BoT-nLE523

DATASHEET

V 1.0.3

CHIPSEN

■ History

Rev	Date	Description	Author
1.0.3	2022. 04. 06	- Land pattern consideration update	Enoch
1.0.2	2022. 02. 23	- Power consumption update	Enoch
1.0.1	2022. 02. 08	- Pin Configuration update - Antenna Design Guide update	Enoch
1.0.0	2022. 02. 07	- First release	Enoch

Table of Contents

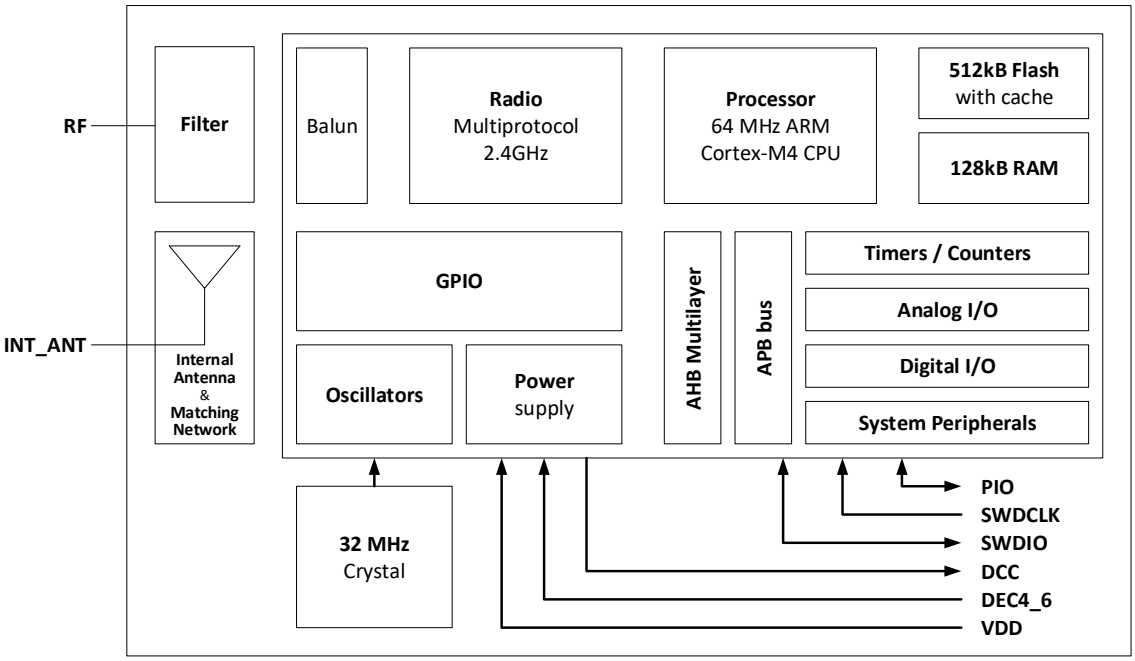
1. General

1.1 Overview

The BoT-nLE523 module is a cost-effective, low-power, true system-on-chip (SoC) for Bluetooth Smart (Bluetooth low energy) applications. It enables robust BLE nodes to be built with very low total bill-of-material costs. BoT-nLE523 combines an excellent RF transceiver with an industry-standard enhanced Cortec-M4 CPU, in-system programmable 512 kB flash memory, 128kB RAM, and many other powerful supporting features and peripherals. The BoT-nLE523 is suitable for systems where very low power.

Consumption is required. Very low-power sleep modes are available. Short transition times between operating modes further enable low power consumption.

1.2 Block Diagram



BoT-nLE523 Block Diagram

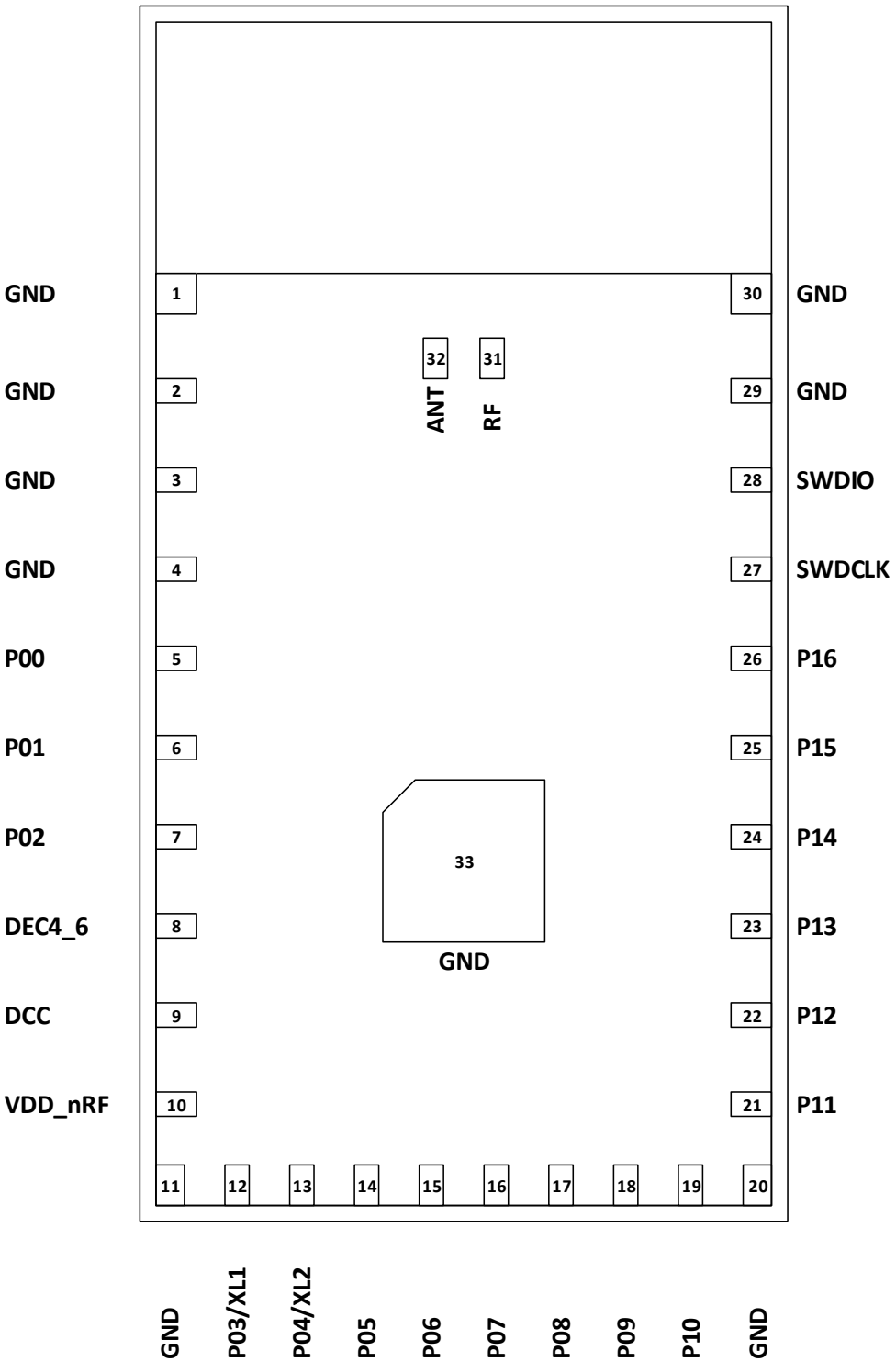
1.3 Features

- BT Ver. : Bluetooth 5.1
- Built in Antenna Bluetooth Smart (Bluetooth Low Energy) Module.
- ARM® Cortex®-M4 32-bit processor with FPU, 64 MHz
- Memory: 512 kB Flash / 128 kB RAM
- RF Output Power: MAX +7 dBm (-20 ~ 7 dBm)
- RF Receive Sensitivity: -93.5 dBm @ Dirty Tx enable, 1Mbps Bluetooth Low Energy mode
- Type 2 near field communication (NFC-A) tag with wakeup-on-field and touch to-pair capabilities
- On-chip LDO and DC/DC converter system (Used LDO by Default)
- Temperature Sensor
- UART (CTS/RTS) with EasyDMA, SPI, and I2C data interfaces.
- 12-Bit 200 ksps ADC with - 7 configurable channels with programmable gain
- Size: 15 mm x 8 mm x 1.8 mm
- Weight: about 0.5 g
- Operating Voltage: 2.7V to 3.6V
- Operating Temperature: -40 to +85℃
- RoHS compliant

1.4 Application

- Computer peripherals and I/O devices
  - · Mouse
  - · Keyboard
  - · Multi-touch trackpad
- Interactive entertainment devices
- Remote control
  - · Gaming controller
- Beacons
- Personal Area Networks
  - · Health/fitness sensor and monitor devices
  - · Medical devices
  - · Key-fobs + wrist watches
- Remote control toys

