EM05-E Hardware Design

LTE Standard Products

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Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any terminal or mobile incorporating the module. Manufacturers of the 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 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.
	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 (U)SIM 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 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 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 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.

About the Document

Revision History

Version	Date	Author	Description
1.0	2017-09-22	Yeoman Chen/ Daryl Du	Initial
1.1	2019-07-22	Frank Wang/ Lorry Xu	1. Removed "*" of EM05-E. 2. Removed content related to emergency call. 3. Added B41 to LTE-TDD bands of EM05-E (Table 1). 4. Updated key features of EM05 (Table 2). 5. Updated the functional diagram (Figure 1). 6. Updated the reference circuit of power supply (Figure 6) and relative description of TVS (Chapter 3.5.1). 7. Updated DC characteristics of FUL_CARD_POWER_OFF# (Table 7). 8. Updated reference circuits of normally short-circuited (U)SIM card connector (Figure 16) and a 6-pin (U)SIM card connector (Figure 18), and relative description of (U)SIM circuit design (Chapter 3.8). 9. Updated reference circuit of USB interface (Figure 19) and relative description of USB interface design (Chapter 3.9). 10. Updated auxiliary mode timing (Figure 21) and relative description of PCM interface (Chapter 3.10). 11. Updated relative description of antenna connection of the module (Chapter 5). 12. Updated module operating frequencies in (Table 19). 13. Updated GNSS frequency (Table 20). 14. Updated antenna requirements (Table 21). 15. Added storage temperature range (Table 26). 16. Added EM05-E current consumption (Table 29). 17. Updated EM05-CE conducted RF output power (Table 30).

			18. Added EM05-CML conducted RF output power (Table 31). 19. Added EM05-E conducted RF output power (Table 32). 20. Added EM05-E conducted RF receiving sensitivity (Table 35).
1.2	2020-01-07	Lorry Xu/ Frank Wang	1. Updated the description of (U)SIM interface (Chapter 3.8). 2. Updated antenna requirements (Table 21). 3. Updated the description of antenna connectors and mating plugs (Chapter 5.3.2). 1. Updated EM05-E current consumption (Table 29).
1.3	2025-12-30	Clark Zhang/ Martis Chen	Numerous changes were made to this document. It should be read in its entirety. 1. Removed the information of EM05-CE and EM05-CML. 2. Added a note specifying that actual applications of supported frequency bands may be subject to local regulations (Chapter 2.1). 3. Added the LTE modulations; Added AGNSS description (Table 3). 4. Added a note on avoiding abnormal RF functions caused by current on the module's pins (Chapter 2.4). 5. Added the EVB kit information (Chapter 2.6). 6. Updated the description on the high-power rated TVS components at the front end of the power supplies; Updated the reference design for VCC power supply (Chapter 3.3.1). 7. Updated the reference design for resetting the module (Figures 14, 15). 8. Added the notes on the (U)SIM card detection function (Chapter 4.1.2). 9. Updated the reference design for (U)SIM interface with a 6-pin (U)SIM card connector (Figure 19). 10. Added the descriptions for W_DISABLE2# (Chapter 4.4.2). 11. Updated the maximum sink current and reference design for LED# (Chapter 4.4.3). 12. Updated the reference design for WOWWAN# (Figure 26). 13. Added the reference design for DPR (Figure 27). 14. Added the reference design for configuration pins

	(Figure 28). 15. Added the PN for antenna connectors (Chapter 5.3.2). 16. Updated the GNSS frequency range (Table 26). 17. Added a note about the impedance condition for power consumption test (Chapter 6.3). 18. Updated the digital I/O characteristic (Chapter 6.4). 19. Added the storage conditions; Added the notification information during module application; Updated the packaging information (Chapter 8).

Contents

Table Index

Figure Index

1 Introduction

This document defines EM05-E module and describes its air interface and hardware interfaces which are connected with your applications.

This document can help you to quickly understand the interface specifications, electrical and mechanical details, as well as other related information of the module. Associated with application note and user guide, you can use the module to design and set up mobile applications easily.

1.1. Reference Standard

The module complies with the following standards:

- *PCI Express M.2 Specification Revision 3.0*
- *Universal Serial Bus 2.0 Specification*
- *ISO/IEC 7816-3*
- *3GPP TS 27.007* and *3GPP TS 27.005*

1.2. Special Mark

Table 1: Special Mark

Mark	Definition
*	Unless otherwise specified, an asterisk (*) after a function, feature, interface, pin name, command, argument, and so on indicates that it is under development and currently not supported; and the asterisk (*) after a model indicates that the model is currently unavailable.

2 Product Overview

2.1. General Description

EM05-E is an LTE/UMTS/HSPA+ wireless communication module with receive diversity. It provides data connectivity on LTE-FDD, LTE-TDD, DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA networks. It also provides GNSS [1] to meet specific application demands.

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

Table 2: Frequency Bands and GNSS Types

Mode	Frequency Band/GNSS Type
LTE-FDD	B1/B3/B7/B8/B20/B28
LTE-TDD	B38/B41
WCDMA	B1/B8
Rx-diversity	Supported
GNSS [1]	GPS, GLONASS, BDS, Galileo, QZSS

NOTE

The module supports the above frequency bands in hardware, but actual applications may be subject to local regulations.

[1] GNSS function is optional.

2.2. Key Features

The following table describes the detailed features of the module.

Table 3: Key Features of the Module

Feature	Details
Function Interface	PCI Express M.2 standard interface
Power Supply	● Supply voltage: 3.135–4.4 V ● Typical supply voltage: 3.3 V
Transmit Power	● Class 3 (23 dBm ±2 dB) for WCDMA bands ● Class 3 (23 dBm ±2 dB) for LTE-FDD bands ● Class 3 (23 dBm ±2 dB) for LTE-TDD bands
LTE Features	● Support up to non-CA Cat 4 ● Support 1.4/3/5/10/15/20 MHz RF bandwidths ● Support DL modulations: QPSK, 16QAM and 64QAM ● Support UL modulations: QPSK and 16QAM ● Support MIMO in DL ● Max. transmission data rates: - FDD: 150 Mbps (DL)/50 Mbps (UL) - TDD: 130 Mbps (DL)/30 Mbps (UL)
UMTS Features	● Support 3GPP Rel-8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA ● Support DL modulations: QPSK, 16QAM and 64QAM ● Support UL modulation: QPSK ● Max. transmission data rates: - DC-HSDPA: 42 Mbps (DL) - HSUPA: 5.76 Mbps (UL) - WCDMA: 384 kbps (DL), 384 kbps (UL)
Internet Protocol Features	● Support Internet protocols: TCP/UDP/PPP/FTP/HTTP/NTP/PING/QMI/NITZ/HTTPS/SMTP/MMS/FTPS/SMTPS/SSL/FILE/MQTT ● Support PAP and CHAP 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: 1.8/3.0 V ● Compliant with *ISO/IEC 7816-3*
Audio Features	● Support one digital audio interface: PCM interface

	● WCDMA: AMR/AMR-WB ● LTE: AMR/AMR-WB ● Support echo cancellation and noise suppression
PCM Interface	● Support 16-bit linear data format ● Support long frame synchronization and short frame synchronization ● Support master and slave modes, but must be the master for long frame synchronization
USB Interface	● Compliant with USB 2.0 specification (slave only), the data transmission rate can reach up to 480 Mbps ● Used for AT command communication, data transmission, GNSS NMEA sentence output, software debugging and firmware upgrade ● Support USB serial drivers for Windows 10/11, Linux 2.6–6.7, Android 4.x–14.x
Antenna Connectors	● Main antenna connector ● Rx-diversity antenna connector ● GNSS antenna connector
Rx-diversity	Support LTE/WCDMA Rx-diversity
GNSS Features (Optional)	● Protocol: NMEA 0183 ● Data update rate: 1 Hz ● Support AGNSS. For more details, see ***document [1]***
AT Commands	● Compliant with *3GPP TS 27.007*, *3GPP TS 27.005* ● Quectel enhanced AT commands
Physical Characteristics	● M.2 Key-B ● Size: 30 mm × 42 mm × 2.3 mm ● Weight: approx. 6.0 g
Temperature Ranges	● Normal operating temperature [2]: -30 °C to +70 °C ● Extended operating temperature [3]: -40 °C to +85 °C ● Storage temperature: -40 °C to +90 °C
Firmware Upgrade	● USB 2.0 interface ● DFOTA
RoHS	All hardware components are fully compliant with EU RoHS directive

[2] To meet the normal operating temperature range requirements, it is necessary to ensure effective thermal dissipation, e.g., by adding passive or active heatsinks, heat pipes, vapor chambers. Within this range, the module's indicators comply with 3GPP specification requirements.

[3] To meet the extended operating temperature range requirements, it is necessary to ensure effective thermal dissipation, e.g., by adding passive or active heatsinks, heat pipes, vapor chambers. Within the range of -40 to -30 °C or 70 to 85 °C, the module retains the ability to establish and maintain functions such as SMS and data transmission, without any unrecoverable malfunction. Radio spectrum and radio network remain uninfluenced, whereas the value of one or more parameters, such as P_{out}, may decrease and fall below the range of the 3GPP specified tolerances. When the temperature returns to the normal operating temperature range, the module's indicators will comply with 3GPP specification requirements again.

2.3. Functional Diagram

The following figure shows a block diagram of the module.

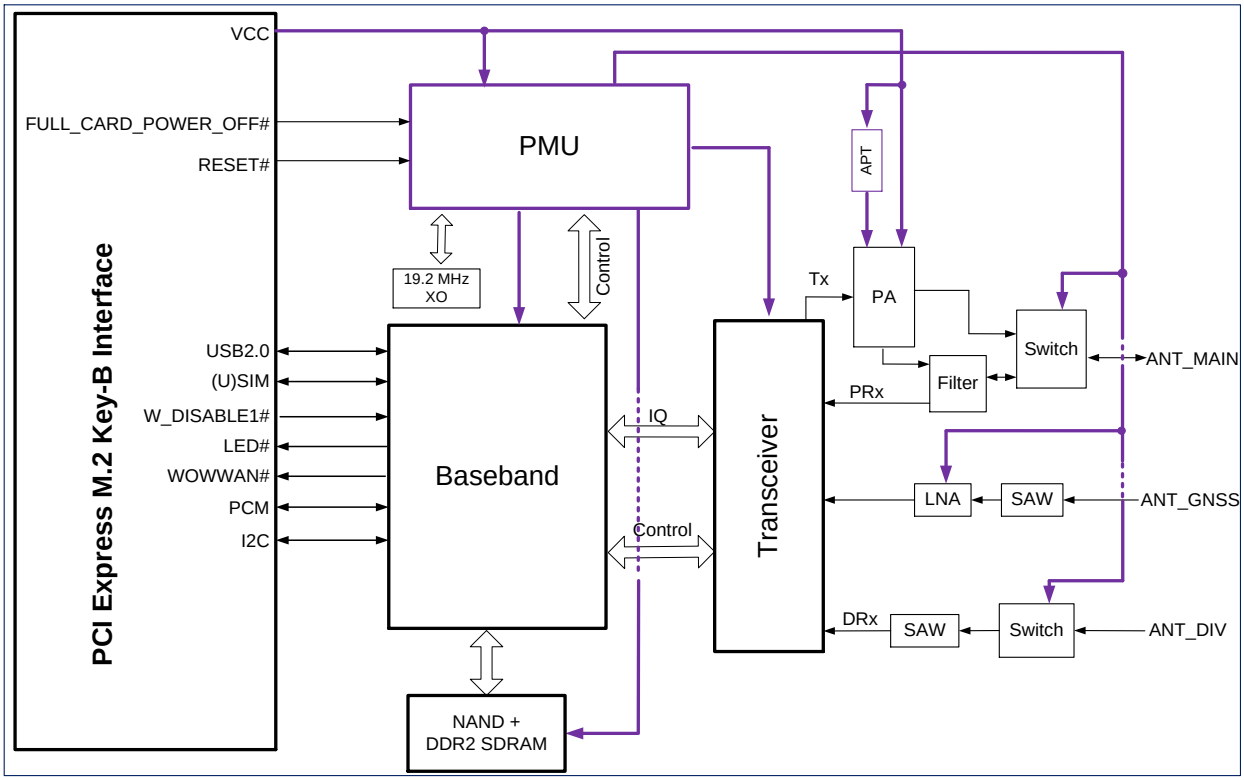
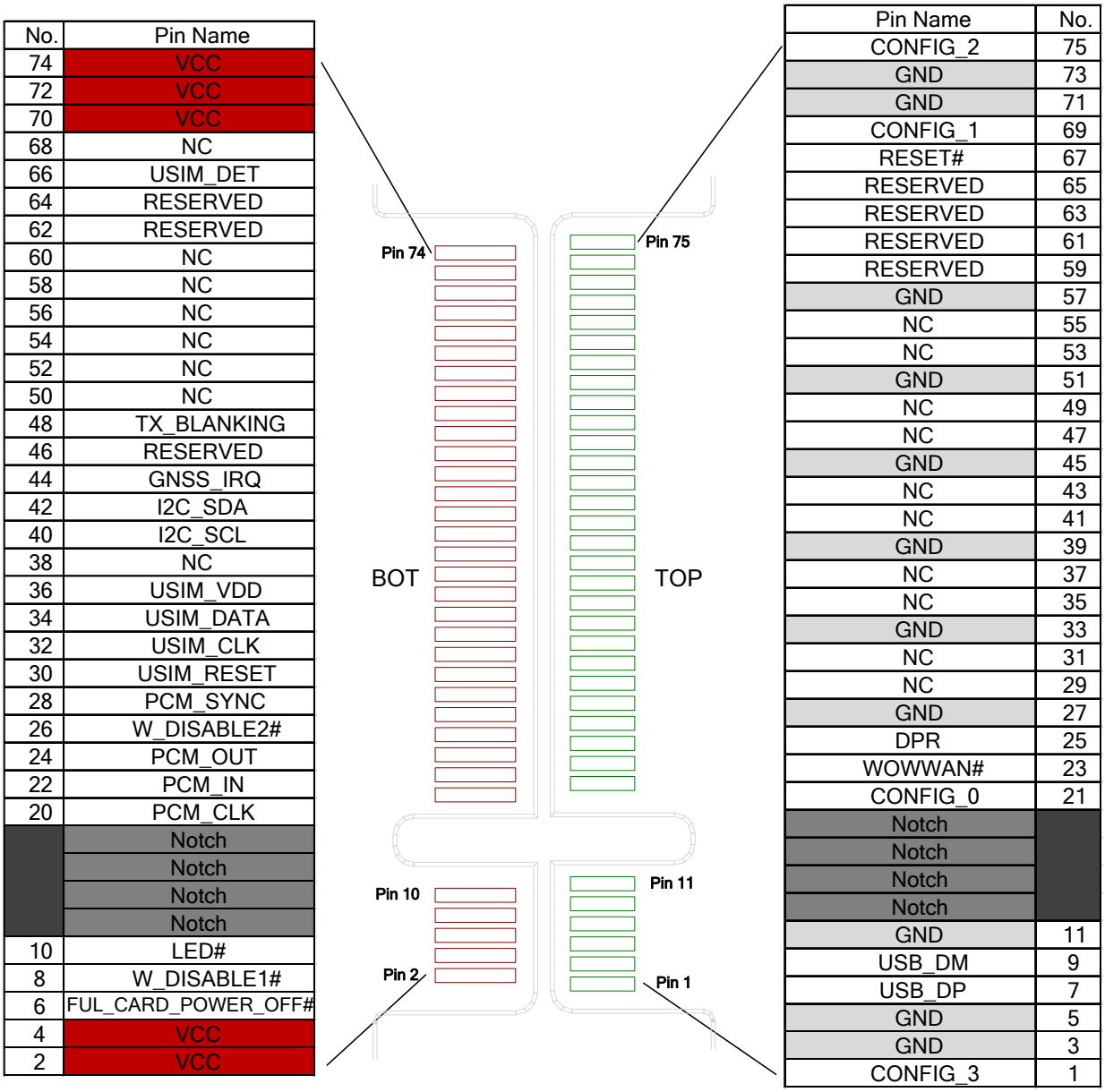


