EFR32ZG14 Z-Wave Long Range Radio Board BRD4206A Reference Manual

The BRD4206A Wireless Gecko Radio Board enables developers to develop Silicon Labs Z-Wave® Long Range controller and gateway applications. The board contains a Wireless Gecko Wireless System-on-Chip and it is optimized for operating at 14 dBm output power. With the on-board SMA connector, conducted testing is supported, and it also enables attachment of external whip antenna for radiated tests.

This document contains a brief introduction and description of the BRD4206A Radio Board features, focusing on the RF section and performance.

RADIO BOARD FEATURES

- Wireless SoC: EFR32ZG14P231F256GM32
  - CPU core: ARM Cortex®-M4 with FPU
  - Flash memory: 256 kB
  - RAM: 32 kB
- Operation frequency: 863-876 MHz and 902-930 MHz
- Transmit power: 14 dBm
- Single SMA connector both for transmit and receive
- Optional printed antenna
- Crystal for HFXO: 39 MHz

Table of Contents

1. Introduction

The EFR32 Wireless Gecko Radio Boards provide a development platform (together with the Wireless Starter Kit Mainboard) for the Silicon Labs EFR32 Wireless Gecko Wireless System-on-Chips and serve as reference designs for the matching networks of the RF interfaces.

The BRD4206A 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 for Z-Wave Long Range applications and visual energy profiling and optimization. The board also serves as an RF reference design for applications targeting wireless operation in the 863-876 MHz and 902-930 MHz bands with 14 dBm output power.

To develop and/or evaluate the EFR32ZG14, the BRD4206A Radio Board can be connected to the Wireless Starter Kit Mainboard to get access to display, buttons, and additional features from Expansion Boards, and also to evaluate the performance of the RF interfaces.

2. Radio Board Connector

2.1 Introduction

The board-to-board connector scheme allows access to all EFR32ZG14 GPIO pins as well as the RESETn signal. For more information on the functions of the available pins, see the EFR32ZG14 data sheet.

2.2 Radio Board Connector Pin Associations

The figure below shows the mapping between the connector and the EFR32ZG14 pins and their function on the Wireless Starter Kit Mainboard.

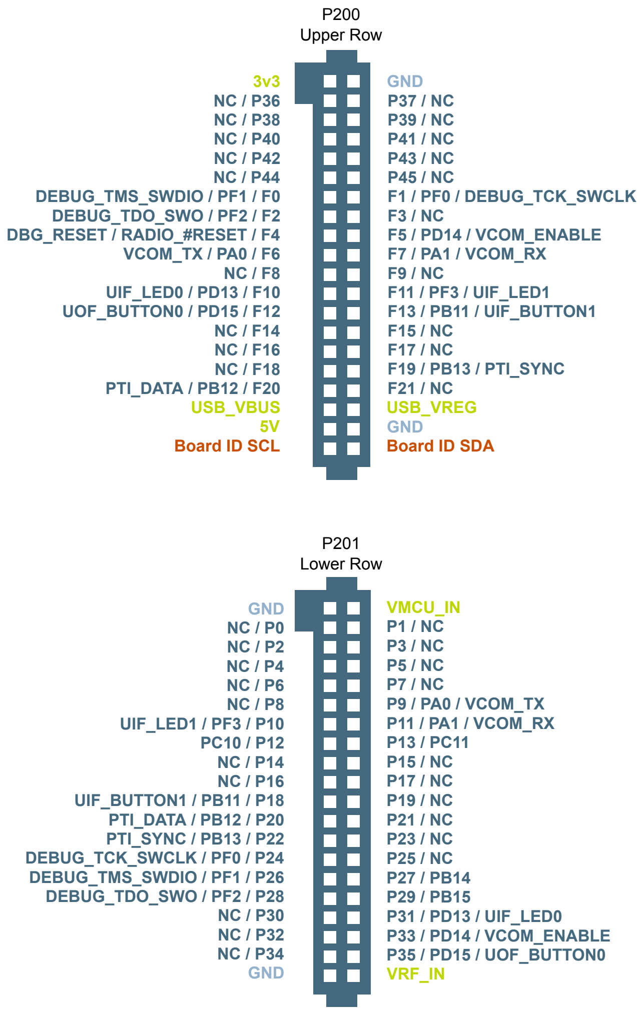

Figure 2.1. BRD4206A Radio Board Connector Pin Mapping

3. Radio Board Block Summary

3.1 Introduction

This section introduces the blocks of the BRD4206A Radio Board.

3.2 Radio Board Block Diagram

The block diagram of the BRD4206A Radio Board is shown in the figure below.

