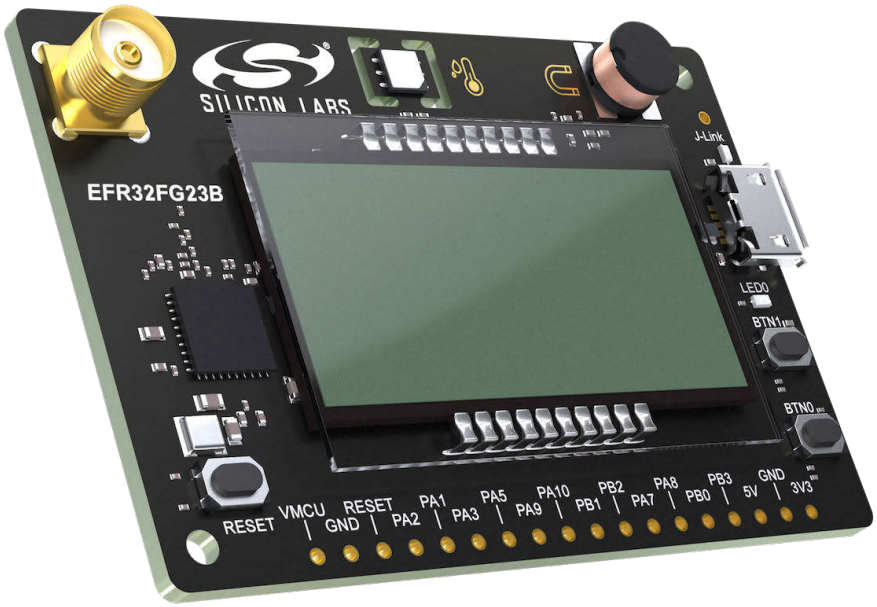
UG508: EFR32FG23 Dev Kit User's Guide

The EFR32FG23 Dev Kit is a low cost, small form factor prototyping and development platform for the EFR32FG23 Wireless System-on-Chip.

The board is small, cost effective, and feature rich. It is an ideal platform for developing energy-friendly connected IoT devices based on the EFR32FG23.

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



TARGET DEVICE

- EFR32FG23 Wireless System-on-Chip (EFR32FG23B010F512IM48)
  - 32-bit ARM® Cortex®-M33 with 78 MHz maximum operating frequency
  - 512 kB flash and 64 kB RAM
  - Energy-efficient radio core with low active and sleep currents
  - Integrated PA with up to 20 dBm (sub-GHz) TX power
  - Robust peripheral set and 31 GPIO

KIT FEATURES

- SMA connector for antenna connection
- 5-digit 7-segment LCD
- Relative humidity and temperature sensor
- LC sensor for metal detection
- User LED and 2 push buttons
- 2.54 mm breakout pads for GPIO access
- 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.

SOFTWARE SUPPORT

- Simplicity Studio™

ORDERING INFORMATION

- FG23-DK2600A

Table of Contents

1. Introduction

The EFR32FG23 Dev Kit has been designed to inspire customers to make battery operated IoT devices with the Silicon Labs EFR32FG23 Wireless System-on-Chip. The highlights of the board include a segment LCD, an Si7021 relative humidity and temperature sensor, and an LC sensor for metal detection.

Programming the EFR32FG23 is easily done using a USB Micro-B cable and the on-board J-Link debugger. A USB virtual COM port (VCOM) 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 EFR32FG23 Dev Kit is supported in Simplicity Studio™, and a Board Support Package (BSP) is provided to give application developers a flying start.

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

Connecting external hardware to the EFR32FG23 Dev Kit can be done using the breakout pads which present 16 GPIOs from the EFR32FG23.

1.1 Kit Contents

The following items are included in the box:

- 1x EFR32FG23 Dev Kit board (BRD2600A)
- 1x 868 MHz antenna (Chilisin BTEA0019130G8R2A01).
- 1x 915 MHz antenna (Chilisin BTEA0019130G9R2A01).
- 1x USB Type A to Micro-B cable.

1.2 Getting Started

Detailed instructions for how to get started with your new EFR32FG23 Dev Kit can be found on the Silicon Labs web pages:

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

1.3 Hardware Content

The following key hardware elements are included on the EFR32FG23 Dev Kit:

- EFR32FG23 with 78 MHz operating frequency, 512 kB flash and 64 kB RAM
- SMA connector for antenna connection
- 5-digit 7-segment LCD
- Silicon Labs Si7021 relative humidity and temperature sensor
- One LED and two push buttons
- 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 (VCOM) and Packet Trace Interface (PTI)
- Mini Simplicity connector for access to energy profiling and advanced wireless network debugging
- Breakout pads for GPIO access and connection to external hardware
- Reset button
- Automatic switchover between USB and battery power
- CR2032 coin cell holder

1.4 Kit Hardware Layout

The layout of the EFR32FG23 Dev Kit is shown below.

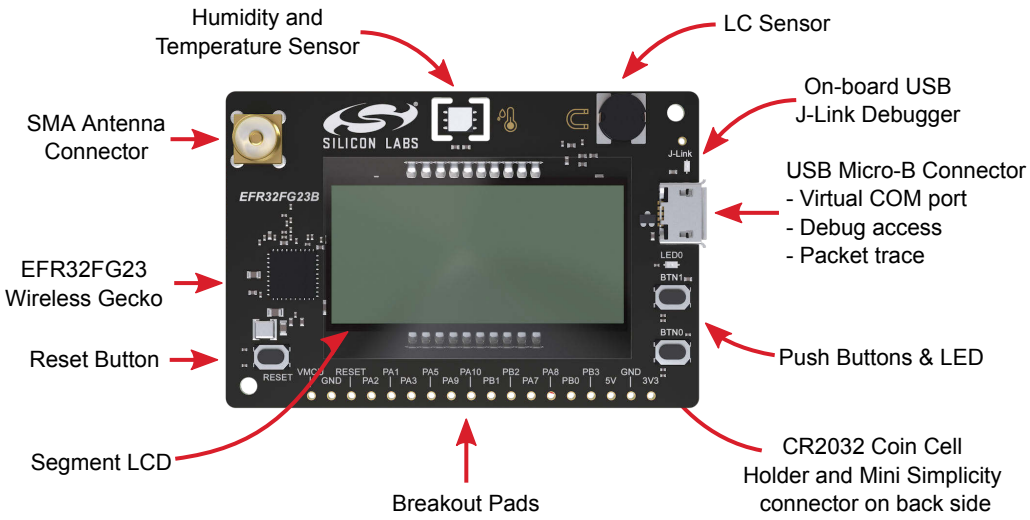


Figure 1.1. EFR32FG23 Dev Kit Hardware Layout

2. Specifications

2.1 Recommended Operating Conditions

The following table is intended to serve as guideline for a correct use of EFR32FG23 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}	2.0	3.0	3.3	V
Supply Input Voltage (VMCU supplied externally)[1,2]	V_{VMCU}	1.8	3.3	3.6	V
Operating Temperature	T_{OP}	—	20	—	˚C

Note:

1. The supply voltage limit may be tighter under certain conditions when using the EFR32FG23's internal dc-dc converter. For more information see the EFR32FG23 data sheet.
2. Not recommended for use with rechargeable Lithium batteries. Most Li-Ion and Li-Po cells exceed 3.6 V when fully charged.

