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Approval Sheet

(產品承認書)

產品名稱 (Product) Bluetooth Low Energy Module

產品型號 (Model No.) **MDBT53** (Chip Antenna)

MDBT53 – P (PCB Antenna)

MDBT53 – U (u.FL Connector)

Index

1. Overall Introduction

Raytac's MDBT53 & MDBT53-P is a BT 5.2 stack (Bluetooth low energy or BLE) module designed based on **Nordic nRF5340 SoC solution**, which incorporates: **GPIO**, **SPI**, **UART**, **TWI**, **I2S, PDM, PWM, ADC**, **NFC** and **USB** interfaces for connecting peripherals and sensors.

Features:

1. Embedded 2.4GHz transceiver supports Bluetooth 5.2 (Bluetooth), IEEE 802.15.4 (THREAD & Zigbee) & 2.4Ghz RF & ANT+ upon customer's preference.
2. Compact size with **(L) 14.3 x (W) 9.3 x (H) 1.85 or 1.6 mm**.
3. Low power requirements, ultra-low peak, average and idle mode power consumption.
4. Be compatible with a large installed base of mobile phones, tablets and computers.
5. Fully coverage of BLE software stack.
6. BLE & RF transmission switching helps products fit all operation system and most hardware.

1.1. Application

- Advanced computer peripherals and I/o devices
  - Multi-touch trackpad
- Advanced wearables
  - Health / fitness sensor and monitor devices
  - Wireless payment enabled devices.
- Wireless audio devices
  - Bluetooth Low Energy Audio
  - True wireless earbuds
  - Headphones, microphones and speakers
- Internet of Things (IoT)
  - Smart home sensors and controllers
  - Industrial IoT sensors and controllers
- Interactive entertainment devices
  - Remote controls
  - Gaming controllers
- Professional Lighting
  - Wireless connected luminaire

1.2. Features

- Supply voltage range 1.7V to 5.5V
- 1.8 V to 3.3 V regulated supply for external components
- Single 32 MHz crystal operation
- 48 general purpose I/O pins
- Operating temperature from -40 to +105°C

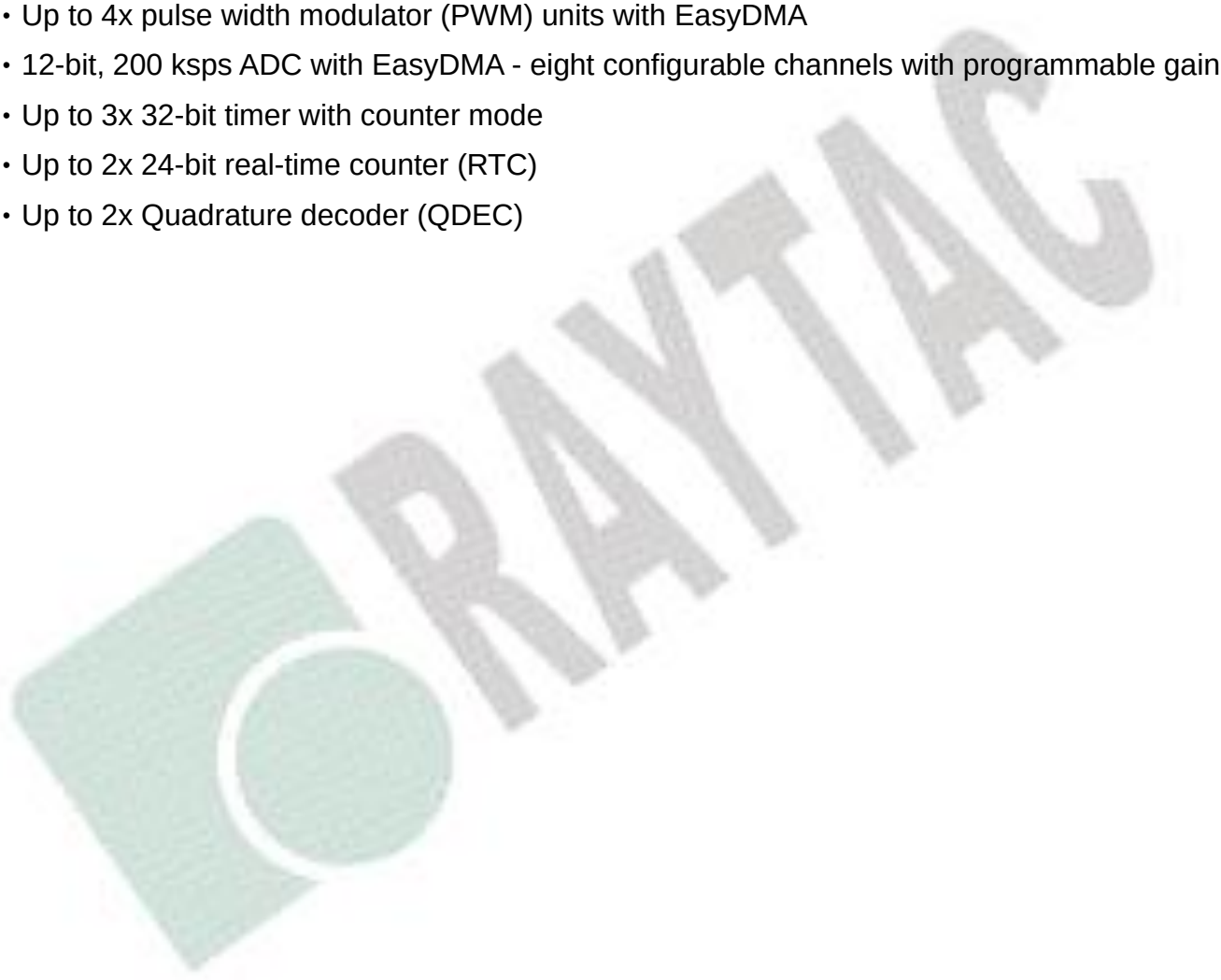
Network Core

- ARM® Cortex®-M33 with TrustZone® technology
- 64 MHz operation
- 256 kB flash
- 64 kB low leakage RAM
- Bluetooth® 5.2, IEEE 802.15.4-2006, 2.4 GHz transceiver
    - -98 dBm sensitivity in 1 Mbps Bluetooth Low Energy mode
    - -104 dBm sensitivity in 125 kbps Bluetooth Low Energy mode (long range)
    - -101 dBm sensitivity in IEEE 802.15.4
    - -20 to +3 dBm configurable TX power
- On-air compatible with nRF52, nRF51, nRF24L, and nRF24AP Series
- Supported data rates:
    - Bluetooth 5.2 - 2 Mbps, 1 Mbps, 500 kbps, and 125 kbps
    - IEEE 802.15.4-2006 - 250 kbps
    - Proprietary 2.4 GHz - 2 Mbps, 1 Mbps
- Angle of Arrival (AoA) and Angle of Departure (AoD) direction finding
- 128-bit AES/ECB/CCM/AAR co-processor (on-the-fly packet encryption)
- SPI master/slave with EasyDMA
- I2C compatible two-wire master/slave with EasyDMA
- UART (CTS/RTS) with EasyDMA
- Up to 3x 32-bit timer with counter mode
- Up to 2x real-time counter (RTC)

Application Core

- ARM® Cortex®-M33 with TrustZone® technology
- 128 MHz or 64 MHz operation
- Single-precision floating-point unit (FPU)
- Digital signal processing (DSP) instructions
- 1 MB flash and 512 kB low leakage RAM

- ARM TrustZone CryptoCell™-312 security subsystem
- USB 2.0 full speed (12Mbps) controller
- QSPI peripheral for communicating with an external flash memory device
- Near field communication (NFC-A) tag with wake-on field
- Up to 5x SPI master/slave with EasyDMA
- Up to 4x I2C compatible two-wire master/slave with EasyDMA
- Up to 4x UART (CTS/RTS) with EasyDMA
- Audio peripherals: I2S, digital microphone interface (PDM)
- Up to 4x pulse width modulator (PWM) units with EasyDMA
- 12-bit, 200 ksps ADC with EasyDMA - eight configurable channels with programmable gain
- Up to 3x 32-bit timer with counter mode
- Up to 2x 24-bit real-time counter (RTC)
- Up to 2x Quadrature decoder (QDEC)

