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.

Contents

1 Introduction .................................................................................................................. 2
2 Considerations with this EVM ..................................................................................... 2
3 Modifications ............................................................................................................... 3
4 Recommended Operation Condition ........................................................................... 3
5 Equipment and EVM Setup.......................................................................................... 4
  5.1 Schematic .................................................................................................................. 4
  5.2 Connector Descriptions .......................................................................................... 5
  5.3 Jumpers and Switches ............................................................................................. 5
  5.4 Test Point Descriptions ......................................................................................... 5
  5.5 Pin Description of the IC ....................................................................................... 6
6 Test Procedure .............................................................................................................. 6
  6.1 Definition .................................................................................................................. 6
  6.2 Recommended Test Equipment ............................................................................... 7
  6.3 Equipment Setup .................................................................................................... 7
  6.4 Procedure ................................................................................................................. 8
7 Test Results .................................................................................................................. 11
  7.1 Steady-State Operation with bq2425x Charger ......................................................... 11
  7.2 Load Step ................................................................................................................. 12
  7.3 Start Up .................................................................................................................... 12
  7.4 Efficiency Data ........................................................................................................ 13
  7.5 AD Insertion and Removal ..................................................................................... 13
  7.6 Thermal Performance ............................................................................................. 14
8 Layout and Bill of Material .......................................................................................... 15
  8.1 bq51020 Traces ....................................................................................................... 15
  8.2 Layout Guidelines ................................................................................................... 15
  8.3 Printed-Circuit Board Layout Example .................................................................... 15
  8.4 bq51020EVM-520 Layout ...................................................................................... 17
  8.5 Bill of Materials (BOM) .......................................................................................... 20

List of Figures

1 bq51020EVM-520 Schematic ..................................................................................... 4
2 bq51020 in Steady State Operation with bq24250 ....................................................... 11
3 Load Step ................................................................................................................... 12
4 Start Up With 500 mA ............................................................................................... 13
5 System Efficiency Versus Output Power .................................................................... 13
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.

1 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
• WPG LED indicator (turns on as V_{OUT} goes high)
• 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**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITION</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>RECT input voltage range</td>
<td>4.0</td>
<td>10.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$I_{AD_EN_sink}$</td>
<td>Sink current</td>
<td>1.0</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{IN}$</td>
<td>Input current range</td>
<td>1.5</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{OUT}$</td>
<td>Output current range</td>
<td>1.5</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{OUT_REG}$</td>
<td>Programmable output voltage$^{(1)}$</td>
<td>4.5</td>
<td>8</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$f_s$</td>
<td>Switching frequency</td>
<td>WPC</td>
<td>110</td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td>$T_J$</td>
<td>Junction temperature</td>
<td>125</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^{(1)}$ 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.
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>
<thead>
<tr>
<th>PIN Number (WCSP)</th>
<th>bq51020</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1, A2, A3, A4, A5, A6</td>
<td>PGND</td>
</tr>
<tr>
<td>B1, B2, B3</td>
<td>AC1</td>
</tr>
<tr>
<td>B4, B5, B6</td>
<td>AC2</td>
</tr>
<tr>
<td>C1</td>
<td>BOOT1</td>
</tr>
<tr>
<td>C2, C3, C4, C5</td>
<td>RECT</td>
</tr>
<tr>
<td>C6</td>
<td>BOOT2</td>
</tr>
<tr>
<td>D1, D2, D3, D4, D5, D6</td>
<td>OUT</td>
</tr>
<tr>
<td>E1</td>
<td>CLAMP1</td>
</tr>
<tr>
<td>E2</td>
<td>AD</td>
</tr>
<tr>
<td>E3</td>
<td>AD_EN</td>
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<tr>
<td>E4</td>
<td>EN1</td>
</tr>
<tr>
<td>E5</td>
<td>VTSB</td>
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<tr>
<td>E6</td>
<td>CLAMP2</td>
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<tr>
<td>F1</td>
<td>COMM1</td>
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<td>F2</td>
<td>FOD</td>
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<td>F3</td>
<td>TERM</td>
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<tr>
<td>F4</td>
<td>EN2</td>
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<td>F5</td>
<td>WPG</td>
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<tr>
<td>F6</td>
<td>COMM2</td>
</tr>
<tr>
<td>G1</td>
<td>VO_REG</td>
</tr>
<tr>
<td>G2</td>
<td>ILIM</td>
</tr>
<tr>
<td>G3</td>
<td>CM_ILIM</td>
</tr>
<tr>
<td>G4</td>
<td>TS/CTRL</td>
</tr>
<tr>
<td>G5</td>
<td>TMEM</td>
</tr>
<tr>
<td>G6</td>
<td>PD_DET</td>
</tr>
</tbody>
</table>

