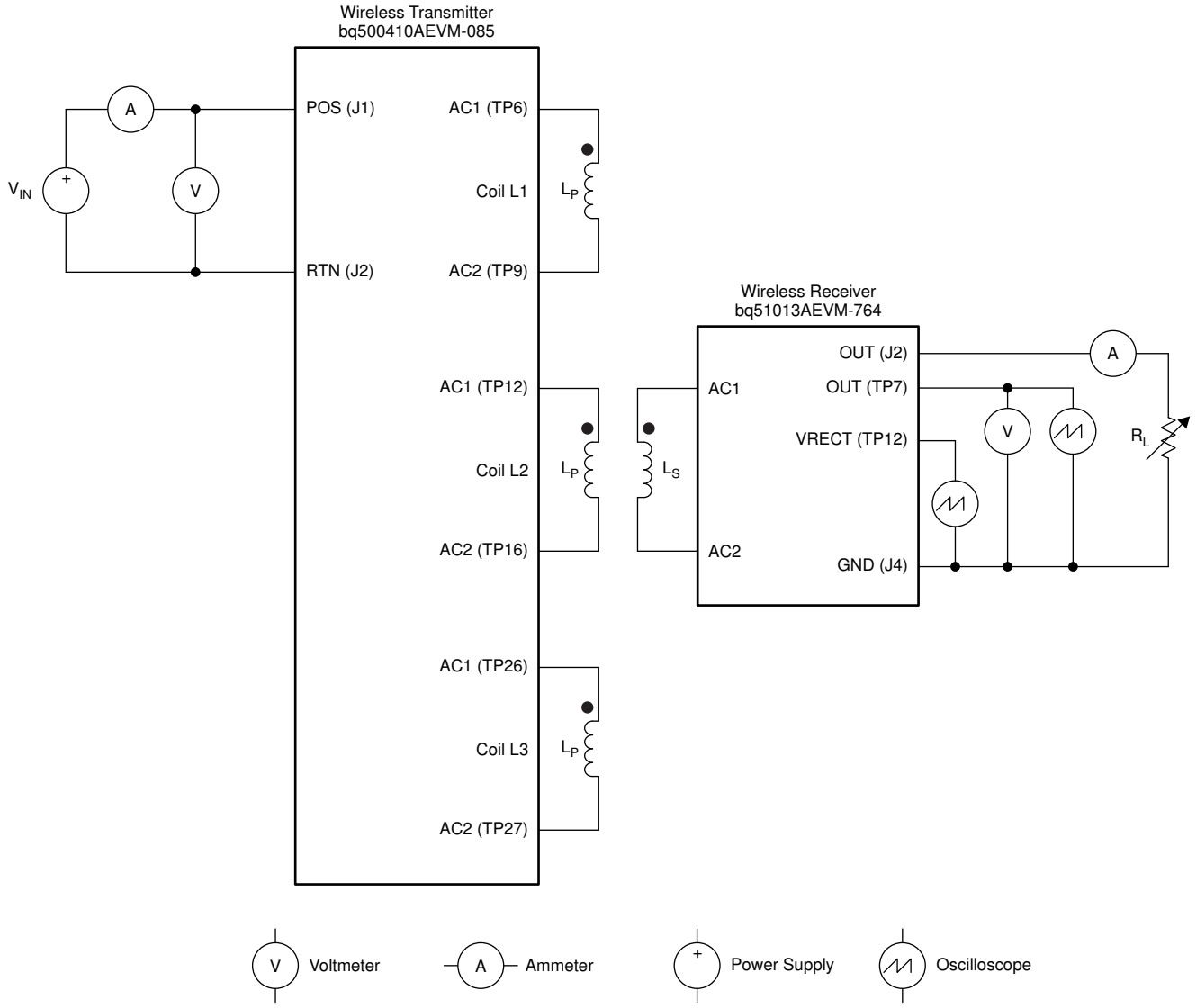


Figure 4. Equipment Setup

6.2.2 EVM Procedures

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

6.2.2.1 Start-Up No Receiver

Turn on V_{IN}, and observe that the green, Power LED, D3, illuminates. Status LED, D4, is off until the power transfer starts.

Apply the scope probe to the test point, TP12, 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.

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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, D4, illuminates green, indicating that communication between the transmitter and the receiver is established and that the power transfer has started.

- The TX buzzer sounds at the start of power transfer. 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 drive waveform on the test point, TP1, when power transfer is active; the frequency is between 110 kHz and 205 kHz depending on load.
- Make tests and measurements applicable to a normal 5-V power supply.

