Mercury BT 5.2 module (Chip Antenna) Integration Guide

Contents

1 Document history

Date	*Author*	*Notes*
July 27, 2023	Alessandro Francesconi, PierGiorgio Peruzzi, Carli Davide	Revision 1.4
September 26, 2023	Alessandro Francesconi, PierGiorgio Peruzzi, Carli Davide	Revision 1.5 – Updated values for “Max TX Duty Cycle”
October 2, 2023	Alessandro Francesconi, PierGiorgio Peruzzi, Carli Davide	Revision 1.6 – Updated chapter “Host board hardware layout recommendations”
November 3, 2023	Alessandro Francesconi, PierGiorgio Peruzzi, Carli Davide	Revision 1.7 – Remove FCC IC/CE certification pending state and added Chapter 9 “Use instructions”

2 Introduction

Mercury is the codename of a family of Bluetooth 5.2 radio modules developed by Datalogic.

Some features:

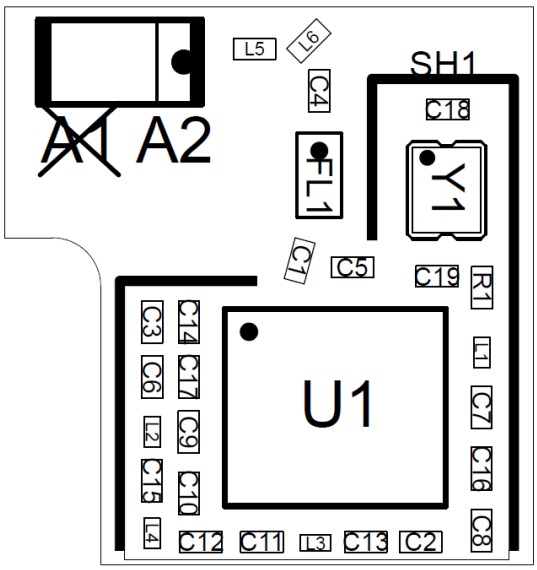
1. Bluetooth Core Specification v5.2
2. Fully integrated Smart Ready module up to HCI layer
3. Based on a Cypress CYW20706 silicon device, includes onboard crystal oscillator and passive components
4. Integrated power amplifier to achieve Class I or Class II output power capability
5. Low power mode support
6. Dual supply voltage for low level logic interface
7. HCI (H4) Serial communications interface through UART
8. Two-wire or three-wire coexistence interface
9. LGA solder pad connections for ease-of-use
10. Working temperature range : –30 °C to +85 °C

2.1 Reference Coding

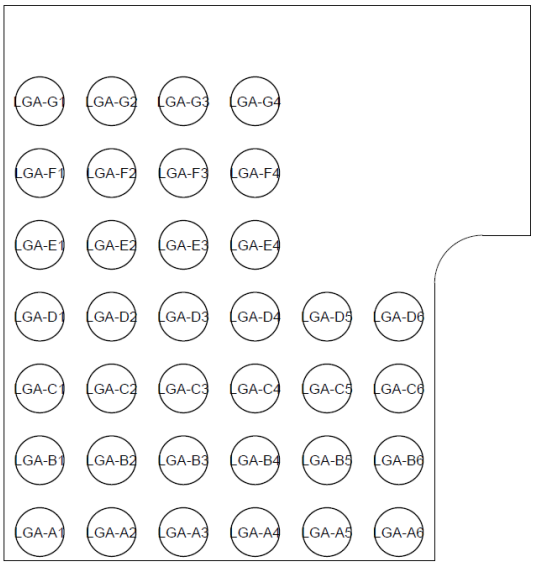
Material Code	6660200xx
Board description	PCBA-0929 MERCURY,MOD,BT5.X,LGA,ANT,CY06
PCB Code	10060200x
Release date	May 15, 2023
Antenna	On-board (chip antenna).

