

# BGX220S Wireless Gecko Bluetooth Xpress Module Data Sheet



The BGX220S is a wireless cable replacement module that eliminates Bluetooth firmware development complexity with a serial interface that can operate as a raw data stream or control the device through an abstracted command API. The BGX220S 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 5.2 compliant stack to future-proof applications as Bluetooth 5.2 adoption increases.

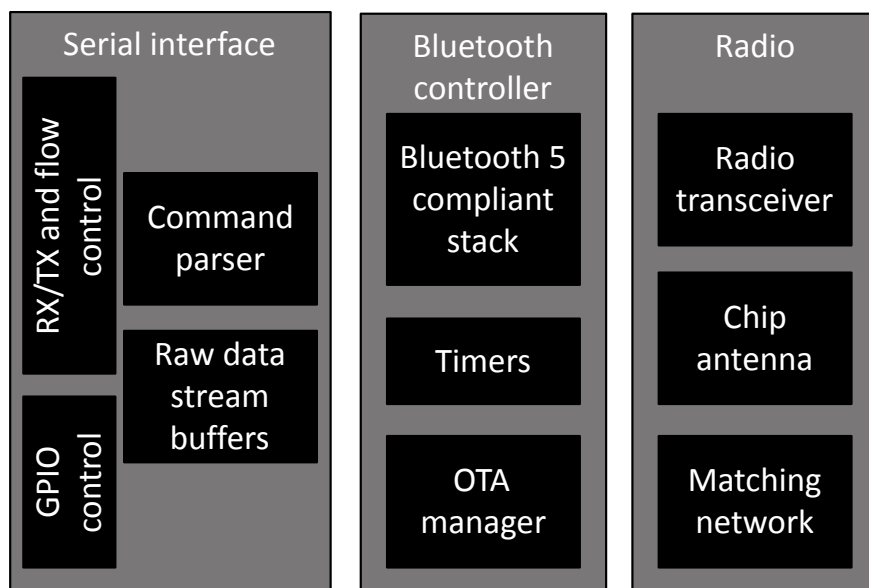
BGX220S modules are a full solution that comes with fully-upgradeable, robust software stacks, world-wide regulatory certifications, and support that will minimize and simplify the engineering and development of your end-products helping to accelerate their time-to-market.

The BGX220S is intended for a broad range of applications, including:

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

## KEY FEATURES

- Bluetooth 5.2 Technologies
- Bluetooth Low Energy
- Built-in antenna
- Up to 6 dBm TX power
- -98.6 dBm BLE RX sensitivity at 1 Mbps
- 8 GPIO pins
- I2C master interface
- Input pin event monitoring and response
- 6.0 mm x 6.0 mm



## 1. Ordering Information

**Table 1.1. Ordering Information**

Ordering Code	Protocol Stack	TX Power Rating	Antenna	RF Shield	Flash (kB)	RAM (kB)	GPIO	Temp Range
BGX220S22HNA21	• Bluetooth 5.2	6 dBm	Built-in	Yes	512	32	8	-40 to 105 °C

**Note:**

1. End-product manufacturers must verify that the module is configured to meet regulatory limits for each region in accordance with the formal certification test reports.
2. Throughout this document, the device in the table above may be referred to by their product family name (e.g. BGX220S), by model name (BGX220S22A), or by full ordering code.

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## 2. System Overview

### 2.1 Block Diagram

The BGX220S module combines an energy-friendly MCU with a highly integrated radio transceiver in a SiP module with a robust, integrated antenna. This section gives a short introduction to the features of the module.

Note that features in the module are not directly configurable in this pre-programmed product, and are instead controlled through the abstracted command and variable set.

The block diagram for the BGX220S module is shown in the figure below. The wireless module includes the EFR32BG22 wireless System on a Chip (SoC), required decoupling capacitors and inductors, 38.4 MHz crystal, RF matching circuit, and integrated antenna.

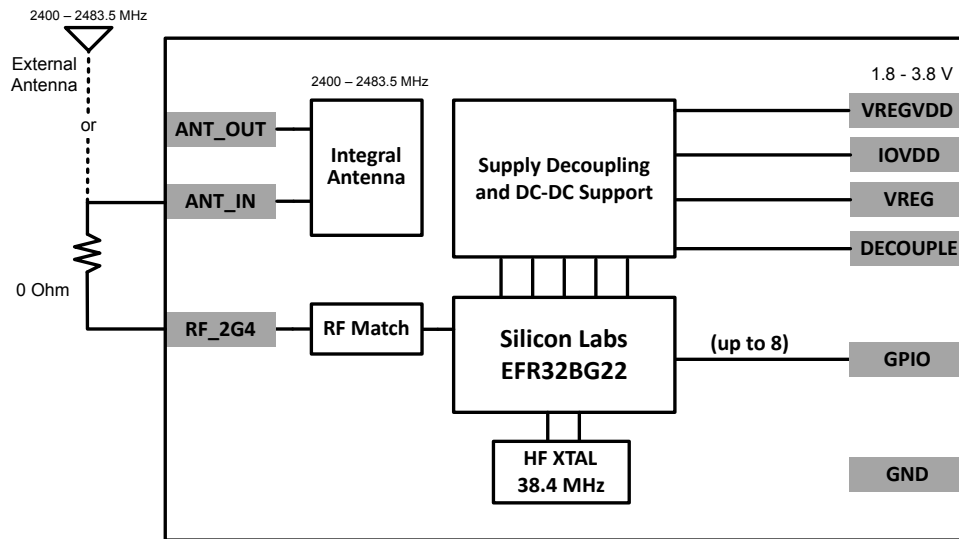


Figure 2.1. BGX220S Block Diagram

A simplified internal schematic for the BGX220S module is shown in [Figure 2.2 BGX220S Module Schematic on page 5](#).

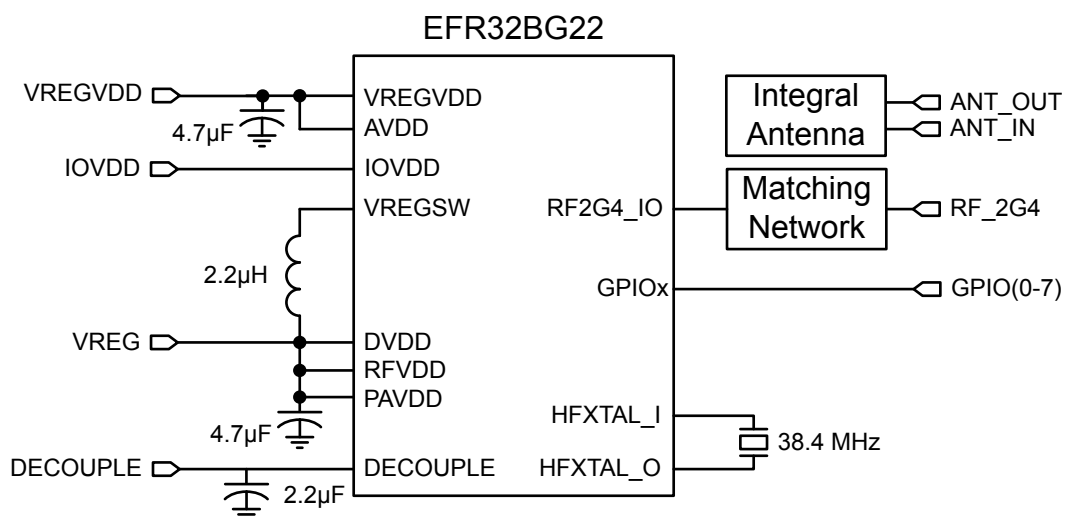


Figure 2.2. BGX220S Module Schematic

## 2.2 EFR32BG22 SoC

The EFR32BG22 SoC features a 32-bit ARM Cortex M33 core, a 2.4 GHz high-performance radio, 512 kB of flash memory, a rich set of MCU peripherals, and various clock management and serial interfacing options. Consult the [EFR32xG22 Wireless Gecko Reference Manual](#) and the [EFR32BG22 Data Sheet](#) for details.

Note that the Flash and other features in this product are not directly accessible, and are instead accessed through the product's abstracted command and variable set.

## 2.3 Antenna

BGX220S modules include an integral antenna on board with the characteristics detailed in the tables below.

**Table 2.1. Antenna Efficiency and Peak Gain**

Parameter	With optimal layout	Note
Efficiency	-1 to -2 dB	Antenna efficiency, gain and radiation pattern are highly dependent on the application PCB layout and mechanical design. Refer to <a href="#">7. Design Guidelines</a> for recommendations to achieve optimal antenna performance.
Peak gain	2.3 dBi	

## 2.4 Power Supply

The BGX220S requires a single nominal supply level of 3.0 V to operate. All necessary decoupling and filtering components are included in the module.

### 3. Electrical Characteristics

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

- Typical values are based on  $T_A=25^\circ\text{C}$  and VDD supply at 3.0 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.

#### 3.1 Absolute Maximum Ratings

Stresses beyond 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 beyond 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 3.1. Absolute Maximum Ratings**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Storage temperature range	$T_{STG}$		-50	—	+150	$^\circ\text{C}$
Voltage on any supply pin	$V_{DDMAX}$		-0.3	—	3.8	V
Junction temperature	$T_{JMAX}$	-N grade	—	—	+105	$^\circ\text{C}$
Voltage ramp rate on any supply pin	$V_{DDRAMP MAX}$		—	—	1.0	V / $\mu\text{s}$
DC voltage on any GPIO pin	$V_{DIGPIN}$		-0.3	—	$V_{IOVDD} + 0.3$	V
Input RF level on RF pin RF_2G4	$P_{RFMAX2G4}$		—	—	+10	dBm
Absolute voltage on RF pin RF_2G4	$V_{MAX2G4}$		-0.3	—	$V_{VREG} + 0.3$	V
Total current into VDD power lines	$I_{VDDMAX}$	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

### 3.2 General Operating Conditions

This table specifies the general operating temperature range and supply voltage range for all supplies. The minimum and maximum values of all other tables are specified over this operating range, unless otherwise noted.