6.2.2.3 Efficiency

To calculate 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.

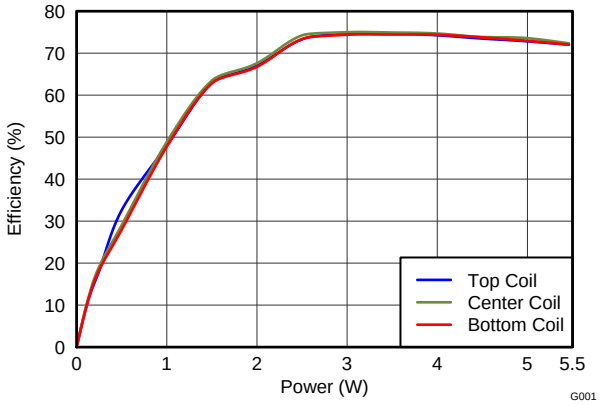


Figure 5. Efficiency Versus Power Across Each Coil, bq500410AEVM-085 Transmitter and bq51013AEVM-764 Receiver

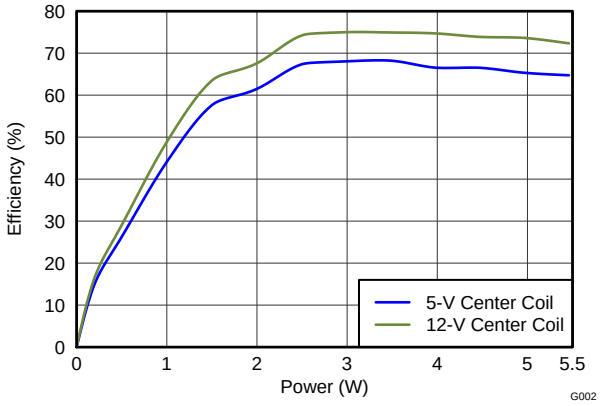


Figure 6. Efficiency Versus Power Center Coil 12-V Input Versus 5-V Input, bq500410-085 Transmitter and bq51013AEVM-764 Receiver

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6.2.2.4 Parasitic Metal Object Detection (PMOD)

This is a safety feature used to detect the presence of a metal object on the charging pad near the TX coil, significant thermal rise is possible on the object. The PMOD circuit compares transmitter power with the power the receiver reports it has received. If the difference exceeds the threshold set by R40 a fault is declared. See the data sheet for additional information on this feature.

6.2.2.5 Thermal Protection, NTC

Thermal protection is provided by an NTC resistor connected to J6. At 1 V on the sense side, U9-2, the thermal fault is set, and the unit is shut down, The Status LED, D4, illuminates red. Typical resistor value for fault is 850 Ω. The system tries to restart in 5 minutes.

7 bq500410AEVM-045 Assembly Drawings and Layout

Figure 8 through Figure 13 show the design of the bq500410AEVM PCB. The EVM has been designed using a 4-layer, 2-oz, copper-clad circuit board 13.9 cm x 13.3 cm with all components on the top side to allow the user to easily view, probe, and evaluate the bq500410A 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. Gerber files are available for download from the EVM product folder.

A 4 layer PCB design is recommend to provide a good low noise ground plane for all circuits. 2-layer PCB presents a high risk of poor performance.

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.

