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Reference Manual
BRD4505B (Rev. A00)

The EZR32WG 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 64/128/256 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 Wonder Gecko the EZR32WG 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: EZR32WG330F256R63G
- CPU core: ARM Cortex-M4
- Flash memory: 256 kB
- RAM: 32 kB
- Sub-GHz transceiver integrated in the Wireless MCU: EZRadioPRO
- Operation frequency: 490 MHz
- Transmit power: 20 dBm
- Single antenna connector both for transmit and receive
- Crystals for LFXO and HFXO: 32.768kHz and 48 MHz.
- Crystal for RF: 30 MHz
- Backup Power Domain Capacitor
- Full speed USB 2.0 (12 Mbps)

Table of Contents

1. Radio Board Connector Pin Associations

The board-to-board connector scheme allows access to all EZR32WG GPIO pins as well as the nRESET signal. The figure below shows the pin mapping on the connector to the radio pins, and their function on the Wireless Starter Kit Mainboard. For more information on the functions of the available pin functions, we refer you to the EZR32WG330 Datasheeet.
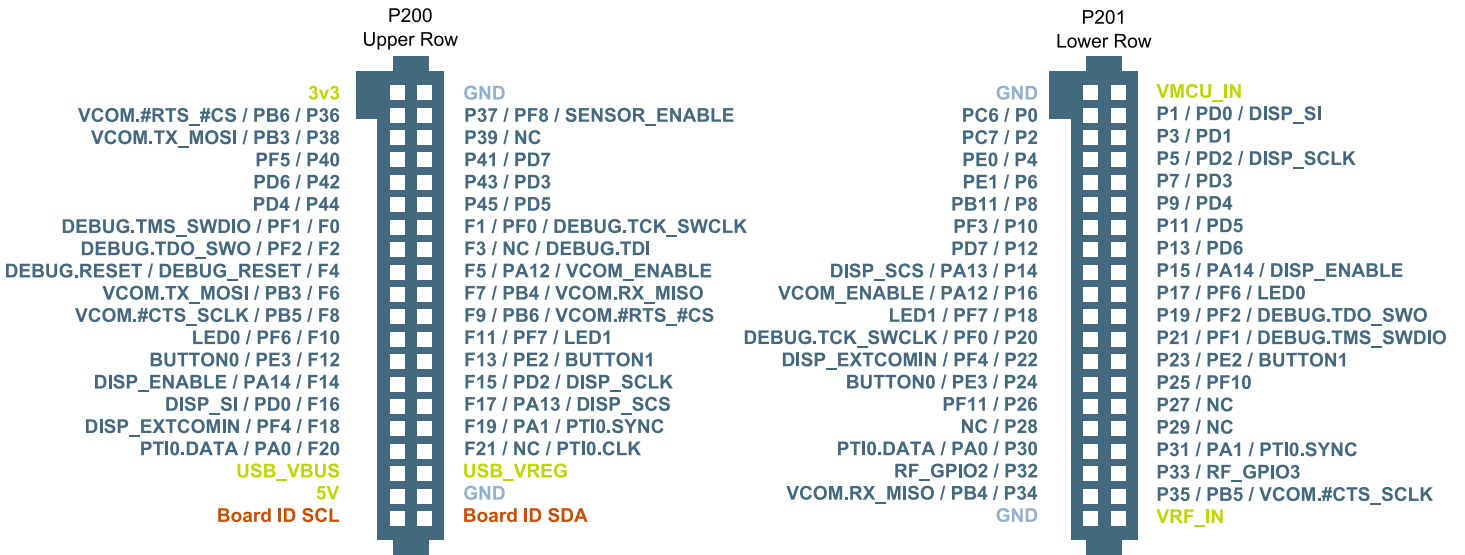
Figure 1.1. EZR32WG Radio Board Radio Board Connector pin mapping

2. EZR32WG330 System-on-Chip Summary

The EEZR32WG330 Wireless MCU is a single-chip solution that combines an Wonder Gecko family MCU solution with an integrated EZRadio or EZRadioPRO sub-GHz RF transceiver. These products are designed to address the specific requirements of low-power embedded systems requiring an RF bidirectional communication link.

