MOKO SMART

MK16 Bluetooth Module

Datasheet

MOKO TECHNOLOGY LTD.

www. mokosmart. com

Version 1.0

Contents

1 Instruction

The MK16 series is a powerful, highly flexible and ultra-low-power **Bluetooth® 5** module designed and built to meet the performance, security, and reliability requirements of battery-powered IoT products running on Bluetooth networks.

Based on the world-famous brand *Silicon Labs* **EFR32BG22C225F512GM32** SoC, the **MK16** enables Bluetooth® Low Energy connectivity while delivering best-in-class RF range and performance, future-proof capability for feature and OTA firmware updates, enhanced security features, and low energy consumption.

MK16 module will be programmed default MOKO MKBSL series firmware and custom firmware can be programmed by MOKO smart too.

While you choose **MK16** modules, *MOKO Smart* will provide technical support for your development or even help you to complete all hardware and firmware design. We can power demanding applications, while simplifying designs and reducing BOM costs to minimize and simplify the engineering and development of your end-products helping to accelerate their time-to-market.

1.1 Key Features

- Bluetooth® 5.2
- Bluetooth® mesh Low Power Node
- Built-in PCB antenna (MK16A only)
- Up to 6 dBm TX Power
- -98.9 dBm BLE RX sensitivity at 1 Mbps
- 32-bit ARM Cortex-M33 core at up to 76.8 MHz
- 512/32 kB of Flash/RAM memory
- Embedded 32.768kHz LF crystal oscillator
- Optimal selection of MCU peripherals
- Up to 14 GPIO pins

1.2 Applications

- Asset Tags and Beacon
- Sports, Fitness, and wellness devices
- Portable Medical
- Connected Home
- Industrial and Building Automation
- Bluetooth mesh Low Power Node

1.3 Product Options

1.3.1 Hardware Options

There are different module models of **MK16** series Bluetooth module. All models have same dimensions and pin assignments.

Currently MK16 is mainly divided into **A series (MK16A) and B series (MK16B)**. The difference is in the antenna design.

MK16A embeds a high-performance PCB antenna.

MK16B uses a u.FL connector (receptacle) and requires an external 2.4Ghz antenna.

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


	MK16A PCB antenna is used. No need to design another antenna. u.FL connector will not be mounted on the PCB.
	MK16B The PCB antenna is disabled. You need to select an external 2.4Ghz antenna to connect to the u.FL connector.
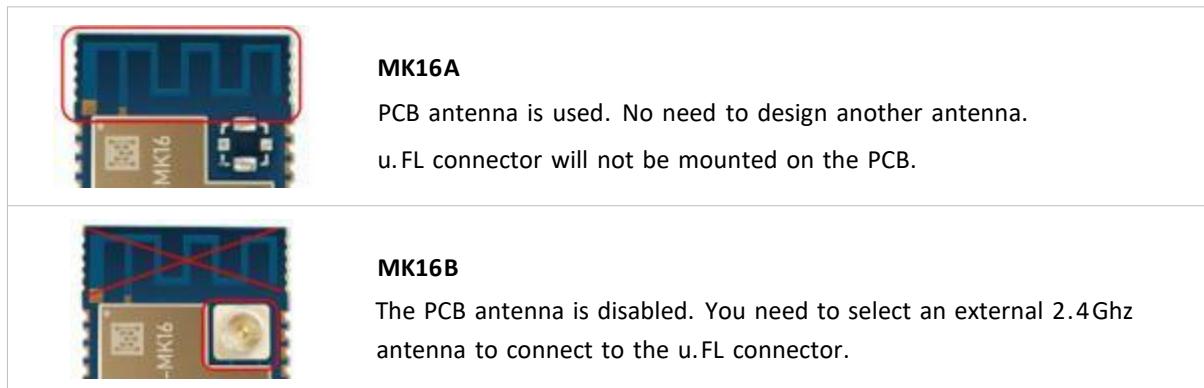
Figure 1: MK16A and MK16B

1.3.2 Firmware Options

For customers to use, MK16 series module will be programmed default MOKO MKBSL-A01 series firmware, which has the functions of UART Wireless Transparent Transmission.

