UG559: xG28 Explorer Kit User's Guide

The xG28 Explorer Kit is an ultra-low-cost, small form factor development and evaluation platform for the EFR32ZG28 Wireless Gecko System-on-Chip.

The xG28 Explorer Kit is focused on rapid prototyping and concept creation of IoT applications. It is designed around the EFR32ZG28 SoC, which is an ideal device family for developing energy-friendly connected IoT applications.

The kit features a USB interface, an on-board SEGGER J-Link debugger, two user-LEDs and buttons, and support for hardware add-on boards via a mikroBus socket and a Qwiic connector. The hardware add-on support allows developers to create and prototype applications using a virtually endless combination of off-the-shelf boards from mikroE, sparkfun, AdaFruit, and Seeed Studios.

TARGET DEVICE

- EFR32ZG28 Wireless Gecko System-on-Chip (EFR32ZG28B312F1024IM48)
- High-performance 2.4 GHz radio
- 32-bit ARM® Cortex®-M33 with 78 MHz maximum operating frequency
- 1024 kB flash and 256 kB RAM

KIT FEATURES

- User LEDs and push buttons
- 20-pin 2.54 mm breakout pads
- mikroBUS™ socket
- Qwiic® connector
- SEGGER J-Link on-board debugger
- Virtual COM port
- Packet Trace Interface (PTI)
- USB-powered

SOFTWARE SUPPORT

- Simplicity Studio

ORDERING INFORMATION

- xG28-EK2705A
- xG28S-EK2705A

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1. Introduction

The xG28 Explorer Kit has been designed to inspire customers to make IoT devices with the Silicon Labs EFR32ZG28 Wireless Gecko System-on-Chip. The kit includes a mikroBUS™ socket and Qwiic® connector, allowing users to add features to the kit with a large selection of off-the-shelf boards.

Programming the xG28 Explorer Kit is easy with a USB Type-C cable and the on-board J-Link debugger. A USB virtual COM port provides a serial connection to the target application, and the Packet Trace Interface (PTI) offers invaluable debug information about transmitted and received packets in wireless links. The xG28 Explorer Kit is supported in Simplicity Studio and a Board Support Package (BSP) is provided to give application developers a flying start.

Connecting external hardware to the xG28 Explorer Kit can be done using the 20 breakout pads, which present peripherals from the EFR32ZG28 Wireless Gecko such as I^2C, SPI, UART, and GPIOs. The mikroBUS socket allows inserting mikroBUS add-on boards which interface with the EFR32ZG28 through SPI, UART, or I^2C. The Qwiic connector can be used to connect hardware from the Qwiic Connect System through I^2C.

1.1 Getting Started

Refer to the Silicon Labs webpage, https://www.silabs.com/dev-tools, for detailed instructions on how to get started with your new xG28 Explorer Kit.

1.2 Ordering Information

The xG28 Explorer Kit is available in two variants: xG28-EK2705A and xG28S-EK2705A kits. See the following table for more information.

Table 1.1. Ordering Information

Part Number	Description	Contents
xG28-EK2705A	xG28 Explorer Kit	1x BRD2705A xG28 Explorer Kit Board
xG28S-EK2705A	xG28 Explorer Kit for Amazon Sidewalk	1x BRD2705A xG28 Explorer Kit Board

Note: xG28S-EK2705A comes pre-flashed with Amazon Sidewalk image and pre-registered with AWS.

1.3 Kit Hardware Layout

xG28 Explorer Kit layout is shown below.

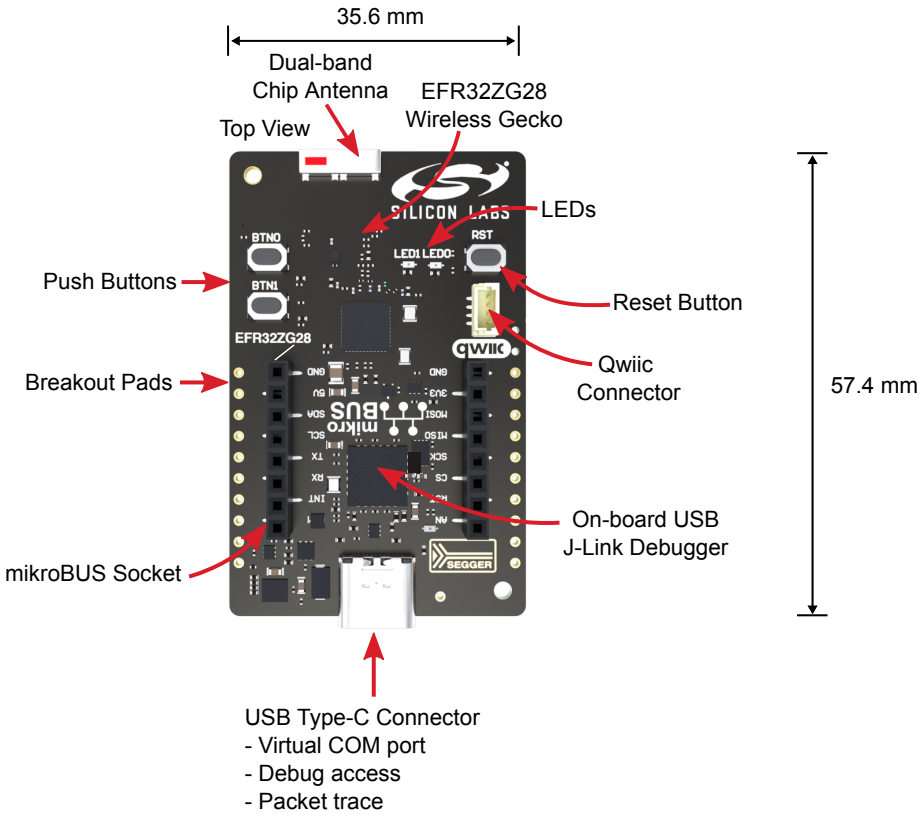

Figure 1.1. xG28 Explorer Kit Hardware Layout

2. Specifications

2.1 Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
USB Supply Input Voltage	V_{USB}	–	+5.0	–	V
Supply Input Voltage (VMCU supplied externally)	V_{VMCU}		+3.3		V
Operating Temperature	T_{OP}	–	+20	–	˚C

2.2 Current Consumption

The operating current of the board greatly depends on the application and the amount of external hardware connected. The table below attempts to give some indication of typical current consumptions for the EFR32ZG28 and the on-board debugger. Note that the numbers are taken from the data sheets for the devices. For a full overview of the conditions that apply for a specific number from a data sheet, the reader is encouraged to read the specific data sheet.

