bq51020EVM (5-W WPC) Integrated Wireless Receiver Power Supply

The bq51020EVM-520 (PWR520-002) wireless power receiver evaluation kit (EVM) from TI is a high performance, easy-to-use development kit for the design of wireless power solutions. It helps designers to evaluate the operation and performance of the bq51020 IC, a secondary-side receiver device for wireless power transfer in portable applications. The bq51020 device is a fully-contained, wireless power receiver capable of operating in WPC v1.1 protocol which allows a wireless power system to deliver up to 5 W to the system when used with a Qi inductive transmitter. The bq51020 device provides a single device power conversion (rectification and regulation) as well as the digital control and communication for WPC specification. The kit enables designers to speed up the development of their end-applications.

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1 Introduction

The bq51020 is an advanced, flexible, secondary-side device for wireless power transfer in portable applications. The bq51020 device integrates an ultra-low-impedance synchronous rectifier, a very-high-efficiency post regulator, digital control, and accurate voltage and current loops. The bq51020 devices provide the AC/DC power conversion while integrating the digital control required. The IC complies with the WPC v1.1 communication protocol.

Together with the bq500xxx primary-side controller transmitter, the bq51020 enables a complete contactless power transfer system for a wireless power supply solution. By utilizing near-field inductive power transfer, the secondary coil embedded in the mobile device can pick up the power transmitted by the primary coil. The voltage from the secondary coil is then rectified and regulated to be used as a power supply for down-system electronics. Global feedback is established from the secondary to the primary in order to control the power transfer process.

A WPC system communication is digital -– packets are transferred from the secondary to the primary. Differential bi-phase encoding is used for the packets. The bit rate is 2Kbps. Various types of communication packets have been defined. These include identification and authentication packets, error packets, control packets, power usage packets and efficiency packets, among others.

2 Considerations with this EVM

The bq51020EVM-520 evaluation module (PWR520-002) demonstrates the receiver portion of the wireless power system. This receiver EVM is a complete receiver-side solution that produces 5-W output power at up to 1-A load with adjustable output voltage.

- The receiver can be used in any number of low-power battery portable devices as a power supply for a battery charger. With contact-free charging capability, no connections to the device are needed.
- Highly-integrated wireless power receiver solution
  - Ultra-efficient synchronous rectifier
  - Very-high efficiency post regulator
  - WPC v1.1-compliant communication and control
  - Only one IC required between RX coil and DC output
- Programmable output voltage to optimize performance for application
- Adaptive Communication current limit (CM_ ILIM) for robust communication.
- Supports 20-V max input
- Low-power dissipative overvoltage clamp
- Overvoltage, overcurrent, overtemperature protection
- Low-profile, external pick-up coil
- Frame is configured to provide correct receiver to transmitter spacing

- Room above coil for testing with battery, key for Foreign Object Detection (FOD) tuning
- Options to adjust the input current limit and output voltage using resistors
- Flexibility for Foreign Object Detection (FOD) tuning
- Adjustable resistor that can be used to set RFOD
- Temperature sensing can be adjusted using external resistors
- Micro-USB connector for adapter testing configuration
- $\overline{\text{WPG}}$ LED indicator (turns on as V_{OUT} goes high)
- $\overline{\text{PD\_DET}}$ LED indicator --turns on as the RX is on TX pad

3 Modifications

See the data sheet (SLUSBX1) when changing components. To aid in such customization of the EVM, the board was designed with devices having 0402 and 0603 or larger footprints. A real implementation likely occupies less total board space.

Note that changing components can improve or degrade EVM performance.

4 Recommended Operation Condition

Table 1 provides a summary of the bq51020EVM-520 performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. bq51020EVM-520 Electrical Performance Specifications

PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
V_{IN}	RECT input voltage range		4.0		10.0	V
$I_{AD\_EN\_sink}$	Sink current				1	mA
I_{IN}	Input current range				1.5	A
I_{OUT}	Output current range	Current limit programming range			1.5	A
$V_{OUT(REG)}$	Programmable output voltage[(1)]	P_{OUT} = 5 W	4.5		8	V
f_s	Switching frequency	WPC	110		205	kHz
T_J	Junction temperature			125		°C

(1) The output voltage can be adjusted using $V_{OUT(REG)}$ resistors. Also the coil needs to change for different voltage for optimal operation of the EVM.

5 Equipment and EVM Setup

5.1 Schematic

Figure 1 shows the bq51020 schematic.

