MDM01

Hardware Design

Version: V1.0

Date: 2024-03-27

Status: Released

Important Notice

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Caution

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the 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.

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 Label Instructions
If using a permanently affixed label, the modular transmitter must be labeled with its own FCC identification number, and, if the FCC identification number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: "Contains FCC ID: 2AKAF-MDM01".
Any similar wording that expresses the same meaning may be used. The Grantee may either provide such a label, an example of which must be included in the application for equipment authorization, or, must provide adequate instructions along with the module which explain this requirement.

OEM Guidance

• **Applicable FCC rules**
This device complies with part 22H/24E/27 of the FCC Rules.

• **The specific operational use conditions**
This module can be used in IoT devices. The input voltage to the module is nominally 3.8V DC. The operational ambient temperature of the module is -35°C~75°C. the external antenna is allowed, such as rod antenna.

• **Limited module procedures**
N/A

• **Trace antenna designs**
N/A

• **RF exposure considerations**
The equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator and your body. If the equipment built into a host as a portable usage, the additional RF exposure evaluation may be required as specified by 2.1093.

• **Antennas**
To meet RF exposure & ERP/ERIP, the maximum net gains of antennas allowed are 8.0 dBi @ FDD (Band 2), 5.0 dBi @ FDD (Band 4) , 9.41 dBi @ FDD (Band 5), 8.69 dBi @ FDD (Band 12) , 8.7 dBi @ FDD (Band 17), 5 dBi @ FDD (Band 66).The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

Label and compliance information
An exterior label on OEM's end product can use wording such as the following: "Contains Transmitter Module FCC ID: 2AKAF-MDM01" or "Contains FCC ID: 2AKAF-MDM01"

• **Information on test modes and additional testing requirements**
The modular transmitter has been fully tested by the module grantee on the required number of channels, modulation types, and modes, it should not be necessary for the host installer to re-test all the available transmitter modes or settings. It is recommended that the host product manufacturer, installing the modular transmitter, perform some investigative measurements to confirm that the resulting composite system does not exceed the spurious emissions limits or band edge limits (e.g., where a different antenna may be causing additional emissions).
The testing should check for emissions that may occur due to the intermixing of emissions with the other transmitters, digital circuitry, or due to physical properties of the host product (enclosure). This investigation is especially important when integrating multiple modular transmitters where the certification is based on testing each of them in a stand-alone configuration. It is important to note that host product manufacturers should not assume that because the modular transmitter is certified that they do not have any responsibility for final product compliance.
If the investigation indicates a compliance concern the host product manufacturer is obligated to

mitigate the issue. Host products using a modular transmitter are subject to all the applicable individual technical rules as well as to the general conditions of operation in Sections 15.5, 15.15, and 15.29 to not cause interference. The operator of the host product will be obligated to stop operating the device until the interference have been corrected.
The final host / module combination need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

- **Additional testing, Part 15 Sub part B disclaimer**

The host integrator installing this module into their product must ensure that the final composite product complies with the FCC requirements by a technical assessment or evaluation to the FCC rules, including the transmitter operation and should refer to guidance in KDB 996369. For host products with certified modular transmitter, the frequency range of investigation of the composite system is specified by rule in Sections 15.33(a)(1) through (a)(3), or the range applicable to the digital device, as shown in Section 15.33(b)(1), whichever is the higher frequency range of investigation.
When testing the host product, all the transmitters must be operating. 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 50 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. Testing laboratories may need to add attenuation or filters depending on the signal strength of any active beacons (if applicable) from the enabled radio(s). See ANSI C63.4, ANSI C63.10 and ANSI C63.26 for further general testing details.
The product under test is set into a link/association with a partnering device, as per the normal intended use of the product. To ease testing, the product under test is set to transmit at a high duty cycle, such as by sending a file or streaming some media content.

About the Document

Revision History

Version	Date	Description
V1.0	2024-03-27	– Released –

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1 Introduction

This document defines the MDM01 module and describes its air interface and hardware interface which are connected with your applications.

With this document, you can quickly understand module interface specifications, electrical and mechanical details, as well as other related information of the module. The document, coupled with application notes and user guides, makes it easy to design and set up wireless applications with the module.

1.1 Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating the module. Manufacturers of the cellular terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all manuals of the product. Otherwise, we assumes no liability for customers' failure to comply with these precautions。

	Full attention must be paid to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the cellular terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If there is an Airplane Mode, it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on an aircraft.
	Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.
	Cellular terminals or mobiles operating over radio signal and cellular network cannot be guaranteed to connect in certain conditions, such as when the mobile bill is unpaid or the USIM card is invalid. When emergency help is needed in such conditions, use emergency call if the device supports it. In order to make or receive a call, the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength. In an emergency, the device with emergency call function cannot be used as the only contact method considering network connection cannot be guaranteed under all circumstances.
	The cellular terminal or mobile contains a transceiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV sets, radios, computers or other electric equipment.

In locations with explosive or potentially explosive atmospheres, obey all posted signs and turn off wireless devices such as mobile phone or other cellular terminals. Areas with explosive or potentially explosive atmospheres include fueling areas, below decks on boats, fuel or chemical transfer or storage facilities, and areas where the air contains chemicals or particles such as grain, dust or metal powders.

2 Product Overview

MDM01 is an LTE-FDD wireless communication module, which provides data connectivity on LTE-FDD networks. It also provides voice functionality for your specific applications.

With a compact profile of 21.9 mm × 22.9 mm ×2.3 mm, LCC+LGA package, small and thin appearance, can meet the needs of terminal equipment for small-size module products. The product has the advantages of full Netcom, network optimization, hard encryption, etc., and is the best choice for cloud speakers, public network intercom, PDA phones, tablet computers, mobile POS, smart wearables, shared payment, smart home appliances, smart security, smart agriculture, smart metering and other scenarios.

Table 2-1: Basic Information

MDM01	
Package	LCC+LGA
PINs	100
Dimensions	(21.9±0.15) mm × (22.9±0.15) mm × (2.3±0.2) mm
Weight	Approx. 2.2g
Mode	FDD LTE: Band2, Band4, Band5, Band12, Band17, Band66

2.1 Product Diagram

The following diagram shows the top and bottom views of the MDM01 module， for authentic appearance and label, please refer to the module received.

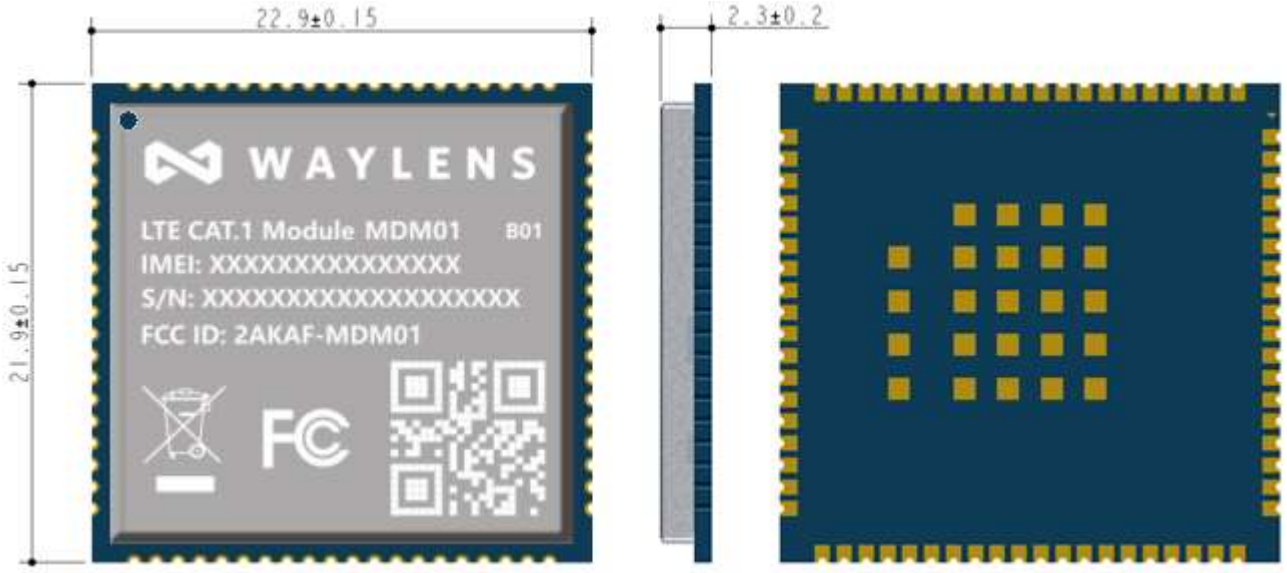


Figure 2-1: Top View and Bottom View of the Module（Unit: mm）

2.2 Key Features

Table 2-2: Key Features of MDM01

Features	Details
Power Supply	● Supply voltage range: 3.4–4.5 V ● Typical supply voltage: 3.8 V
SMS	● Text and PDU modes ● Point-to-point MO and MT ● SMS storage: USIM card
USIM Interface	● Supports 2 external USIM/SIM cards: 1.8/3.0 V ● Support card 2-channel built-in eSIM: 1.8/3.0V
USB Interface	● Compliant with USB 2.0 specification (slave only); with maximum transmission rates up to 480 Mbps ● Used for AT command communication, data transmission, software debugging and firmware upgrade ● Supports USB serial drivers for: Windows 7/8/8.1/10, Linux 2.6-5.14, Android 4.x-11.x, etc.
UART Interfaces	**Main UART:** ● Used for AT command communication and data transmission ● Baud rate: 115200 bps by default ● Supports RTS and CTS hardware flow control **Debug UART:** ● Used for the output of partial logs ● Baud rate: 115200 bps
Audio Features	● Supports one digital audio interface: PCM interface ● Supports one analog audio input and one analog audio output
PCM Interface*	● Used for audio function with external codec
SPI Interface	● Supports only master mode
Camera Interface	● Provides one camera interface supporting cameras up to 0.3 MP; I/O pins only support 1.8 V ● Supports the 2-data-line transmission of SPI
LCD Interface	● Supports LCD display modules with a maximum resolution of 240 x 320 ● Support SPI data transmission such as 4-wire, 1-channel, etc. ● Supports RGB565 format output
Matrix Keypad Interface *	● Supports 5 x 5 matrix keypad
Indications	● NET_STATUS indicates network connectivity status ● STATUS indicates module's operation status
AT Commands	● Compliant with 3GPP TS 27.007, 27.005 and enhanced AT commands
Antenna Interfaces	● Main antenna interface (ANT_MAIN)

	● 50 Ω impedance
Position Fixing	● Supports Wi-Fi Scan
Transmitting Power	● Class 3 (23 dBm ±2 dB) for LTE-FDD bands
LTE Features	● Supports up to Cat.1 FDD ● Supports 1.4/3/5/10/15/20 MHz RF bandwidth ● LTE-FDD: Max. 10 Mbps (DL), Max. 5 Mbps (UL)
Internet Protocol Features	● Supports TCP/UDP/PPP/NTP/NITZ/FTP/HTTP/PING/CMUX/FTPS/SSL/FILE/MQTT protocols ● Supports PAP and CHAP for PPP connections
Operating Temperature	● Operating temperature range: -35 to +75 °C[1] ● Extended temperature range: -40 to +85 °C[2] ● Storage temperature range: -40 to +85 °C
Firmware Upgrade	● Via USB interface or DFOTA

Notes	1. 1) Within operating temperature range, the module meets 3GPP specifications. 2. 2) Within extended temperature range, the module remains the ability to establish and maintain functions such as voice, SMS, data transmission, etc., without any unrecoverable malfunction. Radio spectrum and radio network are not influenced, while one or more specifications, such as Pout, may exceed the specified tolerances of 3GPP. When the temperature returns to the operating temperature range, the module meets 3GPP specifications again.

2.3 Functional Diagram

The following figure shows a block diagram of MDM01 and illustrates the major functional parts.

- **Power management**
- **Baseband**
- **Memory**
- **Radio frequency**
- **Peripheral interfaces**

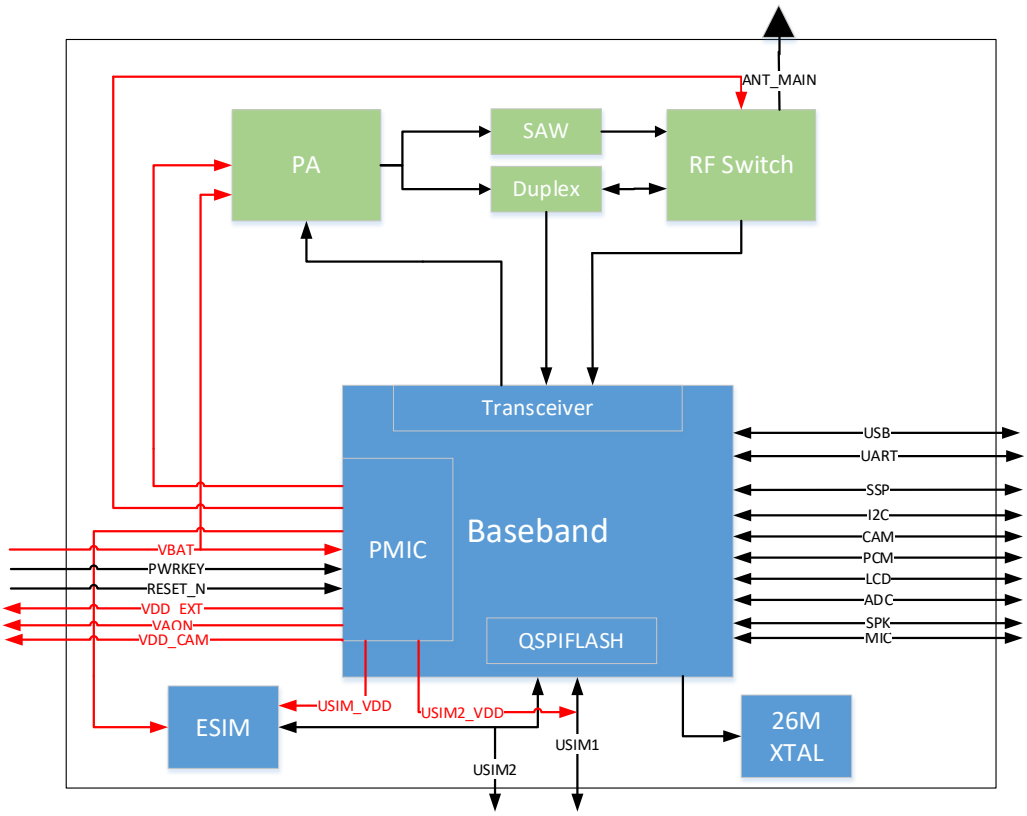


Figure 2-2: Functional Diagram

2.4 Pin Assignment

MDM01 module is equipped with 100 pins, including 76 LCC pins and 24 LGA pins. The following figure shows the pin assignment of MDM01 module.