Table 2.1. Current Consumption

Parameter	Symbol	Condition	Typ	Unit
EFR32ZG28 current consumption with DC-DC, all peripherals disabled[1]	I_{ZG28}	MCU current consumption in EM0 mode (VREGVDD = 3.3 V, VSCALE2, 39 MHz crystal, CPU running Prime from flash at 25 °C)	31	µA/MHz
EFR32ZG28 current consumption with DC-DC in receive mode, active packet reception, and all MCU peripherals disabled[1]	I_{ZG28_RX}	BLE operation, active packet reception (VREGVDD = 3.3 V, VSCALE1, MCU in EM1, HCLK = 39 MHz, 2 Mbit/s, 2 GFSK, f = 2.4 GHz at 25 °C)	5.2	mA
		Proprietary Sub-GHz operation at 915 MHz (VREGVDD = 3.3 V, VSCALE1, MCU in EM1 and all MCU peripherals disabled, HCLK = 39 MHz, 2 Mbit/s, 2 GFSK, at 25 °C)	5.4	mA
		Proprietary Sub-GHz operation at 868 MHz (VDD = 3.0 V, VSCALE1, MCU in EM1, HCLK = 39 MHz, 38.4 kbit/s, 2 GFSK, at 25 °C)	3.9	mA
EFR32ZG28 current consumption with DC-DC in transmit mode, all MCU peripherals disabled[1]	I_{ZG28_TX}	BLE operation (VREGVDD = 3.3 V, VSCALE2, MCU in EM1, HCLK = 39 MHz, f = 2.4 GHz, CW, 10 dBm output power at 25 °C)	23.2	mA
		Proprietary Sub-GHz operation at 915 MHz (VREGVDD = 3.3 V, VSCALE2, MCU in EM1, HCLK = 39 MHz, CW, 14 dBm output power at 25 °C)	25.7	mA
		Proprietary Sub-GHz operation at 868 MHz (VREGVDD = 3.3 V, VSCALE2, MCU in EM1, HCLK = 39 MHz, CW, 14 dBm output power at 25 °C)	25.8	mA
On-board debugger sleep current consumption[2]	I_{DBG}	On-board debugger current consumption when USB cable is not inserted (EFM32GG12 EM4S mode current consumption)	80	nA

1 From EFR32ZG28 data sheet
2 From EFM32GG12 data sheet

3. Hardware

The core of the xG28 Explorer Kit is the EFR32ZG28 Wireless Gecko System-on-Chip. Refer to section 1.3 Kit Hardware Layout for placement and layout of the hardware components.

3.1 Block Diagram

An overview of the xG28 Explorer Kit is illustrated in the figure below.

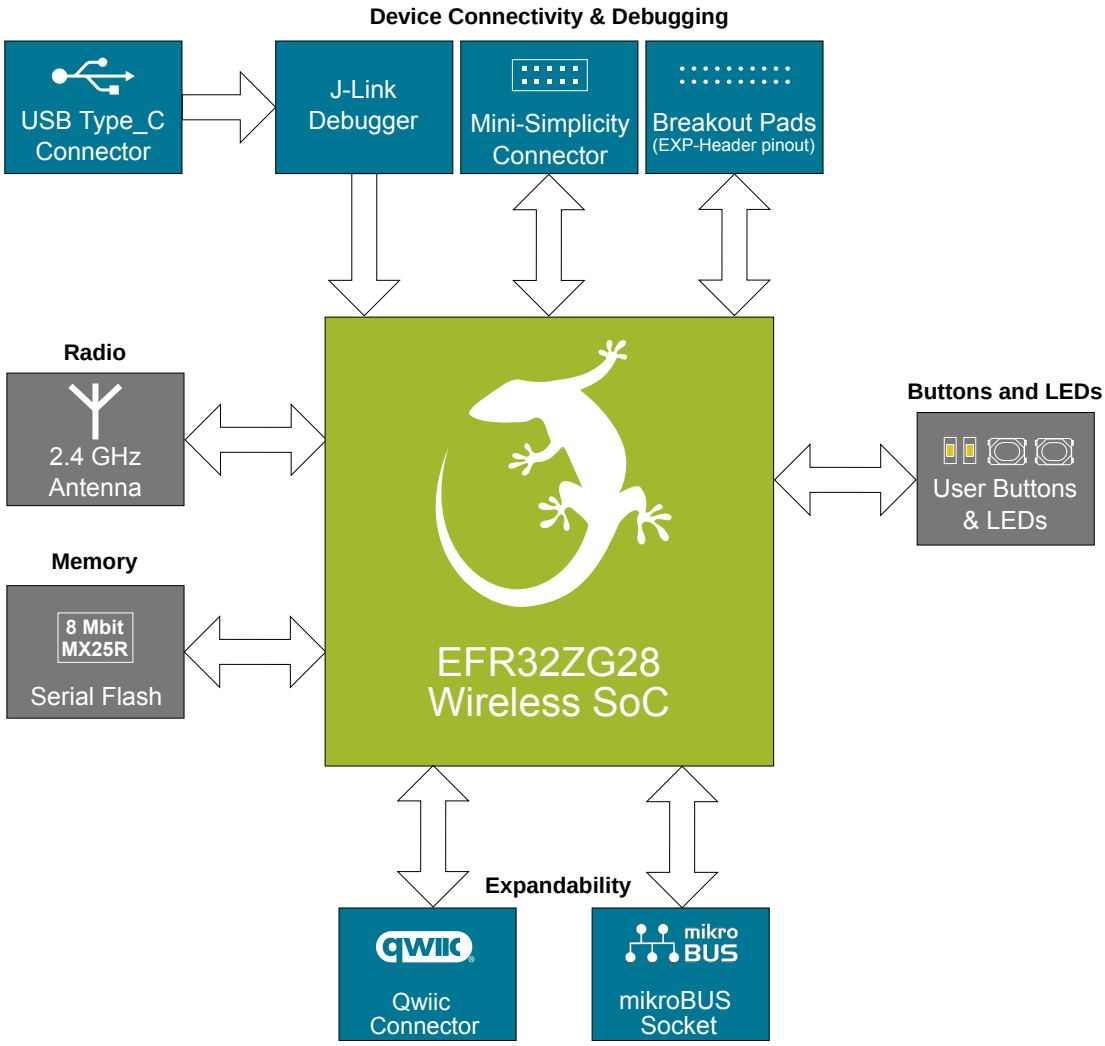

Figure 3.1. Kit Block Diagram

3.2 Power Supply

The kit is powered by the debug USB cable as illustrated in the figure below.