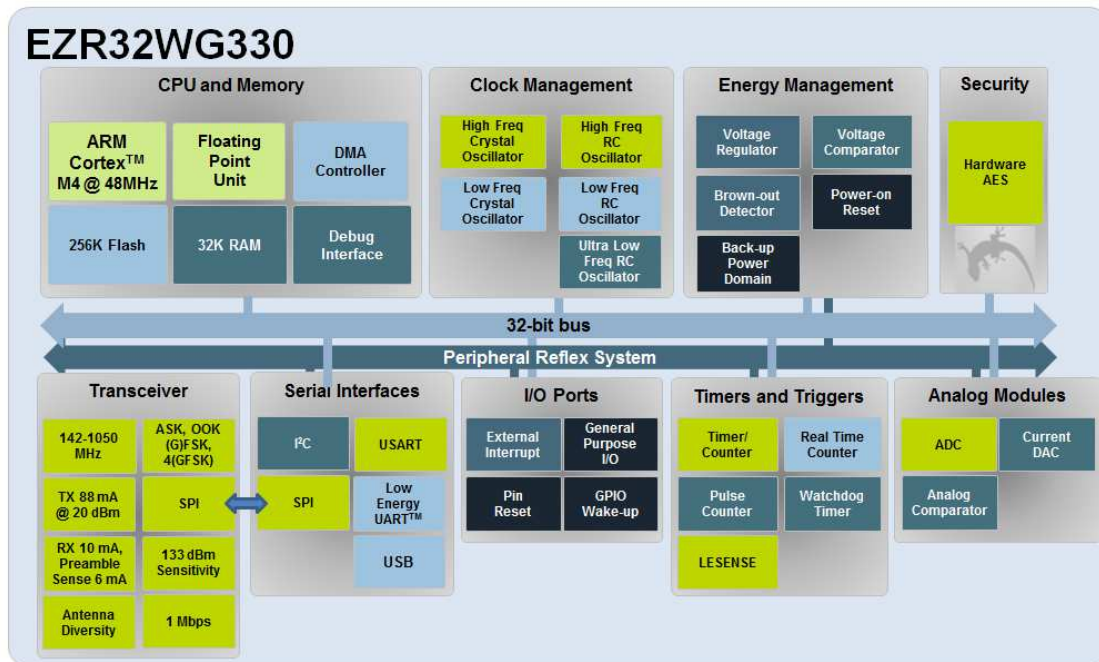The block diagram of the EZR32WG330 is shown in the figure below.

Figure 2.1. EZR32WG330 block diagram

For a complete feature set and in-depth information on the modules, the reader is referred to the EZR32WG330 Reference Manual

2.1 EZR32 Wireless MCU

The EZR32 Wireless MCU are the world's most energy friendly Wireless Microcontroller. With a unique combination of the powerful 32-bit ARM Cortex-M4, innovative low energy techniques, short wake-up time from energy saving modes, and a wide selection of peripherals, the EZR32 WG is well suited for any battery operated application as well as other systems requiring high performance and low-energy consumption.

2.2 EZRadioPRO RF Transceiver

The EZR32WG family of devices is built using high-performance, low-current EZRadio and EZRadioPRO RF transceivers covering the sub-GHz frequency bands from 142 to 1050 MHz. These devices offer outstanding sensitivity of up to –133 dBm (using EZRadioPRO) while achieving extremely low active and standby current consumption. The EZR32WG devices using the transceiver offer frequency coverage in all major bands and include optimal phase noise, blocking, and selectivity performance for narrow band and licensed band applications, such as FCC Part 90 and 169 MHz wireless Mbus. The 69 dB adjacent channel selectivity with 12.5 kHz channel spacing ensures robust receive operation in harsh RF conditions, which is particularly important for narrow band operation. The active mode TX current consumption of 18 mA at +10 dBm and RX current of 10 mA coupled with extremely low standby current and fast wake times is optimized for extended battery life in the most demanding applications. The EZR32WG devices can achieve up to +27 dBm output power with built-in ramping control of a low-cost external FET. The devices can meet worldwide regulatory standards: FCC, ETSI, and ARIB. All devices are designed to be compliant with 802.15.4g and WMbus smart metering standards. The devices are highly flexible and can be programmed and configured via Simplicity Studio, available at www.silabs.com.

For a complete feature set and in-depth information on the modules, the reader is referred to the Data Sheet "Si4463-61-60-C High-Performance, Low-Current Transceiver".

