Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

BT121 BLUETOOTH SMART READY MODULE

DATA SHEET

Wednesday, 13 May 2015

Document Version: 1.2

bluegiga

A Silicon Labs Company

VERSION HISTORY

Date Edited	Comment
1.0	First release of document
1.1	Minor updates
1.2	Minor updates

TABLE OF CONTENTS

1 BT121 overview

BT121 is a Bluetooth Smart Ready module targeted for applications that require both Bluetooth Smart and Classic connectivity. It can connect to legacy devices that only support Bluetooth SPP or Apple® iAP2 profiles as well to devices that support Bluetooth Smart. BT121 integrates a high performance Bluetooth radio, a low-power ARM Cortex micro-controller and a Bluegiga Bluetooth Smart Ready stack software marking it extremely easy-to-use as no RF or Bluetooth software development is needed. BT121 can be used as a modem together with a separate host MCU, but applications can also be embedded into the built-in ARM® Cortex® MCU with the Bluegiga BGScript™ scripting language.

1.1 Key Features

Bluetooth features

- Bluetooth 4.1 Smart Ready compliant
- Master and slave modes
- Up to 6 x BR/EDR connections
- Up to 7 x BLE connections
- 1 x BR/EDR + 7 x BLE connections simultaneously

Radio features

- Integrated antenna
- TX Power
    - +12 dBm with Bluetooth BR/EDR
    - +10 dBm with Bluetooth LE
- RX Sensitivity
    - -96 dBm
- 200-400 meter LoS range

Software features

- Integrated Bluetooth Smart Ready Stack
- SPP, iAP2, GATT over BR Bluetooth profiles
- Any GATT based Bluetooth Smart profile
- 1000 kbps throughput over SPP
- 150 kbps throughput over iAP2
- 100 kbps throughput over BLE
- BGAPI™ serial protocol API over UART for modem usage
- BGLIB™ host API/library which implements BGAPI serial protocol
- BGScript™ scripting language for standalone usage
- Profile Toolkit™ for creating GATT based services

Hardware interfaces

- UART host interface
- 2 x SPI, UART and 2 x I2C peripheral interfaces
- Up to 22 x GPIO with interrupts
- 4 x 12-bit ADC and 2 x 12-bit DAC*
- Internal temperature sensor*
- Internal battery voltage measurement option*
- Clock generator*
- RTC with calendar*

Microcontroller

- ARM Cortex M0
- 48 Mhz
- 16kB RAM
- 128kB flash

Electrical characteristics

- Supply voltage: 2.2V to 3.6V
- Supply voltage: 2.4V to 3.6V when using ADC

Environmental and regulatory

- Temperature range: -40C to +85C
- Bluetooth, CE, FCC and IC, Japan and South-Korea qualified*

Dimensions:

- W x L x H: 11.0 mm x 13.9 mm x 2.2 mm

*) Feature not implemented on engineering samples and engineering samples are not qualified

1.2 Typical applications

BT121 can be used in a wide variety of applications such as health and fitness, PoS (point-of-sales), M2M connectivity, automotive aftermarket, industrial and home automation gateways and others.

1.3 Block diagram

The block diagram for Bluegiga *Bluetooth* Smart Ready module BT121 is shown in below.

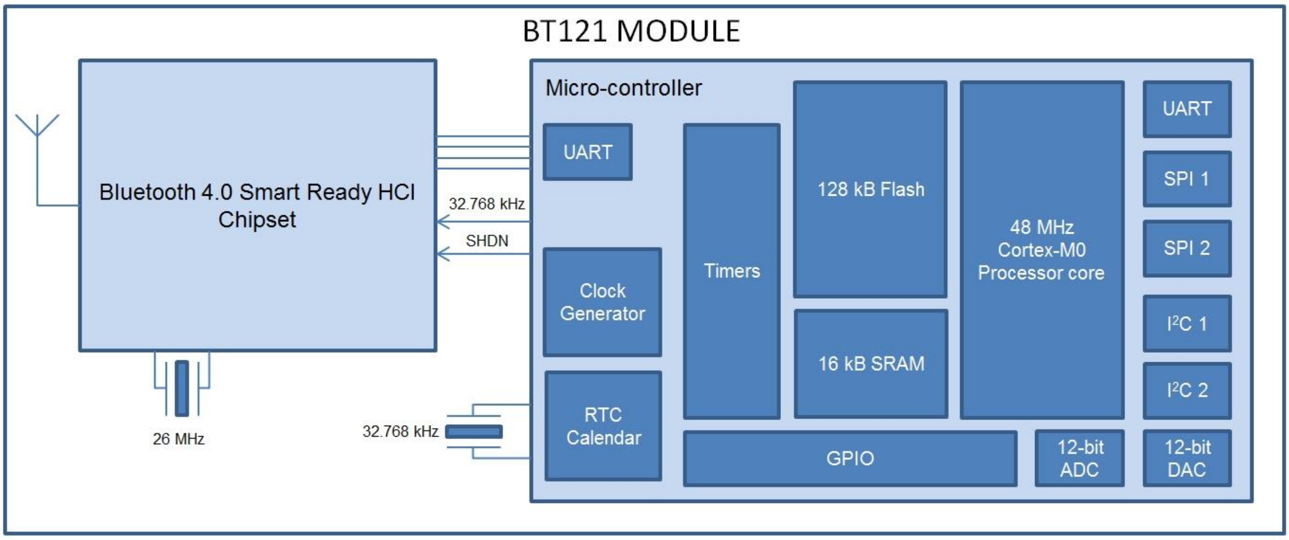


Figure 1 BT121 Bluetooth Smart Ready module block diagram

2 Design guidelines

Certain hardware related design guidelines should always be followed when developing applications based on the BT121 module.

2.1 PCB layout recommendations

- All ground pads should be connected to a ground plane.
- The antenna layout should follow the example shown in ***Figure 2*** below and avoid the designs shown as crossed over.
- BT121 requires minimal free space around the module and only the white area marked in the PCB picture series presented in ***Figure 2*** below needs to be free of copper and components.