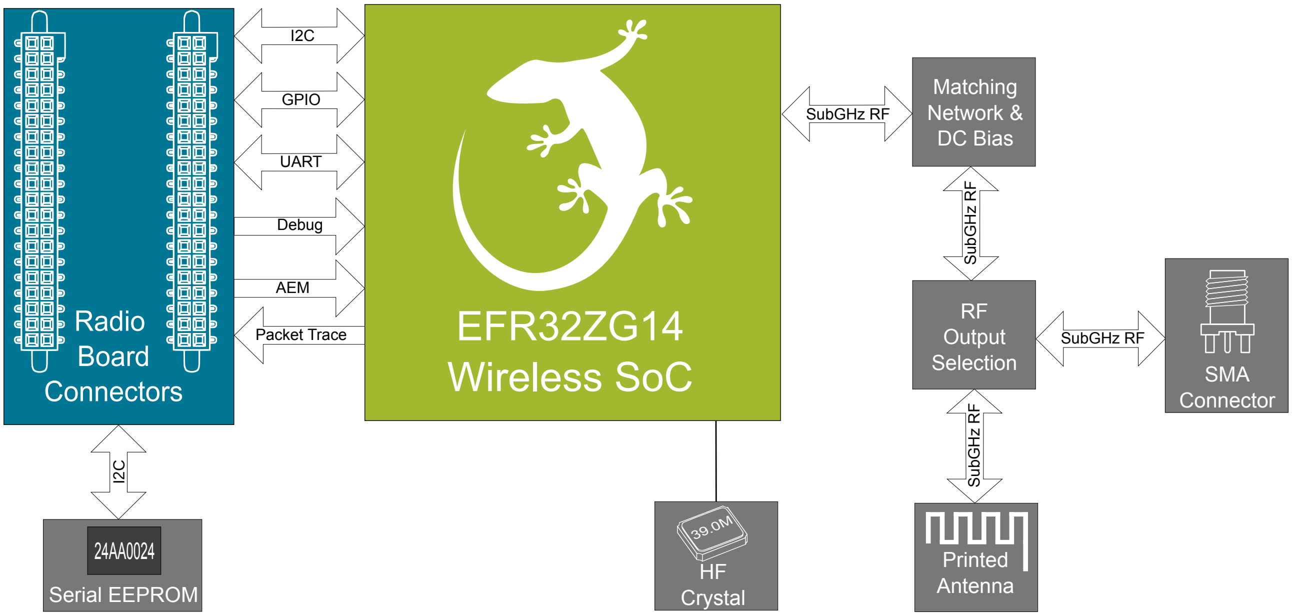

Figure 3.1. BRD4206A Block Diagram

3.3 Radio Board Block Description

3.3.1 Wireless MCU

The BRD4206A Wireless Gecko Radio Board incorporates an EFR32ZG14P231F256GM32 Wireless System-on-Chip featuring 32-bit Cortex®-M4 with FPU core, 256 kB of flash memory, 32 kB of RAM, an integrated sub-GHz ISM band transceiver with output power up to 14 dBm. For additional information on the EFR32ZG14P231F256GM32, refer to the EFR32ZG14 data sheet.

3.3.2 HF Crystal Oscillator (HFXO)

The BRD4206A Radio Board has a 39 MHz crystal mounted. For details regarding the crystal configuration, refer to application note AN0016.1: Oscillator Design Considerations.

3.3.3 Matching Network for Sub-GHz

The BRD4206A Radio Board incorporates a sub-GHz matching network which connects both the sub-GHz TX and RX pins of the EFR32ZG14 to the SMA connector to be able to transmit and receive with one antenna. The component values have been optimized for the 868 MHz band RF performance and current consumption with 14 dBm output power.

For a detailed description of the matching network see section 4.2 Schematic of the RF Section.

3.3.4 SMA Connector

To be able to perform conducted measurements or mount external antenna for radiated measurements, range tests, etc., Silicon Labs added an SMA connector to the radio board. The connector allows an external 50 Ohm cable or antenna to be connected during design verification or testing.

3.3.5 Printed Antenna

The BRD4206A Radio Board includes a printed antenna tuned to have close to 50 Ohm impedance at the 863-930 MHz band.

For a detailed description of the antenna, see section 4.5 Printed Antenna.

3.3.6 Radio Board Connectors

Two dual-row, 0.05” pitch polarized connectors make up the BRD4206A Radio Board interface to the Wireless Starter Kit Mainboard.

For more information on the pin mapping between the EFR32ZG14P231F256GM32 and the connectors, refer to section 2.2 Radio Board Connector Pin Associations.

3.3.7 Serial EEPROM

The BRD4206A Radio Board is equipped with a serial I^2C EEPROM for board identification and to store additional board-related information.

4. RF Section

4.1 Introduction

This section gives a short introduction to the RF section of the BRD4206A Radio Board.

4.2 Schematic of the RF Section

The schematic of the RF section of the BRD4206A Radio Board is shown in the following figure.