Figure 1: Functional Diagram

2.4. Pin Assignment

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



No.	Pin Name
74	VCC
72	VCC
70	VCC
68	NC
66	USIM_DET
64	RESERVED
62	RESERVED
60	NC
58	NC
56	NC
54	NC
52	NC
50	NC
48	TX_BLANKING
46	RESERVED
44	GNSS_IRQ
42	I2C_SDA
40	I2C_SCL
38	NC
36	USIM_VDD
34	USIM_DATA
32	USIM_CLK
30	USIM_RESET
28	PCM_SYNC
26	W_DISABLE2#
24	PCM_OUT
22	PCM_IN
20	PCM_CLK
	Notch
	Notch
	Notch
	Notch
10	LED#
8	W_DISABLE1#
6	FUL_CARD_POWER_OFF#
4	VCC
2	VCC

Pin Name	No.
CONFIG_2	75
GND	73
GND	71
CONFIG_1	69
RESET#	67
RESERVED	65
RESERVED	63
RESERVED	61
RESERVED	59
GND	57
NC	55
NC	53
GND	51
NC	49
NC	47
GND	45
NC	43
NC	41
GND	39
NC	37
NC	35
GND	33
NC	31
NC	29
GND	27
DPR	25
WOWWAN#	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

NOTE

Before the module turns on, ensure the pins DPR* and USIM_DET are not pulled high to avoid current sink damaging the module. For more details, contact Quectel Technical Support.

2.5. Pin Description

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

Table 4: Parameter Definition

Parameter	Description
AIO	Analog Input/Output
DI	Digital Input
DO	Digital Output
DIO	Digital Input/Output
OD	Open Drain
PI	Power Input
PO	Power Output
PU	Pull Up
PD	Pull Down

DC characteristics include power domain and rated current.

Table 5: Pin Description

Pin No.	Pin Name	I/O	Description	DC Characteristics	Comment
1	CONFIG_3	DO	Connected to GND internally		
2	VCC	PI	Main power supply	Vmin = 3.135 V Vnom = 3.3 V Vmax = 4.4 V	A test point is recommended to be reserved.
3	GND		Ground		
4	VCC	PI	Main power supply	Vmin = 3.135 V Vnom = 3.3 V Vmax = 4.4 V	A test point is recommended to be reserved.
5	GND		Ground		

6	FULL_CARD_POWER_OFF#	DI, PD	Turn on/off the module	V_{IH}max = 4.4 V V_{IH}min = 1.19 V V_{IL}max = 0.2 V V_{IL}min = -0.3 V	Internally pulled down with a 100 kΩ resistor. High level: turn-on Low level: turn-off A test point is recommended to be reserved.
7	USB_DP	AIO	USB 2.0 differential data (+)		Require differential impedance of 90 Ω. A test point must be reserved.
8	W_DISABLE1#	DI, PU	Airplane mode control	1.8/3.3 V	Active LOW.
9	USB_DM	AIO	USB 2.0 differential data (-)		Require differential impedance of 90 Ω. A test point must be reserved.
10	LED#	DO	RF status indication LED	VCC	Active LOW.
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	DIO	PCM clock	1.8 V	In maser mode, it is a DO signal; In slave mode, it is a DI signal.
21	CONFIG_0	DO	Not connected internally		
22	PCM_IN	DI, PD	PCM data input	1.8 V	

23	WOWWAN#	OD	Wake up the host	1.8/3.3 V	Active LOW.
24	PCM_OUT	DO	PCM data output	1.8 V	
25	DPR*	DI, PU	Dynamic power reduction	1.8 V	High level by default.
26	W_DISABLE2#*	DI	GNSS enable control	1.8/3.3 V	Active LOW.
27	GND		Ground		
28	PCM_SYNC	DIO	PCM data frame sync	1.8 V	In maser mode, it is a DO signal; In slave mode, it is a DI signal.
29	NC		Not connected		
30	USIM_RESET	DO	(U)SIM card reset	USIM_VDD	
31	NC		Not connected		
32	USIM_CLK	DO	(U)SIM card clock	USIM_VDD	
33	GND		Ground		
34	USIM_DATA	DIO	(U)SIM card data	USIM_VDD	
35	NC		Not connected		
36	USIM_VDD	PO	(U)SIM card power supply	1.8/3.0 V	
37	NC		Not connected		
38	NC		Not connected		
39	GND		Ground		
40	I2C_SCL	OD	I2C serial clock (for external codec)	1.8 V	Internally pulled up to 1.8 V.
41	NC		Not connected		
42	I2C_SDA	OD	I2C serial data (for external codec)	1.8 V	Internally pulled up to 1.8 V.
43	NC		Not connected		
44	GNSS_IRQ*	DI	GNSS interrupt request	1.8 V	
45	GND		Ground		

46	RESERVED		Reserved		
47	NC		Not connected		
48	TX_BLANKING*	DO	Transmit blanking signal for external GNSS module	1.8 V	
49	NC		Not connected		
50	NC		Not connected		
51	GND		Ground		
52	NC		Not connected		
53	NC		Not connected		
54	NC		Not connected		
55	NC		Not connected		
56	NC		Not connected		
57	GND		Ground		
58	NC		Not connected		
59	RESERVED		Reserved		
60	NC		Not connected		
61	RESERVED		Reserved		
62	RESERVED		Reserved		
63	RESERVED		Reserved		
64	RESERVED		Reserved		.
65	RESERVED		Reserved		
66	USIM_DET [4]	DI	(U)SIM card hot-plug detect	1.8 V	
67	RESET#	DI, PU	Reset the module	V_{IH}max = 2.1 V V_{IH}min = 1.3 V V_{IL}max = 0.5 V	Active LOW. A test point is recommended to be reserved if unused.

[4] If you need (U)SIM hot-plug function, USIM_DET must be connected.

68	NC		Not connected		
69	CONFIG_1	DO	Connected to GND internally		
70	VCC	PI	Main power supply	Vmin = 3.135 V Vnom = 3.3 V Vmax = 4.4 V	A test point is recommended to be reserved.
71	GND		Ground		
72	VCC	PI	Main power supply	Vmin = 3.135 V Vnom = 3.3 V Vmax = 4.4 V	A test point is recommended to be reserved.
73	GND		Ground		
74	VCC	PI	Main power supply	Vmin = 3.135 V Vnom = 3.3 V Vmax = 4.4 V	A test point is recommended to be reserved.
75	CONFIG_2	DO	Connected to GND internally		

NOTE

1. The typical supply voltage of VCC is 3.3 V.
2. Keep all NC, RESERVED and unused pins open.

2.6. EVB Kit

Quectel supplies an evaluation board (M.2 EVB) with accessories to develop and test the module. For more details, see ***document [2]***.

3 Operating Characteristics

3.1. Operating Modes

The table below briefly summarizes the various operating modes referred in the following chapters.

Table 6: Overview of Operating Modes

Mode	Details	
Normal Operation Mode	Idle	The module remains registered on the network, and is ready to send and receive data. In this mode, the software is active.
	Voice/Data	The module is connected to network. Its power consumption varies with the network setting and data transmission rate.
Airplane Mode	**AT+CFUN=4** or pulling down W_DISABLE1# pin can set the module into airplane mode where the RF function is invalid.	
Minimum Functionality Mode	**AT+CFUN=0** can set the module to a minimum functionality mode without removing the power supply. In this mode, both RF function and (U)SIM card are invalid.	
Sleep Mode	The module remains the ability to receive paging message, SMS and TCP/UDP data from the network normally. In this mode, the power consumption of the module is reduced to an ultra-low level.	
Turn-off Mode	The module's power supply is cut off by its power management unit. In this mode, the software is inactive and the data interfaces are inaccessible, while the operating voltage (connected to VCC) remains applied.	

NOTE

For details of the AT command, see ***document [3]***.

3.2. Power Saving

3.2.1. Sleep Mode

The module's DRX is able to reduce the power consumption to an ultra-low level during the sleep mode. The figure below shows the relationship between the DRX run time and the power consumption in sleep mode. The longer the DRX cycle is, the lower the power consumption will be. The following figure describes the power saving procedure of the module.

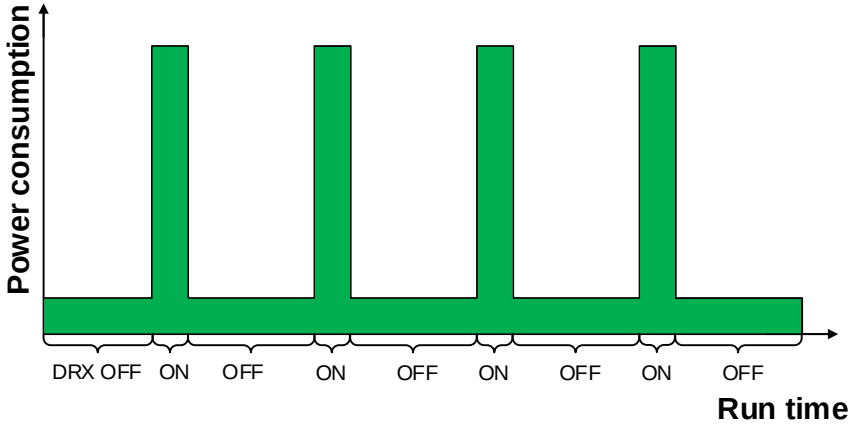


Figure 3: Module Power Consumption in Sleep Mode

NOTE

DRX cycle values are transmitted over the wireless network.

3.2.1.1. USB Application with USB Remote Wakeup Function

If the host supports USB Suspend/Resume and remote wakeup function, the following two preconditions must be met to make the module enter sleep mode.

- Execute **AT+QSCLK=1** to enable the sleep mode, and see ***document [3]*** for details of the AT command.
- The host's USB bus, which is connected to the module's USB interface, enters Suspend state.

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

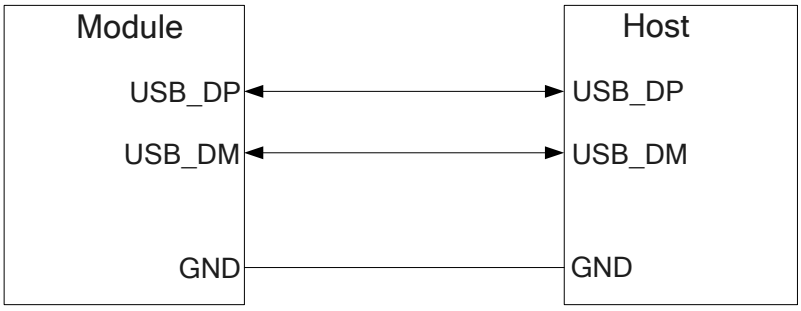


Figure 4: Sleep Mode Application with USB Remote Wakeup

- Sending data to the module via USB will wake up the module.
- When the module has a URC to report, the module will send remote wake-up signals via USB bus to wake up the host.

3.2.1.2. USB Application with USB Suspend/Resume and WOWWAN# Function

If the host supports USB Suspend/Resume but does not support remote wake-up function, the WOWWAN# signal is used to wake up the host.

There are two preconditions to let the module enter sleep mode.

- Execute **AT+QSCLK=1** to enable sleep mode.
- The host's USB bus, which is connected with the module's USB interface, enters Suspend state.

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

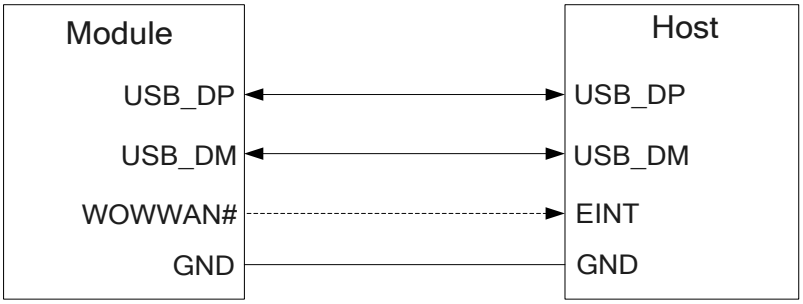


Figure 5: Sleep Mode Application with WOWWAN#

- Sending data to the module via USB will wake up the module.
- When the module has a URC to report, WOWWAN# signal will wake up the host. For more details about WOWWAN# signal, see ***Chapter 4.4.4***.

3.2.2. Airplane Mode

When the module enters airplane mode, the RF function will be disabled, and all AT commands correlative with it will be inaccessible. For more details, refer to ***Chapter 4.4.1***.