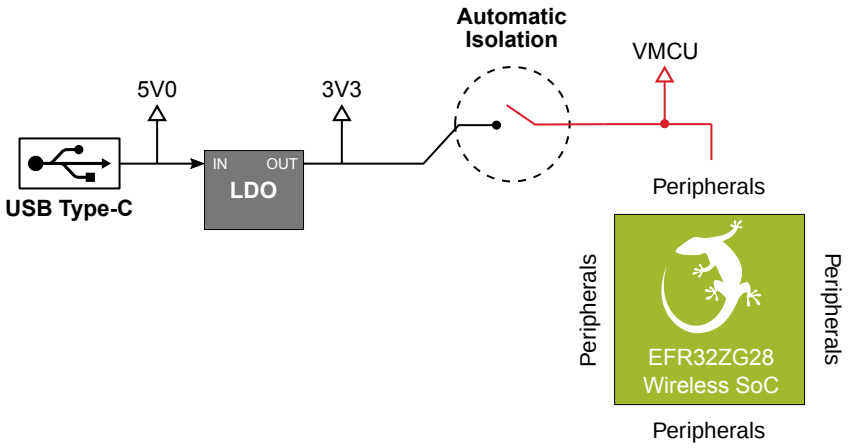

Figure 3.2. xG28 Explorer Kit Power Topology

The 5 V power net on the USB bus is regulated down to 3.3 V using an low-dropout regulator (LDO). An automatic isolation circuit isolates the LDO when the USB cable is not plugged in.

Power can be injected externally on the VMCU net if the USB cable is removed and no other power sources are present on the kit. Failure to follow this guideline can cause power conflicts and damage the LDO.

3.3 EFR32ZG28 Reset

The EFR32ZG28 can be reset by a few different sources:

- A user pressing the RESET button.
- The on-board debugger pulling the #RESET pin low.

3.4 Push Button and LED

The kit has two user push buttons, marked BTN0 and BTN1, that are connected to GPIOs on the EFR32ZG28. The buttons are connected to pin PC00 and PB03, respectively, and they are debounced by an RC filter with a time constant of 1 ms. The logic state of a button is high while that button is not being pressed, and low when it is pressed.

The kit also features two yellow LEDs, marked LED0 and LED1, that are controlled by GPIO pins on the EFR32ZG28. The LEDs are connected to pin PC09 and PC08, respectively, in an active-high configuration.

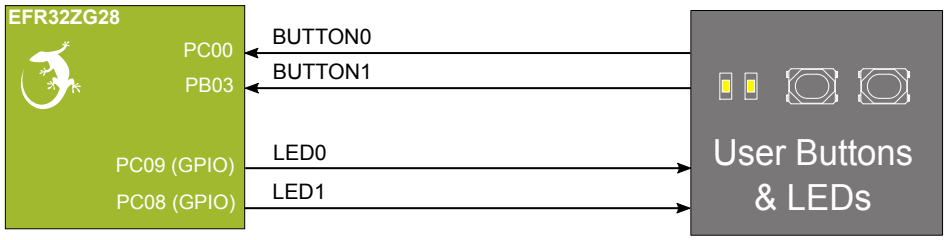

Figure 3.3. Buttons and LEDs

3.5 On-board Debugger

The xG28 Explorer Kit contains a microcontroller separate from the EFR32ZG28 Wireless Gecko that provides the user with an on-board J-Link debugger through the USB Type-C port. This microcontroller is referred to as the "on-board debugger", and is not programmable by the user. When the USB cable is removed, the on-board debugger goes into a very low power shutoff mode (EM4S), consuming around 80 nA typically (EFM32GG12 data sheet number).

In addition to providing code download and debug features, the on-board debugger also presents a virtual COM port for general purpose application serial data transfer. The Packet Trace Interface (PTI) is also supported which offers invaluable debug information about transmitted and received packets in wireless links.

The figure below shows the connections between the target EFR32ZG28 device and the on-board debugger.

Refer to section 4. Debugging for more details on debugging.

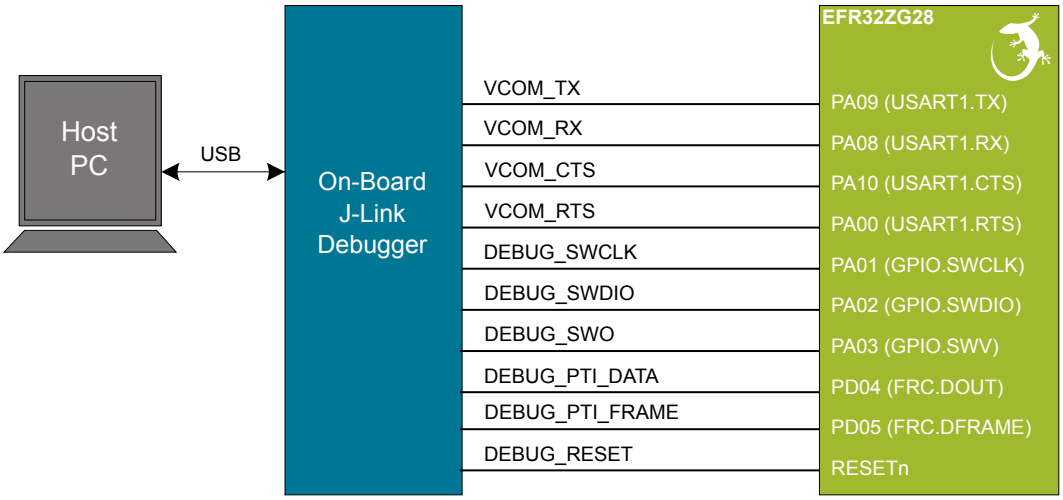

Figure 3.4. On-Board Debugger Connections

3.6 Connectors

The xG28 Explorer Kit features a USB Type-C connector, 20 breakout pads, a mikroBUS connector for connecting mikroBUS add-on boards, and a Qwiic connector for connecting Qwiic Connect System hardware. The connectors are placed on the top side of the board, and their placement and pinout are shown in the figure below. For additional information on the connectors, see the following sub-chapters.

