FCUN69-WWD Hardware Design

5G Series

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Revision History

Version	Date	Description
-	2024-04-29	Creation of the document
1.0.0	2024-04-29	Preliminary

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1 Introduction

1.1. Introduction

The document introduces FCUN69-WWD module and describes its air and hardware interfaces connected to your applications.

This document helps you quickly understand the interface specifications, RF characteristics, electrical and mechanical details, as well as other related information. Associated with application notes and user guides, you can use the module to design and set up mobile applications easily. To facilitate its application in different fields, reference design is also provided, you can see ***document [1]*** to understand the module hardware architecture.

1.2. Reference Standards

The module complies with the following standards:

- *PCI Express M.2 Specification Revision 4.0, Version 1.1*
- *PCI Express Base Specification Revision 4.0*
- *ISO/IEC 7816-3*
- *MIPI Alliance Specification for RF Front-End Control Interface version 2.0*
- *3GPP TS 27.007* and *3GPP TS 27.005*

1.3. 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 sample is currently unavailable.

Hereby, [NETPRISMA INC.] declares that the radio equipment type [FCUN69-WWD] is in compliance with Directive 2014/53/EU. The full text of the EU declaration of conformity is available at the following internet address: https://www.netprisma.us/tech-support/

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The device could be used with a separation distance of 20cm to the human body.

2 Product Overview

2.1. Frequency Bands and Functions

FCUN69-WWD is a 5G NR/LTE/UMTS/HSPA+ wireless communication module with receiving diversity. It provides data connectivity on 5G NR SA and NSA, LTE-FDD, LTE-TDD, DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA networks. FCUN69-WWD is a standard M.2 Key-B WWAN module. For more details, see *PCI Express M.2 Specification Revision 4.0, Version 1.1*.

FCUN69-WWD supports embedded operating systems such as Windows, Linux and Android, and also provides GNSS function (optional) to meet specific application demands.

FCUN69-WWD is an industrial-grade module for industrial and commercial applications only.

The following table shows the frequency bands, MIMO and GNSS systems supported by the module.

Table 2: Frequency Bands & MIMO & GNSS Systems

Mode	Frequency Band
5G NR SA	n1/n2/n3/n5/n7/n8/n12/n13/n14/n18/n20/n25/n26/n28/n29/n30/n38/n40*/n41/ n48/ n66/n70/n71/n75/n76/n77/n78/n79 **DL 4 ×4 MIMO**: n1/n2/n3/n7/n25/n30/n38/n40*/n41/n48/n66/n70/n77/n78/n79 **UL 2 ×2 MIMO**: n38/n41/n48/n77/n78/n79
5G NR NSA	n1/n2/n3/n5/n7/n8/n12/n13/n14/n18/n20/n25/n26/n28/n29/n30/n38/n40*/n41/ n48/ n66/n71/n75/n76/n70/n77/n78/n79 **DL 4 ×4 MIMO**: n1/n2/n3/n7/n25/n30/n66/n38/n40*/n41/n48/n70/n77/n78/n79
LTE	**FDD**: B1/B2/B3/B4/B5/B7/B8/B12/B13/B14/B17/B18/B19/B20/B25/B26/B28/B29/ B30/B32/B66/B71 **TDD**: B34/B38/B39/B40*/B41/B42/B43/B46(LAA)/B48 **DL 4 ×4 MIMO**: B1/B2/B3/B4/B7/B25/B30/B38/B40/B41/B42/B43/B48/B66
WCDMA	B1/B2/B4/B5/B8/B19
GNSS (optional)	GPS/GLONASS/BDS/Galileo/QZSS/SBAS

2.2. Key Features

Table 3: Key Features

Feature	Details
Function Interface	PCI Express M.2 Interface
Power Supply	● Supply voltage: 3.135–4.4 V ● Typical supply voltage: 3.7 V
(U)SIM Interfaces	● Compliant with *ISO/IEC 7816-3*, ETSI and IMT-2000 ● Supported (U)SIM card Class B (3.0 V) and Class C (1.8 V) ● Dual SIM Single Standby
PCIe Interface	● Complaint with PCIe Gen 3 ● PCIe × 1 lane, supporting up to 8 Gbps

*Note：B/N40 not for FCC/IC

	● Used for AT command communication, data transmission, firmware upgrade, software debugging, GNSS NMEA sentence output
Transmitting Power	● 5G NR bands: Class 3 (23 dBm ±2 dB) ● 5G NR HPUE bands (n38/n40/n41/n77/n78/n79): Class 2 (26 dBm ±2 dB) [1] ● 5G NR UL MIMO bands (n41/n77/n78/n79): Class 1.5 (29 dBm +1/-2 dB) ● LTE bands: Class 3 (23 dBm ±2 dB) ● LTE HPUE [2] band (B38/B41/B42/B43): Class 2 (26 dBm ±2 dB) [1] ● WCDMA bands: Class 3 (23 dBm ±2 dB)
5G NR Features	● Compliant with 3GPP Release 16 ● Supported modulations: – Uplink: π/2-BPSK, QPSK, 16QAM, 64QAM and 256QAM – Downlink: QPSK, 16QAM, 64QAM and 256QAM ● Supported SCS: 15 kHz [3] and 30 kHz [3] ● Supported operation modes on all the 5G bands: SA [4] and NSA [4] ● Option 3x, 3a, 3 and Option 2 ● Maximum transmission data rates [5]: – NSA: 3.4 Gbps (DL)/ 550 Mbps (UL) – SA: 2.4 Gbps (DL)/ 900 Mbps (UL) ● SRS: – NSA: 1T4R (n38/n40/n41/n48/n77/n78/n79) – SA: 1T4R (n40), 2T4R (n38/n41/n48/n77/n78/n79)
LTE Features	● Compliant with 3GPP Release 16 ● LTE Category: DL Cat 19/UL Cat 18 ● 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 ● Maximum transmission data rates [5]: 1.6 Gbps (DL)/ 200 Mbps (UL)
UMTS Features	● Compliant with 3GPP Rel-9 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA ● Supported modulations: QPSK, 16QAM and 64QAM ● Maximum transmission data rates [5]: – DC-HSDPA: 42 Mbps (DL) – HSUPA: 5.76 Mbps (UL) – WCDMA: 384 kbps (DL)/384 kbps (UL)
Rx-diversity	5G NR/LTE/WCDMA Rx-diversity
GNSS Features	● Protocol: NMEA 0183 ● Data Update Rate: 1 Hz
Antenna Interfaces	ANT0, ANT1, ANT2, and ANT3
AT Commands	● Compliant with *3GPP TS 27.007* and *3GPP TS 27.005* ● NetPrisma enhanced AT commands
Internet Protocol Features	● NITZ, PING and QMI protocols ● PAP and CHAP for PPP connections
Firmware Upgrade	● PCIe interface ● DFOTA
SMS	● Text and PDU modes ● Point-to-point MO and MT

[1] PC2 is not available in Japan due to the local regulations.
[2] HPUE is only for single carrier.
[3] 5G NR FDD bands only support 15 kHz SCS, and NR TDD bands only support 30 kHz SCS.
[4] See ***document [2]*** for bandwidth supported by each frequency band in the NSA and SA modes. N77 and n78 do not support 25 MHz bandwidth.
[5] The maximum rates are theoretical and the actual values depend on the network configuration.

	● SMS cell broadcast ● SMS storage: ME by default
Physical Characteristics	● M.2 Key-B ● Size: 30.0 mm × 52.0 mm × 2.3 mm ● Weight: approx. 8.7 g
Temperature Range	● Operating temperature range: -30 °C to +75 °C [6] ● Extended temperature range: -40 °C to +85 °C [7] ● Storage temperature range: -40 °C to +90 °C
RoHS	All hardware components are fully compliant with EU RoHS directive

NOTE

There is a reserved eSIM position in the module, so the eSIM function is optional.

[6] 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 the temperature range of -10 °C to +55 °C, the mentioned RF performance margins higher than 3GPP specifications can be guaranteed. When temperature goes beyond temperature range of -10 °C to +55 °C, a few RF performances of module may be slightly off 3GPP specifications.

[7] 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 this range, the module remains the ability to establish and maintain functions such as SMS and emergency call*, 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.

2.3. Functional Diagram

The following figure is a block diagram of FCUN69-WWD.

- Power management
- Baseband
- LPDDR4X SDRAM + NAND Flash
- Radio frequency
- M.2 Key-B interface

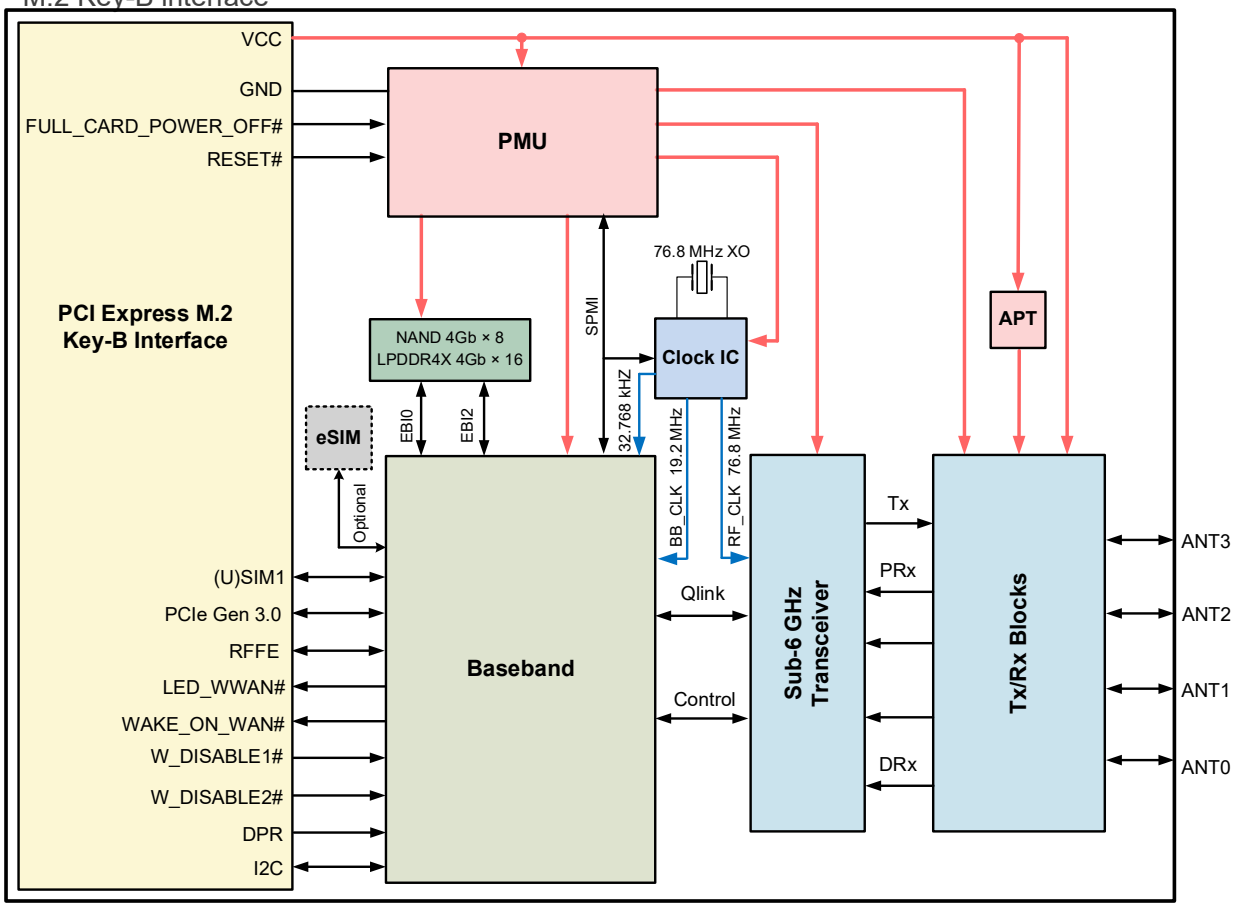
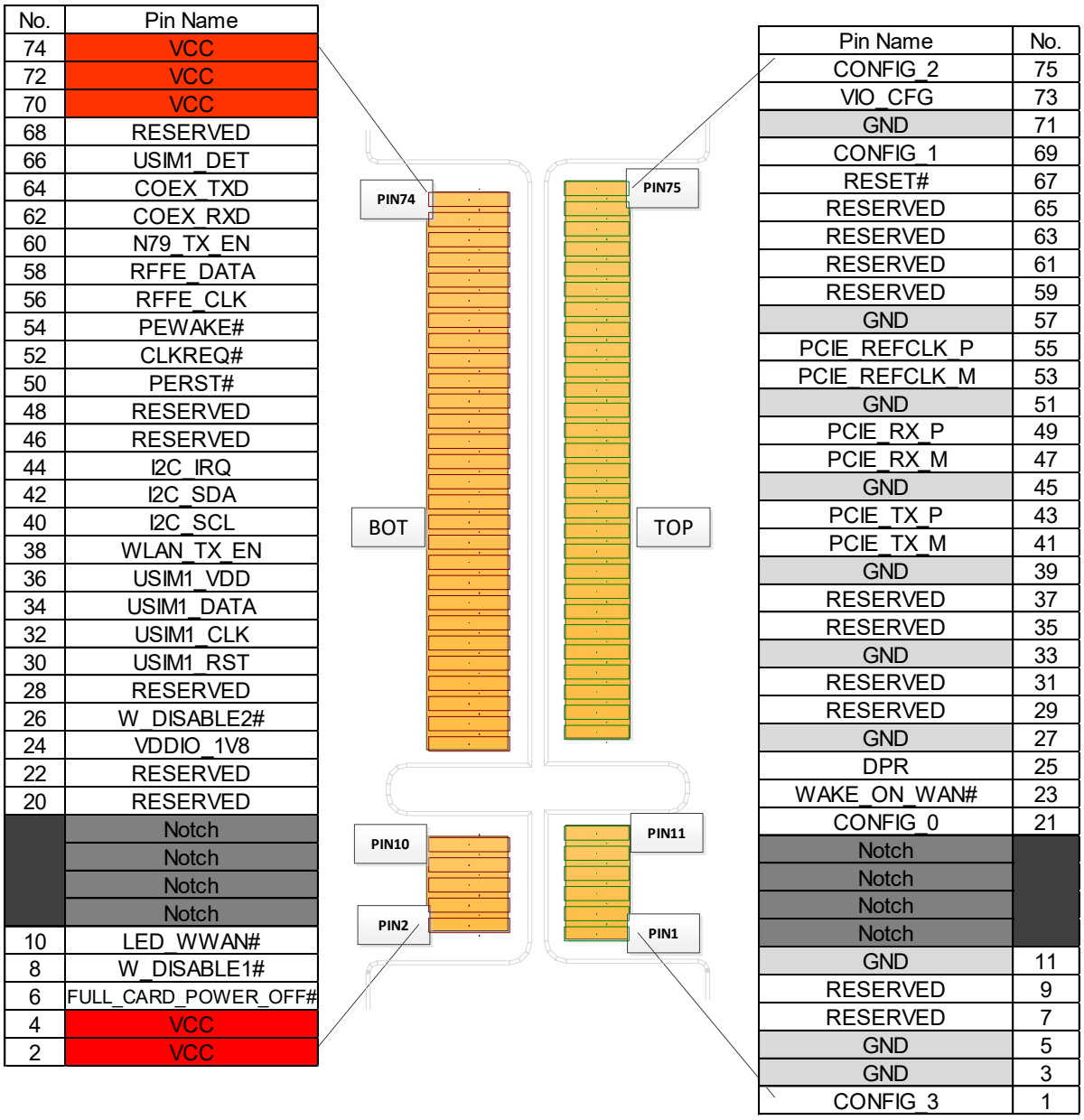


Figure 1: Functional Diagram

2.4. Pin Assignment

The following figure shows the pin assignment of the module.



No.	Pin Name
74	VCC
72	VCC
70	VCC
68	RESERVED
66	USIM1_DET
64	COEX_TXD
62	COEX_RXD
60	N79_TX_EN
58	RFFE_DATA
56	RFFE_CLK
54	PEWAKE#
52	CLKREQ#
50	PERST#
48	RESERVED
46	RESERVED
44	I2C_IRQ
42	I2C_SDA
40	I2C_SCL
38	WLAN_TX_EN
36	USIM1_VDD
34	USIM1_DATA
32	USIM1_CLK
30	USIM1_RST
28	RESERVED
26	W_DISABLE2#
24	VDDIO_1V8
22	RESERVED
20	RESERVED
	Notch
	Notch
	Notch
	Notch
10	LED_WWAN#
8	W_DISABLE1#
6	FULL_CARD_POWER_OFF#
4	VCC
2	VCC

Pin Name	No.
CONFIG_2	75
VIO_CFG	73
GND	71
CONFIG_1	69
RESET#	67
RESERVED	65
RESERVED	63
RESERVED	61
RESERVED	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
RESERVED	37
RESERVED	35
GND	33
RESERVED	31
RESERVED	29
GND	27
DPR	25
WAKE_ON_WAN#	23
CONFIG_0	21
Notch	
Notch	
Notch	
Notch	
GND	11
RESERVED	9
RESERVED	7
GND	5
GND	3
CONFIG_3	1

Figure 2: Pin Assignment

NOTE

Before the module turns on, ensure the pins DPR and USIM1_DET are not pulled high to avoid current sink damaging the module.