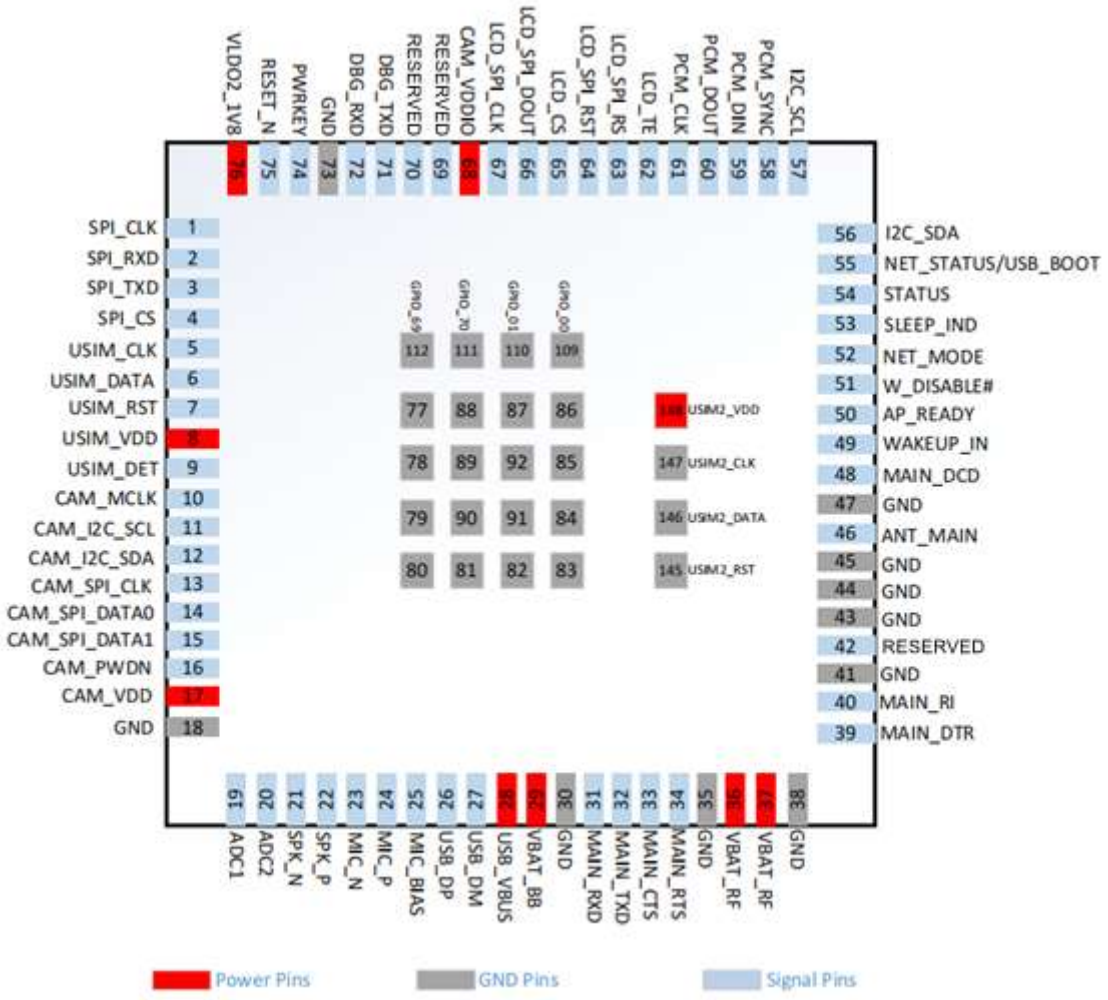


Figure 2-3: MDM01 Pin Assignment (Top View)

2.5 Pin Description

The following tables show the pin definition and description of MDM01 module.

Table 2-3: I/O Parameters Definition

Type	Description
AI	Analog Input
AIO	Analog Input/Output
AO	Analog Output
DI	Digital Input
DIO	Digital Input/Output
DO	Digital Output
OD	Open Drain
PI	Power Input
PO	Power Output

Table 2-4: Pin Description

Power Supply Input					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT_BB	**29**	PI	Power supply for module's baseband part	Vmax = 4.5V Vmin = 3.4V Vnorm =3.8V	It must be provided with sufficient current up to 0.8 A.
VBAT_RF	**36、37**	PI	Power supply for module's RF part	Vmax = 4.5V Vmin = 3.4V Vnorm =3.8V	It must be provided with sufficient current up to 2.0 A.
GND	**18、30、35、38、41、43~45、47、73、77~92**				
Power Supply Output					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VDD_EXT	76	PO	Provide 1.8 V for external circuit	Vnorm = 1.8V I max = 50mA	Power supply for external GPIO's pullup circuits. If unused, keep it open.
Turn on/off					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	**74**	DI	Turn on/off the module	VILmax = 0.5V Vnorm=VBAT_BB	Pull down PWRKEY for a period of time to power on/off.
RESET_N	**75**	DI	Reset the module	VILmax = 0.5V Vnorm = 1.6V	Active Low. If unused, keep it open.
Status Indication					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
NET_MODE	**52**	DO	Indicate the module's network registration mode	1.8V	If unused, keep it open.

SLEEP_IND	**53**	DO	Indicate the module's sleep mode		
STATUS	**54**	DO	Indicate the module's operation status		
NET_STATUS/ USB_BOOT	**55**	DO	Indicates the module's network activity status		Reuse pins, NET_STATUS function after successfully startup. This pin cannot be pulled down to low level before the module is successfully startup if the emergency download mode is not necessary.

USB_BOOT Interface

Pin Name	Pin NO.	I/O	Description	DC Characteristics	Comment
NET_STATUS/ USB_BOOT	**55**	DI	Force the module into emergency download mode	1.8V	Reuse pins, USB_BOOT function when startup. Active low. It is recommended to reserve test points.

USB Interface

Pin Name	Pin NO.	I/O	Description	DC Characteristics	Comment
USB_DP	**26**	AIO	USB differential data (+)	(+)	USB 2.0 compliant. Requires differential impedance of 90 Ω. If unused, keep it open.
USB_DM	**27**	AIO	USB differential data (-)	(-)	
USB_VBUS	**28**	AI	USB connection detect	Vmax = 5.25 V Vmin = 3.0 V Vnom = 5.0 V	If unused, keep it open.

USIM 接口

Pin Name	Pin NO.	I/O	Description	DC Characteristics	Comment
USIM_CLK	**5**	DO	USIM card clock	1.8/3.0V	If unused, keep it open.
USIM_DATA	**6**	DIO	USIM card data		
USIM_RST	**7**	DO	USIM card reset		
USIM_VDD	**8**	PO	USIM card power supply		Either 1.8 V or 3.0 V USIM card is supported and can be identified automatically by the module.
USIM_DET	**9**	DI	USIM card hot-plug detect	1.8V	If unused, keep it open.
USIM2_RST	**145**	DO	USIM2 card reset	1.8/3.0V	If unused, keep it open.
USIM2_DATA	**146**	DIO	USIM2 card data		
USIM2_CLK	**147**	DO	USIM2 card clock		
USIM2_VDD	**148**	PO	USIM2 card power supply		Either 1.8 V or 3.0 V USIM card is supported and can be identified automatically by the module.

Main UART Interface					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
MAIN_RXD	**31**	DI	Main UART receive	1.8V	If unused, keep it open.
MAIN_TXD	**32**	DO	Main UART transmit		
MAIN_CTS	**33**	DO	Main UART clear to send		
MAIN_RTS	**34**	DI	Main UART request to send		
MAIN_DTR	**39**	DI	Main UART data terminal ready		
MAIN_RI	**40**	DO	Main UART ring indication		
MAIN_DCD	**48**	DO	Main UART data carrier detect		
Debug UART Interface					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DBG_TXD	**71**	DO	Debug UART transmit	1.8V	If unused, keep it open.
DBG_RXD	**72**	DI	Debug UART receive		
ADC Interfaces					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ADC1	**19**	AI	General-purpose ADC interface	Voltage range: 0~1.3 V	If unused, keep it open.
ADC2	**20**	AI	General-purpose ADC interface		
I2C Interface					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
I2C_SDA	**56**	OD	I2C serial data	1.8V	Pull each of them up to 1.8 V with an external resistor. If unused, keep it open.
I2C_SCL	**57**	OD	I2C serial clock		
PCM Interface					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PCM_SYNC	**58**	DO	PCM data frame sync	1.8V	If unused, keep it open.
PCM_DIN	**59**	DI	PCM data input		
PCM_DOUT	**60**	DO	PCM data output		
PCM_CLK	**61**	DO	PCM clock		
Analog Audio Interfaces					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
SPK_N	**21**	AO	Analog audio differential output (-)		The interface can drive 32 Ω speaker with power rate at 37 mW. It can also be used to drive external power amplifier devices if the output power rate
SPK_P	**22**	AO	Analog audio differential output (+)		

					cannot meet the demand. If unused, keep it open.
MIC_N	**23**	AI	Microphone analog input (-)		If unused, keep it open.
MIC_P	**24**	AI	Microphone analog input (+)		
MIC_BIAS	**25**	PO	Bias voltage output for microphone		
Camera Interface					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
CAM_MCLK	**10**	DO	Master clock of camera	1.8V	If unused, keep it open.
CAM_I2C_SCL	**11**	OD	I2C clock of camera		
CAM_I2C_SDA	**12**	OD	I2C data of camera		
CAM_SPI_CLK	**13**	DI	SPI clock of camera		
CAM_SPI_DATA0	**14**	DI	SPI data0 of camera		
CAM_SPI_DATA1	**15**	DI	SPI data1 of camera		
CAM_PWDN	**16**	DO	Power down of camera		
CAM_VDD	**17**	PO	Analog power supply of camera	Vnom = 2.8 V	If unused, keep it open.
CAM_VDDIO	**68**	DO	Digital power supply of camera	Vnom = 1.8 V	If unused, keep it open.
LCD interface					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
LCD_TE	**62**	DI	LCD tearing effect	1.8V	If unused, keep it open.
LCD_SPI_RS	**63**	DO	LCD register select		
LCD_SPI_RST	**64**	DO	LCD reset		
LCD_CS	**65**	DO	LCD chip select		
LCD_SPI_DOUT	**66**	DO	LCD data		
LCD_SPI_CLK	**67**	DO	LCD clock		
SPI Interface					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
SPI_CLK	**1**	DO	SPI clock	1.8V	If unused, keep it open.
SPI_RXD	**2**	DI	SPI master mode input		
SPI_TXD	**3**	DO	SPI master mode output		
SPI_CS	**4**	DO	SPI chip select		
Antenna Interface					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_MAIN	**46**	AIO	Main antenna		50Ω impedance.
Other Interfaces					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
WAKEUP_IN	**49**	DI	Wakes up the module	1.8V	If unused, keep it open.
AP_READY	**50**	DI	Application processor ready		If unused, keep it open.

W_DISABLE#	**51**	DI	Airplane mode control		Pull-up by default. In low voltage level, module can enter into airplane mode. If unused, keep it open.

GPIO Interfaces					
Pin Name	**Pin NO.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GPIO_00	**109**	DIO	General-purpose IO	1.8V	If unused, keep it open.
GPIO_01	**110**	DIO	General-purpose IO		
GPIO_70	**111**	DIO	General-purpose IO		
GPIO_69	**112**	DIO	General-purpose IO		

RESERVED PINS		
Pin Name	**Pin NO.**	**Comment**
RESERVED	**42，69，70**	Keep these pins unconnected.

NOTE

- (*) indicates that the function is under development, currently not supported.
- Keep RESERVED pins unconnected.
- Pins USB_BOOT cannot be pulled down before startup.

2.6 EVB

To help you develop applications with the module, we provide an evaluation board, USB to RS-232 converter cable, earphone, antenna and other peripherals to control or test the module.

For more details, see related documents such as SS207_ADP Instructions, SS201_KIT Instructions.

3 Operating Characteristics

3.1 Operating Modes

The following table briefly describes several typical operating modes of the module.

Table 3-1: Overview of Operating Modes

Modes	Details	
Normal Operation	Idle	Software is active. The module remains registered on the network, and it is ready to send and receive data.
	Talk/Data	Network connection is ongoing. In this mode, the power consumption is decided by network setting and data transfer rate.
Minimum Functionality Mode	● AT+CFUN=0 can set the module to a minimum functionality mode without removing the power supply. ● In this case, both RF function and USIM card are invalid.	
Airplane Mode	● AT+CFUN=4 can set the module to airplane mode. ● In this case, RF function is invalid.	
Disable USIM Mode	● AT+CFUN=5 can set the module disable the USIM cards. ● In this case, USIM cards are invalid.	
Sleep Mode	In this mode, the current consumption of the module is reduced to the minimal level. During this mode, the module can still receive paging message, SMS, voice call and TCP/UDP data from the network normally.	
Power Down Mode	In this mode, the module's power supply is cut off by its power management IC. The software is inactive and the serial interfaces are not accessible, while the VBAT pins are still powered	

3.2 Sleep Mode

The module is able to reduce its current consumption to an ultra-low value in the sleep mode. The following chapters describe power saving procedures of the module.

3.2.1 UART Application Scenario

If the host communicates with the module via UART interface, the following preconditions can make the module enter the sleep mode.

- Execute AT+QSCLK=1 to enable sleep mode.
- Drive MAIN_DTR to high level.

The figure illustrates the connection between the module and the host.

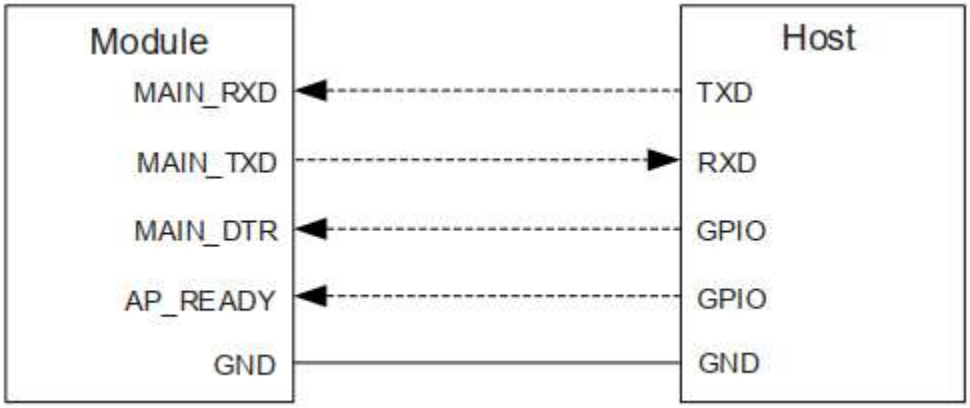


Figure 3-1: Sleep Mode Application via UART

After the module enters sleep mode, it will not respond to AT commands, but URC will report when receiving data/text messages/calls. To wake up the module, the following methods can be used:

- Driving MAIN_DTR low with the host will wake up the module.
- AP_READY pin can indicate whether the host has been wake up.

3.2.2 USB Application Scenario

If the host communicates with the module via USB interface, the following three preconditions can make the module enter the sleep mode.

- Execute AT+QSCLK=1 to enable sleep mode.
- Ensure the MAIN_DTR is held at high level or keep it open.
- Disconnect USB_VBUS.

The following figure shows the connection between the module and the host.

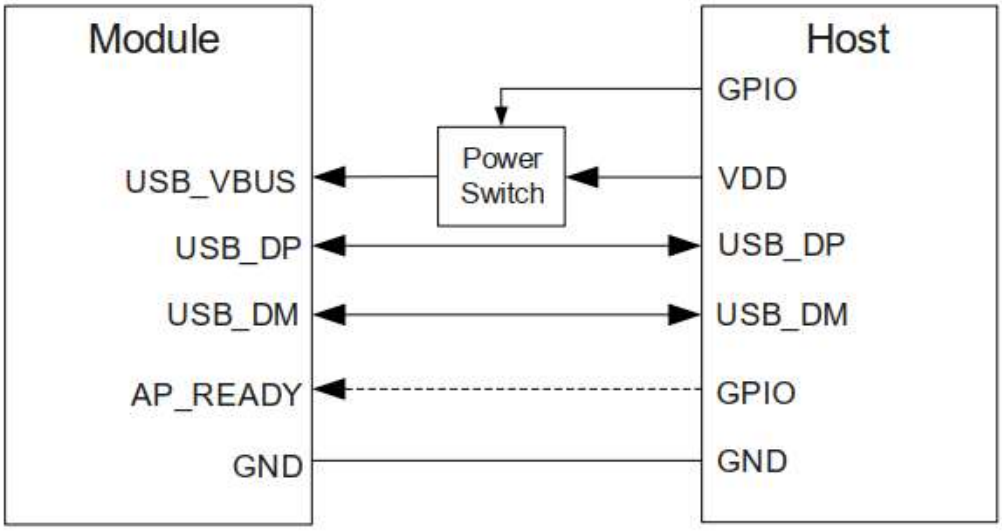


Figure 3-2: Sleep Mode Application via USB

To wake up the module, the following methods can be used:

- Switching on the power switch to supply power to USB_VBUS.
- AP_READY pin can indicate whether the host has been wake up.

