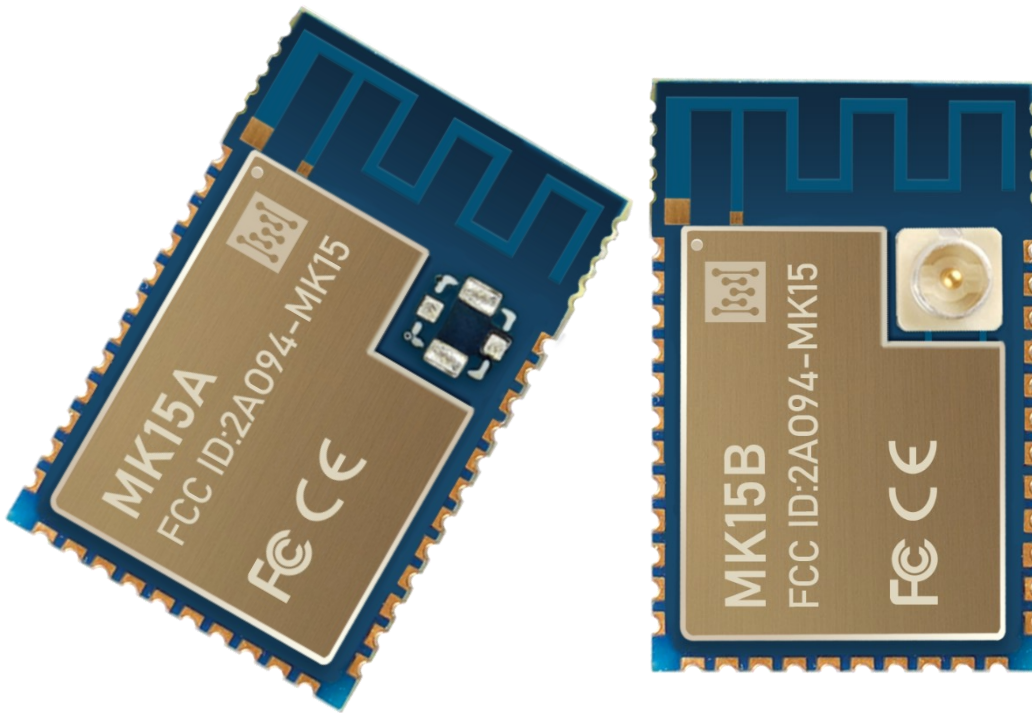




MOKO SMART

MK15 Bluetooth Module Datasheet



MK15 Bluetooth Module

Datasheet

Version 1.2

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1 Instruction

MK15 series is a powerful, highly flexible and ultra-low-power **Bluetooth® 5.0** module based on **Realtek Semiconductor Corp RTL8762CMF** SoC solution, which combines the excellent performance of a leading RF transceiver with a 32-bit ARM® Cortex™-M4F CPU and rich powerful supporting features and peripherals.

MK15 brings out all **RTL8762CMF** hardware capabilities and peripherals including 160KB RAM, 4Mb internal Flash, IR transceiver, hardware key-scan, up to +7.5 dBm transmit power and rich peripheral interfaces such as flexible GPIO, UART, ADC, PWM, SPI, I²C. **MK15** also provides a complete RF solution with no additional RF design.

MK15 supports **Bluetooth® SIG Mesh** and **Bluetooth® 5.0** core specification features of LE 2M PHY (High speed), LE Coded PHY (Long range), Advertising Extensions and CSA#2.

MK15 series modules will be programmed default MOKO MKBR series firmware and custom firmware can be programmed by MOKO smart too.

After you choose **MK15** series module, **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.



1.1 Features and Benefits

- Bluetooth® 5.0 specification
- Bluetooth® SIG Mesh
- Total 160kB SRAM
- Embedded 4Mbits internal Flash
- Rx Sensitivity -97 dBm (1 Mbps), -101dBm (125 kbps)
- Max Tx power to 7.5dBm
- Various Interfaces of GPIO, RTC, SPI, AUXADC, Timers, I²C, PWM, UART
- Hardware key-scan
- Embedded IR transceiver
- Fast AGC control to improve receiving dynamic range
- Supports AES128/192/256 encrypt/decrypt engine
- Switching regulator circuit for low current consumption
- Embedded internal 32K RC oscillator and supports external 32.768kHz XTAL without capacitor (in limited condition)
- Supports GAP, ATT/GATT, SMP, L2CAP
- Generic Applications for GAP Central, Peripheral, Observer and Broadcaster Roles
- Power down – 1uA
- Deep LPS – 2.5uA
- Supports OTA (Over-the-Air)
- Extended Industrial temperature(-40 to +105°C) can be customized
- Fast time-to-market
- No external components required
- Regulatory certifications on request

1.2 Applications

- **Bluetooth Mesh**
 - Smart lighting systems
 - Home automation
 - Sensor networks
- **IoT Sensors**
 - Smart building
 - Smart industry
 - Smart cities
 - Smart home
- **Beacon**
 - RTLS (Real Time Location System)
 - Indoor wayfinding
 - Proximity marketing
 - Person tracking
 - Emergency SOS

1.3 Product Options

1.3.1 Hardware Options

There are different module models of **MK15** series Bluetooth module. All models have same dimensions and pin assignments.

Currently MK15 is mainly divided into **A series (MK15A)** and **B series (MK15B)**. The difference is in the antenna design.

MK15A embeds a high-performance PCB antenna.

MK15B 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.

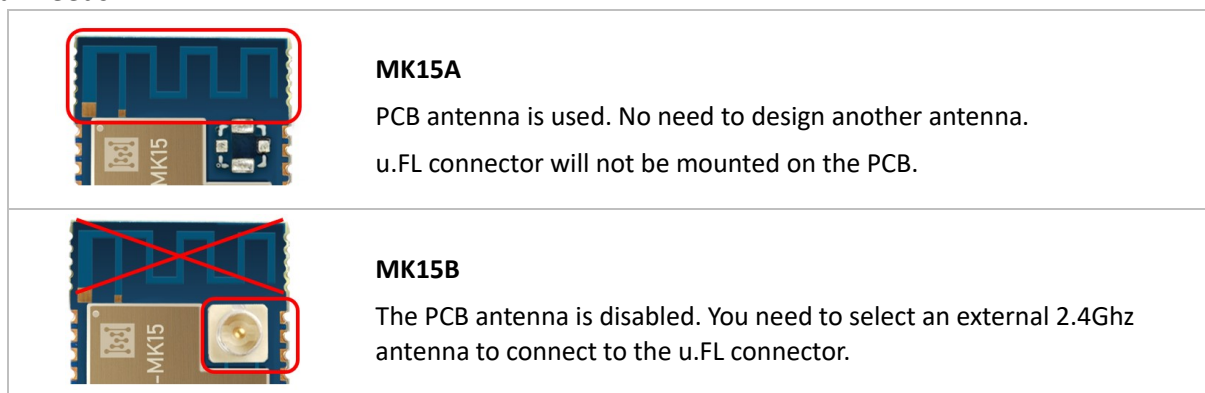


Figure 1: MK15A and MK15B

MK15 series module also reserves pads for mounting 32.768kHz crystal oscillator and matching capacitor. The default model does not mount the 32.768kHz crystal oscillator.

1.3.2 Firmware Options

For customers to use, MK15 series module will be programmed default MOKO MKBR-A01 series firmware, which has the functions of UART Wireless Transparent Transmission and AT commands.

