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RM500Q-AE&RM502Q-AE
Hardware Design

5G Module Series

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About the Document

Revision History

Version	Date	Author	Description
-	2020-10-22	Jared WANG /Hank LIU	Creation of the document
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Contents

Table Index

Figure Index

1 Introduction

The hardware design defines RM500Q-AE&RM502Q-AE and describes the air and hardware interfaces which are connected with customers' applications.

This document helps you quickly understand the interface specifications, electrical and mechanical details, as well as other related information of RM500Q-AE&RM502Q-AE. To facilitate its application in different fields, reference design is also provided for reference. Associated with application notes and user guides, customers can use the module to design and set up mobile applications easily.

This document is applicable to the RM500Q-AE&RM502Q-AE models:

NOTE

"*" means under development

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, Quectel 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 signals and cellular network cannot be guaranteed to connect in all possible conditions (for example, with unpaid bills or with an invalid (U)SIM card. When emergency help is needed in such conditions, use emergency call. 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.
	The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with potentially explosive atmospheres, obey all posted signs to turn off wireless devices such as mobile phone or other cellular terminals. Areas with potentially explosive atmospheres include fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust or metal powders.

2 Product Concept

2.1. General Description

RM500Q-AE&RM502Q-AE are 5G NR/LTE-FDD/LTE-TDD/WCDMA wireless communication modules with receive diversity. They provide data connectivity on 5G NR SA and NSA, LTE-FDD, LTE-TDD, DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA networks with standard PCI Express M.2 interface.

They support embedded operating systems such as Windows, Linux and Android, and also provide GNSS and voice functionality to meet specific application demands.

The following table shows the frequency bands and GNSS type of the module.

Table 1: Frequency Bands and GNSS Type of RM500Q-AE&RM502Q-AE Module

Mode	RM500Q-AE&RM502Q-AE
5G NR	n2/n5/n7/n12/n25/n41/n66/n71/n77
LTE-FDD	B2/eB4/B5/B7/B12/B13/B14/B17/B25/B26/B30/B66/B71
LTE-TDD	B38/B41/B48
WCDMA	B2/B4/B5
GNSS	GPS/GLONASS/BeiDou/Galileo

RM500Q-AE&RM502Q-AE can be applied in the following fields:

- Rugged tablet PC and laptop computer
- Remote monitor system
- Smart metering system
- Wireless router and switch
- Other wireless terminal devices

2.2. Key Features

The following table describes key features of RM500Q-AE&RM502Q-AE.

Table 2: Key Features of RM500Q-AE&RM502Q-AE

Feature	Details
Function Interface	PCI Express M.2 Interface
Power Supply	● Supply voltage: 3.135–4.4 V ● Typical supply voltage: 3.7 V
Transmitting Power	● Class 3 (24 dBm +1/-3 dB) for WCDMA bands ● Class 3 (23 dBm ±2 dB) for LTE bands ● Class 3 (23 dBm ±2 dB) for 5G NR bands ● Class 2 (26 dBm ±2 dB) for LTE B38/B41 bands HPUE [1] ● Class 2 (26 dBm +2/-3 dB) for 5G NR n41/n77 bands HPUE [1]
5G NR Features	● Support 3GPP Rel-15 ● Modulations: Uplink: π/2-BPSK, QPSK, 16QAM, 64QAM and 256QAM Downlink: QPSK, 16QAM, 64QAM and 256QAM ● Support downlink 4 × 4 MIMO on: n2/n7/25/n41/n66/n77 ● Support SCS 15 kHz [2] and 30 kHz [2] ● Supports 5G NR refarmed band bandwidth ≤ 20 MHz ● Supports 5G NR n41/n77 bandwidth ≤ 100 MHz ● Support SA and NSA operation modes ● Support Option 3x, 3a, and Option 2 ● Max. transmission data rates [3]: **RM500Q-AE** NSA: Max 2.5 Gbps(DL)/ 650 Mbps (UL) SA: Max 2.1 Gbps(DL)/ 450 Mbps (UL) **RM502Q-AE** NSA: Max 5 Gbps(DL)/ 650 Mbps (UL) SA: Max 4.2 Gbps(DL)/ 450 Mbps (UL)
LTE Features	● Supports 3GPP Rel-15 ● Support up to CA Cat 16 FDD and TDD ● Supported modulations: Uplink: QPSK, 16QAM and 64QAM and 256QAM Downlink: QPSK, 16QAM and 64QAM and 256QAM ● Supports 1.4/3/5/10/15/20 MHz RF bandwidth ● Support downlink 4 × 4 MIMO on: B2/B4/B7/B25/B30/B38/B41/B48/B66 ● Max. transmission data rates [3]: **RM500Q-AE**

		LTE: Max 1.0 Gbps(DL)/ 200 Mbps (UL)
		RM502Q-AE
		LTE: 2.0 Gbps (DL) /200 Mbps (UL)
UMTS Features	●	Support 3GPP R8 DC-HSDPA, HSPA +, HSDPA, HSUPA and WCDMA
	●	Support QPSK, 16QAM and 64QAM modulation
	●	Max. transmission data rates [2]:
		DC-HSDPA: Max 42 Mbps (DL)
		HSUPA: Max 5.76 Mbps (UL)
		WCDMA: Max 384 kbps (DL)/384 kbps (UL)
Internet Protocol Features	●	Support QMI/NTP* protocols
	●	Support the protocols PAP and EIRP usually used for PPP connections
SMS	●	Text and PDU modes
	●	Point-to-point MO and MT
	●	SMS cell broadcast
	●	SMS storage: ME by default
(U)SIM Interface	●	Support (U)SIM card: Class B (3.0 V) and Class C(1.8 V)
	●	(U)SIM interface
	●	Support Single (U)SIM
USB Interface	●	Compliant with USB 3.1 and 2.0 specifications, with maximum transmission rates up to 10 Gbps on USB 3.1 and 480 Mbps on USB 2.0.
	●	Used for AT command communication, data transmission, firmware upgrade, software debugging, GNSS NMEA sentence output.
	●	Support USB serial drivers for: Windows 7/8/8.1/10, Linux 2.6–5.4, Android 4.x/5.x/6.x/7.x/8.x/9.x/10
PCIe × 1 Interface	●	Complaint with PCIe GEN3, support 8 Gbps per lane, PCIe × 1.
	●	Used for AT command communication, data transmission, firmware upgrade, software debugging, GNSS NMEA sentence output
Rx-diversity	●	Support 5G NR/LTE/WCDMA Rx-diversity
GNSS Features	●	Gen9 Lite of Qualcomm
	●	Protocol: NMEA 0183
	●	Data Update Rate: 1 Hz
AT Commands	●	Compliant with 3GPP TS 27.007, 27.005 and Quectel enhanced AT commands
Antenna Interfaces	●	ANT0, ANT1, ANT2, and ANT3_GNSSL1
Physical Characteristics	●	Size: (52.0 ±0.15) mm × (30.0 ±0.15) mm × (2.3 ±0.2) mm
	●	Weight: approx. 8.7
Temperature Range	●	Operating temperature range: -20 to +60 °C [4]
	●	Restricted Operating temperature range: -30 to -20 °C, +60 to +75 °C
	●	Extended temperature range: -40 to -30 °C, +75 to +85 °C [5]
	●	Storage temperature range: -40 to +90°C
Firmware Upgrade	●	USB 2.0 interface, PCIe interface and DFOTA

RoHS	● All hardware components are fully compliant with EU RoHS directive

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NOTES

1. [1] HPUE is only for single carrier.
2. [2] 5G NR FDD bands only support 15 kHz SCS, NR TDD bands only support 30 kHz SCS.
3. [3] The maximum rates are theoretical and the actual values refer to the network configuration.
4. [4] To meet this operating temperature range, you need to ensure effective thermal dissipation, for example, by adding passive or active heatsinks, heat pipes, vapor chambers, etc. Within this range, the module can meet 3GPP specifications.
5. [5] Within extended temperature range, the module remains the ability to establish and maintain functions such as voice, SMS, data transmission without any unrecoverable malfunction. Radio spectrum and radio network will not be influenced, while one or more specifications, such as P_{out} may undergo a reduction in value, exceeding the specified tolerances of 3GPP. When the temperature returns to the normal operating temperature level, the module will meet 3GPP specifications again.
6. "*" means under development.

2.3. Functional Diagram

The following figure shows a block diagram of RM500Q-AE&RM502Q-AE.

● Power management
● Baseband
● DDR + NAND flash
● Radio frequency
● M.2 Key-B interface
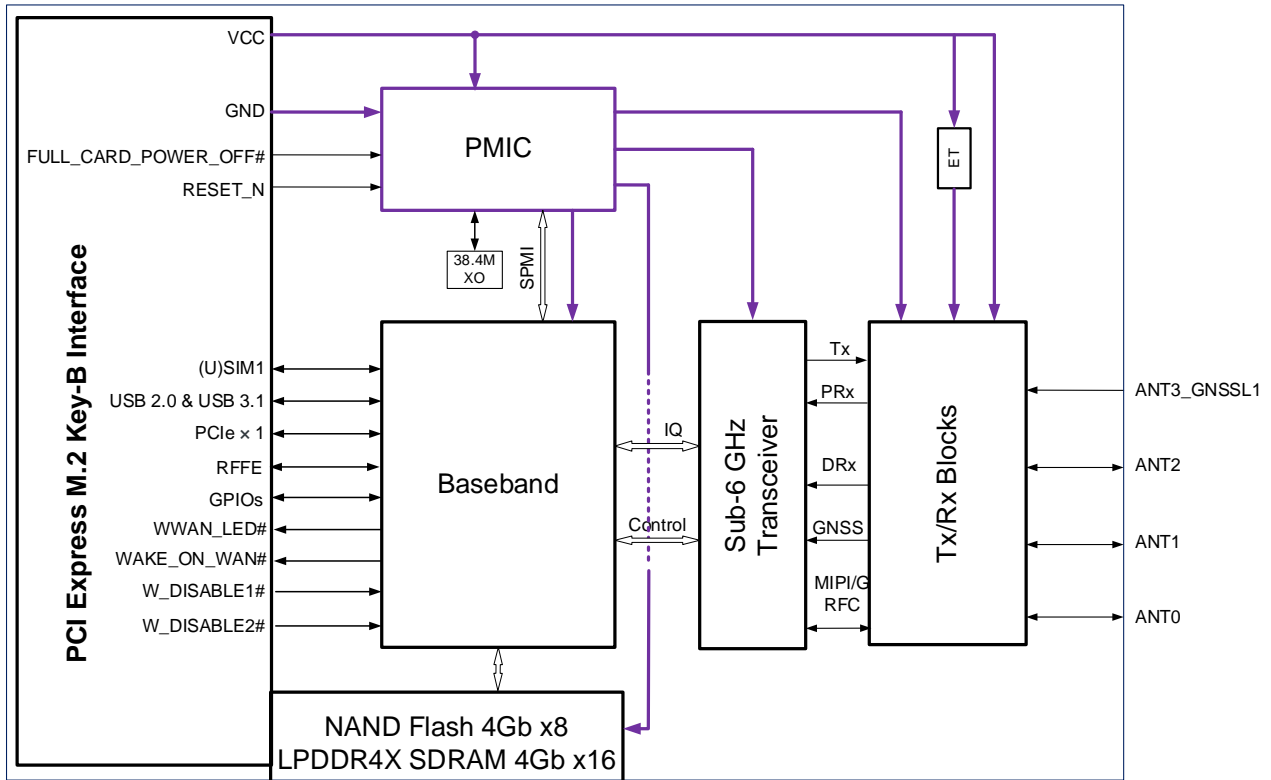
Figure 1: Functional Diagram

2.4. Evaluation Board

To help with the development of applications conveniently with RM500Q-AE&RM502Q-AE, Quectel supplies the evaluation board (PCIe Card EVB), a USB to RS-232 converter cable, a USB type-C cable, antennas and other peripherals to control or test the module. For more details, see *document [1]*.

3 Application Interfaces

The physical connections and signal levels of RM500Q-AE&RM502Q-AE comply with *PCI Express M.2 specification*. This chapter mainly describes the definition and application of the following interfaces/pins of the module:

- Power supply
- (U)SIM interfaces
- USB interface
- PCIe interface
- PCM interface*
- Control and indication interfaces*
- COEX UART interface*
- Antenna tuner control interface*
- Configuration pins

NOTE

"*" means under development.

3.1. Pin Assignment

The following figure shows the pin assignment of the module. The top side contains module and antenna connectors.

No.	Pin Name
74	VCC
72	VCC
70	VCC
68	AP2SDX_STATUS
66	USIM_DET
64	COEX_TXD
62	COEX_RXD
60	WLAN_TX_EN
58	RFFE_DATA
56	RFFE_CLK
54	PCIE_WAKE_N
52	PCIE_CLKREQ_N
50	PCIE_RST_N
48	NC
46	NC
44	NC
42	NC
40	NC
38	SDX2AP_STATUS
36	USIM_VDD
34	USIM_DATA
32	USIM_CLK
30	USIM_RST
28	PCM_SYNC
26	W_DISABLE2#
24	PCM_DOUT
22	PCM_DIN
20	PCM_CLK
	Notch
	Notch
	Notch
	Notch
10	WWAN_LED#
8	W_DISABLE1#
6	FULL_CARD_POWER_OFF#
4	VCC
2	VCC

Pin Name	No.
CONFIG_2	75
GND	73
GND	71
CONFIG_1	69
RESET_N	67
RFFE_VIO_1V8	65
ANTCTL2	63
ANTCTL1	61
LAA_TX_EN	59
GND	57
PCIE_REFCLK_P	55
PCIE_REFCLK_M	53
GND	51
PCIE_RX_P	49
PCIE_RX_M	47
GND	45
PCIE_TX_P	43
PCIE_TX_M	41
GND	39
USB_SS_RX_P	37
USB_SS_RX_M	35
GND	33
USB_SS_TX_P	31
USB_SS_TX_M	29
GND	27
DPR	25
WAKE_ON_WAN#	23
CONFIG_0	21
Notch	
Notch	
Notch	
Notch	
GND	11
USB_DM	9
USB_DP	7
GND	5
GND	3
CONFIG_3	1

Figure 2: Pin Assignment

3.2. Pin Description

Table 3: Definition of I/O Parameters

Type	Description
AI	Analog Input
AO	Analog Output
DI	Digital Input
DO	Digital Output
IO	Bidirectional
OD	Open Drain
PI	Power Input
PO	Power Output

The following table shows the pin definition and description of the module.

Table 4: Pin Description

Pin No.	Pin Name	I/O	Description	Comment
1	CONFIG_3	DO	Not connected internally	
2	VCC	PI	Power supply	V_{min} = 3.135 V V_{norm} = 3.7 V V_{max} = 4.4 V
3	GND		Ground	
4	VCC	PI	Power supply	V_{min} = 3.135 V V_{norm} = 3.7 V V_{max} = 4.4 V
5	GND		Ground	
6	FULL_CARD_ POWER_OFF#	DI	Turn on/off of the module.	Internally pulled down with a 100 kΩ resistor. When it is at low level, the module is turned off.