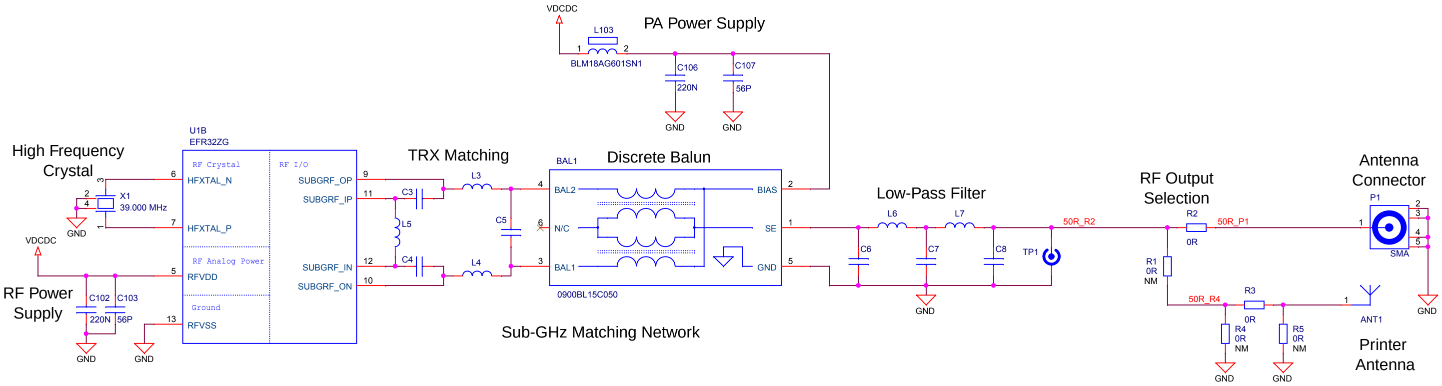

Figure 4.1. Schematic of the RF Section of the BRD4206A

The sub-GHz matching network comprises a balanced impedance matching circuitry, that connects the TX and RX balanced ports and creates a 50 Ohm balanced port. That is transformed to an unbalanced port by a discretet balun, followed by a low-pass filter section. The RF output is by default connected to the SMA connector (through the R2 resistor), but it can be connected to the on-board printed antenna (by repositioning the resistor in the R2 position to the R1 position).

4.3 RF Section Power Supply

On the BRD4206A Radio Board the supply for the radio (RFVDD) and the sub-GHz power amplifier (SUBGRF_ON, SUBGRF_OP pins) is connected to the on-chip DC-DC converter. This way, by default, the DC-DC converter provides 1.8 V for the entire RF section (for the sub-GHz PA it is provided through the discrete balun; for details, see the schematic of the BRD4206A).

4.4 Bill of Materials for the Sub-GHz Matching

The Bill of Materials of the sub-GHz matching network of the BRD4206A Radio Board is shown in the following table.

Table 4.1. Bill of Materials for the BRD4206A Sub-GHz RF Matching Network

Component Name	Value	Manufacturer	Part Number
BAL1	-	Johanson Technology	0900BL15C050
L3	3.3 nH	Murata	LQW15AN3N3B80D
L4	3.3 nH	Murata	LQW15AN3N3B80D
L5	18 nH	Murata	LQW15AN18NJ00D
L6	10 nH	Murata	LQW15AN10NG00D
L7	10 nH	Murata	LQW15AN10NG00D
C3	1.9 pF	Murata	GRM1555C1H1R9WA01D
C4	1.9 pF	Murata	GRM1555C1H1R9WA01D
C5	3.9 pF	Murata	GRM1555C1H3R9WA01D
C6	3.3 pF	Murata	GRM1555C1H3R3CA01D
C7	5.6 pF	Murata	GRM1555C1H5R6BA01D
C8	3.3 pF	Murata	GRM1555C1H3R3CA01D
R1	Not Mounted	-	-
R2	0 Ohm	-	-

4.5 Printed Antenna

The BRD4206A Radio Board includes a printed antenna tuned to have close to 50 Ohm impedance at the 863-930 MHz band, while the radio board is plugged into the WSTK. The antenna is not connected to the RF output by default; the RF output selector 0 Ohm resistor should be repositioned from the R2 to the R1 position in order to enable operation with the printed antenna.

The impedance and reflection of the printed antenna is shown in the following figures.

