MK02 Bluetooth Module
（MK02D、 MK02E）

Datasheet

MOKO TECHNOLOGY LTD.

Version 1.1

Contents

1. Product Instruction

MK02 series is a powerful, highly flexible, ultra low power **Bluetooth® 5** module based on **Nordic® Semiconductor nRF52832 SoC** solution, which has a 32bit Arm® Cortex™-M4 CPU with floating point unit running at 64MHz.

MK02 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 2.4GHz proprietary protocols are also supported.

1.1 Model Classification

There are two models of **MK02** series Bluetooth module — **MK02D and MK02E**. The two models have a small size of 21 x 13.8 x 2.3mm with 30 GPIOs of nRF52832QFAA (QFN48 package).
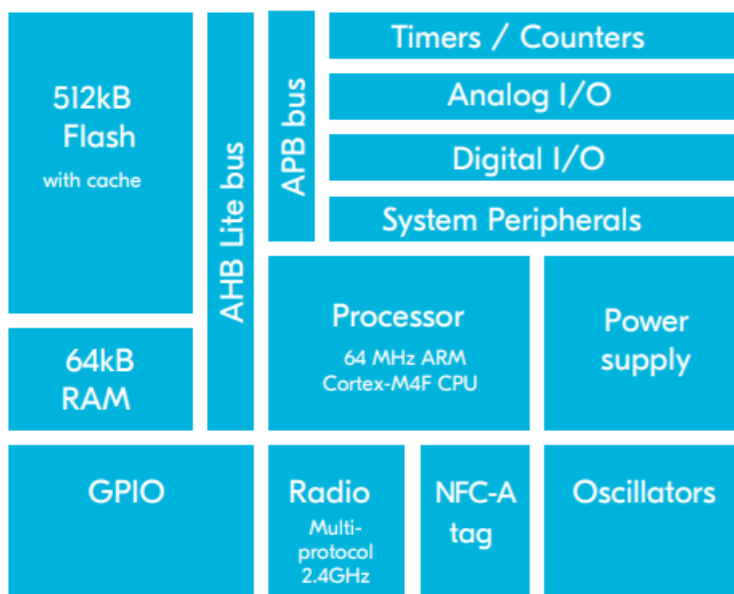
The difference between MK02D and MK02E is the antenna design.

MK02D integrates a high-performance PCB antenna.

MK02E uses a u.FL connector and requires an external 2.4Ghz antenna.

MOKO development team can assist you in selecting high-performance antennas that suit your needs.

1.2 Key Features

- Bluetooth 5
  - 2Mbps
  - CSA#2
  - Advertising Extensions
- 512kB Flash and 64kB RAM
- Supports 1 Mbps and 2 Mbps Bluetooth LE modes
- Sensitivity of -96 dBm for Bluetooth LE
- Wide supply voltage range: 1.7 V to 3.6 V
- Full set of digital interfaces including: SPI, 2-wire, I²S, UART, PDM, QDEC with EasyDMA
- 12-bit, 200ksps ADC
- 128-bit AES ECB/CCM/AAR co-processor
- RAM mapped FIFOs using EasyDMA
- Type 2 near field communication (NFC-A) tag with wakeup-on-field and touch-to-pair capabilities (P09 and P10)
- RAM mapped FIFOs using EasyDMA
- Individual power management for all peripherals
- On-chip DC/DC buck converter
- Small size: 21.0 x 13.8 x 2.3mm (with shield)
- 30 GPIOs

1.3 Applications

- **IoT**

  o Home automation
  o Sensor networks
  o Building automation
  o Industrial automation

- **Personal area networks**

  o Health/fitness sensor and monitor devices
  o Medical devices
  o Key fobs and wrist watches