**Table 3.2. General Operating Conditions**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Operating ambient temperature range	$T_A$	-N temperature grade	-40	—	+105	°C
IOVDDx operating supply voltage (All IOVDD pins)	$V_{IOVDDx}$		1.71	3.0	3.8	V
VREGVDD operating supply voltage	$V_{VREGVDD}$	DCDC in regulation <sup>1</sup>	2.2	3.0	3.8	V
		DCDC in bypass	1.8	3.0	3.8	V

**Note:**

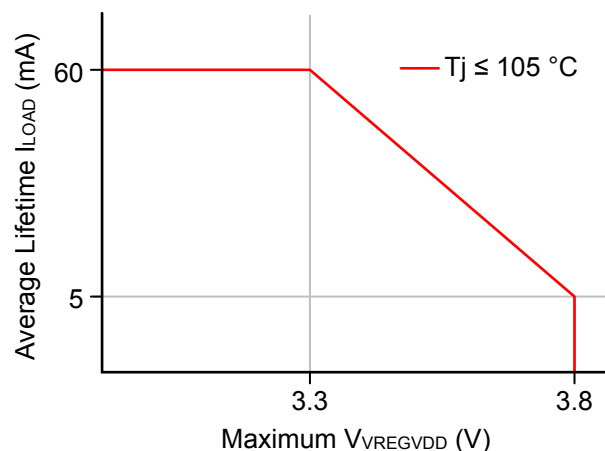
1. The supported maximum  $V_{VREGVDD}$  in regulation mode is a function of temperature and 10-year lifetime average load current. See more details in [3.2.1 DC-DC Operating Limits](#).



### 3.2.1 DC-DC Operating Limits

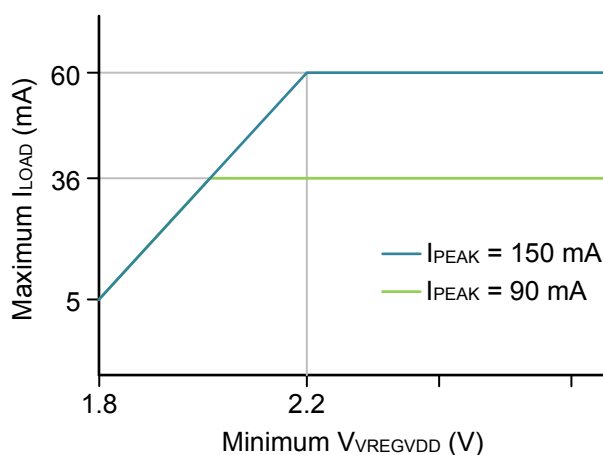
The maximum supported voltage on the VDD supply pin is limited under certain conditions. Maximum input voltage is a function of temperature and the average load current over a 10-year lifetime. [Figure 3.1 Lifetime average load current limit vs. Maximum input voltage on page 9](#) shows the safe operating region under specific conditions. Exceeding this safe operating range may impact the reliability and performance of the DC-DC converter.

The average load current for an application can typically be determined by examining the current profile during the time the device is powered. For example, an application that is continuously powered which spends 99% of the time asleep consuming 2  $\mu\text{A}$  and 1% of the time active and consuming 10 mA has an average lifetime load current of about 102  $\mu\text{A}$ .



**Figure 3.1. Lifetime average load current limit vs. Maximum input voltage**

The minimum input voltage for the DC-DC in EM0/EM1 mode is a function of the maximum load current, and the peak current setting. [Figure 3.2 Transient maximum load current vs. Minimum input voltage on page 9](#) shows the max load current vs. input voltage for different DC-DC peak inductor current settings.



**Figure 3.2. Transient maximum load current vs. Minimum input voltage**

### 3.3 Power Consumption

**Table 3.3. Power Consumption**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Active supply current, Un-connected, Idle	I <sub>ACTIVE_IDLE</sub>	Baud rate ≤ 9600 bps	—	2.0	—	μA
		Baud rate > 9600 bps	—	1.0	—	mA
Active supply current, Advertising	I <sub>ACTIVE_ADV</sub>	Interval = 546.25 ms, Baud rate ≤ 9600 bps	—	30	—	μA
		Interval = 20 ms, Baud rate ≤ 9600 bps	—	0.67	—	mA
		Interval = 546.25 ms, Baud rate > 9600 bps	—	1.0	—	mA
		Interval = 20 ms, Baud rate > 9600 bps	—	1.6	—	mA
Active supply current, Connected, 15 ms Interval	I <sub>ACTIVE_CONN</sub>	Idle, Baud Rate ≤ 9600 bps	—	325	—	μA
		TX/RX (acknowledged) at highest throughput, Baud Rate ≤ 9600 bps	—	TX: 4.7 RX: 3.8	—	mA
		Idle, Baud Rate > 9600 bps	—	3.6	—	mA
		TX/RX (acknowledged) at highest throughput, Baud Rate > 9600 bps	—	TX: 3.8 RX: 3.7	—	mA
Supply current in low power mode	I <sub>LPM</sub>	Radio disabled	—	2.25	—	μA
		Radio enabled, Advertising, Interval = 546.25 ms	—	26	—	μA
		Radio enabled, Advertising, Interval = 20 ms	—	0.65	—	mA

**Note:**

1. All current consumption figures were measured using Bluetooth Xpress firmware version 1.3.2.

### 3.4 RF Transmitter General Characteristics for the 2.4 GHz Band

Unless otherwise indicated, typical conditions are:  $T_A = 25\text{ }^{\circ}\text{C}$ ,  $V_{\text{REGVDD}} = 3.0\text{V}$ . RF center frequency 2.45 GHz.

**Table 3.4. RF Transmitter General Characteristics for the 2.4 GHz Band**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RF tuning frequency range	F <sub>RANGE</sub>		2400	—	2483.5	MHz
Maximum TX power <sup>1</sup>	POUT <sub>MAX</sub>	6 dBm output power	—	6.0	—	dBm
		0 dBm output power	—	-0.5	—	dBm
Minimum active TX Power	POUT <sub>MIN</sub>		—	-27	—	dBm
Output power variation vs VREGVDD supply voltage variation, frequency = 2450 MHz	POUT <sub>VAR_V</sub>	6 dBm output power with VREGVDD voltage swept from 1.8 V to 3.0 V	—	0.04	—	dB
		0 dBm output power, with VREGVDD voltage swept from 1.8 to 3.0 V	—	0.04	—	dB
Output power variation vs temperature, Frequency = 2450 MHz	POUT <sub>VAR_T</sub>	6 dBm output power, (-40 to +105 °C)	—	0.2	—	dB
		0 dBm output power, (-40 to +105 °C)	—	1.3	—	dB
Output power variation vs RF frequency	POUT <sub>VAR_F</sub>	6 dBm output power	—	0.09	—	dB
		0 dBm output power	—	0.15	—	dB
<b>Note:</b> 1. Supported transmit power levels are determined by the ordering part number (OPN). Transmit power ratings for all devices covered in this data sheet can be found in the Max TX Power column of the Ordering Information Table.						

### 3.5 RF Receiver General Characteristics for the 2.4 GHz Band

Unless otherwise indicated, typical conditions are:  $T_A = 25\text{ }^{\circ}\text{C}$ ,  $V_{\text{REGVDD}} = 3.0\text{V}$ . RF center frequency 2.45 GHz.

**Table 3.5. RF Receiver General Characteristics for the 2.4 GHz Band**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RF tuning frequency range	$F_{\text{RANGE}}$		2400	—	2483.5	MHz

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

Unless otherwise indicated, typical conditions are:  $T_A = 25^\circ\text{C}$ ,  $V_{\text{REGVDD}} = 3.0\text{V}$ . RF center frequency 2.45 GHz.

**Table 3.6. RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 1 Mbps Data Rate**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Max usable receiver input level	SAT	Signal is reference signal <sup>1</sup>	—	10	—	dBm
Sensitivity	SENS	Signal is reference signal, 37 byte payload <sup>2</sup>	—	-98.6	—	dBm
		Signal is reference signal, 255 byte payload <sup>1</sup>	—	-97.2	—	dBm
		With non-ideal signals <sup>3 1</sup>	—	-96.6	—	dBm
Signal to co-channel interferer	$C/I_{\text{CC}}$	(see notes) <sup>1 4</sup>	—	8.7	—	dB
$N \pm 1$ Adjacent channel selectivity	$C/I_1$	Interferer is reference signal at +1 MHz offset <sup>1 5 4 6</sup>	—	-6.6	—	dB
		Interferer is reference signal at -1 MHz offset <sup>1 5 4 6</sup>	—	-6.5	—	dB
$N \pm 2$ Alternate channel selectivity	$C/I_2$	Interferer is reference signal at +2 MHz offset <sup>1 5 4 6</sup>	—	-40.9	—	dB
		Interferer is reference signal at -2 MHz offset <sup>1 5 4 6</sup>	—	-39.9	—	dB
$N \pm 3$ Alternate channel selectivity	$C/I_3$	Interferer is reference signal at +3 MHz offset <sup>1 5 4 6</sup>	—	-45.9	—	dB
		Interferer is reference signal at -3 MHz offset <sup>1 5 4 6</sup>	—	-46.2	—	dB
Selectivity to image frequency	$C/I_{\text{IM}}$	Interferer is reference signal at image frequency with 1 MHz precision <sup>1 6</sup>	—	-23.5	—	dB
Selectivity to image frequency $\pm 1$ MHz	$C/I_{\text{IM}_1}$	Interferer is reference signal at image frequency +1 MHz with 1 MHz precision <sup>1 6</sup>	—	-40.9	—	dB
		Interferer is reference signal at image frequency -1 MHz with 1 MHz precision <sup>1 6</sup>	—	-6.6	—	dB
Intermodulation performance	IM	$n = 3$ (see note <sup>7</sup> )	—	-17.1	—	dBm

**Note:**

1. 0.017% Bit Error Rate.
2. 0.1% Bit Error Rate.
3. With non-ideal signals as specified in Bluetooth Test Specification RF-PHY.TS.5.0.1 section 4.7.1
4. Desired signal -67 dBm.
5. Desired frequency  $2402\text{ MHz} \leq F_c \leq 2480\text{ MHz}$ .
6. With allowed exceptions.
7. As specified in Bluetooth Core specification version 5.1, Vol 6, Part A, Section 4.4

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

Unless otherwise indicated, typical conditions are:  $T_A = 25^\circ\text{C}$ ,  $V_{\text{REGVDD}} = 3.0\text{V}$ . RF center frequency 2.45 GHz.