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

Firmware Version	Firmware Features
MKBR-A01	UART wireless transparent transmission AT commands
MKBR-AMN01 (Completed in 2021 Q3)	Bluetooth mesh node UART wireless transparent transmission

Note: This document is a Hardware Datasheet only – it does not cover the software aspects of the MK15. If you want to get more information about firmware or SDKs of MK15, please contact sales of MOKO Smart.



1.3.3 Ordering Information

Product Model	Antenna	32.768kHz XTAL	Firmware Version	Remark
MK15A	PCB	No	MKBR-A01	Default model
MK15A-MN	PCB	No	MKBR-AMN01	Default model (Completed in 2021 Q3)
MK15AX	PCB	YES	MKBR-A01	Custom model
MK15AX-MN	PCB	YES	MKBR-AMN01	
MK15B	u.FL connector	No	MKBR-A01	Default model
MK15B-MN	u.FL connector	No	MKBR-AMN01	Custom mode
MK15BX	u.FL connector	YES	MKBR-A01	
MK15BX-MN	u.FL connector	YES	MKBR-AMN01	

MOKO Smart can provide the default model modules as samples to you to test or develop without MOQ. But if you want the custom models, there will be a MOQ requirement. Please contact sales team of MOKO Smart to get more ordering information.

2 Specifications

Detail	Description
General	
CPU	ARM® 32-bit Cortex®-M4F at 40 MHz
RAM	Total 160kByte RAM consists 4 sectors. RAM1 – 112kByte Data RAM RAM2 – 8kByte Cache Shared RAM RAM3 – 8kByte Cache Shared RAM RAM4 – 32kByte Buffer RAM All the RAM regions can be used to execute code and hold data.
Flash	Embedded 512kByteFlash (448kB for custom use, 64kB has been used for OS) Flash Address Space is a virtual space that is mapped to external Flash to extend the code space in XIP (execute In Place) mode
Dimensions	Length: 21mm±0.2mm Width: 13.8mm±0.2mm Height: 2.3mm+0.1mm/-0.15mm
Bluetooth	
Bluetooth Features	Bluetooth® Low Energy Bluetooth® SIG Mesh 1M LE PHY 2M LE PHY (High speed) LE Coded PHY (Long range) Advertising Extensions CSA #2 (Channel Selection Algorithm #2) GAP, ATT/GATT, SMP, L2CAP Bluetooth Mesh + GATT connection x 3
Low Energy	Multiple level Low Energy state LE L2CAP Connection Oriented Channel support LE low duty directed advertising LE data length extension feature
Roles	Concurrent central, observer, peripheral and broadcaster
BLE Multi-link	One central connects to 4 peripherals simultaneously One peripheral connected by 3 centrals simultaneously Supports up to 11 links (3 centrals and 8 peripherals) when concurrent central and peripheral
Radio	
Frequency	2402MHz – 2480MHz
Modulations	GFSK at 1 Mbps/2 Mbps Long range (125kbps and 500kbps) data rates
Transmit Power	-20dBm, 0dBm, +3dBm, +4dBm, +7.5 dBm
Receiver Sensitivity	-97 dBm sensitivity in 1 Mbps Bluetooth® LE mode -101 dBm sensitivity in 125 kbps Bluetooth® LE mode
Antenna	MK15A series – PCB trace antenna MK15B series – u.FL connector
Hardware	
Power Supply	1.8V to 3.3V DC
Power Regulator	Switching regulator for DC/DC buck setup



MK15 Bluetooth Module

Datasheet

Detail	Description
Clock control	Embedded 40MHz crystal oscillator Embedded 32K RC oscillator and support external 32.768kHz crystal oscillator
Package	34 diameters of Half-holes
PCB Material	FR-4
Impedance	50Ω
Interfaces	25 (max) flexible General Purpose IOs Hardware key-scan Embedded IR transceiver Real-Time counters (RTC) Generic 4-wire SPI master/slave Low power comparators x 8 400ksps, 12bit, 6 channel AUXADC SWD Timers x 8 I ² C x 2 PWM x 8 UART x 2
Storage Temperature	-55 to 125°C
Operating Temperature	-40 to 85°C Extended Industrial temperature -40 to +105°C can be customized
Current Consumption	
Power Down	1uA
Deep LPS	2.5uA (with 160K SRAM in retention state)
Active Rx Mode	Peak current 7.3mA
Active Tx Mode	Peak current 7.9mA@ 0dBm Peak current 9.6mA@ 4dBm Peak current 11.3mA@ 7.5dBm
Certifications	
USA (FCC)	Under progress and completed about in 2021.Q3
Europe (CE)	Under progress and completed about in 2021.Q3
Canada (ISED)	Under progress and completed about in 2021.Q3
Japan (MIC)	Under progress and completed about in 2021.Q3
Australia/New Zealand (RCM)	Under progress and completed about in 2021.Q3
Bluetooth (BQB)	Under progress and completed about in 2021.Q3

