bq500412 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 bq500412 EVM evaluation module (EVM) provides all the basic functions of a Qi-compliant three coil, A6 type, wireless charger pad. The EVM is intended to be used with bq51013BEVM-764 or any other Qi-compliant receiver. Both the WPC 1.0 and WPC 1.1 receivers are supported with this design. The bq500412EVM-584 is a 12-V input design with an optional boost convert for operation from 5-V input.

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1 Applications

The bq500412EVM-584 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 only input power for operation, 12 V at 1 A or 5 V at 2.5 A. 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.

This EVM has the following features:

- WPC A6-Type transmitter coil, 70 mm × 25 mm free positioning area
- Input voltage 12 V or 5 V, using optional boost converter
- 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)
- Reduced parts count from the legacy bq500410A design
- Compact power section design using the CSD97374 NexFET power stage
- LED indicates power transfer or power fault state

2 bq500412EVM-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. bq500412EVM-584 Electrical Performance Specifications

Parameter		Notes and Conditions	Min	Typ	Max	Unit
Input Characteristics						
V_{IN}	Input voltage		11.50	12.0	12.50	V
I_{IN}	Input current	V_{IN} = 12 V, RX I_{OUT} = 1 A at 5 V		570	1000	mA
	Input no-load current	V_{IN} = 12 V, I_{OUT} = 0 A		72		mA
	Input stand-by current	V_{IN} = 12 V		18.75		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} = 12 V, P Out RX = 2.5 W		73		%
η	Full-load efficiency	V_{IN} = Nom, I_{OUT} = Max		70		%

3 Modifications

See the datasheet (SLUSB026) when changing components.

Use LED mode – resistor R32 to change the behavior of the status LED, D6, D7 and D8. The standard value is 42.2 kΩ for control option 1, see the datasheet for additional settings.

FOD threshold setting can be changed using R34. If R34 is removed then FOD function is disabled.

PMOD threshold setting can be changed using R35. If R35 is removed then PMOD function is disabled.

FOD_CAL can be used to change the slope of the FOD LOSS curve for better FOD performance, R33.

4 Connector and Test Point Descriptions

4.1 Input/Output Connections

The connection points are described in Section 4.1.1 through Section 4.1.5.

4.1.1 J1 – V_{IN}

Input power 12 V ±200 mV, return at J2.

4.1.2 J2 – GND

Return for input 12 V at J1.

J3 – Input Power 5 V ±100 mV, return at J4.

J4 – Return for 5 V input at J3

4.1.3 J6 –JTAG

Factory use only.

4.1.4 J7 – Serial Interface

Used with bqTESLA TX Tuning Tool Software for FOD set up.

4.1.5 J5 - Micro USB

Input power connector.

4.2 Test Point Descriptions

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

4.2.1 TP1 – DPWM Signal

Digital output signal from bq500412 to H-Bridge drive.

4.2.2 TP2 – I SENSE Signal

Input current-sense voltage, scale 1 V = 0.5 A.

4.2.3 TP3 – COMM + Signal

Sample of coil voltage for communications with RX.

4.2.4 TP4 – COMM - Signal

Sample of coil return for communications.

4.2.5 TP5 – Reserved

Reserved – no connection.

4.2.6 TP6 – Reserved

Reserved – no connection.

4.2.7 TP7 – V SENSE

Voltage sample of bridge voltage, divider ration 76.8 k / 10 k.

4.2.8 TP8 – Buzzer AC Drive

Output from IC to drive AC buzzer, signals start of power transfer.

4.2.9 TP9 – Buzzer DC Drive

Output from IC to drive DC buzzer, signals start of power transfer.

4.2.10 TP10 - V-in

Sample voltage used for DPL, represents 5-V input.

4.2.11 TP11 – Analog Ground

Low-noise analog ground.

4.2.12 TP12 – Analog Ground

Low-noise analog ground

4.2.13 TP13 – Coil 1 Enable Drive

Output from bq500412, low enables coil 1 drive.

4.2.14 TP14 – Coil 2 Enable Drive

Output from bq500412, low enables coil 2 drive.

4.2.15 TP15 – Coil 3 Enable Drive

Output from bq500412, low enables coil 3 drive.

5 Schematic and Bill of Materials

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

Figure 1 and Figure 2 illustrate the schematics for this EVM.