**Table 3.7. RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 2 Mbps Data Rate**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Max usable receiver input level	SAT	Signal is reference signal <sup>1</sup>	—	10	—	dBm
Sensitivity	SENS	Signal is reference signal, 37 byte payload <sup>2</sup>	—	-95.9	—	dBm
		Signal is reference signal, 255 byte payload <sup>1</sup>	—	-94.3	—	dBm
		With non-ideal signals <sup>3 1</sup>	—	-94.0	—	dBm
Signal to co-channel interferer	$C/I_{\text{CC}}$	(see notes) <sup>1 4</sup>	—	8.8	—	dB
$N \pm 1$ Adjacent channel selectivity	$C/I_1$	Interferer is reference signal at +2 MHz offset <sup>1 5 4 6</sup>	—	-9.2	—	dB
		Interferer is reference signal at -2 MHz offset <sup>1 5 4 6</sup>	—	-6.6	—	dB
$N \pm 2$ Alternate channel selectivity	$C/I_2$	Interferer is reference signal at +4 MHz offset <sup>1 5 4 6</sup>	—	-43.3	—	dB
		Interferer is reference signal at -4 MHz offset <sup>1 5 4 6</sup>	—	-44.0	—	dB
$N \pm 3$ Alternate channel selectivity	$C/I_3$	Interferer is reference signal at +6 MHz offset <sup>1 5 4 6</sup>	—	-48.6	—	dB
		Interferer is reference signal at -6 MHz offset <sup>1 5 4 6</sup>	—	-50.7	—	dB
Selectivity to image frequency	$C/I_{\text{IM}}$	Interferer is reference signal at image frequency with 1 MHz precision <sup>1 6</sup>	—	-23.8	—	dB
Selectivity to image frequency $\pm 2$ MHz	$C/I_{\text{IM}_1}$	Interferer is reference signal at image frequency +2 MHz with 1 MHz precision <sup>1 6</sup>	—	-43.3	—	dB
		Interferer is reference signal at image frequency -2 MHz with 1 MHz precision <sup>1 6</sup>	—	-9.2	—	dB
Intermodulation performance	IM	$n = 3$ (see note <sup>7</sup> )	—	-18.8	—	dBm

**Note:**

1. 0.017% Bit Error Rate.
2. 0.1% Bit Error Rate.
3. With non-ideal signals as specified in Bluetooth Test Specification RF-PHY.TS.5.0.1 section 4.7.1
4. Desired signal -64 dBm.
5. Desired frequency  $2402\text{ MHz} \leq F_c \leq 2480\text{ MHz}$ .
6. With allowed exceptions.
7. As specified in Bluetooth Core specification version 5.1, Vol 6, Part A, Section 4.4

### 3.8 RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 500 kbps Data Rate

Unless otherwise indicated, typical conditions are:  $T_A = 25\text{ }^{\circ}\text{C}$ ,  $V_{\text{REGVDD}} = 3.0\text{V}$ . RF center frequency 2.45 GHz.

**Table 3.8. RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 500 kbps Data Rate**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Max usable receiver input level	SAT	Signal is reference signal <sup>1</sup>	—	10	—	dBm
Sensitivity	SENS	Signal is reference signal, 37 byte payload <sup>2</sup>	—	-102.3	—	dBm
		Signal is reference signal, 255 byte payload <sup>1</sup>	—	-100.9	—	dBm
		With non-ideal signals <sup>3 1</sup>	—	-99.8	—	dBm
Signal to co-channel interferer	$C/I_{\text{CC}}$	(see notes) <sup>1 4</sup>	—	2.7	—	dB
$N \pm 1$ Adjacent channel selectivity	$C/I_1$	Interferer is reference signal at +1 MHz offset <sup>1 5 4 6</sup>	—	-8.0	—	dB
		Interferer is reference signal at -1 MHz offset <sup>1 5 4 6</sup>	—	-7.9	—	dB
$N \pm 2$ Alternate channel selectivity	$C/I_2$	Interferer is reference signal at +2 MHz offset <sup>1 5 4 6</sup>	—	-46.5	—	dB
		Interferer is reference signal at -2 MHz offset <sup>1 5 4 6</sup>	—	-49.9	—	dB
$N \pm 3$ Alternate channel selectivity	$C/I_3$	Interferer is reference signal at +3 MHz offset <sup>1 5 4 6</sup>	—	-48.9	—	dB
		Interferer is reference signal at -3 MHz offset <sup>1 5 4 6</sup>	—	-53.8	—	dB
Selectivity to image frequency	$C/I_{\text{IM}}$	Interferer is reference signal at image frequency with 1 MHz precision <sup>1 6</sup>	—	-48.3	—	dB
Selectivity to image frequency $\pm 1$ MHz	$C/I_{\text{IM}_1}$	Interferer is reference signal at image frequency +1 MHz with 1 MHz precision <sup>1 6</sup>	—	-49.9	—	dB
		Interferer is reference signal at image frequency -1 MHz with 1 MHz precision <sup>1 6</sup>	—	-46.5	—	dB

**Note:**

1. 0.017% Bit Error Rate.
2. 0.1% Bit Error Rate.
3. With non-ideal signals as specified in Bluetooth Test Specification RF-PHY.TS.5.0.1 section 4.7.1
4. Desired signal -72 dBm.
5. Desired frequency  $2402\text{ MHz} \leq F_c \leq 2480\text{ MHz}$ .
6. With allowed exceptions.

### 3.9 RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 125 kbps Data Rate

Unless otherwise indicated, typical conditions are:  $T_A = 25\text{ }^{\circ}\text{C}$ ,  $V_{\text{REGVDD}} = 3.0\text{V}$ . RF center frequency 2.45 GHz.

**Table 3.9. RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 125 kbps Data Rate**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Max usable receiver input level	SAT	Signal is reference signal <sup>1</sup>	—	10	—	dBm
Sensitivity	SENS	Signal is reference signal, 37 byte payload <sup>2</sup>	—	-106.4	—	dBm
		Signal is reference signal, 255 byte payload <sup>1</sup>	—	-106.0	—	dBm
		With non-ideal signals <sup>3 1</sup>	—	-105.6	—	dBm
Signal to co-channel interferer	$C/I_{\text{CC}}$	(see notes) <sup>1 4</sup>	—	0.9	—	dB
$N \pm 1$ Adjacent channel selectivity	$C/I_1$	Interferer is reference signal at +1 MHz offset <sup>1 5 4 6</sup>	—	-13.6	—	dB
		Interferer is reference signal at -1 MHz offset <sup>1 5 4 6</sup>	—	-13.4	—	dB
$N \pm 2$ Alternate channel selectivity	$C/I_2$	Interferer is reference signal at +2 MHz offset <sup>1 5 4 6</sup>	—	-52.6	—	dB
		Interferer is reference signal at -2 MHz offset <sup>1 5 4 6</sup>	—	-55.8	—	dB
$N \pm 3$ Alternate channel selectivity	$C/I_3$	Interferer is reference signal at +3 MHz offset <sup>1 5 4 6</sup>	—	-53.7	—	dB
		Interferer is reference signal at -3 MHz offset <sup>1 5 4 6</sup>	—	-59.0	—	dB
Selectivity to image frequency	$C/I_{\text{IM}}$	Interferer is reference signal at image frequency with 1 MHz precision <sup>1 6</sup>	—	-52.7	—	dB
Selectivity to image frequency $\pm 1$ MHz	$C/I_{\text{IM}_1}$	Interferer is reference signal at image frequency +1 MHz with 1 MHz precision <sup>1 6</sup>	—	-53.7	—	dB
		Interferer is reference signal at image frequency -1 MHz with 1 MHz precision <sup>1 6</sup>	—	-52.6	—	dB

**Note:**

1. 0.017% Bit Error Rate.
2. 0.1% Bit Error Rate.
3. With non-ideal signals as specified in Bluetooth Test Specification RF-PHY.TS.5.0.1 section 4.7.1
4. Desired signal -79 dBm.
5. Desired frequency  $2402\text{ MHz} \leq F_c \leq 2480\text{ MHz}$ .
6. With allowed exceptions.

### 3.10 Non-Volatile Configuration Storage

Table 3.10. Non-volatile Configuration Storage

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Supply voltage during update	VFLASH		1.71	—	3.8	V

### 3.11 High-Frequency Crystal

Table 3.11. High-Frequency Crystal

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Crystal frequency	$f_{\text{HFX TAL}}$		—	38.4	—	MHz
Initial calibrated accuracy	$\text{ACC}_{\text{HFX TAL}}$		-10	+/-5	10	ppm
Temperature drift	$\text{DRIFT}_{\text{HFX TAL}}$	Across specified temperature range	-20	—	20	ppm



### 3.12 GPIO Pins

Unless otherwise indicated, typical conditions are: IOVDD = 3.0 V.

**Table 3.12. GPIO Pins**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Leakage current	$I_{LEAK\_IO}$	MODEx = DISABLED, IOVDD = 1.71 V	—	1.9	—	nA
		MODEx = DISABLED, IOVDD = 3.0 V	—	2.5	—	nA
Input low voltage <sup>1</sup>	$V_{IL}$	Any GPIO pin	—	—	0.3*IOVDD	V
		RESETn	—	—	0.3*DVDD	V
Input high voltage <sup>1</sup>	$V_{IH}$	Any GPIO pin	0.7*IOVDD	—	—	V
		RESETn	0.7*DVDD	—	—	V
Hysteresis of input voltage	$V_{HYS}$	Any GPIO pin	0.05*IOVDD	—	—	V
		RESETn	0.05*DVDD	—	—	V
Output high voltage	$V_{OH}$	Sourcing 20mA, IOVDD = 3.0 V	0.8 * IOVDD	—	—	V
		Sourcing 8mA, IOVDD = 1.71 V	0.6 * IOVDD	—	—	V
Output low voltage	$V_{OL}$	Sinking 20mA, IOVDD = 3.0 V	—	—	0.2 * IOVDD	V
		Sinking 8mA, IOVDD = 1.71 V	—	—	0.4 * IOVDD	V
GPIO rise time	$T_{GPIO\_RISE}$	IOVDD = 3.0 V, $C_{load}$ = 50pF, SLEWRATE = 4, 10% to 90%	—	8.4	—	ns
		IOVDD = 1.71 V, $C_{load}$ = 50pF, SLEWRATE = 4, 10% to 90%	—	13	—	ns
GPIO fall time	$T_{GPIO\_FALL}$	IOVDD = 3.0 V, $C_{load}$ = 50pF, SLEWRATE = 4, 90% to 10%	—	7.1	—	ns
		IOVDD = 1.71 V, $C_{load}$ = 50pF, SLEWRATE = 4, 90% to 10%	—	11.9	—	ns
Pull up/down resistance <sup>2</sup>	$R_{PULL}$	Any GPIO pin. Pull-up to IOVDD: MODEn = DISABLE DOUT=1. Pull-down to VSS: MODEn = WIREDORPULLDOWN DOUT = 0.	35	44	55	kΩ
		RESETn pin. Pull-up to DVDD	35	44	55	kΩ
Maximum filtered glitch width	$T_{GF}$	MODE = INPUT, DOUT = 1	—	27	—	ns