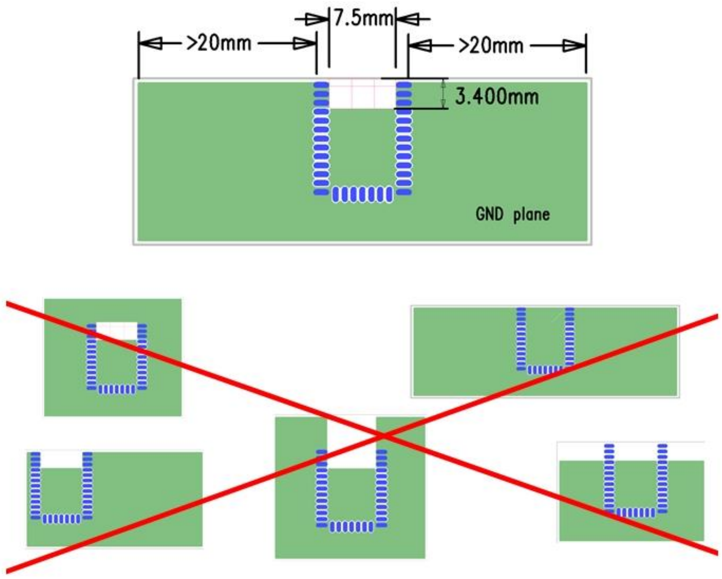


Figure 2 PCB layout recommendations for BT121 application boards

2.2 Power supply recommendations

The regulator used must be capable of supplying a peak current of 150 mA and the regulator must be of a type stable with ceramic capacitors.

2.3 Software application related options

BT121 can be used either as a stand-alone solution by using the Bluegiga BGScript™ scripting language or alternatively if the application software size or other factors require together with an external host processor by using Bluegiga BGAPI™ commands. The decision on which approach to use is most often dictated by the limits set by the internal memory of the BT121 module.

2.4 Firmware updating related recommendations

To enable firmware updating an external UART interface connection as shown in ***Figure 3*** on the next page is mandatory. BT121 firmware can be updated through the UART interface by holding the host MCU in reset state which typically will free the UART lines to be used by the update interface.

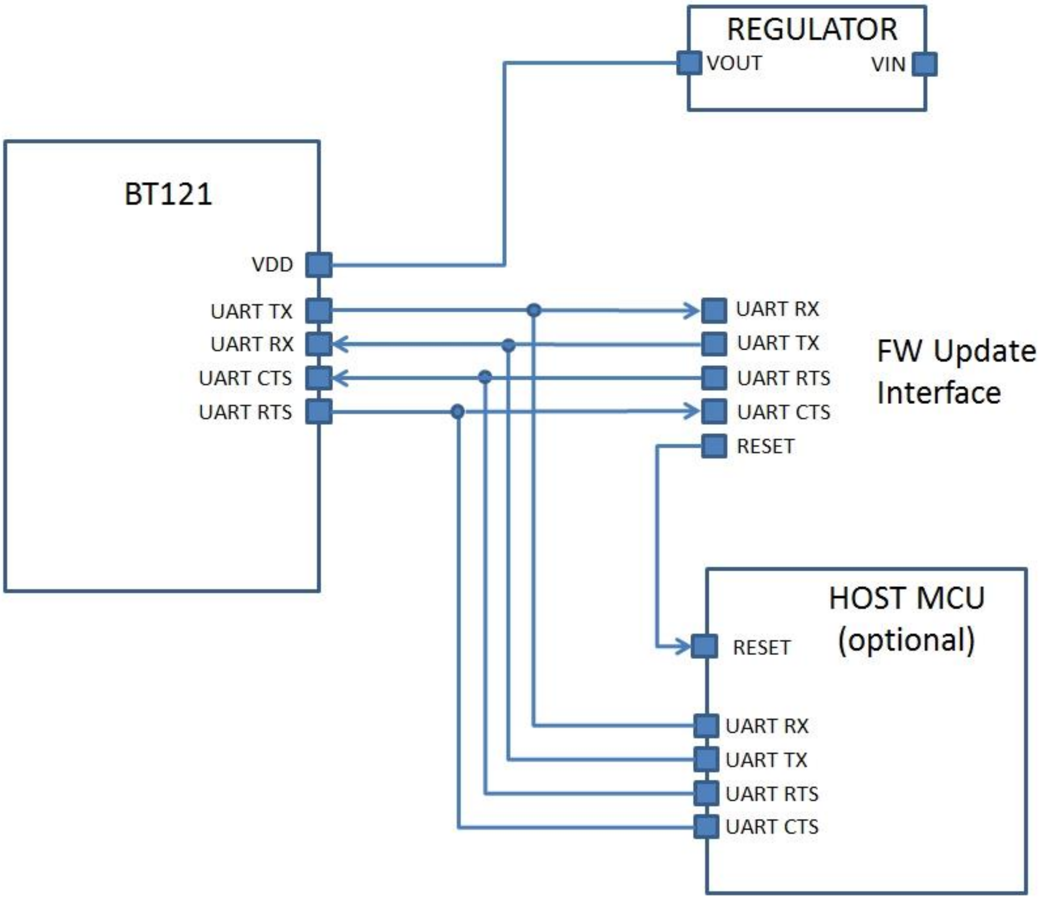


Figure 3 BT121 firmware update via UART connection example

3 Pin-out description

This section contains a description of the BT121 pin-out. Each pin may have one or more functions which are all listed in tables. The pin-out is shown in ***Figure 4*** below.

Figure 4 BT121 pin-out (top view)

3.1 Power, ground, reset, RF and boot loader pins

Power supply, ground, reset signal, RF antenna input/output and boot loader related pins are listed in ***Table 1*** below.

Pin / Pad	Function	Description
30,34	VDD	Module power supply input pins.
1, 2, 3, 13, 21, 31, 32, 33, 41	GND	Ground pin. These are all connected together internally but they should all be individually connected directly to a solid ground plane with vias in close proximity to the pins. This requirement concerns especially the antenna connections.
22,40	RESET	Module reset signal pins. Pulling RESET low will reset the internal processor of the module. These connections have an internal pull-up and can be left floating if not needed.
23,35	BOOT0	Boot mode pin of the microcontroller internal boot loader. This connection has an internal pull-down and should be left floating or pulled low in normal operation. If the Bluegiga DFU is overwritten or disabled, pulling BOOT0 high at reset will allow DFU to be rewritten through the UART (serial port interface).

Table 1 Power, ground, reset, RF and boot loader pins

3.2 GPIO pins

General purpose I/O pins and their functions are listed below.

