BGM220SC12 Module Radio Board BRD4310A Reference Manual

The BRD4310A Wireless Gecko Radio Board contains a Wireless Gecko module which integrates Silicon Labs' EFR32BG22 Wireless Gecko SoC into a small form factor System-in-Package (SiP) module. The fully certified module contains all components (a high-performance transceiver, an energy efficient 32-bit MCU, HF crystal, RF passives, and antenna) required for a system-level implementation of Bluetooth® Low Energy wireless networks operating in the 2.4 GHz band with 0 dBm output power.

The BRD4310A Wireless Gecko Radio Board plugs into the Wireless Starter Kit Mainboard, which is included with the Wireless Gecko Starter Kit and gives access to display, buttons, and additional features from expansion boards. With the supporting Simplicity Studio suite of tools, developers can take advantage of graphical wireless application development, BGScript for Python-like scripting, and visual energy profiling and optimization.

This document contains a brief introduction and description of the BRD4310A Radio Board features, focusing on the RF performance.

RADIO BOARD FEATURES

- Wireless Module: BGM220SC12WGA2
  - CPU core: ARM Cortex®-M33
  - Flash memory: 352 kB
  - RAM: 32 kB
  - Operation frequency: 2.4 GHz
  - Transmit power: 0 dBm
  - Integrated chip antenna, RF matching network, HF crystal, and decoupling
- Option for UFL connector
- Crystal for LFXO: 32.768 kHz
- 8 Mbit low-power serial flash for over-the-air updates

Table of Contents

1. Introduction

The BRD4310A Radio Boards provide a development platform (together with the Wireless Starter Kit Mainboard) for the Silicon Labs Wireless Gecko modules.

By carrying the BGM220SC12 module, the BRD4310A Radio Board is designed to operate in the 2400-2483.5 MHz with the maximum of 0 dBm output power.

To develop and/or evaluate the BGM220SC12 module, the BRD4310A Radio Board can be connected to the Wireless Starter Kit Mainboard to get access to display, buttons, and additional features from expansion boards (EXP boards).
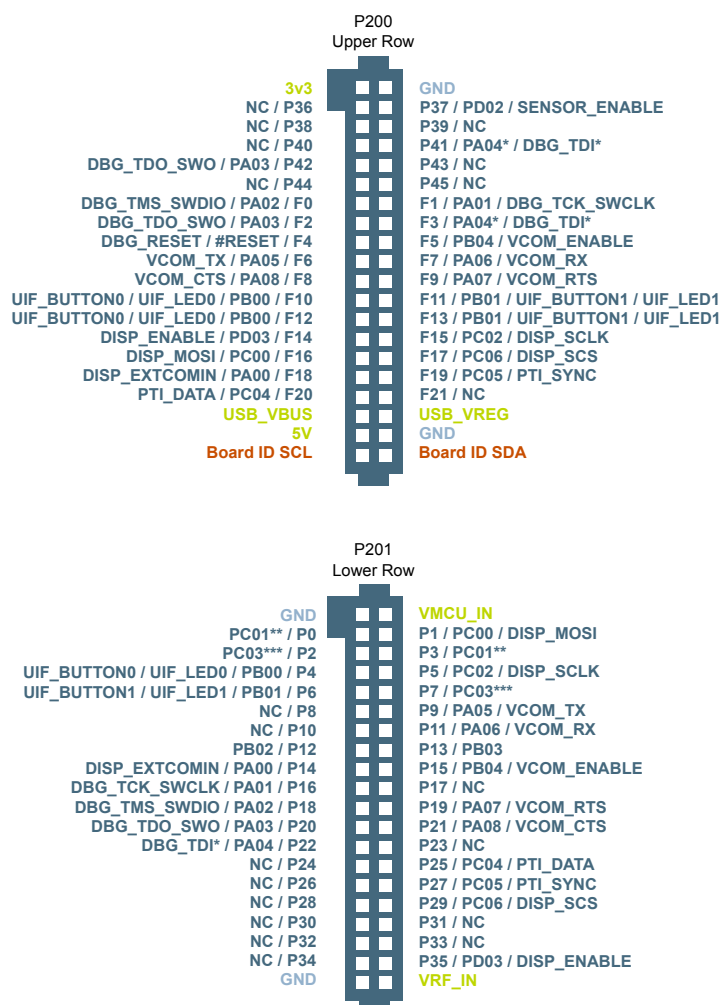
2. Radio Board Connector

