

BoT-TMA50

DATASHEET

V 1.0.0

■ History

Rev	Date	Description	Author
1.0.0	2023. 03. 13	- First release	Enoch

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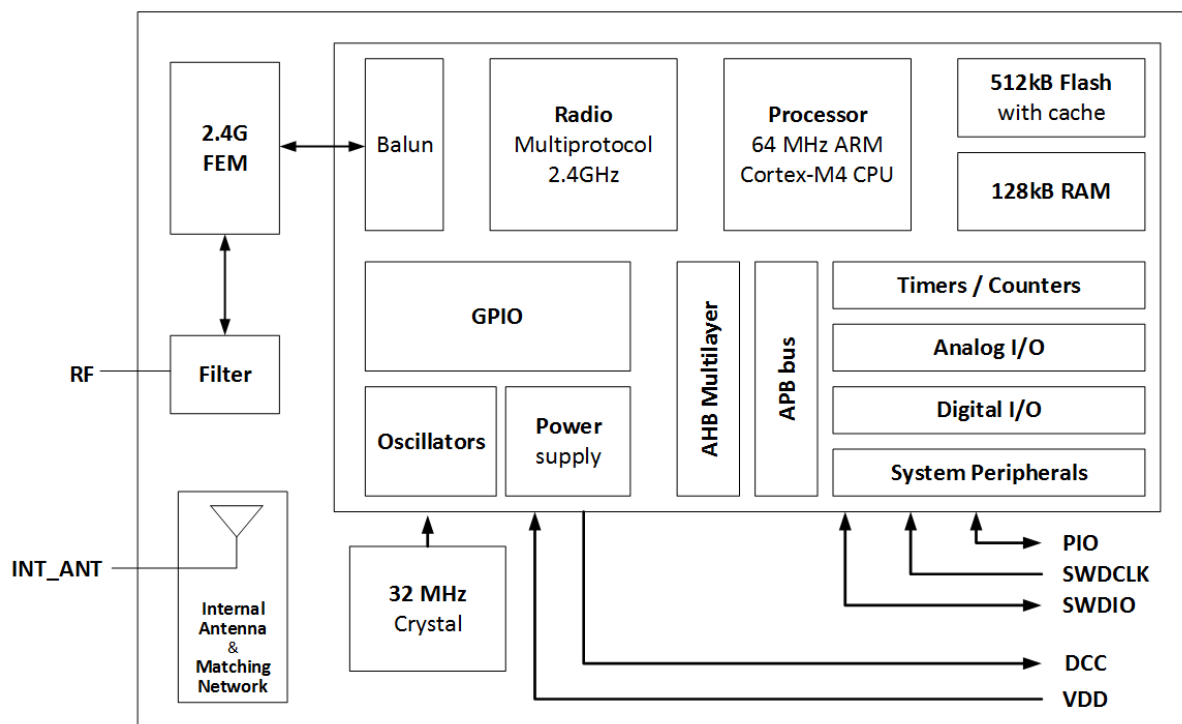
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1. General

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 CortexM4 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 with low power.