- **Interactive entertainment devices**

  o Remote controls
  o Gaming controllers
  o VR/AR

- **Beacons**

- **A4WP wireless chargers and devices**

- **Remote control toys**

- **Computer peripherals and I/O devices**

  o Mouse
  o Keyboard
  o Multi-touch trackpad
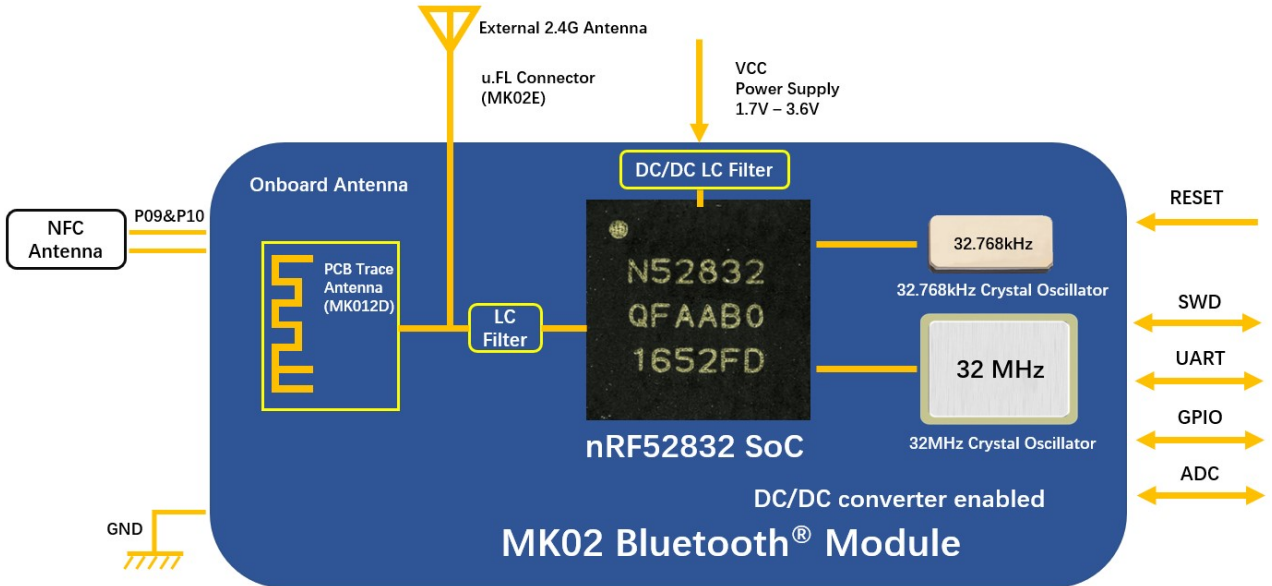 o Gaming

1.4 Product Specifications

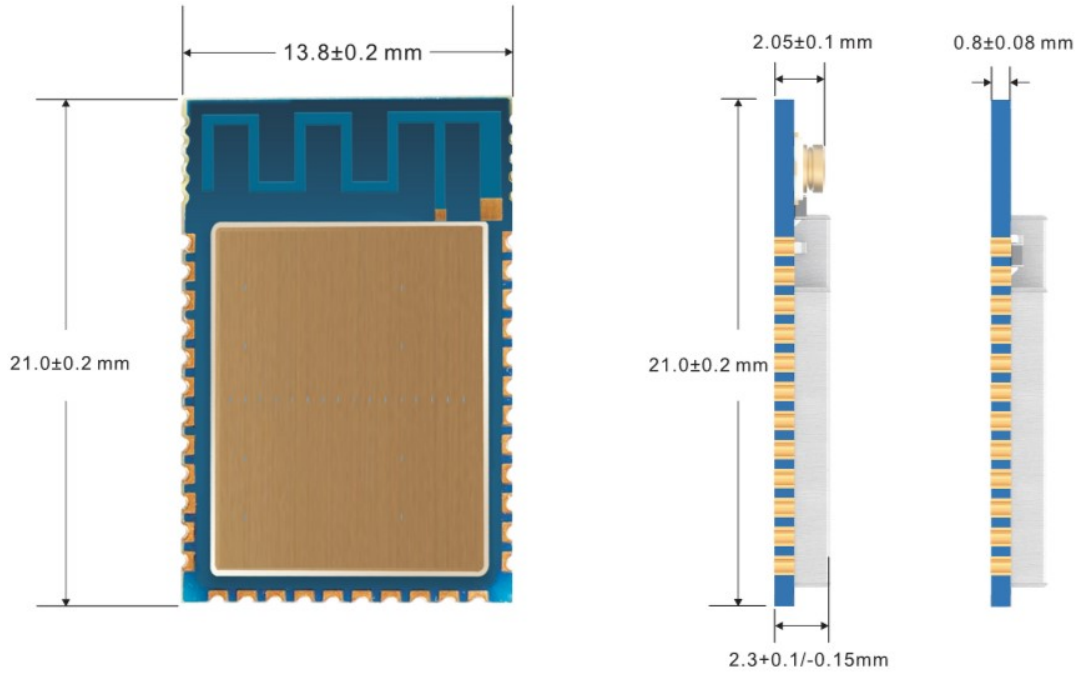| Detail	Description
Bluetooth	
Features	Bluetooth® Low Energy Bluetooth® Mesh 1M LE PHY 2M LE PHY Advertising Extensions CSA #2
Security	AES-128
LE connections	Concurrent central, observer, peripheral, and broadcaster roles with up to twenty concurrent connections along with one observer and one broadcaster
Radio	
Frequency	2360MHz - 2500MHz
Modulations	GFSK at 1 Mbps/2 Mbps data rates
Transmit power	+4 dBm maximum Configurable down to -40dBm
Receiver sensitivity	-96 dBm in 1 Mbps Bluetooth® low energy mode -89 dBm in 2 Mbps Bluetooth® low energy mode -93 dBm in 1 Mbps ANT mode -30 dBm in whisper mode
Antenna	MK02D - PCB trace antenna MK02E - External 2.4Ghz antenna
Advertising distance @1Mbps (Open area)	MK02D - More than 155 meters
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) @1Msps / 1Msps BLE	5.4mA
RX only @ 1Msps / 1Mbps BLE	11.7mA
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