3.3 Airplane Mode

When the module enters airplane mode, the RF function will be disabled, and all AT commands related to it will be inaccessible. This mode can be set via the following ways.

- Hardware

The W_DISABLE# is pulled up by default. Driving it low will set the module into airplane mode.

- Software

AT+CFUN=<fun> provides choices of the functionality level through setting <fun> into 0, 1, 4 or 5.

Table 3-2: AT+CFUN Parameter Description

Parameter	Value	details
<fun>	0	Minimum functionality mode (disable RF function and USIM function)
	1	Full functionality mode (default)
	4	Airplane mode (disable RF function).
	5	Disable USIM function

3.4 Power Supply

3.4.1 Power Supply Pins

The power supply pins of the module are used to connect an external power, supplying power to the RF and baseband circuits of the module. VBAT_RF pins are for RF part, VBAT_BB pins are for baseband part.

MDM01 module provides a VDD_EXT output pin, which can provide a voltage of 1.8V. Its maximum output current is 50mA.

The following table shows the pin definition of Power and GND.

Table 3-3: Pin Definition of Power Supply

Pin NO.	Pin Name	I/O	Description	Min.	Typ.	Max.	Unit
36、37	**VBAT_RF**	PI	Power supply for module's RF part	3.4	3.8	4.5	V
29	**VBAT_BB**	PI	Power supply for module's baseband part	3.4	3.8	4.5	V
76	**VDD_EXT**	PO	Provide 1.8 V for external circuit		1.8		V
18、30、35、38、43~45、47、73、77~92	**GND**		Ground	-	0	-	V

3.4.2 Reference Design for Power Supply

The power supply range of MDM01 module is from 3.4 V to 4.5 V. Make sure the input voltage never drops below 3.4 V. To decrease the voltage drop, use bypass capacitors of about 100 μF with low ESR (ESR = 0.7 Ω) and reserve a multi-layer ceramic chip (MLCC) capacitor array due to their ultra-low ESR. It is recommended to use three ceramic capacitors (100 nF, 33 pF, 10 pF) for composing the MLCC array, and place these capacitors close to the VBAT_BB and VBAT_RF pins. When the external power supply is connected to the module, VBAT_BB and VBAT_RF need to be routed in star structure. The width of the VBAT_RF trace should not be less than 2 mm. In principle, the longer the VBAT trace is, the wider it should be.

In addition, in order to ensure the stability of power source, it is suggested that a TVS diode of which reverse stand-off voltage is 4.7 V and peak pulse power is up to 2550 W should be used.

The following figure shows the star structure of the power supply.

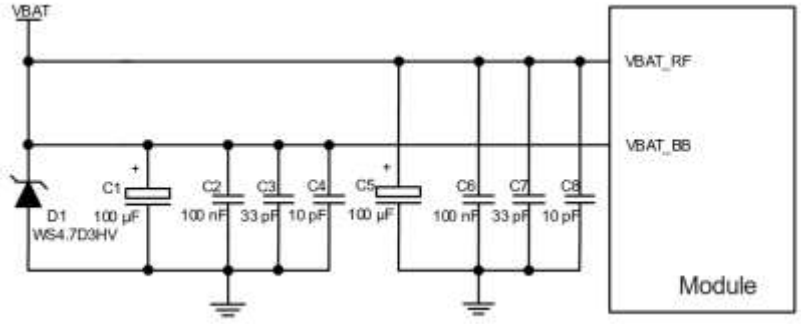


Figure 3-3: Star Structure of the Power Supply

3.4.3 VDD_EXT

MDM01 module provides a VDD_EXT output pin, which can provide a voltage of 1.8V. Its maximum output current is 50mA.

After powering on, VDD_EXT automatically turns on, and still on when in sleep mode. If an external circuit is connected, it will affect the power consumption of the module in sleep mode.

It is recommended that VDD_EXT is only used for external GPIO's pull-up circuits or IO voltage-level shift circuits, and should not be used for other purposes. A TVS diode should be added when using it.

3.5 Turn On

Table 3-4: Pin Definition of PWRKEY

Pin NO.	Pin Name	I/O	Description	Comment
74	**PWRKEY**	DI	Turn on/off the module	Pull down PWRKEY for a period of time to power on/off.

When the module is in power down mode, you can turn it on to normal mode by driving the PWRKEY pin low for at least 500 ms. It is recommended to use an open drain/collector driver to control the PWRKEY.A simple reference circuit is illustrated in the following figure.

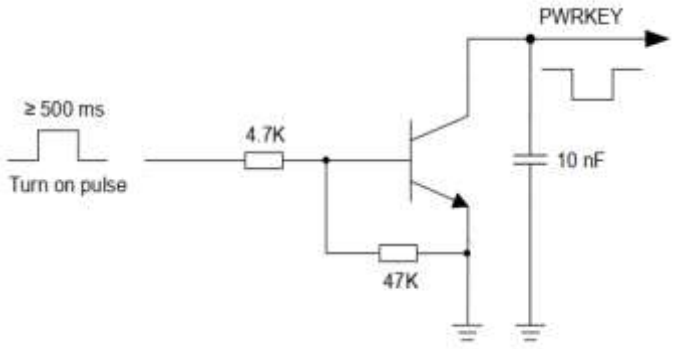


Figure 3-4: Turing on the Module Using Driving Circuit

Another way to control the PWRKEY pin is using a button directly, a TVS component is indispensable to be placed nearby the button for ESD protection. A reference circuit is shown in the following figure.

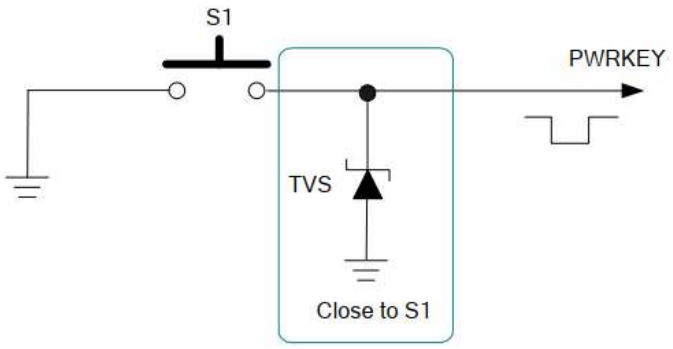


Figure 3-5: Turing on the Module Using Button

PWRKEY can be pulled down directly to GND with a recommended 4.7 kΩ resistor if the module needs to be powered on automatically and shutdown is not needed.

The power-up scenario is illustrated in the following figure.

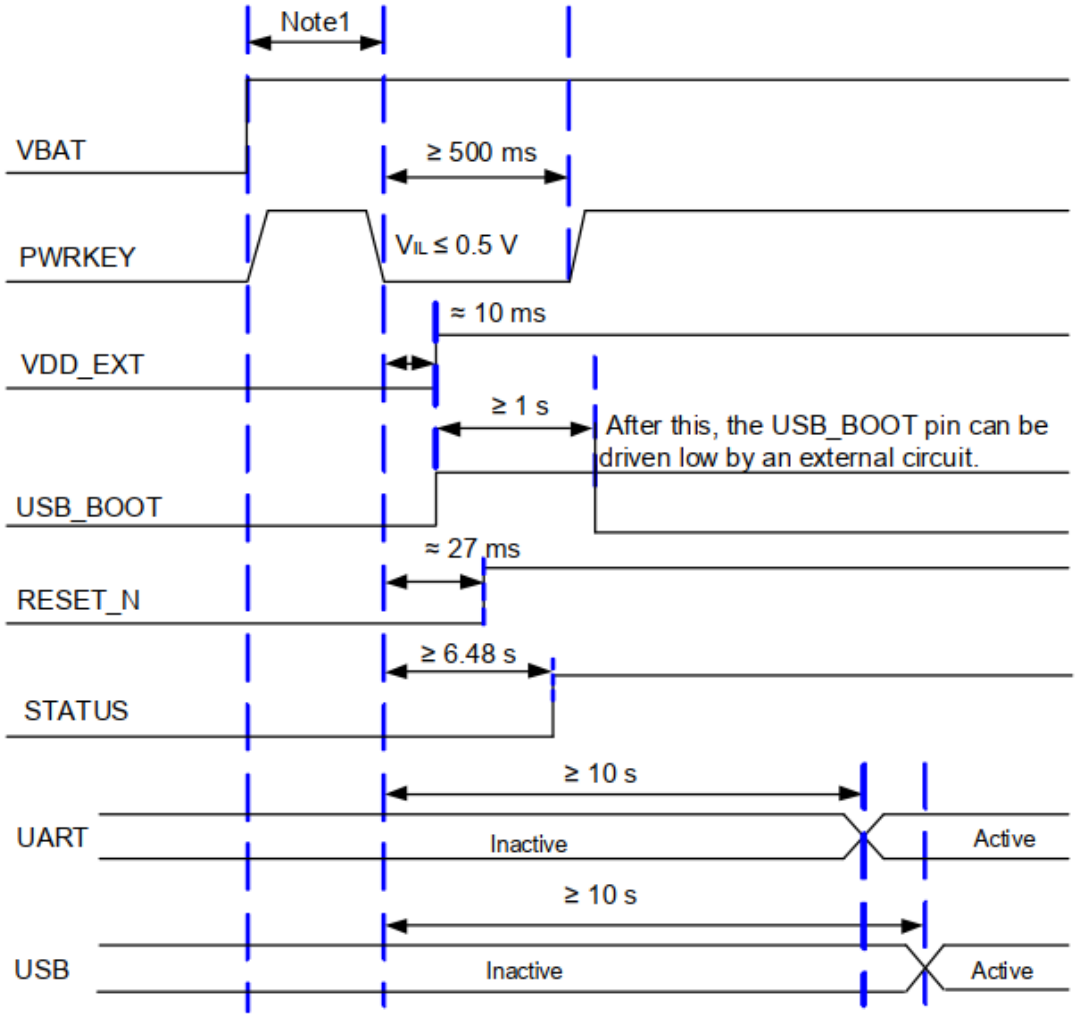


Figure 3-6: Power-up Timing

- Make sure that VBAT is stable before pulling down PWRKEY pin. It is recommended that the time difference between powering up VBAT and pulling down PWRKEY pin is no less than 30 ms.

NOTE

- NET_STATUS/USB0OOT is a USB_BOOT reuse pin. This pin cannot be pulled down to low level before the module is successfully startup if the emergency download mode is not necessary. When pull down USB_BOOT to GND before start-up, the module will enter emergency download mode.

3.6 Turn Off

The following procedures can be used to turn off the module normally.

3.6.1 Turn off with PWRKEY

Drive the PWRKEY pin low for at least 650 ms, then the module will execute power-down procedure after the PWRKEY is released. The power-down scenario is illustrated in the following figure.

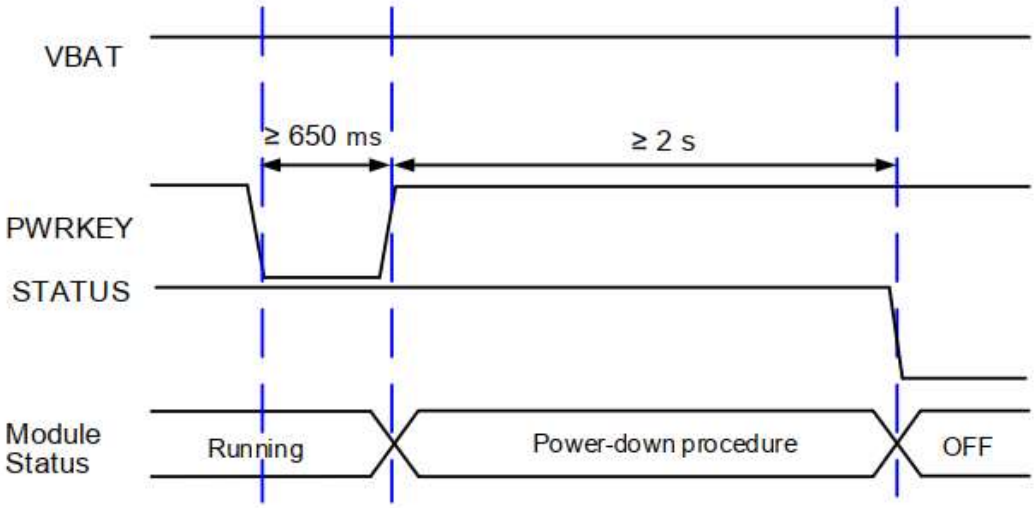


Figure 3-7: Power-down Timing

3.6.2 Turn off with AT Command

It is safe to use AT+QPOWD to turn off the module, which is equal to turn off the module via PWRKEY pin

NOTE

- To avoid corrupting the data in the internal flash, do not switch off the power supply when the module works normally. Only after turning off the module with PWRKEY or AT command can you cut off the power supply.
- When turning off module with AT command, keep PWRKEY at a high level after the execution of turn-off command. Otherwise, the module will be turned on again after being turned off.

3.7 Reset

The RESET_N pin can be used to reset the module. You can reset the module by driving RESET_N low for at least 300 ms and then releasing it.

Table 3-5: Pin Definition of RESET

Pin NO.	Pin Name	I/O	Description	Comment
75	RESET_N	DI	Reset the module	Active low. If unused, keep it open.

The recommended circuit is equal to the PWRKEY control circuit. An open drain/collector driver or button can be used to control the RESET_N.

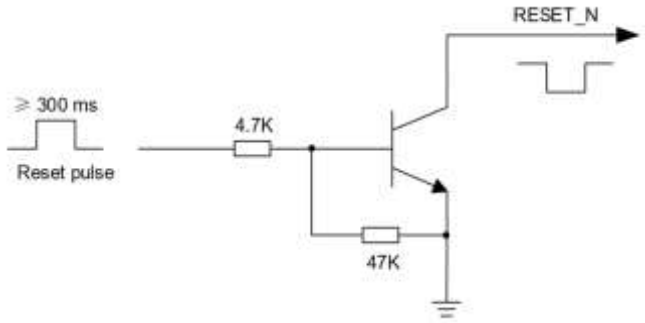


Figure 3-8: Reference Circuit of RESET_N by Using Driving Circuit

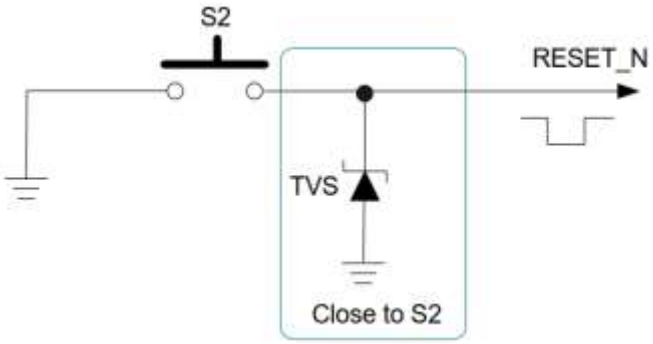


Figure 3-9: Reference Circuit of RESET_N with Button

The reset scenario is illustrated in the following figure.