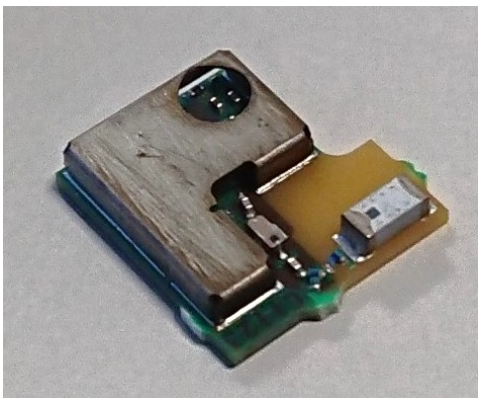
2.2 Module layout

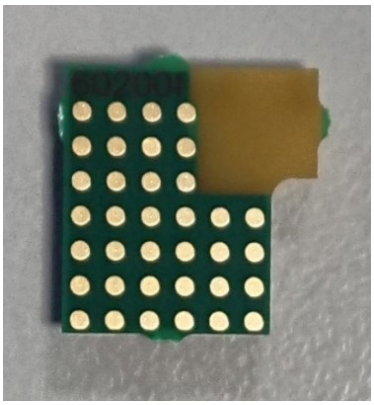
Top view



Bottom view

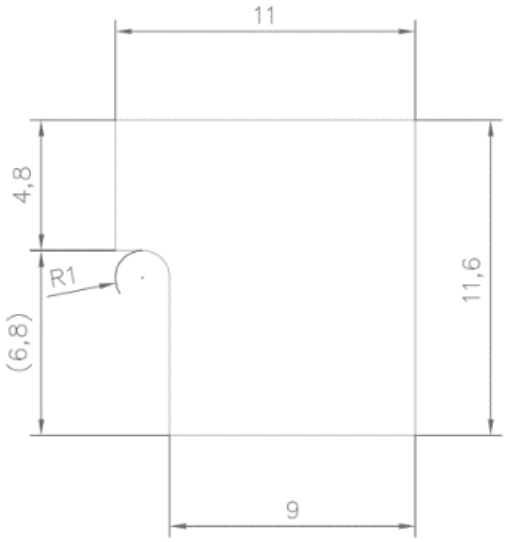




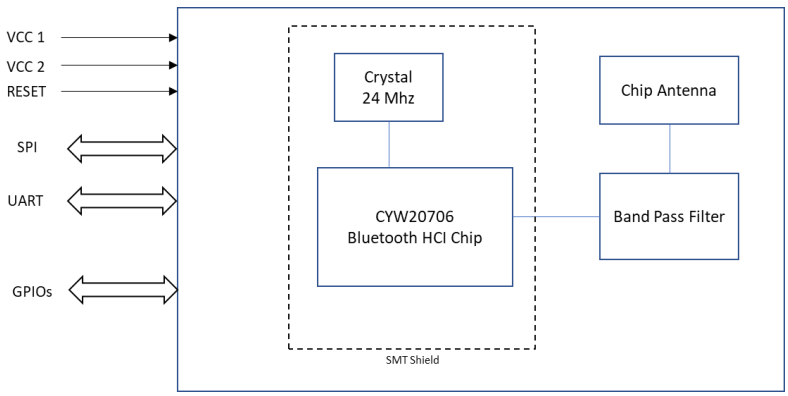


2.3 Module size

Dimensions in mm.



2.4 Block diagram



3 Radio characteristics

The Mercury radio module operates in the ISM frequency band from 2400 MHz to 2483,5 MHz using the Bluetooth® wireless technology.

The Mercury radio module can operate in one of the following 2 modes: Bluetooth Classic or Bluetooth Low Energy. The operating mode is selected by the host system through a configuration message that must be sent to the Mercury module after its power up. It is not possible to configure the module to use both wireless technologies at the same time.

