TI Designs
CC2650 Remote Control Design Guide

TI Designs

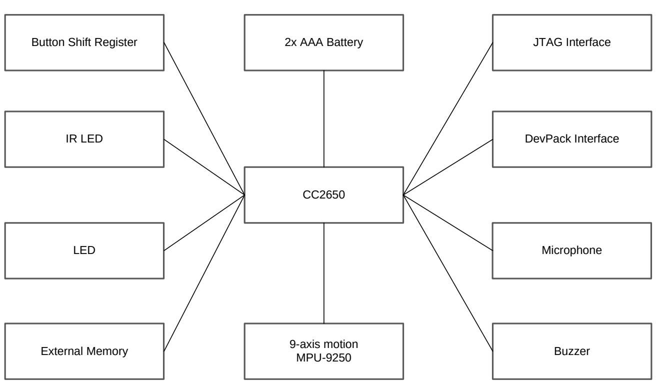
The *CC2650 Remote Control Design* provides the best foundation to quickly test, evaluate, and develop remote control applications based on ZigBee® RF4CE™-compliant software architecture RemoTI™ or *Bluetooth*® low energy software stack.

The design contains schematics and layout files for the CC2560 remote control in addition to a software example demonstrating human interface design (HID) functionality using both RF4CE and *Bluetooth* low energy.

Design Resources

TIDC-CC2650RC	Design Folder
CC2650	Product Folder
TPS22910A	Product Folder
SN74LV164A	Product Folder
Bluetooth Low Energy Software Stack	Product Folder
RemoTI	Product Folder

TI E2E™ Community — ASK Our E2E Experts



Design Features

- Supports Multistandard Wireless Microcontroller (MCU)
  – *Bluetooth* Low Energy
  – ZigBee® RF4CE™
- 1MB of External Flash
- Digital Microphone
- Infrared (IR) LED
- Buzzer
- Accelerometer
- Gyroscope
- DevPack Expansion Header

Featured Applications

- Radio Frequency (RF) Remote Control
- IR Remote Control
- Audio
- Motion Tracking
- Over-the-Air Download
- Multistandard

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1 System Description

The *CC2650 Remote Control Design* provides a reference platform for *Bluetooth* low energy and RF4CE remote control application development. The design is based on the CC2650 SimpleLink™ multistandard wireless microcontroller (MCU).

This TI Design demonstrates the recommended layout for decoupling to achieve the best RF performance. The design uses discrete components for the balun and filter and an inverted F printed-circuit board (PCB) antenna, which gives quality performance at a low cost.

The remote control features 32 metal dome buttons, a bicolored light-emitting diode (LED), a nine-axis micro-electrical-mechanical system (MEMS) motion sensor, a digital microphone, an IR LED, 1MB of external flash, and a buzzer.

The design has a 20-pin JTAG connector interface for programming and debugging and a DevPack interface to add other peripherals to the design such as the DEVPACK-DISPLAY or DEVPACK-LED-AUDIO.

2 Block Diagram

Figure 1 shows the block diagram of the CC2650 remote control.