3. Hardware

The core of the EFR32FG23 Dev Kit is the EFR32FG23 Wireless SoC. The board also contains several peripherals connected to the EFR32FG23. Placement and layout of the hardware components are described in section 1.4 Kit Hardware Layout.

3.1 Block Diagram

An overview of the EFR32FG23 Dev Kit is illustrated in the figure below.

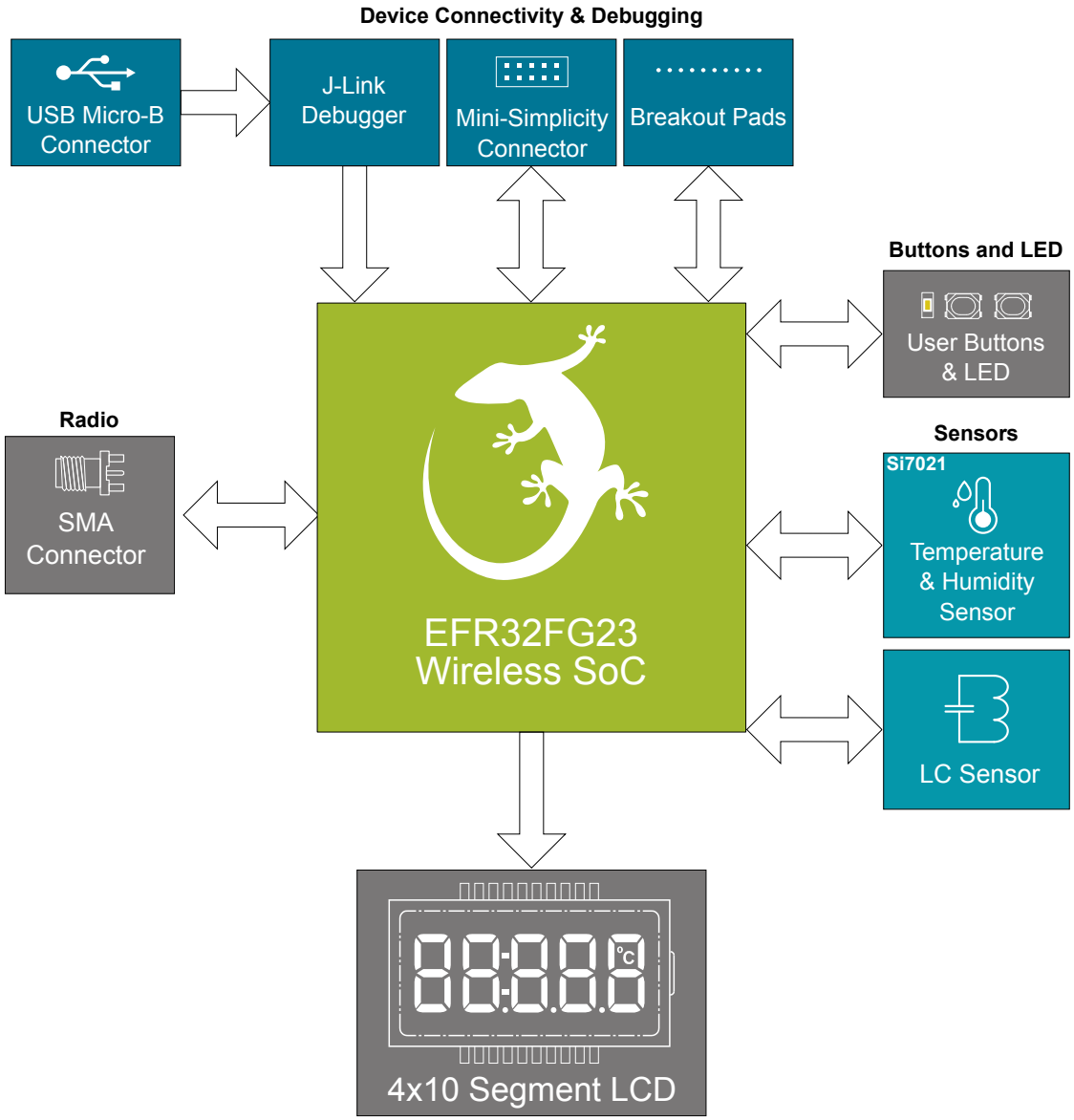


Figure 3.1. Kit Block Diagram

3.2 Power Supply

The kit can be powered through one of these interfaces:

- USB Micro-B
- Battery
- Mini Simplicity connector

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

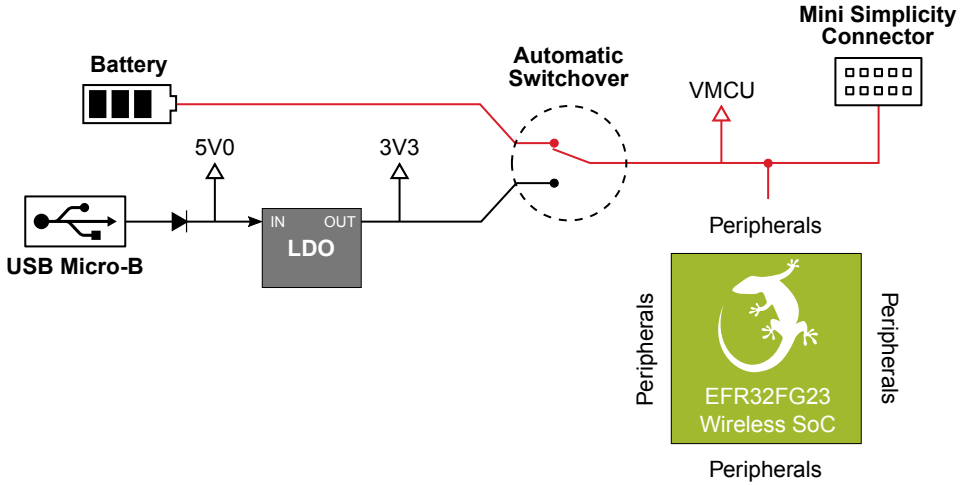


Figure 3.2. EFR32FG23 Dev Kit Power Architecture

Power is normally applied either through the USB cable or 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. This requires that no other power sources are present on the kit, as power is injected directly to the VMCU net. It is important to follow this in order to avoid power conflicts and backfeeding the battery. Powering the EFR32FG23 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. EFR32FG23 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
CR2032 battery	3.0 V	Battery voltage	Disconnected	No voltage present
Mini Simplicity	3.3 V	Debugger dependent	Disconnected	No voltage present

3.3 EFR32FG23 Reset

The EFR32FG23 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 EFR32FG23 Dev Kit contains a set of peripherals that can be accessed from the EFR32FG23:

- One segment LCD
- One Silicon Labs Si7021 relative humidity & temperature sensor
- One LC sensor
- One LED and two push buttons

3.4.1 Segment LCD

A 20-pin segment LCD is connected to the EFR32FG23's LCD peripheral. The LCD has 4 common lines and 10 segment lines, giving a total of 40 segments. These lines are not shared on the breakout pads. Refer to the kit schematic for information on signals to segments mapping.

