

BGX13S Blue Gecko Xpress *Bluetooth*® SiP Module Data Sheet



The BGX13S Blue Gecko Xpress *Bluetooth*® SiP Module family of serial replacement modules eliminate Bluetooth firmware development complexity with a serial interface that can operate as a raw data stream or control the device through a command API. The BGX13S can facilitate a device-to-device cable replacement link or communicate with mobile devices through the Xpress Bluetooth mobile library. The device integrates a Bluetooth 5 compliant stack to future-proof applications as Bluetooth 5 adoption increases.

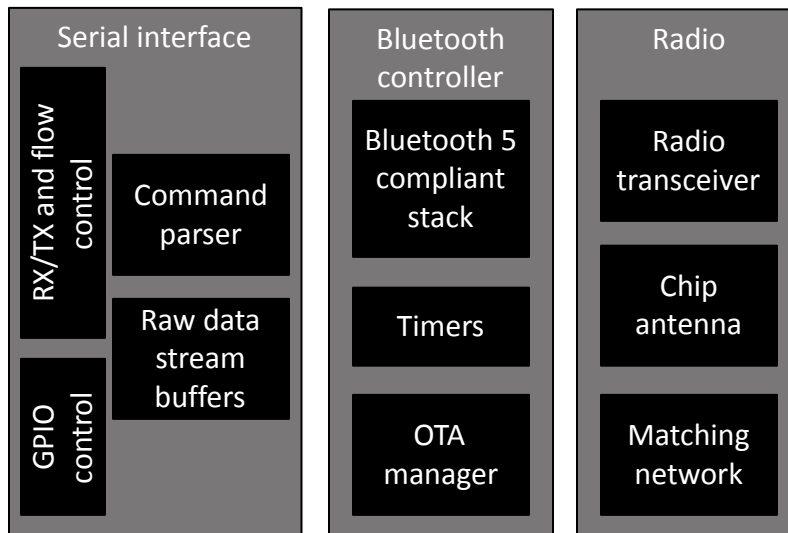
The device is targeted for applications where ultra-small size, reliable high performance RF, low-power consumption, and fast time-to-market are key requirements. At 6.5 × 6.5 × 1.4 mm the BGX13S module fits applications where size is a constraint. BGX13S also integrates a high-performance, ultra-robust antenna, which requires minimal PCB, plastic, and metal clearance. The total PCB area required by BGX13S is only 51 mm². The BGX13S has Bluetooth, CE, full FCC, Japan and South-Korea certifications.

BGX13S SiP modules can be used in a wide variety of applications:

- Health, sports and wellness devices
- Industrial, home and building automation
- Smart phone, tablet and PC accessories

KEY FEATURES

- Bluetooth 5 low energy compliant
- Serial interface with hardware flow control
- GPIO control through command API
- Integrated antenna
- TX power up to 8 dBm
- Encrypted bonding and connectivity
- Operates as central or peripheral
- Onboard Bluetooth stack
- Centralized OTA through mobile app library



1. Ordering Information

Table 1.1. Ordering Information

Ordering Code	Protocol Stack	Frequency Band @ Max TX Power	Antenna	GPIO	Packaging
BGX13S22GA-V31R	Bluetooth Low Energy	2.4 GHz @ 8 dBm	Built-in	8	Reel
BGX13S22GA-V31	Bluetooth Low Energy	2.4 GHz @ 8 dBm	Built-in	8	Tray

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2. Electrical Specifications

2.1 Electrical Characteristics

All electrical parameters in all tables are specified under the following conditions, unless stated otherwise:

- Typical values are based on $T_{AMB} = 25\text{ °C}$ and $V_{BAT} = 3.3\text{ V}$, by production test and/or technology characterization.
- Radio performance numbers are measured in conducted mode, based on Silicon Laboratories reference designs using output power-specific external RF impedance-matching networks for interfacing to a $50\ \Omega$ antenna.
- Minimum and maximum values represent the worst conditions across supply voltage, process variation, and operating temperature, unless stated otherwise.

Refer to for more details about operational supply and temperature limits.

2.1.1 Absolute Maximum Ratings

Stresses above those listed below may cause permanent damage to the device. This is a stress rating only and functional operation of the devices at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability. For more information on the available quality and reliability data, see the Quality and Reliability Monitor Report at <http://www.silabs.com/support/quality/pages/default.aspx>.

Table 2.1. Absolute Maximum Ratings

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Storage temperature range	T_{STG}		-40	—	85	°C
Voltage on any supply pin	V_{DDMAX}		-0.3	—	3.8	V
Voltage ramp rate on any supply pin	$V_{DDRAMPMAX}$		—	—	1	V / μ s
DC voltage on any GPIO pin	V_{DIGPIN}		-0.3	—	IOVDD+0.3	V
Maximum RF level at input	$P_{RFMAX2G4}$		—	—	10	dBm
Total current into supply pins	I_{VDDMAX}	Source	—	—	200	mA
Total current into VSS ground lines	I_{VSSMAX}	Sink	—	—	200	mA
Current per I/O pin	I_{IOMAX}	Sink	—	—	50	mA
		Source	—	—	50	mA
Current for all I/O pins	$I_{IOALLMAX}$	Sink	—	—	200	mA
		Source	—	—	200	mA
Junction temperature	T_J		-40	—	105	°C

2.1.2 Operating Conditions

The following subsections define the operating conditions for the module.

2.1.2.1 General Operating Conditions

Table 2.2. General Operating Conditions

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Operating ambient temperature range	T_A		-40	25	85	°C
VBATT operating supply voltage	V_{VBATT}		2.4	3.3	3.8	V
VBATT current	I_{VBATT}		—	—	200	mA
IOVDD operating supply voltage	V_{IOVDD}		1.62	—	V_{VBATT}	V

2.1.3 Power Consumption

Unless otherwise indicated, typical conditions are: VBATT = 3.3 V. T = 25 °C. Minimum and maximum values in this table represent the worst conditions across process variation at T = 25 °C.

Table 2.3. Power Consumption

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Active supply current, Un-connected, Idle	I _{ACTIVE_IDLE}	Baud rate ≤ 9600 bps	—	3	—	μA
		Baud rate > 9600 bps	—	3.25	—	mA
Active supply current, Advertising	I _{ACTIVE_ADV}	Interval = 546.25 ms, Baud rate ≤ 9600 bps	—	90	—	μA
		Interval = 20 ms, Baud rate ≤ 9600 bps	—	2	—	mA
		Interval = 546.25 ms, Baud rate > 9600 bps	—	3.3	—	mA
		Interval = 20 ms, Baud rate > 9600 bps	—	4.7	—	mA
Active supply current, Connected, 15 ms Interval	I _{ACTIVE_CONN}	Idle, Baud Rate ≤ 9600 bps	—	660	—	μA
		TX/RX (acknowledged) at highest throughput, Baud Rate ≤ 9600 bps	—	3.5	—	mA
		TX/RX (unacknowledged) at highest throughput, Baud Rate ≤ 9600 bps	—	4	—	mA
		Idle, Baud Rate > 9600 bps	—	3.5	—	mA
		TX/RX (acknowledged) at highest throughput, Baud Rate > 9600 bps	—	5.25	—	mA
		TX/RX (unacknowledged) at highest throughput, Baud Rate > 9600 bps	—	7	—	mA
Supply current in low power mode	I _{LPM}	Radio disabled	—	3	—	μA
		Radio enabled, Advertising, Interval = 546.25 ms	—	90	—	μA
		Radio enabled, Advertising, Interval = 20 ms	—	2	—	mA

2.1.4 2.4 GHz RF Transceiver Characteristics

2.1.4.1 RF Transmitter General Characteristics for 2.4 GHz Band

Unless otherwise indicated, typical conditions are: T = 25 °C, VBATT = 3.3 V. DC-DC on. Crystal frequency = 38.4 MHz. RF center frequency 2.45 GHz. Conducted measurement from the antenna feedpoint.

Table 2.4. RF Transmitter General Characteristics for 2.4 GHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Maximum TX power ¹	POUT _{MAX}		—	7.8	—	dBm
Minimum active TX Power	POUT _{MIN}	CW		-30	—	dBm
Output power step size	POUT _{STEP}	-5 dBm < Output power < 0 dBm	—	1	—	dB
		0 dBm < output power < POUT _{MAX}	—	0.5	—	dB
Output power variation vs supply at POUT _{MAX}	POUT _{VAR_V}	2.4 V < V _{VBATT} < 3.3 V	—	2.1	—	dB
Output power variation vs temperature at POUT _{MAX}	POUT _{VAR_T}	From -40 to +85 °C	—	1.7	—	dB
Output power variation vs RF frequency at POUT _{MAX}	POUT _{VAR_F}	Over RF tuning frequency range	—	0.3	—	dB
RF tuning frequency range	F _{RANGE}		2400	—	2483.5	MHz

Note:

- Supported transmit power levels are determined by the ordering part number (OPN). Transmit power ratings for all devices covered in this datasheet can be found in the Max TX Power column of the Ordering Information Table.

2.1.4.2 RF Receiver General Characteristics for 2.4 GHz Band

Unless otherwise indicated, typical conditions are: T = 25 °C, VBATT = 3.3 V. DC-DC on. Crystal frequency = 38.4 MHz. RF center frequency 2.45 GHz. Conducted measurement from the antenna feedpoint.