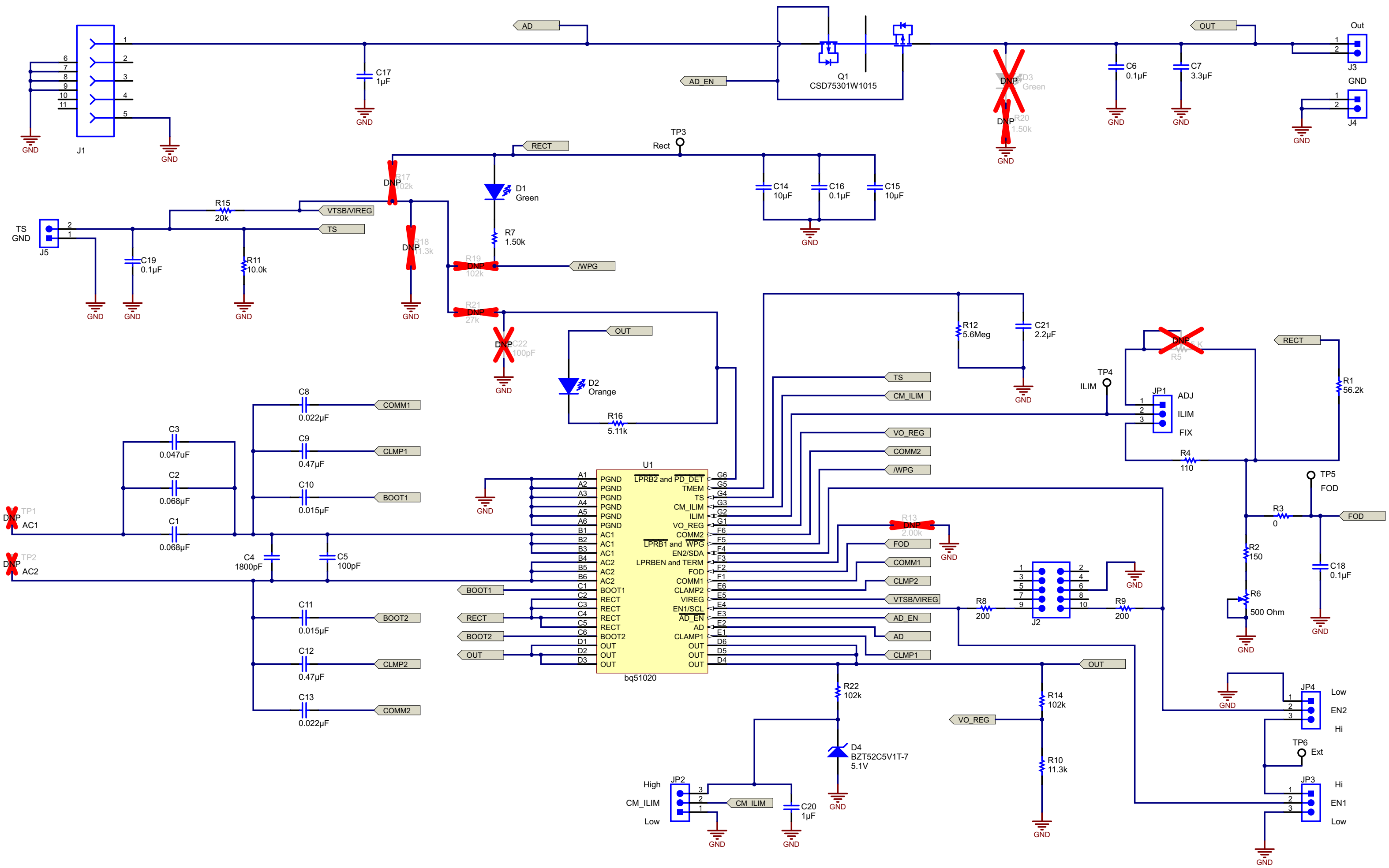

Figure 1. bq51020EVM-520 Schematic

5.2 Connector Descriptions

The connections points are described in the following paragraphs.

5.2.1 J1 – AD External Adapter Input

Power can be provided to simulate an external adapter applied to the receiver in this bq51020EVM-520 (PWR520-002).

5.2.2 J2 – Programming Connector

This connector is populated and is for factory use only

5.2.3 J3 – Output Voltage

Output voltage in wireless power mode up to 1 A; the adapter option is also supported in this PWR520-002.

5.2.4 J4 –GND

Ground return

5.2.5 J5 – TS/CTRL and Return Connector

External connection for temperature sense resistor, see data sheet for additional information. Not populated in this spin.

5.3 Jumpers and Switches

The control jumpers are described in the following paragraphs.

5.3.1 JP1– ILIM (FIX or ADJ)

Maximum output current is set by the ILIM pin. In the FIX position, the current is set to a fixed value of R4 plus RFOD. In the ADJ position, current is set by R5. Note that R5 is not populated in this EVM.

5.3.2 JP2 – CM_ILIM

Enables CM_ILIM feature when pulled low and disable when pulled up.

5.3.3 JP3 – EN1 (Low and High)

EN1 pin, set High using external power supply connected to TP6 .

5.3.4 JP4 – EN2 (Low and High)

EN2 pin, set High using external power supply connected to TP6.

5.4 Test Point Descriptions

The test points are described in the following paragraphs.

5.4.1 TP1 and TP2 – AC1 and AC2 Inputs

This are not populated, they can be used for measuring AC voltage applied to the EVM from the receiver coil.

5.4.2 TP3– Rectified Voltage

The input AC voltage is rectified into unregulated DC voltage (V_{RECT}); additional capacitance is used to filter the voltage before the regulator.

5.4.3 TP4– ILIM

Programming pin for overcurrent limit protection, pin G2 of the IC.

5.4.4 TP5 – FOD

Input for rectified power measurement for FOD feature in WPC, pin F2 of the IC. TP5 is the FOD pin for the bq51020.

5.4.5 TP6 – Ext

Connect to 5-V external power supply. Used to pull EN1 and EN2 high. Any voltage level above 7 V may damage the IC.

5.5 Pin Description of the IC

Table 2. Pin Description

PIN Number (WCSP)	bq51020
A1, A2, A3, A4, A5, A6	PGND
B1, B2, B3	AC1
B4, B5, B6	AC2
C1	BOOT1
C2, C3, C4, C5	RECT
C6	BOOT2
D1, D2, D3, D4, D5, D6	OUT
E1	CLAMP1
E2	AD
E3	$\overline{\text{AD\_EN}}$
E4	EN1
E5	VTSB
E6	CLAMP2
F1	COMM1
F2	FOD
F3	TERM
F4	EN2
F5	$\overline{\text{WPG}}$
F6	COMM2
G1	VO_REG
G2	ILIM
G3	CM_ILIM
G4	TS/CTRL
G5	TMEM
G6	$\overline{\text{PD\_DET}}$

6 Test Procedure

This procedure describes test configuration of the bq51020EVM-520 evaluation board (PWR520-002) for bench evaluation.

6.1 Definition

The following naming conventions are followed.

VXXX :	External voltage supply name (VADP, VTS, V_{OUT})
LOADW:	External load name (LOADR, LOADI)
V(TPyy):	Voltage at internal test point TPyy. For example, V(TP02) means the voltage at TP02.
V(Jxx):	Voltage at header Jxx
V(TP(XXX)):	Voltage at test point XXX. For example, V(ACDET) means the voltage at the test point which is marked as ACDET.
V(XXX, YYY):	Voltage across point XXX and YYY.
I(JXX(YYY)):	Current going out from the YYY terminal of header XX.
Jxx(BBB):	Terminal or pin BBB of header xx.
JPx ON :	Internal jumper Jxx terminals are shorted.
JPx OFF:	Internal jumper Jxx terminals are open.
JPx (-YY-) ON:	Internal jumper Jxx adjacent terminals marked as YY are shorted.

Assembly drawings have locations for jumpers, test points, and individual components.

6.2 Recommended Test Equipment

The following equipment is needed to complete this test procedure:

Power Supplies

- Power Supply #1 (PS #1) capable of supplying 19 V at 1 A is required
- Power Supply #2 (PS #2) capable of supplying 5 V at 1 A is required
- Power Supply #3 (PS #3) capable of supplying 5 V at 1 A is required

Loads

- A resistive load or electronic load that can be set to 5 Ω/1000 mA, 10 Ω/500 mA, and 5 kΩ/1 mA. The power rating should be 5 W.

Meters

- Two DC voltmeters and two DC ammeters

Oscilloscopes

- Not required

bqTesla Transmitter

- The HPA689 transmitter or equivalent is used for the final test.

Recommended Wire Gauge

- For proper operation, TI recommends 22-AWG wire.

6.3 Equipment Setup

The following items ensure proper equipment setup:

Test Set Up

- The final assembly will be tested using a bqTesla transmitter – provided (HPA689). Input voltage to the transmitter is set to 19 VDC ±200 mV, with a current limit of 1.0 A.
- Connect power supply to J1 and J2 of the transmitter, HPA689
- Set power supply to OFF
- Place unit under test (UUT) on the transmitter coil
- UUT will be placed in the center of the HPA689 TX coil. Other bqTesla transmitter base units are also acceptable for this test (ensure the correct input voltage is applied).

Load

- The load is connected between J3-OUT and J4-GND of the UUT

- A DC ammeter is connected between UUT and load
- Set the load for 5 Ω/1000 mA

Jumper Settings

- JP1 → ILIM and FIX are shorted
- JP2 → CM_ILM and High are shorted
- JP3 → EN1 and Low are shorted
- JP4 → EN2 and Low are shorted

Voltage and Current Meters

- Connect the ammeter to measure 19-V input current to the transmitter. Connect the voltmeter to monitor the input voltage at J1 and J2 of TX unit. On UUT a voltmeter is used to measure output voltage at J3 with ground at J4. Connect the ammeter to measure load current.