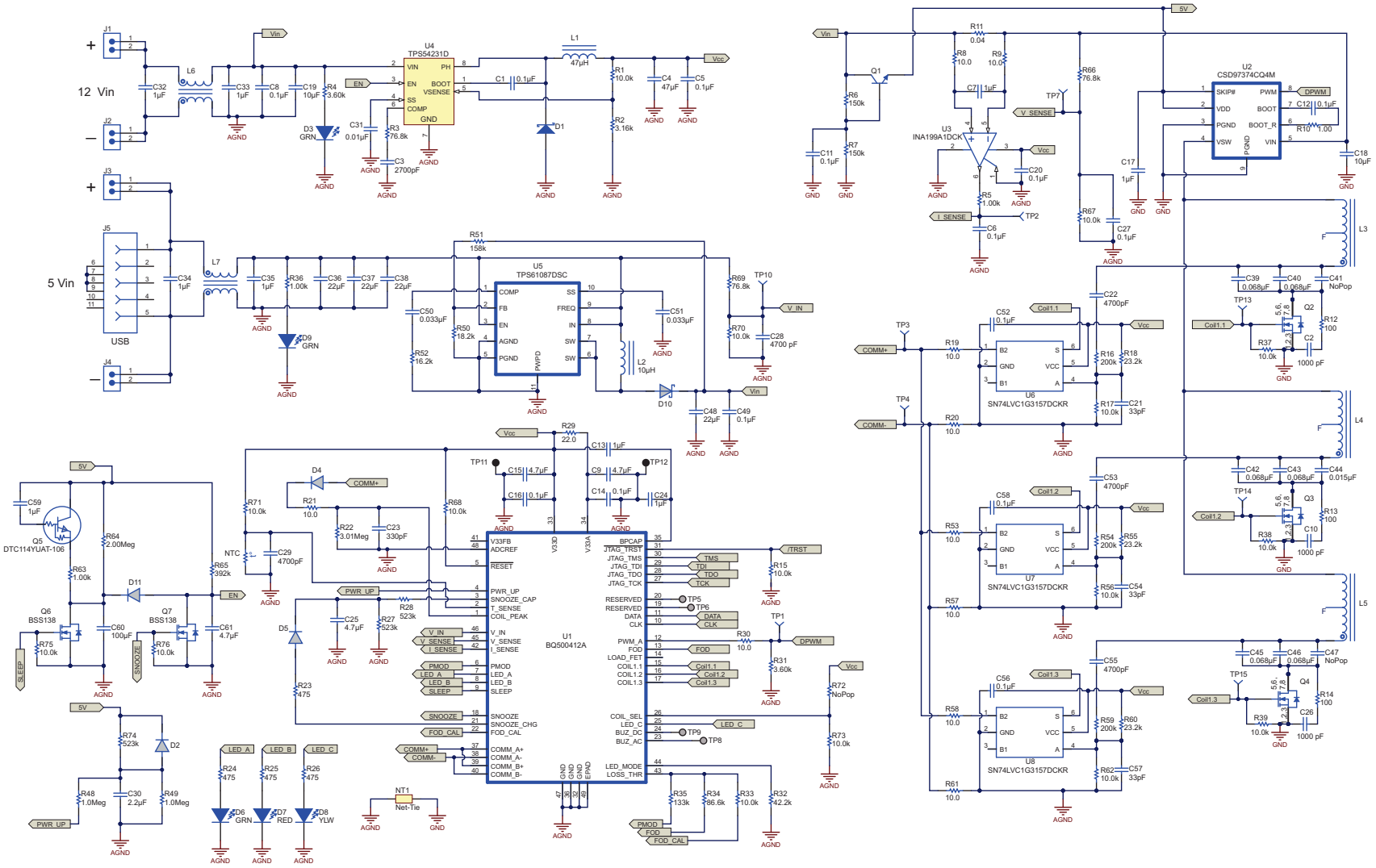


Figure 1. bq500412EVM-584 Schematic (1 of 2)

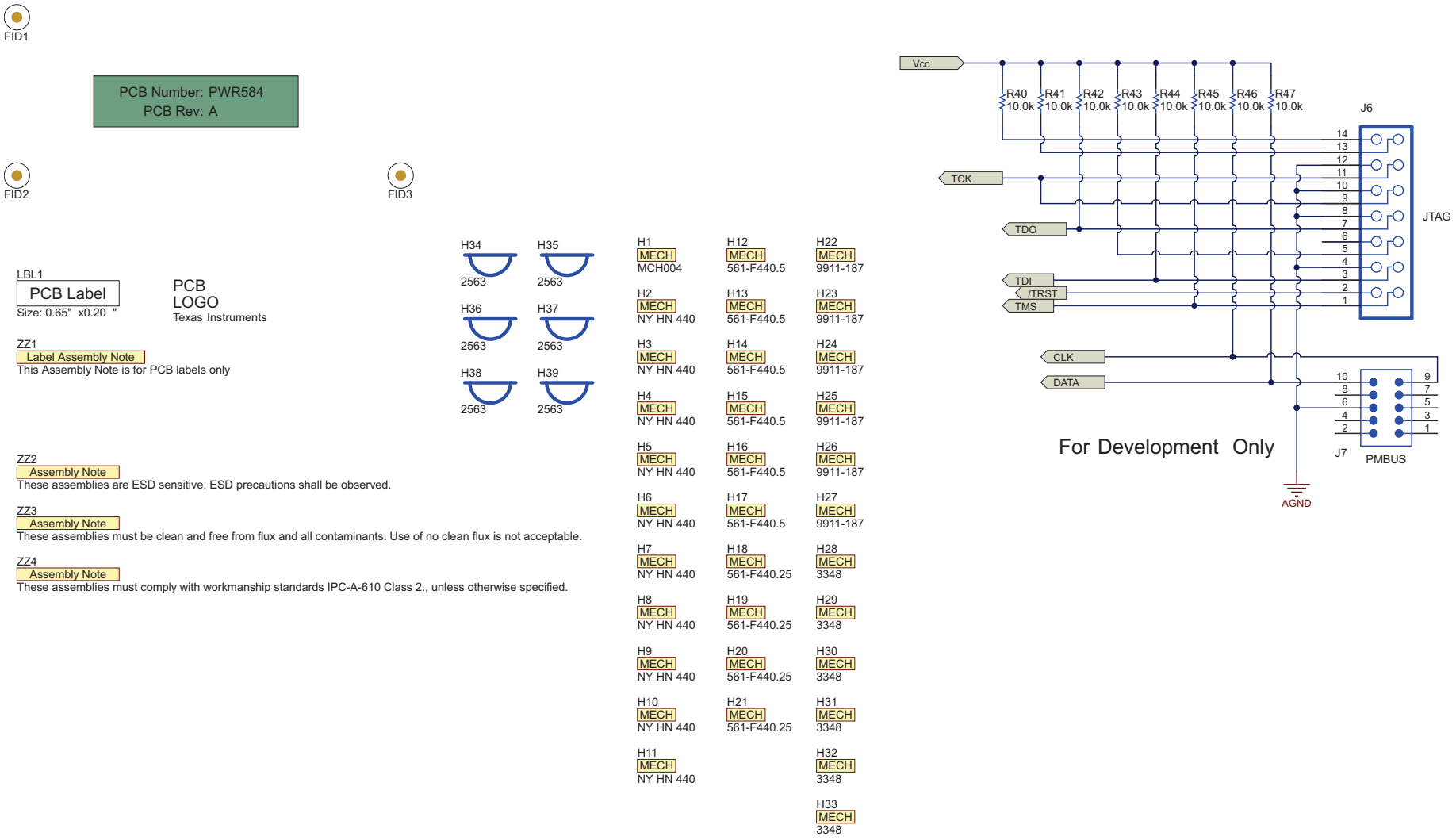


Figure 2. bq500412EVM-584 Schematic (2 of 2)

Table 2 contains the BOM for this EVM.

