UG532: ZGM230S Dev Kit User's Guide

The ZGM230S Dev Kit is a low-cost, small form factor development and evaluation platform for the ZGM230S Z-Wave SiP Module (System-in-Package Module).

The board is a small and cost-effective, feature-rich, prototype and development platform based on the ZGM230S Z-Wave System-in-Package Module. The ZGM230S Dev Kit is an ideal platform for developing energy-friendly connected IoT devices.

A built-in SEGGER J-Link debugger ensures easy debugging through the USB Type-C connector.

TARGET DEVICE

- ZGM230S Z-Wave SiP Module (ZGM230SB27HGN3)
- +14 dBm TX power
- -110.9 dBm RX sensitivity @100 kbps
- 32-bit ARM® Cortex®-M33 with 39 MHz maximum operating frequency
- 512 kB flash and 64 kB RAM
- Integrated DC-DC converter

KIT FEATURES

- SMA connector for antenna connection
- Power control of on-board peripherals for ultra-low power operation
- Relative humidity and temperature sensor
- Ambient light sensor
- Hall effect sensor
- 6-axis inertial sensor
- LC sensor for metal detection
- Pressure sensor
- 8 Mbit flash for OTA programming and data logging
- RGB LED, two single color LEDs, and two push buttons
- 20-pin 2.54 mm breakout pads
- Qwiic® connector
- SEGGER J-Link on-board debugger
- Virtual COM port
- Packet Trace Interface (PTI)
- Mini Simplicity connector for AEM and packet trace using external Silicon Labs debugger
- USB or coin cell battery powered
- External battery connector

SOFTWARE SUPPORT

- Simplicity Studio™

Table of Contents

1. Introduction

The ZGM230S Dev Kit (OPN: ZGM230-DK2603A) has been designed to inspire customers to make battery-operated IoT devices with the Silicon Labs ZGM230S Z-wave System-in-Package (SiP) Module. The highlights of the board include six different environmental sensors accessible to the ZGM230S wireless MCU. The peripherals are grouped into power domains that can be turned on and off by the application code as needed.

Programming the ZGM230S Dev Kit is easily done using 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. Included on the board is an 8 Mbit serial flash that can be used for Over-The-Air (OTA) firmware upgrade, or as a general-purpose, non-volatile memory. The ZGM230S Dev Kit is supported in Simplicity Studio™, and a Board Support Package (BSP) is provided to give application developers a flying start.

Energy profiling and advanced wireless network analysis and debugging tools are available through the provided Mini Simplicity Connector using an external Silicon Labs debugger.

Connecting external hardware to the ZGM230S Dev Kit can be done using the 20 breakout pads, which present peripherals from the ZGM230S Z-Wave SiP Module such as I^{2}C, SPI, UART, and GPIOs. The breakout pads follow the same pinout as the expansion headers (EXP) on other Silicon Labs Starter Kits. The board also features a Qwiic connector which can be used to connect hardware from the Qwiic Connect System through I2C.

1.1 Kit Contents

The following items are included in the box:
- 1x ZGM230S Dev Kit board (BRD2603A).
- 1x 868-915 MHz antenna (LPRS ANT-SS900).

1.2 Getting Started

Detailed instructions for how to get started with your new ZGM230S Dev Kit can be found on the Silicon Labs web page:

https://www.silabs.com/dev-tools

1.3 Hardware Content

The following key hardware elements are included on the ZGM230S Dev Kit:
- ZGM230S SiP Module with 39 MHz operating frequency, 512 kB kB flash, and 64 kB RAM
- SMA antenna connector for wireless transmission
- Silicon Labs Si7021 relative humidity and temperature sensor
- Silicon Labs Si7210 Hall effect sensor
- Vishay VEML6035 ambient light sensor
- TDK InvenSense ICM-20689 6-axis inertial sensor
- Bosch Sensortec BMP384 pressure sensor
- Macronix ultra-low power 8 Mbit SPI flash (MX25R8035F)
- LESENSE metal detector LC-sensor
- Two single color LEDs and two push buttons
- RGB LED
- Power enable signals and isolation switches for ultra-low power operation
- On-board SEGGER J-Link debugger for easy programming and debugging, which includes a USB virtual COM port and Packet Trace Interface (PTI)
- Mini Simplicity connector for access to energy profiling and advanced wireless network debugging
- Qwiic connector for connecting external hardware from the Qwiic Connect System
- Breakout pads for GPIO access and connection to external hardware
- Reset button
- Automatic switchover between USB and battery power
- CR2032 coin cell holder and external battery connector

1.4 Kit Hardware Layout

ZGM230S Dev Kit layout is shown below.
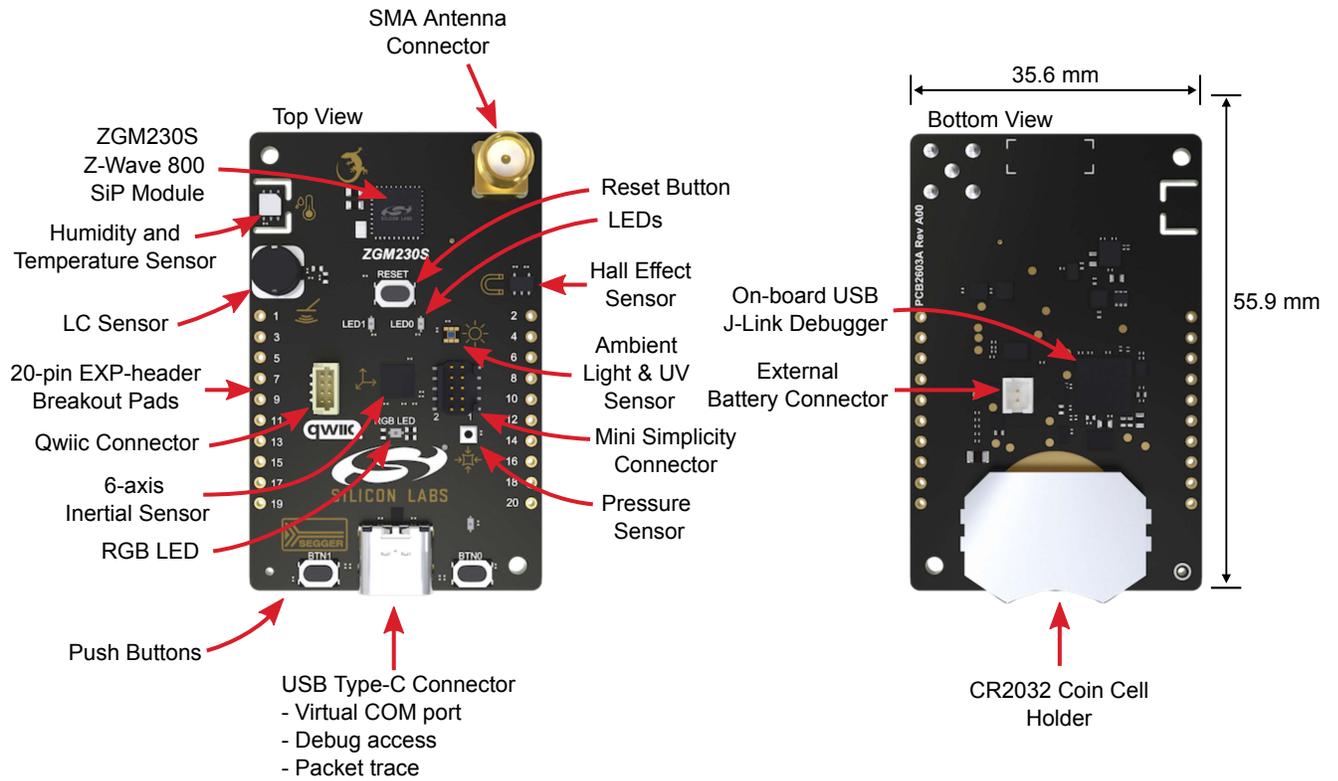
Figure 1.1. ZGM230S Dev Kit Hardware Layout

2. Specifications

2.1 Recommended Operating Conditions

The following table is intended to serve as a guideline for correct use of the ZGM230S Dev Kit, indicating typical operating conditions and some design limits.

Table 2.1. Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
USB Supply Input Voltage	V_{USB}	—	5.0	—	V
Battery Supply Input Voltage	V_{VBAT}	1.9	3.0	3.6	V
Supply Input Voltage (VMCU supplied externally)	V_{VMCU}	1.9	3.3	3.6	V
Operating Temperature	T_{OP}	—	25	—	˚C

2.2 Current Consumption

The table below summarizes the data sheet current consumption of the various components on the board. The operating current of the board greatly depends on the application. The number of enabled sensors, how often they are sampled, and how often the radio is transmitting or receiving are examples of factors that influence the operating current. In many cases the given conditions differ from the operating conditions on the ZGM230S Dev Kit, but the table can still be used as an indication of how much each feature contributes to the total current consumption. More details can be found in the specific data sheet for each device.