3.3. Power Supply

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

Table 7: Definition of VCC and GND Pins

Pin No.	Pin Name	I/O	Description	Power Domain
2, 4, 70, 72, 74	VCC	PI	Main power supply	3.135–4.4 V. Typ. 3.3 V DC power supply.
3, 5, 11, 27, 33, 39, 45, 51, 57, 71, 73	GND		Ground	

3.3.1. Voltage Stability Requirements

The power supply range of the module is from 3.135 V to 4.4 V. Ensure that the input voltage will never drop below 3.135 V, otherwise the module will be turned off automatically. The following figure shows the voltage drop during burst transmission.

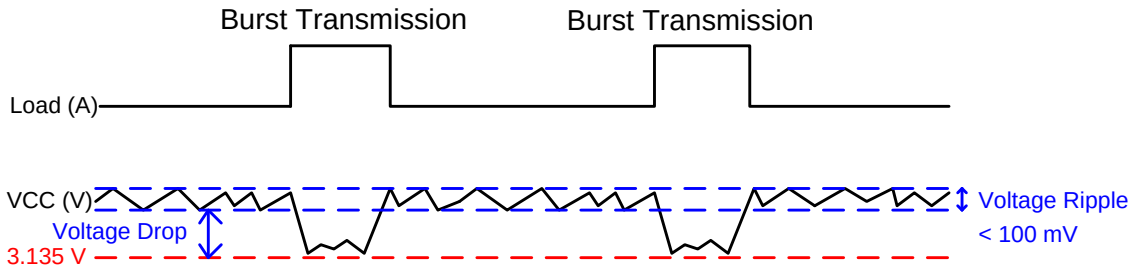


Figure 6: Power Supply Limits During Burst Transmission

To decrease the voltage drop, two filter capacitors of about 220 µF with low ESR (ESR = 0.7 Ω) should be used. A multi-layer ceramic chip capacitor (MLCC) array also should be used due to its ultra-low ESR for the power filtering. 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 at least 2 mm. In principle, the longer the VCC trace is, the wider it should be.

To avoid the ripple and surge and to ensure the stability of the power supplies to the module, add high-power rated TVS components at the front end of the power supplies. If TVS are not added, surges on the input power supplies may cause damage to the module. The following figure shows the reference circuit of VCC.

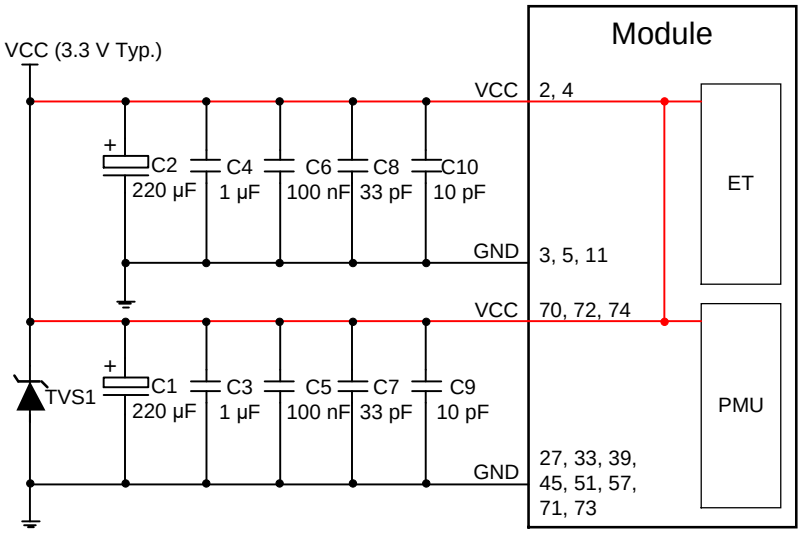


Figure 7: VCC Reference Circuit

3.3.2. Reference Design for Power Supply

The performance of the module largely depends on the power source. The power supply of the module should be able to provide a sufficient current of at least 2.0 A. If the voltage drop between the input voltage and output voltage is not too high, it is suggested that an LDO should be used for the module. If there is a big voltage difference between the input source and the desired output (VCC = 3.3 V Typ.), a buck converter is preferred to be used as the power supply.

The following figure shows a reference design for +5 V input power source. The typical output of the power supply is about 3.3 V and the maximum load current is 3.0 A.

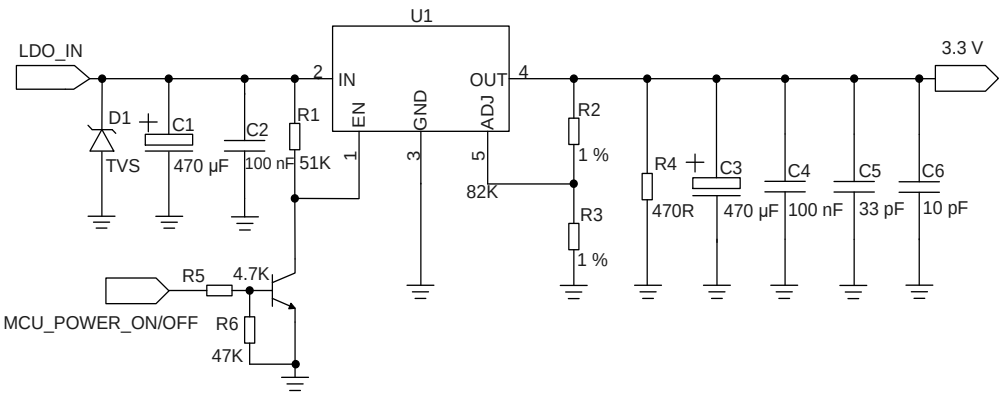


Figure 8: Reference Circuit for the Power Supply

NOTE

To avoid corrupting the data in the internal flash, do not switch off the power supply when the module works normally. It is recommended to pull down RESET# for at least 100 ms before the power supply of the module is cut off.

3.3.3. Monitor the Power Supply

AT+CBC can be used to monitor the VCC voltage value. For more details, see ***document [3]***.

3.4. Turn-on

FULL_CARD_POWER_OFF# is used to turn on/off the module. When the input signal is at high level (≥ 1.19 V), the module will turn on. This input signal can be driven by either 1.8 V or 3.3 V GPIO. Also, FULL_CARD_POWER_OFF# has been pulled down to GND internally with a 100 kΩ resistor.

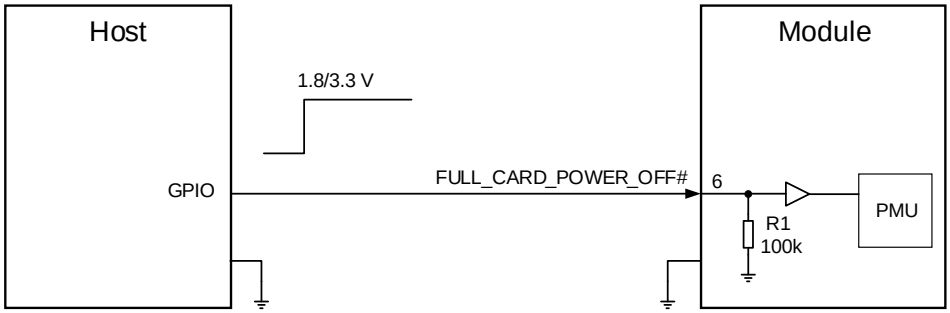
The following table shows the definition of FULL_CARD_POWER_OFF#.

Table 8: Pin Definition of FULL_CARD_POWER_OFF#

Pin No.	Pin Name	I/O	Description	Comment
6	FULL_CARD_ POWER_OFF#	DI, PD	Turn on/off the module	Internally pull down with a 100 kΩ resistor. High level: turn-on Low level: turn-off A test point is recommended to be reserved.

The module can be turned on by driving the FULL_CARD_POWER_OFF# pin to a high level.

It is recommended to use a host's GPIO to control FULL_CARD_POWER_OFF#. A simple reference circuit is illustrated in the following figure.



NOTE: The voltage of FULL_CARD_POWER_OFF# should be at least 1.19 V when the module is at high level.

Figure 9: Turn on the Module with a Host's GPIO

Pull up FULL_CARD_POWER_OFF# to 1.8 V or 3.3 V (recommended) through a resistor (5–10 kΩ), the module can also turn on automatically. In this case, VCC power supply should be cut off to turn off the module. A reference circuit is shown in the following figure.

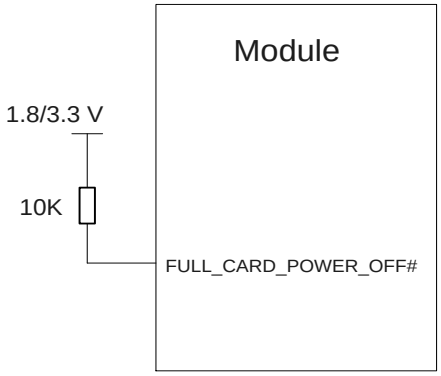


Figure 10: Turn on the Module Automatically

The turn-on timing of the module is illustrated in the following figure.

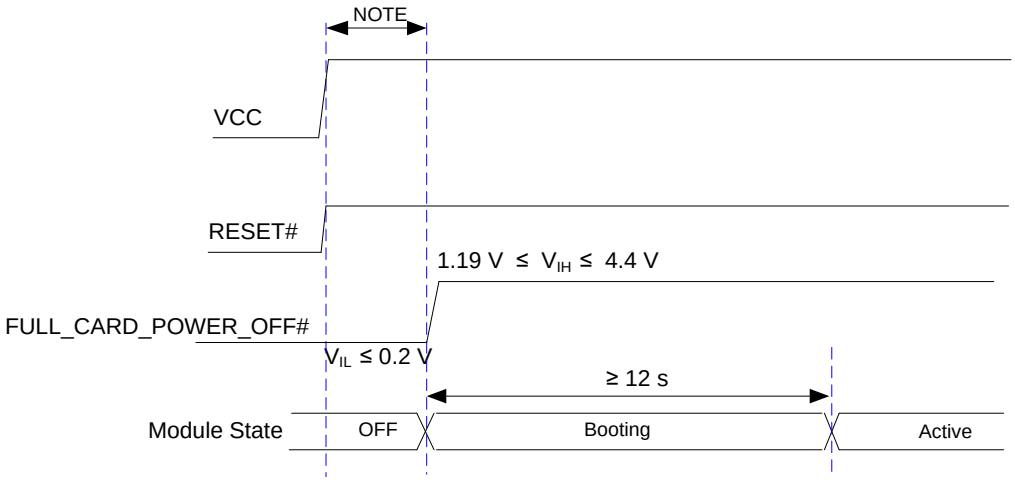


Figure 11: Turn-on Timing

NOTE

Make sure that VCC is stable before pulling up FULL_CARD_POWER_OFF# pin. And the time interval is at least 30 ms.

3.5. Turn-off

The following procedures can be applied to turn off the module normally:

- Hardware: Turn off the module using the FULL_CARD_POWER_OFF# pin.
- Software: Turn off the module using **AT+QPOWD**, and see ***document [3]*** for details of the AT command.

3.5.1. Turn-off with FULL_CARD_POWER_OFF#

Driving FULL_CARD_POWER_OFF# low, the PMU inside the module will be powered off, then the module will be forced to turn off. But it is recommended to pull down RESET# for at least 100 ms before FULL_CARD_POWER_OFF# is driven low to avoid corrupting the data in the internal flash.

The turn-off timing of the module via FULL_CARD_POWER_OFF# is illustrated in the following figure.

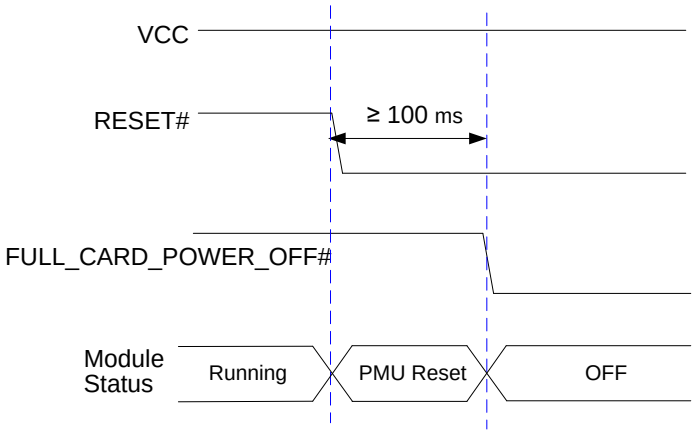


Figure 12: Turn-off Timing with FULL_CARD_POWER_OFF#

3.5.2. Turn-off with AT Command

It is also a safe way to turn off the module by **AT+QPOWD**. After executing such command, you should pull down FULL_CARD_POWER_OFF# pin or cut off VCC power supply after the module is turned off in software, otherwise the module will be turned on again.

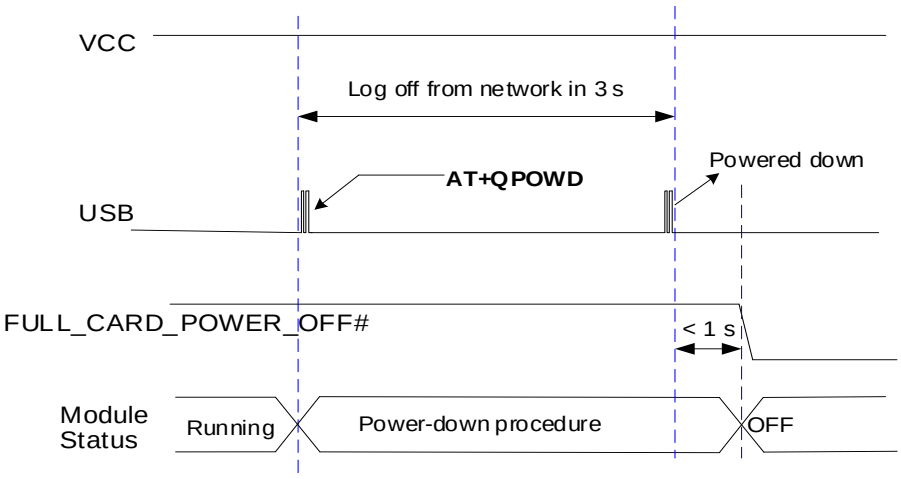


Figure 13: Turn-off Timing with AT Command

During power-down procedure, the module will log off from network and save important data. After the module logs off, it sends a URC "**POWERED DOWN**" and shuts down the internal power supply. If the "**POWERED DOWN**" URC is outputted, the VCC power supply can be cut off.

3.6. Reset the Module

RESET# is an asynchronous and active-low signal. Whenever this pin is active, the module will immediately enter Power-on Reset (POR) condition.