				When it is at high level, the module is turned on.
7	USB_DP	AI, AO	USB 2.0 differential data (+)	
8	W_DISABLE1#*	DI	Airplane mode control. Active LOW.	1.8/3.3 V power domain
9	USB_DM	AI, AO	USB 2.0 differential data (-)	
10	WWAN_LED#*	OD	RF status indication LED	It is an open drain and active LOW signal.
11	GND		Ground	
12	Notch		Notch	
13	Notch		Notch	
14	Notch		Notch	
15	Notch		Notch	
16	Notch		Notch	
17	Notch		Notch	
18	Notch		Notch	
19	Notch		Notch	
20	PCM_CLK*	IO	PCM data bit clock	1.8 V power domain
21	CONFIG_0	DO	Not connected internally	
22	PCM_DIN*	DI	PCM data input	1.8 V power domain
23	WAKE_ON_WAN#*	OD	Wake up the host.	Open drain Active LOW.
24	PCM_DOUT*	DO	PCM data output	1.8 V power domain
25	DPR	DI	Dynamic power reduction. High level by default.	1.8 V power domain
26	W_DISABLE2#*	DI	GNSS disable control.	1.8/3.3 V power domain Active LOW.
27	GND		Ground	
28	PCM_SYNC*	IO	PCM data frame sync	1.8 V power domain
29	USB_SS_TX_M	AO	USB 3.1 transmit (-)	

30	USIM_RST	DO	(U)SIM card reset	1.8/3.0 V power domain
31	USB_SS_TX_P	AO	USB 3.1 transmit data (+)	
32	USIM_CLK	DO	(U)SIM clock	1.8/3.0 V power domain
33	GND		Ground	
34	USIM_DATA	IO	(U)SIM card data	1.8/3.0 V power domain
35	USB_SS_RX_M	AI	USB 3.1 super-speed receive (-)	
36	USIM_VDD	PO	(U)SIM card power supply	1.8/3.0 V power domain
37	USB_SS_RX_P	AI	USB 3.1 super-speed receive (+)	
38	SDX2AP_STATUS	DO	Status indication to AP	1.8 V power domain
39	GND		Ground	
40	NC		NC	
41	PCIE_TX_M	AO	PCIe transmit (-)	
42	NC		NC	
43	PCIE_TX_P	AO	PCIe transmit (+)	
44	NC		NC	
45	GND		Ground	
46	NC		NC	
47	PCIE_RX_M	AI	PCIe receive (-)	
48	NC		NC	
49	PCIE_RX_P	AI	PCIe receive (+)	
50	PCIE_RST_N	DI	PCIe reset.	Open drain Active LOW.
51	GND		Ground	
52	PCIE_CLKREQ_N	DO	PCIe clock request.	Open drain Active LOW.
53	PCIE_REFCLK_M	AI, AO	PCIe reference clock (-)	

54	PCIE_WAKE_N	DO	PCIe wake up	Open drain Active LOW
55	PCIE_REFCLK_P	AI, AO	PCIe reference clock (+)	
56	RFFE_CLK*	DO	Used for external MIPI IC control	1.8 V power domain
57	GND		Ground	
58	RFFE_DATA*	DO	Used for external MIPI IC control	1.8 V power domain
59	LAA_TX_EN	DO	Notification from SDR to WL when LTE transmitting	1.8 V power domain
60	WLAN_TX_EN	DI	Notification from WL to SDR while transmitting	1.8 V power domain
61	ANTCTL1*	DO	Antenna control	1.8 V power domain
62	COEX_RXD	DI	LTE/WLAN coexistence receive data	1.8 V power domain
63	ANTCTL2*	DO	Antenna control	1.8 V power domain
64	COEX_TXD	DO	LTE/WLAN coexistence transmit data	1.8 V power domain
65	RFFE_VIO_1V8	PO	Power supply for RFFE	1.8 V power output
66	USIM_DET	DI	(U)SIM card insertion detection	Internally pulled up to 1.8 V
67	RESET_N	DI	Reset the module.	Internally pulled up to 1.5 V with a 100 kΩ resistor Active LOW.
68	AP2SDX_STATUS	DI	Status indication from AP	1.8 V power domain
69	CONFIG_1	DO	Connected to GND internally	
70	VCC	PI	Power supply	V_{min} = 3.135 V V_{norm} = 3.7 V V_{max} = 4.4 V
71	GND		Ground	
72	VCC	PI	Power supply	Vmin = 3.135 V Vnorm = 3.7 V Vmax = 4.4 V
73	GND		Ground	
74	VCC	PI	Power supply	Vmin = 3.135 V Vnorm = 3.7 V

			Vmax = 4.4 V
75	CONFIG_2	DO	Not connected internally

NOTE

1.Keep all NC, reserved and unused pins unconnected.
2.Pin 61 and Pin 63 are used for antenna tuner

3.3. Operating Modes

The table below briefly summarizes the various operating modes to be mentioned in the following chapters.

Table 5: Overview of Operating Modes

Mode	Details	
Normal Operation	Idle	Software is active. The module has registered on the network, and it is ready to send and receive data.
	Talk/Data	The module is connected to network. In this mode, the power consumption is decided by network setting and data transfer rate.
Minimum Functionality Mode	**AT+CFUN=0** command sets the module to a minimum functionality mode without removing the power supply. In this mode, both RF function and (U)SIM card are invalid.	
Airplane Mode	**AT+CFUN=4** command or driving W_DISABLE1#* pin low will set the module to airplane mode. In this mode, the RF function is invalid.	
Sleep Mode	In this mode, the current consumption of the module is reduced to the minimal level, while the module keeps receiving paging messages, SMS, voice calls and TCP/UDP data from the network.	
Power Down Mode	In this mode, the power management unit shuts down the power supply. Software is inactive, the serial interfaces are inaccessible, and the operating voltage (connected to VCC) remains applied.	

3.4. Power Supply

The following table shows pin definition of VCC pins and ground pins.

Table 6: Definition of VCC and GND Pins

Pin No.	Pin Name	I/O	Power Domain	Description
2, 4, 70, 72, 74	VCC	PI	3.135–4.4 V	3.7 V typical DC supply
3, 5, 11, 27, 33, 39, 45, 51, 57, 71, 73	GND			Ground

3.4.1. Decrease Voltage Drop

The power supply range of the module is from 3.135 V to 4.4 V. Please ensure that the input voltage will never drop below 3.135 V, otherwise the module will be powered off automatically. The following figure shows the maximum voltage drop during radio transmission in 3G/4G/5G networks.
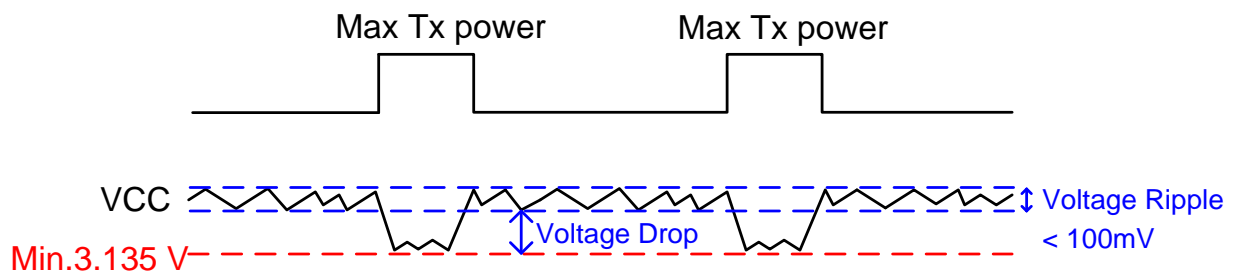
Figure 3: Power Supply Limits during Radio Transmission

The main power supply from an external system must be a single voltage source. To decrease voltage drop, a bypass capacitor of about 100 µF with low ESR (ESR = 0.7 Ω) should be used, and a multi-layer ceramic chip capacitor (MLCC) array also should be used due to its ultra-low ESR. It is recommended to use four ceramic capacitors (1 µF, 100 nF, 33 pF, 10 pF) for composing the MLCC array, and place these capacitors close to VCC pins. The width of VCC trace should be no less than 2 mm. In principle, the longer the VCC trace is, the wider it should be.

In addition, to guarantee stability of the power supply, please use a zener diode with a reverse zener voltage of 5.1 V and a dissipation power of higher than 0.5 W. The following figure shows a reference circuit of VCC.
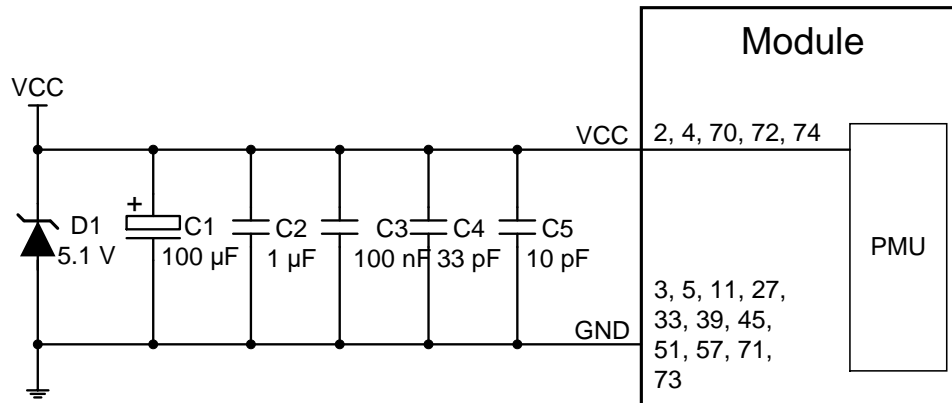
Figure 4: Reference Circuit of VCC Pins

3.4.2. Reference Design for Power Supply

Power design for the module is very important, as the performance of the module largely depends on the power source. The power supply is capable of providing a sufficient current of at least 3 A. If the voltage drop between the input and output is not too high, it is suggested that an LDO is used to supply power for the module. If there is a big voltage difference between the input source and the desired output (VCC = 3.7 V Typ.), a buck DC-DC converter is preferred as the power supply.

The following figure shows a reference design for +5 V input power source based on the DC-DC TPS54319. The typical output of the power supply is about 3.7 V and the maximum load current is 3 A.
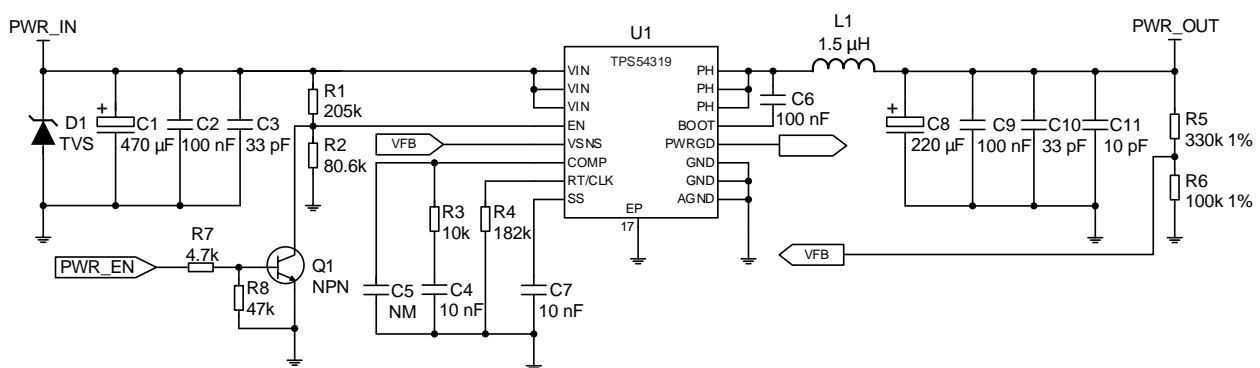
Figure 5: Reference Design of Power Supply

NOTE

To avoid damages to the internal flash, please do not switch off the power supply directly when the module is working. It is suggested that the power supply can be cut off after the module is powered off by pulling down the FULL_CARD_POWER_OFF# pin for more than 10 s.

3.5. Turn on and off Scenarios

3.5.1. Turn on the Module

FULL_CARD_POWER_OFF# asynchronous signal is an Active Low input that is used to turn off the entire module. When the input signal is asserted high (≥ 1.19 V), the module will be enabled. When the input signal is driven low signal (≤ 0.2 V) or Tri-stated, it will force the module to shut down.

This input signal is 3.3 V tolerant and can be driven by either 1.8 V or 3.3 V GPIO. Also, it has internally pulled down with a 100 kΩ resistor.

The following table shows the definition of FULL_CARD_POWER_OFF#.

Table 7: Definition of FULL_CARD_POWER_OFF# Pin

Pin No.	Pin Name	Description	DC Characteristics	Comment
6	FULL_CARD_POWER_OFF#	Turn on/off of the module.	$V_{IH(max)}$ = 4.4 V $V_{IH(min)}$ = 1.19 V $V_{IL(max)}$ = 0.2 V	Internally pulled down with a 100 kΩ resistor When it is at low level, the module is powered off. When it is at high level, the module is powered on.

The timing of turn-on scenario is illustrated in the following figure.
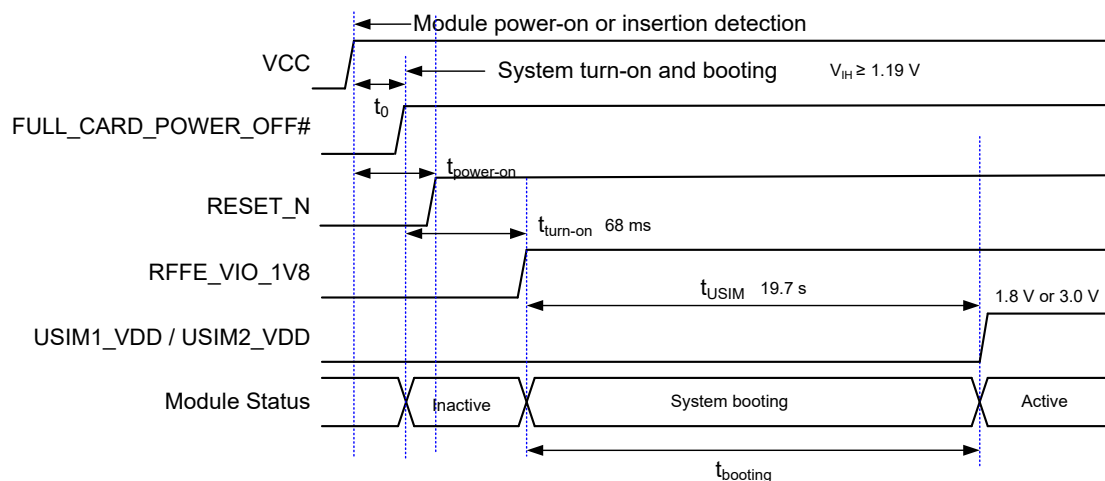
Figure 6: Turn-on Timing of the Module

It is recommended to use a host GPIO to control FULL_CARD_POWER_OFF#. A simple reference circuit is illustrated in the following figure.
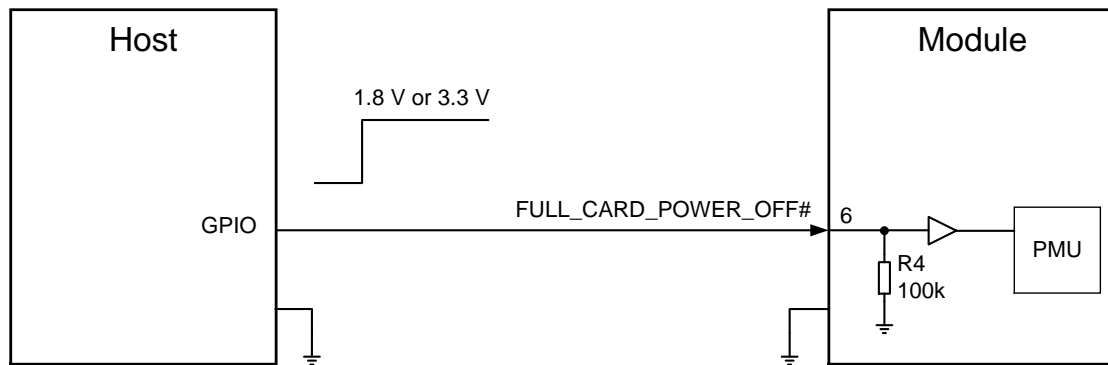
Note: The voltage of pin 6 should be no less than 1.19 V when it is at HIGH level.

Figure 7: Turn on the Module with a Host GPIO

NOTES

1. $t_{power-on}$ is the interval between VCC and RESET_N high voltage level. It is measured when RESET_N is not pulled down by the host device.
2. $t_{turn-on}$ is the interval between FULL_CARD_POWER_OFF# high voltage level and RFFE_VIO_1V8 (an internal LDO output) high voltage level, which is typically 68 ms.
3. t_0 is the interval between VCC and FULL_CARD_POWER_OFF# high voltage level. FULL_CARD_POWER_OFF# could be pulled up at any time decided by the host, as shown in figure above.
4. $t_{booting}$ is the interval between RFFE_VIO_1V8 high voltage level and the USIM_VDD power-on.

3.5.2. Turn off the Module

3.5.2.1. Turn off the Module through FULL_CARD_POWER_OFF#

For the design that turns on the module with a host GPIO, when the power is supplied to VCC, pulling down FULL_CARD_POWER_OFF# pin will turn off the module.

The timing of turning-off scenario is illustrated in the following figure.
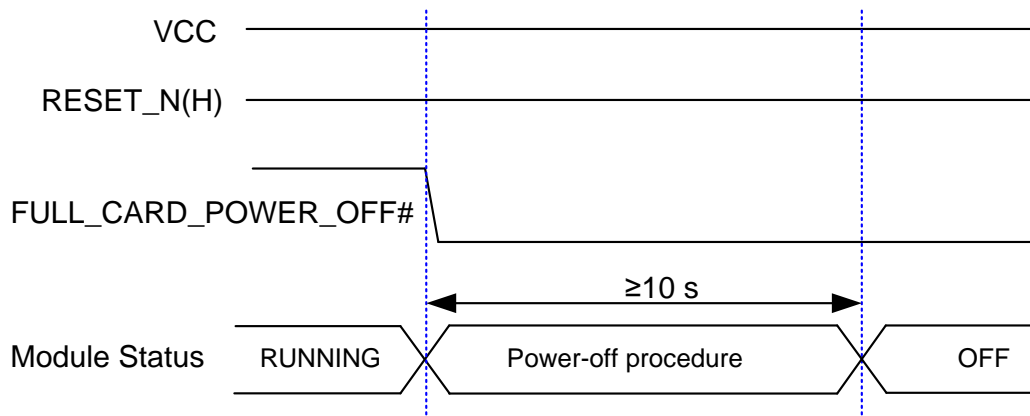
Figure 8: Turn-off Timing through FULL_CARD_POWER_OFF#

3.5.2.2. Turn off the Module through AT Command

It is also a safe way to use **AT+QPOWD** command to turn off the module. For more details about the command, see *document [2]*.

