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WGM110 Wizard Gecko Wi-Fi[®] Module Data Sheet



The Wizard Gecko WGM110 is an all-inclusive Wi-Fi[®] Module targeted for applications where good RF performance, low-power consumption, and easy application development, together with fast time to market, are key requirements. WGM110 has excellent RF performance and can provide long range with robust wireless connectivity.

The WGM110 Module integrates all of the necessary elements required for an IoT Wi-Fi application, including an 802.11b/g/n radio, integrated chip antenna (WGM110A) or an u.FL connector for an external antenna (WGM110E), certifications, a microcontroller, Wi-Fi and IP stacks, an HTTP server, and multiple protocols, such as TCP and UDP.

WGM110 can act as a Wi-Fi client or be used as a Wi-Fi access point, making the provisioning of the device as easy as surfing on the web. WGM110 can host BGScript[™] end user applications, which means applications can be designed without relying on an external microcontroller. Alternatively, the Wi-Fi Module can run in Network Co-Processor (NCP) mode, leaving the complexity of TCP/IP networking to the Module so that the customer's own host controller can be fully dedicated to processing the customer application tasks. The WGM110 Module also has highly flexible hardware interfaces which allows connection to different peripherals and sensors.

In addition to the Wi-Fi Module itself, Silicon Labs offers support to guide and help developers in using WGM110 to build IoT applications, enabling a quick time to market.

KEY POINTS

- Module variants
 - WGM110A (chip antenna)
 - WGM110E (u.FL connector)
- 802.11b/g/n compliant
- TX power: +16 dBm
- RX sensitivity: -98 dBm
- Range: up to 450 m
- CPU core: 32-bit ARM[®] Cortex-M3
- Flash memory: 1 MB
- RAM: 128 kB
- Modular certification
 - FCC
 - IC
 - Japan
 - Korea
- CE compliant
- End-to-end security
- Can host applications
- Small size: 21.0 x 14.4 x 2.0 mm

WGM110 Module Block Diagram

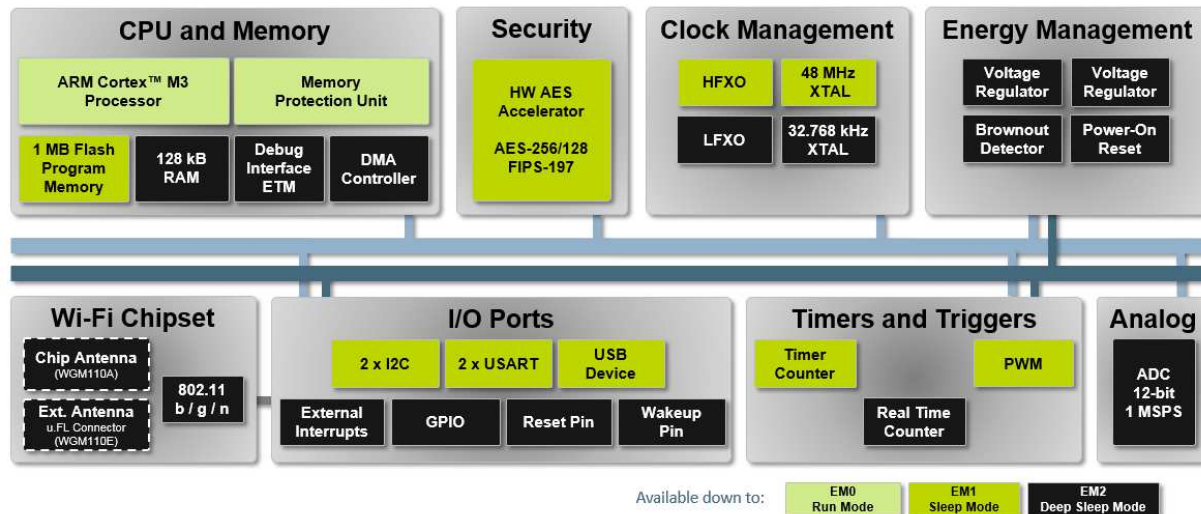


Table of Contents

1. Key Features	1
2. Pinout	2
2.1 Power, Ground and Reset Pads	2
2.2 Peripherals and GPIOs	3
2.2.1 Peripheral and GPIO Pads	3
2.2.2 Peripheral Locations	4
2.2.3 GPIO Port Pins	6
2.2.4 GPIO Input and Output Modes	6
2.2.5 Interrupt Pins	6
2.3 Debug and RF Test Pads	6
3. Interfaces	8
3.1 Host Interfaces	8
3.1.1 UART	8
3.1.2 SPI	11
3.1.3 USB	12
3.2 Peripheral Interfaces and Functions	12
3.2.1 USART (UART/SPI)	13
3.2.2 I ² C	13
3.2.3 Timer / PWM	13
3.2.4 Analog to Digital Converter (ADC)	13
3.3 Firmware Update and RF Test Interfaces	13
3.3.1 ARM Serial Wire Debug (SWD)	14
3.3.2 Device Firmware Upgrade (DFU)	14
3.3.3 RF Test Interface	14
3.3.4 Reference Schematic for SWD Debug and RF Test Interfaces	14
3.4 Real Time Counter (RTC)	14
4. Module Software	15
5. Hardware Design Guidelines	17
5.1 Power Supply Requirements	17
5.2 PCB Design Guidelines	17
5.3 Antenna Design Guidelines	18
5.3.1 Effect of Plastic and Metal Materials	18
5.3.2 Locating the Module Close to Human Body	19
6. Electrical Characteristics	20
6.1 Absolute Maximum Ratings	20
6.2 Recommended Operating Conditions	20
6.3 Input/Output Terminal Characteristics	20
6.4 Power-on Reset	21
6.5 Analog Digital Converter (ADC)	21