Table 2.5. RF Receiver General Characteristics for 2.4 GHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RF tuning frequency range	F _{RANGE}		2400	—	2483.5	MHz
Receive mode maximum spurious emission	SPUR _{RX}	30 MHz to 1 GHz	—	-57	—	dBm
		1 GHz to 12 GHz	—	-47	—	dBm
Max spurious emissions during active receive mode, per FCC Part 15.109(a)	SPUR _{RX_FCC}	216 MHz to 960 MHz, Conducted Measurement	—	-55.2	—	dBm
		Above 960 MHz, Conducted Measurement	—	-47.2	—	dBm
Level above which RFSENSE will trigger ¹	RFSENSE _{TRIG}	CW at 2.45 GHz	—	-24	—	dBm
Level below which RFSENSE will not trigger ¹	RFSENSE _{THRES}	CW at 2.45 GHz	—	-50	—	dBm

Note:

1. RFSENSE performance is only valid from 0 to 85 °C. RFSENSE should be disabled outside this temperature range.

2.1.4.3 RF Receiver Characteristics for Bluetooth Low Energy in the 2.4GHz Band, 1 Mbps Data Rate

Unless otherwise indicated, typical conditions are: T = 25 °C, VBATT = 3.3 V. DC-DC on. Crystal frequency = 38.4 MHz. RF center frequency 2.45 GHz. Conducted measurement from the antenna feedpoint.

Table 2.6. RF Receiver Characteristics for Bluetooth Low Energy in the 2.4GHz Band, 1 Mbps Data Rate

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Max usable receiver input level, 0.1% BER	SAT	Signal is reference signal ¹ . Packet length is 20 bytes.	—	10	—	dBm
Sensitivity, 0.1% BER	SENS	Signal is reference signal ¹ . Using DC-DC converter.	—	-94.1	—	dBm
		With non-ideal signals as specified in RF-PHY.TS.4.2.2, section 4.6.1.	—	-93.8	—	dBm
Signal to co-channel interferer, 0.1% BER	C/I _{CC}	Desired signal 3 dB above reference sensitivity.	—	9.0	—	dB
N+1 adjacent channel selectivity, 0.1% BER, with allowable exceptions. Desired is reference signal at -67 dBm	C/I ₁₊	Interferer is reference signal at +1 MHz offset. Desired frequency 2402 MHz ≤ F _c ≤ 2480 MHz	—	-3.3	—	dB
N-1 adjacent channel selectivity, 0.1% BER, with allowable exceptions. Desired is reference signal at -67 dBm	C/I ₁₋	Interferer is reference signal at -1 MHz offset. Desired frequency 2402 MHz ≤ F _c ≤ 2480 MHz	—	-1.6	—	dB
Alternate selectivity, 0.1% BER, with allowable exceptions. Desired is reference signal at -67 dBm	C/I ₂	Interferer is reference signal at ± 2 MHz offset. Desired frequency 2402 MHz ≤ F _c ≤ 2480 MHz	—	-42.0	—	dB
Alternate selectivity, 0.1% BER, with allowable exceptions. Desired is reference signal at -67 dBm	C/I ₃	Interferer is reference signal at ± 3 MHz offset. Desired frequency 2404 MHz ≤ F _c ≤ 2480 MHz	—	-46.4	—	dB
Selectivity to image frequency, 0.1% BER. Desired is reference signal at -67 dBm	C/I _{IM}	Interferer is reference signal at image frequency with 1 MHz precision	—	-42.0	—	dB
Selectivity to image frequency ± 1 MHz, 0.1% BER. Desired is reference signal at -67 dBm	C/I _{IM+1}	Interferer is reference signal at image frequency ± 1 MHz with 1 MHz precision	—	-47.1	—	dB
Intermodulation performance	IM	Per Core_4.1, Vol 6, Part A, Section 4.4 with n = 3	—	-18.4	—	dBm

Note:

- Reference signal is defined 2GFSK at -67 dBm, Modulation index = 0.5, BT = 0.5, Bit rate = 1 Mbps, desired data = PRBS9; interferer data = PRBS15; frequency accuracy better than 1 ppm.

2.1.4.4 RF Receiver Characteristics for Bluetooth Low Energy in the 2.4GHz Band, 2 Mbps Data Rate

Unless otherwise indicated, typical conditions are: T = 25 °C, VBATT = 3.3 V. DC-DC on. Crystal frequency = 38.4 MHz. RF center frequency 2.45 GHz. Conducted measurement from the antenna feedpoint.

Table 2.7. RF Receiver Characteristics for Bluetooth Low Energy in the 2.4GHz Band, 2 Mbps Data Rate

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Max usable receiver input level, 0.1% BER	SAT	Signal is reference signal ¹ . Packet length is 20 bytes.	—	10	—	dBm
Sensitivity, 0.1% BER	SENS	Signal is reference signal ¹ . Using DC-DC converter.	—	-90.2	—	dBm
		With non-ideal signals as specified in RF-PHY.TS.4.2.2, section 4.6.1.	—	-89.9	—	dBm
Signal to co-channel interferer, 0.1% BER	C/I _{CC}	Desired signal 3 dB above reference sensitivity.	—	8.6	—	dB
N+1 adjacent channel selectivity, 0.1% BER, with allowable exceptions. Desired is reference signal at -67 dBm	C/I ₁₊	Interferer is reference signal at +2 MHz offset. Desired frequency 2402 MHz ≤ F _c ≤ 2480 MHz	—	-7.6	—	dB
N-1 adjacent channel selectivity, 0.1% BER, with allowable exceptions. Desired is reference signal at -67 dBm	C/I ₁₋	Interferer is reference signal at -2 MHz offset. Desired frequency 2402 MHz ≤ F _c ≤ 2480 MHz	—	-11.4	—	dB
Alternate selectivity, 0.1% BER, with allowable exceptions. Desired is reference signal at -67 dBm	C/I ₂	Interferer is reference signal at ± 4 MHz offset. Desired frequency 2402 MHz ≤ F _c ≤ 2480 MHz	—	-40.3	—	dB
Alternate selectivity, 0.1% BER, with allowable exceptions. Desired is reference signal at -67 dBm	C/I ₃	Interferer is reference signal at ± 6 MHz offset. Desired frequency 2404 MHz ≤ F _c ≤ 2480 MHz	—	-45.1	—	dB
Selectivity to image frequency, 0.1% BER. Desired is reference signal at -67 dBm	C/I _{IM}	Interferer is reference signal at image frequency with 1 MHz precision	—	-7.6	—	dB
Selectivity to image frequency ± 2 MHz, 0.1% BER. Desired is reference signal at -67 dBm	C/I _{IM+1}	Interferer is reference signal at image frequency ± 2 MHz with 2 MHz precision	—	-40.30	—	dB
Intermodulation performance	IM	Per Core_4.1, Vol 6, Part A, Section 4.4 with n = 3	—	-18.4	—	dBm

Note:

- Reference signal is defined 2GFSK at -67 dBm, Modulation index = 0.5, BT = 0.5, Bit rate = 2 Mbps, desired data = PRBS9; interferer data = PRBS15; frequency accuracy better than 1 ppm.

2.1.5 Non-Volatile Configuration Storage

Table 2.8. Non-Volatile Configuration Storage

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Update cycles before failure	UC		10000	—	—	cycles
Data retention	RET		10	—	—	years
Supply voltage during update	V _{DD}		2.4	—	3.6	V

2.1.6 General-Purpose I/O (GPIO)

Table 2.9. General-Purpose I/O (GPIO)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Input low voltage ¹	V_{IL}	GPIO pins	—	—	IOVDD*0.3	V
Input high voltage ¹	V_{IH}	GPIO pins	IOVDD*0.7	—	—	V
Output high voltage relative to IOVDD	V_{OH}	Sourcing 3 mA, IOVDD \geq 3 V, Drive Strength = Weak	IOVDD*0.8	—	—	V
		Sourcing 1.2 mA, IOVDD \geq 1.62 V, Drive Strength = Weak	IOVDD*0.6	—	—	V
		Sourcing 20 mA, IOVDD \geq 3 V, Drive Strength = Strong	IOVDD*0.8	—	—	V
		Sourcing 8 mA, IOVDD \geq 1.62 V, Drive Strength = Strong	IOVDD*0.6	—	—	V
Output low voltage relative to IOVDD	V_{OL}	Sinking 3 mA, IOVDD \geq 3 V, Drive Strength = Weak	—	—	IOVDD*0.2	V
		Sinking 1.2 mA, IOVDD \geq 1.62 V, Drive Strength = Weak	—	—	IOVDD*0.4	V
		Sinking 20 mA, IOVDD \geq 3 V, Drive Strength = Strong	—	—	IOVDD*0.2	V
		Sinking 8 mA, IOVDD \geq 1.62 V, Drive Strength = Strong	—	—	IOVDD*0.4	V
Input leakage current	I_{IOLEAK}	All GPIO except LFXO pins, GPIO \leq IOVDD	—	0.1	30	nA
		LFXO Pins, GPIO \leq IOVDD	—	0.1	50	nA
I/O pin pull-up/pull-down resistor ²	R_{PUD}		30	40	65	k Ω
Pulse width of pulses removed by the glitch suppression filter	$t_{IOGLITCH}$		15	25	45	ns
Output fall time, From 70% to 30% of V_{IO}	t_{IOOF}	$C_L = 50$ pF, Drive Strength = Strong	—	1.8	—	ns
		$C_L = 50$ pF, Drive Strength = Weak	—	4.5	—	ns
Output rise time, From 30% to 70% of V_{IO}	t_{IOOR}	$C_L = 50$ pF, Drive Strength = Strong	—	2.2	—	ns
		$C_L = 50$ pF, Drive Strength = Weak	—	7.4	—	ns

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Note: 1. GPIO input threshold are proportional to the IOVDD supply, except for RESETn which is proportional to VBATT. 2. GPIO pull-ups are referenced to the IOVDD supply, except for RESETn, which connects to VBATT.						

3. Typical Connection Diagrams

3.1 Typical BGX13S Connections

Typical connections for the BGX13S module are shown in [Figure 3.1 Typical Connections for BGX13S on page 15](#). This diagram shows connections for:

- Power supplies

Note: The 1V8 pin is the 1.8V output of the internal DC-DC converter. This pin should be left unconnected. Do not add external decoupling or power external circuits from this pin.