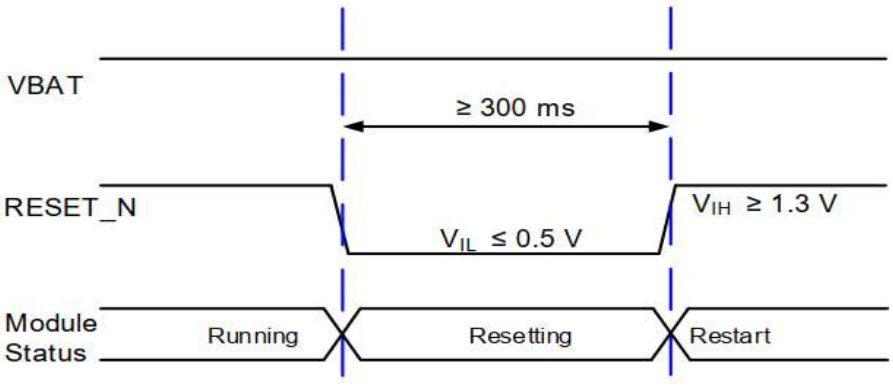


Figure 3-10: Reset Timing

4 Application Interfaces

The following interfaces are described in detail in subsequent chapters:

- **USB interface**
- **USB_BOOT interface**
- **USIM interfaces**
- **UART interfaces**
- **Analog audio interfaces**
- **PCM interface**
- **I2C interface**
- **Camera interface**
- **LCD interface**
- **SPI interface**
- **Matrix keypad interface***
- **ADC interfaces**
- **Status indication**
- **GPIO interface**

4.1 USB Interface

MDM01provides one integrated Universal Serial Bus (USB) interface which complies with the USB 2.0 specification and supports full-speed (12 Mbps) and high-speed (480 Mbps) modes. The USB interface can only serve in the slave mode. It is used for AT command communication, data transmission, software debugging and firmware upgrade.

The following table shows the pin definition of USB interface.

Table 4-1: Pin Definition of USB Interface

Pin NO.	Pin Name	I/O	Description	Comment
28	**USB_VBUS**	AI	USB connection detect	Typical: 5.0 V. If unused, keep it open.
26	**USB_DP**	AIO	USB differential data (+)	Requires differential impedance of 90 Ω. If unused, keep it open.
27	**USB_DM**	AIO	USB differential data (-)	Requires differential impedance of 90 Ω. If unused, keep it open.

It is recommended to reserve test points for debugging and firmware upgrading in your designs. The following figure shows a reference circuit of USB interface.

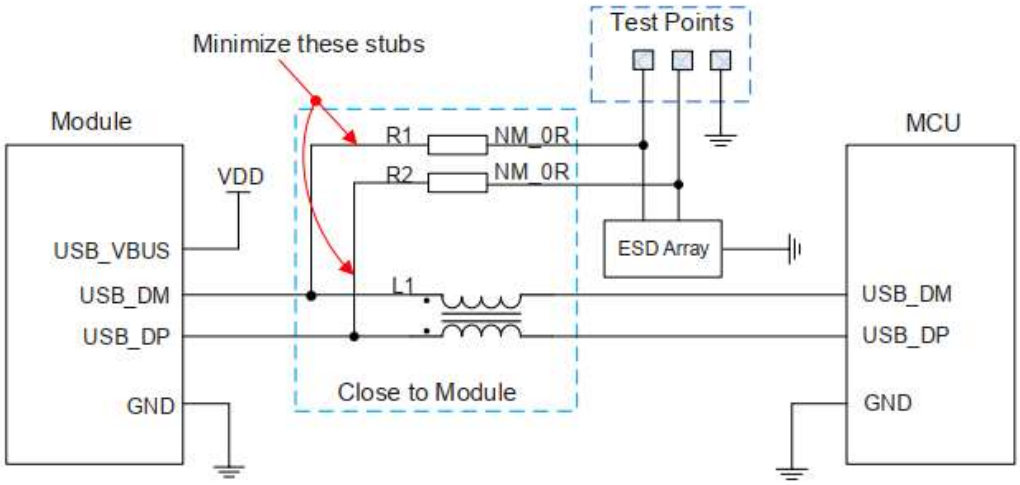


Figure 4-1: Reference Circuit of USB Application

A common mode choke L1 is recommended to be added in series between the module and MCU to suppress EMI spurious transmission. Meanwhile, the 0 Ω resistors (R1 and R2) should be added in series between the module and the test points to facilitate debugging, and the resistors are not mounted by default. To ensure the signal integrity of USB data lines, L1, R1 and R2 must be placed close to the module, and resistors R1 and R2 should be placed close to each other. Keep the extra stubs of trace as short as possible.

NOTE	The following principles should be complied with when designing the USB interface, to meet USB Specifications.

- It is important to route the USB signal traces as differential pairs with ground surrounded. The impedance of USB differential traces is 90 Ω.
- Do not route signal traces under crystals, oscillators, magnetic devices, PCIe and RF signal traces. It is important to route the USB differential traces at inner-layer of the PCB, and surround the traces with ground on that layer and with ground planes above and below.
- Pay attention to the selection of the ESD component on the USB data line. Its parasitic capacitance should not exceed 2 pF and should be placed as close as possible to the USB interface.

4.2 USB_BOOT Interface

MDM01 module provides a USB_BOOT pin. You can pull down NET_STATUS/USB_BOOT to GND before start-up, and the module will enter emergency download mode when it is powered on. In this mode, the module supports firmware upgrade over USB interface.

Table 4-2: Pin Definition of USB_BOOT Interface

Pin NO.	Pin Name	I/O	Description	Comment
55	**NET_STATUS/ USB_BOOT**	DI	Control pin for the module to enter download mode	Reuse pins, USB_BOOT function when startup. Active low. It is recommended to reserve test points.

The following figure shows a reference circuit of NET_STATUS/USB_BOOT interface.

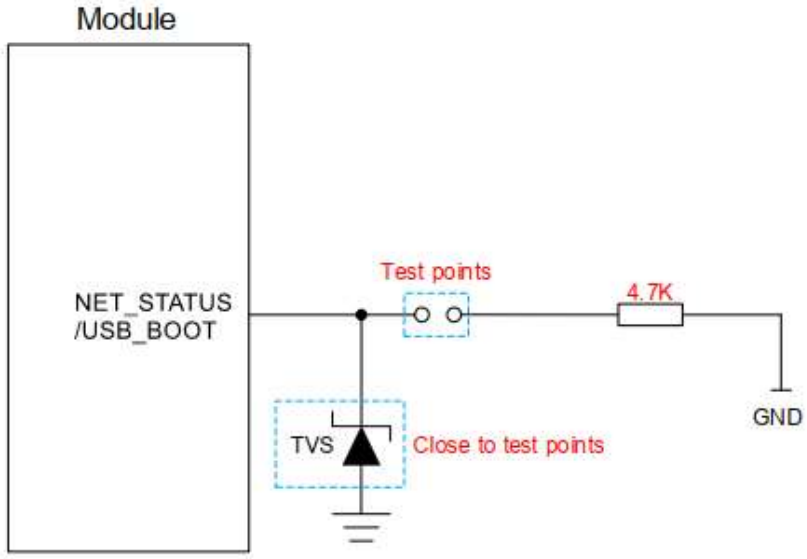


Figure 4-2: Reference Circuit of USB_BOOT Interface

The following figures show a timing sequence for entering emergency download mode of USB_BOOT interface.

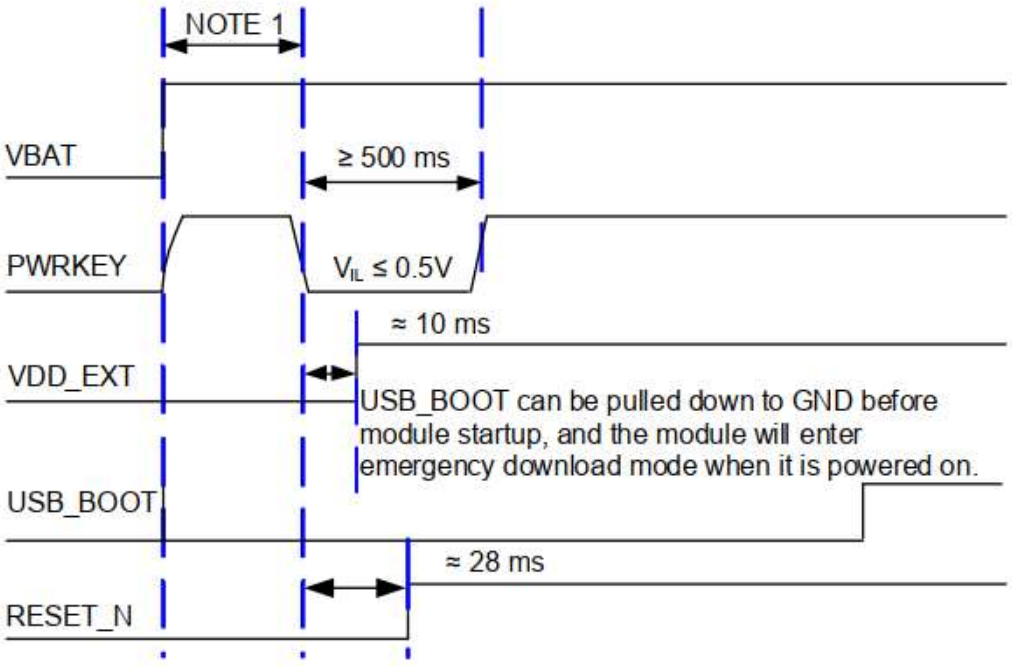


Figure 4-3: Timing Sequence for Entering Emergency Download Mode

NOTE

- Make sure that VBAT is stable before pulling down PWRKEY pin. It is recommended that the time between powering up VBAT and pulling down PWRKEY pin is no less than 30 ms.
- When using MCU to control module to enter the emergency download mode, please follow the above timing sequence. Directly connect the test points as shown in Figure 4-2 can manually force the module to enter download mode.

4.3 USIM Interfaces

MDM01 module provides two USIM interfaces, Optional built-in 3 * 3 mm eSIM chip. The USIM interface circuitry meets ETSI and IMT-2000 requirements. Either 1.8 V or 3.0 V USIM card is supported.

Table 4-3: Pin Definition of USIM Interfaces

Pin NO.	Pin Name	I/O	Description	Comment
8	**USIM_VDD**	PO	USIM card power supply	Either 1.8 V or 3.0 V USIM card is supported and can be identified automatically by the module.
7	**USIM_RST**	DO	USIM card reset	
6	**USIM_DATA**	IO	USIM card data	Need to pull up a 4.7K Ω resistor to the USIM_VDD power supply.
5	**USIM_CLK**	DO	USIM card clock	
9	**USIM_DET**	DI	USIM card hot-plug detect	1.8 V power domain. If unused, keep it open.
148	**USIM2_VDD**	PO	USIM2 card power supply	Either 1.8 V or 3.0 V USIM card is supported and can be identified automatically by the module.
147	**USIM2_RST**	DO	USIM2 card reset	
146	**USIM2_DATA**	IO	USIM2 card data	
145	**USIM2_CLK**	DO	USIM2 card clock	

The built-in eSIM chip uses the USIM2 interface. When using the built-in eSIM, the external USIM2 interface cannot be used.

MDM01 supports USIM card hot-plug via the USIM_DET pin, and both high- and low-level detection are supported. The function is disabled by default, and see AT+QSIMDET in document [1] for more details.

The following figure shows a reference design for USIM card interface.

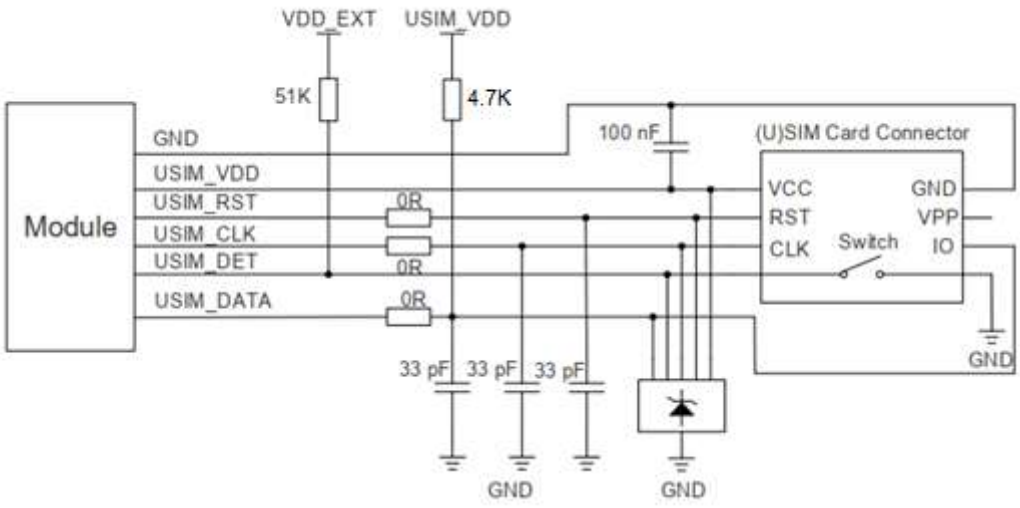


Figure 4-4: Reference Circuit of USIM Interface

If the function of USIM card hot-plug is not needed, please keep USIM_DET disconnected. Only USIM1 interface supports USIM card hot-plug, USIM2 interface not support.

NOTE

To enhance the reliability and availability of the USIM card in application, follow the criteria below in USIM circuit design.

- Ensure the USIM_VDD has a bypass capacitor less than 1 μF, and the capacitor should be close to the USIM card connector
- To offer good ESD protection, add a TVS diode array of which the parasitic capacitance should be less than 15 pF. Add 0 Ω resistors in series between the module and the USIM card to facilitate debugging. The 33 pF capacitors in parallel on USIM_DATA, USIM_CLK and USIM_RST lines are used for filtering interference of EGSM900. Additionally, keep the USIM peripheral circuit close to the USIM card connector.
- The pull-up resistor on USIM_DATA can improve anti-jamming capability of the USIM card. If the USIM card traces are too long, or the interference source is relatively close, it is recommended to add a pull-up resistor near the USIM card connector.
- Place the USIM card connector as close to the module as possible. Keep the trace length as short as possible, at most 200 mm.
- Keep USIM card signals away from RF and VBAT traces.
- To avoid cross-talk between USIM_DATA and USIM_CLK, keep them away from each other and shield them with surrounded ground
- Ensure the ground between the module and the USIM card connector short and wide. Keep the trace width of ground and USIM_VDD no less than 0.5 mm to maintain the same electric potential.

4.4 UART Interfaces

MDM01 provides two UART interfaces and the following shows their features:

Table 4-4: UART Information

UART Types	Supported Baud Rates（bps）	Default Baud Rates（bps）	Functions
Main UART interface	300、1200、4800、9600、14400、19200、28800、38400、56000、57600、115200、128000、230400、460800、921600、1000000、1125000、1800000	115200	1. Data transmission and AT command communication. 2、supports RTS and CTS hardware flow control.
Debug UART Interface	115200	115200	log output

Pin definition of the UART interfaces is here as follows:

Table 4-5: Pin Definition of UART Interface

UART Types	Pin Name	PIN NO.	IO	Description
Main UART interface	**MAIN_RXD**	31	DI	Main UART receive
	MAIN_TXD	32	DO	Main UART transmit
	MAIN_CTS	33	DI	Main UART clear to send
	MAIN_RTS	34	DO	Main UART request to send
	MAIN_DTR	39	DO	Main UART data terminal ready
	MAIN_RI	40	DO	Main UART ring indication
	MAIN_DCD	48	DO	Main UART data carrier detects
Debug UART Interface	**DBG_TXD**	71	DO	Debug UART transmit
	DBG_RXD	72	DI	Debug UART receive

The MDM01 module provides a 1.8 V UART interface. Use a level shifter if the application is equipped with a 3.3 V UART interface. A level shifter TXS0108EPWR provided by Texas Instruments is recommended. The following figure shows a reference design.