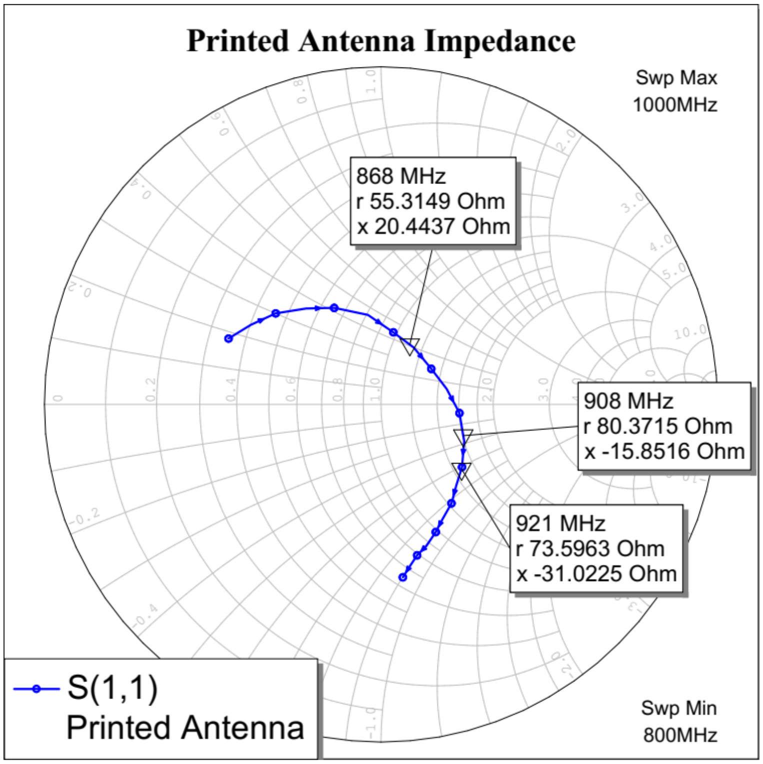

Figure 4.2. Impedance of the Printed Antenna of the BRD4206A

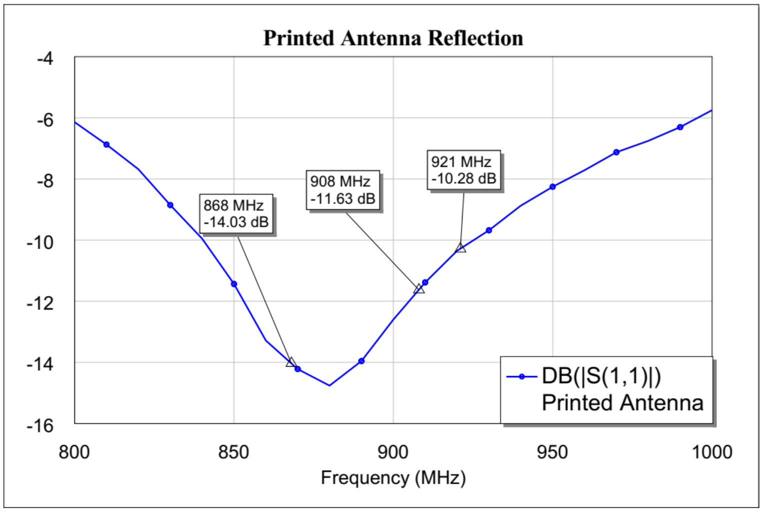

Figure 4.3. Reflection of the Printed Antenna of the BRD4206A

As it can be observed, the impedance is close to 50 Ohm at all of the marked frequencies. The reflection is better than -10 dB.

5. Mechanical Details

The BRD4206A Radio Board is illustrated in the figures below.

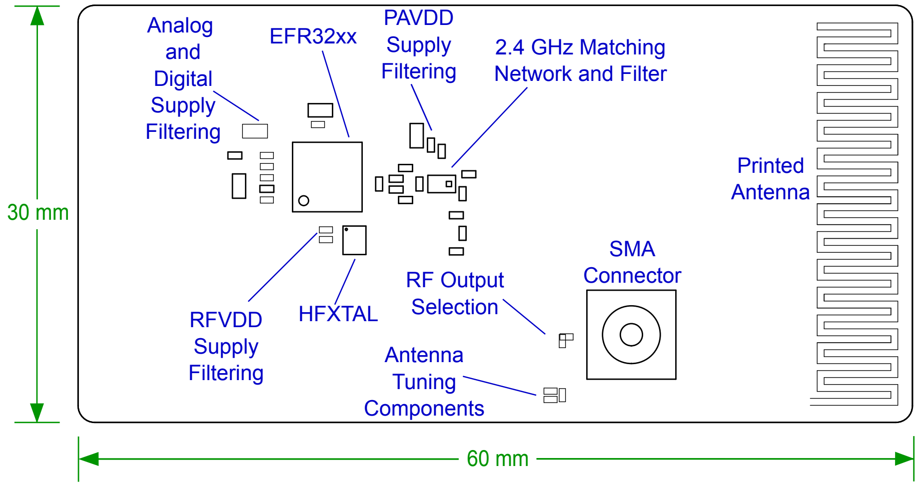

Figure 5.1. BRD4206A Top View

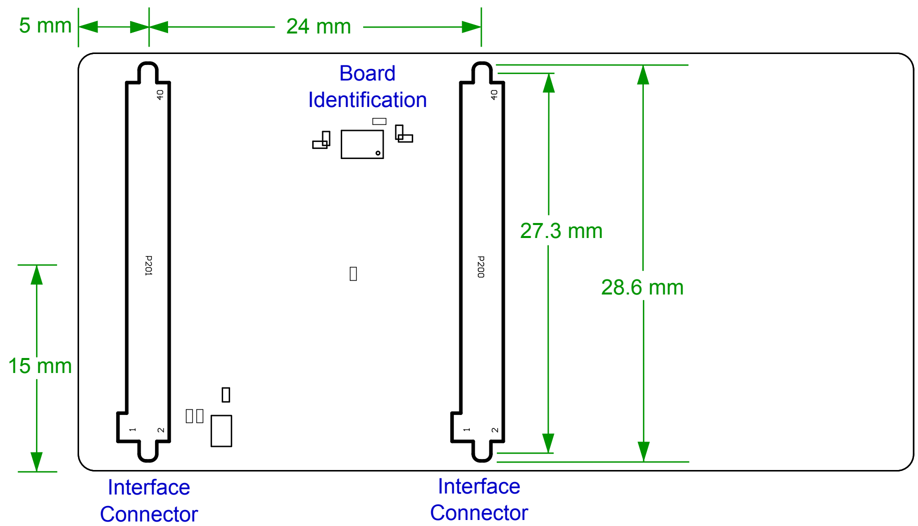

Figure 5.2. BRD4206A Bottom View

6. EMC Compliance

6.1 Introduction

Compliance of the fundamental and harmonic levels of the BRD4206A Radio Board is tested against the following standards:

- 868 MHz:
  - ETSI EN 300-220-1

  908 MHz:
  - FCC 15.247

  921 MHz:
  - FCC 15.247

6.2 EMC Regulation Emission Limits

6.2.1 ETSI EN 300-200-1 Emission Limits for the 868-868.6 MHz Band

Based on ETSI EN 300-220-1, the allowed maximum fundamental power for the 868-868.6 MHz band is 25 mW (14 dBm) e.r.p. both for conducted and radiated measurements.

Note: Further in this document EIRP (Effective Isotropic Radiated Power) will be used instead of e.r.p. (Effective Radiated Power) for the comparison of the radiated limits and measurement results. The 25 mW e.r.p radiated limit is equivalent to 16.1 dBm EIRP.

For the unwanted emission limits see the table below.