PERIPHERAL FUNCTION		GPIO NAME																					
		PA7	PA6	PA5	PA4	PB3	PB4	PB5	PB6	PB7	PB8	PB9	PB10	PB12	PB13	PB14	PB15	PA13	PA14	RTS PA12	CTS PA11	RX PA10	TX PA9
PIN NUMBER		4	5	6	7	8	9	10	11	12	14	15	16	17	18	19	20	24	25	26 37	27 36	28 38	29 39
DEFAULT FUNCTION **		dc	dc	dc	dc	dc	dc	dc	dc	dc	dc	dc	dc	dc	dc	dc	dc	dc	dc	RTS	CTS	RX	TX
5V TOLERANT		N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
UART ***																				RTS	CTS	RX	TX
SPI 1	Alt.1	MOSI	MISO	SCK	NSS*																		
	Alt.2				NSS*	SCK	MISO	MOSI															
SPI 2	Alt.1											NSS*	SCK			MISO	MOSI						
	Alt.2													NSS*	SCK	MISO	MOSI						
I²C 1	Alt.1								SCL	SDA													
	Alt.2										SCL	SDA											
I²C 2	Alt.1																						
	Alt.2														SCL	SDA							
DAC output				AO2	AO1																		
ADC input		AIN7	AIN6	AIN5	AIN4																		
Interrupt channel		7	6	5	4	3	4	5	6	7	8	9	10	12	13	14	15	13	14	12	11	10	9

Table 2 General purpose I/O pins and their functions

* NSS signal is optional, see SPI description (Section *5.4*)
** Default pin functions on production firmware / dc = disconnected, no need to pull up or down
*** UART can be used as a BGAPI™ host interface and DFU firmware updates
If the pins are set as GPIO rather than UART signals the DFU cannot work, see UART (Section *5.2*) and recovery mode (Section *4.4*)

GPIO pins 36, 37, 38 and 39
Reserved for production testing
Must be left unconnected

I2C 2 cannot be used in Alt. 2 configuration

4 Power control

4.1 Power supply requirements

BT121 is powered by a single power supply input (VDD). Nominal input voltage is 3.3 VDC and input voltage range 2.2 V to 3.6 V. If the module's internal ADC and/or DAC functions are used minimum allowed power supply voltage is 2.4V.

The VDD supply should be capable of supplying a peak current of at least 150 mA even though the average current consumption of BT121 will be much less than that. External high frequency bypass capacitors are not needed because the module contains the necessary power supply filtering capacitors.

Careful design of the layout and proper component selection are necessary to prevent switching noise from appearing on the supply line. Such disturbances can be caused by on-board charge pump converters (e.g. RS232 level shifters). Charge pump based converters tend to have strong switching spikes which are difficult to filter out and may degrade RF performance. A ferrite chip can be added in series with the supply line close to the module supply pin to reduce RF interference through the supply line.

There is a total of about 1.5 µF of ceramic capacitors on the VDD line inside the module. When using low drop linear regulators to generate a regulated supply voltage for the VDD line, the stability of the regulator with the low ESR provided by these capacitors should be checked. Many linear regulators and some switched mode ones too are not stable when used with ceramic output capacitors. The regulator datasheets usually have recommendations for output capacitor ESR range or they contain a stability curve to help select components properly. A regulator designated as "stable with ceramic capacitors" is recommended.

4.2 Power saving functionality

BT121 contains two configurable power saving modes. The internal RTC (Real Time Clock) is usually kept always running to avoid the long wake-up time associated with the internal 32 kHz crystal oscillator. The RTC is always available to wake up the module.

4.2.1 Power mode 1

Power mode 1 is a shallow sleep state with all clocks and peripherals running but with the processor core stopped. It is used automatically and has no impact on module performance and does not require special considerations in user applications. See ***Table 3*** on next page.

4.2.2 Power mode 2

Power mode 2 is a deep sleep state, in which most peripheral devices and system clocks are powered down. The UART interfaces cannot operate without clocks, and instant communications with the host are not possible. A separate wake-up command on the host UART or a PIO interrupt can be used to wake up the module, or an RTC event. The radio can also cause a wake-up event. There is a short wake-up delay due to the time required for the internal clocks to stabilize and because of this the module processor is not instantly ready to receive data.

The radio part of the BT121 can be physically shut down with software to reduce module sleep consumption to the minimum. This can be useful when the application only needs to connect to a remote system periodically. Powering the radio up again will require a re-initialization of the radio, which will cause a relatively long delay. See ***Table 3*** on next page.

Power mode	CPU clocks	CPU core	Radio	Wakeup delay	UART	Current consumption *
Active	ON	Running	On	-	Active	10 - 20 mA
Power mode 1	ON	Stopped	On	< 7µs	Active	4 - 10 mA
Power mode 2	OFF	Powered off	On	< 70 µs	Off	50 - 100 µA
Power mode 2 RF OFF	OFF	Powered off	Off	< 500 ms Until radio is on again	Off	5 - 10 µA

Table 3 Power modes with corresponding wakeup delays and current consumption

* Current consumption with radio inactive

The logic flow of the power saving modes in relation to each other is shown in ***Figure 5*** below. It is to be noted that the processor will not lose RAM contents regardless of the power mode used.

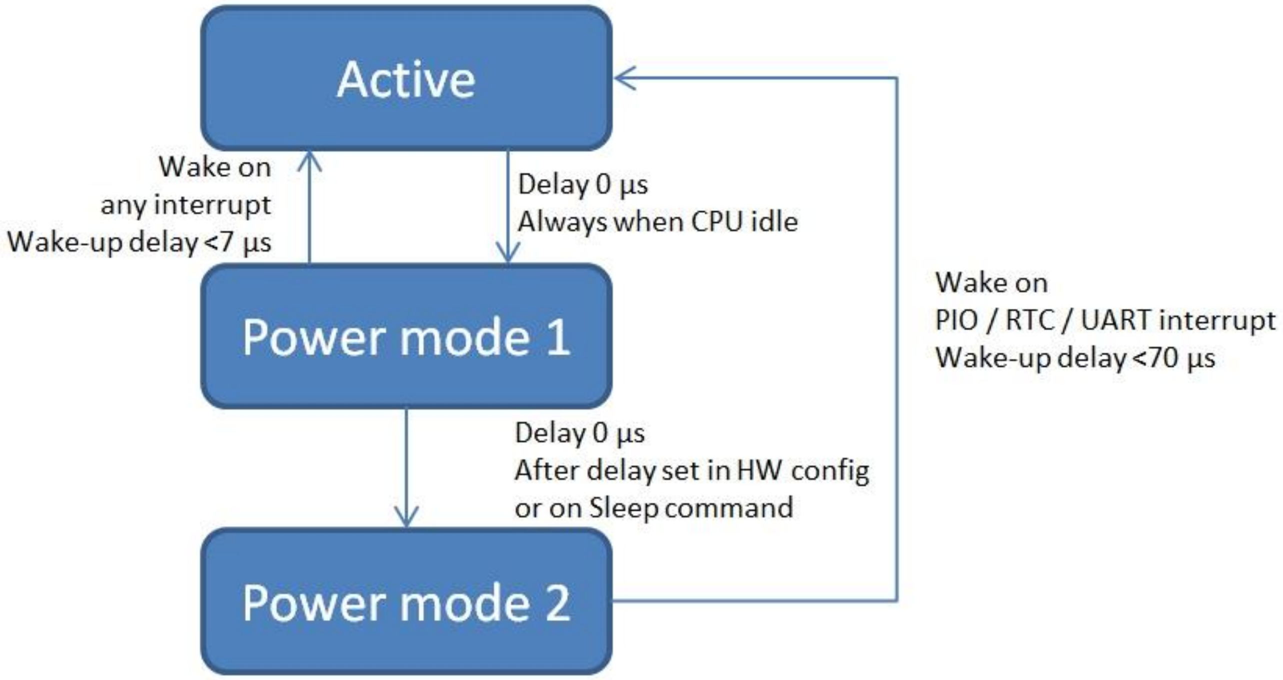


Figure 5 Power modes in relation to each other and to active mode

4.3 Reset

BT121 can be reset by several methods: by pulling the RESET pin low, by the internal system power-up reset functionality or by the internal watchdog timer. The RESET pin is internally connected to a pull-up resistor with a resistance of approximately 40 kohm. The RESET pin should be connected to a push-button, header or test point to enable the use of the system recovery mode.