Please note that triggering RESET# will lead to loss of temporary data in the modem and removal of system drivers. The module will also disconnect the modem from the network.

Table 9: Pin Definition of RESET#

Pin No.	Pin Name	I/O	Description	Comment
67	RESET#	DI, PU	Reset the module	Active LOW. A test point is recommended to be reserved if unused.

Driving RESET# low for 150–460 ms can reset the module. An open collector/open drain driver or button can be used to control the RESET# pin.

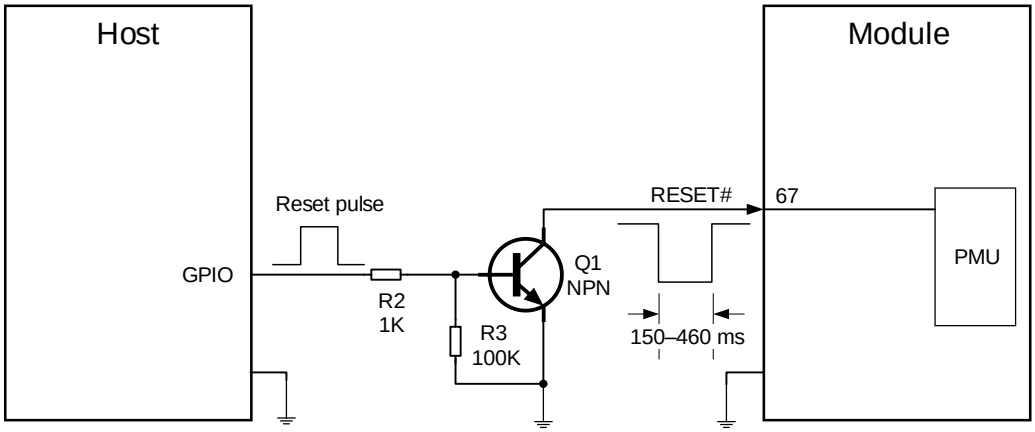
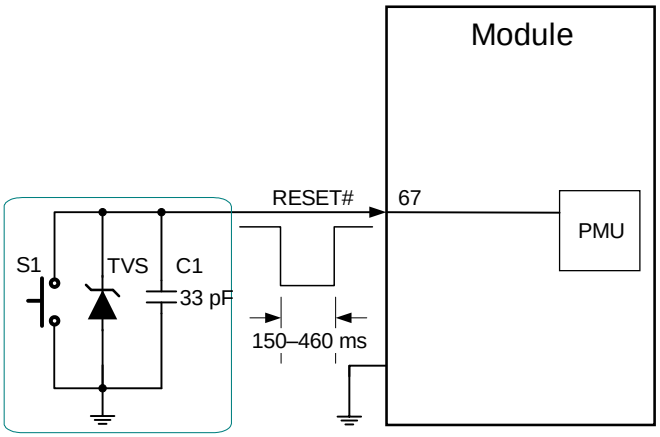


Figure 14: Reference Circuit of RESET# with NPN Driver Circuit



NOTE: The capacitor C1 is recommended not to exceed 47 pF.

Figure 15: Reference Circuit of RESET# with a Button

The reset timing of the module is illustrated in the following figure.

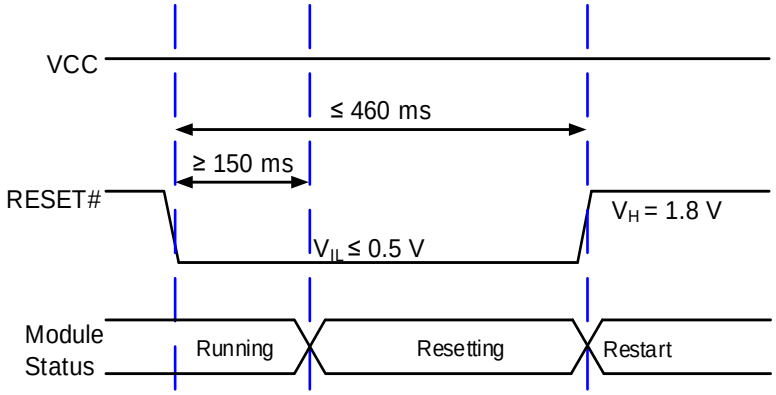


Figure 16: Reset Timing

NOTE

Ensure that there is no large capacitance on RESET# pin.

4 Application Interfaces

The physical interfaces and electrical characteristics of the module comply with PCI Express M.2 specifications. The subsequent chapters will provide detailed descriptions of the following interfaces or functions.

- (U)SIM interface
- USB interface
- PCM and I2C interfaces
- Control and indication interfaces
- Configuration pins

4.1. (U)SIM Interface

The (U)SIM interface circuitry meets ETSI and IMT-2000 requirements. Both 1.8 V and 3.0 V (U)SIM cards are supported.

4.1.1. Pin Definition of (U)SIM Interface

Table 10: Pin Definition of (U)SIM Interface

Pin No.	Pin Name	I/O	Description	Comment
36	USIM_VDD	PO	(U)SIM card power supply	1.8/3.0 V
34	USIM_DATA	DIO	(U)SIM card data	USIM1_VDD
32	USIM_CLK	DO	(U)SIM card clock	
30	USIM_RESET	DO	(U)SIM card reset	
66	USIM_DET [5]	DI	(U)SIM card hot-plug detect	1.8 V

[5] If you need (U)SIM hot-plug function, USIM_DET must be connected.

4.1.2. (U)SIM Card Hot-plug Detection

The module supports (U)SIM card hot-plug via the pin USIM_DET. (U)SIM card insertion is detected by high/low level. (U)SIM card hot-plug function is disabled by default. **AT+QSIMDET** can be used to enable (U)SIM card hot-plug function. See ***document [3]*** for details.

NOTE

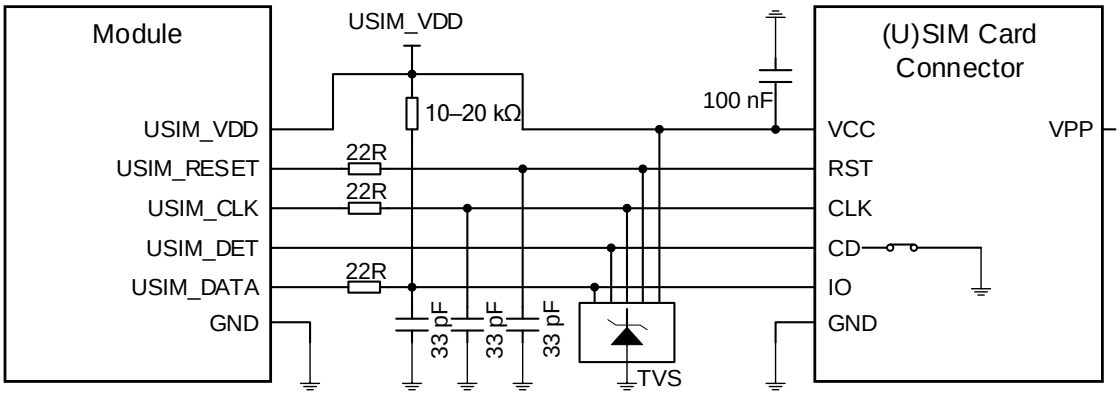
1. USIM_DET will be internally pulled up to 1.8 V by software configuration only when (U)SIM hot-plug is enabled by **AT+QSIMDET**. Hot-plug function takes effect after the module is restarted. For more details about the AT command, see ***document [3]***.
2. If USIM_DET is not used, keep it unconnected. If USIM_DET is used, external pull-up circuit is not needed.
3. If you have any questions on designing, please contact Quectel Technical Support.

4.1.3. Normally Closed (U)SIM Card Connector

With a normally closed (U)SIM card connector, USIM_DET pin is shorted to ground when there is no (U)SIM card inserted. (U)SIM card detection by high level is applicable to this type of connector. After the (U)SIM hot-plug function is enabled:

- When the (U)SIM card is present, CD is disconnected from ground and USIM_DET is at high level.
- When the (U)SIM card is absent, CD is shorted to ground and USIM_DET is at low level.

The following figure shows a reference design for (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.

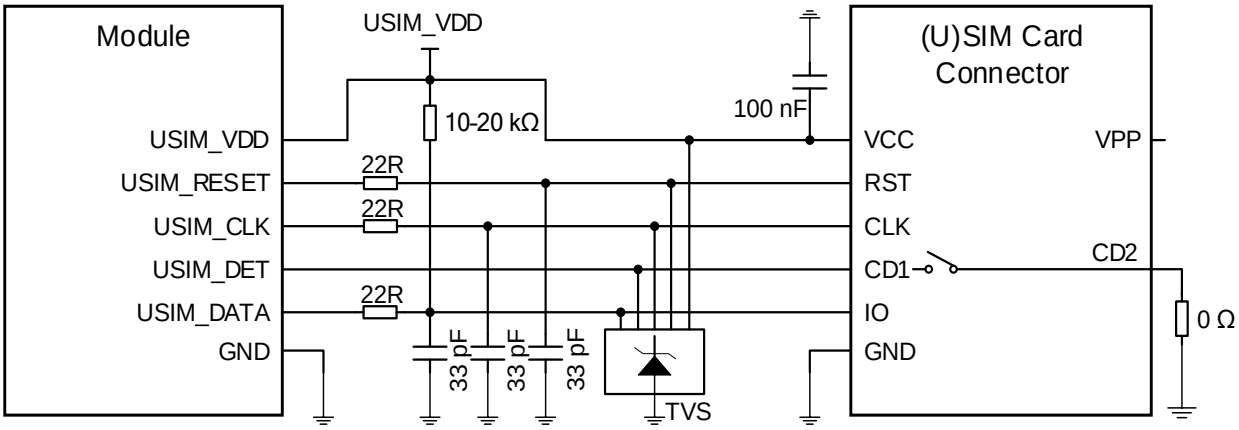
Figure 17: Reference Circuit for Normally Closed (U)SIM Card Connector

4.1.4. Normally Open (U)SIM Card Connector

With a normally open (U)SIM card connector, CD1 and CD2 of the connector are disconnected when there is no (U)SIM card inserted. (U)SIM card detection by low level is applicable to this type of connector. After (U)SIM hot-plug function is enabled:

- When the (U)SIM card is present, CD1 is pulled down to ground and USIM_DET is at low level.
- When the (U)SIM card is absent, CD1 is open from CD2 and USIM_DET is at high level.

The following figure shows a reference design for (U)SIM interface with a normally open (U)SIM card connector.

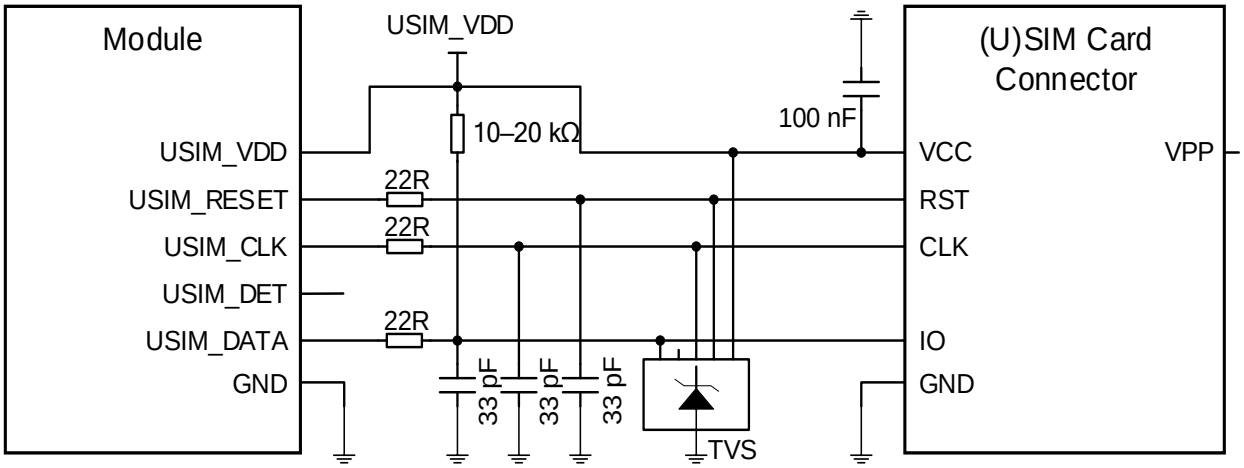


NOTE: All these resistors, capacitors and TVS should be close to (U)SIM card connector in PCB layout.

Figure 18: Reference Circuit for Normally Open (U)SIM Card Connector

4.1.5. (U)SIM Card Connector Without Hot-plug Detection

If (U)SIM card hot-plug detection is not needed, keep USIM_DET unconnected. A reference circuit for (U)SIM interface with a 6-pin (U)SIM card connector is illustrated in the following figure.



NOTE: All these resistors, capacitors and TVS should be close to (U)SIM card connector in PCB layout.

Figure 19: Reference Circuit of (U)SIM Interface with a 6-Pin (U)SIM Card Connector

4.1.6. (U)SIM Interface Design Notices

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

- Keep placement of (U)SIM card connector to the module as close as possible. Keep the trace length as short as possible, at most 200 mm.
- Keep (U)SIM card signals away from RF and VCC traces.
- Keep the trace width of ground and USIM_VDD at least 0.5 mm to maintain the same electric potential.
- To avoid cross-talk between USIM_CLK and USIM_DATA, keep them away from each other and shield them with surrounded ground.
- For better ESD protection, it is recommended to add a TVS array whose parasitic capacitance should not exceed 10 pF. Add 22 Ω resistors in series between the module and the (U)SIM card connector to suppress EMI. The 33 pF capacitors on USIM_DATA, USIM_CLK and USIM_RESET traces 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.

4.2. USB Interface

The USB interface of the module is compliant with USB 2.0 specification and the module only supports slave mode. Meanwhile, it supports high speed (480 Mbps) and full speed (12 Mbps) mode. The USB interface is used for AT command communication, data transmission, GNSS NMEA sentence output, software debugging and firmware upgrade.

The following table shows the pin definition of USB interface.

Table 11: Pin Definition of USB Interface

Pin No.	Pin Name	I/O	Description	Comment
7	USB_DP	AIO	USB 2.0 differential data (+)	Require differential impedance of 90 Ω. Test point must be reserved.
9	USB_DM	AIO	USB 2.0 differential data (-)	

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

The following figure shows the reference circuit of USB interface.