3 Hardware Design

3.1 Block Diagram

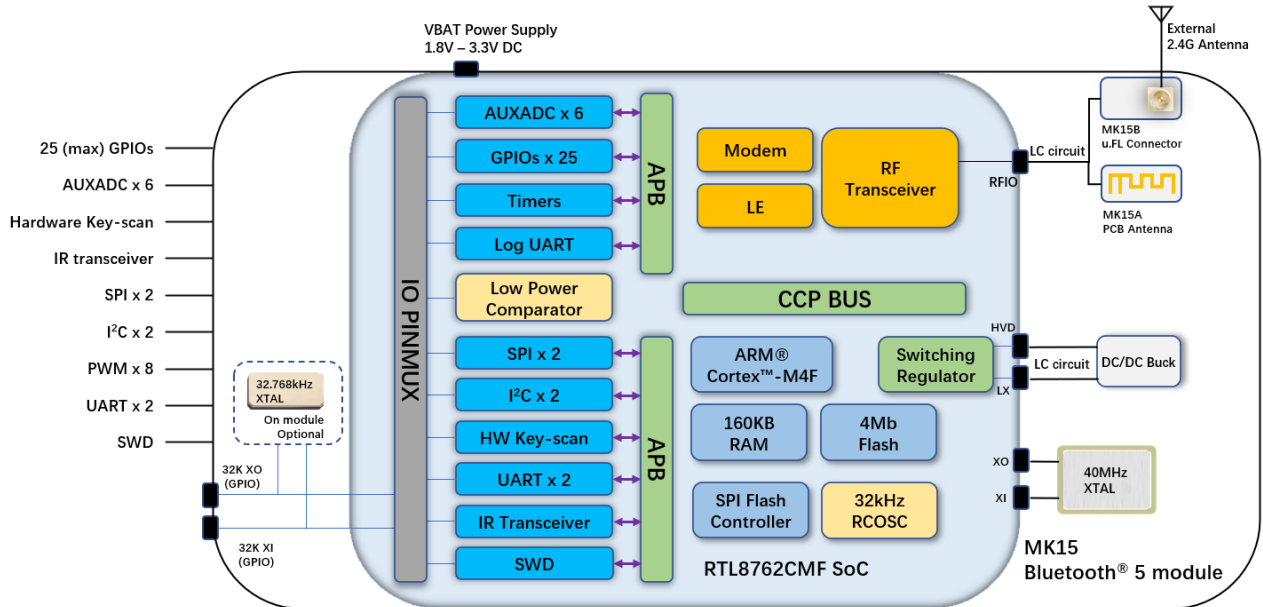


Figure 2: MK15 Block Diagram

3.2 Pin-out and Pin Assignments

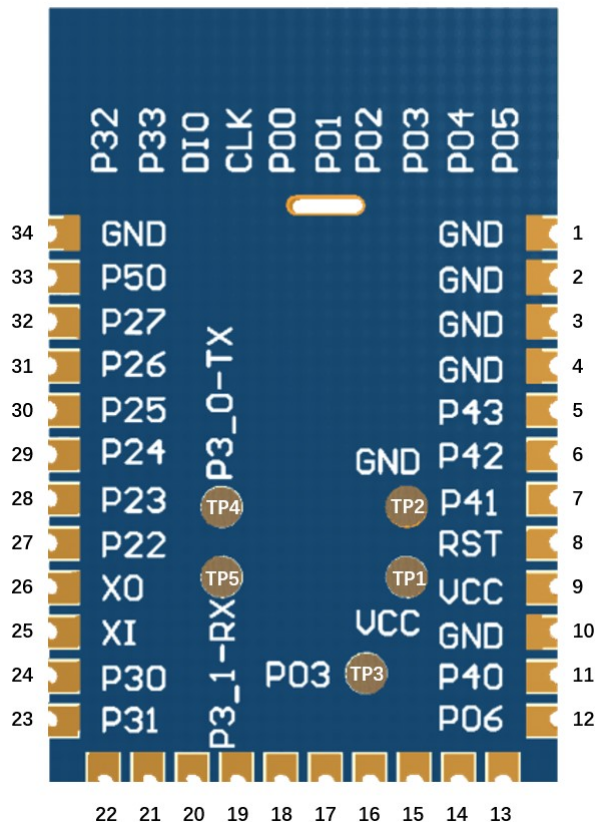


Figure 3: MK15 module pin-out (Rear View)



MK15 Bluetooth Module

Datasheet

Pin No.	Pin Name	Type	Description	Pull Up/Down	Remark
1	GND	Power	Electrical Ground	-	
2	GND	Power	Electrical Ground	-	
3	GND	Power	Electrical Ground	-	
4	GND	Power	Electrical Ground	-	
5	P4_3	Digital I/O	General purpose I/O	Pull Up	GPIO [31] Recommended as SPI0_CSN Up to 20Mhz Timing
6	P4_2	Digital I/O	General purpose I/O	Pull Down	GPIO [30] Recommended as SPI0_MOSI Up to 20Mhz Timing
7	P4_1	Digital I/O	General purpose I/O	Pull Down	GPIO [29] Recommended as SPI0_MISO Up to 20Mhz Timing
8	RESET	Digital Input	Hardware reset pin	Pull Up	Active Low
9	VCC	Power Analog	Power supply	-	1.8 – 3.3V DC
10	GND	Power	Electrical Ground	-	
11	P4_0	Digital I/O	General purpose I/O	Pull Down	GPIO [28] Recommended as SPI0_CLK Up to 20Mhz Timing
12	P0_6	Digital I/O	General purpose I/O	Pull Down	GPIO [6]
13	P0_5	Digital I/O	General purpose I/O	Pull Down	GPIO [5]
14	P0_4	Digital I/O	General purpose I/O	Pull Down	GPIO [4]
15	P0_3	Digital I/O	Log UART TX	Pull Up	GPIO [3] Pull-up for normal operation (log output) Pull-down to bypass executing program code in flash
16	P0_2	Digital I/O	General purpose I/O	Pull Down	GPIO [2]
17	P0_1	Digital I/O	General purpose I/O	Pull Down	GPIO [1]
18	P0_0	Digital I/O	General purpose I/O	Pull Down	GPIO [0]
19	P1_1	Debug Digital I/O	SWDCLK (Default) General purpose I/O	Pull Up	Default as Serial Wire Debug interface GPIO [9]
20	P1_0	Debug Digital I/O	SWDIO (Default) General purpose I/O	Pull Up	Default as Serial Wire Debug interface GPIO [8]
21	P3_3	Digital I/O	General purpose I/O	Pull Down	GPIO [27] Recommended as SPI1_MISO (master only). Up to 20Mhz Timing
22	P3_2	Digital I/O	General purpose I/O	Pull Down	GPIO [26] Recommended as SPI1_CLK (master only). Up to 20Mhz Timing
23	P3_1	Digital I/O	UART TX General purpose I/O	Pull Up	Default as HCI_UART TX for firmware programming (P0_3 pulled down) GPIO [25]
24	P3_0	Digital I/O	UART RX General purpose I/O	Pull Up	Default as HCI_UART RX for firmware programming (P0_3 pulled down) GPIO [24]
25	32K_XI	Analog Digital I/O	Connection for 32.768 kHz XTAL General purpose I/O	Pull Down	Pin share as GPIO when 32.768kHz crystal oscillator is not used GPIO [26]

26	32K_XO	Analog Digital I/O	Connection for 32.768kHz XTAL General purpose I/O	Pull Down	Pin share as GPIO when 32.768kHz XTAL is not used GPIO [27]
27	P2_2	Analog Digital I/O	AUXADC input General purpose I/O	Pull Down	AUXADC input 2 GPIO [18]
28	P2_3	Analog Digital I/O	AUXADC input General purpose I/O	Pull Down	AUXADC input 3 GPIO [19]
29	P2_4	Analog Digital I/O	AUXADC input General purpose I/O	Pull Down	AUXADC input 4 GPIO [20]
30	P2_5	Analog Digital I/O	AUXADC input General purpose I/O	Pull Down	AUXADC input 5 GPIO [21]
31	P2_6	Analog Digital I/O	AUXADC input General purpose I/O	Pull Down	AUXADC input 6 GPIO [22]
32	P2_7	Analog Digital I/O	AUXADC input General purpose I/O	Pull Down	AUXADC input 7 GPIO [23]
33	P5_0	Digital I/O	General purpose I/O	Pull Down	GPIO [25]
34	GND	Power	Electrical Ground	-	
35	TP1 – VCC	Power Analog	Power supply	-	1.8 – 3.3V DC
36	TP2 – GND	Power	Electrical Ground		
37	TP3 – P0_3	Digital I/O	Log UART TX	Pull Up	Same as P0_3
38	TP4 – P3_0	Digital I/O	UART RX General purpose I/O	Pull Up	Same as P3_0
39	TP5 – P3_1	Digital I/O	UART TX General purpose I/O	Pull Up	Same as P3_1

Note:

1. All General Purpose I/Os support 8mA drive capability, wake up function and internal strong/weak pull-up and pull-down function.
2. The SWDIO and SWDCLK pins are suggested to be reserved for firmware debug.
3. MK15 has been mounted with an external 32.768kHz crystal. If you want set 32K_XI and 32K_XO as GPIO, you should use the internal 32kHz RC Oscillator as clock.
4. The central TP (Test Point) pads VCC, GND, P0_3, P3_0, P3_1 have the same function as the table shows. The 5 TP pads are reserved for manufacture programming and debugging.