1.2 Block Diagram



BoT-TMA50 Block Diagram

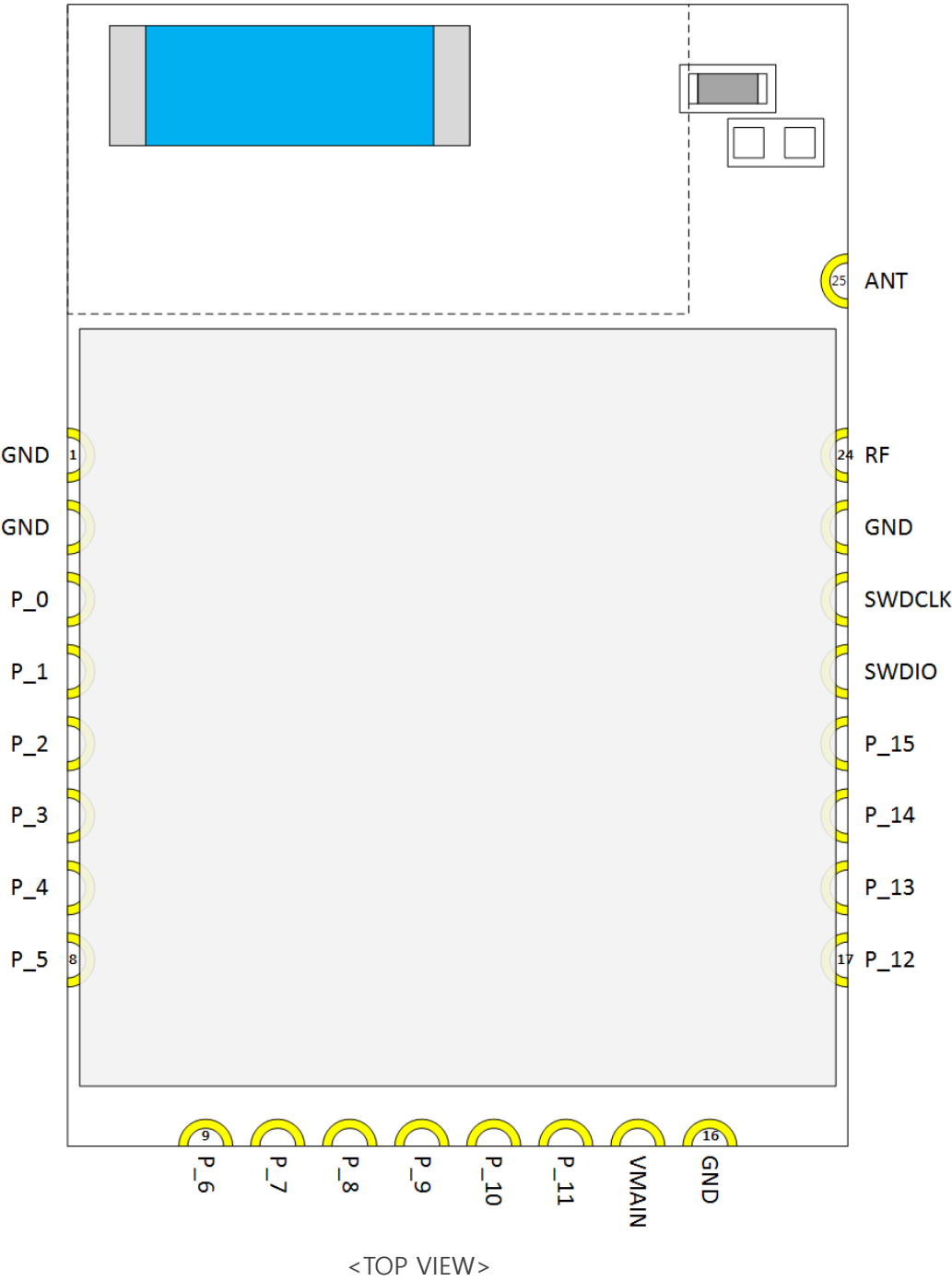
1.3 Features

- Bluetooth 5.x
- 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: up to +20 dBm (E.I.R.P)
- 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 ksp/s ADC with - 7 configurable channels with programmable gain
- Size: 19 mm x 13 mm x 2.4mm (H x W x T)
- Weight: 1.0g
- Operating Voltage: 2.7V to 3.6V
- Operating Temperature: -40 to +85°C(FCC, JAPAN, KC) / -20 to +85°C(CE only)
- 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



