BoT-TMA50

DATASHEET

V 1.0.0

CHIPSEN

■ History

Rev	Date	Description	Author
1.0.0	2022. 07. 26	- First release	Enoch

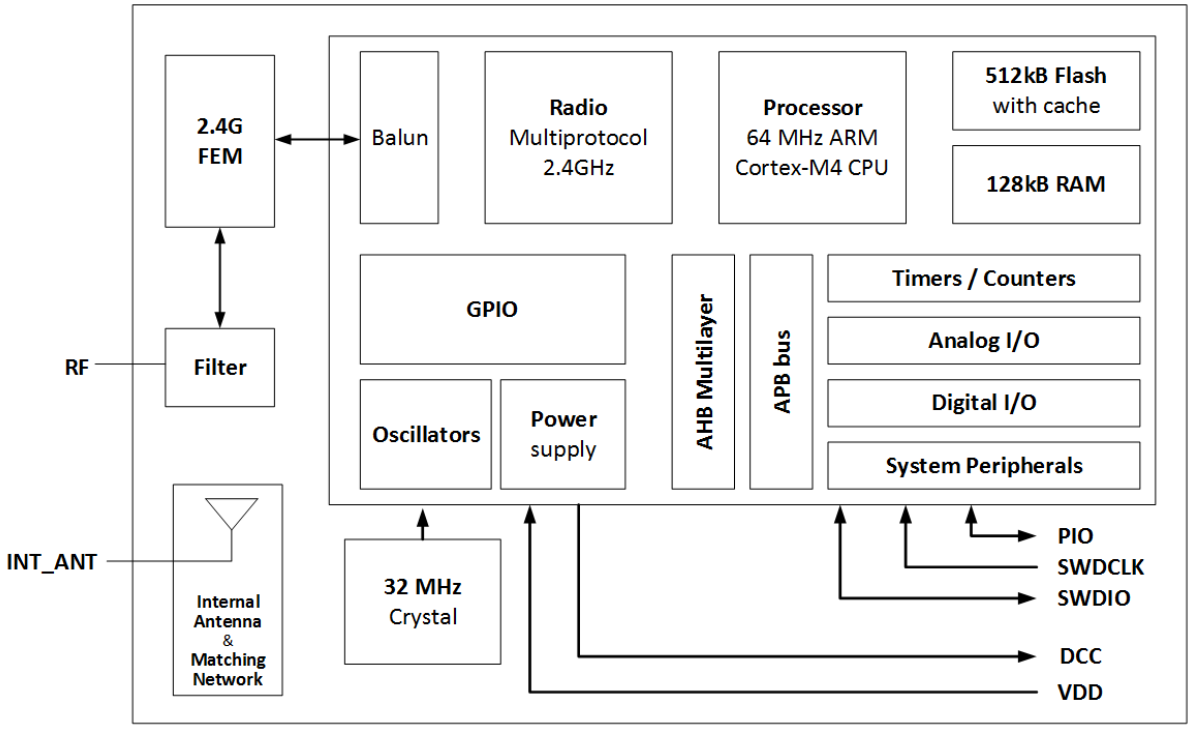
Table of Contents

1. General

1.1 Overview

The BoT-TMA50 module is a cost-effective, 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-TMA50 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-TMA50 is suitable for systems where very low power.

1.2 Block Diagram



BoT-TMA50 Block Diagram

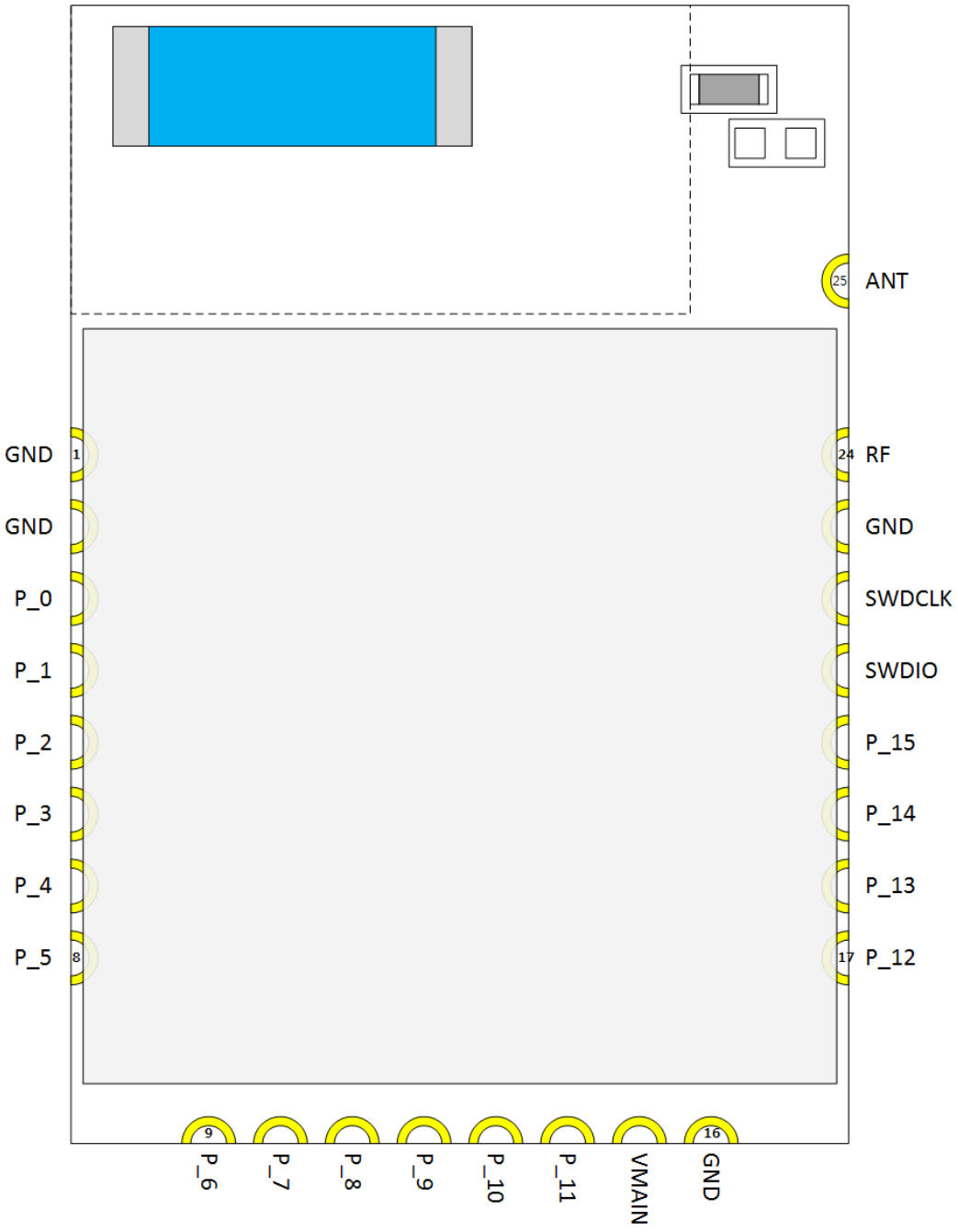
1.3 Features

- 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 +20 dBm
- RF Receive Sensitivity: -98.0 dBm @ Dirty Tx enable, 1Mbps Bluetooth Low Energy mode
- On-chip LDO system
- Temperature Sensor on chip
- UART (CTS/RTS) with EasyDMA, SPI, and I2C data interfaces.
- 12-Bit 200 ksps ADC with - 7 configurable channels with programmable gain
- Size: 19 mm x 13 mm x 2.4T
- 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