Table 2.2. Current Consumption

Parameter	Symbol	Condition	Typ	Unit
ZGM230S Current Consumption[1]	$I_{ZGM230S}$	MCU current consumption in EM0 mode with all peripherals disabled, VREGVDD = IOVDD = 3.3 V, VSCALE1, 39 MHz crystal, CPU running Prime from flash at 25 ˚C	27	µA/MHz
		EM4, BURTC with LFRCO	0.7	µA
		Radio system current consumption in receive mode, active packet reception (VREGVDD = IOVDD = 3.3 V, MCU in EM1 and all MCU peripherals disabled, HCLK = 39 MHz, 100 kbps, 2-GFSK, f = 916 MHz, VSCALE1, EM1P at 25 ˚C)	4.9	mA
		Radio system current consumption in transmit mode (VREGVDD = IOVDD = 3.3 V, MCU in EM1 and all MCU peripherals disabled, HCLK = 39 MHz, f = 916 MHz, CW, 14 dBm output power, VSCALE1 at 25 ˚C)	30	mA
Ambient Light Sensor Current Consumption [2]	$I_{VEML6035}$	Shutdown at 1.8 V	0.5	µA
		Operation mode at 1.8 V (ALS only)	170	µA
RH/Temp Sensor Current Consumption[3]	I_{Si7021}	Standby, -40 to +85˚C	0.06	µA
		RH conversion in progress	150	µA
		Temperature conversion in progress	90	µA
		Peak I_{DD} during I^2C operations	3.5	mA
Hall Effect Magnetic Sensor Current Consumption [4]	I_{DD}	Sleep mode at 3.3 V	50	nA
		Average current for periodic activation at 3.3 V, sleep timer enabled, 200 msec sleep time	0.4	µA
		Conversion in progress at 3.3 V	5	mA
Pressure Sensor Current Consumption[5]	I_{BMP384}	Ultra-low power mode (ODR = 1 Hz)	3.4	µA
		Highest resolution (ODR = 1 Hz)	46.4	µA
IMU Current Consumption[6]	I_{IMU}	Full-chip sleep mode at 1.8 V supply	6	µA
		Gyroscope Only, 100 Hz update rate at 1.8 V supply	1.6	mA
		Accelerometer only, 100 Hz update rate at 1.8 V supply	57	µA
		Gyroscope + Accelerometer, 100 Hz update rate at 1.8 V supply	1.9	mA
Serial Flash Memory Current Consumption [7]	I_{Flash}	Deep power-down current in ultra-low power mode at 1.8 V	0.007	µA
		Standby current in ultra-low power mode at 1.8 V	5	µA
		Write status register current in ultra-low power mode at 1.8 V	3.1	mA
On-board Debugger Sleep Current Consumption [8]	I_{DBG}	On-board debugger current consumption when USB cable is not inserted (EFM32GG12 EM4S mode current consumption)	80	nA

| Parameter	Symbol	Condition	Typ	Unit
Minimum Board Current Consumption	I_{BOARD}	Minimum total board current consumption for VMCU = 3.3 V with ZGM230S in EM4S, the USB cable disconnected, and all peripherals either in sleep mode or disconnected	0.5	µA

Note:

1. From ZGM230S data sheet
2. From VEML6035 data sheet
3. From Si7021-A20 data sheet
4. From Si7210 data sheet
5. From BMP384 data sheet
6. From ICM-20689 data sheet
7. From MX25R8035F data sheet
8. From EFM32GG12 data sheet

3. Hardware

The core of the ZGM230S Dev Kit is the ZGM230S Z-Wave SiP Module (System-in-Package Module). The board also contains several peripherals connected to the ZGM230S. Refer to section 1.4 Kit Hardware Layout for placement and layout of the hardware components.

3.1 Block Diagram

An overview of the ZGM230S Dev Kit is illustrated in the figure below.
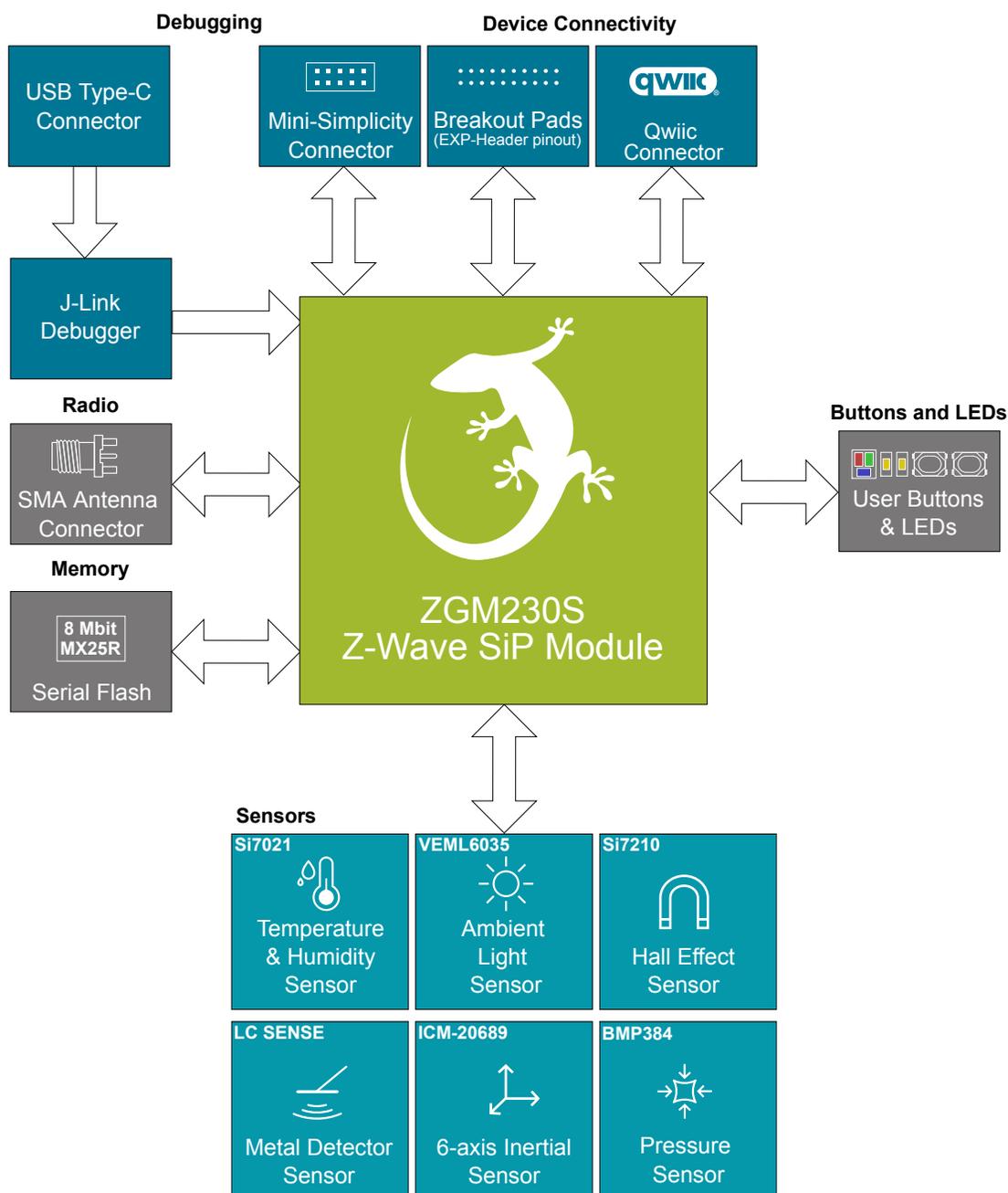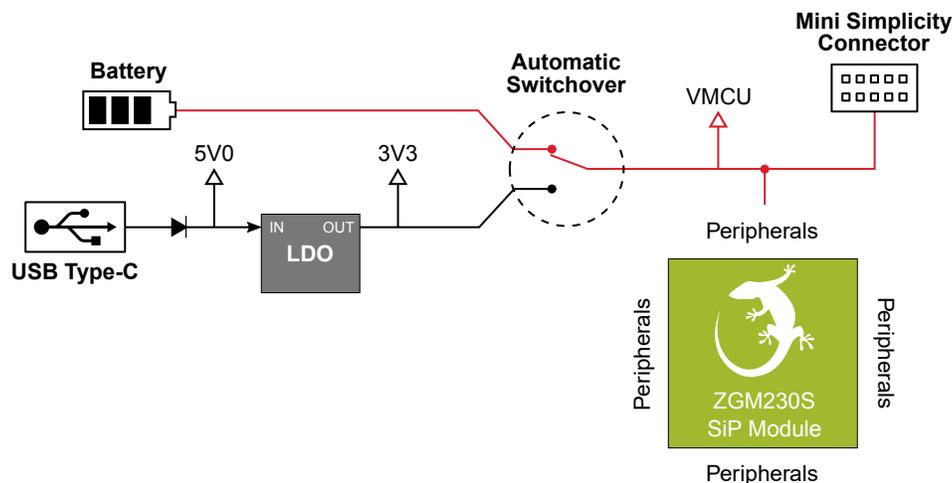

Figure 3.1. Kit Block Diagram

3.2 Power Supply

The kit can be powered through one of these interfaces:

* USB Type-C
* Battery (CR2032 battery or external battery connected through 2-pin battery header)
* Mini Simplicity connector

The figure below shows the power options available on the kit and illustrates the main system power architecture.

Figure 3.2. ZGM230S Dev Kit Power Architecture

Power is normally applied either through the USB cable or a CR2032 battery. A 2-pin 1.25 mm pitch battery connector for external batteries is also available as an alternative to a CR2032 battery. When the USB cable is connected, VBUS is regulated down to 3.3 V. An automatic switchover circuit switches the main system power from battery power to USB power when the USB cable is inserted and protects the battery from reverse current.

Power can also be applied through the Mini Simplicity connector. There must be no other power sources present on the kit as power is injected directly to the VMCU net. It is important to follow this recommendation to avoid power conflicts and backfeeding the battery. Powering the ZGM230S Dev Kit through the Mini Simplicity connector allows current measurements using the Advanced Energy Monitoring (AEM) as described in section 4.2 External Debugger.

Important: When powering the board through the Mini Simplicity connector, the USB and battery power sources must be removed.

The power supply options are summarized in the table below.

Table 3.1. ZGM230S Dev Kit Power Options

Supply Mode	Typical Input Voltage	VMCU Source	3V3	5V
USB power	5.0 V	On-board regulator	On-board regulator	USB VBUS
Battery	3.0 V	Battery voltage	Disconnected	No voltage present
Mini Simplicity	3.3 V	Debugger dependent	Disconnected	No voltage present

3.3 ZGM230S Reset

The ZGM230S can be reset by a few different sources:
* A user pressing the RESET button.
* The on-board debugger pulling the #RESET pin low.
* An external debugger pulling the #RESET pin low.

