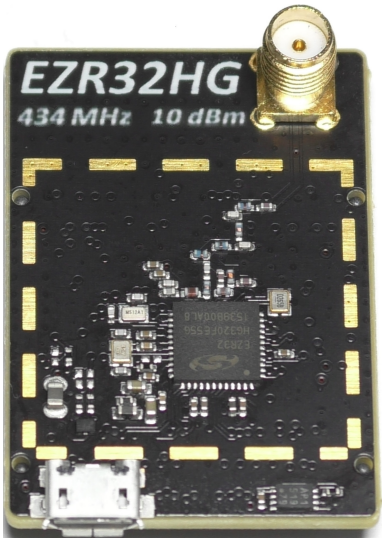
Reference Manual
BRD4542B

The EZR32HG family of Wireless MCUs deliver a high performance, low energy wireless solution integrated into a small form factor package.

By combining a high performance sub-GHz RF transceiver with an energy efficient 32-bit MCU, the family provides designers the ultimate in flexibility with a family of pin-compatible devices that scale from 32/64 kB of flash and support Silicon Labs EZRadio or EZRadioPRO transceivers. The ultra-low power operating modes and fast wake-up times of the Silicon Labs energy friendly 32-bit MCUs, combined with the low transmit and receive power consumption of the sub-GHz radio, result in a solution optimized for battery powered applications.

To develop and/or evaluate the EZR32 Happy Gecko the EZR32HG Radio Board can be connected to the Wireless Starter Kit Mainboard to get access to display, buttons and additional features from Expansion Boards.



RADIO BOARD FEATURES

- Wireless MCU: EZR32HG320F64R55G
- CPU core: ARM Cortex-M0+
- Flash memory: 64 kB
- RAM: 8 kB
- Sub-GHz transceiver integrated in the Wireless MCU: EZRadioPRO
- Operation frequency: 434 MHz
- Transmit power: 10 dBm
- Single antenna connector both for transmit and receive
- Crystals for LFXO and HFXO: 32.768 kHz and 24 MHz.
- Crystal for RF: 30 MHz
- Full speed USB 2.0 (12 Mbps)

1. Introduction

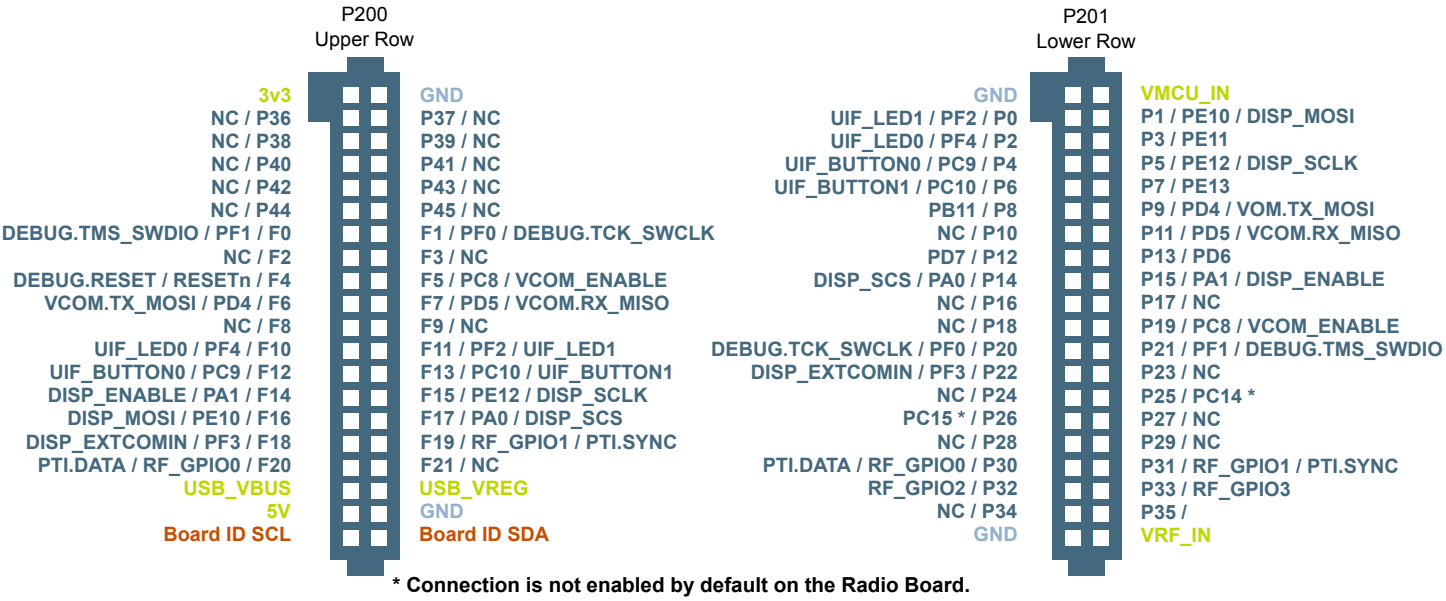
The EZR32 Happy Gecko Radio Boards provide a development platform (together with the Wireless Starter Kit Mainboard) for the Silicon Labs EZR32 Happy Gecko Wireless Microcontrollers and serve as reference designs for the matching network of the RF interface.