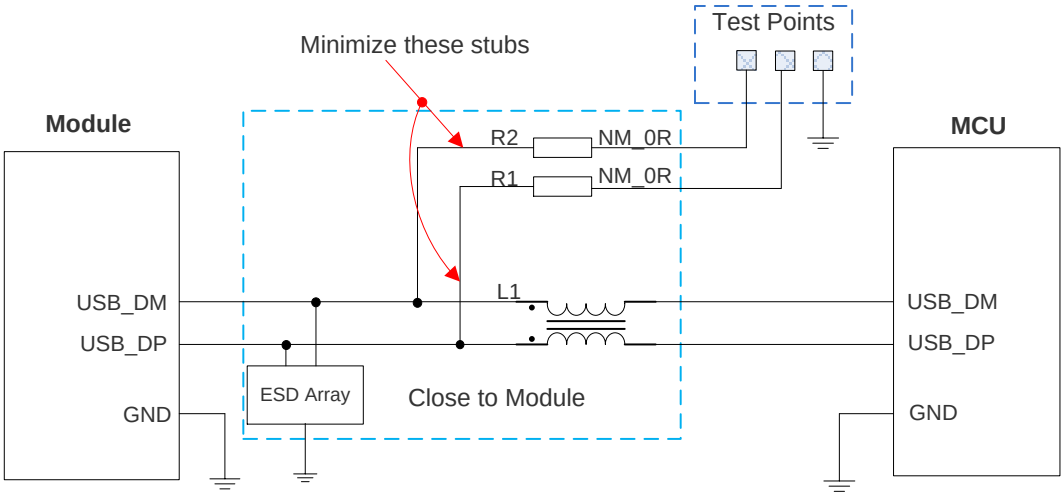


Figure 20: Reference Circuit of USB 2.0 Interface

A common mode choke L1 is recommended to be added in series between the module and your MCU to suppress EMI. 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 integrity of USB data trace signal, L1, R1 and R2 components must be placed close to the module, and these resistors should be placed close to each other. The extra stubs of trace must be as short as possible.

To meet USB 2.0 specification, the following principles should be complied with when designing the USB interface.

- Route the USB signal traces as differential pairs with ground surrounded. The impedance of USB differential trace is 90 Ω.
- Do not route signal traces under crystals, oscillators, magnetic devices and RF signal traces. Route the USB differential traces in inner-layer of the PCB, and surround the traces with ground on the

same layer and with ground planes above and below.
- Pay attention to the influence of junction capacitance of ESD protection components on USB data traces. Typically, the capacitance value should be less than 2 pF.
- Keep the ESD protection components as close to the M.2 gold finger slot.

4.3. PCM and I2C Interfaces

The module provides one Pulse Code Modulation (PCM) interface and one I2C interface. The PCM interface supports the following modes:

- Primary mode (short frame synchronization): the module works as master or slave.
- Auxiliary mode (long frame synchronization): the module works as master only.

The following table shows the pin definition of PCM and I2C interfaces which can be applied to audio codec design.

Table 12: Pin Definition of PCM and I2C Interfaces

Pin No.	Pin Name	I/O	Description	Comment
20	PCM_CLK	DIO	PCM clock	1.8 V In maser mode, it is a DO signal; In slave mode, it is a DI signal.
22	PCM_IN	DI, PD	PCM data input	1.8 V.
24	PCM_OUT	DO	PCM data output	
28	PCM_SYNC	DIO	PCM data frame sync	1.8 V In maser mode, it is a DO signal; In slave mode, it is a DI signal.
40	I2C_SCL	OD	I2C serial clock (for external codec)	Internally pulled up to 1.8 V.
42	I2C_SDA	OD	I2C serial data (for external codec)	

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, the PCM interface operates with a 256 kHz, 512 kHz, 1024 kHz or 2048 kHz PCM_CLK and an 8 kHz, 50 % duty cycle PCM_SYNC.

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.

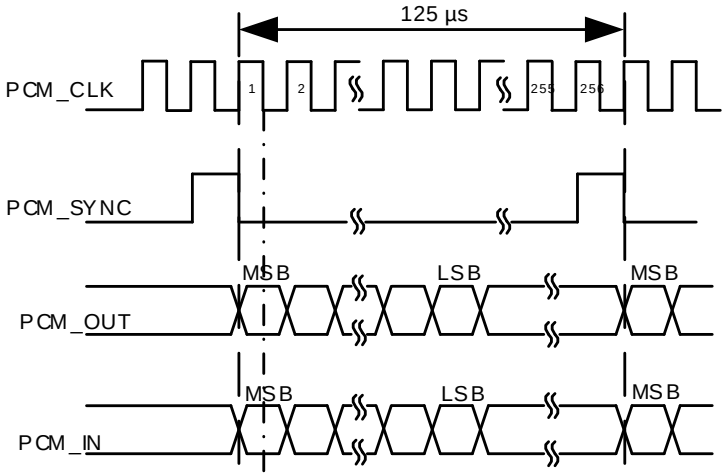


Figure 21: Primary Mode Timing

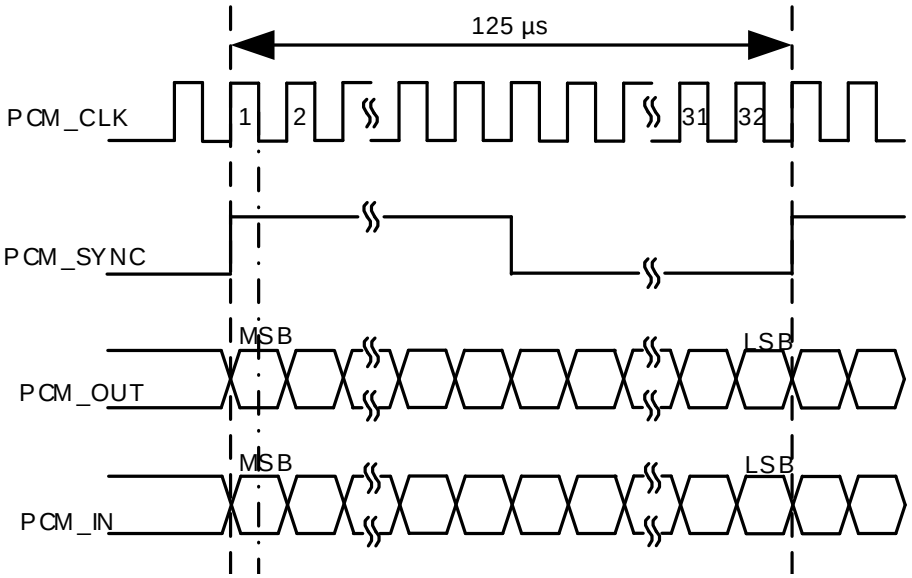


Figure 22: Auxiliary Mode Timing

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 [3]*** for details about **AT+QDAI**.

The following figure shows a reference design of PCM and I2C interfaces with an external codec IC.

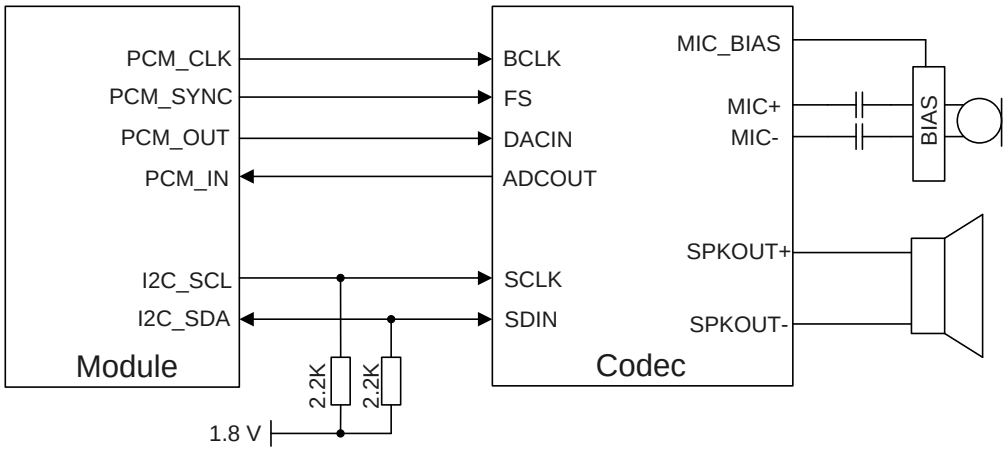


Figure 23: Reference Circuit of PCM and I2C Interfaces with Audio Codec

NOTE

1. It is recommended to reserve an RC (R = 22 Ω, C = 22 pF) circuit on the PCM traces (especially for PCM_CLK) close to the Codec.
2. The module only works as a master device pertaining to I2C interface.

4.4. 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, PU	Airplane mode control	1.8/3.3 V. Active LOW.
26	W_DISABLE2#*	DI	GNSS enable control	
10	LED#	DO	RF status indication LED	VCC. Active LOW.
23	WOWWAN#	OD	Wake up the host	1.8/3.3 V. Active LOW.
25	DPR*	DI, PU	Dynamic power reduction	1.8 V. High level by default.

44	GNSS_IRQ*	DI	GNSS interrupt request	1.8 V
48	TX_BLANKING*	DO	Transmit blanking signal for external GNSS module	

4.4.1. W_DISABLE1#

The module provides a W_DISABLE1# pin to disable or enable airplane mode through hardware operation. The W_DISABLE1# pin is internally 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 AT commands. For details of related AT commands, see ***document [3]***. The following table shows the AT command and corresponding RF function status of the module.

Table 14: RF Function Status

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

NOTE

1. The W_DISABLE1# control function is disabled in firmware by default. It can be enabled by **AT+QCFG="airplanecontrol",1**. See ***document [4]*** for details.
2. Execution of **AT+CFUN** will not affect GNSS function.

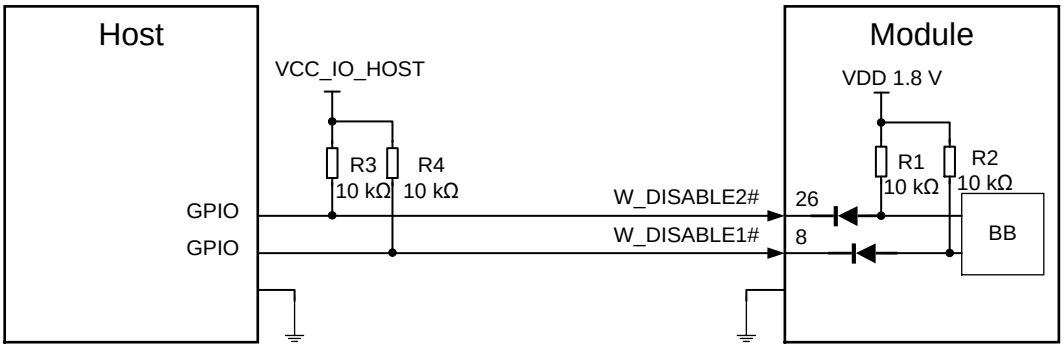
4.4.2. W_DISABLE2#*

The module provides a W_DISABLE2# pin to disable or enable the GNSS function. The W_DISABLE2# pin is internally pulled up by default. Driving it low will disable the GNSS function. The combination of W_DISABLE2# pin and AT commands controls the GNSS function.

Table 15: GNSS Function Status

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

A simple voltage-level translator based on diodes is used on W_DISABLE1# pin and W_DISABLE2# pin which are pulled up to 1.8 V inside the module. As shown in the following figure, the control signals (GPIO) of the host could be 1.8 V or 3.3 V voltage level. W_DISABLE1# and W_DISABLE2# are active LOW, and a reference circuit is shown below.



NOTE: The voltage level of VCC_IO_HOST could be 1.8 V or 3.3 V typically.

Figure 24: W_DISABLE1# and W_DISABLE2# Reference Circuit

4.4.3. LED#

LED# is used to indicate the RF status of the module, and its sink current is up to 9 mA.

To reduce current consumption of the LED, a current-limited resistor must be placed in series with the LED, and the reference circuit is illustrated in the figure as below. The LED is ON when the LED# signal is at low level or outputs PWM pulse.

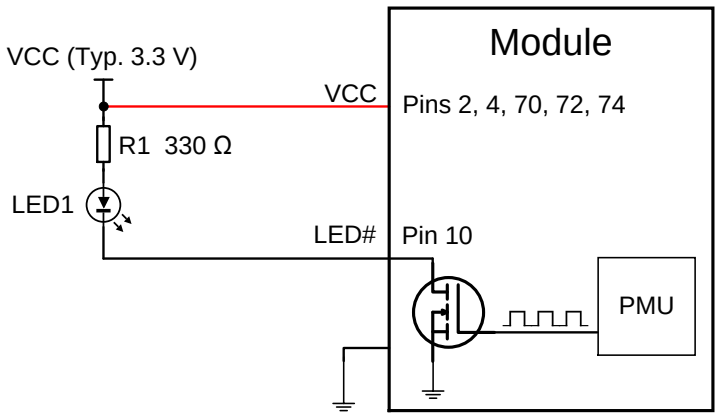


Figure 25: LED# Reference Circuit

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

Table 16: RF Status Indications of LED#

LED# Logic Level	Description
Low Level (LED ON)	RF function is enabled.
High Level (LED OFF)	RF function is disabled if any of the following occurs: ● (U)SIM card is not powered. ● W_DISABLE1# is at low level (airplane mode enabled). ● **AT+CFUN=4** (RF function disabled). ● **AT+CFUN=0** (RF function disabled).

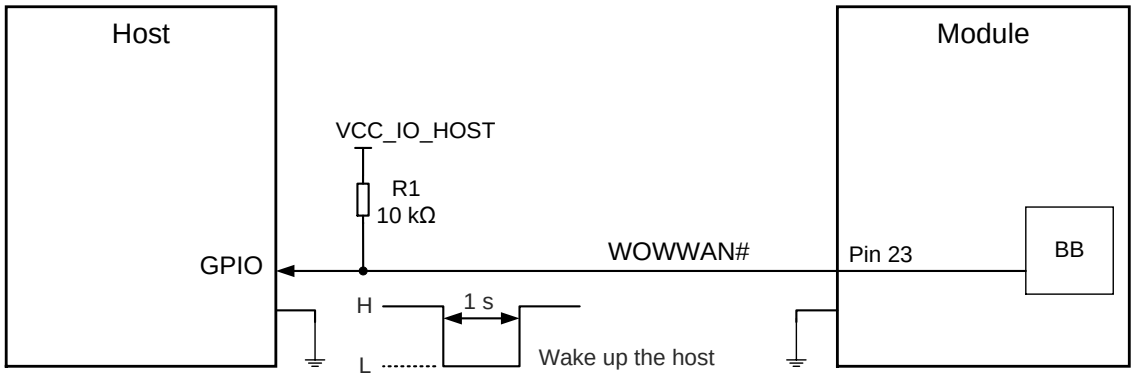
4.4.4. WOWWAN#

The WOWWAN# is an open drain pin, which requires a pull-up resistor on the host. When a URC returns, a one-second low-level pulse will be outputted to wake up the host.