4.4 Recovery mode

Pulling the BOOT0 pin high at reset sets the BT121 module's internal microcontroller into a recovery mode, which allows the Bluegiga DFU to be rewritten to the module using the DumoGUI software. The BOOT0 pin should be connected to a header or test point to enable DFU recovery. The pin is internally connected to a 10 kohm pull-down resistor.

4.5 Clock signals

BT121 generates all the required clock signals internally. The clocks used by the internal microcontroller and external peripherals are synchronized to an internal 32.768 kHz crystal connected to the internal RTC. The micro power RTC is always kept running when the module is supplied with power. It will take approximately two seconds for the RTC oscillator to stabilize after power is connected. To avoid this delay it is recommended that the power supply feed to the BT121 is not switched off but instead the module can be set into the lowest power mode providing the smallest current consumption.

5 Interfaces

5.1 GPIO

BT121 contains a number of pins which can be configured to operate as general purpose digital I/O's, analog inputs or outputs or to be used in combination with various built-in functions. The module contains I2C, SPI, UART, touch pad sensing and various timer functions. Most of the pins are 5V tolerant. All GPIO pins can drive currents of up to +/- 8 mA (up to 20mA with relaxed voltage specifications).

5.1.1 GPIO interrupts

Any GPIO signal can be assigned an interrupt function. However, the module microcontroller has a limited number of interrupt channels available for GPIO's. The microcontroller has two separate GPIO ports, with the external signals divided between the two. An interrupt can be assigned to a specific port signal number from either port, but not for the same number on both ports simultaneously. The principle of GPIO interrupt multiplexing on the Bluegiga *Bluetooth* Smart Ready module BT121 is shown in ***Figure 6*** below.

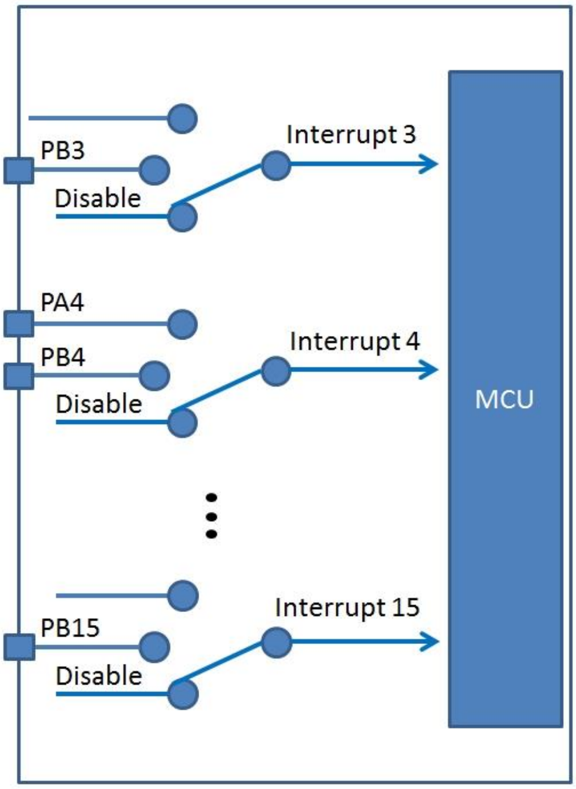


Figure 6 GPIO interrupt multiplexing scheme

5.2 UART

There is one UART port available on the BT121. By default it is used for BGAPI™ host interface but with BGScript™ it can be used as an application UART. The UART supports all standard baud rates up to 4 Mbps. RTS/CTS handshake scheme is supported and recommended for every application for reliable data transfer.

5.3 I^2C

BT121 has up to two I^2C ports available. Both support standard mode up to 100 kbps, fast modes up to 400 kbps and Fast Mode Plus with improved drive capability and clock stretching up to 1 Mbps.

5.4 SPI

BT121 has up to two SPI ports available. Both can be configured for frame sizes from 4 to 16 bits and clock frequencies up to 18 MHz. Both ports provide internal CRC calculation. An optional slave select signal (NSS) is provided for hardware assisted data strobing in applications requiring high bus throughputs.

5.5 ADC

BT121 contains a 4-channel 12-bit ADC with multiple external input sources as well as an internal battery measurement and temperature measurement possibility. ADC input voltage range is 0 to VDD.

5.5.1 Accessory functions of the ADC

In addition to the external ADC inputs an internal temperature sensor or internal supply voltage divider can be selected as the input to ADC.

Power supply range when using internal ADC functions is 2.4 to 3.6 VDC.

5.6 DAC

BT121 contains a 2-channel 12-bit DAC, with two independent outputs. DAC output voltage range is 0 to VDD.

Power supply range when using internal DAC functions is 2.4 to 3.6 VDC.

5.7 Real-time clock

BT121 contains a real-time clock (RTC) with full calendar support and sub-second resolution. The RTC can be used for periodic or specifically programmed wakeups. The RTC is clocked by an internal crystal oscillator which is always on as long as power is supplied to the module.

5.8 Microcontroller programming interface

The preferred method of programming the BT121 is by using the Bluegiga DFU through the UART host interface. A problem may occur if the DFU is disabled by disabling the UART or if the DFU is overwritten accidentally. Then the DFU would need to be re-uploaded.

The two methods of firmware upload are through the SWDIO/SWCLK interface (PA13 and PA14) using an ARM serial debug adapter, or by forcing the BOOT0 signal high and by resetting the module to make it boot into a recovery mode. Then the BGTool software can be used to recover the DFU through the UART interface.

6 Antenna

The internal chip antenna on the BT121 uses the application board ground plane as part of the antenna, and requires at least 20 mm of ground plane on both sides of the module to radiate with optimal efficiency. BT121 must be placed on the application board edge, preferably roughly in the middle of the board edge. The ground plane can be internal to the application PCB, allowing components to be placed on both sides of the module and on both sides of the application board. The module ground pads in the antenna end should be connected to the main ground plane layer with vias in immediate proximity of the pins. Thermal reliefs on the ground pins have a negligible effect on antenna performance. Typical antenna matching curves are shown in ***Figure 7*** below.