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

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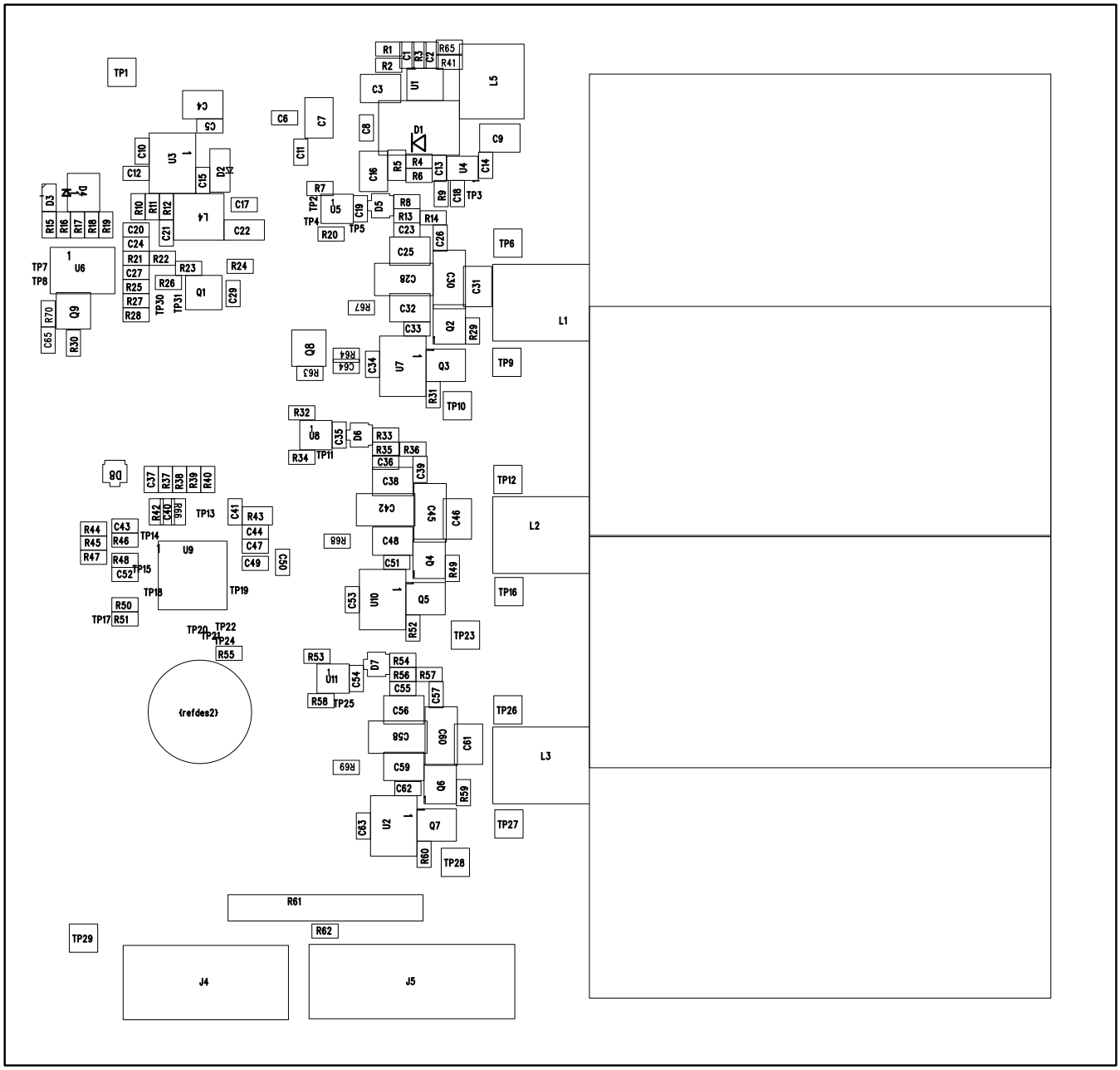


