MK01 Bluetooth Module Datasheet

Bluetooth® Module Datasheet

Contents

1. Product Instruction

MK01 is a powerful, highly flexible, ultra low power **Bluetooth® 5** module based on **Nordic® Semiconductor nRF52832** SoC solution, which has a 32 bit Arm® Cortex™-M4 CPU with floating point unit running at 64 MHz.

MK01 module is multiprotocol capable with full protocol concurrency. It supports **BLE®** (Bluetooth Low Energy), including the high-speed 2 Mbps feature. Bluetooth mesh can be run concurrently with Bluetooth LE, enabling smartphones to provision, commission, configure and control mesh nodes. NFC, ANT and 2.4 GHz proprietary protocols are also supported.

MK01 has a ultra-small size of 10mm x 10mm with 36 LGA (Land Grid Array) 0.4mm x 0.4mm pads providing 22 GPIOs (including 32.768 kHz crystal and reset pins) of nRF52832CIAA (WLCSP package).

1.1 Model Classification

MK01 Bluetooth module has two different models -- **MK01A & MK01B**. The diffenence between MK01A and MK01B is the antenna design.

MK01 integrates a high-performance ceramic chip antenna[1]. BLE advertising distance can reach more than 80 meters.

MK01 uses a u.FL connector[2] and requires an external 2.4Ghz antenna. BLE advertising distance can reach more than 150 meters using 2.4GHz 3dBi Terminal Mount Dipole Antenna[3].

1.2 Key Features
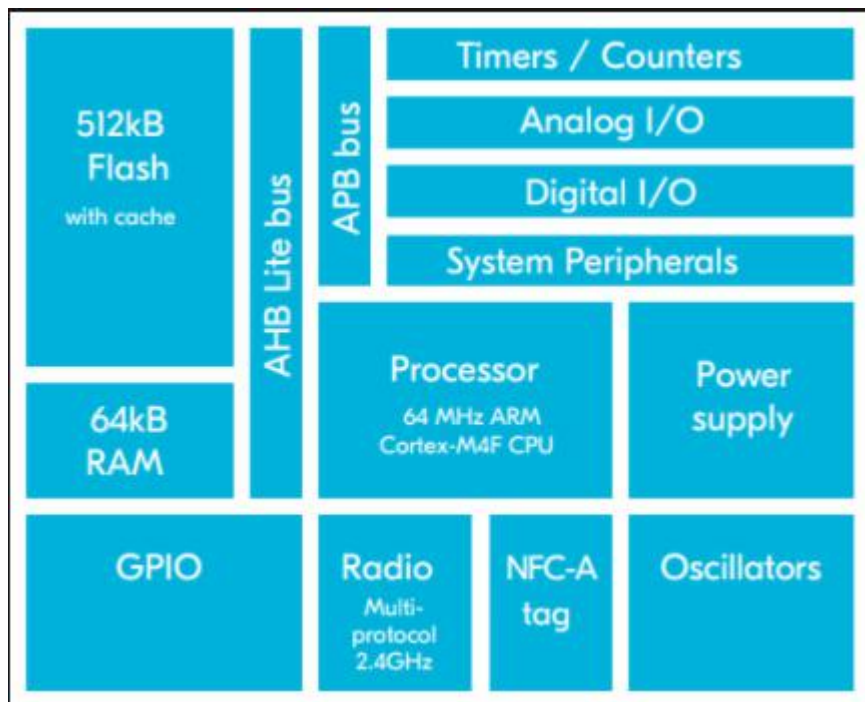
- Bluetooth 5
    - 2Mbps
    - CSA#2
    - Advertising Extensions
- Sensitivity
    -
    - -89 dBm Bluetooth LE 2 Mbps
    -
    - -30 dBm whisper mode
- Supports 2 Mbps Bluetooth LE modes
- Wide supply voltage range: 1.7 V to 3.6 V
- 512kB Flash and 64kB RAM
- Full set of digital interfaces including: SPI/2-wire/I²S/UART/PDM/QDEC with EasyDMA
- 12-bit/200 ksps ADC
- 128-bit AES ECB/CCM/AAR co-processor
- Type 2 near field communication (NFC-A) tag with wakeup-on-field and touchto-pair capabilities (P09 and P10)

- Individual power management for all peripherals
- Default internal LDO regulator setup (Support DC/DC regulator) [4]
- 32.768 kHz +/-250 ppm RC oscillator[5]
- Dimension: 10.0x10.0x2.0mm (with shield)
- 22 GPIOs (including 32.768 kHz crystal and reset pins)
- Firmware: The module can be programmed with MOKO Bluetooth 4.2 master and slave role in one firmware[6] or customer specified firmware

1.3 Applications

- **IoT**
  - Home automation
  - Sensor networks
  - Building automation
  - Industrial automation
- **Personal area networks**
  - Health/fitness sensor and monitor devices
  - Medical devices
  - Key fobs and wrist watches
- **Interactive entertainment devices**
  - Remote controls
  - Gaming controllers
  - VR/AR
- **Beacons**
- **A4WP wireless chargers and devices**
- **Remote control toys**
- **Computer peripherals and I/O devices**
  - Mouse
  - Keyboard
  - Multi-touch trackpad
 - Gaming