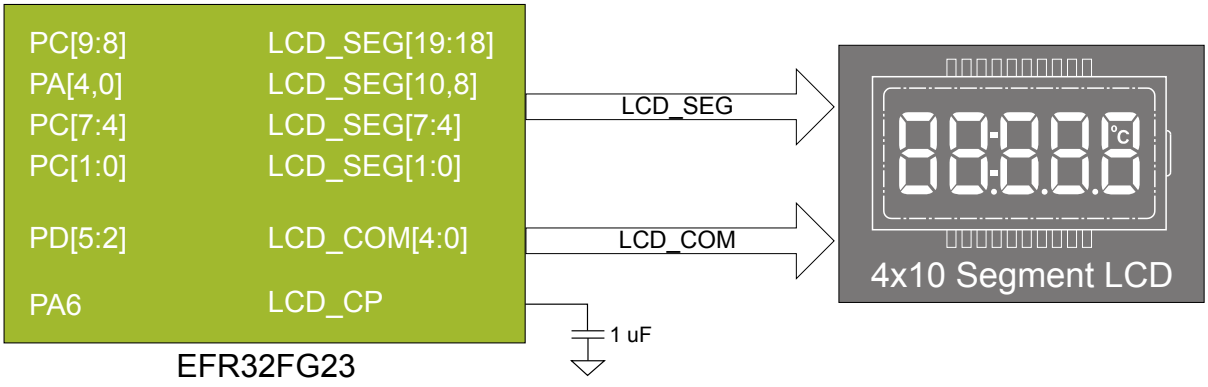


Figure 3.3. Segment LCD

3.4.2 Si7021 Relative Humidity and Temperature Sensor

The Si7021 I²C 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 I²C 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.

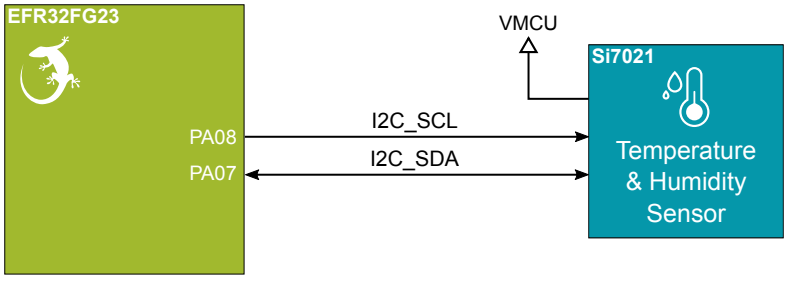


Figure 3.4. Si7021 Relative Humidity and Temperature Sensor

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.

3.4.3 Push Buttons and LED

The kit has two user push button, marked BTN0 and BNT1. They are connected directly to the EFR32FG23 and are debounced by RC filters with a time constant of 1 ms. The logic state of each button is high while the button is not being pressed, and low when the button is pressed. The button connections are shown in the figure below.

The kit also features one yellow LED, marked LED0. The LED is controlled by a GPIO pin on the EFR32FG23 in an active-high configuration. The LED connection is shown in the figure below.

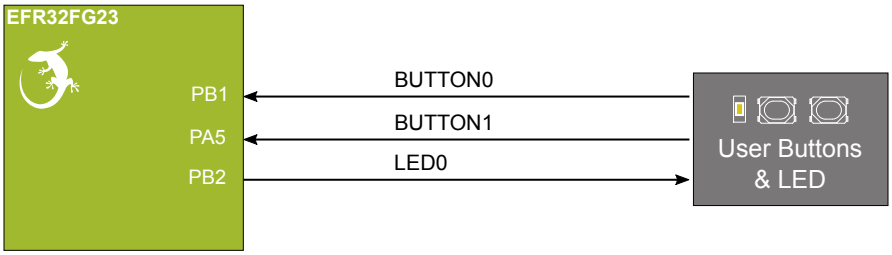


Figure 3.5. Buttons and LED

3.5 On-board Debugger

The EFR32FG23 Dev Kit contains a microcontroller separate from the EFR32FG23 that provides the user with an on-board J-Link debugger through the USB Micro-B 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 EFR32FG23 device and the on-board debugger. The figure also shows the presence of the Mini Simplicity Connector, and how this is connected to the same I/O pins.

Please refer to chapter 4. Debugging for more details on debugging.

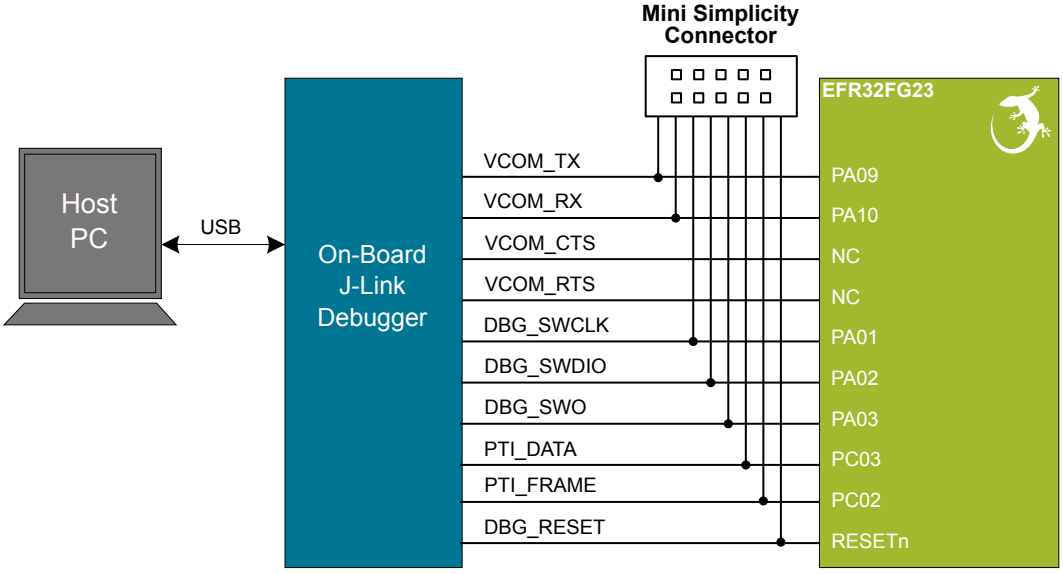


Figure 3.6. On-Board Debugger Connections

3.6 Connectors

Featured on the EFR32FG23 Dev Kit is a Mini Simplicity Connector, a USB Micro-B 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 can be seen in the figure below. For additional information on the connectors see the following sub chapters.

