HUAWEI MU609 Mini PCIe Module

Hardware Guide

Issue 01

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About This Document

Revision History

Document Version	Date	Chapter	Descriptions
01	2013-07-24		Creation

Contents

1 Introduction

This document describes the hardware application interfaces and air interfaces provided by HUAWEI MU609 Mini PCIe Module (hereinafter referred to as the MU609 module).

This document helps hardware engineer to understand the interface specifications, electrical features and related product information of the MU609 module.

2 Overall Description

2.1 About This Chapter

This chapter gives a general description of the MU609 module and provides:

- Function Overview
- Circuit Block Diagram

2.2 Function Overview

Table 2-1 Features

Feature	Description
Physical Dimensions	• Dimensions (L × W × H): 51 mm × 30.4 mm × 3.3 mm • Weight: about 12 g
Operating Temperature	–30°C to +70°C
Storage Temperature	–40°C to +85°C
Power Voltage	DC 3.0 V–3.6 V (typical value is 3.3 V)
Application Interface (52-pin Mini PCIe interface	One standard USIM (Universal Subscriber Identity Module) card (Class B and Class C)
	Audio interface: PCM interface
	USB 2.0 (High Speed)
	RESIN_N: Reset module
	WAKE#: Wake up signal
	W_DISABLE# Signal (The software version is planning)

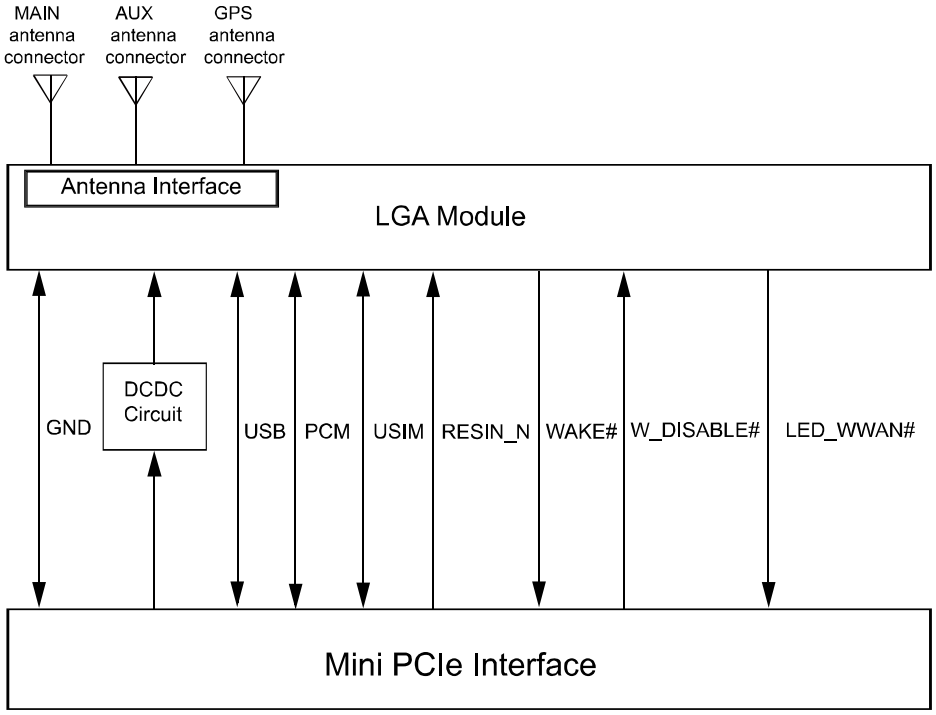
Feature	Description
	LED_WWAN#: Active-low LED signal indicating the state of the card
Antenna connector	WWAN MAIN antenna connector x1 WWAN AUX antenna connector x1 GPS antenna connector x1

2.3 Circuit Block Diagram

Figure 2-1 shows the circuit block diagram of the MU609 Mini PCIe Adapter. The major functional unit of the Mini PCIe Adapter contains the following parts:

- DCDC Circuit
- LGA Module
- Control signals
- Antenna Connectors

Figure 2-1 Circuit block diagram of the MU609 module



3 Description of the Application Interfaces

3.1 About This Chapter

This chapter mainly describes the external application interfaces of the MU609 module, including:

- Mini PCIe Interface
- Power Sources and Grounds
- Power Supply Time Sequence
- WAKE# Signal
- RESIN_N Signal
- W_DISABLE# Signal
- LED_WWAN# Signal
- USB Interface
- USIM Card Interface
- Audio Interface
- RF Antenna Connector
- Reserved Pins
- NC Pins

3.2 Mini PCIe Interface

The MU609 module uses a Mini PCIe interface as its external interface. For details about the module and dimensions, see "Dimensions and Interfaces".

Figure 3-1 shows the sequence of pins on the interface of the Mini PCIe Adapter.