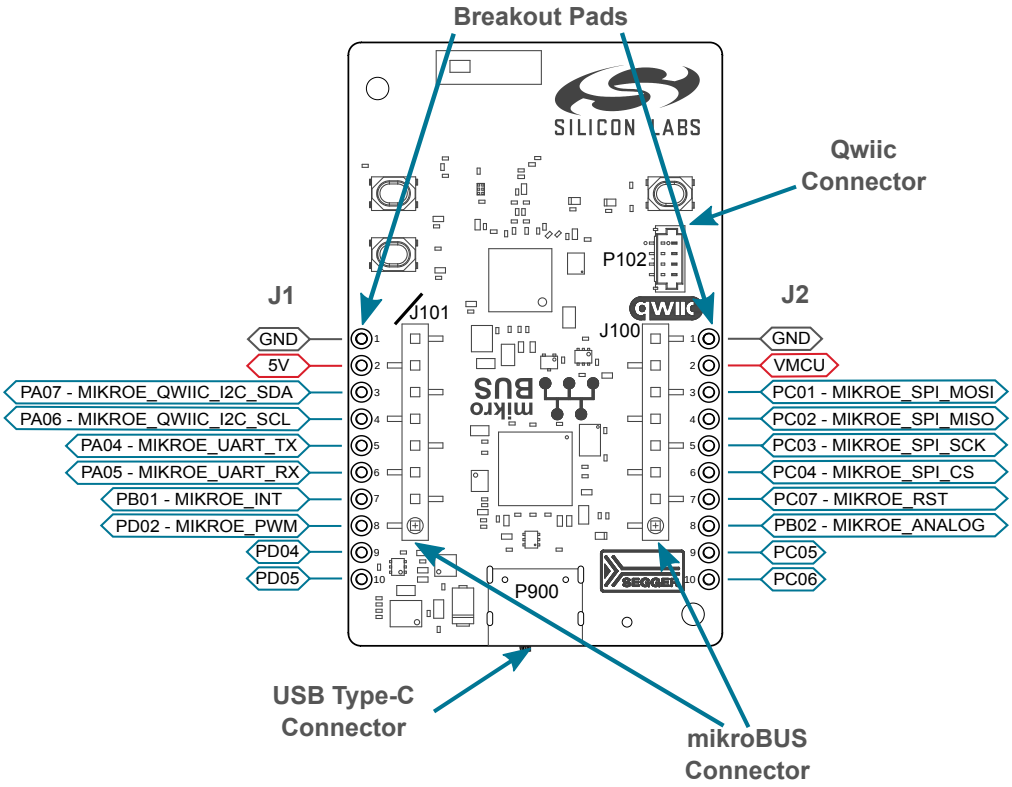

Figure 3.5. xG28 Explorer Kit Connectors

3.6.1 Breakout Pads

Twenty breakout pads are provided and allow connection of external peripherals. There are 10 pads on the left side of the board, and 10 pads on the right. The breakout pads contain a number of I/O pins that can be used with most of the EFR32ZG28 Wireless Gecko's features. Additionally, the VMCU (main board power rail), 3V3 (LDO regulator output), VREFP (ADC positive reference voltage input), and 5V power rails are also exposed on the pads.

The pin-routing on the Wireless Gecko is very flexible, so most peripherals can be routed to any pin. However, pins may be shared between the breakout pads and other functions on the xG28 Explorer Kit. The table below includes an overview of the breakout pads and functionality that is shared with the kit.

Table 3.1. Breakout Pads Pinout

Pin	Connection	Shared Feature
Left-side Breakout Pins		
1	GND	Ground
2	5V	Board USB voltage
3	PA07	MikroBUS I2C_SDA, Qwiic I2C_SDA
4	PA06	MikroBUS I2C_SCL, Qwiic I2C_SCL
5	PA04	MikroBUS UART_TX
6	PA05	MikroBUS UART_RX
7	PD04	MikroBUS INT
8	PD05	MikroBUS PWM
9	PD04	PTI Data
10	PD05	PTI Frame
Right-side Breakout Pins		
1	GND	Ground
2	VMCU	EFR32ZG28 voltage domain
3	PC01	MikroBUS SPI_MOSI
4	PC02	MikroBUS SPI_MISO
5	PC03	MikroBUS SPI_SCK
6	PC04	MikroBUS SPI_CS
7	PC07	MikroBUS RST
8	PB02	MikroBUS Analog
9	PC05	–
10	PC06	–

3.6.2 MikroBUS Socket

The xG28 Explorer Kit features a mikroBUS socket compatible with mikroBUS add-on boards. MikroBUS add-on boards can expand the functionality of the kit with peripherals such as sensors and LCDs. Add-on boards follow the mikroBUS socket pin mapping and communicate with the on-kit EFR32ZG28 through UART, SPI or I^2C. Several GPIOs are exposed on the mikroBUS socket. MikroBUS add-on boards can be powered by the 5V or VMCU power rails, which are available on the mikroBUS socket.

The pinout of the EFR32ZG28 on the kit is made such that all required peripherals are available on the mikroBUS socket. The I^2C signals are, however, shared with the Qwiic connector, and all mikroBUS signals are also routed to adjacent breakout pads.

When inserting a mikroBUS add-on board, refer to the orientation notch on the xG28 Explorer Kit, shown in the figure below, to ensure correct orientation. Add-on boards have a similar notch that needs to be lined up with the one shown below.

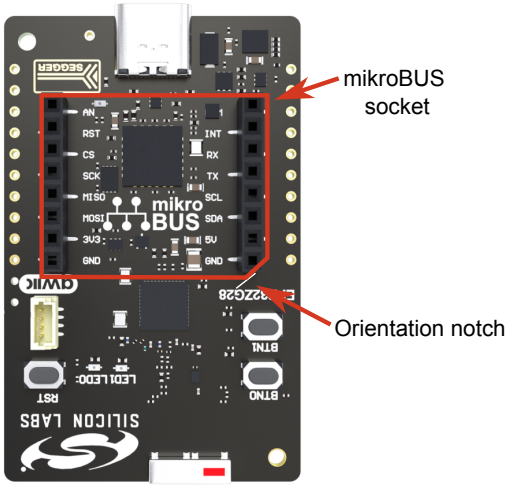

Figure 3.6. mikroBUS Add-on Board Orientation

The table below gives an overview of the mikroBUS socket pin connections to the EFR32ZG28.