- Antenna loop for internal antenna usage or external antenna connection - The RF and ANTENNA pins should be tied together for correct operation of the module. An optional 0R resistor can be added between RF and ANTENNA, making it possible to measure the signal between these pins.
- Reset line

Note:

It is recommended to connect the RESETn line to an open-drain IO pin on the host CPU.

RESETn includes an internal pull-up to the VBATT supply and input logic levels on RESETn are referenced to VBATT. In systems where IOVDD is not equal to VBATT, additional considerations may need to be taken.

- UART connection to an embedded host
- Optional 32.768 kHz crystal - Recommended crystal is KDS part number 1TJG125DP1A0012 or equivalent. Crystal used must have better than 100 ppm accuracy.

Note:

If external low-frequency crystal is unused, LFX TAL pins must be tied to ground - ground connections are detected by device and internal oscillator is used instead.

- Optional BOOT pin connection - BOOT is an active-low digital input that will force the module into a DFU bootloader state after device reset. BOOT can be tied to IOVDD or left disconnected if it is unused.

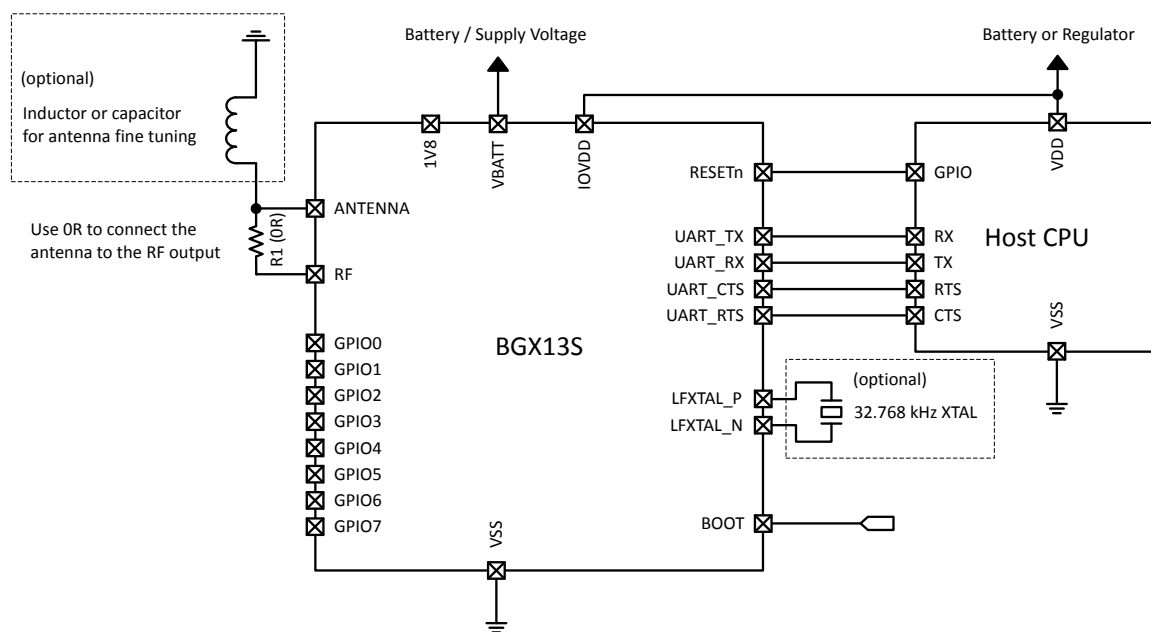


Figure 3.1. Typical Connections for BGX13S

4. Layout Guidelines

For optimal performance of the BGX13S, please follow the PCB layout guidelines and ground plane recommendations indicated in this section.

4.1 Layout Guidelines

This section contains generic PCB layout and design guidelines for the BGX13S module. For optimal performance:

- Place the module at the edge of the PCB, as shown in the figures in this chapter.
- Do not place any metal (traces, components, etc.) in the antenna clearance area.
- Connect all ground pads directly to a solid ground plane.
- Place the ground vias as close to the ground pads as possible.

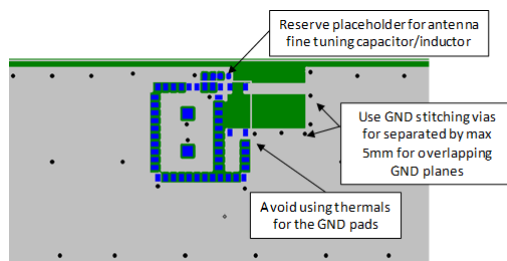


Figure 4.1. BGX13S PCB Top Layer Design

The following rules are recommended for the PCB design:

- Trace to copper clearance 150um
- PTH drill size 300um
- PTH annular ring 150um

Important:

The antenna area must align with the pads precisely. Please refer to the recommended PCB land pattern for exact dimensions.

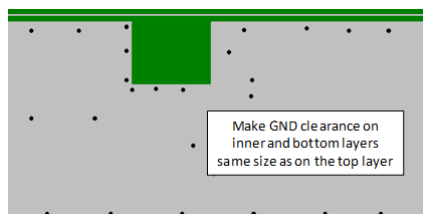


Figure 4.2. BGX13S PCB Middle and Bottom Layer Design

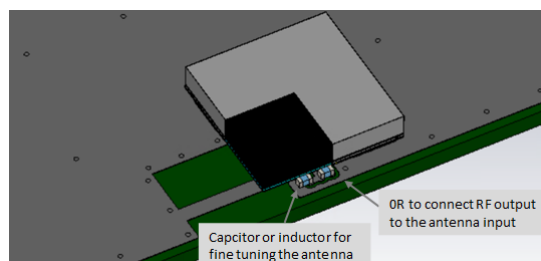


Figure 4.3. Practical Installation of BGX13S on Application PCB

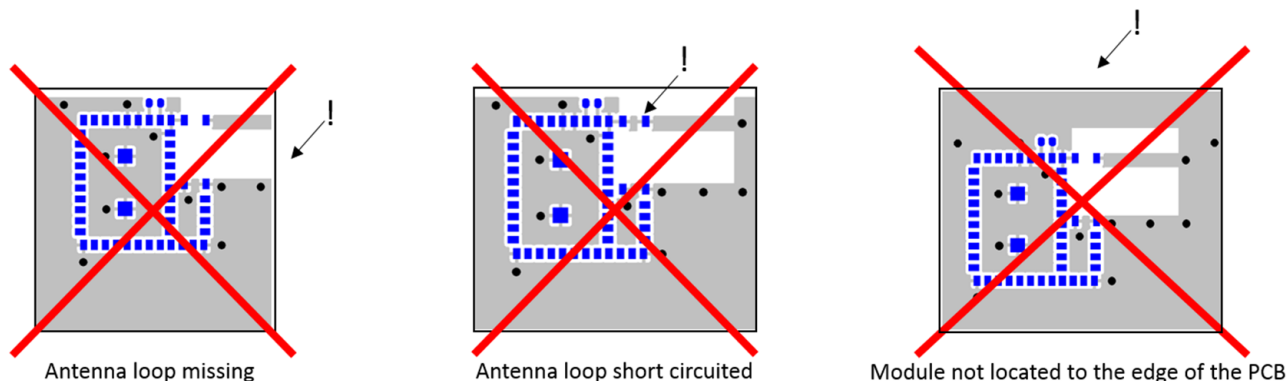


Figure 4.4. Poor Layout Designs for the BGX13S

Layout checklist for BGX13S:

1. Antenna area is aligned relative to the module pads as shown in the recommended PCB land pattern.
2. Clearance area within the inner layers and bottom layer is covering the whole antenna area as shown in the layout guidelines.
3. The antenna loop is implemented on the top layer as shown in the layout guidelines.
4. All dimensions within the antenna area are precisely as shown in the recommended PCB land pattern.
5. The module is placed near the edge of the PCB with max 1mm indentation.
6. The module is not placed in the corner of the PCB.

4.2 Effect of PCB Width

The BGX13S module should be placed at the center of the PCB edge. The width of the board has an impact to the radiated efficiency and, more importantly, there should be enough ground plane on both sides of the module for optimal antenna performance. [Figure 4.5 BGX13S PCB Top Layer Design on page 17](#) gives an indication of ground plane size vs. maximum achievable range.

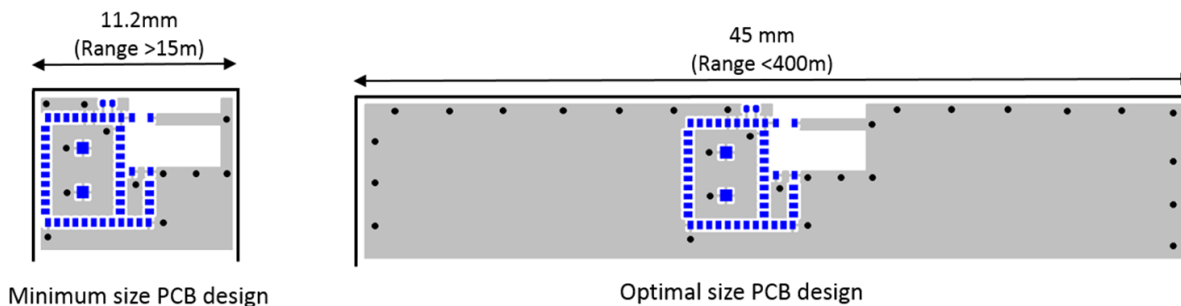


Figure 4.5. BGX13S PCB Top Layer Design

The impact of the board size to the radiated performance is a generic feature of all PCB and chip antennas and it is not a unique feature of the BGX13S. For the BGX13S the depth of the board is not important and does not impact the radiated performance.

4.3 Effect of Plastic and Metal Materials

The antenna on the BGX13S is insensitive to the effects of nearby plastic and other materials with low dielectric constant. No separation between the BGX13S and plastic or other materials is needed. The board thickness has an impact on the module and the additional inductor/capacitor will help to tune the antenna to any board thickness.