RFOD: R6 Set Up

- Connect the ohmmeter between JP5 (FOD) and J4 (GND). Adjust R6 to a 495 Ω reading on the ohmmeter.
- **NOTE:** Sometimes the multimeter cannot read the more than 430 Ω from the FOD resistor due to charged up capacitors in the board. If that happens, use a twizer and short C15 for few seconds, then measure again.

6.4 Procedure

The following operating procedures are provided at a variety of operating loads:

Turn ON Operation and Operation at 1000-mA Load

- Turn ON transmitter power supply (19 V)
- Transmitter – Verify LED D2 is *ON*
- UUT – Adjust load current to 1000 mA ±50 mA
- Put the receiver EVM on the transmitter coil and align them correctly
- After 5 seconds verify that:
  - Transmitter – Status LED D5 should be green, flashing approximately every 1 second
  - The transmitter should beep
  - Transmitter – LED D2 still ON
  - Receiver – LED D1 is ON
  - UUT – Verify that V_{OUT} is 4.9 V to 5.15 V (between J3 and J4)
  - UUT – Verify that the rectified voltage is 5 V to 5.4 V (between TP3 and GND) **NOTE**: a modulation signal is present on this voltage every 250 ms and may cause fluctuation in the reading: use lower value or baseline.

Efficiency Test (1000-mA Load)

- Verify that input current to the TX is less than 500 mA with input voltage at 19 VDC
- Turn OFF the transmitter power supply (19 V)

Turn ON Operation and Operation at 500-mA Load

- Turn ON the transmitter power supply (19 V)
- Transmitter – Verify LED D2 is *ON*
- UUT – Adjust load current to 500 mA ±50 mA
- Put the receiver EVM on the transmitter coil and align them correctly
- After 5 seconds verify that:
  - Transmitter – Status LED D5 should be green, flashing approximately every 1 second.
  - The transmitter should beep
  - Transmitter – LED D2 still ON

- Receiver – LED D1 is ON
- UUT – Verify that V_{OUT} is 4.9 V to 5.2 V (between J3 or TP7 and J4)
- UUT – Verify that the rectified voltage is 5 V to 5.4 V (between TP3 and GND) **NOTE**: a modulation signal is present on this voltage every 250 ms and may cause fluctuation in the reading: use lower value or baseline.

Efficiency Test (500-mA Load)

- Verify that input current to the TX is less than 260 mA with an input voltage at 19 VDC
- Turn OFF the transmitter power supply (19 V)

Operation (1-mA Load)

- Turn ON the transmitter power supply (19 V)
- Transmitter – Verify LED D2 is *ON*
- UUT – Adjust load current to 1 mA ±200 µA
- Put the receiver EVM on the transmitter coil and align them correctly
- After 5 seconds verify that:
  - Transmitter – Status LED D5 should be green, flashing approximately every 1 second.
  - The transmitter should beep
  - Transmitter – LED D2 still ON
  - Receiver – LED D1 is ON
  - UUT – Verify that V_{OUT} is 4.9 V to 5.2 V (between J3 and J4)
  - UUT – Verify that the rectified voltage is 6.9 V to 8.6 V (between TP3 and GND) **NOTE**: a modulation signal is present on this voltage every 250 ms and may cause fluctuation in the reading: use lower value or baseline.

Efficiency Test (1-mA Load)

- Verify that input current to the TX is less than 80 mA with input voltage at 19 VDC
- Turn OFF the transmitter power supply (19 V)
- Remove UUT from transmitter

Adapter Test (500-mA Load)

- Connect 5 V ±250 mV adapter on J1 on the bq51020EVM-520 receiver
- Adjust the load current to 500 mA ±50 mA (J3 *OUT* and J4 *GND*)
- Verify that:
  1. UUT – LED D1 is OFF
  2. UUT – V_{OUT} is 5.0 V ±600 mV (J3)
  3. Transmitter – Status LED D5 is OFF
  4. Put external +5 V power supply to TP6 (Ext) and GND (J4)
  5. Set the EN1 and EN2 jumper as follows:
     - JP3: EN1 and Low are shorted
     - JP4: EN2 and High are shorted
  6. Put the receiver EVM on the transmitter coil and align them correctly while still having the adapter connected to J1 and the external +5 V on TP6.
     - After 5 seconds verify that:
       - Transmitter – Status LED D5 should be green, flashing approximately every 1 second.
       - The transmitter should beep
       - Transmitter – LED D2 is still ON
       - Receiver – LED D1 is ON
       - UUT – Verify that V_{OUT} is 4.9 V to 5.2 V (between J3 and J4)
       - UUT – Verify that the rectified voltage is 5V to 5.6V (between TP3 and GND). **NOTE**: a

modulation signal is present on this voltage every 250 ms and may cause fluctuation in the reading: use lower value or baseline.

  – This disables wired power and prioritizes wireless power

7. Set the EN1 and EN2 jumper as follows:
   - JP3: EN1 and High are shorted
   - JP4: EN2 and High are shorted
8. Put the receiver EVM on the transmitter coil and align them correctly while still having the adapter connected to J1 and the external 5 V on TP6.
9. Verify that:
   - UUT – LED D1 is OFF
   - UUT – V_{OUT} is 0 V ±600 mV (J3)
   - Transmitter – Status LED D5 is ON
   - This means both wired and wireless power are disabled

7 Test Results

7.1 Steady-State Operation with bq2425x Charger

With the power supply off, connect the supply to the bqTESLA transmitter.

- Set up the test bench as described in Section 6.
- Power TX with 19 V.
- Connect the output of RX to a battery charger (bq24250) to charge a battery.
- Set the VBAT to 3.8 V.
- Set the charger current to 1.2 A.
- Set input current limit on the charger to 1 A.
- Monitor the I_{OUT} and V_{OUT} from the RX after putting the receiver EVM on the transmitter coil and align them correctly.
- Figure 2 shows the V_{OUT} and I_{OUT} from the RX as the battery charges.

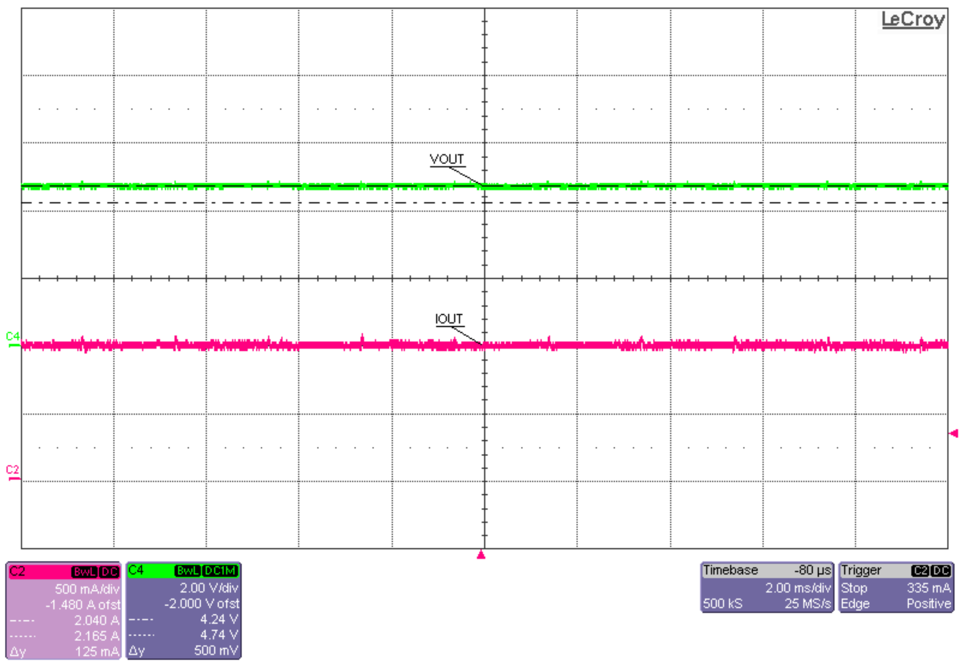

Figure 2. bq51020 in Steady State Operation with bq24250

7.2 Load Step

The procedure for load step is as follows:

- Set up the test bench as described in Section 6.
- Power WPC TX (bq500210) with 19 V.
- Provide a load step from no-load (high impedance) to 1000 mA (if using current source load).
- Monitor on side RX: load current, rectifier voltage, and output voltage as shown in Figure 3.