Figure 7. Placement

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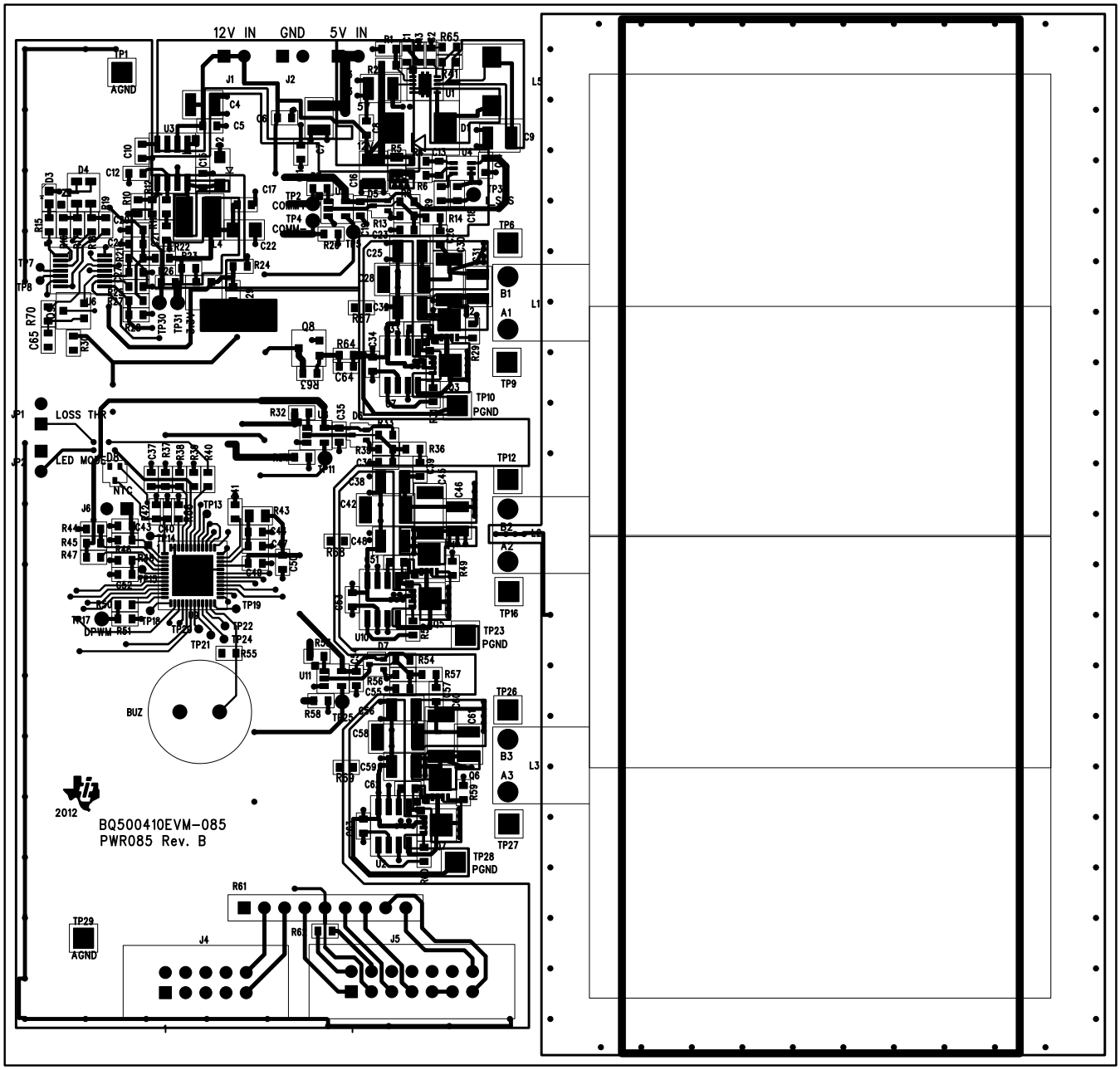


Figure 8. Assembly Top

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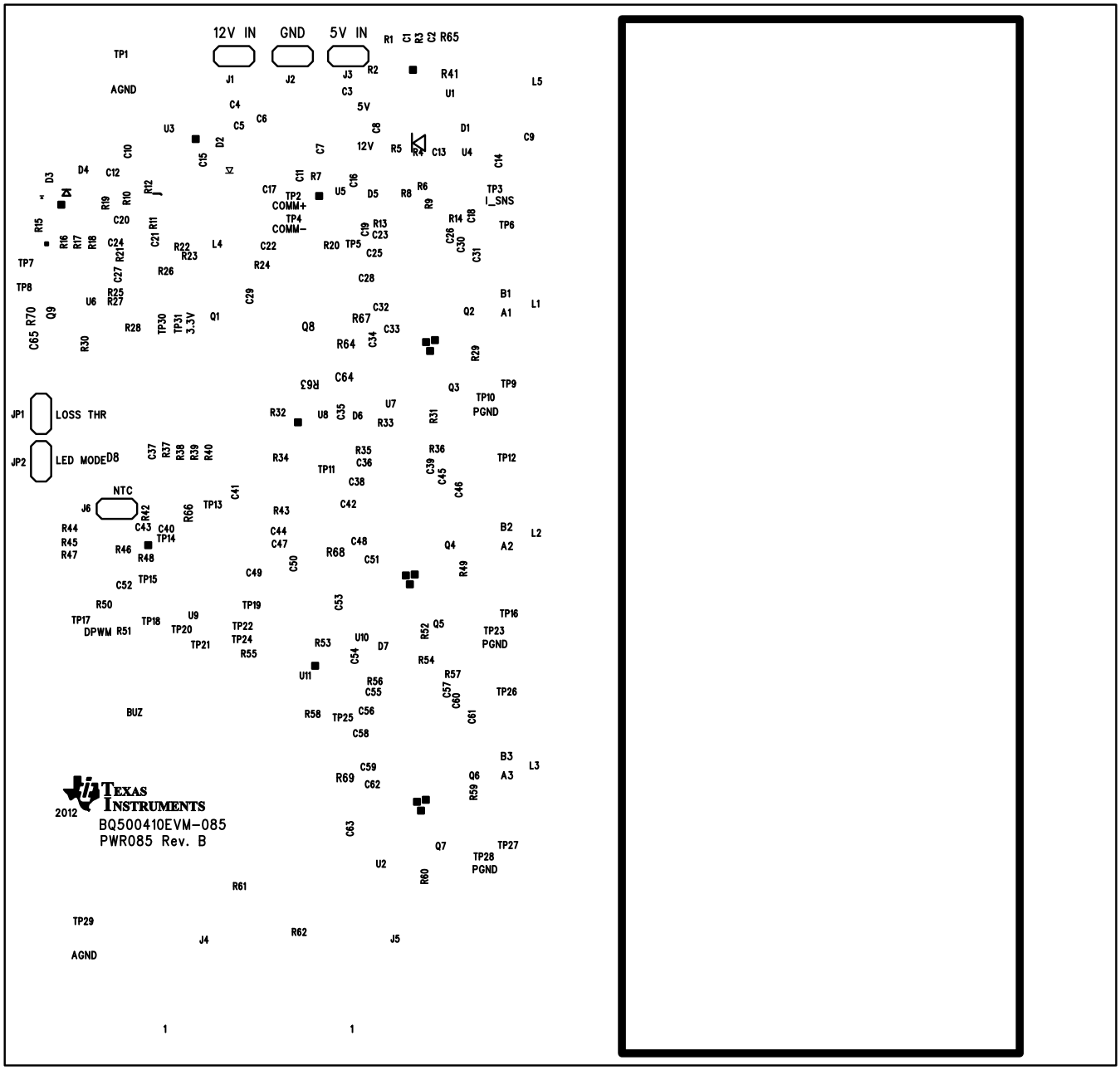