1.5 Pin Configuration



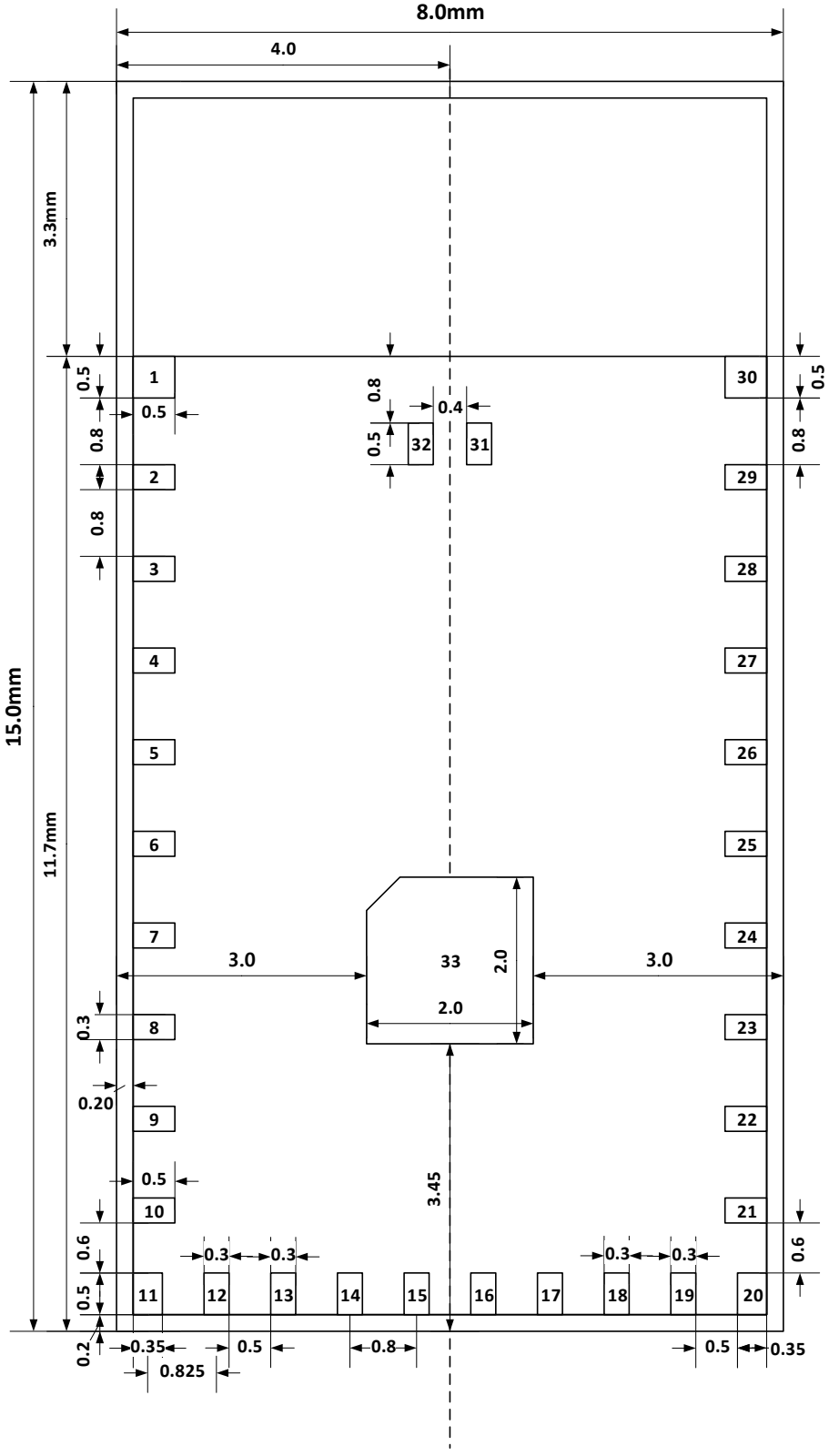
1.6 PIN Description

Pin No.	Pin Name	Pin Function	Description
05	P00	DIGITAL I/O	Standard drive, low frequency I/O only
	AIN1	ANALOG INPUT	
06	P01	DIGITAL I/O	Standard drive, low frequency I/O only
	AIN0	ANALOG INPUT	
07	P02	DIGITAL I/O	Standard drive, low frequency I/O only.
	AIN4	ANALOG INPUT	
12	P03	DIGITAL I/O	General purpose I/O pin.
	XL1	ANALOG INPUT	Connection for 32.768 kHz crystal
13	P04	DIGITAL I/O	General purpose I/O pin.
	XL2	ANALOG INPUT	Connection for 32.768 kHz crystal
14	P05	DIGITAL I/O	General purpose I/O pin.
	AIN2	ANALOG INPUT	Analog input
	CTS [1)]	DIGITAL INPUT	UART CTS
15	0P6	DIGITAL I/O	General purpose I/O pin.
	AIN3	ANALOG INPUT	Analog input
	RTS [1)]	DIGITAL OUTPUT	UART RTS
16	P07	DIGITAL I/O	General purpose I/O pin.
	RXD [1)]	DIGITAL INPUT	UART RXD
17	P08	DIGITAL I/O	General purpose I/O pin.
	TXD [1)]	DIGITAL OUTPUT	UART TXD
18	P09	DIGITAL I/O	General purpose I/O pin.
	AIN6	ANALOG INPUT	Analog input
	FACTORY_RST [1)]	DIGITAL INPUT	DISCONNECT & FACTORY_RESET [2)]
19	P10	DIGITAL I/O	General purpose I/O pin.
	AIN5	ANALOG INPUT	Analog input
	ENTER_SLEEP WAKE_UP [1)]	DIGITAL INPUT	ENTER_SLEEP / WAKE_UP [2)]
21	P11	DIGITAL I/O	General purpose I/O pin.
22	P12	DIGITAL I/O	General purpose I/O pin.
23	P13	DIGITAL I/O	General purpose I/O pin.
	UART ON/OFF [1)]	DIGITAL INPUT	UART ENABLE / DISABLE [2)]
24	P14	DIGITAL I/O	General purpose I/O pin.
	AT COMMAND BYPASS [1)]	DIGITAL INPUT	AT COMMAND / BYPASS [2)]
25	P15	DIGITAL I/O	General purpose I/O pin.
	CONNECTION STATUS [1)]	DIGITAL OUTPUT	CONNECTION STATUS [2)]
26	P16	DIGITAL I/O	General purpose I/O pin.
27	SWDCLK	DIGITAL INPUT	Serial Wire Debug clock input for debug and programming
28	SWDIO	DIGITAL I/O	Serial Wire Debug I/O for debug and programming
31	RF	RF IN / OUT PORT	Bluetooth 50Ω transmitter output / receiver input
32	ANT	INTERNAL ANTENNA IN / OUT	Internal antenna. It should be connected to 31 Pin RF for using internal antenna.
08	DEC4_6	POWER	1.3 V regulator supply decoupling Input from DC/DC converter. Output from 1.3 V LDO
09	DCC	POWER	DC/DC converter output
10	VCC	POWER	Power supply pin.
01,02,03,04 ,11,20,29,3 0,33	GND	GROUND	Ground Pin.

1) This I/O function operate on CHIPSEN commercial firmware.

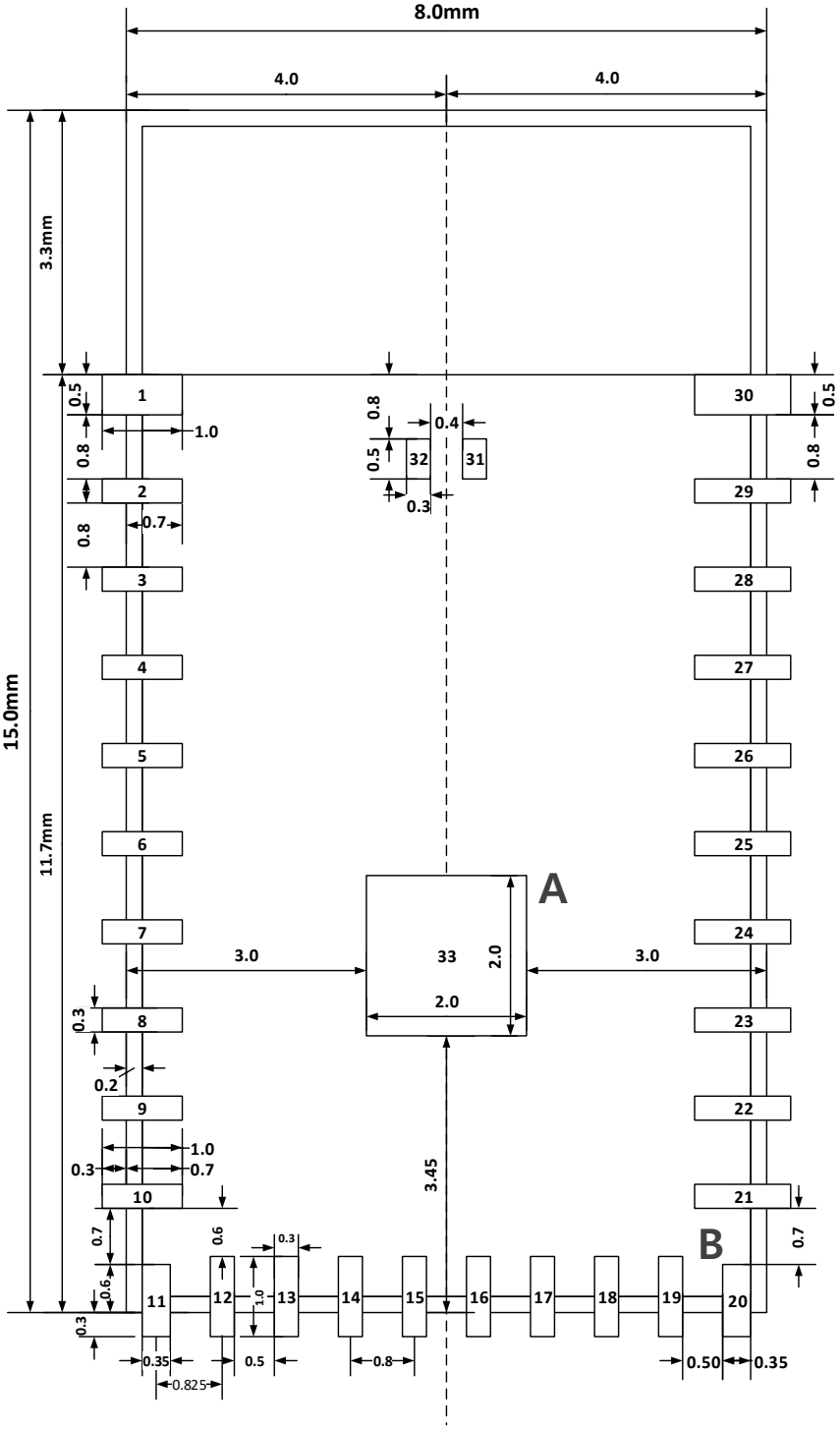
2) For more information refer to CHIPSEN commercial firmware document.

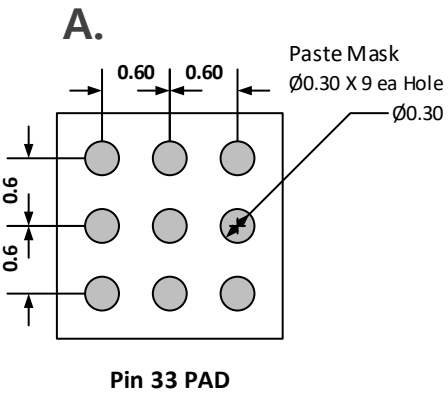
1.7 Dimensions



TOP VIEW

1.8 Land Pattern

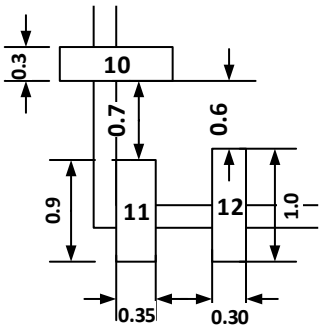




Pin 33 PAD

B.

(Caution) Be careful not to short-circuit pins 10-11 and 20-21 in PCB land pattern and paste mask design.



Land Pattern (TOP VIEW)

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2. Characteristics

2.1 Electrical Characteristics

▪ Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Units
VDD		-0.3	+3.9	V
GND			0	V
$V_{I/O}$, VDD≤3.6V		-0.3	VDD + 0.3	V
$V_{I/O}$, VDD >3.6V		-0.3	+3.9	V
Storage temperature		-40	+125	°C
Radio ra	RF Input Level		10	dBm
MSL	Moisture Sensitivity Level	2		
ESD HBM	Human Body Model		4	kV
ESD CDM	Charged Device Model		750	V
Endurance	Flash Memory Endurance	10000		write/erase cycles
Retention	Flash Memory Retention	10 years		At 85 °C

▪ Recommended Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Units
VDD	LDO Regulator Operation (Default Mode)	2.7	3.3	3.6	V
VDD	DC/DC Regulator Oprtation	2.7	3.3	3.6	V
$t_{R_}$VDD	Supply rise time (0V to 1.7V)			60	ms
TA	Operation temperature	-40	25	85	°C

▪ DC Characteristics

Symbol	Parameter (condition)	Min.	Typ.	Max.	Units
V_{IH}	Input high voltage	0.7 X VDD		VDD	V
V_{IL}	Input low voltage	VSS		0.3 X VDD	V
$V_{OH,SD}$	Output high voltage, standard drive, 0.5 mA, VDD ≥1.7	VDD-0.4		VDD	V
$V_{OH,HDH}$	Output high voltage, high drive, 5 mA, VDD ≥ 2.7 V	VDD-0.4		VDD	V
$V_{OH,HDL}$	Output high voltage, high drive, 3 mA, VDD ≥ 1.7 V	VDD-0.4		VDD	V
$V_{OL,SD}$	Output low voltage, standard drive, 0.5 mA, VDD ≥1.7	VSS		VSS +0.4	V
$V_{OL,HDH}$	Output low voltage, high drive, 5 mA, VDD ≥ 2.7 V	VSS		VSS +0.4	V
$V_{OL,HDL}$	Output low voltage, high drive, 3 mA, VDD ≥ 1.7 V	VSS		VSS +0.4	V
R_{PU}	Pull-up resistance	11	13	16	kΩ
R_{PD}	Pull-down resistance	11	13	16	kΩ
I_{TX},+4dBm,DCDC	TX only run current (DCDC, 3V) P_{RF}=+8 dBm		9.6		mA
I_{TX},+4dBm	TX only run current P_{RF}=+4 dBm		20.7		mA
I_{RX},1M,DCDC	RX only run current (DCDC, 3V) 1Msps		4.6		mA
I_{RX},1M	RX only run current 1Msps		9.6		mA
I_{RX},2M,DCDC	RX only run current (DCDC, 3V) 2Msps		5.2		mA
I_{RX},2M	RX only run current 2Msps		10.7		mA
$I_{ON\_RAMOFF\_EVENT}$	System ON, No RAM retention, Wake on any event		1.1		µA
$I_{ON\_RAMON\_EVENT}$	System ON, Full 128kB RAM retention, Wake on any event		1.8		µA
$I_{ON\_RAMON\_POF}$	System ON, Full 128kB RAM retention, Wake on any event, Power fail comparator enabled		1.9		µA
$I_{ON\_RAMON\_GPIOTE}$	System ON, Full 128kB RAM retention, Wake on GPIOTE input (Event mode)		7.4		µA
$I_{ON\_RAMON\_GPIOTEPORT}$	System ON, Full 128kB RAM retention, Wake on GPIOTE PORT event		1.8		µA
$I_{ON\_RAMON\_RTC}$	System ON, Full 24 kB RAM retention, Wake on RTC (running from LFRC clock)		1.5		µA
$I_{OFF\_RAMOFF\_RESET}$	System OFF, No RAM retention, Wake on reset		0.6		µA
$I_{OFF\_RAMON\_RESET}$	System OFF, Full 128kB RAM retention, Wake on reset		1.3		µA