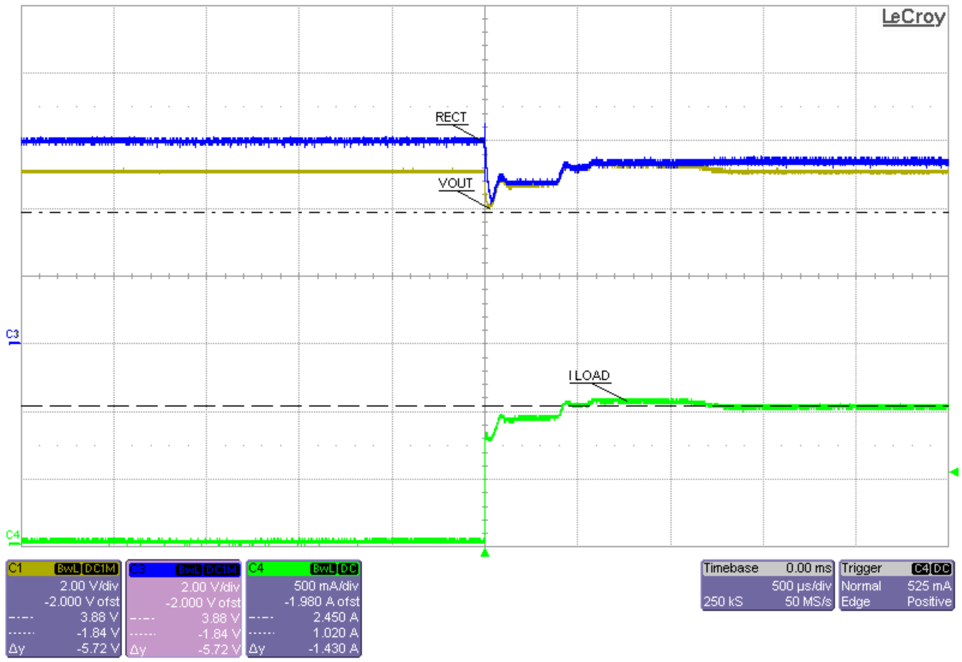

Figure 3. Load Step

7.3 Start Up

The procedure for start-up test with load:

- Set up the test bench as described in Section 6.
- Power the WPC TX
- Apply 10 Ω across J3 and J4, put the receiver EVM on the transmitter coil, and align them correctly
- Monitor the RECT pin, I_{OUT}, and output voltage, as shown in Figure 4.

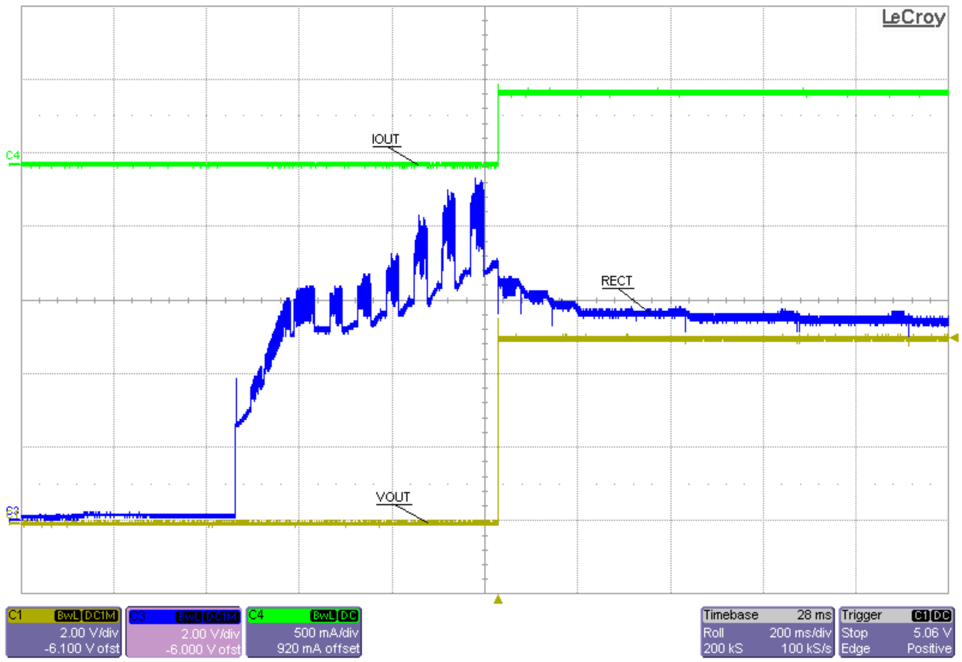

Figure 4. Start Up With 500 mA

7.4 Efficiency Data

7.4.1 Efficiency Versus Output Power (AC-DC)

Figure 5 illustrates the system (DC-DC) efficiency of the bq51020EVM-520 under different transmitters.

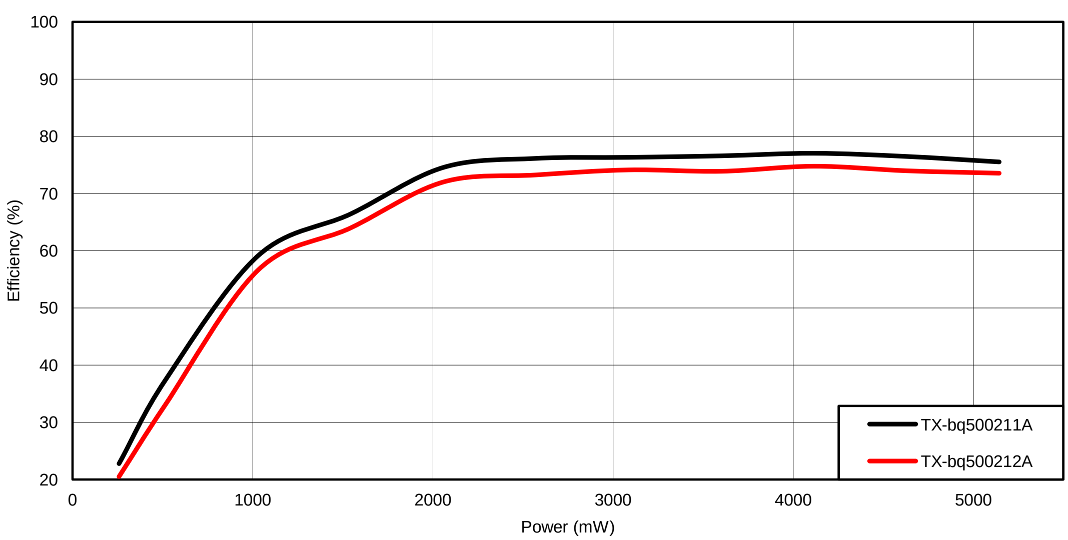

Figure 5. System Efficiency Versus Output Power

7.5 AD Insertion and Removal

Figure 6 illustrates the behavior of the bq51020EVM-520 when the AD is inserted while the EVM is on the transmitter pad. There is some off time during the transition between wireless power and wired power modes.