The BRD4542B is designed to the operate in the European ETSI 433.05-434.79 MHz band, the RF matching network is optimized to operate in the 434 MHz band with 10 dBm output power.

To develop and/or evaluate the EZR32 Happy Gecko the BRD4542B 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 interface.

2. Radio Board Connector Pin Associations

The figure below shows the pin mapping on the connector to the radio pins and their function on the Wireless Starter Kit Mainboard.



*** Connection is not enabled by default on the Radio Board.**
To enable 0 Ohm resistors should be mounted. See the schematic of the Radio Board.

Figure 2.1. BRD4542B Radio Board Connector Pin Mapping

3. Radio Board Block Description

The block diagram of the EZR32HG Radio Board is shown in the figure below. For the exact part numbers of the applied components refer to the BRD4542B BOM.

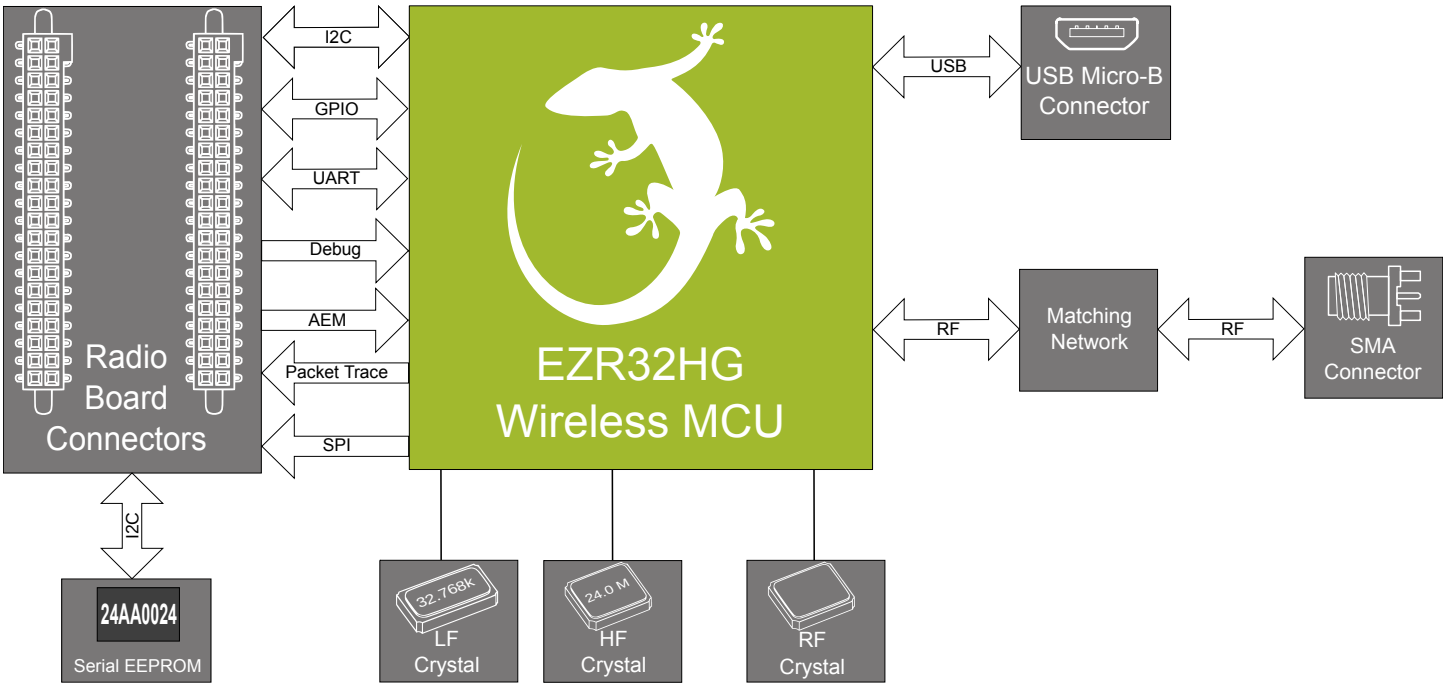


Figure 3.1. EZR32HG Radio Board Block Diagram

3.1 Wireless MCU

The BRD4542B EZR32 Happy Gecko Radio Board incorporates an EZR32HG320F64R55G Wireless Microcontroller featuring 32-bit Cortex-M0+ core, 64 kB of flash memory and 8 kB of RAM. For additional information on the EZR32HG320F64R55G, refer to the EZR32HG320 Data Sheet.

The EZR32HG320F64R55G is built using the Si4455, a high-performance, low-current transciever that is part of Silicon Labs' EZRadio family. The Si4455 contains a +13 dBm power amplifier that is capable of transmitting from –40 to +13 dBm. For a complete feature set and in-depth information on the transciever, refer to the "Si4455 Easy-to-Use, Low-Current OOK/(G)FSK Sub-GHz Transceiver" Data Sheet.

