bq500414Q 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 bq500414Q 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 the bq51013BEVM-764 or any other Qi-compliant receiver. Both the WPC 1.0 and WPC 1.1 receivers are supported with this design. The bq500414QEVM-629 is a 12-V input design

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Avid is a registered trademark of Avid Technology, Inc..

1 Applications

The bq500414QEVM-629 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 Vdc at 1 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 × 20 mm free positioning area
- Designed for 12-Vdc systems
- Optional input power SEPIC converter to produce 12 Vdc from 6 V to 16 V
- Fully WPC 1.1 Foreign Object Detection (FOD) and WPC 1.0 Parasitic Metal Object Detection (PMOD)
- Reduced parts count from the legacy bq500410A design
- LED indicates power transfer or power fault state

2 bq500414QEVM-629 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. bq500414QEVM-629 Electrical Performance Specifications

Parameter		Notes and Conditions	Min	Typ	Max	Unit
Input Characteristics						
V_{IN}	Input voltage bq500414Q		6	12	16	V
I_{IN}	Input current	V_{IN} = 12 V, RX I_{OUT} = 1 A at 5 V		570		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	A
Systems Characteristics						
F_S	Switching frequency	Switching frequency varies with load	120		205	kHz
ηpk	Peak efficiency	V_{IN} = 12 V, P Out RX = 2.5 W		75%		
η	Full-load efficiency	V_{IN} = Nom, I_{OUT} = Max		73.6%		

3 Modifications

See the data sheet (SLUSBE4) when changing components.

Use LED mode – resistor R23 to change the behavior of the status LED, D2, D8 and D9. The standard value is 42.2 kΩ for control option 1, see the datasheet for additional settings.

FOD threshold setting can be changed using R3. If R3 is removed then FOD function is disabled.

PMOD threshold setting can be changed using R22. If R22 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, R52.

Addition of EMI Filter Shield, PWR633 to reduce emissions, see section 6.2.2.6

4 Connector and Test Point Descriptions

This section contains descriptions for the connectors and the test points.

4.1 Connector and Test Point Descriptions

The connection points are described in Section 4.1.1 through Section 4.1.3.

4.1.1 J1 – (Pin 1)$V_{IN,}$ (Pin 2) GND

Pin 1 - Input power 12 Vdc ±500 mV,

Pin 2 - Return for 12Vdc Input (Ground)

4.1.2 J2 – PMBus

Pin 6 - AGND

Pin 9 - PM_CLK

Pin 10 - PM_DATA

4.1.3 J3 –JTAG

Factory use only.

4.1.4 Control Headers

4.1.4.1 JP1 PMOD and FOD Enable / Disable

Shorting Jumper installed = Enable, removed = Disable

4.1.4.2 JP2 LED select bypass

Shorting Jumper installed = LED Bin 0

Default is not installed.

4.2 Test Point Descriptions

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

4.2.1 TP1 – Unused

Reserved – no connection.

4.2.2 TP2 – BUZ_DC

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

4.2.3 TP3 – FOD

Select for FOD threshold

4.2.4 TP4 – COIL1.2

Output from bq500414Q, low enables coil 2 drive.

4.2.5 TP5 – PMOD

Select for PMOD threshold

4.2.6 TP6 – Reserved

Reserved – no connection.

4.2.7 TP7 – Reserved

Reserved – no connection

4.2.8 TP8 – COIL1.3

Output from bq500414Q, low enables coil 3 drive.

4.2.9 TP9 – 12Vdc

System regulated 12V from VIN

4.2.10 TP10 - Reserved

Reserved – no connection

4.2.11 TP11 – Shield / No Shield

Input to configure bq500414Q to operate with EMI shield, PWR633. Low = no shield, high (3.3V) = shield

4.2.12 TP12 – 12Vdc Feedback

Feedback circuit for 12V regulator

4.2.13 TP13 – GND

Ground test point connection

4.2.14 TP14 – I_SENSE

Current as measured in the system 12V supply

4.2.15 TP15 – COMM-

Sample of coil voltage return for communications with RX

4.2.16 TP16 – COMM+

Sample of coil voltage for communications with RX

4.2.17 TP17 – Reserved

Reserved – no connection.

4.2.18 TP18 – DPWM-1A

PWM Output to half bridge drivers

4.2.19 TP19 – Reserved

Reserved – no connection.

4.2.20 TP20 – GND

Ground test point connection

4.2.21 TP21 – GND

Ground test point connection

4.2.22 TP22 – AGND

Analog ground test point connection

4.2.23 TP23 – COIL1.1

Output from bq500414Q, low enables coil 1 drive.

4.2.24 TP24 – AGND

Analog ground test point connection

4.2.25 TP25 – 3.3Vdc_EN

3.3Vdc enable signal to the regulator

4.2.26 TP26 – EN_PWR

Enable signal for the 12Vdc system regulator

4.2.27 TP27 – PWRGD

Power good signal from the 3.3Vdc regulator

4.2.28 TP28 – TANK3

Coil 3 Resonant Tank Drive Signal

4.2.29 TP29 – PHSE3

Coil 3 Drive signal

4.2.30 TP30 – GND

Ground test point connection

4.2.31 TP31 – PHSE1

Coil 1 Drive signal

4.2.32 TP32 – TANK2

Coil 2 Resonant Tank Drive Signal

4.2.33 TP33 – TANK1

Coil 1 Resonant Tank Drive Signal

4.2.34 TP34 – GND

Ground test point connection

4.2.35 TP35 – PHSE2

Coil 2 Drive signal

5 Schematic and Bill of Materials

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

Figure 1 illustrates the schematic for this EVM.

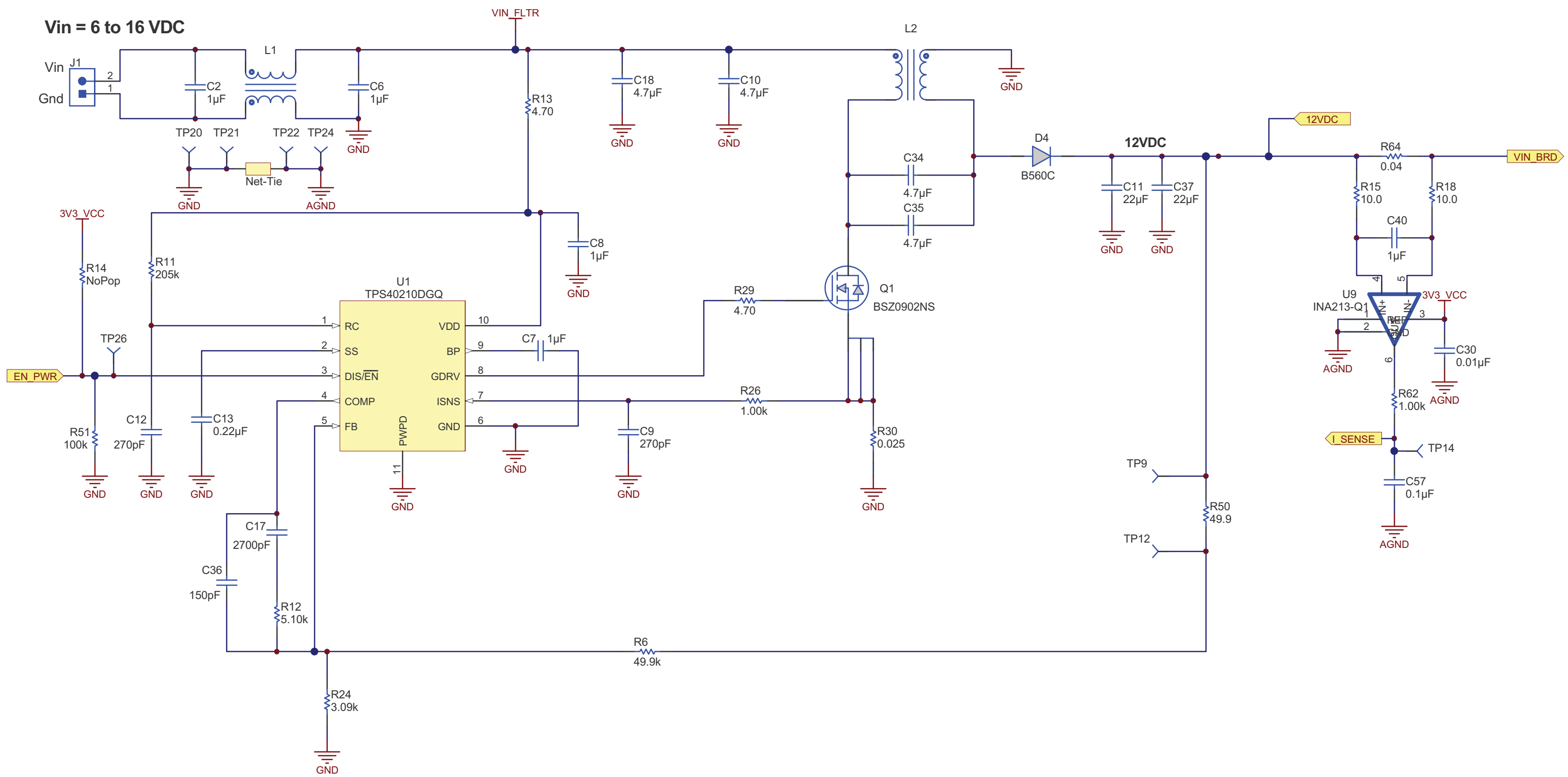


Figure 1. bq500414QEVM-629 Schematic

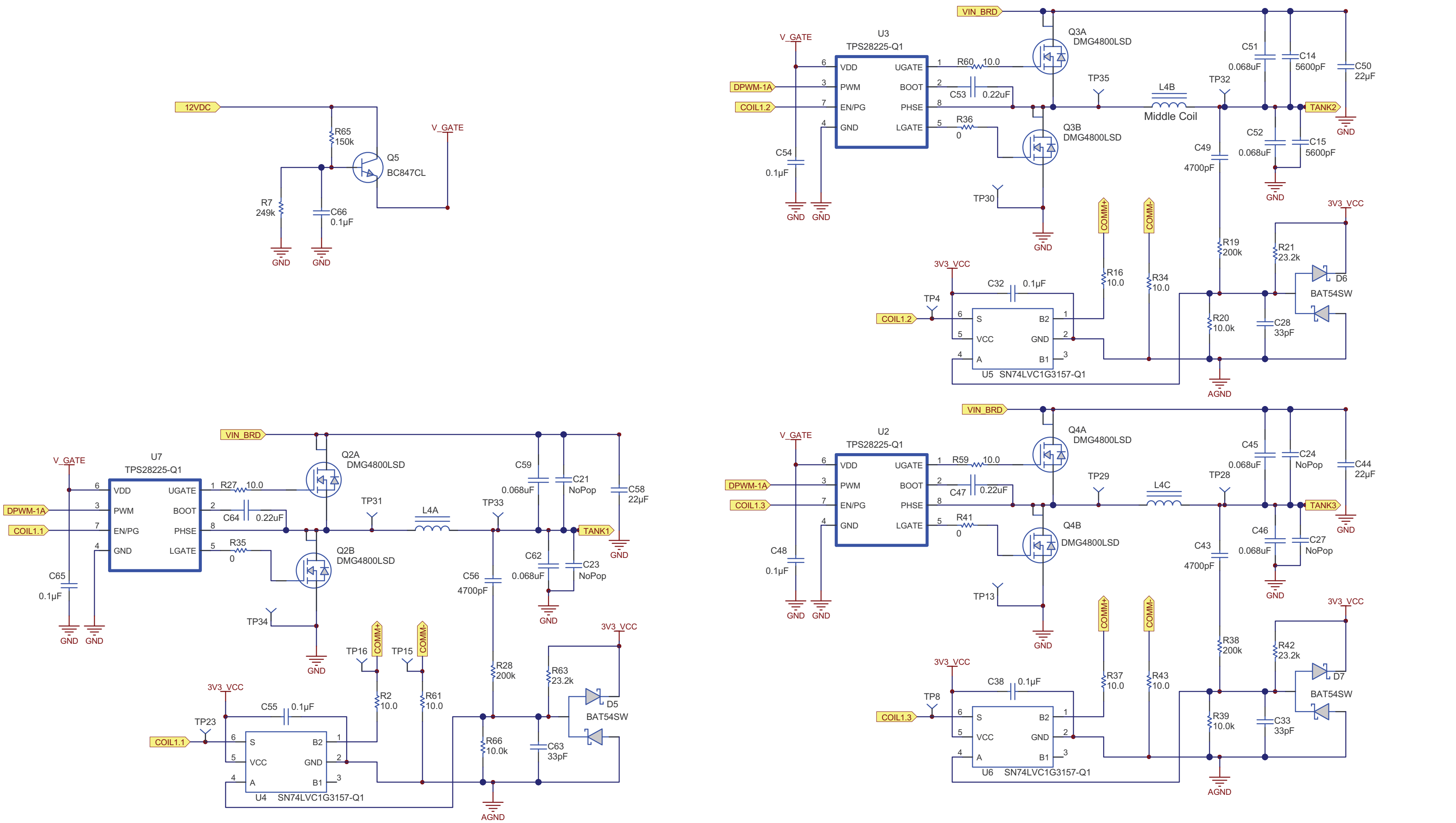


Figure 2. bq500414QEVM-629 Schematic

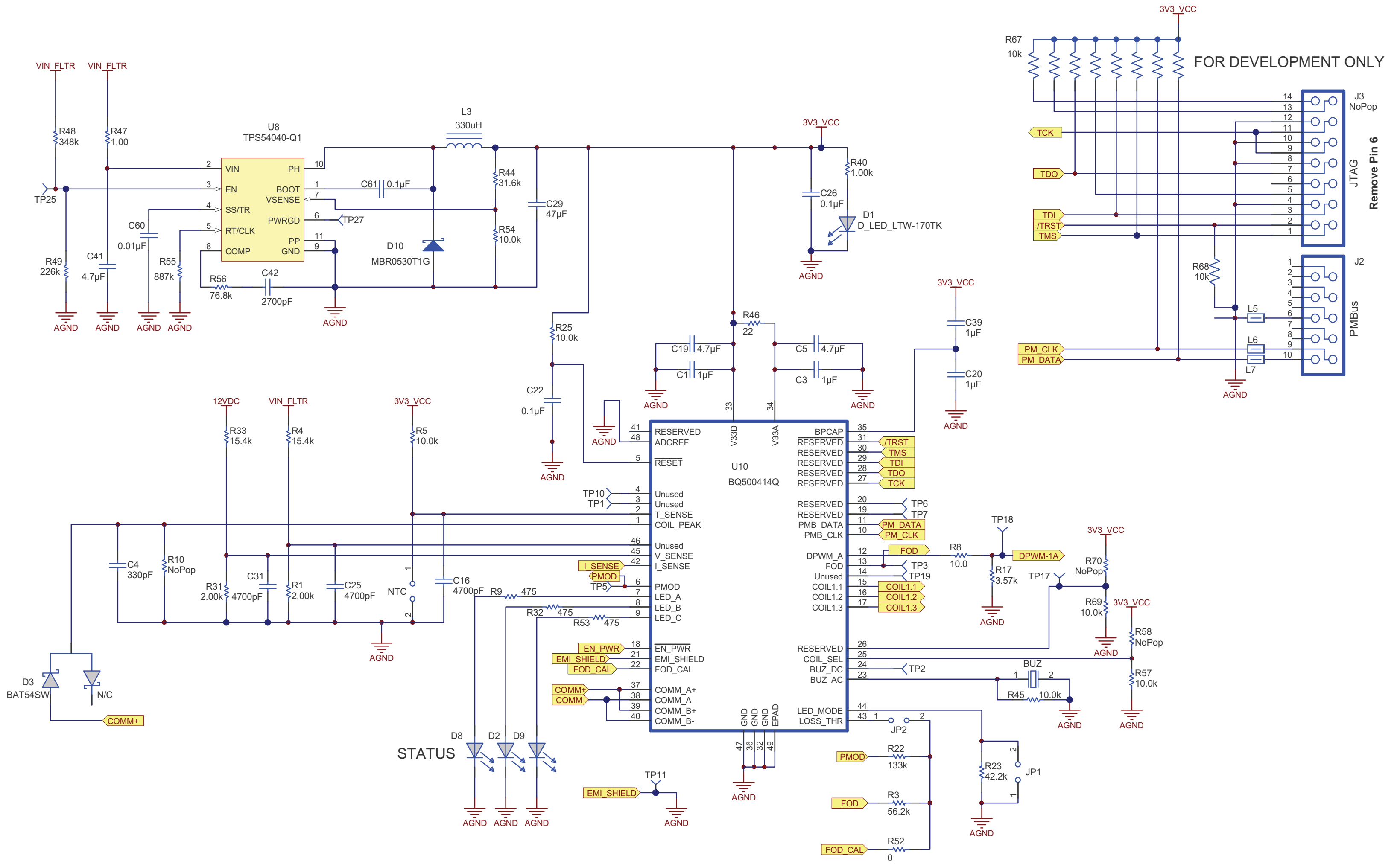


Figure 3. bq500414QEVM-629 Schematic

Table 2 contains the BOM for this EVM.

Table 2. Bill of Materials(1)

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacture
BUZ	1	Buzzer	Piezoelectronic, 12 mm	12 mm	PS1240P02CT3	TDK
C1, C3, C7, C20, C39, C40	6	1uF	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0603	0603	C1608X7R1C105K	TDK
C2, C6	2	1uF	CAP, CERM, 1uF, 50V, +/-10%, X7R, 1210	1210	GRM32RR71H105KA01L	MuRata
C4	1	330pF	CAP, CERM, 330pF, 50V, +/-5%, C0G/NP0, 0603	0603	C1608C0G1H331J	TDK
C5, C19	2	4.7uF	CAP, CERM, 4.7uF, 10V, +/-10%, X5R, 0603	0603	C0603C475K8PACTU	Kemet
C8	1	1uF	CAP, CERM, 1uF, 50V, +/-10%, X7R, 0805	0805	GRM21BR71H105KA12L	MuRata
C9, C12	2	270pF	CAP, CERM, 270pF, 50V, +/-5%, C0G/NP0, 0603	0603	C0603C271J5GACTU	Kemet
C10, C18, C34, C35	4	4.7uF	CAP, CERM, 4.7uF, 50V, +/-10%, X7R, 1210	1210	GRM32ER71H475KA88L	MuRata
C11, C37	2	22uF	CAP, CERM, 22uF, 16V, +/-20%, X7R, 1210	1210	C3225X7R1C226M	TDK
C13	1	0.22uF	CAP, CERM, 0.22uF, 16V, +/-10%, X7R, 0603	0603	C1608X7R1C224K	TDK
C14, C15	2	5600pF	CAP, CERM, 5600pF, 100V, +/-5%, C0G/NP0, 1206	1206	GRM3195C2A562JA01D	MuRata
C16, C31, C43, C49, C56	5	4700pF	CAP, CERM, 4700pF, 50V, +/-10%, X7R, 0603	0603	C0603X472K5RACTU	Kemet
C17, C42	2	2700pF	CAP, CERM, 2700pF, 50V, +/-5%, C0G/NP0, 0603	0603	C1608C0G1H272J	TDK
C22, C32, C38, C48, C54, C55, C57, C61, C65, C66	10	0.1uF	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603	0603	GCM188R71H104KA57B	MuRata
C26	1	0.1uF	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603	0603	GRM188R71H104KA93D	MuRata
C28, C33, C63	3	33pF	CAP, CERM, 33pF, 50V, +/-5%, C0G/NP0, 0603	0603	GRM1885C1H330JA01D	MuRata
C29	1	47uF	CAP, CERM, 47uF, 25V, +/-20%, X5R, 1206	1206	C3216X5R1E476M160AC	TDK
C30, C60	2	0.01uF	CAP, CERM, 0.01uF, 50V, +/-10%, X7R, 0603	0603	GRM188R71H103KA01D	MuRata
C36	1	150pF	CAP, CERM, 150pF, 50V, +/-5%, C0G/NP0, 0603	0603	GRM1885C1H151JA01D	MuRata
C41	1	4.7uF	CAP, CERM, 4.7uF, 25V, +/-10%, X5R, 0805	0805	GRM21BR61E475KA12L	MuRata
C44, C50, C58	3	22uF	CAP, CERM, 22uF, 25V, +/-10%, X5R, 1210	1210	GRM32ER61E226KE15L	MuRata
C45, C46, C51, C52, C59, C62	6	0.068uF	Capacitor, Ceramic, 100V, C0G, 5%	1210	C3225C0G2A683J230AA	TDK
C47, C53, C64	3	0.22uF	Capacitor, Ceramic, 50V, X7R, 10%	603	C1608X7R1H224K080AB	TDK
D1	1	LTW-170TK	Diode. LED, 70 mW, 20mA	0805	LTW-170TK	Lite-on
D2	1	RED	Diode. LED, RED	0805	150080SS75000	Wurth
D3, D5, D6, D7	4	BAT54SW	Diode, Dual Schottky, 200mA, 30V	SOT323	BAT54SWT1G	On Semi
D4	1	B560C	Diode, 5A, 60V	SMC	B560C-13-F	Diodes Inc.
D8	1	GREEN	Diode. LED, GREEN	0805	150080VS75000	Wurth
D9	1	YELLOW	Diode. LED, YELLOW	0805	150080YS75000	Wurth
D10	1	30V	Diode, Schottky, 30V, 0.5A, SOD-123	SOD-123	MBR0530	On Semi
H52	1		Comb filter PCB 5.080"x3.050" x 0.031"	5.080"x3.050" x 0.031"	PWR633	Any
J2	1	N2510-6002-RB	Connector, Male Straight 2x5 pin, 100mil spacing, 4 Wall	0.338 x 0.788 inch	N2510-6002RB	3M
L1	1		Inductor, SMT Dual Winding, CMC	0.492 x 0.492 inch	744284100	Wurth
L2	1		Inductor, SMT Dual Winding, SEPIC	0.492 x 0.492 inch	744871220	Wurth
L3	1	330uH	Inductor, SMT	0.189 x 0.189 inch	744042331	Wurth
L4A, L4B, L4C	1		WPC A6 Coil Assembly, Triple coil		760308106	Wurth
L5, L6, L7	3	1000 ohm	0.2A Ferrite Bead, 1000 ohm @ 100MHz, SMD	0603	74279266	Wurth
Q1	1	BSZ0902NS	MOSFET, NChan, 30V, 13A, 9.4 milliOhm	QFN3.3x3.3 mm	BSZ0902NS	Infineon Technologies
Q2, Q3, Q4	3	DMG4800LSD	MOSFET, DUAL NFET, 30V,	SO8	DMG4800LSD-13	Diodes, Inc

(1) Unless otherwise noted in the Alternate Part Number and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.

Table 2. Bill of Materials[(1)] (continued)

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacture
Q5	1	BC847CL	TRANSISTOR, NPN, HIGH-PERFORMANCE, 500mA	SOT-23	BC847CLT1G	ON Semi
R2, R8, R15, R16, R18, R27, R34, R37, R43, R59, R60, R61	12	10.0	RES, 10.0 ohm, 1%, 0.1W, 0603	0603	CRCW060310R0FKEA	Vishay-Dale
R3	1	56.2k	RES, 56.2k ohm, 1%, 0.1W, 0603	0603	CRCW060356K2FKEA	Vishay-Dale
R22	1	133k	RES, 133k ohm, 1%, 0.1W, 0603	0603	CRCW0603133KFKEA	Vishay-Dale
R5, R20, R25, R39, R45, R54, R57, R66, R69	9	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0710KL	Yageo America
R6	1	49.9k	RES, 49.9k ohm, 1%, 0.1W, 0603	0603	CRCW060349K9FKEA	Vishay-Dale
R7	1	249k	RES, 249k ohm, 1%, 0.1W, 0603	0603	CRCW0603249KFKEA	Vishay-Dale
R9, R32, R53	3	475	RES, 475 ohm, 1%, 0.1W, 0603	0603	CRCW0603475RFKEA	Vishay-Dale
R11	1	205k	RES, 205k ohm, 1%, 0.1W, 0603	0603	CRCW0603205KFKEA	Vishay-Dale
R12	1	5.10k	RES, 5.10k ohm, 1%, 0.1W, 0603	0603	RC0603FR-075K1L	Yageo America
R13, R29	2	4.70	RES, 4.70 ohm, 0.5%, 0.1W, 0603	0603	RT0603DRE074R7L	Yageo America
R17	1	3.57k	RES, 3.57k ohm, 1%, 0.1W, 0603	0603	CRCW06033K57FKEA	Vishay-Dale
R19, R28, R38	3	200k	RES, 200k ohm, 1%, 0.1W, 0603	0603	CRCW0603200KFKEA	Vishay-Dale
R21, R42, R63	3	23.2k	RES, 23.2k ohm, 1%, 0.1W, 0603	0603	CRCW060323K2FKEA	Vishay-Dale
R23	1	42.2k	RES, 42.2k ohm, 1%, 0.1W, 0603	0603	CRCW060342K2FKEA	Vishay-Dale
R24	1	3.09k	RES, 3.09k ohm, 1%, 0.1W, 0603	0603	CRCW06033K09FKEA	Vishay-Dale
R26, R40, R62	3	1.00k	RES, 1.00k ohm, 1%, 0.1W, 0603	0603	RC0603FR-071KL	Yageo America
R30	1	0.025	RES, 0.025 ohm, 1%, 0.5W, 1206	1206	CSR1206FK25L0	Stackpole Electronics Inc
R31	1	2.00k	RES, 2.00k ohm, 1%, 0.1W, 0603	0603	CRCW06032K00FKEA	Vishay-Dale
R33	1	15.4k	RES, 15.4k ohm, 1%, 0.1W, 0603	0603	CRCW060315K4FKEA	Vishay-Dale
R35, R36, R41, R52	3	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R44	1	31.6k	RES, 31.6k ohm, 1%, 0.1W, 0603	0603	CRCW060331K6FKEA	Vishay-Dale
R46	1	22	RES, 22 ohm, 5%, 0.125W, 0805	0805	CRCW080522R0JNEA	Vishay-Dale
R47	1	1.00	RES, 1.00 ohm, 1%, 0.1W, 0603	0603	CRCW06031R00FKEA	Vishay-Dale
R48	1	348k	RES, 348k ohm, 1%, 0.1W, 0603	0603	CRCW0603348KFKEA	Vishay-Dale
R49	1	226k	RES, 226k ohm, 1%, 0.1W, 0603	0603	CRCW0603226KFKEA	Vishay-Dale
R50	1	49.9	RES, 49.9 ohm, 1%, 0.1W, 0603	0603	CRCW060349R9FKEA	Vishay-Dale
R51	1	100k	RES, 100k ohm, 1%, 0.1W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R55	1	887k	RES, 887k ohm, 1%, 0.1W, 0603	0603	CRCW0603887KFKEA	Vishay-Dale
R56	1	76.8k	RES, 76.8k ohm, 1%, 0.1W, 0603	0603	CRCW060376K8FKEA	Vishay-Dale
R64	1	0.04	RES, 0.04 ohm, 1%, 1W, 2010	2010	CSRN2010FK40L0	Stackpole Electronics Inc
R65	1	150k	RES, 150k ohm, 1%, 0.1W, 0603	0603	RC0603FR-07150KL	Yageo America
R67	1	10k	Resistor, Metal Strip, 1 W, 1%	0.083 x 0.158 inch	CSC09A0110K0FEK	Vishay
U1	1	TPS40210DGQ	IC, 4.5V-52V I/P, Current Mode Boost Controller	DGQ0010D	TPS40210DGQ	Texas Instruments
U2, U3, U7	3	TPS28225-Q1	IC, High Frequency 4-Amp Sink Synchronous Buck MOSFET Driver	SO8	TPS28225D	TI
U4, U5, U6	3	SN74LVC1G3157-Q1	IC, SPDT Analog Switch	SOT23-6	SN74LVC1G3157DBV	TI
U8	1	TPS54040-Q1	IC, Swift DC-DC Converter With Eco-Mode, 0.5A, 42V	DGQ0010D	TPS54040DGQ	Texas Instruments

Table 2. Bill of Materials[(1)] (continued)

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacture
U9	1	INA213-Q1	IC, Voltage Output, High or Low Side Measurement, Bi-Directional Zerø-Drift Series	SC-70	INA213AIDCKR	TI
U10	1	BQ500414Q	IC, Qi Compliant Wireless Power Transmitter Manager	VQFN	BQ500414RGZ	TI
C21, C23, C24, C27	0	NoPop	CAP, CERM, 5600pF, 100V, +/-5%, C0G/NP0, 1206	1206	GRM3195C2A562JA01D	MuRata
C25	0	4700pF	CAP, CERM, 4700pF, 50V, +/-10%, X7R, 0603	0603	C0603X472K5RACTU	Kemet
J3	0	NoPop	Header, 2x7 pin, 100mil spacing, Straight, 4 Wall	0.338 x 0.988 inch	2514-6002UB	3M
R1	0	2.00k	RES, 2.00k ohm, 1%, 0.1W, 0603	0603	CRCW06032K00FKEA	Vishay-Dale
R4	0	15.4k	RES, 15.4k ohm, 1%, 0.1W, 0603	0603	CRCW060315K4FKEA	Vishay-Dale
R10, R70	0	NoPop	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0710KL	Yageo America
R14	0	NoPop	RES, 100k ohm, 1%, 0.1W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R58	0	NoPop	RES, 0 ohm, 5%, 0.1W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R68	0	NoPop	Resistor, Chip, 1/16W, 1%	603	STD	STD

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.

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

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 Pin 2, and connect the negative terminal of the V_{IN} source to J1 Pin 1.
- Do not place the bqTESLA™ receiver on the transmitter. Connect a load to the receiver J3 with a return to J4, monitor current through the load with the ammeter, and monitor the current to the load at TP7. All voltmeters must be Kelvin connected (at the pin) to the point of interest.

6.2.1 Equipment Setup Diagram

The diagram in Figure 4 shows the test setup.

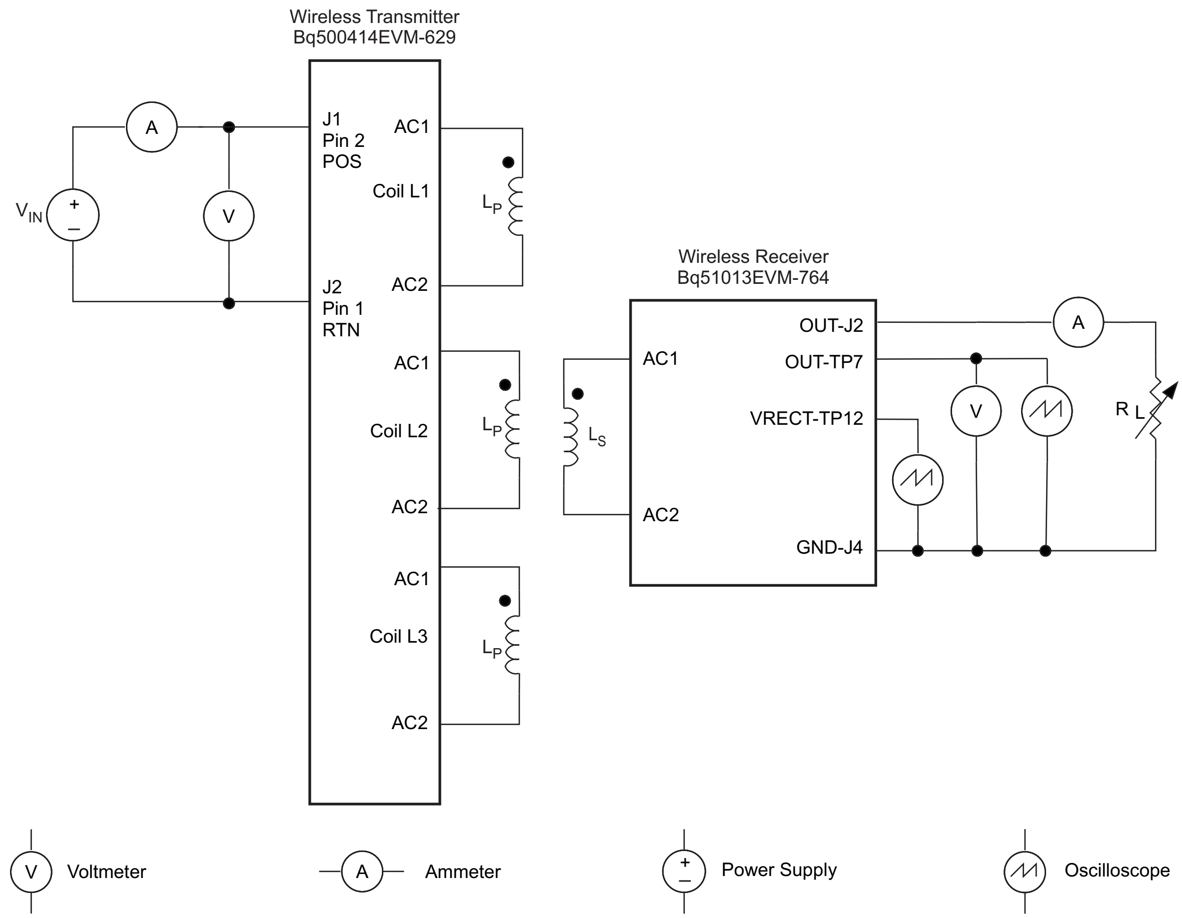


Figure 4. Equipment Setup

6.2.2 EVM Procedures

This section 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, D1, illuminates. Status LEDs D2, D8 and D9 are OFF until the power transfer starts.

Apply the scope probe to test point, TP18, 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, D8, 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 4). Average the input current; the comm pulses modulate the input current, distorting the reading. See Figure 5 for efficiency. Figure 5 shows efficiency with standard EVM.

This shows the efficiency from transmitter input to receiver output. The input power SEPIC converter is included in this circuit and loss is higher due to power loss in two converters. For this test, an input voltage of 13.6 V was used.

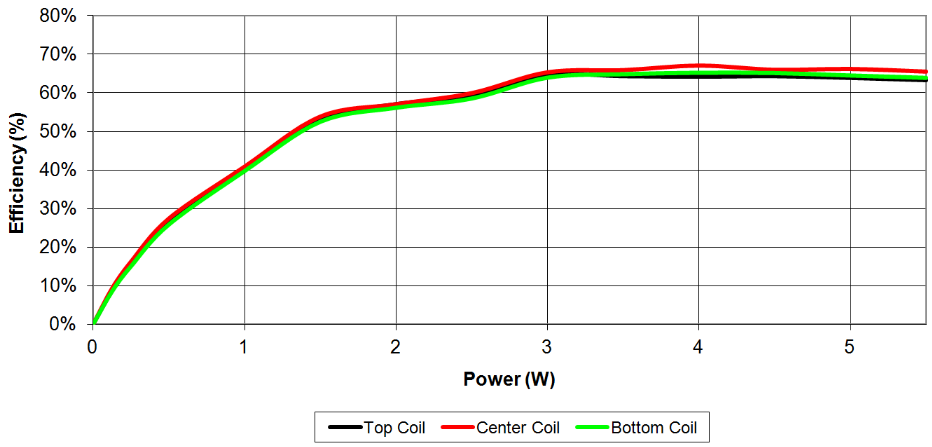


Figure 5. Efficiency versus Power, bq500414QEVM-629 Transmitter and HPA764 Receiver

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 and the PMOD performance and may require re-calibration. This would require the FOD_CAL resistor (R52) to change along with FOD_Threshold resistor (R3) and PMOD resistor (R22). The FOD and PMOD calibration procedure must be repeated.

6.2.2.5 Input Power DC / DC Converter

To support the input voltage range for an automotive application, an optional wide input voltage converter is installed on the board. The TPS40210 is configured as a Single-Ended Primary-Induction Converter (SEPIC) providing a 12-V output from an input voltage that can be above and below 12V.

6.2.2.6 EMI Shield

The EVM is designed to support an EMI Shield above the coils to reduce emissions. The shield, PWR633, is a comb-type filter that is effective between 100 kHz and 2 MHz.

To install the shield:

Remove clear plastic cover and hardware. Install the PWR633 filter using metal hardware provided. The filter is grounded though the metal hardware to the TX coil area.

Circuit changes:

EMI_Shield select pin 21 ground = no shield, high(3.3V) = shield

FOD_CAL R52 no shield = 16.2 kΩ, shield = 8.06 kΩ

NOTE: if ONLY EMI behavior is to be evaluated with the addition of the shield, then circuit changes are not required.

6.2.2.7 Configuration Resistor

Some functions can be configured by an external resistor pull up and connections, see the data sheet (SLUSBE4) for more info:

1. Coil Select R58 and R57, configure for type of coil used
2. Shield / no shield Pin 21, configure for shield or no shield
3. Operating freq pin 26, R70 and R69, option to reduce operating range

6.2.2.8 Thermal Protection, NTC

Thermal protection is provided by an NTC resistor network is connected to pin 2. At 1 V on the sense side (U10-2), the thermal fault is set, and the unit is shut down, The status LED, D7, illuminates red. The system tries to restart in 5 minutes.

6.2.2.9 Foreign Object Detection

The bq500414Q 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 R33 and R31. Input current is measured using sense resistor R64 and current sense amp U9. 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, R52. This calculation changes with external component changes in the power path such as MOSFETs, resonate capacitors, and TX coil. Recalculation of R52 and R3 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, R3 is set to 86.6 kΩ. Increasing R3 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 bq500414Q.

6.2.2.10 WPC Certification

The bq500414QEVM-629 was tested and certified to WPC version 1.2.

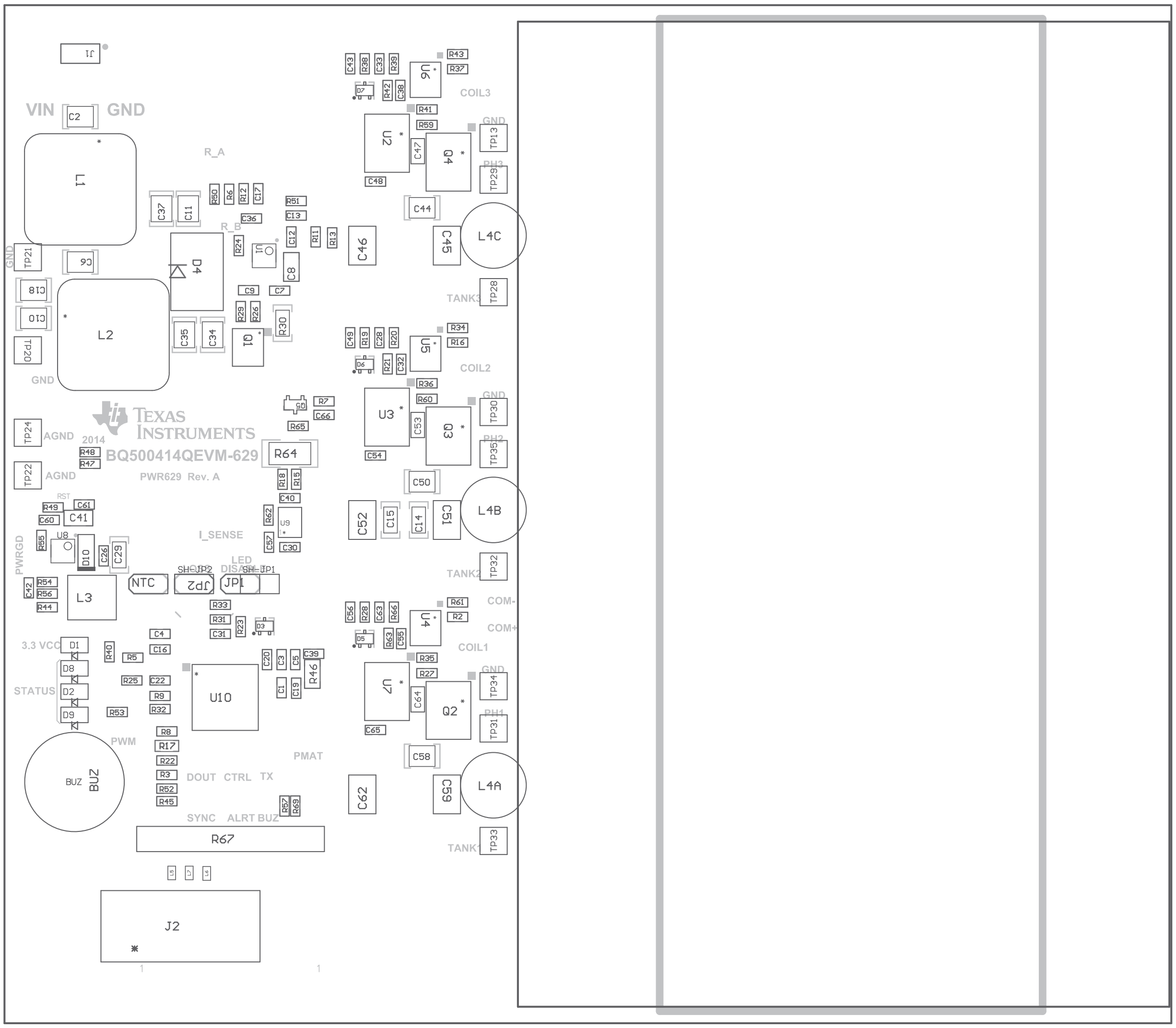
7 bq500414QEVM-629 Assembly Drawings and Layout

Figure 6 through Figure 7 show the design of the bq500414QEVM PCB. The EVM has been designed using a 4-layer, 2-oz, copper-clad circuit board 15.24 cm × 13.335 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 bq500414Q 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 bq500414Q GND EPAD, pin 47, 36, and 32 and filter capacitor returns C19, C1, C5, and C3 should be a good low-impedance path.

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

Note: The clear plastic cover thickness (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 6. Assembly Top

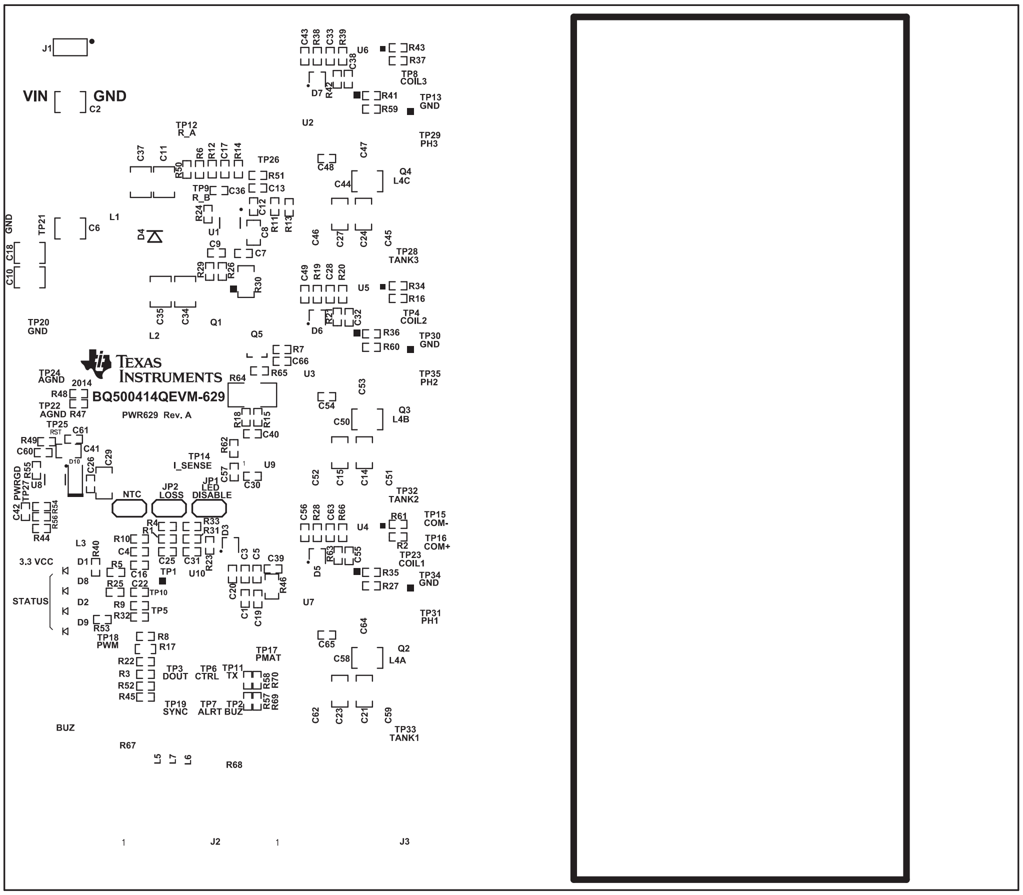


Figure 7. Top Overlay

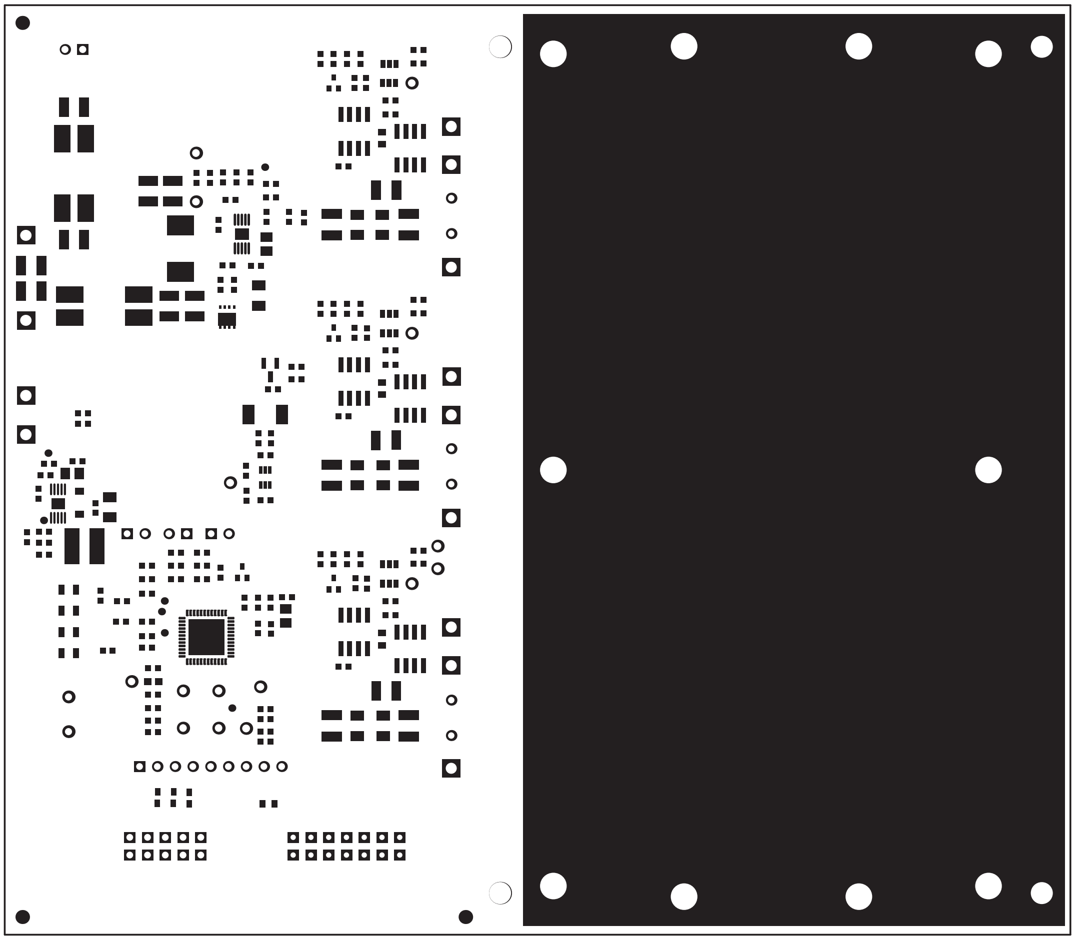


Figure 8. Top Solder

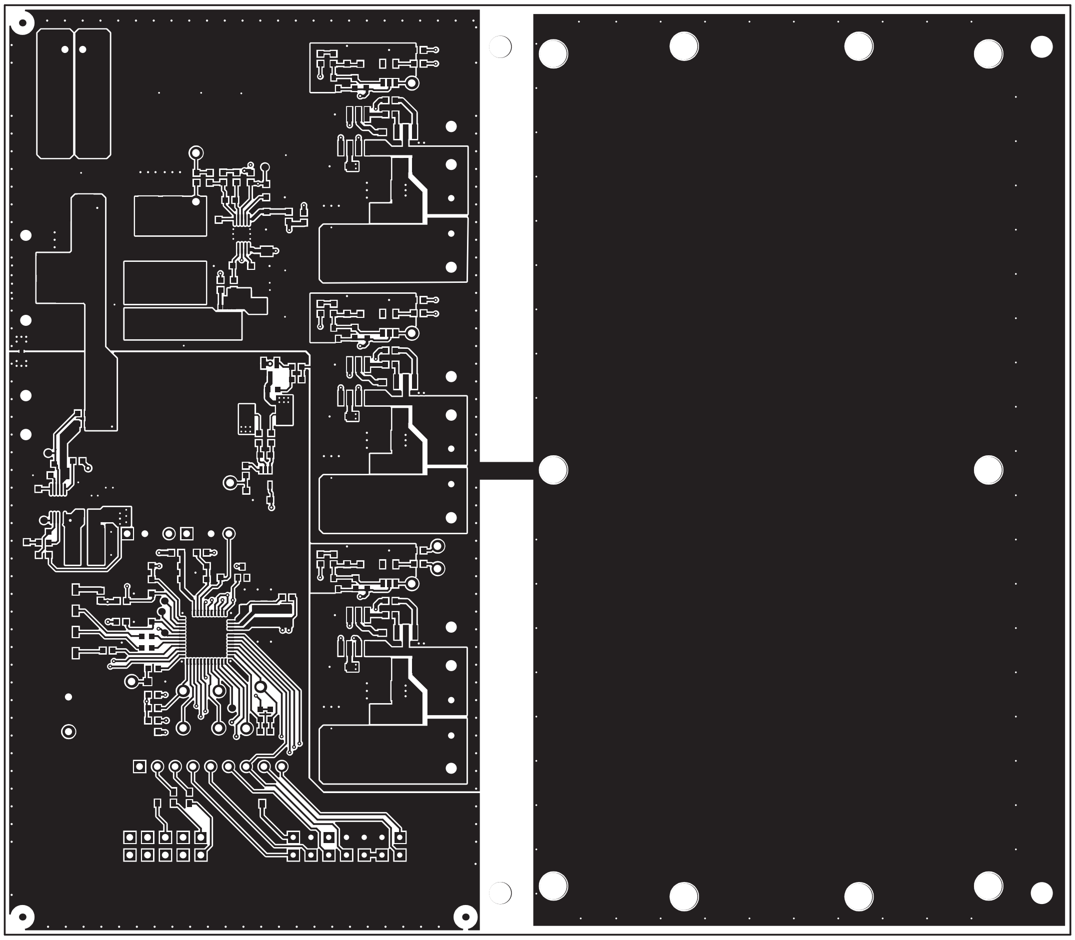


Figure 9. Top Layer

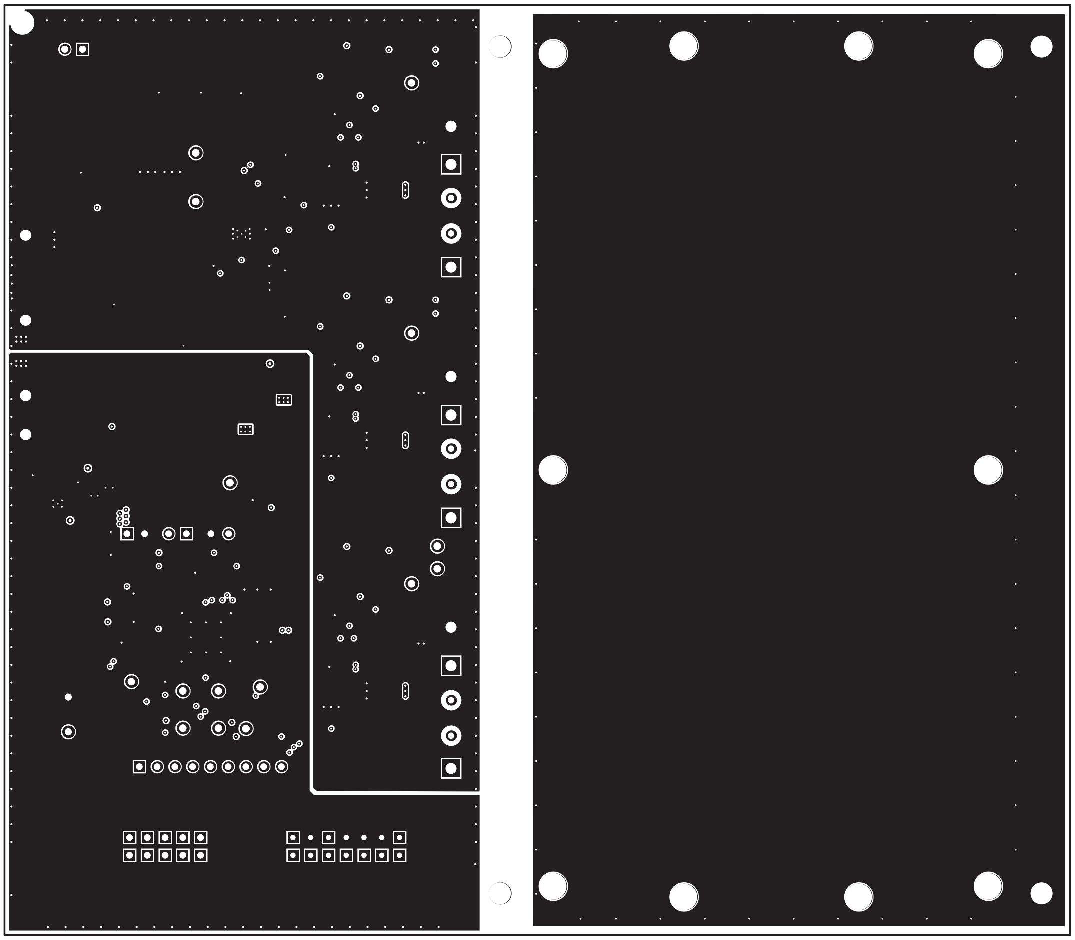


Figure 10. Inner Layer 1

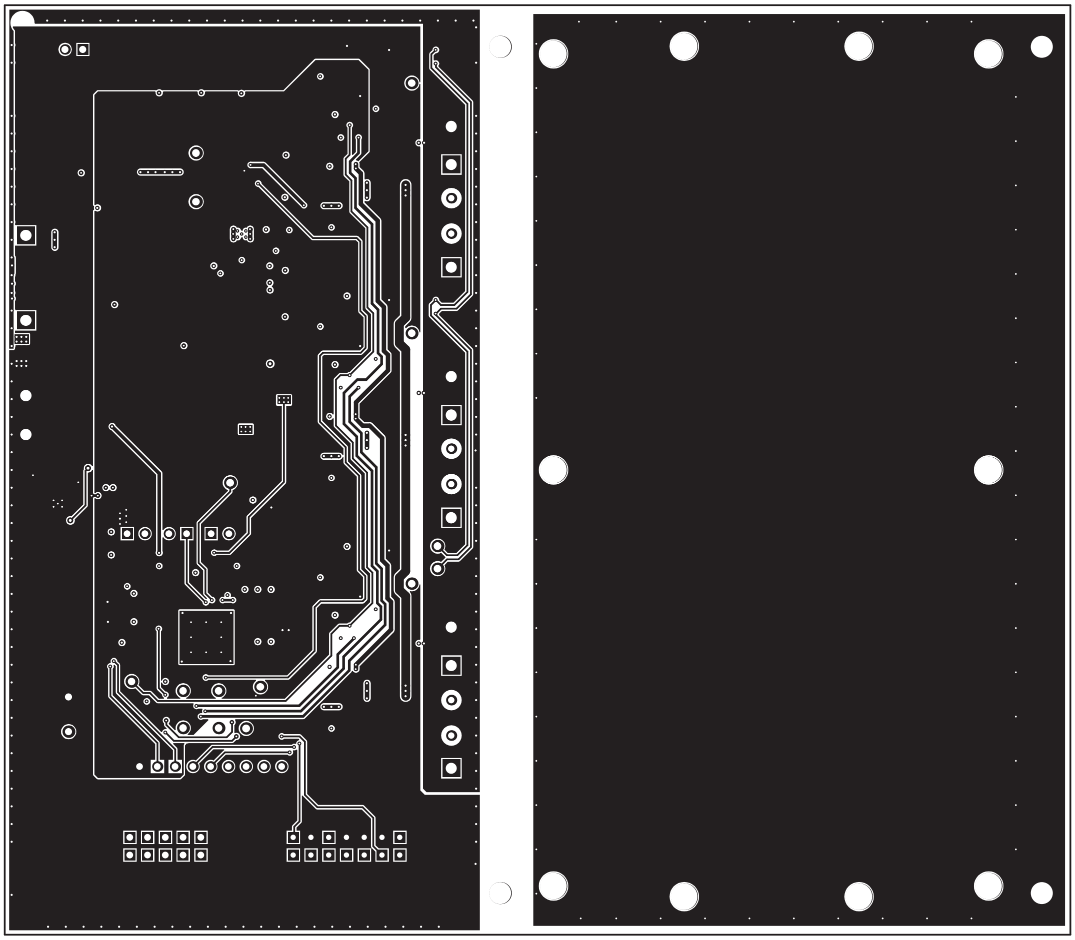


Figure 11. Inner Layer 2

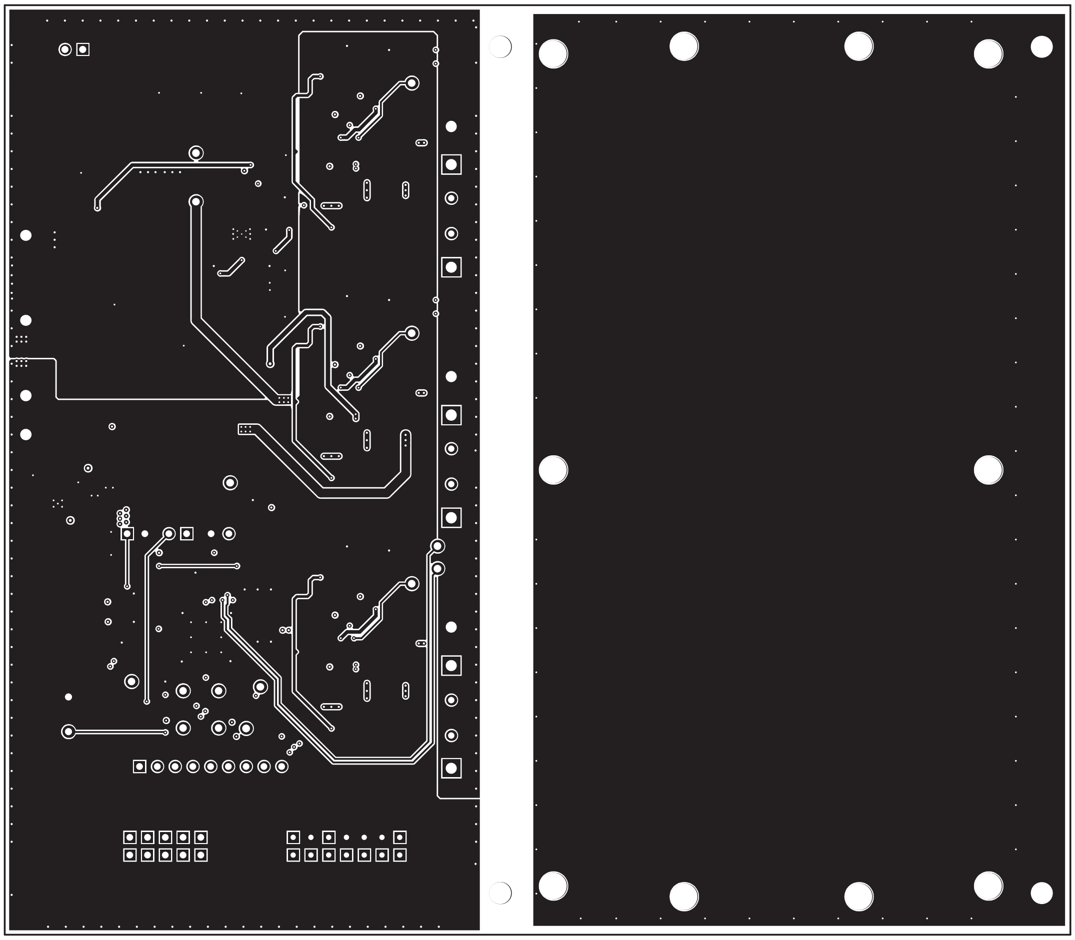


Figure 12. Bottom Layer

8 Reference

For additional information about the bq500414QEVM-629 low-power, wireless, power evaluation kit from Texas Instruments, visit the product folder on the TI Web site at http://www.ti.com/product/bq500414Q

Revision History

Changes from Original (March 2014) to A Revision **Page**

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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 A 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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   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

   3.1.1 *Notice applicable to EVMs not FCC-Approved:*

   This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

   3.1.2 *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

   NOTE: 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

NOTE: 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.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-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.

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.

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.

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

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。 http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered “Radio Frequency Products” in Japan:* EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs 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 EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should 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 also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure 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. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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