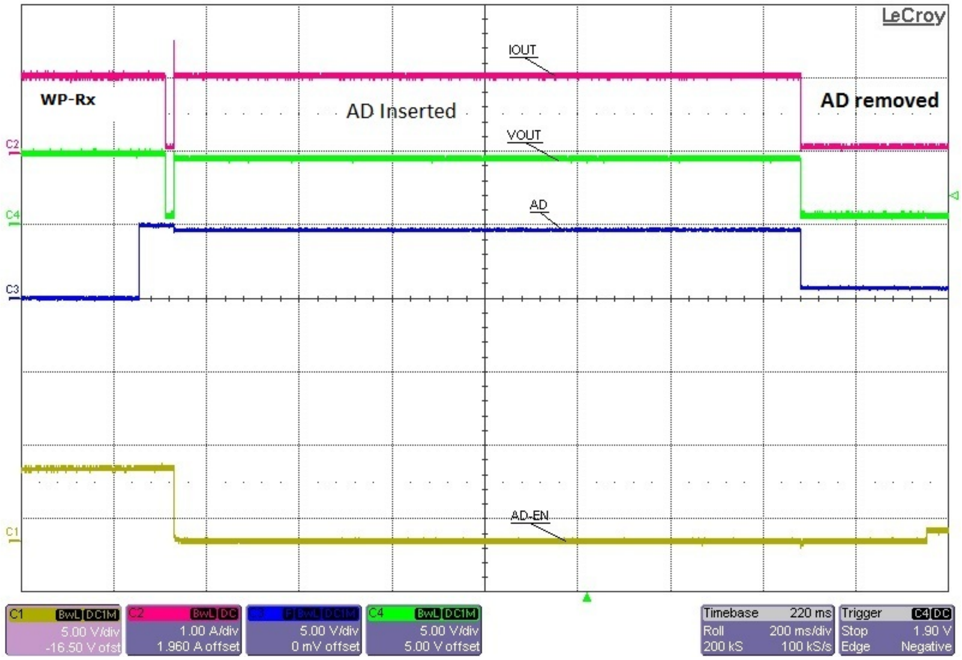

Figure 6. Adapter Insertion and Removal

7.6 Thermal Performance

This section shows a thermal image of the bq51020EVM-520. A 1-A load is used and the output voltage is set to 5 V. There is no air flow and the ambient temperature is 25°C. The peak temperature of the device (39°C in WPC) is well below the maximum recommended operating condition listed in the data sheet.

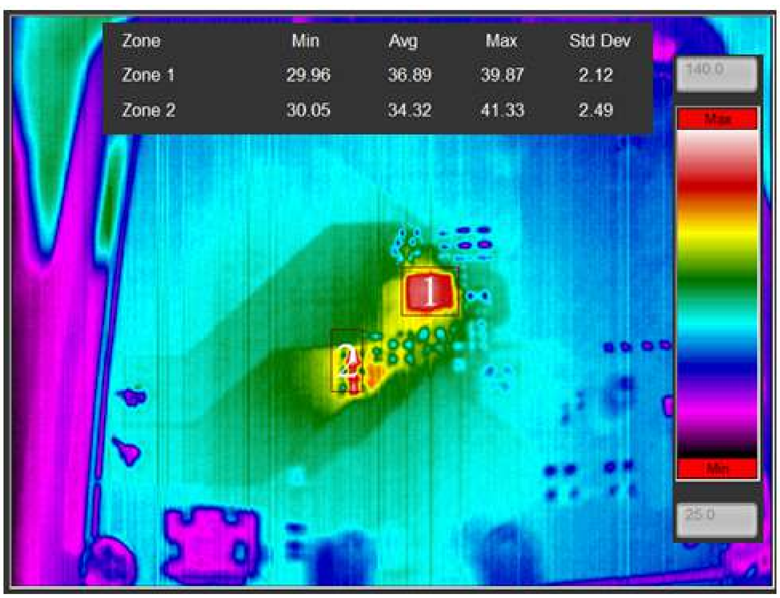

Figure 7. Thermal Image (1000-mA Load)

8 Layout and Bill of Material

8.1 bq51020 Traces

The bq51020 device pins can be classified as follows:

- **Signal/Sensing Traces**
  - TS/CTRL, EN1, EN2, $\overline{\text{PD\_DET}}$, $\overline{\text{WPG}}$, COMM, ILIM, AD, $\overline{\text{ADEN}}$, FOD, TMEM, CM_ILIM, VO_REG, VTSB, Term.
  - Make sure these traces are not interfered by the noisy traces
- **Noisy Traces**
  - AC1, AC2, BOOT, COMM
  - Make sure these traces are isolated from other traces, use ground plan
- **Power Traces**
  - AC1, AC2, OUT, CLAMP, PGND
  - Make sure to use the correct width for the right current rating.

8.2 Layout Guidelines

Use the following layout guidelines:

- The traces from the input connector to the inputs of the bq51020 IC pin should be as wide as possible to minimize the impedance in the lines. Otherwise, this causes a voltage drop and thermal issue.
- Keep the trace resistance as low as possible on AC1, AC2, OUT, and PGND.
- Use the appropriate current rating traces (width) the AC, OUT and PGND.
- The PCB should have a ground plane (return) connected directly to the return of all components through vias (At least two vias per capacitor for power-stage capacitors, one via per capacitor for small-signal components).
- The dissipation of heat path is important. Adding internal layers increases the thermal performance. Multiple vias in the PGND pins of the IC is recommended to decrease the thermal resistance in the board and allow much easier thermal dissipation through inner layer and power ground layers.
- The via interconnect is important and must be optimized near the power pad of the IC and the GND.
- 2-oz copper, or greater, is recommended
- For high-current applications, the balls for the power paths should be connected to as much copper in the board as possible. This allows better thermal performance because the board conducts heat away from the IC.
- It is always good practice to place high frequency bypass capacitors next to RECT and OUT.