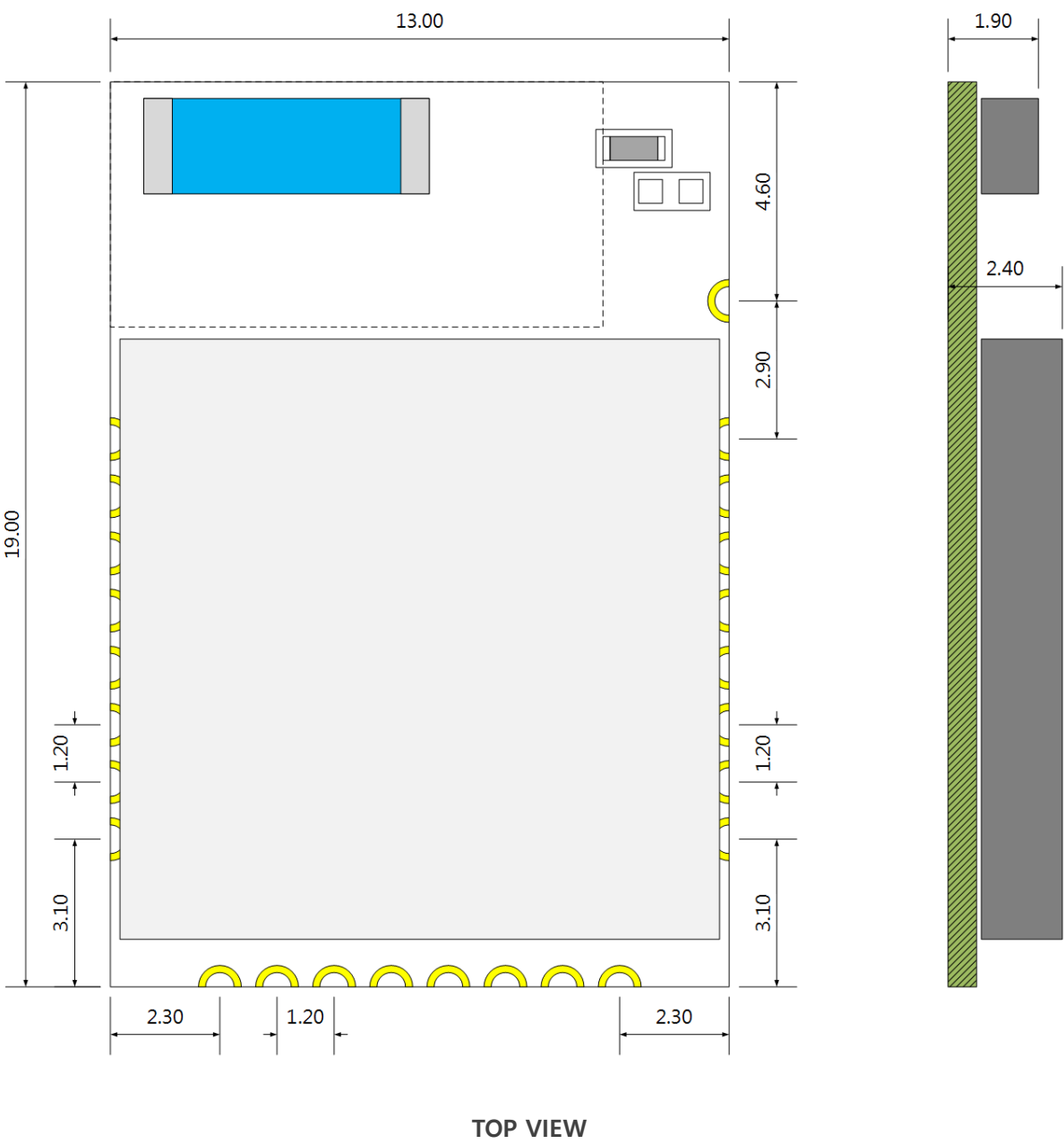
1.6 PIN Description

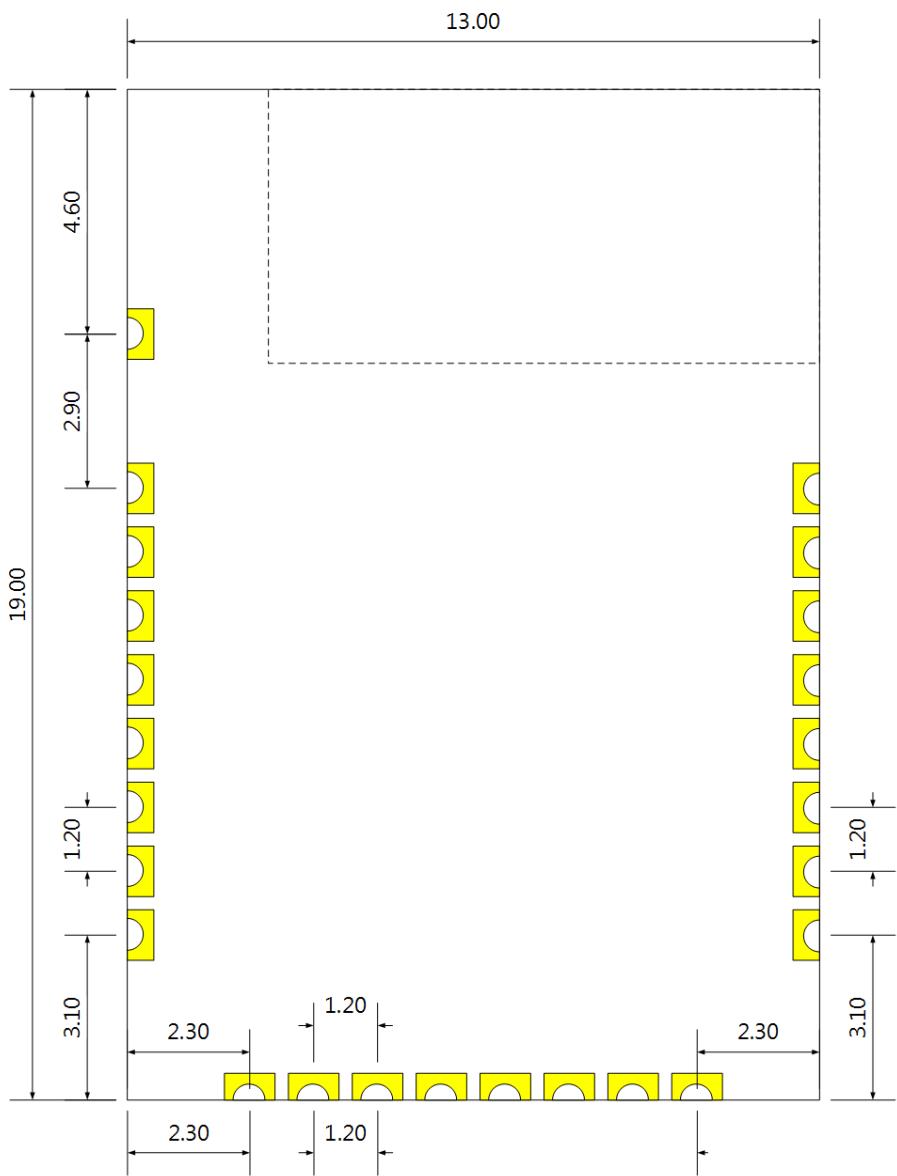
Pin No.	Pin Name	Pin Function	Description
3	P00	DIGITAL I/O	Standard drive, low frequency I/O only
	AIN1	ANALOG INPUT	
4	P01	DIGITAL I/O	Standard drive, low frequency I/O only
	AIN0	ANALOG INPUT	
5	P02	DIGITAL I/O	Standard drive, low frequency I/O only.
	AIN4	ANALOG INPUT	
6	P03	DIGITAL I/O	General purpose 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⁾	UART CTS	UART Clear to Send
12	P09	DIGITAL I/O	General purpose I/O pin.
	RTS ¹⁾	UART RTS	UART Request to Send
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.