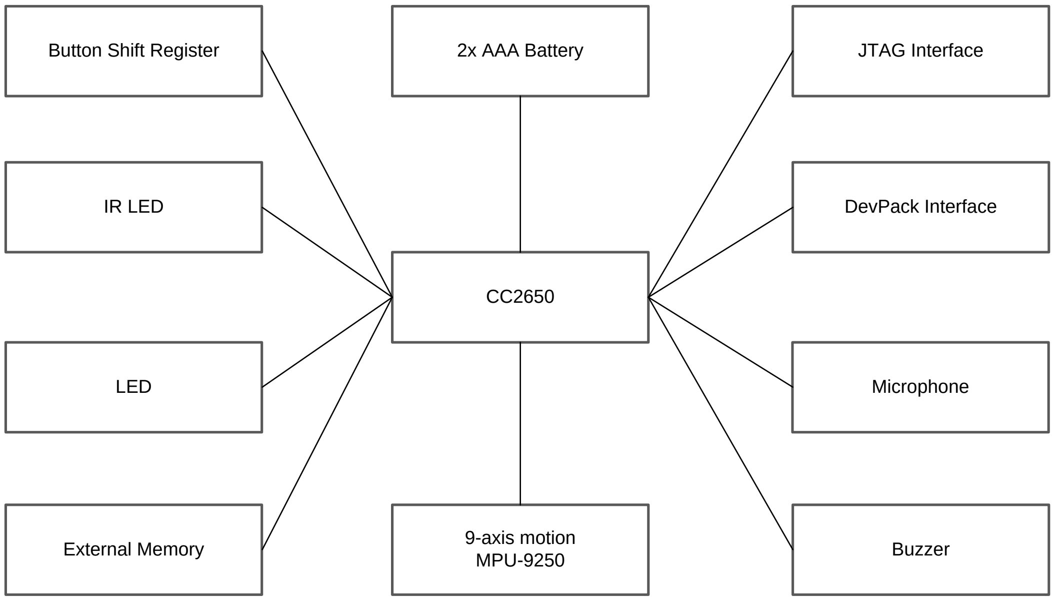

Figure 1. CC2650 Remote Control Block Diagram

2.1 Highlighted Products

The design features the following devices:

- CC2650
- TPS22910A
- SN74LV164A

For more information on each of these devices, see their respective product folders at www.ti.com.

2.1.1 CC2650 SimpleLink™ Multistandard Wireless MCU

The CC2650 is an ultra-low-power wireless MCU that targets *Bluetooth* Smart, ZigBee, 6LoWPAN, and ZigBee RF4CE remote control applications.

The device is a member of the CC26xx family of cost-effective, ultra-low-power 2.4-GHz RF devices. A very low-active RF and MCU current and a low-power mode of current consumption provides excellent battery life and allows for operation on small coin-cell batteries and energy-harvesting applications.

The CC2650 MCU contains a 32-bit ARM® Cortex® -M3 main processor that runs at 48 MHz. The device also contains a rich peripheral feature set that includes a unique, ultra-low-power sensor controller. The sensor controller is ideal for interfacing external sensors and collecting analog and digital data autonomously (or both) while the rest of the system is in sleep mode.