2.5. Pin Definitions

Table 4: Parameter Definition

Parameter	Description
AI	Analog Input
AO	Analog Output
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

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	Not connected internally		
2	VCC	PI	Power supply for the module	Vmin = 3.135 V Vnom = 3.7 V Vmax = 4.4 V	
3	GND		Ground		
4	VCC	PI	Power supply for the module	Refer to pin 2	
5	GND		Ground		
6	FULL_CARD_POWER_OFF#	DI	Turn on/off the module High level: Turn on Low level: Turn off	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.
7	RESERVED		Reserved		
8	W_DISABLE1#	DI	Airplane mode control	1.8/3.3 V	Internally pulled up to 1.8 V with a 100 kΩ resistor. Active LOW.
9	RESERVED		Reserved		

10	LED_WWAN#	OD	RF status LED indicator	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	RESERVED		Reserved		
21	CONFIG_0	DO	Not connected internally		
22	RESERVED		Reserved		
23	WAKE_ON_WAN#	OD	Wake up the host	1.8/3.3 V	Active LOW.
24	VDDIO_1V8	PO	Provide 1.8 V for external circuit	1.8 V	Maximum output current: 50 mA.
25	DPR	DI, PU	Dynamic power reduction	1.8 V	Internally pulled up to 1.8 V.
26	W_DISABLE2#*	DI	GNSS control	1.8/3.3 V	Internally pulled up to 1.8 V with a 100 kΩ resistor. Active LOW.
27	GND		Ground		
28	RESERVED		Reserved		
29	RESERVED		Reserved		
30	USIM1_RST	DO	(U)SIM1 card reset	USIM1_VDD	
31	RESERVED		Reserved		
32	USIM1_CLK	DO	(U)SIM1 card clock	USIM1_VDD	
33	GND		Ground		
34	USIM1_DATA	DIO	(U)SIM1 card data	USIM1_VDD	
35	RESERVED		Reserved		
36	USIM1_VDD	PO	(U)SIM1 card power supply	**High-voltage:** Vmax = 3.05 V Vnom = 2.85 V Vmin = 2.7 V	

				Low-voltage: Vmax = 1.95 V Vnom = 1.8 V Vmin = 1.65 V	
37	RESERVED		Reserved		
38	WLAN_TX_EN*	DI	Notification from WLAN to SDR when WLAN transmitting	1.8 V	
39	GND		Ground		
40	I2C_SCL*	OD	I2C serial clock	1.8 V	Internally pulled up to 1.8 V.
41	PCIE_TX_M	AO	PCIe transmit (-)		Require differential impedance of 85 Ω.
42	I2C_SDA*	OD	I2C serial data	1.8 V	Internally pulled up to 1.8 V.
43	PCIE_TX_P	AO	PCIe transmit (+)		Require differential impedance of 85 Ω.
44	I2C_IRQ*	DI	I2C interruption signal	1.8 V	
45	GND		Ground		
46	RESERVED		Reserved		
47	PCIE_RX_M	AI	PCIe receive (-)		Require differential impedance of 85 Ω.
48	RESERVED		Reserved		
49	PCIE_RX_P	AI	PCIe receive (+)		Require differential impedance of 85 Ω.
50	PERST#	DI	PCIe reset	1.8/3.3 V	Active LOW.
51	GND		Ground		
52	CLKREQ#	OD	PCIe clock request	1.8/3.3 V	Active LOW.
53	PCIE_REFCLK_M	AIO	PCIe reference clock (-)		Clock frequency: 100 MHz. Require differential impedance of 85 Ω.
54	PEWAKE#	OD	PCIe wake up	1.8/3.3 V	Active LOW.
55	PCIE_REFCLK_P	AIO	PCIe reference clock (+)		Clock frequency: 100 MHz. Require differential impedance of 85 Ω.
56	RFFE_CLK* [8]	DO	Used for external MIPI IC control	1.8 V	
57	GND		Ground		
58	RFFE_DATA* [8]	DIO	Used for external MIPI IC control	1.8 V	
59	RESERVED		Reserved		

[8] If this function is required, contact NetPrisma Technical Support for more details.

60	N79_TX_EN*	DO	Notification from SDR to WLAN when n79 transmitting	1.8 V	
61	RESERVED		Reserved		
62	COEX_RXD* [9]	DI	WWAN and WLAN/Bluetooth coexistence receive	1.8 V	
63	RESERVED		Reserved		
64	COEX_TXD* [9]	DO	WWAN and WLAN/Bluetooth coexistence transmit	1.8 V	
65	RESERVED		Reserved		
66	USIM1_DET [10]	DI	(U)SIM1 card hot-plug detect	1.8 V	
67	RESET#	DI	Reset the module	1.8 V	Internally pulled up to 1.8 V. A test point is recommended to be reserved if unused. Active LOW.
68	RESERVED		Reserved		
69	CONFIG_1	DO	Connected to GND internally		
70	VCC	PI	Power supply for the module	Refer to pin 2	
71	GND		Ground		
72	VCC	PI	Power supply for the module	Refer to pin 2	
73	VIO_CFG		Configuration of PCIe sideband signals [11] power domain. NC: supports 1.8/3.3 V; GND: supports 3.3 V		The default state is NC (Not Connected).
74	VCC	PI	Power supply for the module	Refer to pin 2	
75	CONFIG_2	DO	Not connected internally		

NOTE

Keep all RESERVED and unused pins unconnected. All GND pins should be connected to ground.

[9] Note that COEX_RXD and COEX_TXD cannot be used as general UART ports.
[10] USIM1_DET is pulled HIGH by default, and will be internally pulled up to 1.8 V by software configuration only when (U)SIM hot-plug is enabled by **AT+QSIMDET**.
[11] PCIe sideband signals include PERST#, CLKREQ# and PEWAKE#.

3 Operating Characteristics

3.1. Operating Modes

The table below briefly summarizes the various operating modes of the module.

Table 6: Overview of Operating Modes

Mode	Details	
Full Functionality Mode	Idle	Software is active. The module has registered on the network, and it is ready to send and receive data.
	Data	Network is connected. In this mode, the power consumption is determined by network setting and data transmission rate.
Minimum Functionality Mode	**AT+CFUN=0** 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** or driving W_DISABLE1# pin LOW will set the module to airplane mode. In this mode, the RF function is invalid.	
Low Power Mode	In this mode, the module enters D3 cold state.	
Power Down Mode	In this mode, the power management unit shuts down the power supply. Software is inactive, all application interfaces are inaccessible, and the operating voltage (connected to VCC) remains applied.	

NOTE

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

3.2. Airplane Mode

The module provides a W_DISABLE1# pin to disable or enable airplane mode through hardware operation. See ***Chapter 4.11*** for more details.

3.3. Power Supply

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

Table 7: Definition of VCC and GND Pins

Pin	Pin Name	I/O	Description	DC Characteristics
2, 4, 70, 72, 74	VCC	PI	Power supply for the module	Vmin = 3.135 V Vnom = 3.7 V

		Vmax = 4.4 V
3, 5, 11, 27, 33, 39, 45, 51, 57, 71	GND	Ground

3.4. 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 turn off automatically. The voltage ripple of the input power supply should be less than 100 mV. The figure below shows the power supply limits during burst transmission when 3.7 V power supply is applied.

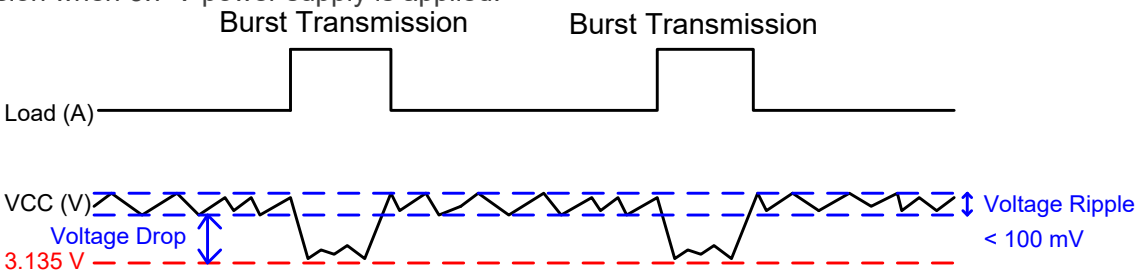


Figure 3: Power Supply Limits during Burst Transmission

Ensure the continuous current capability of the power supply is 3.0 A at least and the peak current capability of the power supply is 4.0 A at least. To decrease the voltage drop, two bypass capacitors of 220 µF with low ESR should be used, and a multi-layer ceramic chip capacitor (MLCC) array should also be used due to its ultra-low ESR. It is recommended to use ceramic capacitors (100 nF, 6.8 nF, 220 pF, 68 pF, 15 pF, 9.1 pF, 4.7 pF) for composing the MLCC array, and place these capacitors close to VCC pins. The width of VCC trace should be not less than 3.0 mm. In principle, the longer the VCC trace is, the wider it should be.

In addition, to guarantee stability of the power supply, it is recommended to use a TVS with working peak reverse voltage of 5.0 V.

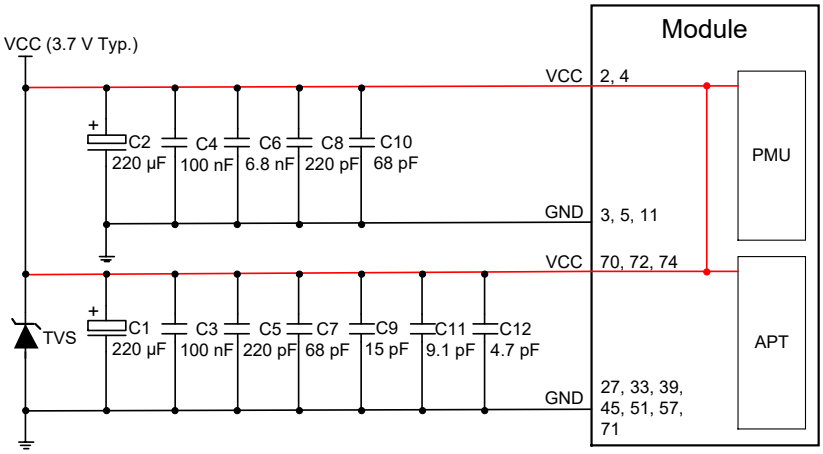


Figure 4: Reference Circuit for VCC

3.5. Reference Design for Power Supply

The performance of the module largely depends on the power source. If the voltage difference between the input and output is not too big, it is suggested that an LDO should be used when supplying 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.

The following figure shows a reference design for +5.0 V input power source based on a DC-DC converter. The typical output of the power supply is 3.7 V.

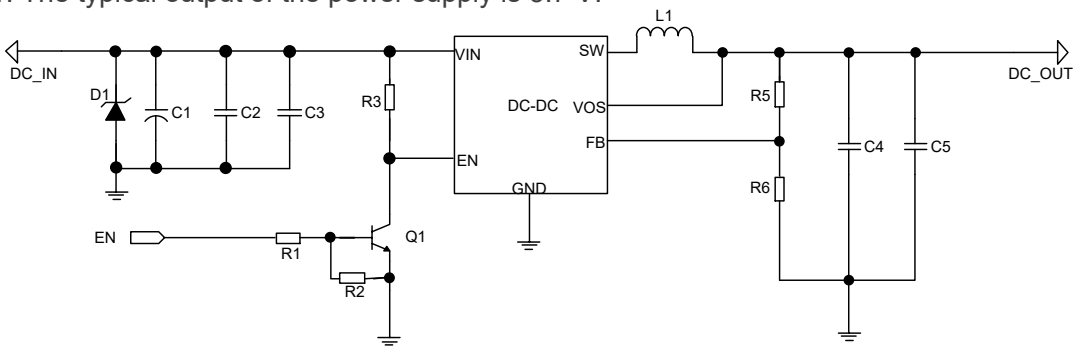


Figure 5: Reference Circuit for Power Supply

NOTE

To avoid corrupting the data in the internal flash, **DO NOT** cut off the power supply before the module is completely turned off by pulling down FULL_CARD_POWER_OFF# pin for more than 900 ms, and **DO NOT** cut off power supply directly when the module is working normally.

3.6. Power Supply Monitoring

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

3.7. Turn On

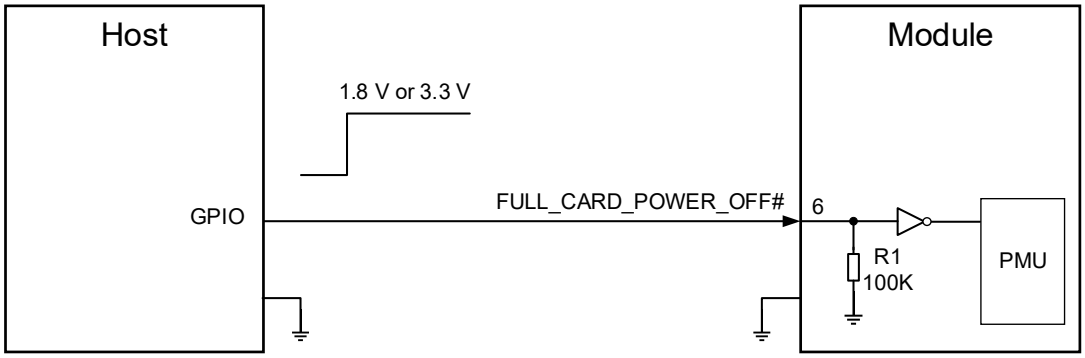
FULL_CARD_POWER_OFF# is used to turn on/off the module or reset the module through hard reset. This input signal is 3.3 V tolerant and can be driven by either 1.8 V or 3.3 V GPIO. And it has been internally pulled down with a 100 kΩ resistor.

When FULL_CARD_POWER_OFF# is driven HIGH (≥ 1.19 V), the module will turn on.

Table 8: Pin Definition of FULL_CARD_POWER_OFF#

Pin No.	Pin Name	I/O	Description	DC Characteristics	Comment
6	FULL_CARD_POWER_OFF#	DI	Turn on/off the module. High level: Turn on Low level: Turn off	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.

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



NOTE: The voltage of pin 6 should be not less than 1.19 V when it is at HIGH level.

Figure 6: Turn On the Module with a Host GPIO

The timing of turn-on scenario is illustrated by the following figure.

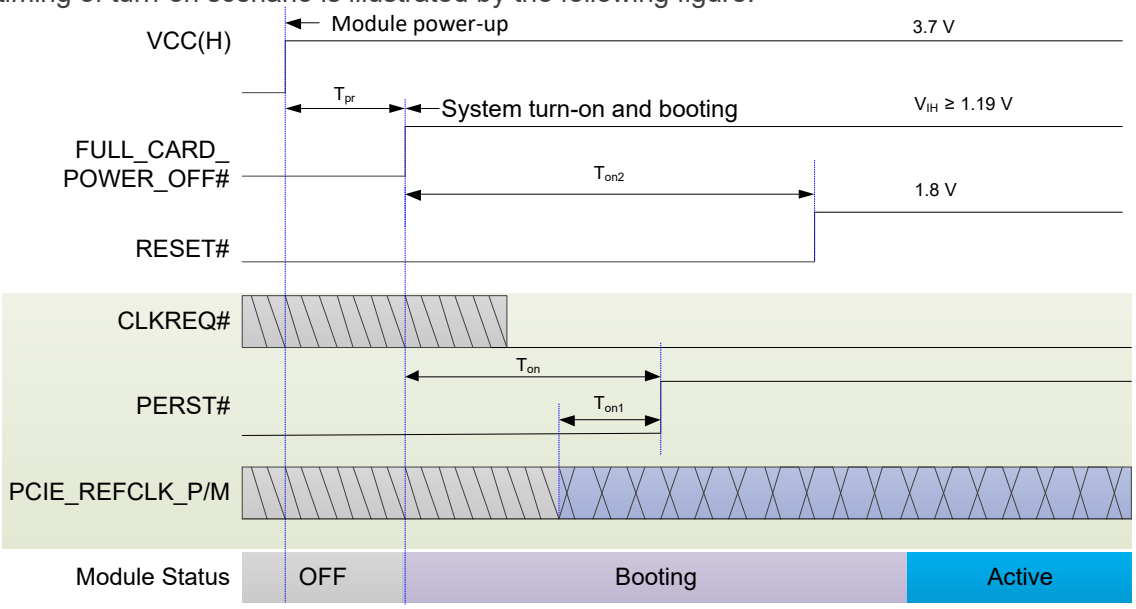


Figure 7: Turn-on Timing of the Module

Table 9: Turn-on Timing of the Module

Symbol	Min.	Typ.	Max.	Comment
T_{pr}	100 ms	-	-	The variation of the module's power-up time before system turn-on and booting depends on the host.
T_{on}	100 ms	-	-	The period when the host GPIO controls the module to exit the PCIe reset state.
T_{on1}	100 µs	-	-	The period during which PCIE_REFCLK_P/M is stable before PERST# is driven high.
T_{on2} [12]	400 ms	-	-	The period from the host pulling up FULL_CARD_POWER_OFF# to the module pulling up RESET# internally and automatically. The module will pull up RESET# internally and automatically after FULL_CARD_POWER_OFF# is driven high.