Detail	Description
Mechanical design	
Dimensions	Length: 21mm±0.2mm Width: 13.8mm±0.2mm Height: 2.3mm+0.1mm/-0.15mm
Package	34 Plated Half-hole pins
PCB material	FR-4
Impedance	50Ω
Hardware	
CPU	ARM® Cortex®-M4 32-bit processor with FPU, 64MHz
Memory	512 kB flash, 64 kB RAM
Interfaces	3x SPI master/slave with EasyDMA 2x I^2C compatible 2-wire master/slave 30 GPIOs 8x 12 bit, 200ksps ADC 3x real-time counter (RTC) 3x 4-channel pulse width modulator (PWM) unit with EasyDMA UART (CTS/RTS) with EasyDMA I^2S with EasyDMA Digital microphone interface (PDM) Quadrature decoder (QDEC) NFC-A Tag
Power supply	1.7V to 3.6V
Operating temperature range	-40 to 85°C
Clock control	32.768 kHz +/-20 ppm crystal oscillator
Power regulator	DC/DC regulator setup
Certifications	
USA (FCC)	FCC part 15 modular certification 47 CFR Part 15, Subpart C FCC ID: 2AO94-MK02
Europe (CE)	EN 300 328 V2.2.2 3.2: Effective use of spectrum allocated EN 301 489-1 V2.2.3 3.1(b): Electromagnetic Compatibility EN 301 489-17 V3.2.4 EN 62368-1: 2014+A11:2017 3.1(a): Health and Safety of the user EN 62479: 2010
Canada (ISED)	Industry Canada RSS-247 and RSS-Gen certification IC: 26442-MK02
Japan (MIC)	Ministry of Internal Affairs and Communications (MIC) of Japan pursuant to the Radio Act of Japan
Australia/New Zealand (RCM)	AS/NZS 4268: 2017, Radio equipment and systems-short range devices

2. Block Diagram

External 2.4G Antenna

u.FL Connector
(MK02E)

VCC
Power Supply
1.7V – 3.6V

DC/DC LC Filter

Onboard Antenna

NFC Antenna — P09&P10

PCB Trace Antenna (MK012D)

LC Filter

N52832
QFAAB0
1652FD

nRF52832 SoC

32.768kHz

32.768kHz Crystal Oscillator

32 MHz

32MHz Crystal Oscillator

DC/DC converter enabled

MK02 Bluetooth® Module

GND

RESET

SWD

UART

GPIO

ADC

3. Mechanical Specifications

3.1 Module Mechanical Dimensions

Symbol	Min.	Typ.	Max.
Length	-0.2mm	21mm	+0.2mm
Width	-0.2mm	13.8mm	+0.2mm
Height (PCB only)	-0.08mm	0.8mm	+0.08mm
Height (with shield)	-0.15mm	2.3mm	+0.1mm

