User's Guide

SLUUAX6B–February 2014–Revised June 2014

# Dual Mode (WPC and PMA) Integrated Wireless Receiver Power Supply

The bq51221EVM-520 (PWR520-001) wireless power receiver evaluation kit (EVM) from Texas Instruments 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 bq51221 IC, (also, this EVM can be used to evaluate the bq51021 IC, a WPC-only receiver) a secondary-side receiver device for wireless power transfer in portable applications. The bq51221 device is a fully contained wireless power receiver capable of operating in both the WPC and PMA protocols which enables a system to not be confined to one standard. The bq51221 provides a single stage power conversion while integrating the digital control and communication. The bq51221 complies with the WPC v1.1 and PMA communication protocol. The kit enables designers to speed up the development of their end-applications.

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# 1 Introduction

The bq5122x is an advanced, flexible, secondary-side device for wireless power transfer in portable applications. The bq5122X devices integrate an ultra-low-impedance synchronous rectifier, a very high efficiency post regulator, digital control, and accurate voltage and current loops. The bq5122X devices provide the AC/DC power conversion while integrating the digital control required. The IC complies with both WPC v1.1 and PMA communication protocol.

Together with the bq50xxx primary-side controller or any type-1 PMA transmitter, the bq5122X 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.

In WPC, the 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 2 Kbits/s. 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.

A PMA-compliant receiver communicates based on continuous transmission of signals from the receiver to the transmitter. The PMA system defines six different communications symbols. These are PMA INC, PMA DEC, PMA NoCHG, PMA EOC, PMA MsgBit and PMA TBD (proprietary for future use). The PMA receiver will transmit these signals back to back with no gaps between them to control the operation point. Each PMA receiver will have a unique PMA RXID, transmitted in the RXID message. Note that the first build of these EVMs do not have RX ID implemented.

# 2 Considerations with this EVM

The bq51221EVM-520 evaluation module (PWR520-001) 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- and PMA-compliant communication and control
  - Only one IC required between RX coil and DC output
- Programmable output voltage to optimize performance for any application
- Adaptive communication current limit (CM_ILIM) for robust communication in WPC mode
- Supports 20-V max input
- Low-power dissipative over voltage clamp
- Over voltage, over current , over temperature protection for both PMA and WPC modes
- 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 resistor or I2C
- Flexibility for 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
- I2C connector (USB-TO-GPIO “HPA172” kit for I2C communication through computer is required)
- $\overline{\text{WPG}}$ LED indicator (turns on as the VOUT goes high)

## 3 Modifications

See the bq51221 data sheet (SLUSBS9) 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 bq51221EVM-520 performance specifications. All specifications are given for an ambient temperature of 25°C.

**Table 1. bq51221EVM-520 Electrical Performance Specifications**

| Parameter | | Test Condition | MIN | TYP | MAX | Unit |
|---|---|---|---|---|---|---|
| Vrect | Rect voltage range | | 4 | | 10 | 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)] | POUT = 5 W | 4.5 | | 8 | V |
| $F_s$ | Switching Frequency | WPC | 110 | | 205 | kHz |
| | | PMA | 235 | | 275 | |
| $T_J$ | Junction Temperature | | | 125 | | °C |

(1) The output voltage can be adjusted using I2C or the VIREG and VOREG resistors. Also the coil needs to be changed for different voltage for optimal operation of the EVM.

# 5 Equipment and EVM Setup

## 5.1 *Schematic*

Figure 1 illustrates the bq51221EVM-520 schematic.

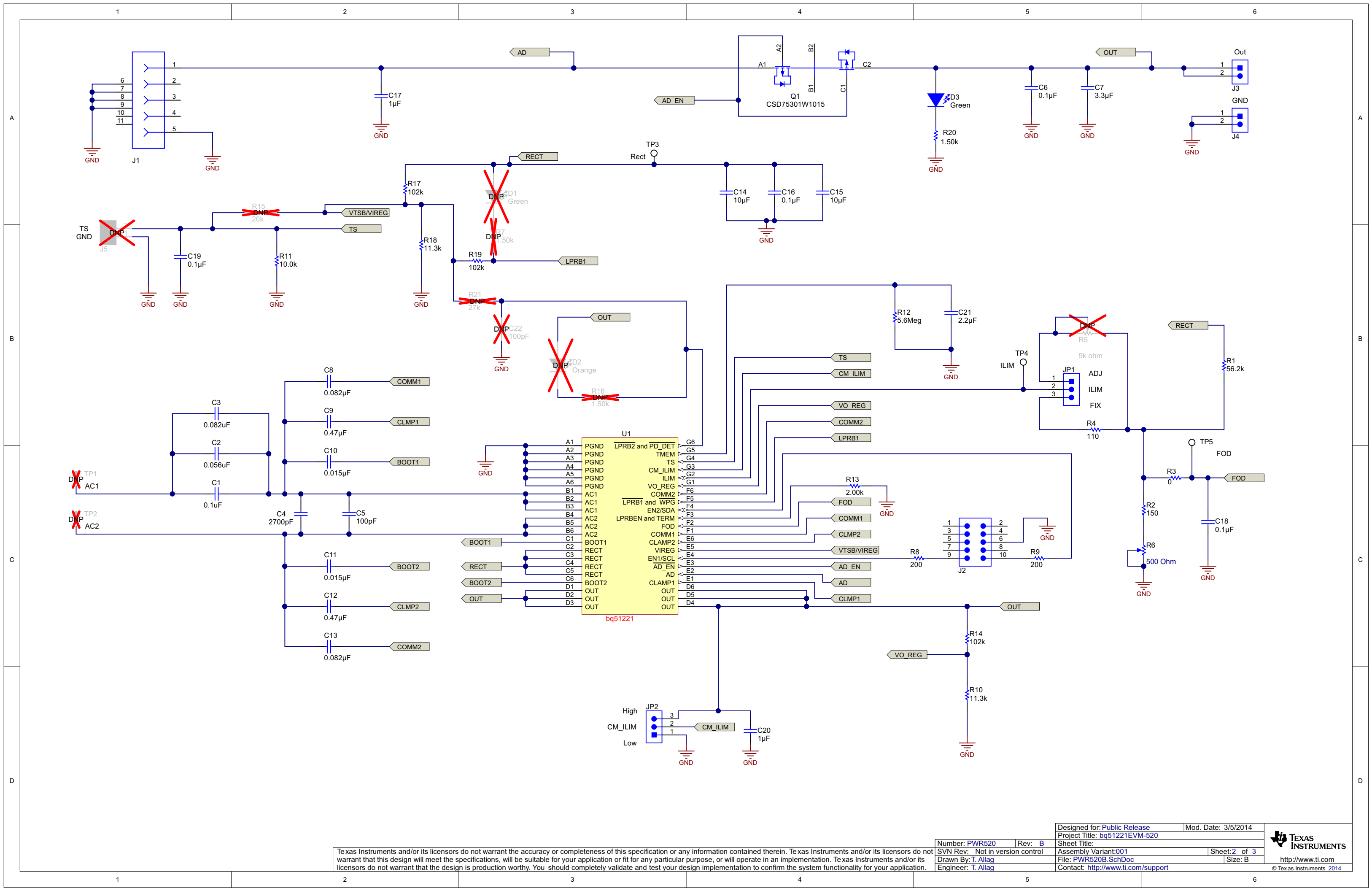



**Figure 1. bq51221EVM-520 Schematic**

## 5.2 Connector and Test Point Descriptions

The connections points are described in the following paragraphs:

**J1 – AD External Adapter Input**
Power can be provided to simulate an external adapter applied to the receiver in the bq51221EVM-520 (PWR520-001).