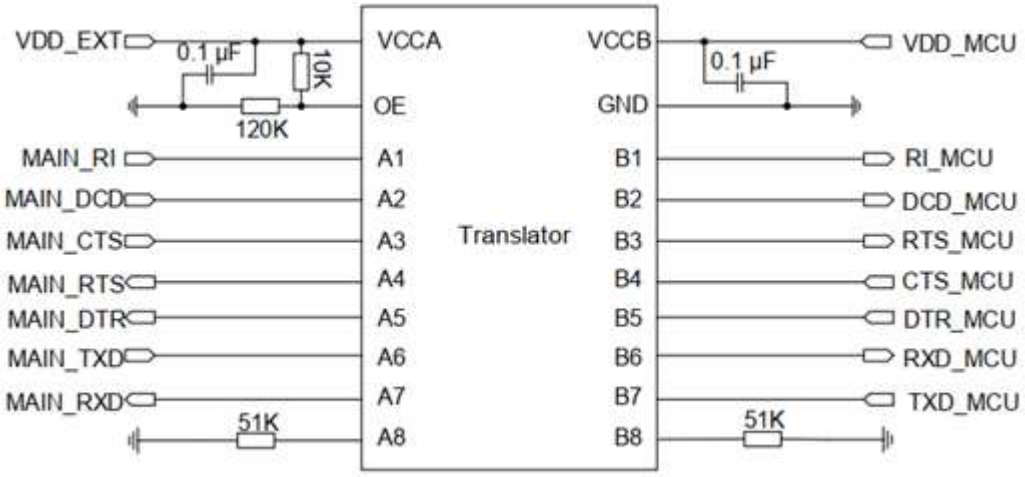


Figure 4-5: Reference Circuit with Translator Chip

Another example with transistor circuit is shown as below. For the design of circuits shown in dotted lines, see that shown in solid lines, but pay attention to the direction of connection.

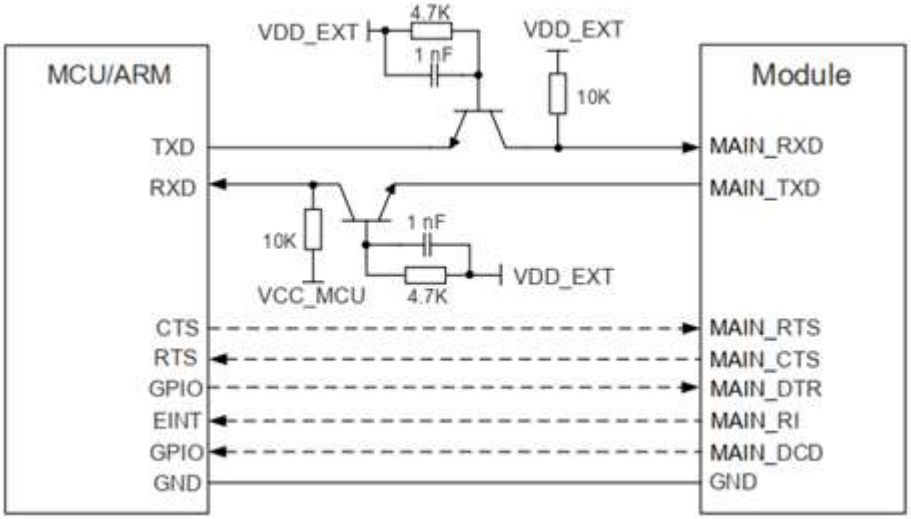


Figure 4-6: Reference Circuit with Transistor Circuit

NOTE

- Transistor circuit solution is not suitable for applications with baud rates exceeding 460 kbps.
- Please note that the module CTS is connected to the host RTS, and the module RTS is connected to the host CTS.

4.5 Analog Audio Interfaces

The MDM01 module provides one analog input channel and one analog output channel. The pin definitions are shown in the following table.

Table 4-6: Pin Definition of Audio Interfaces

Pin NO.	Pin Name	I/O	Description	Comment
21	**SPK_N**	AO	Analog audio differential output (-)	The interface can drive 32 Ω speaker with power rate at 37 mW. It can also be used to drive external power amplifier devices if the output power rate cannot meet the demand. If unused, keep it open.
22	**SPK_P**	AO	Analog audio differential output (+)	
23	**MIC_N**	AI	Microphone analog input (-)	If unused, keep it open.
24	**MIC_P**	AI	Microphone analog input (+)	
25	**MIC_BIAS**	PO	Bias voltage output for microphone	

AI channels are differential input channels, which can be applied to microphone input (usually an electret microphone is used).

AO channels are differential output channels, which can be used in receiver or loudspeaker (with an external audio power amplifier) output. This channel can support both voice output and ringtones.

You can use the AT+QMIC command to adjust the input gain of the microphone, or AT+CLVL command to adjust the volume gain output to the handset. The AT+QSIDET command is used to set the side tone gain. For details, please see document [2].

4.5.1 Audio Interfaces Design Considerations

It is recommended to use the electret microphone with dual built-in capacitors (e.g., 10 pF and 33 pF) for filtering out RF interference, thus reducing TDD noise. The 33pF capacitor is applied for filtering out RF interference when the module is transmitting at EGSM900. Without placing this capacitor, TDD noise could be heard. The 10pF capacitor here is used for filtering out RF interference at DCS1800. Note that the resonant frequency point of a capacitor largely depends on the material and production technique. Therefore, you would have to discuss with your capacitor vendors to choose the most suitable capacitor for filtering out high-frequency noises.

The filter capacitors on the PCB board should be placed as close to the audio devices or audio interfaces as possible, and the traces should be as short as possible. They should go through the filter capacitors before arriving at other connection points.

To reduce radio or other signal interference, RF antennas should be placed away from audio interfaces and audio traces. Power traces should not be parallel with and also should be far away from the audio traces.

The differential audio traces must be routed according to the differential signal layout rule.

4.5.2 Microphone Interface Design

The microphone channel reference circuit is shown in the following figure.

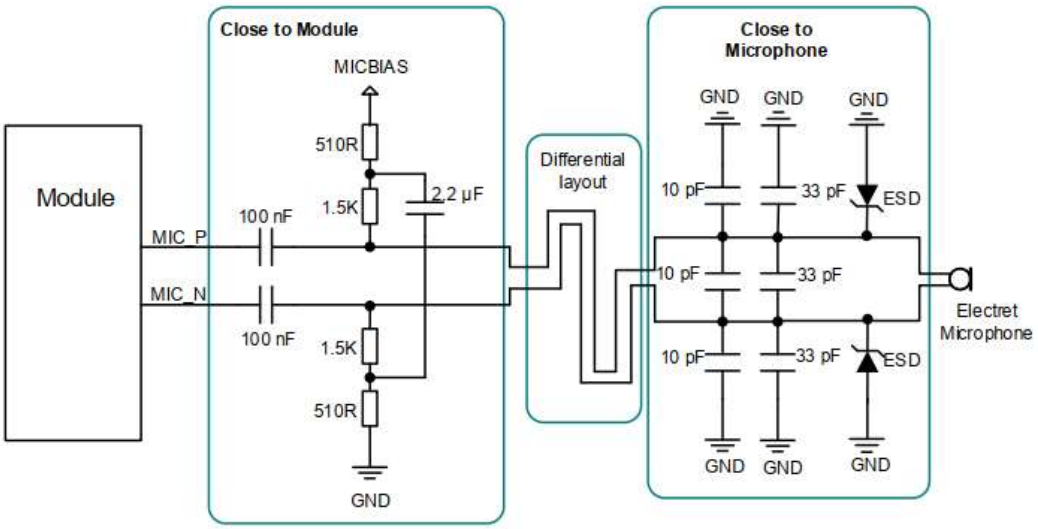


Figure 4-7: Reference Design for Microphone Interface

4.5.3 Loudspeaker Interface Design

The loudspeaker interface reference circuit is shown in the following figure.

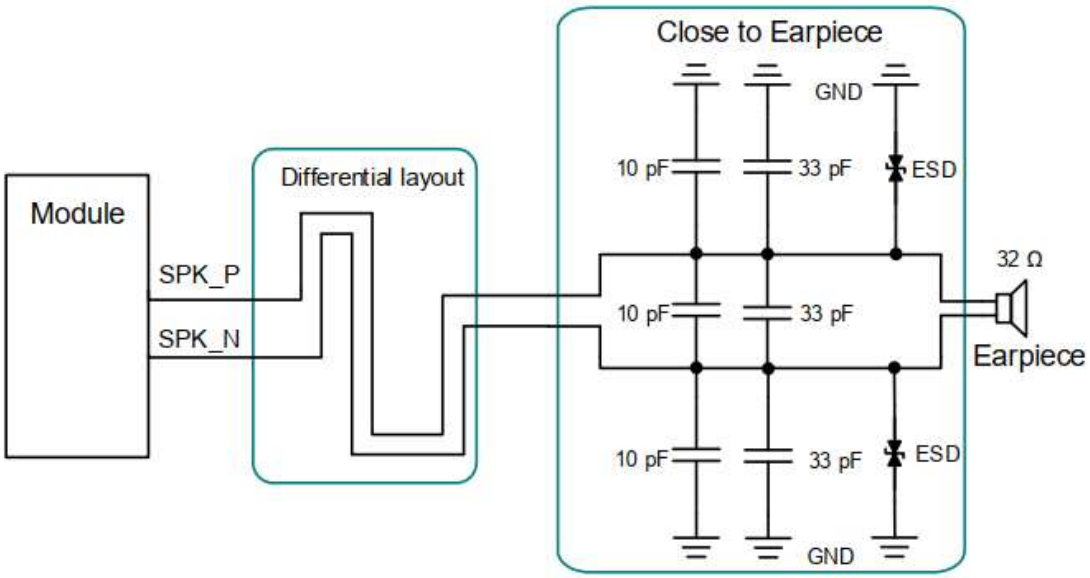


Figure 4-8: Reference Design for Loudspeaker Interface

The loudspeaker interface reference circuit with the audio amplifier (external) Output is shown in the following figure.

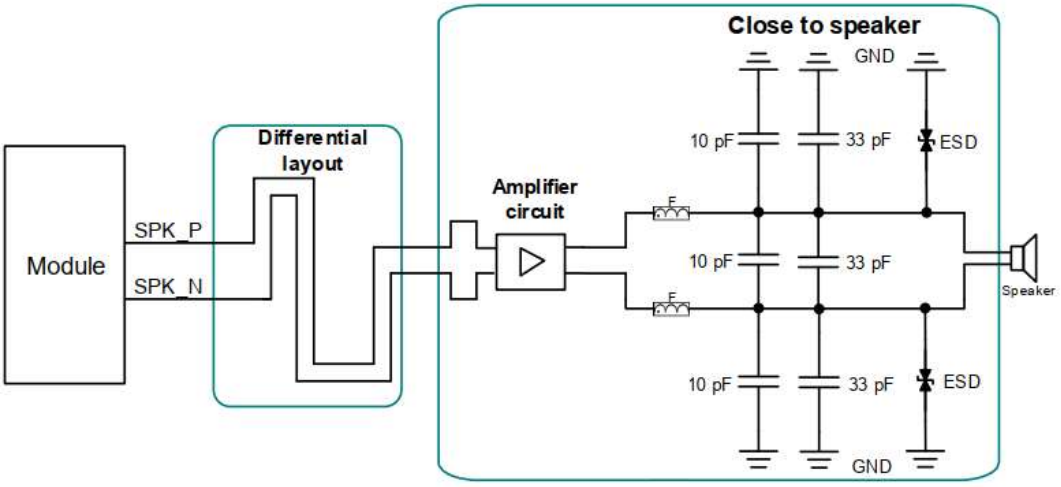


Figure 4-9: Reference Circuit of Audio Amplifier (external) Output

4.6 PCM Interface*

The MDM01 module provides one pulse code modulation (PCM) interface for an external codec IC.

Table 4-7: Pin Definition of PCM Interface

Pin NO.	Pin Name	I/O	Description	Comment
58	**PCM_SYNC**	DO	PCM data frame sync	1.8 V power domain. If unused, keep it open.
59	**PCM_DIN**	DI	PCM data input	
60	**PCM_DOUT**	DO	PCM data output	
61	**PCM_CLK**	DO	PCM clock	

NOTE (*) indicates that the function is under development, currently not supported.

4.7 I2C Interface

The MDM01 module provides one I2C interface, which complies with the I2C bus protocol and does not support multi host mode.

Table 4-8: Pin Definition of I2C Interface

Pin NO.	Pin Name	I/O	Description	Comment
56	**I2C_SDA**	OD	I2C serial data	An external 1.8 V pull-up resistor is Required. If unused, keep it open.
57	**I2C_SCL**	OD	I2C serial clock	

The following figure shows a reference design of I2C interface.

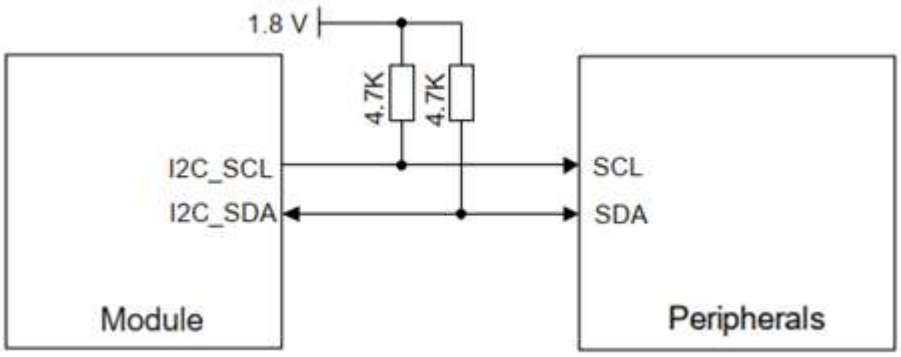


Figure 4-10: Reference Circuit of I2C Application

4.8 Camera Interface

The MDM01 module provides one camera interface supporting camera up to 0.3 MP and the 1-data-line or 2-data-line transmission of SPI.

Table 4-9: Pin Definition of Camera Interface

Pin NO.	Pin Name	I/O	Description	Comment
10	**CAM_MCLK**	DO	Master clock of camera	If unused, keep it open.
11	**CAM_I2C_SCL**	OD	I2C clock of camera	
12	**CAM_I2C_SDA**	OD	I2C data of camera	
13	**CAM_SPI_CLK**	DI	SPI clock of camera	
14	**CAM_SPI_DATA0**	DI	SPI data0 of camera	
15	**CAM_SPI_DATA1**	DI	SPI data1 of camera	
16	**CAM_PWDN**	DO	Power down of camera	
17	**CAM_VDD**	PO	Analog power supply of camera	
68	**CAM_VDDIO**	DO	Digital power supply of camera	

The reference design for CAMERA interface, please see document [3] for more details.

4.9 LCD Interface

The LCD interface of the MDM01 module supports the LCD display with a maximum resolution of 320 × 240, 4-wire 1-channel SPI data transmission, as well as 16-bit RGB565 formats.

Table 4-10: Pin Definition of LCM Interface

Pin NO.	Pin Name	I/O	Description	Comment
62	**LCD_TE**	DI	LCD tearing effect	1.8 V power domain. If unused, keep it open.
63	**LCD_SPI_RS**	DO	LCD register select	
64	**LCD_SPI_RST**	DO	LCD reset	
65	**LCD_CS**	DO	LCD chip select	
66	**LCD_SPI_DOUT**	DO	LCD data	
67	**LCD_SPI_CLK**	DO	LCD clock	

The reference design for LCD interface, please see document [3] for more details.

4.10 SPI Interface

The MDM01 module provides one SPI interface that only supports master mode. It has a working voltage of 1.8 V and a maximum clock frequency of 52 MHz.

Table 4-11: Pin Definition of SPI Interface

Pin NO.	Pin Name	I/O	Description	Comment
1	**SPI_CLK**	DO	SPI clock	1.8 V power domain. If unused, keep it open.
2	**SPI_RXD**	DI	SPI master mode input	
3	**SPI_TXD**	DO	SPI master mode output	
4	**SPI_CS**	DO	SPI chip selects	

The following figure shows a reference design of SPI interface.