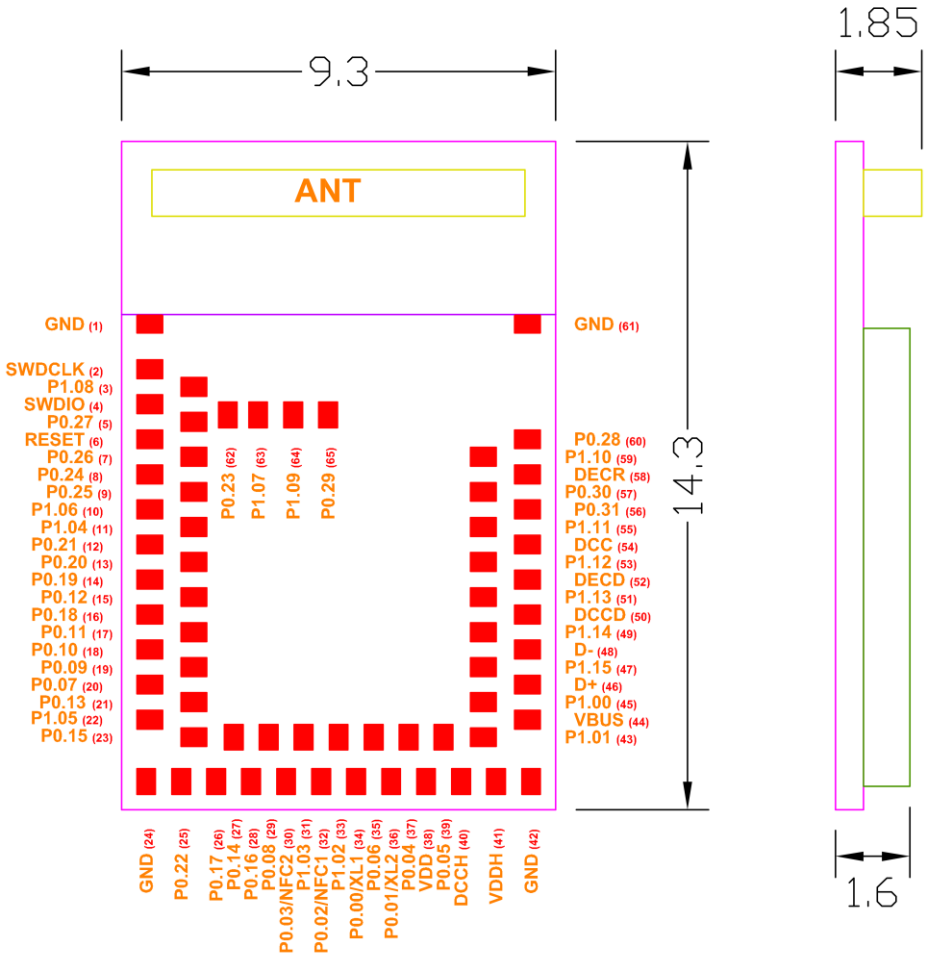


2. Product Dimension

2.1. PCB Dimensions & Pin Indication

- **MDBT53**

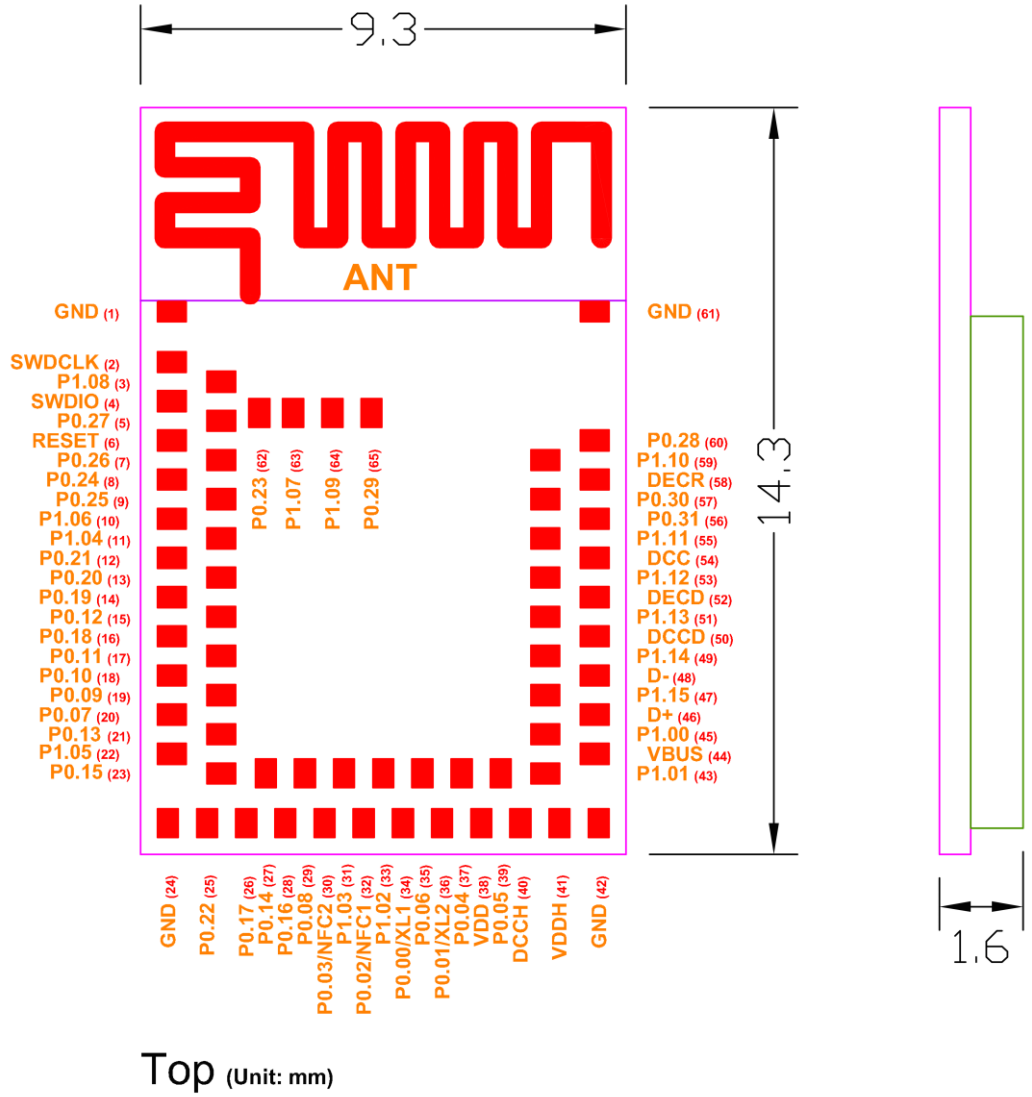
PCB Size (in mm)			
	Min.	Norm	MAX.
L		14.3	
W	- 0.15	9.3	+ 0.2
H		1.85	



Top (Unit: mm)

• MDBT53-P

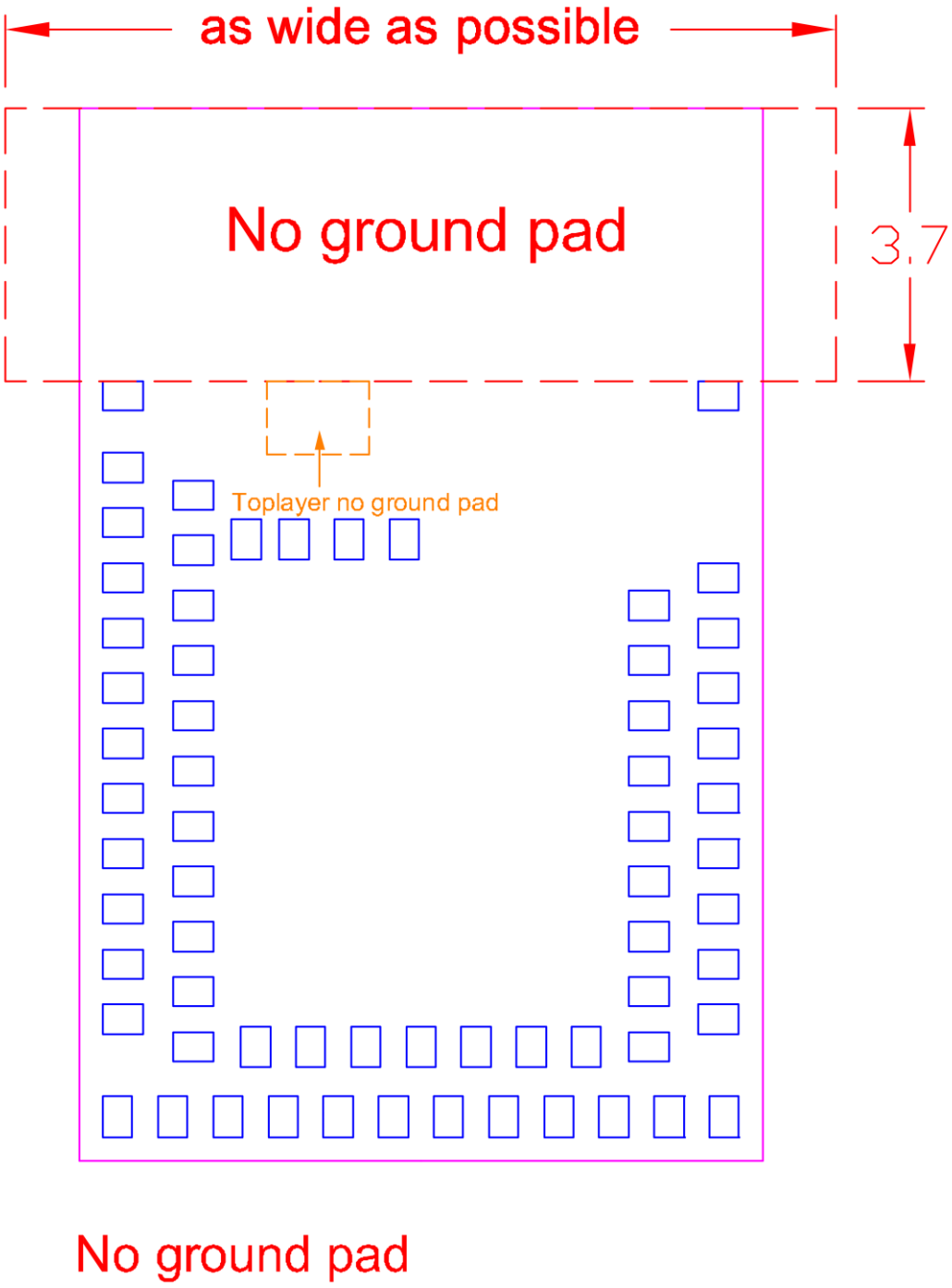
PCB Size (in mm)			
	Min.	Norm	MAX.
L		14.3	
W	- 0.15	9.3	+ 0.2
H		1.6	