<TOP VIEW>

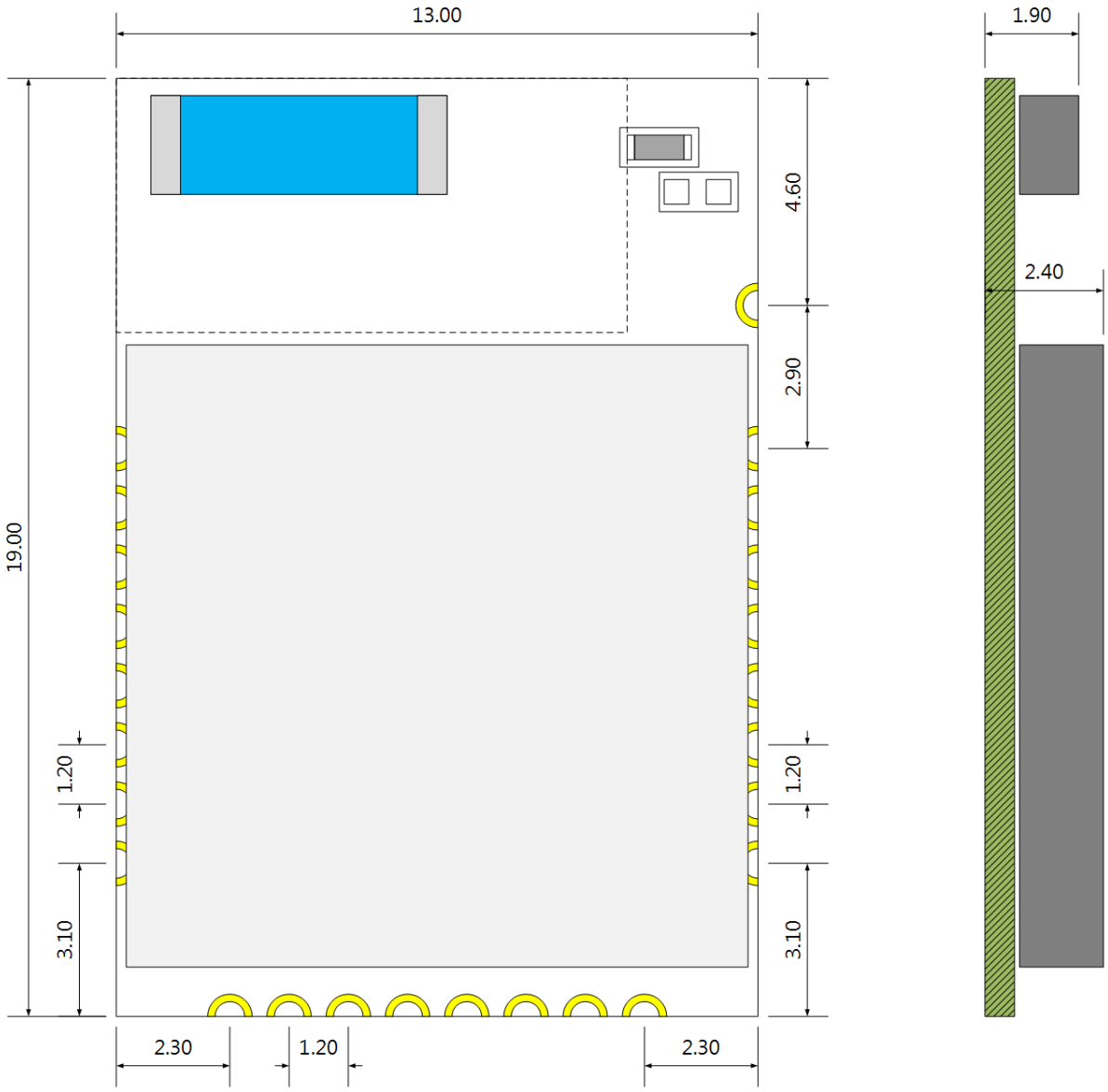
1.6 PIN Description

Pin No.	Pin Name	Pin Function	Description
3	P00	DIGITAL I/O	Standard drive, low frequency I/O only
	AIN1	ANALOG INPUT	
4	P01	DIGITAL I/O	Standard drive, low frequency I/O only
	AIN0	ANALOG INPUT	
5	P02	DIGITAL I/O	Standard drive, low frequency I/O only.
	AIN4	ANALOG INPUT	
6	P03	DIGITAL I/O	General purpose I/O pin.
	AIN5	ANALOG INPUT	Analog input
7	P04	DIGITAL I/O	General purpose I/O pin.
	AIN6	ANALOG INPUT	Analog input
8	P05	DIGITAL I/O	General purpose I/O pin.
	AIN7	ANALOG INPUT	Analog input
9	P06	DIGITAL I/O	General purpose I/O pin.
	FACTORY_RST[1)]	DIGITAL INPUT	DISCONNECT & FACTORY_RESET [2)]
10	P07	DIGITAL I/O	General purpose I/O pin.
11	P08	DIGITAL I/O	General purpose I/O pin.
	CTS[1)]	DIGITAL OUTPUT	UART CTS
12	P09	DIGITAL I/O	General purpose I/O pin.
	RTS[1)]	DIGITAL INPUT	UART RTS
13	P10	DIGITAL I/O	General purpose I/O pin.
	RXD[1)]	DIGITAL INPUT	UART RXD
14	P11	DIGITAL I/O	General purpose I/O pin.
	TXD[1)]	DIGITAL OUTPUT	UART TXD
17	P12	DIGITAL I/O	General purpose I/O pin.
	ENTER_SLEEP &WAKE_UP[1)]	DIGITAL INPUT	ENTER_SLEEP / WAKE_UP [2)]
18	P13	DIGITAL I/O	General purpose I/O pin.
	UART ON/OFF[1)]	DIGITAL INPUT	UART ENABLE / DISABLE [2)]
19	P14	DIGITAL I/O	General purpose I/O pin.
	AT COMMAND &BYPASS[1)]	DIGITAL INPUT	AT COMMAND / BYPASS [2)]
20	P15	DIGITAL I/O	General purpose I/O pin.
	CONNECTION STATUS[1)]	DIGITAL OUTPUT	CONNECTION STATUS [2)]
21	SWDCLK	DIGITAL INPUT	Serial Wire Debug clock input for debug and programming
22	SWDIO	DIGITAL I/O	Serial Wire Debug I/O for debug and programming
24	RF	RF IN / OUT PORT	Bluetooth 50Ω transmitter output / receiver input
25	ANT	INTERNAL ANTENNA IN / OUT	Internal antenna. It should be connected to 24 Pin RF for using internal antenna.
15	VCC	POWER	Power supply pin. *(RF PA POWER Internally connected)*
1,2,16,23	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