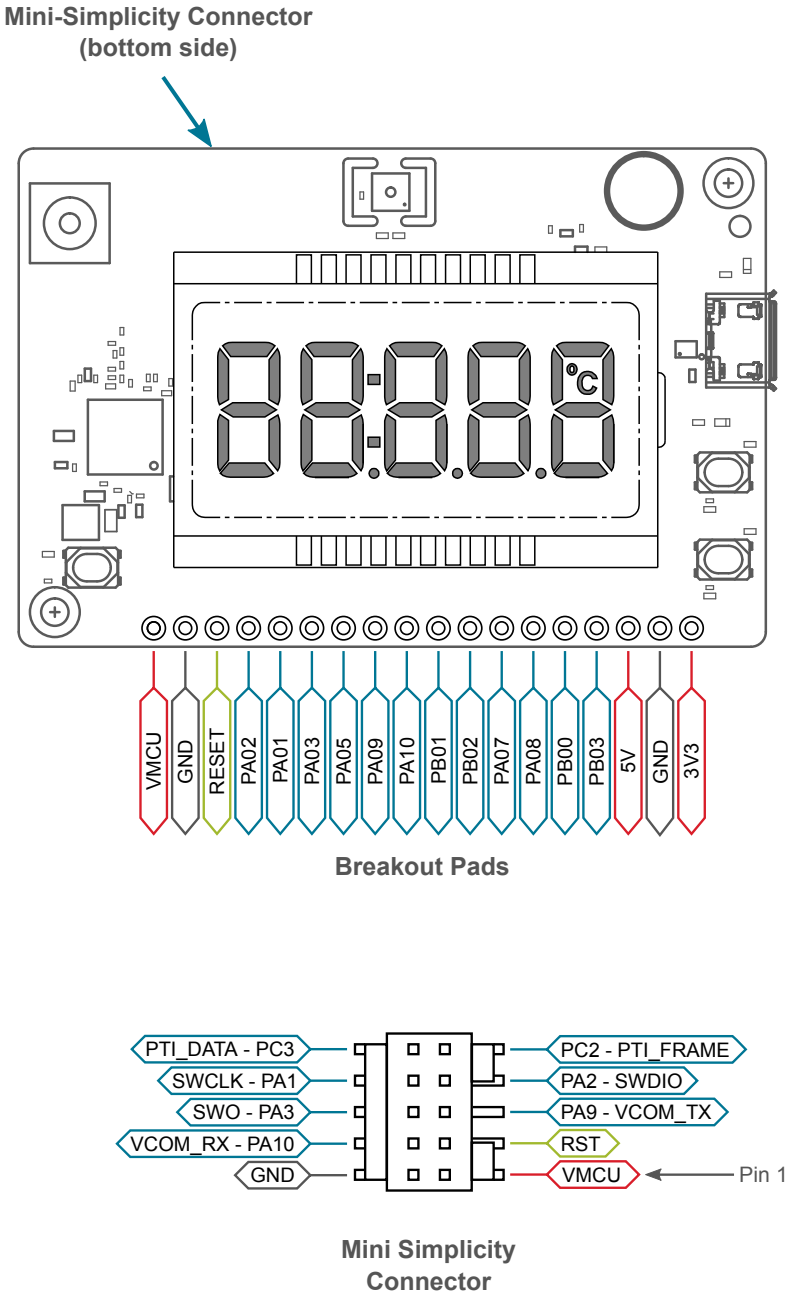


Figure 3.7. EFR32FG23 Dev Kit Connectors

3.6.1 Breakout Pads

18 breakout pads are located on the bottom edge of the board. These allow connection of peripherals or add-on boards. The breakout pads expose I/O pins that can be used with most of the EFR32FG23's features. Additionally, VMCU (main power rail), 3V3 (USB regulator output) and 5V power rails are also exposed.

The pin-routing on EFR32FG23 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 EFR32FG23 Dev Kit. The table below includes an overview of the breakout header and functionality that is shared with the kit.

Table 3.2. Breakout Header Pinout

Pin	Connection	Shared Feature
1	VMCU	VMCU voltage rail
2	GND	Ground
3	RESET	EFR32FG23 reset pin
4	PA2	Debug SWDIO
5	PA1	Debug SWCLK
6	PA3	Debug SWO
7	PA5	BUTTON1
8	PA9	VCOM Tx
9	P10	VCOM Rx
10	PB1	BUTTON0
11	PB2	LED0
12	PA7	Si7021 (I2C SDA)
13	PA8	Si7021 (I2C SCL)
14	PB0	LC sensor excite
15	PB3	LC sensor sense
16	5V	5V voltage rail
17	GND	Ground
18	3V3	3V3 voltage rail

3.6.2 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 (WSTK) 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 EFR32FG23.

Table 3.3. 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	EFR32FG23 reset.
4	VCOM_RX	PA10	Virtual COM Rx
5	VCOM_TX	PA09	Virtual COM Tx
6	SWO	PA03	Serial Wire Output
7	SWDIO	PA02	Serial Wire Data
8	SWCLK	PA01	Serial Wire Clock
9	PTI_FRAME	PC02	Packet Trace Frame
10	PTI_DATA	PC03	Packet Trace Data

3.6.3 Debug USB Micro-B 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 EFR32FG23 Dev Kit contains an on-board SEGGER J-Link Debugger that interfaces to the target EFR32FG23 using the Serial Wire Debug (SWD) interface. The debugger allows the user to download code and debug applications running in the target EFR32FG23. 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 Micro-B 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 EFR32FG23 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 EFR32FG23 Dev Kit. Failure to do so will create power conflicts.

The figure below shows the possible debug options.