Figure 9. Top Silk

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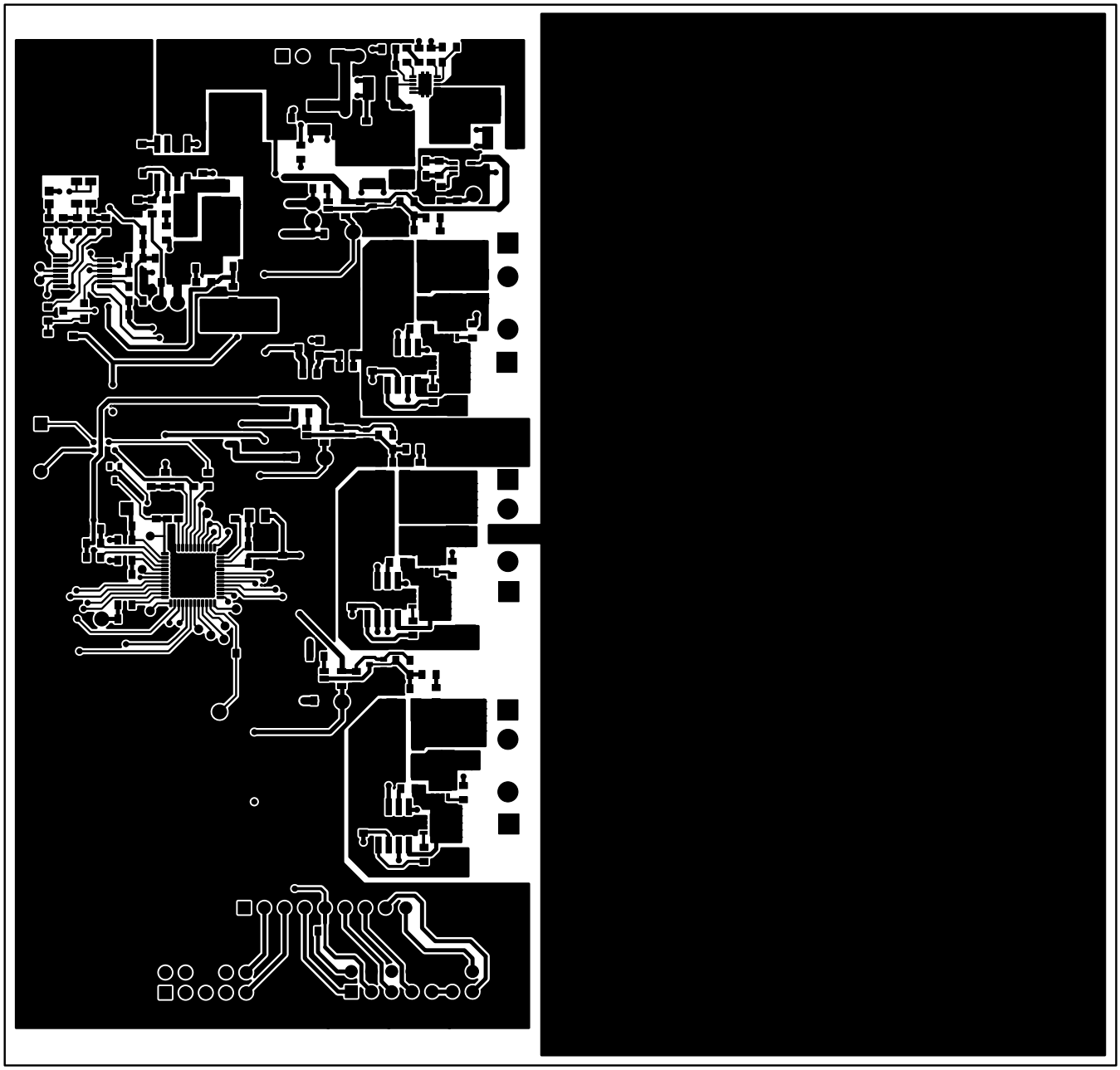