Table 6.1. ETSI EN 300-220-1 Spurious Domain Emission Limits in e.r.p. (and EIRP)

Frequency	47 MHz to 74 MHz 87.5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz	Other frequencies below 1000 MHz	Frequencies above 1000 MHz
Operating	4 nW (-54 dBm e.r.p. = -51.8 dBm EIRP)	250 nW (-36 dBm e.r.p. = -33.9 dBm EIRP)	1 uW (-30 dBm e.r.p. = -27.9 dBm EIRP)
Standby	2 nW (-57 dBm e.r.p. = -54.8 dBm EIRP)	2 nW (-57 dBm e.r.p. = -54.8 dBm EIRP)	20 nW (-47 dBm e.r.p. = -44.8 dBm EIRP)

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

6.2.2 FCC15.247 Emission Limits for the 902-928 MHz Band

FCC 15.247 allows conducted output power up to 1 Watt (30 dBm) in the 902-928 MHz band. For spurious emmissions 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 form 960 MHz to the frequency of the 10th harmonic it is defined as 0.5 mV/m at 3 m distance (equals to -41.2 dBm in EIRP).

In case of operating in the 902-928 MHz band, from the first 10 harmonics only the 2nd and 7th harmonics are not in restricted bands. The 6th is also not in a restricted band, but only if the carrier frequency is above 910 MHz. For these the -20 dBc limit should be applied. For the harmonics, that are in a restricted band, the -41.2 dBm limit should be applied.

7. RF Performance

7.1 Conducted Power Measurements

During measurements, the BRD4206A 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.

7.1.1 Conducted Power Measurements

The BRD4206A Radio Board was connected directly to a Spectrum Analyzer through its SMA connector. The supply for the RF section was 1.8 V provided by the on-chip DCDC converter; for details, see the schematic of the BRD4206A. The transceiver was operated in continuous carrier transmission mode. The output power of the radio was set to 14 dBm.

The typical output spectrums are shown in the following figures.