2.2 RF Characteristics

Symbol	Description	Min.	Typ.	Max.	Units
f_{OP}	Operating frequencies	2360		2500	MHz
$f_{PLL,CH,SP}$	PLL channel spacing		1		MHz
$f_{DELTA,BLE,1M}$	Frequency deviation @ BLE 1Msps		±250		kHz
$f_{DELTA,BLE,2M}$	Frequency deviation @ BLE 2Msps		±320		kHz
P_{RF}	Maximum output power		0	7	dBm
P_{RFC}	RF power control range		28		dB
P_{RFCR}	RF power accuracy			±4	dB
$P_{RF1.1}$	1st Adjacent Channel Transmit Power 1 MHz (1		-25		dBc
$P_{RF2.1}$	2nd Adjacent Channel Transmit Power 2 MHz (1		-54		dBc
$P_{RF1.2}$	1st Adjacent Channel Transmit Power 2 MHz (2		-26		dBc
$P_{RF2.2}$	2nd Adjacent Channel Transmit Power 4 MHz (2		-54		dBc
$P_{RX,MAX}$	Maximum received signal strength at < 0.1% PER		0		dBm
$P_{SENS,IT,SP,1M,BLE}$	Sensitivity, 1Msps BLE ideal transmitter, <=37 bytes BER=1E-3		-93.5		dBm
$P_{SENS,IT,SP,2M,BLE}$	Sensitivity, 2Msps BLE ideal transmitter, <=37		-91		dBm
$RSSI_{ACC}$	RSSI Accuracy Valid range -90 to -20 dBm		±2		dB
$RSSI_{RESOLUTION}$	RSSI resolution		1		dB
$RSSI_{PERIOD}$	Sample period		8		us

2.3 Reference RF Measurement Report (Conduction)

31 RF test cases started: Wed Dec 29 18:55:22 2021

_____Output Power (TP/TRM-LE/CA/BV-01-C)

Initial conditions:

Test Method:	Test mode
Hopping:	off
Payload:	PRBS9
Payload's length:	37 bytes
Number of packets:	1
Path losses:	1.50dB

Limits:

-20.00dBm <= Pavg <= 10.00dBm, Ppk-av <= 3.00dB

Results (power in dBm):

#ch	f(MHz)	Pavg	Ppk	Ppk-av	Pmin	Verdict
0	2402	-0.62	-0.45	0.17	-0.81	PASSED
19	2440	-1.02	-0.85	0.17	-1.21	PASSED
39	2480	-1.54	-1.40	0.14	-1.74	PASSED

Test time: 1 sec.

_____In-band emissions (TP/TRM-LE/CA/BV-03-C)

Initial conditions:

Test Method:	Test mode
Payload:	PRBS9
Payload's length:	37 bytes
Number of sweeps:	10
Path losses:	1.50dB

Limits:

P[N]<=-20.00dBm if abs(M-N)=2,P[N]<=-30.00dBm if abs(M-N)>3,-30.00dBm<=P[i]<=-20.00dBm less then for 3 channels

Results:

freq=2406MHz (M=4), P[N] in dBm:

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-59.58	2422	-60.14	2443	-60.35	2464	-60.04
2402	-59.56	2423	-59.96	2444	-59.98	2465	-60.67
2403	-57.75	2424	-61.75	2445	-59.45	2466	-60.14
2404	-48.77	2425	-62.83	2446	-59.18	2467	-60.15
2405	-24.51	2426	-63.28	2447	-59.85	2468	-60.72
2406	-1.50	2427	-56.19	2448	-60.23	2469	-60.30
2407	-20.78	2428	-59.80	2449	-60.42	2470	-60.03
2408	-49.20	2429	-60.24	2450	-59.95	2471	-60.26
2409	-57.83	2430	-60.57	2451	-60.35	2472	-60.24
2410	-59.63	2431	-60.23	2452	-60.14	2473	-60.25
2411	-59.79	2432	-60.29	2453	-60.08	2474	-60.29
2412	-59.95	2433	-60.51	2454	-60.07	2475	-60.55
2413	-60.00	2434	-60.17	2455	-60.11	2476	-60.28
2414	-60.00	2435	-60.08	2456	-60.34	2477	-60.41
2415	-60.17	2436	-60.24	2457	-60.51	2478	-59.94
2416	-60.18	2437	-59.73	2458	-59.98	2479	-60.25
2417	-59.82	2438	-58.89	2459	-60.19	2480	-60.76
2418	-60.41	2439	-59.63	2460	-60.40	2481	-60.32
2419	-60.50	2440	-60.54	2461	-60.13		
2420	-60.37	2441	-60.27	2462	-60.27		
2421	-60.27	2442	-60.26	2463	-60.81		
					Verdict: PASSED		

freq=2440MHz (M=38), P[N] in dBm:

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-60.13	2422	-58.61	2443	-58.02	2464	-60.28
2402	-60.13	2423	-60.24	2444	-59.41	2465	-60.27
2403	-60.12	2424	-60.37	2445	-60.11	2466	-60.21
2404	-60.00	2425	-60.62	2446	-60.31	2467	-60.51
2405	-59.19	2426	-60.35	2447	-59.93	2468	-60.25
2406	-59.88	2427	-60.39	2448	-60.24	2469	-59.83

2407	-60.04	2428	-60.28	2449	-59.87	2470	-59.80
2408	-58.97	2429	-60.09	2450	-59.98	2471	-60.14
2409	-60.23	2430	-60.34	2451	-60.55	2472	-59.09
2410	-60.47	2431	-60.12	2452	-60.04	2473	-60.03
2411	-60.54	2432	-60.25	2453	-60.20	2474	-60.36
2412	-60.19	2433	-60.41	2454	-60.06	2475	-60.41
2413	-60.51	2434	-59.93	2455	-60.23	2476	-59.85
2414	-60.43	2435	-60.25	2456	-60.14	2477	-60.31
2415	-60.80	2436	-59.23	2457	-59.75	2478	-60.44
2416	-60.45	2437	-57.46	2458	-61.48	2479	-59.52
2417	-60.45	2438	-49.11	2459	-62.75	2480	-59.03
2418	-62.06	2439	-24.87	2460	-63.14	2481	-59.62
2419	-63.22	2440	-1.97	2461	-55.93		
2420	-61.47	2441	-21.16	2462	-60.06		
2421	-53.70	2442	-49.45	2463	-60.51		
					Verdict: PASSED		

freq=2476MHz (M=74), P[N] in dBm:

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-60.21	2422	-60.33	2443	-60.16	2464	-60.27
2402	-60.09	2423	-59.89	2444	-59.31	2465	-60.13
2403	-60.47	2424	-60.32	2445	-60.16	2466	-59.90
2404	-60.28	2425	-60.05	2446	-60.61	2467	-60.10
2405	-60.26	2426	-60.09	2447	-60.21	2468	-60.00
2406	-60.24	2427	-60.37	2448	-60.30	2469	-60.47
2407	-60.56	2428	-60.22	2449	-60.41	2470	-59.95
2408	-60.22	2429	-60.10	2450	-60.35	2471	-59.63
2409	-60.12	2430	-60.43	2451	-60.07	2472	-59.63
2410	-60.57	2431	-59.99	2452	-60.58	2473	-57.86
2411	-60.28	2432	-60.21	2453	-60.31	2474	-48.58
2412	-59.99	2433	-60.37	2454	-61.98	2475	-24.55
2413	-60.02	2434	-60.44	2455	-63.22	2476	-1.56
2414	-60.34	2435	-60.49	2456	-61.27	2477	-21.12
2415	-60.14	2436	-60.39	2457	-53.73	2478	-49.21
2416	-60.20	2437	-60.19	2458	-58.51	2479	-58.14
2417	-60.64	2438	-60.16	2459	-60.33	2480	-59.39
2418	-60.45	2439	-60.00	2460	-60.01	2481	-60.02
2419	-60.46	2440	-60.26	2461	-60.43		
2420	-60.41	2441	-59.21	2462	-60.39		
2421	-60.51	2442	-60.30	2463	-59.97		
					Verdict: PASSED		

Test time: 3 min. 5 sec.

_____Modulation Characteristics (TP/TRM-LE/CA/BV-05-C)

Initial conditions:

Test Method: Test mode
Hopping: off
Payload: 11110000 and 1010 bit patterns
Payload's length: 37 bytes
Number of packets: 10

Limits:

225.0KHz <= df1_avg <= 275.0KHz, df2_pass_rate >= 99.90%, df2/df1 >= 0.80

Results (frequency deviations in KHz):

#ch	f(MHz)	df1_avg	df2_avg	df2_min	df2_rate(%)	df2/df1	Verdict	
0	2402	258.2	253.8	229.6	100.00		0.98	PASSED
19	2440	258.1	254.8	222.7	100.00		0.99	PASSED
39	2480	258.5	257.4	230.8	100.00		1.00	PASSED

Test time: 3 sec.

_____Carrier frequency offset and drift (TP/TRM-LE/CA/BV-06-C)

Initial conditions:

Test Method: Test mode
Payload: 1010 bit pattern
Payload's length: 37 bytes

Number of packets: 10

Limits:

|fTX-f[n]| <= 150.0KHz, |f[0]-f[n]| <= 50.0KHz, |f[1]-f[0]| <= 23.0KHz, |f[n]-f[n-5]| <= 20.0KHz

Results (maximum of absolute values in KHz):

#ch	f(MHz)	fTX-f[n]	f[0]-f[n]	f[1]-f[0]	f[n]-f[n-5]	Verdict	
0	2402	17.1	-4.4	-3.1	3.2		PASSED
19	2440	17.2	-4.2	-1.9	4.2		PASSED
39	2480	17.5	-3.8	-2.1	3.5		PASSED

Test time:<1 sec.