3.2 Recommended PCB Land Pads
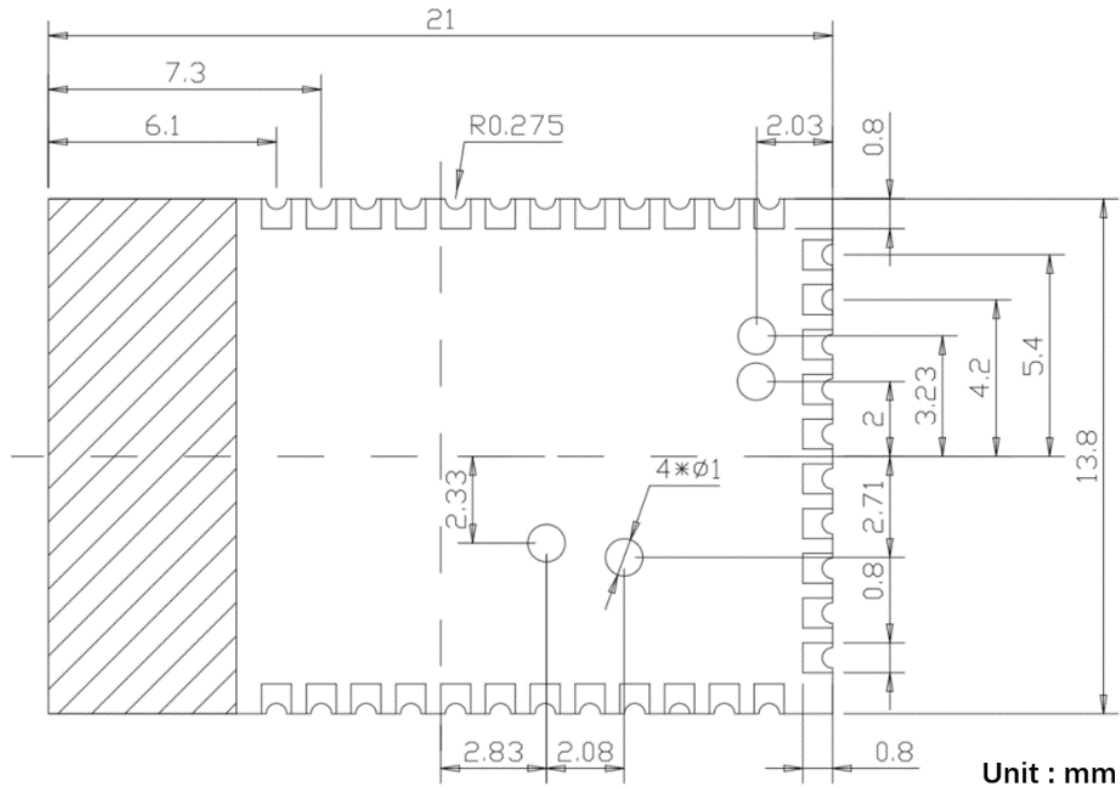
MK02 PCB land pads (TOP View)

Symbol	Typ.
Half-hole Pad (Bottom)	0.8mm x 0.8mm
LGA Round pad	1mm (diameter)
Diameter of Half-hole	0.55mm

4. Pin Assignment

MK02 module pin diagram(Rear View)

Pin No.	Name	Type	Description
1	P25	Digital I/O	General purpose I/O[1]
2	P26	Digital I/O	General purpose I/O[1]
3	P27	Digital I/O	General purpose I/O[1]
4	P28	Digital I/O	General purpose I/O[1]
	AIN4	Analog input 4	SAADC/COMP/LPCOMP input
5	P29	Digital I/O	General purpose I/O[1]
	AIN5	Analog input 5	SAADC/COMP/LPCOMP input
6	P30	Digital I/O	General purpose I/O[1]
	AIN6	Analog input 6	SAADC/COMP/LPCOMP input
7	P31	Digital I/O	General purpose I/O[1]
	AIN7	Analog input 7	SAADC/COMP/LPCOMP input
8	P02	Digital I/O	General purpose I/O
	AIN0	Analog input 0	SAADC/COMP/LPCOMP input
9	VCC	Power	Power Supply: 1.7V-3.6V
10	GND	Power	Ground
11	P03	Digital I/O	General purpose I/O
	AIN1	Analog input 1	SAADC/COMP/LPCOMP input
12	P04	Digital I/O	General purpose I/O
	AIN2	Analog input 2	SAADC/COMP/LPCOMP input

Pin No.	Name	Type	Description
13	P05	Digital I/O	General purpose I/O
	AIN3	Analog input 3	SAADC/COMP/LPCOMP input
14	P06	Digital I/O	General purpose I/O
15	P07	Digital I/O	General purpose I/O
16	P08	Digital I/O	General purpose I/O
17	P09	Digital I/O	General purpose I/O
	NFC1	NFC input	NFC antenna connection
18	P10	Digital I/O	General purpose I/O
	NFC2	NFC input	NFC antenna connection
19	SWDCLK	Digital input	Serial wire debug clock input for debug and programming
20	SWDIO	Digital I/O	Serial wire debug I/O for debug and programming
21	P22	Digital I/O	General purpose I/O
22	P23	Digital I/O	General purpose I/O
23	P11	Digital I/O	General purpose I/O
24	P12	Digital I/O	General purpose I/O
25	P13	Digital I/O	General purpose I/O
26	P14	Digital I/O	General purpose I/O
	TRACEDATA[3]		Trace port output
27	P15	Digital I/O	General purpose I/O
	TRACEDATA[2]		Trace port output
28	P16	Digital I/O	General purpose I/O
	TRACEDATA[1]		Trace port output
29	P17	Digital I/O	General purpose I/O
30	P18	Digital I/O	General purpose I/O
	TRACEDATA[0]/SWO		Trace port output/Single wire output
31	P19	Digital I/O	General purpose I/O
32	P20	Digital I/O	General purpose I/O
	TRACECLK		Trace port clock output
33	P21	Digital I/O	General purpose I/O
	RESET		Configurable as pin reset
34	P24	Digital I/O	General purpose I/O

Note： **Please refer to Nordic nRF52832 Product Specifications for detailed descriptions and features supported about the Pin assignments.**

1. Radio performance parameters, such as sensitivity, may be affected by high frequency digital I/O with large sink/source current close to the Radio power supply and antenna pins. Recommended usage: Low drive, low frequency I/O only.