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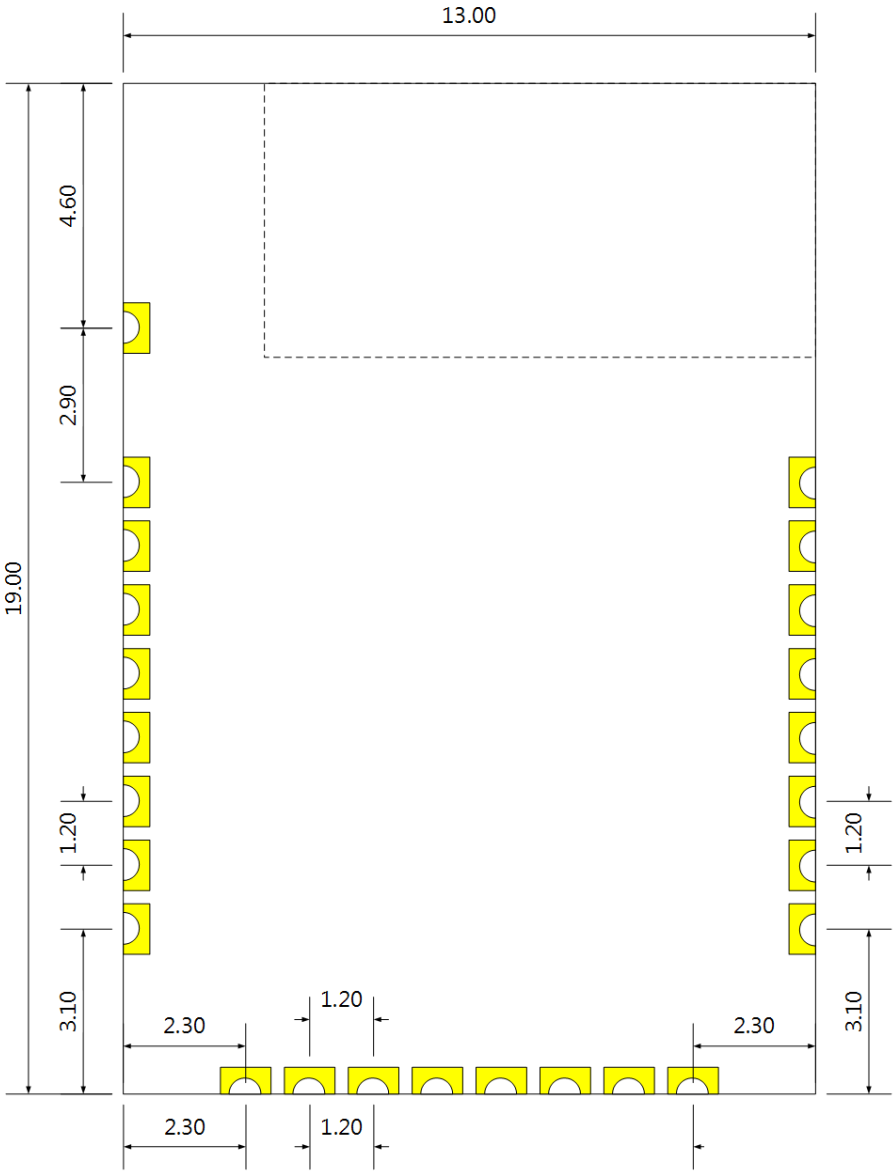
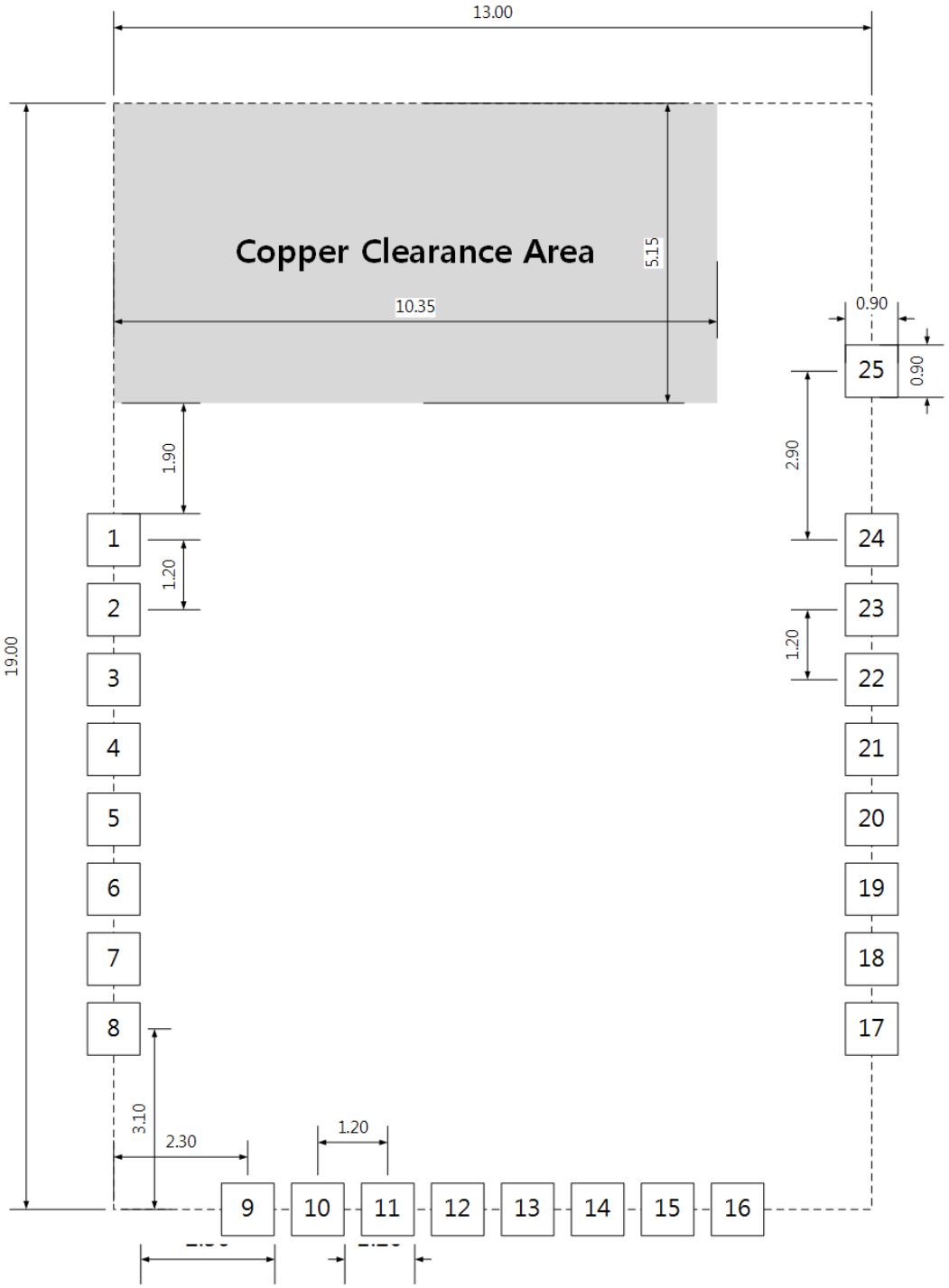


Bottom VIEW

1.8 Land Pattern



Land Pattern (TOP VIEW)

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	℃
Radio	RF Input Level		2	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 ℃

▪ 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 2.7V)			60	ms
TA	Operation temperature	-40	25	85	℃

▪ 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},+20dBm	TX only run current P_{RF}=+20 dBm		TBD		mA
I_{RX},1M	RX only run current 1Msps		TBD		mA
I_{RX},2M	RX only run current 2Msps		TBD		mA

2.2 RF Characteristics

Symbol	Description	Min.	Typ.	Max.	Units
f_{OP}	Operating frequencies	2400		2485	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		-	20	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 Msps)		-20		dBc
$P_{RF2,1}$	2nd Adjacent Channel Transmit Power 2 MHz (1 Msps)		-47		dBc
$P_{RF1,2}$	1st Adjacent Channel Transmit Power 2 MHz (2 Msps)		-21		dBc
$P_{RF2,2}$	2nd Adjacent Channel Transmit Power 4 MHz (2 Msps)		-48		dBc
$P_{RX,MAX}$	Maximum received signal strength at < 0.1% PER		-7		dBm
$P_{SENS,IT,SP,1M,BLE}$	Sensitivity, 1Msps BLE ideal transmitter, <=37 bytes BER=1E-3		-98.0		dBm
$P_{SENS,IT,SP,2M,BLE}$	Sensitivity, 2Msps BLE ideal transmitter, <=37 bytes		-96.0		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 RF Measurement Report (Conduction)

18 RF test cases started: Fri Jun 24 16:25:11 2022

_____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:	21.50dB

Limits:

-20.00dBm <= Pavg <= 25.00dBm, Ppk-av <= 3.00dB

Results (power in dBm):

#ch	f(MHz)	Pavg	Ppk	Ppk-av	Pmin	Verdict
0	2402	20.74	20.89	0.15	20.53	PASSED
19	2440	20.77	20.93	0.16	20.61	PASSED
39	2480	20.55	20.74	0.19	20.39	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:	21.50dB

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	-40.07	2422	-40.20	2443	-40.33	2464	-40.43
2402	-39.60	2423	-40.39	2444	-40.38	2465	-40.35
2403	-37.33	2424	-41.33	2445	-39.43	2466	-39.92
2404	-28.36	2425	-42.47	2446	-39.25	2467	-40.58
2405	-2.77	2426	-42.68	2447	-39.85	2468	-40.64
2406	19.90	2427	-35.65	2448	-40.65	2469	-40.25
2407	0.69	2428	-40.14	2449	-40.39	2470	-39.98
2408	-28.22	2429	-40.92	2450	-40.19	2471	-40.80
2409	-37.21	2430	-40.37	2451	-40.36	2472	-40.46
2410	-39.02	2431	-40.61	2452	-40.49	2473	-40.23
2411	-39.71	2432	-40.27	2453	-40.42	2474	-40.24
2412	-40.03	2433	-40.36	2454	-40.03	2475	-40.63
2413	-40.24	2434	-40.06	2455	-40.36	2476	-40.41
2414	-39.74	2435	-40.12	2456	-40.61	2477	-40.15
2415	-40.56	2436	-39.98	2457	-40.41	2478	-40.29
2416	-40.08	2437	-39.41	2458	-39.74	2479	-40.79
2417	-40.51	2438	-38.52	2459	-40.32	2480	-40.14
2418	-39.96	2439	-39.59	2460	-40.47	2481	-40.29
2419	-40.02	2440	-40.47	2461	-40.18		
2420	-40.45	2441	-40.41	2462	-40.54		
2421	-40.47	2442	-39.97	2463	-40.42		
					Verdict: PASSED		