2.1 Introduction

The board-to-board connector scheme allows access to all BGM220SC12 GPIO pins as well as the RESETn signal. For more information on the functions of the available pins, see the BGM220SC12 data sheet.

2.2 Radio Board Connector Pin Associations

The figure below shows the mapping between the connector and the BGM220SC12 pins and their function on the Wireless Starter Kit Mainboard.

P200
Upper Row

3v3	GND
NC / P36	P37 / PD02 / SENSOR_ENABLE
NC / P38	P39 / NC
NC / P40	P41 / PA04* / DBG_TDI*
DBG_TDO_SWO / PA03 / P42	P43 / NC
NC / P44	P45 / NC
DBG_TMS_SWDIO / PA02 / F0	F1 / PA01 / DBG_TCK_SWCLK
DBG_TDO_SWO / PA03 / F2	F3 / PA04* / DBG_TDI*
DBG_RESET / #RESET / F4	F5 / PB04 / VCOM_ENABLE
VCOM_TX / PA05 / F6	F7 / PA06 / VCOM_RX
VCOM_CTS / PA08 / F8	F9 / PA07 / VCOM_RTS
UIF_BUTTON0 / UIF_LED0 / PB00 / F10	F11 / PB01 / UIF_BUTTON1 / UIF_LED1
UIF_BUTTON0 / UIF_LED0 / PB00 / F12	F13 / PB01 / UIF_BUTTON1 / UIF_LED1
DISP_ENABLE / PD03 / F14	F15 / PC02 / DISP_SCLK
DISP_MOSI / PC00 / F16	F17 / PC06 / DISP_SCS
DISP_EXTCOMIN / PA00 / F18	F19 / PC05 / PTI_SYNC
PTI_DATA / PC04 / F20	F21 / NC
USB_VBUS	USB_VREG
5V	GND
Board ID SCL	Board ID SDA

P201
Lower Row

GND	VMCU_IN
PC01** / P0	P1 / PC00 / DISP_MOSI
PC03*** / P2	P3 / PC01**
UIF_BUTTON0 / UIF_LED0 / PB00 / P4	P5 / PC02 / DISP_SCLK
UIF_BUTTON1 / UIF_LED1 / PB01 / P6	P7 / PC03***
NC / P8	P9 / PA05 / VCOM_TX
NC / P10	P11 / PA06 / VCOM_RX
PB02 / P12	P13 / PB03
DISP_EXTCOMIN / PA00 / P14	P15 / PB04 / VCOM_ENABLE
DBG_TCK_SWCLK / PA01 / P16	P17 / NC
DBG_TMS_SWDIO / PA02 / P18	P19 / PA07 / VCOM_RTS
DBG_TDO_SWO / PA03 / P20	P21 / PA08 / VCOM_CTS
DBG_TDI* / PA04 / P22	P23 / NC
NC / P24	P25 / PC04 / PTI_DATA
NC / P26	P27 / PC05 / PTI_SYNC
NC / P28	P29 / PC06 / DISP_SCS
NC / P30	P31 / NC
NC / P32	P33 / NC
NC / P34	P35 / PD03 / DISP_ENABLE
GND	VRF_IN

* Optional 0R resistor should be mounted to enable this connection. (Mutually exclusive with FLASH_SCS.)
** Mutually exclusive connection. Default: PC01 to P3.
*** Mutually exclusive connection. Default: PC03 to P7.

Figure 2.1. BRD4310A Radio Board Connector Pin Mapping

3. Radio Board Block Summary

3.1 Introduction

This section introduces the blocks of the BRD4310A Radio Board.