6.6 Power Consumption . . . . .	.21
7. RF Characteristics . . . . .	.23
7.1 Supported Frequencies. . . . .	.23
7.2 Typical Receiver Sensitivity . . . . .	.23
7.3 Transmitter Power at Maximum Setting . . . . .	.23
7.4 Antenna Characteristics . . . . .	.23
7.4.1 Typical Antenna Performance (WGM110A) . . . . .	.24
7.4.2 Typical Radiation Pattern Plot (WGM110A) . . . . .	.25
7.4.3 Qualified Antenna Types (WGM110E) . . . . .	.26
8. Physical Dimensions and PCB Land Pattern . . . . .	.27
8.1 Module Top View Dimensions . . . . .	.27
8.2 Module Side View Dimensions . . . . .	.28
8.3 u.FL Connector Placement (WGM110E) . . . . .	.29
8.4 Recommended Application PCB Land Pattern . . . . .	.30
9. Soldering Recommendations . . . . .	.31
10. Tape and Reel Packaging . . . . .	.32
10.1 Tape Material and Dimensions . . . . .	.32
10.2 Reel Material and Dimensions . . . . .	.34
10.3 Module Orientation in Tape . . . . .	.35
10.4 Moisture Sensitivity Level . . . . .	.35
10.5 Tape and Reel Box Dimensions . . . . .	.35
11. Certifications . . . . .	.36
11.1 CE . . . . .	.36
11.2 FCC. . . . .	.36
11.3 IC . . . . .	.38
11.4 MIC Japan . . . . .	.39
11.5 KC South-Korea. . . . .	.39
12. Ordering Information . . . . .	.40
13. Support . . . . .	.41
13.1 Device Support . . . . .	.41
13.1.1 Wireless Starter Kit WSTK6120A . . . . .	.41
13.2 Documentation Support . . . . .	.41
13.3 Knowledge Base . . . . .	.41
13.4 Technical Support . . . . .	.41
14. Revision History. . . . .	.42
14.1 Revision 1.4 . . . . .	.42
14.2 Revision 1.3 . . . . .	.42

14.3 Revision 1.2 . . . . .	.42
14.4 Revision 1.1 . . . . .	.42
14.5 Revision 1.0 . . . . .	.42

1. Key Features

The key features of the WGM110 Module are listed below.

Radio Features

- Antenna
 - Chip Antenna: WGM110A
 - External Antenna: WGM110E (u.FL connector)
- TX Power: +16 dBm
- RX Sensitivity: -98 dBm
- Range: up to 450 m

Wi-Fi Features

- 802.11: b/g/n
- Bit rate: up to 72.2 Mbps
- 802.11 Security: WPA2/WPA Personal, WPA2/WPA Enterprise and WEP
- STA (Station Mode)
- SoftAP (Soft Access Point Mode): up to 5 clients
- Wi-Fi Direct
- WPS: 1.0 (push-button)

IP Stack

- IP version: IPv4
- IP multicast
- TCP: client/server
- UDP: client/server
- TCP sockets: 20+
- DHCP: client/server
- ARP
- DNS: client/server
- mDNS
- DNS-SD
- HTTP: server
- TLS/SSL: client

Software APIs

- BGAPI™ serial protocol API over UART/SPI/USB for modem usage
- BGLIB™ host API which implements BGAPI serial protocol
- BGScript™ scripting language for standalone usage

Software Development Tools

- Free SDK

MCU Features

- ARM® Cortex-M3
- 48 MHz
- 128 kB RAM
- 1 MB Flash

Hardware Interfaces

- Host interface: UART/SPI/USB
- Peripheral interfaces
 - 2 x USART (UART/SPI)
 - 1 x USB (2.0 Full speed)
 - 2 x I²C peripheral interfaces
- Up to 32 x GPIO with interrupts
- 8-channel 12-bit ADC
- 2 x TIMER (3 PWM's each)
- Real-time counter

Electrical Characteristics

- Supply voltage: 2.7 V to 4.8 V for the radio block
- Supply voltage: 1.98 V to 3.8 V for the processor block

Power consumption

- 261 mA TX current at +16 dBm
- 81 mA RX current
- 2.4 mA associated idle consumption
- 18.8 µA deep sleep current

Environmental specifications

- Temperature range: -40°C to +85°C

Modular certification

- FCC
- IC
- Japan
- South-Korea

CE Compliant

Dimensions

- W x L x H: 21.0 mm x 14.4 mm x 2.0 mm

2. Pinout

This section describes the pinout of the WGM110 Module.

Pads in the middle of the Module are intended for ground connections and for RF test and production programming, while pads on the Module edges consist of general purpose input/output, power supply voltage input, ground, and reset signal connections.

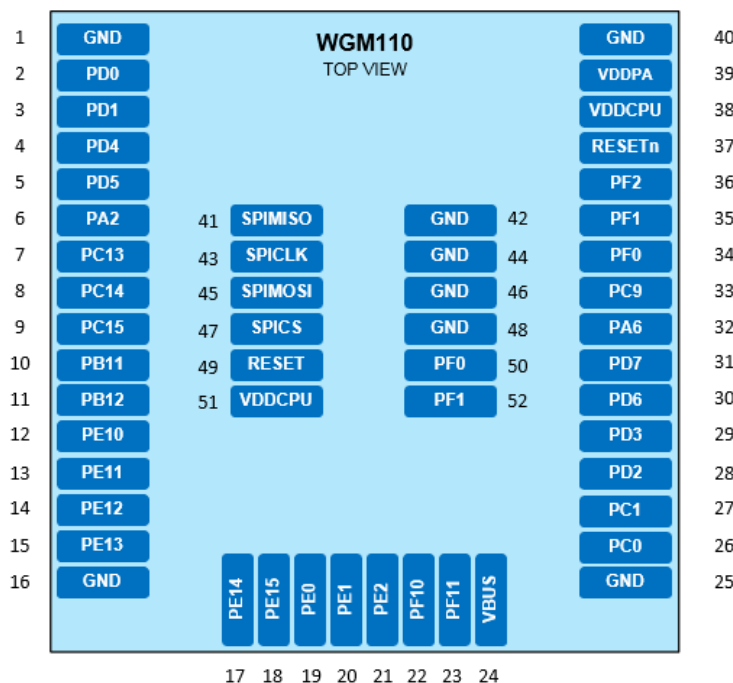


Figure 2.1. WGM110 Pinout (Top View)

2.1 Power, Ground and Reset Pads

The table below lists the power, ground, and reset pads of the WGM110 Module.