Figure 10. Top Layer

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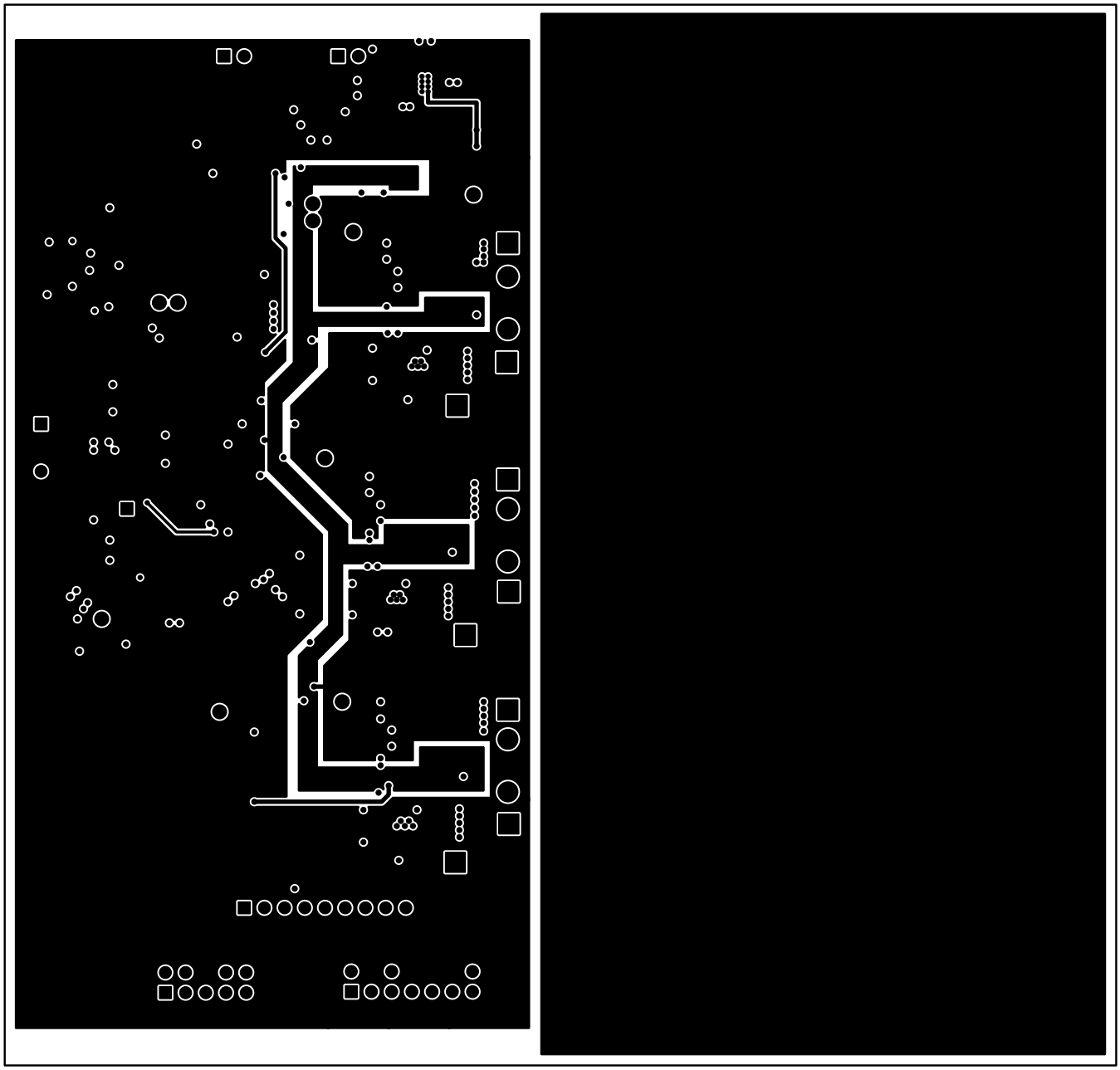