5. Interfaces

5.1 Power Supply

Regulated power for the **MK02** is required. The input voltage VCC range should be 1.7V to 3.6V. Suitable decoupling must be provided by external decoupling circuitry (10uF and 0.1uF). It can reduce the noise from power supply and increase power stability.

5.2 System Function Interfaces

5.2.1 GPIO

The general purpose I/O is organized as one port with up to 30 I/Os enabling access and control of up to 30 pins through one port. Each GPIO can be accessed individually with the following user configurable features:

- Input/output direction
- Output drive strength
- Internal pull-up and pull-down resistors
- Wake-up from high or low level triggers on all pins
- Trigger interrupt on all pins
- All pins can be used by the PPI task/event system; the maximum number of pins that can be interfaced through the PPI at the same time is limited by the number of GPIOTE channels
- All pins can be individually configured to carry serial interface or quadrature demodulator signals
- All pins can be configured as PWM signal

5.2.2 Two-wire Interface (I^{2}C Compatible)

The two-wire interface can communicate with a bi-directional wired-AND bus with two lines (SCL, SDA). The protocol makes it possible to interconnect up to 127 individually addressable devices. The interface is capable of clock stretching, supporting data rates of 100kbps ,250kbps and 400kbps. The module has 2 TWI ports and they properties like following table.

Instance	Master/Slave
TWI 0	Master
TWI 1	Master

5.2.3 Flash Program I/O

The module has two programmer pins, respectively SWDCLK pin and SWDIO pin. The two pin Serial Wire Debug (SWD) interface provided as a part of the Debug Access Port (DAP) offers a flexible and powerful mechanism for non- intrusive debugging of program code. Breakpoints and single stepping are part of this support.

5.2.4 Serial Peripheral Interface

The SPI interfaces enable full duplex synchronous communication between devices. They support a three-wire (SCK, MISO, MOSI) bi-directional bus with fast data transfers. The SPI Master can communicate with multiple slaves using individual chip select signals for each of the slave devices attached to a bus. Control of chip select signals is left to the application through use of GPIO signals. SPI Master has double buffered I/O data. The SPI Slave includes EasyDMA for data transfer directly to and from RAM allowing Slave data transfers to occur while the CPU is IDLE. The GPIOs are used for each SPI interface line can be chosen from any GPIOs on the device and independently. This enables great flexibility in device pinout and efficient use of printed circuit board space and signal routing.

5.2.5 UART

The Universal Asynchronous Receiver/Transmitter offers fast, full-duplex, asynchronous serial communication with built-in flow control (CTS, RTS), support in hardware up to 1 Mbps baud. Parity checking is supported.

Note: The GPIOs are used for each SPI/TWI/UART interface line can be chosen from any GPIOs on the device and configured independently.

5.2.6 Low Power Comparator (LPCOMP)

In System ON, the block can generate separate events on rising and falling edges of a signal, or sample the current state of the pin as being above or below the threshold. The block can be configured to use any of the analog inputs on the device. Additionally, the low power comparator can be used as an analog wakeup source from System OFF or System ON. The comparator threshold can be programmed to a range of fractions of the supply voltage.

5.2.7 Analog to Digital Converter (ADC)

The 12bit incremental Analog to Digital Converter (ADC) enables sampling of up to 8 external signals through a front-end multiplexer. The ADC has configurable input and reference prescaling, and sample resolution (8,10, and 12bit).

- Note: The ADC module uses the same analog inputs as the LPCOMP module. Only one of the modules can be enabled at the same time.