Table 2.1. WGM110 Power, Ground, and Reset Pads

Pad number	Function	Description
38, 51	VDDCPU	Processor core and peripheral interface power supply.
39	VDDPA	RF power amplifier and Wi-Fi core power supply
1, 16, 25, 40, 42, 44, 46, 48	GND	Ground. All ground pads are connected together internally. Connect ground pads directly to a solid ground plane with maximum number of vias in close proximity to pads especially at the antenna end. These ground pads also act as thermal paths which should be used to conduct heat from the module to the PCB. Do not use thermal reliefs on ground pads.
24	VBUS	USB VBUS detect input is used to detect the presence of an external USB port bus voltage. When USB is not used connect VBUS to VDDCPU.

PERIPHERAL AND GPIO PAD MAPPING																																								
Port Name		PA		PB		PC					PD							PE					PF																	
Port Pin #		2	6	11	12	0	1	9	13	14	15	0	1	2	3	4	5	6	7	0	1	2	10	11	12	13	14	15	0	1	2	10	11	12	13	14	15			
Pad #		6	32	10	11	26	27	33	7	8	9	2	3	28	29	4	5	30	31	19	20	21	12	13	14	15	17	18	34	35	36	22	10	11						
Pad #																												50	52											
RX	MISO						.						.					.																						
TX	MOSI					.						.							.																					
TIMER0																																								
CC0													.																							.				
CC1						.								.																					.					
CC2							.								.																						.			
TIMER1																																								
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CH4																.																								
CH5																	.																							
CH6																		.																						
CH7																			.																					
USB																																								
DM																																								.
DP																																								.

2.2.2 Peripheral Locations

Many of the peripheral functions can be configured into multiple locations on the GPIO pads. This allows a more flexible configuration of the Wi-Fi Modules GPIOs.

The following table shows the available locations and the corresponding GPIO pads.

Note: Peripheral function signals must always be grouped to a single location, combining signals from several locations to form a peripheral function is not allowed.

The configuration of the peripheral locations is defined in the hardware configuration file. See [UG161: WGM110 Wi-Fi Module Configuration User's Guide](#) for more details.

Table 2.3. GPIO Peripheral Locations

Peripheral		Signal name	LOC 0	LOC 1	LOC 2	LOC 3	LOC 4	LOC 5	LOC 6	NOTE
USART0	<i>SPI</i>	MOSI	PE10			PE13		PC0		
		MISO	PE11			PE12		PC1		
		CLK	PE12		PC9	PC15				
		CS	PE13			PC14				
	<i>UART</i>	TX	PE10			PE13		PC0		1
		RX	PE11			PE12		PC1		1
		CTS	PE12			PC15				
		RTS	PE13			PC14				
USART1	<i>SPI</i>	MOSI	PC0	PD0	PD7					
		MISO	PC1	PD1	PD6					
		CLK		PD2	PF0					
		CS		PD3	PF1					
	<i>UART</i>	TX	PC0	PD0	PD7					2
		RX	PC1	PD1	PD6					2
		CTS		PD2	PF0					
		RTS		PD3	PF1					
I2C0	SCL		PD7			PC1	PF1	PE13		
	SDA		PD6			PC0	PF0	PE12		
I2C1	SCL		PB12	PE1						
	SDA		PB11	PE0						
USB	DM	PF10								
	DP	PF11								
TIMER0	CC0				PD1		PF0			
	CC1				PD2	PC0	PF1			
	CC2	PA2	PA2		PD3	PC1	PF2			
TIMER1	CC0	PC13	PE10			PD6				
	CC1	PC14	PE11			PD7				
	CC2	PC15	PE12		PB11	PC13				
DEBUG	SWCLK	PF0	PF0	PF0	PF0					
	SWDIO	PF1	PF1	PF1	PF1					

Note: The following notes apply to UART Locations:

- **1:** USART0 as UART: LOC 5 can be used as an UART without handshake.
- **2:** USART1 as UART: LOC 0 can be used as an UART without handshake.

2.2.3 GPIO Port Pins

The table below lists available Ports and corresponding Port pins in the WGM110 Module and the pads they can be routed to.

Table 2.4. Available GPIO Ports and Pins and Related Pads on the WGM110 Module

Pin →	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Port ↓																
Port A										PA6				PA2		
Port B				PB12	PB11											
Port C	PC15	PC14	PC13				PC9								PC1	PC0
Port D									PD7	PD6	PD5	PD4	PD3	PD2	PD1	PD0
Port E	PE15	PE14	PE13	PE12	PE11	PE10								PE2	PE1	PE0
Port F					PF11	PF10								PF2	PF1	PF0

2.2.4 GPIO Input and Output Modes

The GPIO pins on the WGM110 Module can be configured as inputs (options are normal input with pull-up or pull-down or with pull-up with filter or pull-down with filter), outputs (maximum output current 6 mA) or disabled (tristate). The default state of the GPIO pins after reset is "disabled".

For more information on how to configure the GPIO pins and modes, see [WGM110 API Reference Manual](#).

2.2.5 Interrupt Pins

All GPIO pins may be used as interrupts. WGM110 supports up to 14 asynchronous external pin interrupts with the following limitations:

- All pins with the same number are grouped together and multiplexed to trigger one interrupt.
- **Pin 0** from any port cannot be used as an interrupt, because it is reserved for the Module's internal operation.
- **Pin 8 of Port A - F** is not available for external use.