The module is designed to be turned on with a host GPIO. Pull down FULL_CARD_POWER_OFF# pin after the module's USB/PCIe is removed. Otherwise, the module will be powered on again.
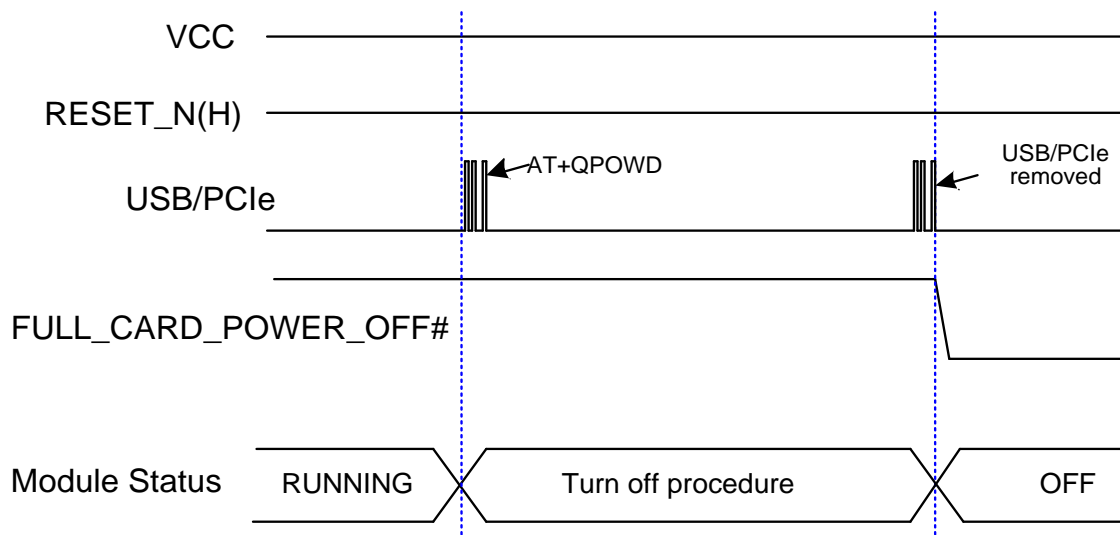
Figure 9: Turn-off Timing through AT Command and FULL_CARD_POWER_OFF#

NOTE

Please pull down FULL_CARD_POWER_OFF# pin immediately or cut off the power supply VCC when the host detects that the module USB/PCIe is removed.

3.6. Reset the Module

RESET_N is an asynchronous and active low signal (1.5 V logic level). Whenever this pin is active, the module will immediately be placed in a Power On Reset (POR) condition.

CAUTION: Triggering the RESET# signal will lead to loss of all data in the modem and the removal of system drivers. It will also disconnect the modem from the network.

Table 8: Definition of RESET_N Pin

Pin No.	Pin Name	Description	DC Characteristics	Comment
67	RESET_N	Reset the module	$V_{IH(max)}$ = 1.5 V $V_{IH(min)}$ = TBD $V_{IL(max)}$ = TBD	Internally pulled up to 1.5 V with a 100 kΩ resistor

The module can be reset by pulling down the RESET_N pin for 200–700 ms. An open collector/drain driver or button can be used to control the RESET_N pin.
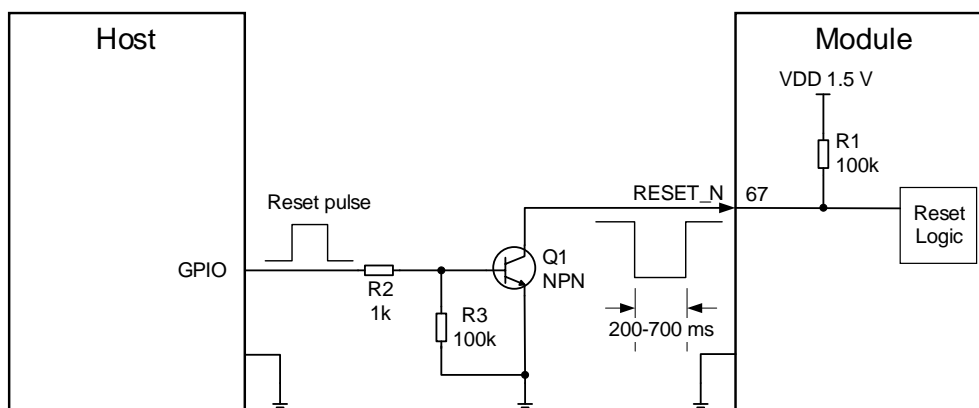
Figure 10: Reference Circuit of RESET_N with NPN Driving Circuit
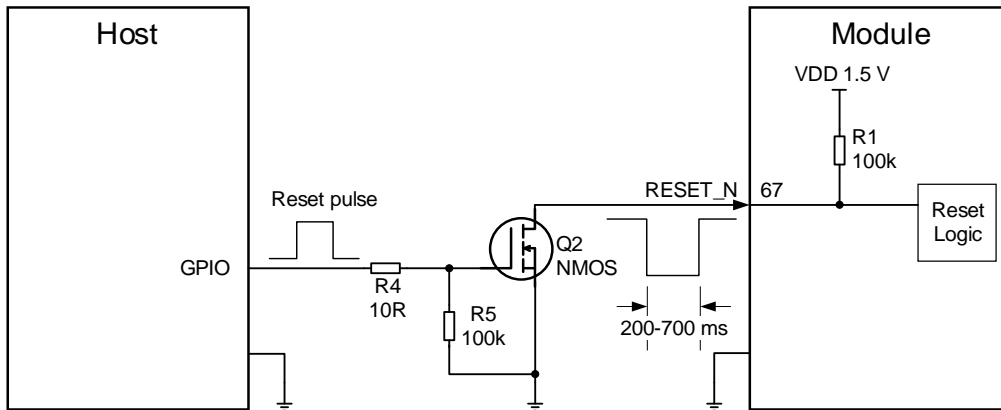
Figure 11: Reference Circuit of RESET_N with NMOS Driving Circuit
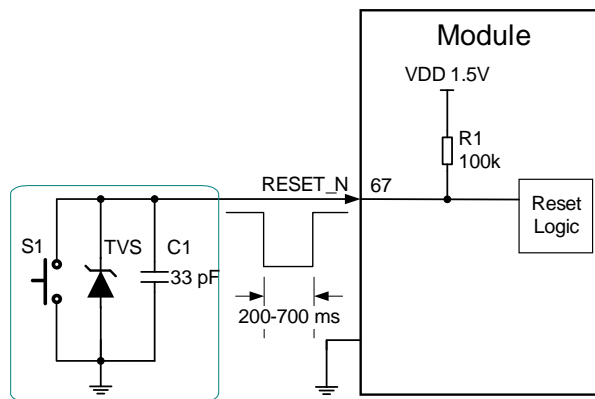
Note: The capacitor C1 is recommended to be less than 47 pF.

The reset scenario is illustrated in the following figure.
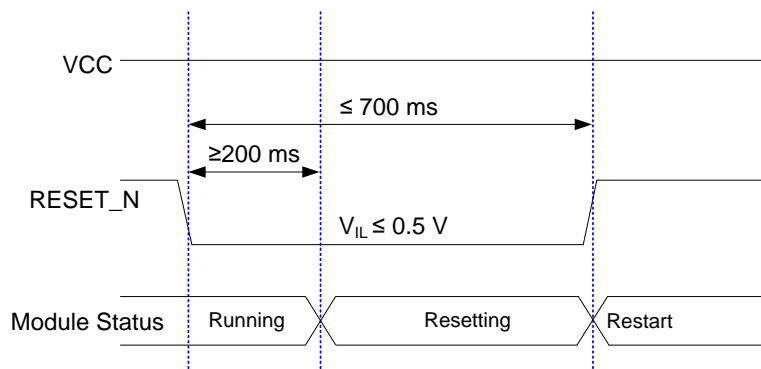
Figure 12: Resetting Timing of the Module

3.7. (U)SIM Interface

The (U)SIM interface circuitry meets ETSI and IMT-2000 requirements. Both Class B (3.0 V) and Class C (1.8 V) (U)SIM cards are supported, and Dual SIM Single Standby* function is supported.

Table 9: Pin Definition of (U)SIM Interfaces

Pin No.	Pin Name	I/O	Description	Comment
36	USIM_VDD	PO	Power supply for (U)SIM card	Class B (3.0 V) and Class C (1.8 V)
34	USIM_DATA	IO	(U)SIM card data	1.8/3.0 V power domain
32	USIM_CLK	DO	(U)SIM card clock	1.8/3.0 V power domain
30	USIM_RST	DO	(U)SIM card reset	1.8/3.0 V power domain
66	USIM_DET	DI	(U)SIM card insertion detection.	Internally pulled up

NOTE

"*" means under development.

RM500Q-AE&RM502Q-AE supports (U)SIM card hot-plug via the USIM_DET pin. With a normally closed (U)SIM card connector, the USIM_DET is normally short-circuited to ground when a (U)SIM card is not inserted, and the USIM_DET will change from low to high voltage level when a (U)SIM card is inserted. The rising edge indicates an insertion of the (U)SIM card. When the (U)SIM card is removed, USIM_DET will change from high to low voltage level. This falling edge indicates a removal of the (U)SIM card.

Normally Closed (U)SIM Card Connector:

● When the (U)SIM is absent, CD is short-circuited to ground and USIM_DET is at low voltage level.
● When the (U)SIM is inserted, CD is open from ground and USIM_DET is at high voltage level.

The following figure shows a reference design of (U)SIM interface with a normally closed (U)SIM card connector.
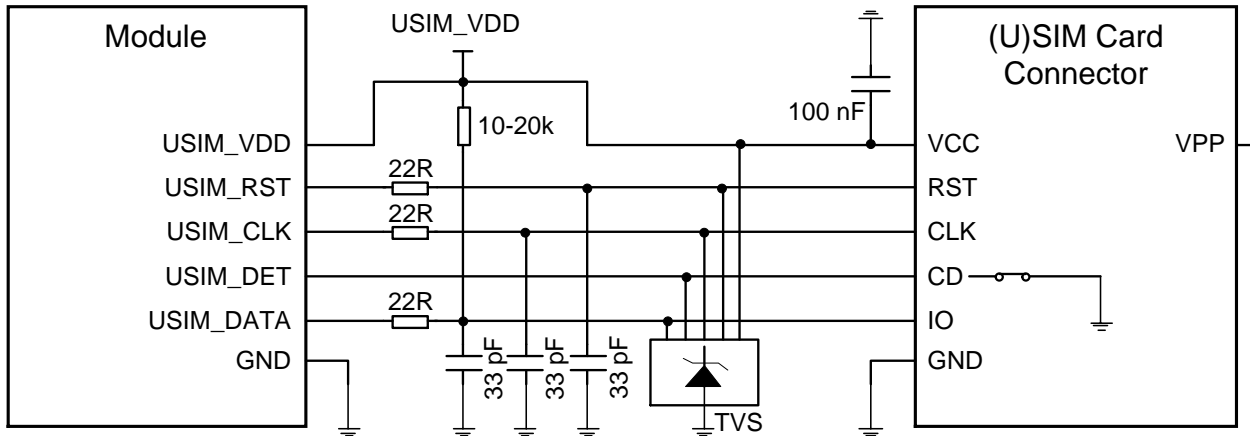
Note: All these resistors, capacitors and TVS should be close to (U)SIM card connector in PCB layout.

Figure 13: Reference Circuit for Normally Closed (U)SIM Card Connector

Normally Open (U)SIM Card Connector:

- When the (U)SIM is absent, CD1 is open from CD2 and USIM_DET is at low voltage level.
- When the (U)SIM is inserted, CD1 is short-circuited to 1.8 V and USIM_DET is at high voltage level.

The following figure shows a reference design of (U)SIM interface with a normally open (NO) (U)SIM card connector.
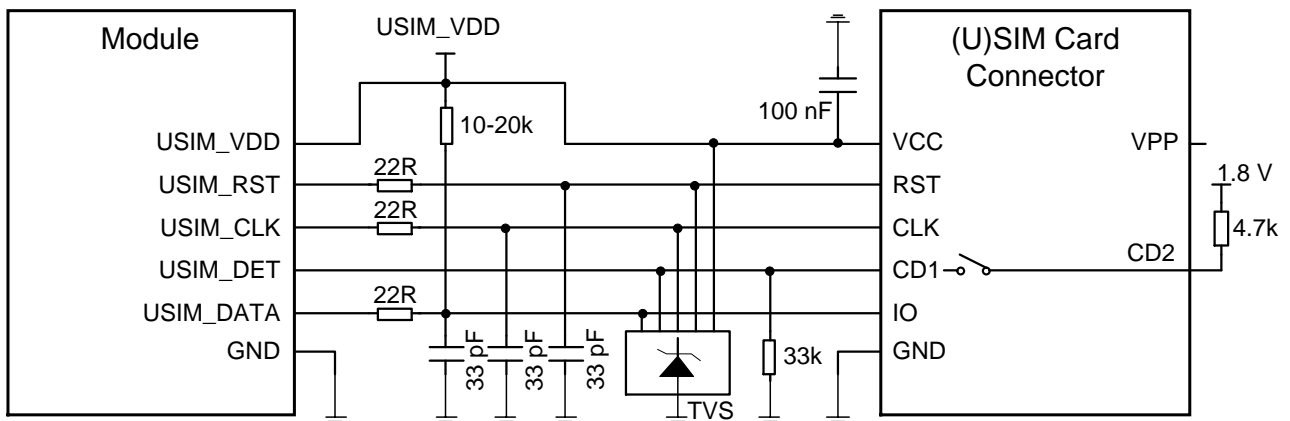
Note: All these resistors, capacitors and TVS should be close to (U)SIM card connector in PCB layout.

Figure 14: Reference Circuit for Normally Open (U)SIM Card Connector

If (U)SIM card detection function is not needed, please keep USIM_DET disconnected. A reference circuit for (U)SIM card interface with a 6-pin (U)SIM card connector is illustrated by the following figure.
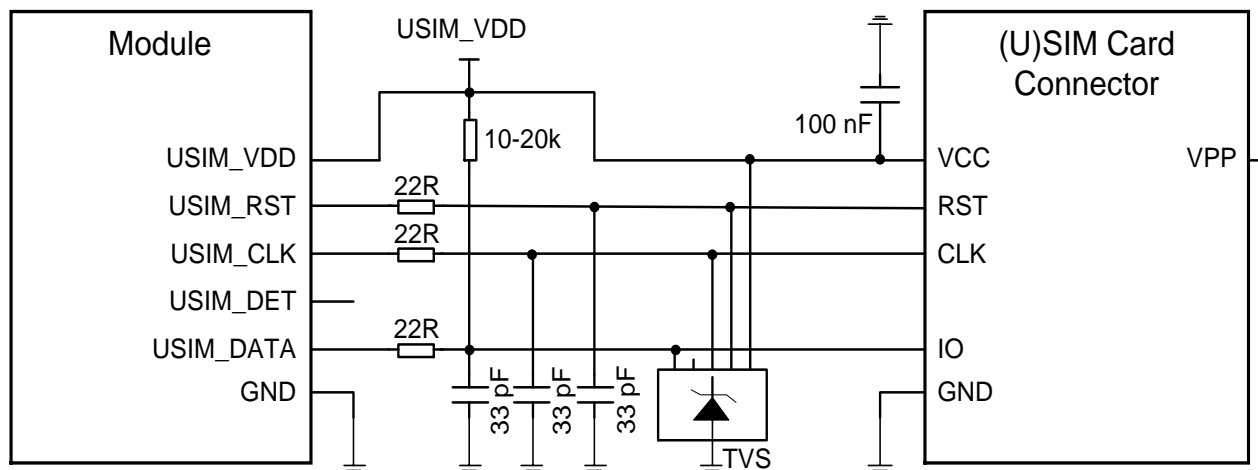
Note: All these resistors, capacitors and TVS should be close to (U)SIM card connector in PCB layout.

Figure 15: Reference Circuit for a 6-Pin (U)SIM Card Connector

To enhance the reliability and availability of the (U)SIM card in applications, please follow the criteria below in (U)SIM circuit design.

● Place the (U)SIM card connector as close to the module as possible. Keep the trace length less than 200 mm.
● Keep (U)SIM card signals away from RF and VCC traces.
● Make sure the ground between the module and the (U)SIM card connector is short and wide. Keep the trace width of ground and USIM_VDD no less than 0.5 mm to maintain the same electric potential.
● To avoid cross-talk between USIM_DATA and USIM_CLK, keep them away from each other and shield them with surrounded ground.
● To offer better ESD protection, add a TVS diode array of which the parasitic capacitance should be not higher than 10 pF. Add 22 Ω resistors in series between the module and the (U)SIM card connector to suppress EMI such as spurious transmission, and to enhance ESD protection. The 33 pF capacitors are used to filter out RF interference.
● For USIM_DATA, a 10–20 kΩ pull-up resistor must be added near the (U)SIM card connector.
● (U)SIM card hot-plug is disabled by default.

3.8. USB Interface

RM500Q-AE&RM502Q-AE module provides one integrated Universal Serial Bus (USB) interface which complies with the USB 3.1 & 2.0 specifications and supports super speed (10) on USB 3.1 and high speed (480 Mbps) and full speed (12 Mbps) modes on USB 2.0. The USB interface is used for AT command communication, data transmission, GNSS NMEA sentence output, software debugging, firmware upgrade.

Please note that only USB 2.0 can be used for firmware upgrade currently.

The following table shows the pin definition of USB interface.