2.3 Communcation Between the MCU and the Radio

Communication between the radio and MCU are done over USART, PRS and IRQ, which requires the pins to be configured in the following way:

Table 2.1. Radio MCU Communication Configuration

pin	Radio Assignment	pin function assignment
PE8	SDN	GPIO Output
PE9	nSEL	Bit-Banged SPI.CS (GPIO Output)
PE10	SDI	US0_TX #0
PE11	SDO	US0_RX #0
PE12	SCLK	US0_CLK #0
PE13	nIRQ	GPIO_EM4WU5 (GPIO Input with IRQ enabled)
PE14	GPIO1	PRS Input
PA15	GPIO0	PRS Input

3. EZR32WG Radio Board block description

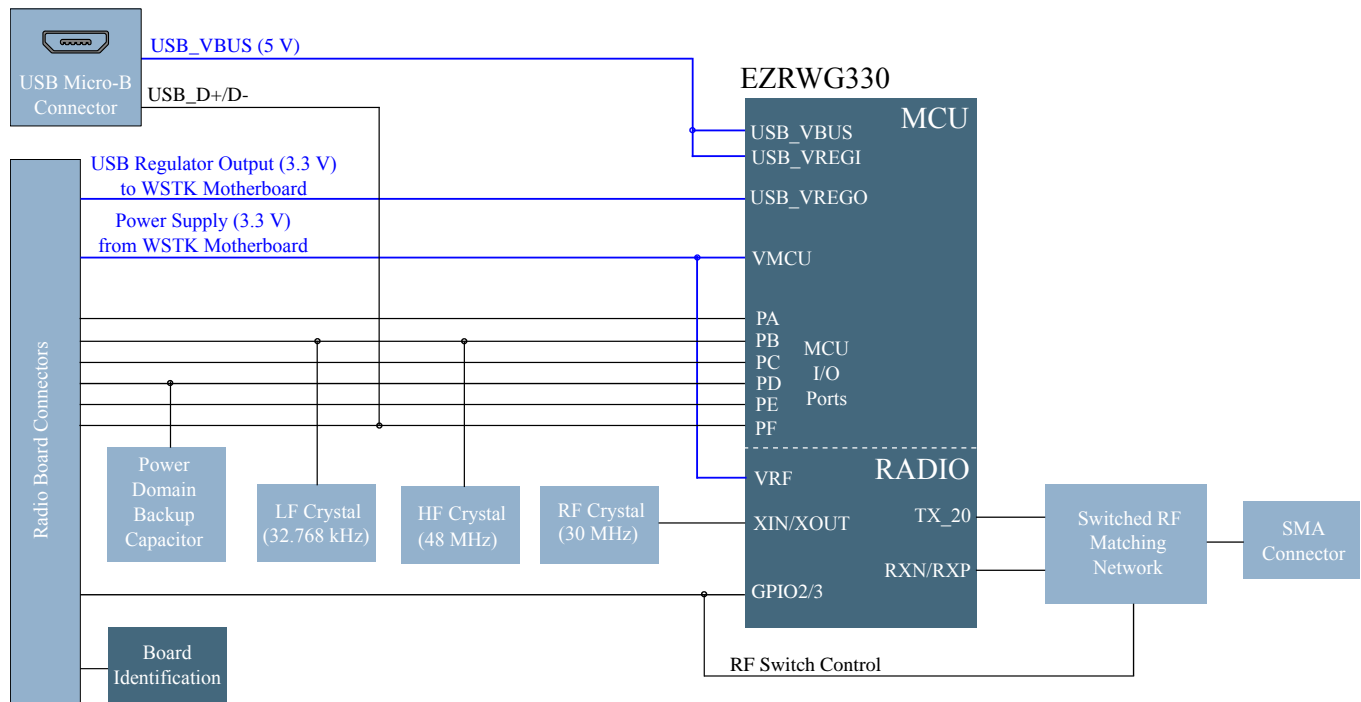The block diagram of the EZR32WG Radio Board is shown in the figure below.

Figure 3.1. EZR32WG Radio Board block diagram

3.1 USB

The EZR32WG Radio Board incorporates a micro USB connector (P/N: ZX62-B-5PA(11)). 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 EZR32WG USB, refer to the EZR32WG330 Data Sheet.