Example:

- If **PB11** is used as an interrupt pin, then the use of **Pin 11** of any other available port as an interrupt is not allowed (**PE11** and **PF11** cannot be used as an interrupt).

2.3 Debug and RF Test Pads

The table below indicates the pads available for debug and RF test connections.

Table 2.5. Debug and RF Test Pads

Debug and RF Test pads						
Port Name	RFPORT				PF	
Pad #	41	43	45	47	34	35
Pad #					50	52
Pad Name	SPIMISO	SPICLK	SPIMOSI	SPICS	PF0	PF1
DEBUG						
SWCLK					.	
SWDIO						.
RF TEST						
SPIMISO	.					
SPIMOSI			.			
SPICLK		.				
SPICS				.		

3. Interfaces

This section describes the features and functionalities of the available host, peripheral, debug, and RF test interfaces.

3.1 Host Interfaces

There are three available host interfaces one of which can be used to connect an external host, typically an MCU, to the WGM110 Wi-Fi Module and use it as a Wi-Fi modem.

3.1.1 UART

UART is one of the available host interfaces on the WGM110 Module, and it is also the default host interface for the WGM110 Modules delivered from the factory.

When using WGM110 UART in transparent mode, we highly recommend to use flow control to avoid the possibility of losing data. Furthermore, we recommend to use DMA on the receiving host, because the SW emulated flow control used in the WGM110 is not as fast as HW flow control, and therefore when CTS is raised, module will most likely still send at least one extra byte. Also using lower baud rates (<1Mbps) can help.

The table below shows the features of the UART host interface:

Table 3.1. UART Host Interface Features and Default Values

Parameter	Features / Supported ranges	Default value
UART baud rate	9600 bps - 6 Mbps	115200 Kbps
Flow control	RTS/CTS	Enabled
Data bits	8 or 9	8
Parity	none, odd, even	None
Stop bits	1 or 2	1
Supported USARTs	USART0 or USART1	-
Location	USART0 <ul style="list-style-type: none"> • LOC 0 • LOC 3 USART1 <ul style="list-style-type: none"> • LOC 1 • LOC 2 	USART 0 LOC 0
Host protocol	BGAPI serial protocol	BGAPI serial protocol

In the table below is a list of recommended baud rates for UART communication.

Table 3.2. UART baud rates

Desired baud rate [baud/s]	Actual baud rate [baud/s]	Error [%]
9600	9600	0.00
14400	14397	-0.02
19200	19200	0.00
28800	28811	0.04
38400	38400	0.00
57600	57553	-0.08
76800	76677	-0.16
115200	115384	0.16
230400	230769	0.16
256000	255319	-0.27
460800	461538	0.16
921600	923076	0.16
2000000	2000000	0.00
2400000	2400000	0.00
3000000	3000000	0.00
4000000	4000000	0.00
4800000	4800000	0.00
6000000	6000000	0.00

3.1.2 SPI

SPI is one of the available host interfaces on the WGM110 Module. SPI must be always enabled and configured by the user, because it is not enabled or configured as default.

The table below shows the features of the SPI host interface:

Table 3.3. SPI Host Interface Features

Parameter	Features (value ranges)
SPI mode	SPI slave
Bit rates	9600 bps - 6 Mbps
Bit order	MSB first
Clock polarity and phase	Configurable
Supported USARTs	USART0 and USART1
Supported locations	All locations
Host protocol	BGAPI serial protocol

The following figure shows the recommended schematics for connecting WGM110 with an external host over SPI. In addition to the selected USART/SPI port signals, one additional GPIO pin must be dedicated to be used as a notify signal to inform the SPI Master that data from module is available.

Note: The SPI host interface can only be used as a **SPI Slave**.

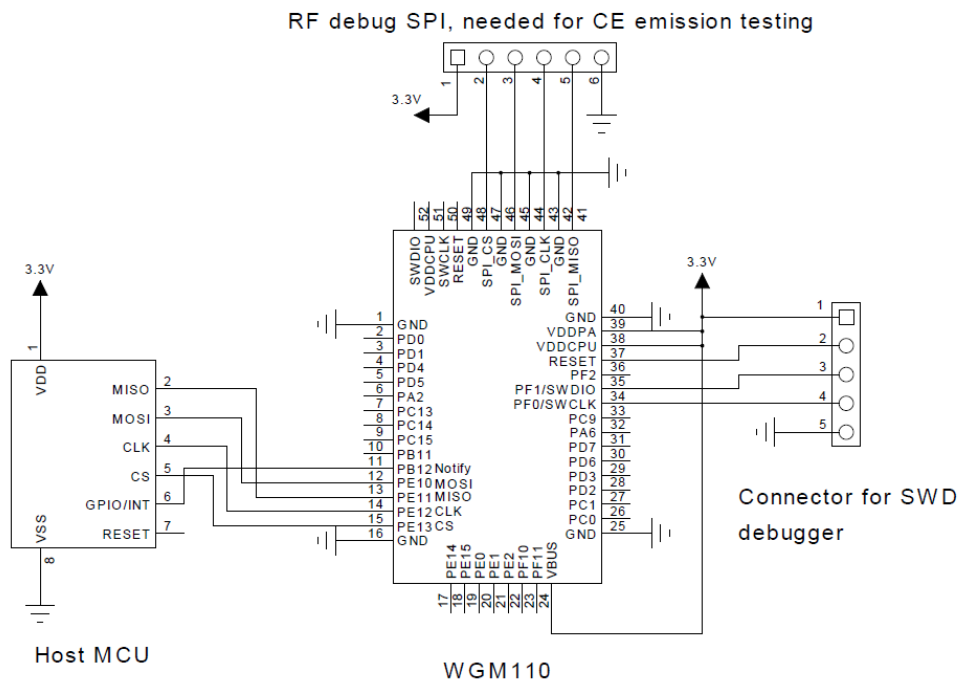


Figure 3.2. Connecting WGM110 with an External Host Using the SPI Interface

Note: In the figure above, the SPI interface is wired using **USART0 Location 0** pins.