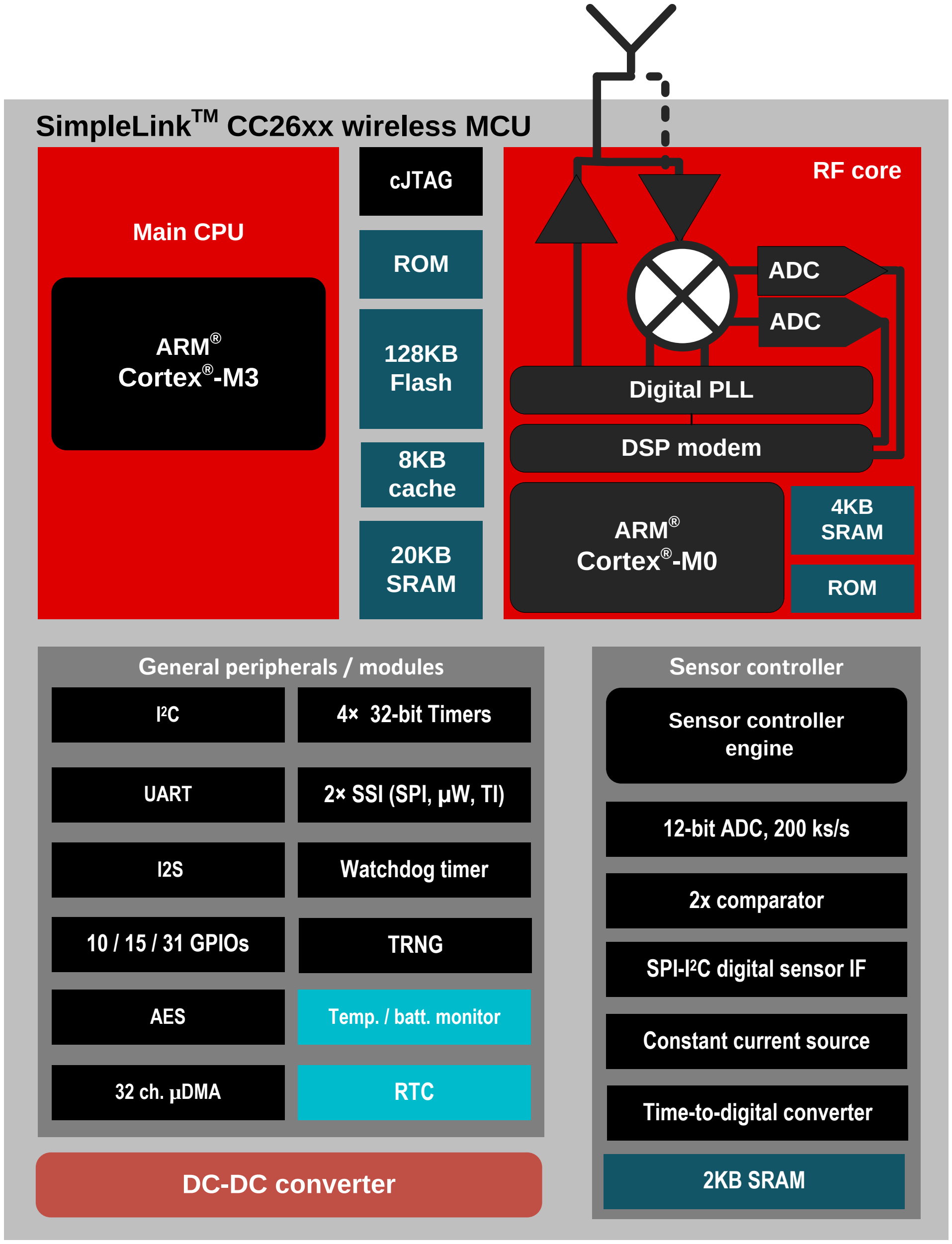

Figure 2. CC2650 Functional Block Diagram

2.1.2 TPS22910A

The TPS22910A is an ultra-small, low-resistance load switch with a controlled ON- and OFF-input turnon, which is capable of interfacing directly with low-voltage general-purpose input/output (GPIO) control signals.

The device design has a low-leakage current during the OFF state. This design prevents downstream circuits from pulling high standby currents from the power supply. The integrated control logic, driver, power supply, and output discharge flash emulation tool (FET) eliminate the requirement for additional external components, which reduces the solution size and bill-of-materials (BOM) count.

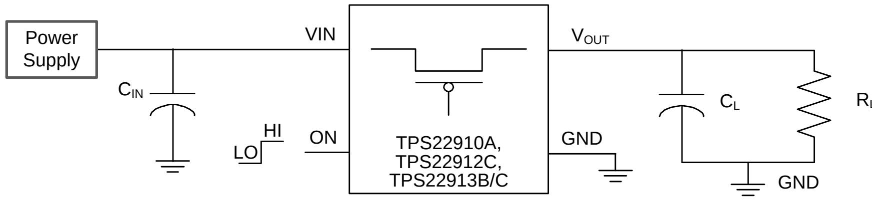

Figure 3. TPS22910A Simplified Schematic

2.1.3 SN74LV164A

The SN74L164A is an 8-bit parallel-out serial-shift register designed for 2- to 5.5-V V_{CC} operations.

The wide operating range of the device allows its use in a variety of systems that use different logic levels. The low propagation delay allows for fast-switching and high-speed operation. The low-ground bounce stabilizes the performance of non-switching outputs while another output switches.