Figure 3-1 Sequence of Mini PCIe interface

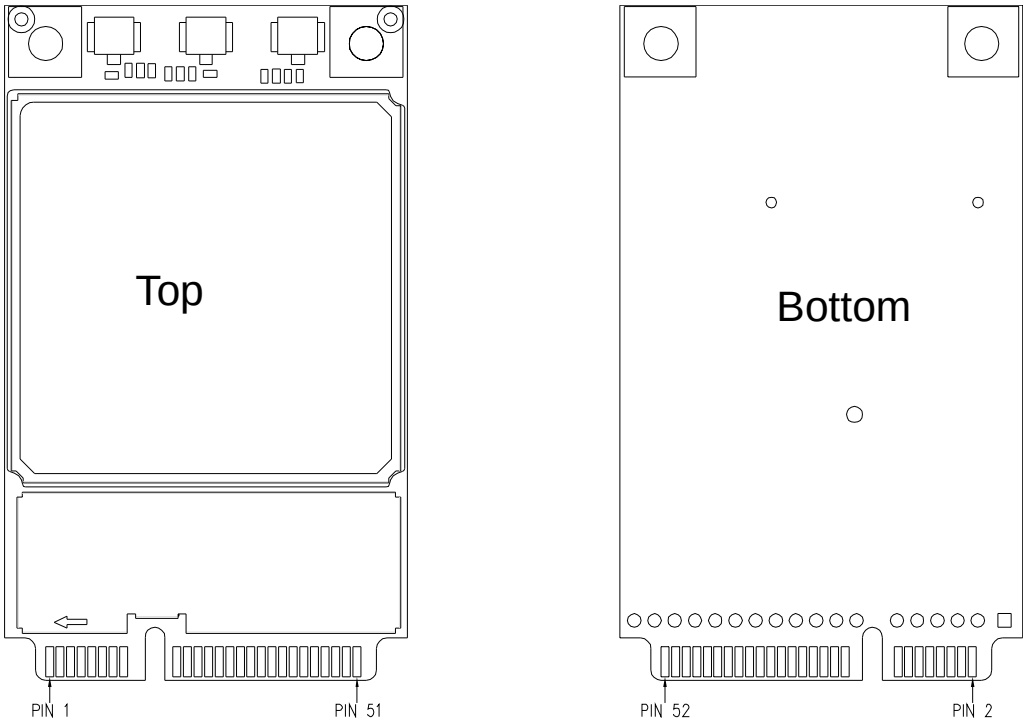


Table 3-1 shows the pin definitions of the Mini PCIe Interface.

Table 3-1 Pin definitions of the Mini PCIe interface

PIN No.	Pin Name		I/O	Description	DC Characteristics (V)		
	Mini PCI Express Standard Description	HUAWEI Pin Description			Min.	Typ.	Max.
1	WAKE#	WAKE#	O	Open collector active low signal. This signal is used to wake up the host.	–0.3	-	-
2	3.3Vaux	VCC_3V3	P	3.3 V DC supply input.	3.0	3.3	3.6
3	COEX1	NC	-	Not connected	-	-	-
4	GND	GND	-	Ground	-	-	-
5	COEX2	NC	-	Not connected	-	-	-
6	1.5 V	NC	-	Not connected	-	-	-
7	CLKREQ#	NC	-	Not connected	-	-	-

PIN No.	Pin Name		I/O	Description	DC Characteristics (V)		
	Mini PCI Express Standard Description	HUAWEI Pin Description			Min.	Typ.	Max.
8	UIM_PWR	UIM_PWR	P	Power source for the external USIM card	-	1.8/2.85	-
9	GND	GND	-	Ground	-	-	-
10	UIM_DATA	UIM_DATA	I/O	External USIM data signal	-	1.8/2.85	-
11	REFCLK-	NC	-	Not connected	-	-	-
12	UIM_CLK	UIM_CLK	O	External USIM clock signal	-	1.8/2.85	-
13	REFCLK+	NC	-	Not connected	-	-	-
14	UIM_RESET	UIM_RESET	O	External USIM reset signal	-	1.8/2.85	-
15	GND	GND	-	Ground	-	-	-
16	UIM_Vpp	NC	-	Not connected	-	-	-
17	Reserved	Reserved	-	Reserved	-	-	-
18	GND	GND	-	Ground	-	-	-
19	Reserved	Reserved	-	Reserved	-	-	-
20	W_DISABLE#	W_DISABLE#	I	The W_DISABLE# signal is an active low signal that when asserted (driven low) by the system shall disable radio operation. The software version is planning.	-	-	-
21	GND	GND	-	Ground	-	-	-
22	PERST#	RESIN_N	I	Reset module Active-low	-	-	-
23	PERn0	NC	-	Not connected	-	-	-
24	3.3Vaux	VCC_3V3	P	3.3 V DC supply input.	3.0	3.3	3.6
25	PERp0	NC	-	Not connected	-	-	-
26	GND	GND	-	Ground	-	-	-

PIN No.	Pin Name		I/O	Description	DC Characteristics (V)		
	Mini PCI Express Standard Description	HUAWEI Pin Description			Min.	Typ.	Max.
27	GND	GND	-	Ground	-	-	-
28	1.5 V	NC	-	Not connected	-	-	-
29	GND	GND	-	Ground	-	-	-
30	SMB_CLK	NC	-	Not connected	-	-	-
31	PETn0	NC	-	Not connected	-	-	-
32	SMB_DATA	NC	-	Not connected	-	-	-
33	PETp0	NC	-	Not connected	-	-	-
34	GND	GND	-	Ground	-	-	-
35	GND	GND	-	Ground	-	-	-
36	USB_D-	USB_DM	I/O	USB signal D-	-	-	-
37	GND	GND	-	Ground	-	-	-
38	USB_D+	USB_DP	I/O	USB signal D+	-	-	-
39	3.3Vaux	VCC_3V3	P	3.3 V DC supply input.	3.0	3.3	3.6
40	GND	GND	-	Ground	-	-	-
41	3.3Vaux	VCC_3V3	P	3.3 V DC supply input.	3.0	3.3	3.6
42	LED_WWAN#	LED_WWAN#	O	Active-low LED signal indicating the state of the card.	-	-	-
43	GND	GND	-	Ground	-	-	-
44	LED_WLAN#	NC	-	Not connected	-	-	-
45	Reserved	PCM_CLK	O	PCM interface clock	–0.3	1.8	2.1
46	LED_WPAN#	NC	-	Not connected	-	-	-
47	Reserved	PCM_DOUT	O	PCM I/F data out	–0.3	1.8	2.1
48	1.5 V	NC	-	Not connected	-	-	-
49	Reserved	PCM_DIN	I	PCM I/F data in	–0.3	1.8	2.1
50	GND	GND	-	Ground	-	-	-
51	Reserved	PCM_SYNC	O	PCM interface sync	–0.3	1.8	2.1