3.2 Radio Board Block Diagram

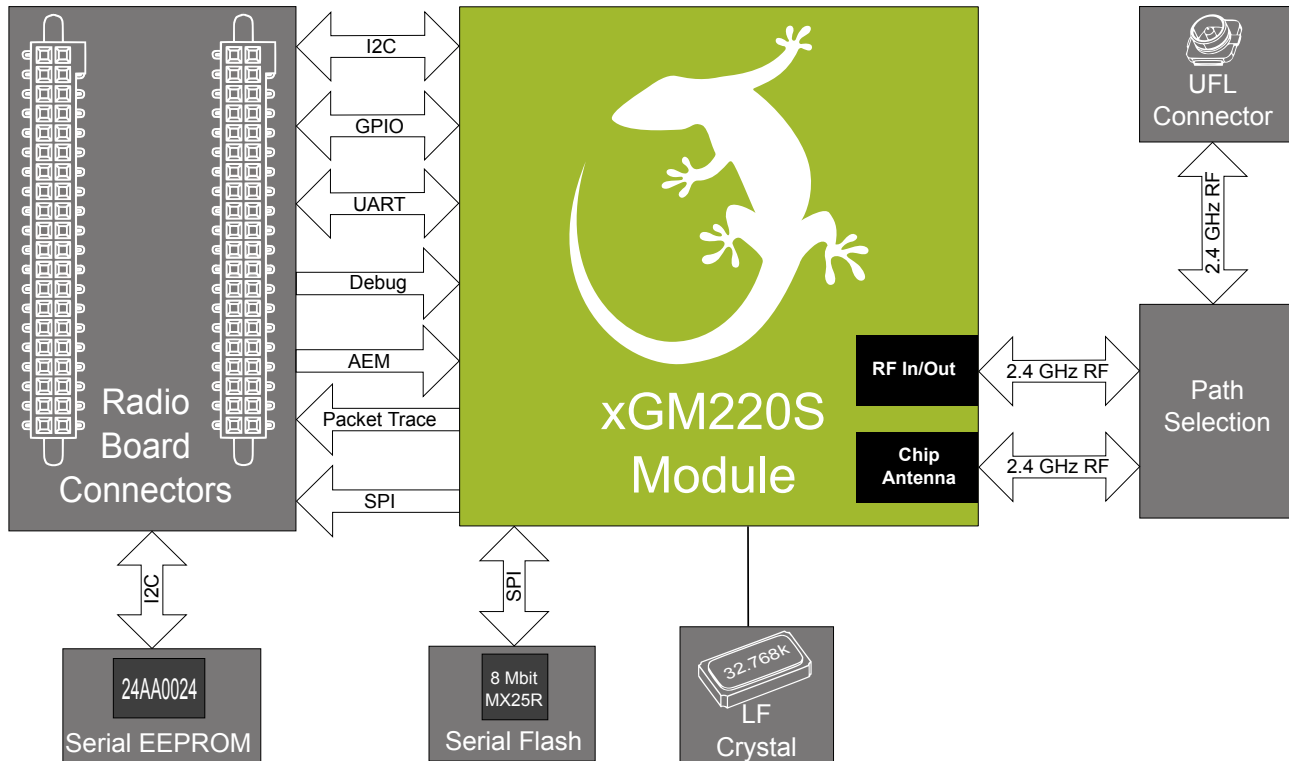The block diagram of the BRD4310A Radio Board is shown in the figure below.

Figure 3.1. BRD4310A Block Diagram

3.3 Radio Board Block Description

3.3.1 Wireless SiP

The BRD4310A Wireless Gecko Radio Board incorporates an BGM220SC12WGA2 Wireless Gecko module featuring 32-bit Cortex®-M33 core, 352 kB of flash memory, 32 kB of RAM and a 2.4 GHz band transceiver with output power up to 0 dBm. For additional information on the BGM220SC12WGA2, refer to the BGM220S data sheet.