**J2 – Programming Connector**
This connector is populated and is used for I2C communication using the USB-TO-GPIO “HPA172” kit.

**J3 – Output Voltage**
Output voltage in wireless power mode up to 1 A; the adapter option is also supported in this PWR520-001.

**J4 –GND**
Ground return

**J5 – TS and Return Connector**
External connection for temperature sense resistor, see the bq51221 data sheet (SLUSBS9) for additional information. Not populated in this spin.

## 5.3 Jumpers/Switches

The control jumpers and switches are described in the following paragraphs:

**JP1– ILIM - Fix or ADJ**
Max output current is set by ILIM pin. In the FIX position, the current is set to a fixed value of R4. In the ADJ position current is set by R5. Note that R5 is not installed in this EVM.

**JP2 – CM_ILIM**
Enables the CM_ILIM feature when pulled low and disables when pulled up (High).

### 5.4 Test Point Descriptions

The test points are described in the following paragraphs:

**TP1 & 2 – AC1 and AC2 Inputs**
These are not populated, they can be used for measuring AC voltage applied to the EVM from the receiver coil.

**TP3– Rectified Voltage**
The input AC voltage is rectified into unregulated DC voltage (RECT); additional capacitance is used to filter the voltage before the regulator.

**TP4– ILIM**
Programming pin for over current limit protection, pin G2 of the IC.

**TP5 – FOD**
Input for rectified power measurement for Foreign Object Detection feature in WPC, pin F2 of the IC. FOD pin for the bq51221.

### 5.5 Pin Description of the IC

**Table 2. Pin Description**

| Pin Number (WCSP) | bq5122x |
|---|---|
| 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 | SCL |
| E5 | VIREC |
| E6 | CLAMP2 |
| F1 | COMM1 |
| F2 | FOD |
| F3 | $\overline{\text{LPRB\_EN}}$ and $\overline{\text{TERM}}$ |
| F4 | SDA |
| F5 | $\overline{\text{LPRB1}}$ and $\overline{\text{WPG}}$ |
| F6 | COMM2 |
| G1 | VO_REG |
| G2 | ILIM |
| G3 | CM_ILIM |
| G4 | TS |
| G5 | TMEM |
| G6 | $\overline{\text{LPRB2}}$ and $\overline{\text{PD\_DET}}$ |

# 6 Test Procedure

This procedure describes test configuration of the bq51221EVM-520 evaluation board (PWR520-001) for bench evaluation.

## 6.1 Definition

The following naming conventions are used:

**VXXX :** External voltage supply name (VAD, VOUT, VTS)

**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 location 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 plug to supply the PMA transmitter (An adapter usually included on the PMA TX module).

**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 power rating should be 5 W.

**Meters**
Two DC voltmeters and two DC ammeters are required.

**Oscilloscopes**
Not required.

**bqTesla Transmitter and PMA Transmitter**

- The transmitter HPA689 or equivalent will be used to test WPC mode
- PMA to test PMA mode (Duracell Powermat for 2 Devices “PMA compatible”—M2PB1)
- For proper operation, 22-AWG wire is recommended

## 6.3 Equipment Setup

### 6.3.1 Test Set Up

- The final assembly will be tested using a bqTesla transmitter (HPA689). Input voltage to the transmitter is set to 19 VDC ±200 mV with current limit of 1.0 A.
- Connect power supply to J1 and J2 of transmitter, HPA689
- Set power supply to OFF
- Place Unit Under Test (UUT) on transmitter coil

- UUT will be placed in the center of HPA689 TX coil. Other bqTesla transmitter base units are also acceptable for this test (Just make sure to apply the right input voltage).
- A PMA (Duracell Powermat TX) transmitter is needed to test the PMA compliance

#### 6.3.2 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

#### 6.3.3 Jumper Settings

JP1 → ILIM and FIX are shorted
JP2 → CM_ILIM and high are shorted

#### 6.3.4 Voltage and Current Meters

Connect ammeter to measure 19-V input current to transmitter. Connect voltmeter to monitor 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 ammeter to measure load current.

#### 6.3.5 RFOD : R6 Set Up

Connect an ohmmeter between TP5 (FOD) and J4 (GND). Adjust R6 to 480 ohm reading on the ohmmeter.

### *6.4 Procedure*

#### 6.4.1 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 ~ 1 sec
- You should hear a beep from the transmitter
- Transmitter—LED D2 still ON
- Receiver—LED D1 is ON
- UUT—Verify that Vout is 4.9 V to 5.1 V ( Between J3 and J4)
- UUT—Verify that rectified voltage should be 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 base line)

#### 6.4.2 Efficiency Test (1000-mA Load)

- Verify that input current to TX is less than 500 mA with input voltage at 19 VDC
- Turn OFF Transmitter Power Supply (19 V)

#### 6.4.3 Turn ON Operation and Operation at 500-mA Load

- Turn ON 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 ~ 1 sec
- You should hear a beep from the transmitter
- Transmitter—LED D2 still ON
- Receiver—LED D1 is ON
- UUT—Verify that Vout is 4.9 V to 5.2 V ( Between J3 or TP7 and J4)
- UUT—Verify that rectified voltage should be 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 base line)

### 6.4.4 Efficiency Test (500-mA Load)

- Verify that input current to TX is less than 260 mA with input voltage at 19 VDC
- Turn OFF Transmitter Power Supply (19 V)

### 6.4.5 Operation (1-mA Load)

- Turn ON 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 ~ 1 sec.
- You should hear a beep from the transmitter
- Transmitter—LED D2 still ON
- Receiver—LED D1 is ON
- UUT—Verify that Vout is 4.9 V to 5.2 V ( Between J3 and J4)
- UUT—Verify that rectified voltage should be 6.6 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 base line)

### 6.4.6 Efficiency Test (1-mA Load)

- Verify that input current to TX is less than 80 mA with input voltage at 19 VDC
- Turn OFF Transmitter Power Supply (19 V)

### 6.4.7 PMA Test (1000-mA Load)

- Turn ON PMA Transmitter power supply(18 V) or by using the adapter that comes with the PMA transmitter
- Put the receiver EVM on the Transmitter coil and align them correctly
- After 5 seconds verify that:
  1. You should hear a beep from the transmitter
  2. Receiver—LED D3 is ON
- UUT—Adjust load current to 1000 mA ±50 mA
- UUT—Verify that Vout is 4.9 V to 5.2 V ( Between J3 and J4)
- UUT—Verify that rectified voltage should be 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 base line)

### 6.4.8 Adapter Test (500-mA Load)

- Connect 5-V ±200 mV adapter on J1 on the PWR520-001 Receiver
- Adjust load current to 500 mA ±50 mA (J3 "OUT" and J4 "GND")
- Verify that:
  1. UUT—LED D3 is ON
  2. UUT—Vout is 5.0 V to 6 V (J3)
  3. Transmitter—Status LED D5 is off