3.4 Peripherals

The ZGM230S Dev Kit contains a set of peripherals that can be accessed from the ZGM230S. All the peripherals have enable signals which can be used to completely turn off the peripherals that are not in use, or they can be put into a state that draws a minuscule amount of power. This option allows for the lowest possible power consumption in every application. The following peripherals are accessible to the ZGM230S:

- One Silicon Labs Si7021 relative humidity & temperature sensor
- One Silicon Labs Si7210 Hall effect sensor
- One Vishay VEML6035 ambient light sensor
- One TDK InvenSense ICM-20689 6-axis inertial measurement sensor
- One Bosch Sensortec BMP384 pressure sensor
- One Macronix MX25R8035F ultra-low power 8 Mbit SPI flash
- Two single color LEDs and two push buttons
- One RGB LED
- One LESENSE LC-Sensor metal detector

The figure below gives an overview of the peripherals that are connected to the ZGM230S. Note that some of the peripherals share the same interface and enable signals. As the enable signals do not have external pull-down resistors on the board, the application code should actively drive the signals either low or high to prevent the lines from floating.
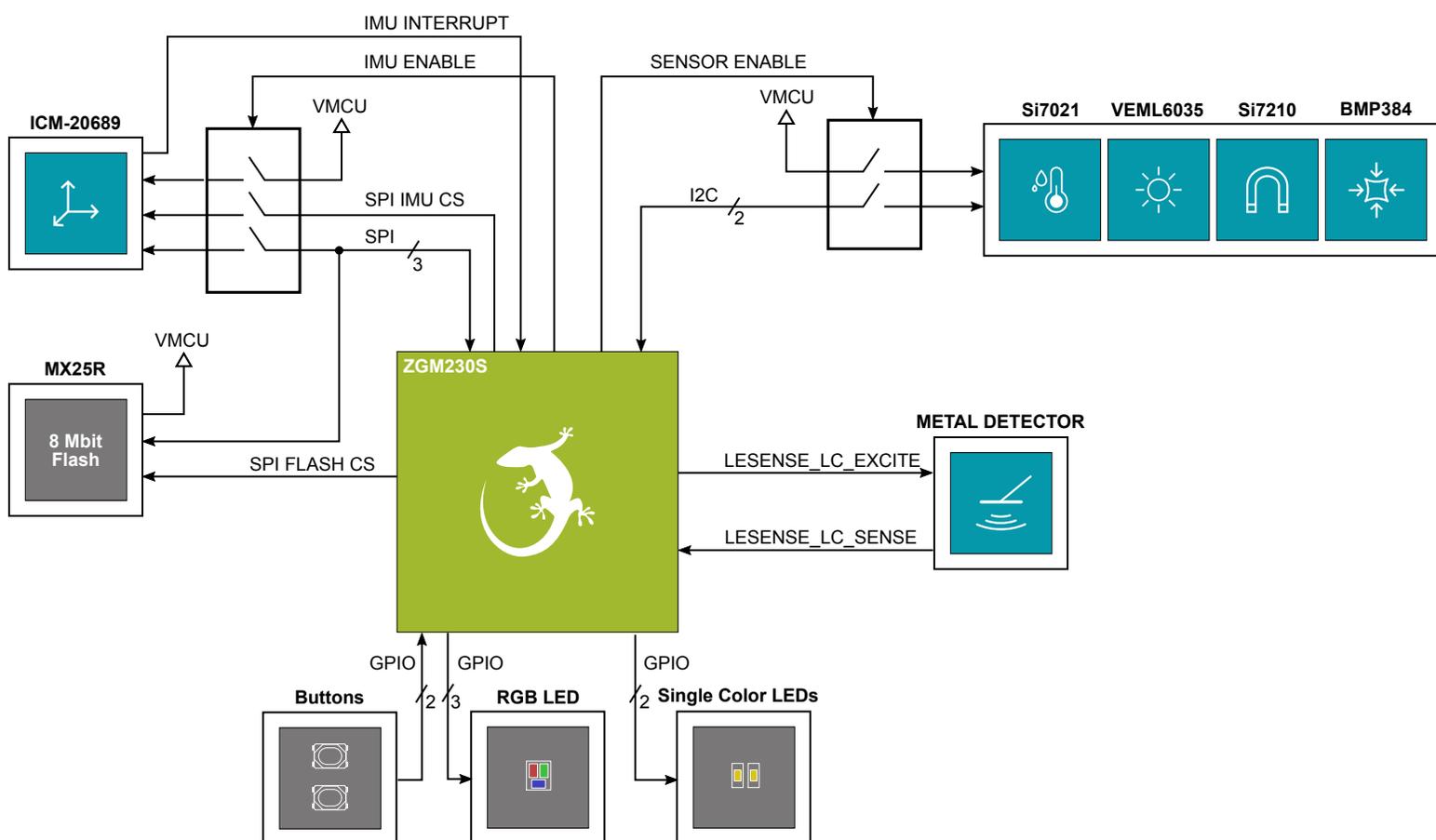
Figure 3.3. Peripherals

3.4.1 Si7021 Relative Humidity and Temperature Sensor

The Si7021 I^{2}C relative humidity and temperature sensor is a monolithic CMOS IC integrating humidity and temperature sensor elements, an analog-to-digital converter, signal processing, calibration data, and an I^{2}C interface. The patented use of industry-standard, low-K polymeric dielectrics for sensing humidity enables the construction of low-power, monolithic CMOS Sensor ICs with low drift and hysteresis, and excellent long term stability. The Si7021 offers an accurate, low-power, factory-calibrated digital solution ideal for measuring humidity, dew-point, and temperature in applications ranging from HVAC/R and asset tracking to industrial and consumer platforms.

On the ZGM230S Dev Kit, the Si7021 is connected through a switch. The switch must therefore be enabled by setting PC07 high before it can be used by the application. This enables power to the Si7021 and connects the I^{2}C lines used for the sensor to the ZGM230S I^{2}C bus. The application code should always drive the PC07 signal either high or low to prevent it from floating. The figure below shows how the Si7021 is connected to the ZGM230S.
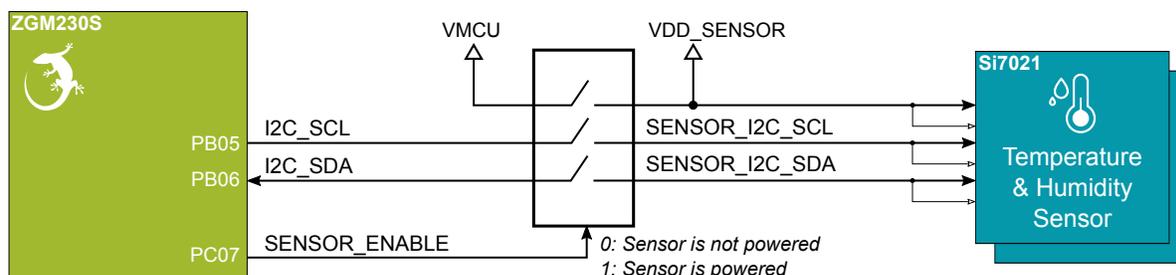

Figure 3.4. Si7021 Relative Humidity and Temperature Sensor

Although measures have been taken to thermally isolate the sensor from the board, temperature readings will be influenced when power is dissipated on the board. More accurate temperature measurements are achieved when powering the board with a battery or through the Mini Simplicity connector as self-heating from the on-board LDO is eliminated and the on-board debugger is put in a low-power state.

3.4.2 Si7210 Hall Effect Sensor

The Si7210 family of Hall effect sensors from Silicon Labs combines a chopper-stabilized Hall element with a low-noise analog amplifier, 13-bit analog-to-digital converter, and an I^{2}C interface. Leveraging Silicon Labs' proven CMOS design techniques, the Si7210 family incorporates digital signal processing to provide precise compensation for temperature and offset drift. The 13-bit magnetic field strength can be read through the I^{2}C interface at any time. Applications for the Si7210 include mechanical position sensing in consumer, industrial, and automotive applications, reed switch replacement, fluid level measurement, speed sensing, and control knobs, and switches.

On the ZGM230S Dev Kit, the Si7210 is connected through a switch. The switch must therefore be enabled by setting PC07 high before it can be used by the application. This enables power to the Si7210 and connects the I^{2}C lines used for the sensor to the ZGM230S I^{2}C bus. The application code should always drive the PC07 signal either high or low to prevent it from floating. The figure below shows how the Si7210 is connected to the ZGM230S.
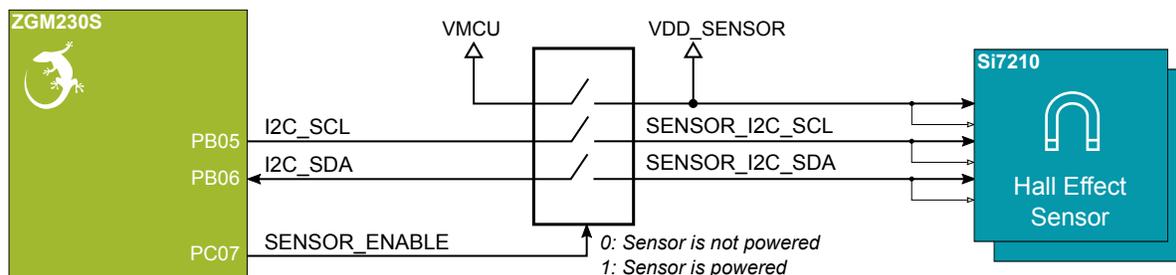

Figure 3.5. Hall Effect Sensor

3.4.3 ICM-20689 6-Axis Inertial Sensor

The ICM-20689 is a 6-axis inertial sensor consisting of a 3-axis gyroscope and a 3-axis accelerometer. The sensor detects acceleration and angular rate in and around the X-, Y-, and Z-axes with integrated 16-bit ADCs and programmable digital filters.