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

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-40.20	2422	-37.72	2443	-37.37	2464	-40.43
2402	-40.47	2423	-40.20	2444	-39.72	2465	-40.36
2403	-40.25	2424	-39.84	2445	-39.25	2466	-40.64
2404	-39.81	2425	-40.44	2446	-40.30	2467	-40.77
2405	-38.36	2426	-40.54	2447	-40.12	2468	-40.30
2406	-39.96	2427	-40.68	2448	-40.06	2469	-40.43

2407	-39.50	2428	-40.57	2449	-40.67	2470	-39.98
2408	-38.56	2429	-40.45	2450	-40.02	2471	-40.05
2409	-40.01	2430	-40.63	2451	-40.25	2472	-38.85
2410	-40.23	2431	-40.13	2452	-40.32	2473	-39.42
2411	-40.39	2432	-40.63	2453	-40.04	2474	-40.10
2412	-40.03	2433	-40.42	2454	-40.22	2475	-39.77
2413	-40.42	2434	-39.81	2455	-40.20	2476	-40.23
2414	-40.70	2435	-40.23	2456	-40.19	2477	-40.48
2415	-40.39	2436	-39.29	2457	-40.13	2478	-40.01
2416	-40.34	2437	-36.97	2458	-41.34	2479	-39.29
2417	-40.05	2438	-27.70	2459	-42.37	2480	-38.77
2418	-42.07	2439	-2.12	2460	-42.47	2481	-39.93
2419	-43.41	2440	20.39	2461	-34.88		
2420	-40.91	2441	0.71	2462	-40.05		
2421	-33.20	2442	-28.42	2463	-40.20		
					Verdict: PASSED		

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

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-40.07	2422	-40.39	2443	-39.61	2464	-40.58
2402	-40.52	2423	-40.04	2444	-38.78	2465	-40.12
2403	-40.46	2424	-40.52	2445	-39.93	2466	-40.52
2404	-40.24	2425	-39.99	2446	-40.46	2467	-39.93
2405	-40.50	2426	-40.58	2447	-40.48	2468	-40.19
2406	-40.58	2427	-40.40	2448	-39.90	2469	-40.36
2407	-39.97	2428	-40.15	2449	-40.33	2470	-40.26
2408	-40.34	2429	-40.19	2450	-40.32	2471	-39.84
2409	-40.14	2430	-40.67	2451	-40.64	2472	-39.16
2410	-40.57	2431	-40.58	2452	-40.86	2473	-37.26
2411	-40.78	2432	-39.95	2453	-40.57	2474	-28.59
2412	-40.22	2433	-40.11	2454	-42.02	2475	-3.20
2413	-40.12	2434	-40.60	2455	-43.12	2476	19.53
2414	-40.45	2435	-40.71	2456	-40.79	2477	0.18
2415	-40.49	2436	-40.39	2457	-32.73	2478	-28.72
2416	-40.18	2437	-40.58	2458	-37.60	2479	-37.66
2417	-40.34	2438	-40.35	2459	-40.39	2480	-39.44
2418	-40.42	2439	-40.29	2460	-39.34	2481	-39.75
2419	-40.74	2440	-39.83	2461	-40.18		
2420	-40.63	2441	-38.47	2462	-40.41		
2421	-40.58	2442	-40.56	2463	-40.19		
					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	258.9	252.7	219.6	100.00		0.98	PASSED
19	2440	258.2	255.1	225.7	100.00		0.99	PASSED
39	2480	258.1	255.7	227.9	100.00		0.99	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	10.7	-5.7	-3.8	-4.4		PASSED
19	2440	10.2	-4.1	-2.5	-3.0		PASSED
39	2480	11.1	-4.8	-4.3	3.4		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: 21.50dB

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	-39.71	2422	-39.97	2443	-39.96	2464	-40.63
2402	-38.07	2423	-40.11	2444	-40.41	2465	-40.50
2403	-32.35	2424	-42.61	2445	-40.11	2466	-40.37
2404	-17.31	2425	-43.18	2446	-39.93	2467	-40.27
2405	7.74	2426	-43.28	2447	-40.24	2468	-40.54
2406	16.23	2427	-35.33	2448	-40.59	2469	-40.13
2407	7.39	2428	-40.08	2449	-40.65	2470	-40.35
2408	-16.25	2429	-40.58	2450	-40.36	2471	-40.80
2409	-32.71	2430	-40.36	2451	-40.81	2472	-40.85
2410	-38.47	2431	-40.74	2452	-40.29	2473	-40.25
2411	-39.52	2432	-40.64	2453	-40.65	2474	-40.39
2412	-40.24	2433	-40.06	2454	-40.12	2475	-40.52
2413	-40.52	2434	-40.66	2455	-40.63	2476	-39.97
2414	-40.56	2435	-40.74	2456	-40.82	2477	-40.11
2415	-40.67	2436	-40.75	2457	-41.01	2478	-40.15
2416	-40.05	2437	-40.51	2458	-40.11	2479	-40.17
2417	-40.34	2438	-39.88	2459	-40.43	2480	-39.85
2418	-40.06	2439	-40.77	2460	-40.46	2481	-40.05
2419	-40.62	2440	-40.51	2461	-40.42		
2420	-40.81	2441	-39.89	2462	-40.23		
2421	-40.50	2442	-39.74	2463	-40.75		

Verdict: PASSED

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

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-40.23	2422	-38.24	2443	-33.44	2464	-40.46
2402	-40.52	2423	-40.55	2444	-38.67	2465	-40.80
2403	-40.84	2424	-40.68	2445	-39.73	2466	-39.79
2404	-40.00	2425	-40.73	2446	-39.66	2467	-40.11
2405	-39.45	2426	-40.68	2447	-39.90	2468	-40.27
2406	-40.47	2427	-39.95	2448	-40.17	2469	-40.71
2407	-39.58	2428	-40.39	2449	-40.05	2470	-40.42
2408	-39.40	2429	-40.55	2450	-40.47	2471	-39.47
2409	-40.08	2430	-40.30	2451	-40.78	2472	-39.43
2410	-40.15	2431	-40.55	2452	-40.53	2473	-39.99
2411	-40.07	2432	-40.19	2453	-39.86	2474	-39.93
2412	-40.41	2433	-40.24	2454	-40.33	2475	-39.84
2413	-40.08	2434	-40.14	2455	-40.16	2476	-40.27
2414	-40.48	2435	-39.54	2456	-40.60	2477	-39.94
2415	-40.99	2436	-38.38	2457	-40.49	2478	-39.88
2416	-40.88	2437	-33.84	2458	-42.43	2479	-39.68

2417	-40.32	2438	-19.04	2459	-43.22	2480	-39.54
2418	-42.38	2439	5.58	2460	-43.47	2481	-40.18
2419	-43.58	2440	14.39	2461	-36.88		
2420	-41.56	2441	5.64	2462	-40.28		
2421	-33.07	2442	-18.14	2463	-40.33		
					Verdict: PASSED		

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

N	P[N]	N	P[N]	N	P[N]	N	P[N]
2401	-40.16	2422	-40.19	2443	-40.42	2464	-39.82
2402	-40.22	2423	-40.92	2444	-39.56	2465	-39.76
2403	-40.02	2424	-40.42	2445	-40.35	2466	-39.89
2404	-40.81	2425	-41.00	2446	-39.88	2467	-40.02
2405	-40.20	2426	-40.25	2447	-40.25	2468	-39.69
2406	-40.32	2427	-40.34	2448	-40.56	2469	-39.86
2407	-40.45	2428	-40.04	2449	-40.42	2470	-39.84
2408	-40.31	2429	-40.40	2450	-40.30	2471	-39.27
2409	-40.53	2430	-40.38	2451	-40.39	2472	-38.43
2410	-41.01	2431	-40.76	2452	-40.23	2473	-32.56
2411	-39.94	2432	-40.18	2453	-40.25	2474	-17.25
2412	-40.65	2433	-40.72	2454	-42.38	2475	7.65
2413	-40.79	2434	-40.59	2455	-43.40	2476	16.06
2414	-40.92	2435	-40.47	2456	-41.37	2477	7.34
2415	-40.50	2436	-40.58	2457	-32.98	2478	-16.27
2416	-40.44	2437	-40.26	2458	-37.88	2479	-32.52
2417	-40.78	2438	-40.60	2459	-40.57	2480	-38.78
2418	-40.45	2439	-40.66	2460	-39.96	2481	-39.78
2419	-40.86	2440	-40.52	2461	-39.93		
2420	-40.77	2441	-39.80	2462	-40.37		
2421	-40.47	2442	-40.59	2463	-39.61		
					Verdict: PASSED		

Test time: 3 min. 6 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	484.3	446.4	398.8	100.00		0.92	PASSED
19	2440	490.0	447.8	404.4	100.00		0.91	PASSED
39	2480	490.8	450.7	401.9	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	11.6	-4.2	3.8	-2.8	PASSED
19	2440	12.3	-5.7	-5.1	-3.6	PASSED
39	2480	11.8	-3.1	-3.1	3.4	PASSED

Test time:<1 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:		-95.00dBm
Path losses:	21.50dB	
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		1416		5.600	PASSED
19	2440	1500		1469		2.067	PASSED
39	2480	1500		1423		5.133	PASSED

Test time: 4 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:	21.50dB	
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 (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:	21.50dB	
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 (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:		-95.00dBm
Path losses:	21.50dB	

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		1370		8.667	PASSED
19	2440	1500		1387		7.533	PASSED
39	2480	1500		1312		12.533	PASSED

Test time: 4 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: 21.50dB
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: -95.00dBm
Path losses: 21.50dB
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		1472		1.867	PASSED
19	2440	1500		1494		0.400	PASSED
39	2480	1500		1463		2.467	PASSED

Test time: 4 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: 21.50dB
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: 4 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:	21.50dB
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.