[12] At booting stage, the host must not drive RESET# low after FULL_CARD_POWER_OFF# is at hign level.

For the laptop application scenario, there are two reset signals to control PERST# pin of the module, and the following figure is for reference. It is recommended that AUX Reset be pulled up before Global PCIe Reset is driven high.

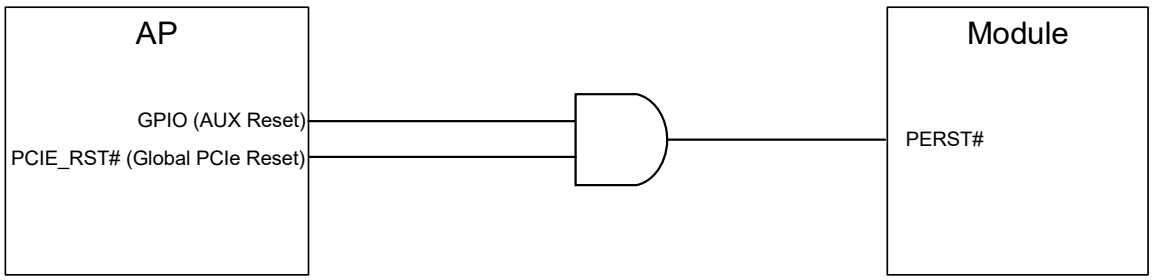


Figure 8: Reference Circuit for Laptop PCIe Reset Logic

3.8. Turn Off

For the design that turns on the module with a host GPIO, when the power is supplied to VCC, driving FULL_CARD_POWER_OFF# pin LOW (≤ 0.2 V) or tri-stating the pin will turn off the module. The timing of turn-off scenario is illustrated by the following figure.

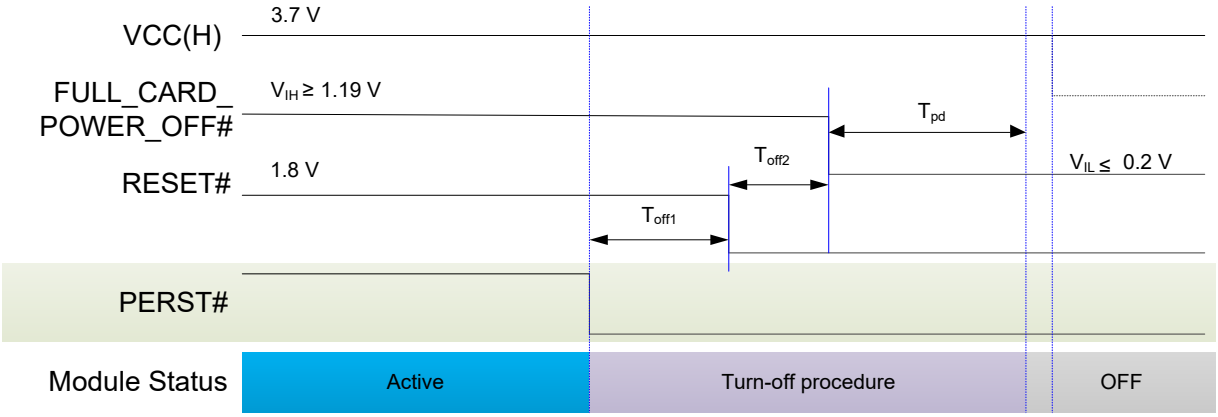


Figure 9: Turn-off Timing through FULL_CARD_POWER_OFF#

Table 10: Turn-off Timing of the Module through FULL_CARD_POWER_OFF#

Symbol	Min.	Typ.	Max.	Comment
T_{off1}	-	100 ms	-	The period from the host pulling down PERST# to it pulling down RESET#.
T_{off2}	0 ms	100 ms	-	The period from the host pulling down RESET# to it pulling down FULL_CARD_POWER_OFF#.
T_{pd}	900 ms	-	-	The period from the host pulling down FULL_CARD_ POWER_OFF# to the module turning off. It is recommended to cut off the VCC when the module has been turned off completely.

3.9. Reset

RESET# is an active LOW signal (1.8 V logic level). When this pin is at low level , the module will immediately enter reset condition.

Note that triggering the RESET# signal will lead to loss of all data in the module and removal of system drivers. It will also disconnect the modem from the network.

Table 11: Pin Definition of RESET#

Pin No.	Pin Name	I/O	Description	DC Characteristics	Comment
67	RESET#	DI	Reset the module.	1.8 V	Internally pulled up to 1.8 V. A test point is recommended to be reserved if unused. Active LOW.

The module can be reset by pulling down the RESET#. An open collector/drain driver can be used to control RESET#.

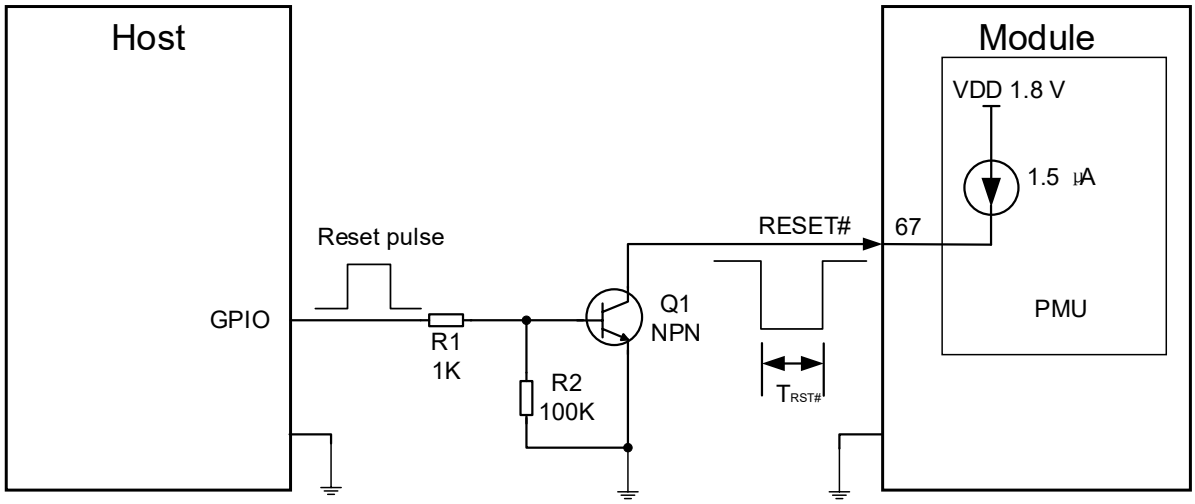


Figure 10: Reference Circuit for RESET# with NPN Driver Circuit

For a warm reset when only the reset signal is pulled LOW, see the timing illustrated by the figure below. In this reset mode, the power of the module will not be turned off.

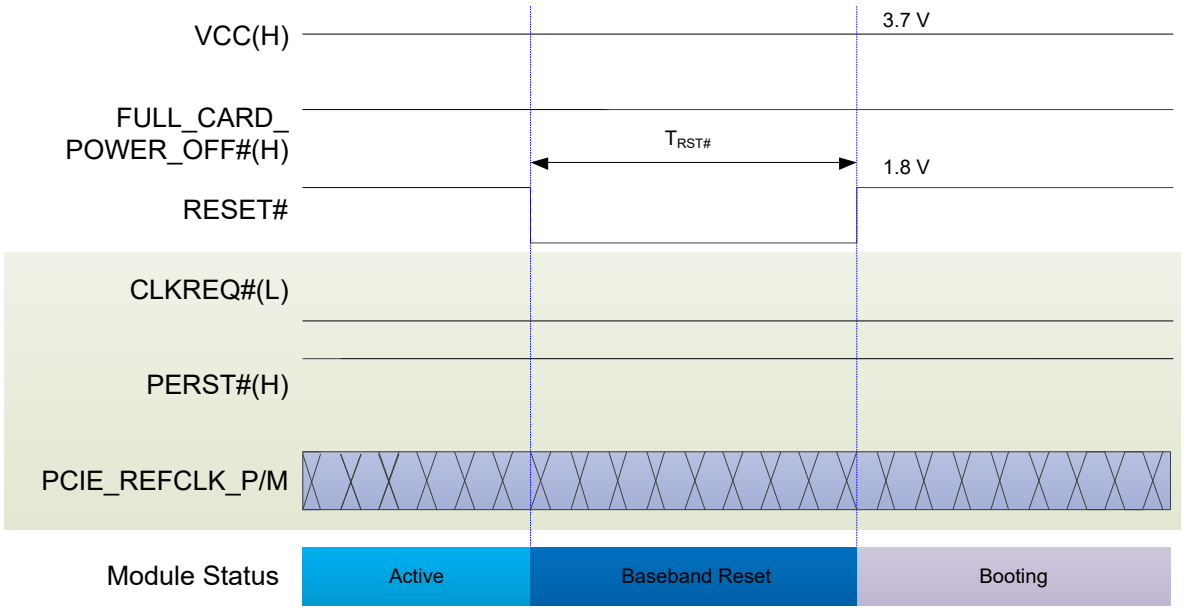


Figure 11: Reset Timing of the Module's Warm Reset

Table 12: Reset Timing of the Module's Warm Reset

Symbol	Min.	Typ.	Max.	Comment
$T_{RST\#}$	200 ms	400 ms	-	Reset baseband chip IC only

For a hard reset, see the timing illustrated by the figure below.

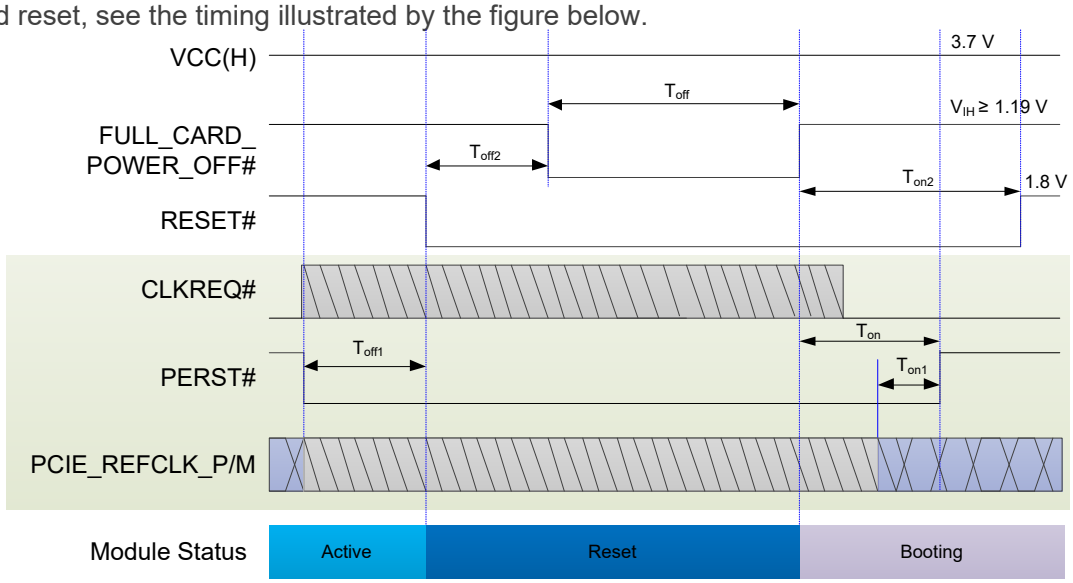


Figure 12: Reset Timing of the Module's Hard Reset

Table 13: Reset Timing of the Module's Hard Reset

Symbol	Min.	Typ.	Max.	Comment

T_{off1}	-	100 ms	-	The period from the host pulling down PERST# to it pulling down RESET#.
T_{off2}	0 ms	100 ms	-	The period from the host pulling down RESET# to it pulling down FULL_CARD_POWER_OFF#.
T_{off}	900 ms	-	-	Module hard reset. Ensure that the module has been turned off completely.
T_{on}	100 ms	-	-	The period when the host GPIO controls the module to exit the PCIe reset state.
T_{on1}	100 µs	-	-	The period during which PCIE_REFCLK_P/M is stable before PERST# is driven high.
T_{on2} [13]	400 ms	-	-	The period from the host pulling up FULL_CARD_POWER_OFF# to the module pulling up RESET# internally and automatically. The module will pull up RESET# internally and automatically after FULL_CARD_POWER_OFF# is driven high.

NOTE

During power-up stage, RESET# will be driven high internally and automatically without the host puling down RESET#. The host's RESET#-controlling GPIO may cause an unexpected module reset during the host reset or modern standby scenario, so pay attention to the signal level of the host GPIO to avoid it.

[13] At booting stage, the host must not drive RESET# low after FULL_CARD_POWER_OFF# is at hign level.

4 Application Interfaces

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

- (U)SIM interfaces
- PCIe interface
- Control and indication interfaces
- Cellular/WLAN COEX interface*
- Antenna tuner control interface
- Configuration pins

4.1. (U)SIM Interfaces

The (U)SIM interface circuitry meets *ISO/IEC 7816-3,* ETSI and IMT-2000 requirements. Both Class B (3.0 V) and Class C (1.8 V) (U)SIM card are supported, and dual SIM single standby function is supported.

4.2. Pin Definition of (U)SIM Interface

Table 14: Pin Definition of (U)SIM Interface

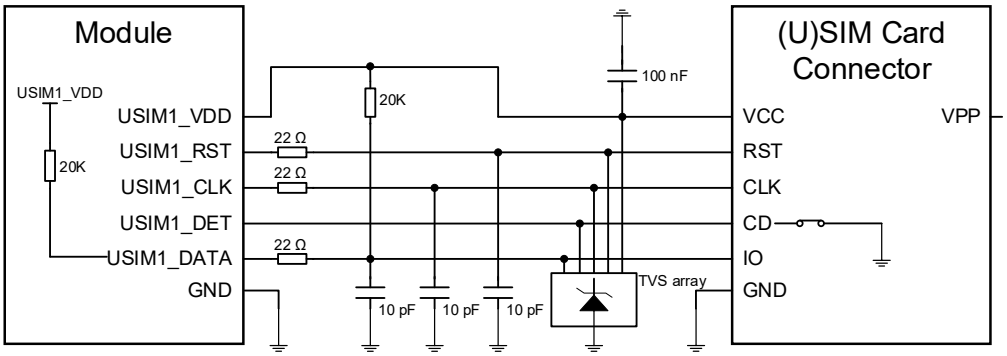
Pin No.	Pin Name	I/O	Description
36	USIM1_VDD	PO	(U)SIM1 card power supply
34	USIM1_DATA	DIO	(U)SIM1 card data
32	USIM1_CLK	DO	(U)SIM1 card clock
30	USIM1_RST	DO	(U)SIM1 card reset
66	USIM1_DET	DI	(U)SIM1 card hot-plug detect

4.3. Normally Closed (U)SIM Card Connector

With a normally closed (U)SIM card connector, USIM1_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. Once (U)SIM hot-plug is enabled by executing **AT+QSIMDET=1,1**, a (U)SIM card insertion will drive USIM1_DET from low to high level, and the removal of it will drive USIM1_DET from high to low level.

- When the (U)SIM card is absent, CD is shorted to ground and USIM1_DET is at low level.
- When the (U)SIM card is present, CD is open from ground and USIM1_DET is at high level.

The following figure shows a reference design for (U)SIM1 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.