PIN No.	Pin Name		I/O	Description	DC Characteristics (V)		
	Mini PCI Express Standard Description	HUAWEI Pin Description			Min.	Typ.	Max.
52	3.3Vaux	VCC_3V3	P	3.3 V DC supply input.	3.0	3.3	3.6

NOTE

- **P** indicates power pins; **I** indicates pins for digital signal input; **O** indicates pins for digital signal output. **AI** indicates pins for analog signal input.
- The **Reserved** pins are internally connected to the module. Therefore, these pins should not be used, otherwise they may cause problems. Please contact with us for more details about this information.
- The **NC (Not Connected)** pins are floating and there are no signal connected to these pins. Therefore, these pins should not be used.

3.3 Power Sources and Grounds

The PCIe Mini Card provides two power sources: one is 3.3 Vaux (+3.3 Vaux) and the other is 1.5 V (+1.5 V). For the PCIe Adapter, however, +3.3 Vaux is the only voltage supply that is available. The input voltage is 3.3 V±9%, as specified by *PCI Express Mini CEM Specifications 1.2.*

Table 3-2 Power and ground specifications

Name	Pins	Minimum	Typical	Maximum
VCC_3V3	2, 24, 39, 41and 52	3.0 V	3.3 V	3.6 V
GND	4, 9, 15, 18, 21, 26, 27, 29, 34, 35, 37, 40, 43, and 50	-		

NOTE

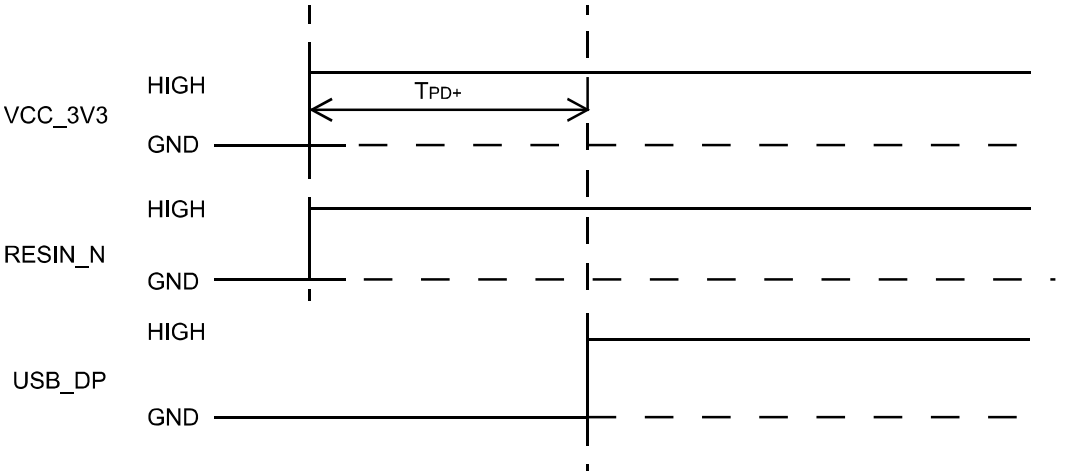
To minimize the RF radiation through the power lines, it is suggested to add ceramic capacitors of 10 pF and 100 nF in the power lines beside the Mini PCIe connector on the host side.

3.4 Power Supply Time Sequence

Power on sequence

Do not toggle RESIN_N pin during the power on sequence. Pulling RESIN_N pin low will extend time for module startup.

Figure 3-2 Power on timing sequence

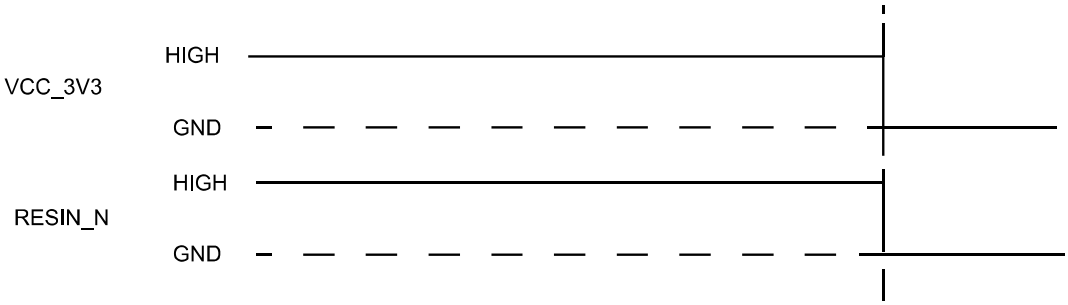


Parameter	Remarks	Time (Nominal value)	Unit
T_{PD+}	Power Valid to USB D+ high	3.0–5.0	s

Power off Sequence

Cutting off the 3.3V power supply will power off the module.