When the selected operating mode is Bluetooth Classic:

- the radio module supports the following modulation modes: Basic Rate (BR) and Enhanced Data Rate (EDR);
- the radio module can be configured to operate according to one of the following three BR/EDR transmitter output power classes:
  - BR/EDR Power Class 1
  - BR/EDR Power Class 2
  - BR/EDR Power Class 3

When the selected operating mode is Bluetooth Low Energy:

- the radio module supports a single modulation mode: Low Energy (LE);
- the radio module can be configured to operate according to one of the following three LE PHY transmitter output power classes:
  - LE PHY Power Class 1.5
  - LE PHY Power Class 2
  - LE PHY Power Class 3

The table below summarizes the characteristics of these operating modes and modulation modes. Please refer to document [1] for further details on these operating modes and modulation modes.

Operating mode	Bluetooth Classic			Bluetooth Low Energy
Modulation mode	Basic Rate (BR)	Enhanced Data Rate (EDR)		Low Energy (LE)
Modulation	GFSK	π/4-DQPSK	8DPSK	GFSK
Gross air data rate	1 Mbps	2 Mbps	3 Mbps	1 Mbps
RF channels	N. 79 channels: f=2402+k MHz, where k=0,…,78			N. 40 channels: f=2402+k*2 MHz, where k=0, … ,39
Max. TX duty cycle	83.3%			84.5%

For all operating modes and modulation modes, over all channels in the ISM frequency band from 2400 MHz to 2483,5 MHz, the maximum RF transmit power measured at the antenna is:

- Class 1: +8,5 dBm +/- 1,5 dBm
- Class 2: -1,5 dBm +/- 1,5 dBm
- Class 3: -16,0 dBm +/- 1,5 dBm

The radio module is uniquely intended to be integrated inside a host product, and to operate from inside the host product. The host product is required to make the radio assembly not accessible by end user of the host product, and to not let the user replace the antenna that belongs to this assembly. This guarantees the radio assembly compliance with FCC Rule 47 CFR 15.203 “Antenna requirements”.

4 Specifications

Table 1. Absolute Maximum Ratings

Parameter	Specification			Units
	Minimum	Nominal	Maximum	
Ambient temperature of operation	–30	25	85	°C
Storage temperature	–40	–	150	°C
VCC_3V3	–0.5	–	3.795	V
VCC_DIGITAL	–0.5	–	3.795	V
VCC_OTP	–0.5	–	3.795	V

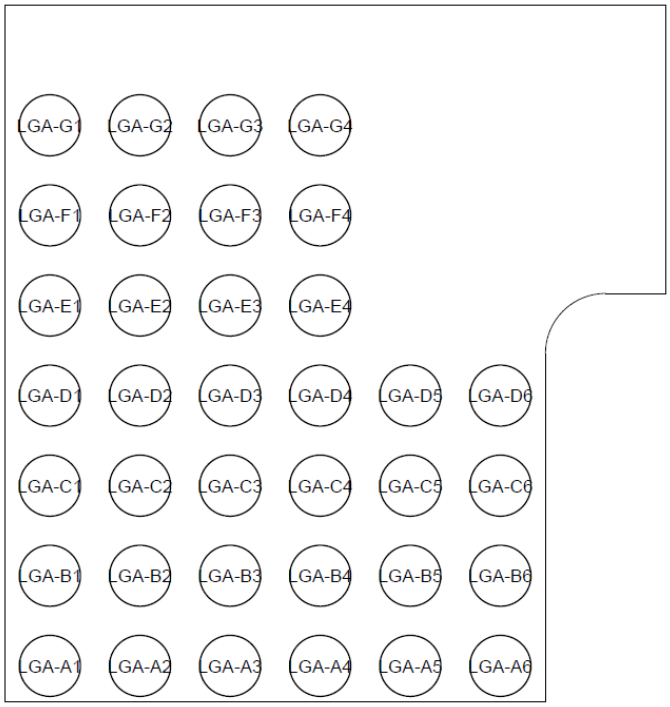
Table 1. Power Supply Specifications

Parameter	Min.	Typ.	Max.	Units
VCC_3V3	3,00	3,30	3,60	V
VCC_DIGITAL	1,62	3,30	3,60	V
VCC_OTP	3,00	3,30	3,60	V