MOKO Smart can help you develop the firmware and can also program your own firmware to modules when manufacture.

Firmware Version	Firmware Features
MKBSL-A01	UART wireless transparent transmission

Note: *This document is a Hardware Datasheet only – it does not cover the software aspects of the MK16 If you want to get more information about firmware or SDKs of MK16, please contact sales of MOKO Smart.*

2 Specifications

Detail	Description
General	
CPU	High-performance 32-bit ARM Cortex-M33® with DSP instruction and floating-point unit for efficient signal processing
RAM	32 kB RAM data memory
Flash	512 kB flash program memory
Dimensions	Length: 21mm±0.2mm Width: 13.8mm±0.2mm Height: 2.3mm+0.1mm/-0.15mm
Bluetooth	
Supported protocols	Bluetooth® Low Energy (Bluetooth 5.2) 1M LE PHY 2M LE PHY (High speed) LE Coded PHY (Long range) Bluetooth® Mesh Low Power Node
Roles	Central, observer, peripheral and broadcaster
Radio	
Frequency	2400 – 2483.5 MHz
Modulations	GFSK at 1 Mbps/2 Mbps Long range (125kbps and 500kbps) data rates
Transmit Power	Up to +6 dBm
Receiver Sensitivity	- 106.7 dBm sensitivity (0.1% BER) at 125 kbps GFSK - 102.5 dBm sensitivity (0.1% BER) at 500 kbps GFSK -98.9 dBm sensitivity (0.1% BER) at 1 Mbps GFSK -96.2 dBm sensitivity (0.1% BER) at 2 Mbps GFSK
Antenna	MK16A series – PCB trace antenna MK16B series – u.FL connector
Hardware	
Power Supply	1.8V to 3.8V DC
Clock control	Embedded 32.768kHz crystal oscillator
Package	34 diameters of Half-holes
PCB Material	FR-4
Impedance	50Ω
Interfaces	Analog to Digital Converter (ADC) - 12-bit @ 1 Msps / 16-bit @ 76.9 ksps Up to 14 General Purpose I/O pins with output state retention and asynchronous interrupts 8 Channel DMA Controller 12 Channel Peripheral Reflex System (PRS) 4 × 16-bit Timer/Counter with 3 Compare/Capture/PWM channels 1 × 32-bit Timer/Counter with 3 Compare/Capture/PWM channels 32-bit Real Time Counter 24-bit Low Energy Timer for waveform generation 1 × Watchdog Timer 2 × UART/SPI/SmartCard (ISO7816) /IrDA/I2S 1 × Enhanced Universal Asynchronous Receiver/Transmitter (EUART) 2 × I2C interface with SMBus support

Detail	Description	5
Storage Temperature	-40 to 105°C	
Operating Temperature	-40 to 85°C Extended Industrial temperature -40 to +125°C can be customized	
Current Consumption		
Deep Sleep	1.4 uA EM2 Deep Sleep current (RTCC running from LFXO, Full RAM retention)	
Shut Off	0. 17 uA Shut Off current (No BURTC, NO LF Oscillator, DCDC bypassed)	
Active Rx Mode	4.3 mA RX current at 1 Mbps GFSK	
Active Tx Mode	4.8 mA TX current at 0 dBm output power 8.8 mA TX current at 6 dBm output power	
Certifications		
USA (FCC)	FCC part 15 modular certification 47 CFR Part 15, Subpart C FCC ID: 2A88A-MK16	
Europe (CE)	EN 300 328 V2.2.2 3.2: Effective and Efficient Use of Radio Spectrum 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	

3 Hardware Design

3.1 Block Diagram

The MK16 module combines an energy-friendly MCU with a highly integrated radio transceiver in a PCB module with a robust, integrated antenna (MK16A only).