# 7 Test Results

## *7.1 Steady State Operation with bq2425x Charger*

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

- Set up the test bench as described in Section 6
- Power PMA TX with 18 V or with the PMA power adapter
- Connect the output of RX to a battery charger (bq24250EVM-150) to charge a battery
- Set the VBAT to 3.8 V
- Set the charger current to ~1.2 A
- Set input current limit from the charger to 1 A
- Monitor the IOUT and VOUT from the RX after putting the receiver EVM on the transmitter coil and align them correctly
- Figure 2 shows the VOUT and IOUT from the RX as the battery charges

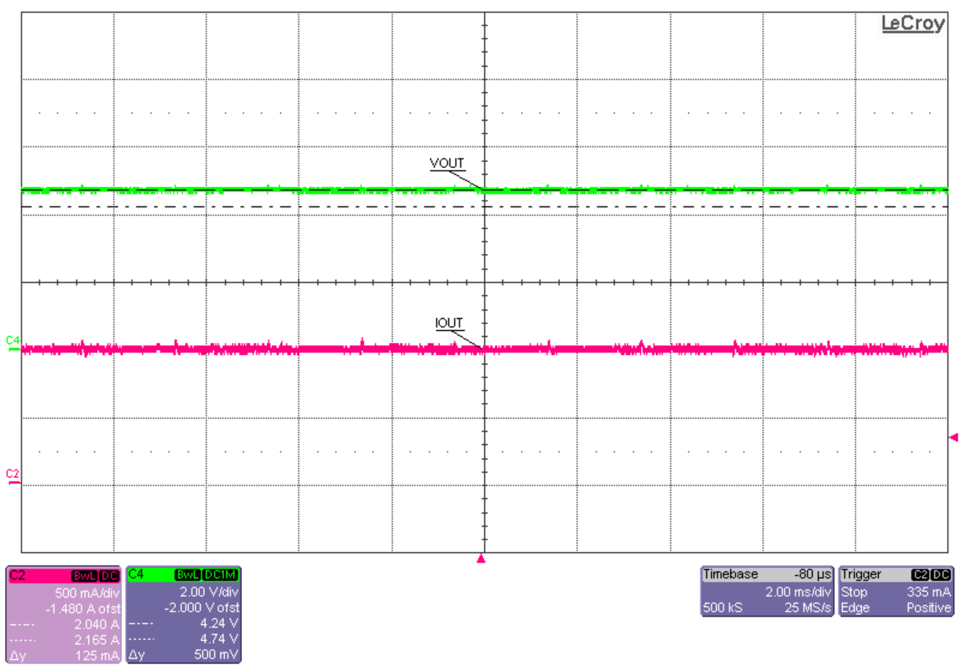



**Figure 2. bq51221 in Steady State Operation with bq24250EVM**

### 7.2 Load Step

The procedure for load step in PMA mode is as follows:

- Set up the test bench as described in Section 6
- Power PMA TX with 18 V or with the PMA power adapter
- Connect the output of RX to a battery charger (bq24250EVM-150) to charge a battery
- Set the VIN_DPM of the charger to 4.6 V
- Set a battery voltage to full charge state and connect system load to system output of the charger. Then, put the receiver EVM on the transmitter coil and align them correctly.
- Provide a load step from no-load (high impedance) to 1000-mA on the system load
- Monitor on side RX: load current, rectifier voltage, and output voltage as shown in Figure 3

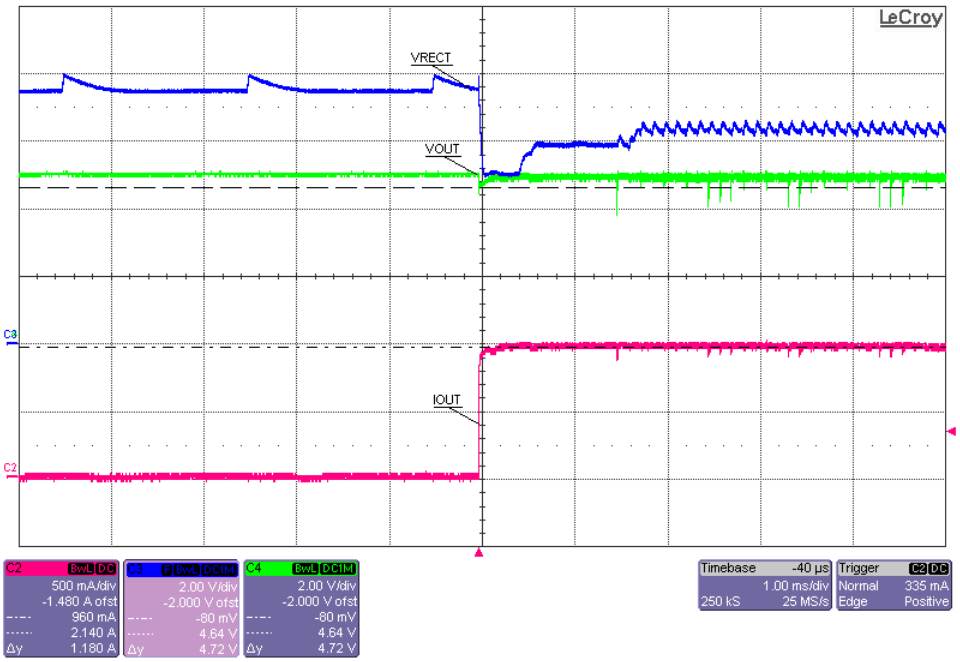
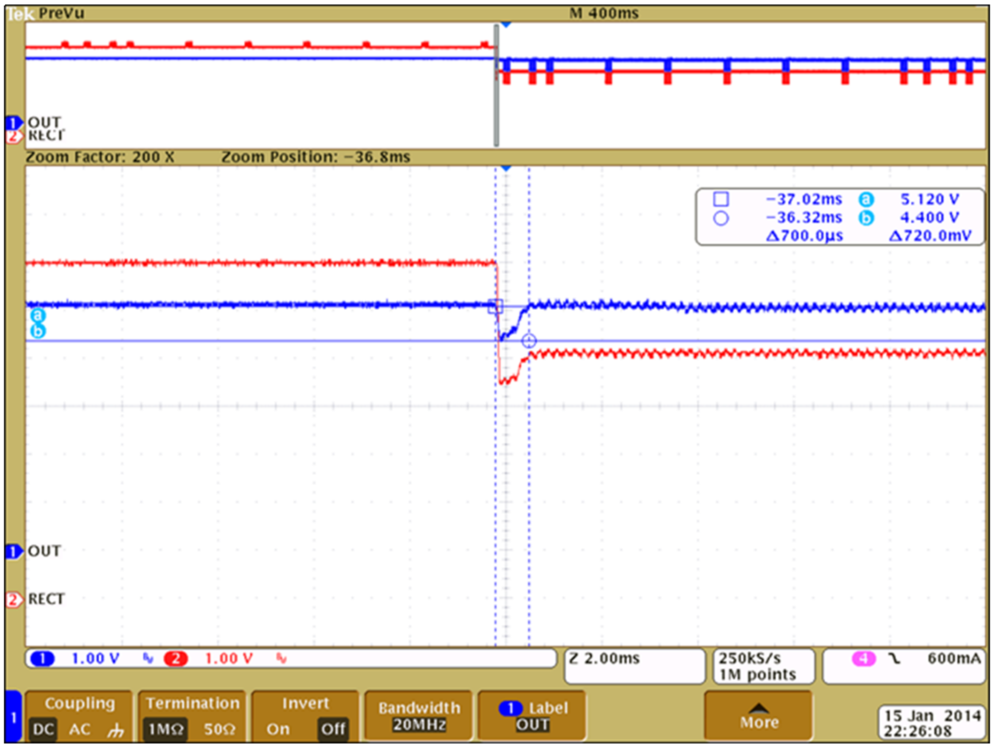