3.3.2 LF Crystal Oscillator (LFXO)

The BRD4310A Radio Board has a 32.768 kHz crystal mounted. For details regarding the crystal configuration, refer to application note AN0016.2: Oscillator Design Considerations.

3.3.3 UFL Connector

To perform conducted measurements, a UFL connector is added to the Radio Board. The connector allows an external 50 Ohm cable or antenna to be connected during design verification or testing.

Note: By default, the 2.4 GHz RF input/output of the module is connected to the antenna input pin of the module by a series 0 Ohm resistor. Connecting the RF input/output to the UFL connector supports conducted measurements, or the connection of an external antenna. Move the series 0 Ohm resistor to the antenna to the position of the series resistor to the UFL connector (see the schematic of the BRD4310A Radio Board for further details). On the layout, the footprints of these two resistors have overlapping pads to prevent simultaneous connection of the antenna and the UFL connector.

3.3.4 Radio Board Connectors

Two dual-row, 0.05" pitch polarized connectors make up the BRD4310A Radio Board interface to the Wireless Starter Kit Mainboard.

For more information on the pin mapping between the BGM220SC12WGA2 and the Radio Board Connector, refer to section 2.2 Radio Board Connector Pin Associations.

3.3.5 Serial Flash

The BRD4310A Radio Board is equipped with an 8 Mbit Macronix MX25R SPI flash that is connected directly to the BGM220SC12 to support over-the-air (OTA) updates. For additional information on the pin mapping, see the BRD4310A schematic.

3.3.6 Serial EEPROM

The BRD4310A Radio Board is equipped with a serial I^{2}C EEPROM for board identification and to store additional board-related information.