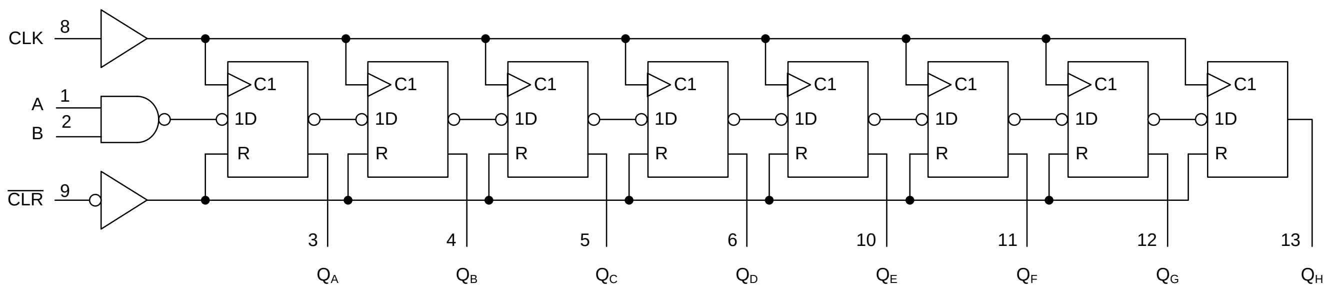

Figure 4. Logic Diagram

3 System Design Theory

The *CC2650 Remote Control Design* is an all-in-one solution for the development of voice-based *Bluetooth* low energy, ZigBee RF4CE, or multistandard remote controls with the CC2640, CC2620, or CC2650 wireless MCUs, respectively. The design provides flexibility and connects to the SimpleLink SensorTag ecosystem using DevPack plug-in modules.

Along with the SimpleLink SensorTag Debugger DevPack, the device provides everything required to start developing. The included hardware and software includes the RemoTI network protocol for RF4CE, *Bluetooth* low energy stack software for *Bluetooth* Smart development, technical documentation, and the E2E™ online community.

The ultra-low-power capabilities of the SimpleLink platform create a remote control solution with advanced features, like the *Find me* tool, gesture and pointing, and voice command, without sacrificing battery life.

4 Getting Started Hardware

The CC2650RC kit includes the CC2650 MCU remote control. There are two bundle options for purchase: one for *Bluetooth* low energy development and the other for RF4CE. These bundles include everything required to start developing. For more information, visit www.ti.com/RC.

5 Getting Started Firmware

To use the out-of-the-box firmware, visit the CC2650RC User's Guide.

5.1 *Bluetooth® Low Energy Stack*

The *Bluetooth* Low Energy Stack (BLE-STACK-2-2-x) includes example software for the remote control.

5.2 RemoTI™

The RF4CE Compliant Protocol Stack (REMOTI-2-x-x) includes example software for the remote control.

6 Test Setup

Figure 5 shows the antenna radiation pattern measured in a 3-m RF-shielded room (anechoic chamber). The device under test (DUT) transmits continuously and then rotates both around its horizontal and vertical axes to create a full-sphere antenna radiation pattern. The DUT rotates a full 360° with one measurement taken at the 15° interval.

The CC2650RC transmits a 5-dBm output continuous wave (CW) at 2440 MHz in this specific test.

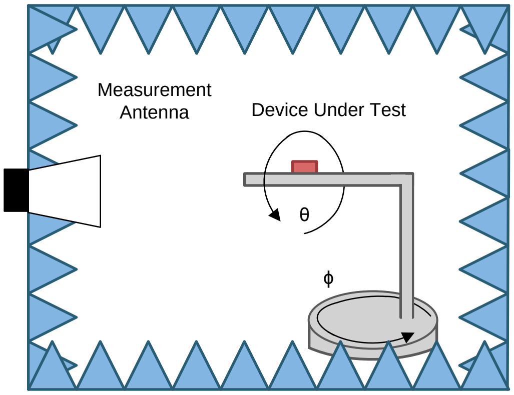

Figure 5. Antenna Radiation Pattern

Figure 6 shows the mounted DUT on the rotating arm. Figure 7 shows the measurement antenna.