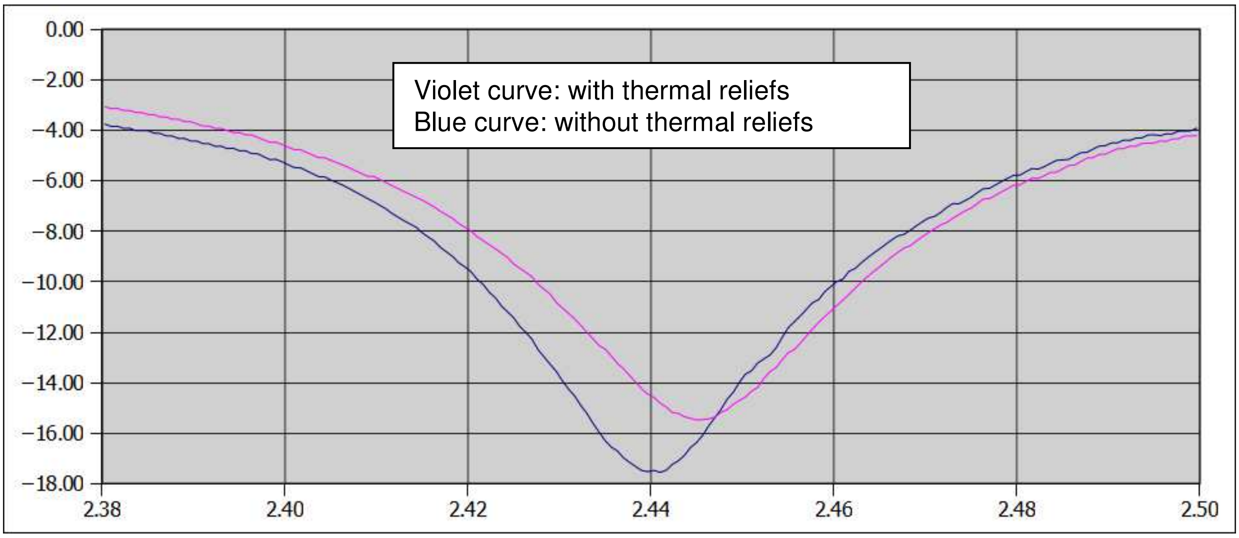


Figure 7 Typical antenna matching

The antenna used on the BT121 is quite robust with regard to adverse effects of close-by metallic materials. The PCB thickness will not affect the antenna operation significantly. The application board can be installed with the PCB bottom side and the antenna edge directly against a plastic casing without adverse effects. On the module top side, there should be at least 3 mm of clearance to the nearest object.

The antenna requires a 7.5 x 3.4 mm sized copper clearance in all layers, with no components or traces on the opposite side of the PCB from the antenna. Sufficient metal clearance is mandatory because the antenna will not function at all without a sufficient opening in the ground plane.

Any metal in close proximity of the antenna will prevent the antenna from radiating freely. It is recommended not to place any metal or other conductive objects closer than 10 mm to the antenna except in the directions of the application board ground planes.

A board cutout is not required for the antenna. In fact, a cutout would cause the antenna to be detuned which in turn will degrade range significantly. The module is also not to be placed in a cut-out recess on the board edge or in the middle of the board which has a central cutout.

On the following pages are examples on how plastic or metal sheets in several different orientations and distances to the antenna effect antenna matching.

6.1 Effect on antenna matching of a plastic sheet placed near the antenna

As an example on how a plastic sheet placed in the vicinity of the module and/or antenna effect the antenna matching we can examine ***Figure 8*** below.

Blue curve
Plastic sheet under antenna touching PCB

Violet curve
Plastic sheet against antenna at module end

Yellow curve
Plastic sheets under antenna touching PCB and against antenna at module end

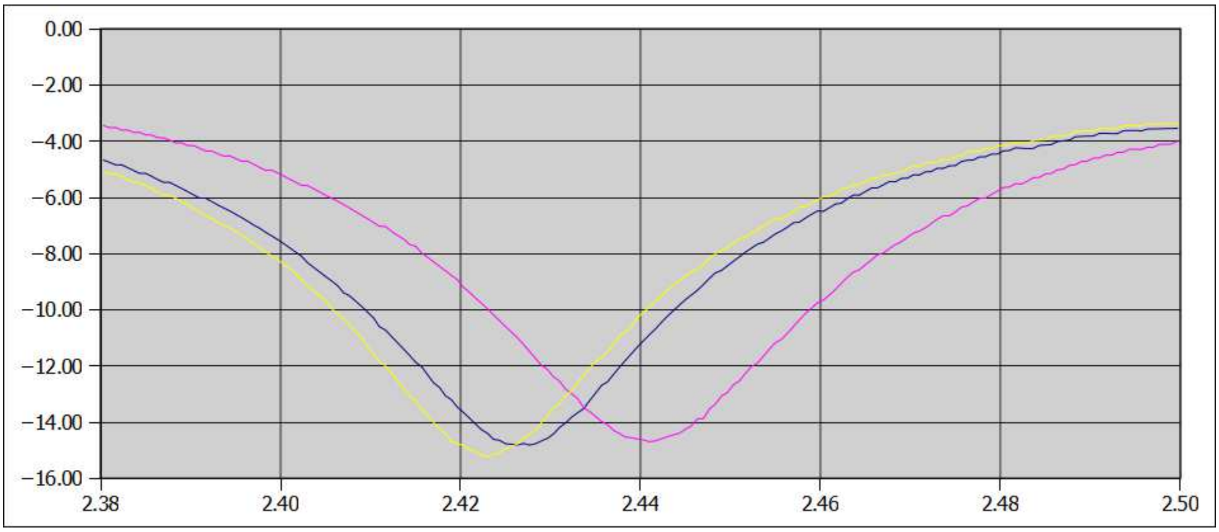
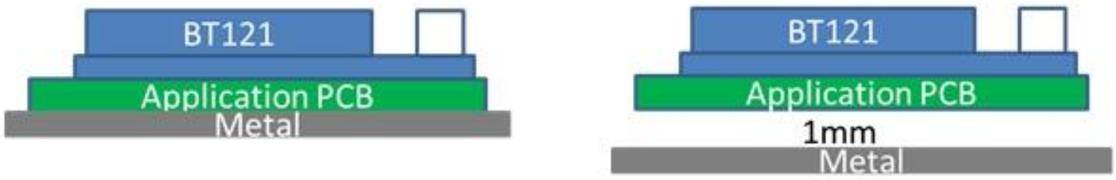


Figure 8 Proximity effect of a 3 mm plastic sheet on antenna matching with different placements

6.2 Effect on antenna matching of a metal sheet placed under the antenna

As an example on how a metal sheet placed in the vicinity of the module and/or antenna effect the antenna matching we can examine ***Figure 9*** below.