Table 3.2. mikroBUS Socket Pinout

mikro-BUS Pin Name	mikroBUS Pin Function	Connection	Shared Feature	Suggested Peripheral Mapping
AN	Analog	PB02	BREAKOUT_RIGHT8	IADC0
RST	Reset	PC07	BREAKOUT_RIGHT7	–
CS	SPI Chip Select	PC04	BREAKOUT_RIGHT6	USARTx.CS
SCK	SPI Clock	PC03	BREAKOUT_RIGHT5	USARTx.CLK
MISO	SPI Main Input Secondary Output	PC02	BREAKOUT_RIGHT4	USARTx.RX
MOSI	SPI Main Output Secondary Input	PC01	BREAKOUT_RIGHT3	USARTx.TX
PWM	PWM Output	PD02	BREAKOUT_LEFT8	TIMER0.CCx
INT	Hardware Interrupt	PB01	BREAKOUT_LEFT7	–
RX	UART Receive	PA05	BREAKOUT_LEFT6	USARTx.RX
TX	UART Transmit	PA04	BREAKOUT_LEFT5	USARTx.TX
SCL	I2C Clock	PA06	BREAKOUT_LEFT4	I2Cx.SCL
SDA	I2C Data	PA07	BREAKOUT_LEFT3	I2Cx.SDA

mikro-BUS Pin Name	mikroBUS Pin Function	Connection	Shared Feature	Suggested Peripheral Mapping
3V3	VCC 3.3V power	VMCU	EFR32ZG28 voltage domain	
5V	VCC 5V power	5V	Board USB voltage	
GND	Reference Ground	GND	Ground	

3.6.3 Qwiic Connector

The xG28 Explorer Kit features a Qwiic connector compatible with Qwiic Connect System hardware. The Qwiic connector provides an easy way to expand the functionality of the xG28 Explorer Kit with sensors, LCDs, and other peripherals over the I^{2}C interface. The Qwiic connector is a 4-pin polarized JST connector, which ensures the cable is inserted the right way.

Qwiic Connect System hardware is daisy chain-able as long as each I^{2}C device in the chain has a unique I^{2}C address.

Note: The Qwiic I^{2}C lines are shared with the on-board I^{2}C sensors, and are also exposed on the breakout pads.

The Qwiic connector and its connections to Qwiic cables and the EFR32ZG28 are illustrated in the figure below.

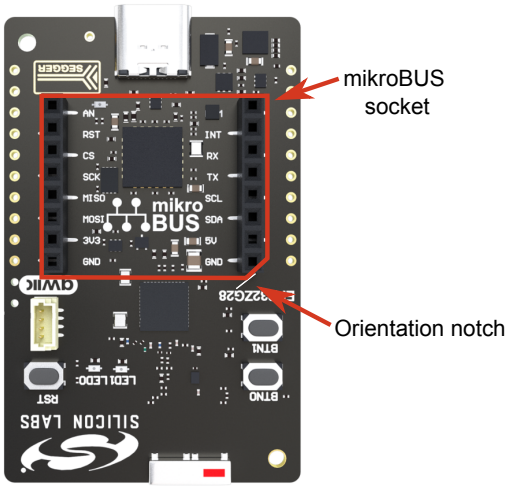

Figure 3.7. Qwiic Connector

The table below gives an overview of the Qwiic connections to the EFR32ZG28.

Table 3.3. Qwiic Connector Pinout

Qwiic Pin	Connection	Shared Feature	Suggested Peripherial Mapping
Ground	GND	Ground	
3.3V	VMCU	EFR32ZG28 voltage domain	
SDA	PA07	–	I2Cx.SDA
SCL	PA06	–	I2Cx.SCL

3.6.4 Debug USB Type-C Connector

The debug USB port can be used for uploading code, debugging, and as a Virtual COM port. More information is available in section 4. Debugging.

4. Debugging

The xG28 Explorer Kit contains an on-board SEGGER J-Link Debugger that interfaces to the target EFR32ZG28 using the Serial Wire Debug (SWD) interface. The debugger allows the user to download code and debug applications running in the target EFR32ZG28. Additionally, it provides a virtual COM port (VCOM) to the host computer that is connected to the target device's serial port for general purpose communication between the running application and the host computer. The Packet Trace Interface (PTI) is also supported by the on-board debugger, which offers invaluable debug information about transmitted and received packets in wireless links. The on-board debugger is accessible through the USB Type-C connector.

4.1 On-board Debugger

The on-board debugger is a SEGGER J-Link debugger running on an EFM32 Giant Gecko. The debugger is directly connected to the debug and VCOM pins of the target EFR32ZG28.

When the debug USB cable is inserted, the on-board debugger is automatically activated and takes control of the debug and VCOM interfaces. This means that debug and communication will **not** work with an external debugger connected at the same time. The on-board LDO is also activated, providing power to the board.

4.2 Virtual COM Port

The virtual COM port is a connection to a UART of the target EFR32ZG28 and allows serial data to be sent and received from the device. The on-board debugger presents this as a virtual COM port on the host computer that shows up when the USB cable is inserted.

Data is transferred between the host computer and the debugger through the USB connection, which emulates a serial port using the USB Communication Device Class (CDC). From the debugger, the data is passed on to the target device through a physical UART connection.

The serial format is 115200 bps, 8 bits, no parity, and 1 stop bit by default.

Note: Changing the baud rate for the COM port on the PC side does not influence the UART baud rate between the debugger and the target device.

5. Radio

5.1 RF Section

This section gives a short introduction to the RF section of the BRD2705A board.

The schematic of the RF section is shown in the figure below.