On the ZGM230S Dev Kit, the ICM-20689 is connected through a switch. The switch must be enabled by setting PD03 high before it can be used by the application. This enables power to the ICM-20689 and connects the SPI lines used for the sensor to the ZGM230S SPI bus. The application code should always drive the PD03 signal either high or low to prevent it from floating. Note the presence of the external pull-up resistor on the interrupt line as this can cause back powering if not handled correctly in software. The SPI CS line is also exported on the breakout pads, so simultaneous SPI operation on the breakout pads and IMU is not possible unless an alternative pin is used for SPI CS on the breakout pads. The figure below shows how the ICM-20689 is connected to the ZGM230S.
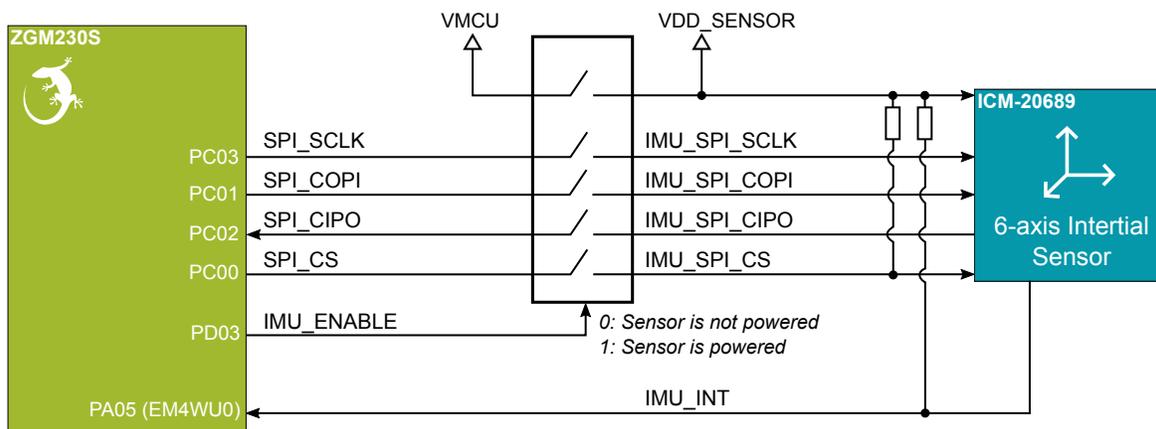

Figure 3.6. ICM-20689 6-Axis Inertial Sensor

The inertial sensor is located close to the geometrical center of the board. The coordinate system and rotation of the sensor follows the right-hand rule, and the spatial orientation of the board is shown in the figure below.
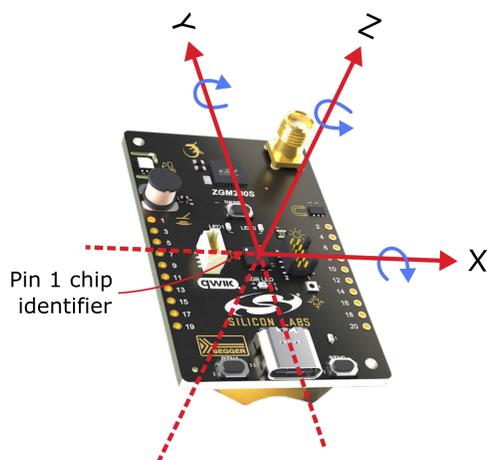

Figure 3.7. ZGM230S Dev Kit Spatial Orientation

3.4.4 VEML6035 Ambient Light Sensor

The VEML6035 is an ambient light sensor with I^2C digital interface.

On the ZGM230S Dev Kit, the VEML6035 is connected through a switch. The switch must therefore be enabled by setting PC07 high before it can be used by the application. This enables power to the VEML6035 and connects the I^2C lines used for the sensor to the ZGM230S I^2C bus. The application code should always drive the PC07 signal either high or low to prevent it from floating. The figure below shows how the VEML6035 is connected to the ZGM230S.
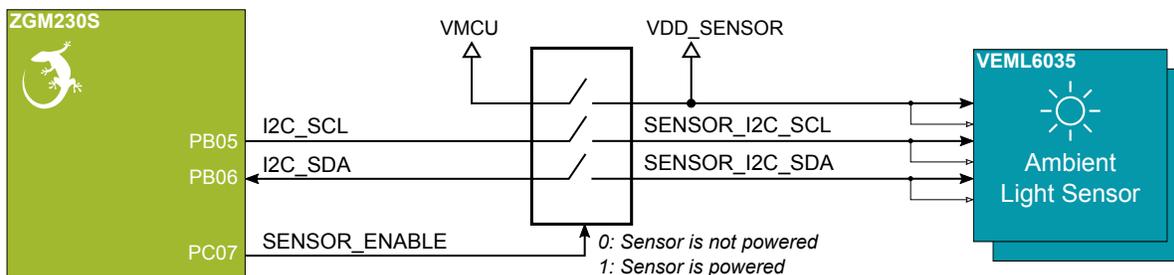

Figure 3.8. VEML6035 Ambient Light Sensor

3.4.5 BMP384 Barometric Pressure Sensor

The BMP384 is a combined absolute barometric pressure sensor and temperature sensor with a digital interface supporting both SPI and I^2C. No external sensing elements are needed, and the device has an integrated ADC and ASIC with built-in configurable IIR filter to suppress noise. Selectable oversampling rates provide trade-off between low power and high resolution, and an option to skip either temperature or pressure measurement is available in case one or the other is unnecessary.

On the ZGM230S Dev Kit, the BMP384 is connected through a switch. The switch must therefore be enabled by setting PC07 high before it can be used by the application. This enables power to the BMP384 and connects the I^2C lines used for the sensor to the ZGM230S I^2C bus. The I^2C lines are shared with other on-board I^2C peripherals. The application code should always drive the PC07 signal either high or low to prevent it from floating. The I^2C bus is shared with the Qwiic Connector and is also exported on the breakout pads. The figure below shows how the BMP384 is connected to the ZGM230S.
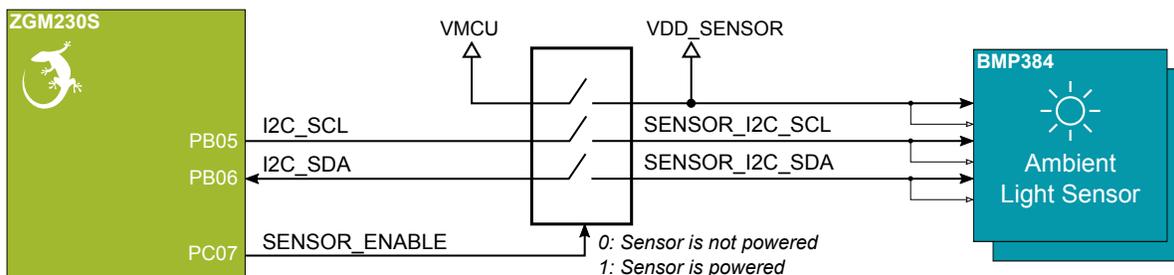

Figure 3.9. BMP384 Absolute Pressure Sensor

3.4.6 External Memory

The ZGM230S Dev Kit includes an 8 Mbit Macronix SPI Flash that is connected directly to the ZGM230S. The MX25R series are ultra-low power serial flash devices, so there is no need for a separate enable switch to keep current consumption down. However, it is important that the flash is always put in deep power down mode when not used. This is done by issuing a command over the SPI interface. In deep power down, the MX25R typically adds approximately 100 nA to the current consumption. The figure below shows how the serial flash is connected to the ZGM230S.
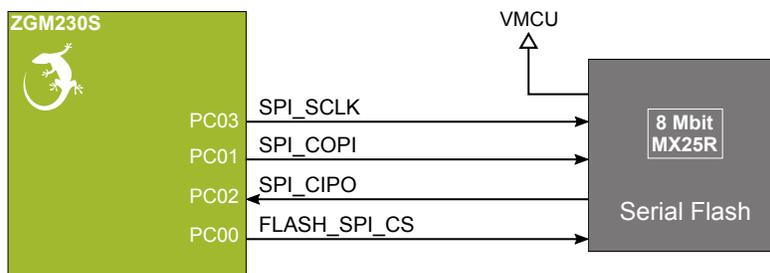

Figure 3.10. Serial Flash

3.4.7 Push Buttons, Single-color LEDs and RGB LED

The kit has two user push buttons marked BTN0 and BTN1. They are connected directly to the ZGM230S and are debounced by RC filters with a time constant of 1 ms. The buttons are connected to pins PB03 and PB02.

The kit also features two yellow LEDs marked LED0 and LED1 that are controlled by GPIO pins on the ZGM230S. The LEDs are connected to pins PC08 and PC09 in an active-high configuration.

The kit has an RGB LED marked LED100, controlled by GPIO pins on the ZGM230S. The LED is connected in an active-low configuration, and each color can be PWM controlled using the ZGM230S's TIMER peripherals to generate a wide variety of colors.
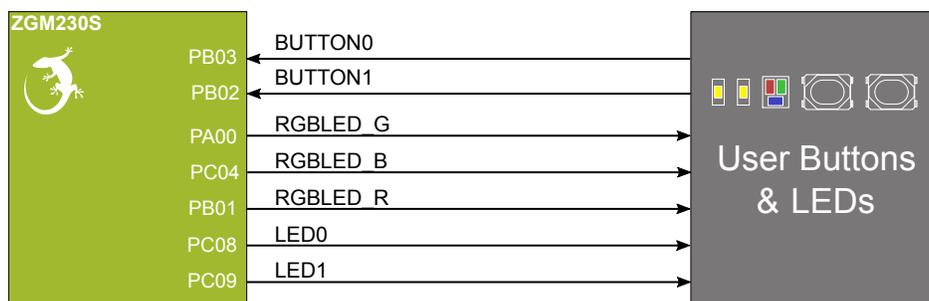

Figure 3.11. Buttons and LEDs

3.4.8 Metal Detector (LC Sensor)

An inductive-capacitive sensor for demonstrating the Low Energy Sensor Interface (LESENSE) is located on the top left of the board. The LESENSE peripheral uses the voltage digital-to-analog converter (VDAC) to set up an oscillating current through the inductor and then uses the analog comparator (ACMP) to measure the oscillation decay time. The oscillation decay time will be affected by the presence of metal objects within a few millimeters of the inductor.