4. Mechanical Details

The BRD4310A Radio Board is illustrated in the figures below.
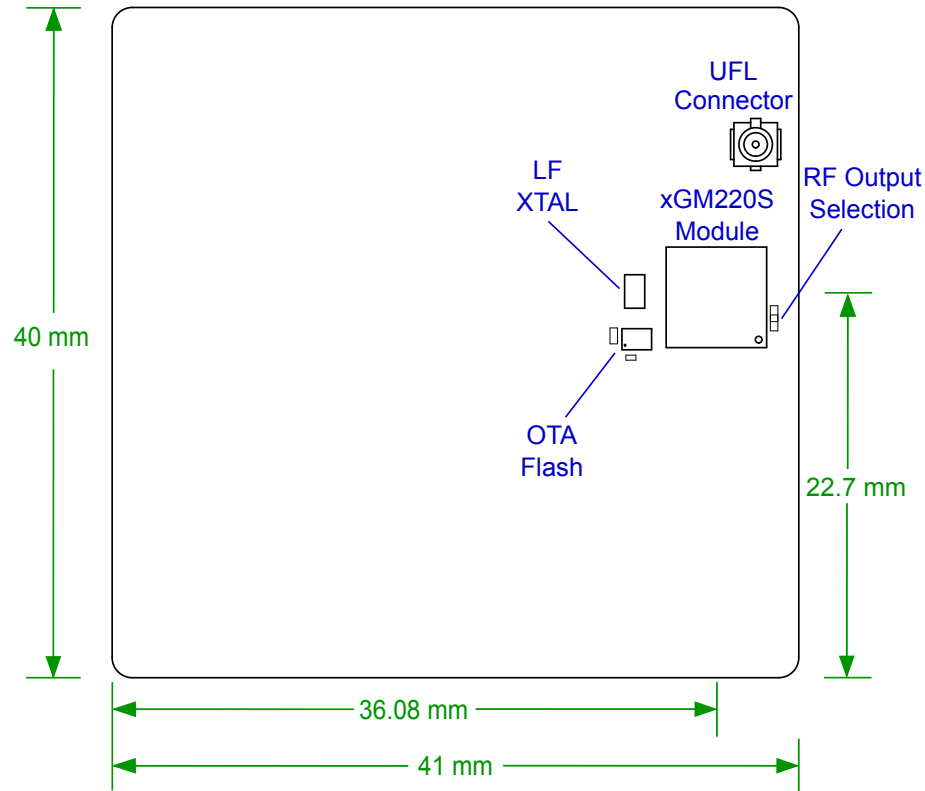
Figure 4.1. BRD4310A Top View
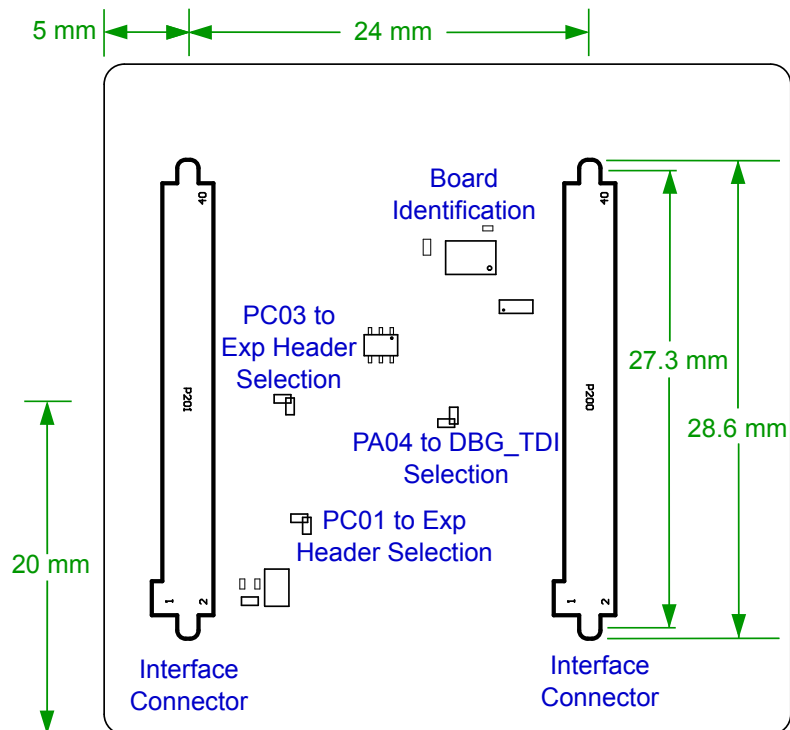
Figure 4.2. BRD4310A Bottom View

5. EMC Compliance

5.1 Introduction

Compliance of the fundamental and harmonic levels of the BRD4310A Radio Board is tested against the following standards:

- 2.4 GHz:
  - ETSI EN 300-328
  - FCC 15.247

5.2 EMC Regulations for 2.4 GHz

5.2.1 ETSI EN 300-328 Emission Limits for the 2400-2483.5 MHz Band

Based on ETSI EN 300-328, the allowed maximum fundamental power for the 2400-2483.5 MHz band is 20 dBm EIRP. For the unwanted emissions in the 1 GHz to 12.75 GHz domain, the specific limit is -30 dBm EIRP.

5.2.2 FCC15.247 Emission Limits for the 2400-2483.5 MHz Band

FCC 15.247 allows conducted output power up to 1 W (30 dBm) in the 2400-2483.5 MHz band. For spurious emissions, the limit is -20 dBc based on either conducted or radiated measurement, if the emission is not in a restricted band. The restricted bands are specified in FCC 15.205. In these bands, the spurious emission levels must meet the levels set out in FCC 15.209. In the range from 960 MHz to the frequency of the 5th harmonic, it is defined as 0.5 mV/m at 3 m distance which equals to -41.2 dBm in EIRP.

If operating in the 2400-2483.5 MHz band, the 2nd, 3rd, and 5th harmonics can fall into restricted bands. As a result, for those harmonics the -41.2 dBm limit should be applied. For the 4th harmonic the -20 dBc limit should be applied.

5.2.3 Applied Emission Limits for the 2.4 GHz Band

The above ETSI limits are applied both for conducted and radiated measurements.