_____In-band emissions at 2 Ms/s (TP/TRM-LE/CA/BV-08-C)

Initial conditions:

Test Method: Test mode
Payload: PRBS9
Payload's length: 31 bytes
Number of sweeps: 10
Path losses: 1.50dB

Limits:

P[N]<=-20.00dBm if abs(M-N)=4 or abs(M-N)= 5,P[N]<=-30.00dBm if abs(M-N)>6,-30.00dBm<=P[i]<=-20.00dBm less then for 3 channels

Results:

freq=2406MHz (M=4), P[N] in dBm:

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-59.44	2422	-60.45	2443	-60.63	2464	-60.12
2402	-58.66	2423	-60.05	2444	-60.14	2465	-60.60
2403	-52.89	2424	-62.95	2445	-60.36	2466	-60.44
2404	-38.62	2425	-63.42	2446	-60.01	2467	-59.96
2405	-13.66	2426	-63.62	2447	-60.28	2468	-60.34
2406	-5.05	2427	-56.05	2448	-60.16	2469	-60.88
2407	-13.89	2428	-59.98	2449	-60.59	2470	-59.82
2408	-37.79	2429	-60.50	2450	-60.05	2471	-60.05
2409	-53.39	2430	-60.20	2451	-60.48	2472	-60.50
2410	-58.89	2431	-60.44	2452	-60.65	2473	-60.26
2411	-60.04	2432	-60.39	2453	-60.08	2474	-59.63
2412	-59.63	2433	-60.48	2454	-60.18	2475	-59.98
2413	-60.10	2434	-60.44	2455	-60.12	2476	-60.31
2414	-60.08	2435	-60.03	2456	-60.34	2477	-59.87
2415	-60.13	2436	-60.24	2457	-60.82	2478	-60.01
2416	-60.11	2437	-60.13	2458	-60.15	2479	-60.40
2417	-60.16	2438	-59.90	2459	-60.03	2480	-60.26
2418	-60.55	2439	-60.08	2460	-60.85	2481	-59.63
2419	-60.24	2440	-60.29	2461	-60.04		
2420	-60.84	2441	-60.66	2462	-60.09		
2421	-60.13	2442	-59.96	2463	-60.70		

Verdict: PASSED

freq=2440MHz (M=38), P[N] in dBm:

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-60.57	2422	-58.68	2443	-53.20	2464	-60.41
2402	-60.30	2423	-60.21	2444	-58.89	2465	-60.01
2403	-59.99	2424	-59.76	2445	-59.75	2466	-60.31
2404	-59.72	2425	-60.37	2446	-59.57	2467	-60.23
2405	-60.18	2426	-60.24	2447	-59.87	2468	-60.20
2406	-60.18	2427	-60.34	2448	-60.32	2469	-60.49
2407	-59.75	2428	-60.33	2449	-59.99	2470	-60.18
2408	-59.35	2429	-60.31	2450	-59.87	2471	-60.04
2409	-60.54	2430	-60.29	2451	-60.41	2472	-59.64
2410	-59.98	2431	-59.86	2452	-60.22	2473	-59.77
2411	-59.91	2432	-59.92	2453	-60.10	2474	-60.07
2412	-60.58	2433	-59.64	2454	-59.93	2475	-60.82
2413	-60.89	2434	-59.72	2455	-60.28	2476	-60.11
2414	-60.82	2435	-60.17	2456	-59.99	2477	-60.29
2415	-60.24	2436	-59.70	2457	-60.07	2478	-60.08
2416	-60.24	2437	-54.72	2458	-62.76	2479	-59.91

2417	-60.65	2438	-40.93	2459	-63.55	2480	-59.94
2418	-62.25	2439	-16.33	2460	-63.62	2481	-60.32
2419	-63.50	2440	-7.19	2461	-56.83		
2420	-61.81	2441	-15.46	2462	-60.04		
2421	-54.32	2442	-38.42	2463	-59.88		
					Verdict: PASSED		

freq=2476MHz (M=74), P[N] in dBm:

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-60.33	2422	-60.38	2443	-60.28	2464	-59.74
2402	-59.80	2423	-60.48	2444	-60.28	2465	-60.18
2403	-59.87	2424	-60.88	2445	-59.95	2466	-60.10
2404	-59.94	2425	-60.42	2446	-60.23	2467	-60.13
2405	-60.01	2426	-60.78	2447	-60.66	2468	-60.17
2406	-59.95	2427	-61.13	2448	-60.26	2469	-60.00
2407	-60.54	2428	-60.37	2449	-59.63	2470	-60.03
2408	-60.36	2429	-60.29	2450	-60.79	2471	-58.96
2409	-60.85	2430	-60.43	2451	-60.83	2472	-58.91
2410	-60.55	2431	-59.98	2452	-60.06	2473	-53.23
2411	-60.88	2432	-60.07	2453	-60.36	2474	-39.10
2412	-60.33	2433	-60.68	2454	-62.31	2475	-14.37
2413	-60.27	2434	-60.90	2455	-63.30	2476	-6.92
2414	-60.42	2435	-60.49	2456	-61.87	2477	-16.23
2415	-60.13	2436	-60.20	2457	-55.16	2478	-39.80
2416	-60.10	2437	-59.73	2458	-58.90	2479	-54.64
2417	-59.87	2438	-60.22	2459	-59.97	2480	-59.59
2418	-60.37	2439	-60.61	2460	-60.83	2481	-59.97
2419	-60.74	2440	-60.60	2461	-60.06		
2420	-60.24	2441	-59.88	2462	-60.00		
2421	-60.29	2442	-59.73	2463	-60.60		
					Verdict: PASSED		

Test time: 3 min. 5 sec.

_____Modulation Characteristics at 2 Ms/s (TP/TRM-LE/CA/BV-10-C)

Initial conditions:

Test Method: Test mode
Hopping: off
Payload: 11110000 and 1010 bit patterns
Payload's length: 31 bytes
Number of packets: 10

Limits:

450.0KHz <= df1_avg <= 550.0KHz, df2_pass_rate >= 99.90%, df2/df1 >= 0.80

Results (frequency deviations in KHz):

#ch	f(MHz)	df1_avg	df2_avg	df2_min	df2_rate(%)	df2/df1	Verdict	
0	2402	483.5	443.4	399.4	100.00		0.92	PASSED
19	2440	485.5	446.8	396.5	100.00		0.92	PASSED
39	2480	492.7	451.8	407.6	100.00		0.92	PASSED

Test time: 4 sec.

_____Carrier frequency offset and drift at 2 Ms/s (TP/TRM-LE/CA/BV-12-C)

Initial conditions:

Test Method: Test mode
Payload: 1010 bit pattern
Payload's length: 31 bytes
Number of packets: 10

Limits:

|fTX-f[n]| <= 150.0KHz, |f[0]-f[n]| <= 50.0KHz, |f[1]-f[0]| <= 23.0KHz, |f[n]-f[n-5]| <= 20.0KHz

Results (maximum of absolute values in KHz):

#ch	f(MHz)	fTX-f[n]	f[0]-f[n]	f[1]-f[0]	f[n]-f[n-5]	Verdict	
0	2402	17.4	-5.0	-3.1	-2.8		PASSED
19	2440	18.2	-4.0	-3.6	4.1		PASSED
39	2480	18.0	4.0	2.8	-2.8		PASSED

Test time:<1 sec.

_____Modulation Characteristics LE Coded (S=8) (TP/TRM-LE/CA/BV-13-C)

Initial conditions:

Test Method:	Test mode
Hopping:	off
Payload:	11110000 bit pattern
Payload's length:	31 bytes
Number of packets:	10

Limits:

225.0KHz <= df1_avg <= 275.0KHz, df1_pass_rate >= 99.90%

Results (frequency deviations in kHz):

#ch	f(MHz)	df1_avg	df1_min	df1_rate(%)	Verdict	
0	2402	258.2	233.3	100.00		PASSED
19	2440	258.3	233.6	100.00		PASSED
39	2480	257.5	229.9	100.00		PASSED

Test time: 3 sec.

_____Carrier frequency offset and drift LE Coded (S=8) (TP/TRM-LE/CA/BV-14-C)

Initial conditions:

Test Method:	Test mode
Payload:	11110000 bit pattern
Payload's length:	31 bytes
Number of packets:	10

Limits:

|fTX-f[n]| <= 150.0KHz, |f[0]-f[n]| <= 50.0kHz, |f[0]-f[3]| <= 19.20kHz, |f[n]-f[n-3]| <= 19.20kHz

Results (maximum of absolute values in kHz):

#ch	f(MHz)	fTX-f[n]	f[0]-f[n]	f[0]-f[3]	f[n]-f[n-3]	Verdict	
0	2402	16.7	2.6	-1.1	16.7		PASSED
19	2440	17.1	2.7	-1.2	17.4		PASSED
39	2480	17.6	2.9	-1.7	17.1		PASSED

Test time: 3 sec.

_____Receiver sensitivity (TP/RCV-LE/CA/BV-01-C)

Initial conditions:

Test Method:	Test mode
Payload:	PRBS9
Payload's length:	37 bytes
Packets to transmit:	1500
RX (DUT) power:	-70.00dBm
Path losses:	1.50dB
Dirty TX mode:	On
PER limit mode:	Specification

Limits:

pkts_sent >= 1500, PER < 30.80%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 5 sec.

_____Maximum input signal level (TP/RCV-LE/CA/BV-06-C)

Initial conditions:

Test Method:	Test mode
Payload:	PRBS9
Payload's length:	37 bytes
Packets to transmit:	1500
RX (DUT) power:	-30.00dBm
Path losses:	1.50dB
PER limit mode:	Specification

Limits:

pkts_sent >= 1500, PER < 30.80%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED

39	2480	1500		1500	0.000	PASSED

Test time: 2 sec.

_____PER Report Integrity (TP/RCV-LE/CA/BV-07-C)

Initial conditions:

Test Method:	Test mode
Payload:	PRBS9
Payload's length:	37 bytes
Packets to transmit:	1500
RX (DUT) power:	-30.00dBm
Path losses:	1.50dB
PER limit mode:	Specification

Limits:

pkts_sent >= 1500, 50.00% <= PER <= 65.40%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		750		50.000	PASSED
19	2440	1500		750		50.000	PASSED
39	2480	1500		750		50.000	PASSED

Test time: 2 sec.

_____Receiver sensitivity at 2 Ms/s (TP/RCV-LE/CA/BV-08-C)

Initial conditions:

Test Method:	Test mode
Payload:	PRBS9
Payload's length:	31 bytes
Packets to transmit:	1500
RX (DUT) power:	-70.00dBm
Path losses:	1.50dB
Dirty TX mode:	On
PER limit mode:	Specification

Limits:

pkts_sent >= 1500, PER < 30.80%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 4 sec.

_____Maximum input signal level at 2 Ms/s (TP/RCV-LE/CA/BV-12-C)

Initial conditions:

Test Method:	Test mode
Payload:	PRBS9
Payload's length:	31 bytes
Packets to transmit:	1500
RX (DUT) power:	-10.00dBm
Path losses:	1.50dB
PER limit mode:	Specification

Limits:

pkts_sent >= 1500, PER < 30.80%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 3 sec.

_____PER Report Integrity at 2 Ms/s (TP/RCV-LE/CA/BV-13-C)

Initial conditions:

Test Method:	Test mode
Payload:	PRBS9
Payload's length:	31 bytes
Packets to transmit:	1500
RX (DUT) power:	-30.00dBm

Path losses: 1.50dB
PER limit mode: Specification
Limits:
pkts_sent >= 1500, 50.00% <= PER <= 65.40%
Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		750		50.000	PASSED
19	2440	1500		750		50.000	PASSED
39	2480	1500		750		50.000	PASSED

Test time: 3 sec.

_____Receiver Sensitivity uncoded data at 1 Ms/s Stable Modulation Index (TP/RCV-LE/CA/BV-14-C)

Initial conditions:
Test Method: Test mode
Payload: PRBS9
Payload's length: 37 bytes
Packets to transmit: 1500
RX (DUT) power: -70.00dBm
Path losses: 1.50dB
Dirty TX mode: On
PER limit mode: Specification
Limits:
pkts_sent >= 1500, PER < 30.80%
Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 4 sec.

_____Maximum input signal level uncoded data at 1 Ms/s Stable Modulation Index (TP/RCV-LE/CA/BV-18-C)

Initial conditions:
Test Method: Test mode
Payload: PRBS9
Payload's length: 37 bytes
Packets to transmit: 1500
RX (DUT) power: -10.00dBm
Path losses: 1.50dB
PER limit mode: Specification
Limits:
pkts_sent >= 1500, PER < 30.80%
Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 3 sec.

_____PER Report Integrity uncoded data at 1 Ms/s Stable Modulation Index (TP/RCV-LE/CA/BV-19-C)

Initial conditions:
Test Method: Test mode
Payload: PRBS9
Payload's length: 37 bytes
Packets to transmit: 1500
RX (DUT) power: -30.00dBm
Path losses: 1.50dB
PER limit mode: Specification
Limits:
pkts_sent >= 1500, 50.00% <= PER <= 65.40%
Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		750		50.000	PASSED
19	2440	1500		750		50.000	PASSED
39	2480	1500		750		50.000	PASSED

Test time: 3 sec.

_____Receiver sensitivity at 2 Ms/s Stable Modulation Index (TP/RCV-LE/CA/BV-20-C)

Initial conditions:

Test Method:	Test mode	
Payload:	PRBS9	
Payload's length:	31 bytes	
Packets to transmit:	1500	
RX (DUT) power:		-70.00dBm
Path losses:	1.50dB	
Dirty TX mode:		On
PER limit mode:		Specification

Limits:

pkts_sent >= 1500, PER < 30.80%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 4 sec.