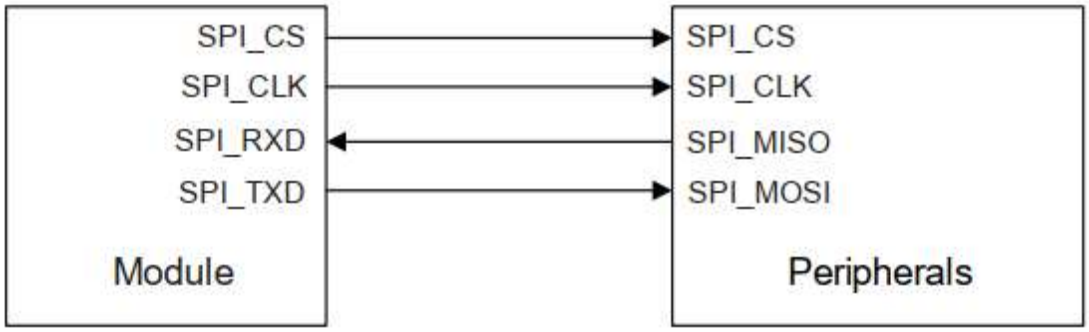


Figure 4-11: Reference Circuit of SPI Application

NOTE

- The module provides a 1.8 V SPI. A voltage-level translator between the module and the host should be used if the application is equipped with a 3.3 V processor or device interface.

4.11 Matrix Keypad Interface*

The MDM01 module supports a 5 × 5 matrix keypad interface.

Table 4-12: Pin Definition of Matrix Keypad Interface

Pin No.	Pin Name	Keypad Signal	I/O	Description	Comment
48	**MAIN_DCD**	**KP_MKIN[1]**	DI	Matrix keypad input 1	1.8 V power domain. If unused, keep it open.
49	**WAKEUP_IN**	**KP_MKOUT[1]**	DO	Matrix keypad output 1	
50	**AP_READY**	**KP_MKIN[2]**	DI	Matrix keypad input 2	
51	**W_DISABLE#**	**KP_MKOUT[2]**	DO	Matrix keypad output 2	
52	**NET_MODE**	**KP_MKIN[3]**	DI	Matrix keypad input 3	
53	**SLEEP_IND**	**KP_MKOUT[3]**	DO	Matrix keypad output 3	
54	**STATUS**	**KP_MKIN[4]**	DI	Matrix keypad input 4	
55	**NET_STATUS/USB_BOOT**	**KP_MKOUT[4]**	DO	Matrix keypad output 4	
57	**I2C_SCL**	**KP_MKIN[5]**	DI	Matrix keypad input 5	
56	**I2C_SDA**	**KP_MKOUT[5]**	DO	Matrix keypad output 5	

NOTE (*) indicates that the function is under development, currently not supported.

4.12 ADC Interfaces

The MDM01 module provides two analog-to-digital converter (ADC) interfaces. You can use AT+QADC to read the voltage value on ADC, See document [1] for more details.

To improve the accuracy of ADC, the trace of ADC interfaces should be surrounded by ground.

Table 4-13: Pin Definition of ADC Interfaces

Pin No.	Pin Name	Description	Comment
19	**ADC1**	General-purpose ADC interface	If unused, keep it open.
20	**ADC2**	General-purpose ADC interface	

The following table describes the characteristic of the ADC interfaces.

Table 4-14: Characteristics of ADC Interfaces

Name	Min.	Typ.	Max.	Unit
Voltage Range	0	-	1.3	V
ADC Resolution	-	-	12	bits

NOTE

- It is prohibited to supply any voltage to ADC pin when VBAT is removed.
- The input voltage of ADC should not exceed its corresponding voltage range. It is recommended to use resistor divider circuit for ADC application.

4.13 Indication Signals

The MDM01 module provides two indication signals, the operating status indications and the network status indications.

Table 4-15: Pin Definition of Indication Signals

Pin NO.	Pin Name	I/O	Description	Comment
52	**NET_MODE**	DO	Indicate the module's network registration mode	1.8 V power domain. If unused, keep it open.
55	**NET_STATUS/USB_BOOT**	DO	Indicate the module's network activity status	Reuse pins, NET_STATUS function after successfully startup. This pin cannot be pulled down to low level before the module is successfully startup if the emergency download mode is not necessary.
53	**SLEEP_IND**	DO	Indicate the module's sleep mode	1.8 V power domain. If unused, keep it open.
54	**STATUS**	DO	Indicate the module's operation status	

4.13.1 Operating Status Indications

The operating indication pins can be used to drive operation status indication LEDs. The module provides two operating indication pins: SLEEP_IND and STATUS. The following table describes logic level changes in different operating status.

Table 4-16: Working State of Operation Status Indication

Pin Name	Status	Description
SLEEP_IND	Always High	Module is on normal mode
	Always Low	Module is on sleep mode
STATUS	Always High	Module is Power on
	Always Low	Module is power off

A reference circuit is shown in the following figure.

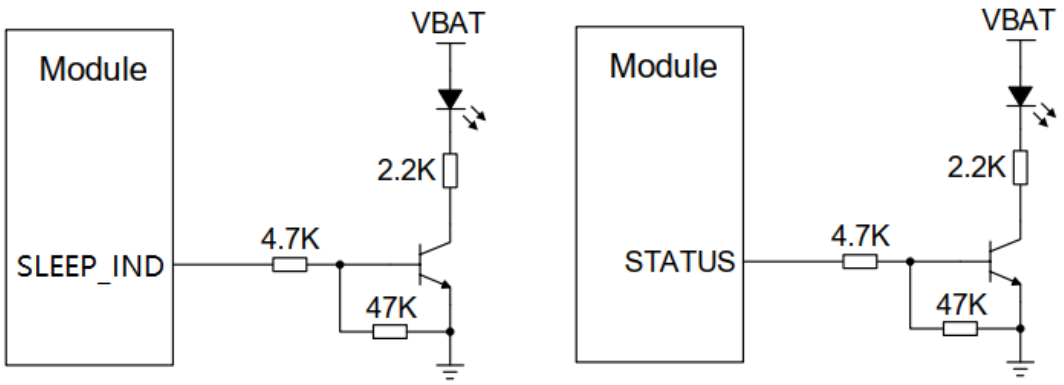


Figure 4-12: Reference Circuit of Operating Status Indication

4.13.2 Network Status Indications

The network indication pins can be used to drive network status indication LEDs. The module provides two network indication pins: NET_MODE and NET_STATUS/USB_BOOT. The following table describes logic level changes in different network status.

Table 4-17: Working State of Network Connection Status/Activity Indication

Pin Name	Status	Description
NET_MODE	Always High	Registered on LTE network
	Always Low	Other
NET_STATUS/ USB_BOOT	Flicker slowly (200 ms high/1800 ms low)	Network searching
	Flicker slowly (1800 ms high/200 ms low)	Idle
	Flicker quickly (125 ms high/125 ms low)	Data transfer is ongoing
	Always High	Voice calling

A reference circuit is shown in the following figures. The NET_STATUS/USB_BOOT pin needs to be controlled by an external NMOS transistor with Vgs (th) ≤ 1V.

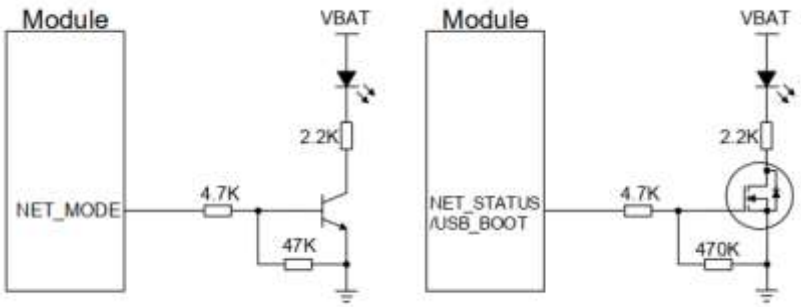


Figure 4-13: Reference Circuit of Network Status Indication

NOTE	The NET_STATUS/USB_BOOT pin defaults to outputting a high level. If a transistor is used, the pin level will be pulled low, and the module will enter emergency download mode and cannot start up successfully.

4.14 GPIO Interfaces

The MDM01 module provides four GPIO interfaces.

Table 4-18: Pin Definition of GPIO Interfaces

Pin No.	Pin Name	Description
109	**GPIO_00**	1.8 V power domain. If unused, keep it open.
110	**GPIO_01**	
111	**GPIO_70**	
112	**GPIO_69**	

5 RF Specifications

5.1 Pin Definition

The MDM01 module provides a main antenna interface. The impedance of antenna port is 50 Ω

Table 5-1: Pin Definition of Antennas

Pin Name	Pin No.	Description
ANT_MAIN	**46**	Main antenna interface
GND	**25,26,28,29**	Ground

NOTE Wi-Fi Scan and the main antenna share the same antenna interface, and the two functions cannot be used simultaneously.

5.2 Operating Frequency

Table 5-2: MDM01 Operating Frequencies

3GPP Band	Receive	Transmit
LTE-FDD Band 2	1850~1910MHz	1930~1990MHz
LTE-FDD Band 4	1710~1755MHz	2110~2155MHz
LTE-FDD Band 5	824~849MHz	869~894MHz
LTE-FDD Band 12	699~716MHz	729~746MHz
LTE-FDD Band 17	704~716MHz	734~746MHz
LTE-FDD Band 66	1710~1780MHz	2110~2200MHz

5.3 Reference Design

A reference design of ANT_MAIN antenna is shown as below. A π-type matching circuit should be reserved for better RF performance, and be placed as close to the antenna as possible. The capacitors are not mounted by default.

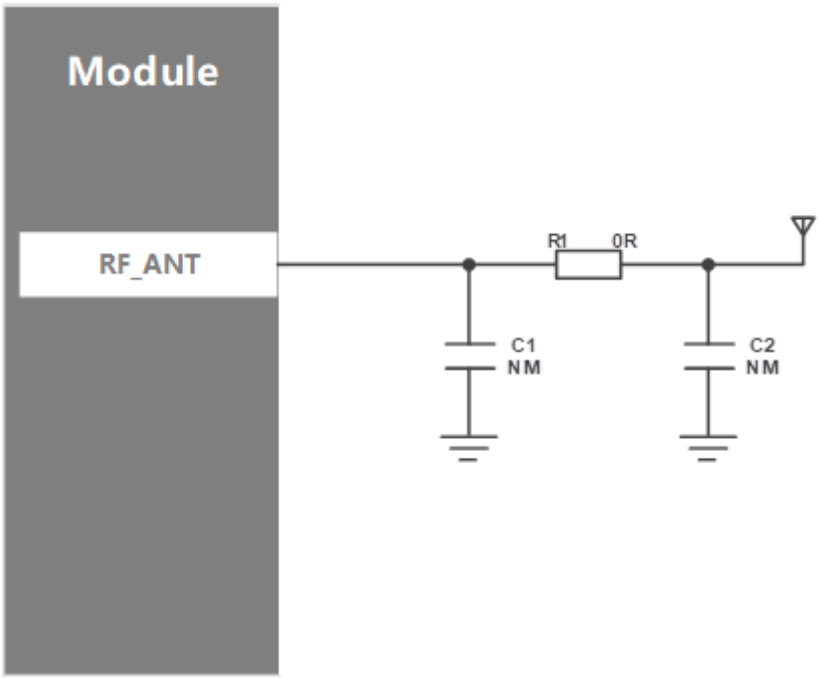


图 5-1: Reference Circuit of RF Antenna Interface

For user's PCB, the characteristic impedance of all RF traces should be controlled to 50 Ω. The impedance of the RF traces is usually determined by the trace width (W), the materials' dielectric constant, height from the reference ground to the signal layer (H), and the space between RF traces and grounds (S). Microstrip or coplanar waveguide is typically used in RF layout to control characteristic impedance. The following are reference designs of microstrip or coplanar waveguide with different PCB structures.

1．Microstrip Design

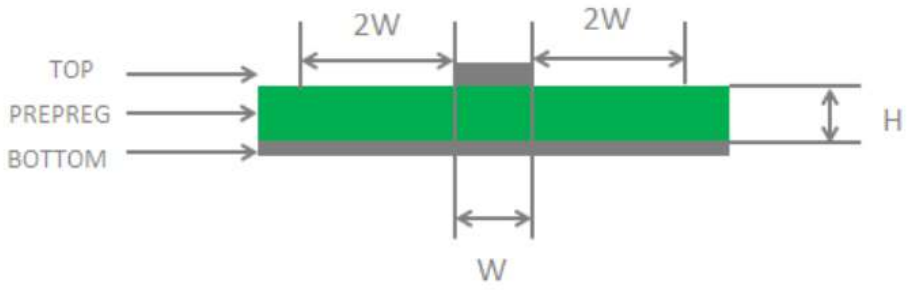
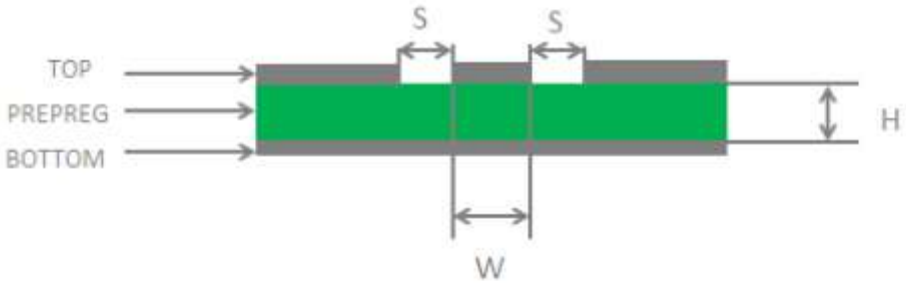
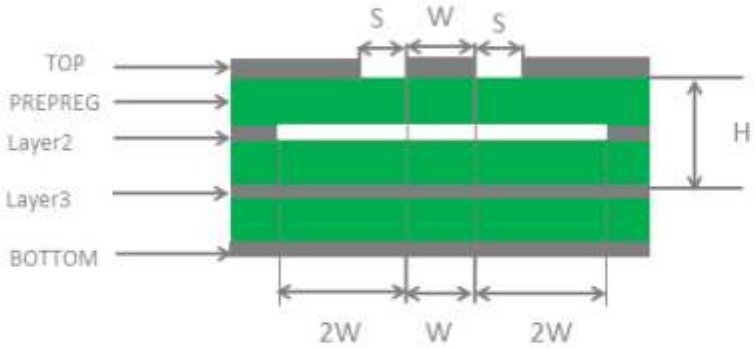


Figure 5-2: Microstrip Design on a 2-layer PCB

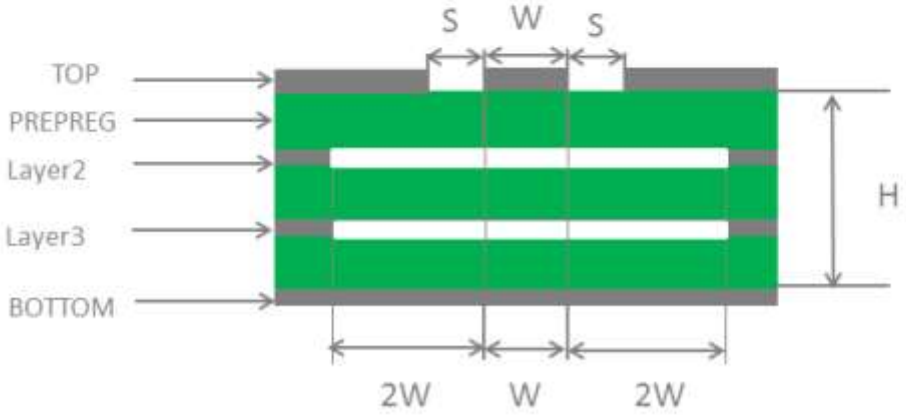
2．Coplanar Waveguide Design



Coplanar Waveguide Design on a 2-layer PCB



Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)



Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

Figure 5-3: Coplanar Waveguide Design

To ensure RF performance and reliability, follow the principles below in RF layout design:

1.Use an impedance simulation tool to accurately control the characteristic impedance of RF traces to 50 Ω.