Figure 3-3 Power off timing sequence



3.5 WAKE# Signal

WAKE# pin (signal that the module uses to wake up the host) supports software control.

This signal is used for 3G module to wake up the host. It is designed as an OC gate, so it should be pulled up by the host and it is active-low.

When the module wakes up the host, the WAKE# pin will output low-level-voltage to wake the host.

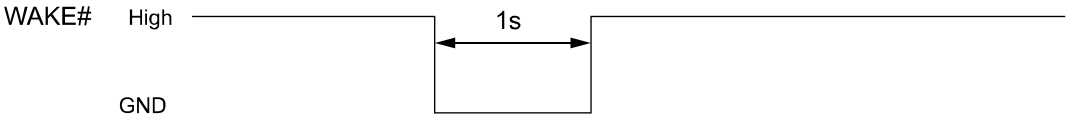
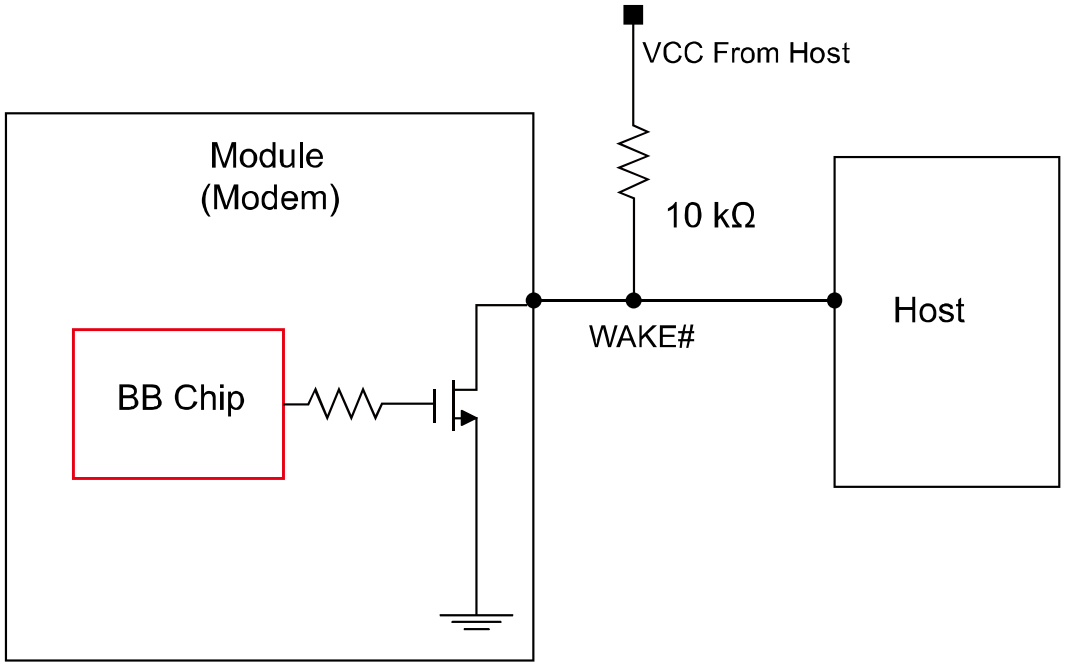


Figure 3-4 Connections of the WAKE# pin

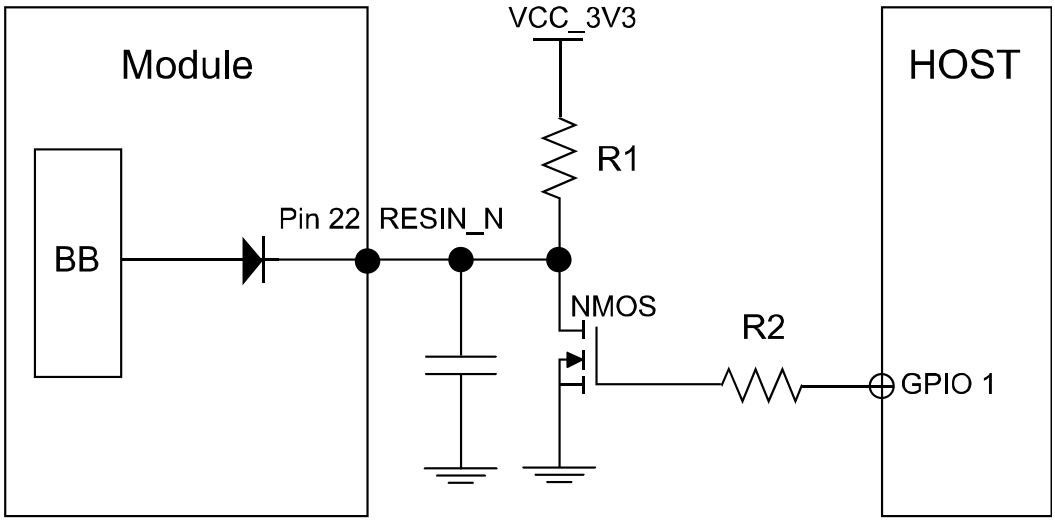


3.6 RESIN_N Signal

The RESIN_N pin is used to reset the module's system. When the module software stops responding, the RESIN_N pin can be pulled down to reset the module hardware.

The RESIN_N signal is internally pulled up to 1.8 V, which is automatically on when 3.3 V is applied and it is active-low.