3.2 USB

The BRD4542B Radio Board incorporates a micro USB connector. The 3.3V USB regulator output is are routed back to the WSTK through the Radio Board Connector so the Radio Board can supply power to the Wireless Starter Kit Mainboard.

For additional information on EZR32HG USB, refer to the EZR32HG320 Data Sheet.

3.3 RF Crystal Oscillator (RFXO)

The BRD4542B Radio Board has a 30 MHz crystal mounted. For more details on crystal or TCXO selection for the RF part of the EZR32 devices refer to "AN785: Crystal Selection Guide for the Si4x6x RF ICs".

3.4 LF Crystal Oscillator (LFXO)

The BRD4542B Radio Board has a 32.768 kHz crystal mounted. For safe startup two capacitors are also connected to the LFXTAL_N and LFXTAL_H pins. For details regarding the crystal configuration, the reader is referred to Application Note "AN0016: EFM32 Oscillator Design Consideration".

3.5 HF Crystal Oscillator (HFXO)

The BRD4542B Radio Board has a 24 MHz crystal mounted. For safe startup two capacitors are also connected to the HFXTAL_N and HFXTAL_H pins. For details regarding the crystal configuration, the reader is referred to Application Note "AN0016: EFM32 Oscillator Design Consideration".

3.6 RF Matching Network

The BRD4542B Radio Board includes a Class E type matching network with a so-called Direct Tie matching configuration where the TX and RX sides are connected together without an additional RF switch, to be able to use one antenna both for transmitting and receiveing. The component values were optimized for the 434 MHz band RF performace and current consumption with 10 dBm output power.