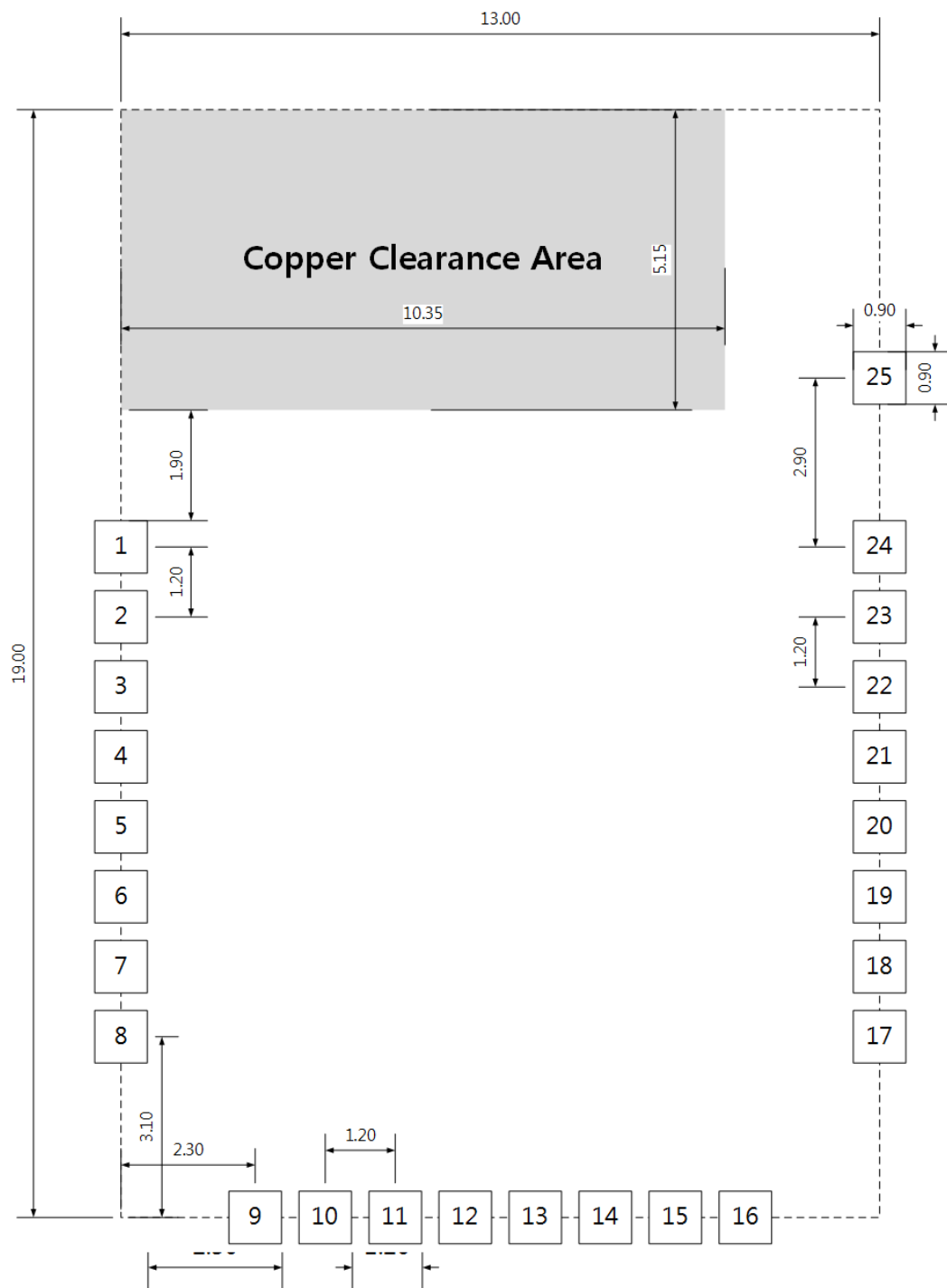
1.7 Dimensions





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_{IO} , VDD \leq 3.6V		-0.3	VDD + 0.3	V
V_{IO} , VDD > 3.6V		-0.3	+3.9	V
Storage temperature		-40	+125	°C
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 °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 Operation	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	°C

▪ DC Characteristics

Symbol	Parameter (condition)	Min.	Typ.	Max.	Units
V_{IH}	Input high voltage	$0.7 \times V_{DD}$		V_{DD}	V
V_{IL}	Input low voltage	V_{SS}		$0.3 \times V_{DD}$	V
$V_{OH,SD}$	Output high voltage, standard drive, 0.5 mA, $V_{DD} \geq 1.7$	$V_{DD}-0.4$		V_{DD}	V
$V_{OH,HDL}$	Output high voltage, high drive, 5 mA, $V_{DD} \geq 2.7$ V	$V_{DD}-0.4$		V_{DD}	V
$V_{OH,HDI}$	Output high voltage, high drive, 3 mA, $V_{DD} \geq 1.7$ V	$V_{DD}-0.4$		V_{DD}	V
$V_{OL,SD}$	Output low voltage, standard drive, 0.5 mA, $V_{DD} \geq 1.7$	V_{SS}		$V_{SS} + 0.4$	V
$V_{OL,HDL}$	Output low voltage, high drive, 5 mA, $V_{DD} \geq 2.7$ V	V_{SS}		$V_{SS} + 0.4$	V
$V_{OL,HDI}$	Output low voltage, high drive, 3 mA, $V_{DD} \geq 1.7$ V	V_{SS}		$V_{SS} + 0.4$	V
R_{PU}	Pull-up resistance	11	13	16	k Ω
R_{PD}	Pull-down resistance	11	13	16	k Ω

2.2 RF Characteristics

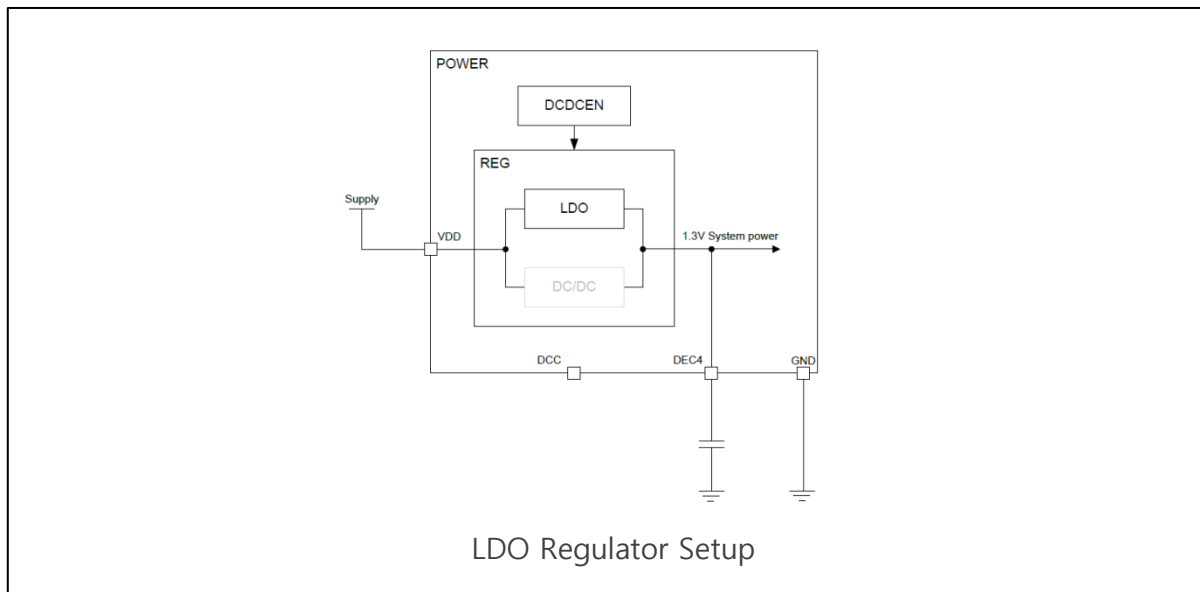
Symbol	Description	Min.	Typ.	Max.	Units
f_{OP}	Operating frequencies	2400		2485	MHz
$f_{PLL,CH,SP}$	PLL channel spacing		1		MHz
$f_{\Delta, BLE, 1M}$	Frequency deviation @ BLE 1Msps		± 250		kHz
$f_{\Delta, BLE, 2M}$	Frequency deviation @ BLE 2Msps		± 320		kHz
P_{RF}	Maximum output power		-	20	dBm
P_{RFC}	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