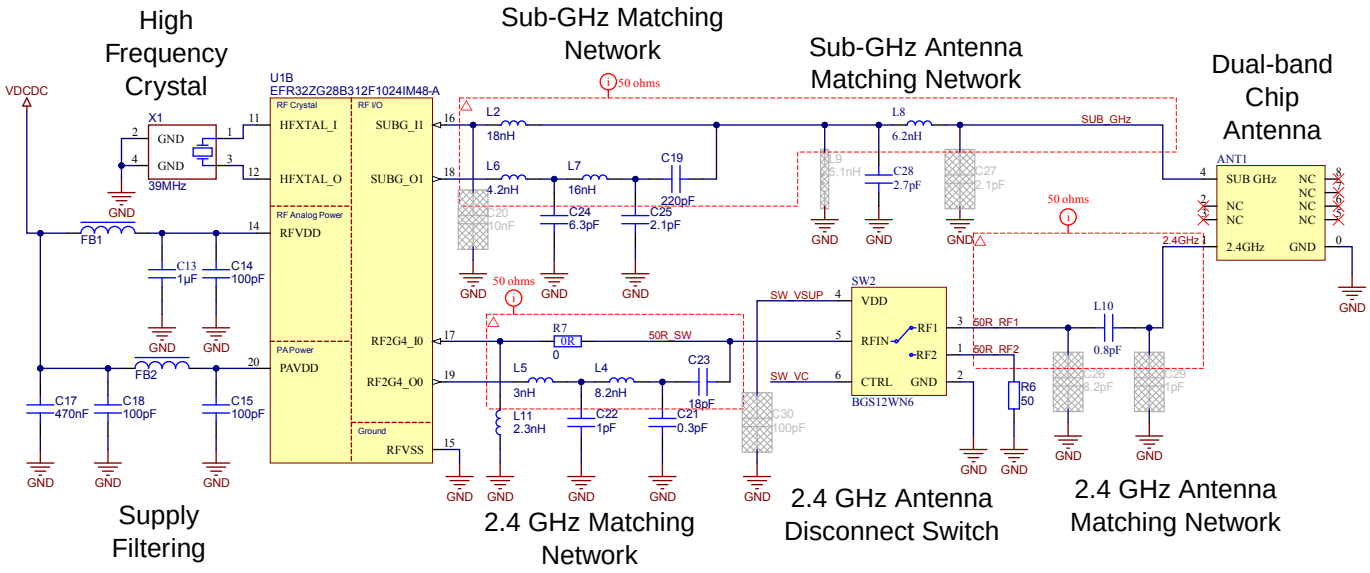

Figure 5.1. Schematic of the RF Section

5.1.1 Description of the RF Matching

The EFR32ZG28 RF port impedances are matched to 50 Ohm. The sub-GHz TX port has a 4-element matching network with a DC block capacitor, and the RX side has a series inductor. The 2.4 GHz TX port also has a 4-element matching network but the RX side has a parallel inductor. An SPDT switch in the 2.4 GHz path disconnects the antenna during the sub-GHz TX operation to reduce the radiation of the sub-GHz harmonics that couple to the 2.4 GHz side within the IC.

5.1.2 RF Section Power Supply

On the BRD2705A, the supply for the radio (RFVDD) and the power amplifier (PAVDD) is connected to the on-chip DC-DC converter. By default, the DC-DC converter provides 1.8 V for the entire RF section (for details, see the BRD2705A schematic).

5.1.3 RF Matching Bill of Materials

The BRD2705A RF matching network bill of materials is shown in the following table.

Table 5.1. BRD2705A RF Matching Network Bill of Materials

Component Name	Value	Manufacturer	Part Number
Sub-GHz RF Matching Network			
L2	18 nH	Murata	LQP03HQ18NH02D
L6	4.2 nH	Murata	LQP03HQ4N2B02D
L7	16 nH	Murata	LQP03HQ16NH02D
C19	220 pF	–	–
C20	Not Mounted	–	–
C24	6.3 pF	Murata	GRM0335C1H6R3WA01D
C25	2.1 pF	Murata	GRM0335C1H2R1BA01D
2.4 GHz RF Matching Network			
L4	8.2 nH	Murata	LQP03HQ8N2H02D
L5	3 nH	Murata	LQP03HQ3N0B02D
L11	2.3 nH	Murata	LQP03HQ2N3W02D
C21	0.3 pF	Murata	GRM0335C1HR30WA01D
C22	1 pF	Murata	GRM0335C1H1R0WA01D
C23	18 pF	Murata	GRM0335C1H180GA01D
R6	50R	–	–
R7	0R	–	–
SW2	–	Infineon	BGS12WN6

5.1.4 Antenna Matching Bill of Materials

The BRD2705A has an on-board ceramic antenna.

The land pattern for the antenna on the PCB layout was designed based on the recommendations of the antenna data sheet. Because there is a difference between the layout (practically the board size) of the BRD2705A and the antenna evaluation board, it was necessary to fine-tune the matching component values. Thus, the applied antenna matching network deviates from the recommendation. The resulting bill of materials is shown in the following table.

Table 5.2. BRD2705A Antenna Matching Network Bill of Materials

Component Name	Value	Manufacturer	Part Number
ANT1	–	Johanson	0900AD47A2450
Sub-GHz Antenna Matching Network			
L8	6.2 nH	Murata	LQP03HQ6N2J02D
L9	Not Mounted	–	–
C27	Not Mounted	–	–
C28	2.7 pF	Murata	GRM0335C1H2R7BA01D
2.4 GHz Antenna Matching Network			
L10	0.8 pF	Murata	GRM0335C1HR80BA01D
C26	Not Mounted	–	–
C29	Not Mounted	–	–

5.2 EMC Compliance

5.2.1 Introduction

BRD2705A Explorer Kit fundamental and harmonic levels compliance is tested against the following standards:

- 868 MHz:
  - ETSI EN 300-220-1
- 915 MHz:
  - FCC 15.247
- 2440 MHz:
  - ETSI EN 300-328
  - FCC 15.247

5.2.2 EMC Regulation Emission Limits for Sub-GHz

5.2.2.1 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, Effective Isotropic Radiated Power (EIRP) will be used instead of Effective Radiated Power (e.r.p.) 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 5.3. 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.

5.2.2.2 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 from 960 MHz to the frequency of the 10th harmonic, the limit is defined as 0.5 mV/m at 3 m distance (equals to -41.2 dBm in EIRP).

If 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.

5.2.3 EMC Regulations for 2.4 GHz

5.2.3.1 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 specified limit is -30 dBm EIRP.

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

FCC 15.247 allows conducted output power up to 1 Watt (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 (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, so for those the -41.2 dBm limit should be applied. For the 4th harmonic, the -20 dBc limit should be applied.

5.2.3.3 Applied Emission Limits

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, and the ETSI EN 300-328 limit is applied for the rest.

Table 5.4. Applied Limits for Spurious Emissions

Harmonic	Frequency	Limit
2nd	4800~4967 MHz	-41.2 dBm
3rd	7200~7450.5 MHz	-41.2 dBm
4th	9600~9934 MHz	-30 dBm
5th	12000~12417.5 MHz	-41.2 dBm

5.2.3.4 Relaxation 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 have been 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 300-328 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 relative levels of the measured modulated signals compared to the unmodulated levels with the above Spectrum Analyzer settings in case of the supported modulation schemes.

Table 5.5. Measured Relaxation Factors for the Supported Modulation Schemes

Applied Modulation (Packet Length: 255 bytes)	BLE Coded PHY: 125 Kb/s (PRBS9) [dB]	BLE Coded PHY: 500 Kb/s (PRBS9) [dB]	BLE 1M PHY: 1 Mb/s (PRBS9) [dB]	BLE 2M PHY: 2 Mb/s (PRBS9) [dB]
2nd harmonic	-2.7	-3.1	-3.3	-9.1
3rd harmonic	-4.8	-5.2	-5.2	-10.7
4th harmonic	-5.5	-6.5	-6.7	-11.9
5th harmonic	-6.3	-6.5	-6.7	-11.4

As it can be observed, the BLE 125 Kb/s coded modulation scheme has the lowest relaxation factors. These values will be used as the worst-case relaxation factors for the radiated measurements.