4 Mechanical Details

4.1 PCBA Mechanical Dimensions

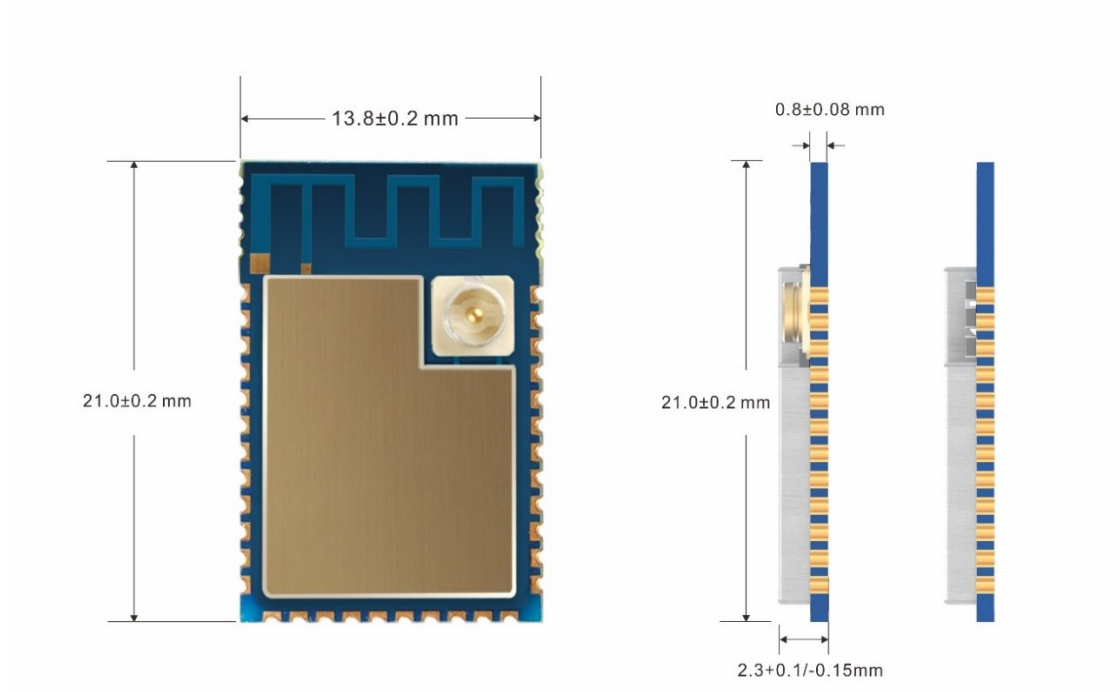


Figure 4: MK15 PCBA dimensions

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 MK15 series Bluetooth module have the same dimensions.

4.2 PCB Land Pads Dimensions

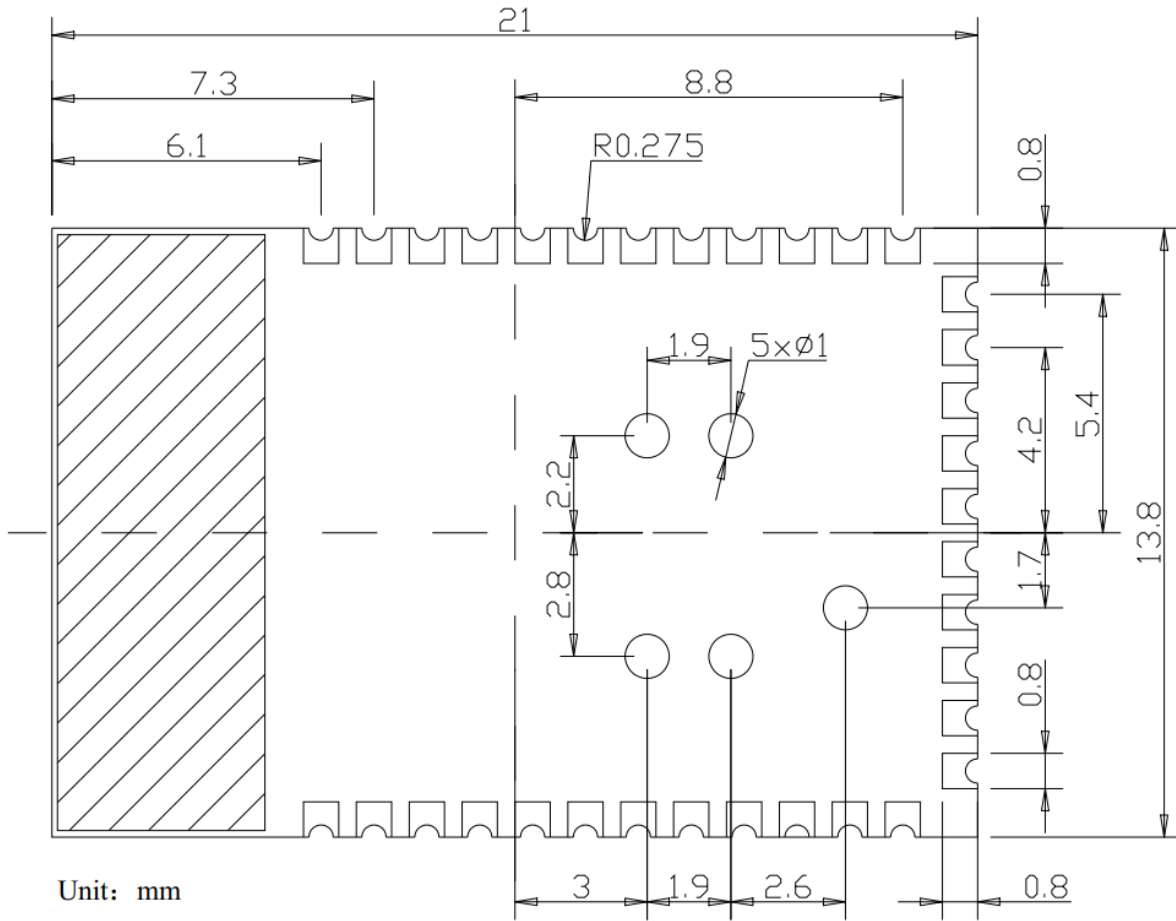


Figure 5: MK15 PCB land pads dimensions (TOP View)

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

MK15B 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.

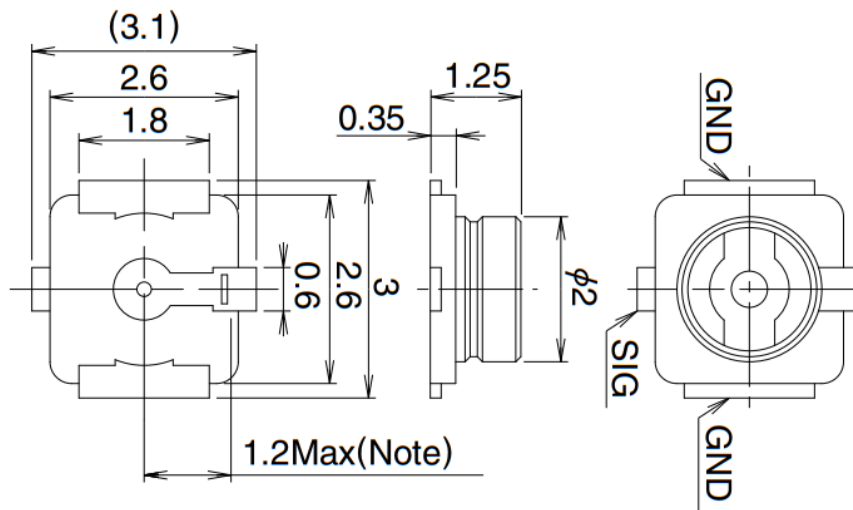


Figure 6: u.FL-R-SMT-1(80) Dimensions

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. Power Specifications

5.1 Power Supply Characteristics

MK15 series is supplied with typical 3V DC by a single power source via VCC pin.