**Note:**

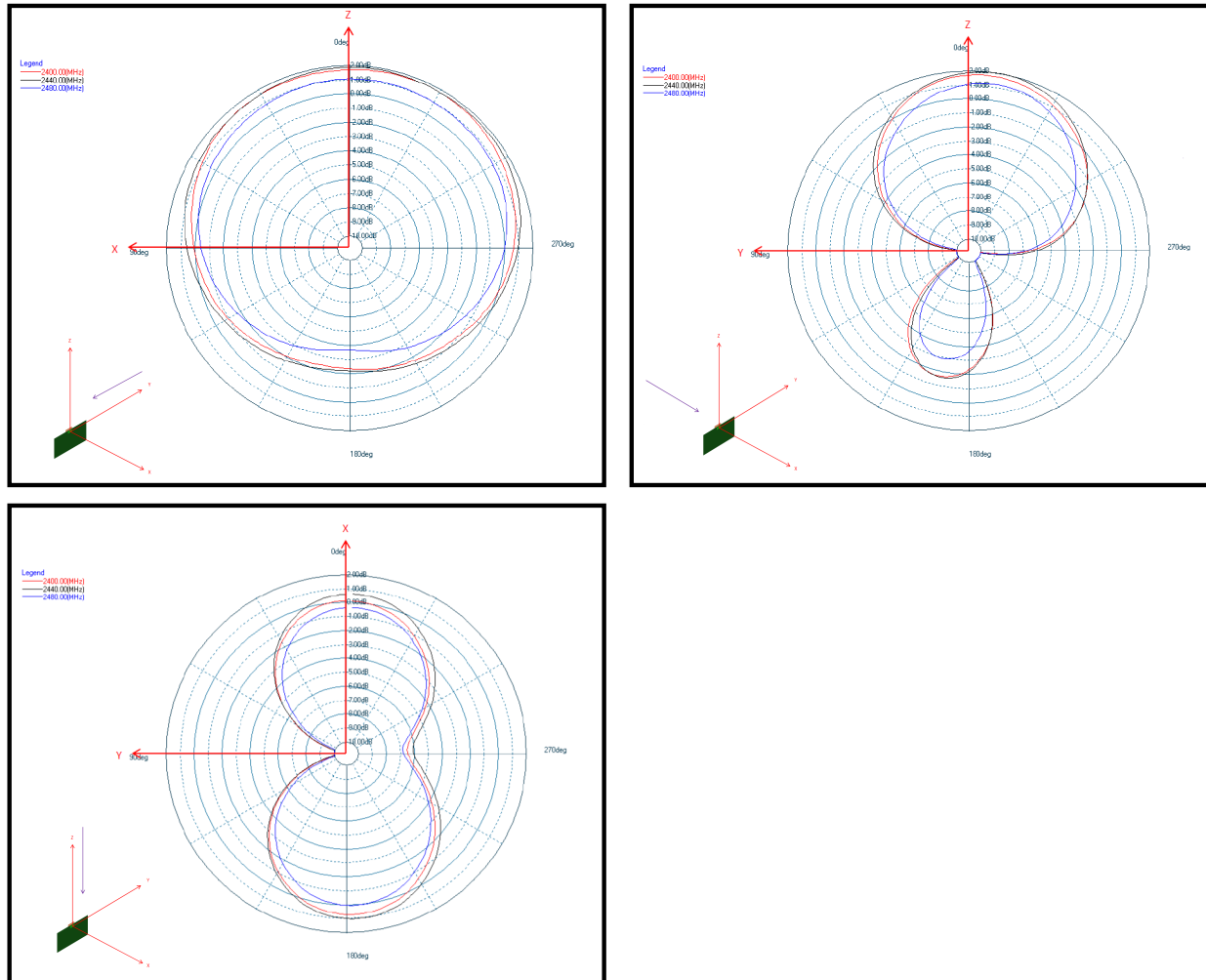
1. GPIO input thresholds are proportional to the IOVDD pin. RESETn input thresholds are proportional to DVDD.
2. GPIO pull-ups connect to IOVDD supply, pull-downs connect to VSS. RESETn pull-up connects to DVDD.

### 3.13 Typical Performance Curves

Typical performance curves indicate typical characterized performance under the stated conditions.

### 3.13.1 Antenna Typical Characteristics

Typical BGX220S radiation patterns for the on-board chip antenna under optimal operating conditions are plotted in the figures that follow. Antenna gain and radiation patterns have a strong dependence on the size and shape of the application PCB the module is mounted on, as well as on the proximity of any mechanical design to the antenna.



Top Left: Phi 0°, Top Right: Phi 90°, Bottom Left: Theta 90°

**Figure 3.3. BGX220S Typical 2D Antenna Radiation Patterns on 55 mm x 20 mm board**

## 4. Reference Diagrams

### 4.1 Typical Connections

The BGX220S can be controlled over the UART interface as a peripheral to an external host processor. Typical power supply and host interface connections are shown in the figure below.

Note that an external pull-up should not be placed on the reset pin.

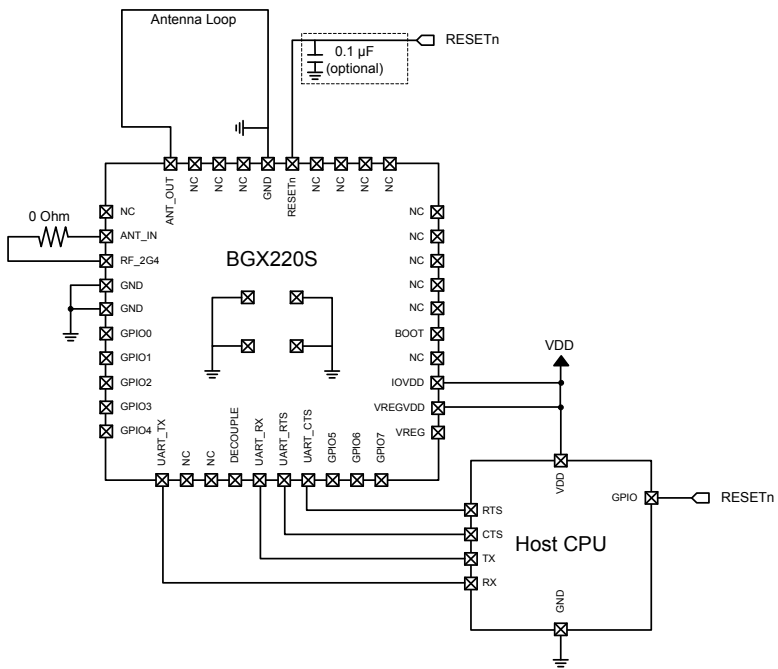


Figure 4.1. Typical Connection Diagram

## 5. 44-Pin SiP Module Device Pinout

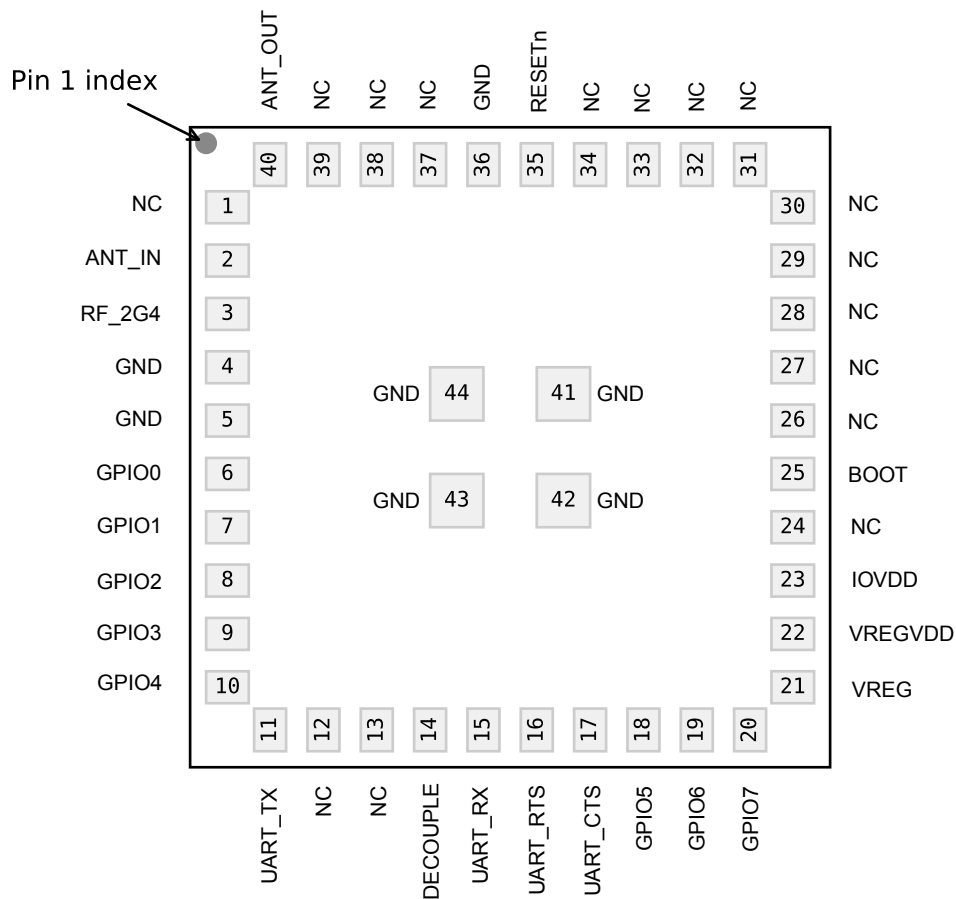


Figure 5.1. 44-Pin SiP Module Device Pinout

Table 5.1. 44-Pin SiP Module Device Pinout

Pin Name	Pin(s)	Description	Pin Name	Pin(s)	Description
NC	1	No connect	ANT_IN	2	Antenna In
RF_2G4	3	2.4 GHz RF input/output	GND	4	Ground
GND	5	Ground	GPIO0	6	Pin with input/output functionality configured through the command API.
GPIO1	7	Pin with input/output functionality configured through the command API.	GPIO2	8	Pin with input/output functionality configured through the command API.
GPIO3	9	Pin with input/output functionality configured through the command API.	GPIO4	10	Pin with input/output functionality configured through the command API.
UART_TX	11	Digital output	NC	12	No connect