The LC sensor can be used for implementing a sensor that wakes up the ZGM230S from sleep when a metal object comes close to the inductor, which again can be used as a utility meter pulse counter, door alarm switch, position indicator or other applications where one wants to sense the presence of a metal object.
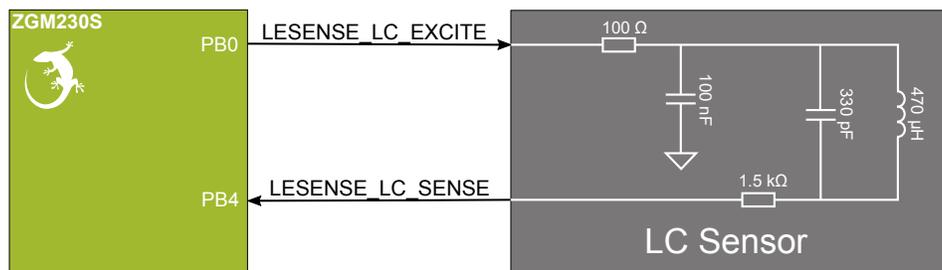
Figure 3.12. LC Metal Sensor

For more information about the LC sensor usage and operation, refer to the application note, "AN0029: Low Energy Sensor Interface -- Inductive Sense", which is available in Simplicity Studio or in the document library on the Silicon Labs website.
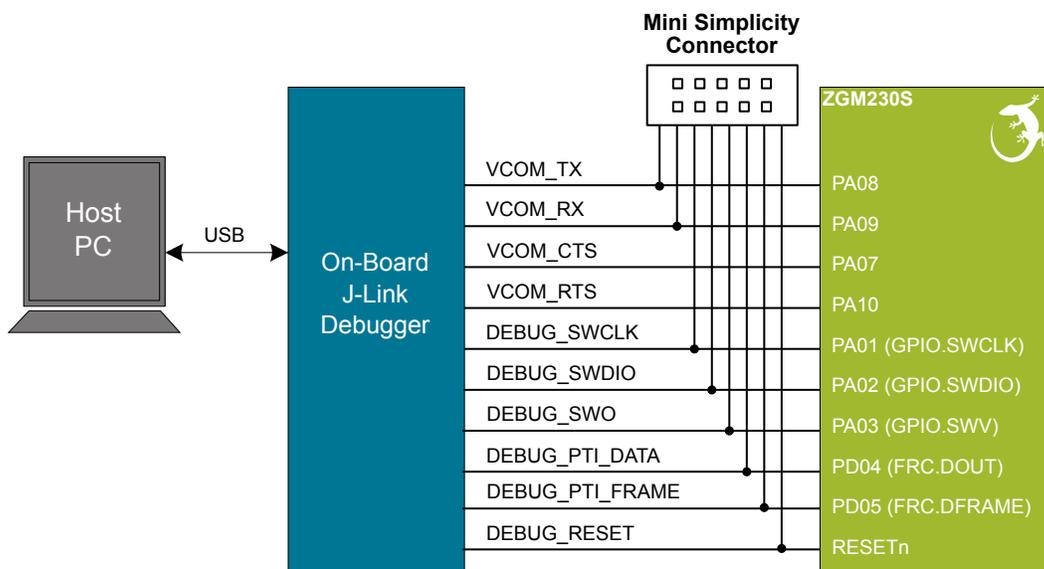
3.5 On-board Debugger

The ZGM230S Dev Kit contains a microcontroller separate from the ZGM230S Z-Wave SiP Module 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).

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 ZGM230S device and the on-board debugger. The figure also shows the Mini Simplicity Connector, and how this is connected to the same I/O pins.

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

Figure 3.13. On-Board Debugger Connections

3.6 Connectors

The ZGM230S Dev Kit features a Mini Simplicity Connector, a USB Type-C connector, and 20 breakout pads that follow the EXP header pinout. The connectors are placed on the top side of the board, and their placement and pinout are seen shown the figure below. For additional information on the connectors see the following sub-chapters.
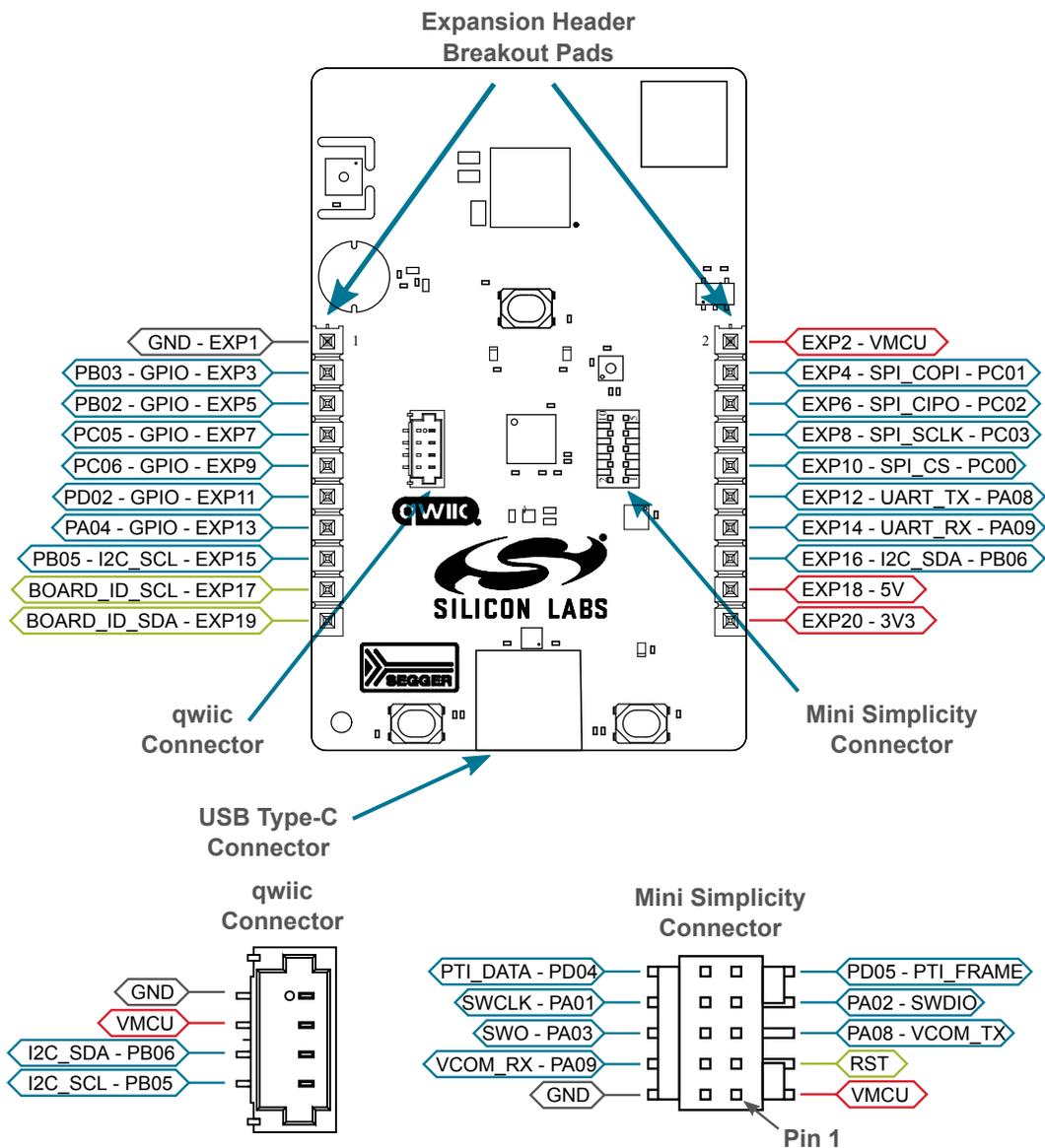
Expansion Header Breakout Pads

GND - EXP1
PB03 - GPIO - EXP3
PB02 - GPIO - EXP5
PC05 - GPIO - EXP7
PC06 - GPIO - EXP9
PD02 - GPIO - EXP11
PA04 - GPIO - EXP13
PB05 - I2C_SCL - EXP15
BOARD_ID_SCL - EXP17
BOARD_ID_SDA - EXP19

EXP2 - VMCU
EXP4 - SPI_COPI - PC01
EXP6 - SPI_CIPO - PC02
EXP8 - SPI_SCLK - PC03
EXP10 - SPI_CS - PC00
EXP12 - UART_TX - PA08
EXP14 - UART_RX - PA09
EXP16 - I2C_SDA - PB06
EXP18 - 5V
EXP20 - 3V3

qwiic Connector

Mini Simplicity Connector

USB Type-C Connector

qwiic Connector

GND
VMCU
I2C_SDA - PB06
I2C_SCL - PB05

Mini Simplicity Connector

PTI_DATA - PD04
SWCLK - PA01
SWO - PA03
VCOM_RX - PA09
GND

PD05 - PTI_FRAME
PA02 - SWDIO
PA08 - VCOM_TX
RST
VMCU

Pin 1

Figure 3.14. ZGM230S Dev Kit Connectors

3.6.1 Breakout Pads

Twenty breakout pads, which follow the EXP header pinout, are provided and allow connection of peripherals or add-on boards. Ten of the pads are located along the left side of the board and ten are located on the right side. The breakout pads expose I/O pins that can be used with most of the ZGM230S's features. Additionally, the VMCU (main power rail), 3V3 (LDO regulator output), and 5V power rails are also exposed.