**Figure 3. Load Step (PMA) with VIN_DPM**

The procedure for load step in WPC mode is as follows:

- Set up the test bench as described in Section 6 for a WPC transmitter
- Power WPC TX with 19 V. Then put the receiver EVM on the transmitter coil and align them correctly.
- Provide a load step from no-load (high impedance) 1000 mA (if using current source load)
- Monitor on side RX: Rectifier voltage, and output voltage as shown in Figure 4




**0 to 1000 mA Step**

**Figure 4. Load Step (WPC)**

## 7.3 TS Control Function

The procedure for temperature sensing (TS) control functions when the TS pin is held high:

- Set up the test bench as described in Section 6
- Power the PMA TX. Then put the receiver EVM on the transmitter coil and align them correctly.
- Drive the TS pin high (2 V) using external power supply
- Monitor the TS pin, PMA signal (If a test fixture is used—to see End of Charge), $\overline{WPG}$, and output voltage as shown in Figure 5

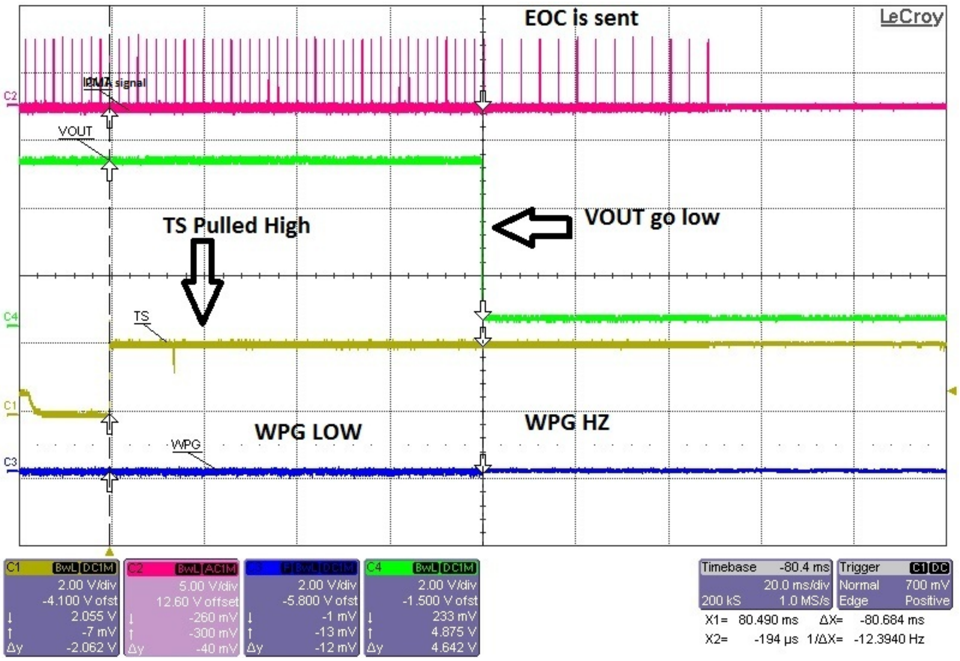



**Figure 5. TS Control Function**

## 7.4 Efficiency Data

The plot shown in Figure 6 illustrates the system (DC-DC) efficiency of the bq51221EVM-520 under different transmitters.

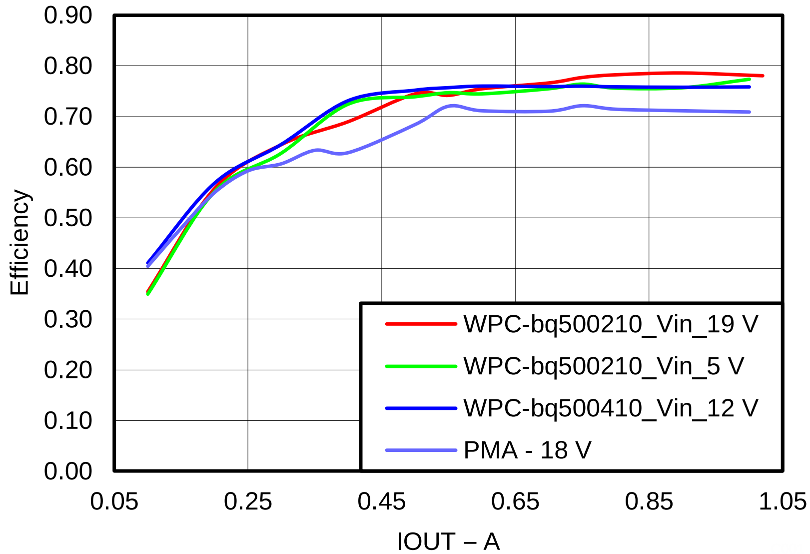



**Figure 6. System Efficiency versus Output Current**

## 7.5 AD Insertion and Removal

The plot shown in Figure 7 illustrates the behavior of the bq51221 when the AD is inserted while the EVM is on the transmitter pad. There is a 36-ms off time during the transition between wireless power and wired power modes.

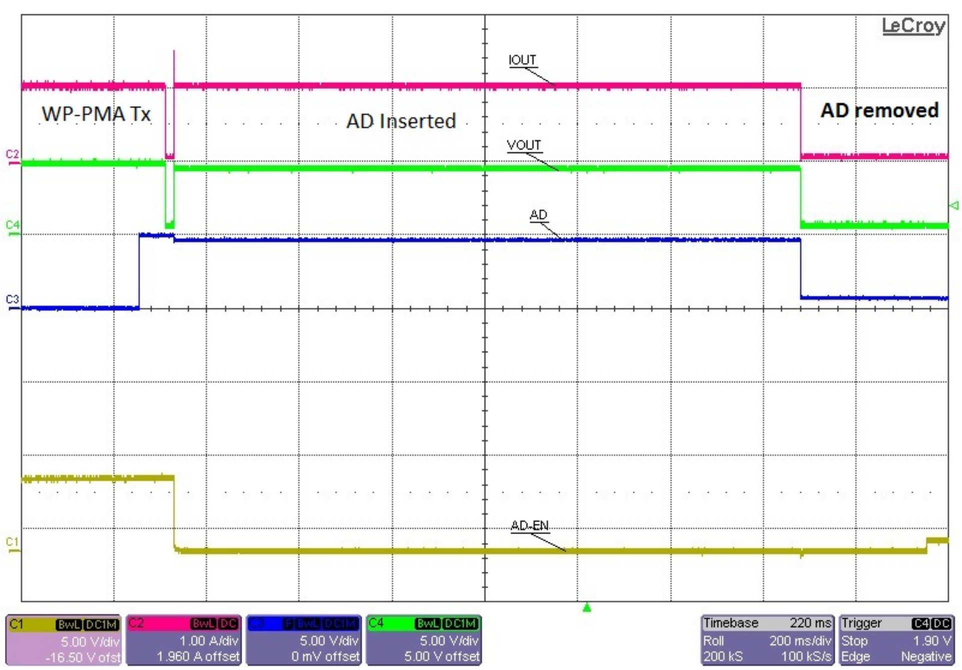



**Figure 7. AD Insertion and Removal**

## 7.6 Thermal Performance

This section shows a thermal image of the bq51221EVM-520 in both WPC and PMA. A 1-A load is used and output voltage is set to 5 V. There is no air flow and the ambient temperature is 25°C. The peak temperature of the IC (39°C in WPC and 37°C in PMA) is well below the maximum recommended operating condition listed in the data sheet.