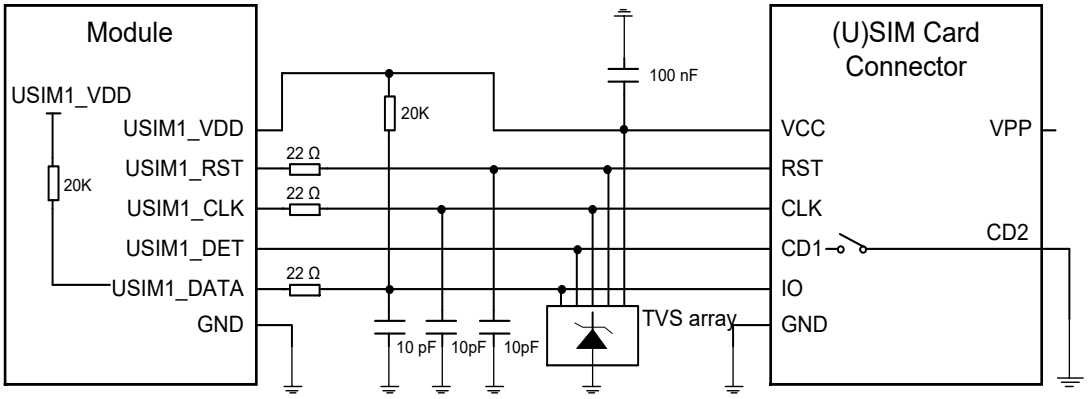
Figure 13: Reference Circuit for Normally Closed (U)SIM Card Connector

4.4. 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. Once (U)SIM hot-plug is enabled by executing **AT+QSIMDET=1,0**, a (U)SIM card insertion will drive USIM1_DET from high to low level, and the removal of it will drive USIM1_DET from low to high level.

- When the (U)SIM card is absent, CD1 is open from CD2 and USIM1_DET is at high level.
- When the (U)SIM card is present, CD1 is pulled down to ground and USIM1_DET is at low level.

The following figure shows a reference design for (U)SIM1 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 14: Reference Circuit for Normally Open (U)SIM Card Connector

NOTE

If the (U)SIM card detection function is not needed, keep USIM1_DET unconnected.

4.5. (U)SIM 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.

- Place the (U)SIM card connector as close to the module as possible, (U)SIM card related resistors, capacitors and ESD protection components should be placed close to the card connector. Keep the trace length as short as possible, at most 200 mm. Keep the trace width of USIM1_DATA, USIM1_CLK, USIM1_RST and USIM1_DET not less than 0.1 mm.
- Keep (U)SIM card signals away from RF and VCC traces.
- Ensure the ground between the module and the (U)SIM card connector is short and wide. Keep the trace width of ground and USIM1_VDD not less than 0.2 mm to maintain the same electric potential.
- To avoid cross-talk between USIM1_DATA and USIM1_CLK, keep them away from each other and shield them with surrounded ground.
- To offer better ESD protection, add a TVS array of which the parasitic capacitance should be not higher than 20 pF. Add 22 Ω resistors in series between the module and the (U)SIM card connector to suppress EMI. The 10 pF capacitors are used to filter out RF interference.
- For USIM1_DATA, it is optional to add a 20 kΩ pull-up resistor near the (U)SIM card connector.

4.6. PCIe Interface

The module provides one integrated PCIe (Peripheral Component Interconnect Express) interface.

- *PCI Express Base Specification Revision 4.0* compliant
- Complaint with PCIe Gen 3.
- Data rate up to 8 Gbps

4.7. Pin Definition of PCIe Interface

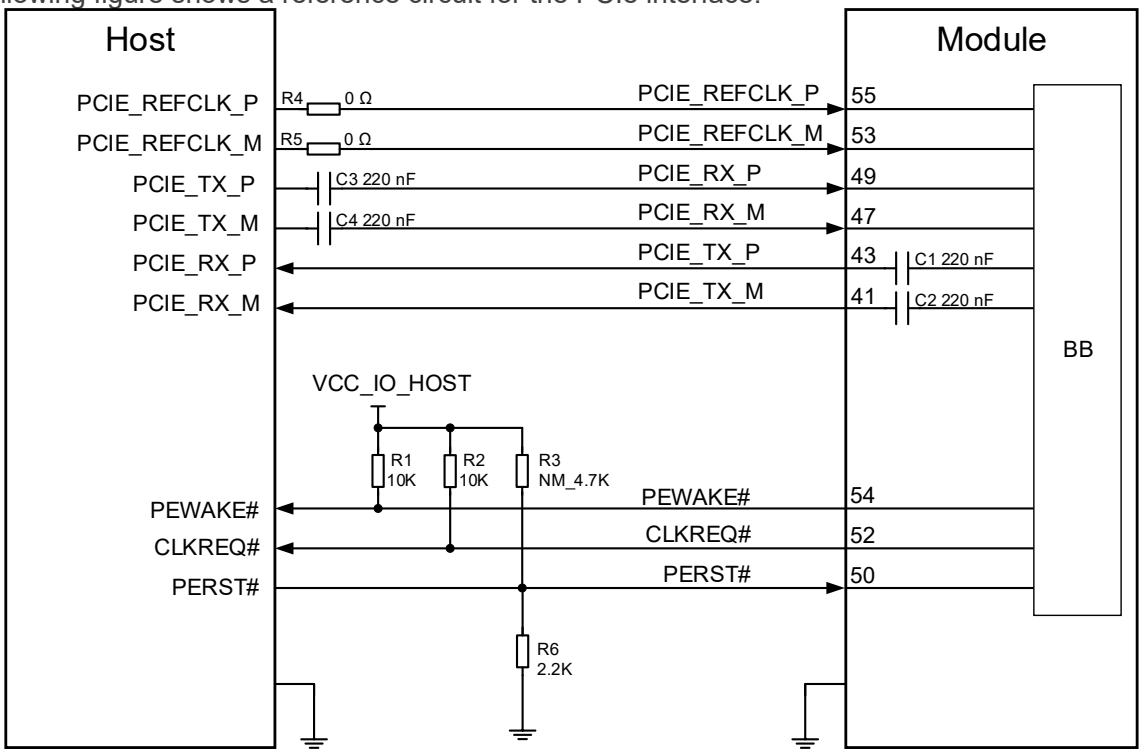
The following table shows the pin definition of PCIe interface.

Table 15: Pin Definition of PCIe Interface

Pin No.	Pin Name	I/O	Description	Comment
55	PCIE_REFCLK_P	AIO	PCIe reference clock (+)	Clock frequency: 100 MHz. Require differential impedance of 85 Ω.
53	PCIE_REFCLK_M	AIO	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	PERST#	DI	PCIe reset	1.8/3.3 V Active LOW.
52	CLKREQ#	OD	PCIe clock request	1.8/3.3 V Active LOW.
54	PEWAKE#	OD	PCIe wake up	1.8/3.3 V Active LOW.

4.8. Reference Design for PCIe Interface

The following figure shows a reference circuit for the PCIe interface.



NOTE: HOST must use a push-pull GPIO to control PERST#.

Figure 15: PCIe Interface Reference Circuit

To ensure the signal integrity of PCIe interface, AC coupling capacitors C3 and C4 should be placed close to the host on PCB. C1 and C2 have been integrated inside the module, so do not place these two capacitors on your schematic and PCB.

The following principles of PCIe interface design should be complied with 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 not more than 200 mm.
- Keep the intra-pair length matching of each differential data pair (P/M) less than 0.7 mm.
- 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.

Table 16: PCIe Trace Length Inside the Module

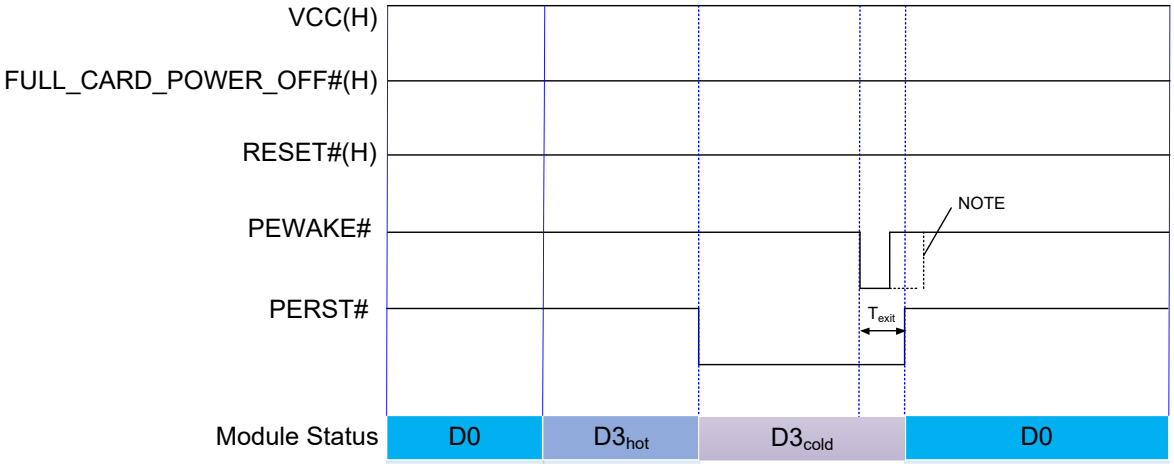
Signal	Pin No.	Length (mm)	Length Mismatch (mm)
PCIE_REFCLK_P	55	12.06	0.03

PCIE_REFCLK_M	53	12.03	
PCIE_TX_P	43	5.10	0.15
PCIE_TX_M	41	4.95	
PCIE_RX_P	49	12.02	0.04
PCIE_RX_M	47	11.98	

4.9. PCIe D3$_{cold}$ State

For the laptop application scenario, module must go through D3$_{hot}$ before entering D3$_{cold}$. In D3$_{hot}$ state, PERST# must be kept in high level.

The module enters D3$_{cold}$ state after PERST# is at low level . The module enters D0 state after PERST# is at high level .



NOTE: PEWAKE# may be pulled up before or after PERST# is pulled up, depending on when host pulls up PERST#. This time period does not affect the normal operation of the module and can be ignored.

Figure 16: PCIe D3$_{cold}$ State Timing

Table 17: Exit D3cold State Timing of the Module

Symbol	Min.	Typ.	Max.	Comment
T_{exit}	50 ms	150 ms	500 ms	The period from the module pulling down PEWAKE# to host pulling up PERST#.

4.10. Control and Indication Interfaces

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

Table 18: Pin Definition of Control and Indication Interfaces

Pin No.	Pin Name	I/O	Description	Comment
8	W_DISABLE1#	DI	Airplane mode control	Internally pulled up to 1.8 V with a 100 kΩ resistor. Active LOW.
26	W_DISABLE2#*	DI	GNSS control	
10	LED_WWAN#	OD	RF status LED indicator	Active LOW.
23	WAKE_ON_WAN#	OD	Wake up the host	Active LOW.
25	DPR	DI, PU	Dynamic power reduction	Internally pulled up to 1.8 V.

4.11. W_DISABLE1#

The module provides a W_DISABLE1# pin to disable or enable airplane mode through hardware operation. W_DISABLE1# 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 AT commands. The following table shows the AT command and corresponding RF function status of the module.

Table 19: RF Function Status

W_DISABLE1# Logic Level	AT Command	RF Function Status	Operating Mode
HIGH	**AT+CFUN=1**	Enabled	Full functionality mode
	AT+CFUN=0	Disabled	Minimum functionality mode
	AT+CFUN=4		Airplane mode
LOW	**AT+CFUN=0** **AT+CFUN=1** **AT+CFUN=4**	Disabled	Airplane mode

4.12. W_DISABLE2#*

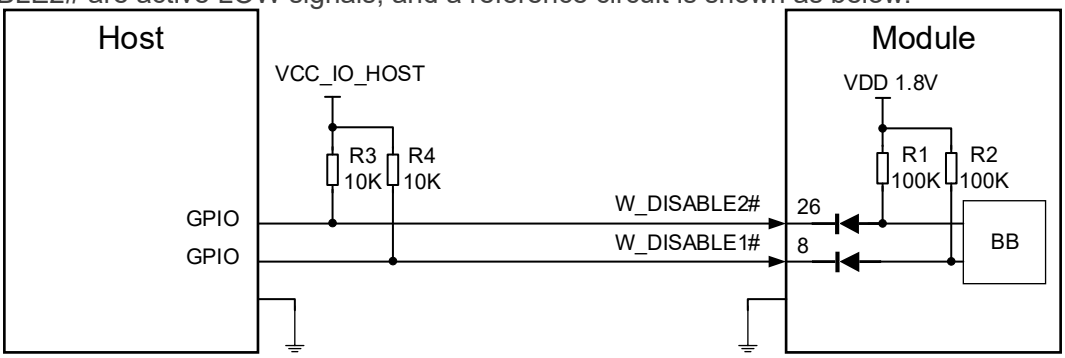
The module provides a W_DISABLE2# pin to disable or enable the GNSS function. The W_DISABLE2# pin is pulled up by default. Driving it LOW will disable the GNSS function. The combination of W_DISABLE2# pin and AT commands can control the GNSS function. For details about the AT commands, see ***document [4]***.

Table 20: GNSS Function Status

W_DISABLE2# Logic Level	AT Command	GNSS Function Status

HIGH	**AT+QGPS=1**	Enabled
HIGH	**AT+QGPSEND**	Disabled
LOW	**AT+QGPS=1**	Disabled
LOW	**AT+QGPSEND**	

A simple voltage-level translator based on diodes is used on W_DISABLE1# and W_DISABLE2# which are pulled up to a 1.8 V voltage in the module, as shown in the following figure. Therefore, 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 17: W_DISABLE1# and W_DISABLE2# Reference Circuit

4.13. LED_WWAN#

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

To reduce power 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 LED_WWAN# signal is at low level.

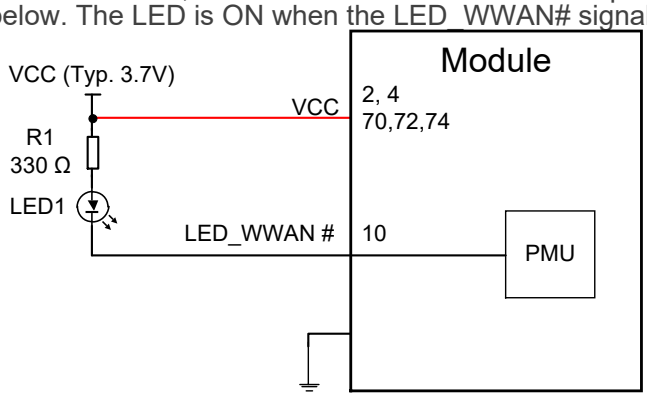


Figure 18: LED_WWAN# Reference Circuit

Table 21: Network Status Indications of LED_WWAN#

LED_WWAN# Logic Level	Description
LOW (LED on)	RF function is turned on.

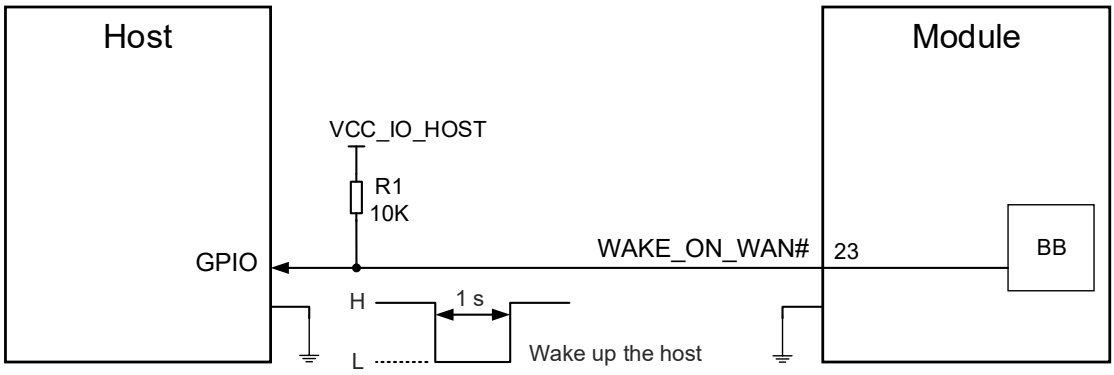
HIGH (LED off)	RF function will be turned off if any of the following occurs: ● The (U)SIM card is not powered. ● W_DISABLE1# is at low level (airplane mode enabled). ● **AT+CFUN=4** (RF function disabled).

4.14. 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 one-second low level pulse signal will be outputted to wake up the host.

Table 22: State of the WAKE_ON_WAN#

WAKE_ON_WAN# State	Module Operation Status
Outputs a one-second pulse signal at low level	SMS
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 19: WAKE_ON_WAN# Signal Reference Circuit

4.15. DPR

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

Table 23: Function of the DPR Signal

DPR Level	Function
HIGH/Floating	NO maximum transmitting power backoff
LOW	Maximum transmitting power backoff by **AT+QSAR**

A reference circuit is shown as below.