3.2 RF Crystal Oscillator

The BRD4505B (Rev. A00) Radio Board has a 30 MHz crystal mounted (P/N: NX2016SA 30 MHz EXS00A-CS06568). 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".

3.3 LF Crystal Oscillator (LFXO)

The BRD4505B (Rev. A00) Radio Board has a 32.768kHz crystal mounted (P/N: MS3V-T1R, 32768Hz, 12.5pF, +/- 20ppm). For safe startup two 22 pF 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".

3.4 HF Crystal Oscillator (HFXO)

The BRD4505B (Rev. A00) Radio Board has a 48 MHz crystal mounted (P/N: ABM11-48.000MHZ-D2X-T3). For safe startup two 10 pF 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".

3.5 Backup Power Domain Capacitor

The BRD4505B (Rev. A00) Radio Board has a 30 mF super capacitor mounted (P/N: PAS311HR-VA6R), connected to the PD8 port of the EZR32WG.

For details regarding the Backup Power Domain, the reader is referred to the EZR32WG330 Data Sheet.

3.6 RF Matching Network

The BRD4505B (Rev. A00) Radio Board includes a Class E type matching network with Switched RF TX and RX sides are connected together with an additional RF switch, to be able to use one antenna both for transmitting and receiveing. The component values were optimized for the 490 MHz band RF performace and current consumption with 20 dBm output power.

For more details on the matching network used on the BRD4505B (Rev. A00) 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 (P/N: 5-1814832-1) 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 (P/N: SFC-120-T2-L-D-A-K-TR) make up the EZR32WG Radio Board interface to the Wireless Starter Kit Mainboard.

For more information on the pin mapping between the EZR32WG330F256R63G and the Radio Board Connector refer to Chapter 1. Radio Board Connector Pin Associations.

4. RF section

The BRD4505B (Rev. A00) Radio Board includes a Class E type TX matching network with the targeted output power of 20 dBm at 490 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 EZRadioPRO chip current with Class E type matching is ~75-90 mA at ~20 dBm power levels (using the 20 dBm PA output and assuming 3.3 V Vdd).

The main disadvantage of the Class E type matches is the high Vdd dependency (the power variation is proportional to the square of the Vdd 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 Switched RF configuration where the TX and RX sides are connected together with 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 Switched RF configuration matching procedure the reader is referred to "AN648: Si4063/Si4463/64/68 TX 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 BRD4505B (Rev. A00) Radio Board is shown in the figure below.
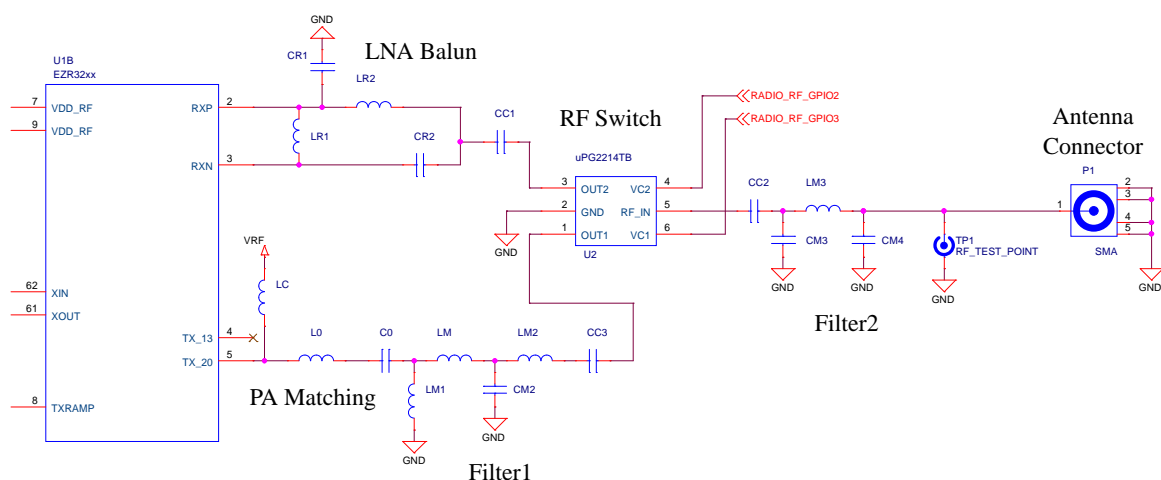

Figure 4.1. RF section of the schematic of the EZR32 Wonder Gecko Radio Board (BRD4505B (Rev. A00))

The matching network has a so-called Switched RF 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 receiving.