2.The GND pins adjacent to RF pins should not be designed as thermal relief pads, and should be fully

connected to ground.

3.The distance between the RF pins and the RF connector should be as short as possible and all the right-angle traces should be changed to curved ones. The recommended trace angle is 135°.

4.There should be clearance under the signal pin of the antenna connector or solder joint. The reference ground of RF traces should be complete. Meanwhile, adding some ground vias around RF traces and the reference ground could help to improve RF performance. The distance between the ground vias and RF traces should be no less than two times the width of RF signal traces (2 ×W).

5.Keep RF traces away from interference sources, and avoid intersection and paralleling between traces on adjacent layers.

5.4 Tx Power

Table 5-3: MDM01 RF Output Power

Frequency Bands	Max. RF Output Power	Min. RF Output Power
Band 2	23dBm ±2dB	<-40dBm
Band 4	23dBm ±2dB	<-40dBm
Band 5	23dBm ±2dB	<-40dBm
Band 12	23dBm ±2dB	<-40dBm
Band 17	23dBm ±2dB	<-40dBm
Band 66	23dBm ±2dB	<-40dBm

5.5 Rx Sensitivity

Table 5-4: MDM01 Conducted RF Receiving Sensitivity

Frequency Bands	Primary	Diversity	Primary + Diversity	3GPP
Band 2(10MHz)	-98.5 dBm	N/A	N/A	-92 dBm
Band 4(10MHz)	-98.5 dBm	N/A	N/A	-94 dBm
Band 5(10MHz)	-98 dBm	N/A	N/A	-92.5 dBm
Band 12(10MHz)	-98 dBm	N/A	N/A	-91 dBm
Band 17(10MHz)	-98 dBm	N/A	N/A	-91 dBm
Band 66(10MHz)	-98.5 dBm	N/A	N/A	-93.5 dBm

5.6 Antenna Design Requirement

Table 5-5: Cable insertion loss Requirements

Frequency Bands	Requirements
FDD-B5/B12/B17	Insertion loss <0.4dB
FDD-B2/B4/B66	Insertion loss <0.6dB

Table 5-6: Antenna Requirements

Parameter	Requirements
Frequency Range	824~2675MHZ
VSWR	≤2
Gain(dBi)	≥1
Max. input power（W）	5
Input impedance（Ω）	50
Efficiency	≥30%

5.7 Recommended RF Soldering

If the RF connector connecting the external antenna is connected to the module through soldering, please pay attention to the stripping and soldering methods of the connecting wires. It must be fully grounded and operated according to the correct soldering method to avoid increased line loss caused by poor soldering.

6 Electrical Characteristics and Reliability

6.1 Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital and analog pins of the module are listed in the following table

Table 6-1: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT_BB	-0.3	6	V
VBAT_RF	-0.3	5.5	V
USB_VBUS	-0.3	5.5	V
Voltage on Digital Pins	-0.3	2.3	V
Voltage at ADC	-	1.8	V

6.2 Power Supply Ratings

Table 6-2: Module Power Supply Ratings

Parameter	Description	Min.	Typ.	Max.	Unit
VBAT_BB	Power supply for module's baseband part	3.4	3.8	4.5	V
VBAT_RF	Power supply for module's RF part	3.4	3.8	4.5	V
USB_VBUS	USB connection detection	3.0	5.0	5.25	V
Peak supply current (during transmission slot)	Maximum power control level	-	1.5	2	A

6.3 Power Consumption

The power consumption of the MDM01 module in various operating modes is shown in the table below, with VBAT power supply of 3.8V.

Table 6-3: MDM01 Current Consumption

Description	Conditions	Typ.（3.8V）	Unit
OFF state	Power down	10	uA
Sleep state	AT+CFUN=0(USB disconnected)	1.1	mA
	AT+CFUN=4(USB disconnected)	1.15	mA
	LTE-FDD @ PF = 32 (USB disconnected)	1.85	mA
	LTE-FDD @ PF = 64 (USB disconnected)	1.49	mA
	LTE-FDD @ PF = 128 (USB disconnected)	1.32	mA
	LTE-FDD @ PF = 256 (USB disconnected)	1.23	mA
Idle state	LTE-FDD @ PF = 64 (USB disconnected)	18.5	mA
LTE data transfer	LTE-FDD Band2	516	mA
	LTE-FDD Band4	550	mA
	LTE-FDD Band5	548	mA
	LTE-FDD Band12	529	mA
	LTE-FDD Band17	530	mA
	LTE-FDD Band66	542	mA

NOTE

- All power consumption data were obtained in a laboratory environment, with a VABT power supply of 3.8V and connected to an RF CMU testing.
- Due to the influence of network parameters in the current network environment, there may be some differences between the power consumption data of the current network and the laboratory

6.4 Digital Logic Level Characteristics

Table 6-4: 1.8V I/O Voltage Level Requirements

Parameter	Description	Min.	Max.	Unit
VIH	Input High Level Voltage Value	1.2	2.0	V
VIL	Input Low Level Voltage Value	-0.3	0.6	V
VOH	Output High Level Voltage Value	1.35	1.8	V
VOL	Output Low Level Voltage Value	-0.3	0.45	V

Table 6-5: USIM 1.8V I/O Voltage Level Requirements

Parameter	Description	Min.	Max.	Unit
USIM_VDD	USIM Power Supply	1.7	1.9	V
VIH	Input High Level Voltage Value	1.2	2.0	V
VIL	Input Low Level Voltage Value	-0.3	0.6	V
VOH	Output High Level Voltage Value	1.35	1.8	V
VOL	Output Low Level Voltage Value	-0.3	0.45	V

Table 6-6: USIM 3.0V I/O Voltage Level Requirements

Parameter	Description	Min.	Max.	Unit
USIM_VDD	USIM Power Supply	2.7	3.05	V
VIH	Input High Level Voltage Value	1.95	3.05	V
VIL	Input Low Level Voltage Value	-0.3	1.0	V
VOH	Output High Level Voltage Value	2.55	3.0	V
VOL	Output Low Level Voltage Value	-0.3	0.45	V

6.5 ESD

If the static electricity generated by various ways discharges to the module, the module maybe damaged to a certain extent. Thus, please take proper ESD countermeasures and handling methods. For example, wearing anti-static gloves during the development, production, assembly and testing of the module; adding ESD protective components to the ESD sensitive interfaces and points in the product design.

The following table shows electrostatics discharge characteristics of the module.

Table 6-7: Electrostatics Discharge Characteristics (25 ºC, 45 % Relative Humidity)

Tested Interface	Contact Discharge	Air Discharge	Unit
VBAT,GND	±5	±10	kV
Antenna Interface	±5	±10	kV
Other Interface	±0.5	±1	kV

6.6 Operating and Storage Temperatures

Table 6-8: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operating Temperature Range	-35	25	+75	℃
Extended Temperature Range	-40	-	+85	℃
Storage Temperature Range	-40	-	+85	℃

NOTE

- Within operating temperature range, the module is 3GPP compliant.
- Within extended temperature range, the module remains the ability to establish and maintain functions such as voice, SMS, data transmission, etc., without any unrecoverable malfunction. Radio spectrum and radio network are not influenced, while one or more specifications, such as Pout, may exceed the specified tolerances of 3GPP. When the temperature returns to the operating temperature range, the module meets 3GPP specifications again.

7 Mechanical Information

This chapter describes the mechanical dimensions of the MDM01 module. All dimensions are measured in millimeter (mm), and the dimensional tolerances are ±0.2 mm unless otherwise specified.

7.1 Mechanical Dimensions

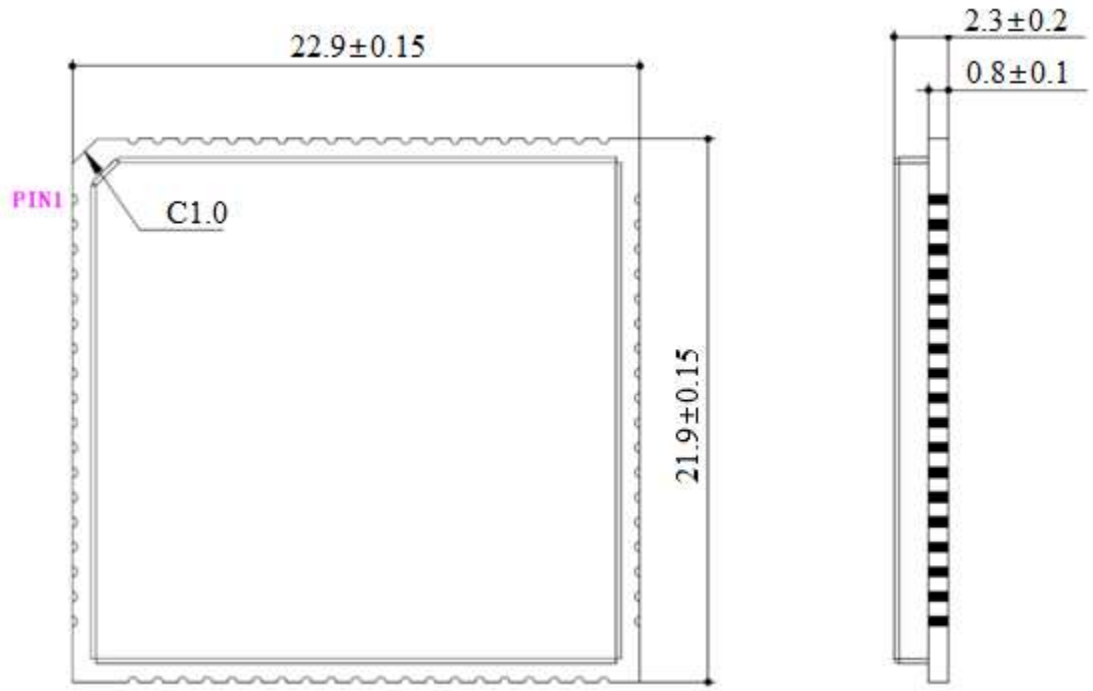


Figure 7-1: Module Top and Side Dimensions

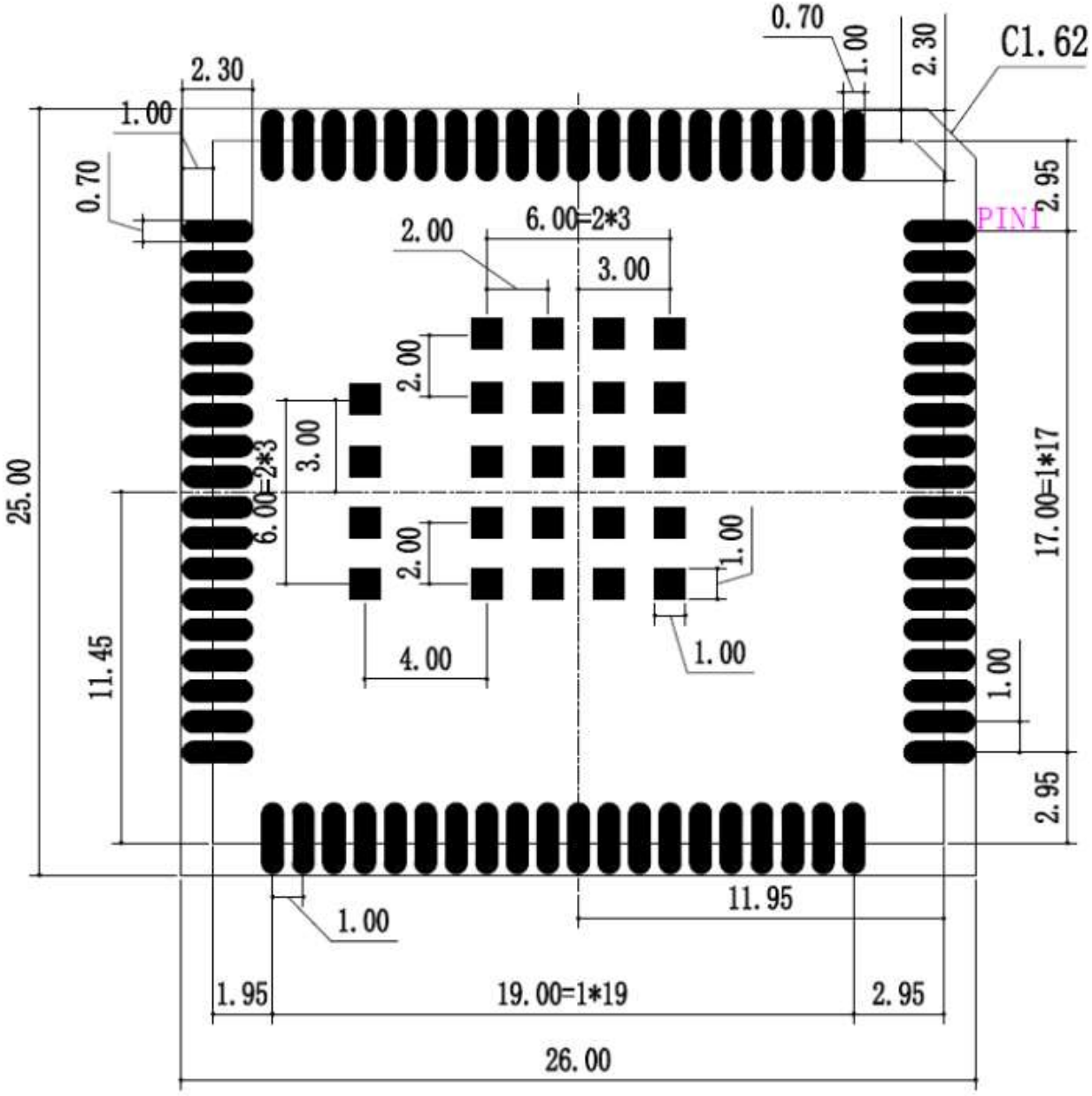


Figure 7-2: Module Bottom Dimensions (Bottom View)