Table 10: Pin Definition of USB Interface

Pin No.	Pin Name	I/O	Description	Comment
7	USB_DP	AI/AO	USB 2.0 differential data bus (+)	
9	USB_DM	AI/AO	USB 2.0 differential data bus (-)	
29	USB_SS_TX_M	AO	USB 3.1 transmit data (-)	Require differential impedance of 90 Ω
31	USB_SS_TX_P	AO	USB 3.1 transmit data (+)	
35	USB_SS_RX_M	AI	USB 3.1 receive data (-)	
37	USB_SS_RX_P	AI	USB 3.1 receive data (+)	

NOTE

"*" means under development.

For more details about the USB 3.1 & 2.0 specifications, please visit http://www.usb.org/home.

The USB 2.0 interface is recommended to be reserved for firmware upgrade in designs. The following figure shows a reference circuit of USB 3.1 & 2.0 interface.
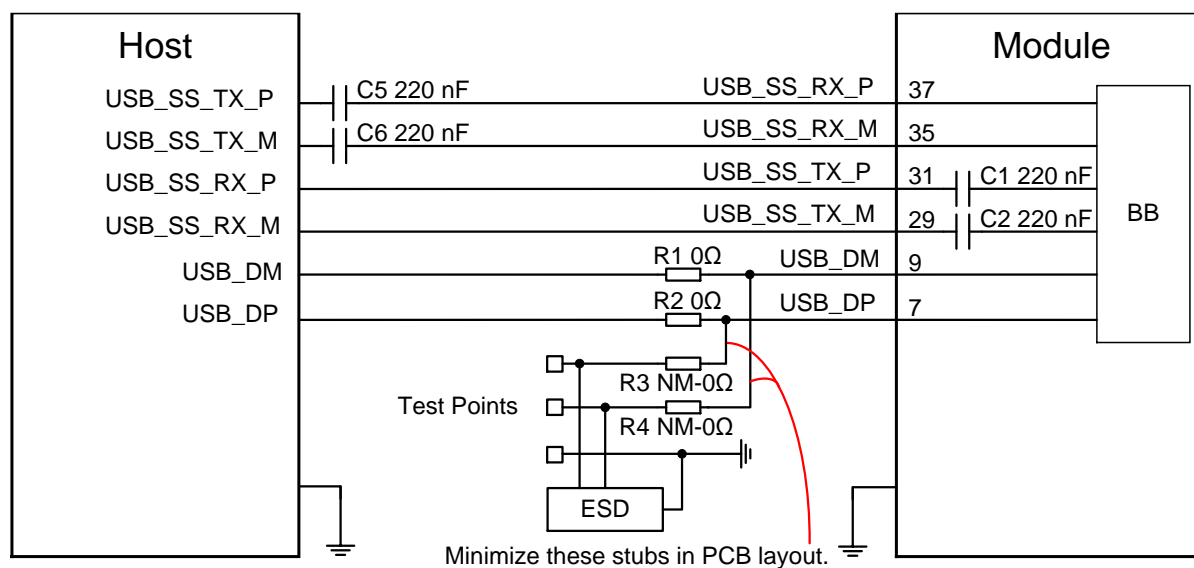
Figure 16: Reference Circuit of USB 3.1 & 2.0 Interface

AC coupling capacitors C5 and C6 must be placed close to the host and close to each other. C1 and C2 have been integrated inside the module, so do not place these two capacitors on customers' schematic and PCB. To ensure the signal integrity of USB 2.0 data traces, R1, R2, R3 and R4 must be placed close to the module, and the stubs must be minimized in PCB layout.

You should follow the principles below when designing for the USB interface to meet USB 3.1 and 2.0 specifications:

- Route the USB signal traces as differential pairs with ground surrounded. The impedance of differential trace of USB 2.0 and 3.1 is 90 Ω.
- For USB 2.0 signal traces, the trace length should be less than 120 mm, and the differential data pair matching should be less than 2 mm. For USB 3.1 signal traces, length matching of each differential data pair (Tx/Rx) should be less than 0.7 mm, while the matching between Tx and Rx should be less than 10 mm.
- Do not route signal traces under crystals, oscillators, magnetic devices, PCIe and RF signal traces. Route the USB differential traces in inner-layer of the PCB, and surround the traces with ground on that layer and with ground planes above and below.
- Junction capacitance of the ESD protection device might cause influences on USB data lines, so you should pay attention to the selection of the device. Typically, the stray capacitance should be less than 1.0 pF for USB 2.0, and less than 0.15 pF for USB 3.1.
- Keep the ESD protection devices as close to the USB connector as possible.
- If possible, reserve 0 Ω resistors on USB_DP and USB_DM lines respectively.

3.9. PCIe Interface

RM500Q-AE&RM502Q-AE modules provide one integrated PCIe (Peripheral Component Interconnect Express) interface which complies with the *PCI Express Base Specification, Revision 3.0* and supports up to 8 Gbps per lane.

- *PCI Express Base Specification Revision 3.0* compliant
- Data rate up to 8 Gbps per lane

The following table shows the pin definition of PCIe interface.

Table 11: Pin Definition of PCIe Interface

Pin No.	Pin Name	I/O	Description	Comment
55	PCIE_REFCLK_P	AI/AO	PCIe reference clock (+)	100 MHz. Require differential impedance of 85 Ω
53	PCIE_REFCLK_M	AI/AO	PCIe reference clock (-)	
49	PCIE_RX_P	AI	PCIe receive (+)	Require differential impedance of 85 Ω
47	PCIE_RX_M	AI	PCIe receive (-)	
43	PCIE_TX_P	AO	PCIe transmit (+)	Require differential impedance of 85 Ω
41	PCIE_TX_M	AO	PCIe transmit (-)	
50	PCIE_RST_N	DI	PCIe reset.	Open drain Active LOW.
52	PCIE_CLKREQ_N	DO	PCIe clock request.	Open drain Active LOW.
54	PCIE_WAKE_N	DO	PCIe wake up	Open drain Active LOW.

3.9.1. PCIe Operating Mode

RM500Q-AE&RM502Q-AE supports endpoint (EP) mode and root complex (RC) mode. In EP mode, the module is configured as a PCIe EP device. In RC mode, the module is configured as a PCIe root complex. The following figure shows a reference circuit for the PCIe interface.
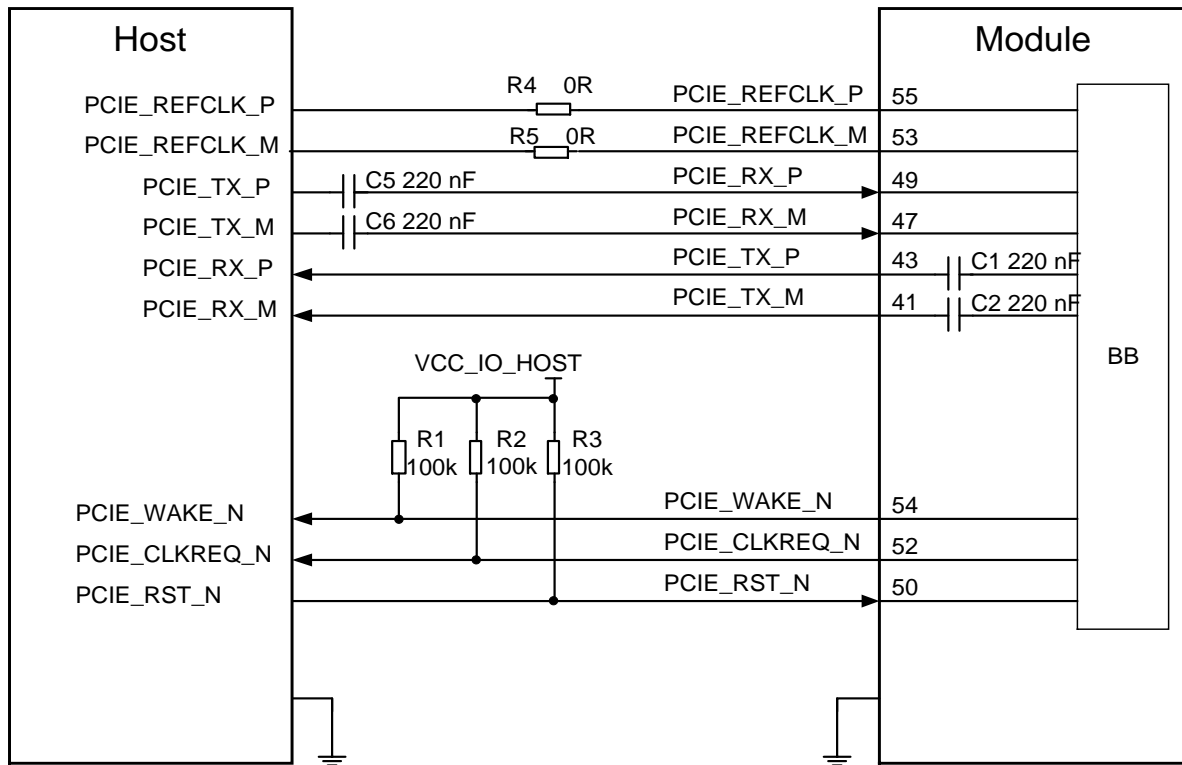
Note: The voltage level of VCC_IO_HOST depends on the host side due to the open drain in pins 50, 52 and 54.

Figure 17: PCIe Interface Reference Circuit

AT+QCFG="pcie/mode" is used to set PCIe RC/EP mode. For more details about the command, see *document [2]*.

To ensure the signal integrity of PCIe interface, AC coupling capacitors C5 and C6 should be placed close to the host on PCB. C1 and C2 have been embedded into the module, so do not place these two capacitors on your schematic and PCB.

Symbol	Parameter	Min	Max	Units
T_{PVPGL}	Power Valid* to PERST# input inactive	Implementation specific; recommended 50 ms		ms
$T_{PERST\#-CLK}$	REFCLK stable before PERST# inactive	100		µs
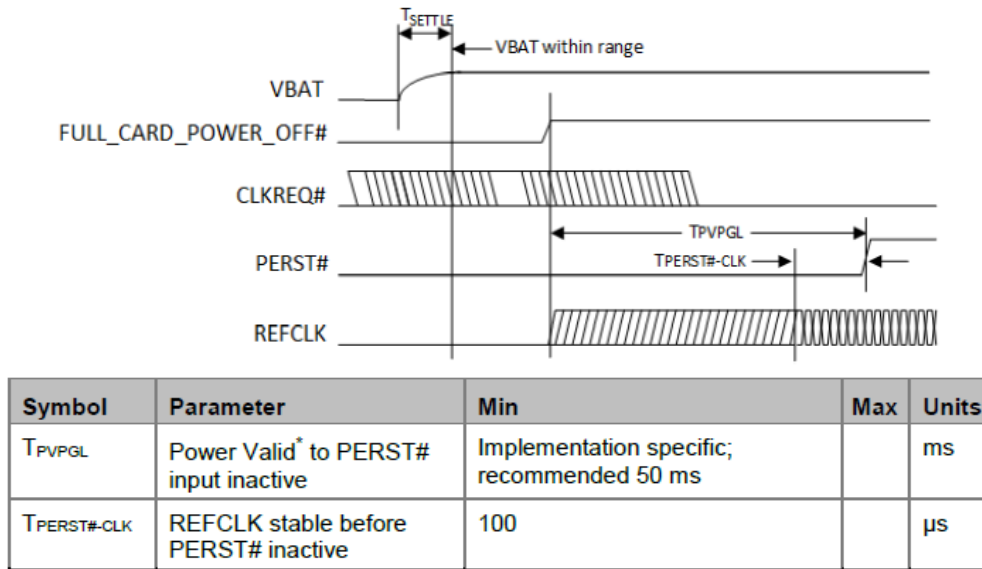
Figure 18: PCIe Power-on Timing Requirements of M.2 Specification
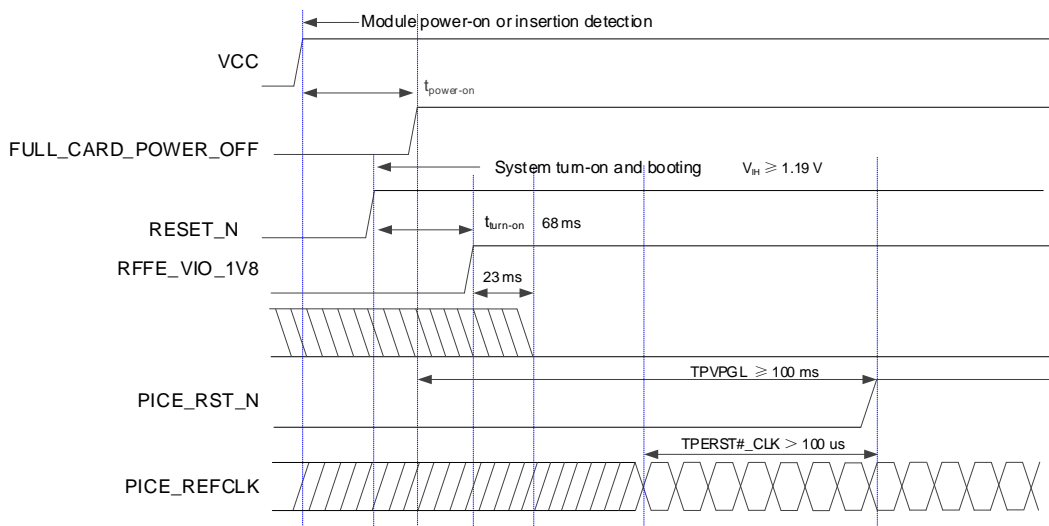
Figure 19: PCIe Power-on Timing Requirements of the Module

The following principles of PCIe interface design should be complied with, so as to meet PCIe specification.

- Keep the PCIe data and control signals away from sensitive circuits and signals, such as RF, audio, crystal and oscillator signals.
- Add a capacitor in series on Tx/Rx traces to prevent any DC bias.
- Keep the maximum trace length less than 300 mm.
- Keep the length matching of each differential data pair (Tx/Rx) less than 0.7 mm for PCIe routing traces.

● Keep the differential impedance of PCIe data trace as 85 Ω ±10 %.
● You must not route PCIe data traces under components or cross them with other traces.

3.9.2. USB and PCIe Modes

RM500Q-AE&RM502Q-AE supports to communicate through both USB and PCIe interfaces, respectively referring to the USB mode and the PCIe mode as described below:

USB Mode

● Supports all USB 2.0/3.1 features
● Supports MBIM/QMI/QRTR/AT
● Communication can be switched to PCIe mode by AT command

USB is the default communication interface between RM500Q-AE&RM502Q-AE module and a host. To use PCIe interface for the communication between a host, an AT command under USB mode can be used. For more details about the AT command, see *document [2]*.

It is suggested that USB 2.0 interface be reserved for firmware upgrade.

USB-AT-based PCIe Mode

● Supports MBIM/QMI/QRTR/AT
● Communication can be switched back to USB mode by AT command

When RM500Q-AE&RM502Q-AE module works at the USB-AT-based (switched from USB mode by AT command) PCIe mode, it supports MBIM/QMI/QRTR/AT, and can be switched back to USB mode by AT command. But the firmware upgrade via PCIe interface is not supported, so USB 2.0 interface must be reserved for the firmware upgrade.

eFuse-based PCIe Mode

● Supports MBIM/QMI/QRTR/AT
● Supports Non-X86 systems and X86 system (supports BIOS PCIe early initial)

RM500Q-AE&RM502Q-AE can also be reprogrammed to PCIe mode based on eFuse. If the communication is switched to PCIe mode by burnt eFuse, the communication cannot be switched back to USB mode.

Note that if the host does not support firmware upgrade through PCIe, then RM500Q-AE&RM502Q-AE USB 2.0 interface (Pin 7 and Pin 9) and two test points (VREG_L6E_1P8 and FORCE_USB_BOOT, reserved on bottom side) must be used for the firmware upgrade. Also, the firmware can be upgraded by the PCIe Card EVB, which could be inserted into a PC. For more details, see *document [1]*.

3.10. PCM Interface*

RM500Q-AE&RM502Q-AE module supports audio communication via Pulse Code Modulation (PCM) digital interface. The PCM interface supports the following modes:

● Primary mode (short frame synchronization): the module works as both master and slave
● Auxiliary mode (long frame synchronization): the module works as master only

In primary mode, the data is sampled on the falling edge of the PCM_CLK and transmitted on the rising edge. The PCM_SYNC falling edge represents the MSB. In this mode, the PCM interface supports 256 kHz, 512 kHz, 1024 kHz or 2048 kHz PCM_CLK at 8 kHz PCM_SYNC, and also supports 4096 kHz PCM_CLK at 16 kHz PCM_SYNC.

In auxiliary mode, the data is sampled on the falling edge of the PCM_CLK and transmitted on the rising edge. The PCM_SYNC rising edge represents the MSB. In this mode, PCM interface operates with a 256 kHz PCM_CLK and an 8 kHz, 50 % duty cycle PCM_SYNC only.