In some cases, it may be necessary to fine tune the antenna to optimize for any specific application layout or mechanical design. A capacitor or an inductor in parallel with the antenna input can be used for optimizing the antenna for any PCB layouts. A capacitor moves the antenna frequency lower and an inductor moves the antenna frequency higher. Capacitor values between 0.1 pF-10 pF and inductor values 3.6 nH-10 nH can be used.

The antenna is extremely robust against any objects in close proximity or in direct contact with the antenna and it is recommended not to adjust the dimensions of the antenna area unless it is clear that a metal object, such as a coin cell battery, within the antenna area is detuning the antenna.

4.4 Effects of Human Body

Placing the module in contact with or very close to the human body will negatively impact antenna efficiency and reduce range.

4.5 2D Radiation Pattern Plots

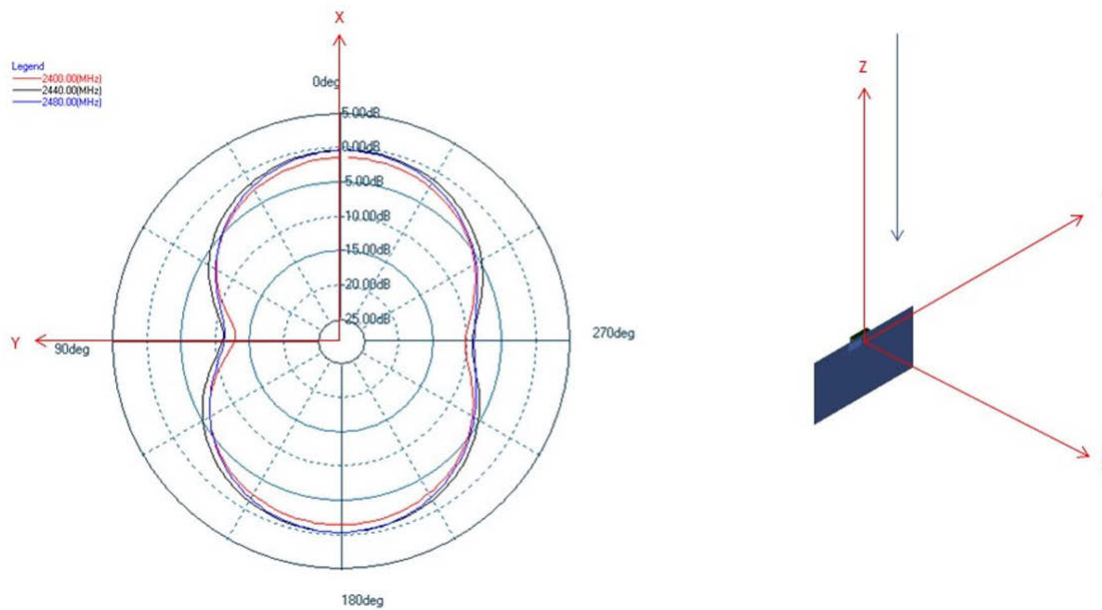


Figure 4.6. Typical 2D Radiation Pattern – Front View

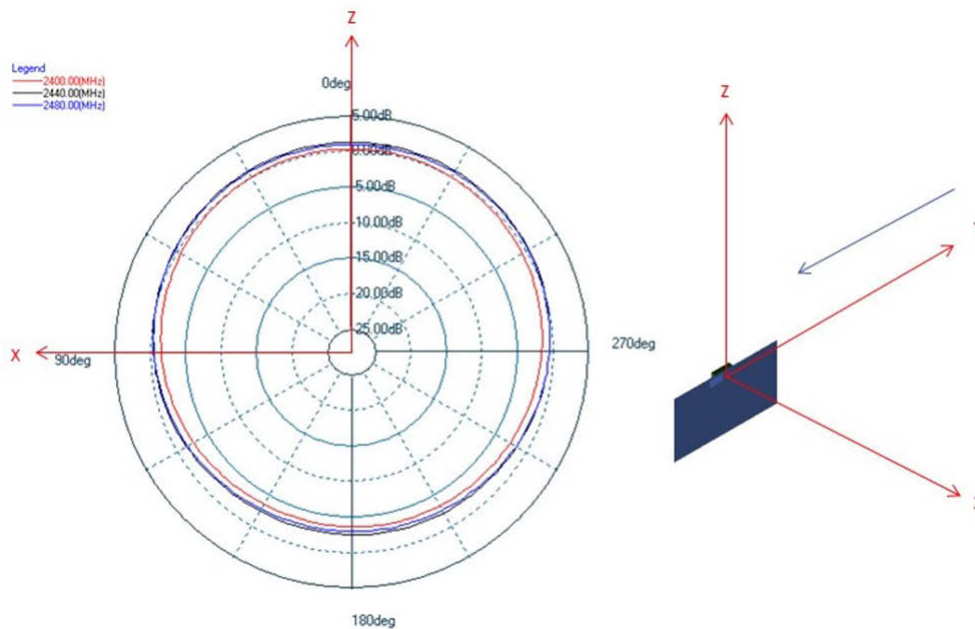


Figure 4.7. Typical 2D Radiation Pattern – Side View

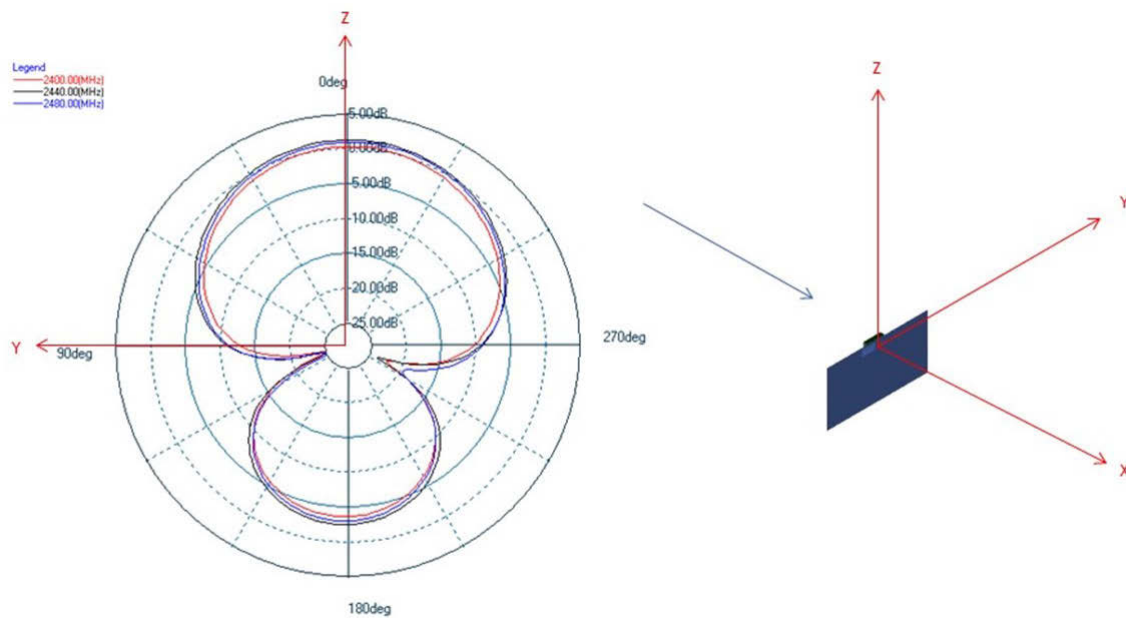


Figure 4.8. Typical 2D Radiation Pattern – Top View

Table 5.1. BGX13S Device Pinout

Pin Name	Pin(s)	Description
VSS	1 4 5 20 31 45 46 48 49 50 51	Ground
RF	3	50 Ohm I/O for external antenna connection.
GPIO0	10	Pin with input/output functionality configured by the command API.
GPIO1	11	Pin with input/output functionality configured by the command API.
GPIO2	12	Pin with input/output functionality configured by the command API.
GPIO3	17	Pin with input/output functionality configured by the command API.
GPIO4	18	Pin with input/output functionality configured by the command API.
GPIO5	26	Pin with input/output functionality configured by the command API.
GPIO6	27	Pin with input/output functionality configured by the command API.
UART_TX	13	Digital output
UART_RX	14	Digital input
UART_CTS	15	Digital input
UART_RTS	16	Digital output
GPIO7	28	Pin with input/output functionality configured by the command API.
VBATT	22	Battery supply voltage input to the internal DC-DC and analog supply.
IOVDD	24	Digital IO power supply.
LFXTAL_P	19	Low frequency external oscillator output pin.
LFXTAL_N	21	Low frequency external oscillator input pin.
RESETn	44	Reset input, active low. To apply an external reset source to this pin, it is required to only drive this pin low during reset, and let the internal pull-up ensure that reset is released.
ANTENNA	2	50 Ohm input, pin for internal 2.4 GHz antenna
1V8	23	1.8V output of the internal DC-DC converter. Do not add external decoupling or power external circuits from this pin.
BOOT	33	Active-low digital input to force module entrance into DFU bootloader state upon device reset. See command API documentation for functional details.
ANT_GND	47	Antenna ground.

Pin Name	Pin(s)	Description
N/C	6 7 8 9 25 29 30 32 34 35 36 37 38 39 40 41 42 43	No Connect.

Note: Pins labeled N/C (No Connect) and any unused GPIO pins should be left disconnected. UART flow control pins may also be left disconnected when feature is unused.

6. Functional Overview

6.1 Introduction

The BGX13S creates a Bluetooth 5 compliant Bluetooth Low Energy cable replacement interface, facilitating a Bluetooth Low Energy link to a second embedded device or a mobile device. An embedded MCU controls the device and communicates across the Bluetooth Low Energy link through a serial interface and control signals. Parameters stored in non-volatile memory and configurable through the serial interface adjust performance characteristics of the device. Silicon Labs offers iOS and Android mobile libraries for Blue Gecko Xpress devices to speed mobile development and simplify communication with the device. This library also controls OTA management, facilitating secure and reliable updates to the device's embedded stack.