5 Host interface

5.1 Pin layout

Land Grid Array (LGA) Package - bottom view



5.2 Pin Functions

No	Name	Dir (1.)	Function
A1	GND		Ground power supply rail.
A2	UART CTS	IN VCC_DIGITAL	HCI UART CTS flow control signal. This pin shall be connected to the host microprocessor, see requirements in the next section.
A3	GND		Ground power supply rail.
A4	VCC_DIGITAL	PS	Digital and I/O power supply voltage. Typ 3,3 Vdc; Range [1,62 ... 3,6] Vdc. Must be powered with a lower or equal voltage than the pin VCC_3V3 (A5). In case of single supply voltage it must be kept connected to pin A5, only in case of low voltage logics interface this pin can be powered separately.
A5	VCC_3V3	PS	Rf Amplifier powers supply voltage Typ 3,3 Vdc; range [3.0 ... 3.6 Vdc]
A6	GND		Ground power supply rail.
B1	UART_RXD	IN VCC_DIGITAL	HCI UART RX data signal. This pin shall be connected to the host microprocessor, see requirements in the next section.

B2	UART_TXD	OUT VCC_DIGITAL	HCI UART TX data signal. This pin shall be connected to the host microprocessor, see requirements in the next section.
B3	UART_RTS	OUT VCC_DIGITAL	HCI UART RTS flow control signal. This pin shall be connected to the host microprocessor, see requirements in the next section.
B4	OTP_EN	IN VCC_OTP	OTP Enable – On board One Time Programable Memory enable pin. If OTP is used pull this pin high else pull this pin low.
B5	VCC_OTP	PS	OTP Supply Voltage. Typ : 3.3 Vdc; range [3.0 to 3.6 Vdc] . Do not connect if OTP is not used.
B6	BTCLK_REQ	OUT VCC_DIGITAL	Shared clock applications – do not connect
C1	SPI_MOSI	OUT VCC_DIGITAL	SPI MOSI signal of the programming interface of the Bluetooth chip. Do not connect to the microprocessor of the host system.
C2	SPI_CLK	OUT VCC_DIGITAL	SPI CLOCK signal of the programming interface of the Bluetooth chip. Do not connect to the microprocessor of the host system.
C3	VDDC_TP	TST	Internal voltage for test only - Core logic supply, typ 1,2 Vdc Keep this pin disconnected.
C4	BT_HOST_WAKE	OUT VCC_DIGITAL	HOST_WAKE – Out of band low power control signal Mercury asserts this line when has data for Host.
C5	BT_DEV_WAKE	IN VCC_DIGITAL	DEVICE_WAKE – Out of band low power control signal Host asserts the line when has data for Mercury
C6	iBtPri PCM_CLK	OUT VCC_DIGITAL	3-Wire Coexistence support for Bluetooth Priority/Status Request or PCM_CLK
D1	SPI_MISO	IN VCC_DIGITAL	SPI MISO signal of the programming interface of the Bluetooth chip. Do not connect to the microprocessor of the host system.
D2	SPI_CS#	OUT VCC_DIGITAL	SPI CHIP SELECT# signal of the programming interface of the Bluetooth chip. Do not connect to the microprocessor of the host system.
D3	JTAG_SEL	IN	ARM JTAG debug mode control. Connect to GND for all applications
D4	GND		Ground power supply rail.
D5	BT_VDD1	TST	Internal voltage for test only - Radio RF/IF supply, typ 1,2 Vdc Keep this pin disconnected.
D6	GND		Ground power supply rail.
E1	GND		Ground power supply rail.
E2	GCI_SECI_IN GPIO_6	IN VCC_DIGITAL	GCI_SECI _IN - Proprietary Global Coexistence Interface (GCI) between Cypress BT and Cypress WLAN.
E3	RESET#	IN VCC_DIGITAL	Active-low reset input This pin shall be connected to the host microprocessor.
E4	GND		Ground power supply rail.
F1	GCI_SECI_OUT GPIO_7	OUT	GCI_SECI _OUT - Proprietary Global Coexistence Interface (GCI) between Cypress BT and Cypress WLAN.
F2	oWlanAct PCM_IN	IN VCC_DIGITAL	3-Wire Coexistence support for Wireless Lan Activity Input or PCM_IN