Table 2. Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
C1, C5, C6, C8, C11, C12, C14, C16, C20, C27, C49, C52, C56, C58	14	0.1uF	CAP, CERM, 0.1uF, 25V, +/-10%, X7R, 0603	0603	C1608X7R1E104K	TDK		
C2, C10, C26	3	1000pF	CAP, CERM, 1000pF, 50V, +/-5%, COG/NPO, 0603	0603	C0603COGG1H102J080	TDK		
C3	1	2700pF	CAP, CERM, 2700pF, 50V, +/-5%, C0G/NP0, 0603	0603	C1608C0G1H272J	TDK		
C4	1	47uF	CAP, CERM, 47uF, 6.3V, +/-20%, X5R, 1206	1206	C3216X5R0J476M	TDK		
C7, C13, C17, C24, C59	5	1uF	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0603	0603	C1608X7R1C105K	TDK		
C9, C15	2	4.7uF	CAP, CERM, 4.7uF, 6.3V, +/-20%, X5R, 0603	0603	C1608X5R0J475M	TDK		
C18, C19	2	10uF	CAP, CERM, 10uF, 16V, +/-20%, X7R, 1210	1210	C3225X7R1C106M	TDK		
C21, C54, C57	3	33pF	CAP, CERM, 33pF, 100V, +/-5%, C0G/NP0, 0603	0603	GRM1885C2A330JA01D	MuRata		
C22, C28, C29, C53, C55	5	4700pF	CAP, CERM, 4700pF, 100V, +/-5%, C0G/NP0, 0805	0805	C2012C0G2A472J	TDK		
C23	1	330pF	CAP, CERM, 330pF, 50V, +/-5%, C0G/NP0, 0603	0603	C1608C0G1H331J	TDK		
C25	1	4.7uF	CAP, CERM, 4.7uF, 10V, +/-20%, X7R, 0805	0805	C2012X7R1A475M	TDK		
C30	1	2.2uF	CAP, CERM, 2.2uF, 10V, +/-10%, X7R, 0603	0603	GRM188R71A225KE15D	MuRata		
C31	1	0.01uF	CAP, CERM, 0.01uF, 25V, +/-5%, C0G/NP0, 0603	0603	C1608C0G1E103J	TDK		
C32, C33, C34, C35	4	1uF	CAP, CERM, 1uF, 25V, +/-10%, X7R, 1206	1206	C3216X7R1E105K	TDK		
C36, C37, C38	3	22uF	CAP, CERM, 22uF, 16V, +/-20%, X5R, 1210	1210	C3225X5R1C226M	TDK		
C39, C40, C42, C43, C45, C46	6	0.068uF	CAP, CERM, 0.068uF, 50V, +/-5%, C0G/NP0, 1206	1206	GRM31C5C1H683JA01L	MuRata	C3216C0G1H683J160AA	TDK
C44	1	0.015uF	CAP, CERM, 0.015uF, 50V, +/-5%, C0G/NP0, 1206	1206	GRM3195C1H153JA01D	MuRata	C3216C0G1H153J060AA	TDK
C48	1	22uF	CAP, CERM, 22uF, 16V, +/-20%, X7R, 1210	1210	C3225X7R1C226M	TDK		
C50, C51	2	0.033uF	CAP, CERM, 0.033uF, 25V, +/-10%, X7R, 0603	0603	GRM188R71E333KA01D	MuRata		
C60	1	100uF	CAP, CERM, 100uF, 6.3V, +/-20%, X5R, 1210	1210	GRM32ER60J107ME20L	MuRata		
C61	1	4.7uF	CAP, CERM, 4.7uF, 16V, +/-10%, X5R, 0805	0805	GRM219R61C475KE15D	MuRata		
D1	1	0.51V	Diode, Schottky, 40V, 0.5A, SOD-123	SOD-123	MBR0540T1G	ON Semiconductor		
D2, D4, D5, D11	4	BAV21WS	Diode, SMD Switching, 200mA, 200V	SOD-323	BAV21WS-7-F	Diodes		
D3, D6, D9	3	GRN	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On		
D7	1	RED	LED, Red, SMD	1.6x0.8x0.8mm	LTST-C190KRKT	Lite-On		
D8	1	YLW	LED, Yellow, SMD	1.6x0.8x0.8mm	LTST-C191KSKT	Lite-On		
D10	1	LS22-E3	Diode, Schottky Rectifier, 2A, 20 V	DO-214AA	LS22-E3	Vishay		
L1	1	47uH	Inductor, Shielded Drum Core, Ferrite, 47uH, 0.25A, 0.94 ohm, SMD	WE-TPC-S	744031470	Wurth Elektronik eiSos		
L2	1	10uH	Inductor, Shielded Drum Core, Ferrite, 10uH, 1.83A, 0.064 ohm, SMD	WE-PD-S	744778910	Wurth Elektronik eiSos		
L3, L4, L5	1	12.5uH	Coil Assembly WPC type A6, Triple coil (L3,L4,L5)	53 mm x 130 mm	760-308-106	Wurth Elektronik		
L6, L7	2	Choke	Inductor, CMC Toroid, 1.5A, 60milliohm	0.197 X 0.197 inch	DLW5BSN102SQ2L	muRata		
NTC	1	10.0k ohm	Thermistor NTC, 10.0k ohm, 1%, 0603	0603	NTCG163JF103F	TDK	-	-
Q1	1	0.7V	Transistor, NPN, 45V, 0.1A, SOT-23	SOT-23	BC847CLT1G	ON Semiconductor	None	None

Table 2. Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
Q2, Q3, Q4	3	MOSFET 60V	MOSFET, N-CH, 60V, 22A, SON 3.3x3.3mm	SON 3.3x3.3mm	FDMC86520L	Fairchild Semiconductor		None
Q5	1	DTC114YUA	Transistor, Digital NPN, 50 V, 100 mA	SC-70	DTC114YUAT-106	Rohm		
Q6, Q7	2	50V	MOSFET, N-CH, 50V, 0.22A, SOT-23	SOT-23	BSS138	Fairchild Semiconductor		None
R1, R15, R17, R33, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R56, R62, R67, R68, R70, R71, R73, R75, R76	24	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0710KL	Yageo America		
R2	1	3.16k	RES, 3.16k ohm, 1%, 0.1W, 0603	0603	RC0603FR-073K16L	Yageo America		
R3, R66, R69	3	76.8k	RES, 76.8k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0776K8L	Yageo America		
R4, R31	2	3.60k	RES, 3.60k ohm, 1%, 0.1W, 0603	0603	RC0603FR-073K6L	Yageo America		
R5, R36, R63	3	1.00k	RES, 1.00k ohm, 1%, 0.1W, 0603	0603	RC0603FR-071KL	Yageo America		
R6, R7	2	150k	RES, 150k ohm, 1%, 0.1W, 0603	0603	RC0603FR-07150KL	Yageo America		
R8, R9, R19, R20, R21, R30, R53, R57, R58, R61	10	10.0	RES, 10.0 ohm, 1%, 0.1W, 0603	0603	RC0603FR-0710RL	Yageo America		
R10	1	1.00	RES, 1.00 ohm, 1%, 0.1W, 0603	0603	RC0603FR-071RL	Yageo America		
R11	1	0.04	RES, 0.04 ohm, 1%, 1W, 2010	2010	CSRN2010FK40L0	Stackpole Electronics Inc		
R12, R13, R14	3	100	RES, 100 ohm, 1%, 0.1W, 0603	0603	CRCW0603100RFKEA	Vishay-Dale		
R16, R54, R59	3	200k	RES, 200k ohm, 1%, 0.1W, 0603	0603	RC0603FR-07200KL	Yageo America		
R18, R55, R60	3	23.2k	RES, 23.2k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0723K2L	Yageo America		
R22	1	3.01Meg	RES, 3.01Meg ohm, 1%, 0.1W, 0603	0603	RC0603FR-073M01L	Yageo America		
R23, R24, R25, R26	4	475	RES, 475 ohm, 1%, 0.1W, 0603	0603	RC0603FR-07475RL	Yageo America		
R27, R28, R74	3	523k	RES, 523k ohm, 1%, 0.1W, 0603	0603	RC0603FR-07523KL	Yageo America		
R29	1	22.0	RES, 22.0 ohm, 1%, 0.1W, 0603	0603	RC0603FR-0722RL	Yageo America		
R32	1	42.2k	RES, 42.2k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0742K2L	Yageo America		
R34	1	86.6k	RES, 86.6k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0786K6L	Yageo America		
R35	1	133k	RES, 133k ohm, 1%, 0.1W, 0603	0603	RC0603FR-07133KL	Yageo America		
R48, R49	2	1.0Meg	RES, 1.0Meg ohm, 5%, 0.1W, 0603	0603	CRCW06031M00JNEA	Vishay-Dale		
R50	1	18.2k	RES, 18.2k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0718K2L	Yageo America		
R51	1	158k	RES, 158k ohm, 1%, 0.1W, 0603	0603	RC0603FR-07158KL	Yageo America		
R52	1	16.2k	RES, 16.2k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0716K2L	Yageo America		
R64	1	2.00Meg	RES, 2.00Meg ohm, 1%, 0.1W, 0603	0603	RC0603FR-072ML	Yageo America		
R65	1	392k	RES, 392k ohm, 1%, 0.1W, 0603	0603	RC0603FR-07392KL	Yageo America		
U1	1	BQ500412RGZ	IC, Qi Compliant Wireless Power Transmitter Manager	VQFN	BQ500412RGZ	TI		None
U2	1	CSD97374CQ4M	IC, Synchronous Buck NexFETPower Stage	QFN	CSD97374CQ4M	TI		None
U3	1		Voltage Output, High or Low Side Measurement, Bi-Directional Zerø-Drift Series Current-Shunt Monitor, DCK0006A	DCK0006A	INA199A1DCK	TI		None
U4	1		Buck Step Down Regulator with 3.5 to 28 V Input and 0.8 to 25 V Output, -40 to 150 degC, 8-Pin SOIC (D), Green (RoHS & no Sb/Br)	D0008A	TPS54231D	TI	Equivalent	None