The breakout pads are pinned out similar to the EXP header found on other Silicon Labs Starter Kits, which ensures that commonly used peripherals such as SPI, UART, and I^{2}C buses are available on fixed locations. The rest of the pins are used for general purpose IO. The EXP header allows the definition of EXP boards that can plug into a number of different Silicon Labs starter kits.

The pin-routing on ZGM230S 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 ZGM230S Dev Kit. The table below includes an overview of the EXP header and functionality that is shared with the kit.

Table 3.2. Expansion Header Pinout

Pin	Connection	EXP Header Function	Shared Feature
		Right Side Breakout Pins	
2	VMCU	ZGM230S voltage domain, included in AEM measurements.	
4	PC01	SPI_COPI	IMU & Flash
6	PC02	SPI_CIPO	IMU & Flash
8	PC03	SPI_SCLK	IMU & Flash
10	PC00	SPI_CS	IMU
12	PA08	UART_TX	Virtual COM Port
14	PA09	UART_RX	Virtual COM Port
16	PB06	I2C_SDA	Sensor I2C bus
18	5V	Board USB voltage	
20	3V3	Board controller supply	
		Left Side Breakout Pins	
1	GND	Ground	
3	PB03	GPIO	Button 0
5	PB02	GPIO	Button 1
7	PC05	GPIO	
9	PC06	GPIO	
11	PD02	GPIO	
13	PA04	GPIO	
15	PB05	I2C_SCL	Sensor I2C bus
17	BOARD_ID_SCL	Connected to Board Controller for identification of add-on boards.	
19	BOARD_ID_SDA	Connected to Board Controller for identification of add-on boards.	

3.6.2 Qwiic Connector

The ZGM230S Dev Kit features a Qwiic connector compatible with Qwiic Connect System hardware. The Qwiic connector provides an easy way to expand the functionality of the ZGM230S Dev Kit with sensors, LCDs, and other peripherals over the I^2C 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^2C device in the chain has a unique I^2C address.

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

The table below gives an overview of the Qwiic connections to the ZGM230S.

Table 3.3. Qwiic Connector Pinout

Qwiic Pin	Connection	Shared Feature
Ground	GND	
3.3V	VMCU	
SDA	PB06	Breakout pads, I^2C sensors
SCL	PB05	Breakout pads, I^2C sensors

3.6.3 Mini Simplicity Connector

The Mini Simplicity connector is a 10-pin 1.27 mm pitch connector that allows the use of an external debugger such as the one found on a Silicon Labs Wireless Starter Kit mainboard. See section 4.2 External Debugger for more details. The pinout of the connector on the board is described in the table below with the names being referenced from the ZGM230S.

Table 3.4. Mini Simplicity Connector Pin Descriptions

Pin number	Function	Connection	Description
1	AEM	VMCU	Target voltage on the debugged application. May be supplied and monitored by the AEM on an external debugger.
2	GND	GND	Ground
3	RST	RESET	ZGM230S reset
4	VCOM_RX	PA09	Virtual COM Rx
5	VCOM_TX	PA08	Virtual COM Tx
6	SWO	PA03	Serial Wire Output
7	SWDIO	PA02	Serial Wire Data
8	SWCLK	PA01	Serial Wire Clock
9	PTI_FRAME	PD05	Packet Trace Frame
10	PTI_DATA	PD04	Packet Trace Data

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 ZGM230S Dev Kit contains an on-board SEGGER J-Link Debugger that interfaces to the target ZGM230S using the Serial Wire Debug (SWD) interface. The debugger allows the user to download code and debug applications running in the target ZGM230S. Additionally, it also provides a VCOM port 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.

An external debugger can be used instead of the on-board debugger by connecting it to the Mini Simplicity Connector. This allows advanced debugging features as described in section 4.2 External Debugger. When using an external debugger it is very important to make sure that there is no power source present on the ZGM230S Dev Kit, as the external debugger might source a voltage on the target power domain (VMCU).

Important: When connecting an external debugger that sources voltage to the VMCU net, the USB cable and battery must be removed from the ZGM230S Dev Kit. Failure to do so will create power conflicts.

The figure below shows the possible debug options.
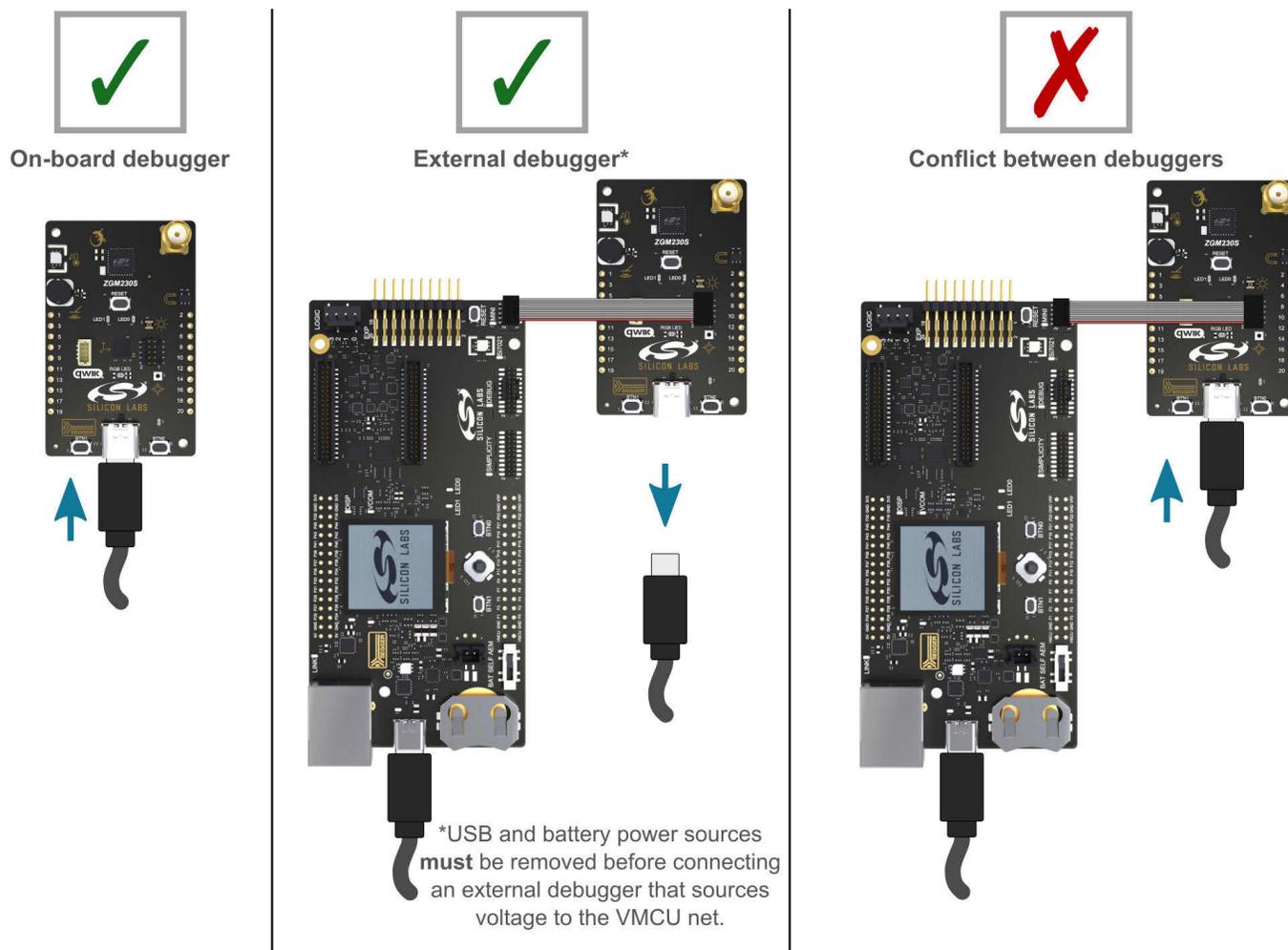
Figure 4.1. ZGM230S Dev Kit Debugging Possibilities

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 ZGM230S.

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.

When the USB cable is removed, the board might still be running on battery power, as described in section 3.2 Power Supply. In this case, the on-board debugger goes into a very low power shutoff mode (EM4S), consuming about 80 nA. This means that battery life-time will not be affected too much by the on-board debugger power consumption. Since the I/O voltage rail of the debugger remains powered in the battery-operated mode, the pins connected to the debug and VCOM interfaces maintain proper isolation and prevent leakage currents.

4.2 External Debugger

A Wireless mainboard from Silicon Labs can be connected to the Mini Simplicity Connector and used for debugging instead of the on-board debugger. For instruction on using the mainboard for debugging, see AN958: Debugging and Programming Interfaces for Custom Designs. Note that the Wireless STK Mainboard (BRD4001A) requires a BRD8010A STK/WSTK Debug Adapter to get access to the Mini Simplicity Connector. Debugging with an external Wireless mainboard gives access to the following debugging features:

• Debugging of the target device through SWD
• Communication using the VCOM port
• Packet Trace Interface (for wireless devices only)
• Advanced Energy Monitor

Note that the Mini Simplicity Connector *cannot* be used at the same time that the on-board debugger is active (USB cable is plugged in). For information on how to correctly connect to the kit, see Figure 4.1 ZGM230S Dev Kit Debugging Possibilities on page 21.

Powering the board when using the Mini Simplicity Connector with a Wireless mainboard can be done using the AEM voltage supply of the Wireless mainboard. When doing this, remove both the USB cable and the coin cell battery from the ZGM230S Dev Kit before connecting the Wireless mainboard to the Mini Simplicity Connector. The power switch on the Wireless mainboard should be set in "AEM". Power-cycling of the board, if necessary, is easily done by flipping the power switch on the Wireless to "BAT" and back to "AEM", assuming a battery is not inserted in the Wireless mainboard.