F3	PCM_OUT	IN/OUT VCC_DIGITAL	I2S_DO/PCM_OUT. Do not connect.
F4	VDD_INT	TST	Internal voltage for test only - Radio PA supply, typ 2,65 Vdc Keep this pin disconnected.
G1	GND		Ground power supply rail.
G2	iBtAct PCM_SYNC	OUT VCC_DIGITAL	3-Wire Coexistence support for Bluetooth Activity Request or PCM_SYNC
G3	GND		Ground power supply rail.
G4	GND		Ground power supply rail.

Note 1 : IN means input pin; OUT means output pin; TST means pin is used for test only; PS means power supply pins. In small characters are reported the power supply domains.
Note 2 : The Mercury BT module fw cannot interact with an Apple authentication coprocessor.

5.3 Host Controller Interface (HCI)

The Mercury module incorporates a UART interface dedicated to the HCI transport layer.
This HCI interface transports commands, events, ACL, and synchronous data between the Bluetooth device, and it is host using HCI data packets.
The UART module supports H4 (4-wires) protocol.
This communication channel is bidirectional and full-duplex.

5.4 Bluetooth Sleep Mode

Addition to the Bluetooth low-power operation (sniff/hold/park), a low power sleep mode with out-of-band control signals has been added to assist the Bluetooth module and the Host in achieving further lower power consumption by allowing each side suspend independently.

Control pins are :

BT_DEV_WAKE (input pin for Mercury)
→Host asserts the line when has data for Mercury module

BT_HOST_WAKE (output pin for Mercury)
→Mercury module asserts the line when has data for Host

6 Requirements

1. Power Supply voltage range option 1 – standard :
   Power supply pins VCC_3V3 an VCC_DIGITAL : from 3,0 V to 3,6 Vdc. Typical supply voltage is 3,3 Vdc.

2. Power Supply voltage range option 2 – for low voltage logic interface :
   Power supply pin VCC_3V3 : from 3,0 V to 3,6 Vdc. Typical supply voltage is 3,3 Vdc.
   Power supply pin VCC_DIGITAL : from 1,7 V to 1,9 Vdc. Typical supply voltage is 1,8 Vdc.

3. All pins shall be connected to dedicated test point pads on the host board, even if they are not connected to anything else on the host board.

4. Pins RX_DATA, TX_DATA, UART_CTS and UART_RTS shall be connected to a full (4-wire) UART peripheral onboard the microprocessor of the host system. This allows to take advantage of hardware flow control and to reach the highest data rate supported by the radio module.

5. The BT_HOST_WAKE pin shall be connected to the host microprocessor to trigger an interrupt able to wake-up the host from deep-sleep states (e.g. with the main clock stopped). This enables the host microprocessor to enter deep-sleep states whenever possible, and to be woken up by the radio module whenever a new packet is received or a new relevant radio event must be processed.

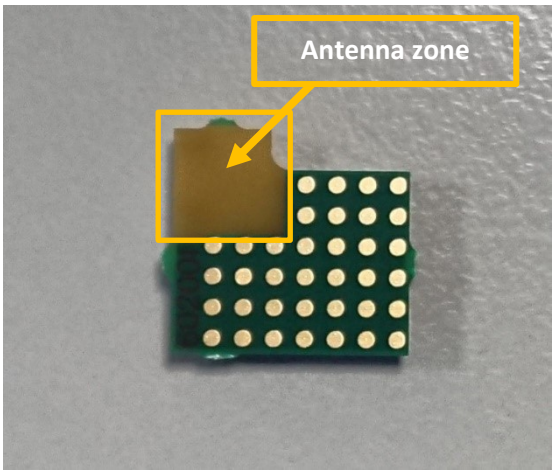
6. The BT_DEV_WAKE pin shall be connected to the Mercury module to trigger internally an interrupt able to wake-up the module from deep-sleep states. This enables the Mercury module to enter in deep-sleep state whenever possible, and to be woken up by the host whenever a new relevant radio event must be processed.