MK02 PIN NO.	Name	Type	Description
4	P28	Digital I/O	General purpose I/O[2]
	AIN4	Analog input 4	SAADC/COMP/LPCOMP input
5	P29	Digital I/O	General purpose I/O[2]
	AIN5	Analog input 5	SAADC/COMP/LPCOMP input
6	P30	Digital I/O	General purpose I/O[2]
	AIN6	Analog input 6	AADC/COMP/LPCOMP input
7	P31	Digital I/O	General purpose I/O[2]
	AIN7	Analog input 7	SAADC/COMP/LPCOMP input
8	P02	Digital I/O	General purpose I/O
	AIN0	Analog input 0	SAADC/COMP/LPCOMP input
11	P03	Digital I/O	General purpose I/O
	AIN1	Analog input 1	SAADC/COMP/LPCOMP input
12	P04	Digital I/O	General purpose I/O
	AIN2	Analog input 2	SAADC/COMP/LPCOMP input
13	P05	Digital I/O	General purpose I/O
	AIN3	Analog input 3	SAADC/COMP/LPCOMP input

5.2.8 NFC

The NFC peripheral (referred to as the 'NFC peripheral' from now on) supports communication signal interface type A and 106kbps bit rate from the NFC Forum.
With appropriate software, the NFC peripheral can be used to emulate the listening device NFC-A as specified by the NFC Forum.
Listed here are the main features for the NFC peripheral:

- NFC-A listen mode operation

- 13.56MHz input frequency

- Bit rate 106kbps

- Wake-on-field low power field detection (SENSE) mode

- Frame assemble and disassemble for the NFC-A frames specified by the NFC Forum

- Programmable frame timing controller

- Integrated automatic collision resolution, CRC and parity functions

| MK02 Pin NO.	Pin Name	Type	Description
17	P09	Digital I/O	General Purpose I/O
	NFC1	NFC input	NFC antenna connection
18	P10	Digital I/O	General Purpose I/O
	NFC2	NFC input	NFC antenna connection

6. Mounting Suggestion

You can refer to the following references for the mounting design of the module with on-board antenna (MK02D with PCB antenna).

For external antenna modules (MK02E needs to connect an external antenna to the u.FL connector), you need to refer to the external antenna design requirements.

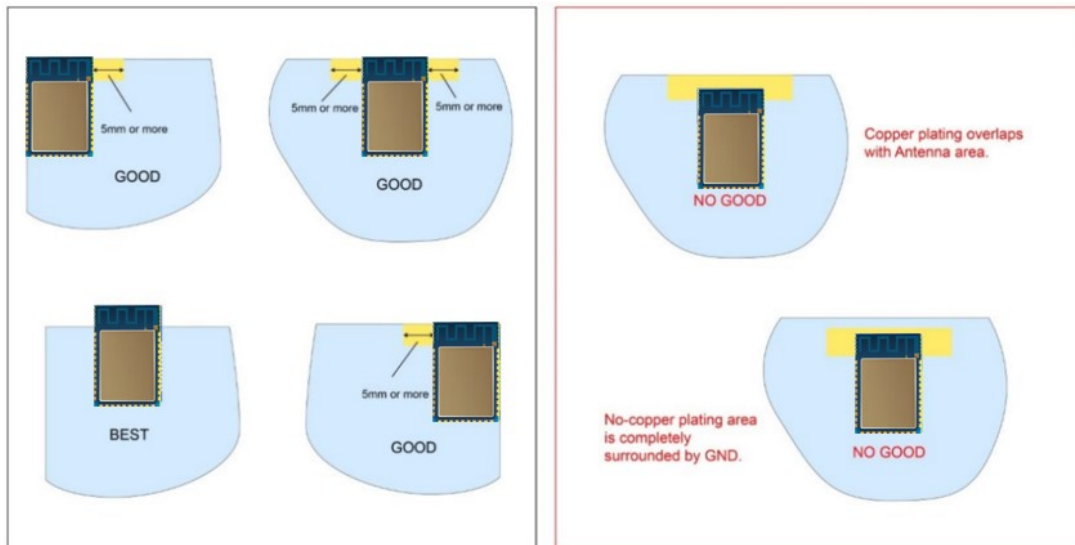**Recommended module mounting example：**
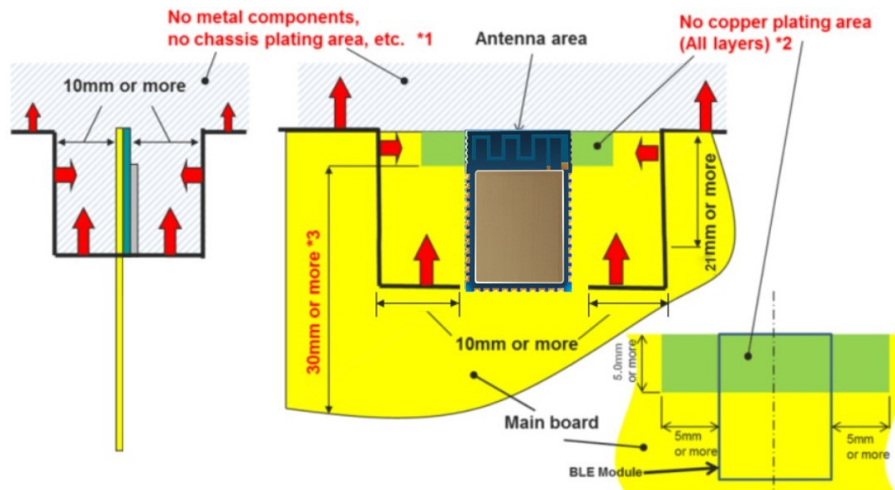
- Please do not place any metal components in blue shaded space(*1), such as signal line and metal chassis as possible except for main board while mounting the components in *1 space on the main board is allowed except for no copper plating area(*2).