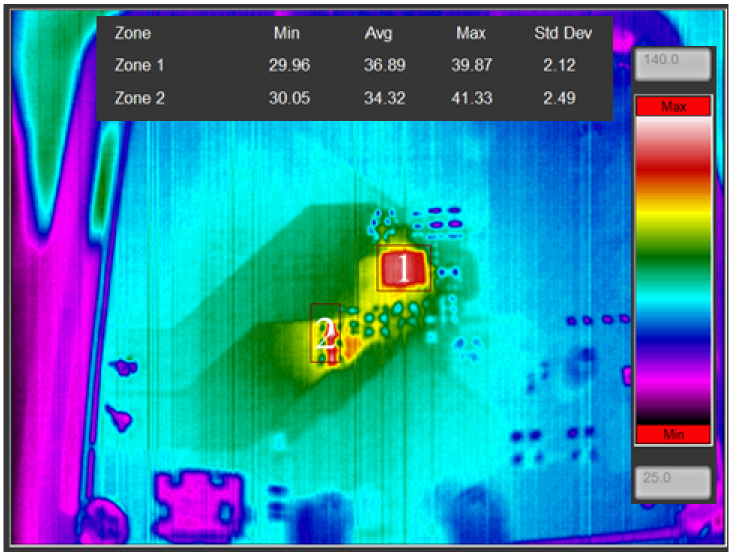



**Figure 8. Thermal Image in WPC Transmitter (1000-mA Load)**

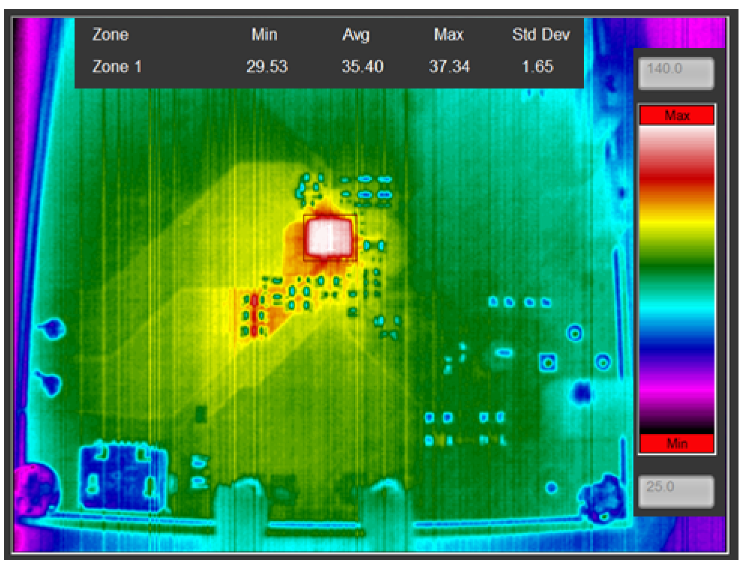



**Figure 9. Thermal Image in PMA Transmitter (1000-mA Load)**

# 8 Dual Mode Coil Design Consideration

## 8.1 Shielding

Implementation of a shielding mechanism is recommended as part of receiver device. Shielding provides protection from possible bi-directional interference between wireless charging system and consumer electronic device. The interference causes may include coupling interference causing development of heat due to eddy currents, impact on wireless charging data transfer, and so forth. It is recommended to apply the shield on all the magnetically active area (between the secondary coil and the electronic device).

## 8.2 Receiver Detection: Attraction and Alignment

When a PMA Transmitter is in standby phase and a receiver is placed on the charging surface, the transmitter detects the presence of the receiver by using either passive method with a “Hall Effect Sensor” or by active method with digital pinging.

In the passive method, the transmitter uses a Hall Effect Sensor to detect the presence of a receiver coil. It measures the voltage difference between no coil on TX and a full aligned coil on TX. If the difference in the hall sensor measurements between the two cases is above 200 mV, the power transfer phase will start as required by PMA. In the active method, it uses a digital pinging method instead. This detection method uses a periodic short pulse or short burst of pulses applied to the primary coil. By measuring the resultant interference on the primary coil, the presence of a receiver can be detected.

For both methods, a PMA-compliant receiver coil design shall include materials that can trigger the Hall Effect Sensor and create enough interference on the digital pinging on the PMA transmitters. The implementation is vendor specific and may rely on the magnetic material used for alignment aid, the shielding, or any other material designers select.

The alignment aid ferrite should have no more than 2 mm distance from charged device outer surface. The recommended shielding ferrite placed on the receiver antenna and the alignment aid fit into the hole at the center of the shielding ferrite as indicated in Figure 10.

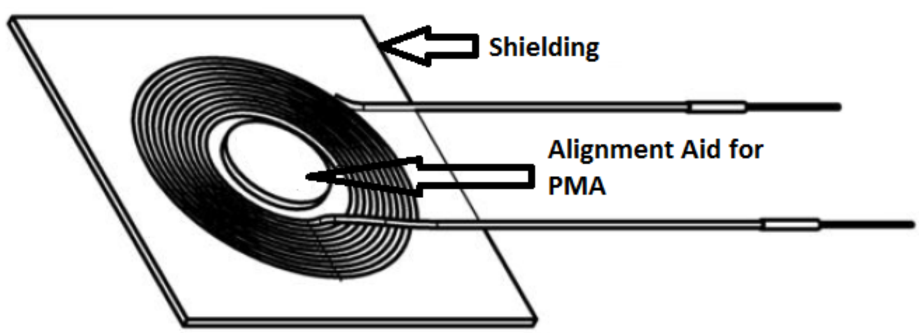



**Figure 10. Dual Mode Coil Example**

## 8.3 Inductor Value

A PMA-compliant receiver operating frequency is between 232 kHz and 278 kHz. For best efficient PMA only systems, the recommended coil self-inductance is around 4-µH range and coil self-resistance is around 300 mΩ. The operating frequency for PMA is higher than WPC. Thus, for dual mode solution the inductance has to be increased to meet WPC requirements. For dual mode applications, a recommended coil self-inductance is about 7.5 µH and coil self-resistance is around 300 mΩ.

In this EVM, the 760308102210 coil from Wurth electronics is used as an example for dual mode solution. Other coils also can be used such as KNCWZ08C409 from Panasonic and ASC-353583M08-S0 V1.0 from Amotech. The resonant capacitors are not required for PMA mode only. To support WPC and PMA, tuning resonant caps according to WPC requirement and with the final configuration of the board is a must. Note that the coil inductance and the required shielding may vary from application to application depending on the final configuration of the board.