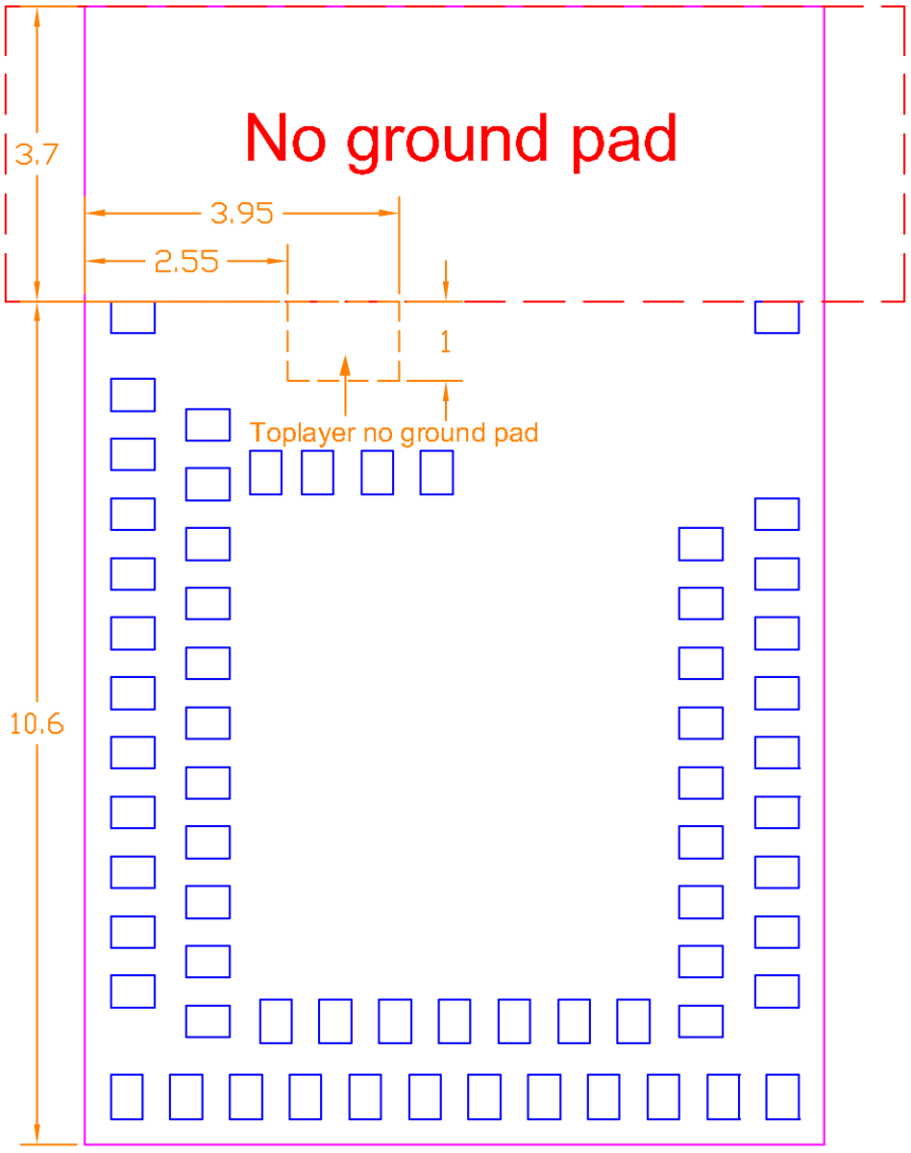


Top (Unit: mm)

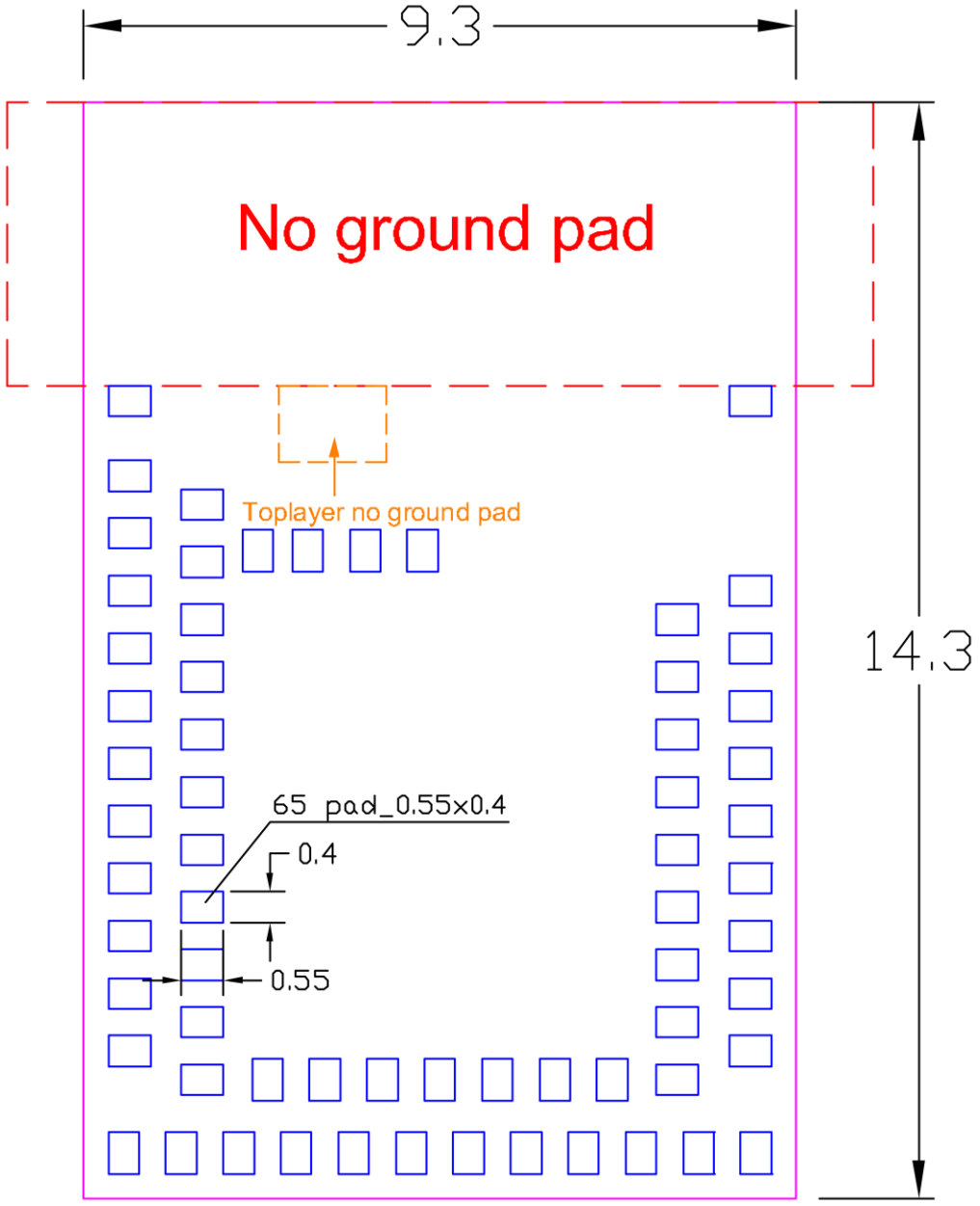
2.2. Recommended Layout of Solder Pad

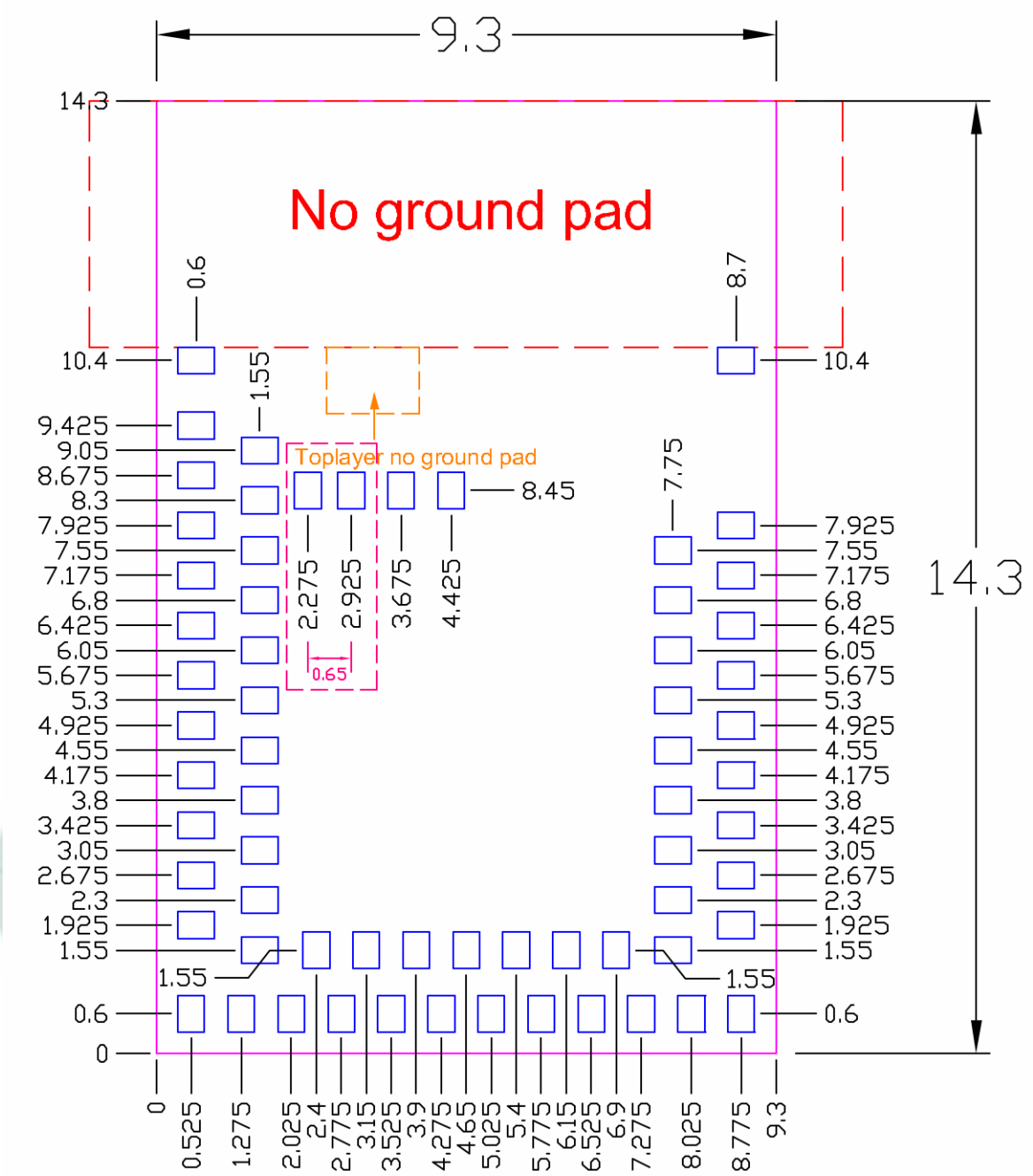
Graphs are all in Top View, Unit in mm.