The module supports 16-bit linear data format. The following figures show the primary mode's timing relationship with 8 kHz PCM_SYNC and 2048 kHz PCM_CLK, as well as the auxiliary mode's timing relationship with 8 kHz PCM_SYNC and 256 kHz PCM_CLK.
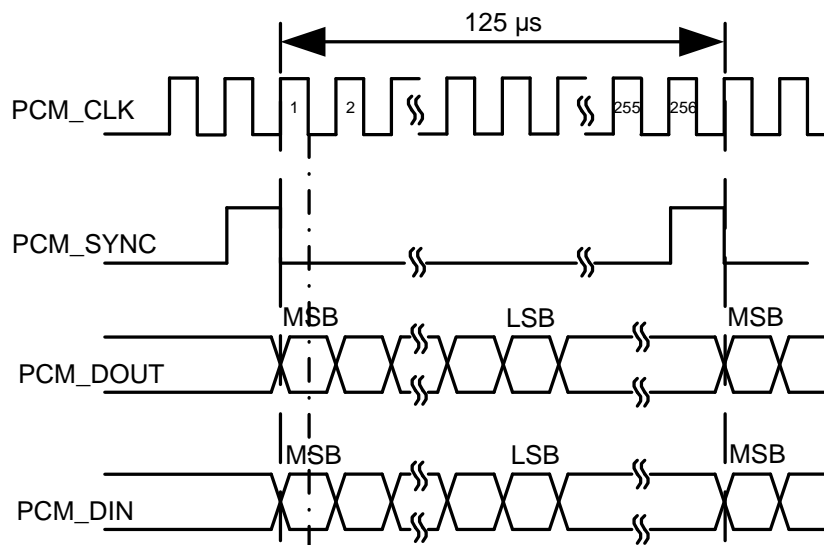
Figure 20: Primary Mode Timing
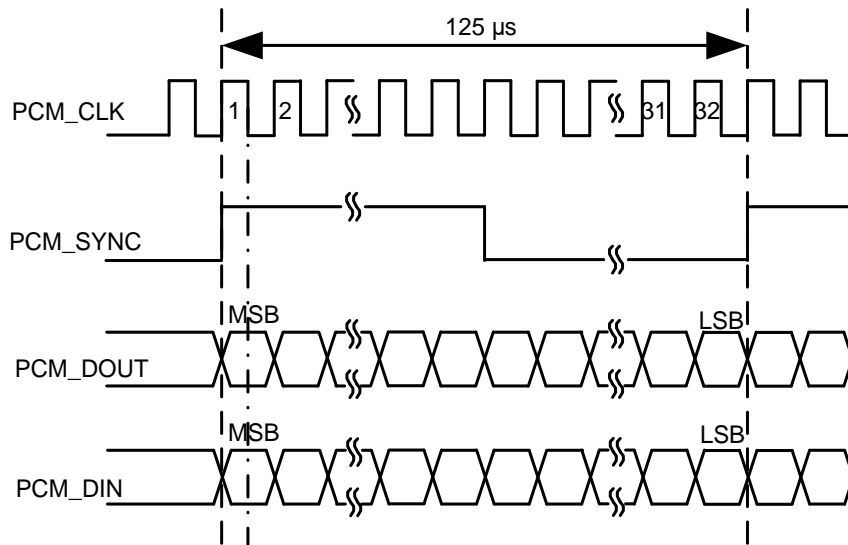
Figure 21: Auxiliary Mode Timing

The following table shows the pin definition of PCM interface which can be applied to audio codec design.

Table 12: Pin Definition of PCM Interface

Pin No.	Pin Name	I/O	Description	Comment
20	PCM_CLK	IO	PCM data bit clock	1.8 V power domain In master mode, it is an output signal. In slave mode, it is an input signal. If unused, keep it open.
22	PCM_DIN	DI	PCM data input	1.8 V power domain
24	PCM_DOUT	DO	PCM data output	1.8 V power domain
28	PCM_SYNC	IO	PCM data frame sync	1.8 V power domain

The clock and mode can be configured by AT command, and the default configuration is master mode using short frame synchronization format with 2048 kHz PCM_CLK and 8 kHz PCM_SYNC. See **document [2]** for details about **AT+QDAI** command.

NOTE

"*" means under development.

3.11. Control and Indication Interfaces

The following table shows the pin definition of control and indication pins.

Table 13: Pin Definition of Control and Indication Interfaces

Pin No.	Pin Name	I/O	Description	Comment
8	W_DISABLE1#*	DI	Airplane mode control. Active LOW.	1.8/3.3 V
10	WWAN_LED#*	OD	Indicate RF status of the module.	Open drain and active low signal.
23	WAKE_ON_WAN#*	OD	Wake up the host.	Open drain and active low signal.
25	DPR*	DI	Dynamic power reduction.	1.8 V power domain. High voltage level by default.
26	W_DISABLE2#*	DI	GNSS disable control.	1.8/3.3 V power domain. Active LOW.
38	SDX2AP_STATUS	DO	Status indication to AP	1.8 V power domain
68	AP2SDX_STATUS	DI	Status indication from AP	1.8 V power domain

NOTE

"*" means under development.

3.11.1. W_DISABLE1#*

The module provides a W_DISABLE1# pin to disable or enable airplane mode through hardware operation. The W_DISABLE1# pin is pulled up by default. Driving it low will set the module to airplane mode. In airplane mode, the RF function will be disabled.

The RF function can also be enabled or disabled through software AT commands. The following table shows the RF function status of the module.

Table 14: RF Function Status

W_DISABLE1# Level	AT Commands	RF Function Status
High Level	**AT+CFUN=1**	Enabled
High Level	**AT+CFUN=0** **AT+CFUN=4**	Disabled
Low Level	**AT+CFUN=0** **AT+CFUN=1** **AT+CFUN=4**	Disabled

3.11.2. W_DISABLE2#*

RM500Q-AE&RM502Q-AE module provides a W_DISABLE2# pin to disable or enable the GNSS function. The W_DISABLE2# pin is pulled up by default. Driving it low will disable the GNSS function. The combination of W_DISABLE2# pin and AT commands can control the GNSS function.

Table 15: GNSS Function Status

W_DISABLE2# Level	AT Commands	GNSS Function Status
High Level	**AT+QGPS=1**	Enabled
High Level	**AT+QGPSEND**	Disabled
Low Level	**AT+QGPS=1**	Disabled
Low Level	**AT+QGPSEND**	

A simple level shifter based on diodes is used on W_DISABLE1# pin and W_DISABLE2# pin which are pulled up to a 1.8 V voltage in the module, as shown in the following figure. So the control signals (GPIO) of the host device could be at 1.8 V or 3.3 V voltage level. W_DISABLE1# and W_DISABLE2# are active low signals, and a reference circuit is shown as below.
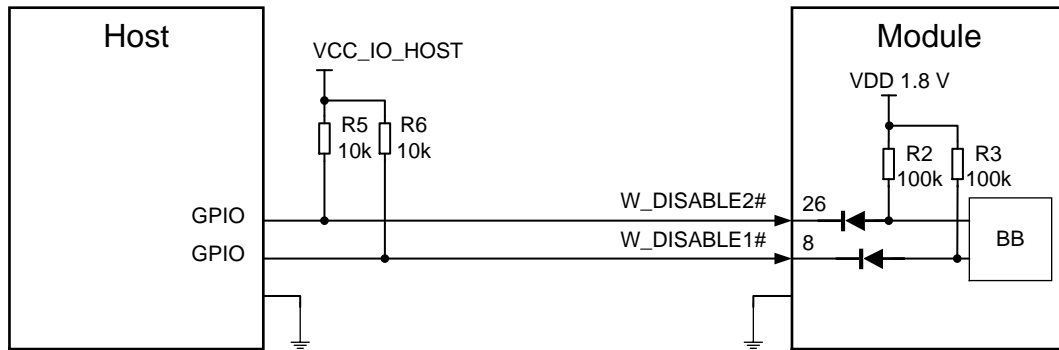
Note: The voltage level of VCC_IO_HOST could be 1.8 V or 3.3 V typically.

Figure 22: W_DISABLE1# and W_DISABLE2# Reference Circuit

3.11.3. WWAN_LED#*

The WWAN_LED# signal is used to indicate RF status of the module, and its sink current is up to 10 mA.

To reduce current consumption of the LED, a current-limited resistor must be placed in series with the LED, as illustrated in the figure below. The LED is ON when the WWAN_LED# signal is at low level.
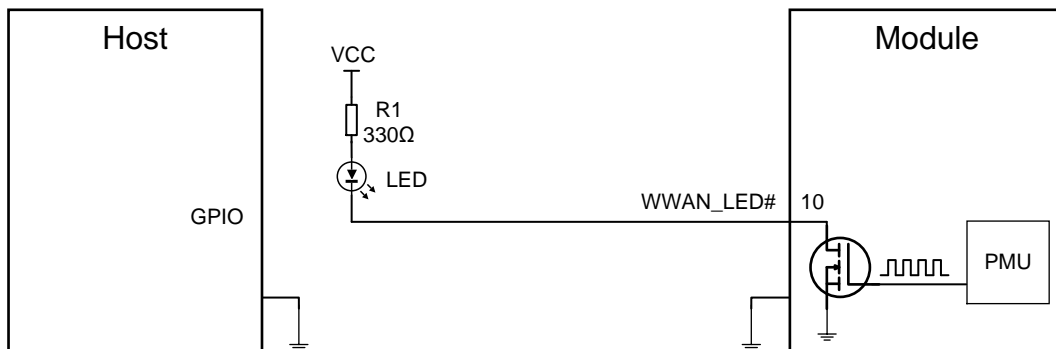
Note: This VCC could be the power supply of the module.

Figure 23: WWAN_LED# Reference Circuit

The following table shows the RF status indicated by WWAN_LED# .

Table 16: Network Status Indications of WWAN_LED#

WWAN_LED# Level	Description
Low Level (LED ON)	RF function is turned on
High Level (LED OFF)	RF function is turned off if any of the following occurs: ● The (U)SIM card is not powered. ● W_DISABLE1# is at low level (airplane mode enabled). ● **AT+CFUN=4** (RF function disabled).

3.11.4. WAKE_ON_WAN#*

The WAKE_ON_WAN# is an open drain pin, which requires a pull-up resistor on the host. When a URC returns, a 1 s low level pulse signal will be outputted to wake up the host. The module operation status indicated by WAKE_ON_WAN# is shown as below.

Table 17: State of the WAKE_ON_WAN#

WAKE_ON_WAN# State	Module Operation Status
Output a 1 s low level pulse signal	Call/SMS/Data is incoming (to wake up the host)
Always at high level	Idle/Sleep
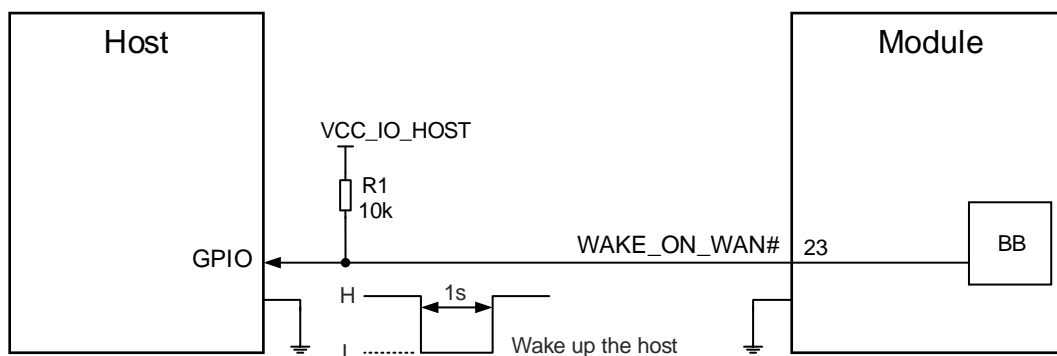
Note: The voltage level on VCC_IO_HOST depends on the host side due to the open drain in pin 23.

Figure 24: WAKE_ON_WAN# Signal Reference Circuit

3.11.5. DPR*

RM500Q-AE&RM502Q-AE module provides a DPR (Dynamic Power Reduction) pin for body SAR

(Specific Absorption Rate) detection. The signal is sent from a host system proximity sensor to the module to provide an input trigger, which will reduce the output power in radio transmission.

Table 18: Function of the DPR Signal

DPR Level	Function
High/Floating	NO max. transmitting power backoff
Low	Max. transmitting power backoff by **AT+QCFG="sarcfg"**

NOTE

See *document [2]* for more details about **AT+QCFG="sarcfg"** command.

3.11.6. STATUS*

RM500Q-AE&RM502Q-AE module provides two status indication pins for communication with IPQ807x device. Pin 38 (SDX2AP_STATUS) outputs the status indication signal to IPQ807x device, and pin 68 (AP2SDX_STATUS) inputs the status indication signal from IPQ807x device.

3.12. Cellular/WLAN Interface*

RM500Q-AE&RM502Q-AE module provides a cellular/WLAN COEX interface, the following table shows the pin definition of this interface.

Table 19: Pin Definition of COEX Interface

Pin No.	Pin Name	I/O	Description	Comment
62	COEX_RXD	DI	LTE/WLAN coexistence receive	1.8 V power domain
64	COEX_TXD	DO	LTE/WLAN coexistence transmit	1.8 V power domain
59	LAA_TX_EN	DO	Notification from SDR to WL when LTE transmitting	1.8 V power domain
60	WLAN_TX_EN	DI	Notification from WL to SDR while transmitting	1.8 V power domain

NOTE

"*" means under development.

3.13. Antenna Tuner Control Interface*

ANTCTL[1:2] are used for antenna tuner control and should be routed to an appropriate antenna control circuit. More details about the interface will be added in the future version of this document.

Table 20: Pin Definition of Antenna Tuner Control Interface

Pin No.	Pin Name	I/O	Description	DC Characteristics
56	RFFE_CLK	DO	Used for external MIPI IC control	V_{OL}max = 0.45 V V_{OH}min = 1.35 V V_{OH}max = 1.8 V
58	RFFE_DATA	DO		
61	ANTCTL1	DO	Antenna Control	V_{OL}max = 0.45 V V_{OH}min = 1.35 V V_{OH}max = 1.8 V
63	ANTCTL2	DO		

NOTE

"*" means under development.

3.14. Configuration Pins

RM500Q-AE&RM502Q-AE module provides four configuration pins, which are defined as below.

Table 21: Definition of Configuration Pins

Pin No.	Pin Name	I/O	Power Domain	Description
21	CONFIG_0	DO	0	Not connected internally
69	CONFIG_1	DO	0	Connected to GND internally

| 75 | CONFIG_2 | DO | 0 | Not connected internally |
| 1 | CONFIG_3 | DO | 0 | Not connected internally |

The following figure shows a reference circuit of these four pins.
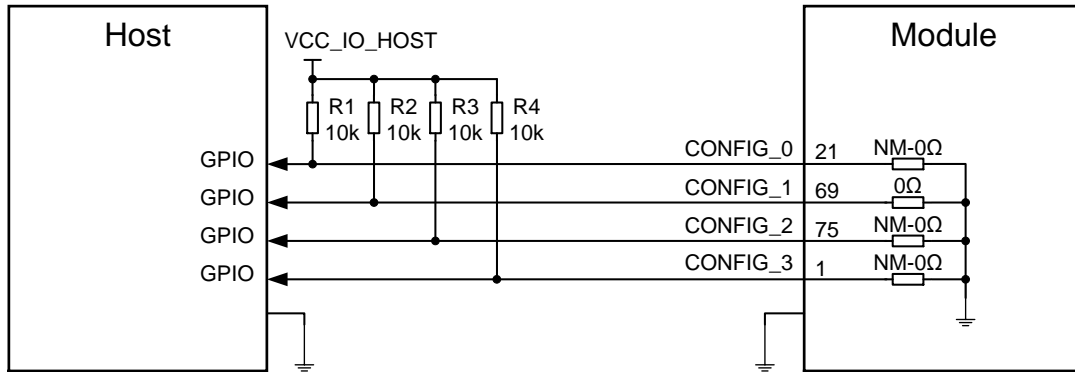
Note: The voltage level of VCC_IO_HOST depends on the host side and could be 1.8 V or 3.3 V.

Figure 25: Recommended Circuit of Configuration Pins

Table 22: Configuration Pins List of M.2 Specification

Config_0 (Pin 21)	Config_1 (Pin 69)	Config_2 (Pin 75)	Config_3 (Pin 1)	Module Type and Main Host Interface	Port Configuration
NC	GND	NC	NC	Quectel defined	N/A

4 GNSS Receiver

4.1. General Description

RM500Q-AE&RM502Q-AE module includes a fully integrated global navigation satellite system solution that supports Gen9-Lite of Qualcomm (GPS, GLONASS, BeiDou/Compass, and Galileo).

The module supports standard NMEA-0183 protocol, and outputs NMEA sentences at 1 Hz data update rate via USB interface by default.

By default, the module GNSS engine is switched off. It has to be switched on via AT command. For more details about GNSS engine technology and configurations, see *document [3]*.

4.2. GNSS Performance

The following table shows GNSS performance of RM500Q-AE&RM502Q-AE.