_____Maximum input signal level at 2 Ms/s Stable Modulation Index (TP/RCV-LE/CA/BV-24-C)

Initial conditions:

Test Method:	Test mode	
Payload:	PRBS9	
Payload's length:	31 bytes	
Packets to transmit:	1500	
RX (DUT) power:		-10.00dBm
Path losses:	1.50dB	
PER limit mode:		Specification

Limits:

pkts_sent >= 1500, PER < 30.80%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 3 sec.

_____PER Report Integrity at 2 Ms/s Stable Modulation Index (TP/RCV-LE/CA/BV-25-C)

Initial conditions:

Test Method:	Test mode	
Payload:	PRBS9	
Payload's length:	31 bytes	
Packets to transmit:	1500	
RX (DUT) power:		-30.00dBm
Path losses:	1.50dB	
PER limit mode:		Specification

Limits:

pkts_sent >= 1500, 50.00% <= PER <= 65.40%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		750		50.000	PASSED
19	2440	1500		750		50.000	PASSED
39	2480	1500		750		50.000	PASSED

Test time: 3 sec.

_____Receiver sensitivity LE Coded (S=2) (TP/RCV-LE/CA/BV-26-C)

Initial conditions:

Test Method:	Test mode	
Payload:	PRBS9	
Payload's length:	31 bytes	
Packets to transmit:	1500	
RX (DUT) power:		-75.00dBm
Path losses:	1.50dB	

Dirty TX mode: On
PER limit mode: Specification
Limits:
pkts_sent >= 1500, PER < 30.80%
Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 7 sec.
_____Receiver sensitivity LE Coded (S=8) (TP/RCV-LE/CA/BV-27-C)
Initial conditions:
Test Method: Test mode
Payload: PRBS9
Payload's length: 31 bytes
Packets to transmit: 1500
RX (DUT) power: -80.00dBm
Path losses: 1.50dB
Dirty TX mode: On
PER limit mode: Specification
Limits:
pkts_sent >= 1500, PER < 30.80%
Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 15 sec.
_____PER Report Integrity LE Coded (S=2) (TP/RCV-LE/CA/BV-30-C)
Initial conditions:
Test Method: Test mode
Payload: PRBS9
Payload's length: 31 bytes
Packets to transmit: 1500
RX (DUT) power: -30.00dBm
Path losses: 1.50dB
PER limit mode: Specification
Limits:
pkts_sent >= 1500, 50.00% <= PER <= 65.40%
Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		750		50.000	PASSED
19	2440	1500		750		50.000	PASSED
39	2480	1500		750		50.000	PASSED

Test time: 6 sec.
_____PER Report Integrity LE Coded (S=8) (TP/RCV-LE/CA/BV-31-C)
Initial conditions:
Test Method: Test mode
Payload: PRBS9
Payload's length: 31 bytes
Packets to transmit: 1500
RX (DUT) power: -30.00dBm
Path losses: 1.50dB
PER limit mode: Specification
Limits:
pkts_sent >= 1500, 50.00% <= PER <= 65.40%
Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		750		50.000	PASSED
19	2440	1500		750		50.000	PASSED
39	2480	1500		750		50.000	PASSED

Test time: 14 sec.

_____Receiver sensitivity LE Coded (S=2) Stable Modulation Index (TP/RCV-LE/CA/BV-32-C)

Initial conditions:

Test Method:	Test mode	
Payload:	PRBS9	
Payload's length:	31 bytes	
Packets to transmit:	1500	
RX (DUT) power:	-75.00dBm	
Path losses:	1.50dB	
Dirty TX mode:	On	
PER limit mode:	Specification	

Limits:

pkts_sent >= 1500, PER < 30.80%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 7 sec.

_____Receiver sensitivity LE Coded (S=8) Stable Modulation Index (TP/RCV-LE/CA/BV-33-C)

Initial conditions:

Test Method:	Test mode	
Payload:	PRBS9	
Payload's length:	31 bytes	
Packets to transmit:	1500	
RX (DUT) power:	-80.00dBm	
Path losses:	1.50dB	
Dirty TX mode:	On	
PER limit mode:	Specification	

Limits:

pkts_sent >= 1500, PER < 30.80%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		1500		0.000	PASSED
19	2440	1500		1500		0.000	PASSED
39	2480	1500		1500		0.000	PASSED

Test time: 16 sec.

_____PER Report Integrity LE Coded (S=2) Stable Modulation Index (TP/RCV-LE/CA/BV-36-C)

Initial conditions:

Test Method:	Test mode	
Payload:	PRBS9	
Payload's length:	31 bytes	
Packets to transmit:	1500	
RX (DUT) power:	-30.00dBm	
Path losses:	1.50dB	
PER limit mode:	Specification	

Limits:

pkts_sent >= 1500, 50.00% <= PER <= 65.40%

Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		750		50.000	PASSED
19	2440	1500		750		50.000	PASSED
39	2480	1500		750		50.000	PASSED

Test time: 6 sec.

_____PER Report Integrity LE Coded (S=8) Stable Modulation Index (TP/RCV-LE/CA/BV-37-C)

Initial conditions:

Test Method:	Test mode	
Payload:	PRBS9	
Payload's length:	31 bytes	
Packets to transmit:	1500	
RX (DUT) power:	-30.00dBm	

Path losses: 1.50dB
PER limit mode: Specification
Limits:
pkts_sent >= 1500, 50.00% <= PER <= 65.40%
Results:

#ch	f(MHz)	pkts_sent	pkts_rcvd	PER(%)	Verdict		
0	2402	1500		750		50.000	PASSED
19	2440	1500		750		50.000	PASSED
39	2480	1500		750		50.000	PASSED

Test time: 14 sec.
_____Quick (Output Power + Modulation Characteristics + Carrier Frequency Offset Drift)
Initial conditions:
Test Method: Test mode
Hopping: off
Payload: 11110000 and 1010 bit patterns
Payload's length: 37 bytes
Number of packets: 2
Path losses: 1.50dB
Limits:
-20.00dBm < Pavg < 10.00dBm, Ppk-av < 3.00dB
df0_max <= 150.0 KHz, df0_min >= -150.0 KHz
|fTX-f[n]| <= 150.0KHz, |f[0]-f[n]| <= 50.0KHz, |f[1]-f[0]| <= 23.0KHz, |f[n]-f[n-5]| <= 20.0KHz
225.0KHz <= df1_avg <= 275.0KHz, df2_pass_rate >= 99.90%, df2/df1 >= 0.80
Results (power in dBm, frequency offsets in KHz):

#ch	f(MHz)	Pavg	Ppk	Ppk-av	Pmin	df0_max	df0_min
0	2402	-0.60	0.09	0.69	-1.47	17.0	16.2
19	2440	-1.18	-0.49	0.69	-2.08	16.2	15.8
39	2480	-1.58	-0.85	0.73	-2.56	16.6	16.5

Results (maximum of absolute values in KHz):

#ch	f(MHz)	fTX-f[n]	f[0]-f[n]	f[1]-f[0]	f[n]-f[n-5]
0	2402	17.0	-2.8	-2.8	2.5
19	2440	17.4	-1.7	1.2	-2.5
39	2480	17.8	-2.2	-1.1	2.6

Results (frequency deviations in KHz):

#ch	f(MHz)	df1_avg	df2_avg	df2_min	df2_rate(%)	df2/df1	Verdict	
0	2402	257.7	253.6	229.7	100.00		0.98	PASSED
19	2440	257.8	255.6	234.5	100.00		0.99	PASSED
39	2480	258.8	257.5	230.9	100.00		0.99	PASSED

Test time: 2 sec.
_____Carr freq offset + Mod char (preamble)
Initial conditions:
Test Method: Test mode
Hopping: off
Payload's length: 37 bytes
Number of packets: 2
Limits:
df0_max <= 150.0 KHz, df0_min >= -150.0 KHz
df2_avg >= 185.0KHz, df2_min >= 92.5KHZ
Results (frequency offsets and deviations in KHz):

#ch	f(MHz)	df0_max	df0_min	df0_avg	df2_avg	df2_min	Verdict
0	2402	19.1	16.8	17.9	252.0	238.0	PASSED
19	2440	16.8	16.0	16.4	254.7	239.4	PASSED
39	2480	17.0	16.3	16.6	261.3	250.2	PASSED

Test time: 1 sec.
31 RF test cases completed: Wed Dec 29 19:03:56 2021

3. Power and clock management

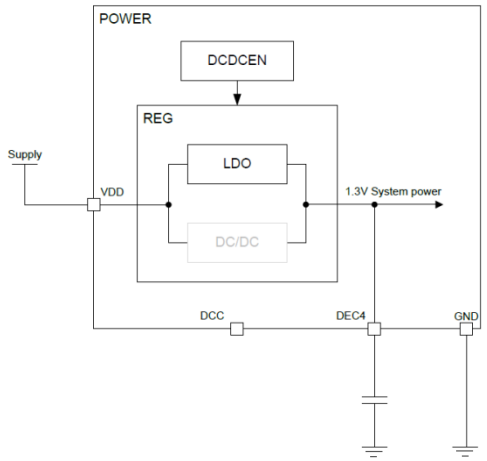
3.1 Regulator

The following internal power regulator alternatives are supported:

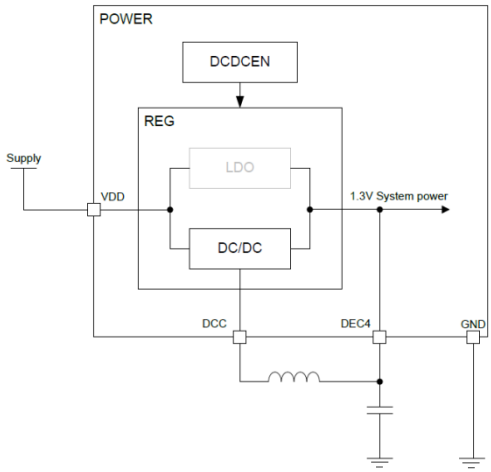
- Internal LDO regulator
- Internal DC/DC converter

The LDO is the default regulator.

Using the DC/DC regulator will reduce current consumption compared to when using the LDO regulator, but the DC/DC regulator requires an external LC filter to be connected, as shown in Figure.



LDO Regulator Setup



DC/DC Regulator Setup

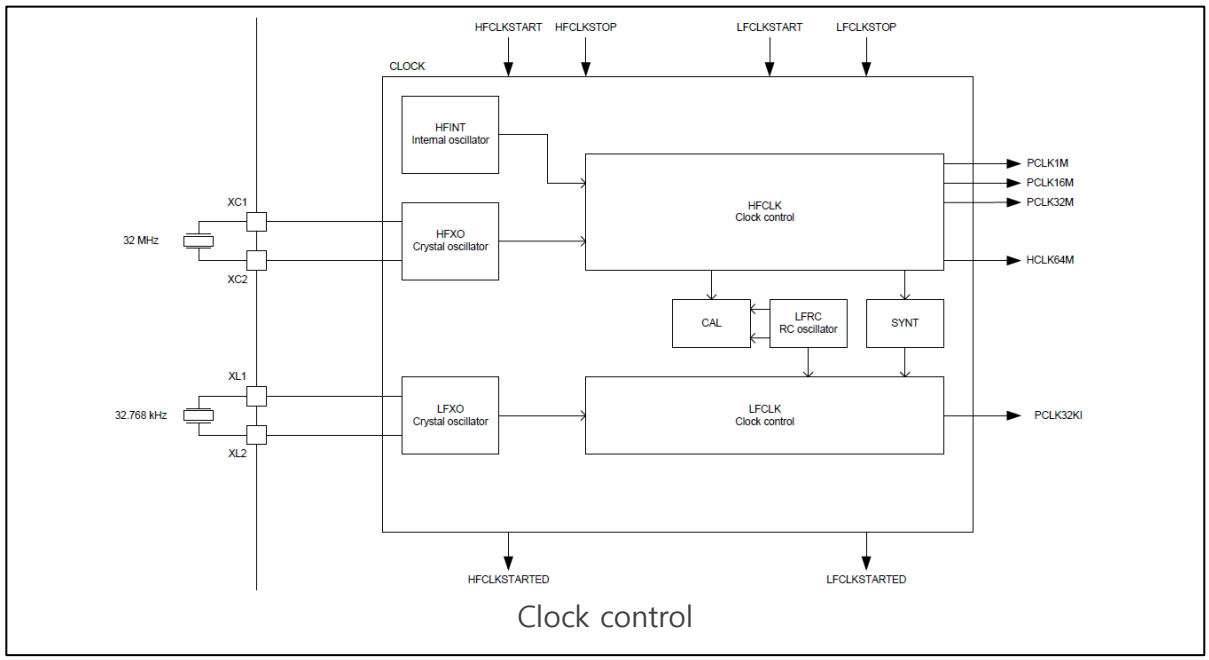
3.2 32.768KHz Crystal Oscillator

The BoT-nLE523 external 32.768KHz Crystal does not required for BLE mode

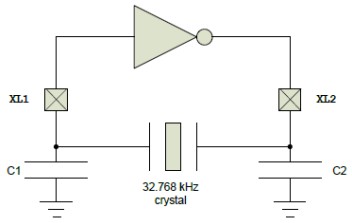
If you choose to use an internal 32.768kHz oscillator, an average of 10uA of current is consumed compared to an external crystal.

The ANT specification requires ± 50ppm accuracy for a 32.768kHz clock. The internal 32.768kHz oscillator may not meet specifications.

BoT-nLE523 F/W does not yet support ANT Mode.



Clock control



Circuit diagram of the 32.768 kHz crystal oscillator

The load capacitance (CL) is the total capacitance seen by the crystal across its terminals and is given by:

$$CL = \frac{(C1' \cdot C2')}{(C1' + C2')}$$

$$C1' = C1 + C_{pcb1} + C_{pin}$$
$$C2' = C2 + C_{pcb2} + C_{pin}$$

C1 and C2 are ceramic SMD capacitors connected between each crystal terminal and ground.

Cpcb1 and Cpcb2 are stray capacitances on the PCB.

▪ 32.768 kHz RC oscillator (LFRC)

Symbol	Description	Min.	Typ.	Max.	Units
f_{NOM_LFRC}	Nominal frequency		32.768		kHz
f_{TOL_LFRC}	Frequency tolerance		±2		%
$f_{TOL\_CAL\_LFRC}$	Frequency tolerance for LFRC after calibration		±500		ppm

▪ 32.768 kHz crystal oscillator (LFXO)

Symbol	Description	Min.	Typ.	Max.	Units
f_{NOM_LFXO}	Crystal frequency		32.768		kHz
$f_{TOL\_LFXO\_BLE}$	Frequency tolerance requirement for BLE stack		±250		ppm
$f_{TOL\_LFXO\_ANT}$	Frequency tolerance requirement for ANT stack		±50		ppm
C_{L_LFXO}	Load capacitance			12.5	pF
C_{0_LFXO}	Shunt capacitance			2	pF
R_{S_LFXO}	Equivalent series resistance			100	kohm
P_{D_LFXO}	Drive level			1	uW
C_{pin}	Input capacitance on XL1 and XL2 pads		4		pF

4. Power Consumption

UART State / BoT State	UART ON[1]	UART OFF[2]		
		Internal Pull-Down	External Pull-Down 470K **Make internal pull-x register to no-pull state using "AT+INTPULLDOWN=OFF" command	Internal Pull-Down & External Pull-Down 470K
Advertising	755uA	266uA	**25uA**	272uA
Connected	1.06mA	609uA	**383uA**	616uA
Sleep[3]	N/A	235uA	**7uA**	242uA

1) : PAD#23(P13, UART ON/OFF control) signal level LOW
2) : PAD#23(P13, UART ON/OFF control) signal level HIGH
3) : PAD#19(P10, ENTER_SLEEP/WAKE_UP control) signal level HIGH

<Measure condition>

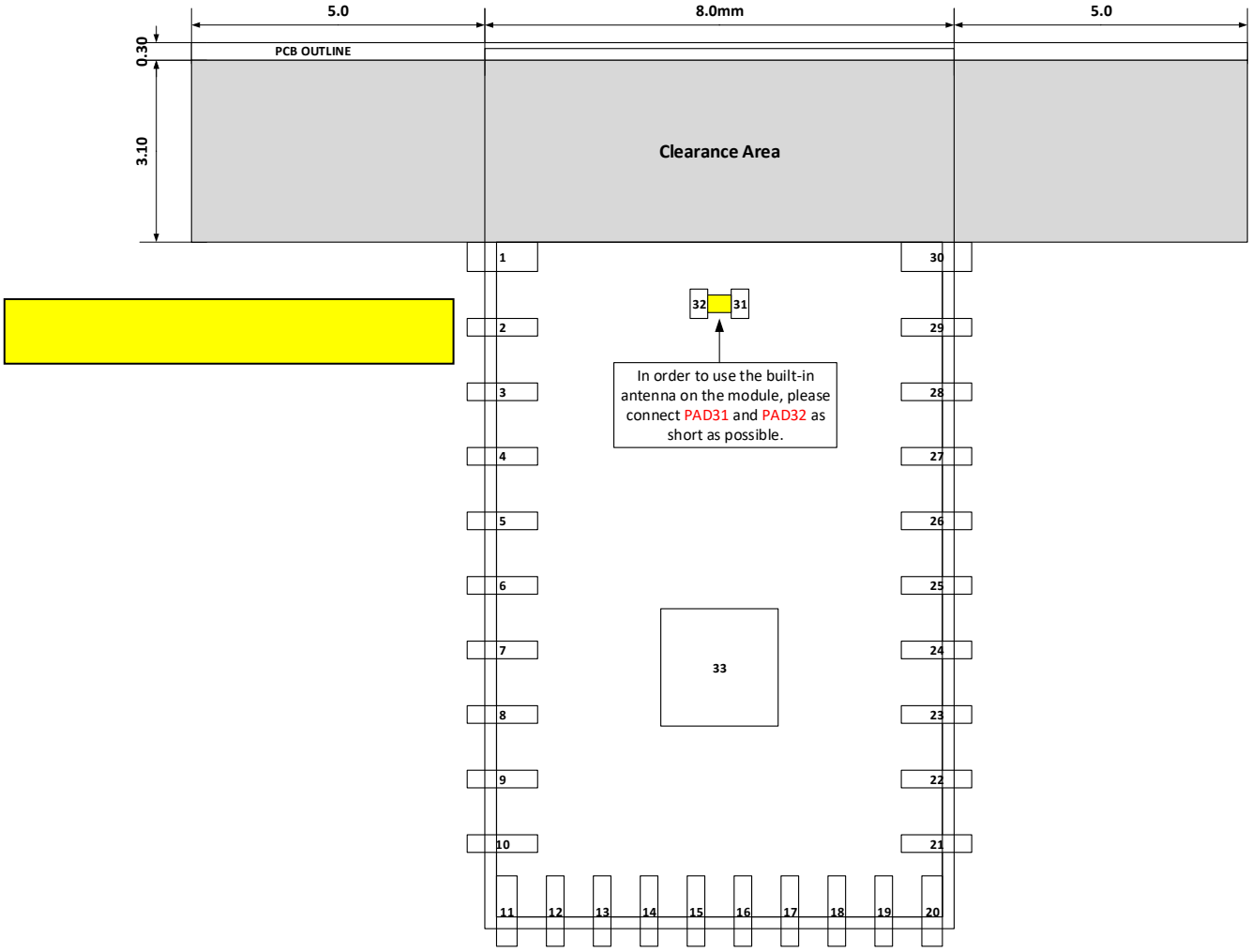
- Firmware : CHIPSEN Standard firmware / over V0.9.0
- Test role : Server role
- Test phone : Samsung Galaxy S8+
- Software setting : Default

<Notice>

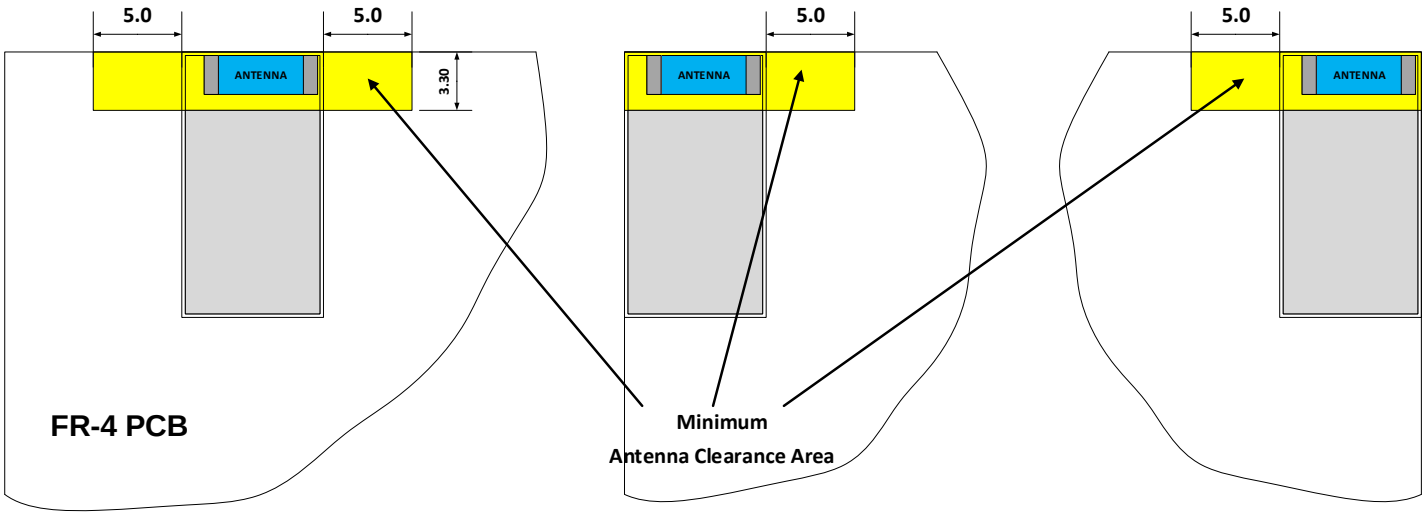
- Power consumption can be change by customer's hardware or(and) software design
- Not recommended to operate UART OFF in Sleep. it makes increase power consumption

5. Antenna

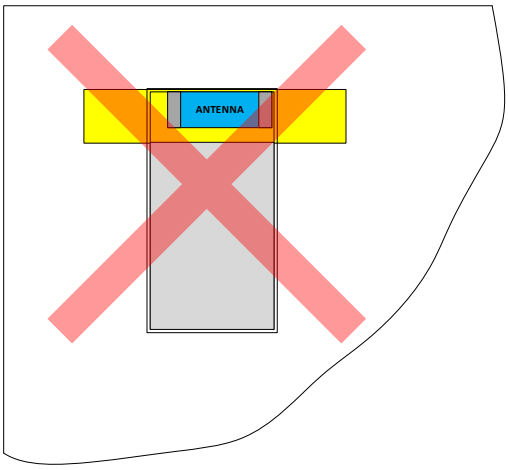
5.1 Antenna Layout Guide



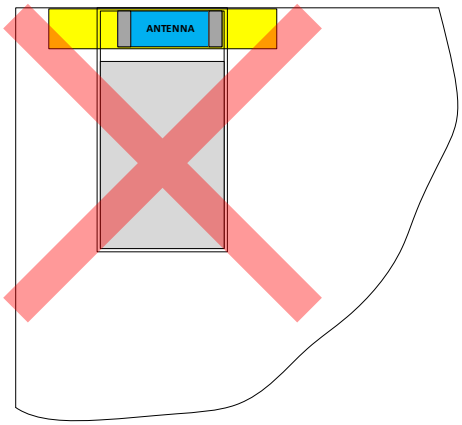
5.2 Recommended Module Mounting



Recommended Module Mounting Example



Antenna 영역을 GND가 둘러싸고 있는 형태

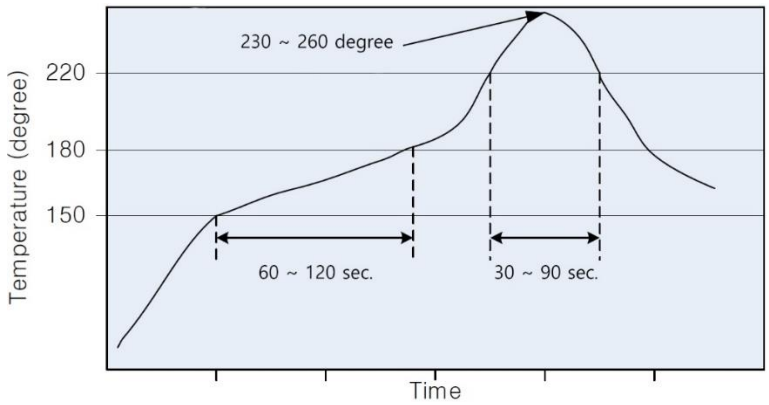


Antenna 영역을 크기를 임의로 조정 또는
Antenna 영역에 GND가 겹치는 형태

Wrong Module Mounting Example

6. Reflow Temperature Profiles

Recommended solder reflow profile are shown in below and follow the lead-free profile I accordance with JEDEC Std 20C.
Table lists the critical reflow temperatures.
Flux residue remaining from board assembly can contribute to electrochemical migration over time.
This depends on number of factors, including flux type, amount of flux residue remaining after reflow, and stress conditions during product use, such as temperature, humidity, and potential difference between pins.
Care should be taken in selecting production board/module assembly processes and materials, taking into account these factors.