Pin Name	Pin(s)	Description	Pin Name	Pin(s)	Description
NC	13	No connect	DECOUPLE	14	Decouple output for on-chip voltage regulator. This pin is internally decoupled, and should be left disconnected.
UART_RX	15	Digital input	UART_RTS	16	Digital output
UART_CTS	17	Digital input	GPIO5	18	Pin with input/output functionality configured through the command API.
GPIO6	19	Pin with input/output functionality configured through the command API.	GPIO7	20	Pin with input/output functionality configured through the command API.
VREG	21	Regulated supply voltage. This pin is internally connected to the SoC DVDD, RFVDD, and PAVDD supply lines. It is not intended to power external circuitry.	VREGVDD	22	Module input power supply. This pin is internally connected to the SoC AVDD and VREGVDD supply lines.
IOVDD	23	I/O power supply	NC	24	No connect
BOOT	25	Active-low digital input to force module entrance into DFU bootloader state upon device reset. See command API documentation for functional details.	NC	26	No connect
NC	27	No connect	NC	28	No connect
NC	29	No connect	NC	30	No connect
NC	31	No connect	NC	32	No connect
NC	33	No connect	NC	34	No connect
RESETn	35	Reset Pin. The RESETn pin is internally pulled up to VREG (DVDD).	GND	36	Ground
NC	37	No connect	NC	38	No connect
NC	39	No connect	ANT_OUT	40	Antenna Out
GND	41	Ground	GND	42	Ground
GND	43	Ground	GND	44	Ground

## 6. Functional overview

### 6.1 Introduction

The BGX220S creates a Bluetooth 5.2 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 Bluetooth 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 [docs.silabs.com](https://docs.silabs.com).

### 6.2 Communication Use Cases

The BGX220S 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 BGX220S 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 BGX220S 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 BGX220S 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 BGX220S 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 BGX220S 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 BGX220S 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 BGX220S 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

BGX220S 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 BGX220S 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 BGX220S, please see [docs.silabs.com](https://docs.silabs.com). BGX220S 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 BGX220S'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. Design Guidelines

### 7.1 Layout and Placement

For optimal performance of the BGX220S the following guidelines are recommended:

- Place the module 1.50 mm from the edge of the copper “keep-in” area at the middle of the long edge of the application PCB, as illustrated in [Figure 7.1 Recommended Layout for BGX220S on page 24](#).
- Copy the exact antenna design from [Figure 7.2 Antenna Layout With Coordinates on page 25](#) with the values for coordinates A to L given in [Table 7.1 Antenna Polygon Coordinates, Referenced to Center of BGX220S on page 25](#).
- Make a cutout in all lower layers aligned with the right edge and the bottom edge of the antenna as indicated by the yellow box in [Figure 7.3 Antenna Clearance in Inner and Bottom Layers on page 26](#).
- Connect all ground pads directly to a solid ground plane in the top layer.
- Connect RF\_2G4 to ANT\_IN through a 0-ohm resistor.
  - The 0-ohm gives the ability to test conducted and to evaluate the antenna impedance in the design.
- Place ground vias as close to the ground pads of the BGX220S as possible.
- Place ground vias along the antenna loop right and bottom side.
- Place ground vias along the edges of the application board.
- Do not place plastic or any other dielectric material in contact with the antenna.
  - A minimum clearance of 0.5 mm is advised.
  - Solder mask, conformal coating and other thin dielectric layers are acceptable directly on top of the antenna region.

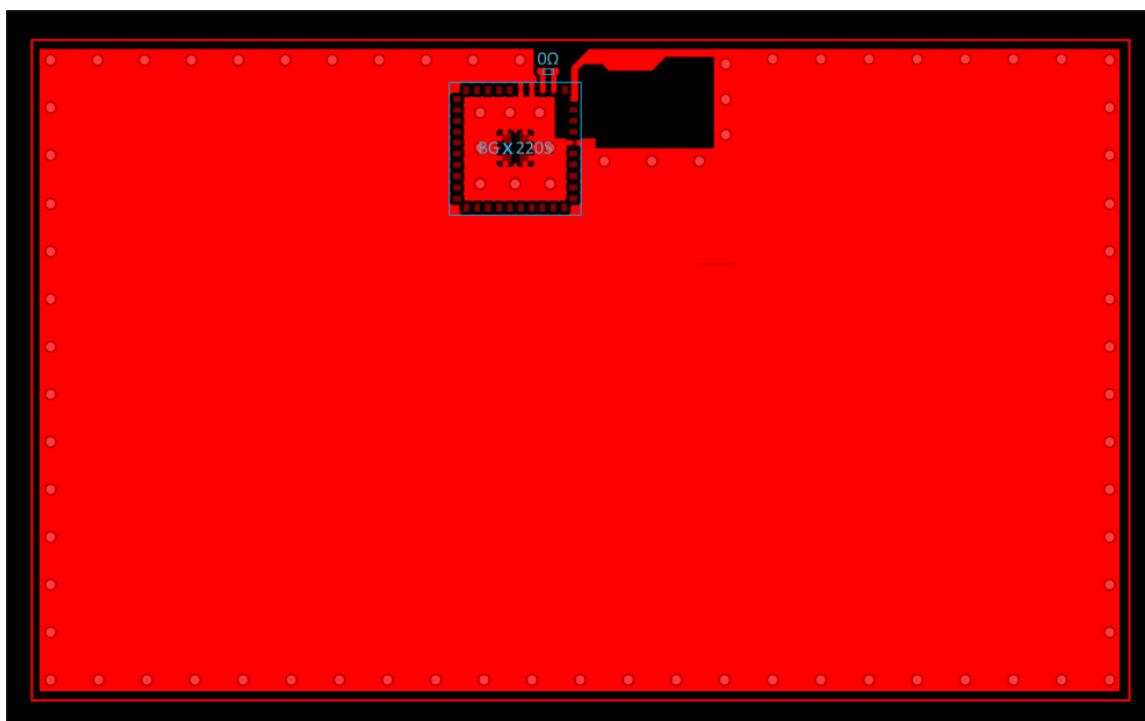


Figure 7.1. Recommended Layout for BGX220S



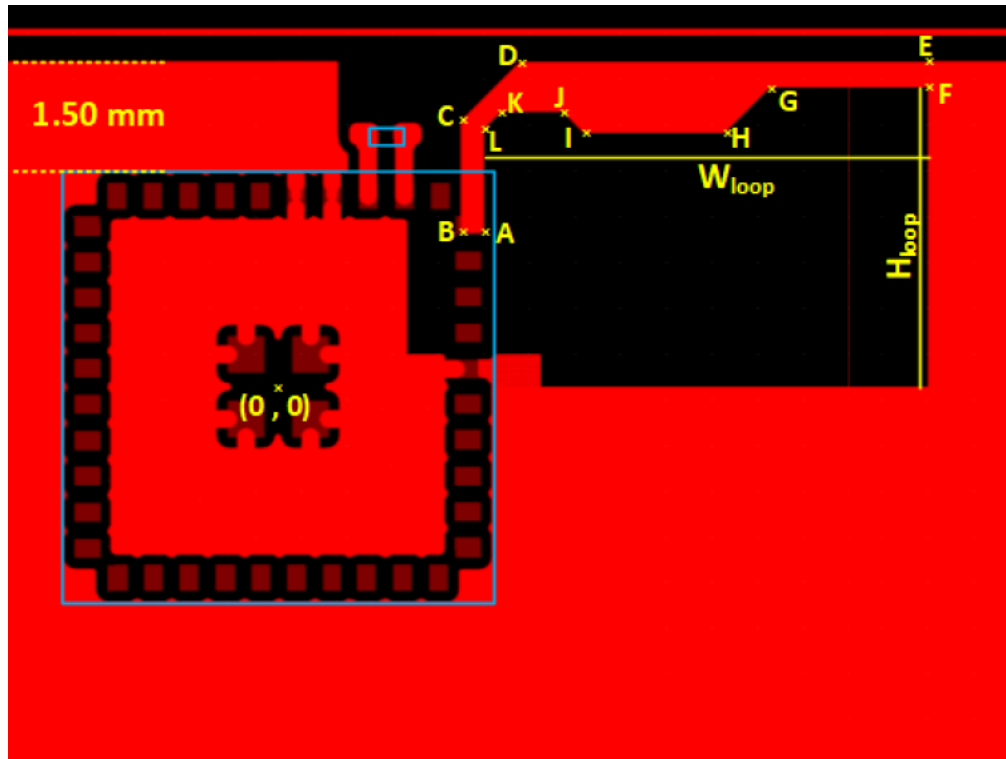


Figure 7.2. Antenna Layout With Coordinates

Table 7.1. Antenna Polygon Coordinates, Referenced to Center of BGX220S

Point	BGX220S22HNA21
A	(2.87, 2.13)
B	(2.54, 2.13)
C	(2.54, 3.69)
D	(3.36, 4.51)
E	(7.75, 4.51)
F	(7.75, 4.15)
G	(6.84, 4.15)
H	(6.21, 3.52)
I	(4.26, 3.52)
J	(3.97, 3.81)
K	(3.10, 3.81)
L	(2.87, 3.58)
W <sub>loop</sub>	4.88
H <sub>loop</sub>	4.15