1.4 Product Specifications

Detail	Description
Bluetooth	
Bluetooth version	Bluetooth 5.2 SoC，supporting Bluetooth Low Energy, Concurrent Central & Peripheral, 2M LE PHY, Advertising Extensions, CSA #2, Bluetooth Mesh
Security	AES-128
LE connections	Concurrent central, observer, peripheral, and broadcaster roles with up to twenty concurrent connections along with one Observer and one broadcaster
Radio	
Frequency	2402MHz - 2480Mhz
Modulations	GFSK at 2 Mbps data rates
Transmit power	+4 dBm maximum
Receiver sensitivity	-96 dBm sensitivity in Bluetooth Low Energy mode
Antenna	MK01A - Ceramic chip, Peak Gain: 0.9dBi / Efficiency: -1.8dB (66%) MK01B - Peak Gain: 3dBi / Efficiency: 85% (2.4GHz 3dBi Terminal Mount Dipole Antenna)
Current consumption	
TX only (DCDC enabled, 3V) @ +4dBm / 0dBm / -4dBm / -20dBm / -40dBm	7.5mA / 5.3mA / 4.2mA / 3.2mA / 2.7mA
TX only @ +4dBm / 0dBm / -4dBm / -20dBm / -40dBm	16.6mA / 11.6mA / 9.3mA / 7.0mA / 5.9mA

RX only (DCDC enabled, 3V) @2Msps / 2Msps BLE	5.8mA
RX only @ 2Msps / 2Mbps BLE	12.9mA
System OFF mode（3V）	0.3uA
System OFF mode with full 64 kB RAM retention（3V）	0.7uA
System ON mode, no RAM retention, wake on RTC（3V）	1.9uA
Mechanical Design	
Dimensions	Length: 10mm±0.2mm； Width: 10mm±0.2mmHeight: 2.0mm+0.1mm/-0.15mm
Package	36 LGA (Land Grid Array) pads
PCB material	FR-4
Impedance	50 Ω
Hardware	
CPU	ARM® Cortex®-M4 32-bit processor with FPU, 64 MHz
Memory	512 kB flash / 64 kB RAM
Interfaces	3xSPI master/slave with EasyDMA 2x I2C compatible 2-wire master/slave 22xGPIO 7x12 bit ADC UART (CTS/RTS) with EasyDMA I2S with EasyDMA PWM

	PDM
	NFC-A
Power supply	1.7V to 3.6V
Operating temperature range	-40 to 85 ℃

2. Circuit Design

2.1 Block Diagram
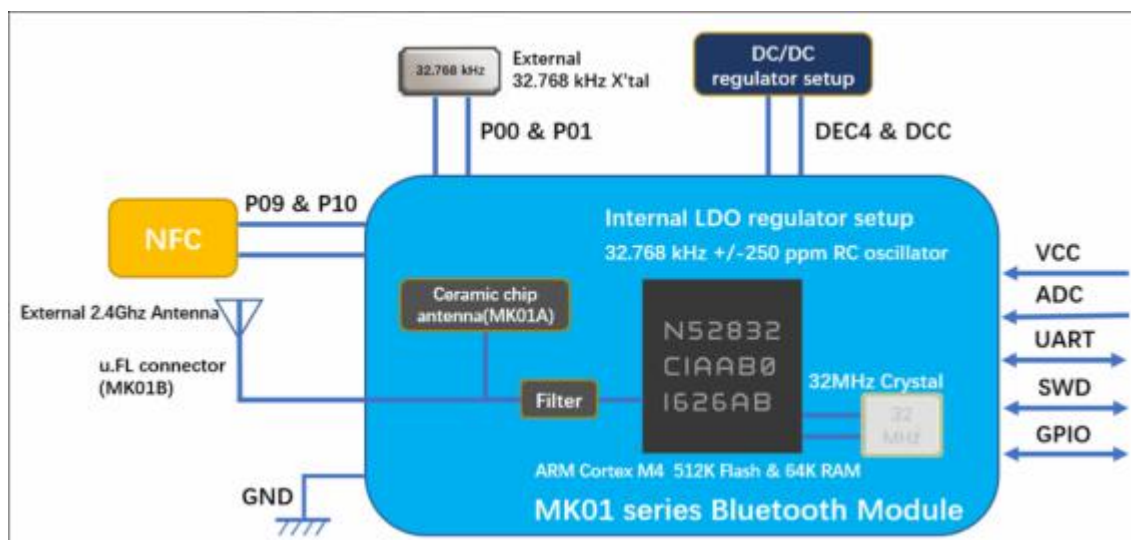
Module default design is using "Internal LDO regulator setup" and "Internal 32.768 kHz RC oscillator".