Figure 20: DPR Reference Circuit

NOTE

See ***document [5]*** for more details about **AT+QSAR**.

4.16. Cellular/WLAN COEX Interface*

The module provides the cellular/WLAN COEX interface, the following table shows the pin definition of this interface.

Table 24: Pin Definition of Cellular/WLAN COEX Interface

Pin No.	Pin Name	I/O	Description
60	N79_TX_EN	DO	Notification from SDR to WLAN when n79 transmitting
38	WLAN_TX_EN	DI	Notification from WLAN to SDR when WLAN transmitting
62	COEX_RXD [14]	DI	WWAN and WLAN/Bluetooth coexistence receive
64	COEX_TXD [14]	DO	WWAN and WLAN/Bluetooth coexistence transmit

4.17. Antenna Tuner Control Interface

RFFE interface are used for antenna tuner control and should be routed to an appropriate antenna control circuit.

Table 25: Pin Definition of Antenna Tuner Control Interface

Pin No.	Pin Name	I/O	Description

[14] Note that COEX_RXD and COEX_TXD cannot be used as general UART ports.

56	RFFE_CLK*	DO	Used for external MIPI IC control
58	RFFE_DATA*	DIO	
24	VDDIO_1V8	PO	Provide 1.8 V for external circuit

NOTE

If RFFE function is required, contact NetPrisma Technical Support for more details.

4.18. Configuration Pins

Configuration pins are used to assist the host to identify the presence of the module in the socket and identify module type. The module provides four configuration pins, which are defined as below.

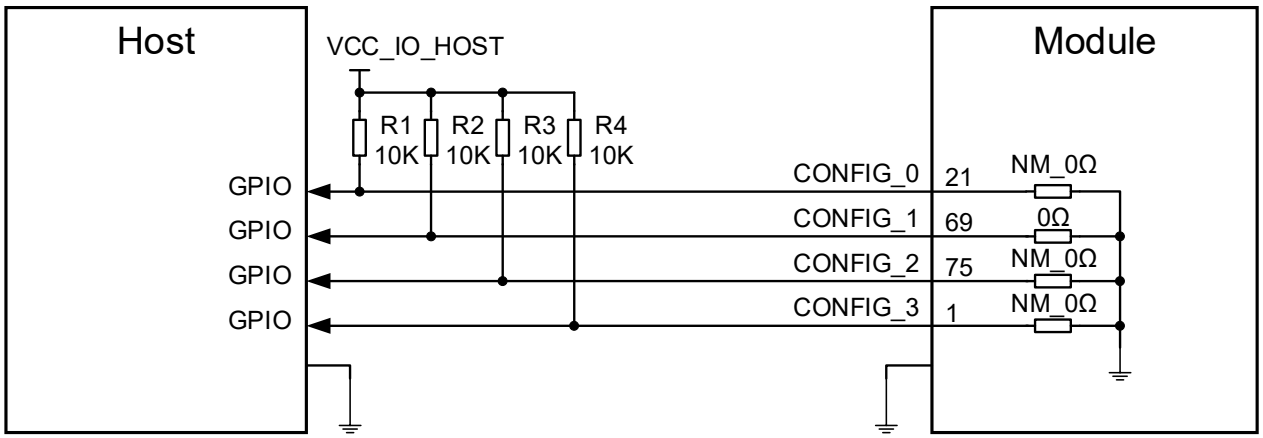
Table 26: Configuration Pins List of M.2 Specification

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	WWAN-PCIe	2 (NetPrisma defined)

Table 27: Configuration Pins of the Module

Pin No.	Pin Name	I/O	Description
21	CONFIG_0	DO	Not connected internally
69	CONFIG_1	DO	Connected to GND internally
75	CONFIG_2	DO	Not connected internally
1	CONFIG_3	DO	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 21: Recommended Circuit for Configuration Pins

5 RF Characteristics

This chapter mainly describes RF characteristics of the module.

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.

5.1. Antenna Interfaces

5.2. Pin Definition

The pin definition of antenna interfaces is shown below.

Table 28: Pin Definition of Antenna Interfaces

Antenna Interfaces	I/O	Description	Comment
ANT0	AIO	**Antenna 0 interface:** **5G NR:** − Reframing: LB TX0/PRX & MHB TX0/PRX & UHB TX1/DRX − n41 TX0/PRX − n77/n78/n79 TX1/DRX **LTE:** LB TX0/PRX & MHB TX0/PRX & UHB TX1/DRX **WCDMA:** LMB TRX	LB: 617–960 MHz MHB: 1427–2690 MHz UHB: 3400–3800 MHz n77/n78: 3300–4200 MHz n79: 4400–5000 MHz LAA: 5150-5925 MHz
ANT1	AIO	**Antenna 1 interface:** **5G NR:** − Reframing: MHB PRX MIMO & UHB PRX MIMO − n41 PRX MIMO − n77/n78/n79 PRX MIMO **LTE:** MHB PRX MIMO & UHB PRX MIMO & LAA PRX **GNSS:** L5	
ANT2	AIO	**Antenna 2 interface:** **5G NR:** − Reframing: MHB TX1 [15] /DRX MIMO & UHB TX0/PRX − n41 TX1/DRX MIMO − n77/n78/n79 TX0/PRX **LTE:** MHB TX1 [15]/DRX MIMO & UHB TX0/PRX	
ANT3	AIO	**Antenna 3 interface:** **5G NR:** − Reframing: LB TX1 [16]/DRX & MHB DRX & UHB DRX MIMO − n41 DRX − n77/n78/n79 DRX MIMO **LTE:** LB TX1 [17]/DRX & MHB DRX & UHB DRX MIMO & LAA DRX **WCDMA:** LMB DRX **GNSS:** L1	

[15] MHB TX1 will be active when supporting Sub 2.6 GHz EN-DC.
[16] LB TX1 n20 will be active when supporting DC_B28_n20.
[17] LB TX1 B20 will be active when supporting DC_B20_n28.

5.3. Cellular Network

5.3.1.1. Receiving Sensitivity

Table 29: Conducted Receiving Sensitivity (Unit: dBm)

Mode	Frequency	SIMO [18]	3GPP (SIMO)
WCDMA	WCDMA B1	-110	-106.7
	WCDMA B2	-110	-104.7
	WCDMA B4	-111	-106.7
	WCDMA B5	-112	-104.7
	WCDMA B8	-112	-103.7
	WCDMA B19	-112	-104.7
LTE	LTE-FDD B1 (10 MHz)	-102	-99.7
	LTE-FDD B2 (10 MHz)	-102.5	-97.7
	LTE-FDD B3 (10 MHz)	-102.5	-96.7
	LTE-FDD B4 (10 MHz)	-103	-99.7
	LTE-FDD B5 (10 MHz)	-102	-95
	LTE-FDD B7 (10 MHz)	-102	-97.7
	LTE-FDD B8 (10 MHz)	-101.5	-94
	LTE-FDD B12 (B17) (5 MHz)	-105	-94
	LTE-FDD B13 (10 MHz)	-99.5	-94
	LTE-FDD B14 (10 MHz)	-100.5	-94
	LTE-FDD B18 (10 MHz)	-101.5	-97
	LTE-FDD B19 (10 MHz)	-102	-97
	LTE-FDD B20 (10 MHz)	-102	-94
	LTE-FDD B25 (5 MHz)	-104.5	-96.2
	LTE-FDD B26 (5 MHz)	-105	-94.5
	LTE-FDD B28 (10 MHz)	-101	-95.5

[18] For the SIMO receiving sensitivity, WCDMA bands are tested with 2 Rx antennas, and LTE and 5G NR bands which are tested with 4 RX antennas please refer to **Table 2: Frequency Bands & MIMO & GNSS Systems**.

	LTE-FDD B29 (10 MHz)	-101	TBD
	LTE-FDD B30 (10 MHz)	-100.5	-98.7
	LTE-FDD B32 (10 MHz)	-99	TBD
	LTE-TDD B34 (10 MHz)	-99	-97
	LTE-TDD B38 (10 MHz)	-101	-99.7
	LTE-TDD B39 (10 MHz)	-99.5	-97
	LTE-TDD B40 (10 MHz)	-101.5	-99.7
	LTE-TDD B41 (20 MHz)	-97.5	-95.9
	LTE-TDD B42 (10 MHz)	-101	-98.2
	LTE-TDD B43 (10 MHz)	-100.5	-98.2
	LTE-TDD B46 (20 MHz)	-95	TBD
	LTE-TDD B48 (10 MHz)	-102	-98.7
	LTE-FDD B66 (10 MHz)	-102	-99.2
	LTE-FDD B71 (10 MHz)	-101.5	-94.2
5G NR	5G NR-FDD n1 (10 MHz)	-102	-99.5
	5G NR-FDD n2 (10 MHz)	-102	-97.5
	5G NR-FDD n3 (10 MHz)	-102	-96.5
	5G NR-FDD n5 (10 MHz)	-101.5	-94.8
	5G NR-FDD n7 (10 MHz)	-101.5	-97.5
	5G NR-FDD n8 (10 MHz)	-101.5	-93.8
	5G NR-FDD n12 (5 MHz)	-105	-97
	5G NR-FDD n13 (10MHz)	-100	-93.8
	5G NR-FDD n14 (10 MHz)	-100.5	-93.8
	5G NR-FDD n18 (10 MHz)	-101.5	-96.8
	5G NR-FDD n20 (10 MHz)	-102	-93.8
	5G NR-FDD n25 (5 MHz)	-104.5	-99.2
	5G NR-FDD n26 (5 MHz)	-105	-97.5
	5G NR-FDD n28 (10 MHz)	-101	-95.5

	5G NR-FDD n29 (10 MHz)	TBD	-101
	5G NR-FDD n30 (10 MHz)	-100	-98.5
	5G NR-TDD n38 (10 MHz)	-101	-99.8
	5G NR-TDD n40 (10 MHz)	-101.5	-99.8
	5G NR-TDD n41 (20 MHz)	-97.5	-94.7
	5G NR-TDD n48 (10 MHz)	-102	-98.3
	5G NR-FDD n66 (10 MHz)	-102	-99.4
	5G NR-FDD n71 (10 MHz)	-101.5	-94
	5G NR-FDD n75 (20 MHz)	TBD	-94
	5G NR-FDD n76 (5 MHz)	TBD	-100
	5G NR-TDD n77 (100 MHz)	-92	-87.3
	5G NR-TDD n78 (100 MHz)	-92	-87.8
	5G NR-TDD n79 (100 MHz)	-91.5	-87.8

5.3.1.2. Transmitting Power

The following table shows the RF output power of the module.

Table 30: Cellular Output Power

Mode	Frequency	Max.	Min.
WCDMA	WCDMA bands	23 dBm ±2 dB (Class 3)	< -50 dBm
LTE	LTE bands	23 dBm ±2 dB (Class 3)	< -40 dBm
	LTE HPUE band (B38/B41/B42/B43)	26 dBm ±2 dB (Class 2) [19]	< -40 dBm
5G NR	5G NR bands	23 dBm ±2 dB (Class 3)	< -40 dBm [20]
	5G NR HPUE bands (n38/n40/n41/n77/n78/n79)	26 dBm ±2 dB (Class 2) [19]	< -40 dBm [20]

5.4. GNSS (Optional)

The module includes a fully integrated global navigation satellite system solution (GPS, GLONASS, BDS, Galileo and QZSS).

[19] PC2 is not available in Japan due to the local regulations.
[20] For 5G NR TDD bands, the normative reference for this requirement is *TS 38.101-1 clause 6.3.1.*

The module supports standard NMEA 0183 protocol, and outputs NMEA sentences at 1 Hz data update rate.

The GNSS engine is switched off by default. It has to be switched on via AT command. For more details about GNSS positioning technology and configuration, see ***document [4].***

5.4.1.1. GNSS Frequency

Table 31: GNSS Frequency

Band	GNSS Constellation Type	Frequency	Unit
L1	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
	BDS	1561.098 ±2.046	MHz
L5	GPS/Galileo/QZSS	1176.45 ±10.23	MHz

5.4.1.2. GNSS Performance

The following table shows GNSS performance of the module.

Table 32: GNSS Performance

Parameter	Description	Condition	Typ.	Unit
Sensitivity	Acquisition	Autonomous	-147	dBm
	Reacquisition	Autonomous	-160	dBm
	Tracking	Autonomous	-160	dBm
TTFF	Cold start @ open sky	Autonomous	27.93	s
		XTRA start	19.25	s
	Warm start @ open sky	Autonomous	11.55	s
		XTRA start	0.94	s
	Hot start @ open sky	Autonomous	1.09	s
		XTRA start	0.79	s
Accuracy	CEP-50	Autonomous @ open sky	1.35	m

NOTE

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

5.5. Antenna Connectors

5.6. Antenna Connector Specifications

The module is mounted with standard 2 mm × 2 mm receptacle antenna connectors for convenient antenna connection. The antenna connector's dimensions are illustrated as below:

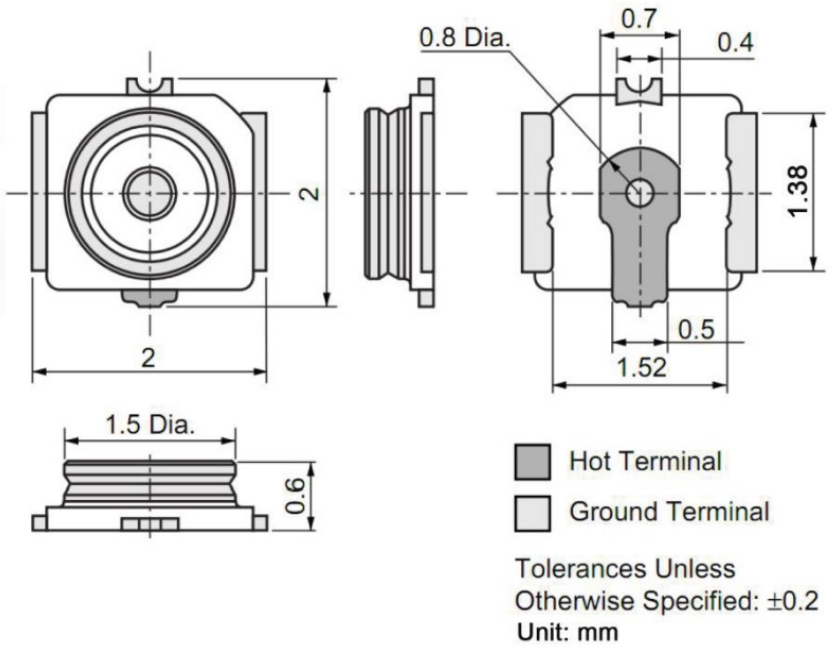


Figure 22: Dimensions of the Receptacle

Table 33: Major Specifications of the RF Connector

Item	Specification
Nominal Frequency Range	DC to 6 GHz

Nominal Impedance	50 Ω
Temperature Rating	-40 °C to +85 °C
Voltage Standing Wave Ratio (VSWR)	Meet the requirements of: Max 1.3 (DC–3 GHz) Max 1.4 (3–6 GHz)

5.7. Antenna Connector Location

The module has four antenna connectors: ANT0, ANT1, ANT2, and ANT3, which are shown below.

Figure 23: FCUN69-WWD Antenna Connectors

NOTE

It is recommended that the straight-line distance between the antenna and the module be greater than 15 mm to achieve better wireless performance of the whole device.

5.8. Antenna Connector Installation

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 Ø 0.81 mm coaxial cable or a maximum height of 1.45 mm utilizing a Ø 1.13 mm coaxial cable.