This functional overview does not cover each command supported by the command API. The complete command API specification is available at <https://docs.silabs.com/bgx/latest/>

6.2 Communication Use Cases

The BGX13S family facilitates two types of Bluetooth Low Energy communication links:

- BGX-to-mobile
- BGX-to-BGX

In the BGX-to-mobile communication use case, the BGX13S operates as a peripheral that is discoverable and connectable when configured to that state through either the command API or the pin states driven by the embedded MCU. Using the Xpress mobile library, mobile applications can scan for BGX13S devices, connect, and communicate with the device in both streaming and remote command modes, where the mobile app can execute command API functions remotely.

In the BGX-to-BGX communication use case, one BGX13S must be configured as the central device and one or more other BGX devices should be configured as a peripheral. Devices can be configured at runtime through the command API, or those settings can be saved to non-volatile memory so that each device wakes from power-on or low power states as either a peripheral or central. For more information on advertising and connection options, please see the command API documentation.

6.3 Embedded Interface

The BGX13S family uses an 8-N-1 USART interface for data and flow control signaling. The interface is used both for a raw data streaming interface and a command interface, depending on additional hardware pin configuration.

UART_TX and UART_RX are defined with flow directions relative to the BGX. Bytes sent from the embedded host to the BGX use the UART_RX pin. Bytes sent from the BGX to the embedded host appear on the UART_TX pin.

UART_CTS is a digital input that controls the state of the UART_RTS digital output on the other end of the wireless link. Assertion of a CTS/RTS pair signals that the embedded MCU driving its respective UART_CTS is available to receive bytes.

The baud rate of the BGX13S is a configurable parameter. For information on the process by which a baud rate change gets processed and executed by the device, please see the command API documentation.

State control signals and visual indicators described below can be assigned to any of the GPIO pins through the command API. These settings can be stored in non-volatile memory and take effect during the next power cycle. For information on configuration of standard GPIO and available special function I/O available on the device, please see the command API documentation.

6.4 Command Mode and Streaming Mode

The BGX13S is designed to wake and offer optimized serial interface with hardware flow control. Hardware flow control signaling is disabled by default. When operating in a peripheral role and when flow control signals are monitored, the device may never need to leave streaming mode during operation.

However, when use cases require more advanced runtime configuration, the device can switch to command interface through pin or escape sequence. Commands defined here can control scanning, advertising, connection state, and GPIO settings.

The command interface is also used to configure and store customizable parameters.

Streaming mode can be switched to command mode through an escape sequence of characters if the sequence has been previously saved in the device's configuration. A command can be issued in command mode to switch to streaming mode. Stream mode and command mode entrance can be controlled through a device port pin state, if a pin has been previously defined for that purpose.

6.5 Command API

Each command begins with a command name followed by arguments, and the syntax of each command is defined in the command API documentation.

The command interface saves settings as key-value pairs. These values can be used at runtime to modify the operational state, and they can also be stored in non-volatile memory. Values stored in non-volatile memory function to configure the device's startup/default state.

6.6 GPIO Control

The BGX13S offers 8 GPIO pins. These pins can be configured as state control pins or visual indicator pins. Alternatively, they can be used as general purpose I/O pins. Digital output settings can be set and digital input state can be read through the command interface locally or remotely through the remote command execution using the mobile libraries.

6.7 Device Configuration

Device configuration is handled through the command API, where commands are executed when the serial interface is set to operate in command mode. These commands can also be executed remotely through the mobile library unless prohibited through previous configuration.

Additionally, a device configuration can be generated and saved using Simplicity Studio's Xpress Configurator tool. A generated configuration can be submitted to Silicon Labs through the process defined in that application. Silicon Labs will then validate the configuration request, generate a custom orderable part number, and deliver first article samples for testing. Developers should contact sales representatives for more information about this process. Once first article samples have been validated by the customer, this custom orderable part number can be ordered directly from Silicon Labs.

6.8 Security Features

BGX13S devices communicate with LE secure connections, establishing encrypted communication upon connection.

Device OTA requires an encrypted image signed by Silicon Laboratories. Only firmware developed, signed, and encrypted by Silicon Labs can be bootloaded successfully on the device.

6.9 OTA

The BGX13S supports secure OTA of the embedded stack and the command interface. Images are encrypted and signed by Silicon Laboratories. OTA can be performed through the mobile library APIs. Specific device firmware versions can be selected and programmed through these APIs. See command API documentation for more information.

For information on new functionality including firmware updates to BGX13S, please see docs.silabs.com. BGX13S module OPN firmware will not be updated to include newly released features available through OTA and DFU updates provided by Silicon Labs. Module OPN firmware will only be updated at manufacturing time to provide security-related enhancements.

Contact Silicon Labs technical support for information on customer factory programming options for custom OPN ordering with a specified device firmware version and for customer factory programming options.

6.10 Direct Test Mode Support

The BGX13S's command API offers a command set that configures the device to support the Direct Test Mode (DTM) protocol as defined in the Bluetooth Core Specification Version 4.2, Volume 6, part F.

See the command API for information about commands to support specific DTM test procedures.

7. Package Specifications

7.1 BGX13S Package Dimensions

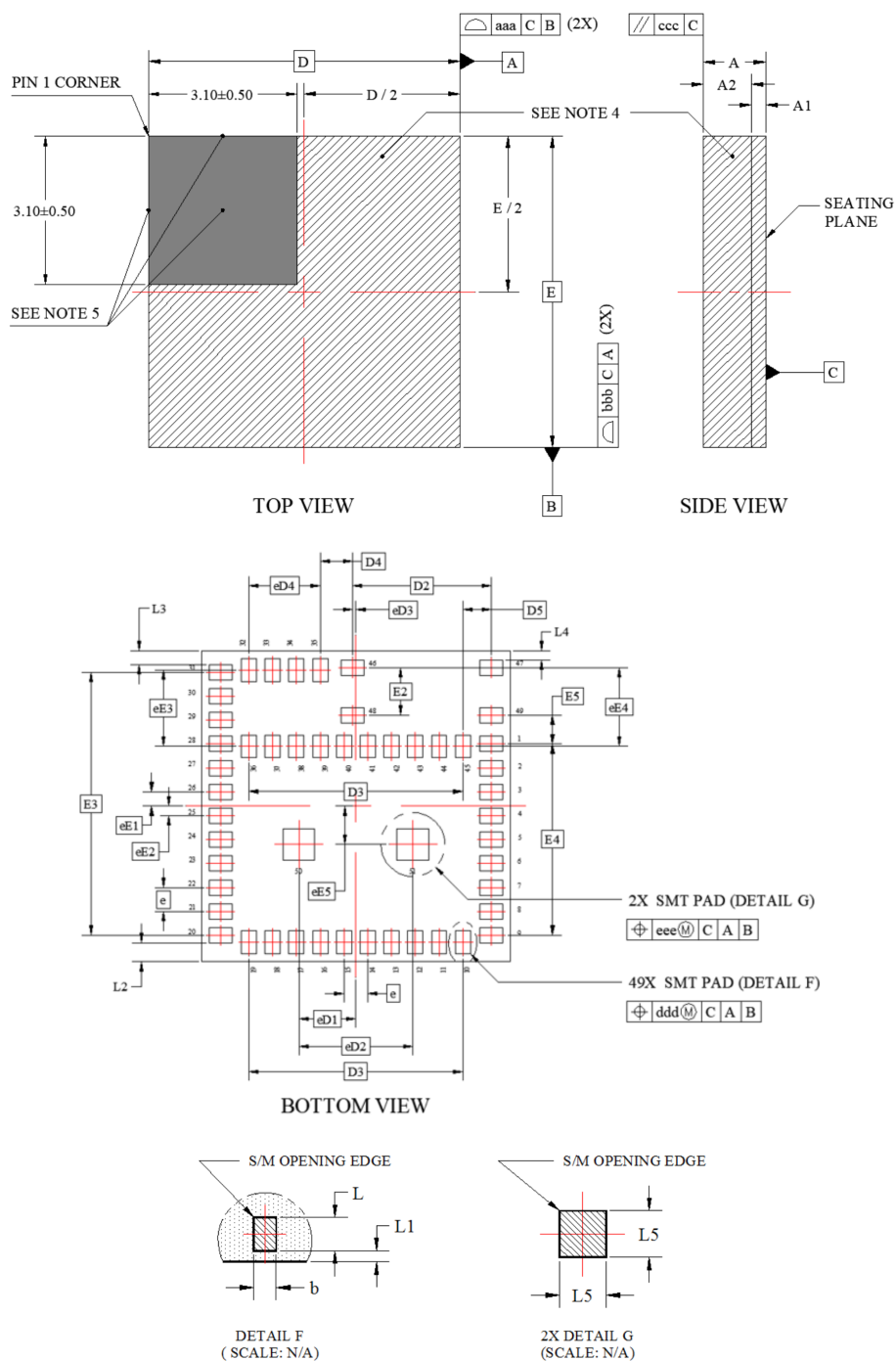


Figure 7.1. BGX13S Package Dimensions

Dimension	MIN	NOM	MAX
A	1.20	1.30	1.40
A1	0.26	0.30	0.34
A2	0.95	1.00	1.05
b	0.27	0.32	0.37

Dimension	MIN	NOM	MAX
D		6.50 BSC	
D2		2.92 BSC	
D3		4.50 BSC	
D4		0.68 BSC	
D5		0.60 BSC	
e		0.50 BSC	
E		6.50 BSC	
E2		1.00 BSC	
E3		5.50 BSC	
E4		4.00 BSC	
E5		0.60 BSC	
L	0.43	0.48	0.53
L1	0.11	0.16	0.21
L2	0.34	0.39	0.44
L3	0.24	0.29	0.34
L4	0.14	0.19	0.24
L5	0.62	0.67	0.72
eD1		1.20 BSC	
eD2		2.40 BSC	
eD3		0.07 BSC	
eD4		1.50 BSC	
eE1		0.30 BSC	
eE2		0.20 BSC	
eE3		1.60 BSC	
eE4		1.65 BSC	
eE5		0.80 BSC	
aaa		0.10	
bbb		0.10	
ccc		0.10	
ddd		0.10	
eee		0.10	

Dimension	MIN	NOM	MAX
-----------	-----	-----	-----

Note:

1. All dimensions shown are in millimeters (mm) unless otherwise noted.
2. Tolerances are:
 - a. Decimal:
 - X.X = ± 0.1
 - X.XX = ± 0.05
 - X.XXX = ± 0.03
 - b. Angular:
 - ± 0.1 Degrees
3. Dimensioning and Tolerancing per ANSI Y14.5M-1994.
4. This drawing conforms to the JEDEC Solid State Outline MO-220.
5. Recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components.
6. Hatching lines means package shielding area.
7. Solid pattern (3.1x3.1mm) shows non-shielding area including its side walls. For side wall, borderline between shielding area and not-shielding area could not be defined clearly like top side.