2.2 Schematic

MK01A

MK01B

2.3 Reference Circuitry
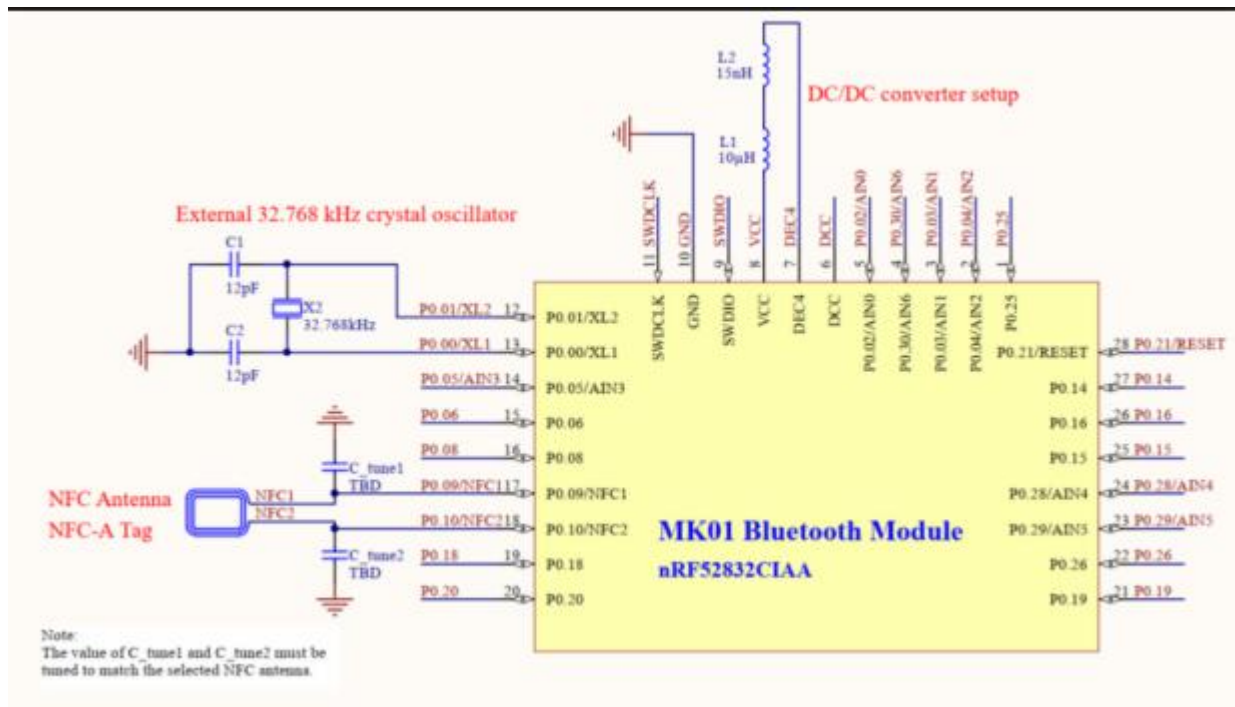
2.3.1 DC/DC regulator setup

- When using DC-DC mode, please add L1 / L2.
- DEC4 decoupling capacitor (1F) is already inside the module.

Designator	Value	Description
L1	10H	Chip inductor, IDC,min = 50 mA, ±20%
L2	15nH	High frequency chip inductor ±10%

2.3.2 External 32.768 kHz crystal

- When using external 32.768 kHz crystal oscillator, please add X2 / C1 / C2.

Designator	Value	Description
X2	32.768 kHz	XTAL SMD, 32.768 kHz, CI=9 pF, ±50 ppm
C1, C2	12 pF	Capacitor, NP0, ±2%

2.3.3 NFC-A Tag

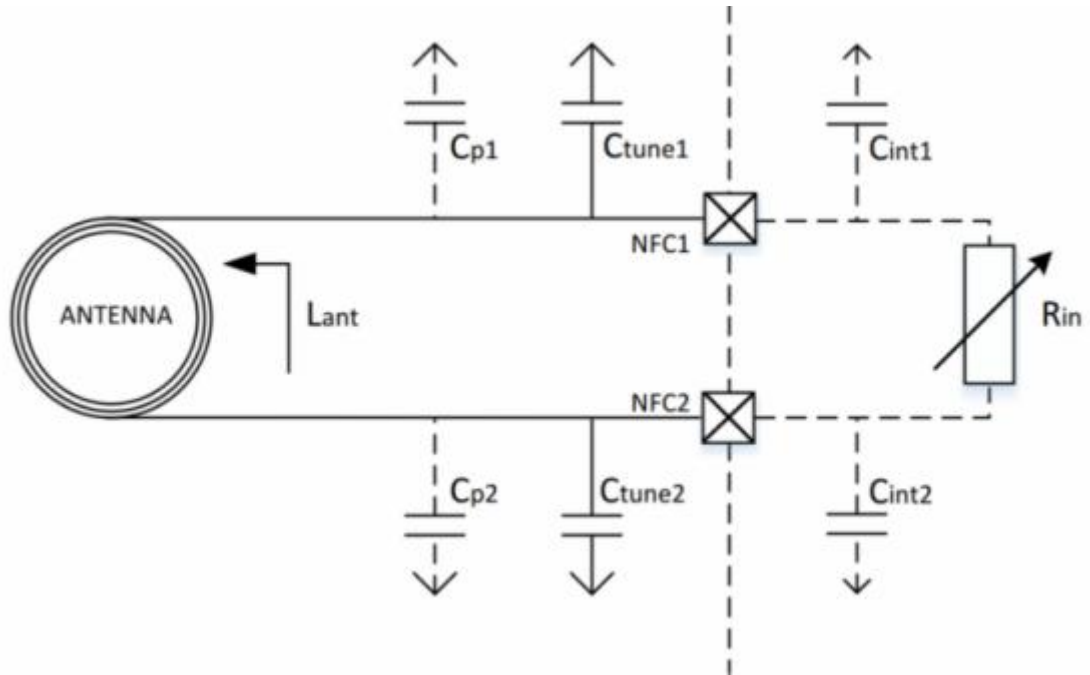- When using NFC-A tag , please add C_tune1 and C_tune2.
- When using NFC-A tag. You should use a NFC Tag antenna coil that must be connected differential between NFC1 and NFC2 pins of the device.
- The value of C_tune1 and C_tune2 must be tuned to match the selected NFC antenna. The two external capacitors should be used to tune the resonance of the antenna circuit to 13.56 MHz.