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.
V(XXX) : External voltage supply name (VADP, VTS, \( V_{\text{OUT}} \))
LOADW: External load name (LOADR, LOADI)
V(TPyy): Voltage at internal test point TPyy. For example, \( V(\text{TP02}) \) means the voltage at TP02.
V(jxx): Voltage at header Jxx
V(TP(XXX)): Voltage at test point XXX. For example, \( V(\text{ACDET}) \) 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 \( \Omega \)/1000 mA, 10 \( \Omega \)/500 mA, and 5 k\( \Omega \)/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
Test Procedure

- 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 \( V_{\text{OUT}} \) 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 – \( V_{\text{OUT}} \) 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](image-url)
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](image)

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.
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.
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, PD_DET, WPG, COMM, ILIM, AD, 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 = AD_EN = TS/CTRL = EN1 = EN2 = TERM = FOD = 1 mA
• 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
### Table 3. bq51020EVM-520 Bill of Materials

<table>
<thead>
<tr>
<th>Designator</th>
<th>Qty</th>
<th>Value</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>Manufacturer</th>
</tr>
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<tbody>
<tr>
<td>PCB</td>
<td>1</td>
<td></td>
<td>Printed Circuit Board</td>
<td></td>
<td>PWR520</td>
<td>Any</td>
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<tr>
<td>C1, C2</td>
<td>2</td>
<td>0.068µF</td>
<td>CAP CER 0.068UF 50V 10% X7R 0603</td>
<td>0603</td>
<td>GRM188R71H683KA93D</td>
<td>Murata</td>
</tr>
<tr>
<td>C3</td>
<td>1</td>
<td>0.047µF</td>
<td>CAP CER 0.047UF 50V 10% X7R 0603</td>
<td>0603</td>
<td>GRM188R71H473KA61D</td>
<td>Murata</td>
</tr>
<tr>
<td>C4</td>
<td>1</td>
<td>1800pF</td>
<td>CAP CER 1800PF 50V 10% X7R 0603</td>
<td>0603</td>
<td>GRM188R71H182KA01D</td>
<td>Murata</td>
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<tr>
<td>C5</td>
<td>1</td>
<td>100pF</td>
<td>CAP, CERM, 100pF, 50V, +/-10%, X7R, 0402</td>
<td>0402</td>
<td>C0603C223KRACTU</td>
<td>Kemet</td>
</tr>
<tr>
<td>C6</td>
<td>1</td>
<td>0.1uF</td>
<td>CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0402</td>
<td>0402</td>
<td>GRM188R61E474KA12D</td>
<td>Murata</td>
</tr>
<tr>
<td>C7, C13</td>
<td>2</td>
<td>0.022µF</td>
<td>CAP CER 0.022UF 25V 10% X7R 0603</td>
<td>0603</td>
<td>GRM188R61E474KA12D</td>
<td>Murata</td>
</tr>
<tr>
<td>C8, C12</td>
<td>2</td>
<td>0.47uF</td>
<td>CAP CER 0.47UF 25V 10% X7R 0603</td>
<td>0603</td>
<td>GRM188R61E474KA12D</td>
<td>Murata</td>
</tr>
<tr>
<td>C9, C10</td>
<td>2</td>
<td>1µF</td>
<td>CAP, CERM, 1µF, 50V, +/-10%, X7R, 0402</td>
<td>0402</td>
<td>GRM188R71H105KA12L</td>
<td>Murata</td>
</tr>
<tr>
<td>C20, C21</td>
<td>2</td>
<td>2µF</td>
<td>CAP, CERM, 2µF, 16V, +/-10%, X5R, 0603</td>
<td>0603</td>
<td>GRM188R61C225KE15D</td>