7.2 BGX13S Recommended PCB Land Pattern

This section describes the recommended PCB land pattern for the BGX13S. The antenna copper clearance area is shown in [Figure 7.2 BGX13S Recommended Antenna Clearance](#) on page 28, while the X-Y coordinates of pads relative to the origin are shown in [Table 7.1 BGX13S Pad Coordinates and Sizing](#) on page 29. The origin is the center point of pin number 47. It is very important to align the antenna area relative to the module pads precisely.

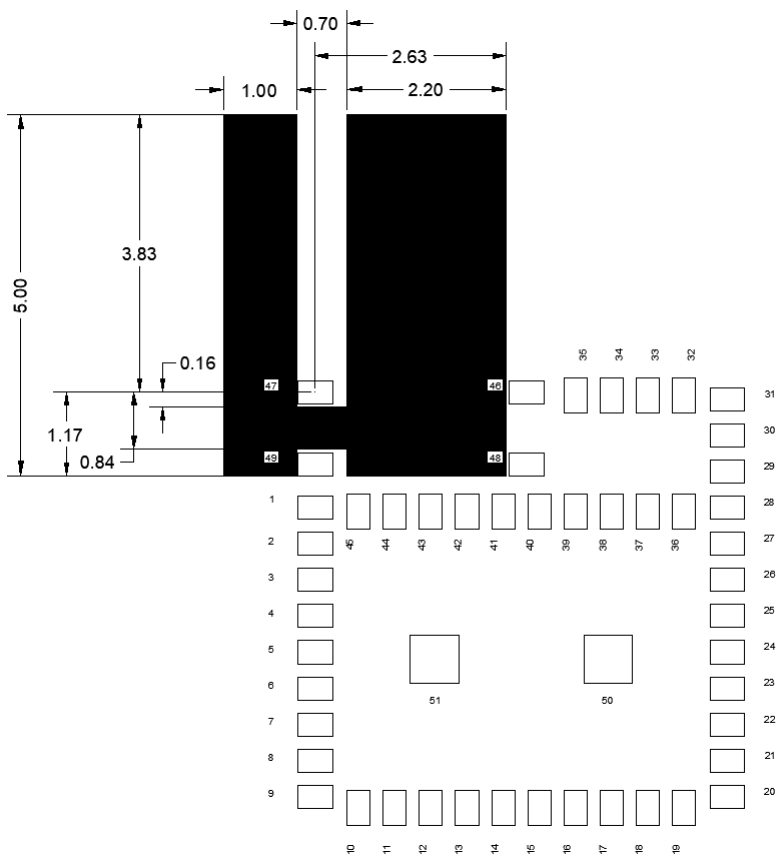


Figure 7.2. BGX13S Recommended Antenna Clearance

Table 7.1. BGX13S Pad Coordinates and Sizing

Pad No.	Pad coordinates (X,Y)	Pad size (mm)	
47	Pad Center, Origin (0,0)	0.32 x 0.48	
1	(0,-1.60)		
2	(0,-2.10)		
9	(0,-5.60)		
10	(0.60,-5.75)		
19	(5.10,-5.75)		
20	(5.70,-5.60)		
31	(5.70,-0.10)		
32	(5.10,-0.05)		
36	(5.10,-1.65)		
45	(0.60,-1.65)		
49	(0,-1.00)		
46	(2.92,0)		
50	(1.65,-3.70)		0.67 x 0.67
51	(4.05,-3.70)		

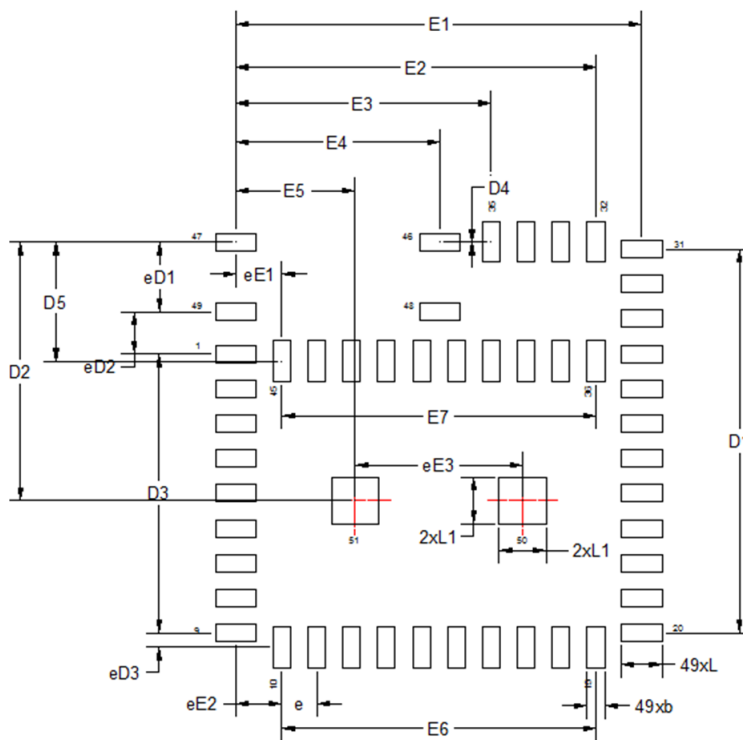


Figure 7.3. BGX13S Recommended PCB Land Pattern

Table 7.2. BGX13S Recommended PCB Land Pattern

Symbol	NOM (mm)
b	0.32 BSC
D1	5.50 BSC
D2	3.70 BSC
D3	4.00 BSC
D4	0.05 BSC
D5	1.65 BSC
eD1	1.00 BSC
eD2	0.60 BSC
eD3	0.15 BSC
e	0.50 BSC
E1	5.70 BSC
E2	5.10 BSC
E3	3.60 BSC
E4	2.92 BSC
E5	1.65 BSC
E6	4.50 BSC
E7	4.50 BSC
L	0.48 BSC

Symbol	NOM (mm)
L1	0.67 BSC
eE1	0.60 BSC
eE2	0.60 BSC
eE3	2.40 BSC

Notes:

1. All feature sizes shown are at Maximum Material Condition (MMC) and a card fabrication tolerance of 0.05mm is assumed.
2. Dimensioning and Tolerancing is per the ANSI Y14.5M-1994 specification.
3. A stainless steel, laser-cut and electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.
4. The stencil thickness should be 0.100mm (4 mils).
5. The stencil aperture to land pad size recommendation is 70% paste coverage.
6. Above notes and stencil design are shared as recommendations only. A customer or user may find it necessary to use different parameters and fine tune their SMT process as required for their application and tooling.

7.3 BGX13S Package Marking

The figure below shows the package markings printed on the module.



Figure 7.4. BGX13S Package Marking

Explanations:

Marking	Explanation
BGX13Sxxx	Model Number
Certification Marks	Certification marks will be printed in this area according to regulatory body requirements.
YWWTTTT	1. Y = Manufacturing Year 2. WW = Manufacturing Work Week 3. TTTT = Trace Code

8. Tape and Reel Specifications

8.1 Tape and Reel Packaging

This section contains information regarding the tape and reel packaging for the BGX13S Blue Gecko Module.

8.2 Reel and Tape Specifications

- Reel material: Polystyrene (PS)
- Reel diameter: 13 inches (330 mm)
- Number of modules per reel: 1000 pcs
- Disk deformation, folding whitening and mold imperfections: Not allowed
- Disk set: consists of two 13 inch (330 mm) rotary round disks and one central axis (100 mm)
- Antistatic treatment: Required
- Surface resistivity: $10^4 - 10^9 \Omega/\text{sq}$.