Table 23: GNSS Performance

Parameter	Description	Conditions	Typ.	Unit
Sensitivity (GNSS)	Cold start	Autonomous	TBD	dBm
	Reacquisition	Autonomous	TBD	dBm
	Tracking	Autonomous	TBD	dBm
TTFF (GNSS)	Cold start @ open sky	Autonomous	TBD	s
		XTRA enabled	TBD	s
	Warm start @ open sky	Autonomous	TBD	s
		XTRA enabled	TBD	s

	Hot start @ open sky	Autonomous	TBD	s
		XTRA enabled	TBD	s
Accuracy (GNSS)	CEP-50	Autonomous @ open sky	TBD	m

NOTES

1. Tracking sensitivity: the minimum GNSS signal power at which the module can maintain lock (keep positioning for at least 3 minutes continuously).
2. Reacquisition sensitivity: the minimum GNSS signal power required for the module to maintain lock within 3 minutes after the loss of lock.
3. Cold start sensitivity: the minimum GNSS signal power at which the module can fix position successfully within 3 minutes after executing cold start command.

5 Antenna Interfaces

RM500Q-AE&RM502Q-AE provides four antenna interfaces, the impedance of antenna port is 50 Ω.

5.1. RF Antenna Interfaces

5.1.1.   Antenna Pin Definition

The pin definition of RF antenna interfaces is shown below.

Table 24: RM500Q-AE&RM502Q-AE Pin Definition of RF Antenna Interfaces

Pin Name	I/O	Description	Comment
ANT0	AI/AO	Antenna0 interface: 5G NR: MHB_TRx & n41/n77/n78/n79_PRX MIMO; LTE: MHB_TRx & UHB_PRX MIMO WCDMA: MHB_TRx	50 Ω impedance

ANT1	AI/AO	Antenna1 interface:
		5G NR: LB_TRx & MHB_DRx MIMO &
		        n41_DRX & n77/n78/n79_DRx MIMO
		LTE: LB_TRx & MHB_DRx MIMO & UHB_DRx MIMO &
		        LAA_PRx
		WCDMA: LB_TRx
			50 Ω impedance

ANT2	AI/AO	Antenna2 interface: 5G NR: MHB_PRX MIMO & n41/n77/n78/n79 TRX LTE: LB_DRX & MHB_PRX MIMO & UHB_TRX WCDMA: LB_DRX	50 Ω impedance
ANT3_ GNSSL1	AI	Antenna3 interface: 5G NR: n41_DRX MIMO & n77/n78/n79_DRX LTE: MHB_DRX & UHB_DRX & LAA_DRX WCDMA: MHB_DRX GNSS: L1	50 Ω impedance

5.1.2. RF Antenna Port Mapping

Table 25: RM500Q-AE & RM502Q-AE RF Antenna Mapping

| Antenna | WCDMA | 4G | 5G NR | | LB (MHz) | MHB (MHz) | n77 (MHz) |
			n41	n77/n78/n79			
ANT0	MHB TRX	MHB_TRx UHB_PRx MIMO	PRx MIMO	PRx_ MIMO	–	1452 to 2690	3300 to 4200
ANT1	LB_TRx	LB_TRx MHB_DRx MIMO, UHB_DRx MIMO, LAA PRx	DRx	DRx_ MIMO	617 to 960	1452 to 2690	3300 to 4200
ANT2	LB_DRx	LB_DRx, MHB_PRx MIMO, UHB_TRx [1]	TRx	TRx	617 to 960	1452 to 2690	3300 to 4200
ANT3_ GNSSL1	MHB DRx	MHB_DRx, UHB_DRX, LAA_DRx	DRx_ MIMO	DRx	–	1452 to 2690	3300 to 4200

[1] LTE UHB frequency range: 3400 – 5000 MHz.

NOTE

5.1.3. Operating Frequency

Table 26: RM500Q-AE&RM502Q-AE Module Operating Frequencies

Band Name	Transmit (MHz)	Receive (MHz)	LTE-FDD	LTE-TDD	UMTS	5G NR
PCS (1900)	1850–1910	1930–1990	B2	–	B2	n2
AWS	1710–1755	2110–2155	B4	–	B4	–
Cell (850)	824–849	869–894	B5	–	B5	n5
IMT-E (2600)	2500–2570	2620–2690	B7	–	–	n7
700 lower A–C	699–716	729–746	B12	–	–	n12
700 upper C	777–787	746–756	B13	–	–	–
700 D	788–798	758–768	B14	–	–	–
B17	704–716	734–746	B17	–	–	–
PCS + G	1850–1915	1930–1995	B25	–	–	n25

B26	814–849	859–894	B26	–	–	–
WCS	2305–2315	2350–2360	B30	–	–	–
B38	2570–2620	2570–2620	–	B38	–	n38
B41/B41-XGP	2496–2690	2496–2690	–	B41	–	n41
B48	3550–3700	3550–3700	–	B48	–	-
B66	1710–1780	2110–2200	B66	–	–	n66
B71	663–698	617–652	B71	–	–	n71
n77	3300–4200	3300–4200	–	–	–	n77

5.1.4. Reference Design of RF Antenna Interface

A reference design of antenna interface is shown as below. A π-type matching circuit should be reserved for better RF performance. The capacitors are not mounted by default.
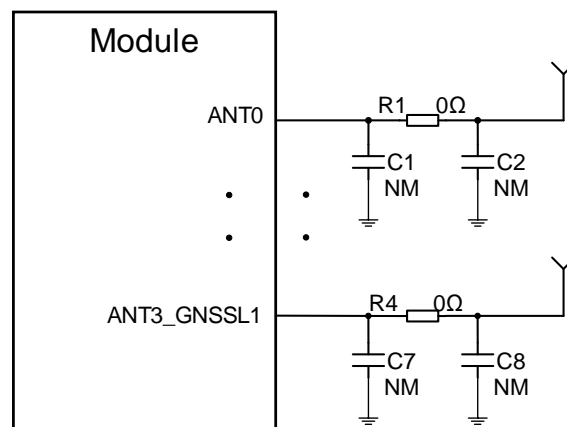
Figure 26: RM500Q-AE&RM502Q-AE Reference Circuit of RF Antenna

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NOTES

1. Keep the characteristic impedance for antenna trace as 50 Ω.
2. Place the π-type matching components as close to the antenna as possible.
3. Digital circuits such as (U)SIM card, USB interface, camera module, display connector and SD card should be kept away from the antenna traces.
4. Keep 75 dB PCB isolation between two antenna traces.
5. Keep 15 dB isolation between each antenna to improve the receiving sensitivity.

5.2. GNSS Antenna Interface

The following table shows frequency specification of GNSS antenna connector.

Table 27: GNSS Frequency

Type	Frequency	Unit
GPS/Galileo/QZSS	1575.42 ±1.023 (L1)	MHz
Galileo	1575.42 ±2.046 (E1)	MHz
QZSS	1575.42 (L1)	MHz
GLONASS	1597.5–1605.8	MHz
BeiDou	1561.098 ±2.046	MHz

NOTES

1. Keep the characteristic impedance for ANT3_GNSSL1 trace as 50 Ω.
2. Place the π-type matching components as close to the antenna as possible.
3. Digital circuits such as (U)SIM card, USB interface, camera module, display connector and SD card should be kept away from the antenna traces.
4. Keep 75 dB isolation between two antenna traces.
5. Keep 15 dB isolation between each antenna to improve the receiving sensitivity.

5.3. Reference Design of RF Layout

For user's PCB, the characteristic impedance of all RF traces should be controlled as 50 Ω. The impedance of the RF traces is usually determined by the trace width (W), the materials' dielectric constant, the height from the signal layer to reference ground (H), and the space between RF trace and ground (S).

Microstrip or coplanar waveguide is typically used in RF layout for characteristic impedance control. The following are reference designs of microstrip or coplanar waveguide with different PCB structures.
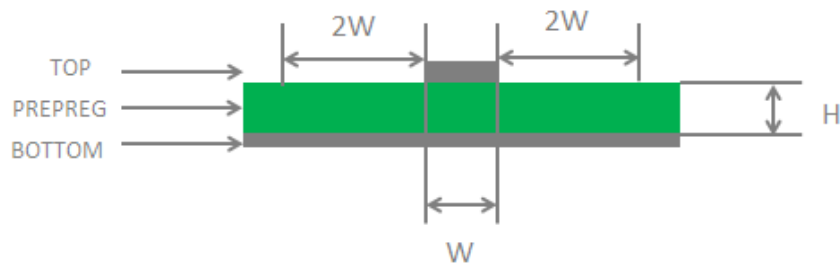
Figure 27: Microstrip Design on a 2-layer PCB
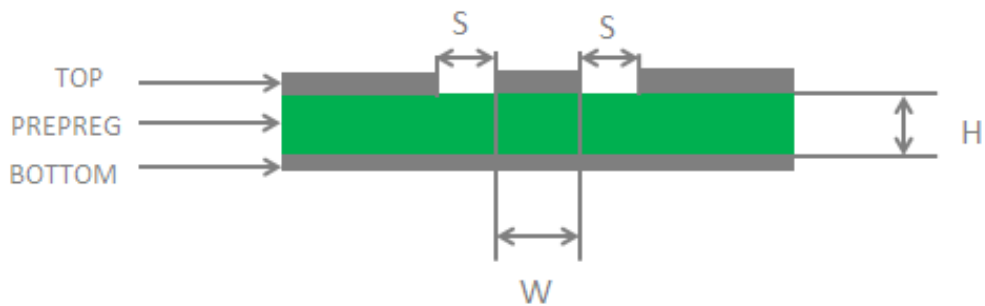
Figure 28: Coplanar Waveguide Design on a 2-layer PCB
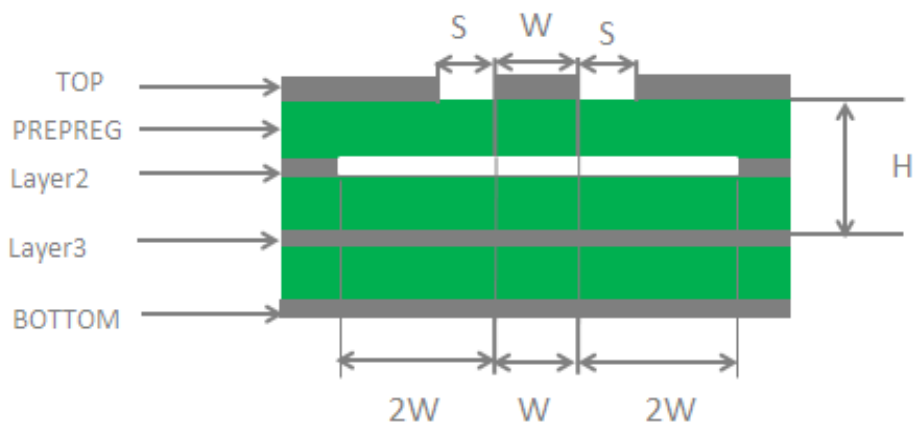
Figure 29: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)
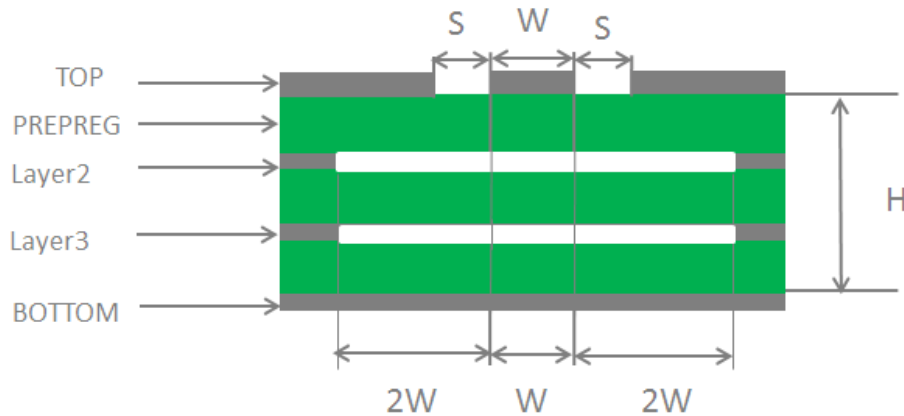
Figure 30: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

To ensure RF performance and reliability, the following principles should be complied with in RF layout design:

● Use an impedance simulation tool to accurately control the characteristic impedance of RF traces to 50 Ω.
● The GND pins adjacent to RF pins should not be designed as thermal relief pads, and should be fully connected to ground.
● 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°.
● 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).
● Keep RF traces away from interference sources, and avoid intersection and paralleling between traces on adjacent layers.

For more details about RF layout, see *document [4]*.

5.4. Antenna Connectors

RM500Q-AE&RM502Q-AE ANT0, ANT1, ANT2 and ANT3_GNSSL1 antenna connectors are shown as below.

Figure 31: RM500Q-AE Antenna Connectors

Figure 32: RM502Q-AE Antenna Connectors

5.4.1 RF Bands Supported by Antenna Connectors

Table 28: RF Bands Supported by RM500Q-AE&RM502Q-AE Antenna Connectors

Pin Name	Description	Frequency
ANT0	Antenna0 interface: 5G NR: MHB_TRx & n41/n77/ _PRx MIMO; LTE: MHB_TRx & UHB_PRx MIMO WCDMA: MHB_TRx	1400–5000 MHz
ANT1	Antenna1 interface: 5G NR: LB_TRx & MHB_DRx MIMO & n41_DRx & n77_DRx MIMO LTE: LB_TRx & MHB_DRx MIMO & UHB_DRx MIMO & LAA_PRx WCDMA: LB_TRX	600–6000 MHz
ANT2	Antenna2 interface: 5G NR:MHB_PRx MIMO & n41/n77 TRx LTE:LB_DRx & MHB_PRx MIMO & UHB_TRx WCDMA: LB_DRx	600–5000 MHz
ANT3_GNSSL1	Antenna3 interface: 5GNR:n41_DRX MIMO & n77_DRX LTE:MHB_DRX & UHB_DRX & LAA_DRx WCDMA:MHB_DRX GNSS: L1	1400–6000 MHz

NOTE

n77 group also includes B42/B48 function.

5.5. Antenna Installation

5.5.1. Antenna Requirements

The following table shows the requirements on WCDMA, LTE, 5G NR antenna and GNSS antenna.

Table 29: Antenna Requirements

Type	Requirements
GNSS	● Frequency range: 1559–1606 MHz ● Polarization: RHCP or linear ● VSWR: < 2 (Typ.) ● Passive antenna gain: >0 dBi
WCDMA/LTE/5G NR	● VSWR: ≤ 3 ● Efficiency: > 30% ● Input Impedance: 50 Ω ● Cable insertion loss: < 1 dB 　WCDMA B5 　LTE B5/B12/B13/B14/B17/B26/B71 　5G NR n5/n12/n71 ● Cable insertion loss: < 1.5 dB 　WCDMA B2/B4 　LTE B2/B4/B25/B66 　5G NR n2/n25/n66 ● Cable insertion loss: < 2 dB 　LTE B7/B38/B41/B48 ● 5G NR n7*/n41/n77

5.5.2. Recommended RF Connector for Antenna Installation

RM500Q-AE&RM502Q-AE is mounted with standard 2 mm × 2 mm receptacle RF connectors for convenient antenna connection.

The connector dimensions are illustrated as below:
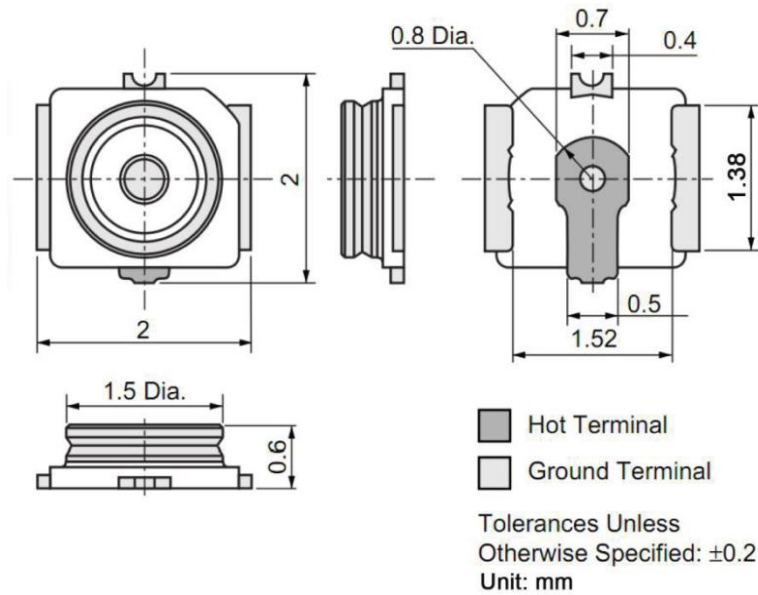
Figure 33: RM500Q-AE&RM502Q-AE RF Connector Dimensions (Unit: mm)

Table 30: Major Specifications of the RF Connector

Item	Specification
Nominal Frequency Range	DC to 6 GHz
Nominal Impedance	50 Ω
Temperature Rating	-40 to +85 °C
Voltage Standing Wave Ratio (VSWR)	Meet the requirements of: Max 1.3 (DC–3 GHz) Max 1.45 (3–6 GHz)

The receptacle RF connector used in conjunction with the module will accept two types of mating plugs that will meet a maximum height of 1.2 mm using a Ø0.81 mm coaxial cable or a maximum height of 1.45 mm utilizing a Ø1.13 mm coaxial cable.