Note: Pin **PB12** is configured as an output and used to notify the external host (SPI Master) that the WGM110 Module has data to send to the host.

3.1.3 USB

USB is one of the available host interfaces on the WGM110 Module. USB must be always enabled and configured by the user, because it is not enabled or configured as default.

The table below shows the features of the USB host interface:

Table 3.4. USB Host Interface Features

Parameter	Compatibility
USB mode	USB device
USB version	2.0 Full speed
USB device class	CDC/ACM (COM port)
Host protocol	BGAPI serial protocol

The next figure shows the recommended schematics for connecting WGM110 Module with an external host over USB.

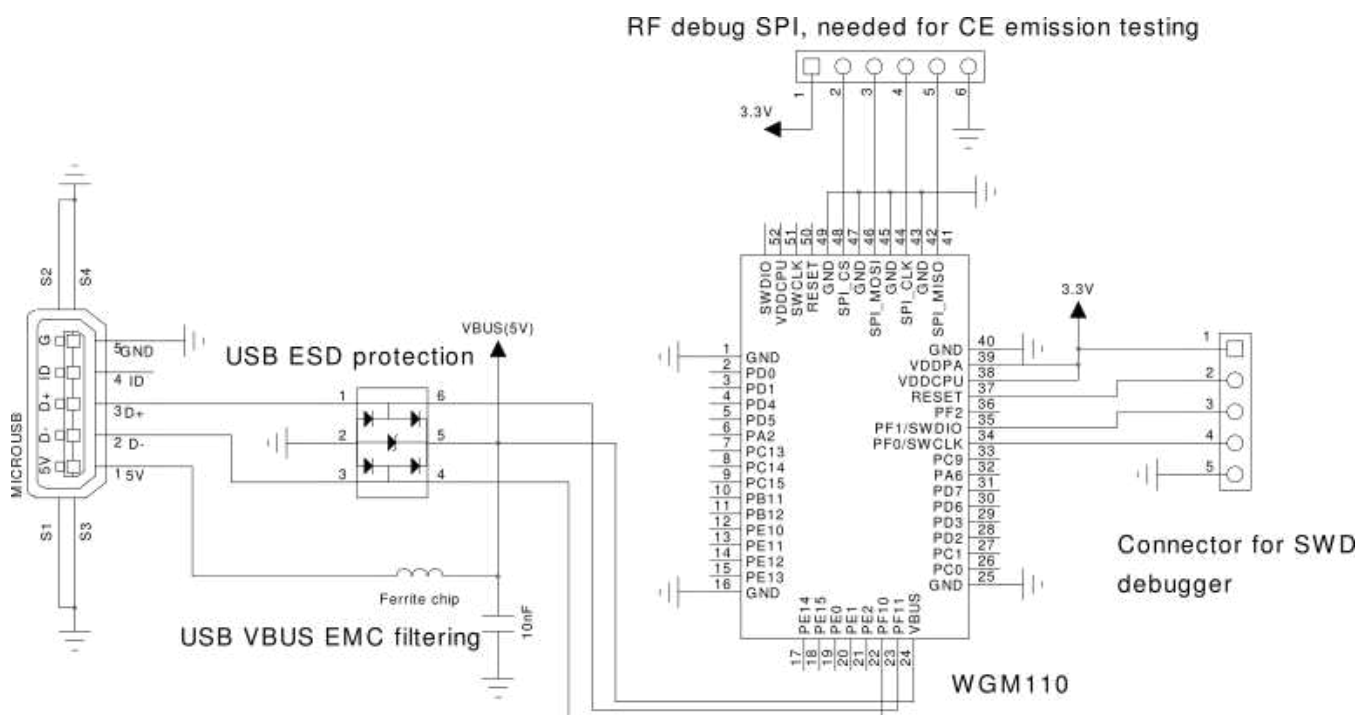


Figure 3.3. Connecting the WGM110 Module with an External Host using the USB Interface

Note: When using the USB interface, the VBUS signal should be connected to the USB host's VBUS line.

Note: If the VBUS line is not available on the host, the module's VBUS signal should be connected to the VDDCPU.

Note: If the USB is not used at all, the VBUS signal can be left unconnected.

3.2 Peripheral Interfaces and Functions

There are several different types of peripheral interface connections available on the WGM110 Module. External sensors and peripheral chips can be connected using the USART (UART/SPI) and I2C interfaces. In addition to the above mentioned connections, WGM110 includes two timers for PWM applications, an 8-channel 12-bit ADC converter and a real time counter.

3.2.1 USART (UART/SPI)

The Universal Synchronous/Asynchronous Receiver/Transmitter (USART) provides a flexible serial I/O interface. It supports full duplex asynchronous UART communication up to 6 Mbps. Both SPI Master and Slave modes are also supported up to 6 Mbps.

Software emulated RTS/CTS handshaking is supported. For this reason there may be up to two extra data bytes transmitted by the Module after the host's RTS has been pulled high.

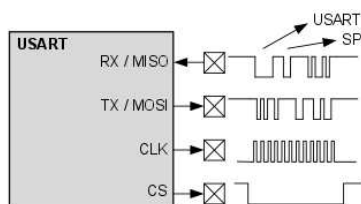


Figure 3.4. USART

3.2.2 I²C

The I²C peripheral provides an interface between the WGM110 Module and a serial I²C bus. It is capable of acting as a I²C Master. Standard-mode is supported, allowing transmission rates up to 100 Kbps.