8.3 Printed-Circuit Board Layout Example

The primary concerns when laying a custom receiver PCB are as follows:

- AC1 and AC2, GND return trace resistance
- OUT trace resistance
- GND connection
- Copper weight ≥ 2 oz

For a 1-A fast charge current application, the current rating for each net is as follows:

- AC1 = AC2 = 1.2 A
- BOOT1 = BOOT2 = 1 A
- RECT = 50 mA
- OUT = 1 A
- COMM1 = COMM2 = 300 mA
- CLAMP1 = CLAMP2 = 500 mA

- ILIM = 10 mA
- AD = $\overline{\text{AD\_EN}}$ = TS/CTRL = EN1 = EN2 = TERM = FOD = 1 mA
- $\overline{\text{PWR}}$ = 10 mA

TI also recommends having the following capacitance on RECT and OUT:

- RECT ≥ 10 µF
- OUT ≥ 1 µF

It is always good practice to place high-frequency bypass capacitors next to RECT and OUT of 0.1 µF. Figure 8 illustrates an example of a WCSP layout:

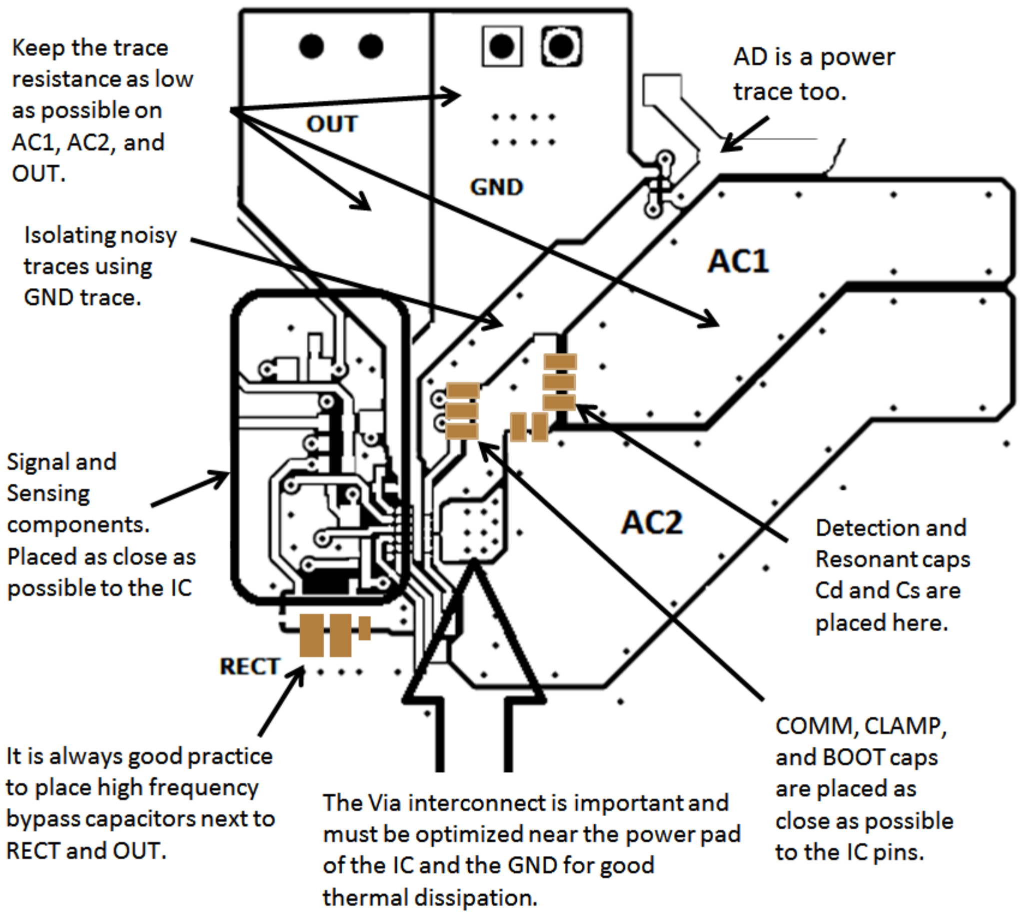

Figure 8. bq51020EVM-520 Layout Example

8.4 bq51020EVM-520 Layout

Figure 9 through Figure 13 show the bq51020EVM-520 PCB layout.