The block diagram for the MK16 module is shown in *Figure 2 MK16 Block Diagram*. The wireless module includes the EFR32BG22C225F512GM32 wireless System on a Chip (SoC), required decoupling capacitors and inductors, 38.4 MHz and 32.768 kHz crystals, RF matching circuit, and integrated PCB antenna (MK16A only).
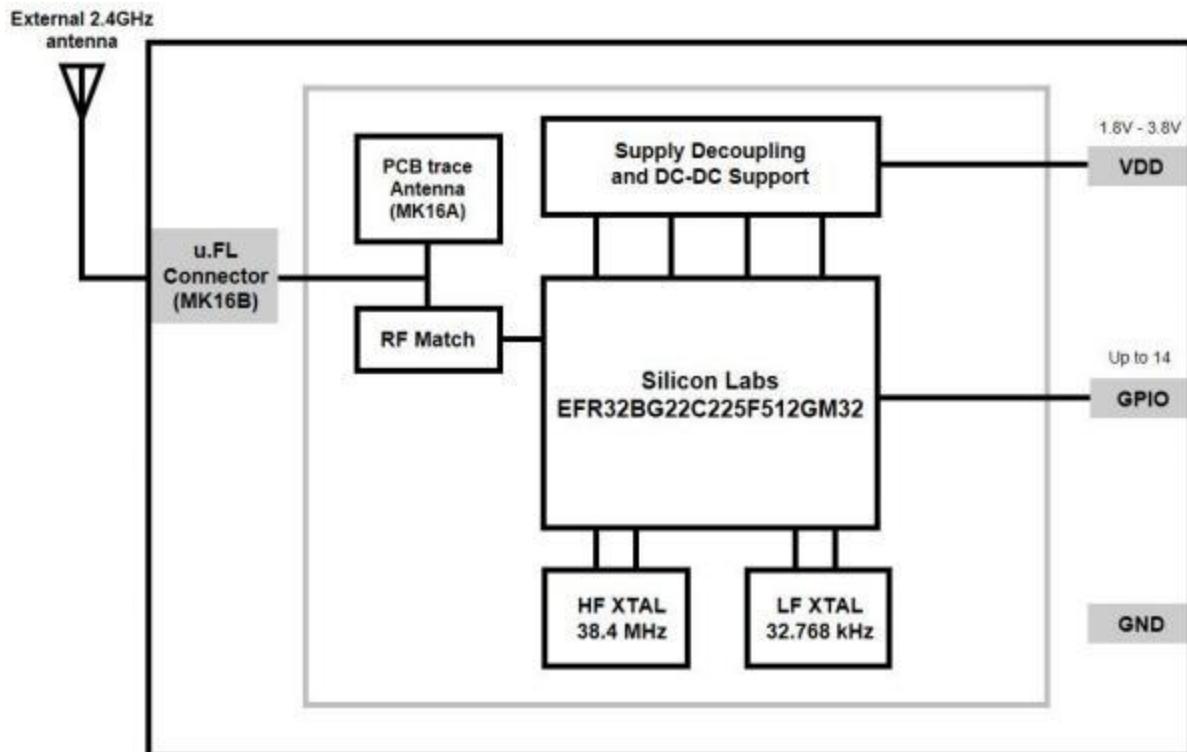