Table 2. Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
U5	1	TPS61087DSC	IC, 600kHz/1.2MHz Step-Up DC-Dc Converter	SON-10	TPS61087DSC	TI		None
U6, U7, U8	3	SN74LVC1G3157DCKR	IC, SPDT Analog Switch	SC-70	SN74LVC1G3157DCKR	TI		None
C41, C47	0	NoPop	CAP, CERM,	1206				
R72	0	NoPop	RES,	0603				

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 12 V and deliver at least 1-A continuous load current; current limit must be set to 2 A. If 5 V is used, the current should be 2.5 A with a current limit of 3 A.

CAUTION

To help assure safety and 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: 12.0 VDC
Max Current: 2.0 A
Efficiency Level V

Or:

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 and 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. The transmitter input current and voltage can be monitored, 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 3 shows the test setup.

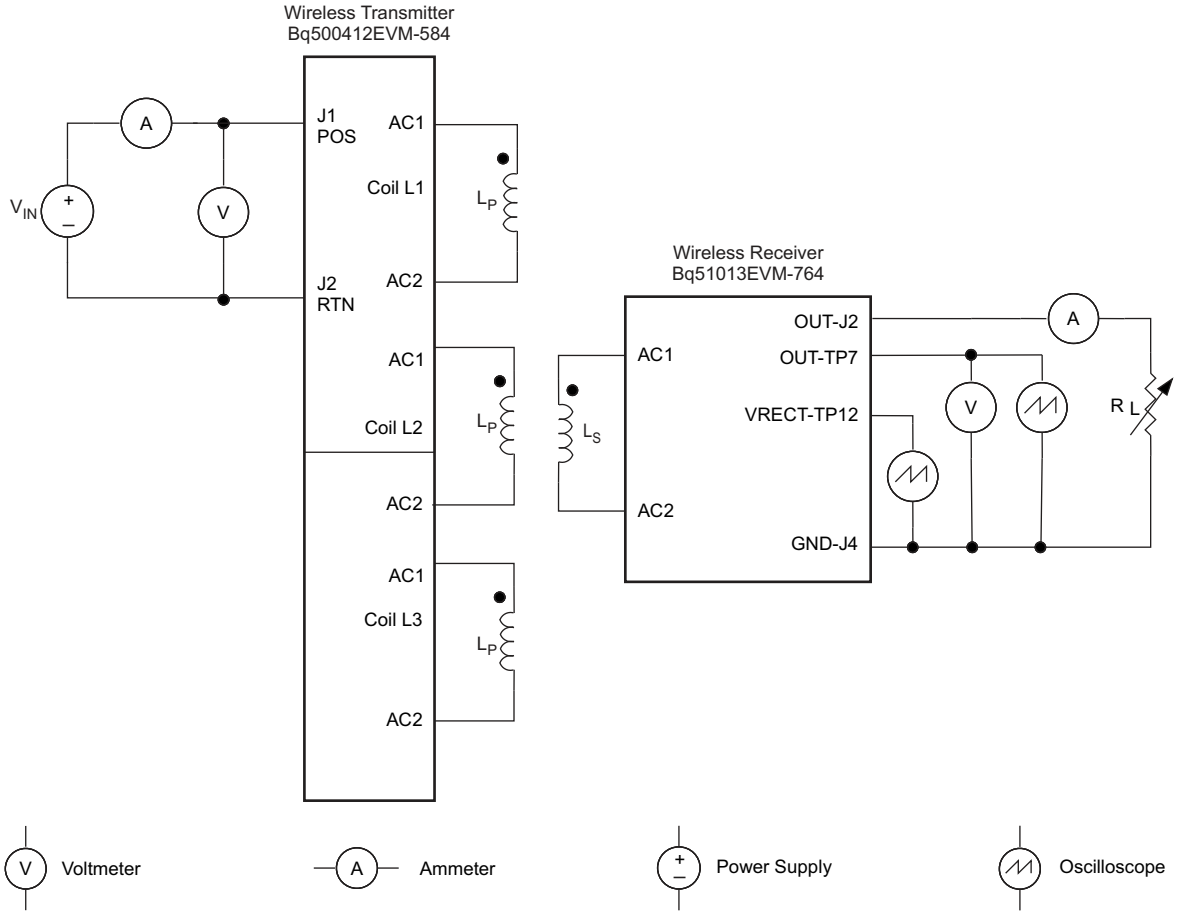


Figure 3. Equipment Setup

6.2.2 EVM Procedures

This section is provided as a guide 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, D3, illuminates. Status LEDs D7, D9 and D5 are OFF until the power transfer starts.

Apply the scope probe to 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, D6, flashes green, indicating that communication between the transmitter and the receiver is established and that power transfer has started.