3. Power and clock management

3.1 Regulator

The following internal power feature;

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



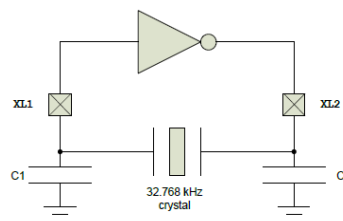
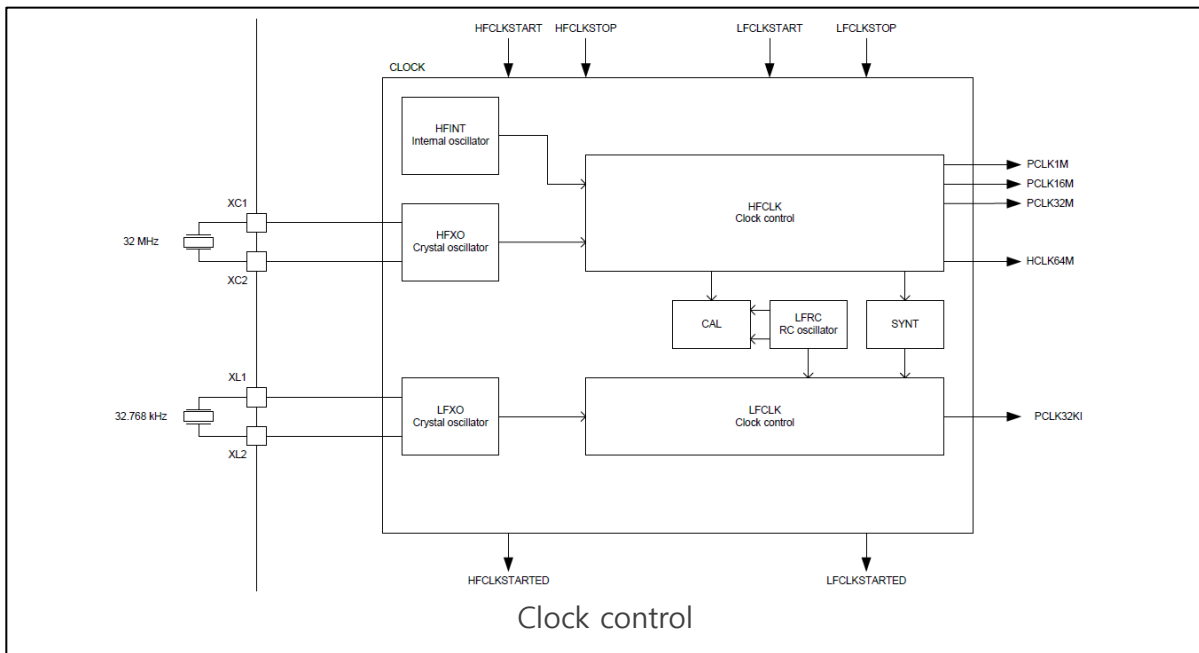
3.2 32.768KHz Crystal Oscillator

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 ± 50 ppm 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.



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)

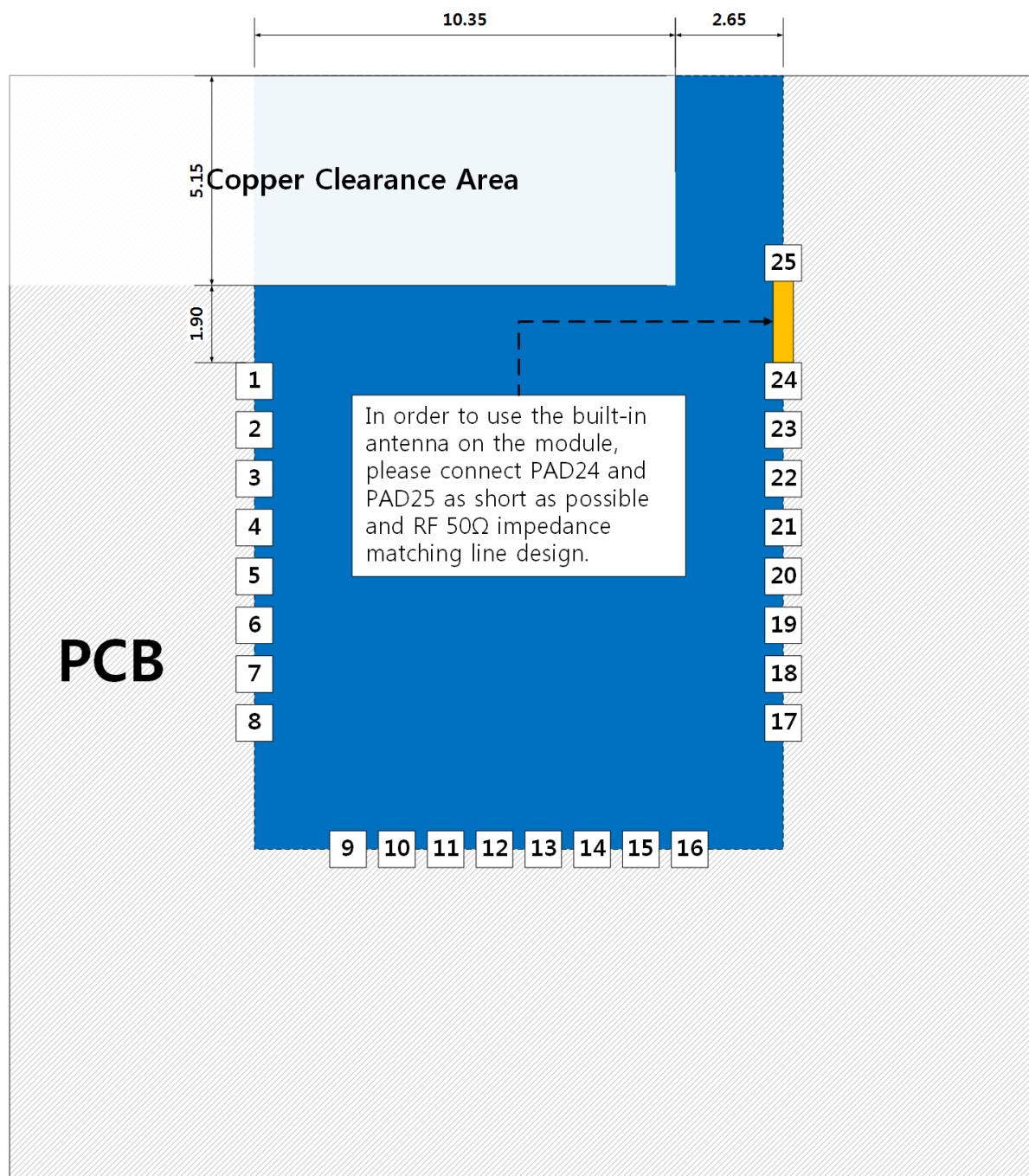
Symbol	Description	Min.	Typ.	Max.	Units
$f_{\text{NOM_LFRC}}$	Nominal frequency		32.768		kHz
$f_{\text{TOL_LFRC}}$	Frequency tolerance		±2		%
$f_{\text{TOL_CAL_LFRC}}$	Frequency tolerance for LFRC after calibration		±500		ppm