*Figure 2: MK16 Block Diagram*

3.2 Simplified Schematic
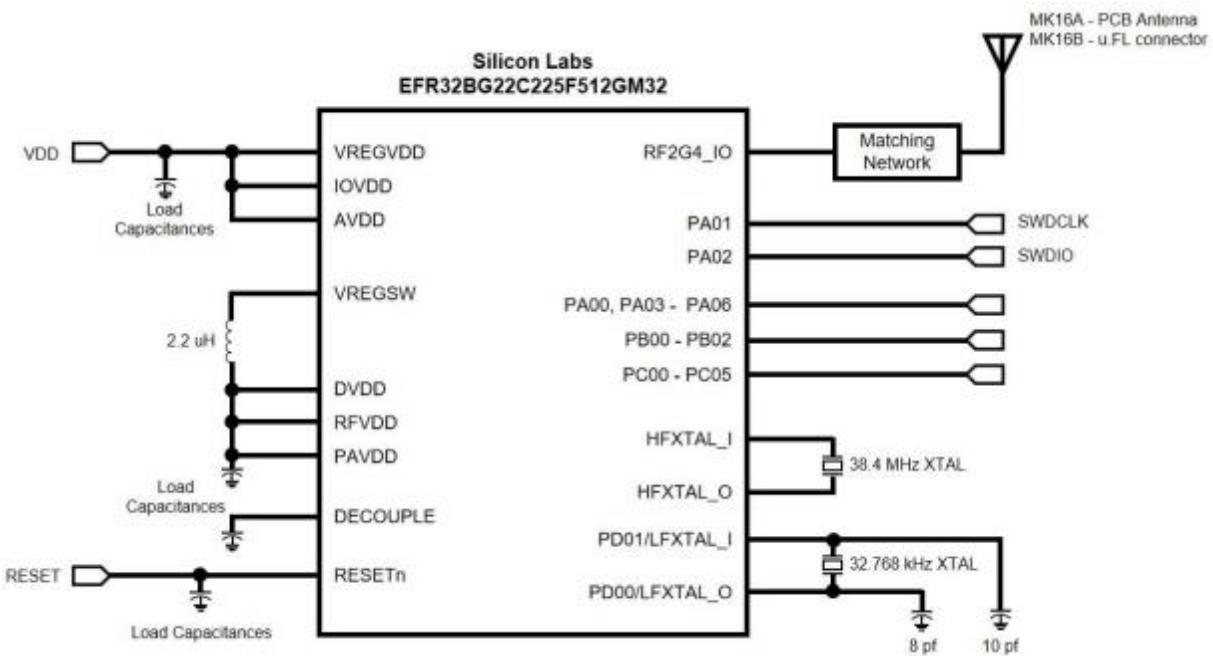
Figure 3: MK16 Simplified Schematic

3.3 Power Supply

The MK16 requires a single nominal supply level of 3.0 V to operate. All necessary decoupling and filtering components are included in the module.

3.4 Pin-out and Pin Assignments

Figure 4: MK16 module pin-out (Rear View)

Pin No.	Pin Name	Type	Description	Remark
1	GND	Power	Electrical Ground	
2	NC			
3	PB02	Digital I/O	General purpose I/O	
4	PA00	Digital I/O	General purpose I/O IADC0.VREFP	
5	PA03	Digital I/O	General purpose I/O SWV/TDO/TEACEDATA0	
6	PA04	Digital I/O	General purpose I/O TDI/ TEACECLK	
7	PA05	Digital I/O	General purpose I/O EM4WU0	
8	PA06	Digital I/O	General purpose I/O	
9	VCC	Power	Power supply	1.8 – 3.8V DC
10	GND	Power	Electrical Ground	
11	NC			
12	NC			
13	GND	Power	Electrical Ground	
14	PB01	Digital I/O	General purpose I/O EM4WU3	
15	NC			
16	PB00	Digital I/O	General purpose I/O IADC0.VREFN	
17	NC			
18	NC			
19	SWDCLK PA01	Debug Digital I/O	SWDCLK (Default) General purpose I/O	Default as Serial Wire Debug interface
20	SWDIO PA02	Debug Digital I/O	SWDIO (Default) General purpose I/O	Default as Serial Wire Debug interface
21	NC			
22	GND	Power	Electrical Ground	
23	GND	Power	Electrical Ground	
24	PC00	Digital I/O	General purpose I/O EM4WU6/THMSW_EN	
25	PC01	Digital I/O	General purpose I/O	
26	PC02	Digital I/O	General purpose I/O	
27	PC03	Digital I/O	General purpose I/O	
28	PC04	Digital I/O	General purpose I/O	
29	PC05	Digital I/O	General purpose I/O EM4WU7	
30	NC			
31	NC			
32	NC			
33	RESETn		Reset Pin. The RESETn pin is pulled up to an internal DVDD supply. An external pull-up is not recommended. To apply an external reset source to this pin, it is required to only drive this pin low during	

			reset, and let the internal pull-up ensure that reset is released. The RESETn pin can be left unconnected if no external reset switch or source is used.
34	GND	Power	Electrical Ground