5.3 Radiated Power Measurements

During the measurements, the board was supplied through its USB connector by connecting to a PC through a USB cable. The board was rotated in three cuts. See the reference plane illustration in the figure below. The radiated powers of the fundamental and the harmonics were measured with horizontal and vertical reference antenna polarizations.

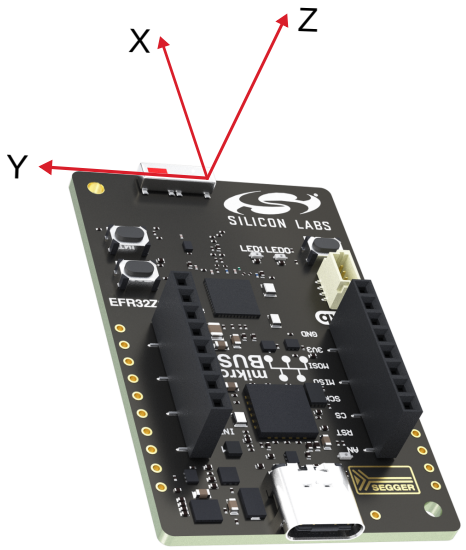

Figure 5.2. DUT Reference Planes

5.3.1 Radiated Power Measurements in the 868 MHz Band

For the 868 MHz radiated power measurements, the output power was set to 14 dBm. The measured radiated powers are shown in the table below.

Table 5.6. Maximums of the Measured Radiated Powers of BRD2705A

Frequency (868 MHz)	Measured Unmodulated EIRP [dBm]	Orientation	Margin [dB]	Limit in EIRP [dBm]
Fund	11.0	XZ/H	5.1	16.1
2nd	-59.9	YZ/V	32.0	-27.9
3rd	-48.1	YZ/H	20.2	-27.9
4th	-59.6	YZ/V	31.7	-27.9
5th	-51.1	YZ/V	23.2	-27.9
6th	-48.4	XZ/H	20.5	-27.9
7th	-51.9	XZ/H	24.0	-27.9
8th	-56.1	YZ/V	28.2	-27.9
9th	-43.4	XZ/H	15.5	-27.9
10th	-50.6	XZ/H	22.7	-27.9

As shown in the table above, with 14 dBm output power, the radiated power of the fundamental is compliant with the 16.1 dBm limit. The radiated harmonic levels are compliant with large margins.

5.3.2 Radiated Power Measurements in the 915 MHz Band

For the 915 MHz radiated power measurements, the output power was set to 14 dBm. The measured radiated powers are shown in the table below.

Table 5.7. Maximums of the Measured Radiated Powers of BRD2705A

Frequency (915 MHz)	Measured Unmodulated EIRP [dBm]	Orientation	Margin [dB]	Limit in EIRP [dBm]
Fund	10.9	XZ/H	19.1	30
2nd	-60.7	YZ/V	>25.0	-20 dBc
3rd	-45.8	YZ/V	4.6	-41.2
4th	-60.2	XZ/V	19.0	-41.2
5th	-49.7	XZ/H	8.5	-41.2
6th	-49.6	XZ/H	>25.0	-20 dBc
7th	-52.9	XZ/H	>25.0	-20 dBc
8th	-55.0	YZ/V	13.8	-41.2
9th	-43.1	YZ/H	1.9	-41.2
10th	-48.0	XZ/H	6.8	-41.2

As shown in the table above, with 14 dBm output power, the radiated power of the fundamental is compliant with the 30 dBm limit. The radiated harmonic levels are also compliant.

5.3.3 Radiated Power Measurements in the 2.4 GHz band

The transceiver was operated in unmodulated carrier transmission mode, the output power of the radio was set to 10 dBm. The results are shown in the table below.

The correction factors are applied based on the BLE 125 Kb/s coded modulation, shown in section 5.2.3.4 Relaxation with Modulated Carrier. For the rest of the supported modulation schemes the correction factors are larger, thus the related calculated margins would be higher compared to the ones shown in the table below. Therefore, the below margins can be considered as worst-case margins.

Table 5.8. Maximums of the Measured Radiated Powers of BRD2705A

Frequency (2440 MHz)	Measured Unmodulated EIRP [dBm]	Orientation	BLE 125 Kb/s Coded Modulation			Limit in EIRP [dBm]
			Correction Factor [dB]	Calculated Modulated EIRP [dBm]	Modulated Margin [dB]	
Fund	12.4	YZ/V	NA (0 is used)	12.4	17.6	30.0
2nd	-48.7	XY/H	-2.7	-51.4	10.2	-41.2
3rd	-52.1	XZ/H	-4.8	-56.9	14.7	-41.2
4th	-53.4	XZ/H	-5.5	-58.9	28.9	-30.0
5th	-44.8	YZ/V	-6.3	-51.1	9.9	-41.2
* Signal level is below the Spectrum Analyzer noise floor.						

As shown in the table above, with 10 dBm output power, the radiated power of the fundamental is compliant with the 30 dBm limit. The radiated harmonic levels are under the applied limits with margins.

5.3.4 Antenna Pattern Measurements in the 868 MHz Band

The measured typical antenna patterns are shown in the figures below.

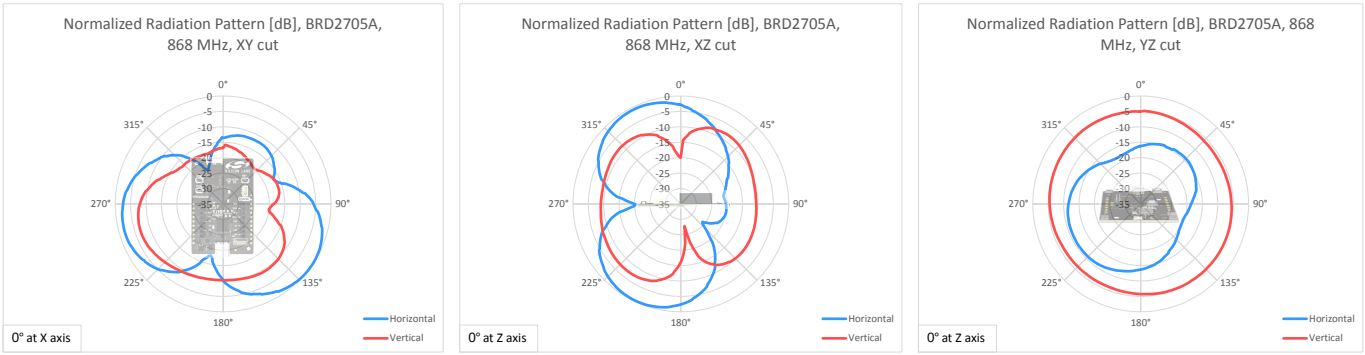

Figure 5.3. Antenna Pattern - 868 MHz

5.3.5 Antenna Pattern Measurement in the 915 MHz Band

The measured typical antenna patterns are shown in the figures below.