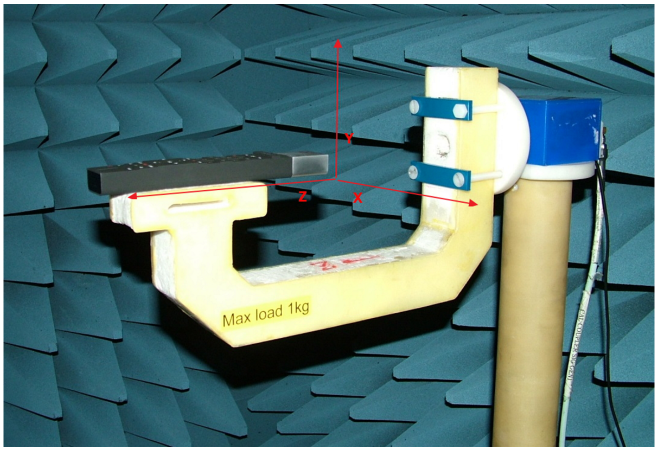

Figure 6. DUT Mounted on Rotating Arm

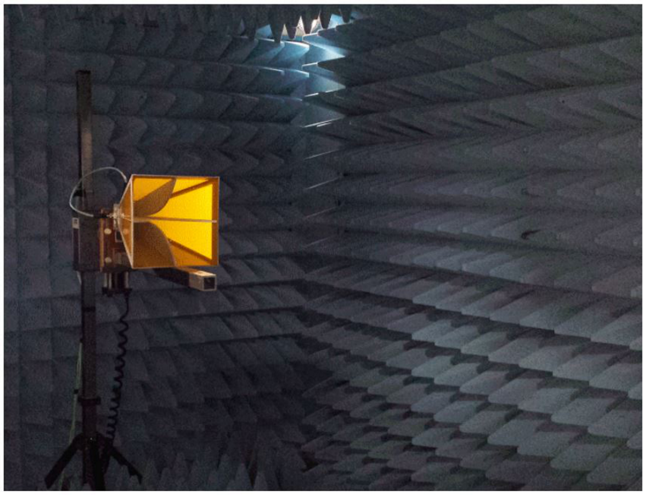

Figure 7. Measurement Antenna

7 Test Data

7.1 Radiated Performance

Table 1 shows the test data from the radiated performance.

Table 1. Radiated Performance

MEASUREMENT	RESULT
Total radiated power	3.35 dBm
Peak EIRP	10.25 dBm
Directivity	6.89 dBi
Efficiency	–1.65 dB
Efficiency	68.4%
Gain	5.24 dBi

7.2 Antenna Pattern Plots

To create the measurements of antenna plots, the CC2650RC lies in the XY plane and the antenna points in the direction of Z. The keypad side of the remote points in the direction of Y. See Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, and Figure 13 for details.