The state of WOWWAN# signal is shown as below.

Table 17: State of WOWWAN# Signal

WOWWAN# State	Module Operation Status
Output a one-second low-level pulse	SMS/Data is incoming (to wake up the host)
Always at high level	Idle/Sleep



NOTE: Since WOWWAN# is open drain pin, the voltage level on VCC_IO_HOST depends on the host.

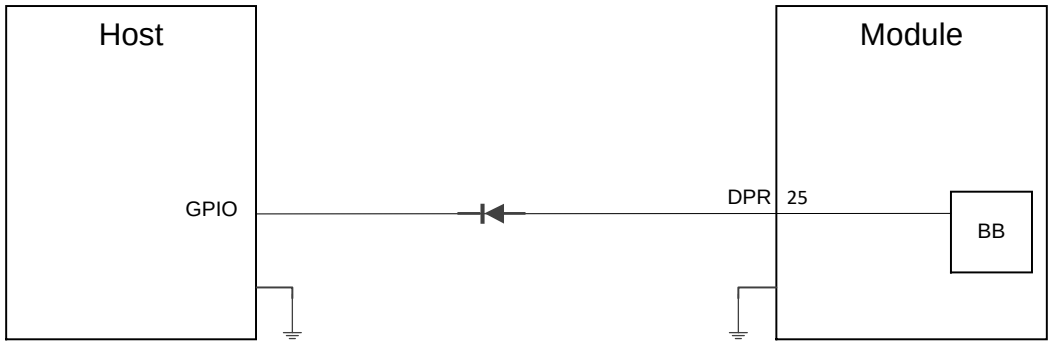
Figure 26: WOWWAN# Reference Circuit

4.4.5. DPR*

The module provides a DPR (Dynamic Power Reduction) pin for body SAR (Specific Absorption Rate) detection. The signal is sent from the proximity sensor of a host system to the module to provide an input trigger, which will reduce the output power in radio transmission.

Table 18: Function of the DPR

DPR Level	Function
High Level/Floating	No backoff of the maximum output power
Low Level	Reduce the maximum output power by **AT+QCFG="sarcfg"**. See ***document [4]*** for details.



NOTE: Host's GPIO could be a 1.8 V or 3.3 V voltage level.

Figure 27: DPR Signal Reference Circuit

4.5. Configuration Pins

The module provides four configuration pins, which are defined as below.

Table 19: Configuration Pins of M.2 Specification

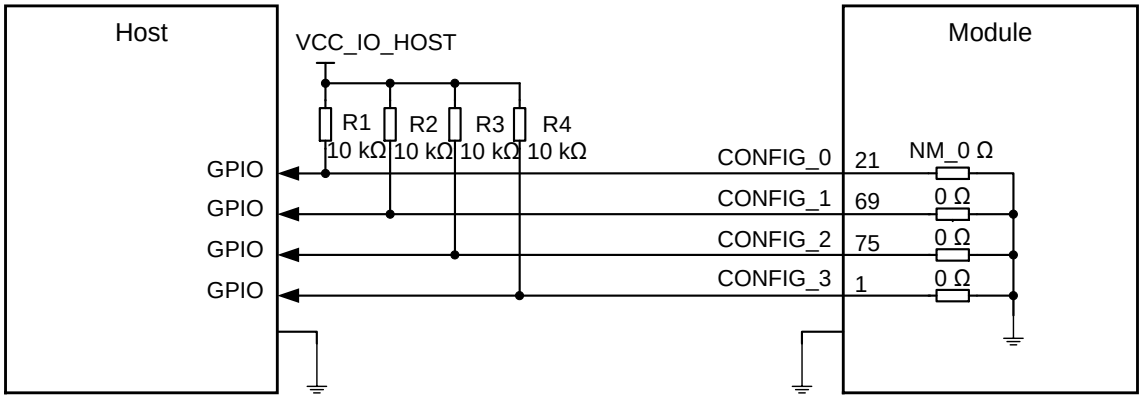
CONFIG_0 (Pin 21)	CONFIG_1 (Pin 69)	CONFIG_2 (Pin 75)	CONFIG_3 (Pin 1)	Module Type and Host Interface	Port Configuration
NC	GND	GND	GND	Quectel defined	-

Configuration pins are used to assist the host to identify the presence of the module in the socket and identify module type.

Table 20: Pin Definition of Configuration Pins

Pin No.	Pin Name	I/O	Description
1	CONFIG_3	DO	Connected to GND internally
21	CONFIG_0	DO	Not connected internally
69	CONFIG_1	DO	Connected to GND internally
75	CONFIG_2	DO	Connected to GND internally

The following figure shows a reference circuit for these configuration pins.



NOTE: The voltage level of VCC_IO_HOST depends on the host and could be 1.8 V or 3.3 V.

Figure 28: Recommended Circuit of Configuration Pins

5 RF Characteristics

Appropriate antenna type and design should be used with matched antenna parameters according to specific application. It is required to perform a comprehensive functional test for the RF design before mass production of terminal products. The entire content of this chapter is provided for illustration only. Analysis, evaluation and determination are still necessary when designing target products.

The module is mounted with three 2 mm × 2 mm antenna connectors for external antenna connection: a main antenna connector, a Rx-diversity antenna connector, and a GNSS antenna connector. The impedance of the antenna connectors is 50 Ω.

5.1. Cellular Network

5.1.1. Operating Frequency

Table 21: Module Operating Frequencies

3GPP Band	Transmit	Receive	Unit
B1	1920–1980	2110–2170	MHz
B3	1710–1785	1805–1880	MHz
B7	2500–2570	2620–2690	MHz
B8	880–915	925–960	MHz
B20	832–862	791–821	MHz
B28	703–748	758–803	MHz
B38	2570–2620	2570–2620	MHz
B41	2555–2655	2555–2655	MHz

NOTE

LTE-TDD B41 supports 100 MHz (2555–2655 MHz).

5.1.2. Receiver Sensitivity

Table 22: Conducted RF Receiver Sensitivity

Frequency Band	Receiver Sensitivity (Typ.)			3GPP (SIMO)	Unit
	Primary	Diversity	SIMO		
WCDMA B1	-109.5	-110.6	-113	-106.7	dBm
WCDMA B8	-110.0	-111.4	-114.1	-103.7	dBm
LTE-FDD B1 (10 MHz)	-97.7	-99	-102	-96.3	dBm
LTE-FDD B3 (10 MHz)	-97.7	-99.1	-102.4	-93.3	dBm
LTE-FDD B7 (10 MHz)	-96.1	-98.1	-100.7	-94.3	dBm
LTE-FDD B8 (10 MHz)	-98.4	-99.8	-102.3	-93.3	dBm
LTE-FDD B20 (10 MHz)	-98.0	-99.8	-102.2	-93.3	dBm
LTE-FDD B28 (10 MHz)	-98.1	-99.6	-102.4	-94.8	dBm
LTE-TDD B38 (10 MHz)	-98.2	-97.9	-101.2	-96.3	dBm
LTE-TDD B41 (10 MHz)	-98.2	-97.4	-101.0	-94.3	dBm

5.1.3. Transmit Power

Table 23: Conducted RF Transmit Power

Frequency Band	Max.	Min.
LTE-FDD Bands	23 dBm ±2 dB	< -39 dBm
LTE-TDD Bands	23 dBm ±2 dB	< -39 dBm
WCDMA Bands	23 dBm ±2 dB	< -49 dBm

5.2. GNSS (Optional) [6]

5.2.1. General Description

The module includes a fully integrated Global Navigation Satellite System (GNSS) solution that supports GPS, GLONASS, BDS, Galileo and QZSS.

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

By default, GNSS engine is switched off and can be switched on via AT command. For more details about GNSS positioning technology and configurations, see ***document [1]***.

5.2.2. GNSS Frequency

The following tables show the frequency specification of GNSS antenna.

Table 24: GNSS Frequency

GNSS Constellation Type	Frequency	Unit
GPS	1575.42 ±1.023	MHz
Galileo	1575.42 ±2.046	MHz
QZSS	1575.42 ±1.023	MHz
GLONASS	1601.7 ±4.2	MHz
BDS	1561.098 ±2.046	MHz

5.3. Antenna Connectors

5.3.1. Antenna Connector Location

The antenna connector locations are shown below.

[6] GNSS function is optional.

Figure 29: Antenna Connectors on the Module

5.3.2. Antenna Connector Size

The module is mounted with standard 2 mm × 2 mm receptacle antenna connectors for convenient antenna connection. The antenna connector's PN is IPEX 20449-001E, and the connector dimensions are illustrated by the figure below:

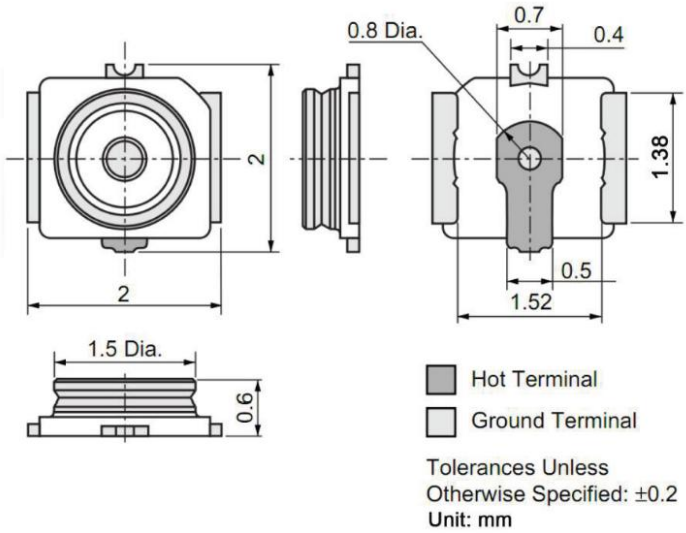


Figure 30: RF Connector Dimensions (Unit: mm)

Table 25: Specifications of Antenna Connectors

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

5.3.3. Antenna Connector Installation

The receptacle accepts two types of mated plugs to meet two maximum mated heights: 1.20 mm (using a Ø 0.81 mm coaxial cable) and 1.45 mm (using a Ø 1.13 mm coaxial cable).

The following figure shows the dimensions of mated plugs using Ø 0.81 mm coaxial cables.

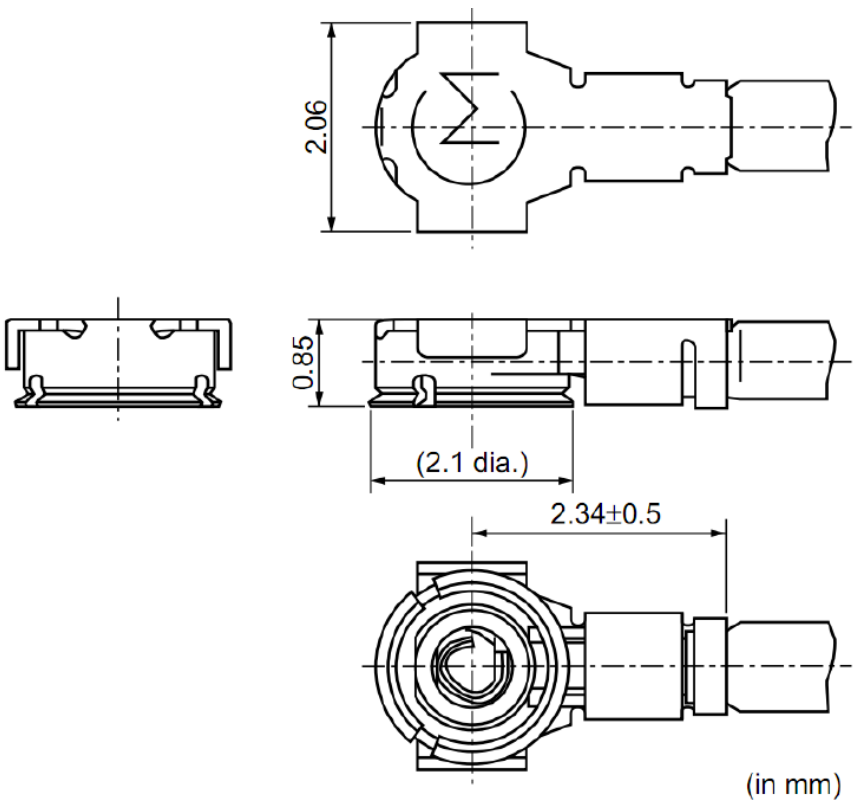


Figure 31: Dimensions of Mated Plugs (Ø 0.81 mm Coaxial Cables) (Unit: mm)

The following figure illustrates the connection between the receptacle antenna connector on the module and the mated plug using a Ø 0.81 mm coaxial cable.

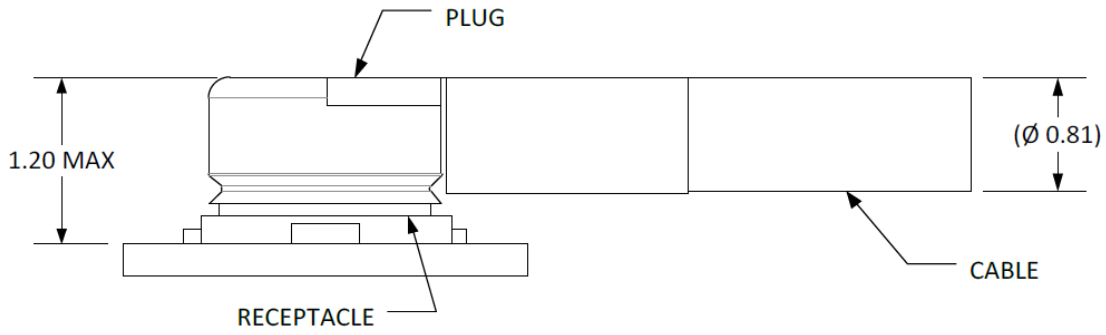


Figure 32: Space Factor of Mated Connectors (Ø 0.81 mm Coaxial Cables) (Unit: mm)

The following figure illustrates the connection between the receptacle antenna connector on the module and the mated plug using a Ø 1.13 mm coaxial cable.