7.2 Recommended Footprint

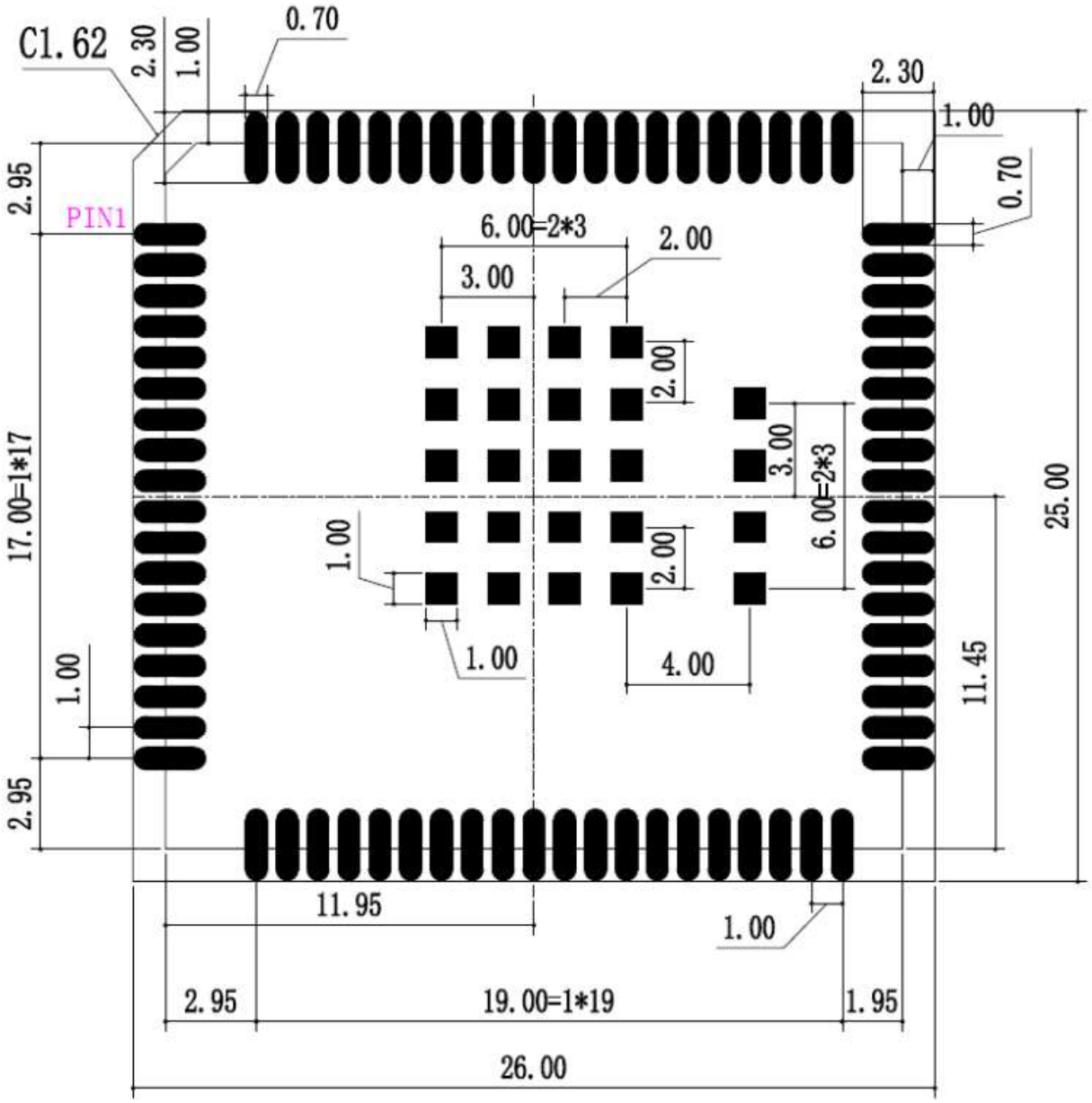


Figure 7-3: Recommended Footprint (Top View)

NOTE	Keep at least 3 mm between the module and other components on the motherboard to improve soldering quality and maintenance convenience.

8 Storage, Manufacturing and Packaging

8.1 Storage Conditions

The MDM01 module is provided with vacuum-sealed packaging. MSL of the module is rated as 3. The storage requirements are shown below.

1. Recommended Storage Condition: The temperature should be below 40°C and the relative humidity should be less than 90 %. The storage life (in vacuum-sealed packaging) is 12 months in Recommended Storage Condition.

2. After the vacuum-sealed packaging is removed, if the following conditions are met, the module can process in reflow soldering or other high-temperature operations.

- The floor life of the module is 168 hours in a plant where the temperature is below 30 °C and relative humidity is below 60 %.
- The module should be stored in an environment where the relative humidity is less than 10 % (e.g., a drying cabinet).

3. The module should be pre-baked to avoid blistering, cracks and inner-layer separation in PCB under the following circumstances:

- The module is not stored in Recommended Storage Condition;
- Violation of the third requirement above occurs;
- Vacuum-sealed packaging is broken, or the packaging has been removed for over 24 hours;
- Before module repairing.

4. If needed, the pre-baking should follow the requirements below:

- The module should be baked for 48 hours at 120 ±5 °C;
- All modules must be soldered to PCB within 24 hours after the baking, otherwise they should be put in a dry environment such as in a drying oven.

NOTE

- To avoid blistering, layer separation and other soldering issues, extended exposure of the module to the air is forbidden. It is recommended to start the solder reflow process within 24 hours after the package is removed if the temperature and moisture do not conform to, or are not sure to conform to IPC/JEDEC J-STD-033. And do not remove the packages of tremendous modules if they are not ready for soldering.
- Take out the module from the package and put it on high-temperature-resistant fixtures before baking. All modules must be soldered to PCB within 24 hours after the baking, otherwise put them in the drying oven. If shorter baking time is desired, see IPC/JEDEC J-STD-033 for the baking procedure.
- Pay attention to ESD protection, such as wearing anti-static gloves, when touching the modules.

8.2 Manufacturing and Soldering

The MDM01 module is packaged in LCC+LGA, and suitable steel mesh needs to be made and a reasonable furnace temperature curve needs to be set during production. Reflow soldering is used for SMT welding.

Push the squeegee to apply the solder paste on the surface of stencil, thus making the paste fill the stencil openings and then penetrate to the PCB. Apply proper force on the squeegee to produce a clean stencil surface on a single pass. To guarantee module soldering quality, the thickness of stencil for the module is recommended to be 0.15–0.20 mm.

The peak reflow temperature should be 235–245 ºC, with 245 ºC as the absolute maximum reflow temperature. To avoid damage to the module caused by repeated heating, it is strongly recommended that the module should be mounted only after reflow soldering for the other side of PCB has been completed. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown below.

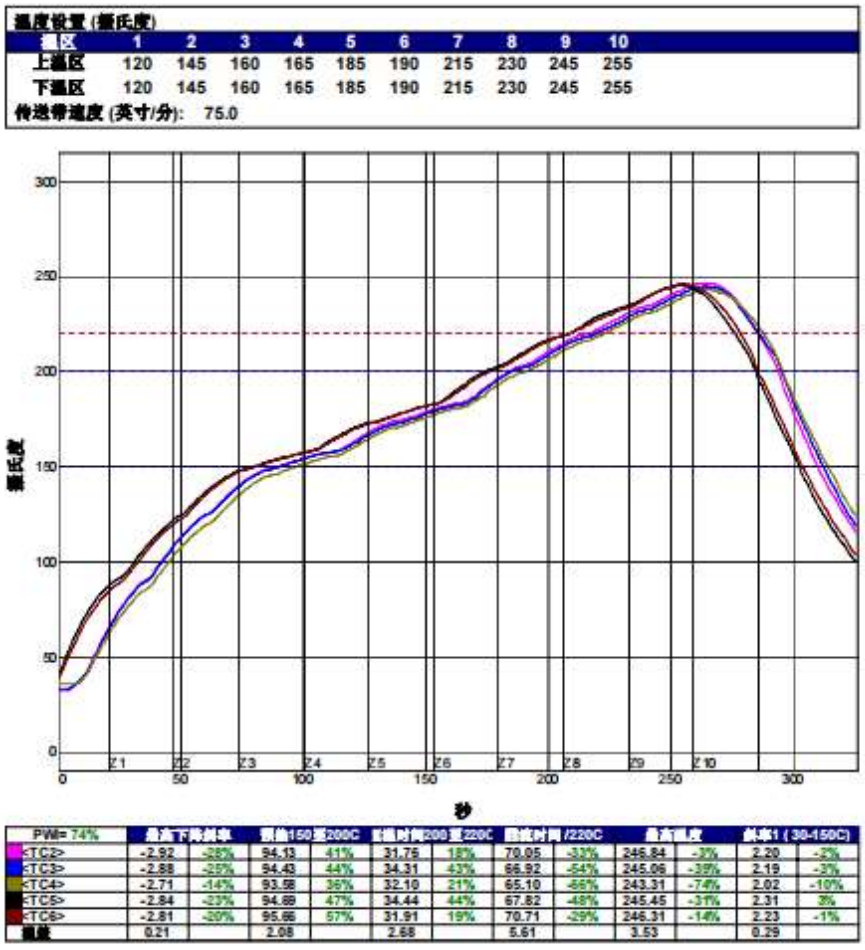


Figure 8-1: Recommended Reflow Soldering Thermal Profile

The process parameter requirements are as follows

- Max slope: below 3℃/sec；
- Cooling down slope: -3～-1℃/sec；
- Soak Zone: 150-200℃; Soak Time: 60-120S；

- Reflow Zone: above 220℃; Reflow time: 60-90S；
- Peak temperature: 245 +0/-5℃

8.3 Packaging Specifications

This chapter describes only the key parameters and process of packaging. All figures below are for reference only. The appearance and structure of the packaging materials are subject to the actual delivery.

The MDM01 module is packaged with the carrier tape in a Vacuum-sealed packaging. Each plastic reel contains 500 modules, with a tape diameter of 330 millimeters. The size chart is as follows:

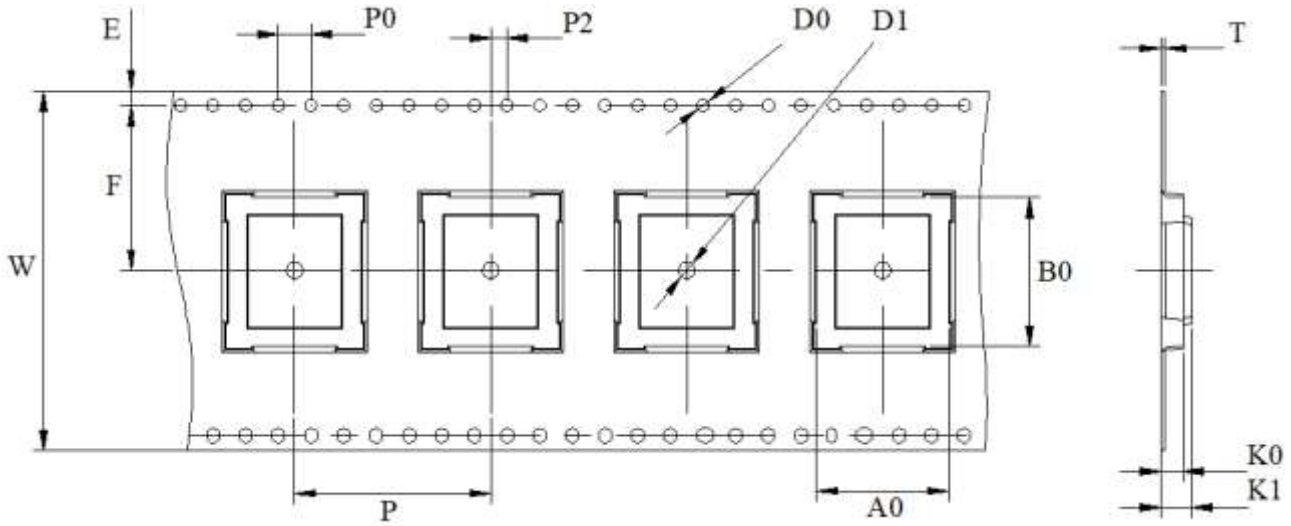


Figure 8-2: Carrier Tape Dimension Drawing

Table 8-1: Carrier Tape Dimension Table (Unit: mm)

W	P	P0	P2	A0	B0	D0	D1	F	E	T	K0	K1
44 +0.30 -0.30	32 +0.10 -0.10	4 +0.10 -0.10	2 +0.10 -0.10	22.5 +0.10 -0.10	23.6 +0.10 -0.10	1.50 +0.10 -0.00	2 +0.15 -0.15	20.2 +0.10 -0.10	1.75 +0.10 -0.10	0.4 +0.05 -0.05	3 +0.10 -0.10	3.3 +0.10 -0.10

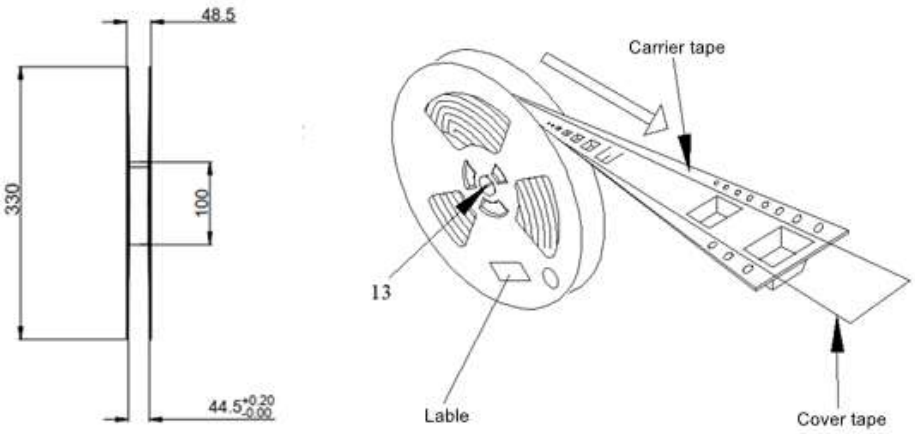


Figure 8-3: Plastic Reel Dimension Drawing (Unit: mm)

9 Appendix References

Table 9-1: Related Documents

No.	Document Name	Description
[1]	MDM01_Q-AT Commands	MDM01 Q-AT Commands
[2]	SS201_ Audio Application Guide	SS201 Audio Application Guide
[3]	SS201_ Hardware reference design	SS201 Hardware reference design

Table 9-2: Terms and Abbreviations

Abbreviation	Description
ADC	Analog to Digital Converter
bps	Bits per Second
CHAP	Challenge Handshake Authentication Protocol
CTS	Clear To Send
CFOTA	Firmware Over-the-Air
DCE	Data Communications Equipment
DL	Downlink
DTE	Data Terminal Equipment
DTR	Data Terminal Ready
DFOTA	Differential Firmware Over-the-Air
ESD	Electrostatic Discharge
ESR	Equivalent Series Resistance
ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplexing
FTP	File Transfer Protocol
FTPS	FTP over SSL
GPIO	General-Purpose Input/Output
HTTP	Hyper Text Transfer Protocol
HTTPS	Hyper Text Transfer Protocol over Secure Socket Layer
I/O	Input/Output
kbps	Kilobit Per Second
LCC	Leadless Chip Carriers
LGA	Land Grid Array
LED	Light Emitting Diode
LTE	Long Term Evolution
Mbps	Million Bits Per Second

Abbreviation	Description
MMS	Multimedia Messaging Service
MQTT	Message Queuing Telemetry Transport
MSL	Moisture Sensitivity Levels
NITZ	Network Identity and Time Zone
NTP	Network Time Protocol
PA	Power Amplifier
PAP	Password Authentication Protocol
PCB	Printed Circuit Board
PCM	Pulse Code Modulation
PDU	Protocol Data Unit
PMIC	Power Management IC
PPP	Point-to-Point Protocol
PSK	Phase Shift Keying
RF	Radio Frequency
RTS	Require To Send
RX	Receive Direction
RXD	Receive Direction Data
SIM	Subscriber Identification Module
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SMTPS	Simple Mail Transfer Protocol Secure
SSL	Secure Sockets Layer
TCP	Transmission Control Protocol
TDD	Time Division Duplexing
TE	Terminal Equipment
TX	Transmitting Direction
TXD	Transmitting Direction Data
UART	Universal Asynchronous Receiver &Transmitter
UDP	User Datagram Protocol
UL	Uplink
UMTS	Universal Mobile Telecommunications System
URC	Unsolicited Result Code
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module
Vmax	Maximum Voltage Value
Vnorm	Normal Voltage Value
Vmin	Minimum Voltage Value
VIHmax	Maximum Input High Level Voltage Value
VIHmin	Minimum Input High Level Voltage Value
VILmax	Maximum Input Low Level Voltage Value

Abbreviation	Description
VILmin	Minimum Input Low Level Voltage Value
VImax	Absolute Maximum Input Voltage Value
VImin	Absolute Minimum Input Voltage Value
VOHmax	Maximum Output High Level Voltage Value
VOHmin	Minimum Output High Level Voltage Value
VOLmax	Maximum Output Low Level Voltage Value
VOLmin	Minimum Output Low Level Voltage Value
VSWR	Voltage Standing Wave Ratio