The required tuning capacitor value is given by the below equations:

$$C'_{tune} = \frac{1}{(2\pi \cdot 13.56\ MHz)^2 \cdot L_{ant}} \quad where\ C'_{tune} = \frac{1}{2} \cdot \left(C_p + C_{int} + C_{tune}\right)$$

$$and\ C_{tune1} = C_{tune2} = C_{tune} \qquad C_{p1} = C_{p2} = C_p \qquad C_{int1} = C_{int2} = C_{int}$$

$$C_{tune} = \frac{2}{(2\pi \cdot 13.56\ MHz)^2 \cdot L_{ant}} - C_p - C_{int}$$

An antenna inductance of Lant = 2 H will give tuning capacitors in the range of 130 pF on each pin. For good performance, match the total capacitance on NFC1 and NFC2.

3. Mechanical specifications

3.1 Module Mechanical Dimensions
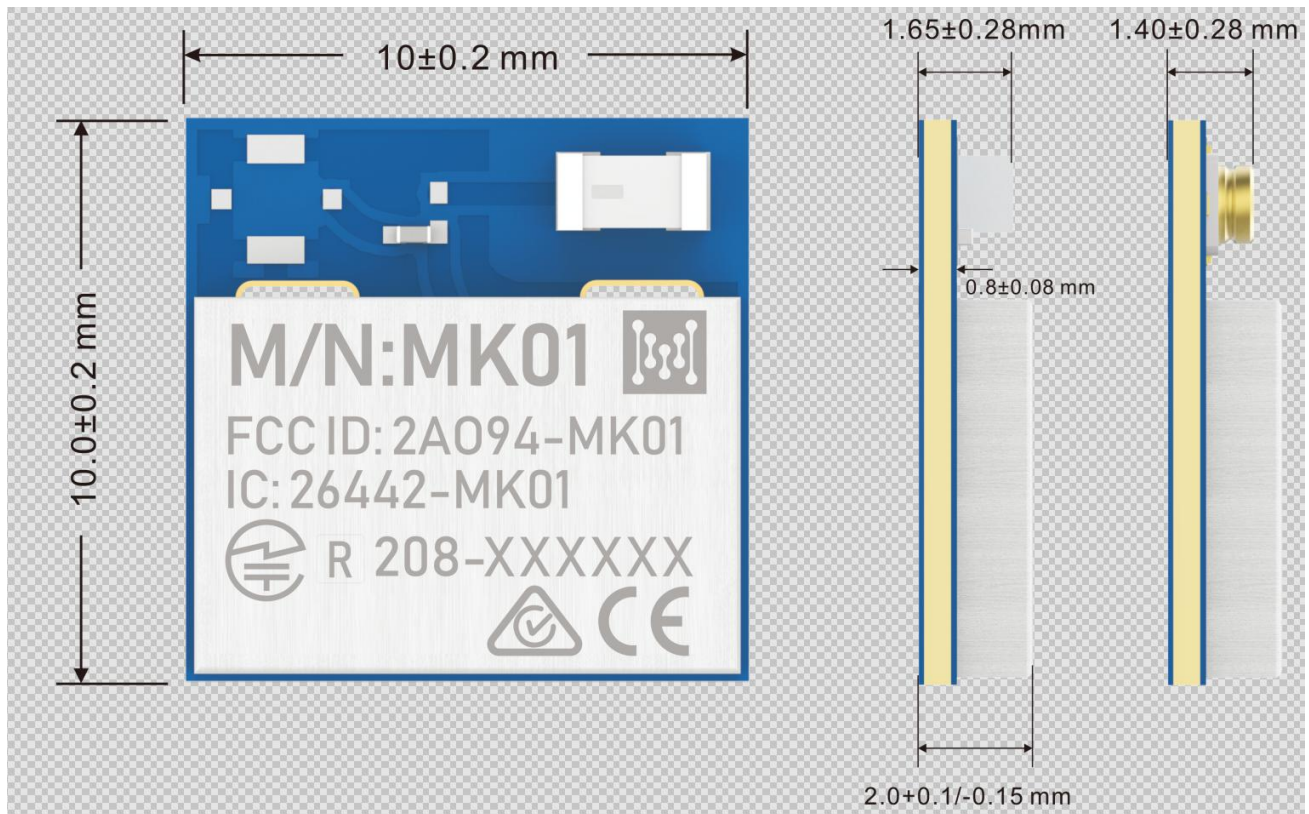
MK01 Dimension

Symbol	Min.	Typ.	Max.
Length	-0.2mm	10mm	+0.2mm
Width	-0.2mm	10mm	+0.2mm
Height(PCB only)	-0.08mm	0.8mm	+0.08mm
Height(with shield)	-0.15mm	2.0mm	+0.1mm