**Note:**

1. All coordinates and dimensions listed in mm.

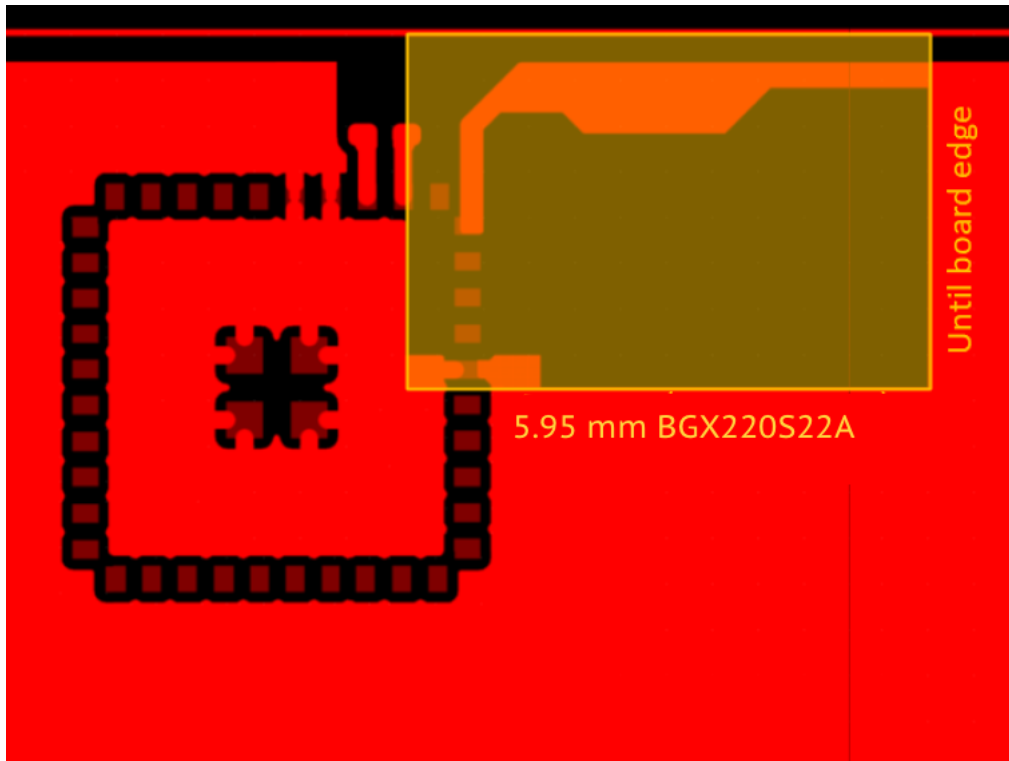


Figure 7.3. Antenna Clearance in Inner and Bottom Layers

## 7.2 Best Design Practices

The design of a good RF system relies on thoughtful placement and routing of the RF signals. The following guidelines are recommended:

- Place the BGX220S and antenna close to the center of the longest edge of the application board.
- Do not place any circuitry between the board edge and the antenna.
- Make sure to tie all GND planes in the application board together with as many vias as can be fitted.
- Generally ground planes are recommended in all areas of the application board except in the antenna keep-out area shown in [Figure 7.3 Antenna Clearance in Inner and Bottom Layers on page 26](#).
- Open-ended stubs of copper in the outer layer ground planes must be removed if they are more than 5 mm long to avoid radiation of spurious emissions.
- The width of the GND plane to the sides of the BGX220S will impact the efficiency of the on-board chip antenna.
  - To achieve optimal performance, a GND plane width of 55 mm for BGX220S is recommended as seen on [Figure 7.4 Illustration of Recommended Board Width on page 27](#).
  - See [3.13.1 Antenna Typical Characteristics](#) for reference.

[Figure 7.5 Non-Optimal Layout Examples on page 28](#) illustrates layout scenarios that will lead to severely degraded RF performance for the application board.

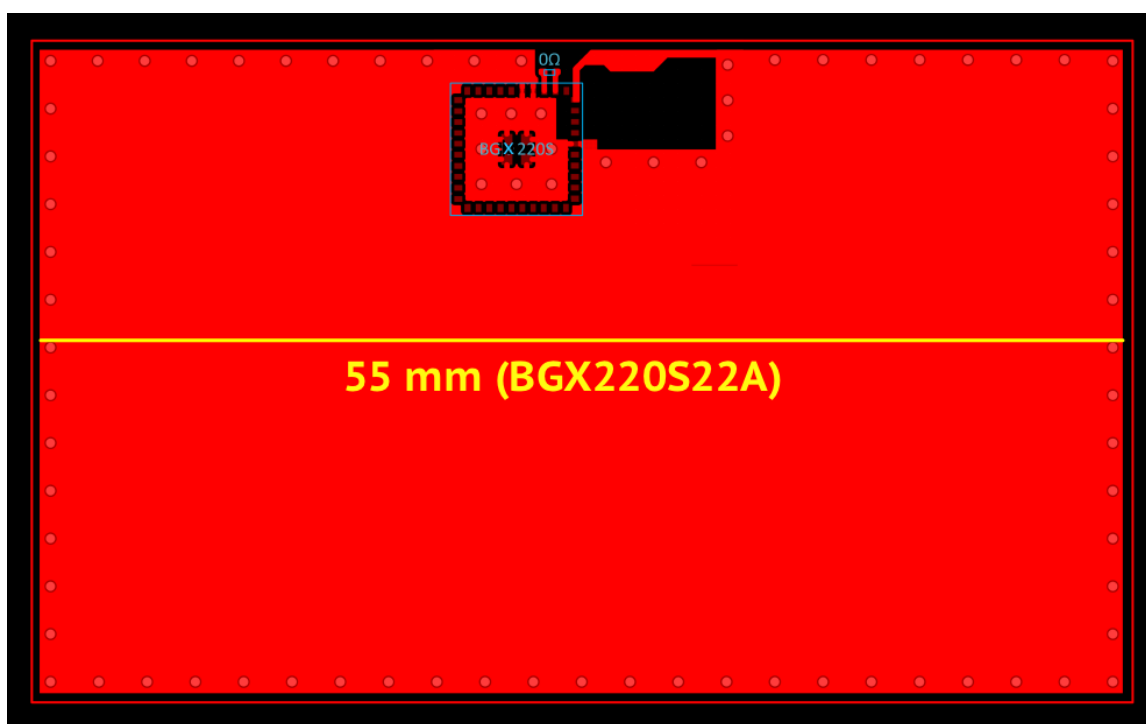


Figure 7.4. Illustration of Recommended Board Width

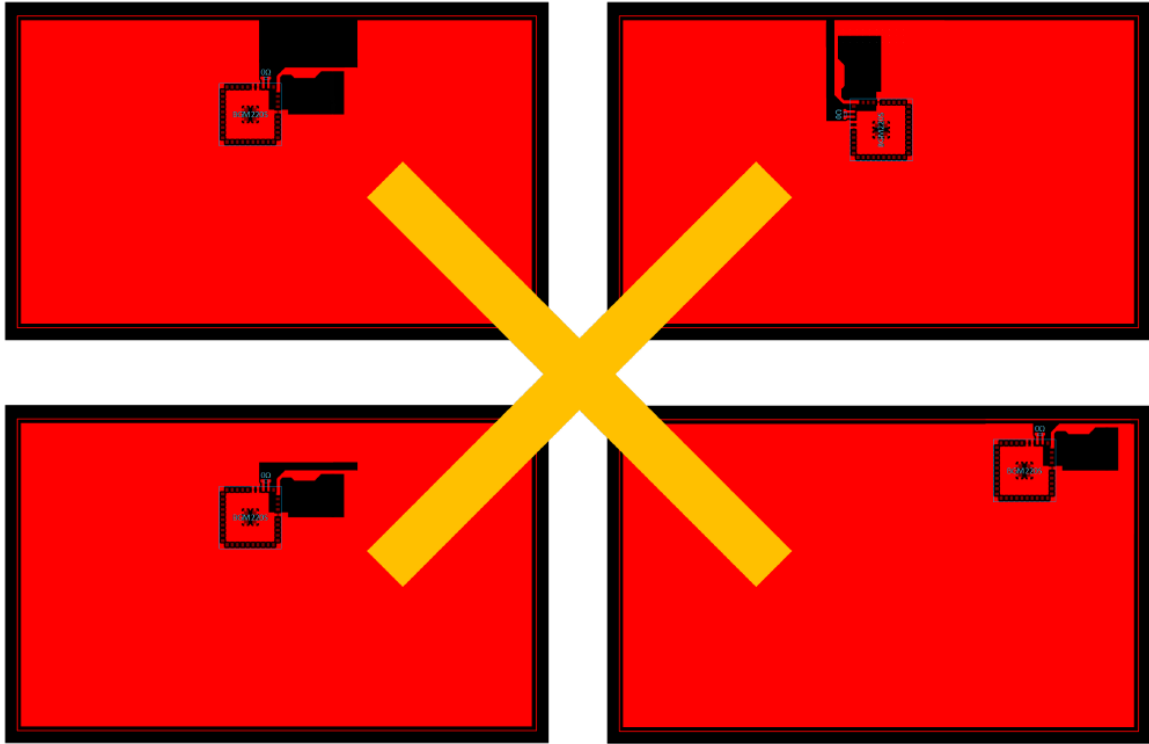


Figure 7.5. Non-Optimal Layout Examples

### 7.3 Radio Performance vs. Carrier Board Size

For many applications, the carrier board size is determined by the overall form factor or size of the additional circuitry. The recommended carrier board width of 55 mm for BGX220S22A is thus not always possible in the end-application. If another form factor is required, the antenna performance of the integrated antenna will be compromised but it may still be sufficiently good for providing the required link quality and range of the end-application. [Figure 7.6 Efficiency of the Integrated Antenna as Function of the Carrier Board Size for BGX220S22A on page 29](#), which is also representative of antenna efficiency of the BGX220S, show the total efficiency of the integrated antenna for different carrier board sizes. As can be seen the best performance is achieved for the carrier board size of 55 mm x 25 mm for the BGX220S22A, with relatively constant performance for larger boards and rapidly declining performance for smaller boards.

The performance of all the sizes tested will be adequate for more than 15 m line-of-sight range and all of the sizes are thus usable.