Violet curve
Metal sheet under antenna touching PCB

Blue curve
Same as on the left but distance is 1 mm

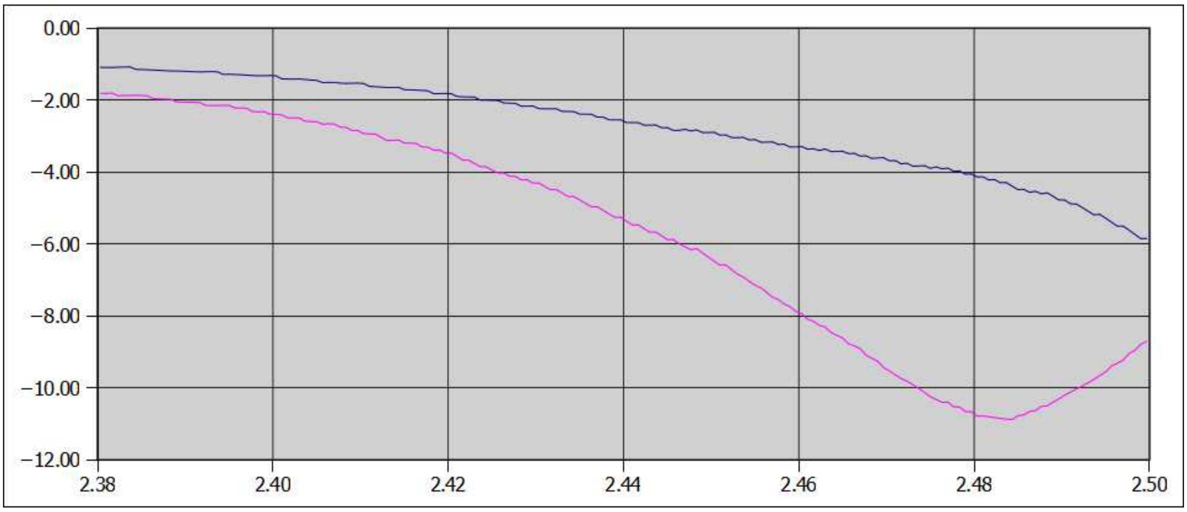
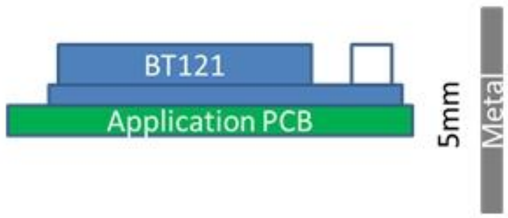


Figure 9 Effect of a metal sheet placed under the antenna on antenna matching

6.3 Effect on antenna matching of a metal sheet placed against the end of the module

As an example on how a metal sheet placed in the vicinity of the module and/or antenna effect the antenna matching we can examine ***Figure 10*** below.



Violet curve Metal sheet against end of module end	**Violet curve** Metal sheet at module end 5 mm distance

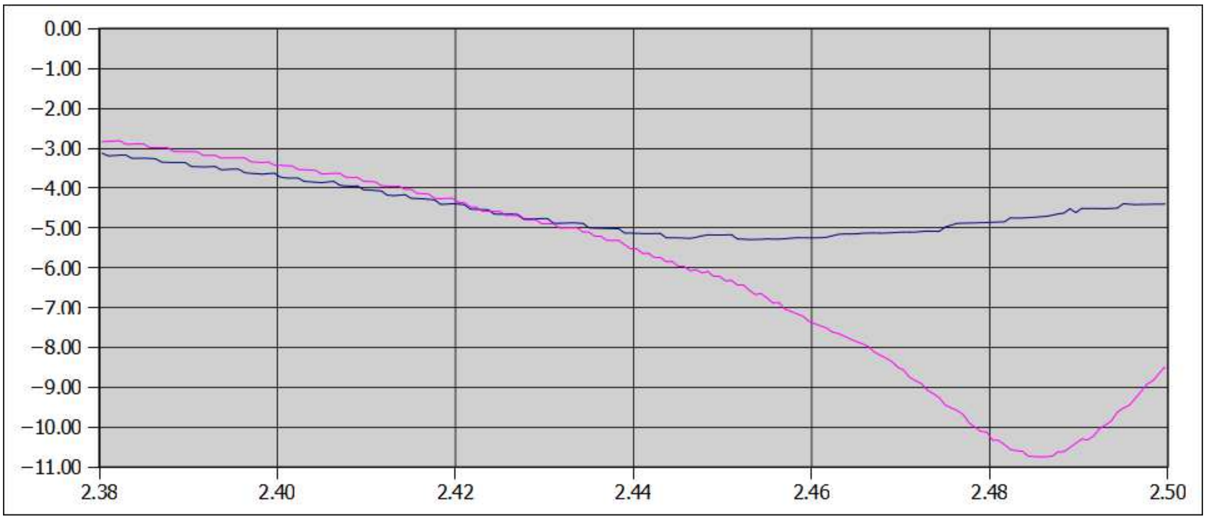


Figure 10 Effect of a metal sheet placed under the antenna on antenna matching

6.4 Measured antenna efficiency

The measured antenna efficiency as a function of frequency is shown in ***Figure 11*** below.

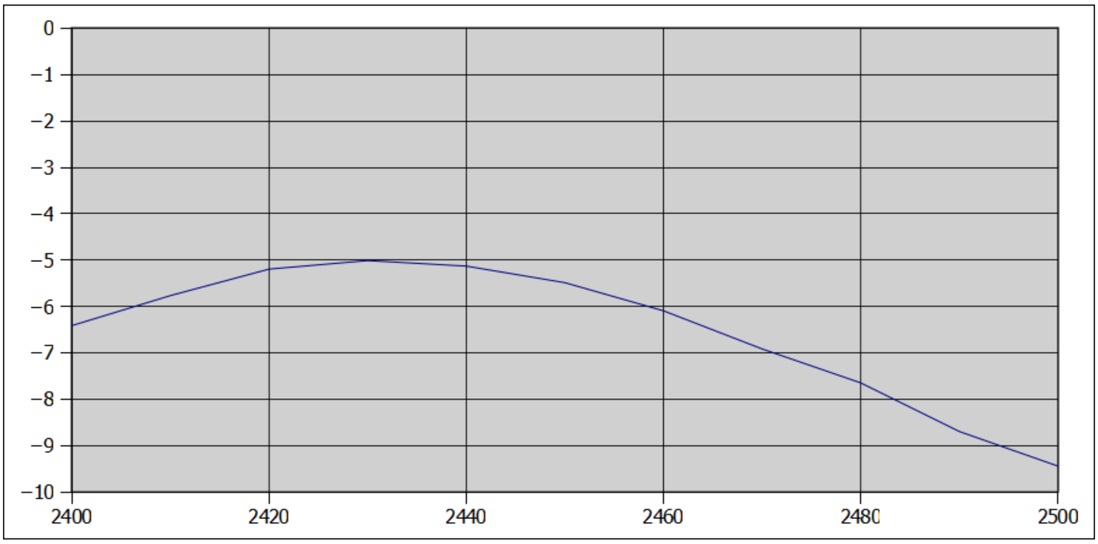


Figure 11 Antenna efficiency related to frequency

6.5 Measured 2D radiation patterns

Typical radiation patters of the BT121 module shown as 2D plots are shown below in ***Figure 12*** (view from module side), ***Figure 13*** (view from antenna end) and on the following page in ***Figure 14*** (view from above module).