3.2 Recommended PCB land pads
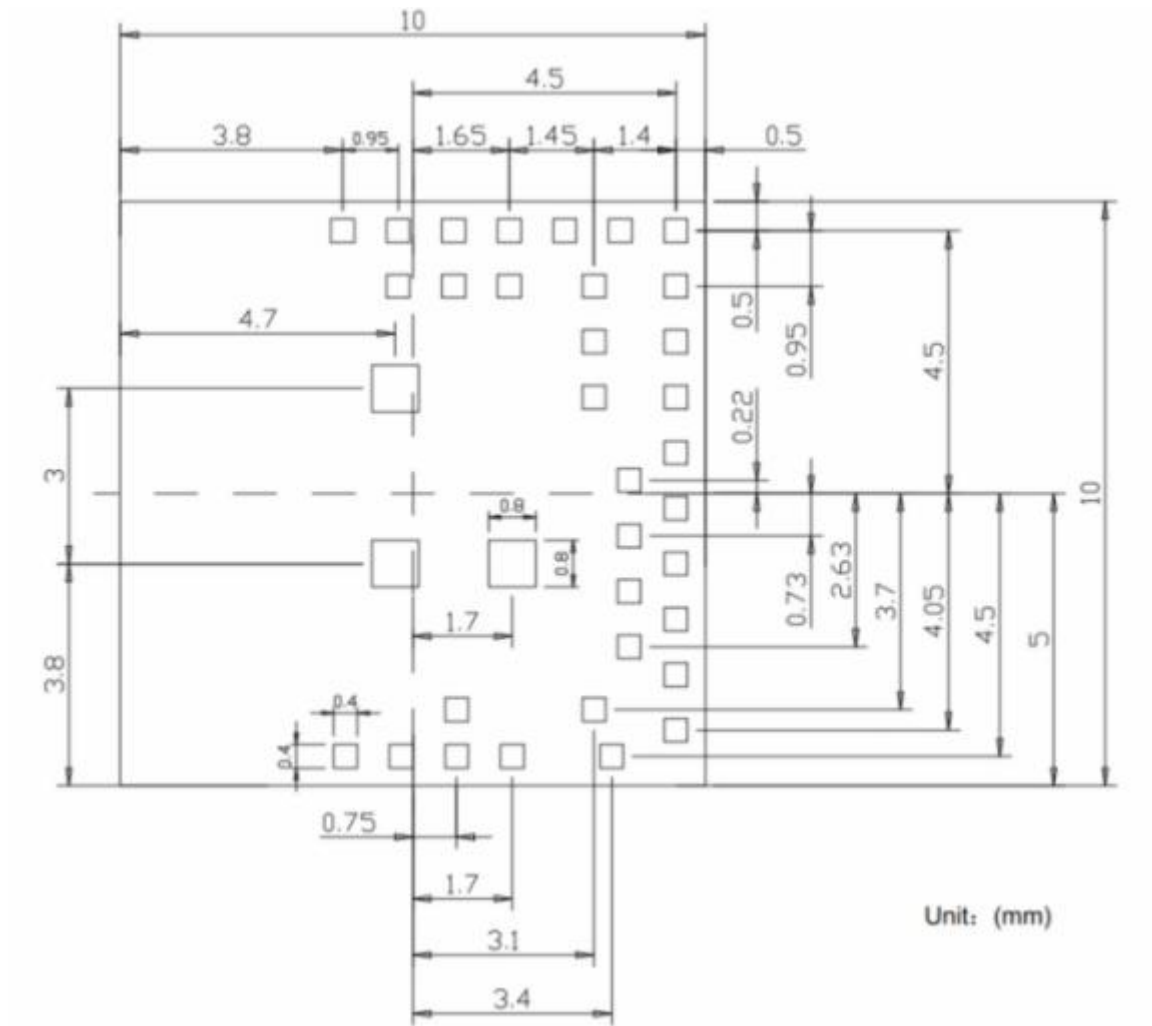
MK01 PCB land pads(Top View)

Symbol	Typ.
LGA Pad(small)	0.4mm x 0.4mm
LGA Pad(big)	0.8mm x 0.8mm

4 Pin Assignment
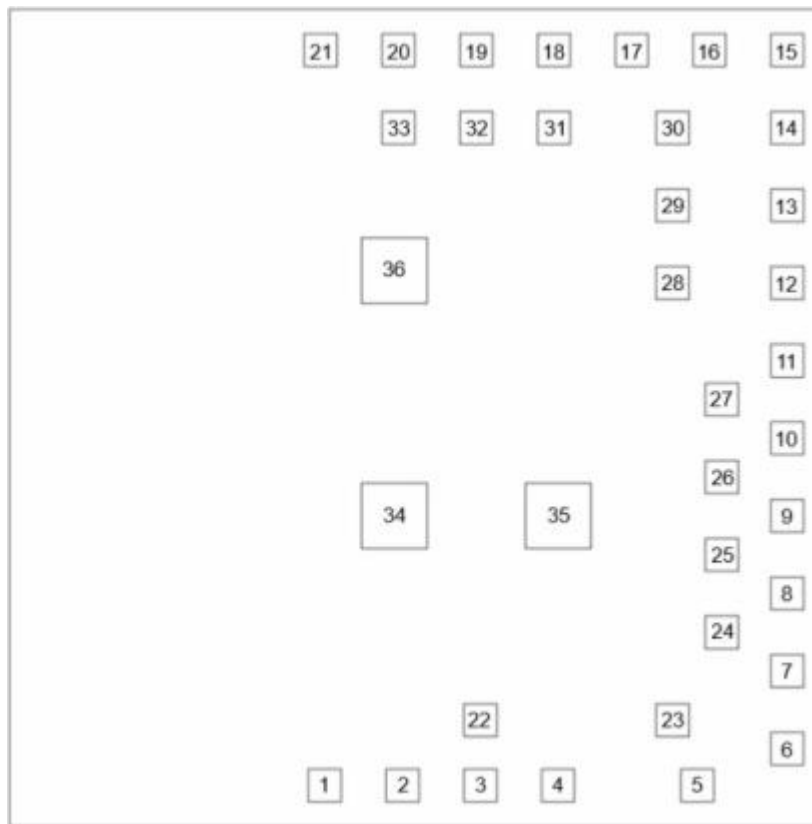
Pin No.	Name	Type	Description	nRF52 port
1	P0.19	Digital I/O	General purpose I/O	P0.19
2	P0.20	Digital I/O	General purpose I/O	P0.20
	TRACECLK		Trace port clock output	
3	P0.18	Digital I/O	General purpose I/O	P0.18
	TRACEDATA[0]		Trace port output	
4	P0.10	Digital I/O	General purpose I/O [7]	P0.10
	NFC2	NFC input	NFC antenna connection	
5	P0.09	Digital I/O	General purpose I/O [7]	P0.09
	NFC1	NFC input	NFC antenna connection	
6	P0.08	Digital I/O	General purpose I/O	P0.08
7	P0.06	Digital I/O	General purpose I/O	P0.06