The FCC restricted band limits are radiated limits only. In addition, Silicon Labs applies the same restrictions to the conducted spectrum. By doing so, compliance with the radiated limits can be estimated based on the conducted measurement, by assuming the use of an antenna with 0 dB gain at the fundamental and the harmonic frequencies.

The overall applied limits are shown in the table below. For the harmonics that fall into the FCC restricted bands, the FCC 15.209 limit is applied. ETSI EN 300-328 limit is applied for the rest.

Table 5.1. Applied Limits for Spurious Emissions for the 2.4 GHz Band

Harmonic	Frequency	Limit
2nd	4800~4967 MHz	-41.2 dBm
3rd	7200~7450.5 MHz	-41.2 dBm
4th	9600~9934 MHz	-30.0 dBm
5th	12000~12417.5 MHz	-41.2 dBm

6. RF Performance

6.1 Conducted Power Measurements

During measurements, the BRD4310A Radio Board was attached to a Wireless Starter Kit Mainboard which was supplied by USB. The voltage supply for the Radio Board was 3.3 V.

6.1.1 Conducted Power Measurements with Unmodulated Carrier

The transceiver was operated in unmodulated carrier transmission mode. The output power of the radio was set to 0 dBm. The typical output spectrums are shown in the following figures.
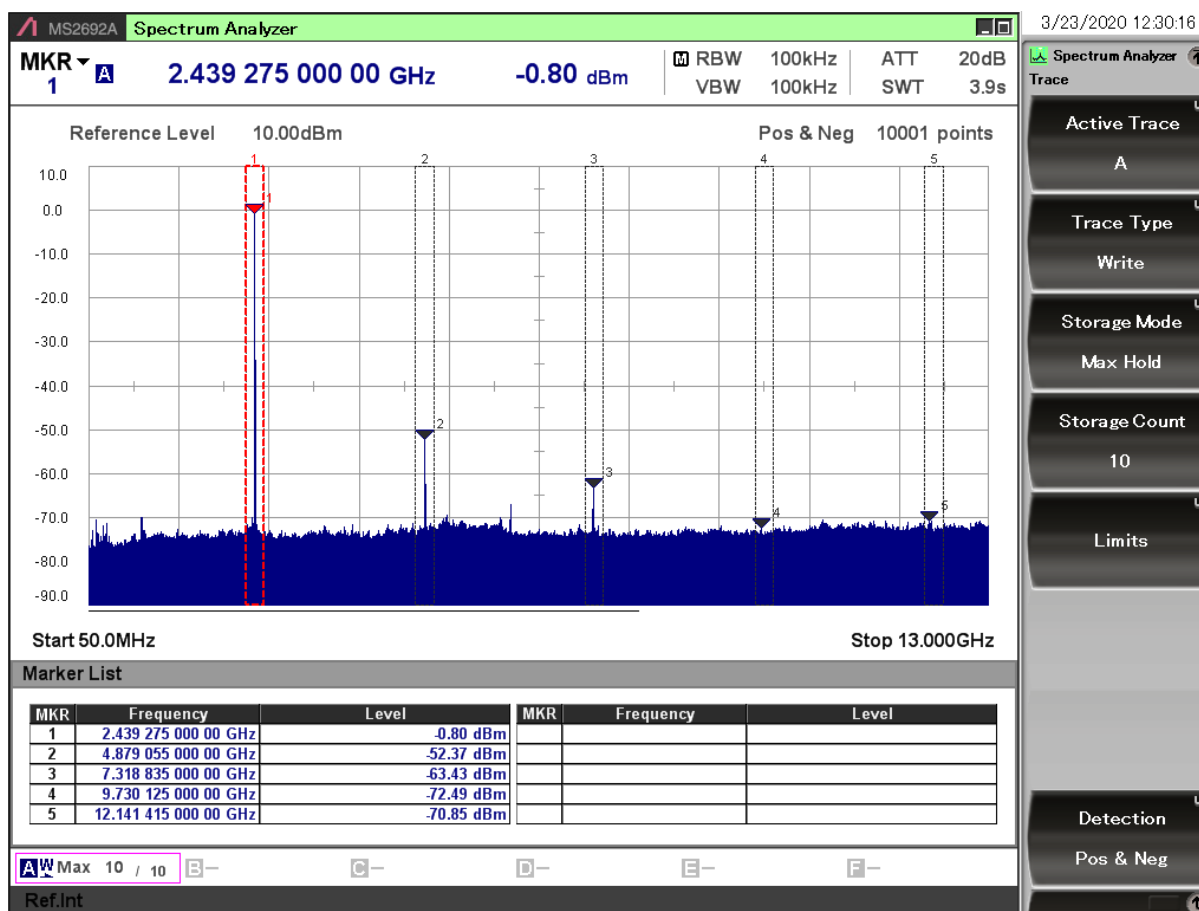