It is possible to have the ZGM230S Dev Kit powered by a battery, and still use the Mini Simplicity Connector with a Wireless mainboard for debugging and communication. In this case, the power switch on the Wireless mainboard must be set to the "BAT" position and the coin cell battery on the Wireless mainboard must be removed. In this case, level shifters on the Wireless mainboard itself take care of interfacing to different voltage levels on the ZGM230S Dev Kit. Connecting the board to an external debugger in other ways than those described above might create power conflicts, compromise the ability to monitor power consumption, and hazardously feed power back to the on-board battery.

Important: Always remove the battery if you are not sure whether the external debugger is sourcing voltage to ZGM230S Dev Kit.

4.3 Virtual COM Port

The virtual COM port (VCOM) is a connection to a UART on the ZGM230S and allows serial data to be sent and received from the device. The on-board debugger presents this connection 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. However, it is possible to change the VCOM baud rate through the kits' Admin Console available through Simplicity Studio.

Alternatively, the VCOM port can also be used through the Mini Simplicity Connector with an external Wireless mainboard. Using the VCOM port through the Mini Simplicity Connector with an external Wireless mainboard works in a similar way, but requires that the USB cable to the on-board debugger is unplugged. The board controller on the Wireless mainboard then makes the data available over USB (CDC) or an IP socket. Flow control is not available over the Mini Simplicity Connector.

5. Radio

5.1 Introduction

The ZGM230SB27HGN3 module includes a 50 Ω-matched RFIO pin. On the ZGM230S Dev Kit (BRD2603A board), the pin is connected to an SMA connector, enabling conducted measurements or attachment of an external antenna for radiated measurements.

This section gives a short introduction to the RF performance of the BRD2603A board.

5.2 EMC Compliance

5.2.1 Introduction

BRD2603A Dev Kit fundamental and harmonic levels compliance is tested against the following standards:
- 868.4 MHz:
  - ETSI EN300-220-1
- 908.4 MHz:
  - FCC 15.247
- 921.4 MHz:
  - ARIB-T108

5.2.2 EMC Regulation Emission Limits

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 5.1. 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.

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).

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.

5.2.2.3 ARIB STD-T108 Emission Limits for the 920.5-923.5 MHz Band

Based on ARIB STD-T108, the allowed maximum fundamental power for the 920.5-923.5 MHz band is 250 mW (24 dBm) both for conducted and radiated measurements.

For the unwanted emission limits, see the table below.

Table 5.2. ARIB STD-T108 Spurious Domain Emission Limits (Conducted)

Frequency	710 - 900 MHz 900 - 915 MHz 930 - 1000 MHz	920.3 - 924.3 MHz (except for |f-fc| <= (200+100xn) kHz)	Other frequencies below 1000 MHz	1000 - 1215 MHz	Frequencies above 1215 MHz
Spurious Emission Limits	-55 dBm	-29 dBm	-36 dBm	-45 dBm	-30 dBm
Secondary Emission Limits (Receiver)	-55 dBm	—	-54 dBm	-47 dBm	-47 dBm

The above limits are also applied for the radiated measurements (assuming 0 dB antenna gain).

5.3 RF Performance

5.3.1 Conducted Power Measurements

During the conducted measurements, the BRD2603A board was supplied through its USB connector by connecting to a PC through a USB cable. The supply for the RF section (RFVDD) and the power amplifier (PAVDD) was 1.8 V provided by the on-chip DCDC converter.

The RF output of the board was connected directly to a Spectrum Analyzer. The transceiver was operated in continuous carrier transmission mode, the output power was set to 14 dBm.

5.3.1.1 Conducted Power Measurements

The typical output spectrums are shown in the following figures.
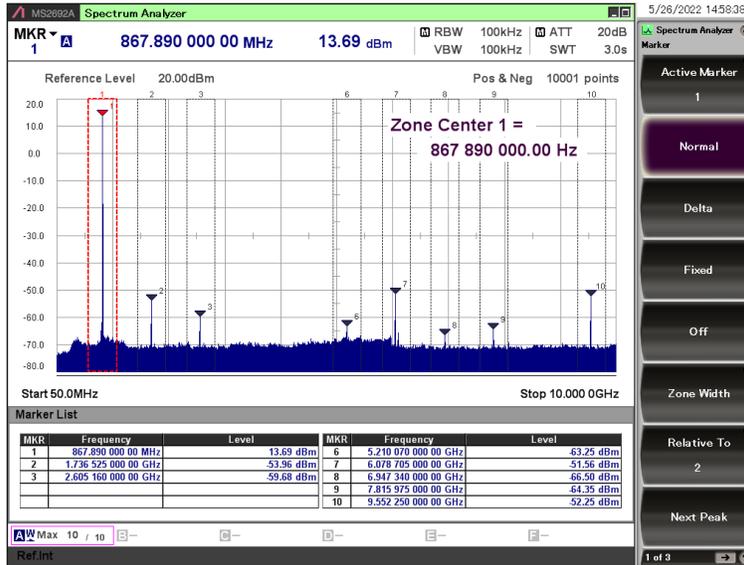
Figure 5.1. Typical Output Spectrum of the BRD2603A in the 868 MHz Band
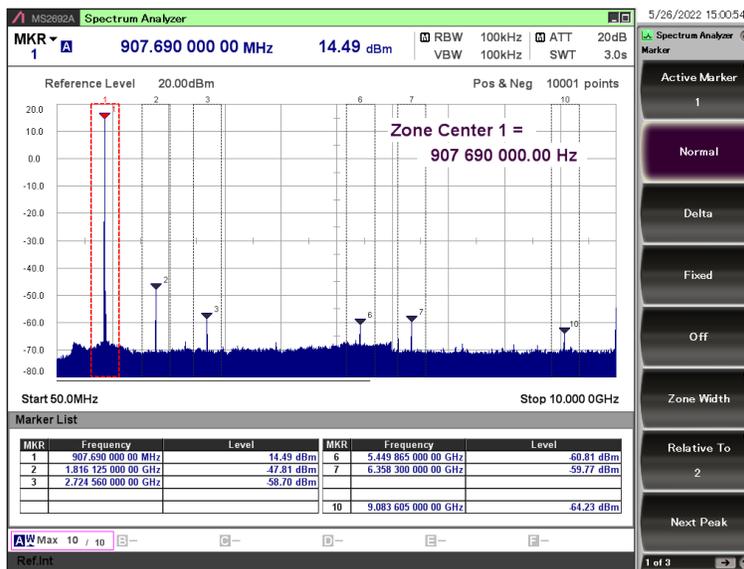
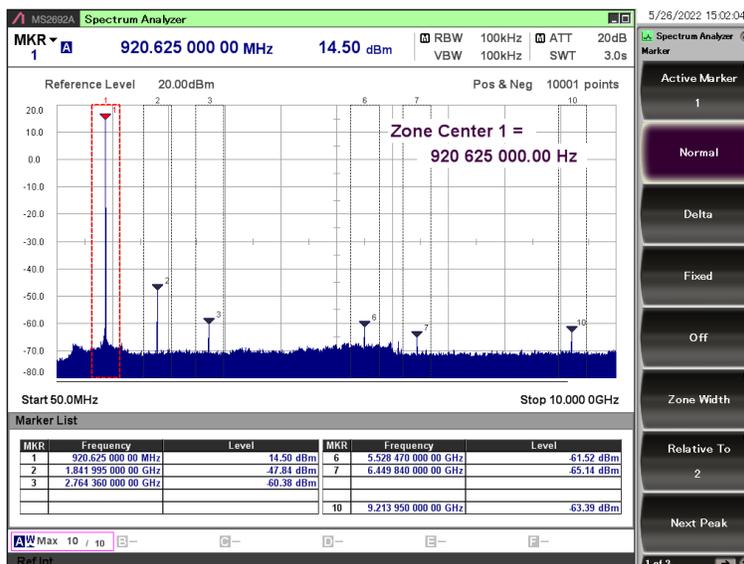**Figure 5.2. Typical Output Spectrum of the BRD2603A in the 908 MHz Band**

Figure 5.3. Typical Output Spectrum of the BRD2603A in the 921 MHz Band

As shown in the figures, the fundamental is a bit lower than 14 dBm in the 868 MHz bans, and a bit higher than 14 dBm in the bands above 900 MHz. So, it is under the ETSI, FCC, and ARIB limits in all bands. The unwanted emissions are also under their corresponding limit, so the conducted spectrums are compliant with the regulation limits.

5.3.2 Radiated Power Measurements

The output power of the ZGM230S was set to 14 dBm. The board was supplied through its USB connector by connecting to a PC through a USB cable.

During the measurements, 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.
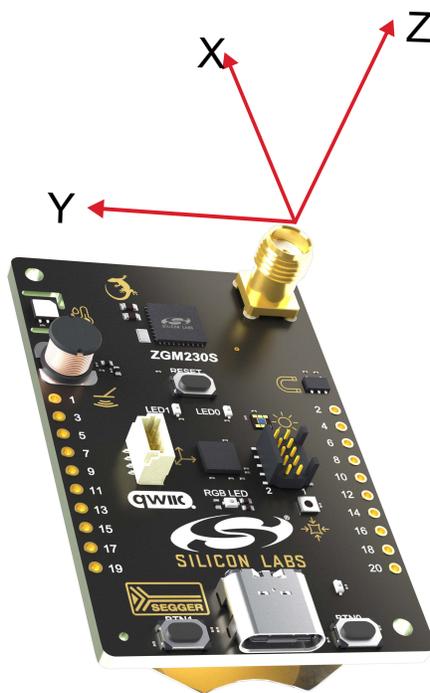
Figure 5.4. DUT Reference Planes

5.3.2.1 Radiated Measurements

For the radiated power measurements, an external compressed whip antenna (LPRS ANT-SS900) was used as a transmitter antenna. It was connected to the on-board SMA connector.