The following figure shows the specifications of mating plugs using Ø0.81 mm coaxial cables.
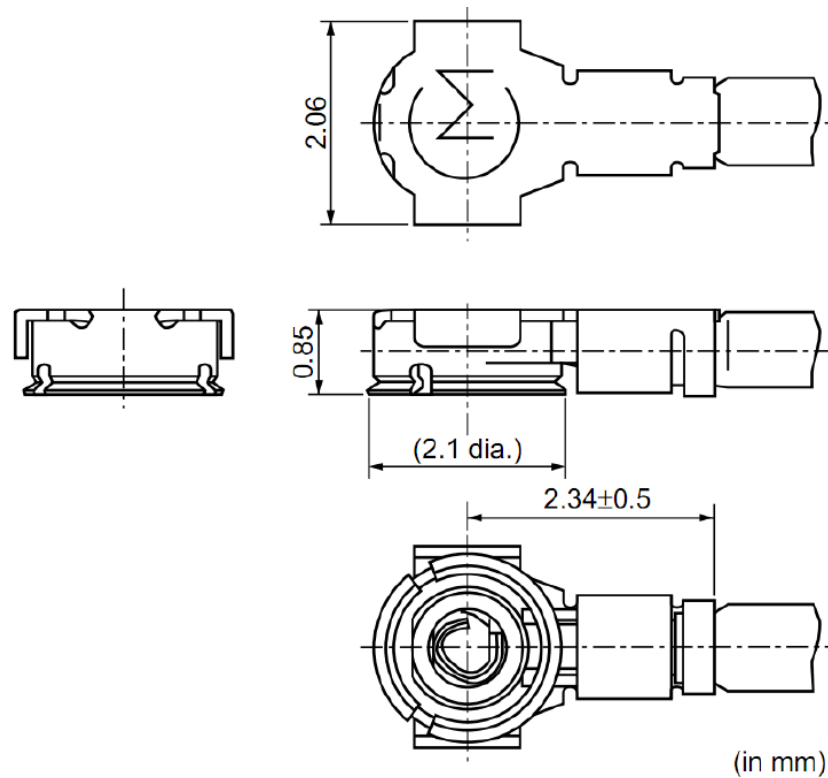
Figure 34: Specifications of Mating Plugs Using Ø0.81 mm Coaxial Cables

The following figure illustrates the connection between the receptacle RF connector on the module and the mating plug using a Ø0.81 mm coaxial cable.
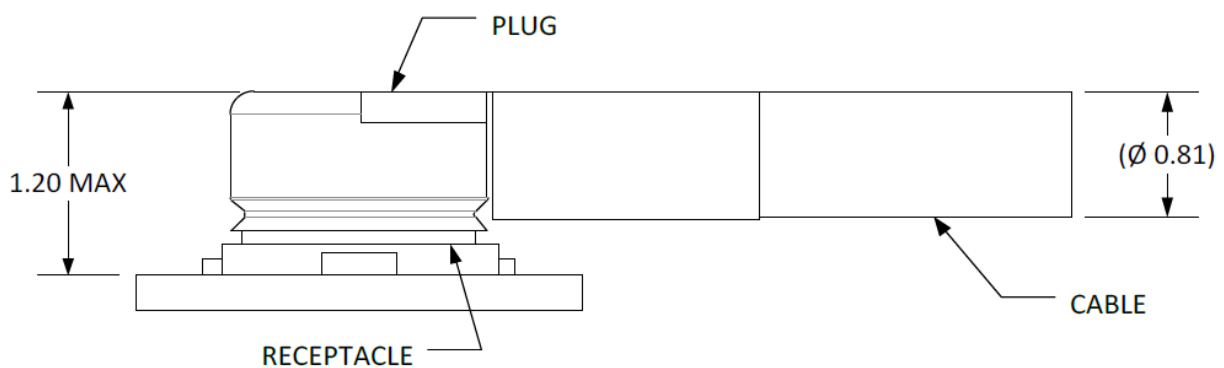
Figure 35: Connection between RF Connector and Mating Plug Using Ø0.81 mm Coaxial Cable

The following figure illustrates the connection between the receptacle RF connector on the module and the mating plug using a Ø1.13 mm coaxial cable.
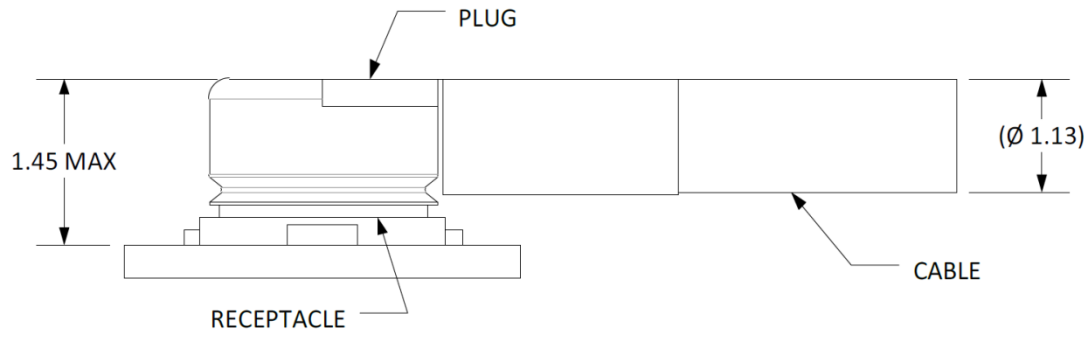
Figure 36: Connection between RF Connector and Mating Plug Using Ø1.13 mm Coaxial Cable

6 Reliability, Radio and Electrical Characteristics

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 31: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VCC	-0.3	4.7	V
Voltage at Digital Pins	-0.3	2.3	V

6.2. Power Supply Requirements

The typical input voltage of the module is 3.7 V, as specified by *PCIe M.2 Electromechanical Specification Rev 1.0*. The following table shows the power supply requirements of the module.

Table 32: Power Supply Requirements

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Power Supply	3.135	3.7	4.4	V
Voltage Ripple		–	30	100	mV
Voltage Drop		–	–	165	mV

6.3. I/O Requirements

Table 33: I/O Requirements

Parameter	Description	Min.	Max.	Unit
V_{IH}	Input high voltage	$0.7 \times V_{DD18}$ [1]	$V_{DD18} +0.3$	V
V_{IL}	Input low voltage	-0.3	$0.3 \times V_{DD18}$	V
V_{OH}	Output high voltage	V_{DD18}-0.5	V_{DD18}	V
V_{OL}	Output low voltage	0	0.4	V

NOTE

[1] V_{DD18} is the I/O power domain of the module.

6.4. Operating and Storage Temperatures

Table 34: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operating Temperature Range[1]	-20	+25	+60	ºC
Extended Temperature Range[2]	-40		+85	ºC
Storage temperature Range	-40		+90	ºC

NOTES

1. [1] To meet this operating temperature range, you need to ensure effective thermal dissipation, for example, by adding passive or active heatsinks, heat pipes, vapor chambers, etc. Within this range, the module meets 3GPP specifications.
2. [2] To meet this extended temperature range, you need to ensure effective thermal dissipation, for example, by adding passive or active heatsinks, heat pipes, vapor chambers, etc. Within this range, the module remains the ability to establish and maintain functions such as voice, SMS, emergency call, etc., without any unrecoverable malfunction. Radio spectrum and radio network are not

influenced, while one or more specifications, such as P_{out}, may undergo a reduction in value, exceeding the specified tolerances of 3GPP. When the temperature returns to the normal operating temperature level, the module will meet 3GPP specifications again.

6.5. Current Consumption

Table 35: RM500Q-AE&RM502Q-AE Current Consumption

Description	Conditions	Typ.	Unit
OFF state	**Power down**	TBD	µA
Sleep state	**AT+CFUN=0** (USB disconnected)	TBD	mA
	WCDMA PF = 64 (USB disconnected)	TBD	mA
	WCDMA PF = 128 (USB disconnected)	TBD	mA
	WCDMA PF = 512 (USB disconnected)	TBD	mA
	LTE-FDD PF = 32 (USB disconnected)	TBD	mA
	LTE-FDD PF = 64 (USB disconnected)	TBD	mA
	LTE-FDD PF = 128 (USB disconnected)	TBD	mA
	LTE-TDD PF = 32 (USB disconnected)	TBD	mA
	LTE-TDD PF = 64 (USB disconnected)	TBD	mA
	LTE-TDD PF = 128 (USB disconnected)	TBD	mA
Idle state	WCDMA PF = 64 (USB disconnected)	TBD	mA
	WCDMA PF = 64 (USB connected)	TBD	mA
	LTE-FDD PF = 64 (USB disconnected)	TBD	mA
	LTE-FDD PF = 64 (USB connected)	TBD	mA
	LTE-TDD PF = 64 (USB disconnected)	TBD	mA
	LTE-TDD PF = 64 (USB connected)	TBD	mA
WCDMA data transfer (GNSS OFF)	WCDMA B2 HSDPA CH9800 @ 23 dBm	TBD	mA
	WCDMA B2 HSUPA CH9800 @ 23 dBm	TBD	mA

	WCDMA B4 HSDPA CH1638 @ 23 dBm	TBD	mA
	WCDMA B4 HSUPA CH1638 @ 23 dBm	TBD	mA
	WCDMA B5 HSDPA CH4407 @ 23 dBm	TBD	mA
	WCDMA B5 HSUPA CH4407 @ 23 dBm	TBD	mA
LTE data transfer (GNSS OFF)	LTE-FDD B2 CH900 @ 23 dBm	TBD	mA
	LTE-FDD B4 CH2175 @ 23 dBm	TBD	mA
	LTE-FDD B5 CH2525 @ 23 dBm	TBD	mA
	LTE-FDD B7 CH3100 @ 23 dBm	TBD	mA
	LTE-FDD B12 CH5095 @ 23 dBm	TBD	mA
	LTE-FDD B13 CH5230 @ 23 dBm	TBD	mA
	LTE-FDD B14 CH5330 @ 23 dBm	TBD	mA
	LTE-FDD B17 CH5790 @ 23 dBm	TBD	mA
	LTE-FDD B25 CH8365 @ 23 dBm	TBD	mA
	LTE-FDD B26 CH8865 @ 23 dBm	TBD	mA
	LTE-FDD B30 CH9820 @ 23 dBm	TBD	mA
	LTE-TDD B38 CH38000 @ 23 dBm	TBD	mA
	LTE-TDD B41 CH40620 @ 23 dBm	TBD	mA
	LTE-TDD B48 CH55990 @ 23 dBm	TBD	mA
	LTE-FDD B66 CH66886 @ 23 dBm	TBD	mA
	LTE-FDD B71 CH68761 @ 23 dBm	TBD	mA
5G NR data transfer (GNSS OFF)	5G NR-TDD n41 CH501204 @ 23 dBm	TBD	mA
	5G NR-TDD n41 CH518598 @ 23 dBm	TBD	mA
	5G NR-TDD n41 CH535998 @ 23 dBm	TBD	mA
	5G NR-TDD n77 CH620668 @ 23 dBm	TBD	mA
	5G NR-TDD n77 CH650000 @ 23 dBm	TBD	mA
	5G NR-TDD n77 CH679332 @ 23 dBm	TBD	mA

5G NR-FDD n2 CH387000 @ 23 dBm	TBD	mA
5G NR-FDD n2 CH392000 @ 23 dBm	TBD	mA
5G NR-FDD n2 CH397000 @ 23 dBm	TBD	mA
5G NR-FDD n5 CH174800 @ 23 dBm	TBD	mA
5G NR-FDD n5 CH176300 @ 23 dBm	TBD	mA
5G NR-FDD n5 CH177800 @ 23 dBm	TBD	mA
5G NR-FDD n7 CH525000 @ 23 dBm	TBD	mA
5G NR-FDD n7 CH531000 @ 23 dBm	TBD	mA
5G NR-FDD n7 CH537000 @ 23 dBm	TBD	mA
5G NR-FDD n12 CH146800 @ 23 dBm	TBD	mA
5G NR-FDD n12 CH147500 @ 23 dBm	TBD	mA
5G NR-FDD n12 CH148200 @ 23 dBm	TBD	mA
5G NR-FDD n66 CH423000 @ 23 dBm	TBD	mA
5G NR-FDD n66 CH429000 @ 23 dBm	TBD	mA
5G NR-FDD n66 CH435000 @ 23 dBm	TBD	mA
5G NR-FDD n71 CH124400 @ 23 dBm	TBD	mA
5G NR-FDD n71 CH126900 @ 23 dBm	TBD	mA
5G NR-FDD n71 CH129400 @ 23 dBm	TBD	mA

6.6. RF Output Power

The following table shows the RF output power of RM500Q-AE&RM502Q-AE.

Table 36: RF Output Power

Mode	Frequency	Max.	Min.
WCDMA	WCDMA bands	24 dBm +1/-3 dB (Class 3)	< -50 dBm

LTE	LTE bands	23 dBm ±2 dB (Class 3)	< -40 dBm
	LTE HPUE bands (B38/B41/)	26 dBm ±2 dB (Class 2)	< -40 dBm
5G NR	5G NR bands	23 dBm ±2 dB (Class 3)	< -40 dBm (BW: 5–20 MHz) [1]
	5G NR HUPE bands (n41/n77)	26 dBm +2/-3 dB (Class 2)	< -40 dBm (BW: 5–20 MHz) [1]

NOTE

[1] For 5G NR TDD bands, the normative reference for this requirement is *TS 38.101-1 [2] clause 6.3.1*

6.7. RF Receiving Sensitivity

The following tables show conducted RF receiving sensitivity of RM500Q-AE&RM502Q-AE.

Table 37: RM500Q-AE&RM502Q-AE Conducted RF Receiving Sensitivity

Mode	Frequency	Primary	Diversity	SIMO [1]	3GPP (SIMO)
WCDMA	WCDMA B2	TBD	TBD	TBD	-106.7 dBm
	WCDMA B4	TBD	TBD	TBD	-106.7 dBm
	WCDMA B5	TBD	TBD	TBD	-104.7 dBm
LTE	LTE-FDD B2 (10 MHz)	TBD	TBD	TBD	-96.3 dBm
	LTE-FDD B4 (10 MHz)	TBD	TBD	TBD	-96.3 dBm
	LTE-FDD B5 (10 MHz)	TBD	TBD	TBD	-94.3 dBm
	LTE-FDD B7 (10 MHz)	TBD	TBD	TBD	-94.3 dBm
	LTE-FDD B12 (10 MHz)	TBD	TBD	TBD	-93.3 dBm
	LTE-FDD B13 (10 MHz)	TBD	TBD	TBD	-93.3 dBm
	LTE-FDD B14 (10 MHz)	TBD	TBD	TBD	-93.3 dBm
	LTE-FDD B17 (10 MHz)	TBD	TBD	TBD	-93.3 dBm

	LTE-FDD B25 (10 MHz)	TBD	TBD	TBD	-92.8 dBm
	LTE-FDD B26 (10 MHz)	TBD	TBD	TBD	-93.8 dBm
	LTE-FDD B30 (10 MHz)	TBD	TBD	TBD	-95.3 dBm
	LTE-TDD B38 (10 MHz)	TBD	TBD	TBD	-96.3 dBm
	LTE-TDD B41 (10 MHz)	TBD	TBD	TBD	-94.3 dBm
	LTE-TDD B48 (10 MHz)	TBD	TBD	TBD	-95 dBm
	LTE-FDD B66 (10 MHz)	TBD	TBD	TBD	-96.5 dBm
	LTE-FDD B71 (10 MHz)	TBD	TBD	TBD	-94.2 dBm
5G NR	5G NR-FDD n2 (20 MHz) (SCS: 15 kHz)	TBD	TBD	TBD	-94.0 dBm
	5G NR-FDD n5 (10 MHz) (SCS: 15 kHz)	TBD	TBD	TBD	-95.0 dBm
	5G NR-FDD n7 (20 MHz) (SCS: 15 kHz)	TBD	TBD	TBD	-92.0 dBm
	5G NR-FDD n12 (10 MHz) (SCS: 15 kHz)	TBD	TBD	TBD	-94.0 dBm
	5G NR-FDD n25 (20 MHz) (SCS: 15 kHz)	TBD	TBD	TBD	-90.5 dBm
	5G NR-TDD n41 (20 MHz) (SCS: 30 kHz)	TBD	TBD	TBD	-92.0 dBm
	5G NR-FDD n66 (20 MHz) (SCS: 15 kHz)	TBD	TBD	TBD	-93.5 dBm
	5G NR-FDD n71 (10 MHz) (SCS: 15 kHz)	TBD	TBD	TBD	-94.0 dBm
	5G NR-TDD n77 (20 MHz) (SCS: 30 kHz)	TBD	TBD	TBD	-92.9 dBm

NOTE

[1] SIMO is a smart antenna technology that uses a single antenna at the transmitter side and two antennas at the receiver side, which improves Rx performance.

6.8. ESD Characteristics

The module is not protected against electrostatic discharge (ESD) in general. Consequently, it is subject

to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates the module.

The following table shows the module electrostatic discharge characteristics.