<td>Murata</td>
</tr>
<tr>
<td>D1</td>
<td>1</td>
<td>Green</td>
<td>LED, Green, SMD</td>
<td>1.6x0.8x0.8mm</td>
<td>LTST-C190GKT</td>
<td>Lite-On</td>
</tr>
<tr>
<td>D2</td>
<td>1</td>
<td>Orange</td>
<td>LED, Orange, SMD</td>
<td>1.6x0.8x0.8mm</td>
<td>LTST-C190KFKT</td>
<td>Lite-On</td>
</tr>
<tr>
<td>D4</td>
<td>1</td>
<td>5.1V</td>
<td>Diode, Zener, 5.1V, 300mW, SOD-523</td>
<td>SOD-523</td>
<td>BZT52C5VT-7</td>
<td>Diodes Inc.</td>
</tr>
<tr>
<td>H1</td>
<td>1</td>
<td></td>
<td>Tape segment, Low Static Polymide Film. Cut tape section from 36 yard roll</td>
<td>1.5” x 2.3”</td>
<td>S419-1-1/2”</td>
<td>3M</td>
</tr>
<tr>
<td>H2</td>
<td>1</td>
<td></td>
<td>Case Modified Polycase LP-11B with 4 screws</td>
<td></td>
<td>J6838A</td>
<td>Poly case</td>
</tr>
<tr>
<td>H3</td>
<td>1</td>
<td></td>
<td>Coil, RX with Attractor</td>
<td></td>
<td>IWSA4832FE9R7J50</td>
<td>Vishay</td>
</tr>
<tr>
<td>H4, H5, H6, H7</td>
<td>4</td>
<td>#4 x 3/8” pan head phillips screw</td>
<td>#4 x 3/8”</td>
<td>PSMS 004 0038 PH</td>
<td>Bandit Fastener</td>
<td>Vishay</td>
</tr>
<tr>
<td>H8, H9, H10, H11</td>
<td>4</td>
<td>Spacers, 0.100” Thk x 0.25” OD x 0.147” ID</td>
<td>0.1” Thk</td>
<td>905-100</td>
<td>Bivar</td>
<td></td>
</tr>
<tr>
<td>J1</td>
<td>1</td>
<td></td>
<td>Receptacle, Micro-USB-B, Right Angle, SMD</td>
<td>Micro USB receptacle</td>
<td>10507-0001</td>
<td>Molex</td>
</tr>
<tr>
<td>J2</td>
<td>1</td>
<td></td>
<td>Connector, 100mil Shrouded, High-Temperature, Gold, TH</td>
<td>5x2 Shrouded header</td>
<td>N2510-6002-RB</td>
<td>3M</td>
</tr>
<tr>
<td>J3, J4, J5</td>
<td>3</td>
<td></td>
<td>Header, 100mil, 2x1, Tin plated, TH</td>
<td>Header, 2 PIN, 100mil, Tin</td>
<td>PEC02SAAN</td>
<td>Sullins Connector Solutions</td>
</tr>
<tr>
<td>JP1, JP2, JP3, JP4</td>
<td>4</td>
<td></td>
<td>Header, 100mil, 3x1, Tin plated, TH</td>
<td>Header, 3 PIN, 100mil, Tin</td>
<td>PEC03SAAN</td>
<td>Sullins Connector Solutions</td>
</tr>
<tr>
<td>LBL1, LBL2</td>
<td>2</td>
<td></td>
<td>Thermal Transfer Printable Labels, 0.650” W x 0.200” H - 10,000 per roll</td>
<td>PCB Label 0.650”H x 0.200”W</td>
<td>THT-14-423-10</td>
<td>Brady</td>
</tr>
<tr>
<td>Q1</td>
<td>1</td>
<td>-20V</td>
<td>MOSFET, P-CH, -20V, -1.2A, 2x3 DSBGA</td>
<td>2x3 DSBGA</td>
<td>CSD75301W1015</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>R1</td>
<td>1</td>
<td>56.2k</td>
<td>RES, 56.2k ohm, 1%, 0.063W, 0402</td>
<td>0402</td>
<td>CRCW040256K2PKED</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R2</td>
<td>1</td>
<td>150</td>
<td>RES, 150 ohm, 5%, 0.063W, 0402</td>
<td>0402</td>
<td>CRCW0402150RNED</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R3</td>
<td>1</td>
<td>0</td>
<td>RES, 0 ohm, 5%, 0.063W, 0402</td>
<td>0402</td>
<td>CRCW0402000020ED</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R4</td>
<td>1</td>
<td>110</td>
<td>RES, 110 ohm, 1%, 0.063W, 0402</td>
<td>0402</td>
<td>CRCW0402110RKFED</td>
<td>Vishay-Dale</td>
</tr>
</tbody>
</table>
### Table 3. bq51020EVM-520 Bill of Materials (continued)