**WARNING: Any antenna tuning or change of the loop dimensions will void the modular certification of modules with modular certification. In that case, a Permissions Change to the modular approval is required.**

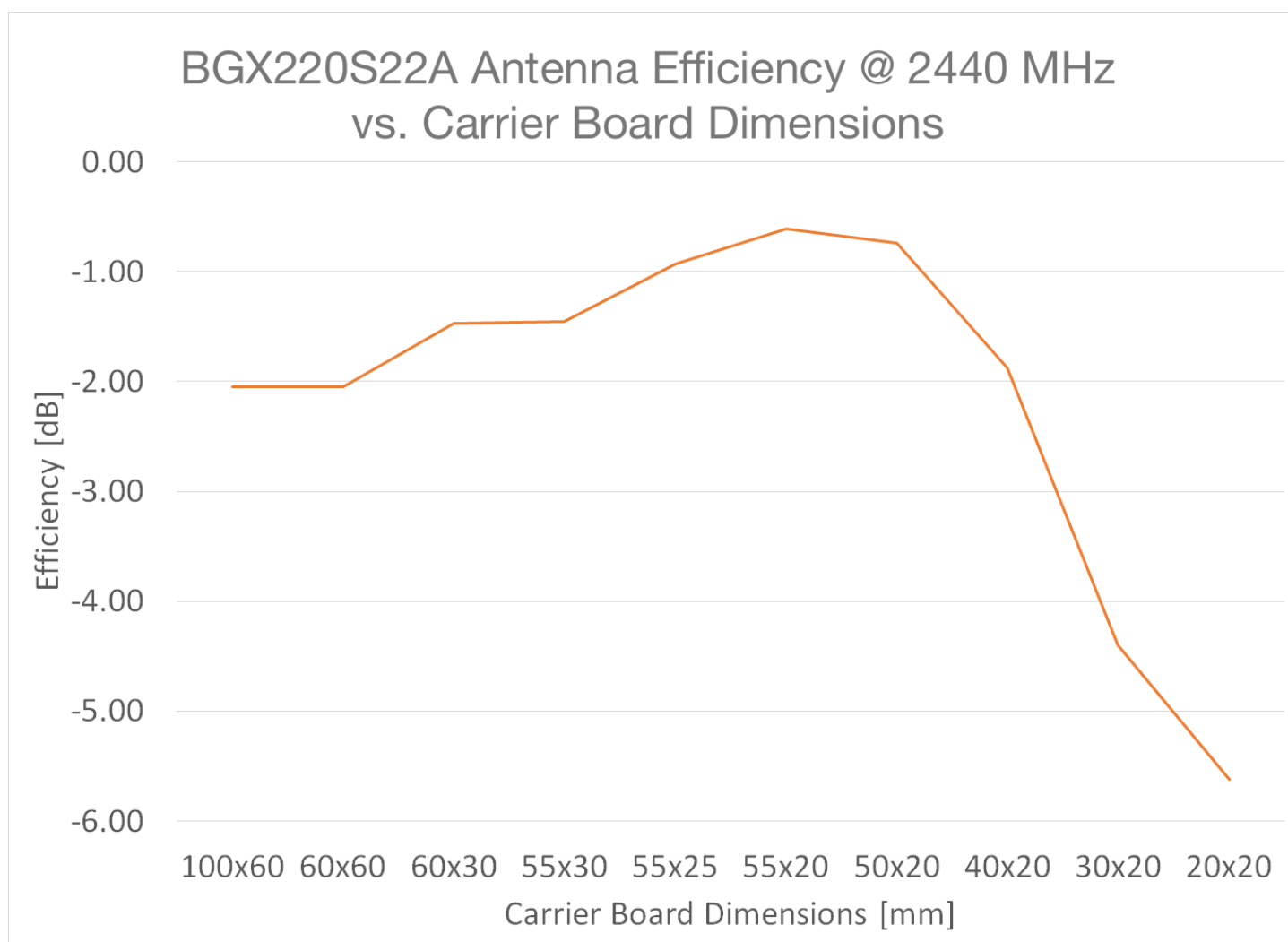


Figure 7.6. Efficiency of the Integrated Antenna as Function of the Carrier Board Size for BGX220S22A

### 7.4 Proximity to Other Materials

Placing plastic or any other dielectric material directly in contact with the antenna may cause performance degradation. A clearance of minimum 0.5 mm is recommended to avoid excessive detuning of the antenna. Solder mask, conformal coating, and other thin dielectric layers are acceptable directly on top of the antenna region. 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.

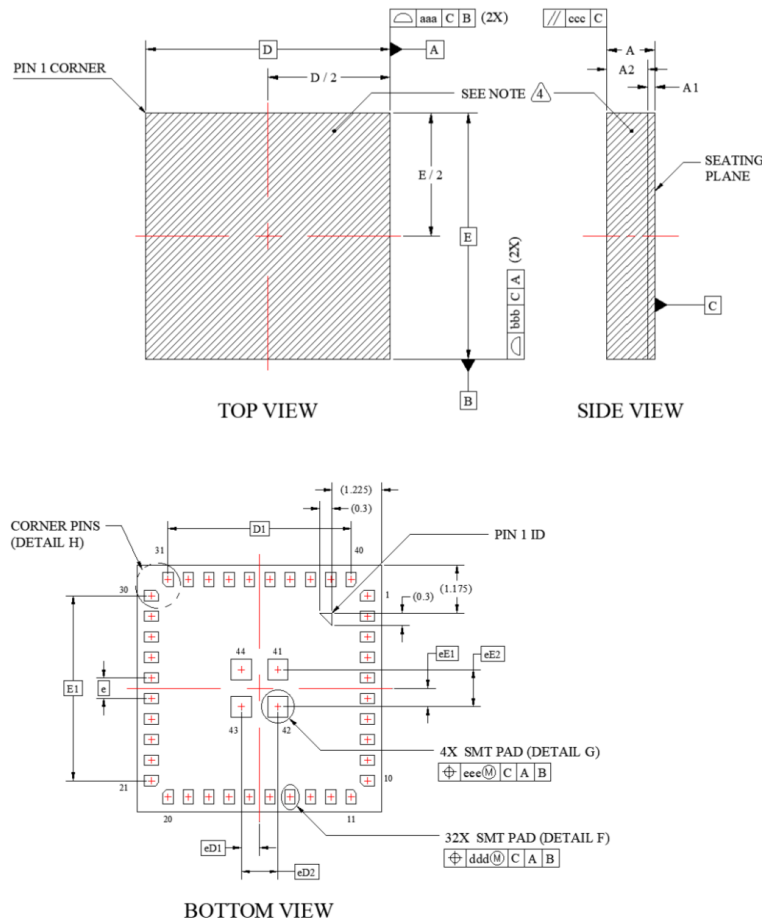
## 7.5 Proximity to Human Body

Placing the module in contact with or very close to the human body will negatively impact antenna efficiency and reduce range. Furthermore, additional certification may be required if the module is used in a wearable device.

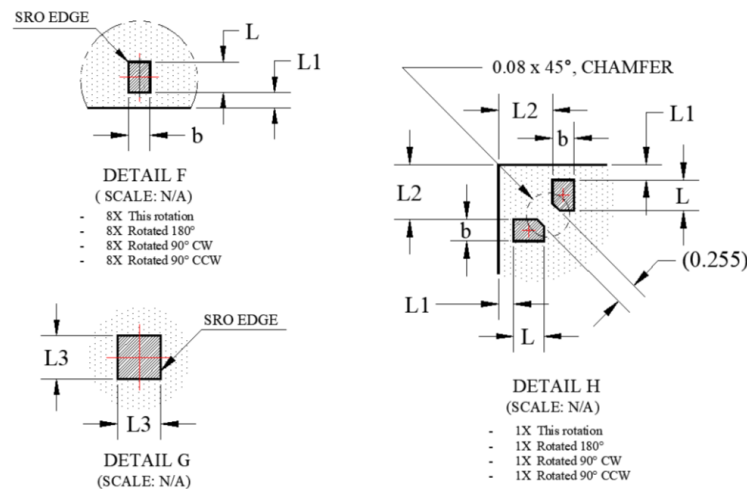
## 8. Package Specifications

### 8.1 Package Dimensions

The package dimensions are shown in [Figure 8.1 Package Dimensions - Full on page 31](#) and [Figure 8.2 Package Dimensions - Detail on page 31](#).



**Figure 8.1. Package Dimensions - Full**



**Figure 8.2. Package Dimensions - Detail**

**Table 8.1. Package Dimensions**

Dimension	MIN	NOM	MAX
A	1.080	1.180	1.280
A1	0.140	0.180	0.220
A2	0.950	1.000	1.050
b	0.200	0.250	0.300
D	6.000 BSC		
D1	4.500 BSC		
e	0.500 BSC		
E	6.000 BSC		
E1	4.500 BSC		
L	0.300	0.350	0.400
L1	0.125	0.175	0.225
L2	0.575	0.625	0.675
L3	0.450	0.500	0.550
eD1	0.450 BSC		
eD2	0.900 BSC		
eE1	0.450 BSC		
eE2	0.900 BSC		
aaa	0.100		
bbb	0.100		
ccc	0.100		
ddd	0.100		
eee	0.100		

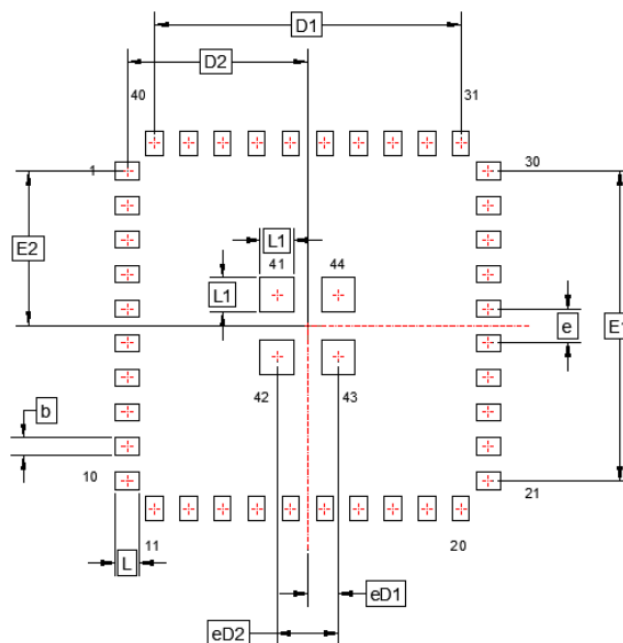
**Note:**

- The dimensions in parenthesis are reference.
- All dimensions in millimeters (mm).
- Unless otherwise specified, tolerances are:
  - Decimal: X.X = +/- 0.1  
X.XX = +/- 0.05  
X.XXX = +/- 0.03
  - Angular: +/- 0.1 (In Deg)
- Hatching lines means package shielding area.