Table 38: Electrostatic Discharge Characteristics (Temperature: 25 ⁰C, Humidity: 40 %)

Tested Interfaces	Contact Discharge	Air Discharge	Unit
VCC, GND	±5	±10	kV
Antenna Interfaces	±4	±8	kV
Other Interfaces	±0.5	±1	kV

6.9. Thermal Dissipation

RM500Q-AE&RM502Q-AE is designed to work over an extended temperature range. In order to achieve a maximum performance while working under extended temperatures or extreme conditions (such as with maximum power or data rate) for a long time, it is strongly recommended to add a thermal pad or other thermally conductive compounds between the module and the main PCB for thermal dissipation.

The thermal dissipation area on the bottom (i.e. the area for adding thermal pad) is shown as below on the below, and conductive compounds are also added on the BB, MCP, PMU, WTR, PA-1, PA-2 chips inside the module. The dimensions are measured in mm.
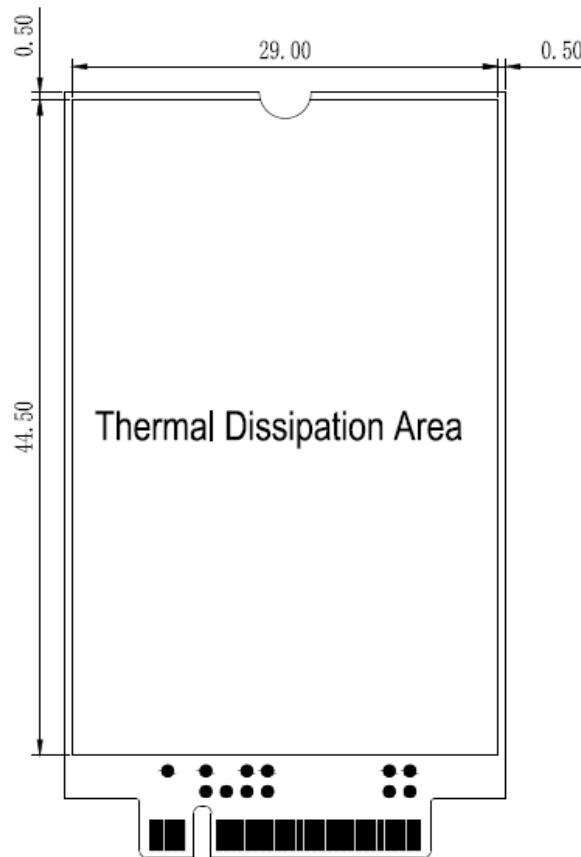
Figure 37: Thermal Dissipation Area on Bottom Side of Module

There are other measures to enhance heat dissipation performance:

● Add ground vias as many as possible on PCB.
● Maximize airflow over/around the module.
● Place the module away from other heating sources.
● Module mounting holes must be used to attach (ground) the device to the main PCB ground.
● It is NOT recommended to apply solder mask on the main PCB where the module's thermal dissipation area is located.
● Select an appropriate material, thickness and surface for the outer housing (i.e. the mechanical enclosure) of the application device that integrates the module so that it provides good thermal dissipation.
● Customers may also need active cooling to pull heat away from the module.
● If possible, add a heatsink on the top of the module. A thermal pad should be used between the heatsink and the module, and the heatsink should be designed with as many fins as possible to increase heat dissipation area.

NOTE

If a conformal coating is necessary for the module, do NOT use any coating material that may chemically

react with the PCB or shielding cover, and prevent the coating material from flowing into the module.

7 Mechanical Dimensions and Packaging

This chapter mainly describes mechanical dimensions and packaging specifications of RM500Q-AE&RM502Q-AE. All dimensions are measured in mm, and the tolerances are ±0.05 mm unless otherwise specified.

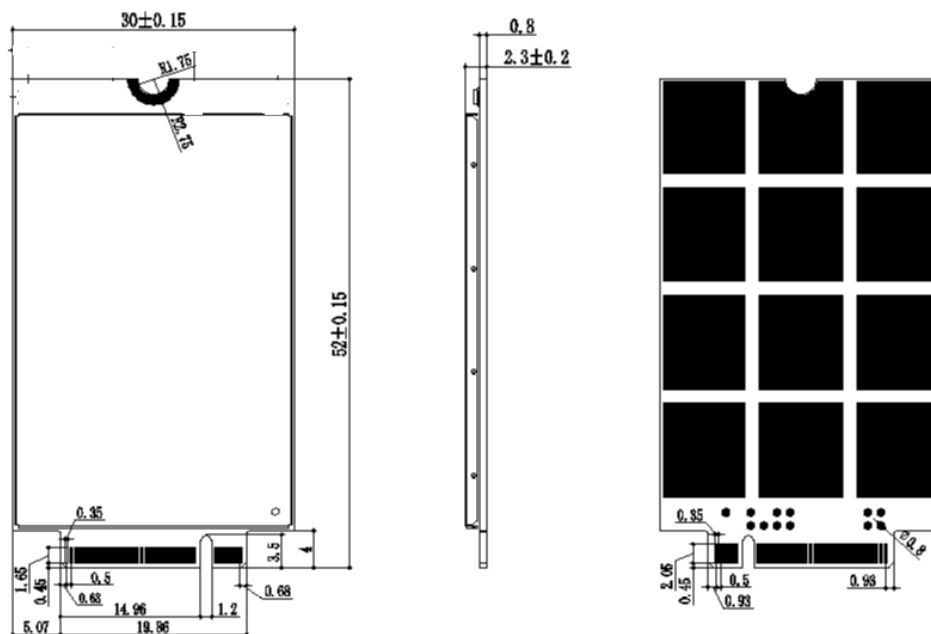## 7.1. Mechanical Dimensions of the Module

Figure 38: Mechanical Dimensions of the Module (Unit: mm)

7.2. Top and Bottom Views of the Module
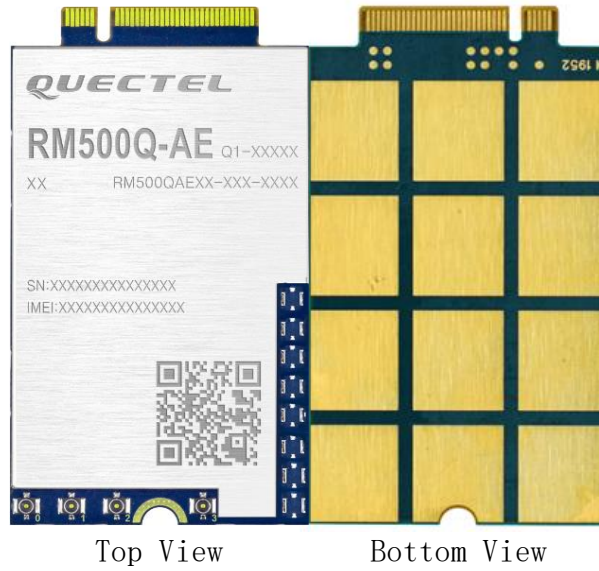
Figure 39: RM500Q-AE Top View and Bottom view
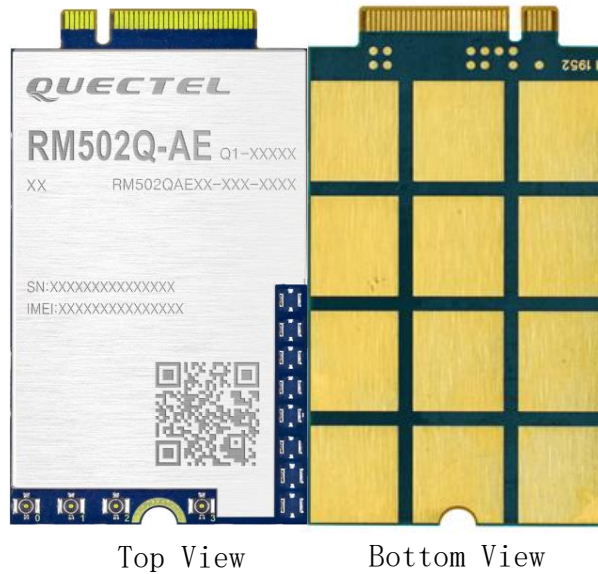
Figure 40: RM502Q-AE Top View and Bottom View

7.3. M.2 Connector

The module adopts a standard PCI Express M.2 connector which compiles with the directives and standards listed in *document [5]*.

7.4. Packaging

The modules are packaged in trays. The following figure shows the tray size.
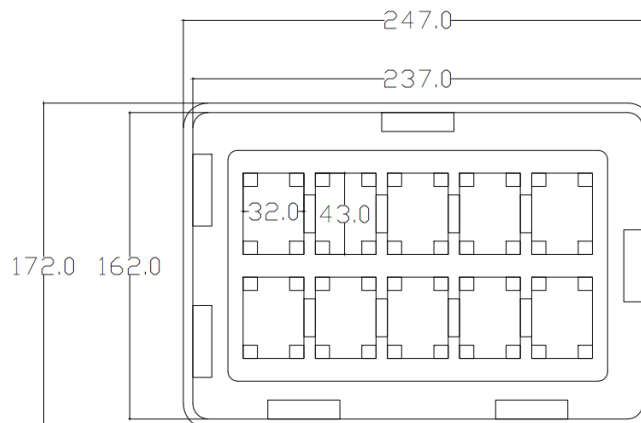
Figure 41: Tray Size (Unit: mm)

Each tray contains 10 modules. The smallest package contains 100 modules. Tray packaging procedures are as below.

1. Use 10 trays to package 100 modules at a time (tray size: 247 mm × 172 mm).
2. Place an empty tray on the top of the 10-tray stack.
3. Fix the stack with masking tape in "#" shape as shown in the following figure.
4. Pack the stack with conductive bag, and then fix the bag with masking tape.
5. Place the list of IMEI No. into a small carton.
6. Seal the carton and then label the seal with sealing sticker (small carton size: 250 mm × 175 mm × 128 mm).

Figure 42: Tray Packaging Procedure

8 Appendix References

Table 39: Related Documents

SN.	Document Name	Remark
[1]	Quectel_PCIe_Card_EVB_User_Guide	PCIe card EVB user guide
[2]	Quectel_RG50xQ&RM5xxQ_Series_AT_Commands_Manual	AT commands manual for RG50xQ, RM5xxQ series
[3]	Quectel_RG50xQ&RM5xxQ_Series_GNSS_Application_Note	The GNSS application note for RG50xQ and RM5xxQ series
[4]	Quectel_RF_Layout_Application_Note	RF layout application note
[5]	PCI Express M.2 Specification Rev3.0	PCI express M.2 specification

Table 40: Terms and Abbreviations

Abbreviation	Description
bps	Bit Per Second
DFOTA	Delta Firmware Upgrade Over-The-Air
DL	Downlink
DPR	Dynamic Power Reduction
EIRP	Equivalent Isotropically Radiated Power
ESD	Electrostatic Discharge
FDD	Frequency Division Duplexing
GLONASS	Global Navigation Satellite System (Russia)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

GSM	Global System for Mobile Communications
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
kbps	Kilo Bits Per Second
LAA	License Assisted Access
LED	Light Emitting Diode
LTE	Long Term Evolution
Mbps	Mega Bits Per Second
ME	Mobile Equipment
MIMO	Multiple-Input Multiple-Output
MLCC	Multiplayer Ceramic Chip Capacitor
MO	Mobile Originated
MT	Mobile Terminated
PAP	Password Authentication Protocol
PCB	Printed Circuit Board
PCIe	Peripheral Component Interconnect Express
PCM	Pulse Code Modulation
PDU	Protocol Data Unit
PME	Power Management Event
PPP	Point-to-Point Protocol
RF	Radio Frequency
Rx	Receive
SAR	Specific Absorption Rate
SMS	Short Message Service
Tx	Transmit

UART	Universal Asynchronous Receiver & Transmitter
UL	Uplink
URC	Unsolicited Result Code
USB	Universal Serial Bus
(U)SIM	(Universal) Subscriber Identity Module
V_{IH}	Input High Voltage Level
V_{IL}	Input Low Voltage Level
V_{OH}	Output High Voltage Level
V_{OL}	Output Low Voltage Level
WCDMA	Wideband Code Division Multiple Access

Installation engineers need to be aware of the potential risk of the thermal effects of radio frequency energy and how to stay protected against undue risk.

The EUT is a mobile device; maintain at least a 20 cm separation between the EUT and the user's body and must not transmit simultaneously with any other antenna or transmitter.

OEM/Integrators Installation Manual

Important Notice to OEM integrators 1. This module is limited to OEM installation ONLY. 2. This module is limited to installation in mobile or fixed applications, according to Part 2.1091(b). 3. The separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093 and different antenna configurations 4. For FCC Part 15.31 (h) and (k): The host manufacturer is responsible for additional testing to verify compliance as a composite system. When testing the host device for compliance with Part 15 Subpart B, the host manufacturer is required to show compliance with Part 15 Subpart B while the transmitter module(s) are installed and operating. The modules should be transmitting and the evaluation should confirm that the module's intentional emissions are compliant (i.e. fundamental and out of band emissions). The host manufacturer must verify that there are no additional unintentional emissions other than what is permitted in Part 15 Subpart B or emissions are complaint with the transmitter(s) rule(s). The Grantee will provide guidance to the host manufacturer for Part 15 B requirements if needed.

Important Note

notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify to Quectel that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the USI, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application

End Product Labeling

When the module is installed in the host device, the FCC/IC ID label must be visible through a window on the final device or it must be visible when an access panel, door or cover is easily re-moved. If not, a second label must be placed on the outside of the final device that contains the following text: "Contains FCC ID: XMR2020RM500QAE" "Contains IC: 10224A-2021RM500AE". The FCC ID/IC ID can be used only when all FCC/IC compliance requirements are met.

Antenna

(1) The antenna must be installed such that 20 cm is maintained between the antenna and users,

(2) The transmitter module may not be co-located with any other transmitter or antenna.

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC/IC authorization is no longer considered valid and the FCC ID/IC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC/IC authorization.

To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, maximum antenna gain (including cable loss) must not exceed

Test Mode	Antenna Gain (dBi)	Test Mode	Antenna Gain (dBi)
WCDMA B2	8.00	LTE B38	5.00
WCDMA B4	5.00	LTE B41	5.00
WCDMA B5	5.00	LTE B48*	5.00
LTE B2	8.00	LTE B66	5.00
LTE B4	5.00	LTE B71	5.00
LTE B5	5.00	n2	8.00
LTE B7	8.00	n5	5.00
LTE B12	5.00	n7	8.00
LTE B13	5.00	n12	5.00
LTE B14	5.00	n25	8.00
LTE B17	5.00	n41	5.00
LTE B25	8.00	n66	5.00
LTE B26	5.00	n71	5.00
LTE B30*	5.00	n77	5.00

Note: "*" means when using these max gain antenna, the host manufacturer should reduce the conducted power to meet the FCC maximum RF output power limit.

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as show in this manual

Federal Communication Commission Interference Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This 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 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.

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

List of applicable FCC rules

This module has been tested and found to comply with part 22, part 24, part 27, part 90, 15.247 and 15.407 requirements for Modular Approval.

The modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

This device is intended only for OEM integrators under the following conditions: (For module device use)

1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2) The transmitter module may not be co-located with any other transmitter or antenna.

As long as 2 conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator & your body.

Industry Canada Statement

This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions:

(1) This device may not cause interference; and

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."

Radiation Exposure Statement

This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator & your body

Déclaration d'exposition aux radiations:

Cet équipement est conforme aux limites d'exposition aux rayonnements ISED établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20 cm de distance entre la source de rayonnement et votre corps.

This device is intended only for OEM integrators under the following conditions: (For module device use)

1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and

2) The transmitter module may not be co-located with any other transmitter or antenna. As long as 2 conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

Cet appareil est conçu uniquement pour les intégrateurs OEM dans les conditions suivantes: (Pour utilisation de dispositif module)

1) L'antenne doit être installée de telle sorte qu'une distance de 20 cm est respectée entre l'antenne et les utilisateurs, et
2) Le module émetteur peut ne pas être coïmplanté avec un autre émetteur ou antenne.

Tant que les 2 conditions ci-dessus sont remplies, des essais supplémentaires sur l'émetteur ne seront pas nécessaires. Toutefois, l'intégrateur OEM est toujours responsable des essais sur son produit final pour toutes exigences de conformité supplémentaires requis pour ce module installé.

IMPORTANT NOTE:

In the event that these conditions cannot be met (for example certain laptop configurations or colocation with another transmitter), then the Canada authorization is no longer considered valid and the IC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate Canada authorization.

NOTE IMPORTANTE:

Dans le cas où ces conditions ne peuvent être satisfaites (par exemple pour certaines configurations d'ordinateur portable ou de certaines co-localisation avec un autre émetteur), l'autorisation du Canada n'est plus considéré comme valide et l'ID IC ne peut pas être utilisé sur le produit final. Dans ces circonstances, l'intégrateur OEM sera chargé de réévaluer le produit final (y compris l'émetteur) et l'obtention d'une autorisation distincte au Canada.

End Product Labeling

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: "Contains IC: 10224A-2021RM500AE".

Plaque signalétique du produit final

Ce module émetteur est autorisé uniquement pour une utilisation dans un dispositif où l'antenne peut être installée de telle sorte qu'une distance de 20cm peut être maintenue entre l'antenne et les utilisateurs. Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: "Contient des IC: 10224A-2021RM500AE".

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

Manuel d'information à l'utilisateur final

L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module.

Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel.