User's Guide
SLVUAO6–June 2016

bq501210 bqTESLA™ Wireless Power TX EVM

The bq501210EVM-756 wireless power transmitter evaluation module from TI is a high-performance, easy-to-use development module for the design of wireless power solutions. The bq501210 evaluation module (EVM) provides all the basic functions of a Qi-compliant, wireless charger pad. The 15-V to 19-V input, single coil transmitter (TX) enables designers to speed the development of their end-applications. The EVM supports WPC v1.0, WPC v1.1, and WPC v1.2 receivers (RX) and supports output power up to 15 W when paired with a WPC v1.2 15-W receiver.

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bqTESLA is a trademark of Texas Instruments.
Avid is a registered trademark of Avid Technology, Inc..

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1 Applications

The bq501210EVM-756 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 a single 15-V to 19-V power supply capable of up to 2.0 A to operate and combines the transmitter electronics, input power circuit, LED indicators, and the transmitting coil on the single printed-circuit board (PCB). The EVM is a non-space optimized, open design allowing easy access to key points of the electrical schematic.

This EVM has the following features:

- Qi-Certified WPC v1.2 for 15-W operation with a WPC v1.2 15-W receiver
- 5-W solution for WPC v1.1 or v1.2 Baseline Power Profile (BPP) receivers
- 15-V to 19-V input and fixed operating frequency for full 15-W results
- 12-V input for reduced power (> 10 W) solutions
- Enhanced Foreign Object Detection (FOD) with FOD ping detecting objects prior to power transfer
- WPC v1.2 FOD, WPC v1.1 FOD, and WPC v1.0 Parasitic Metal Object Detection (PMOD)
- Transmitter-coil mounting pad providing the correct receiver interface
- Compact power section design using the bq500101 NexFET power stage
- High-accuracy current sense design using the bq500100 current monitor
- WPC MP-A5 type transmitter coil
- LED and audio indication of power transfer

2 bq501210EVM-756 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. bq501210EVM-756 Electrical Performance Specifications

Parameter		Notes and Conditions	Min	Typ	Max	Unit
Input Characteristics						
V_{IN}	Input voltage	P_{OUT} up to 15 W	15		19	V
		P_{OUT} up to 10 W	12		19	
		P_{OUT} up to 4.5 W	4.5	5.0	19	
I_{IN}	Input current	V_{IN} = Nom, I_{OUT} = 1.5 A at 10 V		2.0		A
	Input no-load current	V_{IN} = Nom, I_{OUT} = 0 A		90		mA
	Input stand-by current	V_{IN} = Nom		4		mA
Output Characteristics – WPC v1.2 10-V Nominal Output Receiver						
V_{OUT}	Output voltage	V_{IN} = Nom, I_{OUT} = 1.5A , V_{OUT} = 10 V	9.7	10.0	10.3	V
I_{OUT}	V_{IN} = Min to Max	V_{IN} = Min to Max, V_{OUT} = 10 V	0		1.5	A
Systems Characteristics						
f_{SW}	Switching frequency during power transfer	V_{IN} at startup > 6 V		130		kHz
		V_{IN} at startup < 6 V		110		
		V_{IN} at startup < 6 V followed by HVDCP change from 5 V to 9 V or 12 V		130		
ηpk	Peak efficiency	V_{IN} = Nom, P Out RX = 13.0 W		84		%
η	Full-load efficiency	V_{IN} = Nom, I_{OUT} = Max		84		%

3 Modifications

See the bq501210 data sheet (SLUSCF5) when changing components:

- **Use LED Mode** – (Resistor R9) to change the behavior of the status LEDs D6, D7, and D8. The standard value is 42.2 kΩ for control option 1, see the data sheet for additional settings.
- **NTC** – Connector JP3 provides the option for connecting a negative temperature coefficient (NTC) sensor for thermal protection, see the data sheet for additional settings.
- **FOD** – R8 threshold and R49 FOD_Cal (see Section 6.2.2.7)
- **FOD_Ping** – R47 and R48 (see Section 6.2.2.7)
- **PMOD** – R16 threshold and disable (see Section 6.2.2.7)

4 Connector and Test Point Descriptions

4.1 Input/Output Connections

The connection points are described in Section 4.1.1 through Section 4.1.9.

4.1.1 J1 – V_{IN}

Input power 12 V to 19 V, return at J2. 15 V to 19 V recommended for full 15-W delivery.

4.1.2 J2 – GND

Return for input power, input at J1.

4.1.3 J3 – JTAG

Factory use only, not populated.

4.1.4 J4 – Serial Interface

I^2C interface connection to communicate with the device. Used with bqTESLA TX Tuning Tool to monitor behavior.

4.1.5 J5 – Micro-USB

Micro-USB input used for HVDCP testing.

4.1.6 JP1 – FOD / PMOD Enable

Shorting jumper must be installed to enable FOD and PMOD functions. See the data sheet for additional details. Default - Shorted.

4.1.7 JP2 – LED Mode

External connection for LED MODE resistor, if R9 is removed. When shorted, the device disables the LED and inhibits low-power mode. This is useful for troubleshooting. Default - Open.

4.1.8 JP3 – NTC

The connection point for the external temperature sensor. See the data sheet for more information. Default - Open.

4.1.9 JP4 – Input Selection

Shunt selects 19-V input (J1) or micro-USB input (J5). Default position is J1 for 19-V input.

4.2 Test Point Descriptions

The test points are described in Section 4.2.1 through Section 4.2.25.

4.2.1 TP1 – FP_GAIN

FOD ping calibration gain setting, see the data sheet for more information.

4.2.2 TP2 – Drive A

Output from power section A of H-Bridge, U2.

4.2.3 TP3 – Coil Monitor L / C

Coil signal at junction between transmitter coil and resonant capacitors.

4.2.4 TP4 – Low Noise Analog Ground

Low noise ground test point (TP).

4.2.5 TP5 – Low Noise Analog Ground

Low noise ground TP.

4.2.6 TP6 – PEAK_DET

Peak detect circuit - input to PEAK_DET of bq501210.

4.2.7 TP7 – Demodulation Comm + Output

Primary communications channel, input to COMM_A+, COMM_B+, and COMM_C+ of bq501210, U1 from demodulation circuit.

4.2.8 TP8 – I_Sense

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

4.2.9 TP9 – RAIL+

Sample voltage from rail converter output, input to bq501210 rail control circuit.

4.2.10 TP10 – Proprietary Packet

RX_PROP indicates RX proprietary packet received.

4.2.11 TP11 – V33FB

Reserved, leave this pin open.

4.2.12 TP12 – Low Noise Analog Ground

Low noise ground TP.

4.2.13 TP13 – Debug only

TX_COMM is used for debug only. This pin echoes all TX_COMM.

4.2.14 TP14 – FP_OFFSET

FOD ping circuit setting, see the data sheet for more information.

4.2.15 TP15 – Drive B

Output from power section B of H-Bridge, U3.

4.2.16 TP16 – FOD_Cal

FOD calibration resistor test point, connected to pin 22 of bq501210.

4.2.17 TP17 – Low Noise Analog Ground

Low noise ground TP.

4.2.18 TP18 – Rail Output Voltage

Output voltage from rail buck converter that feeds H-Bridge power section.

4.2.19 TP19 – PWM_RAIL

Digital input to rail converter power section from bq501210. Signal is PWM, used to control rail voltage.

4.2.20 TP20 – DPWM-A Signal

Digital output signal from bq501210 to H-Bridge drive for U2.

4.2.21 TP21 – DPWM-B Signal

Digital output signal from bq501210 to H-Bridge drive for U3.

4.2.22 TP22 – BUZZ_DC

DC output when power transfer is started. Can be used to drive a DC style buzzer or LED. See the data sheet for more information.

4.2.23 TP23 – Unused IC Pin 30

Unused pin.

4.2.24 TP24 – Unused IC Pin 29

Unused pin.

4.2.25 TP25 – Unused IC Pin 6

Unused pin.

5 Schematic and Bill of Materials

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

Figure 1 through Figure 6 illustrate the schematics for this EVM.

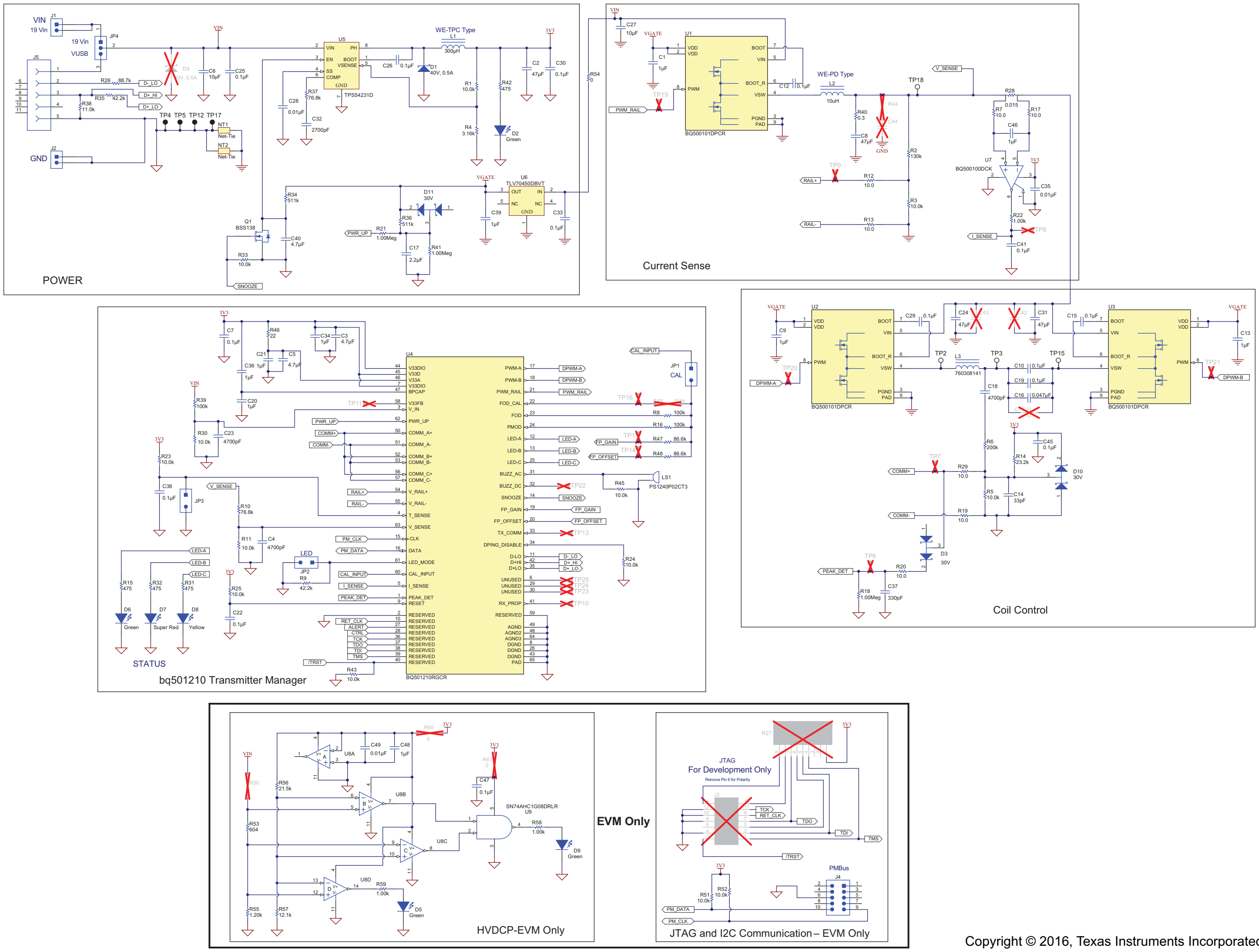

Figure 1. bq501210EVM-756 Full Schematic

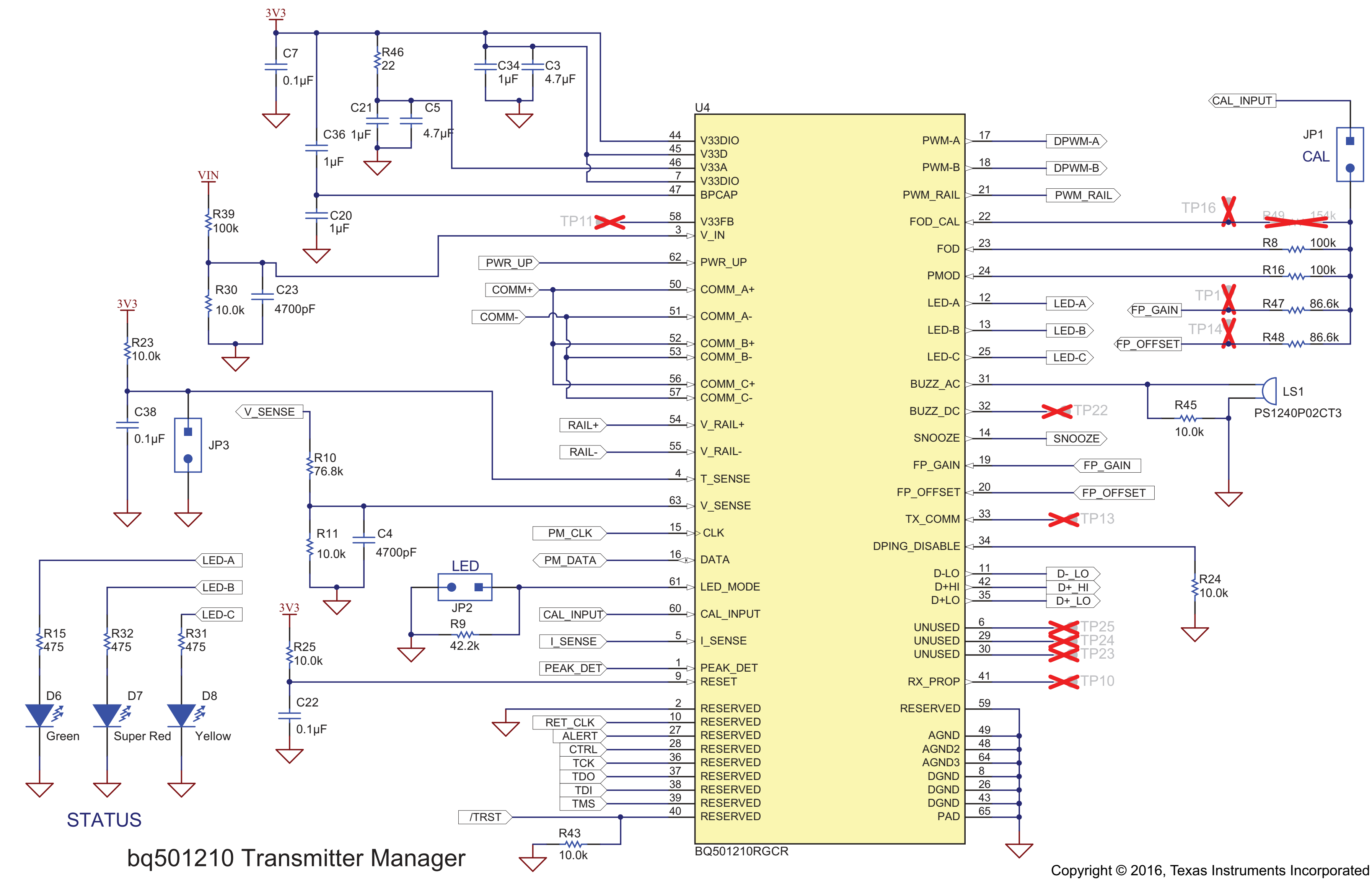

Figure 2. bq501210EVM-756 Transmitter Manager Schematic

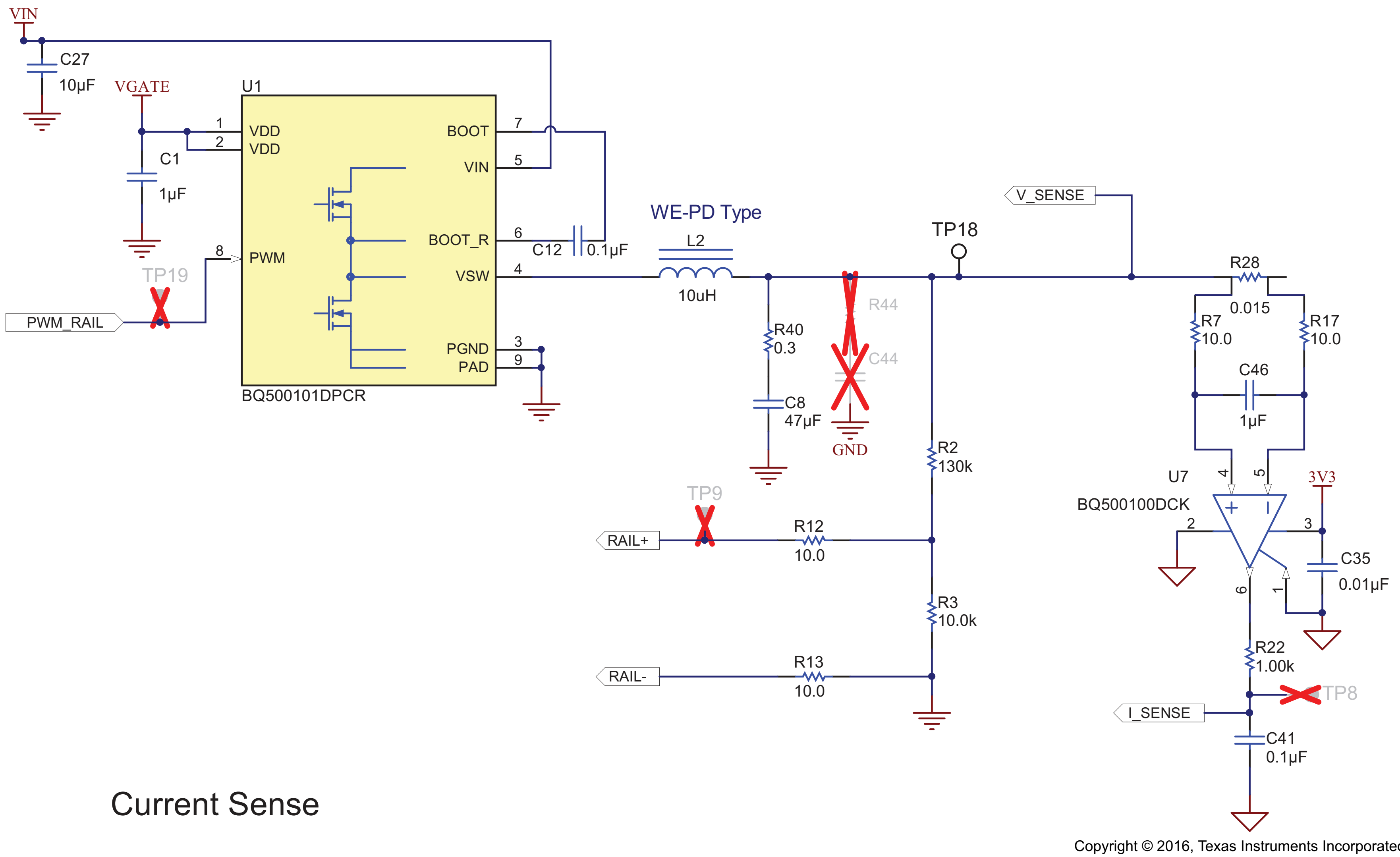

Figure 3. bq501210EVM-756 Current Sense Schematic

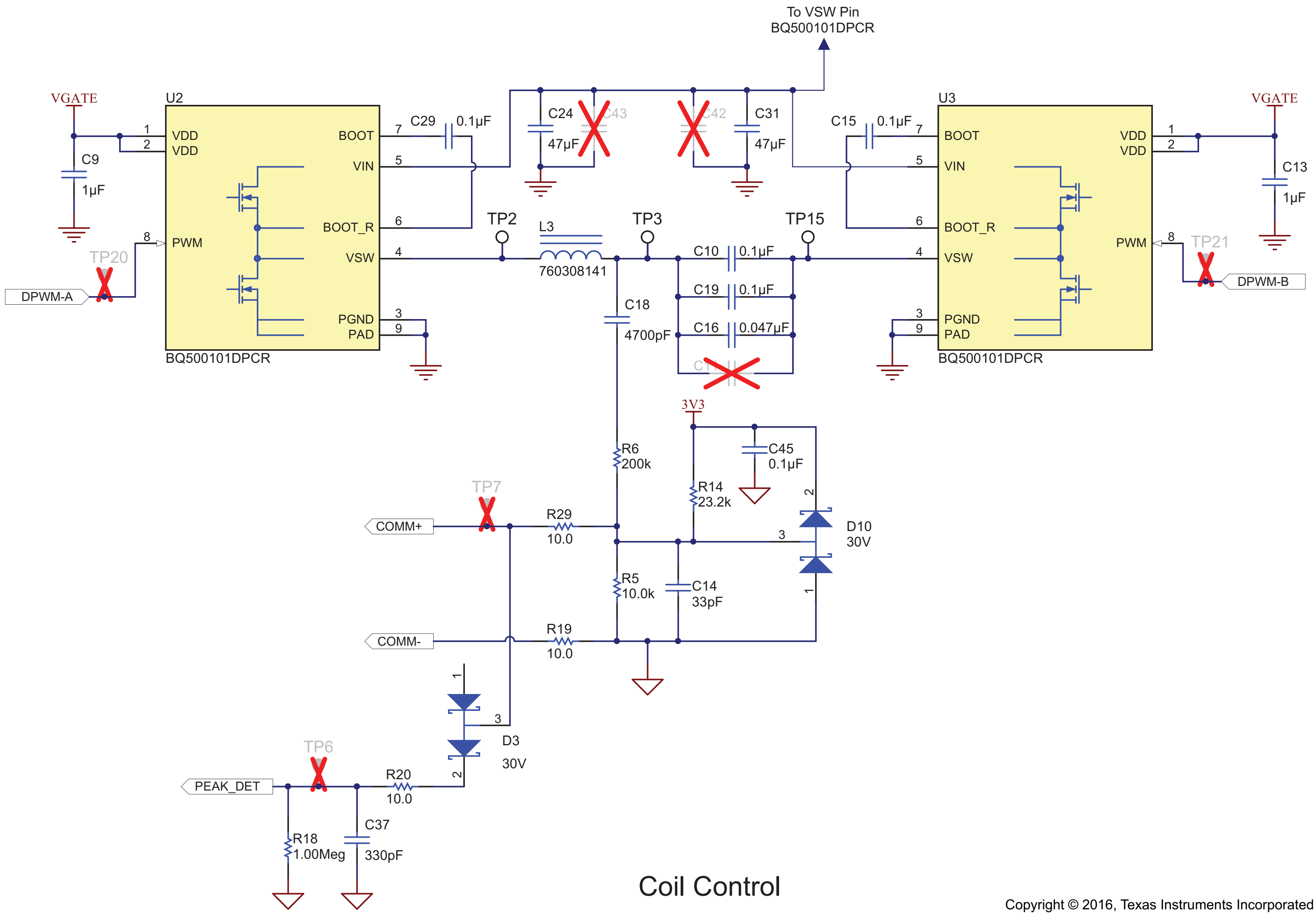

Figure 4. bq501210EVM-756 Coil Control Schematic

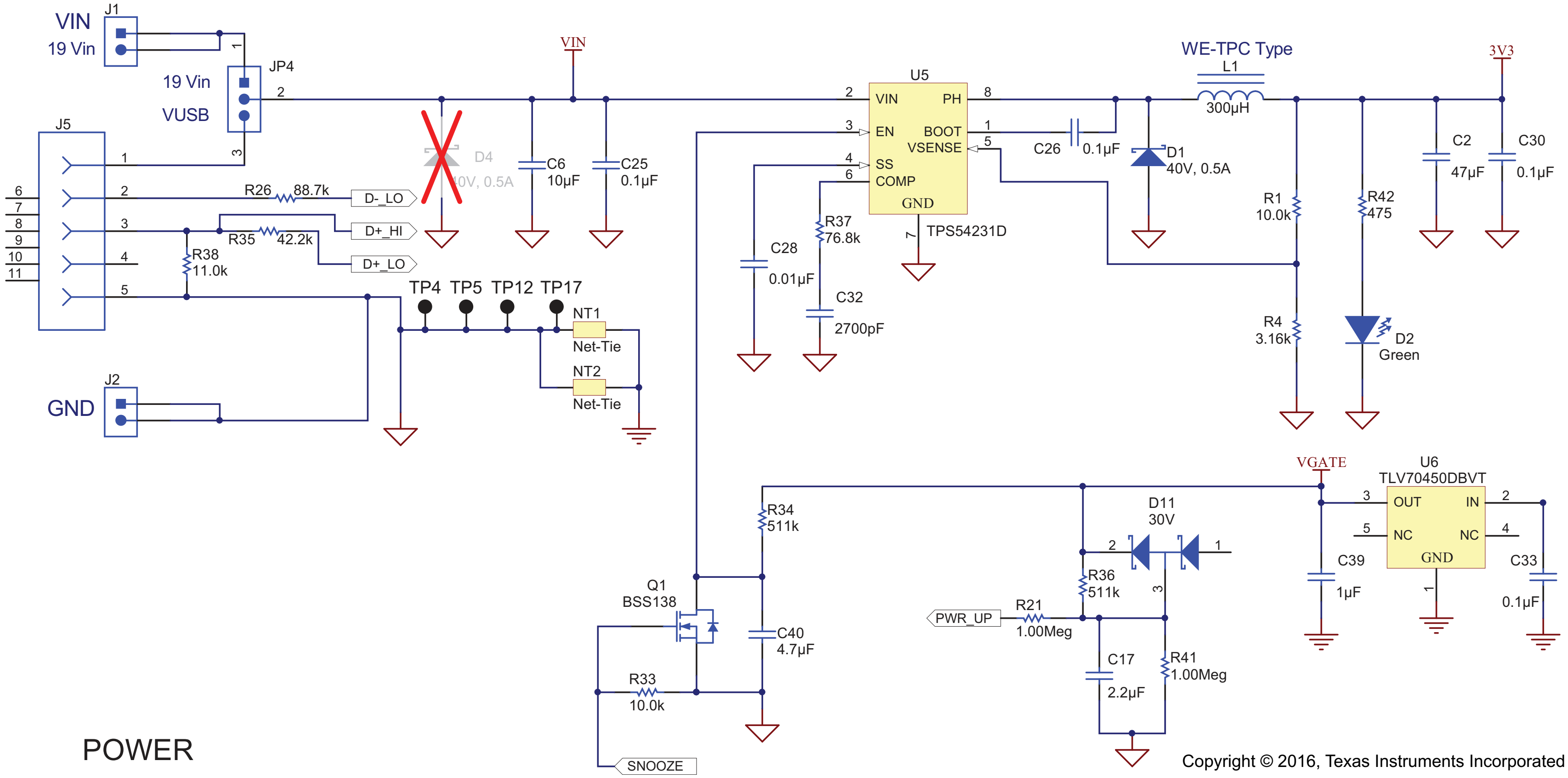

Figure 5. bq501210EVM-756 Power Schematic

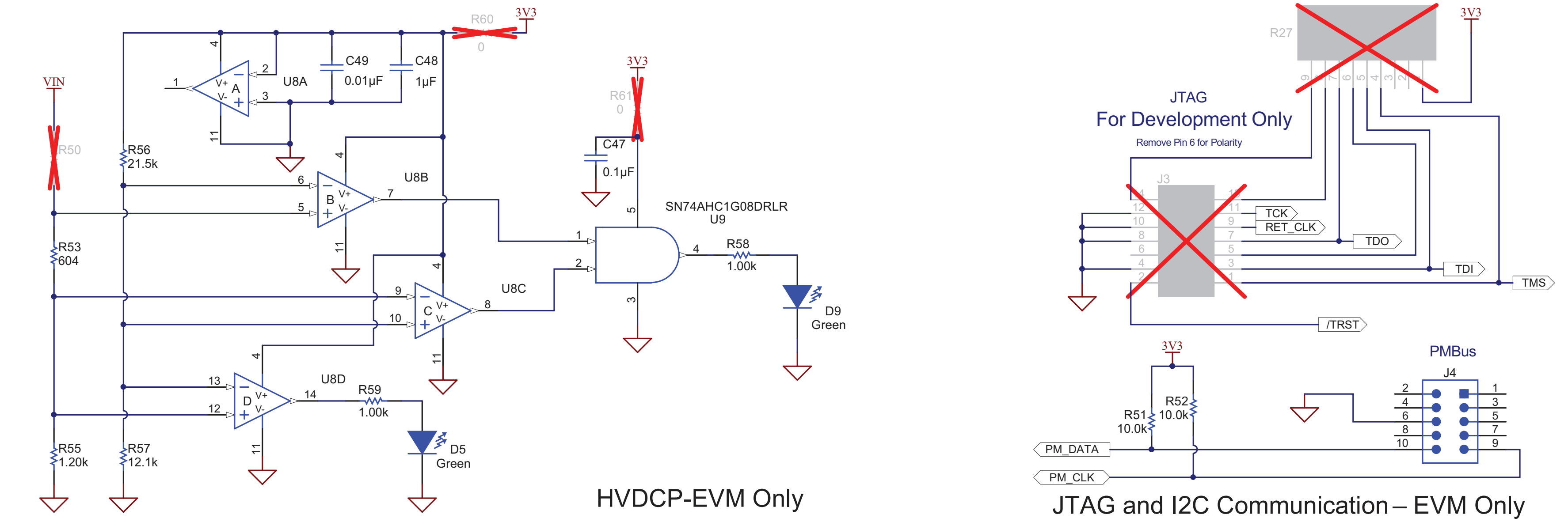

Figure 6. bq501210EVM-756 Schematic

Table 2 contains the BOM for this EVM.

Table 2. Bill of Materials(1)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
U1, U2, U3	3		Synchronous Buck NexFET Power Stage, DPC0008A	DPC0008A	BQ500101DPCR	Texas Instruments
U4	1		WPC 1.2 Wireless Power Transmitter Manager with 15-W Power Deliver, RGC0064B	RGC0064B	BQ501210RGCR	Texas Instruments
U5	1		Buck Step Down Regulator with 3.5 to 28 V Input and 0.8 to 25 V Output, -40 to 150°C, 8-Pin SOIC (D), Green (RoHS & no Sb/Br)	D0008A	TPS54231D	Texas Instruments
U6	1		Single Output LDO, 150 mA, Fixed 5 V Output, 2.5 to 24 V Input, with Ultra-Low IQ, 5-pin SOT-23 (DBV), -40 to 125°C, Green (RoHS & no Sb/Br)	DBV0005A	TLV70450DBVT	Texas Instruments
U7	1		BQ500100, DCK0006A	DCK0006A	BQ500100DCK	Texas Instruments
L1	1	300uH	Inductor, Shielded, 300uH, 0.13A, 4.1 ohm, SMD	4.8x1.8x4.8mm	744042331	Wurth Elektronik eiSos
L2	1	10uH	Inductor, Shielded Drum Core, Ferrite, 10uH, 2.6A, 0.0515 ohm, SMD	10x3x10mm	7447713100	Wurth Elektronik eiSos
L3	1	10uH	Inductor, Wirewound, 10uH, 9A, 0.028 ohm, TH	54.4x6.5x54.4mm	760308141	Wurth Elektronik eiSos
C1, C9, C13, C20, C21, C34, C36, C39	8	1uF	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0603	0603	GRM188R71C105KA12D	Murata
C2	1	47uF	CAP, CERM, 47uF, 6.3V, +/-10%, X5R, 1206	1206	GRM31CR60J476KE19L	Murata
C3, C5, C40	3	4.7uF	CAP, CERM, 4.7uF, 10V, +/-10%, X5R, 0603	0603	CGB3B1X5R1A475K055AC	TDK
C4, C18, C23	3	4700pF	CAP, CERM, 4700pF, 50V, +/-10%, X7R, 0603	0603	GRM188R71H472KA01D	Murata
C6, C27	2	10uF	CAP, CERM, 10uF, 35V, +/-10%, X7R, 1210	1210	GRM32ER7YA106KA12L	Murata
C7, C12, C15, C22, C25, C26, C29, C30, C33, C38, C41, C45	12	0.1uF	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603	0603	GRM188R71H104KA93D	Murata
C8	1	47uF	CAP, CERM, 47 µF, 25 V, +/- 20%, X5R, 1206_190	1206_190	C3216X5R1E476M160AC	TDK
C10, C19	2	0.1uF	CAP, CERM, 0.1uF, 100V, +/-5%, C0G/NP0, 1812	1812	C1812C104J1GACTU	Kemet
C14	1	33pF	CAP, CERM, 33pF, 50V, +/-5%, C0G/NP0, 0603	0603	GRM1885C1H330JA01D	Murata
C16	1	0.047uF	CAP, CERM, 0.047uF, 100V, +/-5%, C0G/NP0, 1812	1812	C4532C0G2A473J200KA	TDK
C17	1	2.2uF	CAP, CERM, 2.2uF, 25V, +/-10%, X5R, 1206	1206	GRM316R61E225KA12D	Murata
C24, C31	2	47uF	CAP, CERM, 47uF, 25V, +/-20%, X5R, 1206	1206	C3216X5R1E476M160AC	TDK
C28, C35	2	0.01uF	CAP, CERM, 0.01uF, 50V, +/-10%, X7R, 0603	0603	GRM188R71H103KA01D	Murata
C32	1	2700pF	CAP, CERM, 2700pF, 50V, +/-5%, C0G/NP0, 0603	0603	GRM1885C1H272JA01D	Murata
C37	1	330pF	CAP, CERM, 330pF, 50V, +/-5%, C0G/NP0, 0603	0603	GRM1885C1H331JA01D	Murata
C46	1	1uF	CAP, CERM, 1 µF, 16 V, +/- 10%, X7R, 0603	0603	GRM188R71C105KA12D	Murata
D1	1	40V, 0.5A	Diode, Schottky, 40V, 0.5A, SOD-123	SOD-123	MBR0540T1G	ON Semiconductor
D2, D6	2	Green	LED, Green, SMD	LED_0603	150060VS75000	Wurth Elektronik eiSos
D3, D10, D11	3	30V	Diode, Schottky, 30V, 0.2A, SOT-323	SOT-323	BAT54SWT1G	Fairchild Semiconductor
D7	1	Super Red	LED, Super Red, SMD	LED_0603	150060SS75000	Wurth Elektronik eiSos
D8	1	Yellow	LED, Yellow, SMD	LED_0603	150060YS75000	Wurth Elektronik eiSos
J5	1		Receptacle, Micro-USB-B, Right Angle, SMD	Micro USB receptacle	105017-0001	Molex
LS1	1		Buzzer, Piezo, 4kHz, 12.2mm, TH	12.2x4.0mm	PS1240P02CT3	TDK
Q1	1	50V	MOSFET, N-CH, 50V, 0.22A, SOT-23	SOT-23	BSS138	Fairchild Semiconductor

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

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

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
R1, R3, R5, R11, R23, R24, R25, R30, R33, R43, R45	11	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R2	1	130k	RES, 130k ohm, 1%, 0.1W, 0603	0603	CRCW0603130KFKEA	Vishay-Dale
R4	1	3.16k	RES, 3.16k ohm, 1%, 0.1W, 0603	0603	CRCW06033K16FKEA	Vishay-Dale
R6	1	200k	RES, 200k ohm, 1%, 0.1W, 0603	0603	CRCW0603200KFKEA	Vishay-Dale
R7, R17	2	10.0	RES, 10.0, 1%, 0.1 W, 0603	0603	CRCW060310R0FKEA	Vishay-Dale
R8	1	100k	RES, 100 k, 1%, 0.1 W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R9, R35	2	42.2k	RES, 42.2 k, 1%, 0.1 W, 0603	0603	CRCW060342K2FKEA	Vishay-Dale
R10, R37	2	76.8k	RES, 76.8k ohm, 1%, 0.1W, 0603	0603	CRCW060376K8FKEA	Vishay-Dale
R12, R13, R19, R20, R29	5	10.0	RES, 10.0 ohm, 1%, 0.1W, 0603	0603	CRCW060310R0FKEA	Vishay-Dale
R14	1	23.2k	RES, 23.2k ohm, 1%, 0.1W, 0603	0603	CRCW060323K2FKEA	Vishay-Dale
R15, R31, R32, R42	4	475	RES, 475 ohm, 1%, 0.1W, 0603	0603	CRCW0603475RFKEA	Vishay-Dale
R16	1	100k	RES, 100k ohm, 1%, 0.1W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R18, R21, R41	3	1.00Meg	RES, 1.00Meg ohm, 1%, 0.1W, 0603	0603	CRCW06031M00FKEA	Vishay-Dale
R22	1	1.00k	RES, 1.00k ohm, 1%, 0.1W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale
R26	1	88.7k	RES, 88.7 k, 1%, 0.1 W, 0603	0603	CRCW060388K7FKEA	Vishay-Dale
R28	1	0.015	RES, 0.015, 0.5%, 0.5 W, 1206 sense	1206 sense	LVK12R015DER	Ohmite
R34, R36	2	511k	RES, 511 k, 1%, 0.1 W, 0603	0603	CRCW0603511KFKEA	Vishay-Dale
R38	1	11.0k	RES, 11.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0711KL	Yageo America
R39	1	100k	RES, 100 k, 1%, 0.1 W, 0603	0603	RC0603FR-07100KL	Yageo America
R40	1	0.3	RES, 0.3, 1%, 0.5 W, 1206	1206	CSR1206FKR300	Stackpole Electronics Inc
R46	1	22	RES, 22 ohm, 0.5%, 0.1W, 0805	0805	RR1220Q-220-D	Susumu Co Ltd
R47, R48	2	86.6k	RES, 86.6 k, 1%, 0.1 W, 0603	0603	CRCW060386K6FKEA	Vishay-Dale
R49	0	154k	RES, 154 k, 1%, 0.1 W, 0603	0603	CRCW0603154KFKEA	Vishay-Dale
R54	1	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo America
SH-JP1, SH-JP4	2	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M
TP2, TP3, TP15, TP18	4	White	Test Point, Compact, White, TH	White Compact Testpoint	5007	Keystone
TP4, TP5, TP12, TP17	4	Black	Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone

6 Test Setup

6.1 Equipment

6.1.1 WPC v1.2 15-W Receiver

Use a WPC v1.2 15-W receiver for evaluation. When paired with the bq51025EVM-749, the system can produce 10 W. If a low power Qi-compliant receiver such as bq51020EVM-520 or bq51013BEVM-764 is used, then the maximum output power is 5 W. Note that the following test set-up only discusses the WPC v1.2 15-W RX configuration.

6.1.2 Voltage Source

To deliver 15 W, the input voltage source must provide a regulated DC voltage of 15 V to 19 V and deliver at least 2-A continuous load current; current limit must be set to 3 A.

CAUTION

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.

External Power Supply Requirements:

Nom Voltage:15.0–19.0 V_{DC}

Max Current: 2.0 A

Efficiency Level V

External Power Supply Regulatory Compliance Certifications: Recommend selection and use of an external power supply which meets TI’s required minimum electrical ratings in addition to complying with applicable regional product regulatory/safety certification requirements such as (by example) UL, CSA, VDE, CCC, PSE, and so forth.

The bq501210EVM-756 works with 5-V to 19-V input voltage. Levels between 15 V and 19 V will deliver 15 W, which is required for a WPC Extended Power Profile (EPP) transmitter.

5-V input supplies are aimed to negotiate to HVDCP voltages of 9 V or 12 V which enables Fast Charging of capable receivers. The system may also deliver power as a normal 5-V transmitter, however, the power level will be reduced and providing power to higher voltage receivers may not be successful. A typical 5-V receiver has shown to produce 4.5 W consistently. Coupling and other factors will greatly influence the results of each system.

6.1.3 Meters

Monitor the output voltage of the 15-W RX 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 at 7 V to 12 V (dependent on the RX used) with a maximum current of 2 A. The load can be resistive or electronic.

6.1.5 Oscilloscope

Use a dual-channel oscilloscope with appropriate probes to observe the VOUT of the 15-W RX 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 15-W RX to the load.

6.2 Equipment Setup

- Verify jumper positions
  - JP1 - Shorted
  - JP2 - Open
  - JP3 - Open
  - JP4 - 19-V input selected
- With the power supply OFF, connect the supply to the bq501210EVM-756 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 15-W RX on the transmitter. Connect a load to OUT with a return to GND, monitor current through the load with the ammeter, and monitor the voltage to the load at OUT. All voltmeters must be Kelvin connected (at the pin) to the point of interest.

6.2.1 Equipment Setup Diagram

The diagram in Figure 7 shows the test setup.

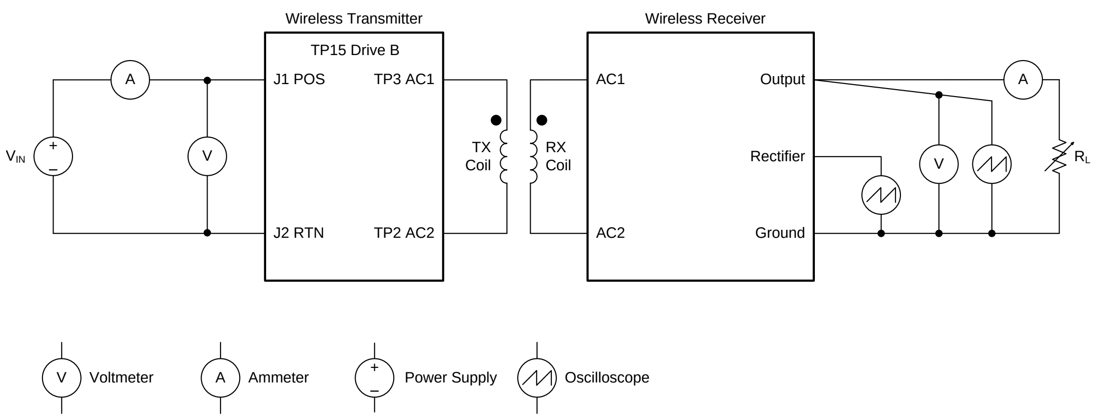

Figure 7. Equipment Setup

6.2.2 EVM Procedures

This section provides guidance for a few general test procedures to exercise the functionality of the presented hardware. Figure 8 shows the TX and RX test points.

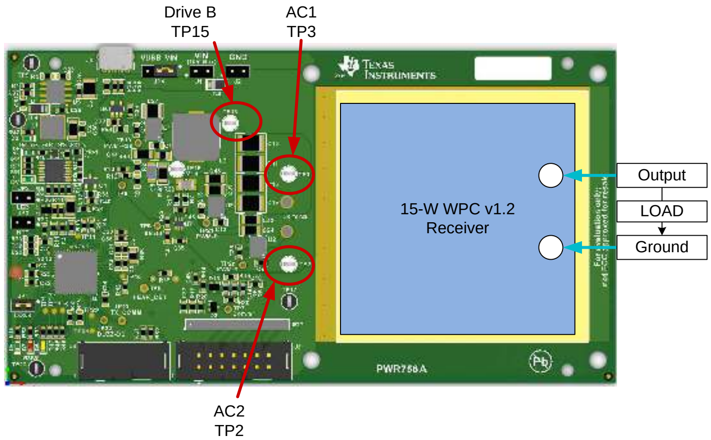

Figure 8. EVM Test Points

Some key notes are shown in the following sub-sections.

6.2.2.1 Start-Up No Receiver

Turn on V_{IN}, and observe that the green power LED D2 is flashing. LEDs D6, D7, D8, D9 and D12 are OFF until the power transfer starts.

Apply the scope probe to the TX test point, TP15 drive B. Figure 9 shows TP15 and the input current during the ping stage.

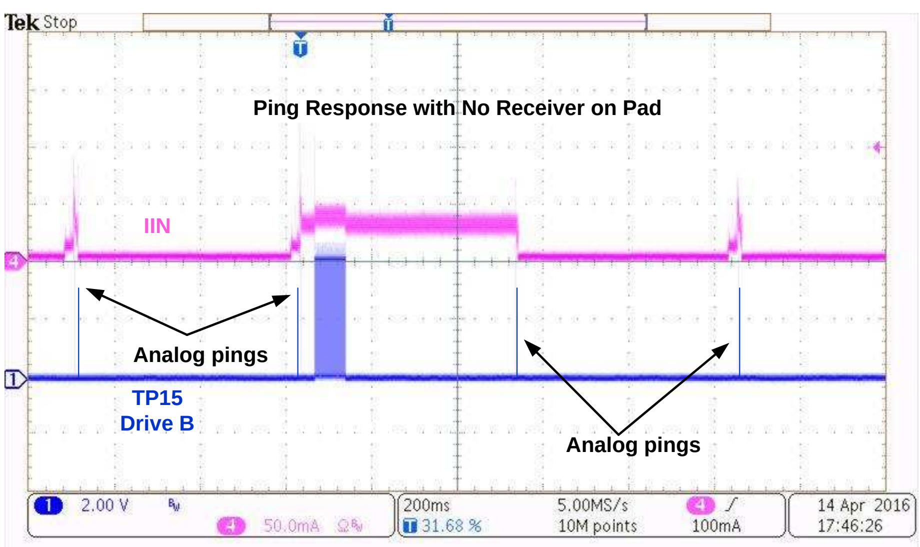

Figure 9. Analog and Digital Pings with No RX

Observe the single-pulse burst approximately every 500 ms. A digital ping is longer and is added at random intervals. This digital ping begins communication with a receiver placed on the TX coil. In most cases, the Analog pin will detect a receiver being placed on the TX pad. The digital ping is a backup which captures any certified RX. Note that the overall current during the analog pin is substantially lower than the digital ping.

6.2.2.2 Apply Receivers

Place the15-W RX on the top of the transmitting coil. Align the centers of the RX and TX coils. In the next few seconds, observe that there is a "beep" from the TX and the status LED D6 flashes. Depending on the 15-W RX chosen, there may be LED indicators. These are an indication that communication between the transmitter and the receiver is established and that power transfer has begun.

- The TX status LED, D6, flashes green during power transfer.
- Typical RX output voltage is 10 V, and the output current range is 0 mA to 1.5 A.
- Observe a continuous sine-wave on the TX test point TP15 when power transfer is active; the frequency is 130 kHz.
- Make tests and measurements applicable to a normal 10-V power supply.

6.2.2.3 Efficiency

Measure the system efficiency by measuring 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 7). Average the input current (the communication pulses modulate the input current, distorting the reading). Figure 10 shows efficiency.

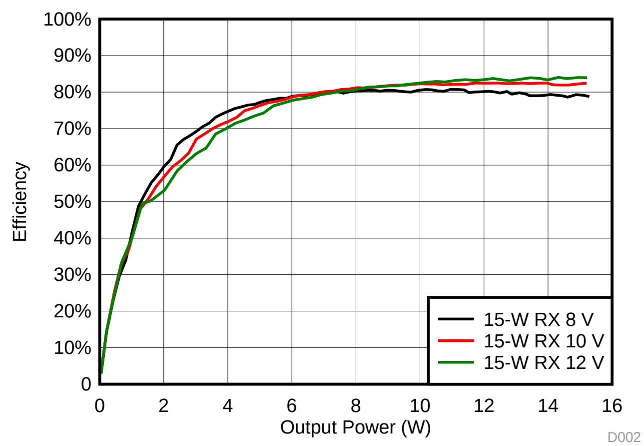

Figure 10. Efficiency vs Power, bq501210EVM-756 Transmitter and a 15-W Receiver

6.2.2.4 TX LED Behavior

The LED behavior of D6, D7 and D8 is set by the resistance from the LED_MODE pin to ground. The default for the bq501210EVM-756 is 42.2 kΩ, making this LED CONTROL OPTION 1 (as seen in the bq501210 data sheet, Table 3, LED Modes.

D2 – Green LED indicator of 3.3-V DC-to-DC converter. During STANDBY (no RX), D2 flashes at about a one-half second rate. D2 is ON during power transfer and during fault conditions.

D6 – Green status LED driven by bq501210 (LED-A). Blinks during power transfer, D6 blinks about once per second for 5 W or 15 W and about twice per second for the proprietary 10 W solution with the bq51025 RX.

D7 – Red status LED driven by bq501210 (LED-B). On during fault condition (for example: FOD failure and Temperature Fault) and blinks during FOD warning.

D8 – Yellow status LED driven by bq501210 (LED-C). D8 is unused for LED Option 1.

D9 – Green LED controlled by TX input voltage. Only on when the input voltage is between 8 V and 12 V.

D12 – Green LED controlled by TX input voltage. On when the input voltage is above 12 V. See Section 6.2.2.8 for more information on D9 and D12.

NOTE: Status LED behavior is controlled by LED mode resistor R9, 42.4 kΩ for mode 1. See the bq501210 data sheet for additional options and configurations of LEDs D6, D7, and D8.

6.2.2.5 Start Up Receiver Placed on Transmitter

The transmitter sends a digital ping about every 500 ms. If a receiver is present, it powers up and replies, then begins the power transfer. Figure 11 is a scope capture of the bq501210EVM-756 beginning a power transfer with the 15-W RX.

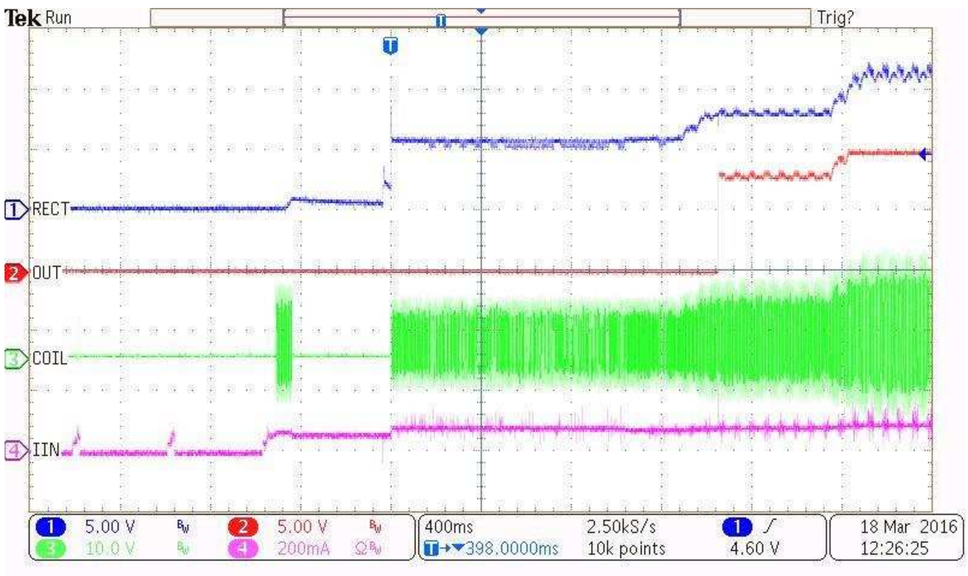

Figure 11. Start Up

The bq501210 device supports 2-way communication between the receiver and transmitter. All communication between the TX and RX is initiated by the RX. The TX will respond as appropriate. Figure 12 shows the activity of the request and response during the startup phase. The TX_COMM (TP13) is a test point that shows the simplified information sent from the TX to the RX following the WPC v1.2 2-way communication protocol. See the WPC v1.2 specification for details on the communication protocol.

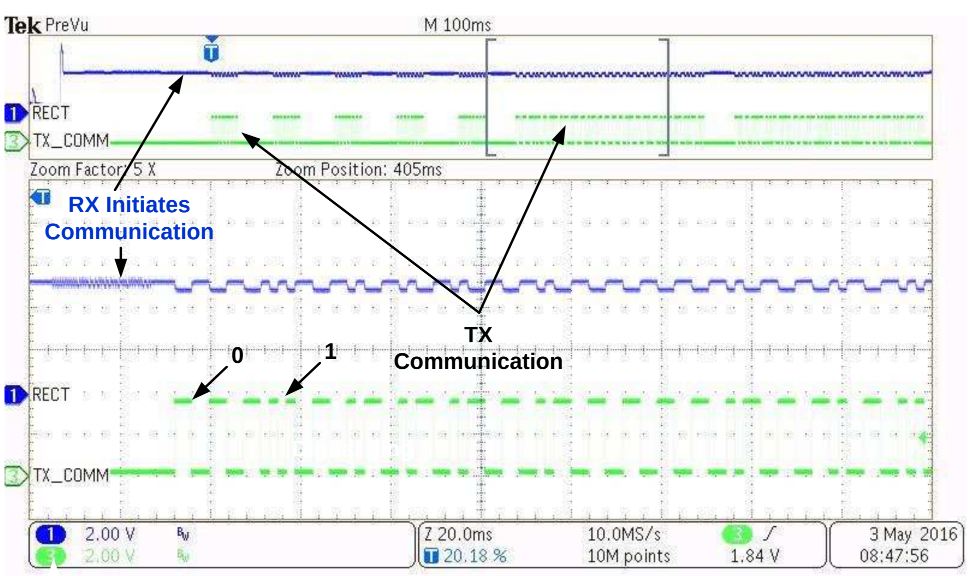

Figure 12. TX_COMM at Start Up

6.2.2.6 Thermal Protection, NTC

Thermal protection is provided by an NTC resistor connected to JP3. At approximately 1 V on the sense side (T_SENSE), the thermal fault is set, and the unit is shut down. The status LED, D8, illuminates. The system tries to restart in 5 minutes.

6.2.2.7 Foreign Object Detection (FOD) and Parasitic Metal Object Detection (PMOD)

The bq501210 EVM supports multiple levels of protection against heating metal objects placed in the magnetic field during power transfer. PMOD is used for older WPC v1.0 version receivers and FOD is used for WPC v1.1 and WPC v1.2.

The first level is a short FOD ping that detects most objects before any power transfer is initiated, analysis of the impulse response is used. Resistors R47 and R48 are used to tune this function, see the data sheet for additional information.

The second level is power loss accounting, a comparison between power transmitted to the receiver (RX) with the power the RX reported receiving. The difference is lost power possibly going into a foreign object. 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 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 R8, 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 V_SENSE though R10 and R11. Input current is measured using sense resistor R28 and current sense amp U7 (bq500100). Since these measurements are used to calculate the power lost through a foreign object, both measurements must be 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, R49. This calculation changes with external component changes in the power path such as MOSFETs, resonate capacitors, and the TX coil. Recalculation of R49 and R8 is required if changes are made.
- **Receiver Reported Power** – The receiver calculates and reports power it receives in the message packet *Received Power Packet*.

The FOD threshold on the EVM is set to 600 mW, R8 is set to 100 kΩ. Increasing R8 increases the threshold and reduces the sensitivity to foreign objects.

This loss threshold is determined after making a measurement of transmitter performance using a receiver calibrated for FOD similar to a unit manufactured by Avid® Technology. Contact Texas Instruments for the FOD calibration procedure for bq501210.

The PMOD threshold on the EVM is set to 600 mW, R16 is 100 kΩ. Removing R16 disables this function.

6.2.2.8 HVDCP: High Voltage Dedicated Charger Port

The HVDCP Circuitry is shown in Figure 6. The purpose of this circuitry is to give a visual indication of the negotiation result when using a USB power source that has HVDCP capability. The circuit has been disabled by default on this EVM to allow more precise measurement of efficiency. To enable the circuit, simply insert 0-Ω resistors for R60 and R61 along with an 8.66-kΩ resistor for R50.

To enable the USB port, jumper JP4 must be set to select USB. When an HVDCP supply is plugged into J5, 5 V is passed to the system. The negotiation for higher voltage is done through the resistors on the D+/D- pins.

Once the circuit is enabled, two LEDs will indicate the voltage level of the system. When D9 is on, it indicates the system is about 9 V. D12 indicates the USB is > 12 V.

6.2.2.9 Thermal Performance

This section shows a thermal image of the bq501210EVM-756. A 1500-mA load is used at the 10-V 15-W receiver output. Output power is approximately 15 W, 1.5 A at 10 V. The maximum board temperature, at L2, is 35.5°C.

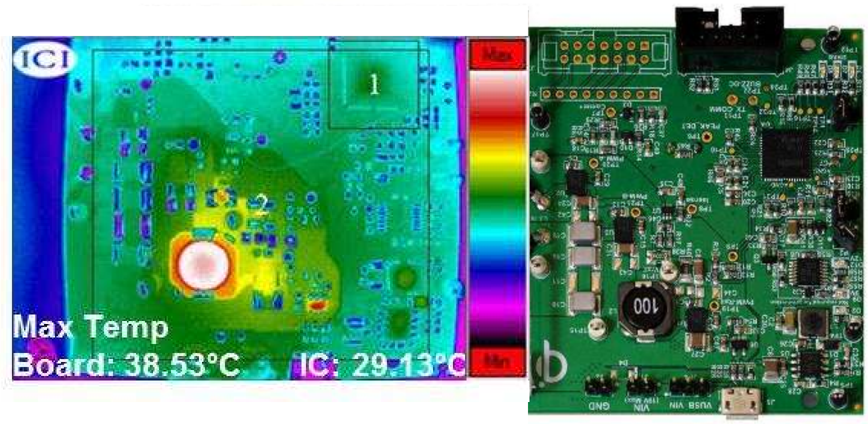

Figure 13. Thermal Performance

7 bq501210EVM-756 Assembly Drawings and Layout

Figure 15 through Figure 20 show the design of the bq501210EVM PCB. The EVM layout has been designed with the intent of easy access to critical notes and, therefore, is not optimized for space. The EVM has been designed using a 4-layer, 2-oz, copper-clad circuit board, 13.2 cm × 7.24 cm with all components in a 4.0-cm x 5.0-cm active area on the top side and all active traces to the top and bottom layers to allow the user to easily view, probe, and evaluate the bq501210 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 (bq501210EVM-756).

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 bq501210 GND pins and filter capacitor returns for V33A and V33D should be a good low-impedance path.

Special note should be taken of R28, the sense resistor in the Current Sense Schematic (Figure 14). The current sense layout is critical in the FOD performance. To get the best performance we use a 4-terminal resistor which allows the sense pins to go directly to the current monitor eliminating any solder connection resistance to be eliminated to get the true voltage across the sense resistor.

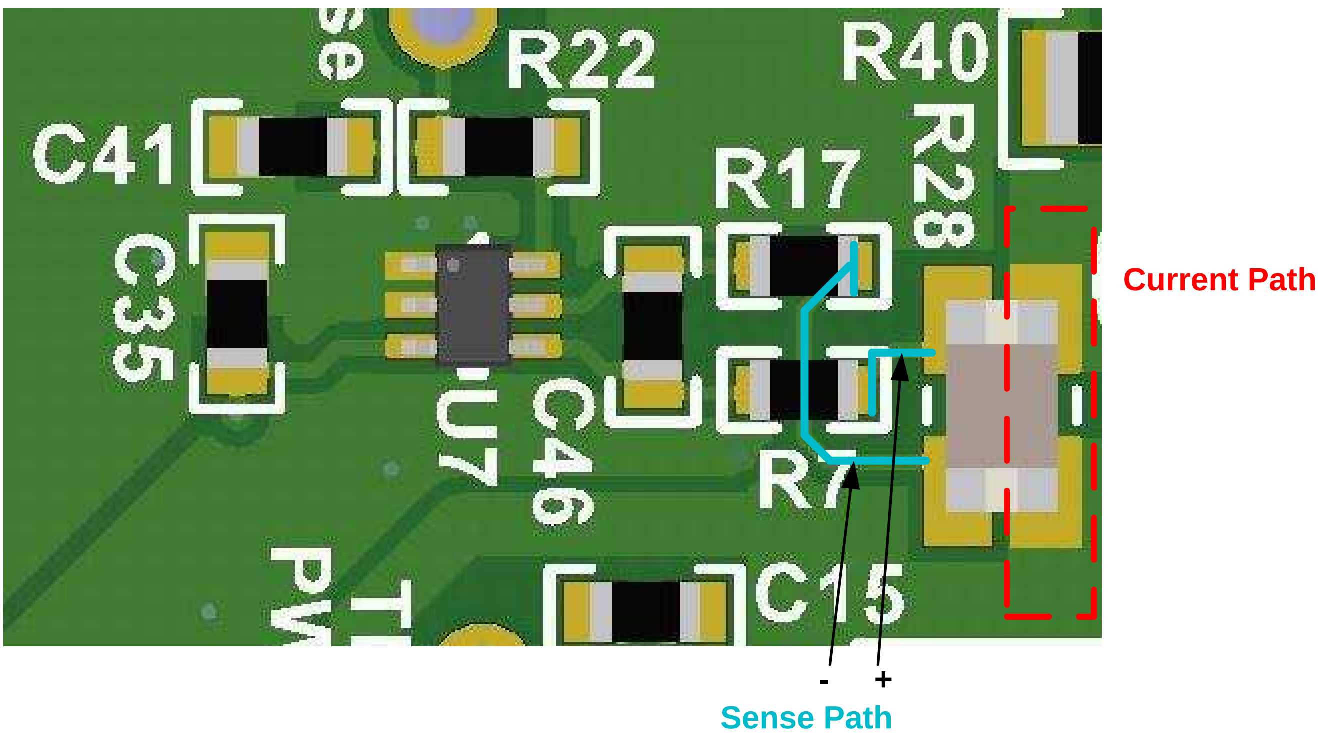

Figure 14. Sense Resistor Layout

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 (0.93 in or 2.4 mm) is the z-gap thickness for the transmitter, which is within the WPC specification limits.

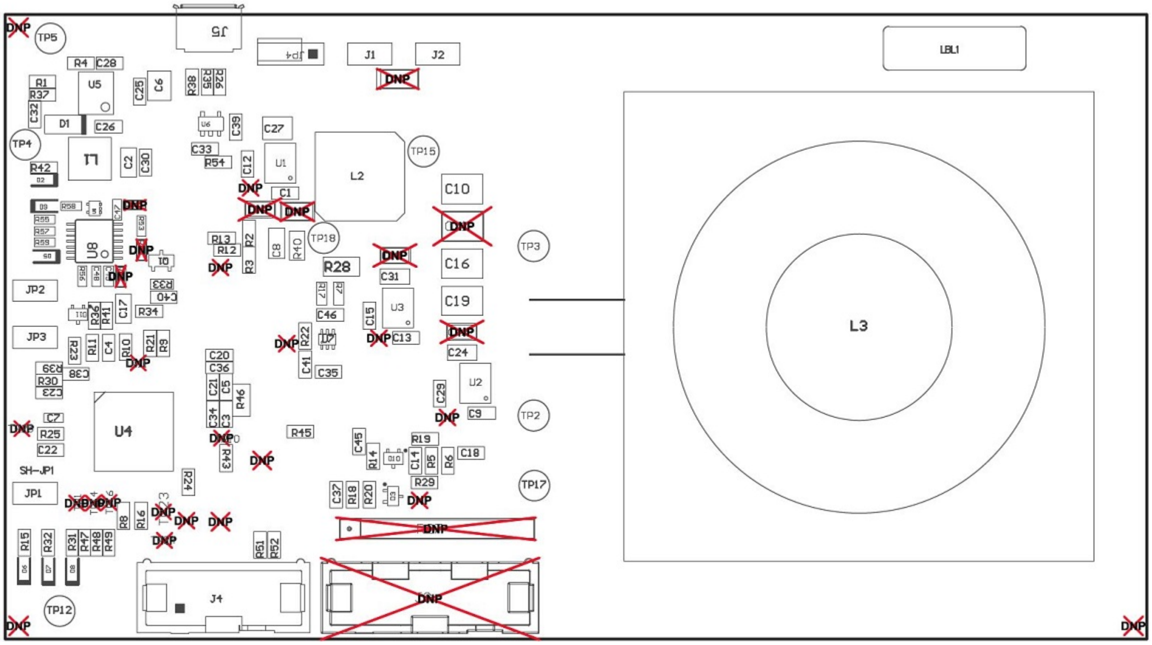

Figure 15. Assembly Top

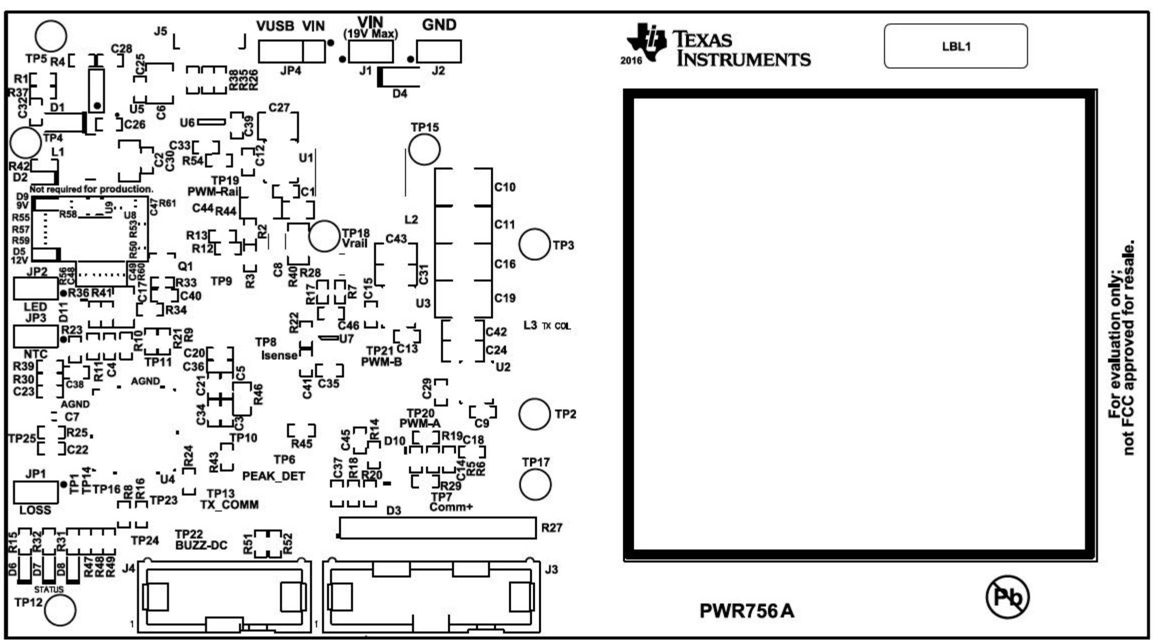

Figure 16. Top Silk

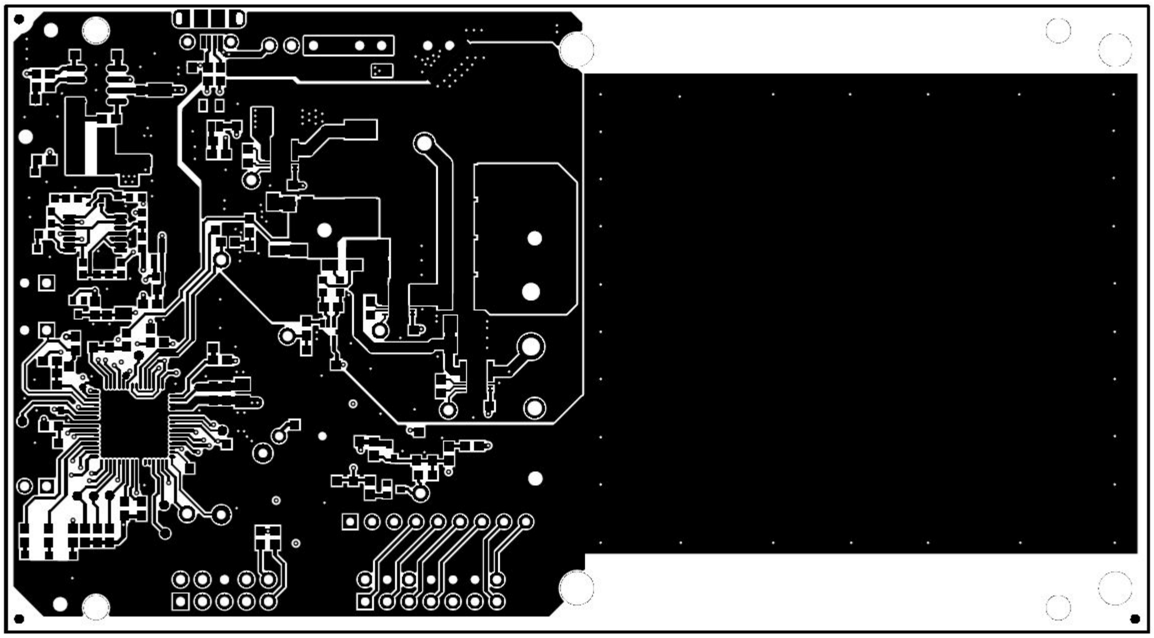

Figure 17. Top Layer

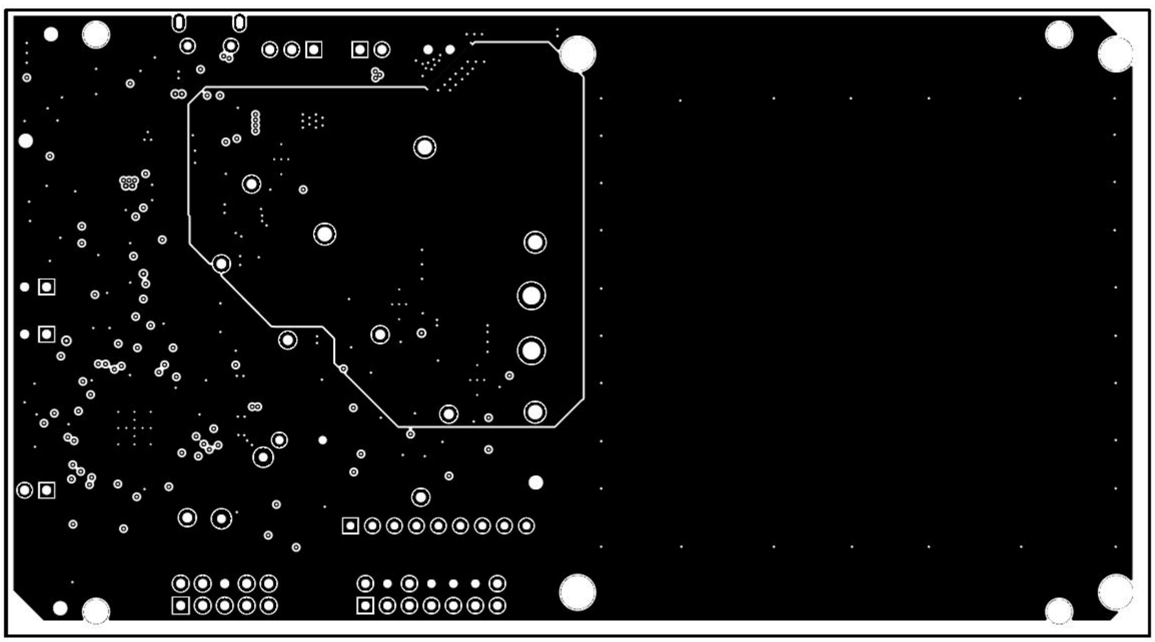

Figure 18. Inner Layer 1

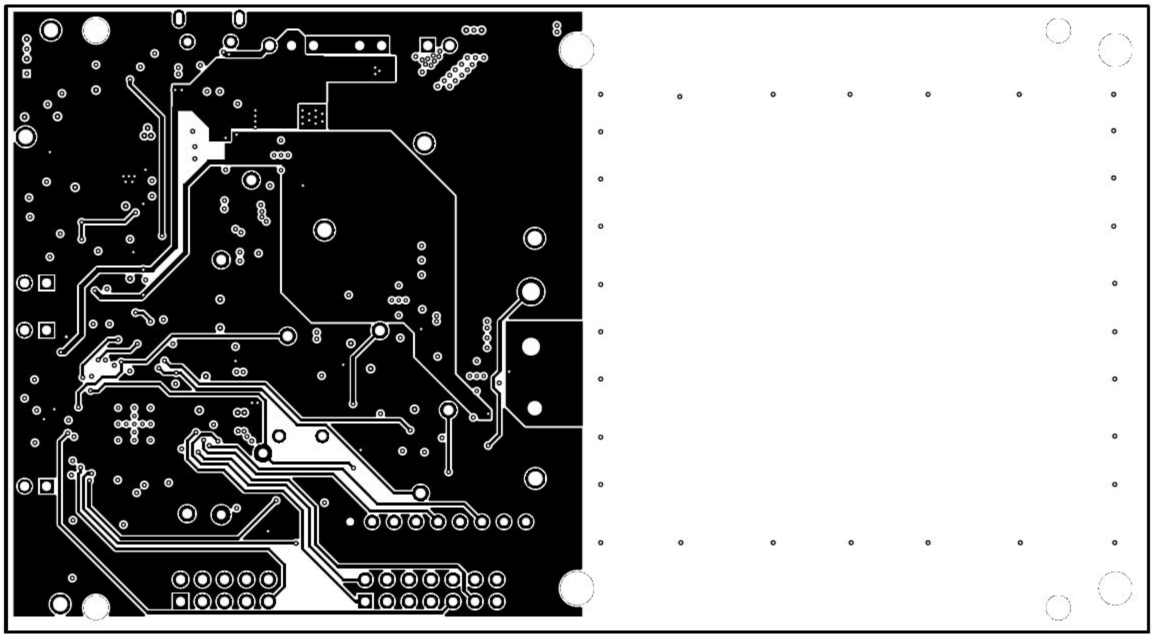

Figure 19. Inner Layer 2

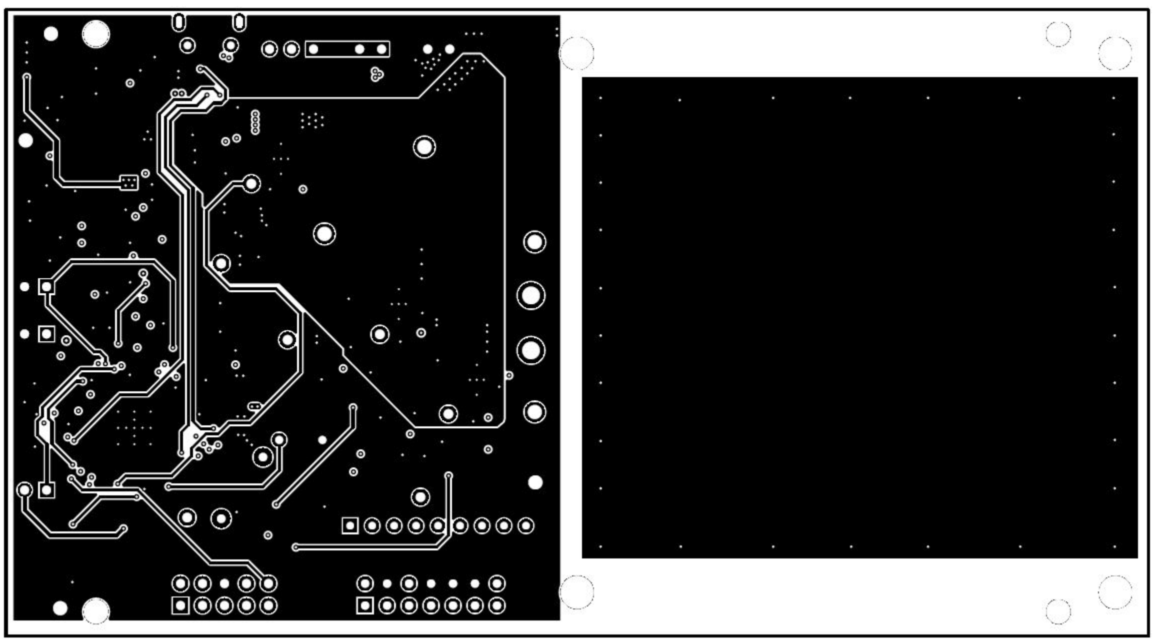

Figure 20. Bottom Layer

8 Reference

For additional information about the bq50120 WPC v1.2 Wireless Power Transmitter with 15-W Power Delivery and its Evaluation module, visit the product folder on the TI Web site at http://www.ti.com/product/bq501210.

For additional information on all of TI's wireless power products, visit www.ti.com/wirelesspower.

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- *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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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

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