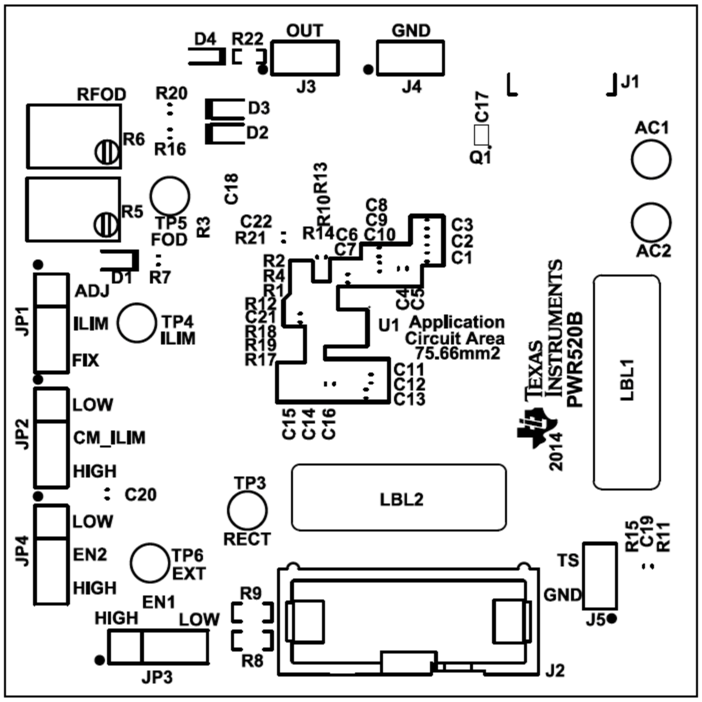

Figure 9. bq51020EVM-520 Top Assembly

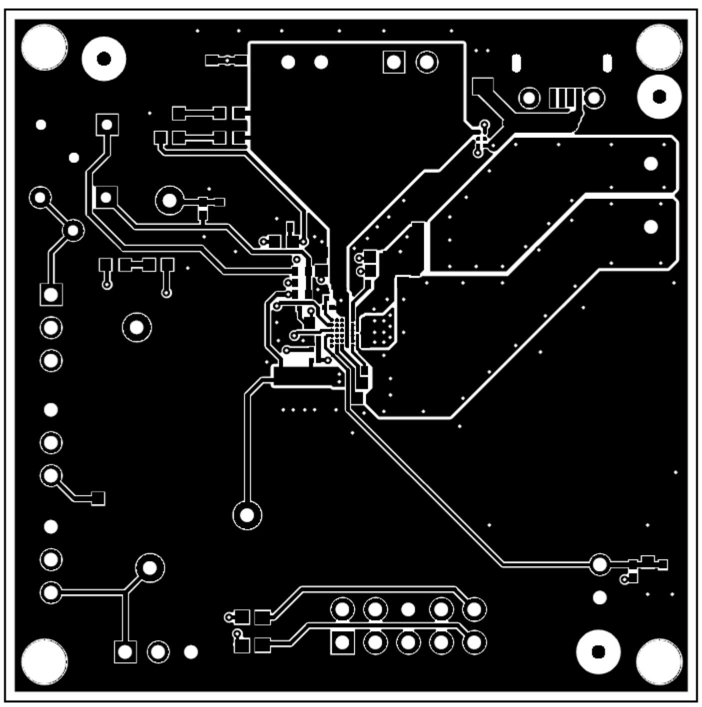

Figure 10. bq51020EVM-520 Layer 1

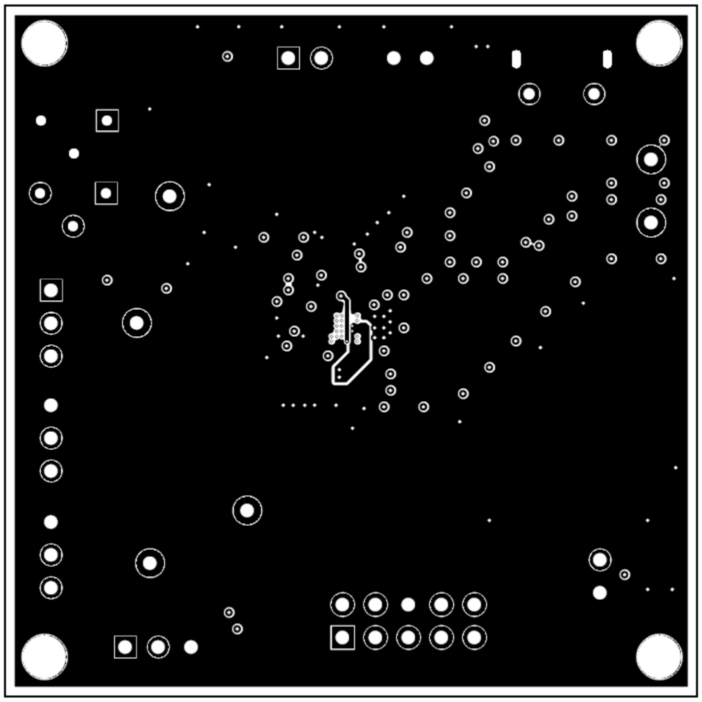

Figure 11. bq51020EVM-520 Layer 2

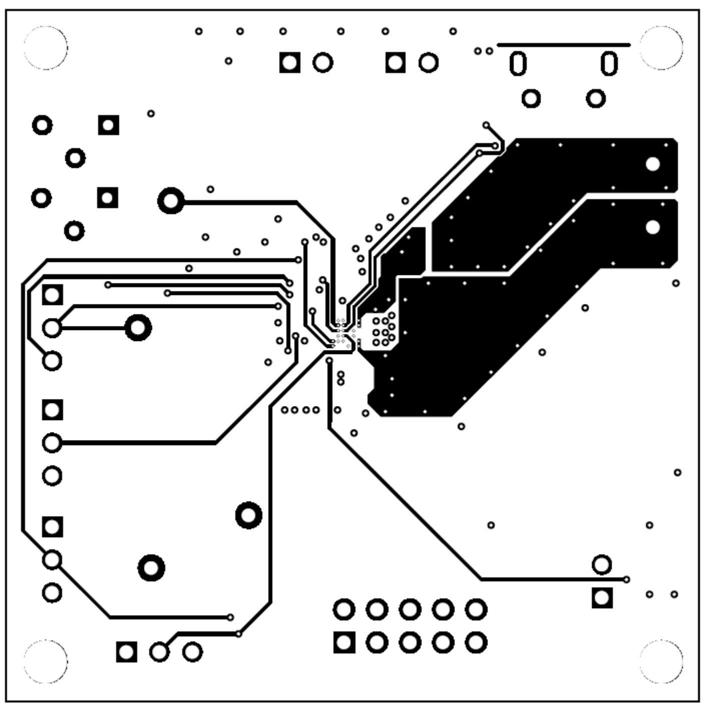

Figure 12. bq51020EVM-520 Layer 3

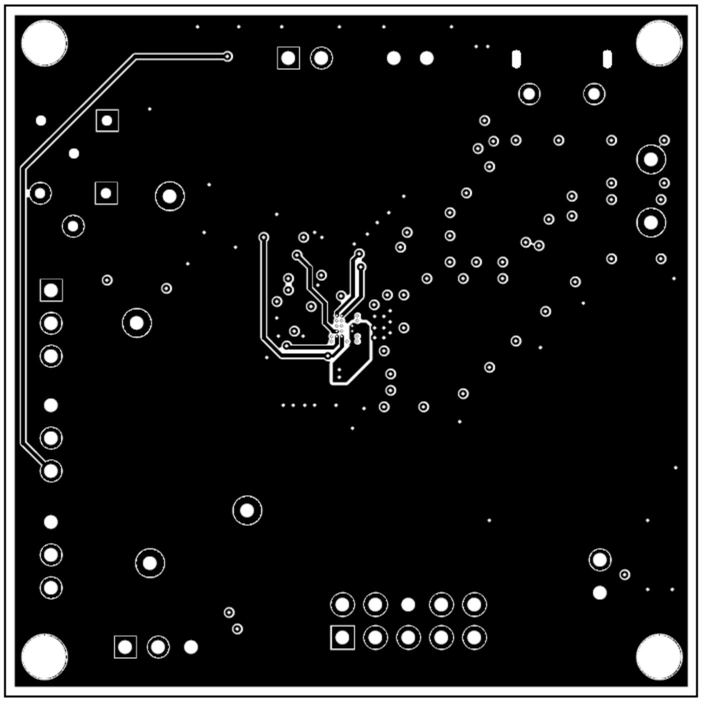

Figure 13. bq51020EVM-520 Layer 4

8.5 Bill of Materials (BOM)

Table 3 lists the BOM for the EVM.