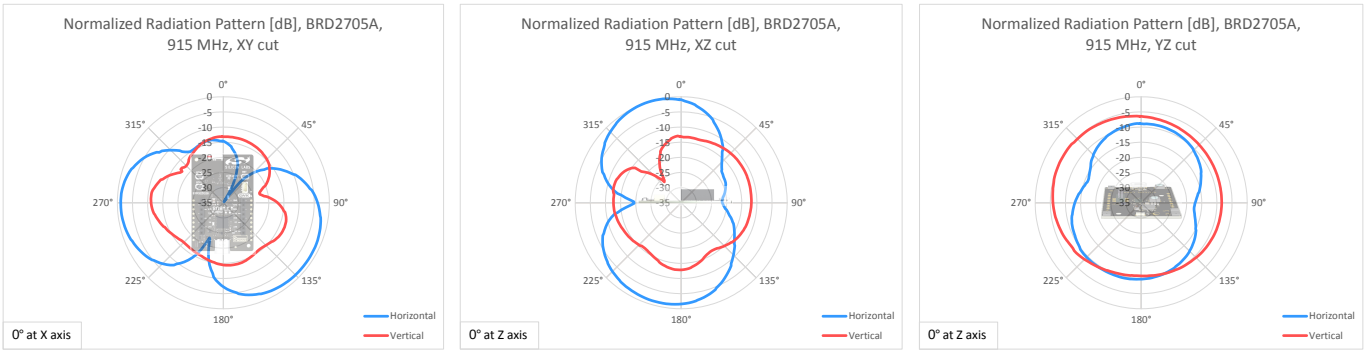

Figure 5.4. Antenna Pattern - 915 MHz

5.3.6 Antenna Pattern Measurements in the 2.4 GHz Band

The measured typical antenna patterns are shown in the figures below.

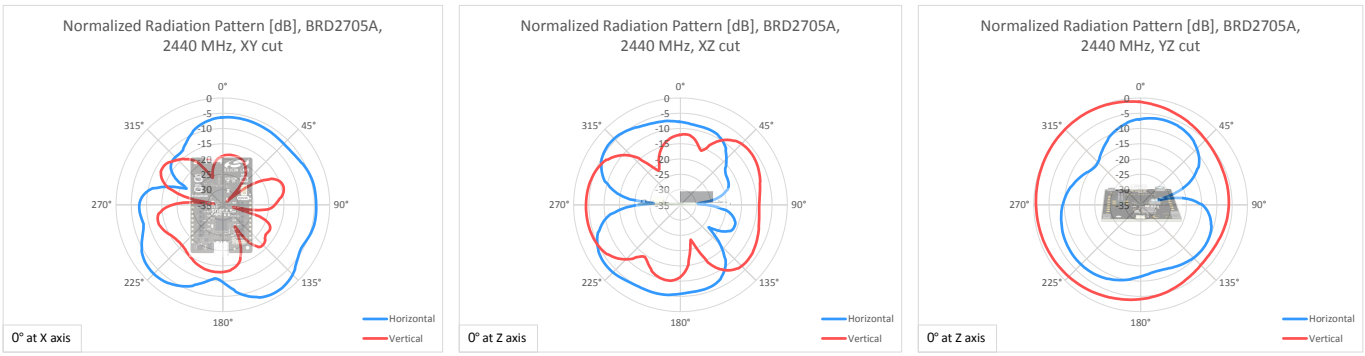

Figure 5.5. Antenna Pattern - 2.4 GHz

5.4 EMC Compliance Recommendations

5.4.1 Recommendations for 868 MHz ETSI EN 300-200-1 Compliance

As shown in the previous section, the BRD2705A board is compliant with the emission limits of the ETSI EN 300-200-1 regulation in the 868 MHz band with 14 dBm output power.

5.4.2 Recommendations for 915 MHz FCC 15.247 Compliance

As shown in the previous section, the BRD2705A board is compliant with the emission limits of the FCC 15.247 regulation in the 915 MHz band with 14 dBm output power.

5.4.3 Recommendations for 2.4 GHz ETSI EN 300-328 Compliance

As shown in the previous section, the BRD2705A board is compliant with the emission limits of the ETSI EN 300-328 regulation in the 2.4 GHz band with 10 dBm output power.

5.4.4 Recommendations for 2.4 GHz FCC 15.247 Compliance

As shown in the previous section, the BRD2705A board is compliant with the emission limits of the FCC 15.247 regulation in the 2.4 GHz band with 10 dBm output power.

6. Schematics, Assembly Drawings, and BOM

Schematics, assembly drawings, and Bill of Materials (BOM) are available through Simplicity Studio when the kit documentation package has been installed. They are also available from the kit page on the Silicon Labs website: silabs.com.

7. Kit Revision History

The kit revision can be found printed on the kit packaging label, as outlined in the figure below. The revision history given in this section may not list every kit revision. Revisions with minor changes may be omitted.

Figure 7.1. Kit Label

7.1 xG28-EK2705A Revision History

Table 7.1. xG28-EK2705A Revision History

Revision	Released	Description
A01	18 May 2023	Initial version.

7.2 xG28S-EK2705A Revision History

Table 7.2. xG28S-EK2705A Revision History

Revision	Released	Description
A00	10 Oct 2024	Initial version.

7.3 Errata

There are no known errata at present.

8. Board Revision History and Errata

8.1 Revision History

The board revision can be found laser printed on the board, and the board revision history is summarized in the following table.

Table 8.1. BRD2705A Revision History

Revision	Released	Description
A01	18 May 2023	Initial version.

8.2 Errata

There are no known errata at present.

9. Document Revision History

Revision 1.1

March 2025

- Adding xG28S-EK2705A kit ordering information and revision history.

Revision 1.0

August 2023

- Initial document release.

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