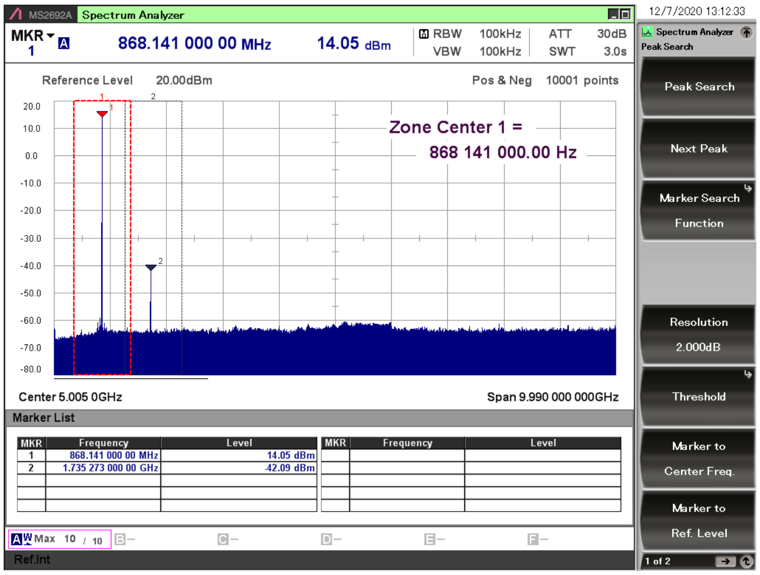

Figure 7.1. Typical Output Spectrum of the BRD4206A in the 868 MHz band

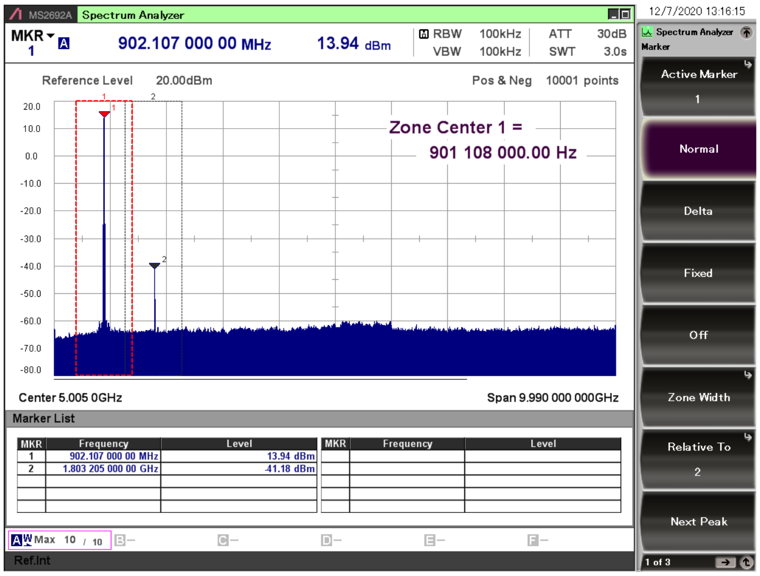

Figure 7.2. Typical Output Spectrum of the BRD4206A in the 908 MHz band

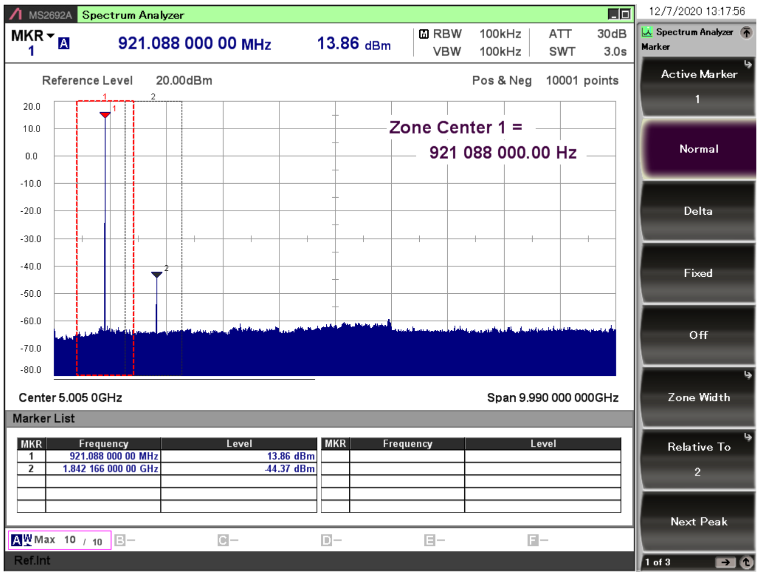

Figure 7.3. Typical Output Spectrum of the BRD4206A in the 921 MHz band

As shown in the figures, the fundamental is around 14 dBm, so it is under the ETSI and FCC limits in all bands. The unwanted emissions are also under their corresponding limit, so the conducted spectrums are compliant with the regulation limits.

7.1.2 Conducted Power Measurements with Modulated Carrier

Depending on the applied modulation scheme, and the spectrum analyzer settings specified by the relevant EMC regulations, the measured power levels are usually lower compared to the results with unmodulated carrier. These differences will be measured and used as relaxation factors on the results of the radiated measurement performed with unmodulated carrier. This way, the radiated compliance with modulated transmission can be evaluated.

In this case, both the ETSI EN 300-220-1 and the FCC 15.247 regulations define the following spectrum analyzer settings for measuring the unwanted emissions above 1 GHz:

- Detector: Average
- RBW: 1 MHz

The table below shows the measured differences for the Z-Wave Long Range modulation scheme. These values will be used as relaxation factors for the radiated measurements.

Table 7.1. Measured Relaxation Factors

Harmonic	Z-Wave Long Range
2nd harmonic	-2.0
3rd harmonic	-4.5
4th harmonic	-7.9
5th harmonic	-9.1
6th harmonic	-11.5
7th harmonic	NA
8th harmonic	NA
9th harmonic	NA
10th harmonic	NA

Note: Above the 6th harmonic the conducted power levels were under the spectrum analyzer noise floor, so it was not possible to measure the relaxation.

7.2 Radiated Power Measurements

During measurements, the BRD4206A 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.

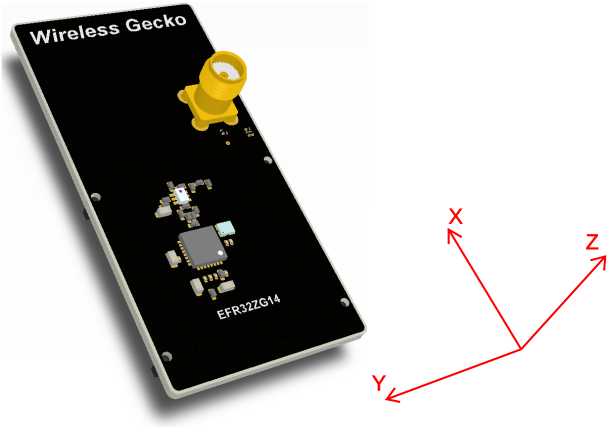

Figure 7.4. Illustration of Reference Planes with a Radio Board

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.

7.2.1 Radiated Measurements

For the radiated power measurements, an external whip antenna (P/N: ANT-SS900) was used as a transmitter antenna. It was connected to the SMA connector of the BRD4206A Radio Board. The supply for the RF section was 1.8 V provided by the on-chip DCDC converter; for details, see the schematic of the BRD4206A. The transceiver was operated in continuous carrier transmission mode. The output power of the radio was set to 14 dBm.

The measured radiated powers are shown in the table below. The correction factors are applied based on the Z-Wave Long Range modulation scheme, showed in section 7.1.2 Conducted Power Measurements with Modulated Carrier.

Table 7.2. Maximums of the Measured Radiated Powers in EIRP [dBm] and the Calculated Modulated Margins in [dB]

Frequency (868.4 MHz)	Measured Un-modulated EIRP [dBm]	Orientation	Z-Wave Long Range Transmission			Limit in EIRP [dBm]
			Correction Factor [dB]	Calculated Modulated EIRP [dBm]	Modulated Margin [dB]	
Fund	10.9	YZ/H	NA (0 is used)	10.9	5.2	16.1
2nd	-47.1	XZ/H	-2.0	-49.1	21.2	-27.9
3rd	-49.1	XZ/H	-4.5	-53.6	25.7	-27.9
4th	-49.7	XZ/V	-7.9	-57.6	29.7	-27.9
5th	-59.3	XY/V	-9.1	-68.4	40.5	-27.9
6th	-42.3	XZ/H	-11.5	-53.8	25.9	-27.9
7th	-49.7	XZ/V	NA (0 is used)	-49.7	21.8	-27.9
8th	Noise*	-/-	NA (0 is used)	-	>20	-27.9
9th	Noise*	-/-	NA (0 is used)	-	>20	-27.9
10th	Noise*	-/-	NA (0 is used)	-	>20	-27.9
* Signal level is below the Spectrum Analyzer noise floor.						