Figure 6.1. Typical Output Spectrum of the BRD4310A; PAVDD = 3.3 V

As shown in the figure above, the fundamental is slightly lower than 0 dBm and all of the unwanted emissions are under the applied limits.

Depending on the applied modulation scheme, the measured power levels are usually lower compared to the results with unmodulated carrier, so the levels of the harmonics will be lower if modulated transmission is used.

Note: The conducted measurement is performed by connecting the on-board UFL connector to a Spectrum Analyzer through an SMA Conversion Adapter (P/N: HRMJ-U.FLP(40)). This connection itself introduces approximately 0.3 dB insertion loss.

6.2 Radiated Power Measurements

During measurements, the BRD4310A Radio Board was attached to a Wireless Starter Kit Mainboard which was supplied by USB. The voltage supply for the Radio Board was 3.3 V. The radiated power was measured in an antenna chamber by rotating the board 360 degrees with horizontal and vertical reference antenna polarizations in the XY, XZ, and YZ cuts. The measurement planes are illustrated in the figure below.

Figure 6.2. Illustration of Reference Planes with a Radio Board Plugged into the Wireless Starter Kit Mainboard

Note: The radiated measurement results presented in this document were recorded in an unlicensed antenna chamber. Also, the radiated power levels may change depending on the actual application (PCB size, used antenna, and so on). Therefore, the absolute levels and margins of the final application are recommended to be verified in a licensed EMC testhouse.

6.2.1 Radiated Measurements in the 2.4 GHz Band

The supply for the module (VDD) was 3.3 V provided by the mainboard; for details, see the BRD4310A schematic. The transceiver was operated in continuous carrier transmission mode. The output power of the radio was set to 0 dBm based on the conducted measurement.

The fundamental was set to the frequency where the maximum antenna gain was measured. The results are shown in the table below.

Note: The frequency in which the antenna gain has its maximum value can vary between modules due to the technological spreading of the passive RF components and the antenna.

Table 6.1. Maximums of the Measured Radiated Powers in EIRP [dBm]

Frequency	EIRP [dBm]	Orientation	Margin [dB]	Limit in EIRP [dBm]
Fund	0.3	XY/H	29.2	30.0
2nd	<-50*	-/-	>10	-41.2
3rd	<-50*	-/-	>10	-41.2
4th	<-50*	-/-	>20	-30.0
5th	<-50*	-/-	>10	-41.2
* Signal level is below the Spectrum Analyzer noise floor.				

As shown in the table above, due to the antenna gain, the fundamental is slightly higher than the output power based the conducted measurement. The harmonics are below the Spectrum Analyzer noise floor.