For more details on the matching network used on the BRD4542B see Chapter 4.1 Matching Network.

3.7 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.

3.8 Radio Board Connectors

Two dual-row, 0.05” pitch polarized connectors make up the EZR32HG Radio Board interface to the Wireless Starter Kit Mainboard.

For more information on the pin mapping between the EZR32HG320F64R55G and the Radio Board Connector refer to Chapter 2. Radio Board Connector Pin Associations.

4. RF Section

The BRD4542B Radio Board includes a Class E type TX matching network with the targeted output power of 10 dBm at 434 MHz.

The main advantage of the Class E matching types is their very high efficiency. They are proposed for applications where the current consumption is most critical, e.g., the typical total EZRadio chip current with Class E type matching is ~18 mA at ~10 dBm (using the 13dBm PA output and assuming 3.3 V supply voltage).

The main disadvantage of the Class E type matches is the high supply voltage dependency (the power variation is proportional to the square of the supply voltage change: i.e. the decrease in power can be ~6 dB in the 1.8–3.8 V range) and the inaccurate nonlinear power steps. Also their current consumption and the peak voltage on the TX pin are sensitive to the termination impedance variation, and they usually require slightly higher order filtering and thus higher bill of materials cost.

The matching network is constructed with a so-called Direct Tie configuration where the TX and RX sides are connected together without an additional RF switch, to be able to use one antenna both for transmitting and receiveing. Careful design procedure was followed to ensure that the RX input circuitry does not load down the TX output path while in TX mode and that the TX output circuitry does not degrade receive performance while in RX mode.

For detailed explanation of the Class E type TX matching and the Direct Tie configuration matching procedure the reader is referred to "AN693: Si4455 Low-Power PA Matching". For detailed description of the RX matching the reader is referred to "AN643: Si446x/Si4362 RX LNA Matching".

4.1 Matching Network

The matching network structure used on the BRD4542B Radio Board is shown in the figure below.

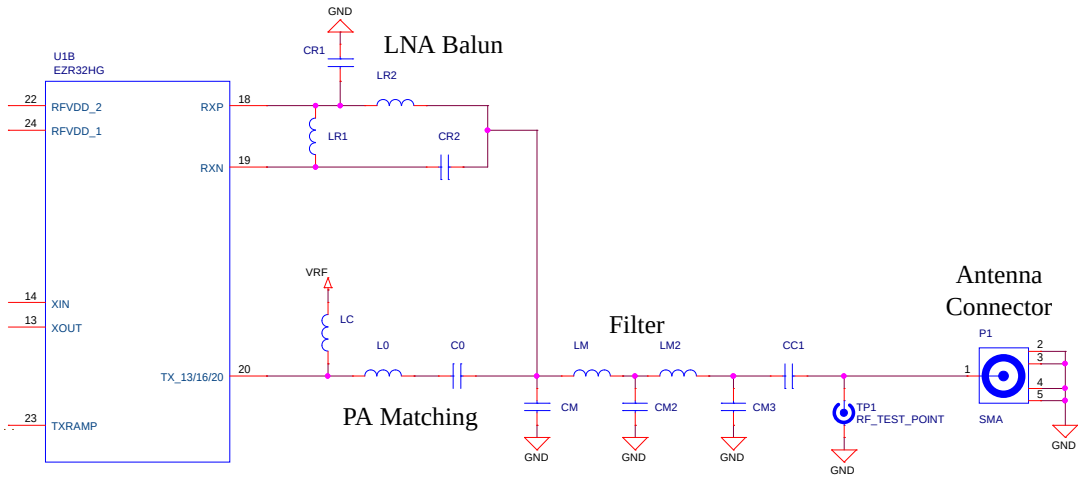


Figure 4.1. RF Section of the Schematic of the BRD4542B EZR32 Happy Gecko Radio Board

The component values were optimized for the 434 MHz band RF performace and current consumption with 10 dBm output power. The resulting component values with part numbers are listed in the table below.