4 Mechanical Details

4.1 PCBA Mechanical Dimensions
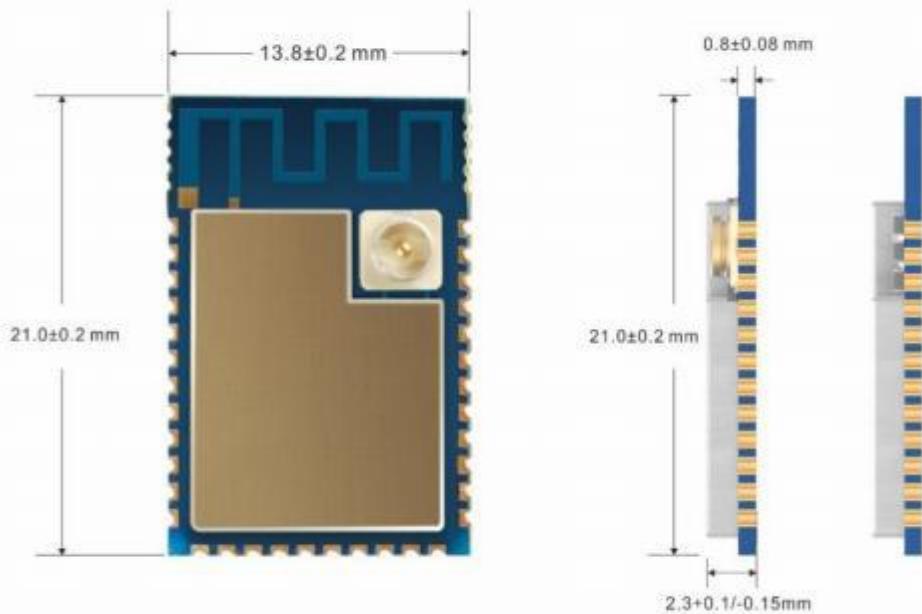
Figure 5: MK16 PCBA dimensions

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

Note: *All models of MK16 series Bluetooth module have the same dimensions.*

4.2 PCB Land Pads Dimensions
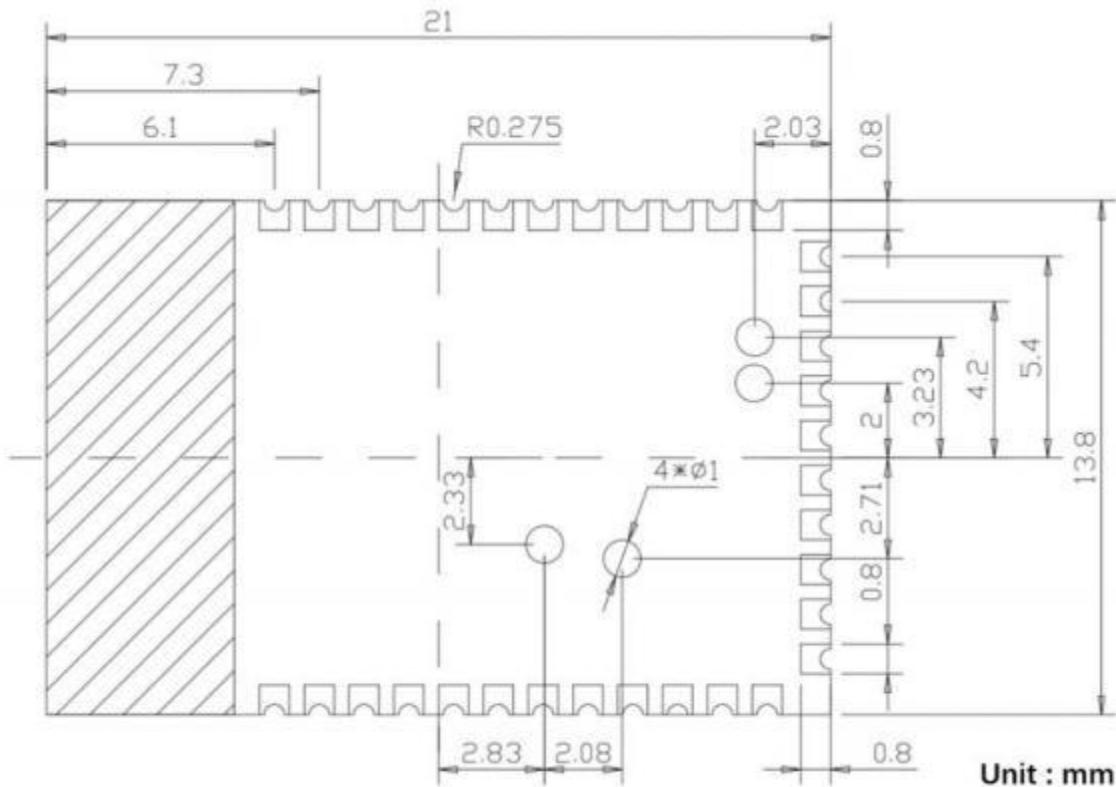
Figure 6: MK16 PCB land pads dimensions (TOP View)

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

4.3 u.FL Connector Dimensions

MK16B has mounted a micro SMT u.FL series connector (receptacle), which needs an external 2.4Ghz antenna to connect. The model of the connector is *u.FL-R-SMT-1(80).*

According to the dimensions of the connector to choose an antenna with a right plug which can connect to the receptacle appropriately.
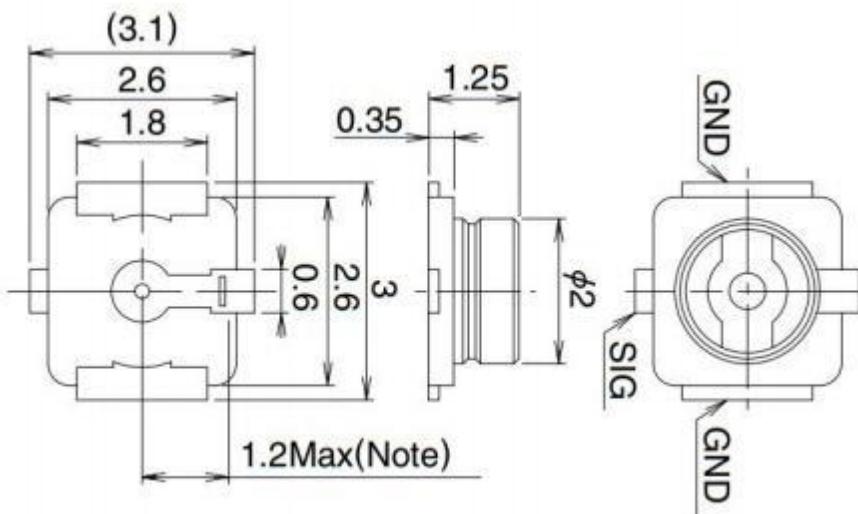

Figure 7: u.FL-R-SMT-1(80) Dimensions

Note: More information about the u.FL connector, please refer to

https://www.hirose.com/en/product/document?clcode=&productname=&series=U.FL&documenttype=Catalog&lang=en&documentid=D31697_en

5. Mounting Design Suggestions

5.1 Recommended Mounting and PCB Layout

You can refer to the following references for the mounting design and PCB layout of the MK16 module, especially for the MK16A model which has PCB on-board antenna.

For external antenna modules (MK16B needs to connect an external antenna to the u.FL connector), you also need to refer to the external antenna design requirements.

The recommended mounting and PCB layout suggestion:

- Locate MK16 series module close to the edge of the host PCB (mandatory for MK16A for on-board PCB trace antenna to radiate properly).

- Ensure there is no copper in the antenna keep-out area on any layers of the host PCB. Keep all mounting hardware and metal clear of the area to allow proper antenna radiation.

- Keep the antenna area as far away as possible from the power supply and metal components.

- Ensure no exposed copper is on the underside of the module.

- A different host PCB thickness dielectric will have small effect on antenna.

- Use solid GND plane on inner layer (for best EMC and RF performance).

- All module GND pins must be connected to the host PCB 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 the copper flood to the inner GND plane. If GND flood copper is on the bottom of the module, then connect it with GND vias to the inner GND plane.

- Use a good layout method to avoid excessive noise coupling with signal lines or supply voltage lines.