Figure 3-5 Connections of the RESIN_N pin

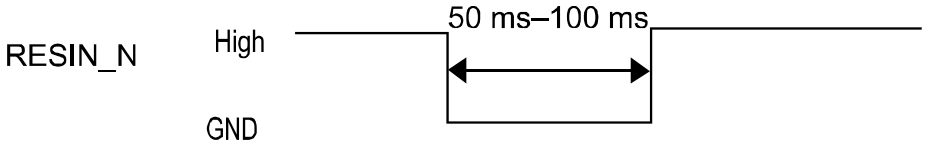


CAUTION

- As the RESIN_N signal are relatively sensitive, it is recommended that you install a 10 nF–0.1 µF capacitor near the RESIN_N pin of the interface for filtering. In addition, when you design a circuit on the PCB of the interface board, it is recommended that the circuit length should not exceed 20 mm and that the circuit should be kept at a distance of 2.54 mm (100 mil) at least from the PCB edge. Furthermore, you need to wrap the area adjacent to the signal wire with a ground wire. Otherwise, the module may be reset due to interference.
- The maximum Forward Voltage Drop of the diode used in the module is 0.6 V. So when the host wants to reset the module, the low-level-voltage in the RESIN_N pin should below 50 mV.

The MU609 module supports hardware reset function. If the software of the MU609 module stops responding, you can reset the hardware through the RESIN_N signal as shown in Figure 3-6 . When a low-level pulse is supplied through the RESIN_N pin, the hardware will be reset. After the hardware is reset, the software starts powering on the module and reports relevant information according to the actual settings. For example, the AT command automatically reports ^SYSSTART.

Figure 3-6 Reset pulse timing



NOTE

- The RESIN_N pin must not be pulled down for more than 1s.
- The RESIN_N pin is optional, which can be not connected.

3.7 W_DISABLE# Signal

The W_DISABLE# signal is provided to allow users to disable wireless communications of the module.

The software version is planning.

3.8 LED_WWAN# Signal

MU609 provides a LED_WWAN# signal to indicate the RF status.

Table 3-3 State of the LED_WWAN# pin

No.	Operating Status	LED_WWAN#
1	No service/Restricted service	Outputs: low(0.1s)-high (0.1s)-low (0.1s)-high (1.7s) 2s cycle
2	Register to the network	Outputs: low (0.1s)-high (1.9s) 2s cycle
3	Dial-up successfully	Outputs: low

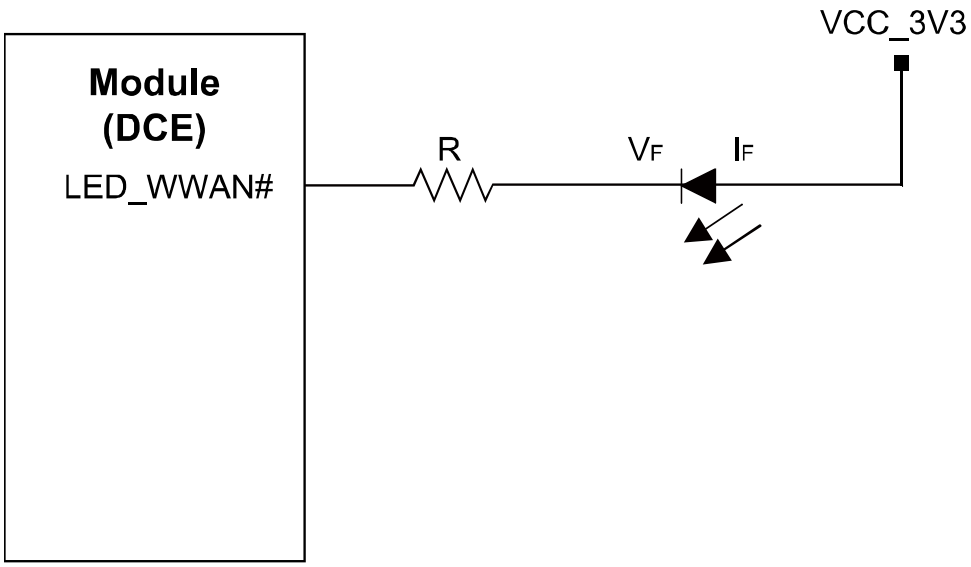
NOTE

The LED function can not be supported when the firmware version is 11.xxx.xx.xx.xx.

External Circuits

Figure 3-7 shows the recommended circuits of the LED_WWAN# pin. According to LED feature, you can adjust the LED brightness by adjusting the resistance of resistor R.

Figure 3-7 Driving circuit



3.9 USB Interface

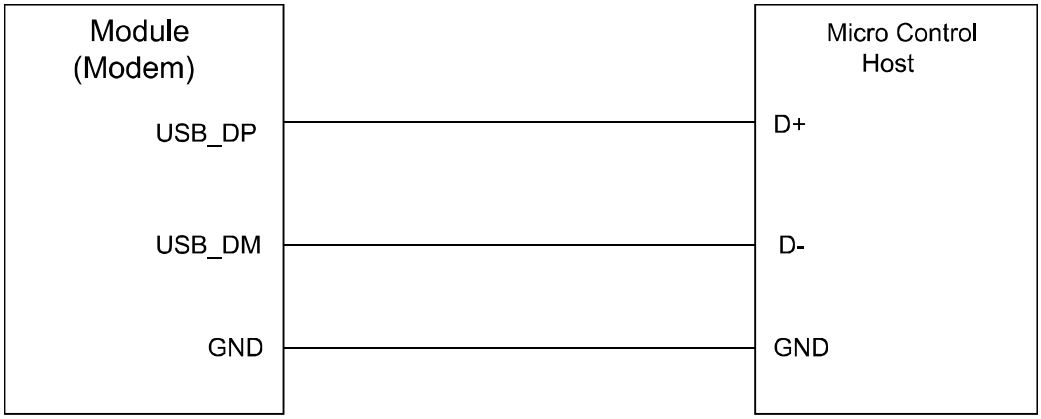
The MU609 module is compliant with USB 2.0 protocol. The USB interface is powered directly from the VBAT supply. The USB input/output lines are compatible with the USB 2.0 signal specifications. Figure 3-8 shows the circuit of the USB interface.