7. In the buried layer just under the BT Module put a ground plane as big as the whole pcb and connect it to all the Ground pins of Mercury module. Add as many vias as possible.

8. As close as possible to the supply pins VCC_3V3 an VCC_DIGITAL put strong bypass capacitors, connected directly to the supply pins and to the Ground pins around them. No vias shall be used within the capacitors and the LGA pad of the module. Put as many vias as possible between the Gound supply pins and the first buried Ground plane.

7 Host board hardware layout recommendations

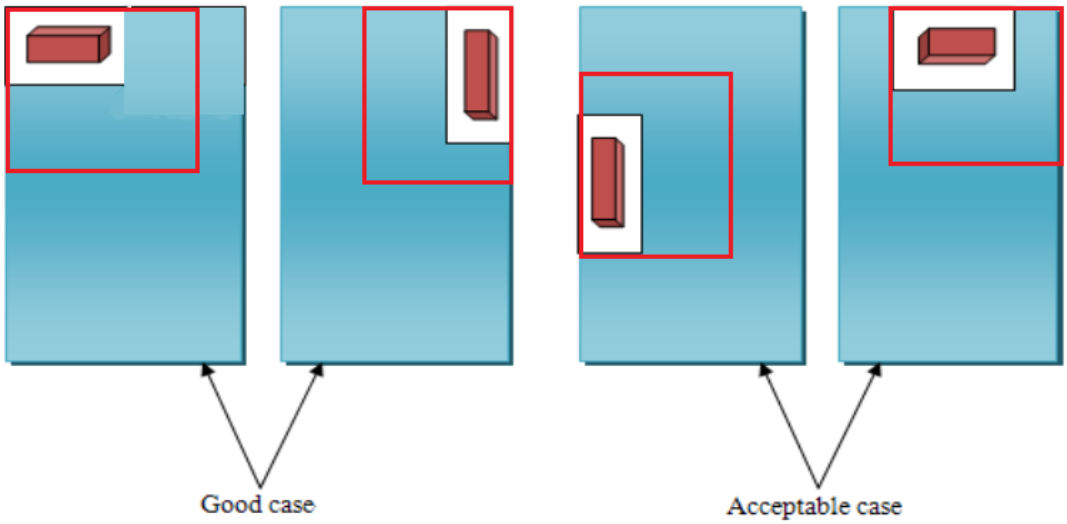
To let the Mercury BT 5.2 Chip Antenna radio module achieve the best RF performance once integrated on the host electronic board, it is strongly advised to follow the recommendations listed below during the design of the host board.



The placement of the Mercury module is very important :