- (*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:

  o Avoid running any signal line below module whenever possible.

  o No ground plane below antenna.

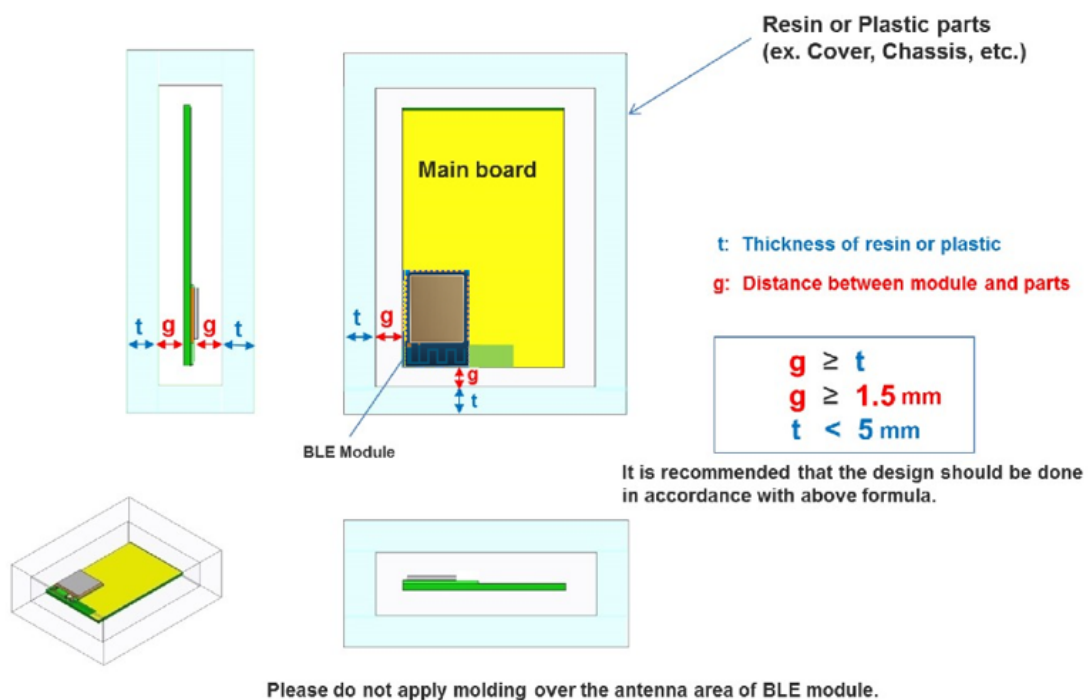 o If possible, cut-off the portion of main board below antenna.

Other module mounting examples:

5mm or more — GOOD

5mm or more — 5mm or more — GOOD

BEST

5mm or more — GOOD

Copper plating overlaps with Antenna area.

NO GOOD

No-copper plating area is completely surrounded by GND.

NO GOOD

Placement of resin or plastic parts:

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

Main board

t g g t

t g

BLE Module

g
t

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.

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).