Figure 8: Recommended Module Mounting Examples

5.2 Mechanical Enclosure

Care should be taken when designing and placing the MK16 series module into an enclosure. Metal should be kept clear from the antenna area, both above and below. Any metal around the module can negatively impact RF performance.

The module is designed and tuned for the antenna and RF components to be in free air. Any potting, epoxy fill, plastic over-molding, or conformal coating can negatively impact RF performance and must be evaluated by the customer.

Placement of metal/plastic enclosure:

- 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 MK16 series 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.

- The standard reflow profile has four zones: ①preheat, ②soak, ③ reflow, ④cooling. 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.
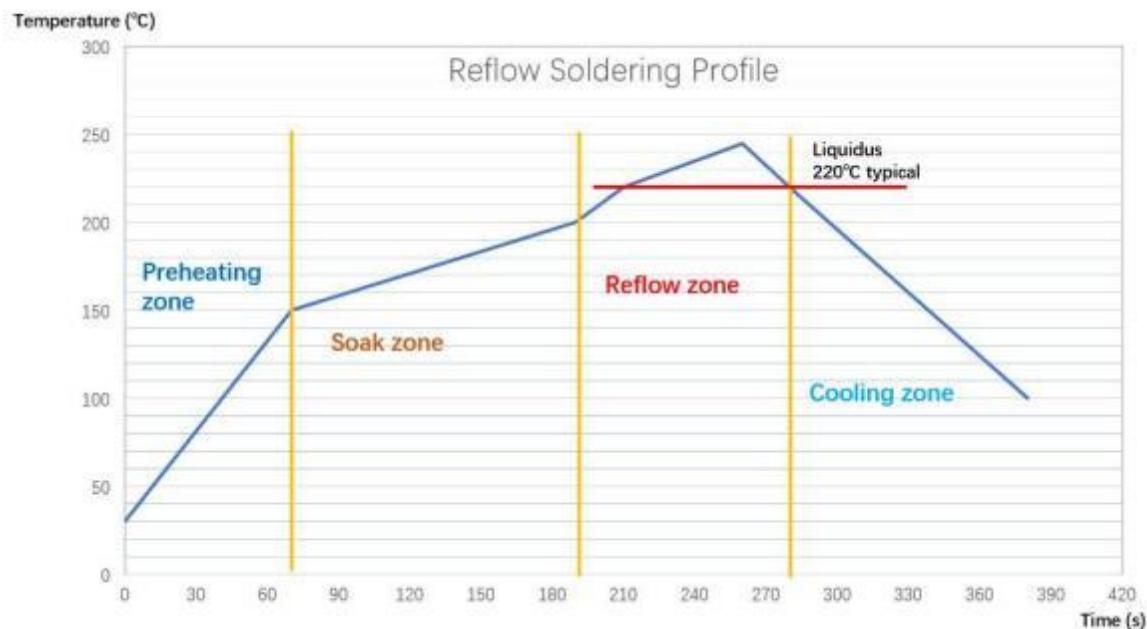
Figure 9: Temperature-Time Profile for Reflow Soldering

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

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
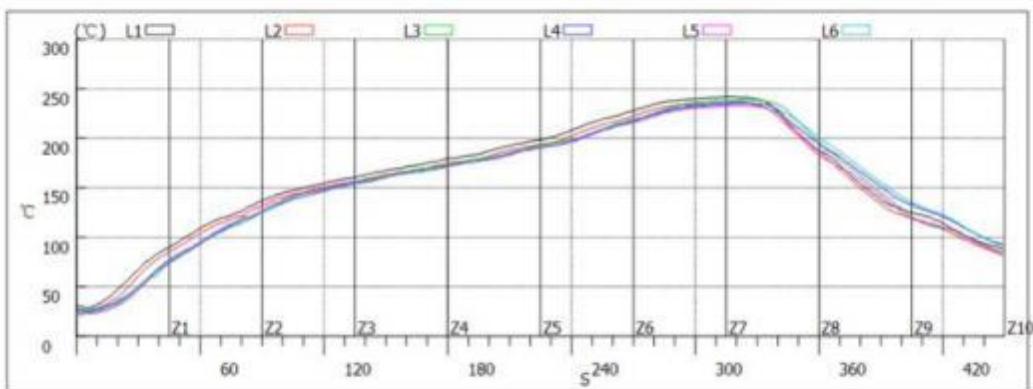
| TCS	Peak(℃)	Peak difference	Peak at time(s)	190(℃)time above	Preheat(50-150℃) Slope	Time(s)	Soak(150-200℃) Slope	Time(s)	Reflow(220-260℃) Slope	Time(s)	Liquid phase (220℃) time(s)	Cooling(260-100℃) Slope	Time(s)
Line1	242.25		518	152	1.14	88	0.42	119	0.65	62	85	-1.39	115
Line2	236.75		310	140	1.06	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	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