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

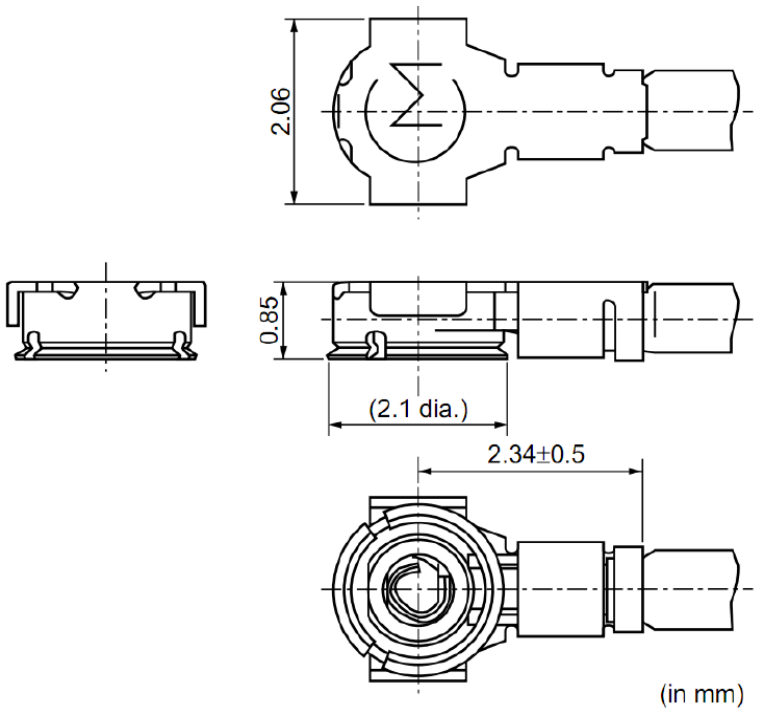


Figure 24: Dimensions of Mated Plugs (Ø 0.81 mm Coaxial Cables)

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

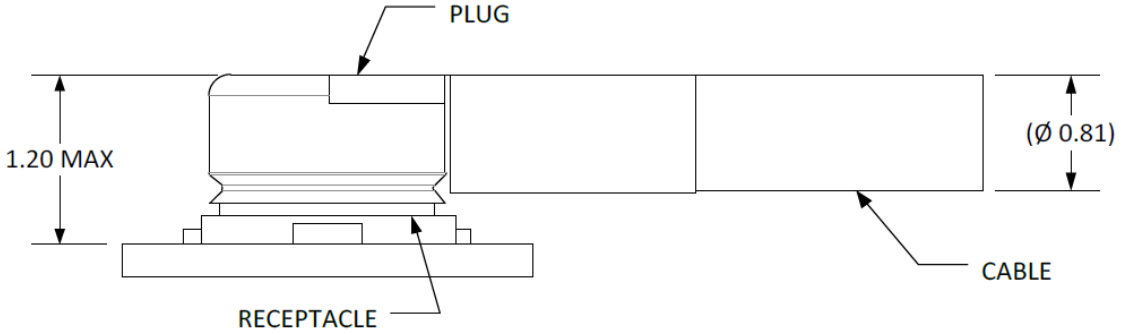


Figure 25: Space Factor of Mated Connectors (Ø 0.81 mm Coaxial Cables) (Unit: mm)

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

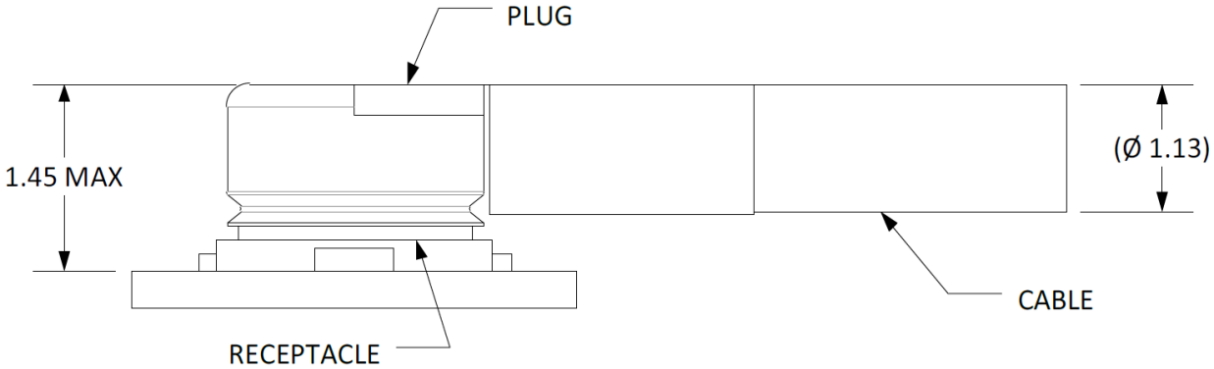


Figure 26: Space Factor of Mated Connectors (Ø 1.13 mm Coaxial Cables) (Unit: mm)

5.9. Recommended RF Connector Installation

5.9.1.1. Assemble Coaxial Cable Plug Manually

The illustration for plugging in a coaxial cable plug is shown below, θ = 90° is acceptable, while θ ≠ 90° is not.

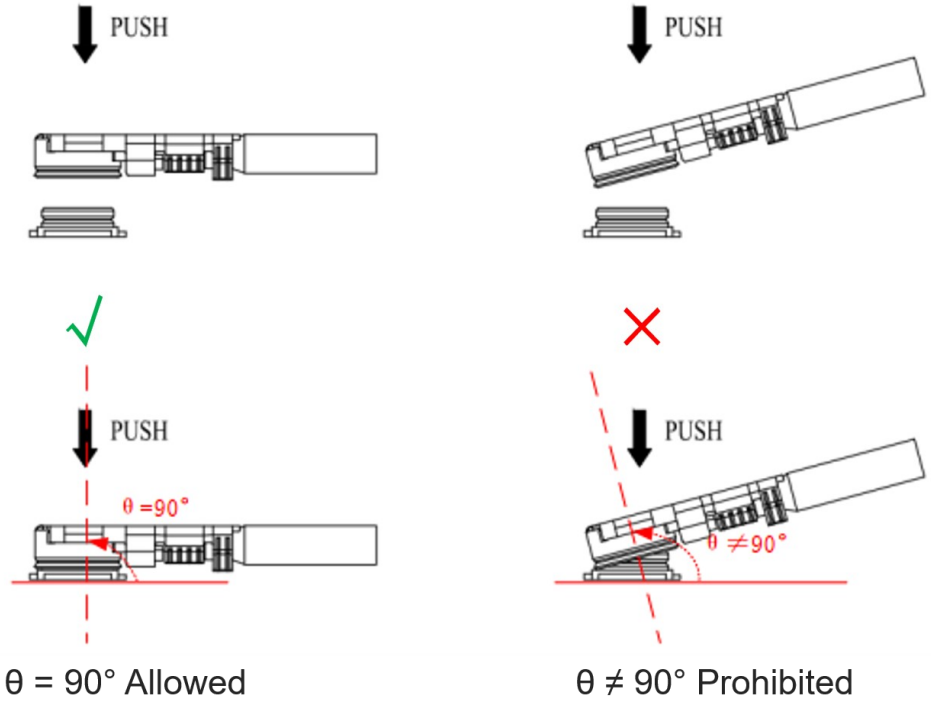


Figure 27: Plug in a Coaxial Cable Plug

The illustration of pulling out the coaxial cable plug is shown below, θ = 90° is acceptable, while θ ≠ 90° is not.

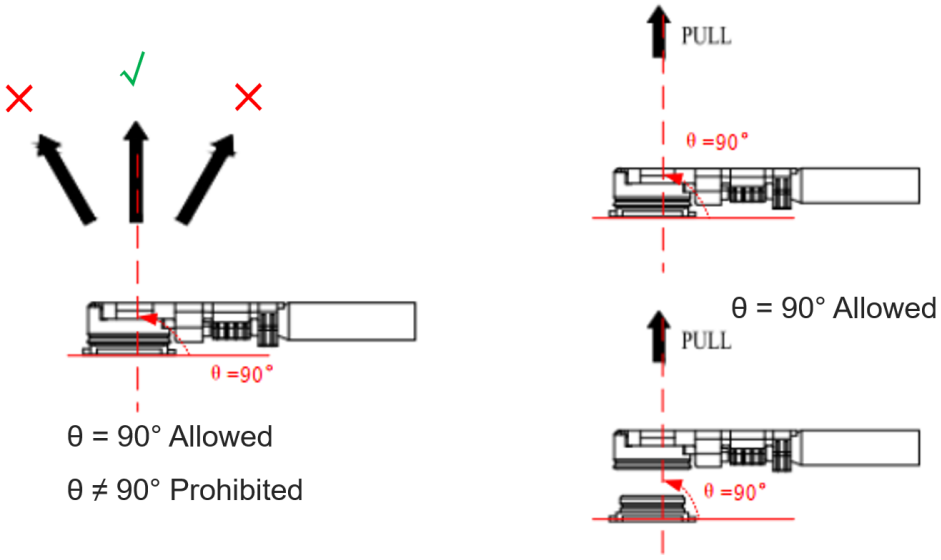


Figure 28: Pull out a Coaxial Cable Plug

5.9.1.2. Assemble Coaxial Cable Plug with Jig

The pictures of installing the coaxial cable plug with a jig is shown below, θ = 90° is acceptable, while θ ≠ 90° is not.

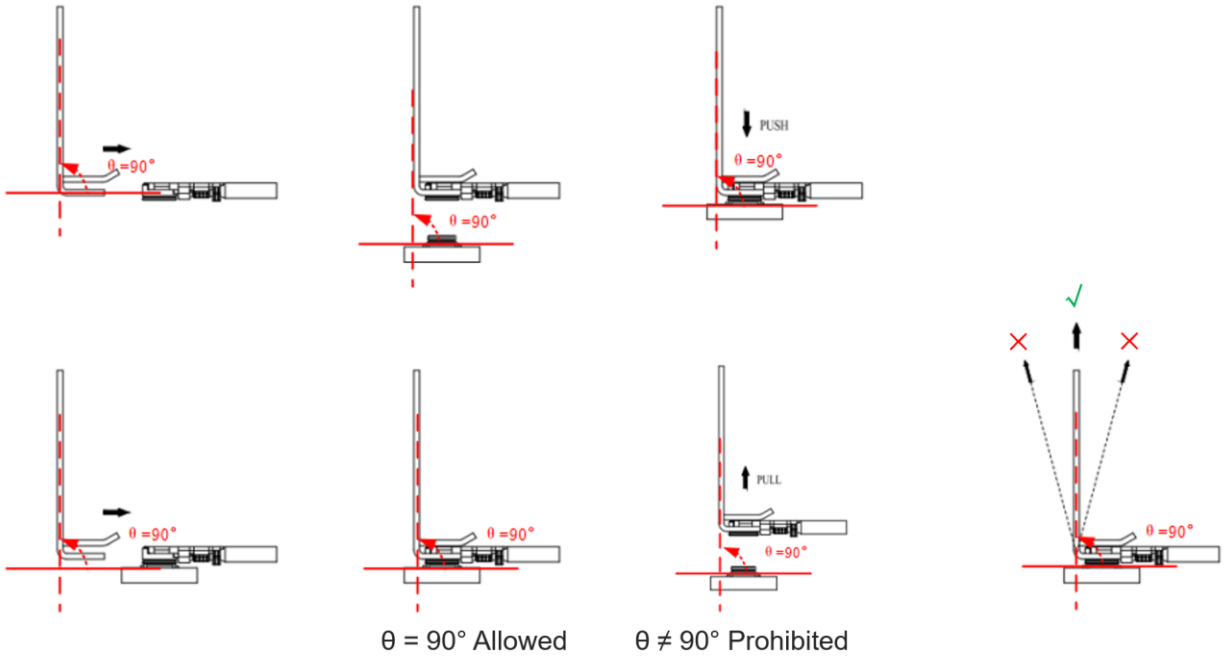


Figure 29: Install the Coaxial Cable Plug with Jig

5.10. Recommended Manufacturers of RF Connector and Cable

RF connectors and cables by I-PEX4 are recommended. For more details, visit https://www.i-pex.com.

5.11. Antenna Requirements

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

Table 34: Antenna Requirements

Type	Requirements
Cellular	● VSWR: ≤ 2 ● Efficiency: > 30 % ● 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)
GNSS	● Frequency range: – L1: 1559–1609 MHz – L5: 1166–1187 MHz ● Polarization: RHCP or linear ● VSWR: ≤ 2 (Typ.) ● Passive antenna gain: > 0 dBi

NOTE

It is recommended to use a passive GNSS antenna when LTE B13 or B14 is supported, as the use of active antenna may generate harmonics which will affect the GNSS performance.

6 Electrical Characteristics and Reliability

6.1. Absolute Maximum Ratings

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

Table 35: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VCC	-0.3	4.7	V
Voltage at 1.8 V Digital Pins	-0.3	2.3	V
Voltage at 3.3 V Digital Pins	-0.3	3.6	V

6.2. Power Supply Requirements

The typical input voltage of the module is 3.7 V, the following table shows the power supply requirements of the module.

Table 36: Power Supply Requirements

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Power Supply for the module	3.135	3.7	4.4	V
Voltage Ripple		-	30	100	mV

6.3. Power Consumption

Table 37: Averaged Power consumption

Mode	Condition	Band/Combination	Typ.	Unit
Power-off	Power off	-	150	μA

Radio off	Flight mode	-	2.73	mA
No SIM	Radio on	-	3.77	mA
LTE idle	Attached disconnected	-	4.38	mA
	Connected in Si03	-	4.34	mA
LTE	LTE LB @ 24 dBm	B5	TBD	mA
	LTE MB @ 24 dBm	B1	TBD	mA
	LTE HB @ 24 dBm	B7	TBD	mA
LTE CA	DL 3CA, 256QAM	CA_1A-3A-7A	TBD	mA
	UL 1CA, 256QAM			
	Tx power @ 24 dBm			
5G EN-DC idle	Attached disconnected	-	4.52	mA
	Connected in Si03	-	4.47	mA
5G SA (1 Tx)	5G NR LB @ 23 dBm	n5	TBD	mA
	5G NR MB @ 23 dBm	n1	TBD	mA
	5G NR HB @ 23 dBm	n7	TBD	mA
	5G NR UHB @ 26 dBm	n78	TBD	mA
5G SA (2 Tx)	5G NR UL 2 × 2 MIMO @ 26 dBm	n78	TBD	mA
LTE + 5G EN-DC	LTE DL, 256QAM	DC_3A_n78A	TBD	mA
	LTE UL QPSK			
	NR DL, 256QAM			
	NR UL QPSK			
	LTE Tx Power @ 23 dBm			
	NR Tx Power @ 23 dBm			

NOTE

1. The power consumption test is performed with EVB at room temperature without any thermal dissipation measure.
2. The power consumption above is for reference only, contact NetPrisma Technical Support for a detailed power consumption test report of the module.

6.4. Digital I/O Characteristic

Table 38: Logic Levels of 1.8 V Digital I/O

Parameter	Description	Min.	Max.	Unit
VDDIO_1V8	Supply voltage	1.7	1.94	V
V_{IH}	High-level input voltage	0.65 × VDDIO_1V8	VDDIO_1V8 + 0.3	V
V_{IL}	Low-level input voltage	-0.3	0.35 × VDDIO_1V8	V
V_{OH}	High-level output voltage	VDDIO_1V8 - 0.45	-	V
V_{OL}	Low-level output voltage	-	0.45	V

Table 39: Logic Levels of 3.3 V Digital I/O

Parameter	Description	Min.	Max.	Unit
3.3 V	Supply voltage	3.135	3.465	V
V_{IH}	High-level input voltage	2.0	3.6	V
V_{IL}	Low-level input voltage	-0.5	0.8	V

Table 40: (U)SIM High/Low-voltage I/O Requirements

Parameter	Description	Min.	Max.	Unit
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	-	V
V_{OL}	Low-level output voltage	-	0.4	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 41: Electrostatic Discharge Characteristics (Temperature: 25–30 ºC, Humidity: 40 ±5 %)

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

6.6. Operating and Storage Temperatures

Table 42: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operating Temperature Range [21]	-30	+25	+75	ºC
Extended Temperature Range [22]	-40	-	+85	ºC
Storage temperature Range	-40	-	+90	ºC

[21] 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 the temperature range of -10 °C to +55 °C, the mentioned RF performance margins higher than 3GPP specifications can be guaranteed. When temperature goes beyond temperature range of -10 °C to +55 °C, a few RF performances of module may be slightly off 3GPP specifications.
[22] 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 this range, the module remains the ability to establish and maintain functions such as SMS and emergency call*, 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.