- The status LED, D6, flashes a green light during power transfer.
- Typical output voltage is 5 V, and the output current range is 0 mA to 1 A.

6.2.2.3 Efficiency

To measure system efficiency, measure the output voltage, 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 3). Average the input current; the comm pulses modulate the input current, distorting the reading. See Figure 4 for efficiency. Figure 4 shows efficiency with standard EVM.

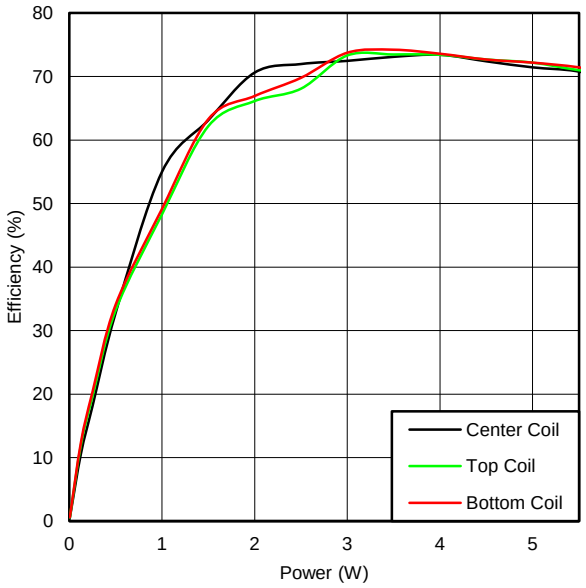


Figure 4. Efficiency versus Power, bq500412EVM-584 Transmitter and HPA764 Receiver

6.2.2.4 Efficiency

Efficiency is affected by changes in the power section. Higher R_{DSON} MOSFET increases loss. This is a design decision and a trade off between cost and performance.

Parts selected for the EVM design are optimized for efficiency.

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, R33 to change along with FOD_Threshold resistor, R34. The 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 network is connected to pin 2. 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 system tries to restart in 5 minutes.

6.2.2.7 Foreign Object Detection

The bq500412 EVM incorporated the 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 R34, 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 45 though R69 and R70. Input current is measured using sense resistor R11 and current sense amp U3. Both measurements must 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, R33. This calculation changes with external component changes in the power path such as MOSFETs, resonate capacitors, and TX coil. Recalculation of R33 and R34 is 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 550 mW, R34 is set to 86.6 kΩ. Increasing R34 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 the unit manufactured by Avid® Technology. Contact Texas Instruments for the FOD calibration procedure for bq500412.

6.2.2.8 WPC Certification

The bq500412EVM-584 was tested and certified to WPC version 1.2.

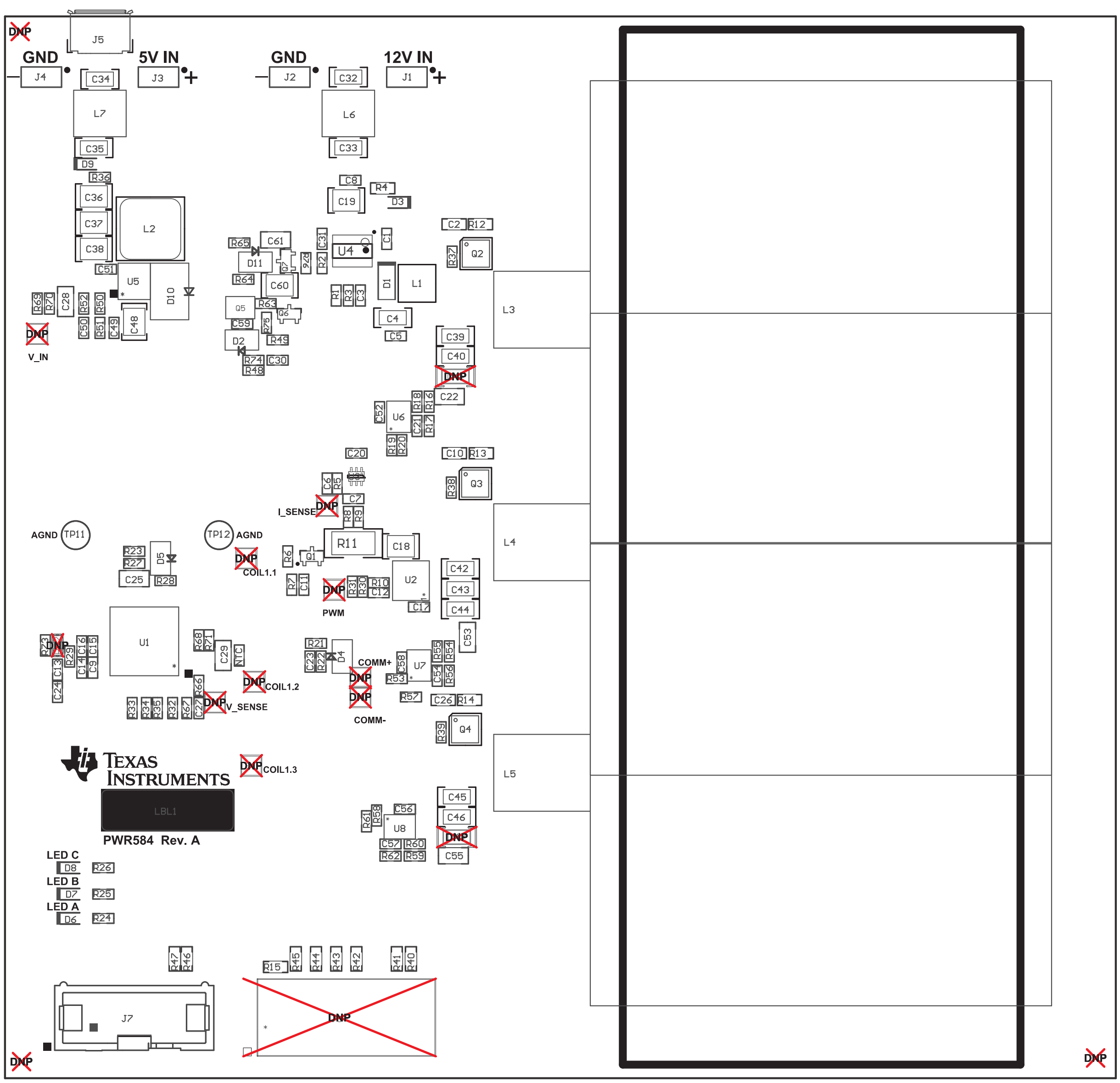
7 bq500412EVM-584 Assembly Drawings and Layout

Figure 5 through Figure 10 show the design of the bq500412EVM PCB. The EVM has been designed using a 4-layer, 2-oz, copper-clad circuit board 14 cm × 13 cm, but components fit into an 8-cm × 5.0-cm area on the top side. All parts are easy to view, probe, and evaluate the bq500412 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 bq500412 GND pin 47, 36, and 32 and filter capacitor returns C15, C16, C9, and C14 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 (0.093 in or 2.4 mm) is the z-gap thickness for the transmitter.



Components marked 'DNP' should not be populated, and may not be listed in the bill of materials.

Figure 5. Assembly Top

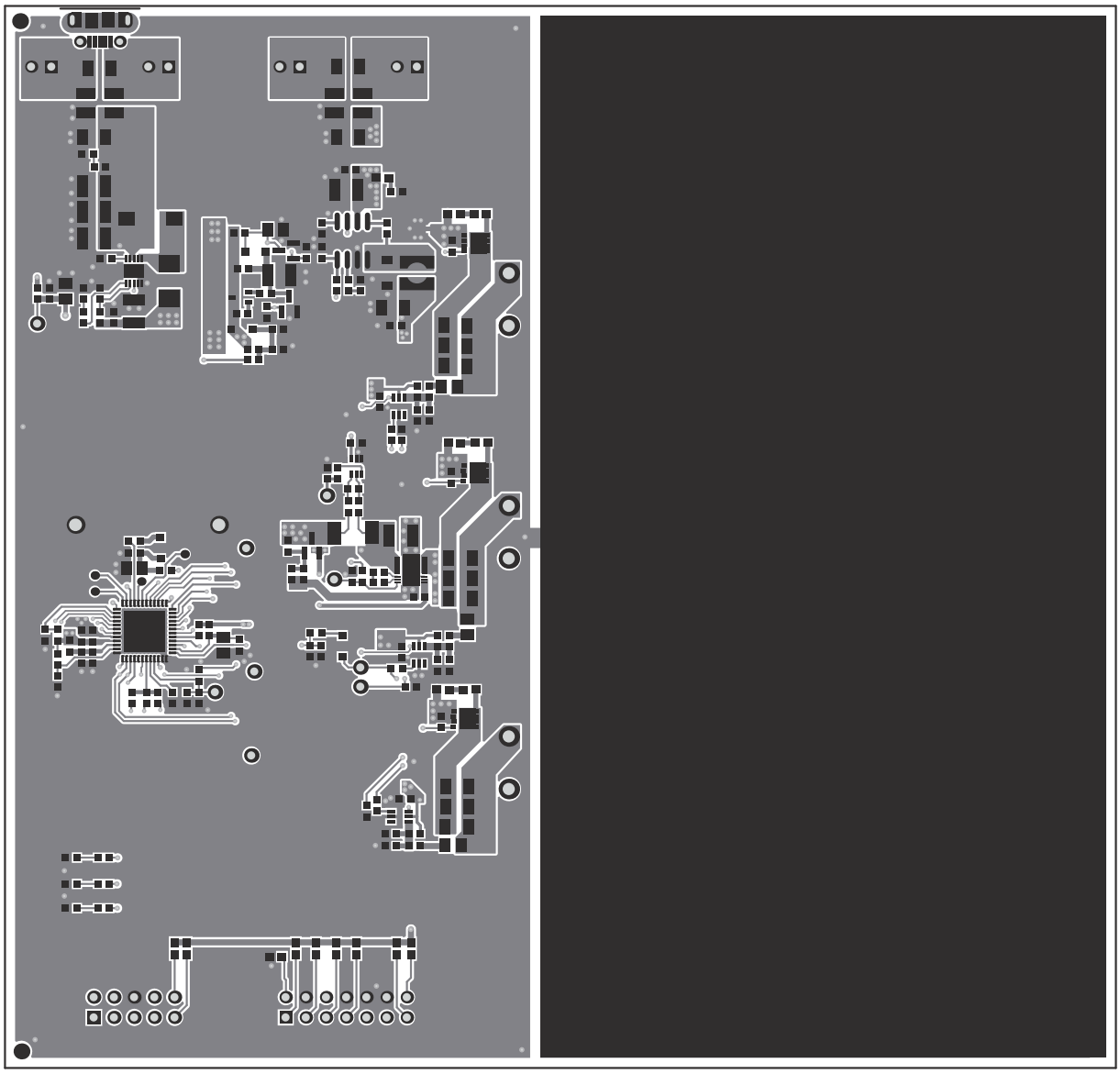


Figure 6. Top Silk

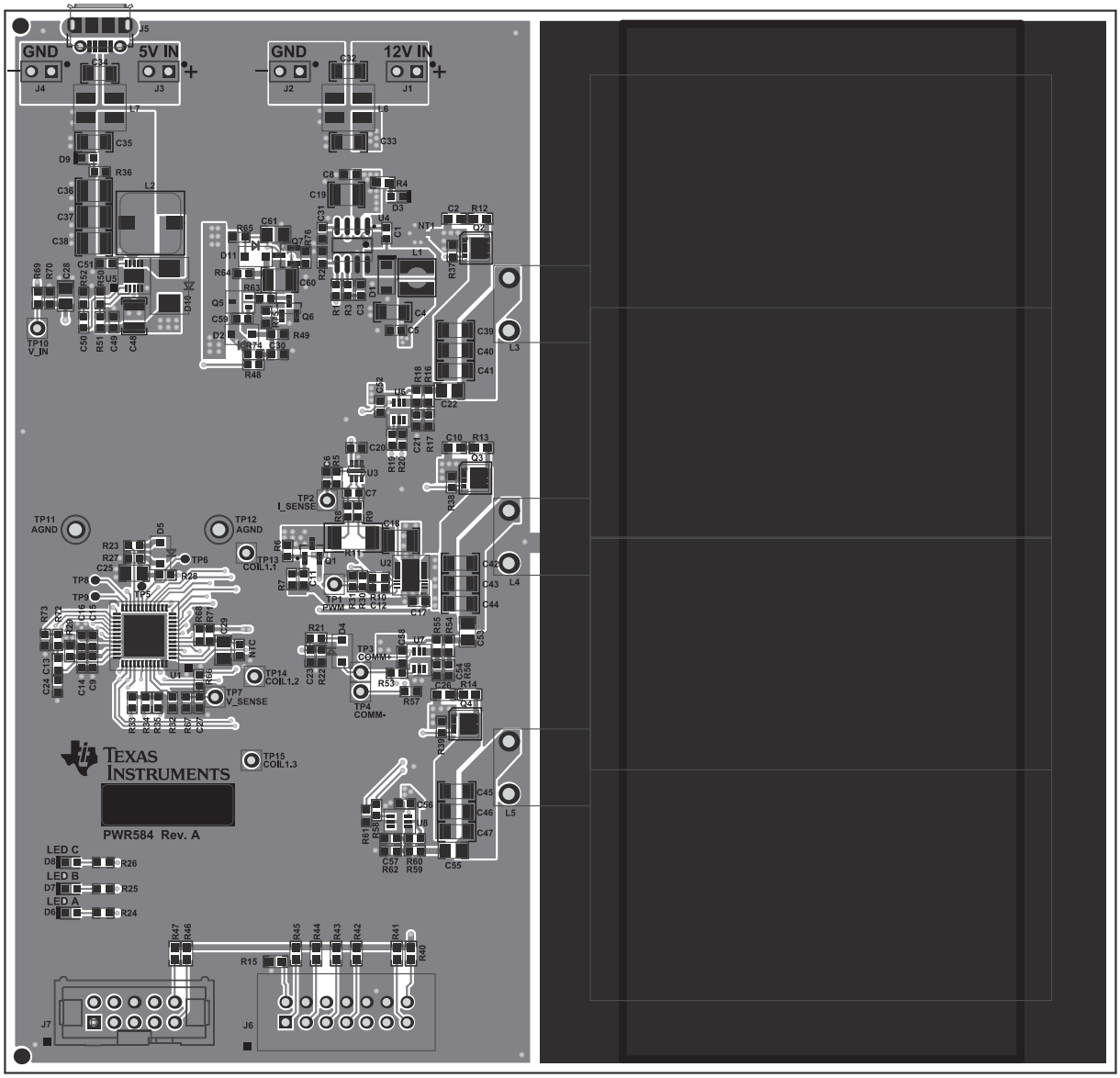


Figure 7. Top Layer

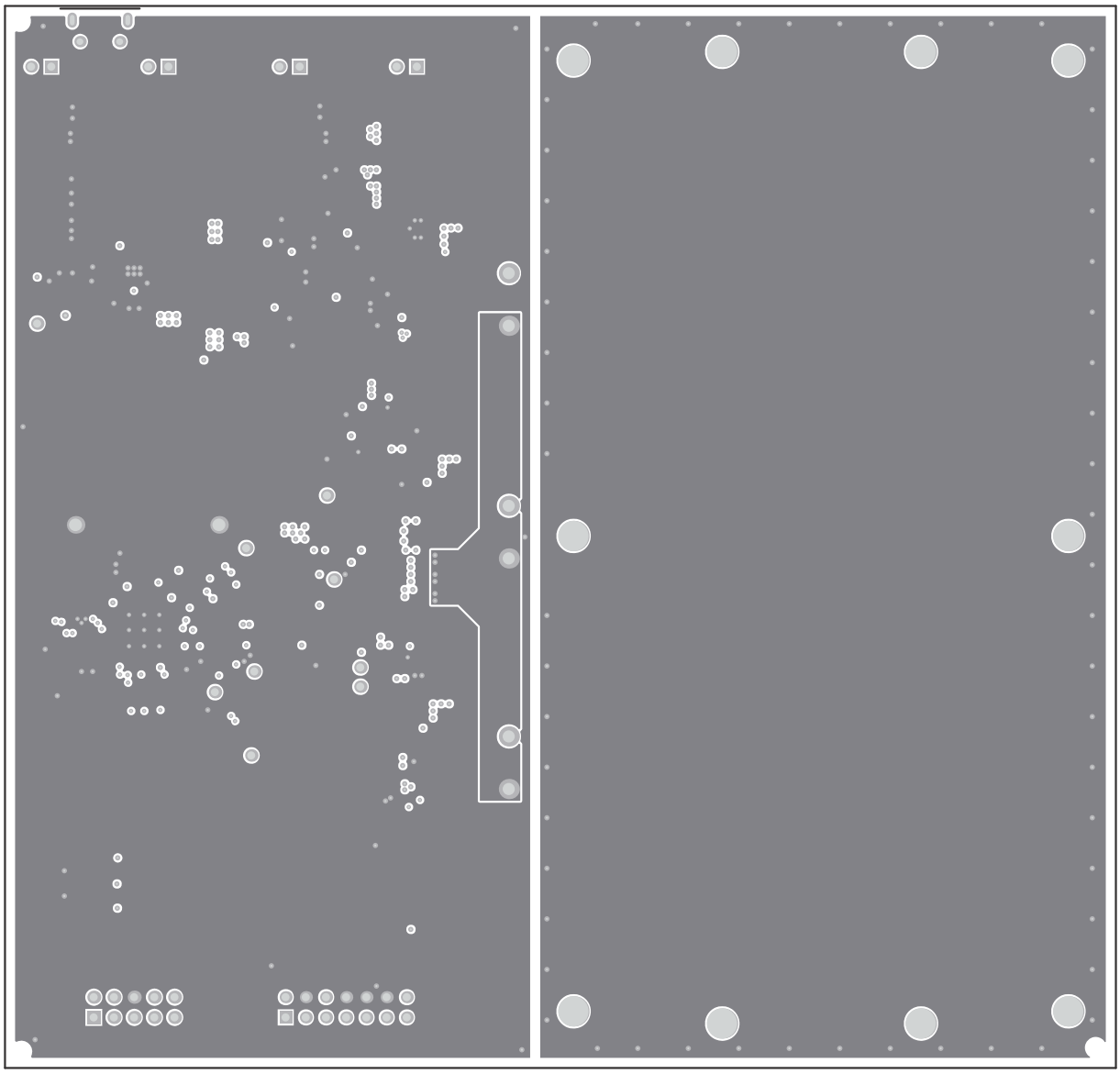


Figure 8. Layer 2

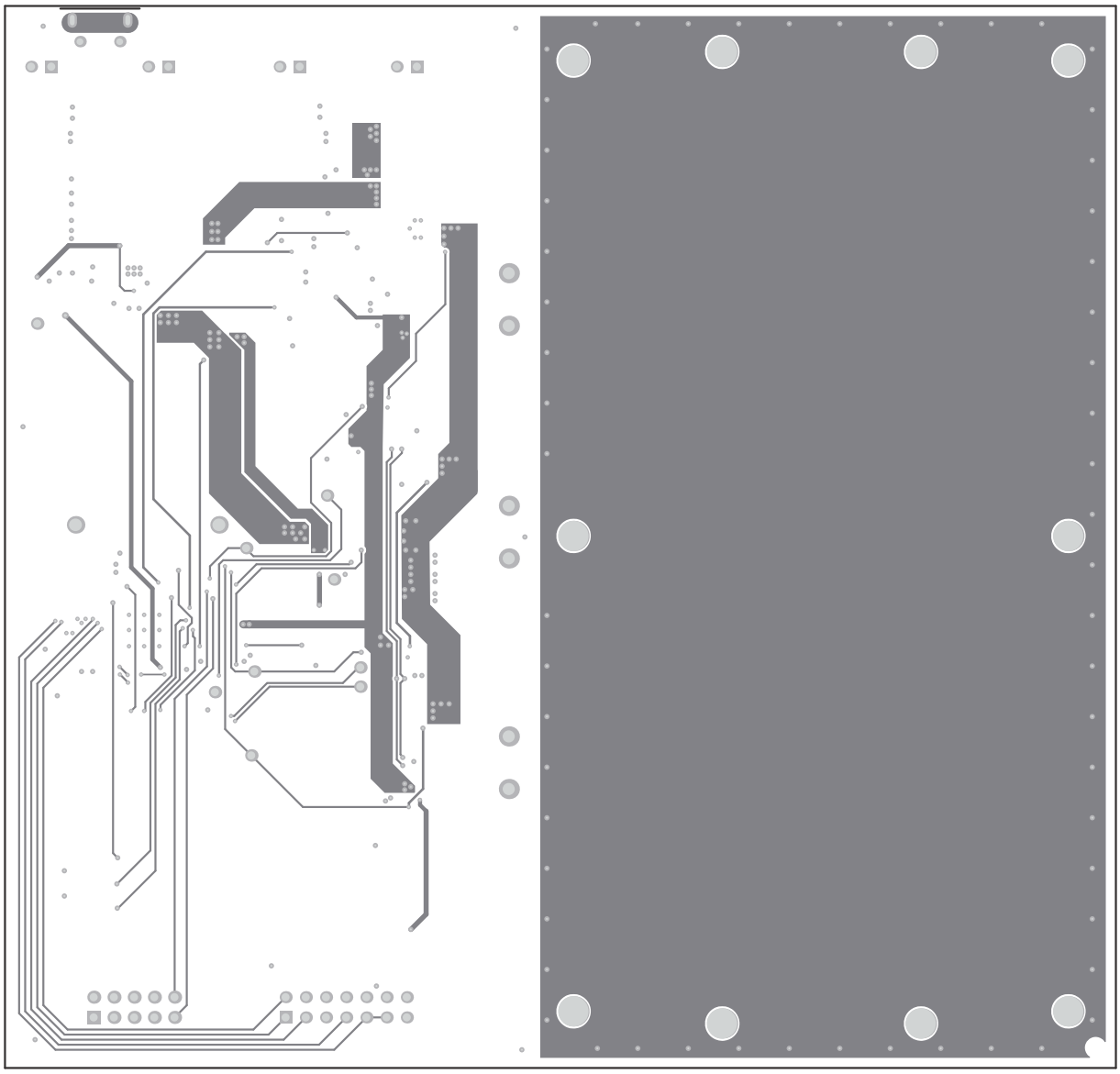


Figure 9. Layer 3

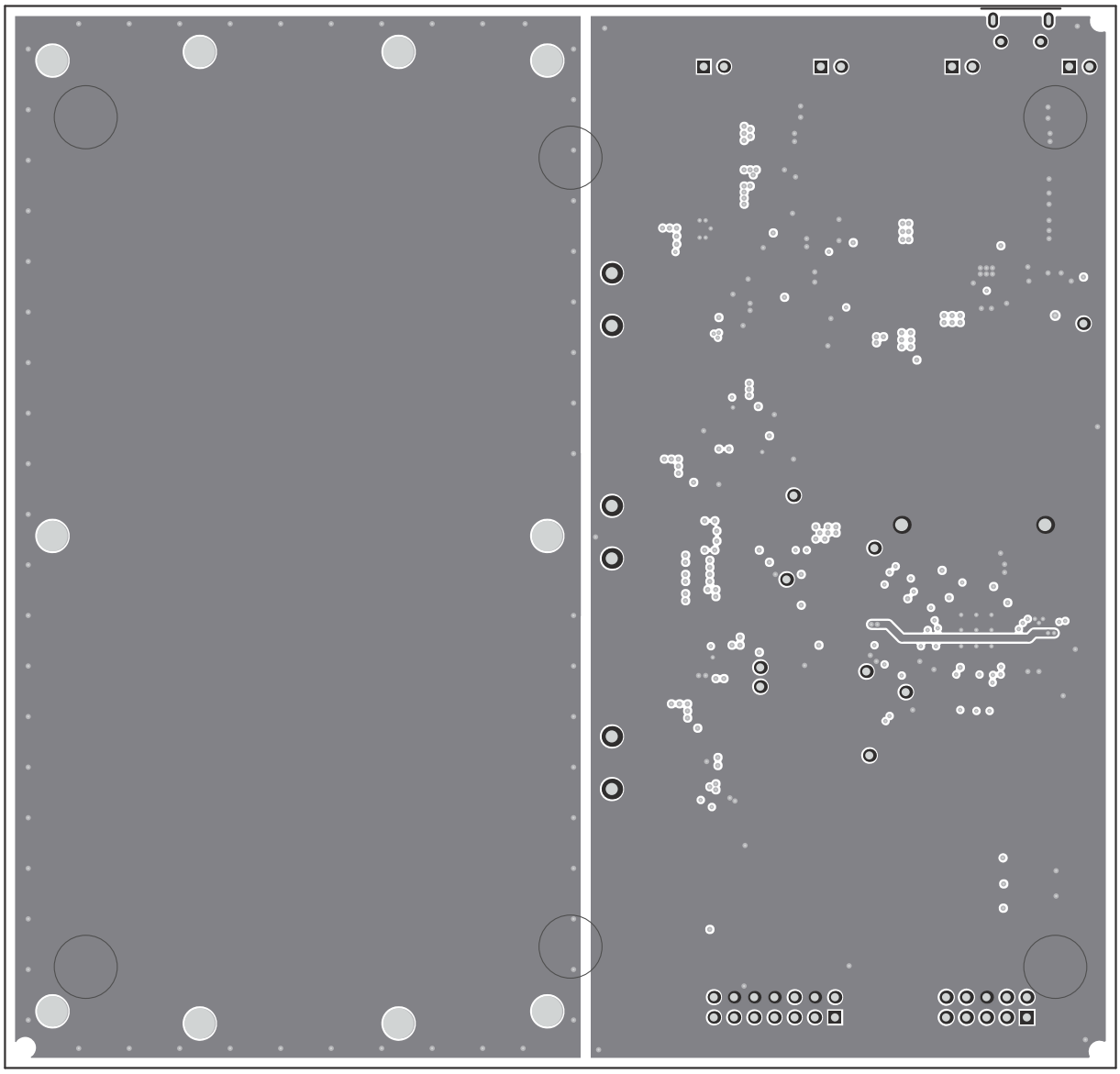


Figure 10. Bottom Layer

8 Reference

For additional information about the bq500412EVM-584 low-power, wireless, power evaluation kit from Texas Instruments, visit the product folder on the TI Web site at http://www.ti.com/product/bq500412

9 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.

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Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

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As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of EVMs for RF Products in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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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. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. 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.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

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