Toplayer no ground pad


9.3
No ground pad
Toplayer no ground pad
14.3
65 pad_0.55x0.4
0.4
0.55



Top View (Unit ： mm)

recommended solder pad layout

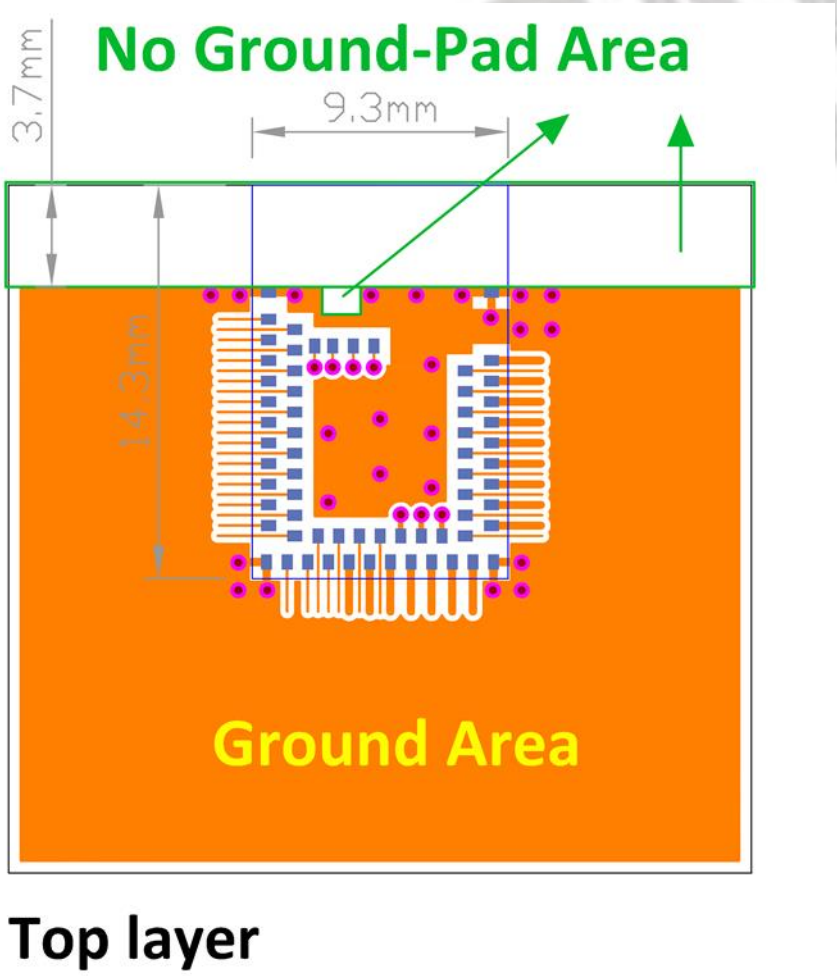
2.3. RF Layout Suggestion (aka Keep-Out Area)

Please follow below instruction to have better wireless performance. Make sure to keep the "No-Ground-Pad" as wider as you can when there is no enough space in your design.

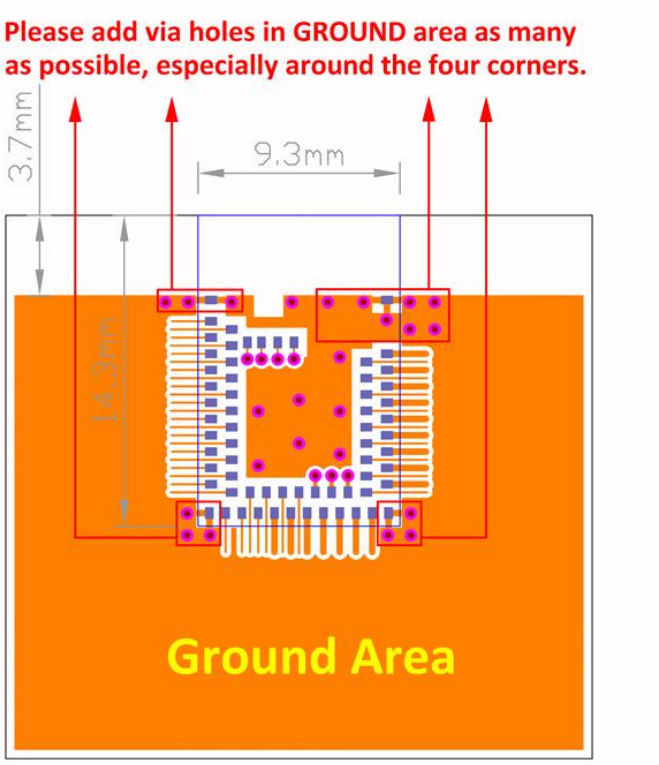
No Ground Pad should be included in the corresponding position of the antenna in **EACH LAYER**.

Place the module towards the edge of PCB to have better performance than placing it on the center.

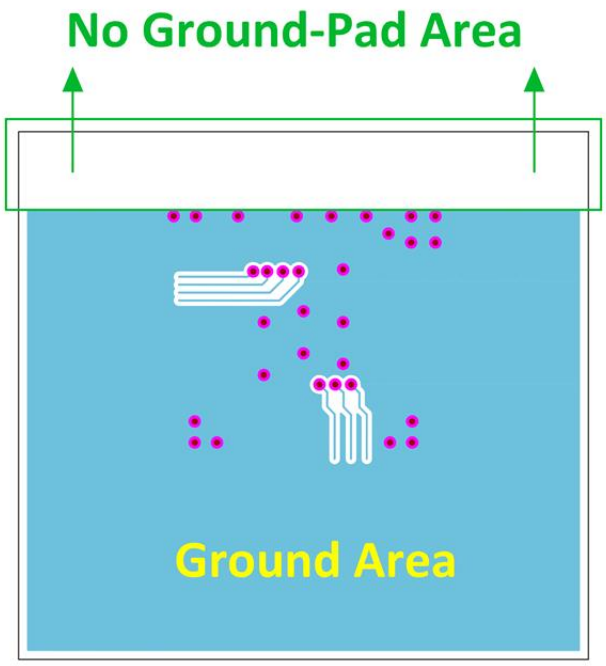
Welcome to send us your layout in PDF for review at service@raytac.com or your contact at Raytac with title "Layout reviewing – Raytac Model No. – YOUR company's name".