Symbol	Function	Minimum	Typical	Maximum	Units
VCC	Single power source for whole module	1.8	3	3.3	V

5.2 Power Consumption

MK15 series module defines three power states for various conditions.

- **Active Mode:** All clock and power is turned on. All functions operate in this mode.
- **Deep LPS Mode:** High-speed clock and core domain power is turned off. The CPU stops running. Data can be retained in retention SRAM.
- **Power Down Mode:** Except in an “always-on” power domain, all clock sources and power are turned off. Power down mode can only be woken by GPIO pins.

Power Mode	Always on Registers	32kHz XTAL/RC oscillator	Retention SRAM	CPU	Wakeup Method	Current Consumption (Typical)
Power Down	ON	OFF	OFF	OFF	By GPIO	1uA
Deep LPS	ON	ON	160K SRAM in retention state	OFF	By GPIO/timer	2.5uA
Active RX Mode	ON	ON	-	ON	-	7.3mA
Active TX Mode @0dBm TX Power	ON	ON	-	ON	-	7.9mA
Active TX Mode @4dBm TX Power	ON	ON	-	ON	-	9.6mA
Active Tx Mode @7.5dBm TX Power	ON	ON	-	ON	-	11.3mA

Condition: VCC = 3V, Temperature = 25 °C

6. Peripheral Interfaces

6.1 Descriptions

MK15 series module peripheral interfaces descriptions are shown in the table below.

Physical Address	Function
0x4000 0000 – 0x4000 0FFF	SYS Control
0x4000 1000 – 0x4000 17FF	GPIO
0x4000 2000 – 0x4000 2FFF	Timer
0x4000 3000 – 0x4000 37FF	IR RC
0x4000 4000 – 0x4000 47FF	2-Wire SPI
0x4000 5000 – 0x4000 57FF	Hardware Key-scan
0x4001 0000 – 0x4001 0FFF	AUXADC
0x4001 1000 – 0x4001 11FF	UART_1
0x4001 2000 – 0x4001 23FF	UART_2
0x4001 3000 – 0x4001 33FF	SPI_0
0x4001 3400 – 0x4001 37FF	SPI_1
0x4001 4000 – 0x4001 4FFF	AES Engine
0x4001 5000 – 0x4001 53FF	I ² C_0
0x4001 5400 – 0x4001 57FF	I ² C_1
0x4002 0000 – 0x4002 0FFF	Reserved
0x4002 1000 – 0x4002 1FFF	Reserved
0x4002 4000 – 0x4002 43FF	UART_2
0x4002 4800 – 0x4002 4BFF	Reserved

6.2 Pin Multiplexer

All GPIO pins in MK15 series module are configurable via the built-in pin multiplexer (PINMUX). Figure 7 shows the PINMUX and GPIO PADS control path. In the MK15, all pins have an internal pull-up and pull-down resistor for controlling GPIO_PU and GPIO_PD.

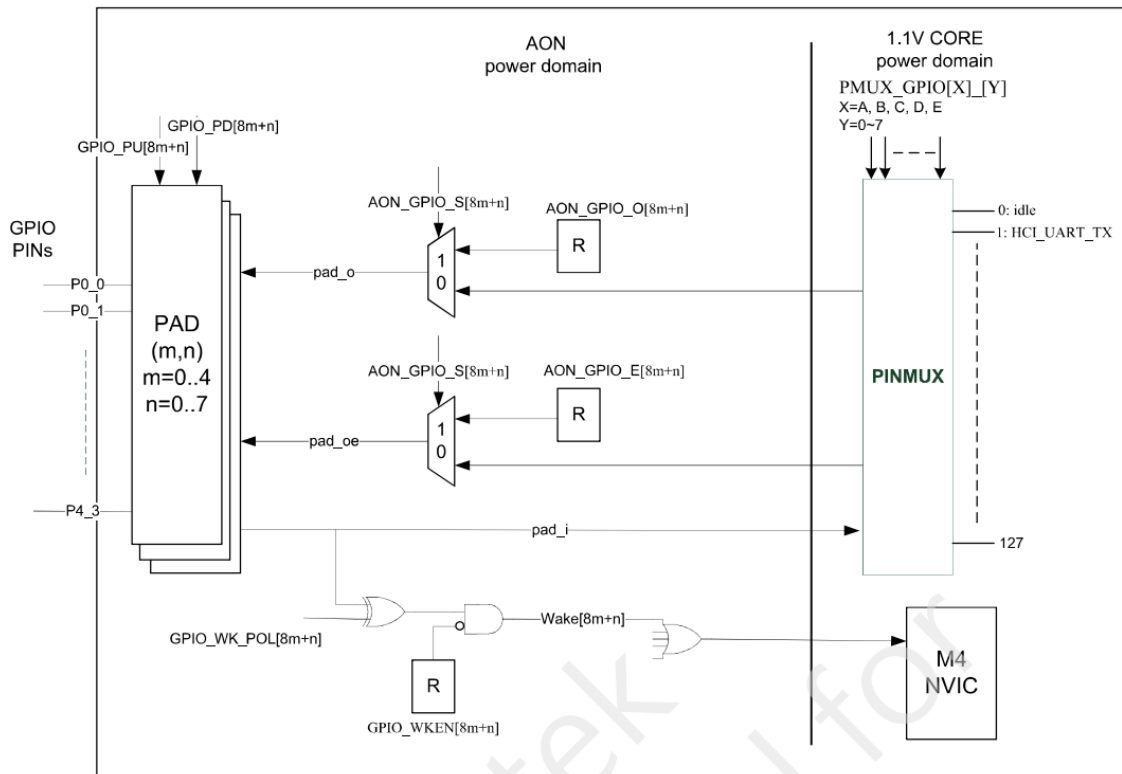


Figure 7: PINMUX and GPIO PADS Control Path

6.3 Clock

For optimal power consumption and performance, MK15 series module offers high and low frequency clocks. The high frequency clock is generated by an 40MHz crystal oscillator and the low frequency clock is generated by a 32.768kHz/32kHz crystal oscillator.

In normal mode the high frequency clock is kept running to provide clock to the CPU, Bluetooth core, and the peripheral block. In low power mode the high frequency clock is turned off for power saving. The 32.768kHz/32kHz crystal oscillator low frequency clock remains on to provide clock to the RTC (Real Time Counter), Bluetooth core, and PMU (Power Management Unit).

MK15 series module has a built-in 32kHz RC oscillator, which can be used as a low-speed clock source to instead the 32.768kHz/32kHz crystal oscillator. With run-time self-calibration algorithm and limited user environment variation less than 1°C per second, the BLE link could be maintained via the internal 32kHz RC oscillator.

MK15 series module reserves pads for mounting 32.768kHz crystal oscillator and matching capacitor and 32K_XI and 32K_XO pins to connect the external 32.768kHz crystal oscillator. If 32kHz/32.768kHz XTAL is not used, these 2 pins can be configured as General purpose I/O.