8	P0.05	Digital I/O	General purpose I/O	P0.05
	AIN3	Analog input	SAADC/COMP/LPCOMP input	
9	P0.00	Digital I/O	General purpose I/O	P0.00
	XL1	Analog input	Connection for 32.768 kHz crystal (LFXO)	
10	P0.01	Digital I/O	General purpose I/O	P0.01
	XL2	Analog input	Connection for 32.768 kHz crystal (LFXO)	
11	DEC4	Power	1.3 V regulator supply decoupling Input from DC/DC converter. Output from 1.3 V LDO	DEC4
12	GND	Power	Electrical Ground	VSS
13	VCC	Power	Power supply. An internal 4.7 µF bulk capacitor is included on the module. However, it is good design practice to add additional bulk capacitance as required for your application, i.e. those with heavy GPIO usage and/or current draw.	VDD
14	DCC	Power	DC/DC converter output	DCC
15	P0.02	Digital I/O	General purpose I/O	P0.02
	AIN0	Analog input	SAADC/COMP/LPCOMP input	
16	P0.30	Digital I/O	General purpose I/O [8]	P0.30
	AIN6	Analog input	SAADC/COMP/LPCOMP input	
17	P0.03	Digital I/O	General purpose I/O	P0.03
	AIN1	Analog input	SAADC/COMP/LPCOMP input	
18	P0.04	Digital I/O	General purpose I/O	P0.04

|	AIN2	Analog input	SAADC/COMP/LPCOMP input	
19	P0.25	Digital I/O	General purpose I/O [8]	P0.25
20	GND	Power	Electrical Ground	VSS
21	GND	Power	Electrical Ground	VSS
22	P0.21	Digital I/O	General purpose I/O	P0.21
	RESET		Configurable as pin reset	
23	P0.14	Digital I/O	General purpose I/O	P0.14
	TRACEDATA[3]		Trace port output	
24	P0.15	Digital I/O	General purpose I/O	P0.15
	TRACEDATA[2]		Trace port output	
25	P0.16	Digital I/O	General purpose I/O	P0.16
	TRACEDATA[1]		Trace port output	
26	SWDCLK	Digital input	Serial wire debug clock input for debug and programming	SWDCLK
27	SWDIO	Digital I/O	Serial wire debug I/O for debug and programming	SWDIO
28	P0.28	Digital I/O	General purpose I/O	P0.28
	AIN4	Analog input	SAADC/COMP/LPCOMP input	
29	P0.29	Digital I/O	General purpose I/O [8]	P0.29
	AIN5	Analog input	SAADC/COMP/LPCOMP input	
30	P0.26	Digital I/O	General purpose I/O [8]	P0.26
31-36	GND	Power	Electrical Ground	VSS

MK01 module pin assignment (Top View)

5. Mounting Suggestion

You can refer to the following references for the mounting design of the module with on-board antenna (MK01A with ceramic chip antenna on PCB).

For external antenna modules (MK01B needs to connect an external antenna to the u.FL connector), you need to refer to the external antenna design requirements.

Recommended module mounting example
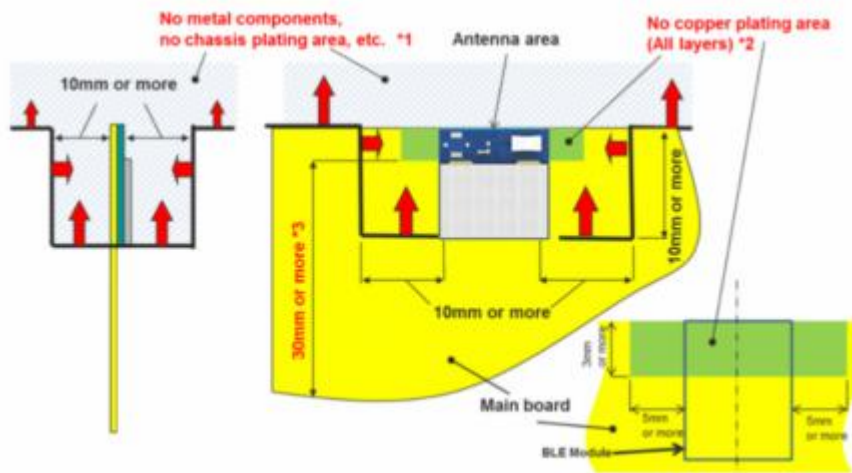
- Please do not place any metal components in blue shaded space(*1), such as signal line and metal chassis as possible except for main board while mounting the components in *1 space on the main board is allowed except for no copper plating area(*2).
- (*2)This area is routing prohibited area on the main board. Please do not place copper on any layer.
- (*3)Characteristics may deteriorate when GND pattern length is less than 30mm. It should be 30 mm or more as possible.
- For the best Bluetooth range performance, the antenna area of module shall extend 3 mm outside the edge of main board, or 3 mm outside the edge of a ground plane. Ground plane shall be at least 5 mm from the edge of the antenna area of module.
- All module GND pins MUST be connected to main board GND. Place GND vias close to module GND pads as possible. Unused PCB area on surface layer can flooded with copper but place GND vias regularly to connect copper flood

to inner GND plane. If GND flood copper underside the module then connect with GND vias to inner GND plane.