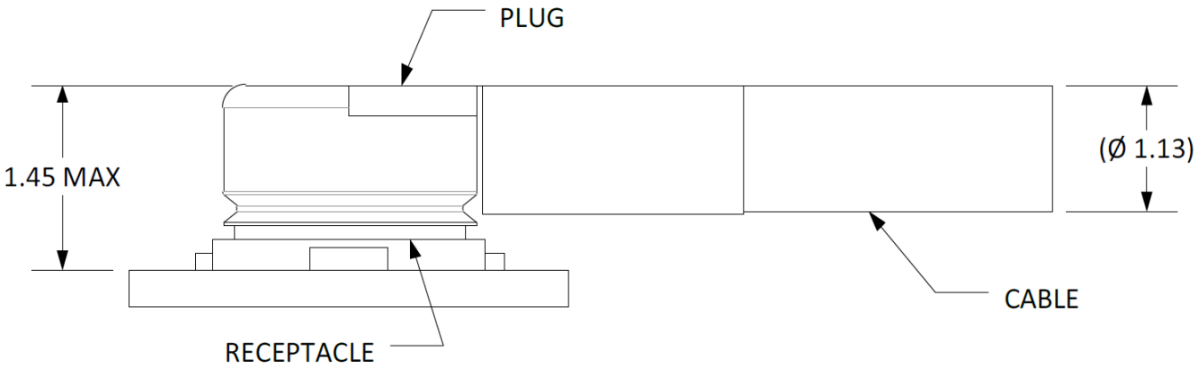


Figure 33: Space Factor of Mated Connectors (Ø1.13 mm Coaxial Cables) (Unit: mm)

5.4. Antenna Design Requirements

The following table shows the requirements on the main antenna, Rx-diversity antenna and GNSS antenna.

Table 26: Antenna Requirements

Type	Requirements
GNSS (Optional)	● Frequency range: 1559–1606 MHz ● Polarization: RHCP or linear ● VSWR: ≤ 2 (Typ.) ● Passive antenna gain: > 0 dBi

Cellular	● VSWR: ≤ 2 ● Efficiency: > 30 % ● Max input power: 50 W ● Input impedance: 50 Ω ● Cable insertion loss: **< 1 dB:** LB (< 1 GHz) **< 1.5 dB:** MB (1–2.3 GHz) **< 2 dB:** HB (> 2.3 GHz)

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 27: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VCC	-0.3	4.7	V
Peak Current of VCC	-	2.0	A
Voltage at Digital Pins	-0.3	2.3	V

6.2. Power Supply Ratings

The input voltage of the module is 3.135–4.4 V, as specified by *PCI Express M.2 Specification Revision 3.0*. The following table shows the power supply requirements of the module.

Table 28: Power Supply Ratings

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Main power supply	3.135	3.3	4.4	V

6.3. Power Consumption

Table 29: Power Consumption of the Module

Description	Condition	Typ.	Unit
OFF state	Turn off	20	μA
Sleep state	**AT+CFUN=0**	1.1	mA
	WCDMA PF = 64 (USB disconnected)	2.1	mA
	WCDMA PF = 64 (USB Suspend)	2.4	mA
	WCDMA PF = 128 (USB disconnected)	1.6	mA
	WCDMA PF = 256 (USB disconnected)	1.4	mA
	WCDMA PF = 512 (USB disconnected)	1.3	mA
	LTE-FDD PF = 32 (USB disconnected)	3.9	mA
	LTE-FDD PF = 64 (USB disconnected)	2.5	mA
	LTE-FDD PF = 64 (USB Suspend)	2.7	mA
	LTE-FDD PF = 128 (USB disconnected)	1.9	mA
	LTE-FDD PF = 256 (USB disconnected)	1.5	mA
	LTE-TDD PF = 32 (USB disconnected)	4.2	mA
	LTE-TDD PF = 64 (USB disconnected)	2.6	mA
	LTE-TDD PF = 64 (USB Suspend)	2.9	mA
	LTE-TDD PF = 128 (USB disconnected)	1.9	mA
	LTE-TDD PF = 256 (USB disconnected)	1.5	mA
Idle state	WCDMA PF = 64 (USB disconnected)	21.0	mA
	WCDMA PF = 64 (USB connected)	32.0	mA
	LTE-FDD PF = 64 (USB disconnected)	20.0	mA
	LTE-FDD PF = 64 (USB connected)	32.0	mA

	LTE-TDD PF = 64 (USB disconnected)	22.0	mA
	LTE-TDD PF = 64 (USB connected)	33.0	mA
WCDMA data transmission (GNSS OFF)	WCDMA B1 HSDPA @ 21.88 dBm	580.0	mA
	WCDMA B1 HSUPA @ 21.17 dBm	576.0	mA
	WCDMA B8 HSDPA @ 22.10 dBm	568.0	mA
	WCDMA B8 HSUPA @ 21.54 dBm	567.0	mA
LTE data transmission (GNSS OFF)	LTE-FDD B1 @ 22.65 dBm	787.0	mA
	LTE-FDD B3 @ 22.65 dBm	854.0	mA
	LTE-FDD B7 @ 22.93 dBm	952.0	mA
	LTE-FDD B8 @ 22.42 dBm	746.0	mA
	LTE-FDD B20 @ 22.17 dBm	872.0	mA
	LTE-FDD B28 @ 22.23 dBm	800.0	mA
	LTE-TDD B38 @ 22.72 dBm	529.0	mA
	LTE-TDD B41 @ 22.72 dBm	514.0	mA
WCDMA voice call	WCDMA B1 @ 22.86 dBm	634.0	mA
	WCDMA B8 @ 23.11 dBm	613.0	mA

NOTE

The above power consumption data are tested under 50 Ω impedance.

6.4. Digital I/O Characteristics

Table 30: 1.8 V I/O Requirements

Parameter	Description	Min.	Max.	Unit
V_{IH}	High-level input voltage	1.65	2.1	V

V_{IL}	Low-level input voltage	-0.3	0.54	V
V_{OH}	High-level output voltage	1.3	1.8	V
V_{OL}	Low-level output voltage	0	0.4	V

Table 31: 3.3 V I/O Requirements

Parameter	Description	Min.	Max.	Unit
3.3 V	Power domain	3.135	3.464	V
V_{IH}	High-level input voltage	2.0	3.6	V
V_{IL}	Low-level input voltage	-0.5	0.8	V

Table 32: 1.8 V (U)SIM I/O Requirements

Parameter	Description	Min.	Max.	Unit
USIM_VDD	(U)SIM card power supply	1.65	1.95	V
V_{IH}	High-level input voltage	0.7 × USIM_VDD	USIM_VDD + 0.3	V
V_{IL}	Low-level input voltage	-0.3	0.2 × USIM_VDD	V
V_{OH}	High-level output voltage	0.8 × USIM_VDD	USIM_VDD	V
V_{OL}	Low-level output voltage	0	0.4	V

Table 33: 3.0 V (U)SIM I/O Requirements

Parameter	Description	Min.	Max.	Unit
USIM_VDD	(U)SIM card power supply	2.7	3.05	V
V_{IH}	High-level input voltage	0.7 × USIM_VDD	USIM_VDD + 0.3	V
V_{IL}	Low-level input voltage	-0.3	0.2 × USIM_VDD	V
V_{OH}	High-level output voltage	0.8 × USIM_VDD	USIM_VDD	V
V_{OL}	Low-level output voltage	0	0.4	V

NOTE

The maximum voltage value of V_{IL} for RESET# and W_DISABLE1# is 0.5 V.

6.5. ESD Protection

Static electricity occurs naturally and it may damage the module. Therefore, applying proper ESD countermeasures and handling methods is imperative. For example, wear anti-static gloves during the development, production, assembly and testing of the module; add ESD protection components to the ESD sensitive interfaces and points in the product design.

Table 34: ESD Characteristics (Temperature: 25–30 ºC, Humidity: 40 ±5 %)

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

NOTE

For a good ESD performance, the module mounting holes must be used to attach the device to the main PCB ground closely.

6.6. Thermal Dissipation

In order to achieve better performance of the module, it is recommended to comply with the following principles for thermal consideration:

- On your PCB design, please keep placement of the module away from heating sources, especially high power components such as ARM processor, and audio power amplifier, power supply.
- Do not place components on the opposite side of the PCB area where the module is mounted, in order to facilitate adding of heatsink when necessary.
- Do not apply solder mask on the opposite side of the PCB area where the module is mounted, so as to ensure better heat dissipation performance.

- The reference ground of the area where the module is mounted should be complete, and add ground vias as many as possible for better heat dissipation.
- Make sure the ground pads of the module and PCB are fully connected.
- According to your application demands, the heatsink can be mounted on the top of the module, or the opposite side of the PCB area where the module is mounted, or both of them.
- The heatsink should be designed with as many fins as possible to increase heat dissipation area. Meanwhile, a thermal pad with high thermal conductivity should be used between the heatsink and module/PCB.

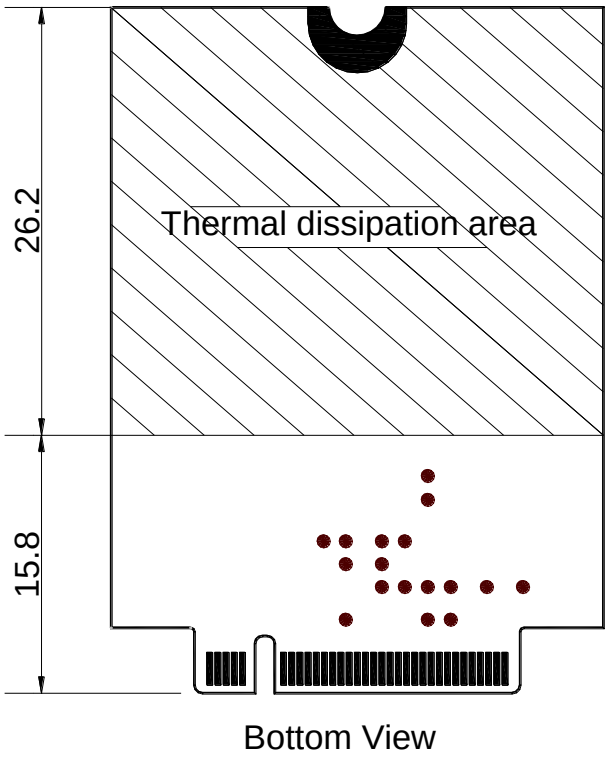


Figure 34: Thermal Dissipation Area on Bottom Side of the Module (Unit: mm)

NOTE

The module offers the best performance when the internal BB chip stays below 105 °C. When the maximum temperature of the BB chip reaches or exceeds 105 °C, the module works normal but provides reduced performance (such as RF output power and data rate). When the maximum BB chip temperature reaches or exceeds 115 °C, the module will disconnect from the network, and it will recover to network connected state after the maximum temperature falls below 115 °C. Therefore, the thermal design should be maximally optimized to make sure the maximum BB chip temperature always maintains below 105 °C. You can execute **AT+QTEMP** and get the maximum BB chip temperature from the first returned value. For more details of the command, see ***document [5]***.

The table below shows the heat dissipation performance after adding a heat sink between the module and the main PCB.

Table 35: Heat Dissipation Performance

Scenario	Testing Time	Temperature		
		Baseband	PA	Unit
No heat sink	15 minutes	112	112	°C
Add a heat sink	15 minutes	90	89	°C

NOTE

The test conditions: LTE B8, BW = 1.4 MHz and with max. transmit power in ambient temperature 70°C.

6.7. Operating and Storage Temperatures

Table 36: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Normal Operating Temperature [7]	-30	+25	+70	ºC
Extended Operating Temperature [8]	-40	+25	+85	ºC
Storage Temperature	-40	+25	+90	ºC

[7] To meet the normal operating temperature range requirements, it is necessary to ensure effective thermal dissipation, e.g., by adding passive or active heatsinks, heat pipes, vapor chambers. Within this range, the module's indicators comply with 3GPP specification requirements.

[8] To meet the extended operating temperature range requirements, it is necessary to ensure effective thermal dissipation, e.g., by adding passive or active heatsinks, heat pipes, vapor chambers. Within the range of -40 to -30 °C or 70 to 85 °C, the module retains the ability to establish and maintain functions such as SMS and data transmission, without any unrecoverable malfunction. Radio spectrum and radio network remain uninfluenced, whereas the value of one or more parameters, such as P_{out}, may decrease and fall below the range of the 3GPP specified tolerances. When the temperature returns to the normal operating temperature range, the module's indicators will comply with 3GPP specification requirements again.

7 Mechanical Information

This chapter describes the mechanical dimensions of the module. All dimensions are measured in millimeter (mm), and the dimensional tolerances are ±0.15 mm unless otherwise specified.