## 8.2 Recommended PCB Land Pattern

The recommended PCB Land Pattern is shown in [Figure 8.3 Module Land Pattern on page 33](#)



**Figure 8.3. Module Land Pattern**

**Table 8.2. PCB Land Pattern Dimensions**

Dimension	Typ (mm)
D1	4.50
D2	2.65
E1	4.50
E2	2.25
eD1	0.45
eD2	0.90
b	0.25
e	0.50
L	0.35
L1	0.50

### Note:

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 0.100 mm (4 mils).
5. The stencil aperture to land pad size recommendation is 80% 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.**

8.3 Top Marking

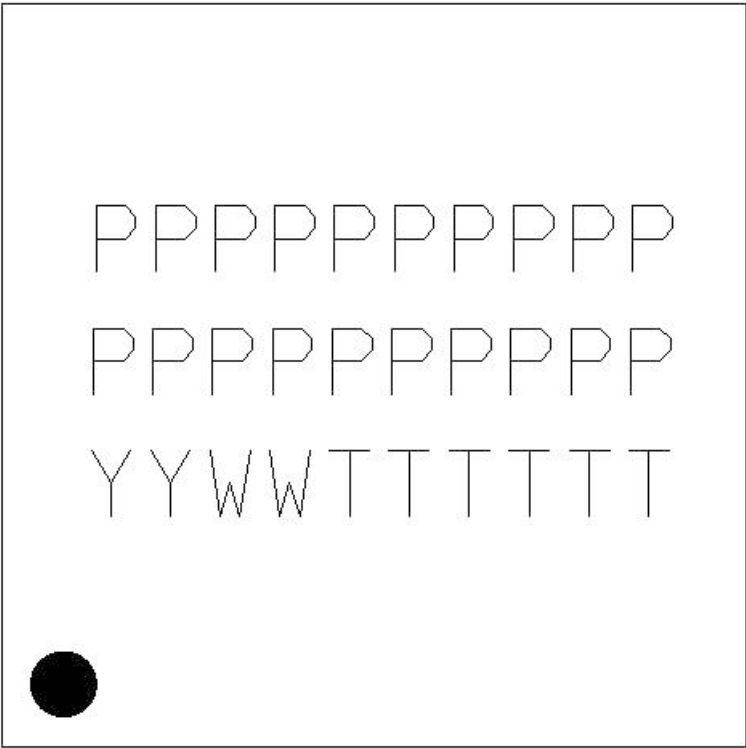


Figure 8.4. BGX220S Top Marking

Table 8.3. Top Marking Definition

OPN	Line 1 Marking	Line 2 Marking	Line 3 Marking
BGX220S22HNA21	BGX220S22A	SC22HNA2	See note below
<b>Note:</b> YY = Year. WW = Work Week, TTTTTTTT = Trace Code			

## 9. Soldering Recommendations

It is recommended that final PCB assembly of the BGX220S follows the industry standard as identified by the Institute for Printed Circuits (IPC). This product is assembled in compliance with the J-STD-001 requirements and the guidelines of IPC-AJ-820. Surface mounting of this product by the end user is recommended to follow IPC-A-610 to meet or exceed class 2 requirements.

### CLASS 1 General Electronic Products

Includes products suitable for applications where the major requirement is function of the completed assembly.

### CLASS 2 Dedicated Service Electronic Products

Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically the end-use environment would not cause failures.

### CLASS 3 High Performance/Harsh Environment Electronic Products

Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems.

**Note:** General SMT application notes are provided in the AN1223 document.

## 10. Tape and Reel

BGX220S modules are delivered to the customer in tray (490 pcs / tray) or reel (2500 pcs / reel) packaging with the dimensions below. All dimensions are given in mm unless otherwise indicated.

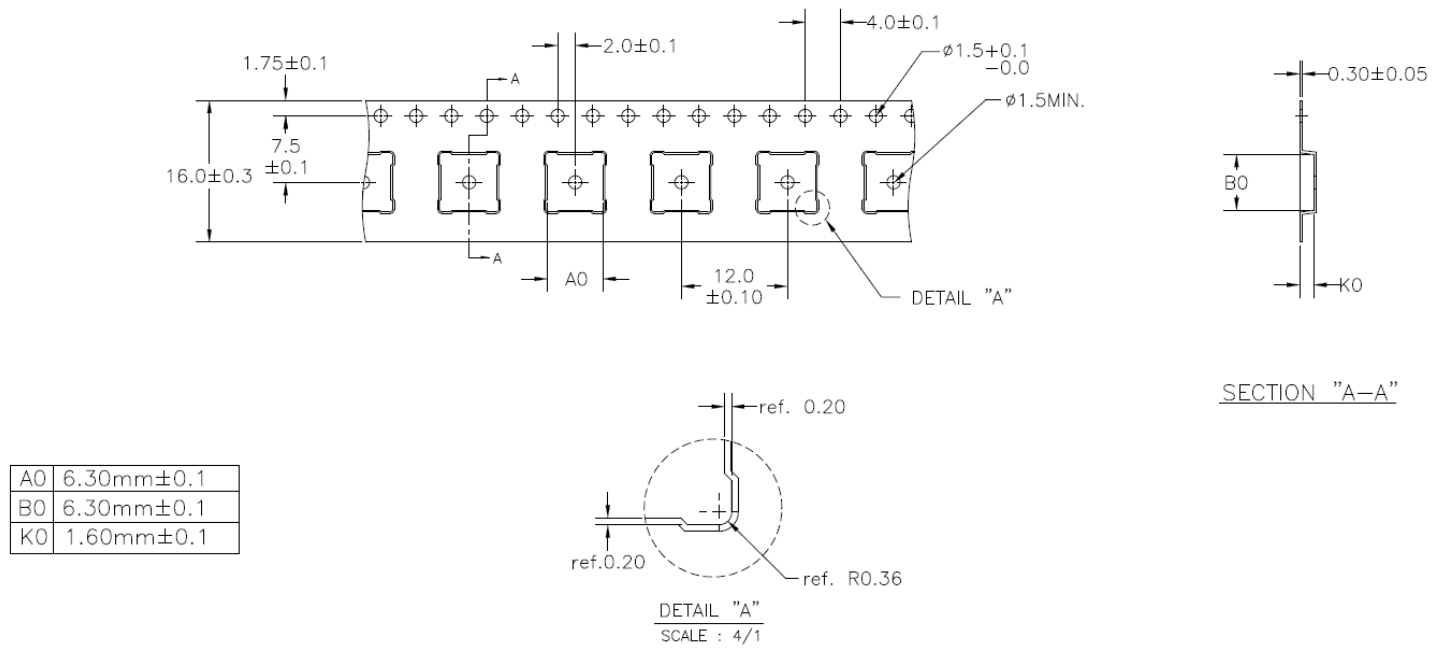


Figure 10.1. Carrier Tape Dimensions

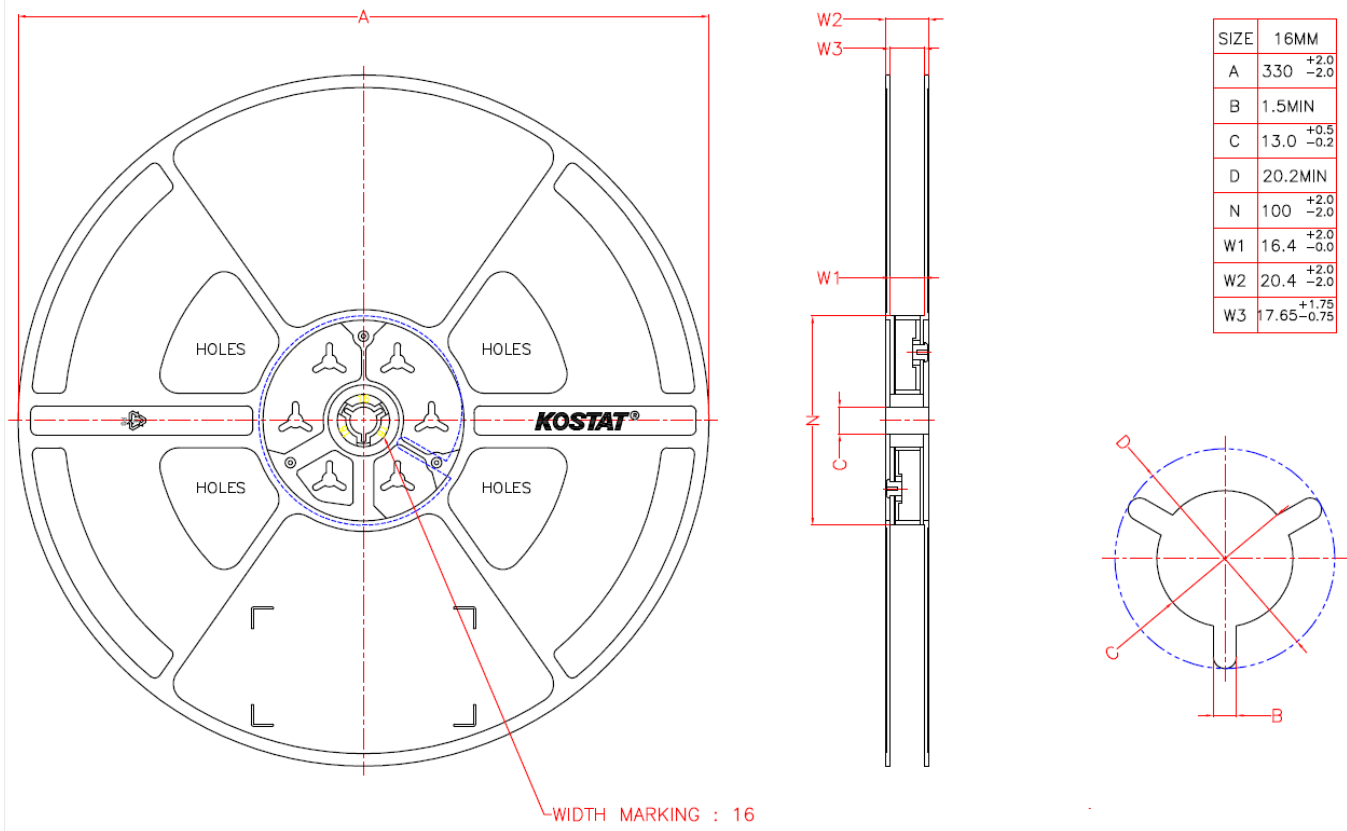


Figure 10.2. Reel Dimensions

## 11. Certifications

Please refer to the corresponding chapter 11 of the BGM220S modules for all information regarding regulatory radio approvals and Bluetooth qualification information. The BGX220S22A is derived from the BGM220S22A and shares the same test reports and certifications.

### 11.1 Certifications for Model BGM220S22A

Certification is not yet completed for the BGM220SC22WGA2 and BGM220SC22HNA2.

## 12. Revision History

### Revision 1.0

Initial release.

# Simplicity Studio

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



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## Disclaimer

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