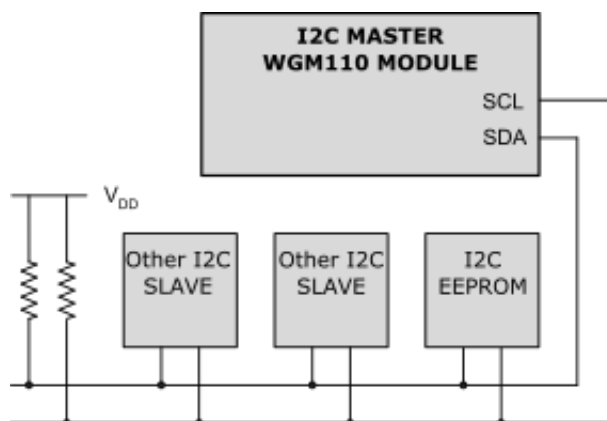


Figure 3.5. WGM110 Acting as an I²C Master with Several I2C Slaves Connected to the Module

3.2.3 Timer / PWM

Timer peripherals count events and can be used to generate PWM outputs. The core of each timer is a 16-bit counter. There are two timers, each with three separate outputs configurable for PWM applications.

3.2.4 Analog to Digital Converter (ADC)

The ADC inside the WGM110 Module is based on Successive Approximation Register (SAR) architecture and has a resolution of up to 12 bits (1 MSPS). The ADC includes user selectable integrated voltage references but also allows the use of an external reference. There are 8 fixed GPIO pins configurable for single-ended ADC inputs.

3.3 Firmware Update and RF Test Interfaces

Firmware updates can be done over the ARM Serial Wire Debug (SWD) interface, which is the recommended firmware update interface for development and production programming.

It is also possible to update the firmware using the Device Firmware Update (DFU) protocol by using an interface configured as the host interface (UART, SPI or USB).

4. Module Software

This section gives a short overview of the software provided with the WGM110 Module and describes the basic methods of using the Module. The figure below shows the block diagram of the software provided with the WGM110 Module and how it relates to the software on the external host.

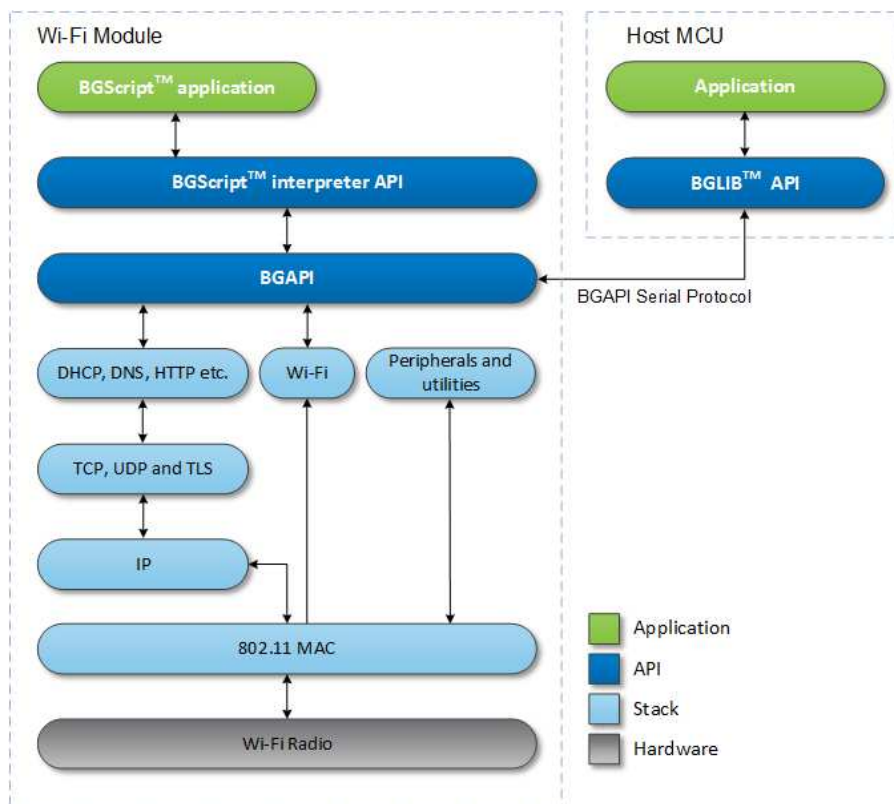


Figure 4.1. WGM110 Software Allows Both BGScript™ Based or Host MCU Based Control of the Module

The WGM110 Module includes full Wi-Fi and IP stacks, an HTTP/HTTPS server, and multiple protocols, such as TCP and UDP. Key security features include WPA2/WPA Personal and Enterprise support and TLS/SSL for end-to-end encryption. The WGM110 SDK contains all necessary tools for developing and deploying IoT applications for the WGM110 Module

The Wi-Fi Module has been designed to allow flexibility in selecting the most suitable design architecture. There are three main architectural options for using the WGM110 Module:

- Network Co-Processor (NCP) mode, in which the Module is connected to an external host MCU via the BGLIB API
- Stand-alone mode, in which the module is used to run BGScript applications
- Mixed mode, in which is a combination of the two above listed modes

Network Co-Processor (NCP) mode

The NCP mode is the choice to use when there is a need to implement a more complicated IoT application and the resources of an external MCU are needed. In the NCP mode, the external host MCU is connected to the Module using one of the three available host interfaces (UART, SPI, or USB). The WGM110 Module provides a high-level BGAPI to manage Wi-Fi as well as data connections. Silicon Labs provides a thin API layer (BGLib) written in ANSI C for the host, which can take care of creating and parsing the messages sent over the host interface. For evaluation purposes, GUI tools are also provided as part of the SDK.

Data between the WGM110 Module and the external host MCU can be routed either through the BGAPI or via another physical interface. For example, a serial-to-TCP/IP solution, if one UART interface is used for sending and receiving BGAPI commands; the second UART can be bound with a TCP/IP socket. Data written to the second UART will be seamlessly passed to the TCP/IP socket.