Table 4.1. Bill of Materials for the BRD4542B RF Matching Network

Component name	Value	Manufacturer	Part Number
C0	20 pF	Murata	GRM1555C1H200J
CM	5.6 pF	Murata	GRM1555C1H5R6D
CM2	15 pF	Murata	GRM1555C1H150J
CM3	8.2 pF	Murata	GRM1555C1H8R2D
CR1	5.1 pF	Murata	GRM1555C1H5R1D
CR2	2.7 pF	Murata	GRM1555C1H2R7C
CC1	220 pF	Murata	GRM1555C1H221J
L0	56 nH	Coilcraft	0402HP-56NXJL
LC	220 nH	Coilcraft	0402HPH-R22XJL
LM	18 nH	Coilcraft	0402HP-18NXJL
LM2	18 nH	Coilcraft	0402HP-18NXJL
LR1	56 nH	Coilcraft	0402HP-56NXJL
LR2	56 nH	Coilcraft	0402HP-56NXJL

The Application Note "AN693: Si4455 Low-Power PA Matching" contains component values for reference matching networks which were developed for the EZRadioPRO Pico Boards. For the WSTK radio boards some fine-tuning of the component values may be necessary due to different parasitic effects (bonding wire, layout etc.). For optimized RF performance the component values listed in the table above may differ from the ones listed in the referred Application Note.

For the reader’s specific application and board layout the adjustment of the final matching values might be necessary. The above component values should be used as starting points and the values modified slightly to zero-in on the best filter response and impedance match to 50 ohm. To minimize the differences due to different layout parasitics Silicon Labs recommends copying the layout of the RF section of the radio board as is. If that is not possible, refer to "AN685: Layout Design Guide for the Si4455/435x RF ICs" for layout design recommendations.

5. Mechanical Details

The BRD4542B EZR32 Happy Gecko Radio Board is illustrated in the figures below.