The measured radiated powers are shown in the table below.

Table 5.3. Maximums of the Measured Radiated Powers of BRD2603A

Frequency (868 MHz)	Measured Unmodulated EIRP [dBm]	Orientation	Margin [dB]	Limit in EIRP [dBm]
Fund	14.9	XZ/H	1.2	16.1
2nd	-56.8	XZ/H	28.9	-27.9
3rd	-58.2	YZ/H	30.3	-27.9
4th	-64.0	XY/V	36.1	-27.9
5th	-61.9	YZ/H	34.0	-27.9
6th	-59.4	XY/H	31.5	-27.9
7th	-55.0	YZ/H	27.1	-27.9
8th	-59.0	XZ/H	31.1	-27.9
9th	-48.1	XZ/H	20.2	-27.9
10th	-52.4	XZ/V	24.5	-27.9

Table 5.4. Maximums of the Measured Radiated Powers of BRD2603A

Frequency (908 MHz)	Measured Unmodulated EIRP [dBm]	Orientation	Margin [dB]	Limit in EIRP [dBm]
Fund	16.1	XZ/H	13.9	30.0
2nd	-53.0	XZ/H	>25.0	-20 dBc
3rd	-58.7	XY/H	17.5	-41.2
4th	<-65.0*	—	>25.0	-41.2.
5th	<-65.0*	—	>25.0	-41.2
6th	-60.9	XZ/V	19.7	-41.2
7th	-59.5	XY/H	>25.0	-20 dBc
8th	-58.5	XZ/V	17.3	-41.2
9th	-50.4	XY/V	9.2	-41.2
10th	-52.2	XZ/H	11.0	-41.2
* Signal level is below the Spectrum Analyzer noise floor.				

Table 5.5. Maximums of the Measured Radiated Powers of BRD2603A

Frequency (921 MHz)	Measured Unmodulated EIRP [dBm]	Orientation	Margin [dB]	Limit in EIRP [dBm]
Fund	14.3	XZ/H	9.7	24.0
2nd	-57.7	XY/V	27.7	-30.0
3rd	-61.0	XZ/H	31.0	-30.0
4th	-61.3	XZ/H	31.3	-30.0
5th	-60.3	XZ/H	30.3	-30.0
6th	-57.7	XZ/V	27.7	-30.0
7th	-56.9	XZ/H	26.9	-30.0
8th	-54.9	XY/V	24.9	-30.0
9th	-47.4	XZ/H	17.4	-30.0
10th	-49.3	XZ/H	19.3	-30.0

As shown in the tables above, the fundamental is below the regulation limits in all bands. The harmonics are also compliant with large margins.

5.3.2.2 Antenna Pattern Measurements

The measured normalized antenna patterns are shown in the following figures.
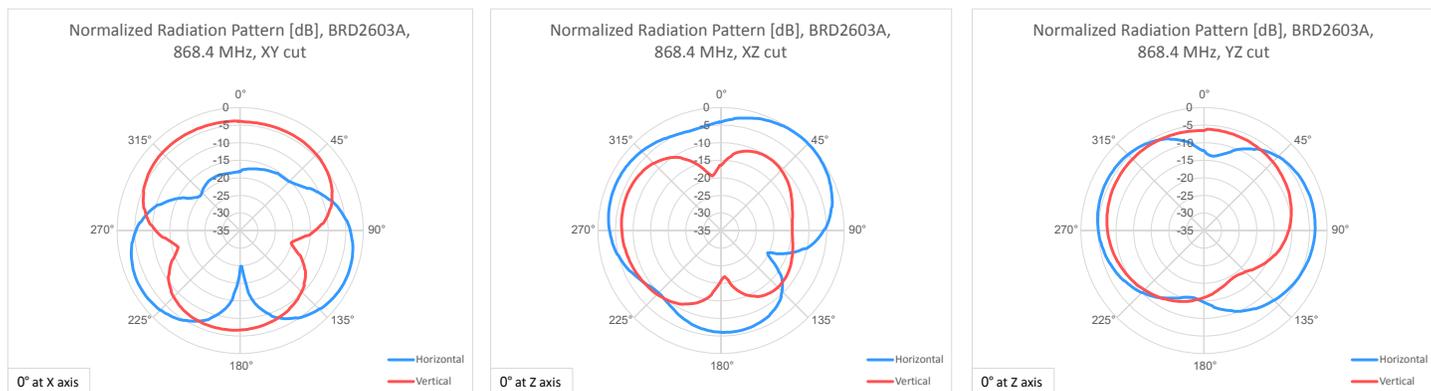
Figure 5.5. Normalized Antenna Pattern in the 868 MHz band
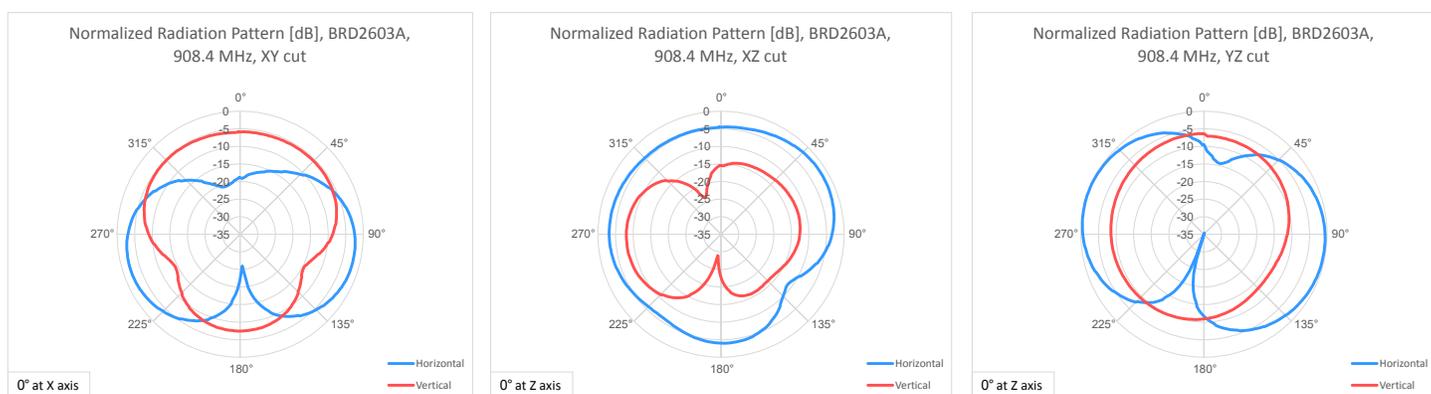
Figure 5.6. Normalized Antenna Pattern in the 908 MHz band
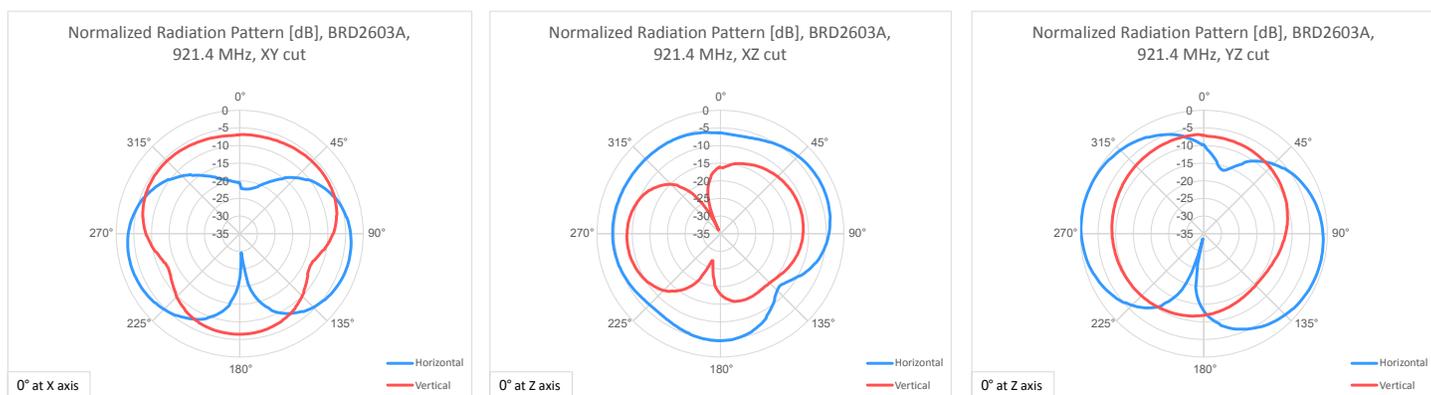
Figure 5.7. Normalized Antenna Pattern in the 921 MHz band

5.4 EMC Compliance Recommendations

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

As shown in the previous section, the BRD2603A board is compliant with the emission limits of the ETSI ETSI EN 300-200-1 regulation in the 868.4 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 BRD2603A board is compliant with the emission limits of the FCC 15.247 regulation in the 908.4 MHz band with 14 dBm output power.

5.4.3 Recommendations for 921 MHz ARIB STD-T108 Compliance

As shown in the previous section, the BRD2603A board is compliant with the emission limits of the ARIB STD-T108 regulation in the 921.4 MHz band with 14 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 and Errata

7.1 Revision History

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

Figure 7.1. Revision Info

Table 7.1. Kit Revision History

Kit Revision	Released	Description
A01	25 May 2022	Initial release revision with BRD2603A Rev. A01.

7.2 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 Table 8.1 Board Revision History on page 33. The revision history given in this section may not list every kit revision. Revisions with minor changes may be omitted.

Table 8.1. Board Revision History

Board	Released	Description
BRD2603A Rev. A01	10 May 2022	Initial release revision.

8.2 Errata

Table 8.2. Board Errata

Board	Problem	Description
BRD2603A Rev. A01	No known erratas.	—

9. Document Revision History

Revision 1.0

June 2022

- Initial document release.

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