Top layer

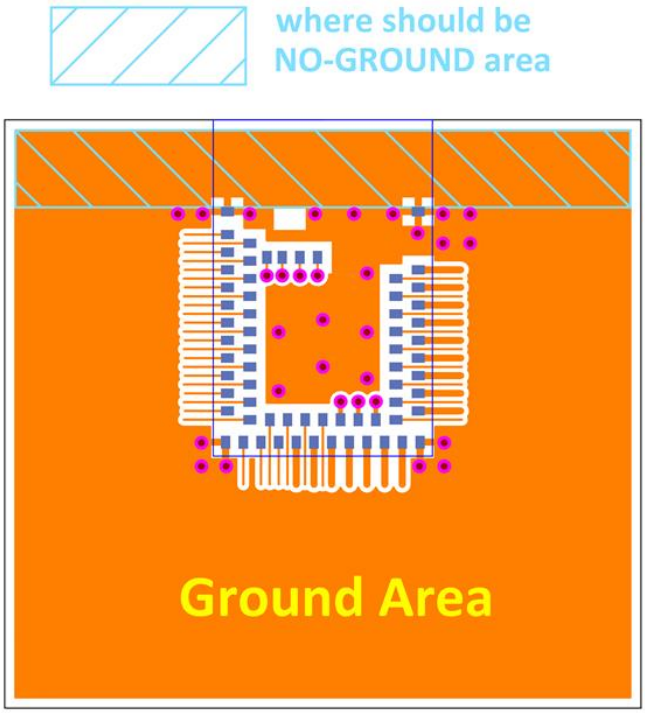


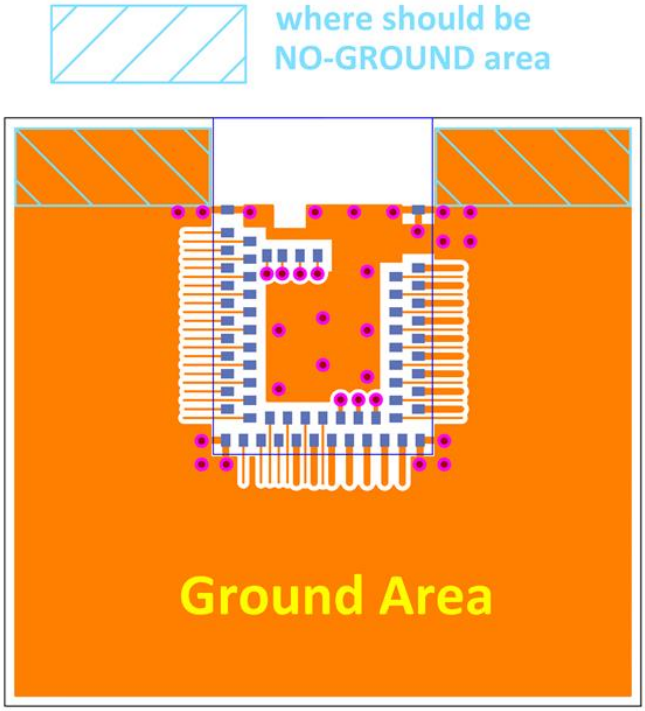
Top layer



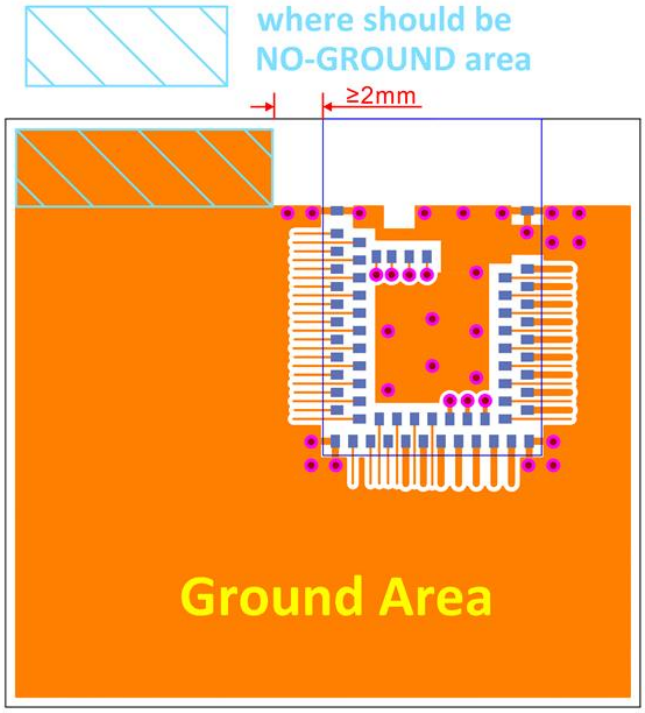
Bottom layer

Examples of “**NOT RECOMMENDED**” layout





If there is limited space for layout, the module can be put on the **upper right corner** to minimize the layout space.



2.4. Footprint & Design Guide

Please visit “Support” page of our website to download. The package includes footprint, 2D/3D drawing, reflow graph/solder profile and recommended spec for external 32.768khz.

2.5. Pin Assignment

Pin No.	Name	Pin Function	Description
(1)	**GND**	Power	Ground
(2)	**SWCLK**	Debug	Serial wire debug I/O for debug and programming
(3)	**P1.08**	Digital I/O	General-purpose I/O
(4)	**SWDIO**	Debug	Serial wire debug I/O for debug and programming
(5)	**P0.27**	Digital I/O	General-purpose I/O
	AIN6	Analog input	Analog input
(6)	**nRESET**	Reset	Pin RESET with internal pull-up resistor
(7)	**P0.26**	Digital I/O	General-purpose I/O
	AIN5	Analog input	Analog input
(8)	**P0.24**	Digital I/O	General-purpose I/O
(9)	**P0.25**	Digital I/O	General-purpose I/O
	AIN4	Analog input	Analog input
(10)	**P1.06**	Digital I/O	General-purpose I/O
(11)	**P1.04**	Digital I/O	General-purpose I/O
(12)	**P0.21**	Digital I/O	General-purpose I/O
(13)	**P0.20**	Digital I/O	General-purpose I/O
(14)	**P0.19**	Digital I/O	General-purpose I/O
(15)	**P0.12**	Digital I/O	General-purpose I/O
	DCX	DCX for SPIM4	Dedicated pin for high-speed SPI
(16)	**P0.18**	Digital I/O	General-purpose I/O
	CSN	CSN for QSPI	Dedicated pin for Quad SPI
(17)	**P0.11**	Digital I/O	General-purpose I/O
	CSN	CSN for SPIM4	Dedicated pin for high-speed SPI
(18)	**P0.10**	Digital I/O	General-purpose I/O
	MISO	MISO for SPIM4	Dedicated pin for high-speed SPI
(19)	**P0.09**	Digital I/O	General-purpose I/O
	MOSI	MOSI for SPIM4	Dedicated pin for high-speed SPI
(20)	**P0.07**	Digital I/O	General-purpose I/O
	AIN3	Analog input	Analog input

Pin No.	Name	Pin Function	Description
(21)	**P0.13**	Digital I/O	General-purpose I/O
	IO0	IO0 for QSPI	Dedicated pin for Quad SPI
(22)	**P1.05**	Digital I/O	General-purpose I/O
(23)	**P0.15**	Digital I/O	General-purpose I/O
	IO2	IO2 for QSPI	Dedicated pin for Quad SPI
(24)	**GND**	Power	Ground
(25)	**P0.22**	Digital I/O	General-purpose I/O
(26)	**P0.17**	Digital I/O	General-purpose I/O
	SCK	SCK for QSPI	Dedicated pin for Quad SPI
(27)	**P0.14**	Digital I/O	General-purpose I/O
	IO1	IO1 for QSPI	Dedicated pin for Quad SPI
(28)	**P0.16**	Digital I/O	General-purpose I/O
	IO3	IO3 for QSPI	Dedicated pin for Quad SPI
(29)	**P0.08**	Digital I/O	General-purpose I/O
	SCK	SCK for SPIM4	Dedicated pin for high-speed SPI
(30)	**P0.03**	Digital I/O	General-purpose I/O
	NFC2	NFC input	NFC antenna connection
(31)	**P1.03**	Digital I/O	General-purpose I/O
	TWI	TWI 1 Mbps	High-speed pin for 1 Mbps TWI
(32)	**P0.02**	Digital I/O	General-purpose I/O
	NFC1	NFC input	NFC antenna connection
(33)	**P1.02**	Digital I/O	General-purpose I/O
	TWI	TWI 1 Mbps	High-speed pin for 1 Mbps TWI
(34)	**P0.00**	Digital I/O	General-purpose I/O
	XL1	Analog input	Connection for 32.768 kHz crystal
(35)	**P0.06**	Digital I/O	General-purpose I/O
	AIN2	Analog input	Analog input
(36)	**P0.01**	Digital I/O	General-purpose I/O
	XL2	Analog input	Connection for 32.768 kHz crystal

Pin No.	Name	Pin Function	Description
(37)	**P0.04**	Digital I/O	General-purpose I/O
	AIN0	Analog input	Analog input
(38)	**VDD**	Power	Power supply
(39)	**P0.05**	Digital I/O	General-purpose I/O
	AIN1	Analog input	Analog input
(40)	**DCCH**	Power	DC/DC converter output
(41)	**VDDH**	Power	High voltage power supply
(42)	**GND**	Power	Ground
(43)	**P1.01**	Digital I/O	General-purpose I/O
(44)	**VBUS**	Power	5V input for USB 3.3V regulator
(45)	**P1.00**	Digital I/O	General-purpose I/O
(46)	**D+**	Digital I/O	USB D+
(47)	**P1.15**	Digital I/O	General-purpose I/O
(48)	**D–**	Digital I/O	USB D-
(49)	**P1.14**	Digital I/O	General-purpose I/O
(50)	**DCCD**	Power	DC/DC converter output
(51)	**P1.13**	Digital I/O	General-purpose I/O
(52)	**DECD**	Power	Digital regulator supply decoupling
(53)	**P1.12**	Digital I/O	General-purpose I/O
(54)	**DCC**	Power	DC/DC converter output
(55)	**P1.11**	Digital I/O	General-purpose I/O
(56)	**P0.31**	Digital I/O	General-purpose I/O
(57)	**P0.30**	Digital I/O	General-purpose I/O
(58)	**DECR**	Power	Regulator supply decoupling
(59)	**P1.10**	Digital I/O	General-purpose I/O
(60)	**P0.28**	Digital I/O	General-purpose I/O
	AIN7	Analog input	Analog input
(61)	**GND**	Power	Ground

Pin No.	Name	Pin Function	Description
(62)	P0.23	Digital I/O	General-purpose I/O
(63)	P1.07	Digital I/O	General-purpose I/O
(64)	P1.09	Digital I/O	General-purpose I/O
(65)	P0.29	Digital I/O	General-purpose I/O

3. Main Chip Solution

RF IC	Crystal Frequency
Nordic NRF5340	32MHZ / CL = 8pF / 20ppm

32MHz crystal is already inside the module. The module does NOT include external capacitor of 32MHZ. Please follow below instruction to enable FW setting of internal capacitor.

Bit number				31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
ID				B A A A A A
Reset 0x00000000				**0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0**
ID	R/W	Field	Value ID	Value	Description
A	RW	CAPVALUE			Value representing capacitance, calculated using provided equation
B	RW	ENABLE			Enable on-chip capacitors on XC1 and XC2
			Disabled	0	Capacitor disabled (use external caps)
			Enabled	1	Capacitor enabled

Decimal: 268
Hexadecimal: 0x0000010c
Binary: 0b00000000000000000000000100001100

SDK Default setting: B =1, internal capacitor enable / A = 01100

4. Specification

Any technical spec shall refer to Nordic's official documents as final reference. Contents below are from "nRF5340 Objective Production Specification v1.1", please click to download full spec.