For detailed explanation of the TX matching process, see "AN648: Si4063/Si4463/64/68 TX Matching". Due to the Switched RF configuration of the matching, the RX matching should also taken into account during the TX matching procedure. The above Application Note contains component values and a shorter description for the RX matching as well. For detailed description of the RX matching refer to "AN643: Si446x/Si4362 RX LNA Matching".

The component values were optimized for the 490 MHz band RF performace and current consumption with 20 dBm output power. The resulting component values with part numbers are listed in the table below.

Table 4.1. Bill of Materials for the BRD4505B (Rev. A00) RF matching network

Component name	Value	Part Number
C0	3.9 pF	GRM1555C1H3R9B
CM2	5.6 pF	GRM1555C1H5R6C
CM3	9.1 pF	GRM1555C1H9R1D
CM4	9.1 pF	GRM1555C1H9R1D
CR1	3.9 pF	GRM1555C1H3R9C
CR2	2.2 pF	GRM1555C1H2R2B
CC1	150 pF	GRM1555C1H151J
CC2	150 pF	GRM1555C1H151J
CC3	150 pF	GRM1555C1H151J
L0	24 nH	0402HP-24NXJL
LC	220 nH	0402HPH-R22XJL
LM	27 nH	0402HP-27NXJL
LM1	24 nH	0402HP-24NXJL
LM2	27 nH	0402HP-27NXJL
LM3	15 nH	0402HP-15NXJL
LR1	51 nH	0402HP-51NXJL
LR2	47 nH	0402HP-47NXJL

The Application Note "AN648: Si4063/Si4463/64/68 TX 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 "AN629: Si4460/61/63/64 RF ICs Layout Design Guide" for layout design recommendations.

5. Mechanical details

The EZR32 Wonder Gecko Radio Board (BRD4505B (Rev. A00)) is illustrated in the figures below.
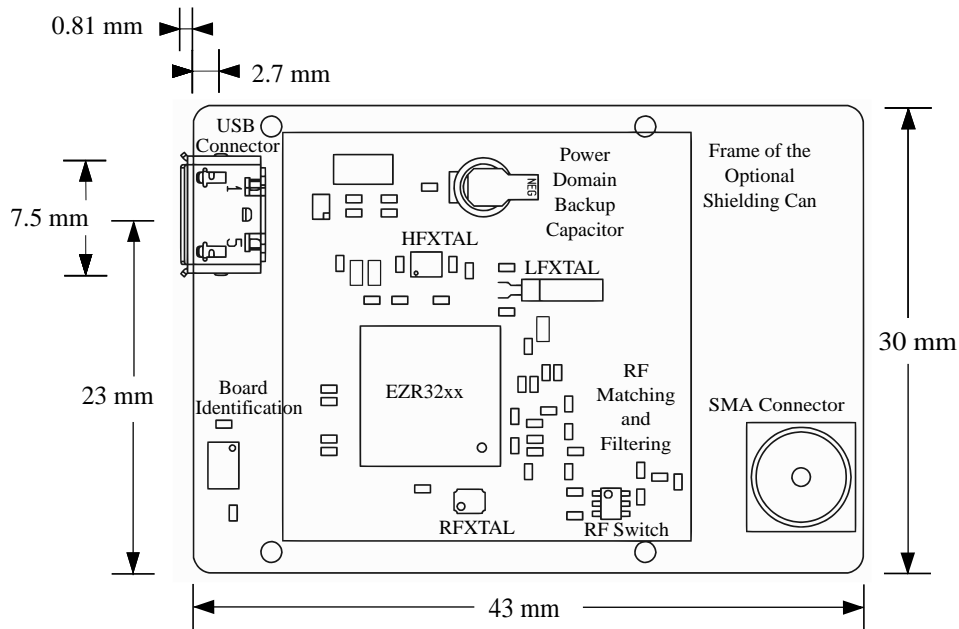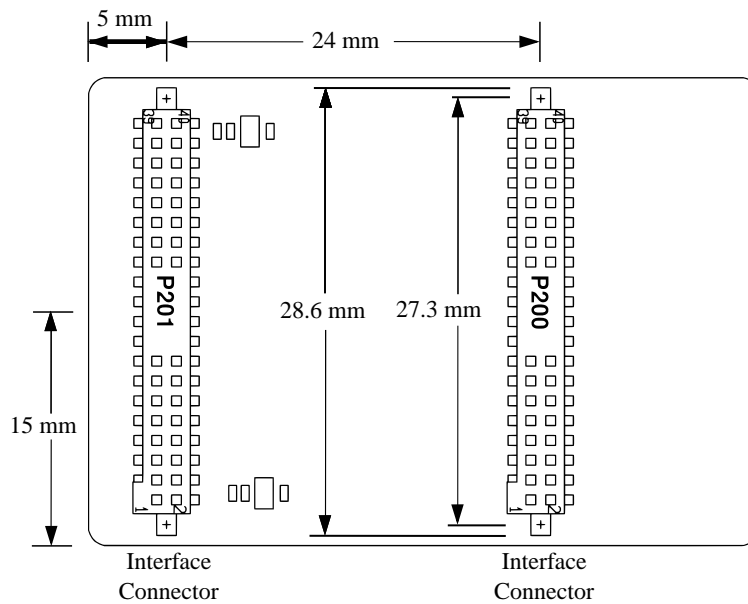