Stand-alone mode

The stand-alone mode is especially suitable for more lightweight IoT applications, and there is no need for hosting an external MCU controller. This will naturally result in HW BOM cost savings. The WGM110 Module is natively running and controlled by a BGScript application.

Mixed mode

The WGM110 Module can also be used in a mixed mode, where both the NCP and Stand-alone approaches are used in parallel. In this case the BGScript application on the module can be run completely independent from any MCU action. Normally the approach is to automate certain processes in BGScript (e.g. Wi-Fi network scanning and connection) to relieve the host from doing these.

Note: To learn more about the WGM110 Module software, the SDK and the APIs in general please read the [QSG122: WGM110 Wi-Fi Module Software Quick-Start Guide](#).

Note: For a complete reference of the API, please see the [WGM110 API Reference Manual](#).

5. Hardware Design Guidelines

WGM110 is an easy-to use Module with regard to hardware application design, but certain guidelines must be followed to guarantee optimal performance. These guidelines are listed in the next sub-sections.

5.1 Power Supply Requirements

WGM110 Module consists of two separate internal blocks, the microcontroller and the Wi-Fi radio block. Individual power supplies are needed for both the MCU and the Wi-Fi radio blocks.

The WGM110 Module is designed to operate with a 3.3 V nominal input voltage supplied to the two supply inputs as follows:

- The **VDDCPU** powers the MCU and can be fed with a voltage between 2.0 V and 3.8 V. The regulator supplying VDDCPU should be able to supply at least 30 mA.
- The **VDDPA** pad can be supplied with a voltage between 2.7 V and 4.8 V and supplies the RF power amplifier and the internal switch-mode converter powering the Wi-Fi digital core. VDDPA may draw short peaks up to 350 mA.

In lithium battery powered applications, VDDPA can be connected directly to the battery, while a regulator is needed to supply the VDDCPU with a lower voltage, as needed by the design. Care should be taken that the supply source is capable of supplying enough current for the heavy load peaks of the power amplifier.

External high frequency bypass capacitors are not needed because the module contains the required supply filter capacitors. However, care should be taken to prevent strong switching noise from being superimposed on the supply lines. Such noise can be generated, for example, by on-board charge pump converters used in RS232 level shifters. Note that there is a total of about 20 μF of low ESR ceramic capacitors on the VDDPA line and approximately 2 μF on the VDDCPU line inside the module. When using external regulators to generate regulated supplies for the module, the stability of the regulator with the low ESR provided by these capacitors should be checked. Many low-drop linear regulators and some switched mode regulators are not stable when using ceramic output capacitors. The datasheet of the regulator typically lists recommendations concerning suitable capacitors, including data on ESR range and/or stability curves. A regulator with a statement “*stable with ceramic capacitors*” is recommended.

5.2 PCB Design Guidelines

For optimal performance of the WGM110 Module, please follow these guidelines:

- Place the Module at the edge of the PCB (does not apply to WGM110E), as shown in the figure below.
- Do not place any metal (traces, components, battery, etc.) within the clearance area of the antenna, shown in the figure below as a white rectangle between the pad rows (does not apply to WGM110E).
- Connect all ground pads directly to a solid ground plane.
- Place the ground vias as close to the ground pads as possible.
- Do not place plastic or any other dielectric material in touch with the antenna.

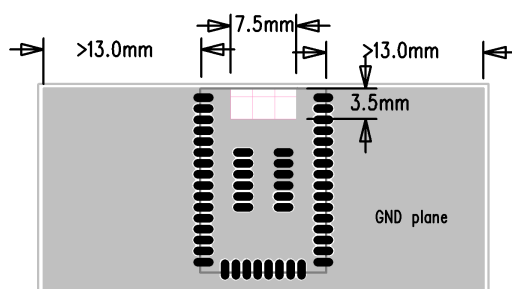


Figure 5.1. Recommended Application PCB Layout for WGM110A Module

The layouts shown in the figure below will result in severely degraded RF-performance.

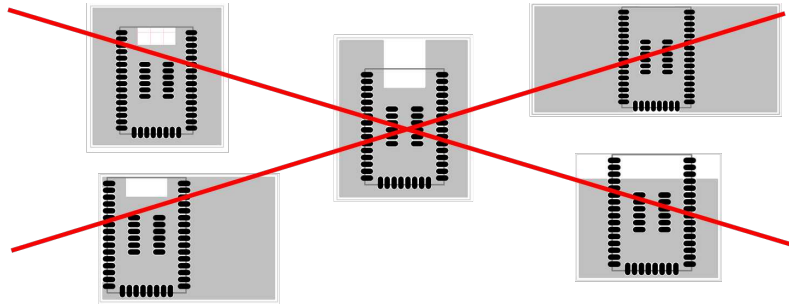


Figure 5.2. Non-optimal Application PCB Layouts for WGM110A Module

The impact of the size of the ground plane on the achievable range of the maximum range available for the WGM110A Module is shown below. As can be seen from the image, the curve indicates that the maximum range is achieved with an approximately 35 - 40 mm wide ground plane. Narrower ground planes can be used but will result in compromised RF performance.

