

## **MK01 Bluetooth Module Datasheet**

# **Bluetooth® Module Datasheet**

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# 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).

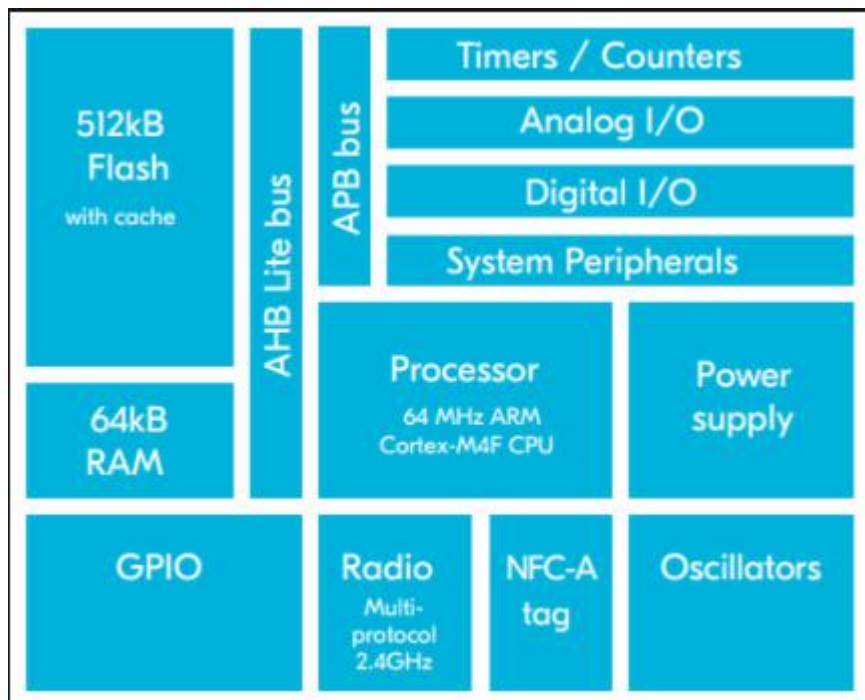
## 1.1 Model Classification

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

**MK01** integrates a high-performance ceramic chip antenna<sup>1</sup>. BLE advertising distance can reach more than 80 meters.

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

## 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/I<sup>2</sup>S/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) <sup>4</sup>
- 32.768 kHz +/-250 ppm RC oscillator<sup>5</sup>
- 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<sup>6</sup> 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