4.1. Absolute Maximum Ratings

	Min.	Max.	Unit
Supply voltages			
VDD	-0.3	+3.9	V
VDDH	-0.3	+5.8	V
VBUS	-0.3	+5.8	V
VSS		0	V
I/O pin voltage			
$V_{I/O}$, VDD ≤ 3.6 V	-0.3	VDD + 0.3	V
$V_{I/O}$, VDD > 3.6 V	-0.3	3.9	V
Environmental aQFN package			
Storage temperature	-40	+125	°C
Moisture Sensitivity Level (MSL)		2	
ESD Human Body Model (HBM)		2 (all pins except DECR and DECN, rated at 1.4 kV)	kV
ESD Charged Device Model (CDM)		500	V
Flash memory			
Endurance	10 000 write/erase cycles		
Retention	10 years at 40°C		

4.2. Operating Conditions

Symbol	Parameter	Min.	Nom.	Max.	Units
VDD	VDD supply voltage, independent of DCDC enable	1.7	3.0	3.6	V
VDDH	VDDH supply voltage, independent of DCDC enable	2.5	3.7	5.5	V
VBUS	VBUS USB supply voltage	4.35	5.0	5.5	V
TA	Operating temperature	-40	25	105	°C

4.3. Electrical Specifications

4.3.1. General Radio Characteristics

Symbol	Description	Min.	Typ.	Max.	Units
f_{OP}	Operating frequencies	2360		2500	MHz
$f_{PLL,CH,SP}$	PLL channel spacing		1.0		MHz
$f_{DELTA,1M}$	Frequency deviation @ 1 Mbps		±170		kHz
$f_{DELTA,BLE,1M}$	Frequency deviation @ Bluetooth LE 1 Mbps		±250		kHz
$f_{DELTA,2M}$	Frequency deviation @ 2 Mbps		±320		kHz
$f_{DELTA,BLE,2M}$	Frequency deviation @ Bluetooth LE 2 Mbps		±500		kHz
fsk_{BPS}	On-the-air data rate	125		2000	kbps
$f_{chip,\ IEEE\ 802.15.4}$	Chip rate in IEEE 802.15.4 mode		2000		kchip/s

4.3.2. Radio Current Consumption (Transmitter)

Symbol	Description	Min.	Typ.	Max.	Units
$I_{TX,PLUS3dBM,DCDC}$	TX only run current DC/DC, 3 V, P_{RF} = +3 dBm		5.1		mA
$I_{TX,PLUS3dBM}$	TX only run current P_{RF} = +3 dBm		11.3		mA
$I_{TX,0dBM,DCDC}$	TX only run current DC/DC, 3 V, P_{RF} = 0 dBm		3.4		mA
$I_{TX,0dBM}$	TX only run current P_{RF} = 0 dBm		9.1		mA
$I_{TX,MINUS4dBM,DCDC}$	TX only run current DC/DC, 3 V, P_{RF} = -4 dBm		2.7		mA
$I_{TX,MINUS4dBM}$	TX only run current P_{RF} = -4 dBm		7.2		mA
$I_{TX,MINUS8dBM,DCDC}$	TX only run current DC/DC, 3 V, P_{RF} = -8 dBm		2.2		mA
$I_{TX,MINUS8dBM}$	TX only run current P_{RF} = -8 dBm		5.8		mA
$I_{TX,MINUS12dBM,DCDC}$	TX only run current DC/DC, 3 V, P_{RF} = -12 dBm		2.0		mA
$I_{TX,MINUS12dBM}$	TX only run current P_{RF} = -12 dBm		5.0		mA
$I_{TX,MINUS16dBM,DCDC}$	TX only run current DC/DC, 3 V, P_{RF} = -16 dBm		1.8		mA
$I_{TX,MINUS16dBM}$	TX only run current P_{RF} = -16 dBm		4.5		mA
$I_{TX,MINUS20dBM,DCDC}$	TX only run current DC/DC, 3 V, P_{RF} = -20 dBm		1.7		mA
$I_{TX,MINUS20dBM}$	TX only run current P_{RF} = -20 dBm		4.2		mA
$I_{TX,MINUS40dBM,DCDC}$	TX only run current DC/DC, 3 V, P_{RF} = -40 dBm		1.5		mA
$I_{TX,MINUS40dBM}$	TX only run current P_{RF} = -40 dBm		3.8		mA
$I_{START,TX,DCDC}$	TX start-up current DC/DC, 3 V, P_{RF} = 4 dBm		2.4		mA
$I_{START,TX}$	TX start-up current, P_{RF} = 4 dBm		5.4		mA

4.3.3. Radio Current Consumption (Receiver)

Symbol	Description	Min.	Typ.	Max.	Units
$I_{RX,1M,DCDC}$	RX only run current DC/DC, 3 V, 1 Mbps/1 Mbps Bluetooth LE mode		2.7		mA
$I_{RX,1M}$	RX only run current LDO, 3 V, 1 Mbps/1 Mbps Bluetooth LE mode		6.7		mA
$I_{RX,2M,DCDC}$	RX only run current DC/DC, 3 V, 2 Mbps/2 Mbps Bluetooth LE mode		3.1		mA
$I_{RX,2M}$	RX only run current LDO, 3 V, 2 Mbps/2 Mbps Bluetooth LE mode		7.9		mA
$I_{START,RX,1M,DCDC}$	RX start-up current DC/DC, 3 V, 1 Mbps/1 Mbps Bluetooth LE mode	..	..	..	mA
$I_{START,RX,1M}$	RX start-up current 1 Mbps/1 Mbps Bluetooth LE mode	..	..	..	mA

4.3.4. Transmitter Specification

Symbol	Description	Min.	Typ.	Max.	Units
P_{RF}	Maximum output power		3.0		dBm
P_{RFC}	RF power control range		23.0		dB
P_{RFCR}	RF power accuracy		±2		dB
$P_{RF1,1}$	1st Adjacent Channel Transmit Power 1 MHz (1 Mbps)		-24		dBc
$P_{RF2,1}$	2nd Adjacent Channel Transmit Power 2 MHz (1 Mbps)		-52		dBc
$P_{RF1,2}$	1st Adjacent Channel Transmit Power 2 MHz (2 Mbps)		-25		dBc
$P_{RF2,2}$	2nd Adjacent Channel Transmit Power 4 MHz (2 Mbps)		-50		dBc
E_{vm}	Error vector magnitude in IEEE 802.15.4 mode	..	..	..	%rms
$P_{harm2nd,\ IEEE\ 802.15.4}$	2nd harmonics in IEEE 802.15.4 mode		-51		dBm
$P_{harm3rd,\ IEEE\ 802.15.4}$	3rd harmonics in IEEE 802.15.4 mode		-51		dBm

4.3.5. RSSI Specifications

Symbol	Description	Min.	Typ.	Max.	Units
$RSSI_{ACC}$	RSSI accuracy		±2		dB
$RSSI_{RESOLUTION}$	RSSI resolution		1		dB
$RSSI_{PERIOD}$	RSSI sampling time from RSSI_START task		0.25		µs
$RSSI_{SETTLE}$	RSSI settling time after signal level change		15		µs

4.3.6. Receiver Operation

Symbol	Description	Min.	Typ.	Max.	Units
$P_{RX,MAX}$	Maximum received signal strength at < 0.1% PER		0		dBm
$P_{SENS,IT,1M}$	Sensitivity, 1 Mbps nRF mode ideal transmitter [12]		-95		dBm
$P_{SENS,IT,2M}$	Sensitivity, 2 Mbps nRF mode ideal transmitter [12]		-92		dBm
$P_{SENS,IT,SP,1M,BLE}$	Sensitivity, 1 Mbps Bluetooth LE ideal transmitter, packet length ≤ 37 bytes BER = 1E-3 [13]		-98		dBm
$P_{SENS,IT,LP,1M,BLE}$	Sensitivity, 1 Mbps Bluetooth LE ideal transmitter, packet length ≥ 128 bytes BER = 1E-4 [14]		-97		dBm
$P_{SENS,IT,SP,2M,BLE}$	Sensitivity, 2 Mbps Bluetooth LE ideal transmitter, packet length ≤ 37 bytes		-95		dBm
$P_{SENS,IT,BLE\ LE125k}$	Sensitivity, 125 kbps Bluetooth LE mode		-104		dBm
$P_{SENS,IT,BLE\ LE500k}$	Sensitivity, 500 kbps Bluetooth LE mode		-100		dBm
$P_{SENS,IEEE\ 802.15.4}$	Sensitivity in IEEE 802.15.4 mode		-101		dBm

[12] Typical sensitivity applies when ADDR0 is used for receiver address correlation. When ADDR[1...7] are used for receiver address correlation, the typical sensitivity for this mode is degraded by 3 dB.

[13] As defined in the *Bluetooth Core Specification v4.0 Volume 6: Core System Package (Low Energy Controller Volume)*.

[14] Equivalent BER limit < 10E-04.

4.4. Application CPU Performance

Symbol	Description	Min.	Typ.	Max.	Units
$W_{FLASH128}$	CPU wait states, running CoreMark at 128 MHz from flash, cache disabled			4	
$W_{FLASHCACHE128}$	CPU wait states, running CoreMark at 128 MHz from flash, cache enabled			5	
W_{RAM128}	CPU wait states, running CoreMark at 128 MHz from RAM		0		
$W_{FLASH64}$	CPU wait states, running CoreMark at 64 MHz from flash, cache disabled			5	
$W_{FLASHCACHE64}$	CPU wait states, running CoreMark at 64 MHz from flash, cache enabled			6	
W_{RAM64}	CPU wait states, running CoreMark at 64 MHz from RAM		0		
$CM_{FLASHCACHE128}$	CoreMark, running from flash, cache enabled, HFXO128M		514		CoreMark
$CM_{FLASH128/MHz}$	CoreMark per MHz, running from flash, cache enabled, HFXO128M		4.0		CoreMark/MHz
$CM_{FLASH128/mA}$	CoreMark per mA, running from flash, cache enabled, DCDC 3V, HFXO128M		66		CoreMark/mA
$CM_{FLASHCACHE64}$	CoreMark, running from flash, cache enabled, HFXO64M		257		CoreMark
$CM_{FLASH64/MHz}$	CoreMark per MHz, running from flash, cache enabled, HFXO64M		4.0		CoreMark/MHz
$CM_{FLASH64/mA}$	CoreMark per mA, running from flash, cache enabled, DCDC 3V, HFXO64M		72.5		CoreMark/mA