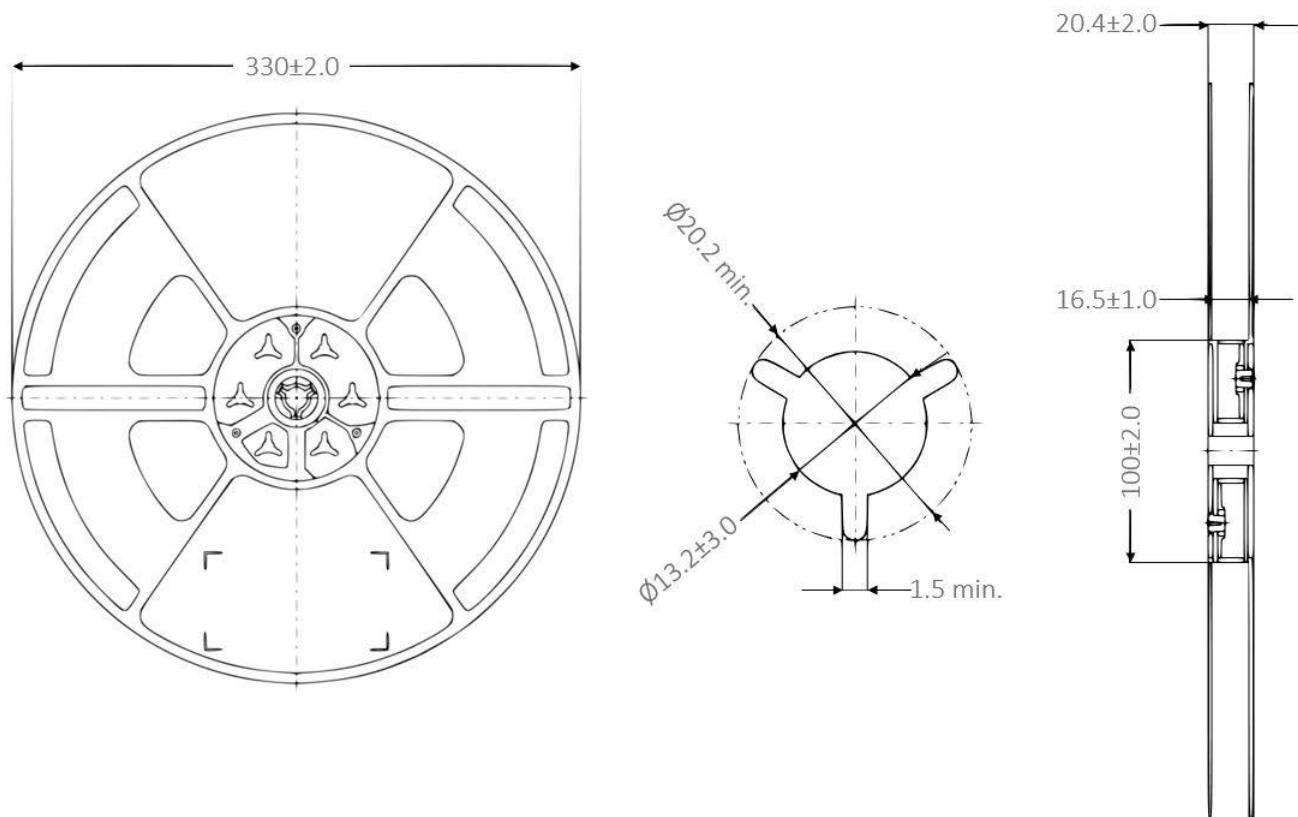


Figure 8.1. Reel Dimensions - Side View

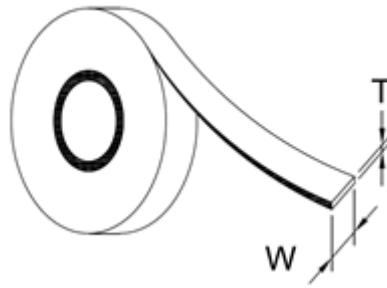
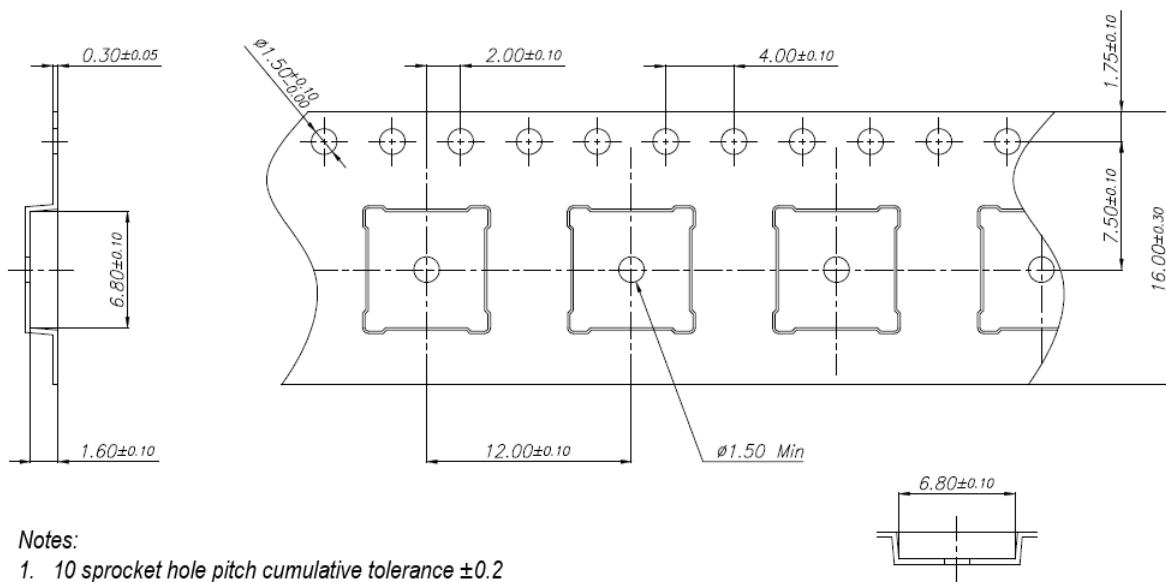


Figure 8.2. Cover tape information

Symbol	Dimensions [mm]
Thickness (T)	0.05 ± 0.005
Width (W)	13.3 ± 0.1



Notes:

1. 10 sprocket hole pitch cumulative tolerance ±0.2
2. Camber not to exceed 1mm in 250mm
3. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.

Figure 8.3. Tape information

8.3 Orientation and Tape Feed

The user direction of feed, start and end of tape on reel and orientation of the modules on the tape are shown in the figure below.

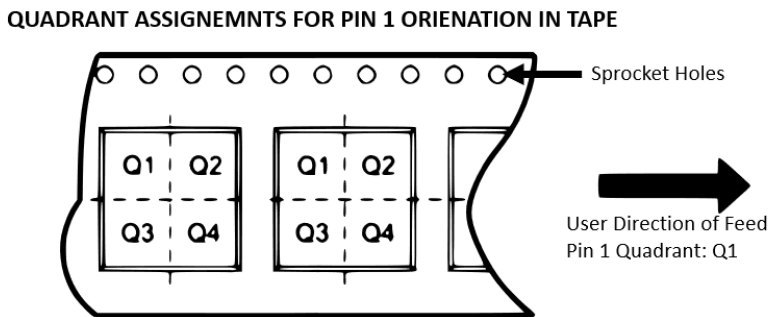


Figure 8.4. Module Orientation and Feed Direction

8.4 Tape and Reel Box Dimensions

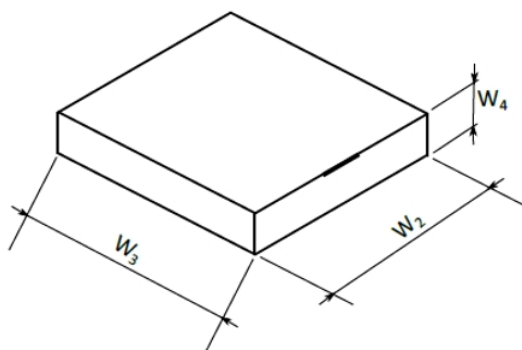


Figure 8.5. Tape and Reel Box Dimensions

Symbol	Dimensions [mm]
W_2	349
W_3	337
W_4	60

8.5 Moisture Sensitivity Level

Reels are delivered in packing which conforms to MSL3 (Moisture Sensitivity Level 3) requirements.

9. Soldering Recommendations

9.1 Soldering Recommendations

The BGX13S is compatible with industrial standard reflow profile for Pb-free solders. The reflow profile used is dependent on the thermal mass of the entire populated PCB, heat transfer efficiency of the oven, and particular type of solder paste used.

- Refer to technical documentations of particular solder paste for profile configurations.
- Avoid using more than two reflow cycles.
- A no-clean, type-3 solder paste is recommended.
- A stainless steel, laser-cut and electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.
- Recommended stencil thickness is 0.100mm (4 mils).
- Refer to the recommended PCB land pattern for an example stencil aperture size.
- For further recommendation, please refer to the JEDEC/IPC J-STD-020, IPC-SM-782 and IPC 7351 guidelines.
- Above notes and stencil design are shared as recommendations only. A customer or user may find it necessary to use different parameters and fine tune their SMT process as required for their application and tooling.

10. Certifications

10.1 Qualified Antenna Types

The BGX13S has been designed to operate with a standard 2.14 dBi dipole antenna. Any antenna of a different type or with a gain higher than 2.14 dBi is strictly prohibited for use with this device. Using an antenna of a different type or gain more than 2.14 dBi will require additional testing for FCC, CE and IC. The required antenna impedance is 50 Ω .

Table 10.1. Qualified Antennas for BGX13S

Antenna Type	Maximum Gain
Dipole	2.14 dBi

10.2 Bluetooth

The BGX13S is pre-qualified as a Low Energy RF-PHY tested component, having Declaration ID of D039577 and QDID of 119769. For the qualification of an end product embedding the BGX13S, the above should be combined with the most up to date Wireless Gecko Link Layer and Host components.

10.3 CE

The BGX13S22 module is in conformity with the essential requirements and other relevant requirements of the Radio Equipment Directive (RED) (2014/53/EU). Please note that every application using the BGX13S22 will need to perform the radio EMC tests on the end product, according to EN 301 489-17. Separate RF testing is not required provided that the customer follows the module manufacturer's recommendations and instructions and does not make modifications (e.g. to the provided antenna solutions or requirements). A formal DoC is available via www.silabs.com

10.4 FCC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesirable operation.

Any changes or modifications not expressly approved by Silicon Labs could void the user's authority to operate the equipment.

FCC RF Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions for satisfying RF exposure compliance. This transmitter meets both portable and mobile limits as demonstrated in the RF Exposure Analysis. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter except in accordance with FCC multi-transmitter product procedures.