Table 3-4 Definition of the USB interface

Pin No.	Pin Name	I/O	Description	DC Characteristics (V)		
				Min.	Typ.	Max.
36	USB_DM	I/O	USB signal D-	-	-	-
38	USB_DP	I/O	USB signal D+	-	-	-

According to USB protocol, for bus timing or electrical characteristics of MU609 USB signal, please refer to the chapter 7.3.2 of *Universal Serial Bus Specification 1.2.*

Figure 3-8 Recommended circuit of USB interface



3.10 USIM Card Interface

3.10.1 Overview

The MU609 module provides a USIM card interface complying with the ISO 7816-3 standard and supports both Class B and Class C USIM cards.

Table 3-5 USIM card interface signals

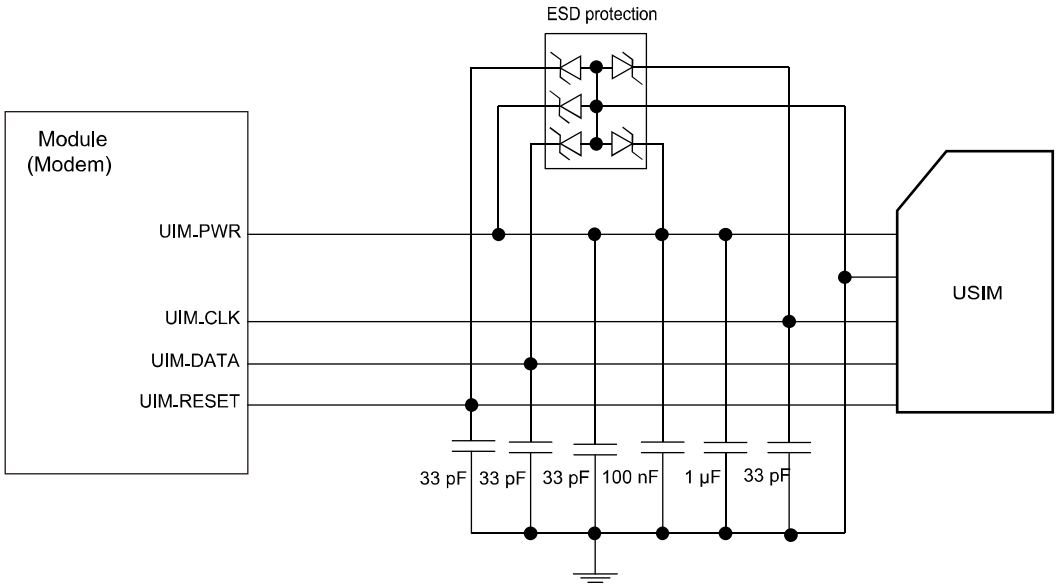
Pin No.	Pin Name	I/O	Description	DC Characteristics (V)		
				Min.	Typ.	Max.
14	UIM_RESET	O	External USIM reset signal	-	1.8/2.85	-
12	UIM_CLK	O	External USIM clock signal	-	1.8/2.85	-
10	UIM_DATA	I/O	External USIM data signal	-	1.8/2.85	-
8	UIM_PWR	P	Power source for the external USIM card	-	1.8/2.85	-

3.10.2 Circuit Recommended for the USIM Card Interface

As the Mini PCIe Adapter is not equipped with an USIM socket, you need to place an USIM socket on the user interface board.

Figure 3-9 shows the circuit of the USIM card interface.

Figure 3-9 Circuit of the USIM card interface



CAUTION

- To meet the requirements of 3GPP TS 51.010-1 protocols and electromagnetic compatibility (EMC) authentication, the USIM socket should be placed near the PCIe interface (it is recommended that the PCB circuit connects the PCIe interface and the USIM socket does not exceed 100 mm), because a long circuit may lead to wave distortion, thus affecting signal quality.
- It is recommended that you wrap the area adjacent to the UIM_CLK and UIM_DATA signal wires with ground. The Ground pin of the USIM socket and the Ground pin of the USIM card must be well connected to the power Ground pin supplying power to the PCIe Adapter.
- A 100 nF capacitor and1 µF capacitor are placed between the UIM_PWR and GND pins in a parallel manner (If UIM_PWR circuit is too long, that the larger capacitance such as 4.7 µF can be employed if necessary). Three 33 pF capacitors are placed between the UIM_DATA and Ground pins, the UIM_RESET and Ground pins, and the UIM_CLK and Ground pins in parallel to filter interference from RF signals.
- It is recommended to take electrostatic discharge (ESD) protection measures near the USIM card socket. The TVS diode with Vrwm of 5 V and junction capacitance less than 10 pF must be placed as close as possible to the USIM socket, and the Ground pin of the ESD protection component is well connected to the power Ground pin that supplies power to the PCIe Adapter.