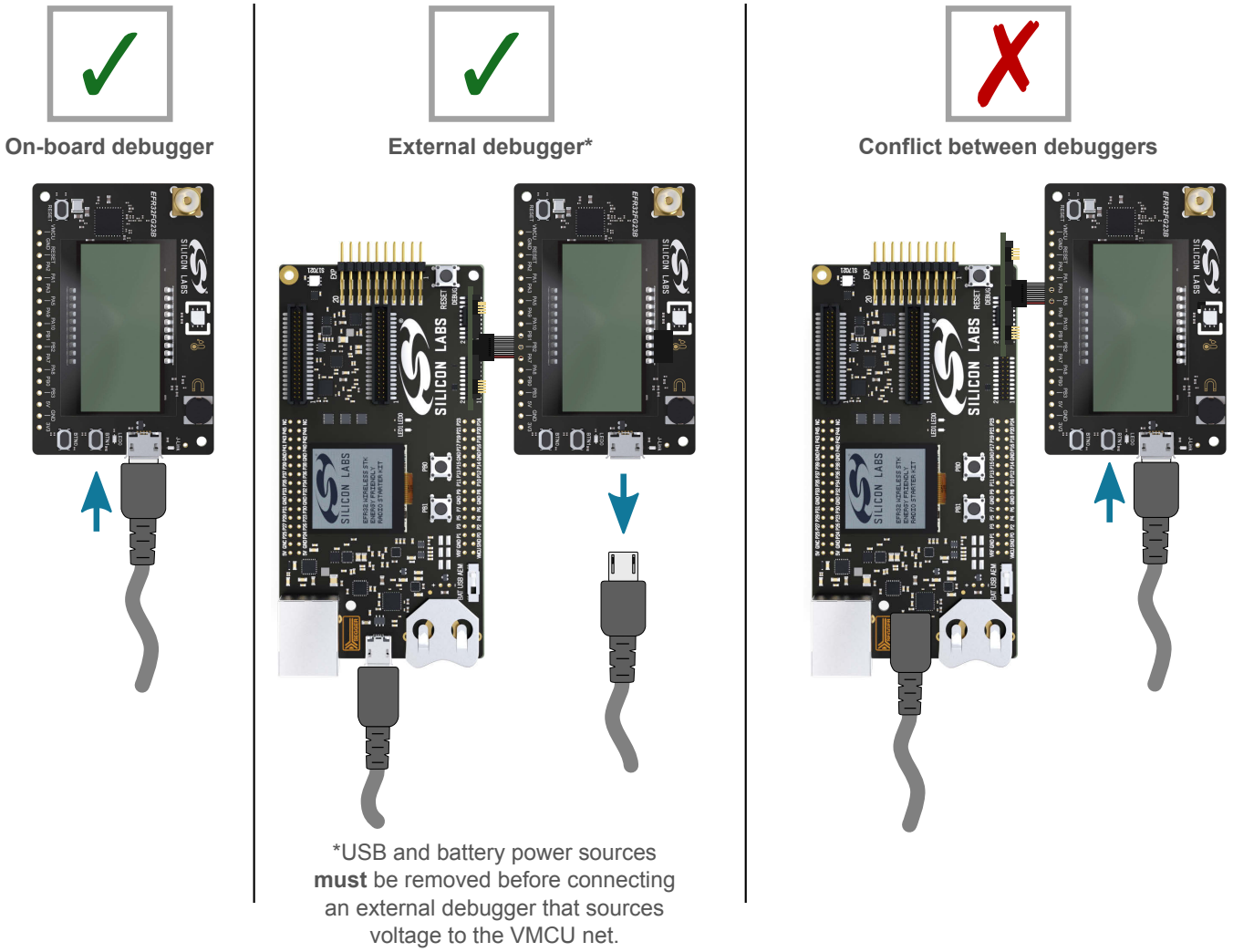


Figure 4.1. EFR32FG23 Dev Kit Debugging Possibilities

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 EFR32FG23.

When the debug USB cable is inserted, the on-board debugger is automatically active, 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 lifetime 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 Starter Kit (Wireless STK) mainboard with a debug adapter board from Silicon Labs can be connected to the Mini Simplicity Connector and used for debugging instead of the on-board debugger. For instruction on how this can be done see "AN958: Debugging and Programming Interfaces for Custom Designs". Debugging with an external Wireless STK 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 as 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 EFR32FG23 Dev Kit Debugging Possibilities on page 14.

Powering the board when using the Mini Simplicity Connector with a Wireless STK mainboard and adapter board can be done using the AEM voltage supply of the Wireless STK mainboard. When doing this, remove both the USB cable and the coin cell battery from the EFR32FG23 Dev Kit before connecting the Wireless STK mainboard to the Mini Simplicity Connector. The power switch on the Wireless STK mainboard should be set in "AEM". Power-cycling of the board, if necessary, can easily be done by flipping the power switch on the Wireless STK to "BAT" and back to "AEM" assuming a battery is not inserted in the Wireless STK mainboard.

It is possible to have the EFR32FG23 Dev Kit powered by a battery, and still use the Mini Simplicity Connector with a Wireless STK mainboard for debugging and communication. In this case the power switch on the Wireless STK mainboard must be set to the "BAT" position and the coin cell battery on the Wireless STK mainboard must be removed. In this case level shifters on the Wireless STK itself take care of interfacing to different voltage levels on the EFR32FG23 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 might 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 EFR32FG23 Dev Kit.

4.3 Virtual COM Port

The virtual COM port (VCOM) is a connection to a UART on the EFR32FG23, 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. 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 STK. Using the VCOM port through the Mini Simplicity Connector with an external Wireless STK works in a similar way, but requires that the USB cable to the on-board debugger is unplugged. The board controller on the Wireless STK 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 RF Section

This section gives a short introduction to the RF section of the BRD2600A board.

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

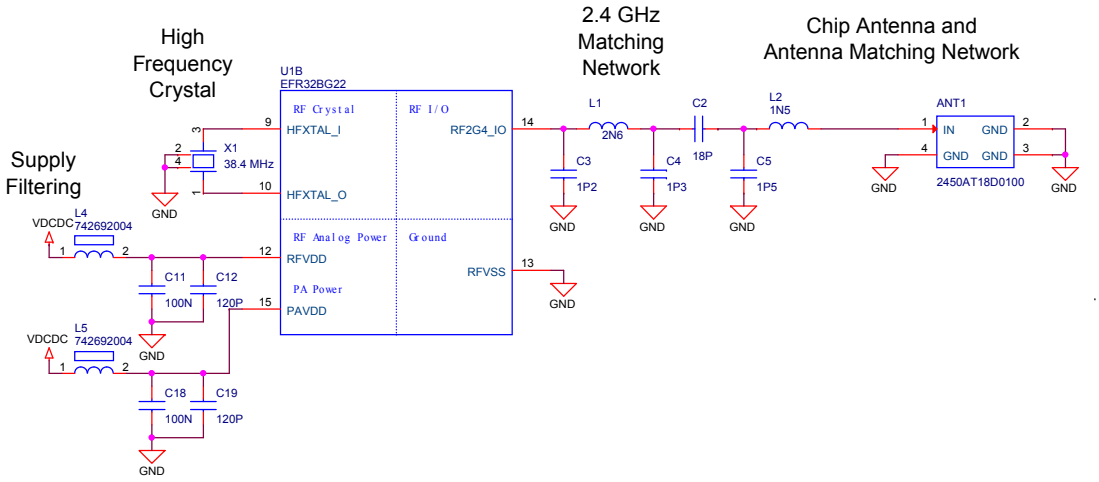


Figure 5.1. Schematic of the RF section

5.1.1 Description of the Sub-GHz RF Matching

The EFR32FG23 has two TX outputs (SUBG_O1, SUBG_O2) and two RX inputs (SUBG_I1, SUBG_I2). The matching network connects one of the TX outputs (SUBG_O1) and one of the RX inputs (SUBG_I0) to a single SMA connector while transforming the impedances to 50 Ohms. 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.

The matching includes the RX and TX impedance matching circuitries, TX filter section and a DC blocking capacitor in the TX path.

For the unused pins, there is option to connect them to ground through a series capacitor, but by default, they are left floating.

5.1.2 RF Section Power Supply

On the BRD2600A the supply for the radio (RFVDD) and the power amplifier (PAVDD) are 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 schematic of the BRD2600A).

5.1.3 RF Matching Bill of Materials

The Bill of Materials of the BRD2600A RF matching network is shown in the following table.

Table 5.1. Bill of Materials of the BRD2600A RF Matching Network

Component name	Value	Manufacturer	Part Number
L1	4.2 nH	Murata	LQP03HQ4N2B02D
L2	16 nH	Murata	LQP03HQ16NH02D
L3	0 Ohm	-	-
L4	18 nH	Murata	LQP03HQ18NH02D
C1	Not Mounted	-	-
C2	5.9 pF	Murata	GJM0335C1E5R9CB01D
C3	2.1 pF	Murata	GRM0335C1H2R1BA01D
C4	Not Mounted	-	-
C5	Not Mounted	-	-
C11	220 pF	Murata	GRM0335C1H221GA01D
C12	Not Mounted	-	-
C13	Not Mounted	-	-

5.2 EMC Regulations

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

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

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

For the unwanted emission limits see the table below.