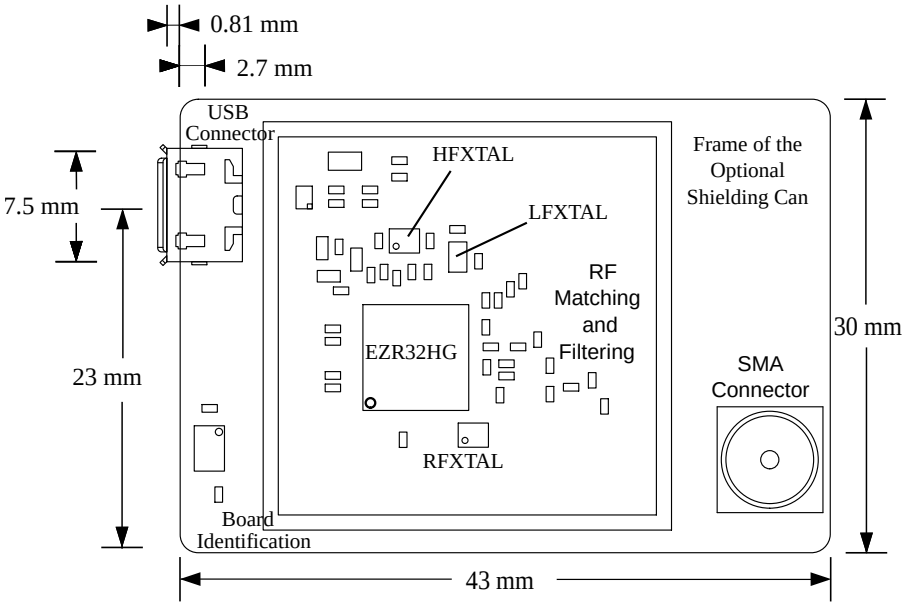


Figure 5.1. BRD4542B Top View

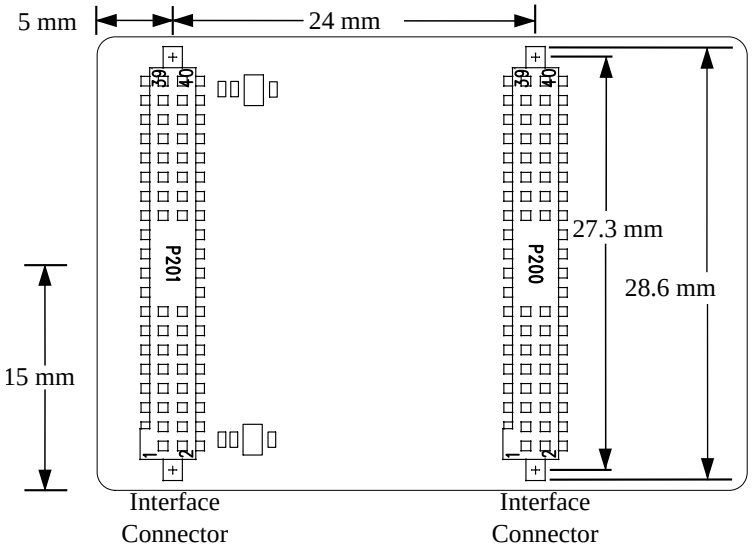


Figure 5.2. BRD4542B Bottom View

6. EMC Compliance

The BRD4542B EZR32 Happy Gecko Radio Board is dedicated for operation in the European ETSI 434.050-434.790 MHz band for non-specific use. The relevant ETSI EN 300-220-1 regulation specifies the maximum allowed level of the fundamental power and spurious emissions.

In this document the compliance of the Radio Board fundamental power and harmonic emissions with the regulation limits will be investigated at 434MHz (up to the frequency of the 10th harmonic).

6.1 ETSI EN 300-200-1 Emission Limits for the 433.050-434.790 MHz Band

Based on ETSI EN 300-220-1 the allowed maximum fundamental power for the 433.050-434.790 MHz band is 10 mW (+10 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 limits and measurement results. The 10 mW e.r.p radiated limit is equivalent to +12.1 dBm EIRP.

For the unwanted emission limits see the table below.

7. RF Performance

7.1 Measurement setup

The BRD4542B EZR32 Happy Gecko Radio Board was attached to a Wireless Starter Kit Mainboard (BRD4001 (Rev. A02)) and its transceiver was operated in continuous carrier transmission mode. The output power of the radio was set to 10 dBm (PA_PWR_LVL = 0x1F, PA_BIAS_CLKDUTY = 0xC0 at VRF=3.3 V).

7.2 Conducted Power Measurements

In case of the conducted measurements the output power was measured by connecting the EZR32HG Radio Board directly to a Spectrum Analyzer (P/N: MS2692A) through its on-board SMA connector. At 10 dBm output power and 3.3 V supply voltage the measured typical current consumption of the RF section of the board is 18 mA.

A typical output spectrum is shown in the figure below.