Table 7.3. Maximums of the Measured Radiated Powers in EIRP [dBm] and the Calculated Modulated Margins in [dB]

Frequency (908.4 MHz)	Measured Un-modulated EIRP [dBm]	Orientation	Z-Wave Long Range Transmission			Limit in EIRP [dBm]
			Correction Factor [dB]	Calculated Modulated EIRP [dBm]	Modulated Margin [dB]	
Fund	12.9	XY/H	NA (0 is used)	12.9	17.1	30.0
2nd	-42.6	XZ/H	-2.0	-44.6	>20	-20 dBc
3rd	-51.2	XZ/H	-4.5	-55.7	14.5	-41.2
4th	-58.4	YZ/H	-7.9	-66.3	25.1	-41.2
5th	-65.6	XY/H	-9.1	-74.7	33.5	-41.2
6th	-37.1	XZ/H	-11.5	-48.6	7.4	-41.2
7th	-49.6	XZ/V	NA (0 is used)	-49.6	>20	-20 dBc
8th	-56.4	XZ/H	NA (0 is used)	-56.4	15.2	-41.2
9th	Noise*	-/-	NA (0 is used)	-	>20	-41.2
10th	Noise*	-/-	NA (0 is used)	-	>20	-41.2
* Signal level is below the Spectrum Analyzer noise floor.						

Table 7.4. Maximums of the Measured Radiated Powers in EIRP [dBm] and the Calculated Modulated Margins in [dB]

Frequency (921.4 MHz)	Measured Un-modulated EIRP [dBm]	Orientation	Z-Wave Long Range Transmission			Limit in EIRP [dBm]
			Correction Fac-tor [dB]	Calculated Modulated EIRP [dBm]	Modulated Mar-gin [dB]	
Fund	12.4	XY/H	NA (0 is used)	12.4	17.6	30.0
2nd	-39.3	XZ/H	-2.0	-41.3	>20	-20 dBc
3rd	-51.3	XZ/H	-4.5	-55.8	14.6	-41.2
4th	-56.5	YZ/H	-7.9	-64.4	23.2	-41.2
5th	-65.4	XY/H	-9.1	-74.5	33.3	-41.2
6th	-38.4	XZ/H	-11.5	-49.9	>20	-20 dBc
7th	-51.0	XZ/V	NA (0 is used)	-51.0	>20	-20 dBc
8th	-55.4	XZ/H	NA (0 is used)	-55.4	14.2	-41.2
9th	Noise*	-/-	NA (0 is used)	-	>20	-41.2
10th	Noise*	-/-	NA (0 is used)	-	>20	-41.2
* Signal level is below the Spectrum Analyzer noise floor.						

As shown in the tables above, the fundamental is below the regulation limits in all bands. The unmodulated power level of the 6th harmonic violates the FCC limit in case of the 908.4 MHz operation, but the modulated power level is compliant with the applied relaxation.