7.1. Mechanical Dimensions

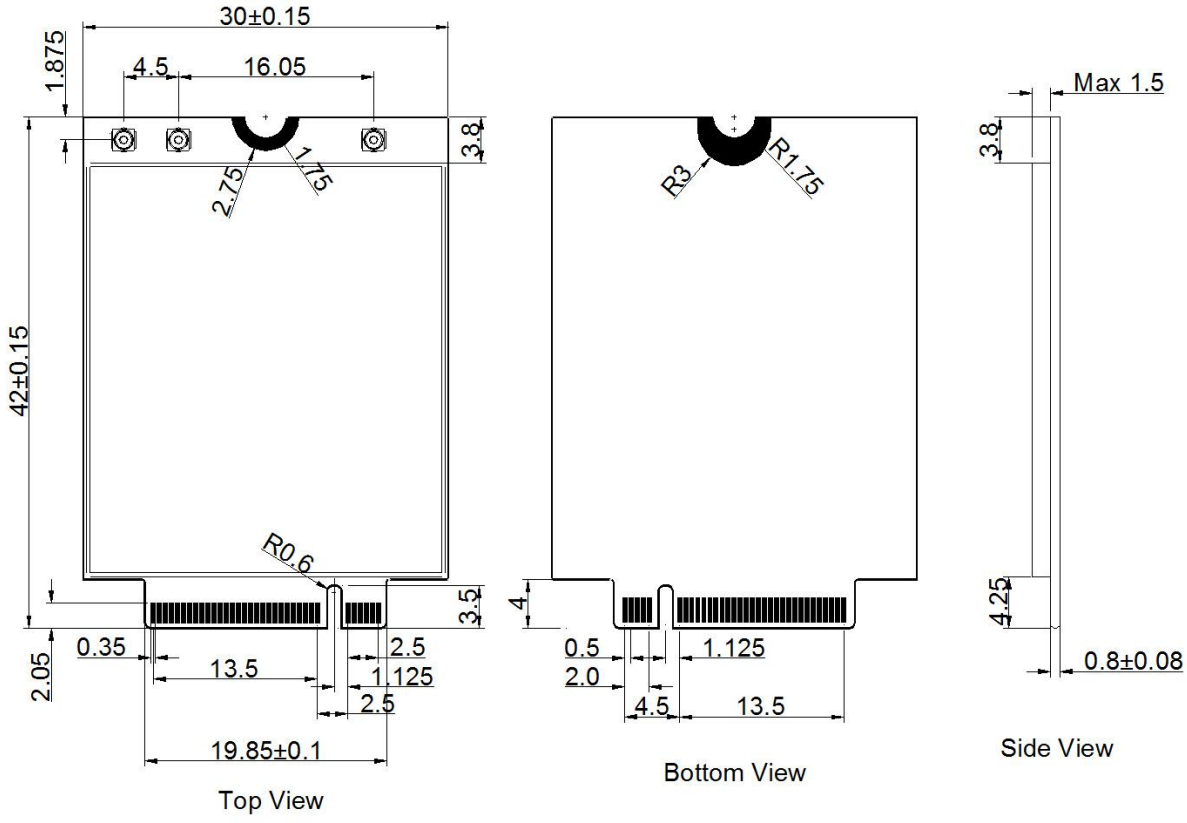


Figure 35: Mechanical Dimensions

7.2. Top and Bottom Views

Figure 36: Top and Bottom Views of the Module

NOTE

Images above are for illustration purpose only and may differ from the actual module. For authentic appearance and label, please refer to the module received from Quectel.

7.3. M.2 Connector

The module adopts a standard PCI Express M.2 connector which compiles with the directives and standards listed in *PCI Express M.2 Specification Revision 3.0.*

8 Storage and Packaging

8.1. Storage Conditions

The storage requirements are shown below.

1. Recommended Storage Condition: the temperature should be 23 ±5 °C and the relative humidity should be 35–60 %.

2. Shelf life: 12 months in Recommended Storage Condition.

NOTE

Pay attention to ESD protection, such as wearing anti-static gloves, when touching the modules.

8.2. Notification

Please follow the principles below in the module application.

8.2.1. Coating

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.

8.2.2. Cleaning

Avoid using ultrasonic technology for module cleaning since it can damage crystals inside the module.

8.2.3. Installing

Fix the module firmly to avoid poor contact caused by shaking. It is recommended to install the module on the socket with a screw as shown below.

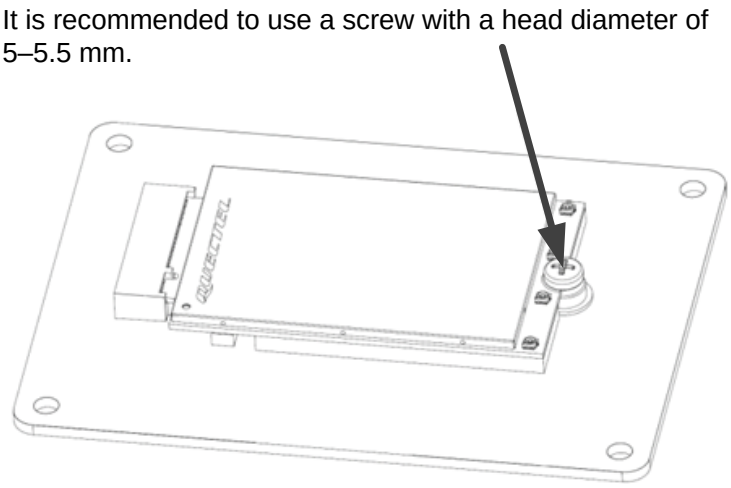


Figure 37: Installation Schematic

8.2.4. Others

- Avoid using materials that contain mercury (Hg), such as adhesives, for module processing, even if the materials are RoHS compliant and their mercury content is below 1000 ppm (0.1 %).
- Corrosive gases may corrode the electronic components inside the module, affecting their reliability and performance, and potentially leading to a shortened service life that fails to meet the designed lifespan. Therefore, do not store or use unprotected modules in environments containing corrosive gases such as hydrogen sulfide, sulfur dioxide, chlorine, and ammonia.

8.3. Packaging Specification

This chapter outlines the key packaging parameters and processes. All figures below are for reference purposes only, as the actual appearance and structure of packaging materials may vary in delivery.

The modules are packed in a blister tray packaging as specified in the sub-chapters below.

8.3.1. Blister Tray

Blister tray dimensions are illustrated in the following figure:

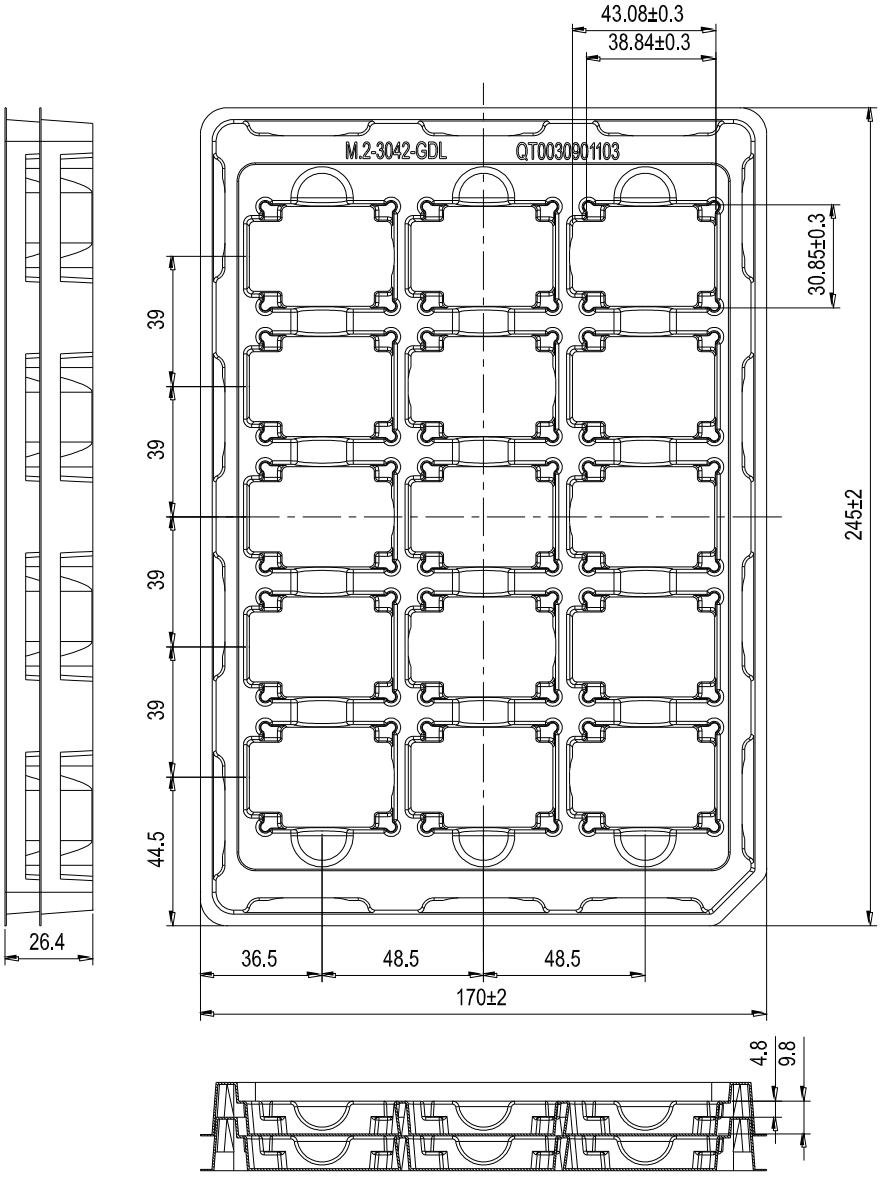
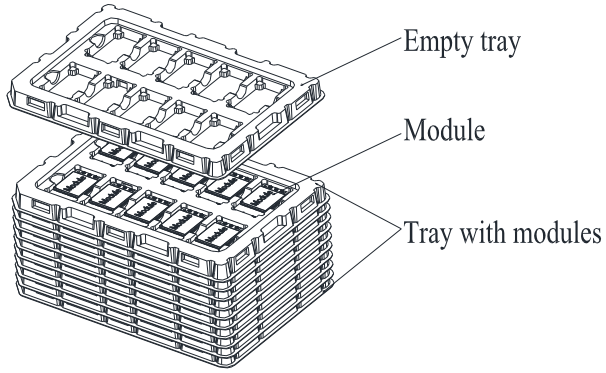


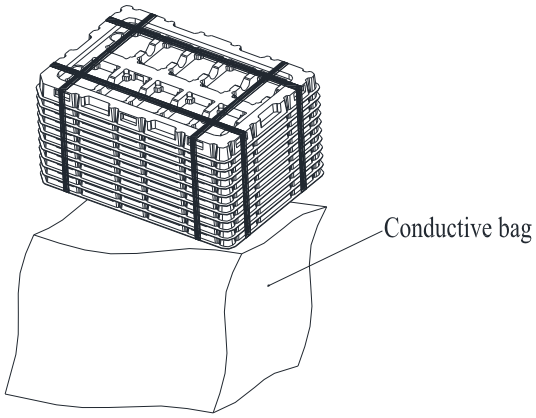
Figure 38: Blister Tray Dimension Drawing (Unit: mm)

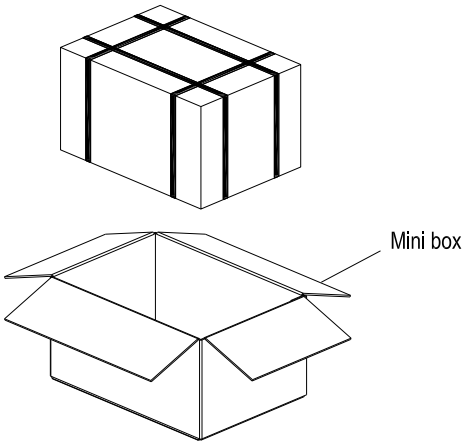
8.3.2. Packaging Process



Each blister tray packs 15 modules. Stack 10 trays with modules, and place 1 empty tray on top.

Fasten the 11 trays and place them into a conductive bag and fasten it.





Pack the conductive bag with blister trays into a mini box. 1 mini box can pack 150 modules.

Place the 4 packaged mini boxes into 1 carton and seal it. 1 carton can pack 600 modules.

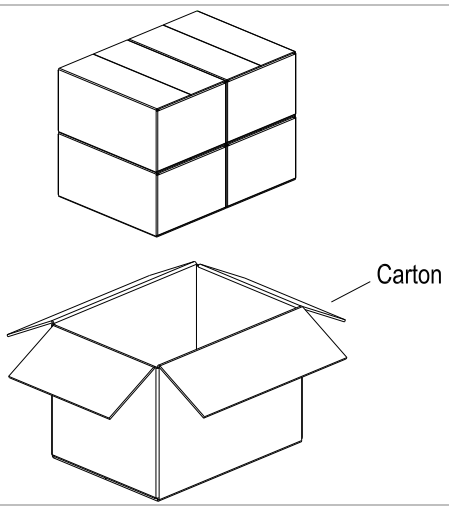


Figure 39: Packaging Process

9 Appendix References

Table 37: Related Documents

Document Name
[1] Quectel_EC2x&EG2x&EG9x&EM05_Series_GNSS_Application_Note
[2] Quectel_M.2_EVB_User_Guide
[3] Quectel_EC2x&EG2x&EG9x&EM05_Series_AT_Commands_Manual
[4] Quectel_EC2x&EG2x&EG9x&EM05_Series_QCFG_AT_Commands_Manual
[5] Quectel_EC2x&EG2x&EG9x&EM05_Series_Software_Thermal_Management_Guide

Table 38: Terms and Abbreviations

Abbreviation	Description
AGNSS	Assisted GNSS (Global Navigation Satellite System)
bps	bits per second
CHAP	Challenge-Handshake Authentication Protocol
DC-HSDPA	Double Carrier-High-Speed Downlink Packet Access
DFOTA	Delta Firmware Upgrade Over-The-Air
DL	Downlink
DPR	Dynamic Power Reduction
DRX	Discontinuous Reception
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FDD	Frequency Division Duplexing

FTP	File Transfer Protocol
FTPS	FTP over SSL/FTP Secure
GLONASS	Global Navigation Satellite System (Russia)
GNSS	Global Navigation Satellite System
GPIO	General-Purpose Input/Output
GPS	Global Positioning System
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
kbps	kilobits per second
LDO	Low-dropout Regulator
LED	Light Emitting Diode
LTE	Long Term Evolution
Mbps	Megabits per second
MIMO	Multiple-Input Multiple-Output
MLCC	Multilayer Ceramic Chip Capacitor
MSB	Most Signification Bit
NC	Not Connected
NMEA	NMEA (National Marine Electronics Association) 0183 Interface Standard
NPN	Negative-Positive-Negative
NTP	Network Time Protocol
PAP	Password Authentication Protocol
PCB	Printed Circuit Board
PCM	Pulse Code Modulation

PDU	Protocol Data Unit
PF	Paging Frame
PPP	Point-to-Point Protocol
PING	Packet Internet Groper
PN	Part Number
PWM	Pulse Width Modulation
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RFFE	RF Front-End
RoHS	Restriction of Hazardous Substances
Rx	Receive
SAR	Specific Absorption Rate
SIMO	Single-Input Multiple-Output
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SMTPS	Simple Mail Transfer Protocol Secure
SSL	Secure Sockets Layer
TBD	To Be Determined
TCP	Transmission Control Protocol
TDD	Time Division Duplex
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
V_{IL}	Input Low Voltage
V_{OH}	Output High Voltage
V_{OL}	Output Low Voltage
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access