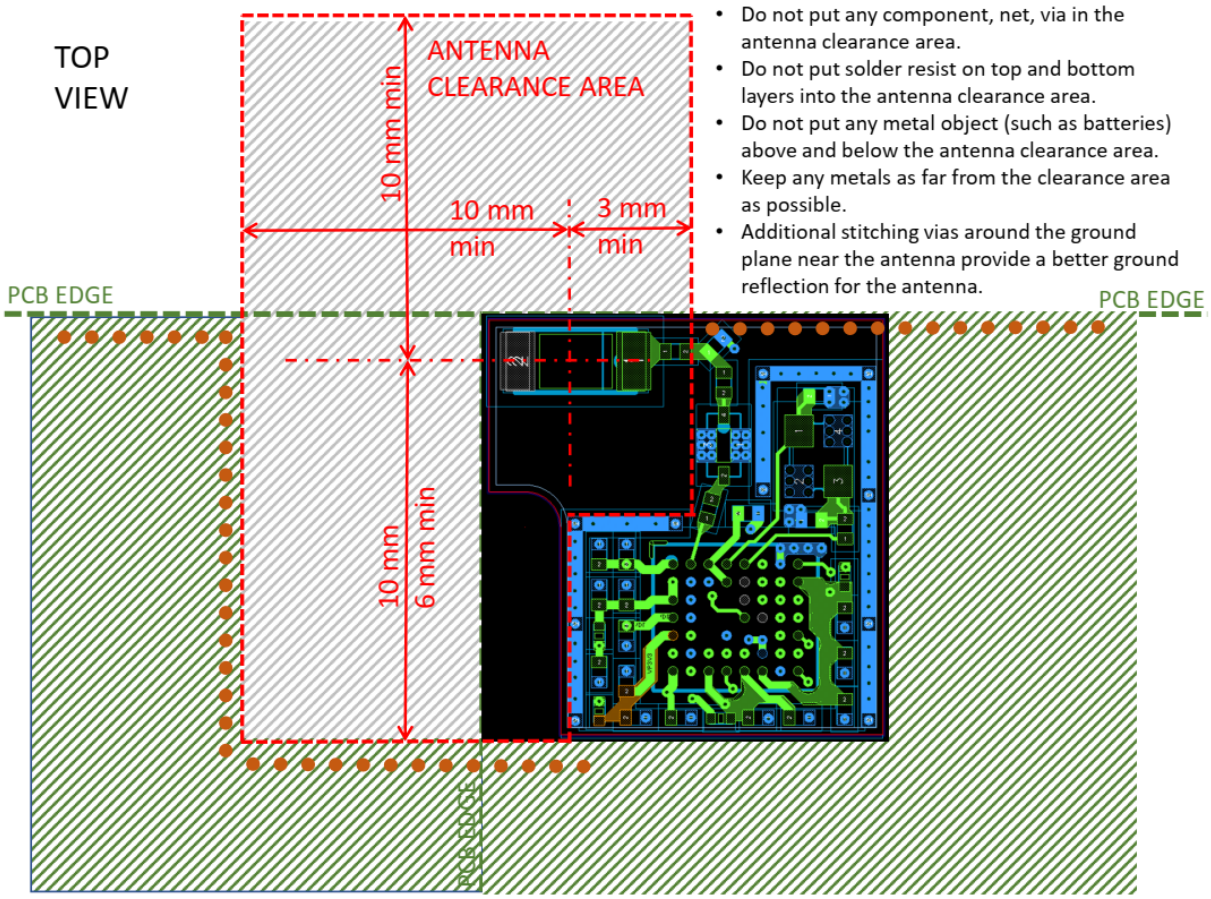
- Position of the module on the border of the pcb with the antenna parallel to the edge.
  The better solution is positioning the module on the corner.

  Allowed placement are the follows :



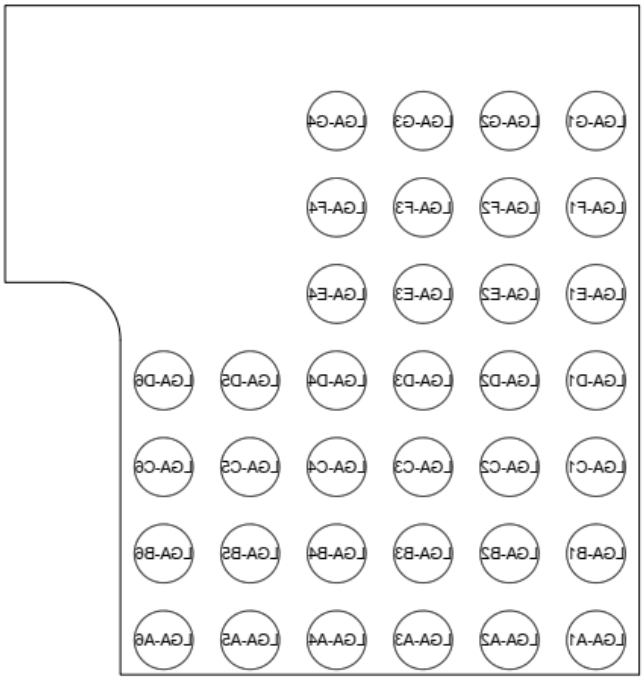
- The top layer of the host board should have a solid copper to be connected to the GROUND in the area beneath the “non-Antenna zone” of the radio module (shown in the picture above), without any signal routed in this area on the top layer.