Table 5.2. 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 FCC15.247 Emission Limits for the 902-928 MHz Band

FCC 15.247 allows conducted output power up to 1 Watt (30 dBm) in the 902-928 MHz band. For spurious emmissions the limit is -20 dBc based on either conducted or radiated measurement, if the emission is not in a restricted band. The restricted bands are specified in FCC 15.205. In these bands the spurious emission levels must meet the levels set out in FCC 15.209. In the range form 960 MHz to the frequency of the 10th harmonic it is defined as 0.5 mV/m at 3 m distance (equals to -41.2 dBm in EIRP).

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

5.3 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.

FCC 15.247 regulation requires the 6 dB bandwidth of the modulated signal to be not less than 500 kHz. It also specifies the following Spectrum Analyzer settings for measuring the unwanted emissions above 1 GHz:

- Detector: Average
- RBW: 1 MHz

Based on measurements, among the available modulation schemes, the one with the narrowest 6 dB bandwidth, that complies with the >=500 kHz condition is the 2GFSK modulation with 500 kbps datarate and 175 KHz deviation. The following table shows the relative levels of the measured modulated signals compared to the unmodulated levels with the specified Spectrum Analyzer settings in case of the above modulation scheme.

Table 5.3. Measured Relaxation Factors

Frequency (915 MHz)	Modulation: 2GFSK, 500 kbps, 175 kHz [dB]
2nd harmonic	1.9
3rd harmonic	3.4
4th harmonic	4.3
5th harmonic	4.6
6th harmonic	4.9
7th harmonic	5.1
8th harmonic	5.4
9th harmonic	5.3
10th harmonic	Under noise level (0 is used)

The above values will be used as worst case relaxation factors for the 915 MHz radiated measurements.

5.4 RF Performance

5.4.1 Conducted Power Measurements

During the conducted measurements, the BRD2600A 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.

5.4.1.1 Conducted Measurements in the 868 MHz Band

The typical output spectrum is shown in the following figure.

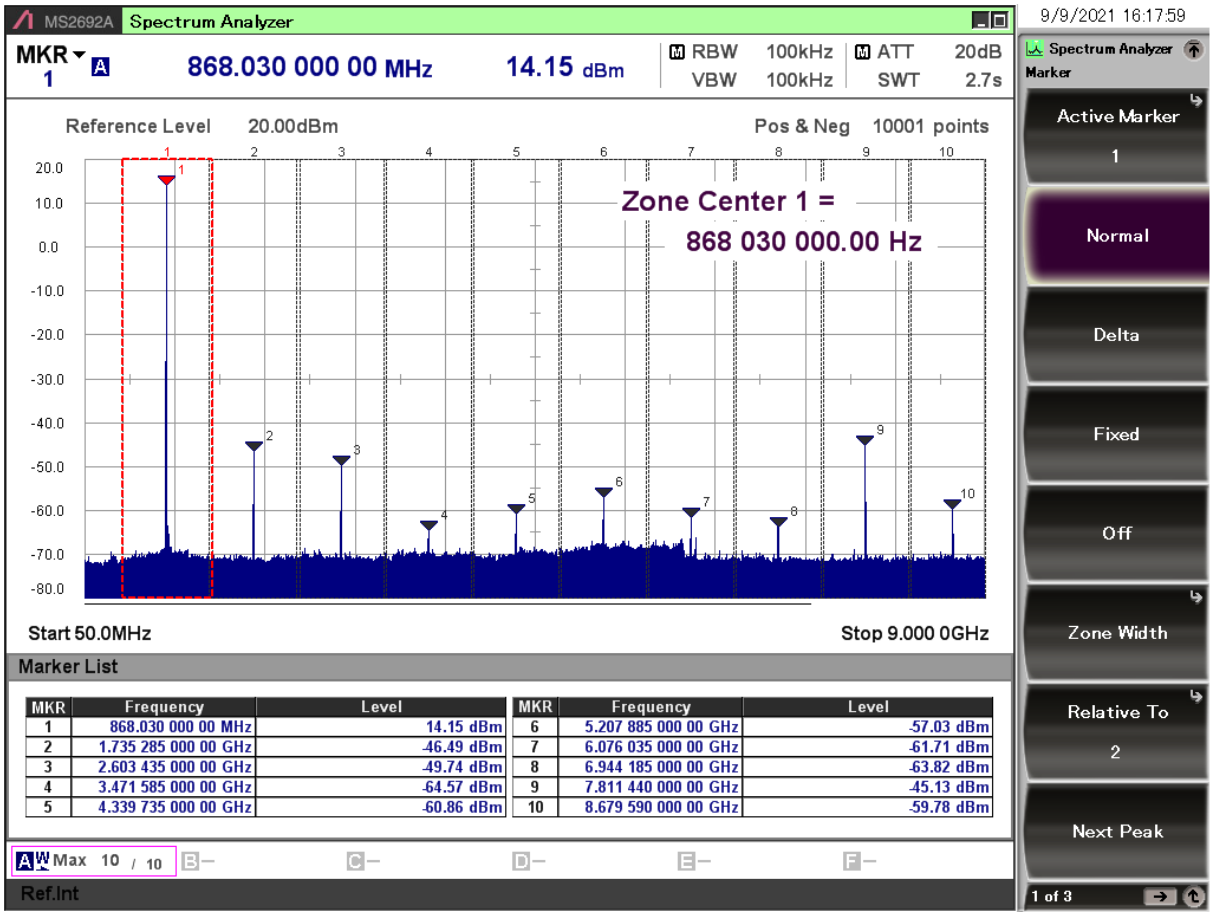


Figure 5.2. Typical Output Spectrum of the BRD2600A at 868 MHz with 14 dBm output power

As shown in the figure above, the fundamental is around 14 dBm, so it is under the ETSI limit of 16.1 dBm. The unwanted emissions are under their corresponding limit.

5.4.1.2 Conducted Measurements in the 915 MHz Band

The typical output spectrum is shown in the following figure.