▪ 32.768 kHz crystal oscillator (LFXO)

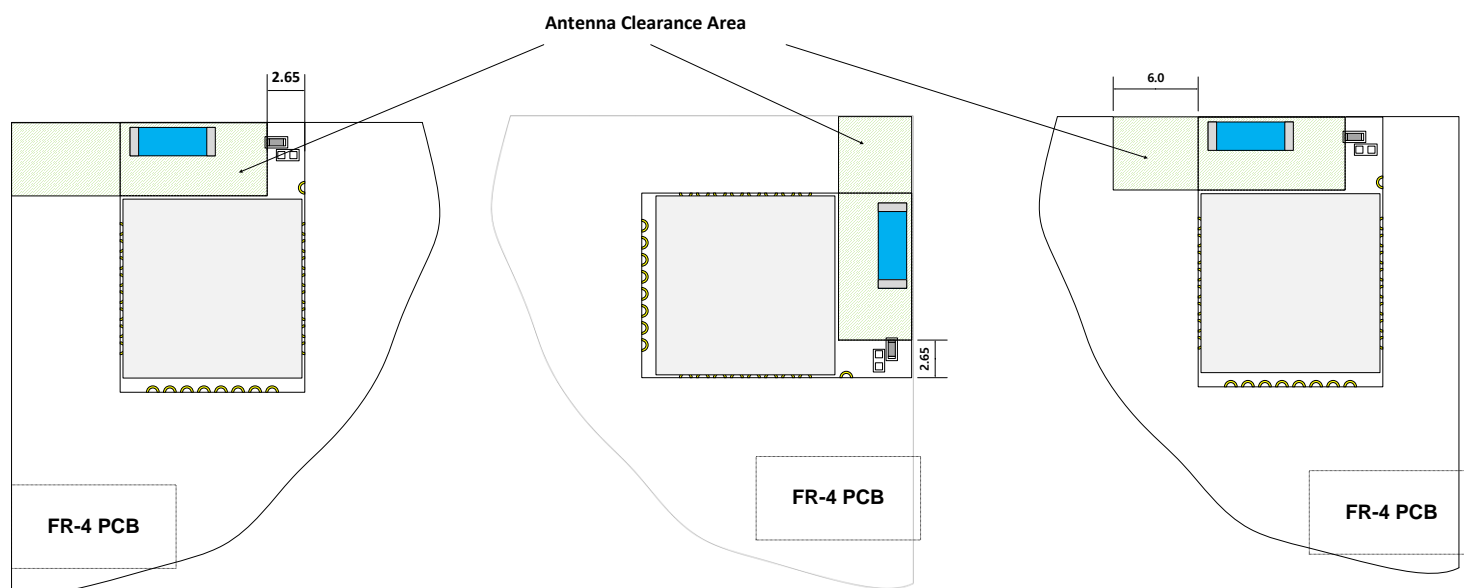
Symbol	Description	Min.	Typ.	Max.	Units
$f_{\text{NOM_LFXO}}$	Crystal frequency		32.768		kHz
$f_{\text{TOL_LFXO_BLE}}$	Frequency tolerance requirement for BLE stack		±250		ppm
$f_{\text{TOL_LFXO_ANT}}$	Frequency tolerance requirement for ANT stack		±50		ppm
$C_{\text{L_LFXO}}$	Load capacitance			12.5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

4. Antenna design Guide

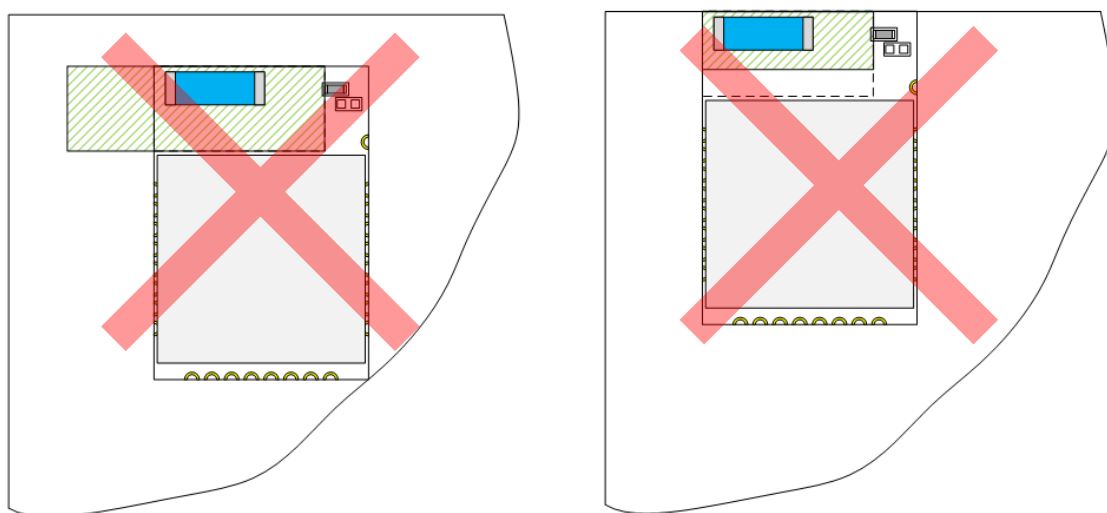
4.1 Internal Antenna Layout Guide



4.1.1 Recommended Module Mounting



Recommended Module Mounting Example



Wrong Module Mounting Example

5. Reflow Temperature Profiles

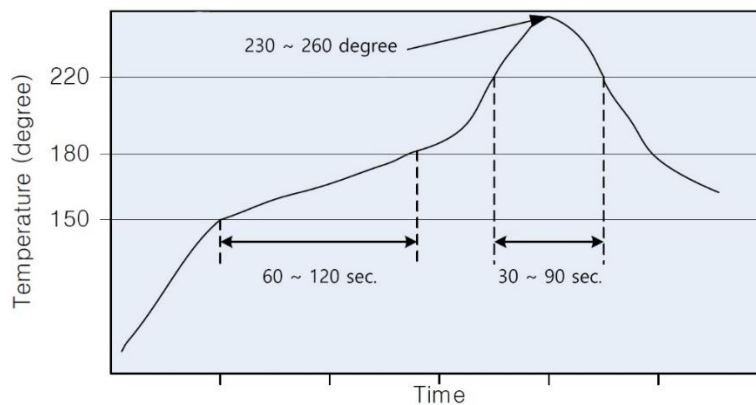
Recommended solder reflow profile are shown in below and follow the lead-free profile I accordance with JEDEC Std 20C.

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. Certifications

This section details the regulatory certification status of BoT-TMA50 modules in various regions.

6.1 Qualified Antennas

BoT-TMA50 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-TMA50 Tested Report can be used in the regulatory areas that have a full modular radio approval (USA, Canada, Korea, Japan) 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 3.5dBi is needed, it can be added as a permissive change, requiring some radiated emission testing. Antenna types with more gain than 3.5dBi 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.

6.2 CE

The BoT-TMA50 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-TMA50 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.



6.3 FCC

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.

FCC Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.

OEM INTEGRATION INSTRUCTIONS:

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

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-TMA50".

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.

6.4 Requirement per KDB996369 D03**6.4.1 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)

6.4.2 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.

6.4.3 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.

6.4.4 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-TMA50.

6.4.5 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.

6.4.6 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-TMA50."

6.4.7 Information on test modes and additional testing requirements⁵

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.

6.5 JAPAN-MIC

The BoT-TMA50 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.

6.6 KC

The BoT-TMA50 have a RF certification for import and use in South Korea. Their certification number is R-C-csi-BoT-TMA50.

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.