Pin No.	Pin Name	Description	Remark
25	32K_XI	Connection for 32kHz/32.768kHz crystal oscillator General purpose I/O	Pin share as GPIO when 32kHz/32.768kHz crystal oscillator is not used GPIO [26]
26	32K_XO	Connection for 32kHz/32.768kHz crystal oscillator General purpose I/O	Pin share as GPIO when 32kHz/32.768kHz crystal oscillator is not used GPIO [27]

6.4 Real-Time Counter (RTC)

There are 24-bit counters with four individual comparators. The counter is clocked by a 32.768kHz XTAL or 32k RC oscillator with 12-bit pre-scalar. The comparators output can interrupt the CPU and wake up the module from DLPS mode. The **RTC Block Diagram** is shown in Figure 8 below.

The RTC Features:

- 12-bits pre-scale counter
- 24-bits read only RTC counter
- 32.768kHz XTAL or 32k RC oscillator clock resource
- 4 independent comparators (with interrupt)
- 1 tick interrupt
- RTC counter overflow interrupt

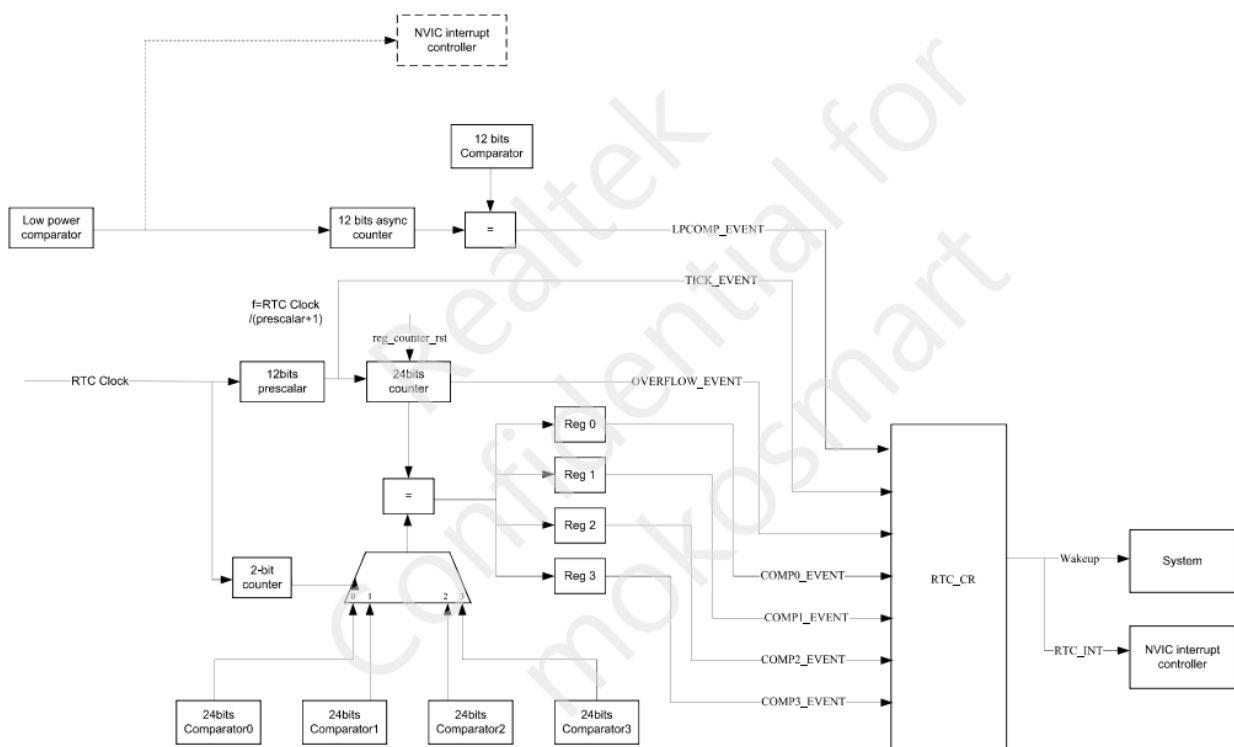


Figure 8: RTC Block Diagram

6.5 PWM/Hardware Timer (TIM)

MK15 supports 8 PWM/TIM modules. The **Hardware Timer Table** (Base Address: 0x4000 2000) is shown below.

The Timer/PWM Features:

- 8 independent Timer (2 Timer is dedicated for Internal usage)
- Independent input clock divider 1/2 1/4, 1/8,1/16, 1/40 (on all Timers)
- 3 mode (free run/user define/PWM)
- 32bits counter
- Complementary PWM output & Dead zone (only Timer2, Timer3)
- PWM output state read back (<100kHz)

Address Range (Base+)	Function
0x00 to 0x10	Timer 0 Registers
0x14 to 0x24	Timer 1 Registers
0x28 to 0x38	Timer 2 Registers
0x3C to 0x4C	Timer 3 Registers
0x50 to 0x60	Timer 4 Registers
0x64 to 0x74	Timer 5 Registers
0x78 to 0x88	Timer 6 Registers
0x8C to 0x9C	Timer 7 Registers
0xb0 to 0xcc	TimerNLoadCount2Registers

6.6 GPIO

MK15 series module provides highly flexible GPIOs for development. GPIO function can be assigned to the IO PAD via Pin Multiplexer register. The all 25 GPIOs are shown in the **Mapping Table** below.

The GPIO Features:

- At most 25 GPIOs
- Input/output function
- Independence interrupts
- 3 interrupt trigger conditions (level/edge/dual-edge)
- Hardware interrupt de-bounce

Pin No.	Pin Name	GPIO No.	Remark
5	P4_3	GPIO [31]	Recommended as SPI0_CSN
6	P4_2	GPIO [30]	Recommended as SPI0_MOSI
7	P4_1	GPIO [29]	Recommended as SPI0_MISO
11	P4_0	GPIO [28]	Recommended as SPI0_CLK
12	P0_6	GPIO [6]	

Pin No.	Pin Name	GPIO No.	Remark
13	P0_5	GPIO [5]	
14	P0_4	GPIO [4]	
16	P0_2	GPIO [2]	
17	P0_1	GPIO [1]	
18	P0_0	GPIO [0]	
19	P1_1	GPIO [9]	Default as Serial Wire Debug interface Not recommended as GPIO
20	P1_0	GPIO [8]	Default as Serial Wire Debug interface Not recommended as GPIO
21	P3_3 *	GPIO [27]	Recommended as SPI1_MISO (master only)
22	P3_2 *	GPIO [26]	Recommended as SPI1_CLK (master only)
23	P3_1 *	GPIO [25]	Default as HCI_UART TX for firmware programming (P0_3 pulled down)
24	P3_0	GPIO [24]	Default as HCI_UART RX for firmware programming (P0_3 pulled down)
25	32K_XI *	GPIO [26]	Connection for 32.768 kHz XTAL Pin share as GPIO when 32.768kHz crystal oscillator is not used
26	32K_XO *	GPIO [27]	Connection for 32.768 kHz XTAL Pin share as GPIO when 32.768kHz crystal oscillator is not used
27	P2_2	GPIO [18]	AUXADC input 2
28	P2_3	GPIO [19]	AUXADC input 3
29	P2_4	GPIO [20]	AUXADC input 4
30	P2_5	GPIO [21]	AUXADC input 5
31	P2_6	GPIO [22]	AUXADC input 6
32	P2_7	GPIO [23]	AUXADC input 7
33	P5_0 *	GPIO [25]	

Note: The pins with * (P3_1/ P5_0, P3_2/ 32K_XI, P3_3/ 32K_XO) have the same GPIO number. If one pin is configured as GPIO function, the other pin should be used as PADs.