6.7. Thermal Dissipation

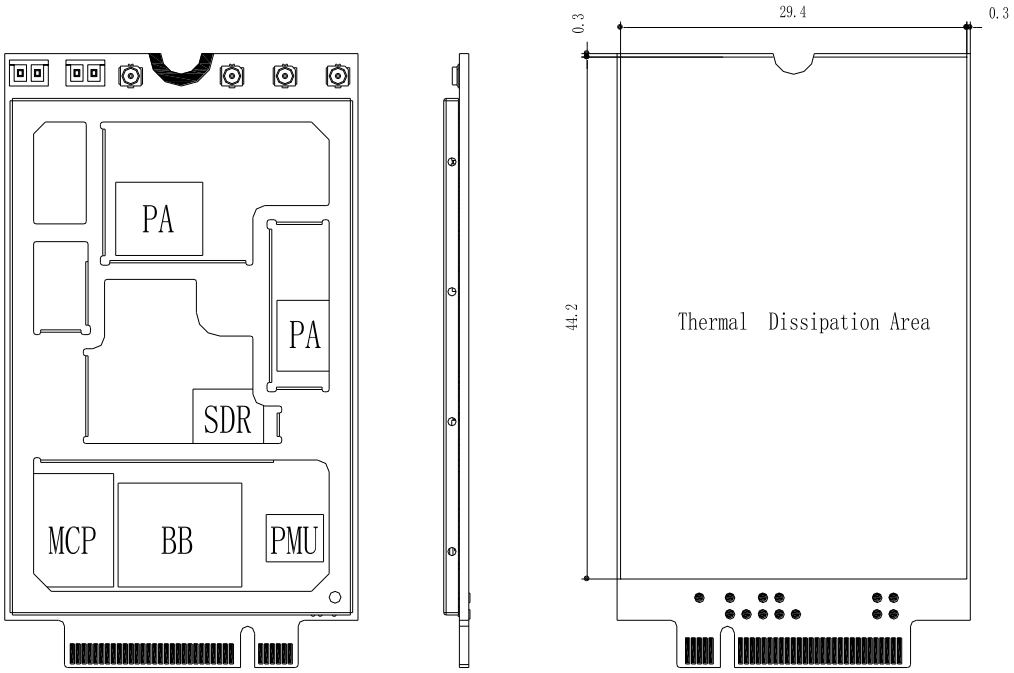


Figure 30: Thermal Dissipation Area Inside and on Bottom Side of the Module

The module offers the best performance when all internal IC chips are working within their operating temperatures. When the IC chip reaches or exceeds the maximum junction temperature, the module may still work but the performance and function (such as RF output power and data rate) will be affected to a certain extent. Therefore, the thermal design should be maximally optimized to ensure all internal IC chips always work within the recommended operating temperature range.

The following principles for thermal consideration are provided for reference:

- Keep the module away from heat sources on your PCB, especially high-power components such as processor, power amplifier, and power supply.
- Maintain the integrity of the PCB copper layer and drill as many thermal vias as possible.
- Expose the copper in the PCB area where module is mounted.
- Apply a soft thermal pad with appropriate thickness and high thermal conductivity between the module and the PCB to conduct heat.
- Follow the principles below when the heatsink is necessary:
  - Do not place large size components in the area where the module is mounted on your PCB to reserve enough place for heatsink installation.
  - Attach the heatsink to the shielding cover of the module; In general, the base plate area of the heatsink should be larger than the module area to cover the module completely;
  - Choose the heatsink with adequate fins to dissipate heat;
  - Choose a TIM (Thermal Interface Material) with high thermal conductivity, good softness and good wettability and place it between the heatsink and the module;
  - Fasten the heatsink with four screws to ensure that it is in close contact with the module to prevent the heatsink from falling off during the drop, vibration test, or transportation.

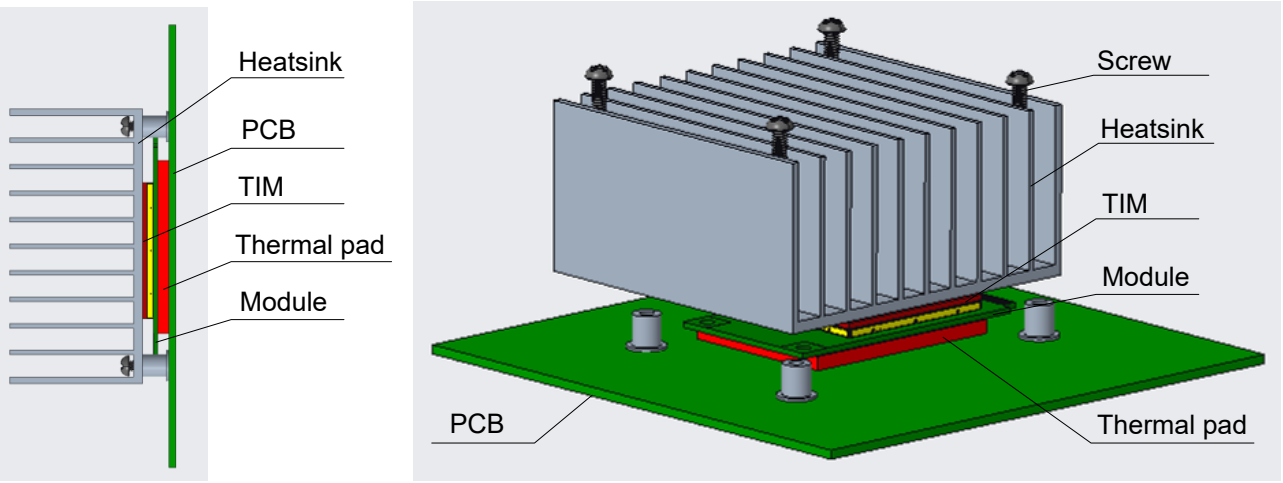


Figure 31: Placement and Fixing of the Heatsink

7 Mechanical Dimensions

This chapter mainly describes mechanical dimensions and packaging specifications of FCUN69-WWD. All dimensions are measured in mm, and the dimensional tolerances are ±0.15 mm unless otherwise specified.

7.1. Mechanical Dimensions

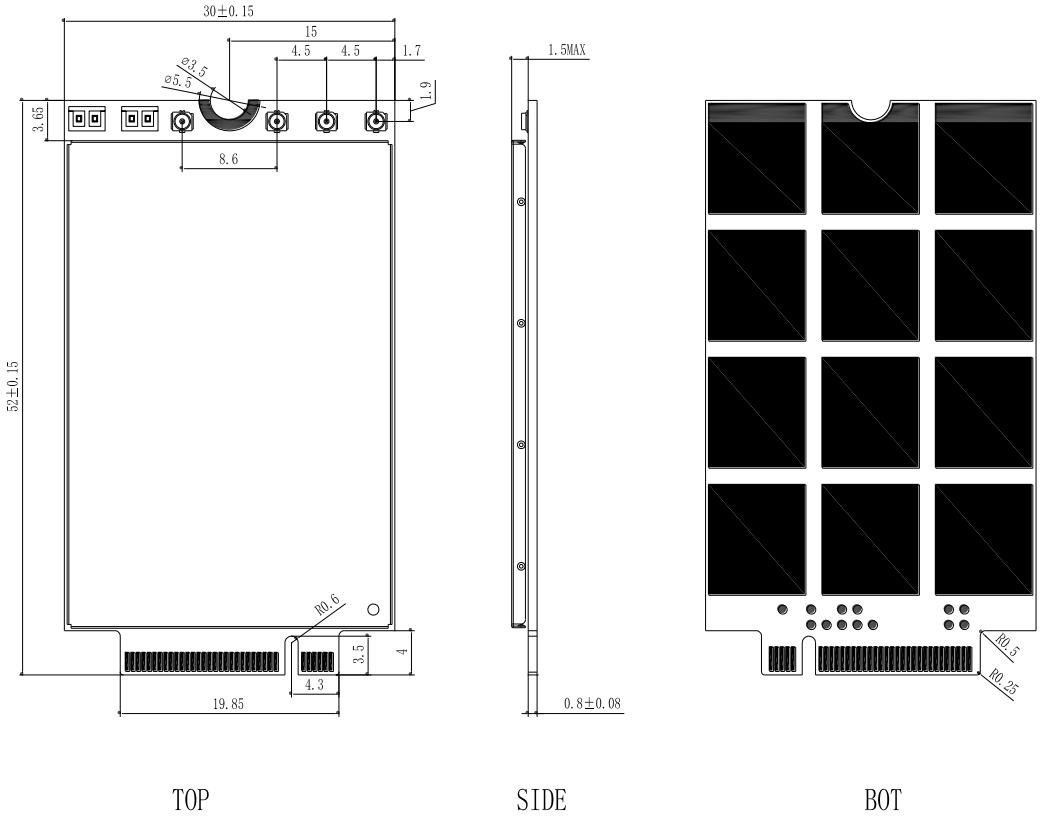


Figure 32: Mechanical Dimensions of the Module (Unit: mm)

7.2. Top and Bottom Views

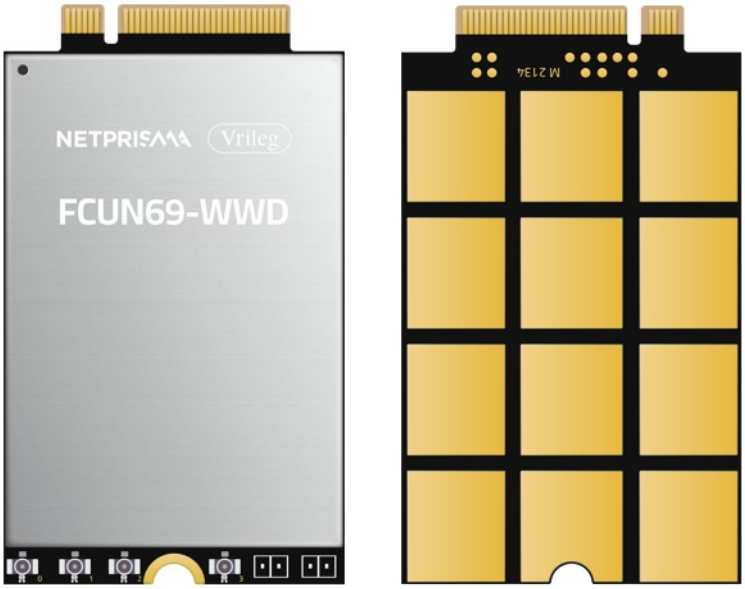


Figure 33: Top and Bottom Views of the Module

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 NetPrisma.

7.3. M.2 Connector

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

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 module application.

8.3. 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.

8.4. Cleaning

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

8.5. Installing

The module needs to be fixed firmly to avoid poor contact caused by shaking. When installing the module, it is recommended to be mounted on the socket with a screw as shown below.

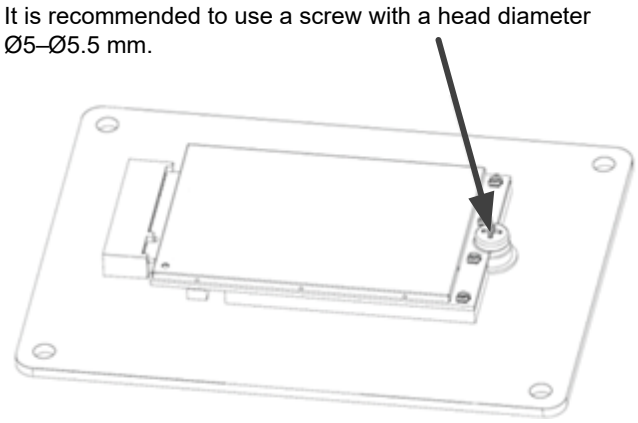


Figure 34: Installation Schematic

8.6. 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.

8.7. Blister Tray

Blister tray dimensions are illustrated in the following figure:

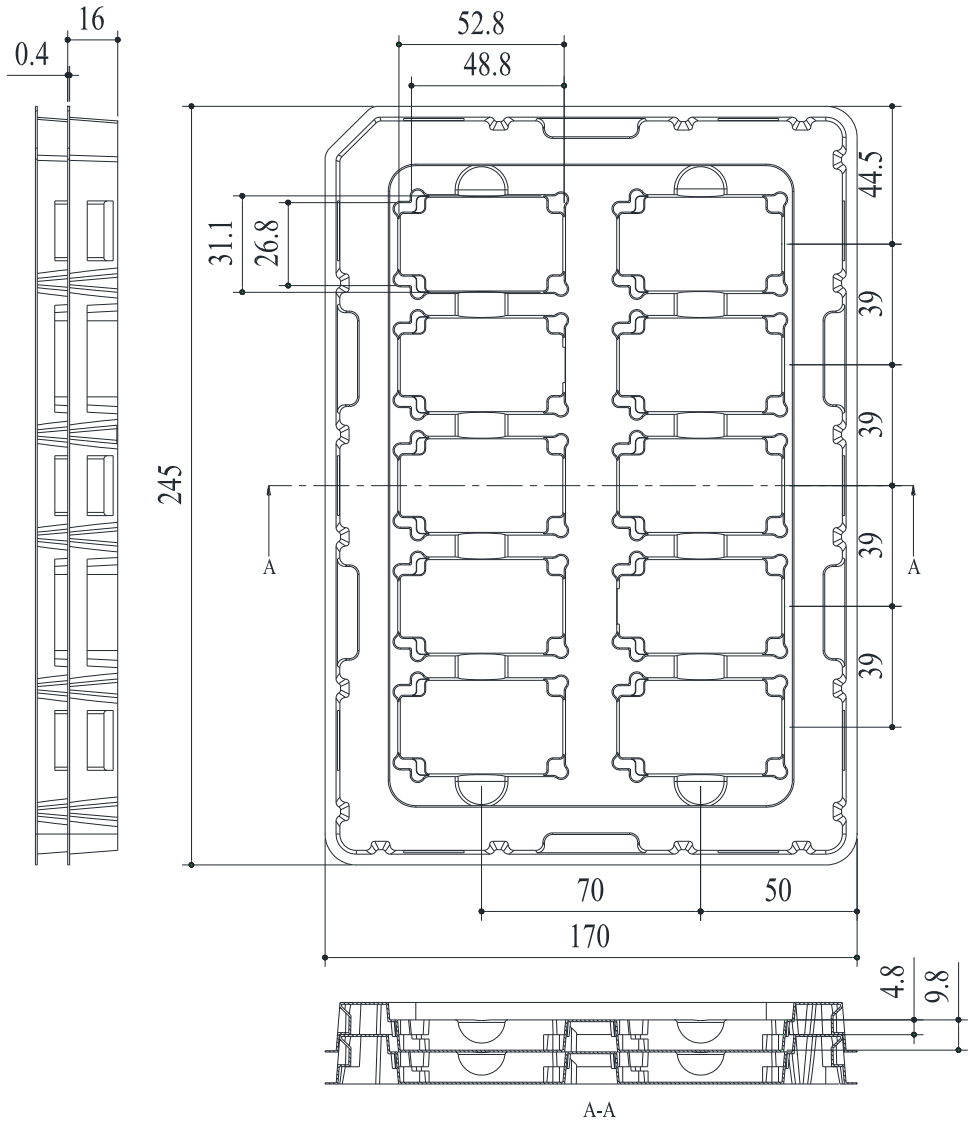
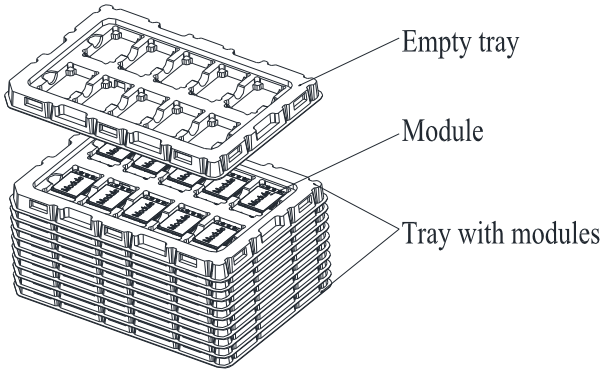


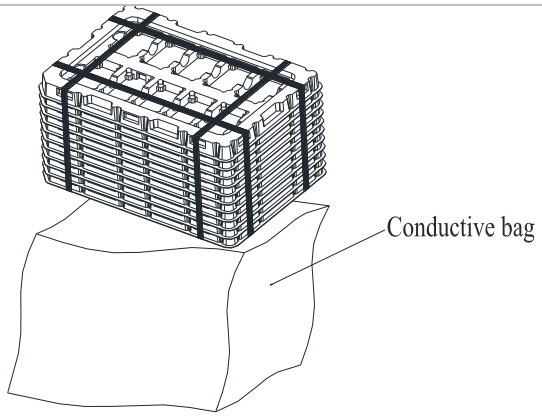
Figure 35: Blister Tray Dimension Drawing (Unit: mm)

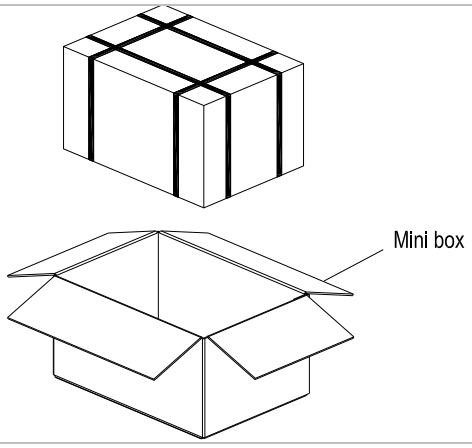
8.8. Packaging Process



Each blister tray packs 10 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 100 modules.