_____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:	21.50dB
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.

_____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:	21.50dB

Limits:

-20.00dBm < Pavg < 25.00dBm, 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	20.68	21.39	0.71	19.79	-3.8	-4.0
19	2440	20.51	21.25	0.74	19.57	12.5	9.7
39	2480	20.40	21.15	0.75	19.44	12.4	8.9

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	-6.3	-3.3	-1.1	3.5
19	2440	12.5	-3.3	1.1	2.6
39	2480	12.8	3.9	2.0	2.5

Results (frequency deviations in KHz):

#ch	f(MHz)	df1_avg	df2_avg	df2_min	df2_rate(%)	df2/df1	Verdict

0	2402	259.1	253.2	224.4	100.00	0.98	PASSED
19	2440	258.1	255.9	233.7	100.00	0.99	PASSED
39	2480	258.1	255.9	220.1	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	12.9	10.0	11.4	252.9	235.5	PASSED
19	2440	10.0	9.2	9.6	255.9	245.5	PASSED
39	2480	12.9	9.8	11.3	254.4	242.4	PASSED

Test time: 1 sec.

18 RF test cases completed: Fri Jun 24 16:32:12 2022

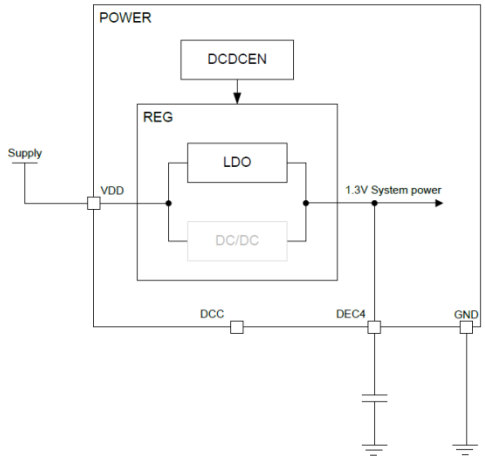
Total test time: 7 min. 1 sec.

3. Power and clock management

3.1 Regulator

The following internal power feature;

- Internal LDO regulator (LDO is the default regulator.)



LDO Regulator Setup

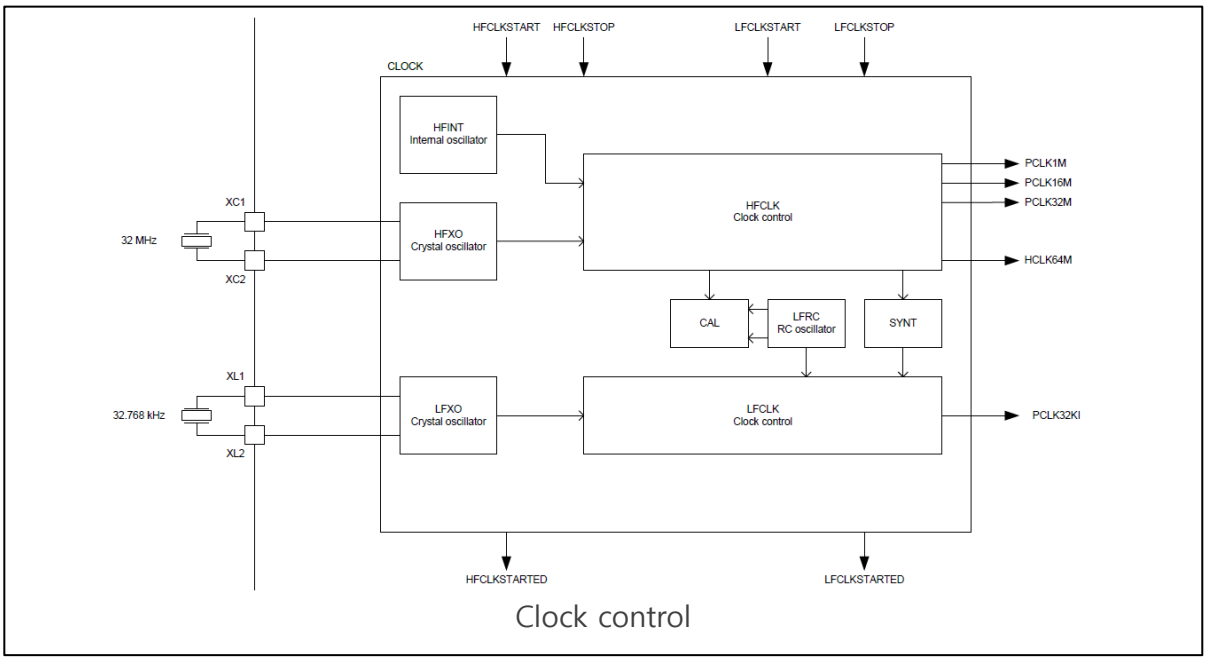
3.2 32.768KHz Crystal Oscillator

The BoT-TMA50 external 32.768KHz Crystal does not required for BLE mode

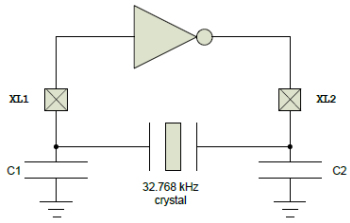
If you choose to use an internal 32.768kHz oscillator, an average of a few hundred uA of current is consumed more than an external crystal.

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

BoT-TMA50 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)