- The module shall have a free area around and below the antenna.
  In the whole area beneath the "Antenna zone" of the radio module (shown in the picture above), all the layers of the host board shall be free of components, copper and solder resist elements.
  The free reserved area around the antenna (in red) shall follow the minimum measures of below.
  It is strongly recommended to increase the free area in the direction of the orange arrows.



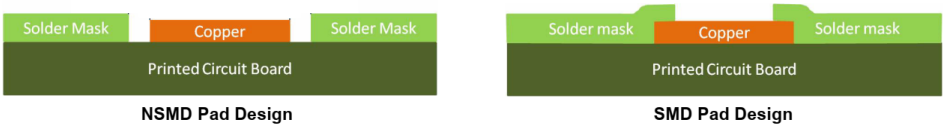
8 Fooprint

Land Grid Array (LGA) Package – top view



Pad Surface Finishes : Almost all PCB finishes are compatible with LGAs including Hot Air Solder Leveled (HASL), Organic Solderability Protectant (OSP), Electroless Nickel Immersion Gold (ENIG), Immersion Sn, and Immersion Ag. Datalogic suggests the PCB surface finish shelf life be monitored to ensure the life has not "expired". Surfaces should always be free of dirt and other contaminants before PCB assembly.

Solder Mask Layer : It is suggested to use Non-solder Mask Defined (NSMD) PCB pad designs, which typically provides better thermal fatigue life. Some field use conditions may require the use of Solder Mask Defined (SMD) pads for better drop/shock survivability. The difference between NSMD and SMD is shown in Figure below :



NSMD Pad Design **SMD Pad Design**

NSMD and SMD Pad Designs The NSMD solder mask opening diameter is suggested to be 0.125 mm larger than the solderable area (i.e. Cu diameter). However, it is critical to understand the PCB fabrication capabilities of PCB suppliers. Also, finer BGA pitches may require.

9 Use instructions

Section	Comment
2.2 List of applicable FCC rules	This module has been assessed against the following FCC rule parts: CFR 47 FCC Part 15 C (15.247, DTS and DSS)
2.3 Summarize the specific operational use conditions	The host device integrating the module cannot be operated on aircrafts. Module shall be integrated as per this guide and not modified.
2.4 Limited module procedures	N.A.
2.5 Trace antenna designs	N.A.
2.6 Rf Exposure considerations	This device meets the SAR exemption threshold listed in KDB 447498 and is authorized for portable and mobile operation. Co-location of this module with other transmitters that operate simultaneously are required to be evaluated using the FCC multi-transmitters procedures.
2.7 Antennas	The module has a permanently attached antenna.
2.8 Label and compliance information	The host integrators must ensure that FCC labelling requirements are met. This includes a clearly visible label on the “end product” enclosure or e-label stating "Contains FCC ID: U4FBT-MRY-A1"
2.9 Information on test modes and additional testing requirements	N.A.
2.10 Additional testing, Part 15 Subpart B disclaimer **2.11 Note EMI considerations** **2.12 How to make changes**	This modular transmitter is only FCC authorized for the specific rule parts (47CFR Part 15.247) listed on the grant, and the host product manufacturer is responsible for compliance with any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. The host manufacturer is strongly recommended to confirm compliance with FCC/ISED requirements for the transmitter when the module is installed in the host. This module is a stand-alone modular. If the end product will involve the Multiple simultaneously transmitting condition or different operational conditions for a stand-alone modular transmitter in a host, the host manufacturer has to consult with the module manufacturer for the installation method in the end system. Host manufacturer is recommended to use D 04 Module iIntegration Guide. The final host product may also need to be evaluated against FCC rules part 15 Subpart B (criteria for unintentional radiators) in order to be properly authorized for operation as part 15B – digital device.

10 References

[1] Bluetooth SIG, «Bluetooth Core Specification Version 4.1,» 03 December 2013. [Online]. Available: hiips://www.bluetooth.com/specifications/adopted -specifications.