<table>
<thead>
<tr>
<th>Designator</th>
<th>Qty</th>
<th>Value</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>R6</td>
<td>1</td>
<td>500 Ohm</td>
<td>Trimmer, 500 ohm, 0.25W, TH</td>
<td>4.5x8x6.7mm</td>
<td>3266W-1-501LF</td>
<td>Bourns</td>
</tr>
<tr>
<td>R7</td>
<td>1</td>
<td>1.50k</td>
<td>RES, 1.50k ohm, 1%, 0.1W, 0603</td>
<td></td>
<td>3603</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R8, R9</td>
<td>2</td>
<td>200</td>
<td>RES, 200 ohm, 1%, 0.1W, 0603</td>
<td></td>
<td>3603</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R10</td>
<td>1</td>
<td>11.3k</td>
<td>RES, 11.3k ohm, 1%, 0.05W, 0201</td>
<td></td>
<td>0201</td>
<td>Panasonic</td>
</tr>
<tr>
<td>R11</td>
<td>1</td>
<td>10.0k</td>
<td>RES, 10.0k ohm, 1%, 0.063W, 0402</td>
<td></td>
<td>0402</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R12</td>
<td>1</td>
<td>5.6Meg</td>
<td>RES, 5.6Meg ohm, 5%, 0.05W, 0201</td>
<td></td>
<td>0201</td>
<td>Rohm</td>
</tr>
<tr>
<td>R13</td>
<td>1</td>
<td>100k</td>
<td>RES, 102k ohm, 1%, 0.05W, 0201</td>
<td></td>
<td>0201</td>
<td>Panasonic</td>
</tr>
<tr>
<td>R15</td>
<td>1</td>
<td>20k</td>
<td>RES, 20k ohm, 5%, 0.063W, 0402</td>
<td></td>
<td>0402</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R16</td>
<td>1</td>
<td>5.11k</td>
<td>RES, 5.11k ohm, 1%, 0.1W, 0603</td>
<td></td>
<td>0603</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R22</td>
<td>1</td>
<td>102k</td>
<td>RES, 102k ohm, 1%, 0.063W, 0402</td>
<td></td>
<td>0402</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>TP3, TP4, TP5</td>
<td>3</td>
<td>White</td>
<td>Test Point, TH, Miniature, White</td>
<td></td>
<td>Keystone5002</td>
<td>5002</td>
</tr>
<tr>
<td>TP6</td>
<td>1</td>
<td>White</td>
<td>Test Point, TH, Miniature, White</td>
<td></td>
<td>White Miniature Testpoint</td>
<td>5002</td>
</tr>
<tr>
<td>U1</td>
<td>1</td>
<td></td>
<td>WPC MODE (Qi) INTEGRATED WIRELESS RECEIVER POWER SUPPLY, YFP0042AWCG</td>
<td></td>
<td>YFP0042AWCG</td>
<td>bq51020YFP</td>
</tr>
<tr>
<td>C22</td>
<td>0</td>
<td>100pF</td>
<td>CAP, CERM, 100pF, 50V, +/-10%, X7R, 0402</td>
<td></td>
<td>0402</td>
<td>CCR0402KRX7R0B101</td>
</tr>
<tr>
<td>D2</td>
<td>0</td>
<td>Green</td>
<td>LED, Green, SMD</td>
<td></td>
<td>LTST-C190GK7</td>
<td>Lite-On</td>
</tr>
<tr>
<td>FID1, FID2, FID3</td>
<td>0</td>
<td></td>
<td>Fiducial mark. There is nothing to buy or mount.</td>
<td></td>
<td>Fiducial</td>
<td>N/A</td>
</tr>
<tr>
<td>R5</td>
<td>0</td>
<td>5 K</td>
<td>Trimmer, 5k ohm, 0.25W, TH</td>
<td>4.5x8x6.7mm</td>
<td>3266W-1-502LF</td>
<td>Bourns</td>
</tr>
<tr>
<td>R13</td>
<td>0</td>
<td>2.00k</td>
<td>RES, 2.00k ohm, 1%, 0.1W, 0603</td>
<td></td>
<td>0603</td>
<td>RC0603FR-072KL</td>
</tr>
<tr>
<td>R17, R19</td>
<td>0</td>
<td>102k</td>
<td>RES, 102k ohm, 1%, 0.05W, 0201</td>
<td></td>
<td>0201</td>
<td>ERJ-1GEF1023C</td>
</tr>
<tr>
<td>R18</td>
<td>0</td>
<td>11.3k</td>
<td>RES, 11.3k ohm, 1%, 0.05W, 0201</td>
<td></td>
<td>0201</td>
<td>ERJ-1GEF1132C</td>
</tr>
<tr>
<td>R20</td>
<td>0</td>
<td>1.50k</td>
<td>RES, 1.50k ohm, 1%, 0.1W, 0603</td>
<td></td>
<td>0603</td>
<td>CRCW06031K50FKEA</td>
</tr>
<tr>
<td>R21</td>
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<td>27k</td>
<td>RES, 27k ohm, 5%, 0.1W, 0603</td>
<td></td>
<td>0603</td>
<td>CRCW060327K0JNEA</td>
</tr>
<tr>
<td>TP1, TP2</td>
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<td>Black</td>
<td>Test Point, Miniature, Black, TH</td>
<td></td>
<td>Black Miniature Testpoint</td>
<td>5001</td>
</tr>
</tbody>
</table>
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12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

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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.
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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 their 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. 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.
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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