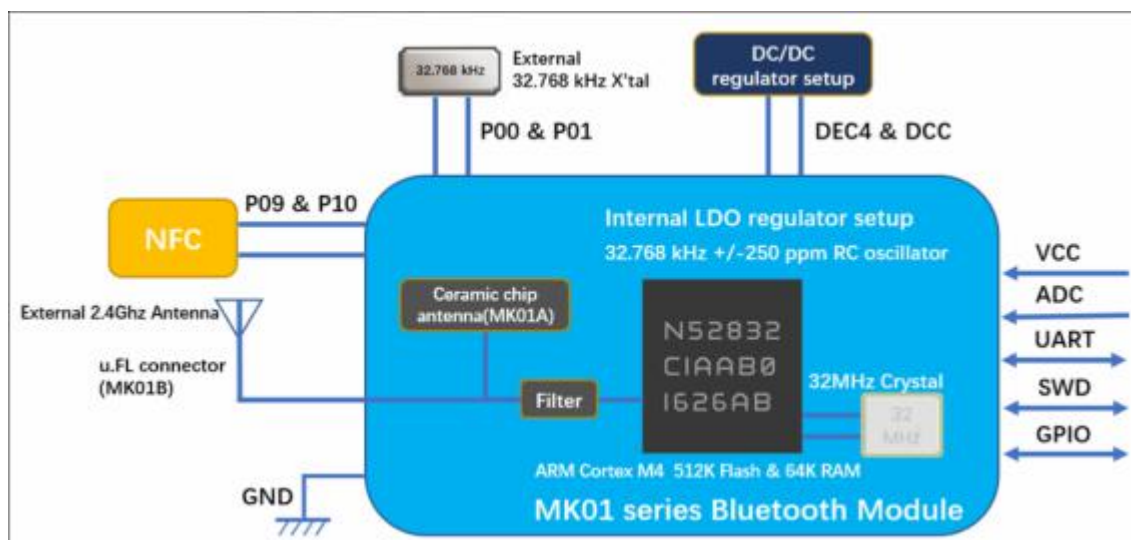
| Detail                                                              | Description                                                                                                                                                 |
|---------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Bluetooth</b>                                                    |                                                                                                                                                             |
| 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        |
| <b>Radio</b>                                                        |                                                                                                                                                             |
| 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%)<br>MK01B - Peak Gain: 3dBi / Efficiency: 85% (2.4GHz 3dBi Terminal Mount Dipole Antenna) |
|                                                                     |                                                                                                                                                             |
| <b>Current consumption</b>                                          |                                                                                                                                                             |
| 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                                                                                                                                                         |
| <b>Mechanical Design</b>                           |                                                                                                                                                               |
| 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                                                                                                                                                          |
| <b>Hardware</b>                                    |                                                                                                                                                               |
| CPU                                                | ARM® Cortex®-M4 32-bit processor with FPU, 64 MHz                                                                                                             |
| Memory                                             | 512 kB flash / 64 kB RAM                                                                                                                                      |
| Interfaces                                         | 3xSPI master/slave with EasyDMA<br>2x I2C compatible 2-wire master/slave<br>22xGPIO<br>7x12 bit ADC<br>UART (CTS/RTS) with EasyDMA<br>I2S with EasyDMA<br>PWM |

|                             |              |
|-----------------------------|--------------|
|                             | PDM<br>NFC-A |
| Power supply                | 1.7V to 3.6V |
| Operating temperature range | -40 to 85 °C |