4.5. Network CPU Performance

Symbol	Description	Min.	Typ.	Max.	Units
W_{FLASH}	CPU wait states, running from flash, cache disabled	0		4	
$W_{FLASHCACHE}$	CPU wait states, running from flash, cache enabled	0		5	
W_{RAM}	CPU wait states, running from RAM		0		
$CM_{FLASHCACHE}$	CoreMark, running from flash, cache enabled		244		CoreMark
$CM_{FLASH/MHz}$	CoreMark per MHz, running from flash, cache enabled		3.8		CoreMark/ MHz
$CM_{FLASH/mA}$	CoreMark per mA, running from flash, cache enabled		101		CoreMark/ mA

4.6. Power Management

4.6.1. Sleep

Symbol	Description	Min.	Typ.	Max.	Units
I_{ON_IDLE1}	System ON, 0 kB application RAM, wake on any event		1.3		uA
$I_{ON\_IDLE1,LDO}$	System ON, 0k application RAM, wake on any event, regulator = LDO		3.3		uA
I_{ON_IDLE2}	System ON, wake on any event		1.3		uA
$I_{ON\_IDLE2,LDO}$	System ON, wake on any event, regulator = LDO		3.4		uA
I_{ON_IDLE3}	System ON, wake on any event, power-fail comparator enabled		1.3		uA
$I_{ON\_IDLE3,128MHz}$	System ON, wake on any event, power-fail comparator enabled, clock=HFINT128M		785		uA
I_{ON_IDLE4}	System ON, wake on GPIOTE input (event mode, LATENCY=LowLatency)		48		uA
$I_{ON\_IDLE4\_LP}$	System ON, wake on GPIOTE input (event mode, LATENCY=LowPower)		1.3		uA
I_{ON_IDLE5}	System ON, wake on GPIOTE PORT event		1.3		uA
I_{ON_IDLE6}	System ON, 0 kB application RAM, wake on RTC (running from LFXO clock)		1.5		uA
I_{ON_IDLE7}	System ON, wake on RTC (running from LFXO clock)		1.5		uA
I_{ON_IDLE8}	System ON, 0 kB application RAM, wake on RTC (running from LFXO clock), 5 V supply on VDDH, VREGH output = 3.3 V		1.7		uA
I_{ON_IDLE7}	System ON, 0 kB network RAM, wake on network RTC (running from LFXO clock)		1.5		uA
I_{ON_IDLE8}	System ON, 64 kB network RAM, wake on network RTC (running from LFXO clock)		1.7		uA

Symbol	Description	Min.	Typ.	Max.	Units
I_{ON_IDLE9}	System ON, 0 kB application RAM, wake on RTC (running from LFRC clock)		2.1		uA
I_{ON_IDLE10}	Both cores in System ON, wake on any event. VREQH=Disabled.		1.3		uA
$I_{ON\_IDLE10\_VREQH}$	Both cores in System ON, wake on any event. VREQH=Enabled.		1.4		uA
I_{OFF0}	System OFF, 0 kB application RAM, wake on reset		1.0		uA
$I_{OFF0,LDO}$	System OFF, 0 kB application RAM, wake on reset; regulator = LDO		1.4		uA
I_{OFF1}	System OFF, 0 kB application RAM, wake on LPCOMP		0.9		uA
I_{OFF2}	System OFF, wake on reset		0.9		uA
I_{OFF3}	System OFF, 0 kB application RAM, wake on reset, 5 V supply on VDDH, VREGH output = 3.3V		1.1		uA
$I_{OFF3,LDO}$	System OFF, 0 kB application RAM, wake on reset, 5 V supply on VDDH, VREGH output = 3.3V; regulator = LDO		1.4		uA
I_{OFF4}	System OFF, 512 kB application RAM + 64 kB network RAM, wake on reset		2.4		uA

4.6.2. Application CPU Running

Symbol	Description	Min.	Typ.	Max.	Units
$I_{APPCPU0}$	CPU running CoreMark from flash, regulator = LDO, clock = HFINT128M		15.5		mA
$I_{APPCPU2}$	CPU running CoreMark from flash, clock = HFXO128M		8.0		mA
$I_{APPCPU3}$	CPU running CoreMark from flash, clock = HFXO64M		3.6		mA
$I_{APPCPU4}$	CPU running CoreMark from flash, clock = HFINT128M		7.8		mA
$I_{APPCPU5}$	CPU running CoreMark from flash		3.3		mA
$I_{APPCPU8}$	CPU running CoreMark from RAM, clock = HFINT128M		7.9		mA
$I_{APPCPU9}$	CPU running CoreMark from RAM		3.4		mA
$I_{APPCPU10}$	CPU running CoreMark from RAM, clock = HFXO128M		8.2		mA
$I_{APPCPU11}$	CPU running CoreMark from RAM, clock = HFXO64M		3.6		mA

4.6.3. Network CPU Running

Symbol	Description	Min.	Typ.	Max.	Units
$I_{NETCPU0}$	CPU running CoreMark from flash, regulator = LDO		5.1		mA
$I_{NETCPU1}$	CPU running CoreMark from flash		2.4		mA
$I_{NETCPU2}$	CPU running CoreMark from flash, clock = HFXO64M		2.6		mA
$I_{NETCPU3}$	CPU running CoreMark from RAM, regulator = LDO		4.3		mA
$I_{NETCPU4}$	CPU running CoreMark from RAM		2.0		mA
$I_{NETCPU5}$	CPU running CoreMark from RAM, clock = HFXO64M		2.2		mA

4.6.4. I2S Active

Symbol	Description	Min.	Typ.	Max.	Units
I_{I2S0}	I2S transferring data @ 2 x 16 bit x 16 kHz (CONFIG.MCKFREQ = 32MDIV63, CONFIG.RATIO = 32X), clock = HFXO64M		2000		uA
I_{I2S1}	I2S transferring data @ 2 x 16 bit x 16 kHz (CONFIG.MCKFREQ = 510000, CONFIG.RATIO = 32X), clock = HFXO ACLK @ 12.288 MHz		2170		uA
I_{I2S2}	I2S transferring data @ 2 x 16 bit x 48 kHz (CONFIG.MCKFREQ = 505286656, CONFIG.RATIO = 32X), clock = HFXO ACLK @ 12.288 MHz		2310		uA

4.6.5. NFCT Active

Symbol	Description	Min.	Typ.	Max.	Units
I_{SENSE}	System ON, current in SENSE STATE (this current does not apply when in NFC field)		1.3		uA
$I_{ACTIVATED}$	System ON, current in ACTIVATED STATE, clock = HFXO64M		1080		uA

4.6.6. PDM Active

Symbol	Description	Min.	Typ.	Max.	Units
$I_{PDM,RUN}$	PDM receiving and processing data @ 1 Msps (RATIO = 64, PDMCLKCTRL = 135274496), stereo mode, clock = HFXO64M		655		uA
$I_{PDM,RUN,ACLK}$	PDM receiving and processing data @ 1 Msps (RATIO = 64, PDMCLKCTRL = 343597056), stereo mode, HFXO ACLK = 12.288 MHz		1045		uA

4.6.7. PWM Active

Symbol	Description	Min.	Typ.	Max.	Units
$I_{PWM,RUN0}$	PWM running at 125 kHz, top = 10, duty = 50%		560		uA
$I_{PWM,RUN1}$	PWM running at 16 MHz, top = 10, duty = 50%		560		uA
$I_{PWM,RUN1,LDO}$	PWM running at 16 MHz, top = 10, duty = 50%; regulator = LDO		1035		uA
$I_{PWM,RUN2}$	PWM running at 125 kHz, top = 10, duty = 50%, clock = HFXO64M		750		uA
$I_{PWM,RUN3}$	PWM running at 16 MHz, top = 10, duty = 50%, clock = HFXO64M		755		uA

4.6.8. QDEC Active

Symbol	Description	Min.	Typ.	Max.	Units
$I_{QDEC,RUN}$	QDEC running		480		uA

4.6.9. QSPI Active

Symbol	Description	Min.	Typ.	Max.	Units
$I_{QSPI,IDLE}$	QSPI idle (enabled, but not activated)		45		uA
$I_{QSPI,ACTIVE}$	QSPI active (activated, but not transferring data)		1790		uA
$I_{QSPI,DATA}$	QSPI transferring data (activated, and transferring data to/ from external flash memory), SCKFREQ = 96 MHz, quad mode, clock = HFXO192M		4430		uA

4.6.10. SAADC Active

Symbol	Description	Min.	Typ.	Max.	Units
$I_{SAADC,RUN}$	SAADC sampling @ 16 ksps, acquisition time = 20 us, clock = HFXO64M		980		uA
$I_{SAADC,TASK}$	SAADC sampling @ 1 kHz from RTC in task mode, LPOP=LowLat, acquisition time = 20 us, clock = HFINT64M and LFXO		770		uA
$I_{SAADC,TASK,LPOP}$	SAADC sampling @ 1 kHz from RTC in task mode,LPOP=LowPower , acquisition time = 20 us, clock = HFINT64M and LFXO		160		uA

4.6.11. Timer Running

Symbol	Description	Min.	Typ.	Max.	Units
I_{TIMER0}	One TIMER running @ 1 MHz		475		uA
I_{TIMER1}	One TIMER running @ 1 MHz, clock = HFXO64M		670		uA
I_{TIMER2}	One TIMER running @ 16 MHz		560		uA
$I_{TIMER2,LDO}$	One TIMER running @ 16 MHz; regulator = LDO		1040		uA
I_{TIMER3}	One TIMER running @ 16 MHz, clock = HFXO64M		750		uA
$I_{TIMER3,LDO}$	One TIMER running @ 16 MHz, clock = HFXO64M; regulator LDO		1280		uA
I_{TIMER4}	One TIMER running @ 16 MHz, clock = HFINT128M		750		uA
$I_{NET,TIMER0}$	One network TIMER running @ 1 MHz		170		uA
$I_{NET,TIMER1}$	One network TIMER running @ 1 MHz, clock = HFXO64M		400		uA
$I_{NET,TIMER2}$	One network TIMER running @ 16 MHz		220		uA
$I_{NET,TIMER3}$	One network TIMER running @ 16 MHz, clock = HFXO64M		445		uA