7. Cautions

7.1 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.
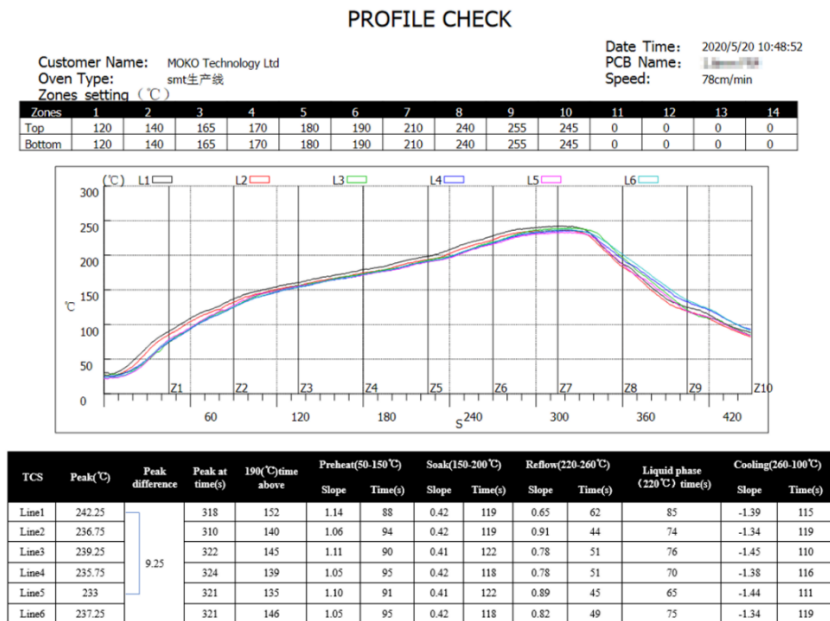
Temperature-Time Profile for Reflow Soldering:
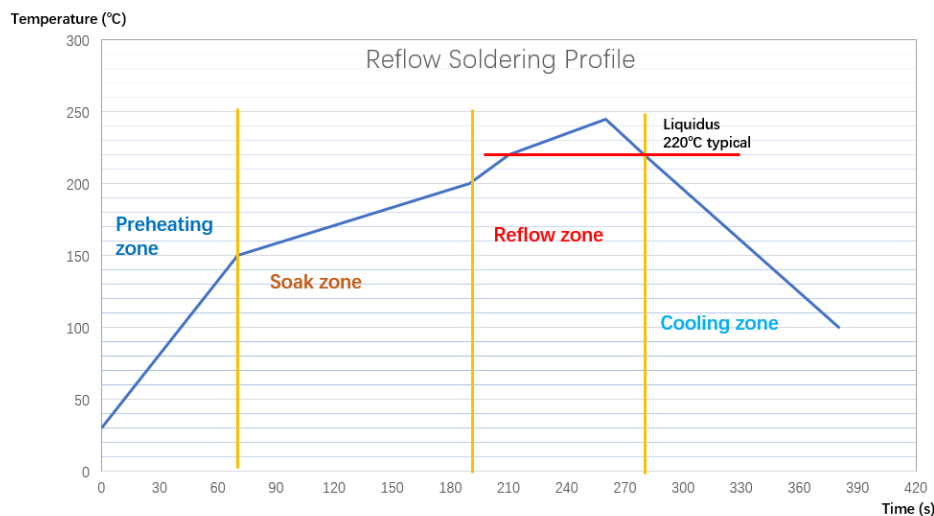
- The standard reflow profile has four zones: ①**preheat,** ②**soak,** ③**reflow,** ④**cooling**. The profile describes the ideal temperature curve of the top layer of the PCB.

- During reflow, modules should not be above 260°C and not for more than 30 seconds.

Specification	Value
Temperature Increase Rate	<2.5°C/s
Temperature Decrease Rate	Free air cooling
Preheat Temperature	0-150°C
Preheat Period (Typical)	40-90s
Soak Temp Increase Rate	0.4-1°C/s
Soak Temperature	150-200°C
Soak Period	60-120s
Liquidus Temperature (SAC305)	220°C
Time Above Liquidous	45-90s
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
Date Time: 2020/5/20 10:48:52
PCB Name:
Speed: 78cm/min

Zones setting (℃)

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℃)		Soak(150-200℃)		Reflow(220-260℃)		Liquid phase (220℃) time(s)	Cooling(260-100℃)	
					Slope	Time(s)	Slope	Time(s)	Slope	Time(s)		Slope	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	9.25	322	145	1.11	90	0.41	122	0.78	51	76	-1.45	110
Line4	235.75		324	139	1.05	95	0.42	118	0.78	51	70	-1.38	116
Line5	233		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.

7.2 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.

7.3 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:

  o Storage in salty air or in an environment with a high concentration of corrosive gas.

  o Storage in direct sunlight

  o Storage in an environment where the temperature may be outside the range specified.

  o 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.

Revision History

Revision	Description of changes	Approved	Revision Date
V1.0	Initial Release	Kevin	2020.09.04
V1.1	Updated Section 1.4	Victor	2020.10.15

The contents of this datasheet are subject to change without prior notice for further improvement. MOKO team reserves all the rights for the final explanation.

Please contact MOKO sales team or visit https://www.mokosmart.com to get more related information if needed.

MOKO TECHNOLOGY LTD.

4F,Buidling2, Guanghui Technology Park,
MinQing Rd, Longhua, Shenzhen, Guangdong, China

Tel:86-755-23573370-829

Support_BLE@mokotechnology.com

https://www.mokosmart.com