Figure 5.1. BRD4505B (Rev. A00) top view

Figure 5.2. BRD4505B (Rev. A00) bottom view

6. RF performance

6.1 Measurement setup

The EZR32 Wonder Gecko Radio Board (BRD4505B (Rev. A00))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 20 dBm (DDAC = 7Fh).

6.2 Conducted Power Measurements

In case of the conducted measurements the output power was measured by connecting the EZR32WG Radio Board directly to a Spectrum Analyzer (P/N: MS2692A) through its on-board SMA connector. At 20 dBm output power and 3.3 V supply voltage the measured typical current consumption of the RF section of the board is 75 mA.

A typical output spectrum up to 10 GHz is shown in the figure below.
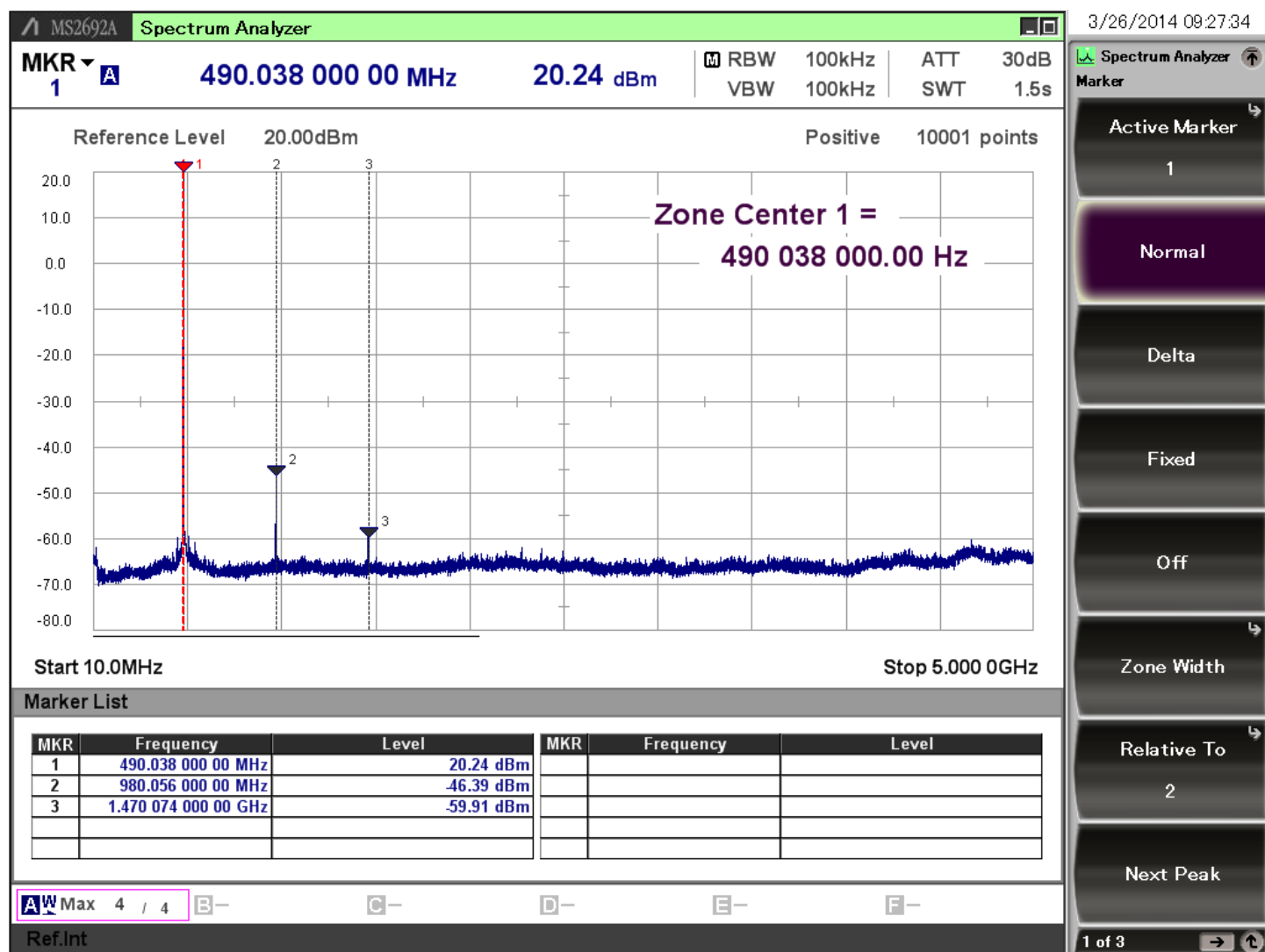
Figure 6.1. Typical output spectrum of the BRD4505B (Rev. A00) Radio Board; with DDAC=7Fh at Vdd=3.3 V