4.6.12. SPIM Active

Symbol	Description	Min.	Typ.	Max.	Units
I_{SPIM0}	SPIM transferring data @ 2 Mbps		935		uA
I_{SPIM1}	SPIM transferring data @ 2 Mbps, clock = HFXO64M		1145		uA
I_{SPIM2}	SPIM transferring data @ 8 Mbps		1705		uA
I_{SPIM3}	SPIM transferring data @ 8 Mbps, clock = HFXO64M		1930		uA
I_{SPIM4}	SPIM transferring data @ 32 Mbps		2115		uA
I_{SPIM5}	SPIM transferring data @ 32 Mbps, clock = HFXO64M		2345		uA

4.6.13. SPIS Active

Symbol	Description	Min.	Typ.	Max.	Units
I_{SPIS0}	SPIS configured and idle (enabled, no CSN activity)		145		uA
I_{SPIS1}	SPIS transferring data @ 2 Mbps		713		uA
I_{SPIS2}	SPIS transferring data @ 2 Mbps, clock = HFXO64M		913		uA

4.6.14. TWIM Active

Symbol	Description	Min.	Typ.	Max.	Units
I_{TWIM0}	TWIM transferring data @ 100 kbps		965		uA
I_{TWIM1}	TWIM transferring data @ 100 kbps, clock = HFXO64M		1170		uA
I_{TWIM2}	TWIM transferring data @ 400 kbps		1000		uA
I_{TWIM3}	TWIM transferring data @ 400 kbps, clock = HFXO64M		1205		uA
I_{TWIM4}	TWIM transferring data @ 1000 kbps		2050		uA
I_{TWIM5}	TWIM transferring data @ 1000 kbps, clock = HFXO64M		2295		uA

4.6.15. TWIS Active

Symbol	Description	Min.	Typ.	Max.	Units
$I_{TWIS,IDLE}$	TWIS configured and enabled (IDLE state)		45		uA
I_{TWIS0}	TWIS transferring data @ 100 kbps		945		uA
I_{TWIS1}	TWIS transferring data @ 400 kbps		985		uA
I_{TWIS2}	TWIS transferring data @ 100 kbps, clock = HFXO64M		1150		uA
I_{TWIS3}	TWIS transferring data @ 400 kbps, clock = HFXO64M		1185		uA

4.6.16. UARTE Active

Symbol	Description	Min.	Typ.	Max.	Units
$I_{UARTE,IDLE0}$	UARTE RX idle (started, waiting for data, no data transfer)		645		uA
$I_{UARTE,IDLE1}$	UARTE RX idle (started, waiting for data, no data transfer), clock = HFXO64M		840		uA
I_{UARTE0}	UARTE transferring data @ 1200 bps, clock = HFXO64M		885		uA
I_{UARTE1}	UARTE transferring data @ 115200 bps, clock = HFXO64M		890		uA
I_{UARTE2}	UARTE receiving data @ 115200 bps, clock = HFXO64M		890		uA
I_{UARTE3}	UARTE transmitting and receiving data @ 115200 bps, clock = HFXO64M		895		uA

4.6.17. USBD Active

Symbol	Description	Min.	Typ.	Max.	Units
$I_{USB,ACTIVE,VBUS}$	Current from VBUS supply, USB active		1.2		mA
$I_{USB,SUSPEND,VBUS}$	Current from VBUS supply, USB suspended, CPU sleeping		180		uA
$I_{USB,ACTIVE,VDD}$	Current from VDD supply (normal voltage mode), all RAM retained, CPU running, USB active		3.0		mA
$I_{USB,SUSPEND,VDD}$	Current from VDD supply (normal voltage mode), all RAM retained, CPU sleeping, USB suspended		815		uA
$I_{USB,SUSPEND,VDD,LDO}$	Current from VDD supply (normal voltage mode), all RAM retained, CPU sleeping, USB suspended, regulator = LDO		135		uA
$I_{USB,ACTIVE,VDDH}$	Current from VDDH supply (high voltage mode), VDD=3 V (VREGH output), all RAM retained, CPU running, USB active		3.2		mA
$I_{USB,SUSPEND,VDDH}$	Current from VDDH supply (high voltage mode), VDD=3 V (VREGH output), all RAM retained, CPU sleeping, USB suspended		2340		uA
$I_{USB,SUSPEND,VDDH,LDO}$	Current from VDDH supply (high voltage mode), VDD=3 V (VREGH output), all RAM retained, CPU sleeping, USB suspended, regulator = LDO		125		uA
$I_{USB,DISABLED,VDD}$	Current from VDD supply, USB disabled, VBUS supply connected, all RAM retained, CPU sleeping		3		uA

5. FCC Compliance

This equipment has been tested and found to comply with the limits for a Class digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to the radio communications. However, there are no guarantees that interference will not occur in a particular installation.

Troubleshooting

If this equipment does cause harmful interference to radio reception, which can be determined by turning the equipment off and on, the user is encouraged to correct the interference by one or more of the following instructions.

・Reorient or relocate the receiving antenna.
・Increase the separation between the equipment and receiver.
・Consult dealer or an experienced radio technician.

Conditions

Operation is subject to the following conditions

・This device may not cause harmful interference.
・This device must accept any interference received, including interference that may cause undesired operation.

FCC Caution

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Any changes or modifications not expressly approved by the party responsible for compliance could void the authority to operate equipment.

RF Exposure

FCC RF Radiation Exposure Statement:

1. This Transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
2. For body worn operation, this device has been tested and meets FCC RF exposure guidelines. When used with an accessory that contains metal may not ensure compliance with FCC RF exposure guidelines.

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

1) this device may not cause harmful interference and
2) this device must accept any interference received, including interference that may cause undesired operation.

Required End Product Labeling

Any device incorporating this module must include an external, visible, permanent marking or label which states: “Contains FCC ID: SH6MDBT53”

Applicable FCC Rules

This module has been tested and found to comply with the following requirements for Modular Approval.

- Part 15.247 - Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

Additional testing, Part 15 Subpart B disclaimer

The modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification.

The final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

Test Modes

This device uses various test mode programs for test set up which operate separate from production firmware. Host integrators should contact the grantee for assistance with test modes needed for module/host compliance test requirements.

Antennas

The following external antenna type have been approved for use with this module.

Radio	Model	Antenna Type	Freq. (MHz)	Max. Peak Antenna Gain (dBi)
BLE	MDBT53	Chip	2402-2480	-0.39
BLE	MDBT53-P	PCB	2402-2480	-2.32
BLE	MDBT53-U	u.FL Connector	2402-2480	5

In the end product, the antenna(s) used with this transmitter must be installed and must not be co-located or operation in conjunction with any other antenna or transmitter except in accordance with FCC multi-transmitter product procedures.

End Product Labeling

This transmitter module is authorized only for use in device where the antenna may be installed such that 5mm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following:

Contains FCC ID: SH6MDBT53

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warming as shown in this manual.

6. IC Caution

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

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

Avis Canadien

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. *L'appareil ne doit pas produire de brouillage;*
2. *L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.*

RF Radiation Exposure Statement:

1. To comply with the Canadian RF exposure compliance requirements, this device and its antenna must not be co-located or operating in conjunction with any other antenna or transmitter.

2. For body worn operation, this phone has been tested and meets RF exposure guidelines when used with an accessory that contains no metal. Use of other accessories may not ensure compliance with RF exposure guidelines.

Déclaration de l'exposition aux radiations RF:

1. Pour se conformer aux exigences de conformité RF canadienne l'exposition, cet appareil et son antenne ne doivent pas être co-localisés ou fonctionnant en conjonction avec une autre antenne ou transmetteur.
2. Pour le fonctionnement du corps, ce téléphone a été testé et répond aux directives d'exposition RF lorsqu'il est utilisé avec un accessoire qui ne contient pas de métal. Utilisation d'autres accessoires peut ne pas assurer le respect des directives d'exposition RF.

Required End Product Labeling

Any device incorporating this module must include an external, visible, permanent marking or label which states: "Contains IC : 8017A-MDBT53"

Obligation d'étiquetage du produit final:

Tout dispositif intégrant ce module doit comporter un externe, visible, marquage permanent ou une étiquette qui dit: "Contient IC : 8017A-MDBT53"

Antennas

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

Antennes

Cet émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous avec le gain maximal admissible indiqué . types d'antennes non inclus dans cette liste , ayant un gain supérieur au gain maximum indiqué pour ce type , sont strictement interdits pour une utilisation avec cet appareil.

Radio	ISED HVIN	Antenna Type	Freq. (MHz)	Max. Peak Antenna Gain (dBi)
BLE	MDBT53	Chip	2402-2480	-0.39
BLE	MDBT53-P	PCB	2402-2480	-2.32
BLE	MDBT53-U	u.FL Connector	2402-2480	5

7. NCC 警語

根據 NCC 低功率電波輻射性電機管理辦法規定

LP0002 低功率射頻器材技術規範_章節 3.8.2

取得審驗證明之低功率射頻器材，非經核准，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。

低功率射頻器材之使用不得影響飛航安全及干擾合法通信;經發現有干擾現象時,應立即停用，並改善至無干擾時方得繼續使用。

前述合法通信，指依電信管理法規定作業之無線電通信。

低功率射頻器材須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

此模組於取得認證後將依規定於模組本體標示審驗合格標籤，並要求平台廠商於平台上標示。

「本產品內含射頻模組：ID 編號 XXXXX」字樣