# 9 Layout and Bill of Materials

## 9.1 bq5122x Traces

The bq5122x device pins traces can be classified as follows:

- **Signal/Sensing Traces**

TS/CTRL, SDA, SCL, $\overline{\text{LPRB2}}$/$\overline{\text{PD\_DET}}$, $\overline{\text{LPRB1}}$/$\overline{\text{WPG}}$ ,COMM, CHG, ILIM, AD, $\overline{\text{AD\_EN}}$, FOD, TMEM, CM_ILIM, VO_REG, VIREG, LPRB_EN/TERM.

Make sure these trace are not being interfered by the noisy traces.

- **Noisy Traces**

AC1, AC2, BOOT, COMM

Make sure to isolated these traces from other traces, you can use ground plan.

- **Power Traces**

AC1, AC2, OUT, CLAMP, PGND

Make sure to use the right width for the right current rating.

## 9.2 Layout Guidelines

- The traces from the input connector to the inputs of the bq5122x IC pin should be as wide as possible to minimize the impedance in the lines. Otherwise, a voltage drop and thermal issue will be caused.
- Keep the trace resistance as low as possible on AC1, AC2, and OUT.
- Use the appropriate current rating traces (width) on the AC, OUT, CLAMP and GND.
- 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 pulls 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 a good practice to place high frequency bypass capacitors next to RECT and OUT.

## 9.3 Printed-Circuit Board Layout Example

The primary concerns when doing a layout for 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 = 10 mA
- OUT = 1 A
- COMM1 = COMM2 = 300 mA
- CLAMP1 = CLAMP2 = 500 mA
- ILIM = 10 mA

- AD = $\overline{AD\_EN}$ = TS-CTRL = SCL = SDA = TERM = FOD = 1 mA
- CHG = 10 mA

It is also recommended to have 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 11 illustrates an example of a WCSP layout.

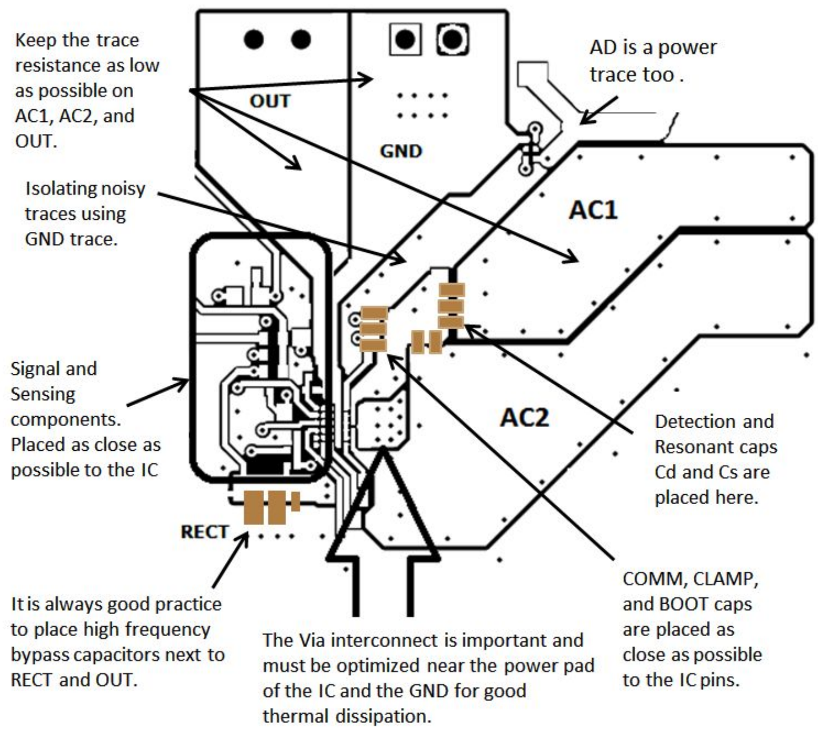



**Figure 11. bq51221EVM-520 Layout Example**

### 9.4 bq51221EVM-520 Layout

Figure 12 through Figure 16 illustrate the bq51221EVM-520 layout views.