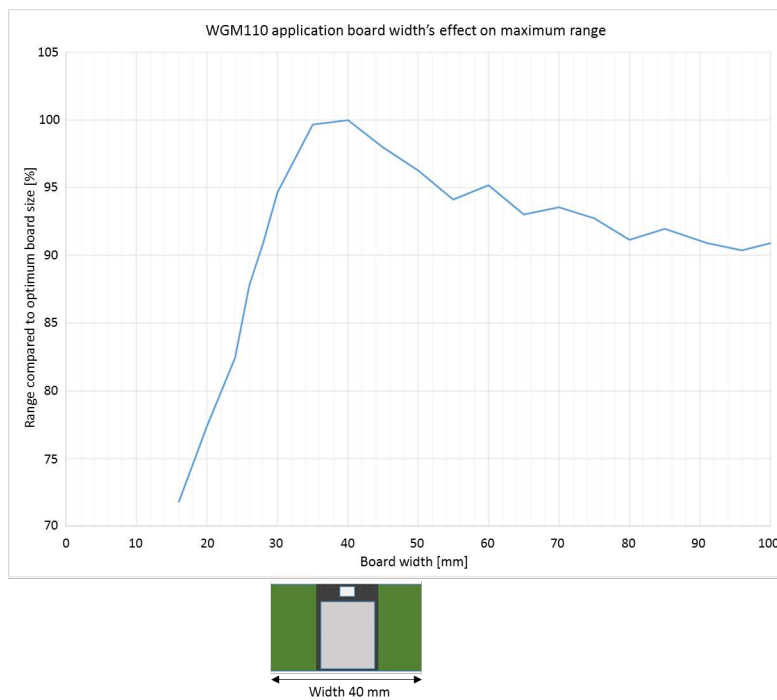


Figure 5.3. Guideline For the Achievable Range vs. Ground Plane Width for WGM110A

5.3 Antenna Design Guidelines

This section contains information regarding the optimal functioning of the antenna when using the WGM110A version. When using the WGM110E version with an external antenna follow the antenna manufacturers design related information typically available from the antenna data sheet.

5.3.1 Effect of Plastic and Metal Materials

Do not place plastic or any other dielectric material in touch with the antenna.

Any metallic objects in close proximity to the antenna will prevent the antenna from radiating freely. The minimum recommended distance of metallic and/or conductive objects is 10 mm in any direction from the antenna except in the directions of the application PCB ground planes.

5.3.2 Locating the Module Close to Human Body

When using the Module in an application where the radio is located close to human body, the human RF exposure must be evaluated. FCC, IC, and CE all have different standards for evaluating the RF exposure and, because of this, each standard will require a different minimum separation distance between the Module and human body. Certification of WGM110 allows the following minimum separation distances without any actions required from the end product manufacturer but the allowed minimum separation distances differ slightly between the WGM110A and WGM110E versions as indicated in the table below.

Table 5.1. Minimum Allowed Separation Distances for WGM110 A and E Variants

Certification	WGM110A	WGM110E
FCC	21 mm	21 mm
IC	25 mm	30 mm
CE	The RF exposure must be evaluated using the end product	The RF exposure must be evaluated using the end product

For FCC and IC, using the Module in end products where the separation distance is smaller than those listed above is allowed but requires evaluation of the RF exposure in the final assembly and applying for a *Class 2 Permissive Change* or *Change of ID* to be applied to the existing FCC/IC certificates of the Module.

For CE certification, RF exposure must be evaluated using the end product in all cases.

Note: Placing the Module in touch or very close to the human body will have a negative impact on the efficiency of the antenna thus reducing range.

6. Electrical Characteristics

This section contains tables with electrical characteristics of WGM110 Module.

6.1 Absolute Maximum Ratings

The values indicated in the table below define the absolute maximum ratings for WGM110 Module.

Table 6.1. Absolute Maximum Ratings

Rating	Min	Max	Unit
Storage Temperature	-40	85	°C
VDDPA	0	6	V
VDDCPU	0	3.8	V
GPIO Terminal Voltages	-0.3	VDDCPU + 0.3	V

6.2 Recommended Operating Conditions

The values indicated in the table below define the recommended operating value ranges for WGM110 Module.

Table 6.2. Recommended Operating Conditions

Rating	Min	Max	Unit
Operating Temperature Range (including internal heating)	-40	85	°C
VDDPA	2.7	4.8	V
VDDCPU	1.98	3.8	V

6.3 Input/Output Terminal Characteristics

The values indicated in the table below define the input and output terminal characteristics for WGM110 Module.

Table 6.3. Digital Input/Output Terminal Electrical Characteristics

Digital terminals	Min	Typ	Max	Unit
Input voltage levels				
VIL input logic level low 1.7 V ≤ VDD ≤ 3.6 V	—	—	0.3VDD	V
VIH input logic level high 1.7 V ≤ VDD ≤ 3.6 V	0.7 VDD	—	—	V
Output voltage levels				
VOL output logic level low, Vdd = 3.3 V, Iol = 20 mA, strongest drive	—	—	0.2 × VDD	V
VOH output logic level high Vdd = 3.3 V, Ioh = -20 mA, strongest drive	0.8 × VDD	—	—	V
Internal pull-up resistor	—	40	—	kΩ

Digital terminals	Min	Typ	Max	Unit
Internal pull-down resistor	—	40	—	kΩ
Pulse width of pulses to be removed by the glitch suppression filter when enabled	10		50	ns

6.4 Power-on Reset

The values indicated in the table below define the power-on reset signal characteristics for WGM110 Module.

Table 6.4. Power-on Reset Characteristics

Power-on Reset	Min	Typ	Max	Unit
Power-on reset threshold (rising edge)	—	—	1.96	V

6.5 Analog Digital Converter (ADC)

The values indicated in the table below define the ADC characteristics for WGM110 Module.

Table 6.5. ADC Characteristics

Power-on Reset	Min	Typ	Max	Unit
Input impedance	1	—	—	MΩ
Input voltage range (single ended)	0	—	Vref	V
Common mode input range	0	—	VDDCPU	V
Range of external reference voltage	1.25	—	VDDCPU	V
Resolution	—	—	12	bits
ADC clock frequency	—	—	13	MHz
Acquisition time (programmable)	1	—	256	ADC CLK cycles
Conversion time (6-bit)	7	—	—	ADC CLK cycles
Conversion time (8-bit)	11	—	—	ADC CLK cycles
Conversion time (12-bit)	13	—	—	ADC CLK cycles
Offset error (single-ended)	—	0.3	—	mV
Integral non-linearity	—	±1.2	±3	LSB

6.6 Power Consumption

The values indicated in the table below define the power consumption characteristics and the typical power consumption in practical use cases respectively for WGM110 Module.