Place the 4 packaged mini boxes into 1 carton and seal it. 1 carton can pack 400 modules.

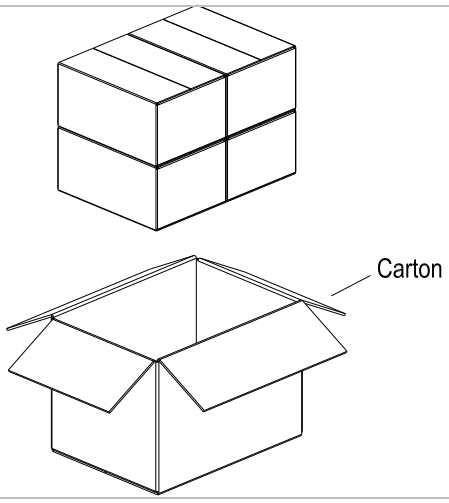


Figure 36: Packaging Process

9 Appendix A References

Table 43: Related Documents

Document Name
[1] NetPrisma_FCUN69-WWD_Reference_Design
[2] NetPrisma_FCUN69-WWD_CA&EN-DC_Features
[3] NetPrisma_FCUN69-WWD_AT_Commands_Manual
[4] NetPrisma_FCUN69-WWD_GNSS_Application_Note
[5] NetPrisma_FCUN69-WWD_RF_Application_Note

Table 44: Terms and Abbreviations

Abbreviation	Description
APT	Average Power Tracking
BIOS	Basic Input Output System
bps	Bit Per Second
BW	Bandwidth
CHAP	Challenge-Handshake Authentication Protocol
COEX	Coexistence
CPE	Customer Premise Equipment
CSQ	Cellular Signal Quality
DC-DC	Direct Current to Direct Current
DFOTA	Delta Firmware Upgrade Over-The-Air
DC-HSDPA	Dual-carrier High Speed Downlink Packet Access
DL	Downlink
DPR	Dynamic Power Reduction
DRX	Diversity Reception (***Chapter 5***)
EN-DC	E-UTRA New Radio Dual Connectivity

EP	End Point
ESD	Electrostatic Discharge
eSIM	embedded Subscriber Identity Module
ET	Envelope Tracking
E-UTRA	Evolved Universal Terrestrial Radio Access
FDD	Frequency Division Duplexing
FOTA	Firmware Over-The-Air
GLONASS	Global Navigation Satellite System (Russia)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HB	High Band
HPUE	High Power User Equipment
HSDPA	High Speed Downlink Packet Access
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
IC	Integrated Circuit
kbps	Kilo Bits Per Second
LAA	License Assisted Access
LED	Light Emitting Diode
LTE	Long Term Evolution
MB	Middle Band
Mbps	Mega Bits Per Second
ME	Mobile Equipment
MIMO	Multiple-Input Multiple-Output
MLCC	Multilayer Ceramic Chip Capacitor
MO	Mobile Originated
MSB	Most Significant Bit

MT	Mobile Terminated
NR	New Radio
PAP	Password Authentication Protocol
PCB	Printed Circuit Board
PCIe	Peripheral Component Interconnect Express
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
PRX	Primary Receive
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
QZSS	Quasi-Zenith Satellite System
RC	Root Complex
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
RFFE	RF Front-End
Rx	Receive
SAR	Specific Absorption Rate
SCS	Sub-Carrier Spacing
SIMO	Single Input Multiple Output
SMS	Short Message Service
TBD	To Be Determined
TCP	Transmission Control Protocol
TDD	Time Division Duplexing
TTFF	Time to First Fix
Tx	Transmit
UART	Universal Asynchronous Receiver & Transmitter
UDP	User Datagram Protocol
UHB	Ultra High Band

UL	Uplink
URC	Unsolicited Result Code
(U)SIM	(Universal) Subscriber Identity Module
V_{IH}	High-level Input Voltage
V_{IL}	Low-level Input Voltage
V_{OH}	High-level Output Voltage
V_{OL}	Low-level Output Voltage
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network
WWAN	Wireless Wide Area Network

10 Appendix B Operating Frequency

Table 45: Operating Frequencies (5G)

5G	Duplex Mode	Uplink Operating Band	Downlink Operating Band	Unit
n1	FDD	1920–1980	2110–2170	MHz
n2	FDD	1850–1910	1930–1990	MHz
n3	FDD	1710–1785	1805–1880	MHz
n5	FDD	824–849	869–894	MHz
n7	FDD	2500–2570	2620–2690	MHz
n8	FDD	880–915	925–960	MHz
n12	FDD	699–716	729–746	MHz
n13	FDD	777–787	746–756	MHz
n14	FDD	788–798	758–768	MHz
n18	FDD	815–830	860–875	MHz
n20	FDD	832–862	791–821	MHz
n24	FDD	1626.5–1660.5	1525–1559	MHz
n25	FDD	1850–1915	1930–1995	MHz
n26	FDD	814–849	859–894	MHz
n28	FDD	703–748	758–803	MHz
n29	SDL	-	717–728	MHz
n30	FDD	2305–2315	2350–2360	MHz
n34	TDD	2010–2025	2010–2025	MHz
n38	TDD	2570–2620	2570–2620	MHz
n39	TDD	1880–1920	1880–1920	MHz
n40	TDD	2300–2400	2300–2400	MHz
n41	TDD	2496–2690	2496–2690	MHz
n46	TDD [23]	5150–5925	5150–5925	MHz

[23] FCUN69-WWD only supports the downlink operating band of n46.

5G	Duplex Mode	Uplink Operating Band	Downlink Operating Band	Unit
n47	TDD	5855–5925	5855–5925	MHz
n48	TDD	3550–3700	3550–3700	MHz
n50	TDD	1432–1517	1432–1517	MHz
n51	TDD	1427–1432	1427–1432	MHz
n53	TDD	2483.5–2495	2483.5–2495	MHz
n65	FDD	1920–2010	2110–2200	MHz
n66	FDD	1710–1780	2110–2200	MHz
n67	SDL	-	738–758	MHz
n70	FDD	1695–1710	1995–2020	MHz
n71	FDD	663–698	617–652	MHz
n74	FDD	1427–1470	1475–1518	MHz
n75	SDL	-	1432–1517	MHz
n76	SDL	-	1427–1432	MHz
n77	TDD	3300–4200	3300–4200	MHz
n78	TDD	3300–3800	3300–3800	MHz
n79	TDD	4400–5000	4400–5000	MHz
n80	SUL	1710–1785	-	MHz
n81	SUL	880–915	-	MHz
n82	SUL	832–862	-	MHz
n83	SUL	703–748	-	MHz
n84	SUL	1920–1980	-	MHz
n85	FDD	698–716	728–746	MHz
n86	SUL	1710–1780	-	MHz
n89	SUL	824–849	-	MHz
n90	TDD	2496–2690	2496–2690	MHz
n91	FDD	832–862	1427–1432	MHz
n92	FDD	832–862	1432–1517	MHz
n93	FDD	880–915	1427–1432	MHz

5G	Duplex Mode	Uplink Operating Band	Downlink Operating Band	Unit
n94	FDD	880–915	1432–1517	MHz
n95	SUL	2010–2025	-	MHz
n96	TDD	5925–7125	5925–7125	MHz
n97	SUL	2300–2400	-	MHz
n98	SUL	1880–1920	-	MHz
n99	SUL	1626.5–1660.5	-	MHz

Table 46: Operating Frequencies (2G + 3G + 4G)

2G	3G	4G	Duplex Mode	Uplink	Downlink	Unit
-	B1	B1	FDD	1920–1980	2110–2170	MHz
PCS1900	B2/BC1	B2	FDD	1850–1910	1930–1990	MHz
DCS1800	B3	B3	FDD	1710–1785	1805–1880	MHz
-	B4	B4	FDD	1710–1755	2110–2155	MHz
GSM850	B5/BC0	B5	FDD	824–849	869–894	MHz
-	B6	-	FDD	830–840	875–885	MHz
-	B7	B7	FDD	2500–2570	2620–2690	MHz
EGSM900	B8	B8	FDD	880–915	925–960	MHz
-	B9	B9	FDD	1749.9–1784.9	1844.9–1879.9	MHz
-	B10	B10	FDD	1710–1770	2110–2170	MHz
-	B11	B11	FDD	1427.9–1447.9	1475.9–1495.9	MHz
-	B12	B12	FDD	699–716	729–746	MHz
-	B13	B13	FDD	777–787	746–756	MHz
-	B14	B14	FDD	788–798	758–768	MHz
-	-	B17	FDD	704–716	734–746	MHz
-	-	B18	FDD	815–830	860–875	MHz
-	B19	B19	FDD	830–845	875–890	MHz
-	B20	B20	FDD	832–862	791–821	MHz
-	B21	B21	FDD	1447.9–1462.9	1495.9–1510.9	MHz

2G	3G	4G	Duplex Mode	Uplink	Downlink	Unit
-	B22	B22	FDD	3410–3490	3510–3590	MHz
-	-	B24	FDD	1626.5–1660.5	1525–1559	MHz
-	B25	B25	FDD	1850–1915	1930–1995	MHz
-	B26	B26	FDD	814–849	859–894	MHz
-	-	B27	FDD	807–824	852–869	MHz
-	-	B28	FDD	703–748	758–803	MHz
-	-	B29	FDD [24]	-	717–728	MHz
-	-	B30	FDD	2305–2315	2350–2360	MHz
-	-	B31	FDD	452.5–457.5	462.5–467.5	MHz
-	-	B32	FDD [24]	-	1452–1496	MHz
-	B33	B33	TDD	1900–1920	1900–1920	MHz
-	B34	B34	TDD	2010–2025	2010–2025	MHz
-	B35	B35	TDD	1850–1910	1850–1910	MHz
-	B36	B36	TDD	1930–1990	1930–1990	MHz
	B37	B37	TDD	1910–1930	1910–1930	MHz
-	B38	B38	TDD	2570–2620	2570–2620	MHz
-	B39	B39	TDD	1880–1920	1880–1920	MHz
-	B40	B40	TDD	2300–2400	2300–2400	MHz
-	-	B41	TDD	2496–2690	2496–2690	MHz
-	-	B42	TDD	3400–3600	3400–3600	MHz
-	-	B43	TDD	3600–3800	3600–3800	MHz
-	-	B44	TDD	703–803	703–803	MHz
-	-	B45	TDD	1447–1467	1447–1467	MHz
-	-	B46	TDD [25]	5150–5925	5150–5925	MHz
-	-	B47	TDD	5855–5925	5855–5925	MHz
-	-	B48	TDD	3550–3700	3550–3700	MHz
-	-	B50	TDD	1432–1517	1432–1517	MHz

[24] Restricted to E-UTRA operation when carrier aggregation is configured. The downlink operating band is paired with the uplink operating band (external) of the carrier aggregation configuration that is supporting the configured Pcell.
[25] FCUN69-WWD only supports the downlink operating band of B46.

2G	3G	4G	Duplex Mode	Uplink	Downlink	Unit
-	-	B51	TDD	1427–1432	1427–1432	MHz
-	-	B52	TDD	3300–3400	3300–3400	MHz
-	-	B65	FDD	1920–2010	2110–2200	MHz
-	-	B66	FDD [26]	1710–1780	2110–2200	MHz
-	-	B67	FDD [24]	-	738–758	MHz
-	-	B68	FDD	698–728	753–783	MHz
-	-	B69	FDD [24]	-	2570–2620	MHz
-	-	B70	FDD [27]	1695–1710	1995–2020	MHz
-	-	B71	FDD	663–698	617–652	MHz
-	-	B72	FDD	451–456	461–466	MHz
-	-	B73	FDD	450–455	460–465	MHz
-	-	B74	FDD	1427–1470	1475–1518	MHz
-	-	B75	FDD [24]	-	1432–1517	MHz
-	-	B76	FDD [24]	-	1427–1432	MHz
-	-	B85	FDD	698–716	728–746	MHz
-	-	B87	FDD	410–415	420–425	MHz
-	-	B88	FDD	412–417	422–427	MHz

[26] The range 2180–2200 MHz of the DL operating band is restricted to E-UTRA operation when carrier aggregation is configured.
[27] The range 2010–2020 MHz of the DL operating band is restricted to E-UTRA operation when carrier aggregation is configured and TX-RX separation is 300 MHz. The range 2005–2020 MHz of the DL operating band is restricted to E-UTRA operation when carrier aggregation is configured and TX-RX separation is 295 MHz.

11.1 FCC

11.1.1. 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.

11.1.2. 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 XXXX 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.

11.1.3. 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: 2BEY3FCUN69WWDA” “Contains IC: 32052-FCUN69WWDA”
The FCC ID/IC ID can be used only when all FCC/IC compliance requirements are met.

11.1.4. Antenna Installation

(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.
(3)Only antennas of the same type and with equal or less gains as shown below may be used with this module. Other types of antennas and/or higher gain antennas may require additional authorization for operation.

Band	MAX Gain (dBi)
WCDMA B2	8.00
WCDMA B4	5.00
WCDMA B5/NR N5	9.42
LTE B2/2C/NR N2	8.00
LTE B4	5.00
LTE B5/5B	9.41
LTE B7/7C/NR N7	8.00
LTE B12	8.70
LTE B13/NR N13	9.16
LTE B14/NR N14	9.23
LTE B17	8.74
LTE B25/NR N25	8.00
LTE B26(814-824)	9.36
LTE B26(824-849)	9.41
LTE B30/NR N30	-1.02
LTE B38/38C/NR N38/NR N38 MIMO	5.00
LTE B41/41C/NR N41	5.00
LTE B42/42C	2.00
LTE B43/43C	2.00
LTE B48/48C/NR N48/NR N48 MIMO	-2.00
LTE B66/66B/66C/NR N66	5.00
LTE B71/NR N71	8.48
NR N12	8.71
NR N26(814-824)	9.37
NR N26(824-849)	9.42

NR N41 MIMO	3.00
NR N70	5.00
NR N77(3450-3550)	2.00
NR N77(3450-3550) MIMO	0.00
NR N77(3700-3980)	2.00
NR N77(3700-3980) MIMO	0.00
NR N78(3450-3550)	2.00
NR N78(3450-3550) MIMO	0.00
NR N78(3700-3800)	2.00
NR N78(3700-3800) MIMO	0.00

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.

11.1.5. 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.

11.1.6. 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.

11.1.7. List of applicable FCC rules

This module has been tested and found to comply with part 22, part 24, part 27, part 90 and part 96 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.

11.1.8. 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.

11.1.9. 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.

11.2. IC

11.2.1. 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."

11.2.2. 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.

11.2.3. 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.

11.2.4. 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.

11.2.5. 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.

11.2.6. IMPORTANT NOTE:
In the event that these conditions can not 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 can not 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.

11.2.7. 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

11.2.8. 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: 32052-FCUN69WWDA".

11.2.9.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: 32052-FCUN69WWDA ".

11.2.10.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.

11.2.11.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.

11.2.12 Antenna Requirements

The following antennae were approved with the prototype:
This radio transmitter [32052-FCUN69WWDA] has been approved by innovation, Science and development Economic Canada to operate with the types of antennas listed below, with the maximum allowable gain indicated. The types of antennas not included in this list that have a gain of any type listed are strictly prohibited for use with this device.

Les antennes suivantes ont été approuvées avec le prototype:
Cet émetteur radio [32052-FCUN69WWDA] a été approuvé par innovation, Science et développement économique Canada pour fonctionner avec les types d'antennes énumérés ci-dessous, avec le gain maximal autorisé indiqué. Les types d'antennes non inclus dans cette liste qui ont un gain tout type lis ted sont strictement interdits pour une utilisation avec cet appareil.

Band	Description	Gain (dBi)
WCDMA B2/LTE B2/2C/NR N2	PIFA Antenna	0.25
WCDMA B4/LTE B4/		1.47
WCDMA B5/LTE B5/5B/NR N5		2.68
LTE B7/7C/NR N7		0.55
LTE B12/NR N12		-0.2
LTE B13/NR N13		1.54
LTE B14/NR N14		2.42
LTE B17		-0.2
LTE B25/NR N25		0.25
LTE B26/NR N26		2.87
LTE B30/NR N30		-5.7
LTE B38/38C/NR N38		-0.23
LTE B4141C/NR N41		0.78
LTE B42/42C		-6.1
LTE B43/43C		-6.1
LTE B48/48C/NR N48		-6.1
LTE B66/66C/66B/NR N66		1.47
LTE B71/NR N71		1.22
NR N77		-6.1
NR N78		-6.1