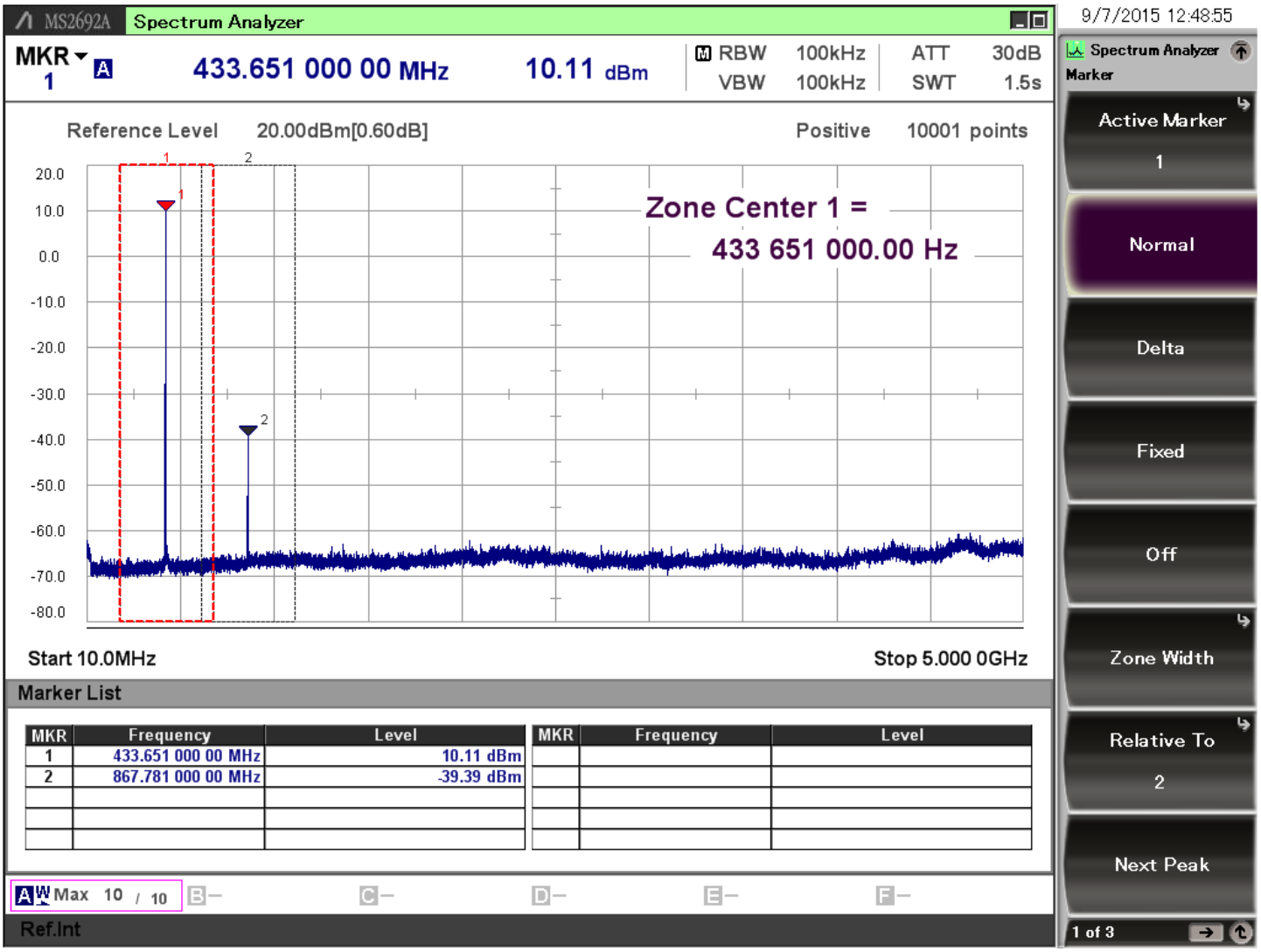


Figure 7.1. Typical Output Spectrum of the BRD4542B Radio Board

As it can be observed the only unwanted emission above -60 dBm is the double-frequency harmonic but its -39.39 dBm power is compliant with the -27.8 dBm limit with large margin.

Note: In practice comercially available whip antennas usually have ~0-2 dB gain at the fundamental and < 0 dB gain at the harmonic frequencies so if the conducted levels are compliant with the emission limits with small margin it is likely that the margin on the harmonics radiated by an external whip antenna will be higher. Unfortunately in most cases, the PCB radiation (from traces or and/or components) is stronger so using shielding, applying larger duty cycle correction (if allowed) or reduction of the fundamental power could be necessary.

7.3 Radiated Power Measurements

For radiated measurements an external whip antenna (P/N: ANT-433-CW-QW-SMA) was used. The power supply for the board were two AA batteries (3 V). The batteries were connected to the Wireless Starter Kit Mainboard through its External Power Supply connector with minimal wire length to minimize the wire radiation.