7.2.2 Antenna Pattern Measurements

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

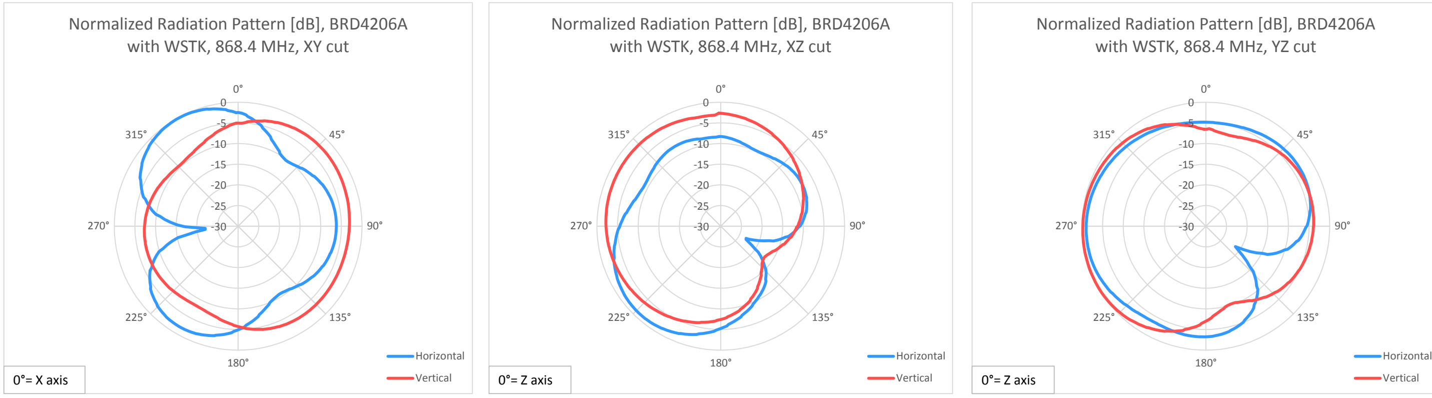

Figure 7.5. Normalized Antenna Pattern in the 868 MHz band

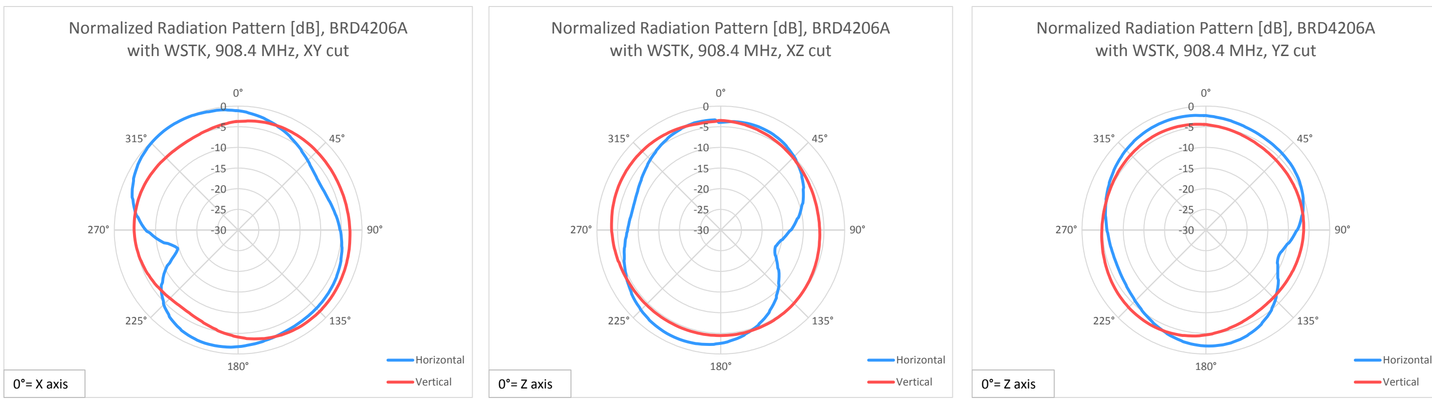

Figure 7.6. Normalized Antenna Pattern in the 908 MHz band

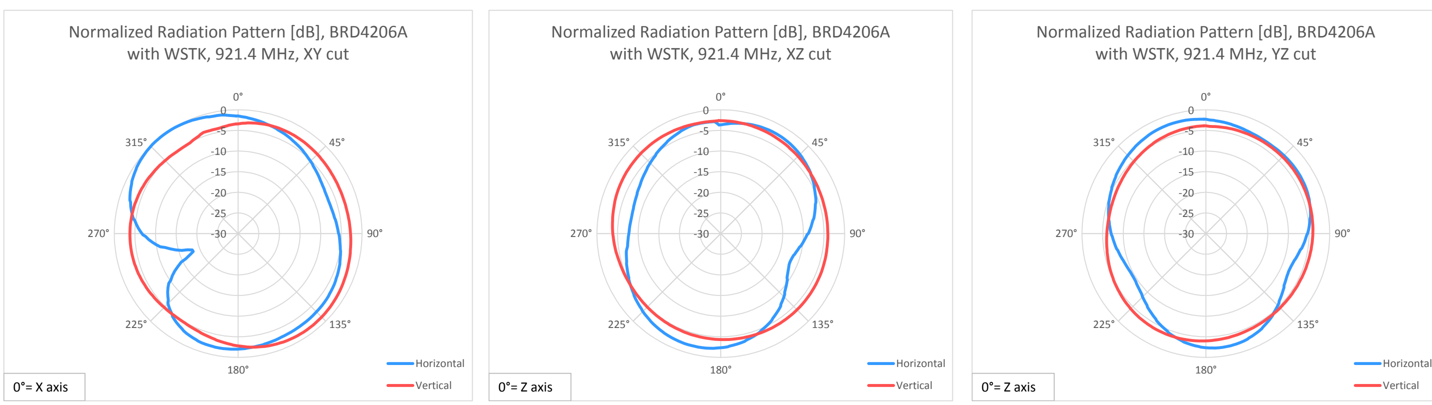

Figure 7.7. Normalized Antenna Pattern in the 921 MHz band

8. EMC Compliance Recommendations

8.1 Recommendations for 868 MHz ETSI EN 300-220-1 compliance

As it was shown in the previous chapter the BRD4206A Wireless Gecko Radio Board is compliant with the emission limits of the ETSI EN 300-220-1 regulation with 14 dBm output power.

8.2 Recommendations for 908 MHz and 921 MHz FCC 15.247 compliance

As it was shown in the previous chapter, the BRD4206A Wireless Gecko Radio Board is compliant with the emission limits of the FCC 15.247 regulation with 14 dBm output power.

9. 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.

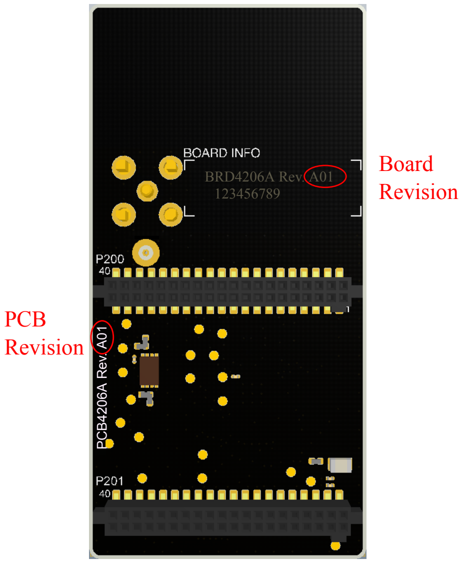

Figure 9.1. Revision Info

Table 9.1. BRD4206A Radio Board Revision History

Board Revision	Description
A01	New PCB rev. for 50 Ohm line keepout fix.
A00	Initial production release.

10. Errata

Table 10.1. BRD4206A Radio Board Errata

Board Revision	Problem	Description
A00	Sligthly mistuned 50 Ohm transmission line impedance.	Ground keepout of the 50 Ohm transmission line was calculated for a different PCB stackup, so the resulting line impedance was higher by ~4 Ohm.

11. Document Revision History

Revision 1.0

Dec, 2020

- Initial document release.

Simplicity Studio

One-click access to MCU and wireless tools, documentation, software, source code libraries & more. Available for Windows, Mac and Linux!

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