Process Step	Lead-Free Solder
Ramp rate	3°C/sec
Preheat	Max. 150°C to 180°C, 60 to 180 sec
Time above liquidus	+220°C 30 to 90 sec
Peak temperature	+255°C ±5°C
Time within 5°C of peak temperature	10 to 20 sec
Ramp-down rate	6°C/sec max

WARNING : For BoT-nLE523
If you have reflow process multiple times in your product, you must be proceed this module in the final reflow process. If not the Shield can will drop out if shield-can adopted.

7. Certifications

This section details the regulatory certification status of BoT-nLE523 modules in various regions.

7.1 Qualified Antennas

BoT-nLE523 modules have been tested and certified both with the built-in antenna and with an external antenna attached to the RF pin. Please contact to manufacture for details for the qualified antenna.

Any antenna of the same general type and of equal or less directional gain as listed in BoT-nLE523 Tested Report can be used in the regulatory areas that have a full modular radio approval (Korea, Japan, USA and EU) as long as spot-check testing is performed to verify that no performance changes compromising compliance have been introduced. In countries applying the ETSI standards, like the EU countries, the radiated emissions are always tested with the end-product and the antenna type is not critical, but antennas with higher gain may violate some of the regulatory limits.

If an antenna of a different type (such as a chip antenna, a PCB trace antenna or a patch) with a gain less than or equal to qualified antennas is needed, it can be added as a permissive change, requiring some radiated emission testing. Antenna types with more gain than qualified antennas may require a fully new certification. Since the exact permissive change procedure is chosen on a case by case basis, please consult your test house and/or certification body for understanding the correct approach. You might also want or need to get in touch with manufacture for any authorization letter that your certification body might ask for.

7.2 JAPAN-MIC

The BoT-nLE523 is certified in Japan.

Since September 1, 2014 it is allowed (and highly recommended) that a manufacturer who integrates a radio module in their host equipment places the certification mark and certification number on the outside of the host equipment. This combination of mark and number, and their relative placement, is depicted in Figure, and depending on the size of the module it might also appear on the top shield markings of the radio module. The certification mark and certification number must be placed close to the text in the Japanese language which is provided below. This change in the Radio Law has been made in order to enable users of the combination of host and radio module to verify if they are actually using a radio device which is approved for use in Japan.

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

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

Translation of the text:

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

The "Giteki" marking shown in the following figures must be affixed to an easily noticeable section of the specified radio-enabled host equipment. Note that such section may be required to contain additional information if the end-device embedding the module is also subject to a telecom approval.

The manufacturer of the final product is also responsible to provide a Japanese language version

of the User Manual and/or Installation Instructions as a companion document coming with the final product when placed on the market in Japan.

7.3 CE

The BoT-nLE523 modules have been tested against the relevant harmonized/designated standards and are in conformity with the essential requirements and other relevant requirements of the Radio Equipment Directive (RED) (2014/53/EU) and of the Radio Equipment Regulations (RER) (S.I. 2017/1206).

Please notice that every end-product integrating a BoT-nLE523 module will need to perform the radio EMC tests on the whole assembly, according to the ETSI 301 489-x relevant standards. Furthermore, it is ultimately the responsibility of the manufacturer to ensure the compliance of the end-product as a whole. The specific product assembly is likely to have an impact to RF radiated characteristics, when compared to the bare module. Hence, manufacturers should carefully consider RF radiated testing with the final product assembly, especially taking into account the gain of the external antenna if any, and the possible deviations in the PSD, EIRP and spurious emissions measurements, as defined in the ETSI 300 328 standard.

The modules are entitled to carry the CE and UKCA Marks, and a formal Declaration of Conformity (DoC) is available at the product manufacture web page.

7.4 FCC

FCC MODULAR APPROVAL INFORMATION EXAMPLES for Manual

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.

(2) This device must accept any interference received, including interference that may cause undesired operation.

CAUTION: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B 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 radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

OEM INTEGRATION INSTRUCTIONS:

This device is intended only for OEM integrators under the following conditions:

The transmitter module may not be co-located with any other transmitter or antenna. The module shall be only used with the internal on-board antenna that has been originally tested and certified with this module. External antennas are not supported. As long as these 3 conditions above are met, further transmitter test will not be required.

However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.). The end-product may need Verification testing, Declaration of Conformity testing, a Permissive Class II Change or new Certification. Please involve a FCC certification specialist in order to determine what will be exactly applicable for the end-product.

Validity of using the module certification:
In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization for this module in combination with the host equipment is no longer considered valid and the FCC ID of the module cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization. In such cases, please involve a FCC certification specialist in order to determine if a Permissive Class II Change or new Certification is required.

Upgrade Firmware:
The software provided for firmware upgrade will not be capable to affect any RF parameters as certified for the FCC for this module, in order to prevent compliance issues.

End product labeling:
The final end product must be labeled in a visible area with the following: “Contains FCC ID: 2APB6-BOT-NLE523”.

Information that must be placed in the end user manual:
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/warning as show in this manual.

WARNING
Changes or modifications not expressly approved by the manufacturer could void the user’s authority to operate the equipment.

CAUTION: Exposure to Radio Frequency Radiation.
Antenna shall be mounted in such a manner to minimize the potential for human contact during normal operation. The antenna should not be contacted during operation to avoid the possibility of exceeding the FCC radio frequency exposure limit.

Requirement per KDB996369 D03
List of applicable FCC rules
List the FCC rules that are applicable to the modular transmitter. These are the rules that specifically establish the bands of operation, the power, spurious emissions, and operating fundamental frequencies.
Explanation: This module meets the requirements of FCC part 15C(15.247)

Summarize the specific operational use conditions
Describe use conditions that are applicable to the modular transmitter, including for example any limits on antennas, etc. For example, if point-to-point antennas are used that require reduction in power or compensation for cable loss, then this information must be in the instructions. If the use condition limitations extend to professional users, then instructions must state that this information also extends to the host manufacturer’s instruction manual. In addition, certain information may also be needed, such as peak gain per frequency band and minimum gain, specifically for master devices in 5 GHz DFS bands.
Explanation: The EUT has a Chip Antenna, and the antenna use a permanently attached antenna which is not replaceable.

Limited module procedures
If a modular transmitter is approved as a “limited module,” then the module manufacturer is responsible for approving the host environment that the limited module is used with. The manufacturer of a limited module must describe, both in the filing and in the installation instructions, the alternative means that the limited module manufacturer uses to verify that the host meets the necessary requirements to satisfy the module limiting conditions.
A limited module manufacturer has the flexibility to define its alternative method to address the conditions that limit the initial approval, such as: shielding, minimum signaling amplitude, buffered modulation/data inputs, or power supply regulation. The alternative method could include that the limited module manufacturer reviews detailed test data or host designs prior to giving the host manufacturer approval.

This limited module procedure is also applicable for RF exposure evaluation when it is necessary to demonstrate compliance in a specific host. The module manufacturer must state how control of the product into which the modular transmitter will be installed will be maintained such that full compliance of the product is always ensured. For additional hosts other than the specific host originally granted with a limited module, a Class II permissive change is required on the module grant to register the additional host as a specific host also approved with the module.
Explanation: The Module is not a limited module.

Trace antenna designs
For a modular transmitter with trace antenna designs, see the guidance in Question 11 of KDB Publication 996369 D02 FAQ – Modules for Micro-Strip Antennas and traces. The integration information shall include for the TCB review the integration instructions for the following aspects:
layout of trace design, parts list (BOM), antenna, connectors, and isolation requirements.
a) Information that includes permitted variances (e.g., trace boundary limits, thickness, length, width, shape(s), dielectric constant, and impedance as applicable for each type of antenna);
b) Each design shall be considered a different type (e.g., antenna length in multiple(s) of frequency, the wavelength, and antenna shape (traces in phase) can affect antenna gain and must be considered);
c) The parameters shall be provided in a manner permitting host manufacturers to design the printed circuit (PC) board layout;
d) Appropriate parts by manufacturer and specifications;
e) Test procedures for design verification; and
f) Production test procedures for ensuring compliance.
The module grantee shall provide a notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify the module grantee that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the grantee, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.
Explanation: Yes, The module with trace antenna designs, and This manual has been shown the layout of trace design, antenna, connectors, and isolation requirements.

RF exposure considerations
It is essential for module grantees to clearly and explicitly state the RF exposure conditions that permit a host product manufacturer to use the module. Two types of instructions are required for RF exposure information: (1) to the host product manufacturer, to define the application conditions (mobile, portable – xx cm from a person's body); and (2) additional text needed for the host product manufacturer to provide to end users in their end-product manuals. If RF exposure statements and use conditions are not provided, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID (new application).
Explanation: This module complies with FCC RF radiation exposure limits set forth for an uncontrolled environment.
This module is designed to comply with the FCC statement, FCC ID is: 2APB6-BOT-NLE523.

Antennas
A list of antennas included in the application for certification must be provided in the instructions. For modular transmitters approved as limited modules, all applicable professional installer instructions must be included as part of the information to the host product manufacturer. The antenna list shall also identify the antenna types (monopole, PIFA, dipole, etc. (note that for example an "omni-directional antenna" is not considered to be a specific "antenna type")
For situations where the host product manufacturer is responsible for an external connector, for example with an RF pin and antenna trace design, the integration instructions shall inform the installer that unique antenna connector must be used on the Part 15 authorized transmitters used in the host product. The module manufacturers shall provide a list of acceptable unique connectors.
Explanation: The EUT has a Chip Antenna, and the antenna use a permanently attached antenna which is unique.

Label and compliance information
Grantees are responsible for the continued compliance of their modules to the FCC rules. This includes advising host product manufacturers that they need to provide a physical or e-label stating “Contains FCC ID” with their finished product. See Guidelines for Labeling and User Information for RF Devices – KDB Publication 784748.
Explanation: The host system using this module, should have label in a visible area indicated the following texts: "Contains FCC ID: 2APB6-BOT-NLE523.”

Information on test modes and additional testing requirements
Additional guidance for testing host products is given in KDB Publication 996369 D04 Module Integration Guide. Test modes should take into consideration different operational conditions for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product.
The grantee should provide information on how to configure test modes for host product evaluation for different operational conditions for a stand-alone modular transmitter in a host, versus with multiple, simultaneously transmitting modules or other transmitters in a host.
Grantees can increase the utility of their modular transmitters by providing special means, modes, or instructions that simulates or characterizes a connection by enabling a transmitter. This can greatly simplify a host manufacturer’s determination that a module as installed in a host complies with FCC requirements.
Explanation: Top band can increase the utility of our modular transmitters by providing instructions that simulates or characterizes a connection by enabling a transmitter.

Additional testing, Part 15 Subpart B disclaimer
The grantee should include a statement that 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. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.
Explanation: The module without unintentional-radiator digital circuity, so the module does not require an evaluation by FCC Part 15 Subpart B. The host shoule be evaluated by the FCC Subpart B.