6.7 Hardware Key-scan

MK15 series module supports a Configurable 12 rows x 20 columns key matrix with key-scan engine. Each IO PADs could be configured as any row or column pin of Key-scan to reduce complexity of PCB routing.

The Hardware Key-scan Features:

- Configurable matrix; max matrix (12 row x 20column)
- Configurable matrix scan clock
- Configurable de-bounce time
- Configurable scan interval
- Configurable all-key release detect time
- 26 depth Key FIFO
- Key filter (one key)

6.8 IR Controller



The built-in IR module provides a flexible way of transmitting and receiving IR code used in remote controls. It could send IR waveform within IR carrier and received IR waveform within IR carrier.

IR Transmitter Feature:

- Programmable IR carrier (10kHz ~ 60kHz)
- Programmable IR carrier duty
- Programmable IR carrier cycle number
- Hardware output waveform control
- TX FIFO Depth: 32

IR Receiver Feature

- Programmable sample clock (max clock 40MHz)
- Ability to learn IR waveform directly (carrier frequency = < 60kHz)
- Automatic/manual trigger mode
- Hardware waveform sample (not be interfered by software task)
- RX FIFO Depth: 32

6.9 SPI

There are two individual SPI interfaces in MK15 series module. SPI0 supports master and slave mode. SPI1 supports master mode only. The recommended pins for SPI interfaces are shown in the table below, these pins can reach the max 20MHz Timing.

Pin No.	Pin Name	IO PADS	SPI
5	P4_3	GPIO [31]	Recommended as SPI0_CSN
6	P4_2	GPIO [30]	Recommended as SPI0_MOSI
7	P4_1	GPIO [29]	Recommended as SPI0_MISO
11	P4_0	GPIO [28]	Recommended as SPI0_CLK
21	P3_3	GPIO [27]	Recommended as SPI1_MISO (master only)
22	P3_2	GPIO [26]	Recommended as SPI1_CLK (master only)

SPI0 Features:

- Master & slave mode
- Supports Clock Mode 0 ~ 3 (CPOL, CPHA)
- 4 transmit mode: TX only, RX only, Full-duplex, EEPROM
- 2 x n SPI CLK Divider (Max. 20MHz)
- Supports 4-32bits SPI data frame (master)
- Supports 4-16bits SPI data frame (slave)
- 1 Hardware CS (master)



- 32bits FIFO; 36 depth (master)
- 16bits FIFO; 64 depth (slave)
- DMA transfer supported

SPI1 Features

- Master mode only
- Support Clock Mode 0 ~ 3 (CPOL, CPHA)
- 4 transmit mode: TX only, RX only, Full-duplex, EEPROM
- 2 x n SPI CLK Divider (Max. 20MHz)
- Supports 4-32bits SPI data frame (master)
- 3 Hardware CS (master)
- 32bits FIFO; 36 depth (master)
- DMA transfer supported

6.10 I²C

There are two separate I²C interfaces in MK15 series module. Each I²C interface is comprised of Serial Data Line (SDA) and Serial Clock Line (SCL). Both I²C interfaces can be configured to master or slave mode.

The I²C Features:

- Master/Slave mode
- Supports 7/10 bits I²C address
- Configurable I²C address (slave mode)
- Standard speed (0 - 100kHz), Fast speed (100kHz - 400kHz)
- TX FIFO 8 bits x 24
- RX FIFO 8bits x 40
- DMA supported

6.11 UART

There are two general hardware UARTs (UART0, UART1) and one log output UART2 (P0_3).

Any GPIOs (except the not recommended GPIOs) can be configured as general UART by Pin Multiplexer.

UART2 (P0_3) is dedicated for log UART output and can be used for firmware programming in mass production. Pull up P0_3 for normal operation, enable log output only. Pull down P0_3 to bypass executing program code, and HCI_UART (P3_0 RX, P3_1 TX) connected to Host Controller Interface of the MCU is enabled for UART programming.

The MK15 series module provides multiple UART baud-rate configured by register setting. The



common band-rate example is shown in table below. The UART clock error between two devices should be less than $\pm 2.5\%$.

The UART Features:

- Supports 7/8 Data Format
- 1/2 bit Stop bit
- Configurable parity bit: odd/even
- Programmable baud rate (max. baud rate 4,000,000)
- Hardware flow control
- RX line idle state detect
- DMA supported

Baud Rate (bps)	Error (%)	Baud Rate (bps)	Error (%)
1200	-0.23	460800	0.17
9600	<0.01	500000	<0.01
14400	<0.01	921600	0.18
19200	<0.01	1000000	<0.01
28800	<0.01	1382400	0.17
38400	<0.01	1444400	-0.31
57600	<0.01	1500000	<0.01
76800	0.01	1843200	-0.35
115200	<0.01	2000000	0.02
128000	0.02	2764800	0.14
153600	-0.10	3000000	0.06
230400	0.03	4000000	0.03

6.12 AUXADC

The MK15 module provides 6 channels 12bits, 400kpbs AUXADC for external analog signal sensing and internal VCC voltage monitoring. The pins can be configured as AUXADC are shown in the table below.

The AUXADC Features:

- A 12bits, max 400ksps AUXADC with 6 channel sharing
- Flexible sampling schedule table for multi-channel sampling
- Divided mode: Support 0 – VCC input range with internal resistor divider
- VCC voltage sensing
- Supports single-ended mode and differential mode

Pin No.	Pin Name	IO PADs	AUXADC
27	P2_2	GPIO [18]	AUXADC input 2

Pin No.	Pin Name	IO PADS	AUXADC
28	P2_3	GPIO [19]	AUXADC input 3
29	P2_4	GPIO [20]	AUXADC input 4
30	P2_5	GPIO [21]	AUXADC input 5
31	P2_6	GPIO [22]	AUXADC input 6
32	P2_7	GPIO [23]	AUXADC input 7

6.13 Serial Wire Debug (SWD)

The MK15 series module provides Serial Wire Debug (SWD) interface as part of the Debug Access Port (DAP), in conjunction with the Basic Branch Buffer (BBB). This offers a flexible and powerful mechanism for non-intrusive program code debugging. Developers can easily add breakpoints in the code and perform single-step debugging.

Pin No.	Pin Name	IO PADS	SWD
19	P1_1	GPIO [9]	Default as SWDCLK
20	P1_0	GPIO [8]	Default as SWDIO

6.14 Direct Memory Access Controller (DMA)

The DMA Features:

- 6 DMA Channels
- Independent interrupts and control bit for every channel
- 4 transfer mode: Memory to memory, memory to peripheral, peripheral to memory, peripheral to peripheral
- Max block length 4095
- Multi-block supported (Channel 0 & 2)
- Scatter-gather supported (Channel 1 & 3)
- Safe abort/abnormal abort/suspend transfer
- Transferred items counter (single block)
- Hardware handshake interface for peripheral

7. Mounting Design Suggestions

7.1 Recommended Mounting and PCB Layout

You can refer to the following references for the mounting design and PCB layout of the MK15 module, especially for the MK15A model which has PCB on-board antenna.

For external antenna modules (MK15B 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 MK15 series module close to the edge of the host PCB (mandatory for MK15A 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 be 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.