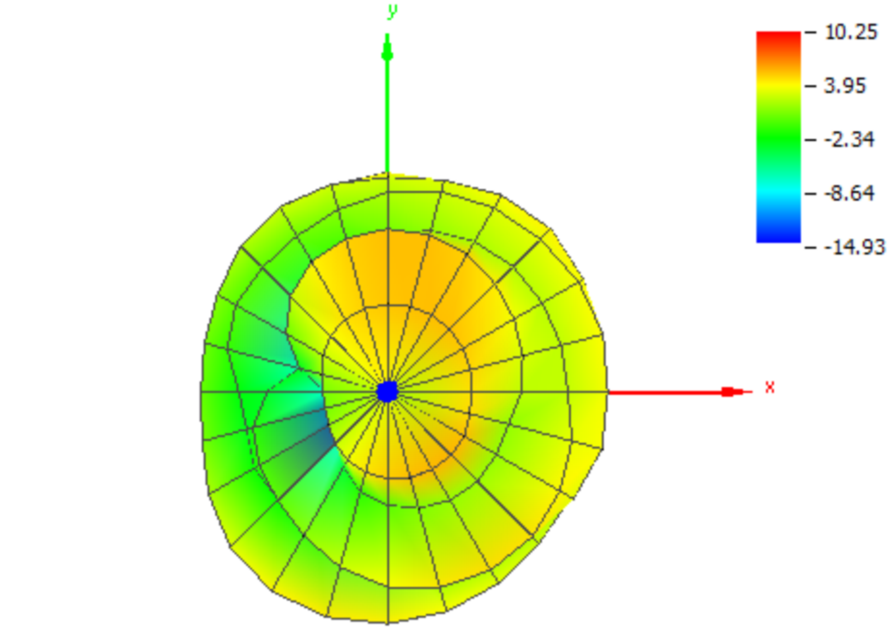

Figure 8. Radiation Pattern Plot Front

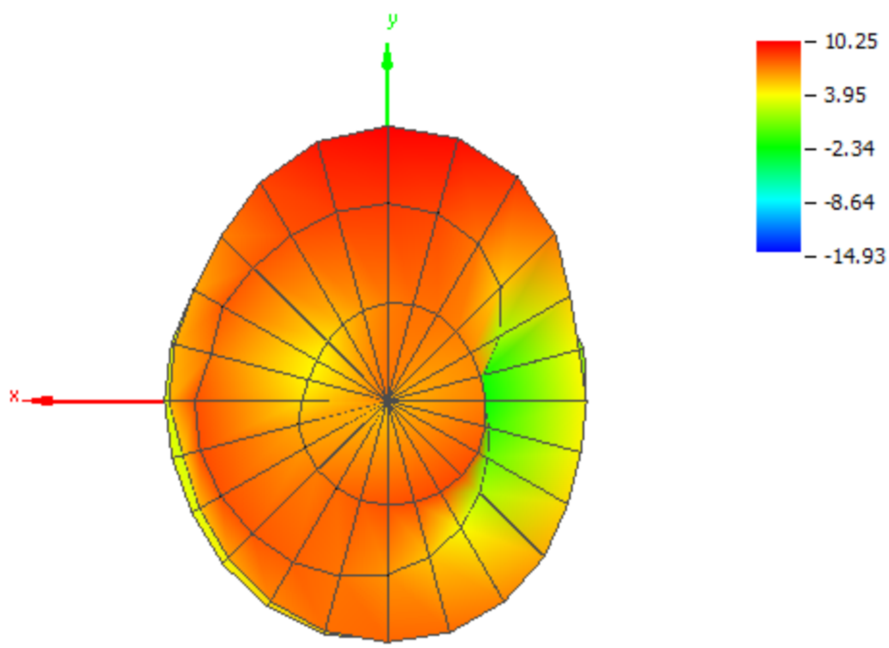

Figure 9. Radiation Plot Pattern Back

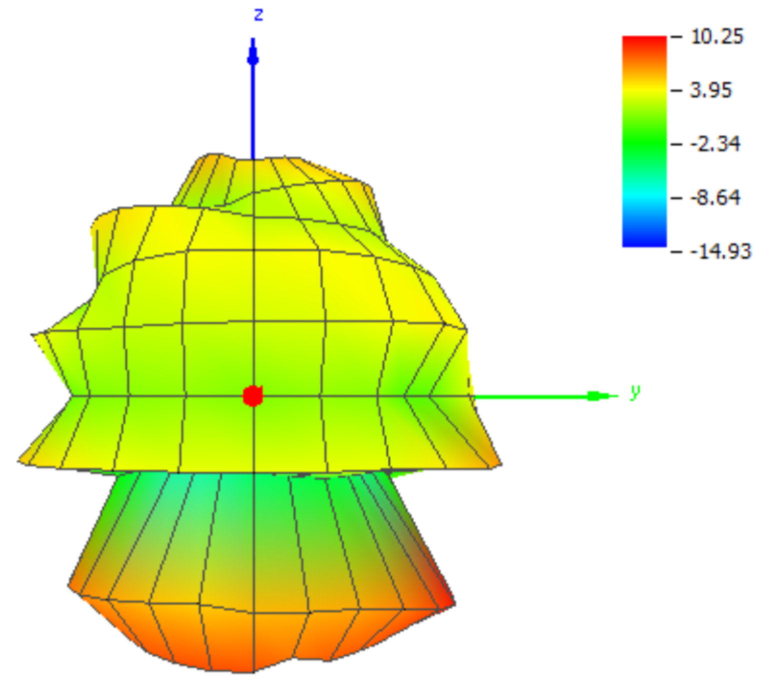

Figure 10. Radiation Pattern Plot Right Side

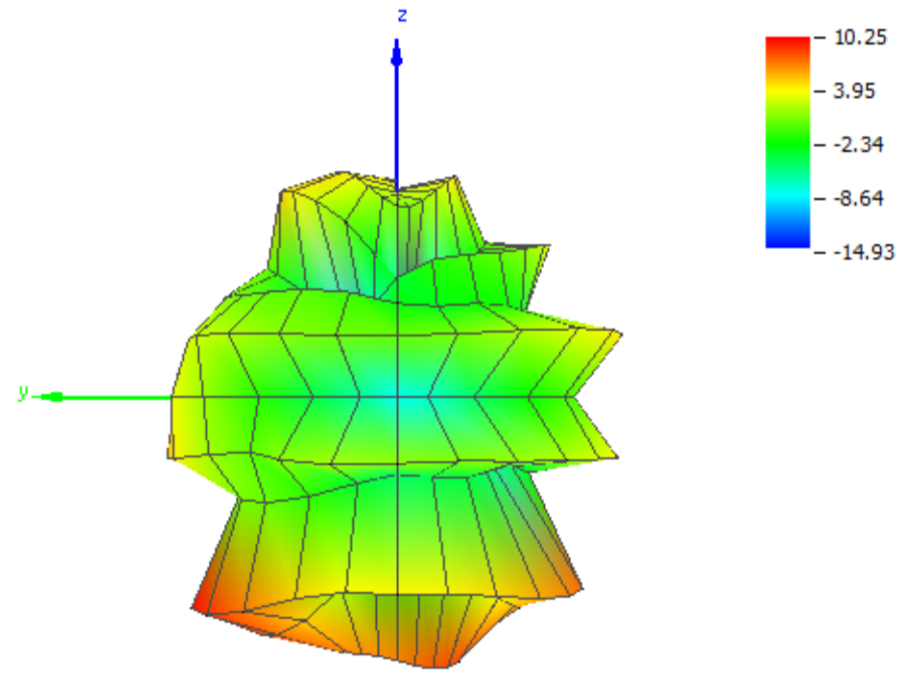

Figure 11. Radiation Plot Left Side

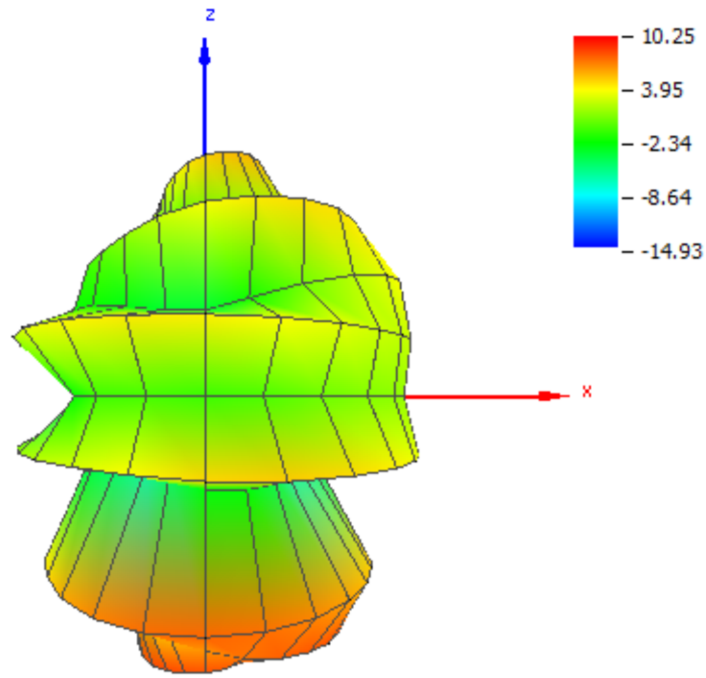

Figure 12. Radiation Pattern Plot Top

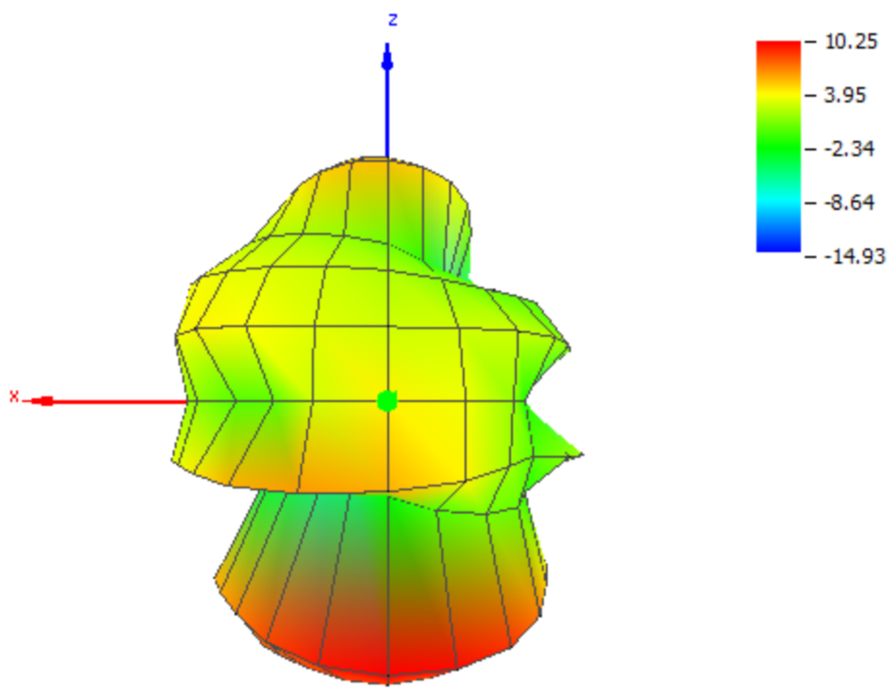

Figure 13. Radiation Pattern Plot Bottom

8 Design Files

8.1 Schematics

To download the schematics for each board, visit TIDC-CC2650RC.

8.2 Bill of Materials

To download the BOM for each board, visit TIDC-CC2650RC.

8.3 PCB Layout Recommendations

8.3.1 Layout Considerations for CC2650 SimpleLink™ Multistandard Wireless MCU

Ensure the following layout considerations:

- The layout of the RF components follows the reference design.
- The grounded RF components have multiple ground vias close to corresponding pads to minimize impedance.