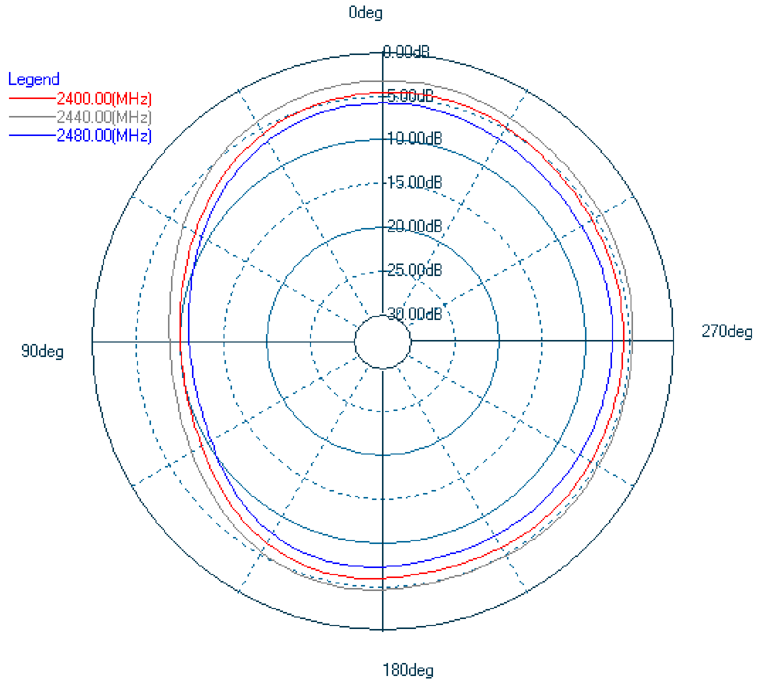


Figure 12 Typical 2D radiation pattern for BT121 with view from module side

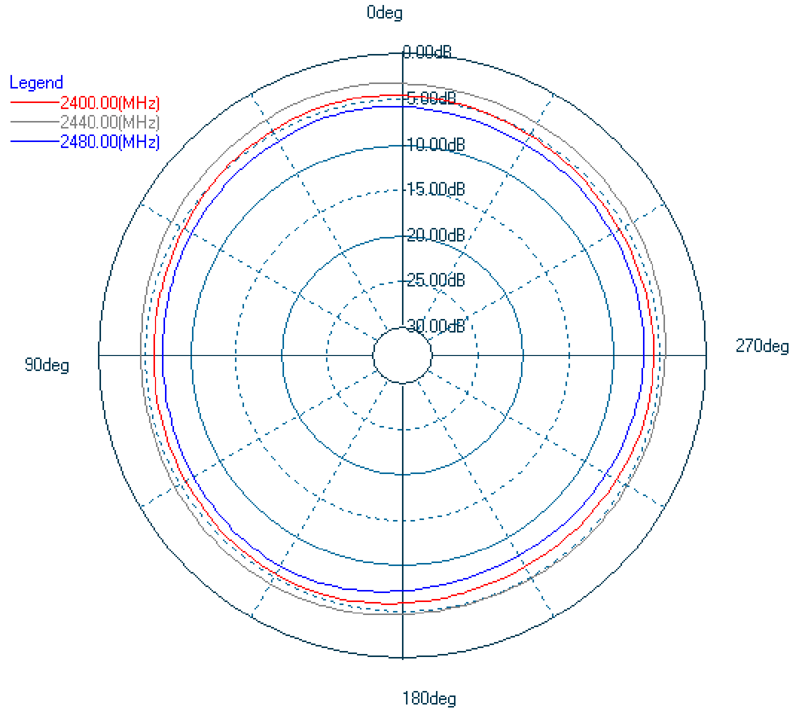


Figure 13 Typical 2D radiation pattern for BT121 with view from antenna end side

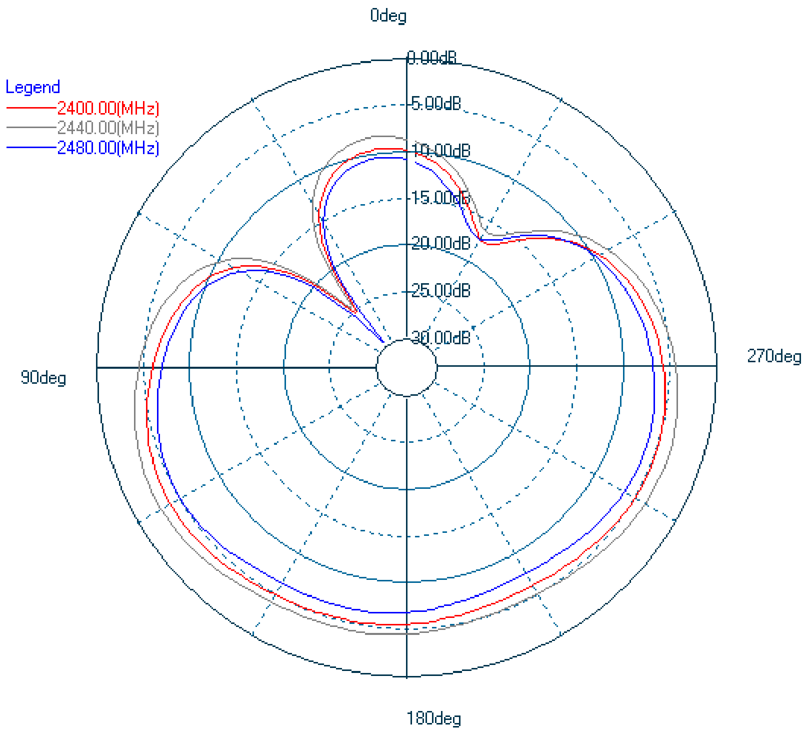


Figure 14 Typical 2D radiation pattern for BT121 with view from above module

6.6 Measured 3D radiation patterns

Typical radiation patters of the BT121 module shown as 3D plots are shown below. ***Figure 15*** represents a radiation pattern from module end side opposite to antenna and ***Figure 16*** from above the module.