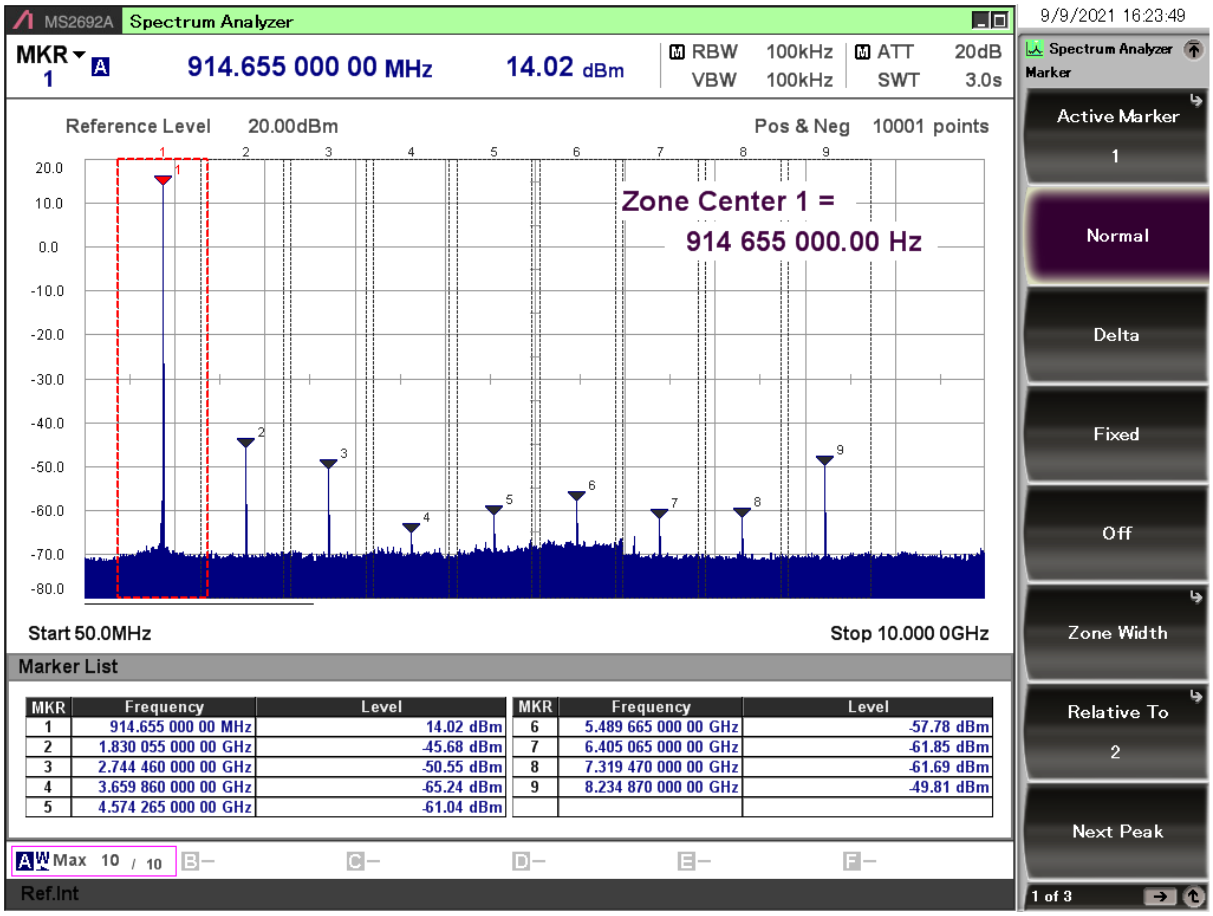


Figure 5.3. Typical Output Spectrum of the BRD2600A at 915 MHz with 14 dBm output power

As shown in the figure above, the fundamental is around 14 dBm, so it is under the FCC limit of 30.0 dBm. The unwanted emissions are under their corresponding limits.

5.4.2 Radiated Power Measurements

During the radiated measurements, the BRD2600A 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, and the output power was set to 14 dBm.

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, and the antenna patterns at the fundamental frequencies were measured with horizontal and vertical reference antenna polarizations.

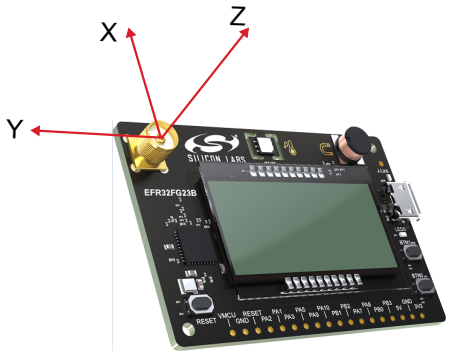


Figure 5.4. DUT Reference Planes

5.4.2.1 Radiated Measurements in the 868 MHz Band

For the 868 MHz radiated power measurements, an external whip antenna (Chilisin BTEA0019130G8R2A01) 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 5.4. Maximums of the Measured Radiated Powers of BRD2600A

Frequency (868 MHz)	Measured Unmodulated EIRP [dBm]	Orientation	Margin [dB]	Limit in EIRP [dBm]
Fund	13.6	XY/V	2.5	16.1
2nd	-47.8	XZ/H	19.9	-27.9
3rd	-41.4	YZ/H	13.5	-27.9
4th	-54.5	XY/V	26.6	-27.9
5th	-55.4	XY/V	27.5	-27.9
6th	-51.5	XY/V	23.6	-27.9
7th	-51.3	XY/V	23.4	-27.9
8th	-51.2	XY/V	23.3	-27.9
9th	-38.0	XZ/H	10.1	-27.9
10th	-46.8	XY/V	18.9	-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.

5.4.2.2 Radiated Measurements in the 915 MHz Band

For the 915 MHz radiated power measurements, an external whip antenna (Chilisin BTEA0019130G8R2A01) 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 5.5. Maximums of the Measured Radiated Powers of BRD2600A

Frequency (915 MHz)	Measured Un-modulated EIRP [dBm]	Orientation	Modulation: 2GFSK, 500 kbps, 175 kHz			Limit in EIRP [dBm]
			Relaxation Factor [dB]	Calculated Modulated EIRP [dBm]	Modulated Margin [dB]	
Fund	15.7	XY/V	N/A (0 is used)	15.7	14.3	30.0
2nd	-49.7	YZ/H	1.9	-51.6	>20	-20dBc
3rd	-42.7	XZ/H	3.4	-46.0	4.8	-41.2
4th	-56.5	XY/V	4.3	-60.8	19.5	-41.2
5th	-53.5	XY/V	4.6	-58.1	16.8	-41.2
6th	-52.6	YZ/H	4.9	-57.5	>20	-20dBc
7th	-51.8	XY/V	5.1	-56.9	>20	-20dBc
8th	-50.8	XY/V	5.4	-56.2	15.0	-41.2
9th	-39.3	YZ/H	5.3	-44.6	3.3	-41.2
10th	-47.1	XY/V	N/A (0 is used)	-47.1	5.9	-41.2

As shown in the table above, with 14 dBm output power, the radiated power of the fundamental is compliant with the 30.0 dBm limit. The 9th harmonic is above the limit in case of the unmodulated carrier transmission. But with the relaxation of the applicable modulation schemes, the margin is at least 3.3 dB.