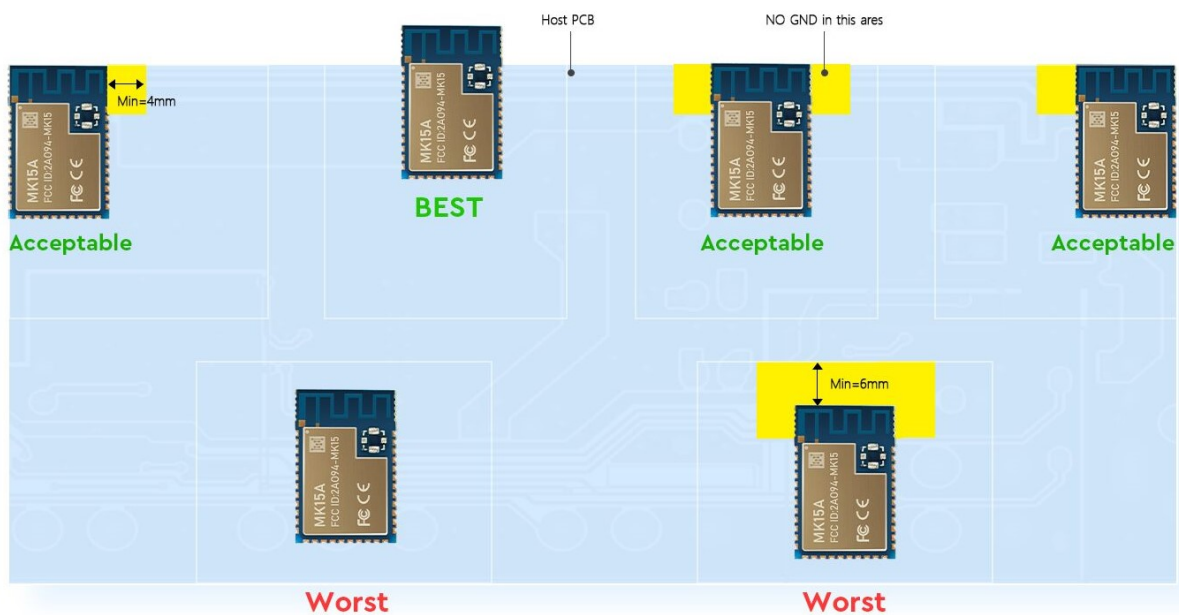


Figure 9: Recommended Module Mounting Examples



7.2 Mechanical Enclosure

Care should be taken when designing and placing the MK15 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 MK15 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).

8. Cautions

8.1 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, ③reflow, 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.

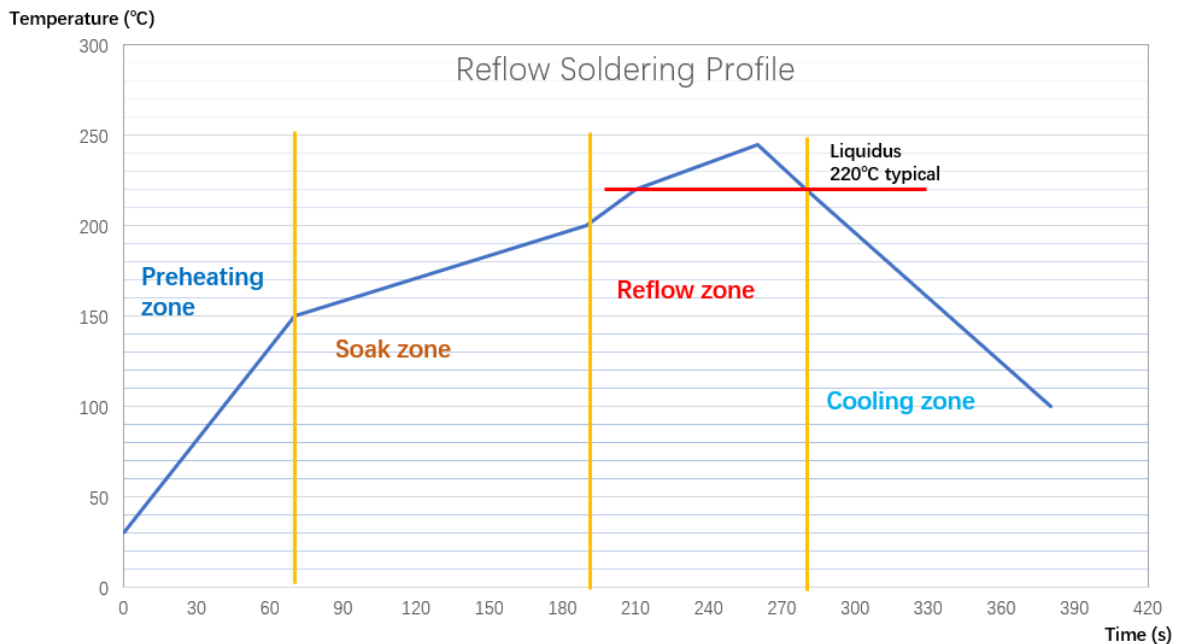


Figure 10: Temperature-Time Profile for Reflow Soldering

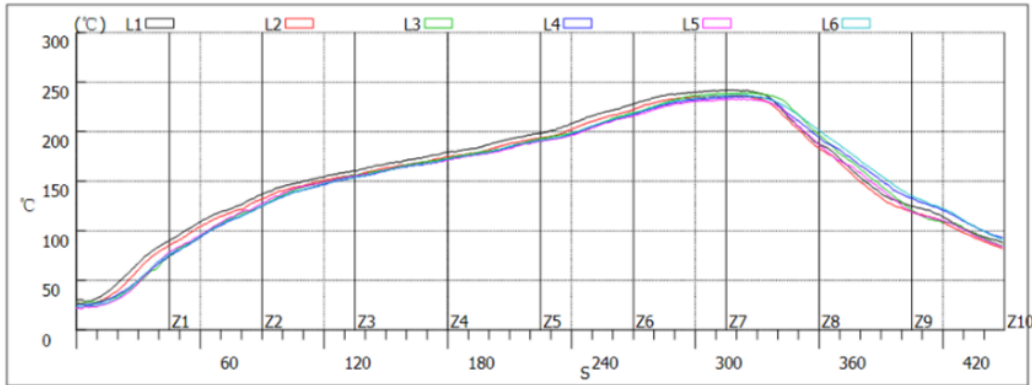
Specification	Value
Temperature Increase Rate	<2.5°C/s
Temperature Decrease Rate	Free air cooling
Preheat Temperature	0-150°C
Preheat Period (Typical)	40-90s
Soak Temp Increase Rate	0.4-1°C/s
Soak Temperature	150-200°C
Soak Period	60-120s
Liquidus Temperature (SAC305)	220°C
Time Above Liquidous	45-90s
Reflow Temperature	230-250°C
Absolute Peak Temperature	260°C

PROFILE CHECK

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

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(°C)	Peak difference	Peak at time(s)	Preheat(50-150°C)		Soak(150-200°C)		Reflow(220-260°C)		Liquid phase (220°C) time(s)	Cooling(260-100°C)		
				190(°C)time above	Slope	Time(s)	Slope	Time(s)	Slope		Time(s)	Slope	Time(s)
Line1	242.25	9.25	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		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 11: Example of MOKO Smart SMT reflow soldering

8.2 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.

8.3 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.


Revision History

Version	Comments	Contributor(s)	Revision Date
V1.0	Initial Release	Kevin Huang	2021/04/16
V1.1	Modify some descriptions of GPIO	Kevin Huang	2021/04/21
V1.2	Modify some descriptions of UART	Kevin Huang	2021/04/28

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.mokoblue.com> to get more related information if needed.

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