The DUT was rotated in 360 degree with horizontal and vertical reference antenna polarizations in the XY, XZ and YZ cuts. The measurement axes are as shown in the figure below.

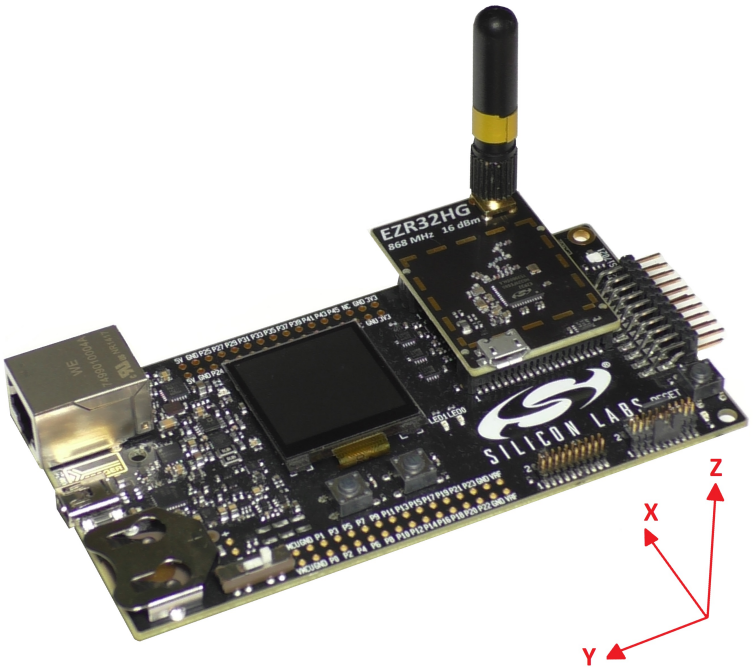


Figure 7.2. DUT: Radio Board with Wireless Starter Kit Mainboard (Illustration)

The measured radiated powers are shown in the table below.

Table 7.1. Maximums of the Measured Radiated Powers of the BRD4542B

434 MHz	EIRP [dBm]	Orientation	Margin [dB]	Limit in EIRP [dBm]
Fund	12.3	XZ/H	-0.2	12.1
2nd	-42.5	XY/V	8.6	-33.9
3rd	-69.2	XY/V	-41.3	-27.9
4th	-66.5	YZ/H	-38.6	-27.9
5th	-58.1	YZ/H	-30.2	-27.9
6th	-59.4	XZ/H	-31.5	-27.9
7th	-58.8	XZ/H	-30.9	-27.9
8th	-55.3	YZ/V	-27.4	-27.9
9th	Noise*	-/-	>20	-27.9
10th	Noise*	-/-	>20	-27.9
* Signal level is below the Spectrum Analyzer noise floor.				

As it can be observed the fundamental and all of the harmonics comply with the ETSI EN 300-220-1 limits with large margin.

One may notice that the radiated harmonic levels, in general, are higher compared to the levels expected based on the conducted measurement. Investigations showed that this increase is due to the PCB radiations (components and PCB traces).

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 etc.) therefore the absolute levels and margins of the final application is recommended to be verified in a licensed EMC testhouse!

8. EMC Compliance Recommendations

8.1 Recommendations for ETSI Compliance

As it was shown in the previous chapters the BRD4542B EZR32 Happy Gecko Radio Board is compliant with the harmonic emission limits of the ETSI EN 300-220-1 regulation in the 434.050-434.790 MHz band with 10 dBm output power. Although the BRD4542B Radio Board has an option for mounting a shielding can, that is not required for the compliance. Due to the conducted fundamental is marginally exceeding the limit slight output power reduction could be necessary for the radiated compliance.

9. Document Revision History

Table 9.1. Document Revision History

Revision Number	Effective Date	Change Description
1.0	29.04.2016	Initial release

10. Board Revisions

Table 10.1. BRD4542B Radio Board Revisions

Radio Board Revision	Description
A00	Initial release

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