TI Designs

Long Range Bluetooth™ Low Energy Design Guide

TI Designs

TI Designs provide the foundation that you need including methodology, testing, and design files to quickly evaluate and customize the system. TI Designs help you accelerate your time to market.

Design Resources

- TIDC-Bluetooth-Low-Energy-Long-Range
- SWRA422
- Tool Folder Containing Design Files
- App Note PDF

Design Features

Bluetooth™ Smart Long-Range Designs:

- Bluetooth Low Energy (Bluetooth Smart) is suited for long-range applications with a smartphone or tablet
- Users can achieve a range of up to 500 meters with CC2590 at both ends of the link
- Suitable for full-house coverage with Bluetooth Low Energy

Featured Applications

For Internet of Things (IoT) applications that require up to 500+ meters range:

- Home and Building Automation
- Industrial Remote Display
- Retail Beaoning
- Home Health Monitoring
An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.
1 System Description

For complete data, see Using CC2590 Front End with CC2541 Application Note (SWRA422).

This TI design is based on CC2541 with the CC2590 range extender to increase output power and improve sensitivity, achieving longer range through increased link budget.

The CC2541 is one of TI's Bluetooth™ low-energy RF System-on-Chips (SoCs). The CC2590 is a range extender that can be used together with TI's RF SoC for the 2.4-GHz unlicensed industrial, scientific, and medical (ISM) band. The CC2590 includes a power amplifier (PA) for higher output power and a low-noise amplifier (LNA) for improved receiver sensitivity. When used together, the solution has output power of 10 dBm and sensitivity reaching –95 dBm. This power gives a total link budget of 105 dB when the CC2541 and CC2590 are used on both sides of the link. The CC2590 can connect directly to the CC2541 with the addition of a few passive components. The CC2590 has an internal balun and a single-ended RF output pin. Three control signals are required to control the range extender; the SW control is handled automatically by the Bluetooth low-energy stack. To achieve the best RF performance, users must follow the reference design closely when using the CC2590.

1.1 Performance

For complete data, see Using CC2590 Front End with CC2541 Application Note (SWRA422).

1.1.1 Current Consumption

TC = 25°C, VDD = 3.0 V, f = 2440 MHz. The CC2541 and CC2590 are both set to receive in high-gain mode. All parameters are measured in the CC2541–CC2590EM reference design with a load of 50 Ω.

Table 1. CC2541–CC2590EM Current Consumption

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITION</th>
<th>TYPICAL</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive Current</td>
<td>Wait for sync, –90 dBm input level</td>
<td>21.6</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Wait for sync, –50 dBm input level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmit Current</td>
<td>TXPOWER = 0xF1</td>
<td>41.1</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>TXPOWER = 0xE1</td>
<td>36.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TXPOWER = 0xD1</td>
<td>32.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TXPOWER = 0xC1</td>
<td>30.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TXPOWER = 0xB1</td>
<td>28.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TXPOWER = 0xA1</td>
<td>27.5</td>
<td></td>
</tr>
<tr>
<td>Power Down Current</td>
<td>PM2</td>
<td>1</td>
<td>µA</td>
</tr>
</tbody>
</table>

1.1.2 RF Performance

![Figure 1. Output Power vs. Supply Voltage](image1)

![Figure 2. Sensitivity vs. Supply Voltage](image2)
References

2 References

TI Documents:
1. Using CC2590 Front End with CC2541 Application Note (SWRA422)
2. CC2541 2.4-GHz Bluetooth™ low energy and Proprietary System-on-Chip Data Manual (SWRS110)
3. CC2540 2.4-GHz Bluetooth™ low energy System-on-Chip Data Manual (SWRS084)
4. CC2590 2.4-GHz RF Front End, 14-dBm Output Power Data Manual (SWRS080)
IMPORTANT NOTICE FOR TI REFERENCE DESIGNS

Texas Instruments Incorporated (“TI”) reference designs are solely intended to assist designers (“Buyers”) who are developing systems that incorporate TI semiconductor products (also referred to herein as “components”). Buyer understands and agrees that Buyer remains responsible for using its independent analysis, evaluation and judgment in designing Buyer’s systems and products.

TI reference designs have been created using standard laboratory conditions and engineering practices. **TI has not conducted any testing other than that specifically described in the published documentation for a particular reference design.** TI may make corrections, enhancements, improvements and other changes to its reference designs.

Buyers are authorized to use TI reference designs with the TI component(s) identified in each particular reference design and to modify the reference design in the development of their end products. **HOWEVER, NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY THIRD PARTY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT, IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used.** Information published by TI regarding third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

**TI REFERENCE DESIGNS ARE PROVIDED “AS IS”. TI MAKES NO WARRANTIES OR REPRESENTATIONS WITH REGARD TO THE REFERENCE DESIGNS OR USE OF THE REFERENCE DESIGNS, EXPRESS, IMPLIED OR STATUTORY, INCLUDING ACCURACY OR COMPLETENESS. TI DISCLAIMS ANY WARRANTY OF TITLE AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, QUIET ENJOYMENT, QUIET POSSESSION, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS WITH REGARD TO TI REFERENCE DESIGNS OR USE THEREOF. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY BUYERS AGAINST ANY THIRD PARTY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON A COMBINATION OF COMPONENTS PROVIDED IN A TI REFERENCE DESIGN. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, SPECIAL, INCIDENTAL, CONSEQUENTIAL OR INDIRECT DAMAGES, HOWEVER CAUSED, ON ANY THEORY OF LIABILITY AND WHETHER OR NOT TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, ARISING IN ANY WAY OUT OF TI REFERENCE DESIGNS OR BUYER’S USE OF TI REFERENCE DESIGNS.**

TI reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques for TI components are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

Reproduction of significant portions of TI information in TI data books, data sheets or reference designs is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards that anticipate dangerous failures, monitor failures and their consequences, lessen the likelihood of dangerous failures and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in Buyer’s safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed an agreement specifically governing such use.

Only those TI components that have specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components that have not been so designated is solely at Buyer’s risk, and Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.