OEM Responsibilities to comply with FCC Regulations:

OEM integrator is responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

- With BGX13S22 the antenna(s) must be installed such that a minimum separation distance of 0 mm is maintained between the radiator (antenna) and all persons at all times.
- The transmitter module must not be co-located or operating in conjunction with any other antenna or transmitter except in accordance with FCC multi-transmitter product procedures.

Important Note:

In the event that the above conditions cannot be met (for certain configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

End Product Labeling

The variants of BGX13S Modules are labeled with their own FCC ID. If the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. In that case, the final end product must be labeled in a visible area with the following:

"Contains Transmitter Module FCC ID: QOQ13"

Or

"Contains FCC ID: QOQ13"

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module or change RF related parameters in the user manual of the end product.

10.5 ISED Canada

ISED

This radio transmitter (IC: 5123A-13) has been approved by Industry Canada to operate with the antenna types listed above, with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

This device complies with Industry Canada's license-exempt RSS standards. Operation is subject to the following two conditions:

1. This device may not cause interference; and
2. This device must accept any interference, including interference that may cause undesired operation of the device

RF Exposure Statement

Exception from routine SAR evaluation limits are given in RSS-102 Issue 5.

The models BGX13S22GA meet the given requirements when the minimum separation distance to human body is 15 mm.

RF exposure or SAR evaluation is not required when the separation distance is same or more than stated above. If the separation distance is less than stated above the OEM integrator is responsible for evaluating the SAR.

OEM Responsibilities to comply with IC Regulations

The BGX13S modules have been certified for integration into products only by OEM integrators under the following conditions:

- The antenna(s) must be installed such that a minimum separation distance as stated above is maintained between the radiator (antenna) and all persons at all times.
- The transmitter module must not be co-located or operating in conjunction with any other antenna or transmitter.

As long as the two conditions above are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

IMPORTANT NOTE

In the event that these conditions cannot be met (for certain configurations or co-location with another transmitter), then the ISED authorization is no longer considered valid and the IC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate ISED authorization.

End Product Labeling

The BGX13S module is labeled with its own IC ID. If the IC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. In that case, the final end product must be labeled in a visible area with the following:

"Contains Transmitter Module IC: 5123A-13 "

or

"Contains IC: 5123A-13"

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module or change RF related parameters in the user manual of the end product.

ISED (Français)

Industrie Canada a approuvé l'utilisation de cet émetteur radio (IC: 5123A-13) en conjonction avec des antennes de type dipolaire à 2.14dBi ou des antennes embarquées, intégrée au produit. L'utilisation de tout autre type d'antenne avec ce composant est proscrite.

Ce composant est conforme aux normes RSS, exonérées de licence d'Industrie Canada. Son mode de fonctionnement est soumis aux deux conditions suivantes:

1. Ce composant ne doit pas générer d'interférences.
2. Ce composant doit pouvoir est soumis à tout type de perturbation y compris celle pouvant nuire à son bon fonctionnement.

Déclaration d'exposition RF

L'exception tirée des limites courantes d'évaluation SAR est donnée dans le document RSS-102 Issue 5.

Les modules BGX13S22GA répondent aux exigences requises lorsque la distance minimale de séparation avec le corps humain est de 15 mm.

La déclaration d'exposition RF ou l'évaluation SAR n'est pas nécessaire lorsque la distance de séparation est identique ou supérieure à celle indiquée ci-dessus. Si la distance de séparation est inférieure à celle mentionnées plus haut, il incombe à l'intégrateur OEM de procéder à une évaluation SAR.

Responsabilités des OEM pour une mise en conformité avec le Règlement du Circuit Intégré

Le module BGX13S a été approuvé pour l'intégration dans des produits finaux exclusivement réalisés par des OEM sous les conditions suivantes:

- L'antenne (s) doit être installée de sorte qu'une distance de séparation minimale indiquée ci-dessus soit maintenue entre le radiateur (antenne) et toutes les personnes avoisinante, ce à tout moment.
- Le module émetteur ne doit pas être localisé ou fonctionner avec une autre antenne ou un autre transmetteur que celle indiquée plus haut.

Tant que les deux conditions ci-dessus sont respectées, il n'est pas nécessaire de tester ce transmetteur de façon plus poussée. Cependant, il incombe à l'intégrateur OEM de s'assurer de la bonne conformité du produit fini avec les autres normes auxquelles il pourrait être soumis de fait de l'utilisation de ce module (par exemple, les émissions des périphériques numériques, les exigences de périphériques PC, etc.).

REMARQUE IMPORTANTE

ans le cas où ces conditions ne peuvent être satisfaites (pour certaines configurations ou co-implantation avec un autre émetteur), l'autorisation ISED n'est plus considérée comme valide et le numéro d'identification ID IC ne peut pas être apposé sur le produit final. Dans ces circonstances, l'intégrateur OEM sera responsable de la réévaluation du produit final (y compris le transmetteur) et de l'obtention d'une autorisation ISED distincte.

Étiquetage des produits finis

Les modules BGX13S sont étiquetés avec leur propre ID IC. Si l'ID IC n'est pas visible lorsque le module est intégré au sein d'un autre produit, cet autre produit dans lequel le module est installé devra porter une étiquette faisant apparaître les référence du module intégré. Dans un tel cas, sur le produit final doit se trouver une étiquette aisément lisible sur laquelle figurent les informations suivantes:

“Contient le module transmetteur: 5123A-13 ”

or

“Contient le circuit: 5123A-13”

L'intégrateur OEM doit être conscient qu'il ne doit pas fournir, dans le manuel d'utilisation, d'informations relatives à la façon d'installer ou de d'enlever ce module RF ainsi que sur la procédure à suivre pour modifier les paramètres liés à la radio.

10.6 Japan

The BGX13S22GA are certified in Japan with certification number 209-J00306.

Since September 1, 2014 it is allowed (and highly recommended) that a manufacturer who integrates a radio module in their host equipment can place the certification mark and certification number (the same marking/number as depicted on the label of the radio module) on the outside of the host equipment. The certification mark and certification number must be placed close to the text in the Japanese language which is provided below. This change in the Radio Law has been made in order to enable users of the combination of host and radio module to verify if they are actually using a radio device which is approved for use in Japan.

Certification Text to be Placed on the Outside Surface of the Host Equipment:

当該機器には電波法に基づく、技術基準適合証明等を受けた特定無線設備を装着している。

Translation of the text:

“This equipment contains specified radio equipment that has been certified to the Technical Regulation Conformity Certification under the Radio Law.”

The "Giteki" marking shown in the figures below must be affixed to an easily noticeable section of the specified radio equipment. Note that additional information may be required if the device is also subject to a telecom approval.



Figure 10.1. GITEKI Mark and ID

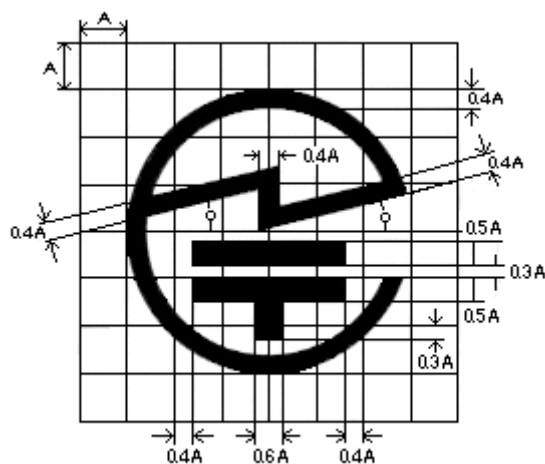


Figure 10.2. GITEKI Mark

10.7 KC (South-Korea)

The BGX13S22GA have certification in South-Korea.

Certification number: MSIP-CRM-BGT-13

11. Revision History

Revision 1.1

November 2019

- Updated OPNs in [1. Ordering Information](#).
- Updated [3.1 Typical BGX13S Connections](#) with new layout guidelines.
- Updated [4.3 Effect of Plastic and Metal Materials](#) with the new layout guidelines.
- Removed the Antenna Tuning image from [4.3 Effect of Plastic and Metal Materials](#).
- Added note in [5.1 BGX13S Device Pinout](#) to leave unused and no-connect pins disconnected.
- Added [8. Tape and Reel Specifications](#).
- Updated [Figure 7.2 BGX13S Recommended Antenna Clearance on page 28](#) in [7.2 BGX13S Recommended PCB Land Pattern](#).
- Updated [Figure 4.1 BGX13S PCB Top Layer Design on page 16](#) and [Figure 4.2 BGX13S PCB Middle and Bottom Layer Design on page 16](#).
- Added [Figure 4.3 Practical Installation of BGX13S on Application PCB on page 16](#).
- Added certification chapter [10. Certifications](#).
- Added default hardware flow control settings to [6.4 Command Mode and Streaming Mode](#) description.
- Changed "BLE" to "Bluetooth Low Energy" throughout.
- Minor typographical corrections, including capitalization, mis-spellings and punctuation marks, throughout document.

Revision 1.0

December 2018

- [6.9 OTA](#): Updated firmware update policy.
- [2.1.1 Absolute Maximum Ratings](#): Corrected storage temperature.
- [Table 2.2 General Operating Conditions on page 6](#): Added V_{IOVDD} specification line.
- [Table 2.8 Non-Volatile Configuration Storage on page 12](#): Corrected minimum supply voltage during update.
- [Table 2.9 General-Purpose I/O \(GPIO\) on page 13](#): Added details about RESETn supply reference.
- [2.1.4.1 RF Transmitter General Characteristics for 2.4 GHz Band](#): Removed references to internal supply connections.
- [3.1 Typical BGX13S Connections](#): Updated recommended connection details for RESETn, BOOT, and 1V8.
- [7.3 BGX13S Package Marking](#): Replaced detailed certification marks and text description with Certification Mark area.

Revision 0.5

August 2018

- Public Release

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