- Even when above mentioned condition is satisfied, communication performance may be significantly deteriorated depending on the structure of the product. Bluetooth range performance is degraded if a module is placed in the middle of the main board.

- For main board layout:
  - Avoid running any signal line below module whenever possible.
  - No ground plane below antenna.
  - If possible, cut-off the portion of main board below antenna.

Other module mounting examples
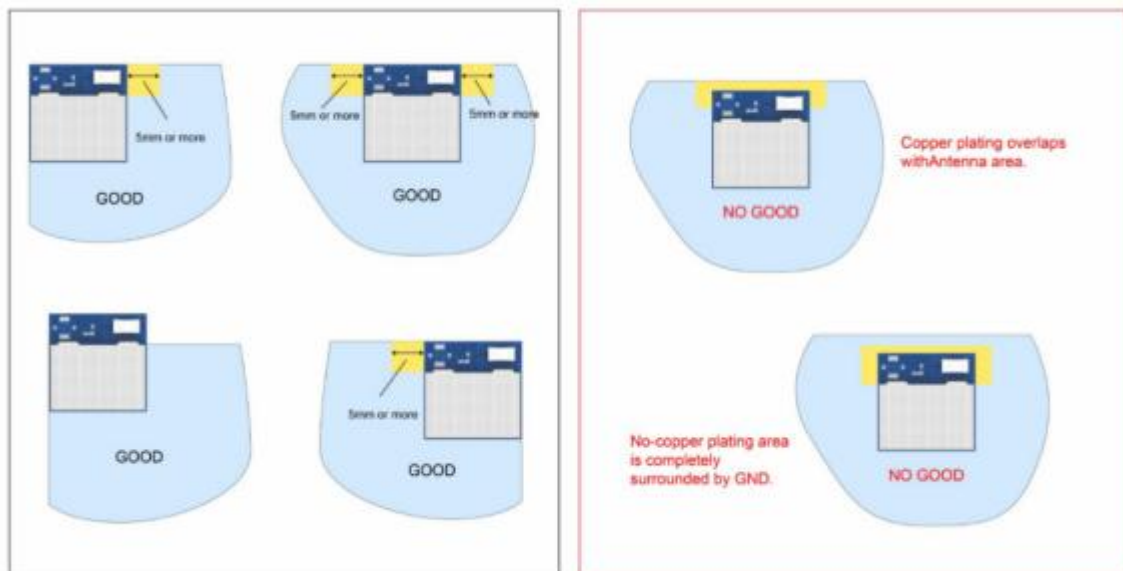
Placement of resin or plastic parts

Resin or Plastic parts
(ex. Cover, Chassis, etc.)

Main board

t: Thickness of resin or plastic
g: Distance between module and parts

$$g \geq t$$
$$g \geq 1.5\,mm$$
$$t < 5\,mm$$

It is recommended that the design should be done in accordance with above formula.

BLE Module

Please do not apply molding over the antenna area of BLE module.
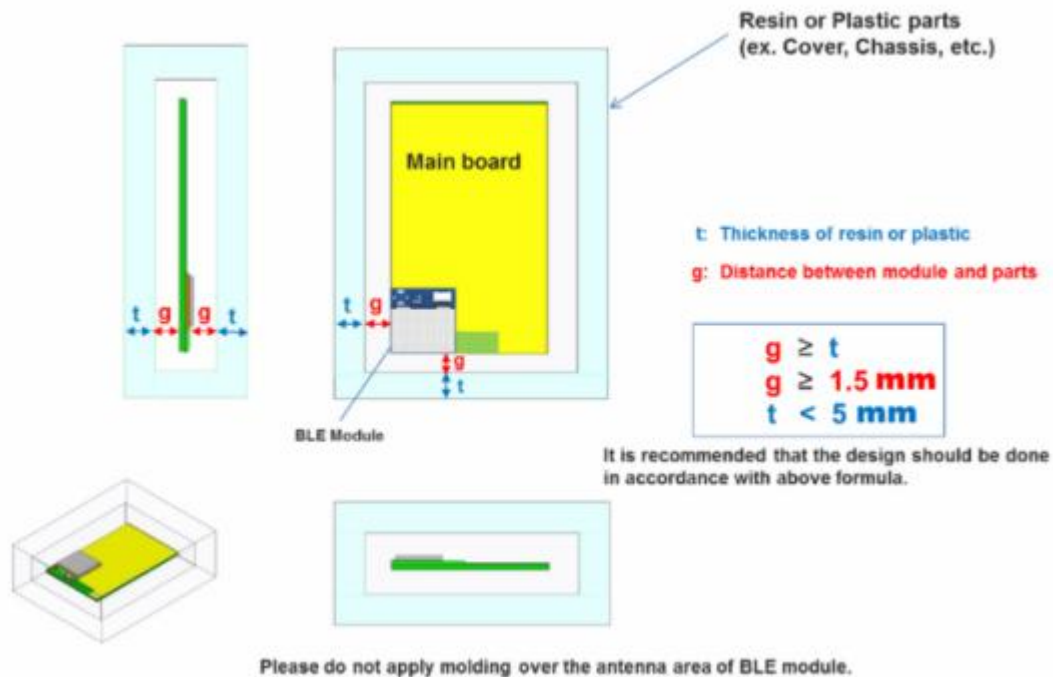
Placement of metal parts

- Minimum safe distance for metal parts without seriously compromising the antenna (tuning) is 40 mm top/bottom and 30 mm left or right.
- Metal close to the module antenna (bottom, top, left, right, any direction) will have degradation on the antenna performance. The amount of that degradation is entirely system dependent, meaning you will need to perform some testing with your host application.
- Any metal closer than 20 mm will begin to significantly degrade performance (S11, gain, radiation efficiency).
  - It is best that you test the range with a mock-up (or actual prototype) of the product to assess effects of enclosure height (and materials, whether metal or plastic).