7.5 KC

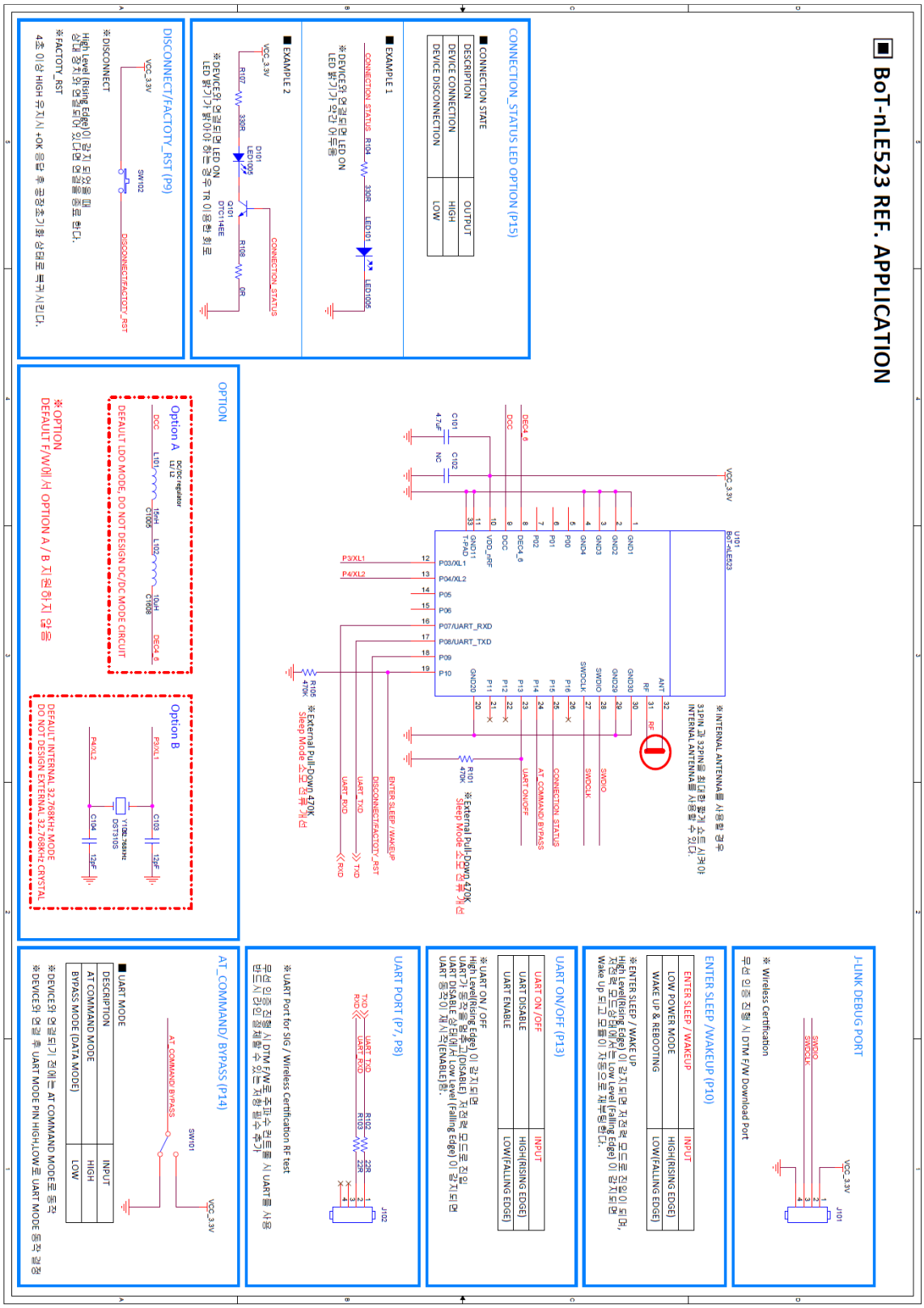
The BoT-nLE523 have a RF certification for import and use in South Korea. Their certification number is ***R-R-csi-BoT-nLE523***. When integrating the RF-certified module, an end-product is exempted from doing the RF emission testing as long as the recommended design guidance is followed, and the approved antennas are used. EMC testing, and any other relevant tests, might still be required for full compliance.

8. Application Schematic

Design consideration

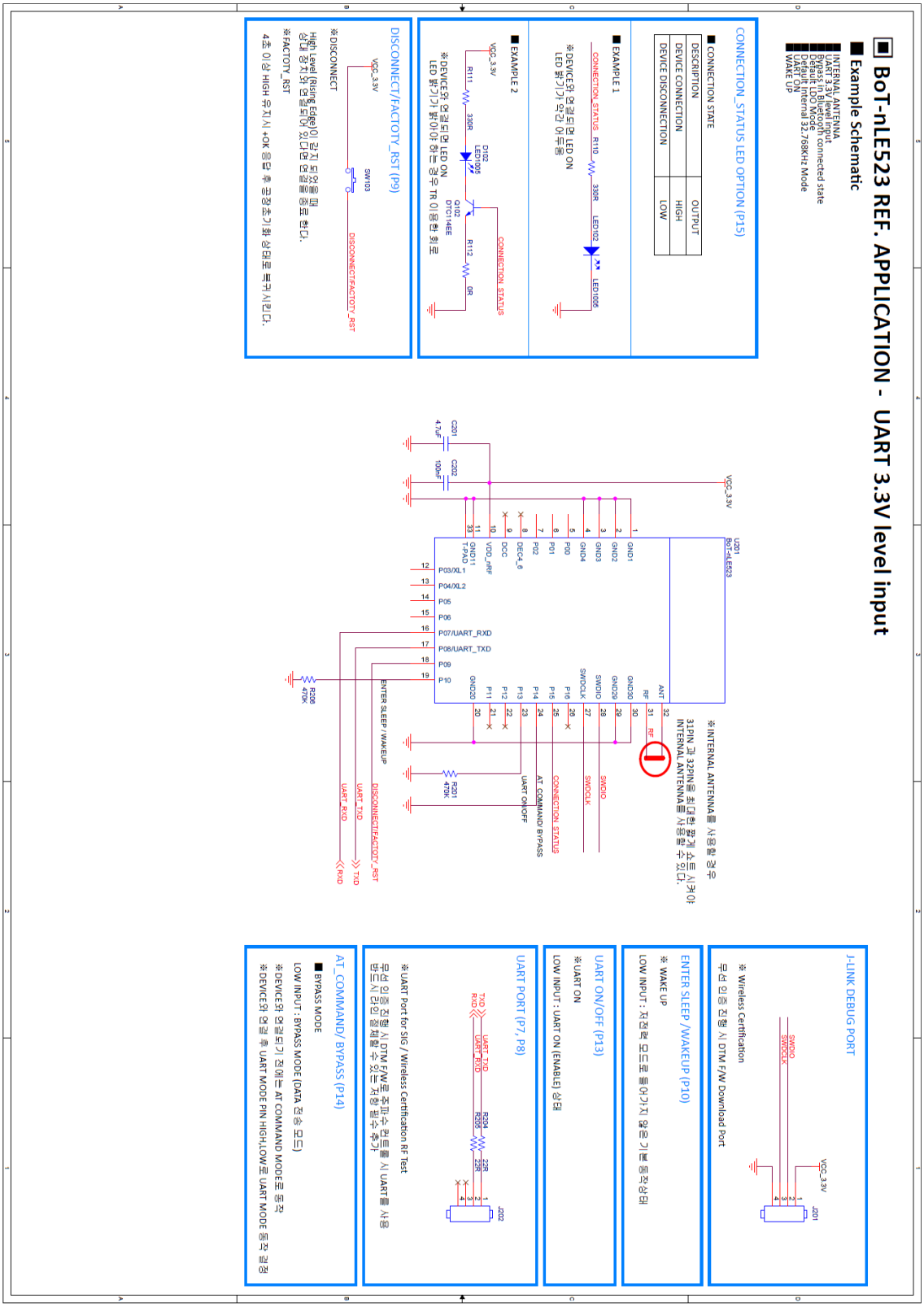
- All I/O(including UART) should be up after VCC applied.
- All I/O(including UART) should NOT be present fast or be held high before VCC is high.

8.1 Reference Application

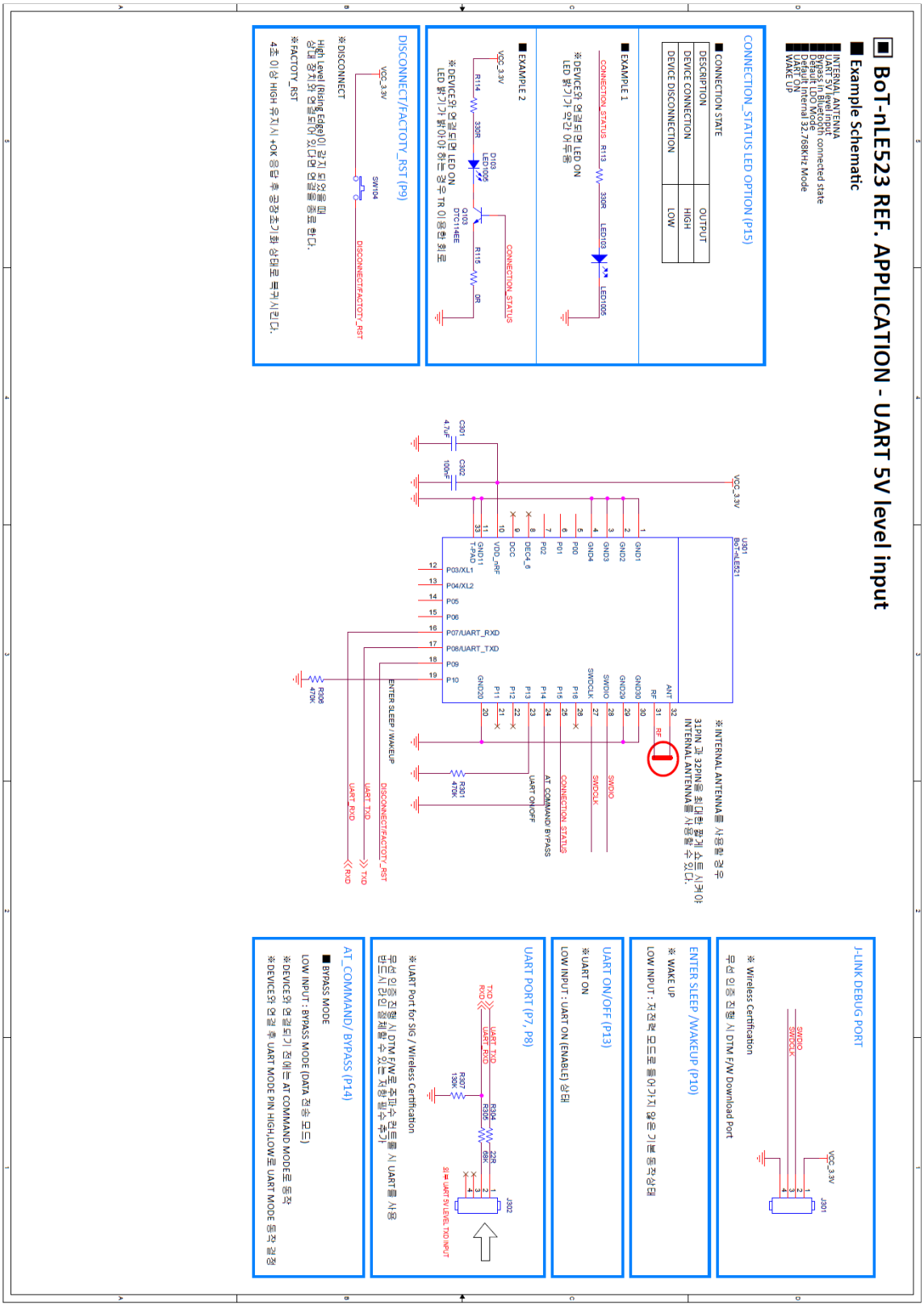


CHIPSEN

8.2 Internal ANT. / 3.3V UART Application



8.3 Internal ANT. / 5V UART Application



8.4 External ANT. / 3.3V UART Application