3.11 Audio Interface

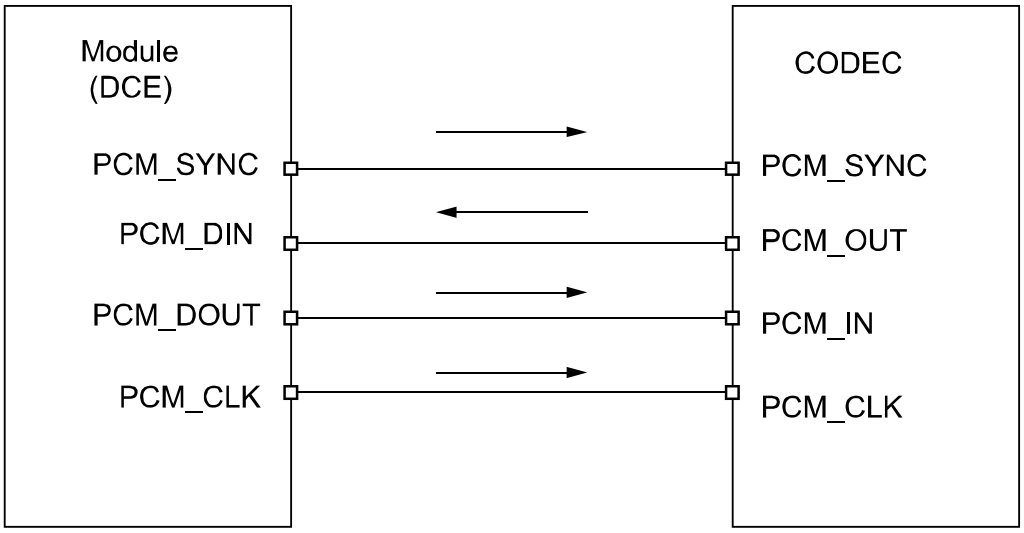
The MU609 module provides one PCM digital audio interface. Table 3-6 lists the signals on the digital audio interface.

Table 3-6 Signals on the digital audio interface

Pin No.	Pin Name	I/O	Description	DC Characteristics (V)		
				Min.	Typ.	Max.
45	PCM_CLK	O	PCM clock	–0.3	1.8	2.1
49	PCM_DIN	I	PCM data input	–0.3	1.8	2.1
51	PCM_SYNC	O	PCM interface sync	–0.3	1.8	2.1
47	PCM_DOUT	O	PCM data output	–0.3	1.8	2.1

The MU609 module interface enables communication with an external codec to support linear format.

Figure 3-10 Circuit diagram of the interface of the PCM (MU609 module is used as PCM master)



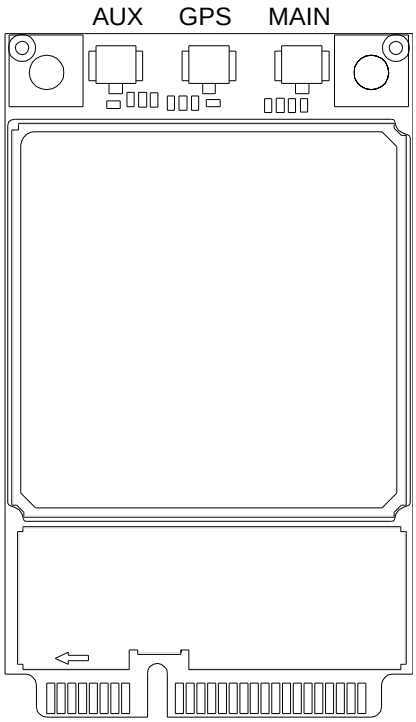
NOTE

- PCM_SYNC: Output when PCM is in master mode;
- PCM_CLK: Output when PCM is in master mode;
- The PCM function of MU609 only supports master mode;
- It is recommended that a TVS be used on the related interface, to prevent electrostatic discharge and protect integrated circuit (IC) components.

3.12 RF Antenna Connector

The MU609 module provides three antenna connectors (MAIN, GPS and AUX) for connecting the external antennas.

Figure 3-11 RF antenna connectors



The antenna connectors must be used with coaxial cables with characteristic impedance of 50 Ω.

3.13 Reserved Pins

The MU609 module provides 2 reserved pins. All of reserved pins cannot be used by the customer.

Table 3-7 Reserved pins

Pin No.	Pin Name	I/O	Description
17, 19	Reserved	-	Reserved, please keep open.

3.14 NC Pins

The MU609 module has 17 NC pins. All of NC pins should not be connected. Please keep these pins open.

Table 3-8 NC pins

Pin No.	Pin Name	I/O	Description
3, 5–7, 11, 13, 16, 23, 25, 28, 30–33, 44, 46, 48	NC	-	Not connected, please keep open.

4 RF Specifications

4.1 About This Chapter

This chapter describes the RF specifications of the MU609 module, including:

- Operating Frequencies
- Conducted RF Measurement
- Conducted Rx Sensitivity and Tx Power
- Antenna Design Requirements

4.2 Operating Frequencies

Table 4-1 shows the RF bands supported by the MU609 module.