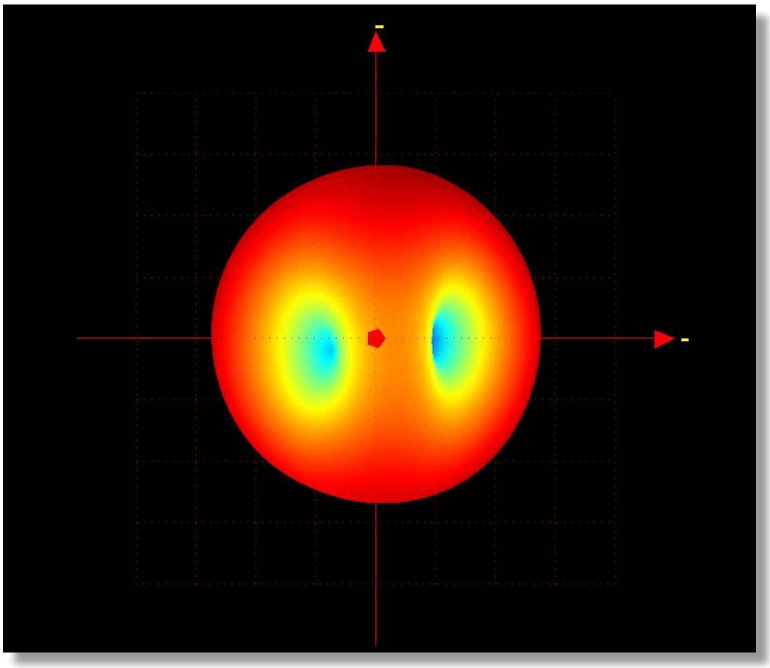


Figure 15 Typical 3D radiation pattern for BT121 with view from module end opposite to antenna

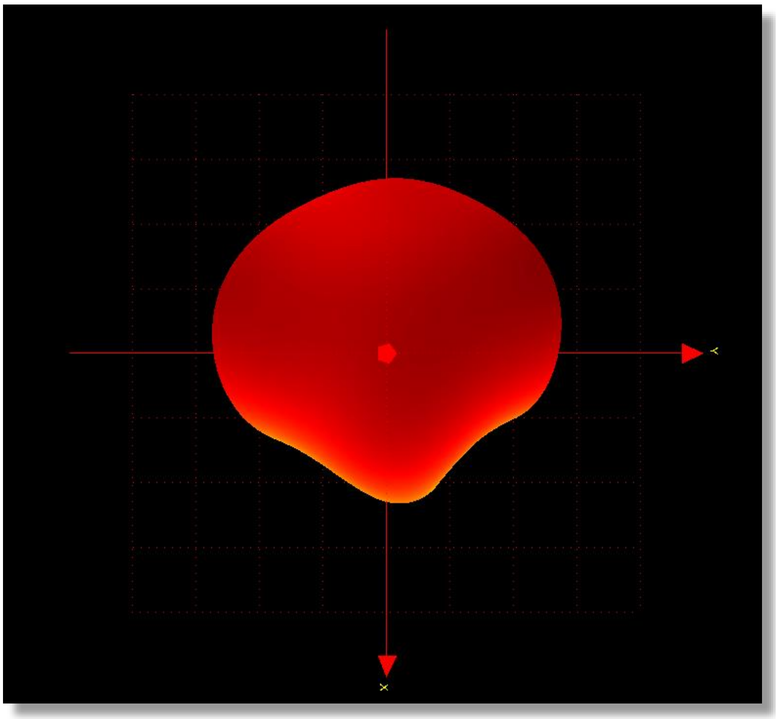


Figure 16 Typical 3D radiation pattern for BT121 with view from above the module

7 Bluetooth Stack Software

Bluegiga's *Bluetooth* Smart Ready Software is a complete *Bluetooth* Smart Ready software stack for BT121 *Bluetooth* Smart Ready module. The software implements a full *Bluetooth* BR/EDR and LE compatible *Bluetooth* Stack and L2CAP, RFCOMM, SMP and ATT protocols as well as *Bluetooth* SPP, Apple iAP2, GATT over BT profiles and any GATT based *Bluetooth* Smart profile.

The *Bluetooth* Smart Ready Software also is supported by a complete SDK for developing *Bluetooth* Smart Ready applications using either an external host or BGAPI™ serial protocol over UART or fully standalone applications based on a simple scripting language called BGScript™.

Several profiles and software project examples are offered as part of the *Bluetooth* Smart Ready SDK to help expedite the development of *Bluetooth* Smart Ready compatible end-user products.

The main parts of the Bluegiga Bluetooth Smart Ready software stack are shown below.

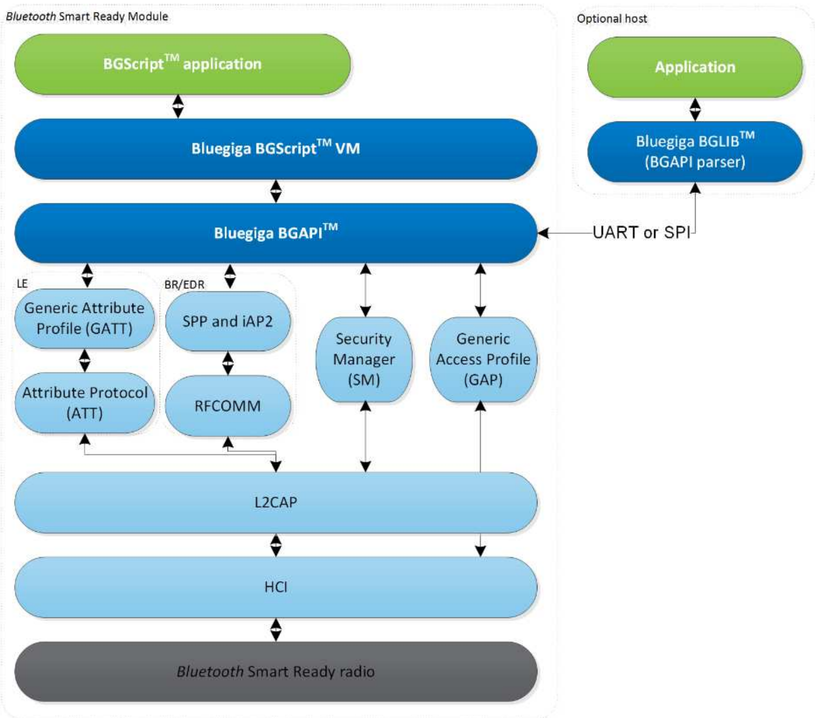


Figure 17 Bluegiga Bluetooth Smart Ready software stack

To learn more about the Bluetooth Smart Ready software stack, the SDK and the APIs please read ***Bluetooth Smart Ready Software Getting Started Guide.***