Figure 11. Layer 2

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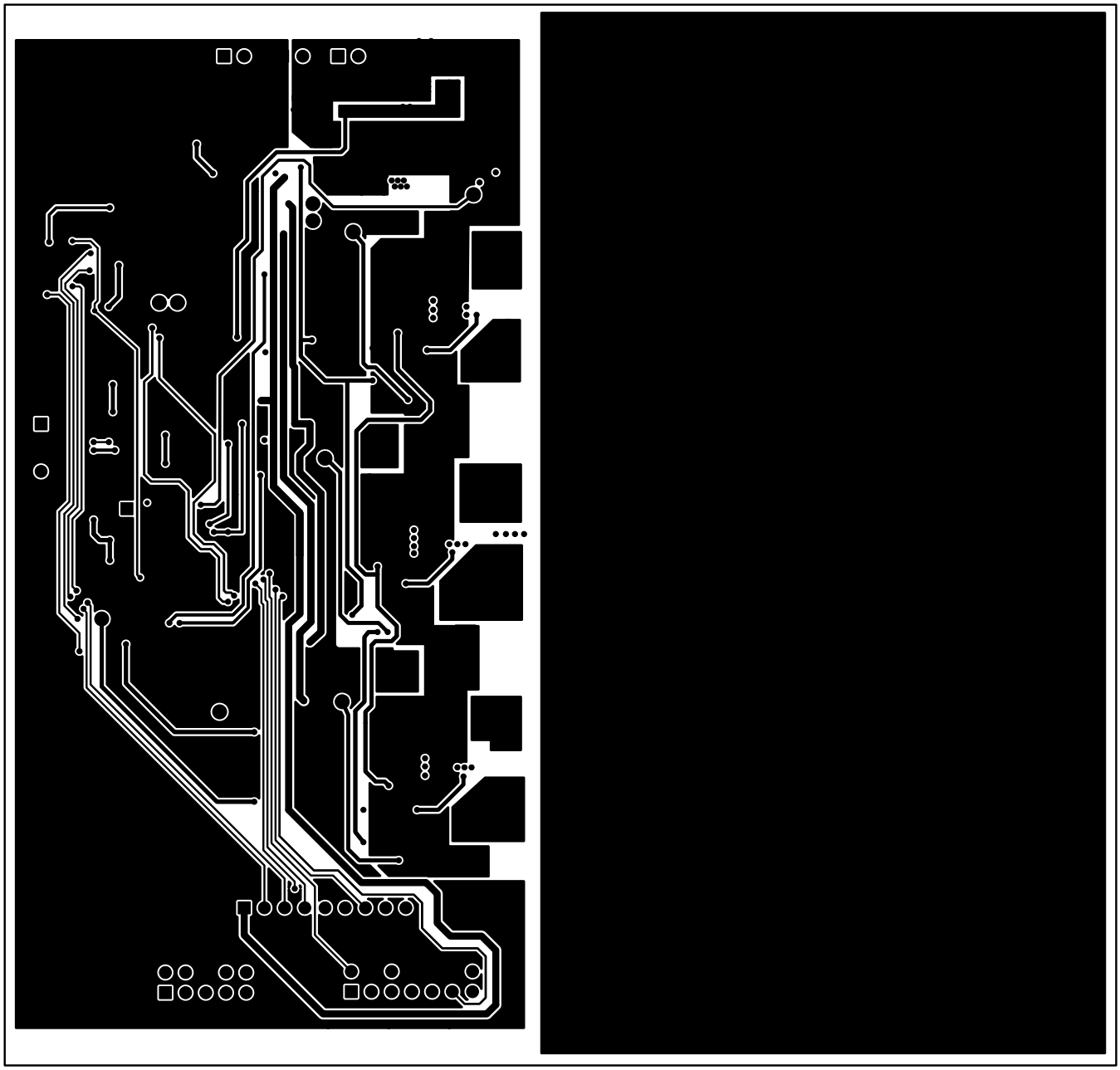