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 reductionof the fundamental power could be necessary.

6.3 Radiated Power Measurements

For radiated measurements an external whip antenna (P/N: HT-A-450-6100) 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 6.2. DUT: BRD4505B (Rev. A00) Radio Board with Wireless Starter Kit Mainboard

The measured radiated powers are shown in the table below.

Table 6.1. Results of the radiated power measurements

490 MHz	Measured maximums of the radiated power in EIRP [dBm]						AMR limit in EIRP [dBm]
	XY		XZ		YZ		
	H	V	H	V	H	V	
Fundamental	+18.7	+20.2	+21.8	+16.2	+22.4	+14.9	+19.1
2nd harmonic	-52.7	-48.0	-51.5	-51.4	-51.9	-53.2	-33.9
3rd harmonic	-46.3	-56.0	-45.8	-80.9	-48.5	-48.0	-27.9
4th harmonic	-59.0	-52.8	-57.1	-55.8	-56.8	-54.3	-27.9
5th harmonic	-54.6	-56.1	-52.4	-54.6	-57.9	-53.4	-27.9
6th harmonic	-59.1	-57.7	-58.9	-55.9	-53.3	-59.3	-27.9
7th harmonic	-57.0	-54.2	-54.5	-56.4	-55.7	-53.6	-27.9
8th harmonic	-58.9	-60.4	-57.3	-60.2	-57.8	-58.5	-27.9

490 MHz	Measured maximums of the radiated power in EIRP [dBm]						AMR limit in EIRP [dBm]
	XY		XZ		YZ		
	H	V	H	V	H	V	
9th harmonic	-57.6	-55.6	-55.9	-58.3	-55.9	-55.7	-27.9
10th harmonic	-55.4	-54.3	-51.1	-54.3	-54.8	-54.3	-27.9
Note: * Signal level is below the Spectrum Analyzer noise floor.							

One may notice that the radiated harmonic levels 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!

7. Document Revision History

Table 7.1. Document Revision History

Revision Number	Effective Date	Change Description
1.10	19.03.2015	Radio Board errata added.
1.00	23.02.2015	Major content update.
0.10	04.02.2015	Initial document version.

8. Errata

Table 8.1. BRD4505B Radio Board Errata

Radio Board Revision	Problem	Description
A00	USB functionality broken.	In this revision USB_VREGI and USB_VREGO pins have been swapped. This means that USB does not work on this revision of the BRD4505B radio board. If you require USB functionality, please contact support for a replacement.
	Missing MCU peripherals	Due to EZR32WG330F256R63G chip errata, UART peripherals are not available. UART functionality on USART peripherals remain unaffected.

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