## 2. Circuit Design

### 2.1 Block Diagram

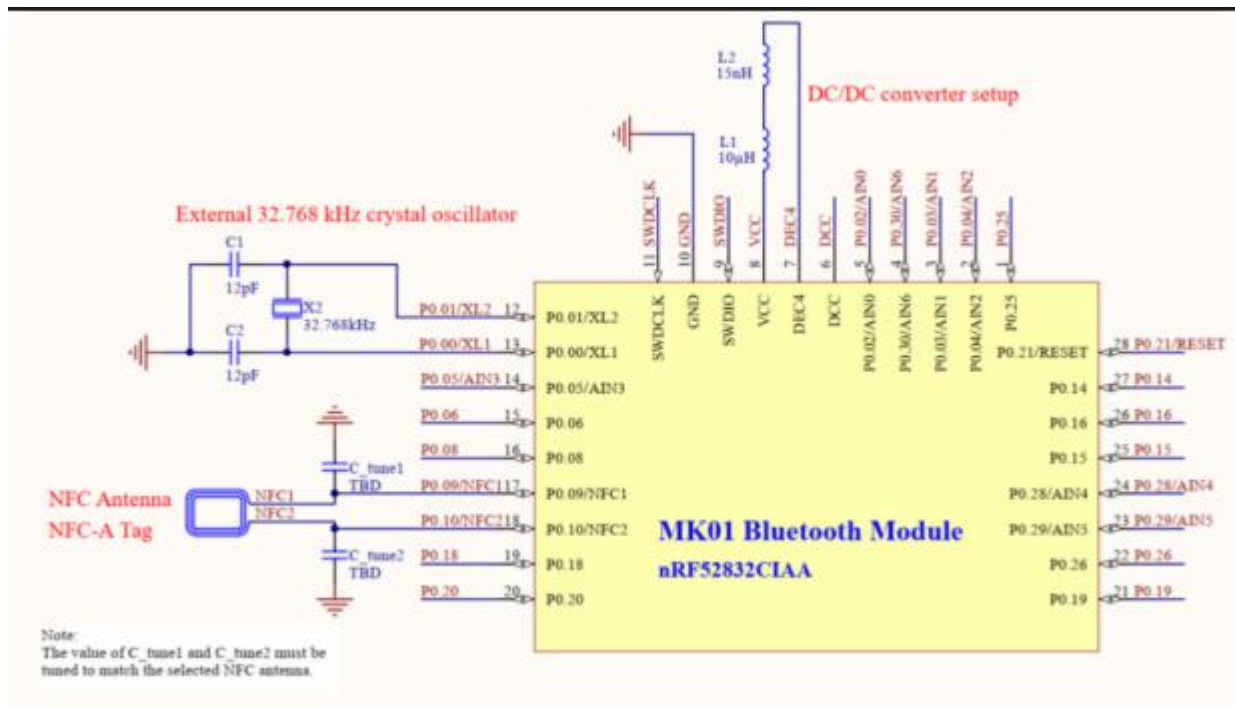


Module default design is using "Internal LDO regulator setup" and "Internal 32.768 kHz RC oscillator".

### 2.2 Schematic

**MK01A**





### 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%    |

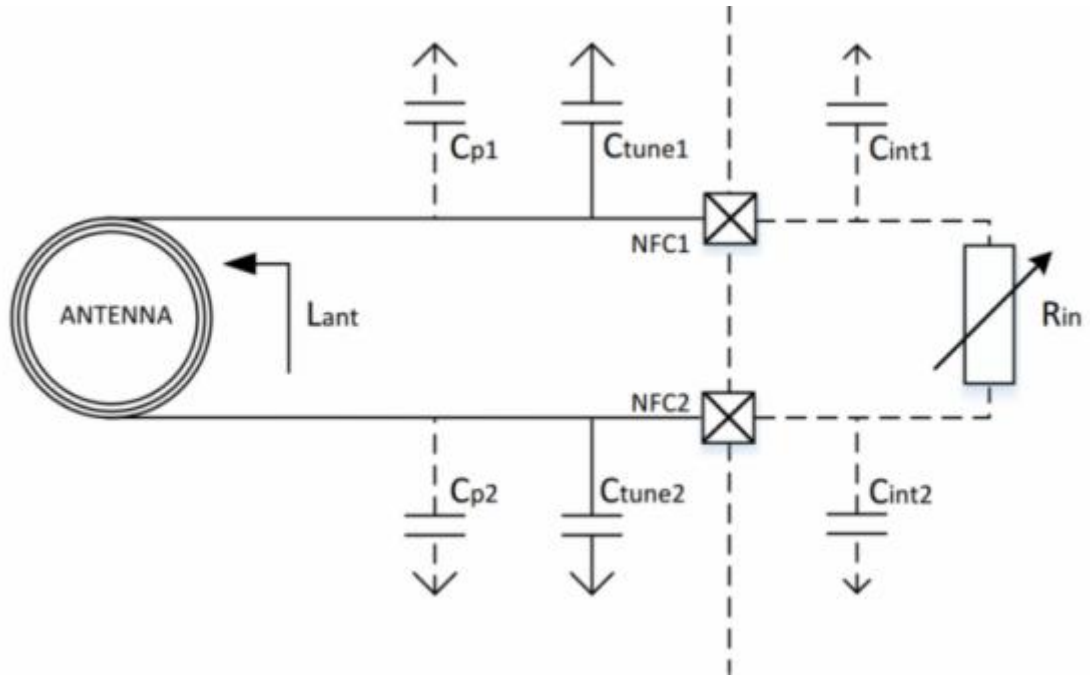
### 2.3.2 External 32.768 kHz crystal

- 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:

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

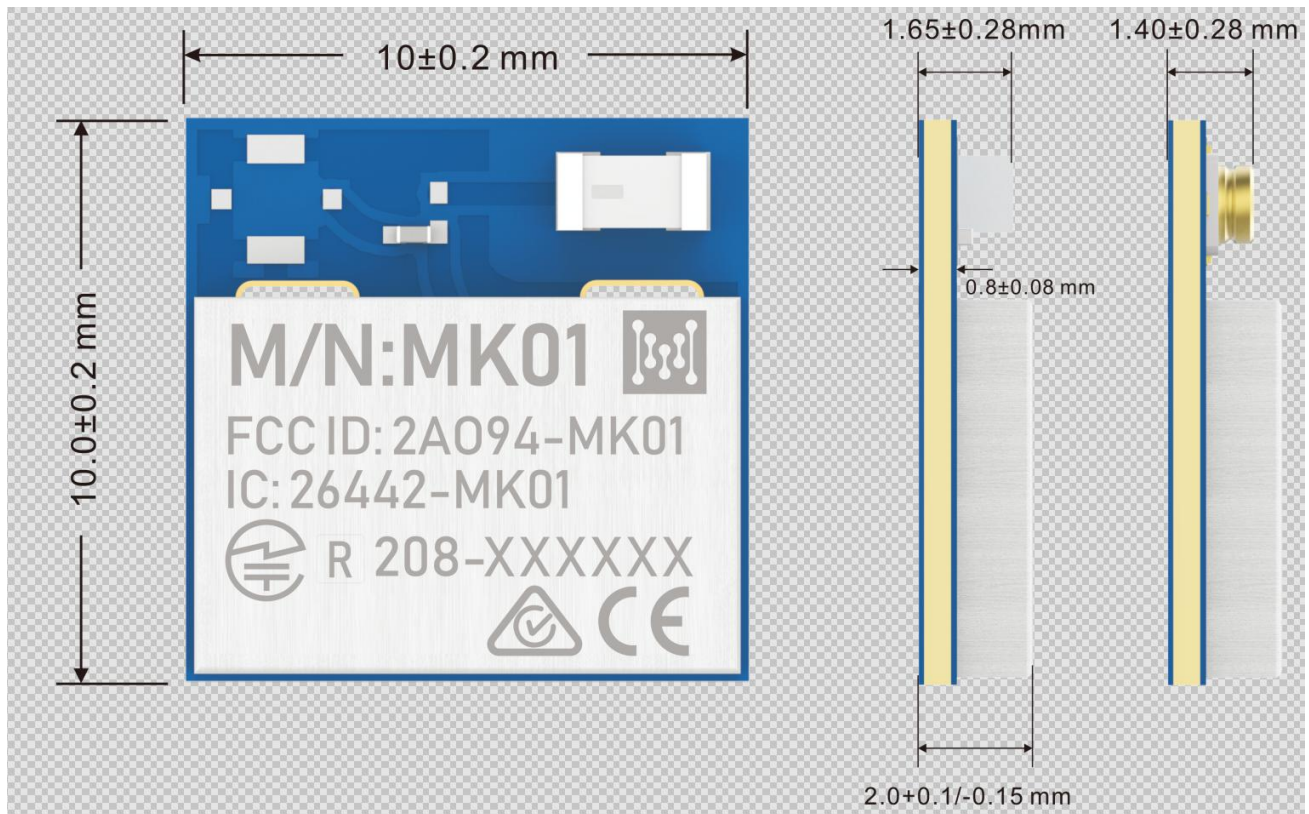
$$\text{and } C_{tune1} = C_{tune2} = C_{tune} \quad C_{p1} = C_{p2} = C_p \quad C_{int1} = C_{int2} = C_{int}$$

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

An antenna inductance of  $L_{ant} = 2 \text{ H}$  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

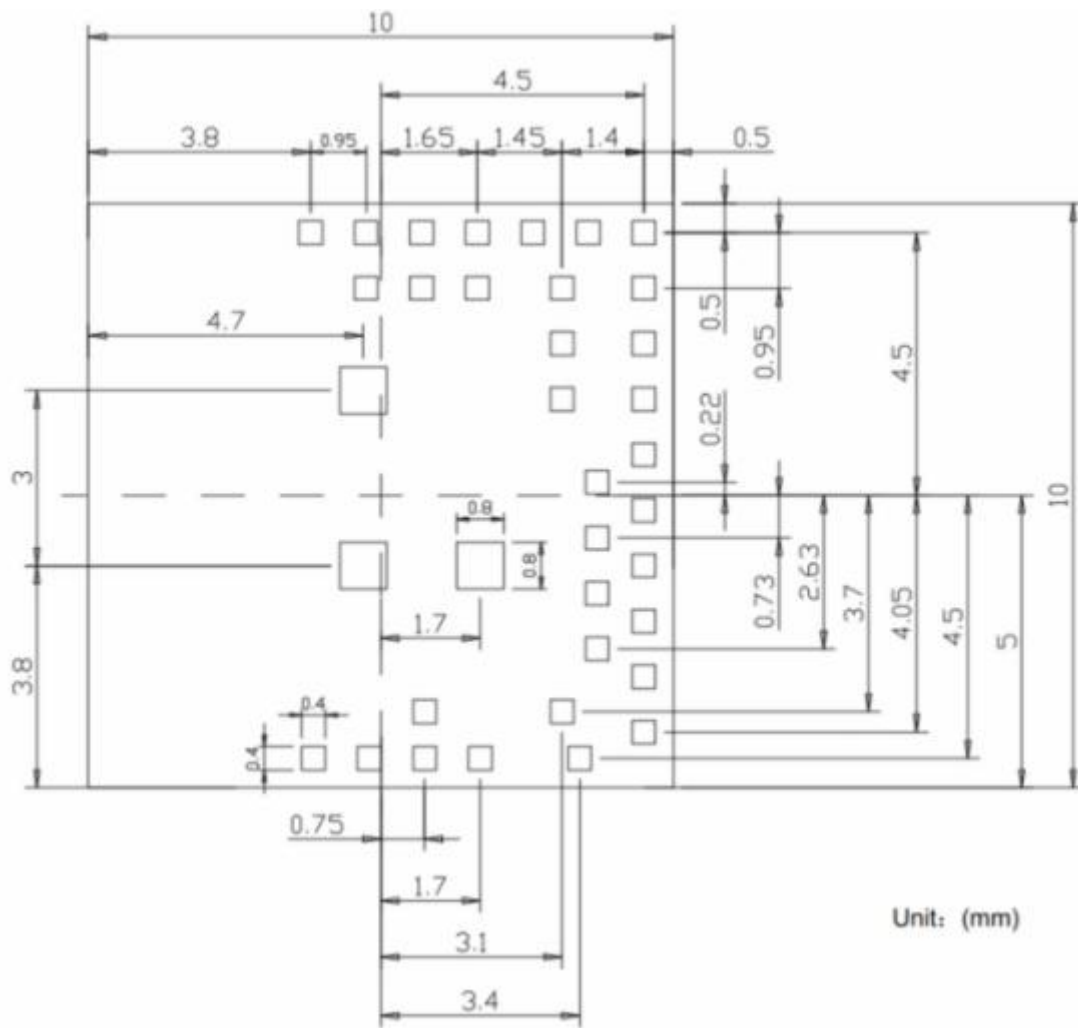
### 3.1 Module Mechanical Dimensions



**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  |

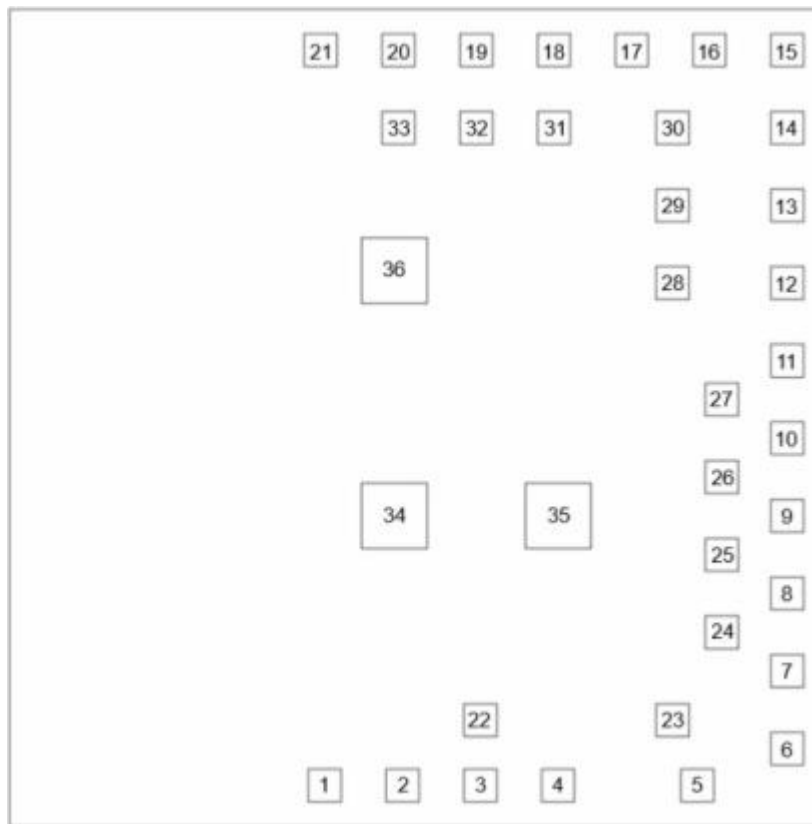
### 3.2 Recommended PCB land pads



### 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 <sup>7</sup> | P0.10      |
|         | NFC2         | NFC input   | NFC antenna connection           |            |
| 5       | P0.09        | Digital I/O | General purpose I/O <sup>7</sup> | 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<br>Input from DC/DC converter. Output from 1.3 V LDO                                                                                                                                                            | DEC4  |
| 12 | GND   | Power        | Electrical Ground                                                                                                                                                                                                                                 | VSS   |
| 13 | VCC   | Power        | Power supply.<br>An internal 4.7 $\mu$ F 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 <sup>8</sup>                                                                                                                                                                                                                  | 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 <sup>8</sup>                        | 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 <sup>8</sup>                        | P0.29  |
|       | AIN5         | Analog input  | SAADC/COMP/LPCOMP input                                 |        |
| 30    | P0.26        | Digital I/O   | General purpose I/O <sup>8</sup>                        | P0.26  |
| 31-36 | GND          | Power         | Electrical Ground                                       | VSS    |

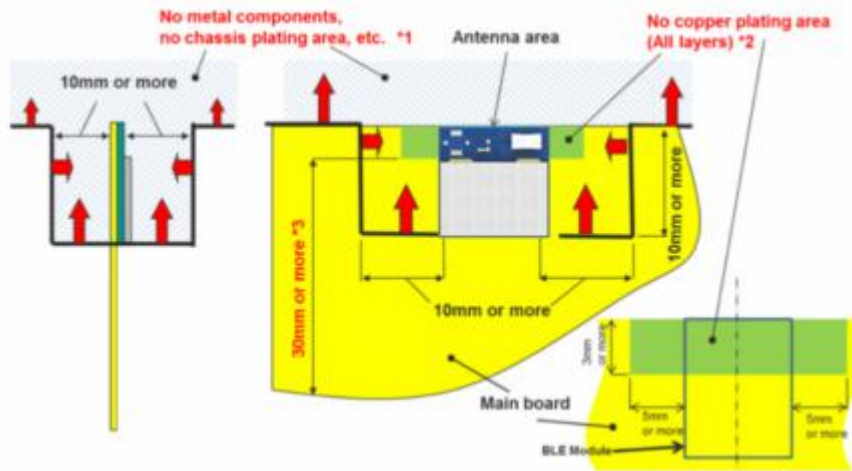
**MK01 module pin assignment (Top View)**

## 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

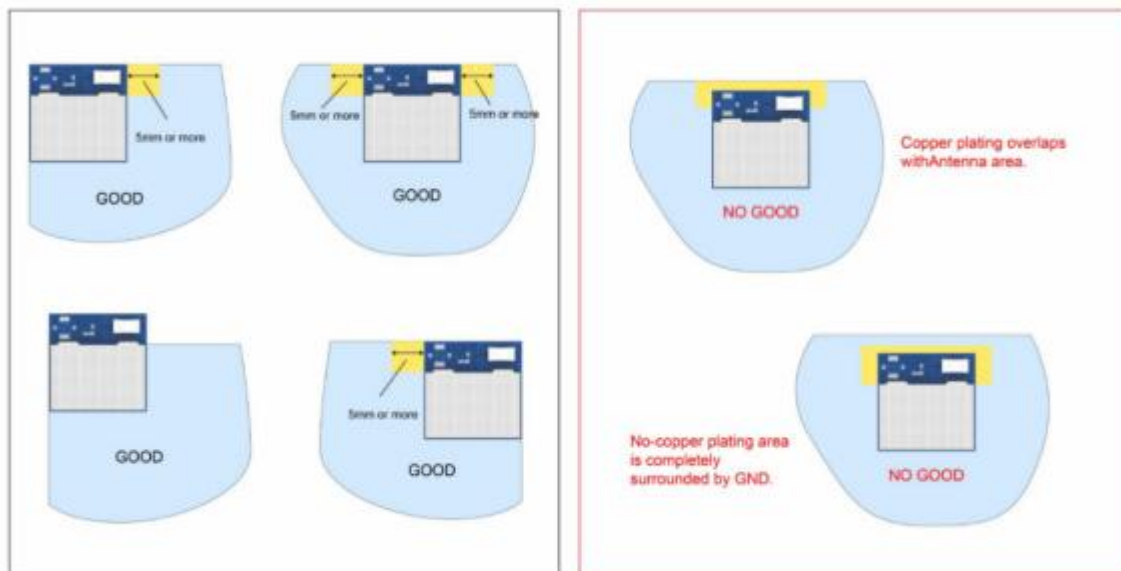


- Please do not place any metal components in blue shaded space(\*1), such as signal line and metal chassis as possible except for main board while mounting the components in \*1 space on the main board is allowed except for no copper plating area(\*2).
- (\*2)This area is routing prohibited area on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

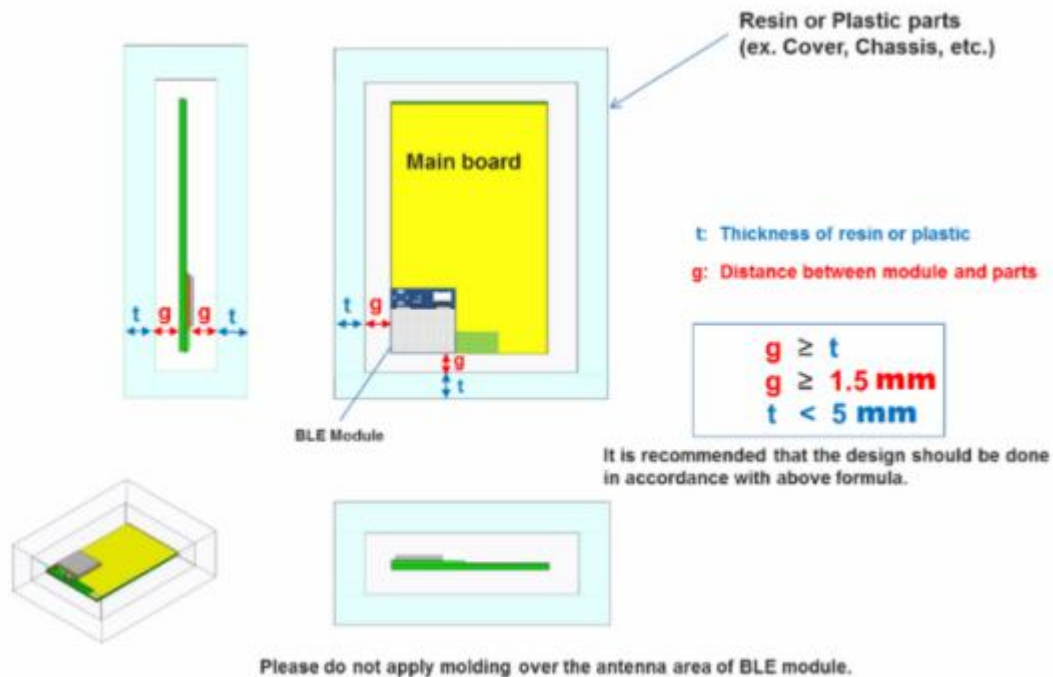
to inner GND plane. If GND flood copper underside the module then connect with GND vias to inner GND plane.