Figure 12. Layer 3

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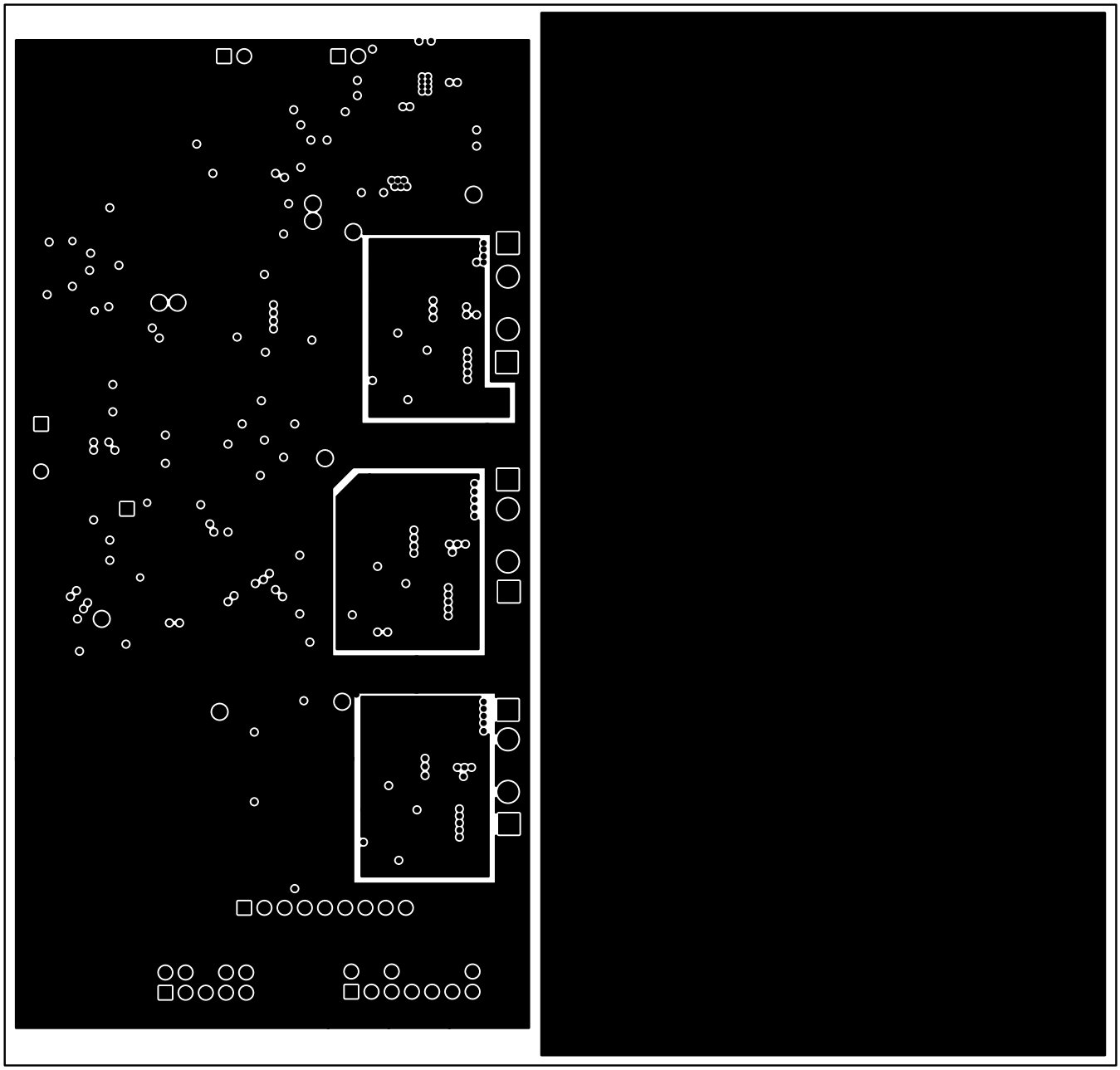


Figure 13. Bottom Layer

8 Reference

For additional information about the bq500410AEVM-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/bq500410A.html.

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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.

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European Union CE Mark

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