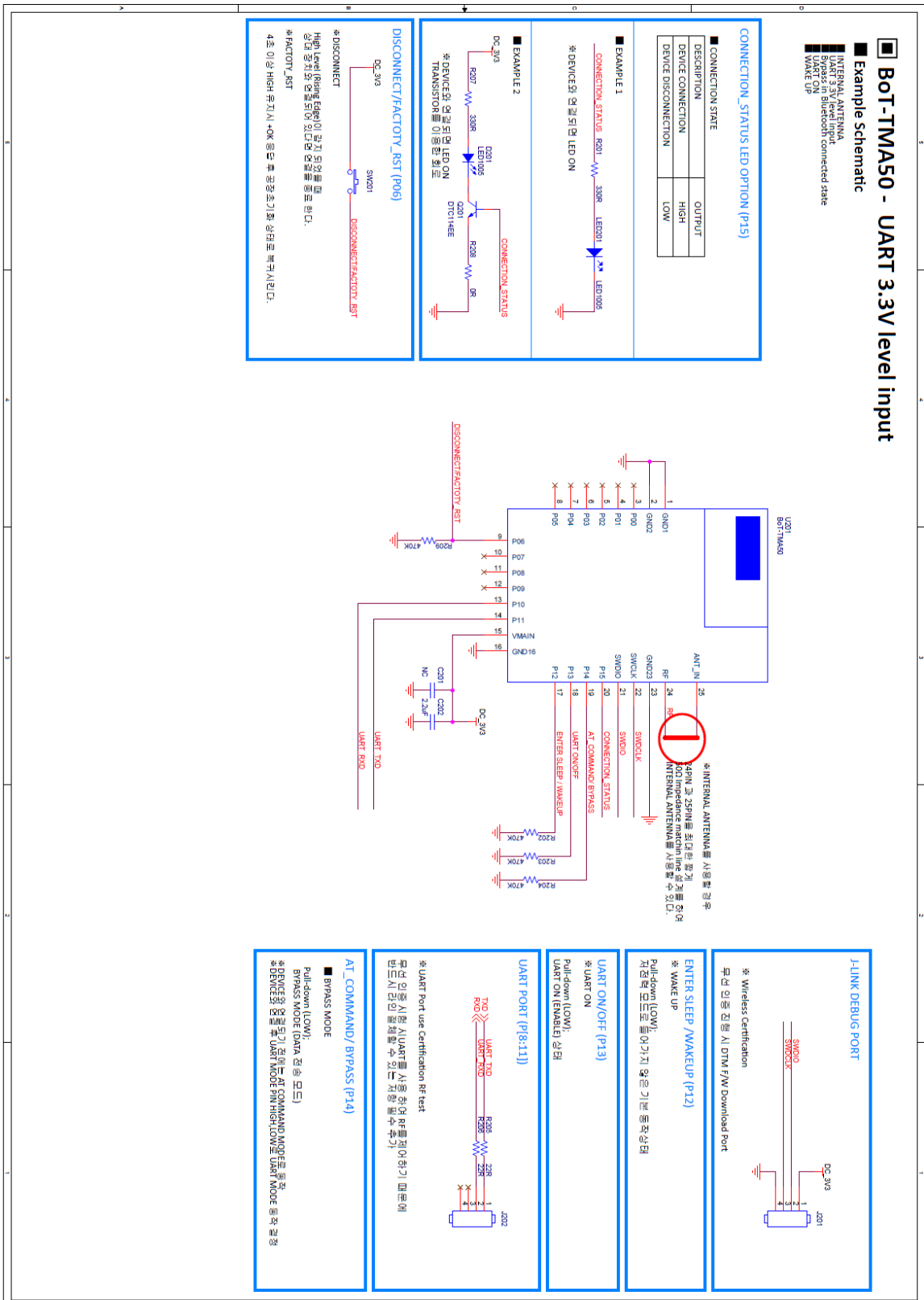


7. Application Schematic

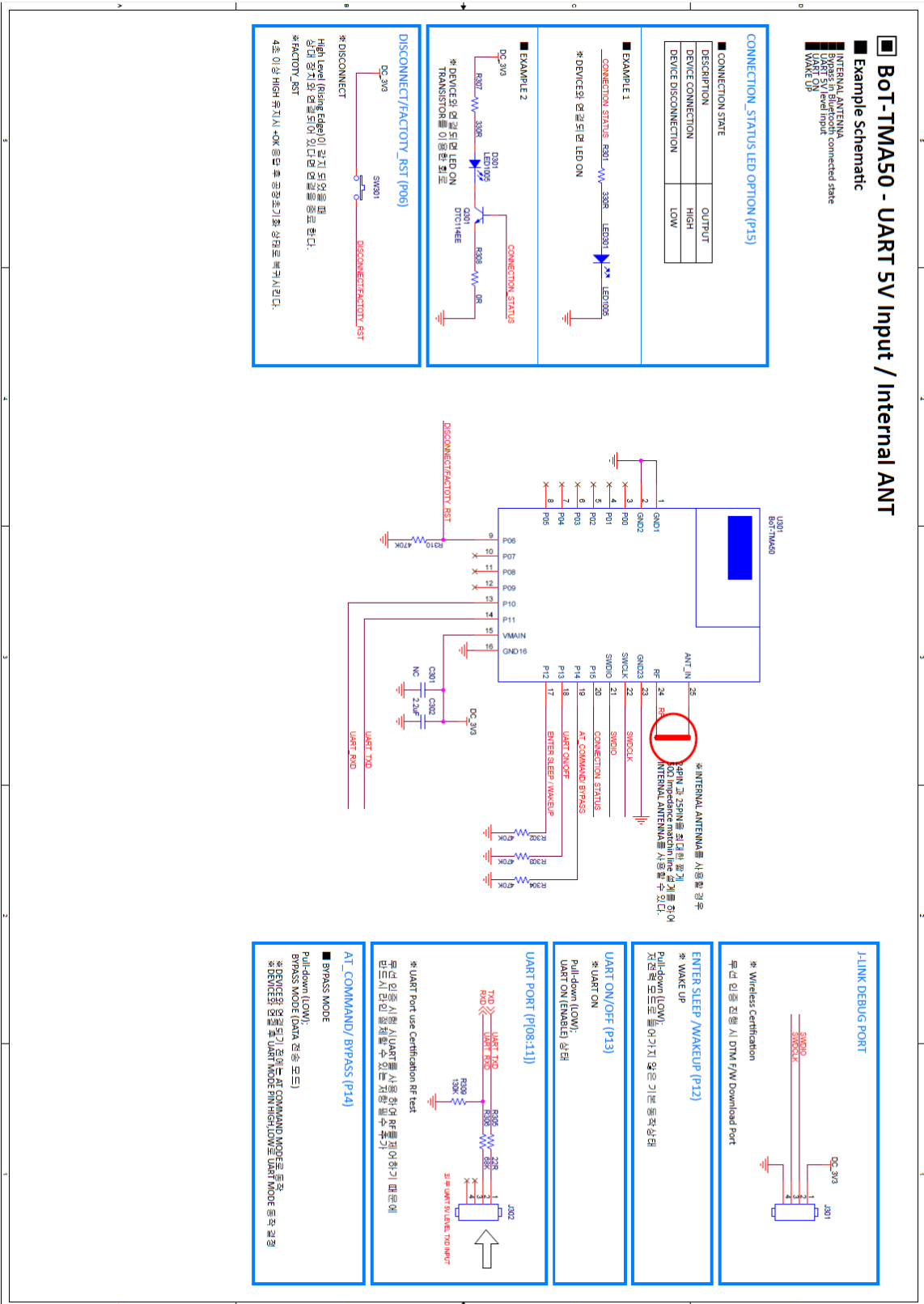
Design consideration

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

7.2 3V3, INTERNAL ANTENNA



7.3 5V, INTERNAL ANTENNA



7.4 3V3, EXTERNAL ANTENNA