- 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



## 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

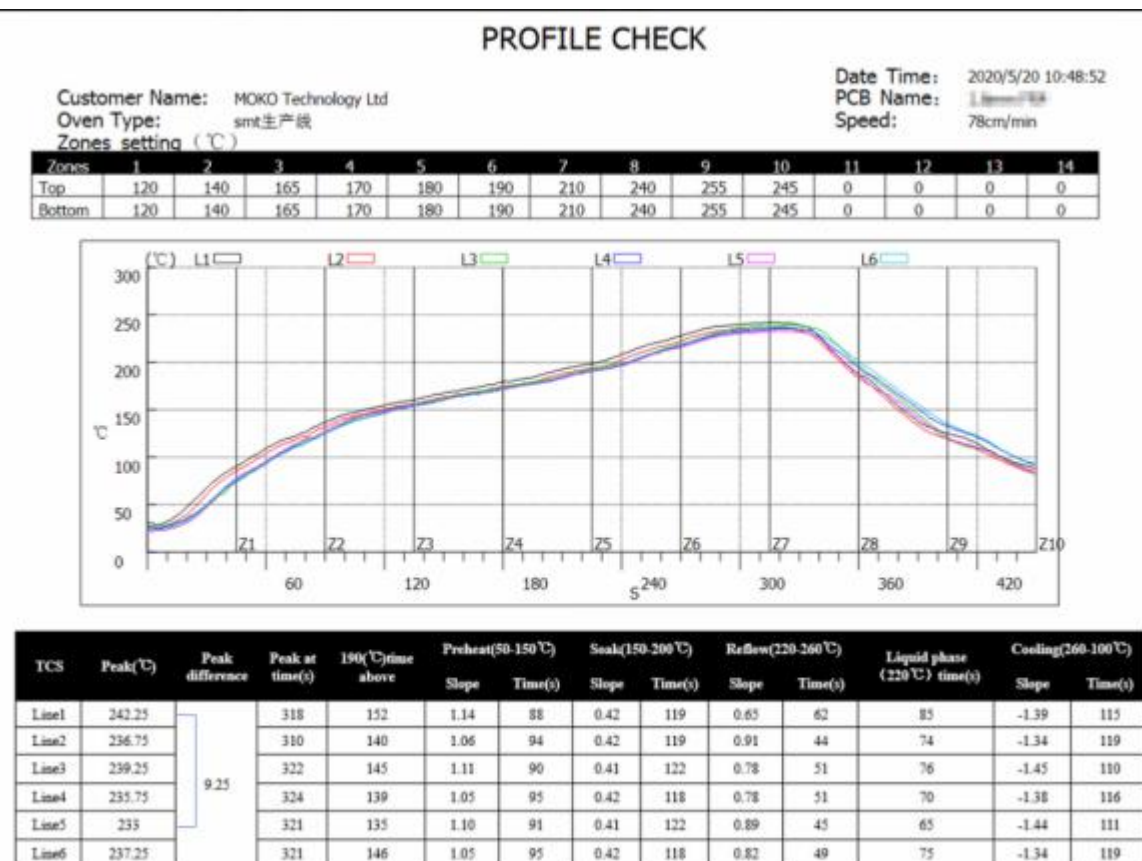


- The standard reflow profile has four zones: ①**preheat**, ②**soak**, ③**reflow** and ④**cooling**. The profile describes the ideal temperature curve of the top layer of the PCB.
- During reflow, modules should not be above 260° and not for more than 30 seconds.

| 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



**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