6. Cautions

6.1 Reflow Soldering

Reflow soldering is a vitally important step in the SMT process. The temperature curve associated with the reflow is an essential parameter to control to ensure the correct connection of parts. The parameters of certain components will also directly impact the temperature curve selected for this step in the process.

Temperature-Time Profile for Reflow Soldering

- The standard reflow profile has four zones: ①**preheat, ②soak, ③reflow and ④cooling**. The profile describes the ideal temperature curve of the top layer of the PCB.
- During reflow, modules should not be above 260° and not for more than 30 seconds.

Specification	Value	Unit
Temperature Increase Rate	<2.5	°C / s
Temperature Decrease Rate	Free air cooling	-
Preheat Temperature	0 - 150	°C
Preheat Period (Typical)	40 - 90	s
Soak Temp Increase Rate	0.4 - 1	°C / s
Soak Temperature	150 - 200	°C
Soak Period	60 - 120	s
Liquidus Temperature (SAC305)	220	°C

Time Above Liquidous	45 - 90	s
Reflow Temperature	230 - 250	°C
Absolute Peak Temperature	260	°C

Example of MOKO SMT reflow soldering

PROFILE CHECK

Customer Name: MOKO Technology Ltd
Oven Type: smt生产线
Zones setting (℃)

Date Time: 2020/5/20 10:48:52
PCB Name:
Speed: 78cm/min

Zones	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Top	120	140	165	170	180	190	210	240	255	245	0	0	0	0
Bottom	120	140	165	170	180	190	210	240	255	245	0	0	0	0

TCS	Peak(℃)	Peak difference	Peak at time(s)	190(℃)time above	Preheat(50-150℃) Slope	Preheat(50-150℃) Time(s)	Soak(150-200℃) Slope	Soak(150-200℃) Time(s)	Reflow(220-260℃) Slope	Reflow(220-260℃) Time(s)	Liquid phase (220℃) time(s)	Cooling(260-100℃) Slope	Cooling(260-100℃) Time(s)
Line1	242.25		318	152	1.14	88	0.42	119	0.65	62	85	-1.39	115
Line2	236.75		310	140	1.06	94	0.42	119	0.91	44	74	-1.34	119
Line3	239.25		322	145	1.11	90	0.41	122	0.78	51	76	-1.45	110
Line4	235.75	9.25	324	139	1.05	95	0.42	118	0.78	51	70	-1.38	116
Line5	235		321	135	1.10	91	0.41	122	0.89	45	65	-1.44	111
Line6	237.25		321	146	1.05	95	0.42	118	0.82	49	75	-1.34	119

Note: The module is LGA package. Please be careful of the amount of solder paste. The module may be lifted due to excess solder.

6.2 Usage Condition Notes

- Follow the conditions written in this specification, especially the recommended condition ratings about the power supply applied to this product.
- The supply voltage has to be free of AC ripple voltage (for example from a battery or a low noise regulator output). For noisy supply voltages, provide a decoupling circuit (for example a ferrite in series connection and a bypass capacitor to ground of at least 47uF directly at the module).

- Take measures to protect the unit against static electricity. If pulses or other transient loads (a large load applied in a short time) are applied to the products, check and evaluate their operation before assembly on the final products.
- The supply voltage should not be exceedingly high or reversed. It should not carry noise and/or spikes.
- This product away from other high frequency circuits.
- Keep this product away from heat. Heat is the major cause of decreasing the life of these products.
- Avoid assembly and use of the target equipment in conditions where the products' temperature may exceed the maximum tolerance.
- This product should not be mechanically stressed when installed.
- Do not use dropped products.
- Do not touch, damage or soil the pins.
- Pressing on parts of the metal shield or fastening objects to the metal shield will cause damage.

6.3 Storage Notes

- The module should not be stressed mechanically during storage.
- Do not store these products in the following conditions or the performance characteristics of the product, such as RF performance will be adversely affected:
  - Storage in salty air or in an environment with a high concentration of corrosive gas.
  - Storage in direct sunlight
  - Storage in an environment where the temperature may be outside the range specified.
  - Storage of the products for more than one year after the date of delivery storage period.
- Keep this product away from water, poisonous gas and corrosive gas.
- This product should not be stressed or shocked when transported.

6.4.FCC Statement

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

FCC Radiation Exposure Statement

RF warning statement:

The device has been evaluated to meet general RF exposure requirement. The device can be used in portable exposure condition without restriction.

6.5 IC warning

This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions:

- This device may not cause interference;

- This device must accept any interference,including interference that may cause undesired operation of the device

- French:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils

radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le

brouillage est susceptible d'en compromettre le fonctionnement."

The MK01 module is designed to comply with the FCC statement. FCC ID is 2AO94-MK01. The host system using MK01, should have label indicated it contain modular's FCC ID 2AO94-MK01

This radio module must not installed to co-locate and operating simultaneously with other radios in host system , additional testing and equipment authorization may be required to operating simultaneously with other radio.

This device complies with Part 15, Subpart C, Section 15.247 of the FCC Rules