Figure 10: Example of MOKO Smart SMT reflow soldering

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 :

  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.

7．Qualification and Approvals

7.1 United States

FCC WARNING

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

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, and（2）this device must accept any interference received, including interference that may cause undesired operation.

This device and its antenna(s) must not be co-located or operating in conjunction with any other antenna or transmitter.

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.

To maintain compliance with FCC's RF Exposure guidelines, This equipment should be installed and operated with minimum distance between 20cm the radiator your body: Use only the supplied antenna.

Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

The availability of some specific channels and/or operational frequency bands are country dependent and are firmware programmed at the factory to match the intended destination.

The firmware setting is not accessible by the end user. The final end product must be labelled in a visible area with the following:

"Contains Transmitter Module FCC ID:2A88A-MK16

Requirement per KDB996369 D03

2.2 List of applicable FCC rules

This module meets the requirements of FCC part 15C(15.247).

2.3 Summarize the specific operational use conditions

The MK16A only has a PCB antenna and the antenna gain is 0.29dBi. The MK16B has a u.FL connector, and the lab's engineer uses a FPC antenna for testing, which antenna gain is 4.42dBi. You have to select an external 2.4Ghz antenna which antenna gain is no more than 4.42dBi.

2.4 Limited module procedures

The module is not a limited module. It's a single(full) module.

2.5 Trace antenna designs

Not applicable

2.6 RF exposure considerations

This module complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body." This module is designed to comply with the FCC statement, FCC ID: 2A88A-MK16

2.7 Antennas

The MK16A only has a PCB antenna and the antenna gain is 0.29d Bi. The MK16B has a u.FL connector and the antenna gain is 4.42dBi.

Please refer to the Antenna Report for details.

2.8 Label and compliance information

The host system using this module, should have label in a visible area indicated the following texts: "Contains FCC ID: 2A88A- MK16

2.9 Information on test modes and additional testing requirements

This testing is performed with the host product configured in typical operational modes to check the fundamental-frequency and spurious emissions for compliance with all the applicable rules.

The transmitters can be enabled by using publicly-available drivers and turned on, so the transmitters are active. In certain conditions it might be appropriate to use a technology-specific call box (test set) where accessory devices or drivers are not available.

When testing for emissions from the unintentional radiator, the transmitter shall be placed in the receive mode or idle mode, if possible. If receive mode only is not possible then, the radio shall be passive (preferred) and/or active scanning. In these cases, this would need to enable activity on the communication BUS (i.e., PCIe, SDIO, USB) to ensure the unintentional radiator circuitry is enabled.

2.10 Additional testing, Part 15 Subpart B disclaimer

Host Product Manufacture that uses this module that Part 15B evaluation of the finished product is still required.

7.2 European Union Regulatory Compliance

Information about regulatory compliance of the European Union for the MK16 module is available in the MK16 Declaration of Conformity.

7.2.1 Radio Equipment Directive (RED) 2014/53/EU

The MK16 module complies with the essential requirements and other relevant provisions of Radio Equipment Directive (RED) 2014/53/ EU.

7.2.2 Labeling and User Information Requirements

The label on the final products which contain the MK16 module must follow CE marking requirements. The "R&TTE Compliance Association Technical Guidance Note 01" provides guidance on final product CE marking.

Revision History

Version	Comments	Contributor(s)	Revision Date
V1.0	Initial Release	Kevin Huang	2022/12/30

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