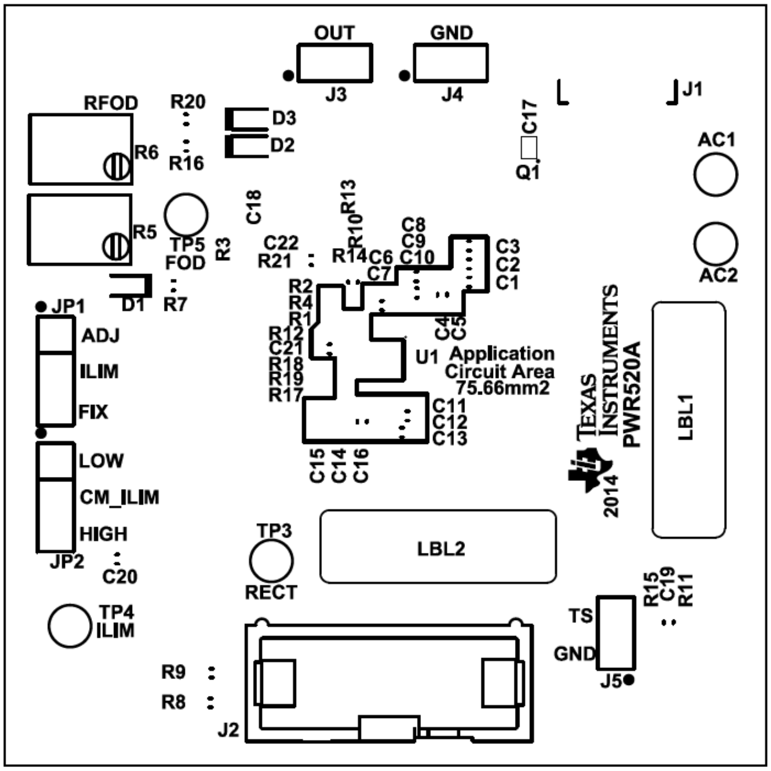



Figure 12. bq51221EVM-520 Top Assembly

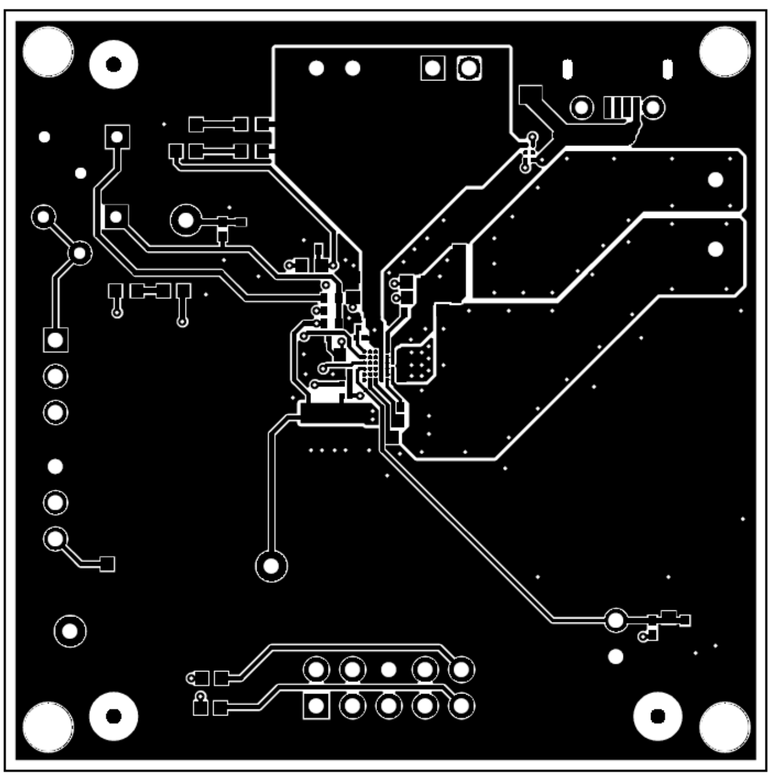


Figure 13. bq51221EVM-520 Layer 1

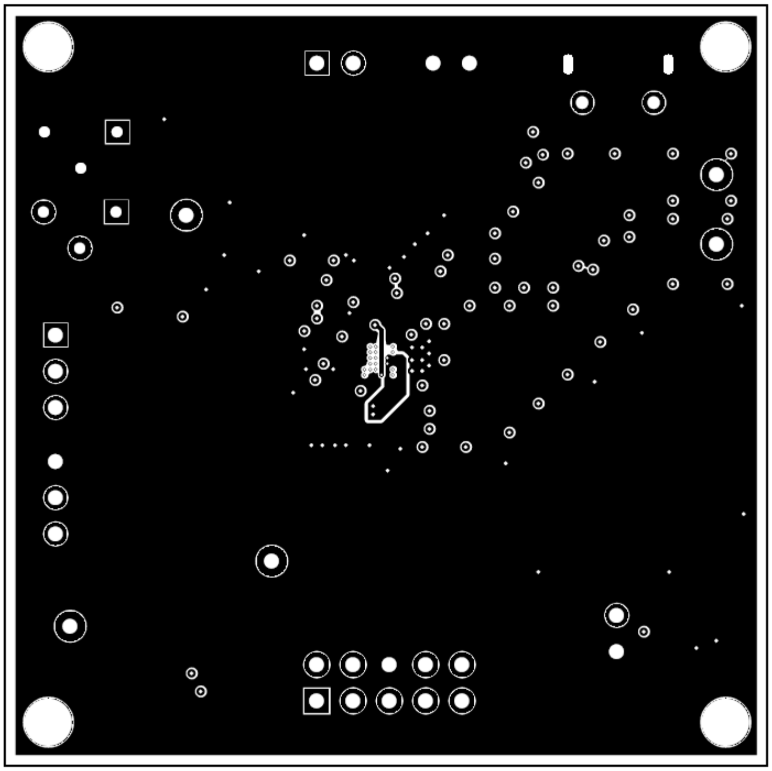


**Figure 14. bq51221EVM-520 Layer 2**

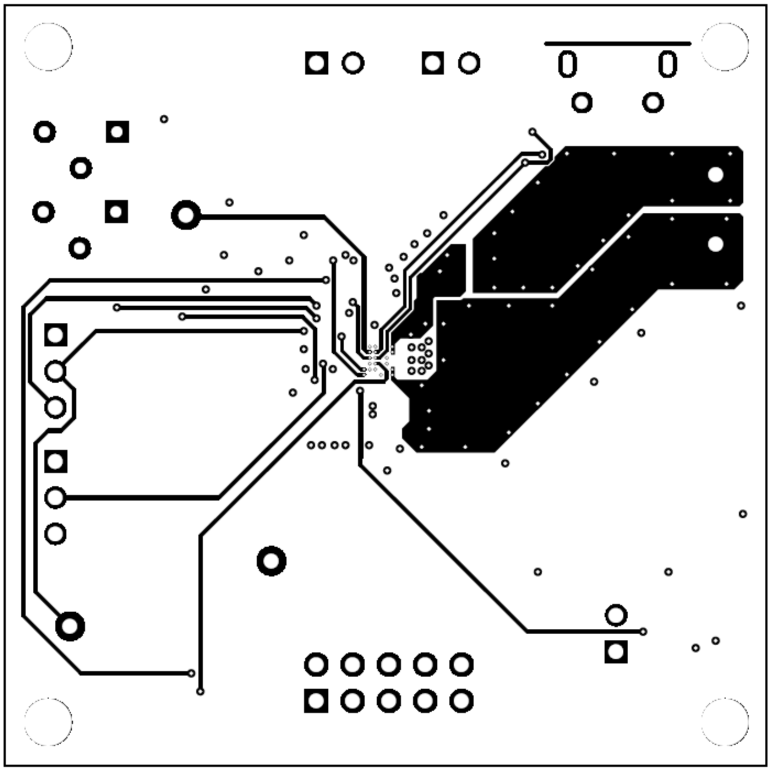


**Figure 15. bq51221EVM-520 Layer 3**

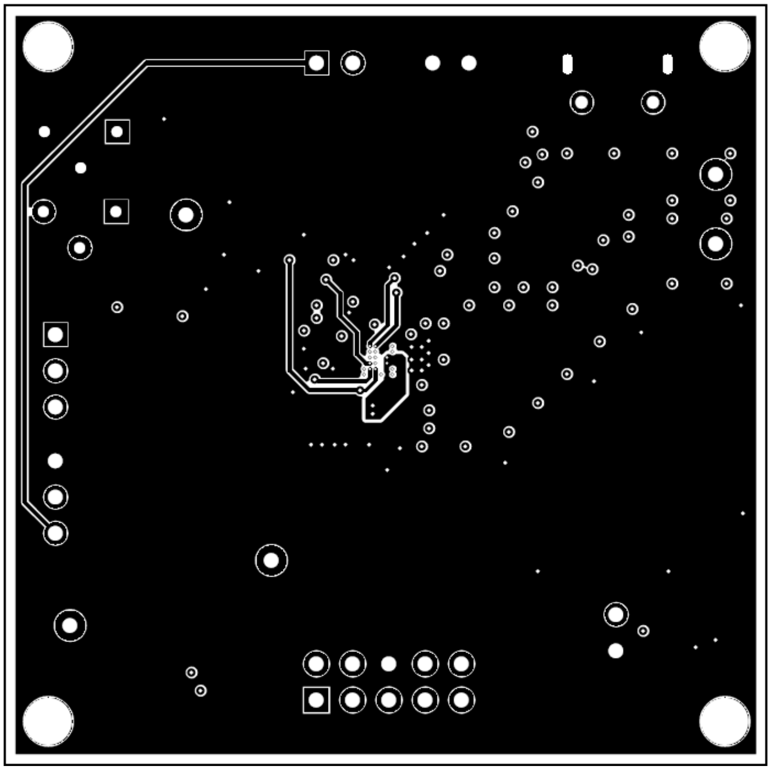


Figure 16. bq51221EVM-520 Layer 4

## 9.5 Bill of Materials

Table 3 lists the BOM for the bq51221EVM-520.