Table 3. bq51020EVM-520 Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB	1		Printed Circuit Board		PWR520	Any
C1, C2	2	0.068µF	CAP CER 0.068UF 50V 10% X7R 0603	0603	GRM188R71H683KA93D	MuRata
C3	1	0.047uF	CAP CER 0.047UF 50V 10% X7R 0603	0603	GRM188R71H473KA61D	MuRata
C4	1	1800pF	CAP CER 1800PF 50V 10% X7R 0603	0603	GRM188R71H182KA01D	MuRata
C5	1	100pF	CAP, CERM, 100pF, 50V, +/-10%, X7R, 0402	0402	CC0402KRX7R9BB101	Yageo America
C6	1	0.1uF	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0402	0402	C1005X7R1H104K050BB	TDK
C7	1	3.3uF	CAP, CERM, 3.3uF, 25V, +/-10%, X5R, 0603	0603	C1608X5R1E335K080AC	TDK
C8, C13	2	0.022uF	CAP CER 0.022UF 25V 10% X7R 0603	0603	C0603C223K3RACTU	Kemet
C9, C12	2	0.47uF	CAP, CERM, 0.47uF, 25V, +/-10%, X5R, 0603	0603	GRM188R61E474KA12D	MuRata
C10, C11	2	0.015uF	CAP, CERM, 0.015uF, 50V, +/-10%, X7R, 0402	0402	GRM155R71H153KA12D	MuRata
C14, C15	2	10uF	CAP, CERM, 10uF, 25V, +/-10%, X5R, 0805	0805	C2012X5R1E106K125AB	TDK
C16, C19	2	0.1uF	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603	0603	GCM188R71H104KA57B	MuRata
C17	1	1uF	CAP, CERM, 1uF, 50V, +/-10%, X7R, 0805	0805	GRM21BR71H105KA12L	MuRata
C18	1	0.1uF	CAP, CERM, 0.1uF, 16V, +/-10%, X7R, 0402	0402	GRM155R71C104KA88D	MuRata
C20	1	1uF	CAP, CERM, 1uF, 25V, +/-10%, X7R, 0603	0603	GRM188R71E105KA12D	MuRata
C21	1	2.2uF	CAP, CERM, 2.2uF, 16V, +/-10%, X5R, 0603	0603	GRM188R61C225KE15D	MuRata
D1	1	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On
D2	1	Orange	LED, Orange, SMD	1.6x0.8x0.8mm	LTST-C190KFKT	Lite-On
D4	1	5.1V	Diode, Zener, 5.1V, 300mW, SOD-523	SOD-523	BZT52C5V1T-7	Diodes Inc.
H1	1		Tape segment, Low Static Polyimide Film. Cut tape section from 36 yard roll	1.5" x 2.3"	5419-1 1/2"	3M
H2	1		Case Modified Polycase LP-11B with 4 screws		J-6838A	Polycase
H3	1		Coil, RX with Attractor		IWAS4832FFEB9R7J50	Vishay
H4, H5, H6, H7	4		#4 x 3/8" pan head phillips screw	#4 x 3/8"	PSMS 004 0038 PH	BandF Fastener
H8, H9, H10, H11	4		Spacer, 0.100" Thk x 0.25" OD x 0.147" ID	0.1" THK	905-100	Bivar
J1	1		Receptacle, Micro-USB-B, Right Angle, SMD	Micro USB receptacle	105017-0001	Molex
J2	1		Connector, 100mil Shrouded, High-Temperature, Gold, TH	5x2 Shrouded header	N2510-6002-RB	3M
J3, J4, J5	3		Header, 100mil, 2x1, Tin plated, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions
JP1, JP2, JP3, JP4	4		Header, 100mil, 3x1, Tin plated, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions
LBL1, LBL2	2		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady
Q1	1	-20V	MOSFET, P-CH, -20V, -1.2A, 2x3 DSBGA	2x3 DSBGA	CSD75301W1015	Texas Instruments
R1	1	56.2k	RES, 56.2k ohm, 1%, 0.063W, 0402	0402	CRCW040256K2FKED	Vishay-Dale
R2	1	150	RES, 150 ohm, 5%, 0.063W, 0402	0402	CRCW0402150RJNED	Vishay-Dale
R3	1	0	RES, 0 ohm, 5%, 0.063W, 0402	0402	CRCW04020000Z0ED	Vishay-Dale
R4	1	110	RES, 110 ohm, 1%, 0.063W, 0402	0402	CRCW0402110RFKED	Vishay-Dale

Table 3. bq51020EVM-520 Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
R6	1	500 Ohm	Trimmer, 500 ohm, 0.25W, TH	4.5x8x6.7mm	3266W-1-501LF	Bourns
R7	1	1.50k	RES, 1.50k ohm, 1%, 0.1W, 0603	0603	CRCW06031K50FKEA	Vishay-Dale
R8, R9	2	200	RES, 200 ohm, 1%, 0.1W, 0603	0603	CRCW0603200RFKEA	Vishay-Dale
R10	1	11.3k	RES, 11.3k ohm, 1%, 0.05W, 0201	0201	ERJ-1GEF1132C	Panasonic
R11	1	10.0k	RES, 10.0k ohm, 1%, 0.063W, 0402	0402	CRCW040210K0FKED	Vishay-Dale
R12	1	5.6Meg	RES, 5.6Meg ohm, 5%, 0.05W, 0201	0201	MCR006YRTJ565	Rohm
R14	1	102k	RES, 102k ohm, 1%, 0.05W, 0201	0201	ERJ-1GEF1023C	Panasonic
R15	1	20k	RES, 20k ohm, 5%, 0.063W, 0402	0402	CRCW040220K0JNED	Vishay-Dale
R16	1	5.11k	RES, 5.11k ohm, 1%, 0.1W, 0603	0603	CRCW06035K11FKEA	Vishay-Dale
R22	1	102k	RES, 102k ohm, 1%, 0.063W, 0402	0402	CRCW0402102KFKED	Vishay-Dale
SH-JP1, SH-JP2, SH-JP3, SH-JP4	4	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M
TP3, TP4, TP5	3	White	Test Point, TH, Miniature, White	Keystone5002	5002	Keystone
TP6	1	White	Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
U1	1		WPC MODE (Qi) INTEGRATED WIRELESS RECEIVER POWER SUPPLY, YFP0042AWCG	YFP0042AWCG	bq51020YFP	Texas Instruments
C22	0	100pF	CAP, CERM, 100pF, 50V, +/-10%, X7R, 0402	0402	CC0402KRX7R9BB101	Yageo America
D3	0	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
R5	0	5 K	Trimmer, 5k ohm, 0.25W, TH	4.5x8x6.7mm	3266W-1-502LF	Bourns
R13	0	2.00k	RES, 2.00k ohm, 1%, 0.1W, 0603	0603	RC0603FR-072KL	Yageo America
R17, R19	0	102k	RES, 102k ohm, 1%, 0.05W, 0201	0201	ERJ-1GEF1023C	Panasonic
R18	0	11.3k	RES, 11.3k ohm, 1%, 0.05W, 0201	0201	ERJ-1GEF1132C	Panasonic
R20	0	1.50k	RES, 1.50k ohm, 1%, 0.1W, 0603	0603	CRCW06031K50FKEA	Vishay-Dale
R21	0	27k	RES, 27k ohm, 5%, 0.1W, 0603	0603	CRCW060327K0JNEA	Vishay-Dale
TP1, TP2	0	Black	Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone

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4. User agrees and acknowledges that certain EVMs may not be designed or manufactured by TI.
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9. User assumes sole responsibility to determine whether EVMs may be subject to any applicable federal, state, or local laws and regulatory requirements (including but not limited to U.S. Food and Drug Administration regulations, if applicable) related to its handling and use of EVMs and, if applicable, compliance in all respects with such laws and regulations.
10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.
11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.
12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

Certain Instructions. User shall operate EVMs within TI's recommended specifications and environmental considerations per the user's guide, accompanying documentation, and any other applicable requirements. Exceeding the specified ratings (including but not limited to input and output voltage, current, power, and environmental ranges) for EVMs may cause property damage, personal injury or death. If there are questions concerning these ratings, 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the applicable 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 EVMs' schematics located in the applicable EVM user's guide. When placing measurement probes near EVMs during normal operation, please be aware that EVMs may become very warm. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use EVMs.

Agreement to Defend, Indemnify and Hold Harmless. User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, 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 handling and/or use of EVMs. User's indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

Safety-Critical or Life-Critical Applications. If user intends to use EVMs in evaluations of safety critical applications (such as life support), and a failure of a TI product considered for purchase by user for use in user's product would reasonably be expected to cause severe personal injury or death such as devices which are classified as FDA Class III or similar classification, then user must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

RADIO FREQUENCY REGULATORY COMPLIANCE INFORMATION FOR EVALUATION MODULES

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General Statement for EVMs Not Including a Radio

For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs 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: For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. 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 TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

U.S. Federal Communications Commission Compliance

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 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 its 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.

Industry Canada Compliance (English)

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.

Canada Industry Canada Compliance (French)

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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

Important 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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