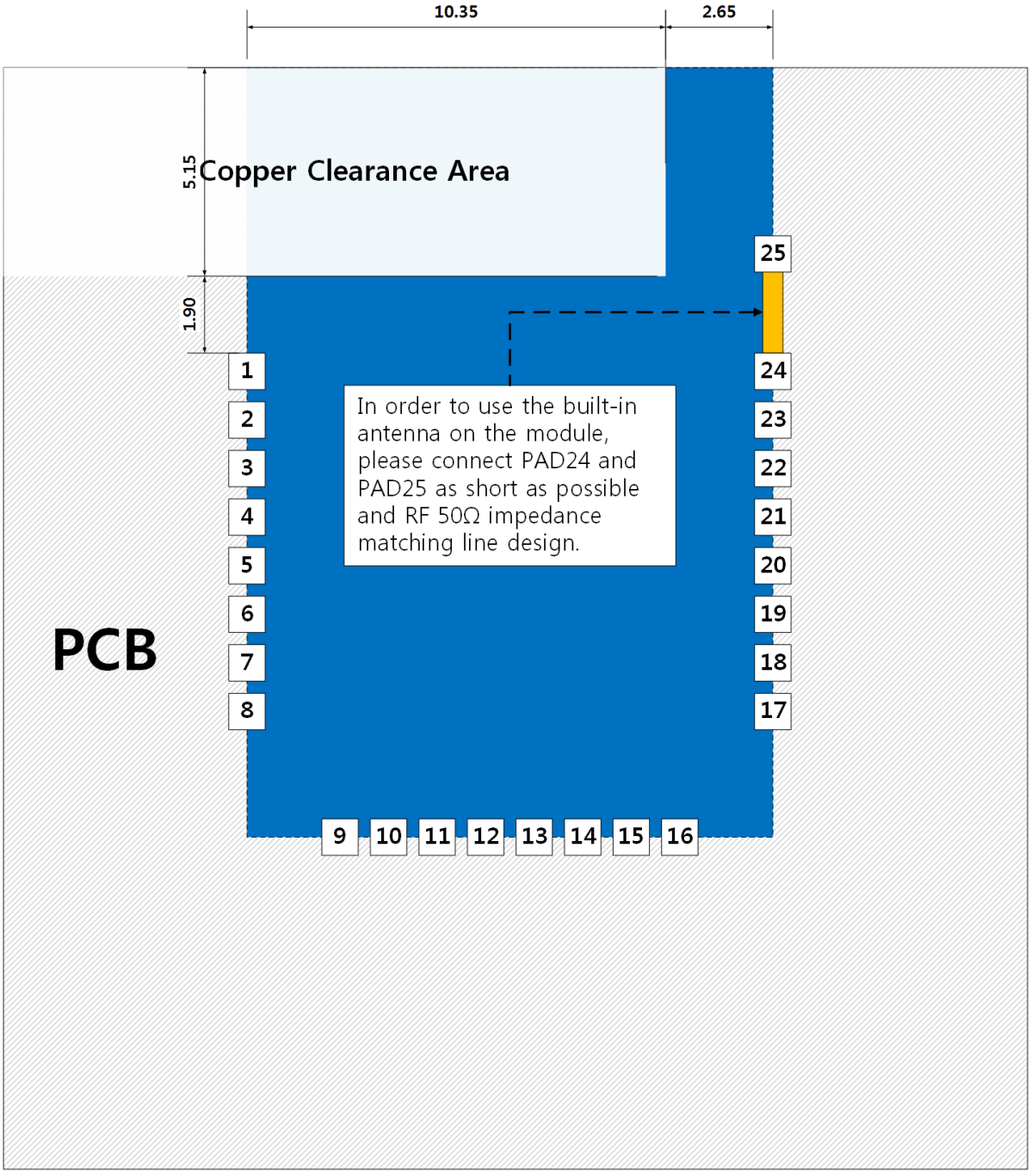
Symbol	Description	Min.	Typ.	Max.	Units
f_{NOM_LFRC}	Nominal frequency		32.768		kHz
f_{TOL_LFRC}	Frequency tolerance		±2		%
$f_{TOL\_CAL\_LFRC}$	Frequency tolerance for LFRC after calibration		±500		ppm

▪ 32.768 kHz crystal oscillator (LFXO)

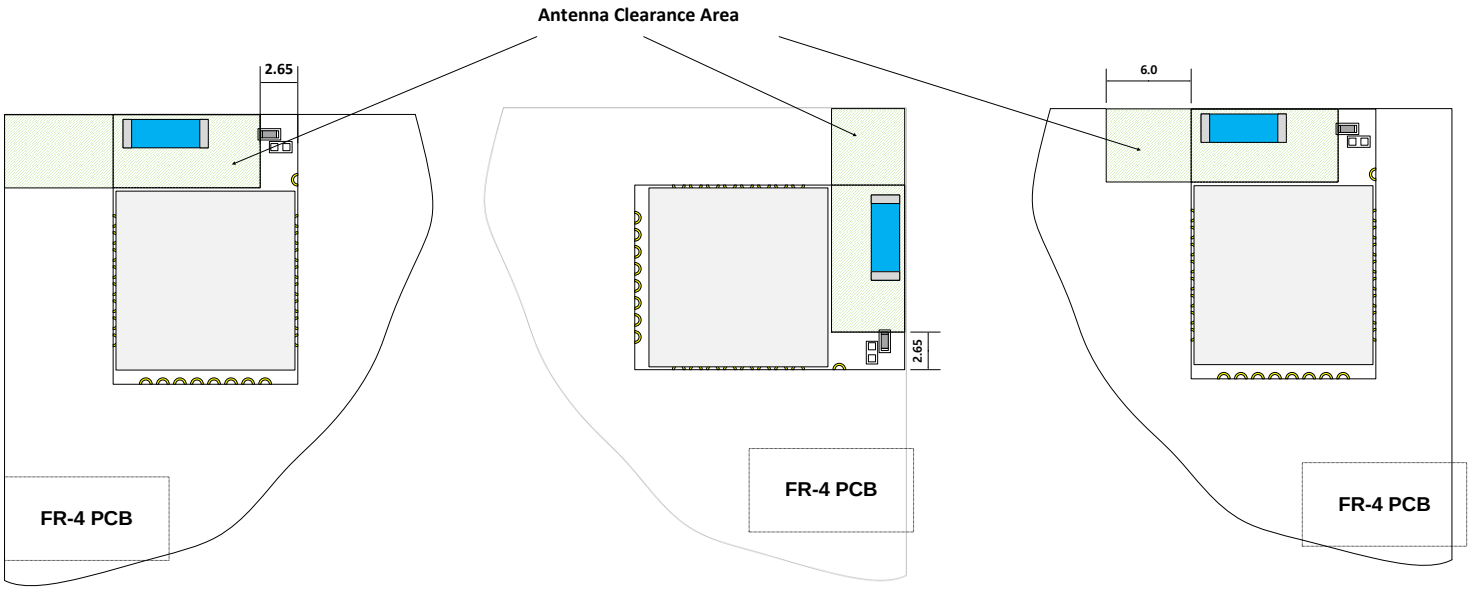
Symbol	Description	Min.	Typ.	Max.	Units
f_{NOM_LFXO}	Crystal frequency		32.768		kHz
$f_{TOL\_LFXO\_BLE}$	Frequency tolerance requirement for BLE stack		±250		ppm
$f_{TOL\_LFXO\_ANT}$	Frequency tolerance requirement for ANT stack		±50		ppm
C_{L_LFXO}	Load capacitance			12.5	pF
C_{0_LFXO}	Shunt capacitance			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. Antenna

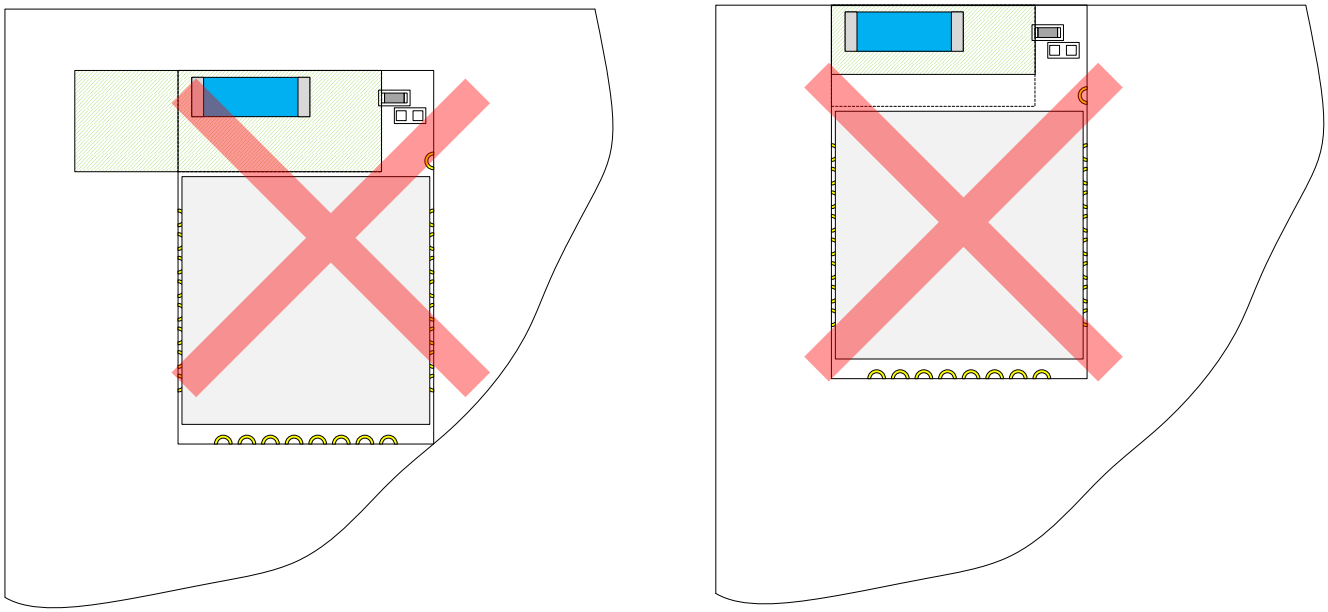
4.1 Internal Antenna Layout Guide



4.2 Recommended Module Mounting



Recommended Module Mounting Example



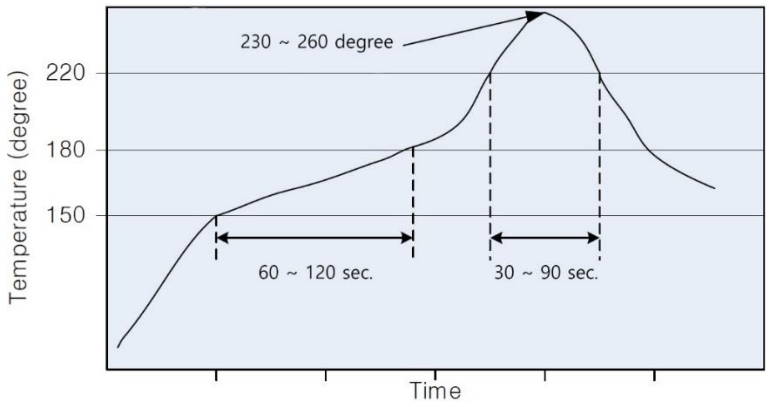
Antenna 영역을 GND가 둘러싸고 있는 형태

Antenna 영역을 크기를 축소 하거나
Antenna 영역에 GND가 겹치는 형태

Wrong Module Mounting Example

5. 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

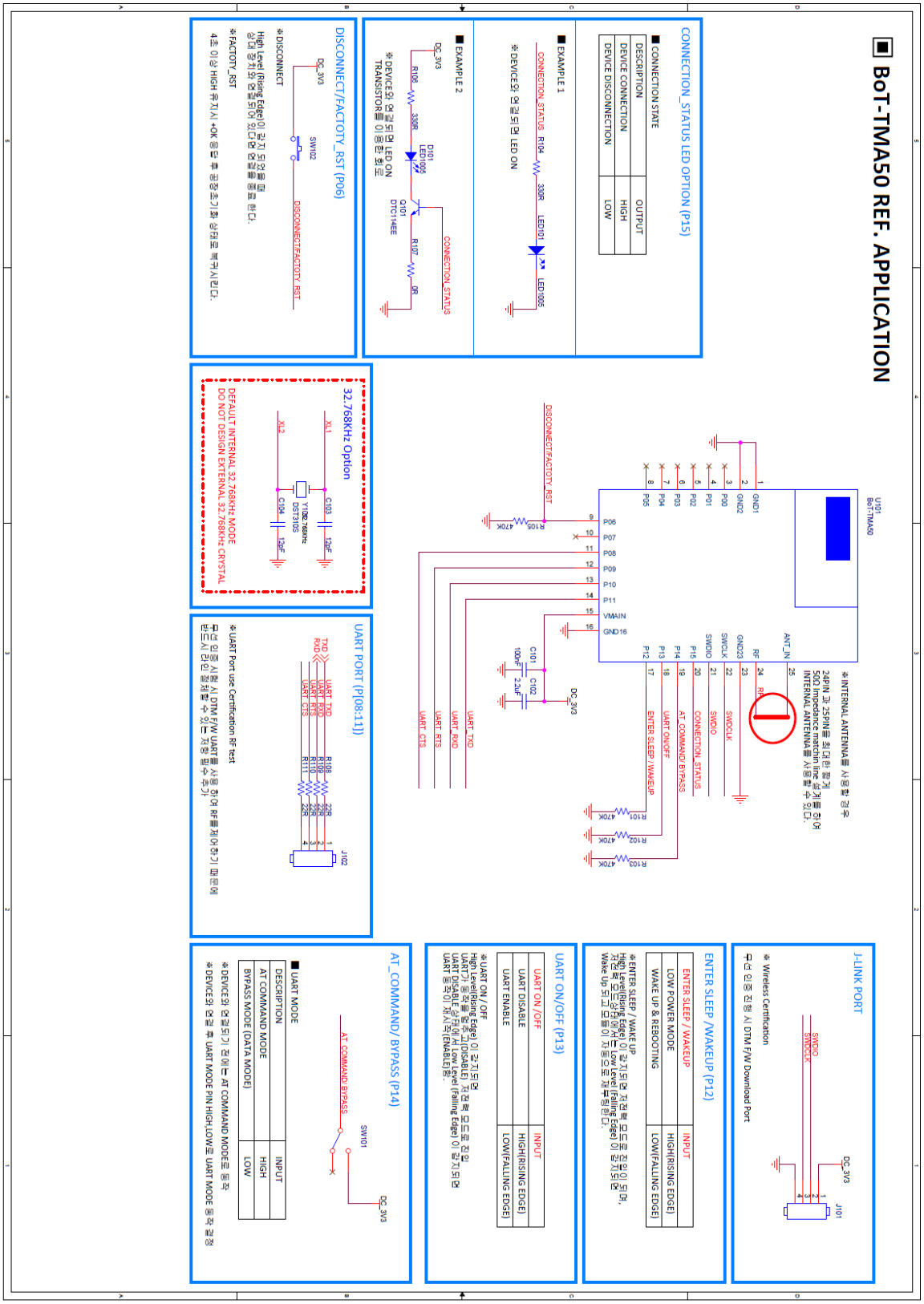
WARNING : For BoT-TMA50
If you have reflow process multiple times in your product, you must be proceed this module in the final reflow process. If not the Shield can will drop out if shield-can adopted.

6. 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.