**Table 3. bq51221EVM-520 Rev. B Bill of Materials**

| RefDes | Qty | Value | Description | Package Reference | Part No. | Manufacturer |
|---|---|---|---|---|---|---|
| C1 | 1 | 0.1uF | CAP, CERM, 0.1uF, 50V, ±10%, X7R, 0603 | 603 | C0603C104K5RACTU | Kemet |
| C2 | 1 | 0.056uF | CAP, CERM, 0.056uF, 50V, ±10%, X7R, 0603 | 603 | GRM188R71H563KA93D | Murata |
| C3 | 1 | 0.082uF | CAP, CERM, 0.082uF, 50V, ±10%, X7R, 0603 | 603 | GRM188R71H823KA93D | Murata |
| C4 | 1 | 2700pF | CAP, CERM, 2700pF, 50V, ±10%, X7R, 0603 | 603 | GRM188R71H272KA01D | Murata |
| C5 | 1 | 100pF | CAP, CERM, 100pF, 50V, ±10%, X7R, 0402 | 402 | CC0402KRX7R9BB101 | Yageo America |
| C6 | 1 | 0.1uF | CAP, CERM, 0.1uF, 50V, ±10%, X7R, 0402 | 402 | C1005X7R1H104K050BB | TDK |
| C7 | 1 | 3.3uF | CAP, CERM, 3.3uF, 25V, ±10%, X5R, 0603 | 603 | C1608X5R1E335K080AC | TDK |
| C8, C13 | 2 | 0.082uF | CAP, CERM, 0.082uF, 25V, ±10%, X7R, 0603 | 603 | GRM188R71E823KA01D | Murata |
| C9, C12 | 2 | 0.47uF | CAP, CERM, 0.47uF, 25V, ±10%, X5R, 0603 | 603 | GRM188R61E474KA12D | Murata |
| C10, C11 | 2 | 0.015uF | CAP, CERM, 0.015uF, 50V, ±10%, X7R, 0402 | 402 | GRM155R71H153KA12D | Murata |
| C14, C15 | 2 | 10uF | CAP, CERM, 10uF, 25V, ±10%, X5R, 0805 | 805 | C2012X5R1E106K125AB | TDK |
| C16, C19 | 2 | 0.1uF | CAP, CERM, 0.1uF, 50V, ±10%, X7R, 0603 | 603 | GCM188R71H104KA57B | Murata |
| C17 | 1 | 1uF | CAP, CERM, 1uF, 50V, ±10%, X7R, 0805 | 805 | GRM21BR71H105KA12L | Murata |
| C18 | 1 | 0.1uF | CAP, CERM, 0.1uF, 16V, ±10%, X7R, 0402 | 402 | GRM155R71C104KA88D | Murata |
| C20 | 1 | 1uF | CAP, CERM, 1uF, 25V, ±10%, X7R, 0603 | 603 | GRM188R71E105KA12D | Murata |
| C21 | 1 | 2.2uF | CAP, CERM, 2.2uF, 16V, ±10%, X5R, 0603 | 603 | GRM188R61C225KE15D | Murata |
| C22 | 0 | 100pF | CAP, CERM, 100pF, 50V, ±10%, X7R, 0402 | 402 | CC0402KRX7R9BB101 | Yageo America |
| D3 | 1 | Green | LED, Green, SMD | 1.6x0.8x0.8mm | LTST-C190GKT | Lite-On |
| 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—See Coil Design section | | 760308102210 | Wurth |
| H4–H7 | 4 | | #4 x 3/8" pan head phillips screw | #4 x 3/8" | PSMS 004 0038 PH | B&F Fastener |
| H8–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 | 2 | | Header, 100mil, 2x1, Tin plated, TH | Header, 2 PIN, 100mil, Tin | PEC02SAAN | Sullins Connector Solutions |
| JP1, JP2 | 2 | | 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 | 402 | CRCW040256K2FKED | Vishay-Dale |
| R2 | 1 | 150 | RES, 150 ohm, 5%, 0.063W, 0402 | 402 | CRCW0402150RJNED | Vishay-Dale |

**Table 3. bq51221EVM-520 Rev. B Bill of Materials (continued)**

| RefDes | Qty | Value | Description | Package Reference | Part No. | Manufacturer |
|---|---|---|---|---|---|---|
| R3 | 1 | 0 | RES, 0 ohm, 1%, 0.063W, 0402 | 402 | CRCW04020000Z0ED | Vishay-Dale |
| R4 | 1 | 110 | RES, 110 ohm, 1%, 0.063W, 0402 | 402 | CRCW0402110RFKED | Vishay-Dale |
| R6 | 1 | 500 | Trimmer, 500 ohm, 0.25W, TH | 4.5x8x6.7mm | 3266W-501LF | Bourns |
| R8, R9 | 2 | 200 | RES, 200 ohm, 1%, 0.1W, 0603 | 603 | RT0603BRD07200RL | Yageo America |
| R10, R18 | 2 | 11.3k | RES, 11.3k ohm, 1%, 0.05W, 0201 | 201 | ERJ-1GEF1132C | Panasonic |
| R11 | 1 | 10.0k | RES, 10.0k ohm, 1%, 0.063W, 0402 | 402 | CRCW040210K0FKED | Vishay-Dale |
| R12 | 1 | 5.6Meg | RES, 5.6Meg ohm, 5%, 0.05W, 0201 | 201 | MCR006YRTJ565 | Rohm |
| R13 | 1 | 2.00k | RES, 2.00k ohm, 1%, 0.1W, 0603 | 603 | RC0603FR-072KL | Yageo America |
| R14, R17, R19 | 3 | 102k | RES, 102k ohm, 1%, 0.05W, 0201 | 201 | ERJ-1GEF1023C | Panasonic |
| R20 | 1 | 1.50k | RES, 1.50k ohm, 1%, 0.1W, 0603 | 603 | CRCW06031K50FKEA | Vishay-Dale |
| R21 | 0 | 27k | RES, 27k ohm, 5%, 0.1W, 0603 | 603 | CRCW060327K0JNEA | Vishay-Dale |
| SH-JP1, SH-JP2 | 2 | 1x2 | Shunt, 100mil, Gold plated, Black | Shunt | 969102-0000-DA | 3M |
| TP–TP5 | 3 | White | Test Point, TH, Miniature, White | Keystone5002 | 5002 | Keystone |
| U1 | 1 | | DUAL MODE (Qi and PMA) INTEGRATED WIRELESS RECEIVER POWER SUPPLY, YFP0042AWCG | YFP0042AWCG | bq51221YFP | Texas Instruments |
| D1 | 0 | Green | LED, Green, SMD | 1.6x0.8x0.8mm | LTST-C190GKT | Lite-On |
| D2 | 0 | Orange | LED, Orange, SMD | 1.6x0.8x0.8mm | LTST-C190KFKT | Lite-On |
| FID1–FID3 | 0 | | Fiducial mark. There is nothing to buy or mount. | Fiducial | N/A | N/A |
| J5 | 0 | | Header, 100mil, 2x1, Tin plated, TH | Header, 2 PIN, 100mil, Tin | PEC02SAAN | Sullins Connector Solutions |
| R5 | 0 | 5K | Trimmer, 5k ohm, 0.25W, TH | 4.5x8x6.7mm | 3266W-502LF | Bourns |
| R7, R16 | 0 | 1.50k | RES, 1.50k ohm, 1%, 0.1W, 0603 | 603 | CRCW06031K50FKEA | Vishay-Dale |
| R15 | 0 | 20k | RES, 20k ohm, 5%, 0.063W, 0402 | 402 | CRCW040220K0JNED | Vishay-Dale |
| TP1, TP2 | 0 | Black | Test Point, Miniature, Black, TH | Black Miniature Testpoint | 5001 | Keystone |

# Revision History

| **Changes from A Revision (March 2014) to B Revision** | **Page** |
| --- | --- |
| • Added information in the abstract including the bq51021 IC as a device that can be evaluated with this EVM. | 1 |

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**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.

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**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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