- From the antenna to the ground vias in the exposed pad, an uninterrupted and solid ground plane exists under all the RF components.
- There are no traces under the RF path by placing the balun or RF filter as close to the CC6250 device as possible.
- The matching antenna components are as close to the antenna as possible.
- The decoupling capacitors are as close to their VDD pins as possible.
- The ground return path from the decoupling capacitors to the CC2650 is as short and direct as possible.
- The DC-DC components (L1 and C8) are close to the DCDC_SW pin (pin 33).
- The ground connection of the DC-DC capacitor is as short and direct as possible to avoid ground switching noise.
- Shunt components in the RF path are in opposite directions to avoid crosstalk.

8.3.2 Layout Prints

To download the layout prints for each board, visit TIDC-CC2650RC.

8.4 Altium Project

To download the Altium project files for each board, visit TIDC-CC2650RC.

8.5 Gerber Files

To download the Gerber files, visit TIDC-CC2650RC.

8.6 Assembly Drawings

To download the assembly drawings for each board, visit TIDC-CC2650RC.

9 References

1. Texas Instruments, *CC2650 SimpleLink Multistandard Wireless MCU*, CC2650 Data Sheet (SWRS158)
2. Texas Instruments, *TPS2291xx Ultra-small, Low On Resistance Load Switch With Controlled Turn-On*, TPS2291xxx Data Sheet (SLVSB49)
3. Texas Instruments, *SNx4LV164A 8-Bit Parallel-Out Serial Shift Registers*, SN54LV164A and SN74LV164A Data Sheet (SCLS403)

10 About the Author

MARTIN BRINKMANN is an Application Engineer at Texas Instruments. He supports customers in development and testing of low-power RF designs for 2.4-GHz systems (*Bluetooth* low energy and RF4CE). Martin earned his Master of Science in Electrical Engineering (MSEE) from the University of Oslo, Norway.

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