5.4.2.3 Antenna Pattern Measurements in the 868 MHz Band

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

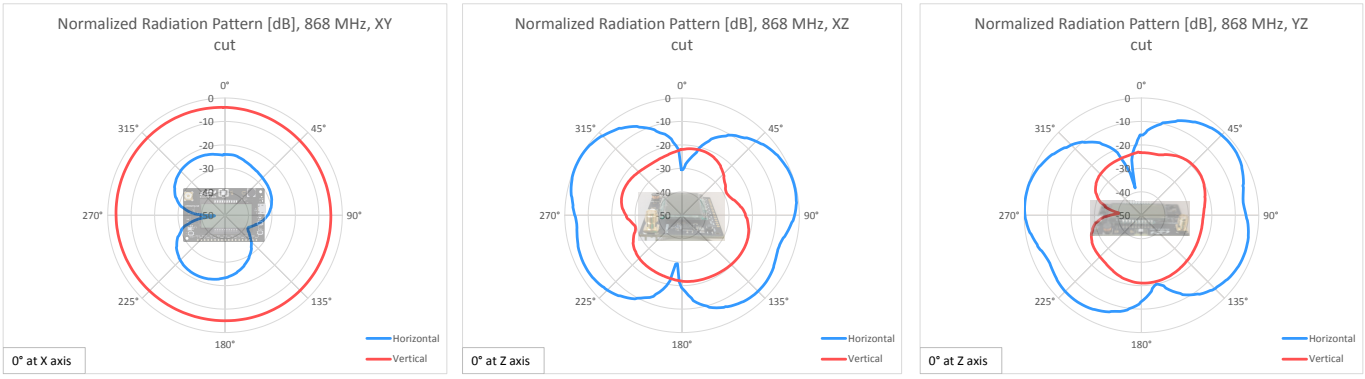


Figure 5.5. Antenna Pattern - 868 MHz

5.4.2.4 Antenna Pattern Measurement in the 915 MHz Band

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

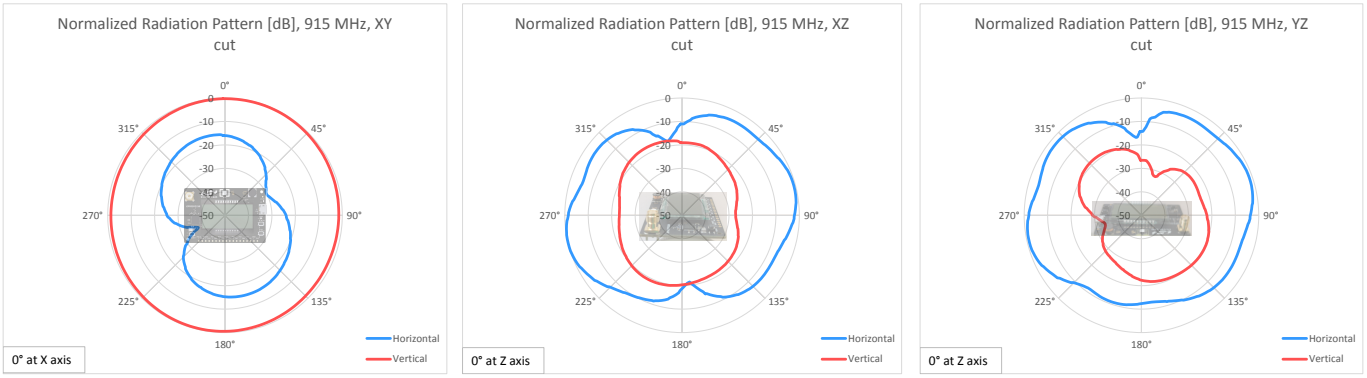


Figure 5.6. Antenna Pattern - 915 MHz

5.5 EMC Compliance Recommendations

5.5.1 Recommendations for 868 MHz ETSI ETSI EN 300-200-1 compliance

As it was shown in the previous section, the BRD2600A board is compliant with the emission limits of the ETSI ETSI EN 300-200-1 regulation in the 868 MHz Band with 14 dBm output power.

5.5.2 Recommendations for 915 MHz FCC 15.247 compliance

To be compliant with the FCC 15.247 regulation, not only the emission limit requirements should be fulfilled, but (among others) the 6 dB bandwidth requirement as well.

Although with 14 dBm output power and unmodulated carrier the radiated 9th harmonic of the BRD2600A board exceeds its corresponding limit, using a modulation scheme, that fulfills the 6 dB bandwidth requirement, the 9th harmonic has at least 3.3 dB margin. Therefore the board is compliant with the emission limits of the FCC 15.247 regulation in the 915 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: http://www.silabs.com/.

7. Kit 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.

Figure 7.1. Revision Info

Table 7.1. Kit Revision History

Kit Revision	Released	Description
A01	2021-08-24	Initial kit revision with BRD2600A Rev. A02.

8. Board Revision History and Errata

8.1 Board Revision History

The board revision can be found laser printed on the back side of the board.

Table 8.1. BRD2600A Revision History

Board Revision	Released	Description
A02	2021-05-26	Initial version.

8.2 Errata

There are no known errata.

9. Document Revision History

Revision 1.0

September, 2021

- Initial document version.

Simplicity Studio

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

IoT Portfolio
www.silabs.com/IoT

SW/HW
www.silabs.com/simplicity

Quality
www.silabs.com/quality

Support & Community
www.silabs.com/community

Disclaimer
Silicon Labs intends to provide customers with the latest, accurate, and in-depth documentation of all peripherals and modules available for system and software implementers using or intending to use the Silicon Labs products. Characterization data, available modules and peripherals, memory sizes and memory addresses refer to each specific device, and "Typical" parameters provided can and do vary in different applications. Application examples described herein are for illustrative purposes only. Silicon Labs reserves the right to make changes without further notice to the product information, specifications, and descriptions herein, and does not give warranties as to the accuracy or completeness of the included information. Without prior notification, Silicon Labs may update product firmware during the manufacturing process for security or reliability reasons. Such changes will not alter the specifications or the performance of the product. Silicon Labs shall have no liability for the consequences of use of the information supplied in this document. This document does not imply or expressly grant any license to design or fabricate any integrated circuits. The products are not designed or authorized to be used within any FDA Class III devices, applications for which FDA premarket approval is required or Life Support Systems without the specific written consent of Silicon Labs. A "Life Support System" is any product or system intended to support or sustain life and/or health, which, if it fails, can be reasonably expected to result in significant personal injury or death. Silicon Labs products are not designed or authorized for military applications. Silicon Labs products shall under no circumstances be used in weapons of mass destruction including (but not limited to) nuclear, biological or chemical weapons, or missiles capable of delivering such weapons. Silicon Labs disclaims all express and implied warranties and shall not be responsible or liable for any injuries or damages related to use of a Silicon Labs product in such unauthorized applications.
Note: This content may contain offensive terminology that is now obsolete. Silicon Labs is replacing these terms with inclusive language wherever possible. For more information, visit www.silabs.com/about-us/inclusive-lexicon-project

Trademark Information
Silicon Laboratories Inc.®, Silicon Laboratories®, Silicon Labs®, SiLabs® and the Silicon Labs logo®, Bluegiga®, Bluegiga Logo®, Clockbuilder®, CMEMS®, DSPLL®, EFM®, EFM32®, EFR, Ember®, Energy Micro, Energy Micro logo and combinations thereof, "the world's most energy friendly microcontrollers", Ember®, EZLink®, EZRadio®, EZRadioPRO®, Gecko®, Gecko OS, Gecko OS Studio, ISOmodem®, Precision32®, ProSLIC®, Simplicity Studio®, SiPHY®, Telegesis, the Telegesis Logo®, USBXpress®, Zentri, the Zentri logo and Zentri DMS, Z-Wave®, and others are trademarks or registered trademarks of Silicon Labs. ARM, CORTEX, Cortex-M3 and THUMB are trademarks or registered trademarks of ARM Holdings. Keil is a registered trademark of ARM Limited. Wi-Fi is a registered trademark of the Wi-Fi Alliance. All other products or brand names mentioned herein are trademarks of their respective holders.

SILICON LABS

Silicon Laboratories Inc.
400 West Cesar Chavez
Austin, TX 78701
USA

www.silabs.com