6.1 Reference Application



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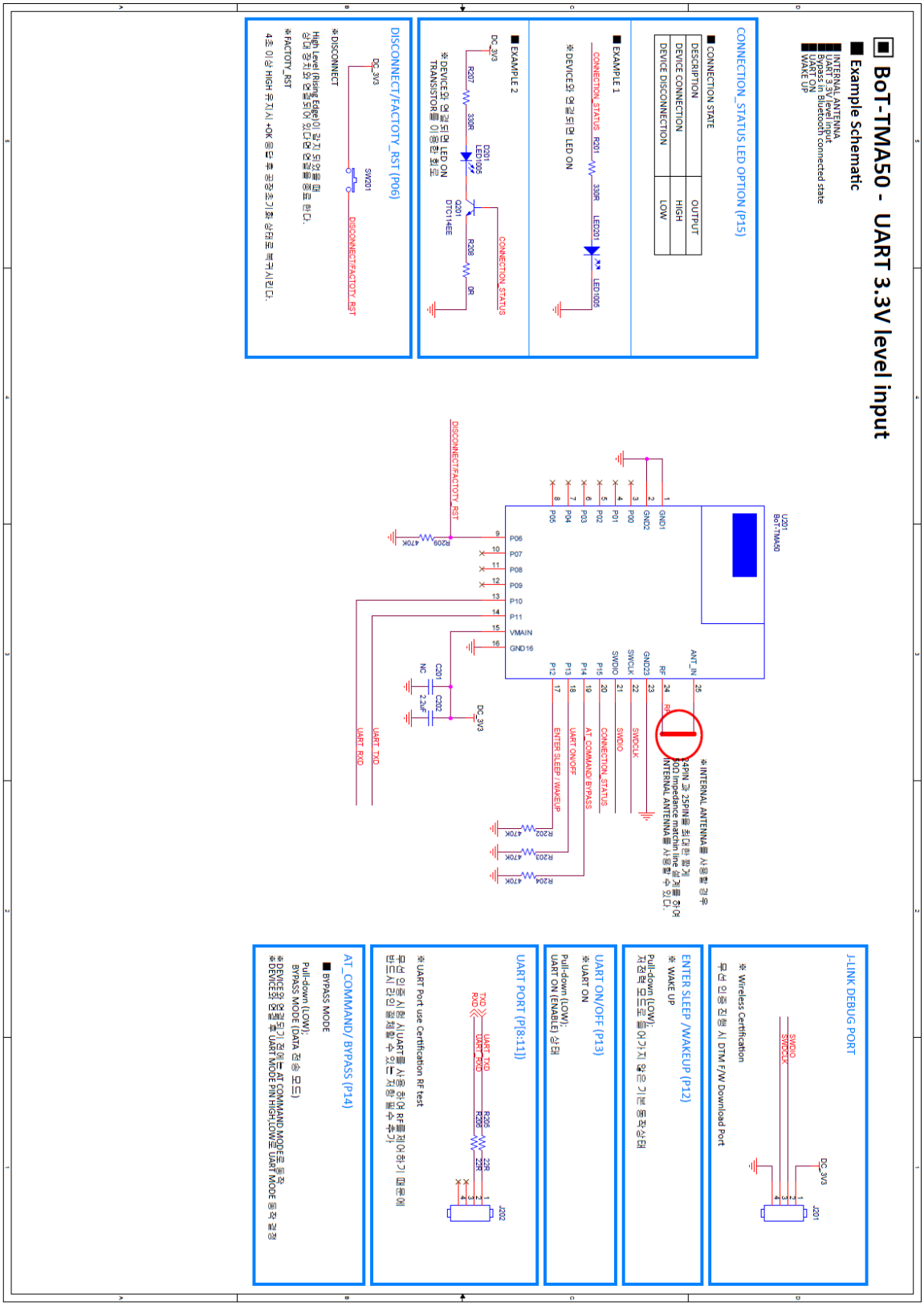
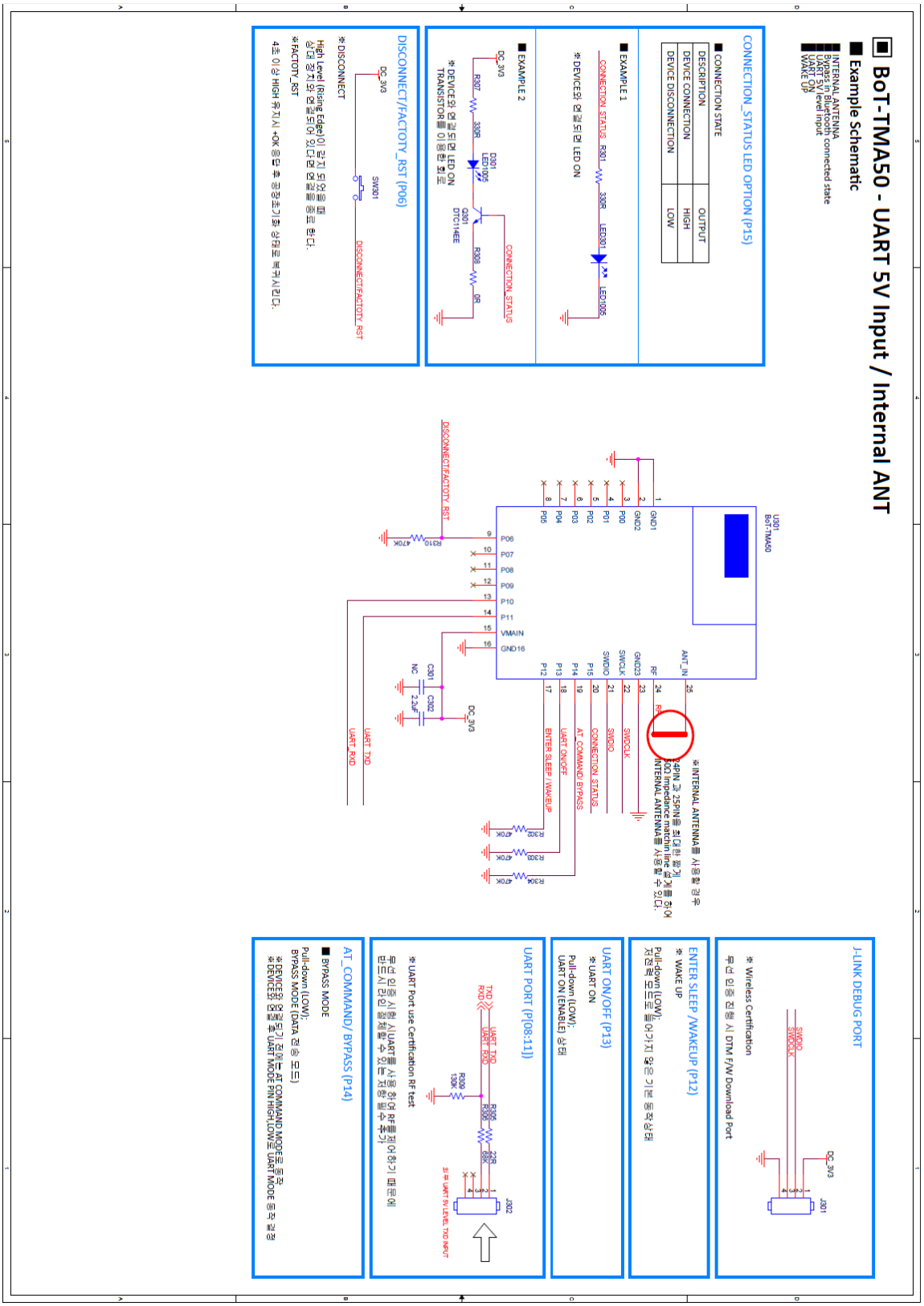
6.2 3V3, INTERNAL ANTENNA



6.3 5V, INTERNAL ANTENNA



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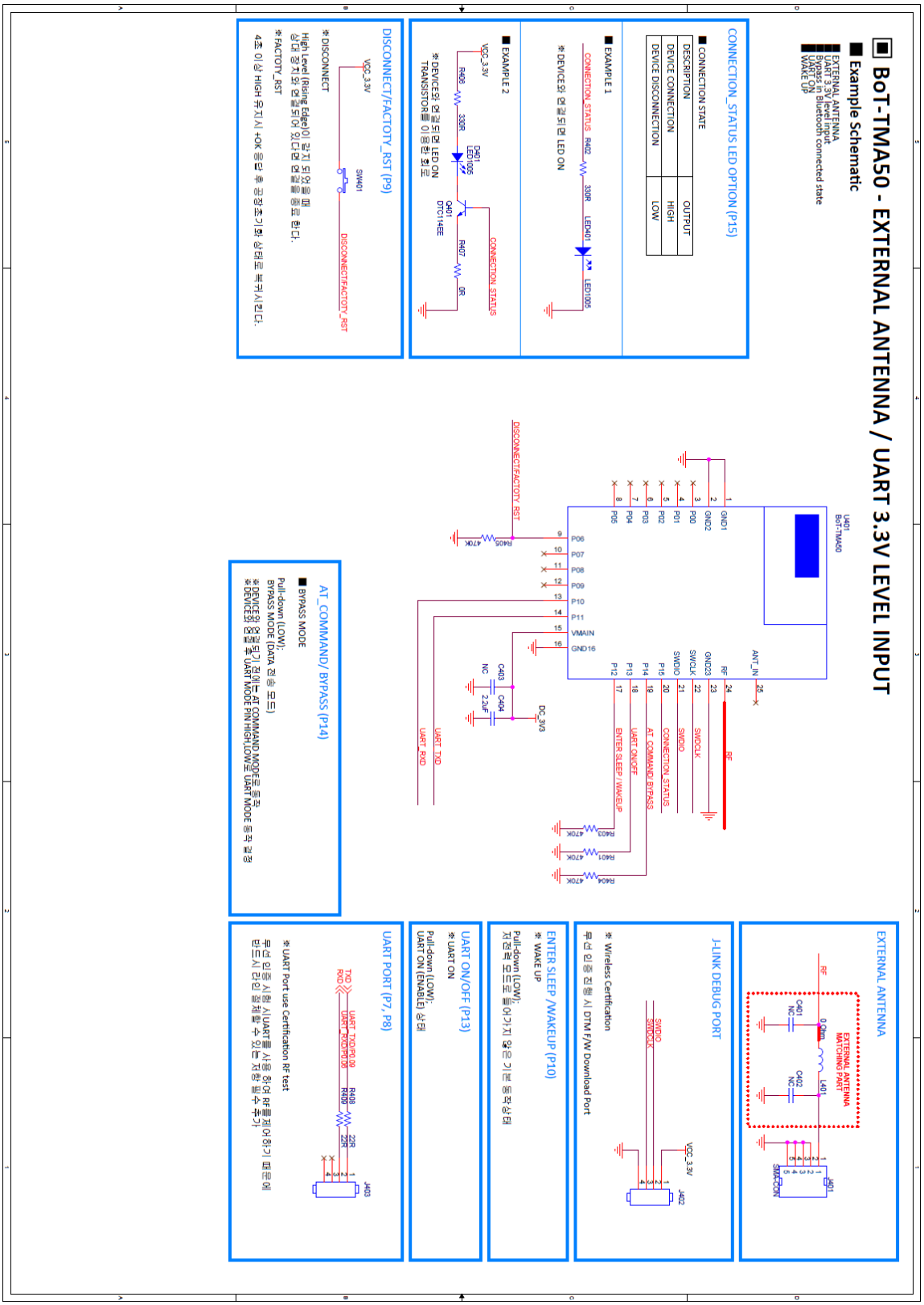
6.4 3V3, EXTERNAL ANTENNA



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