6.2.2 Antenna Pattern Measurements

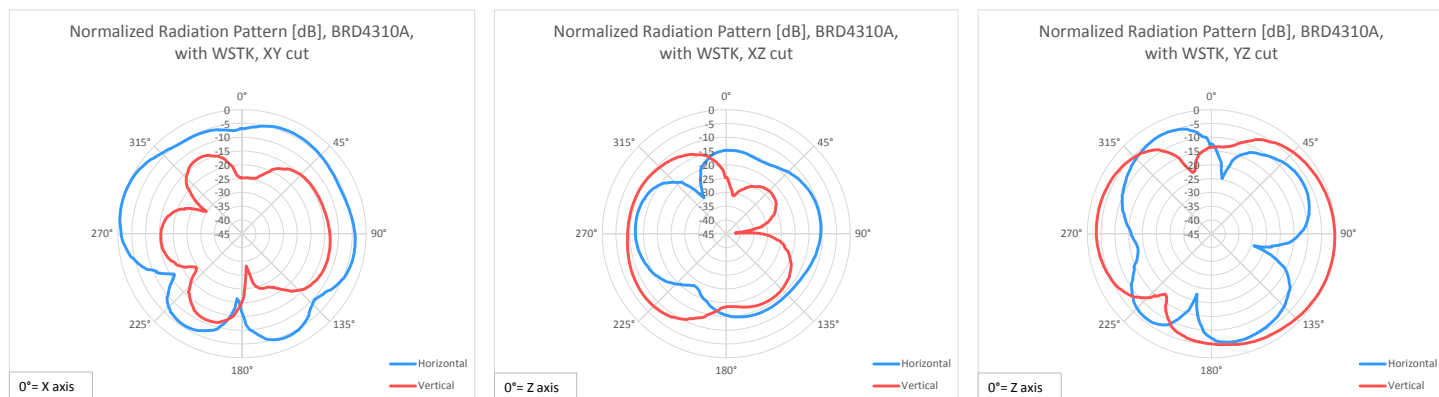The measured normalized antenna patterns are shown in the following figures.

Normalized Radiation Pattern [dB], BRD4310A, with WSTK, XY cut

0°= X axis

Normalized Radiation Pattern [dB], BRD4310A, with WSTK, XZ cut

0°= Z axis

Normalized Radiation Pattern [dB], BRD4310A, with WSTK, YZ cut

0°= Z axis

Figure 6.3. Normalized Antenna Pattern of the BRD4310A with the Wireless Starter Kit Mainboard

7. EMC Compliance Recommendations

7.1 Recommendations for 2.4 GHz ETSI EN 300-328 Compliance

As shown in section 6. RF Performance, the power of the fundamental frequency of the BRD4310A Wireless Gecko Radio Board with 0 dBm output is compliant with the 20 dBm limit of the ETSI EN 300-328 regulation in both the conducted and radiated measurements. The harmonic emissions are under the -30 dBm limit with large margin.

7.2 Recommendations for 2.4 GHz FCC 15.247 Compliance

As shown in section 6. RF Performance, the power of the fundamental frequency of the BRD4310A Wireless Gecko Radio Board with 0 dBm output is compliant with the 30 dBm limit of the FCC 15.247 regulation. The harmonic emissions are under the applied limits.

8. Board Revision History

The board revision is laser engraved in the Board Info field on the bottom side of the PCB, as outlined in the figure below. The revision printed on the silkscreen is the PCB revision.
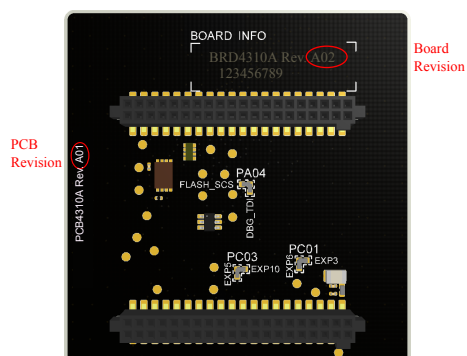
Figure 8.1. Revision Info

Table 8.1. BRD4310A Radio Board Revision History

Board Revision	Description
A02	Updated U1 OPN.
A01	Updated X2 OPN. Removed ground isolation.
A00	Initial production release.

9. Errata

There are no known errata at present.

10. Document Revision History

Revision 1.0

May, 2020

- Initial document release.

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