Table 4-1 RF bands

Operating Band	Tx	Rx
UMTS Band I	1920 MHz–1980 MHz	2110 MHz–2170 MHz
UMTS Band II	1850 MHz–1910 MHz	1930 MHz–1990 MHz
UMTS Band V	824 MHz–849 MHz	869 MHz–894 MHz
UMTS Band VIII	880 MHz–915 MHz	925 MHz–960 MHz
GSM 850	824 MHz–849 MHz	869 MHz–894 MHz
GSM 900	880 MHz–915 MHz	925 MHz–960 MHz
GSM 1800 (DCS)	1710 MHz–1785 MHz	1805 MHz–1880 MHz
GSM 1900 (PCS)	1850 MHz–1910 MHz	1930 MHz–1990 MHz
GPS	-	1574.42 MHz–1576.42 MHz

4.3 Conducted RF Measurement

4.3.1 Test Environment

Test instrument	R&S CMU200
Power supply	KEITHLEY 2306
RF cable for testing	L08-C014-350 of DRAKA COMTEQ or Rosenberger Cable length: 29 cm

NOTE

- The compensation for different frequency bands relates to the cable and the test environment.
- The instrument compensation needs to be set according to the actual cable conditions.

4.3.2 Test Standards

Huawei modules meet 3GPP TS 51.010-1 and 3GPP TS 34.121-1 test standards. Each module passes strict tests at the factory and thus the quality of the modules is guaranteed.

4.4 Conducted Rx Sensitivity and Tx Power

4.4.1 Conducted Receive Sensitivity

The conducted receive sensitivity is a key parameter that indicates the receiver performance of MU609 module. The conducted receive sensitivity refers to the weakest signal that the module at the antenna port can receive. The BER must meet the 3GPP protocol requirements in the case of the minimum signal.

Table 4-2 lists the typical tested values of the MU609 module.

Table 4-2 MU609 module conducted Rx sensitivity (Unit: dBm)

Band	Typical	Note
GSM 850	–109	BER Class II < 2.44%
GSM 900	–109.5	BER Class II < 2.44%
DCS 1800	–108	BER Class II < 2.44%
PCS 1900	–108	BER Class II < 2.44%
WCDMA B1 Main Rx	–109.5	BER < 0.1%
WCDMA B2 Main Rx	–109	BER < 0.1%
WCDMA B5 Main Rx	–110.5	BER < 0.1%

Band	Typical	Note
WCDMA B8 Main Rx	–111	BER < 0.1%

Table 4-3 MU609 module GPS main characteristics

Item	Typical Value
Receive Sensitivity (Cold start)	–145 dBm
Receive Sensitivity (Hot start)	–154 dBm
Receive Sensitivity (Tracking mode)	–154 dBm
TTFF@-130dBm (Cold start)	35s
TTFF@-130dBm (Hot start)	1s

NOTE
The test values are the average of some test samples.

4.4.2 Conducted Transmit Power

The conducted transmit power is another indicator that measures the performance of MU609 module. The conducted transmit power refers to the maximum power that the module tested at the antenna connector can transmit. According to the 3GPP protocol, the required transmit power varies with the power class.

Table 4-4 lists the typical tested values of the MU609 module.

Table 4-4 MU609 module conducted Tx power (unit: dBm)

Band	Typical	Note
GSM 850	32	-1/+1.5 dB
GSM 900	32	-1/+1.5 dB
DCS 1800	29	-1/+1.5 dB
PCS 1900	29	-1/+1.5 dB
WCDMA B1	23	-1/+1.5 dB
WCDMA B2	23	-1/+1.5 dB
WCDMA B5	23	-1/+1.5 dB
WCDMA B8	23	-1/+1.5 dB

4.5 Antenna Design Requirements

4.5.1 Antenna Design Indicators

Antenna Efficiency

Antenna efficiency is the ratio of the input power to the radiated or received power of an antenna. The radiated power of an antenna is always lower than the input power due to the following antenna losses: return loss, material loss, and coupling loss. The efficiency of an antenna relates to its electrical dimensions. To be specific, the antenna efficiency increases with the electrical dimensions. In addition, the transmission cable from the antenna connector of PCIe Adapter to the antenna is also part of the antenna. The cable loss increases with the cable length and the frequency. It is recommended that the cable loss is as low as possible, for example, MXHP32HP1000 made by Murata or equivalent.

The following antenna efficiency (free space) is recommended for MU609 module to ensure high radio performance of the module:

- **Efficiency of the primary antenna: ≥ 40% (below 960 MHz); ≥ 50% (over 1710 MHz)**
- **Efficiency of the diversity antenna: ≥ half of the efficiency of the primary antenna in receiving band**
- **Efficiency of the GPS antenna: ≥ 50%**

In addition, the efficiency should be tested with the transmission cable.

S11 or VSWR

S11 indicates the degree to which the input impedance of an antenna matches the reference impedance (50 Ω). S11 shows the resonance feature and impedance bandwidth of an antenna. Voltage standing wave ratio (VSWR) is another expression of S11. S11 relates to the antenna efficiency. S11 can be measured with a vector analyzer.

The following S11 value is recommended for the antenna of MU609 module:

- **S11 of the primary antenna: ≤ –6 dB**
- **S11 of the diversity antenna: ≤ –6 dB**
- **S11 of the GPS antenna: ≤ –10 dB**

In addition, S11 is less important than the efficiency, and S11 has weak correlation to wireless performance.

Isolation

For a wireless device with multiple antennas, the power of different antennas is coupled with each other. Antenna isolation is used to measure the power coupling. The power radiated by an antenna might be received by an adjacent antenna, which decreases the antenna radiation efficiency and affects the running of other devices. To avoid this problem, evaluate the antenna isolation as sufficiently as possible at the early stage of antenna design.

Antenna isolation depends on the following factors:

- Distance between antennas
- Antenna type
- Antenna direction

The primary antenna must be placed as near as possible to the MU609 module to minimize the cable length. The diversity antenna needs to be installed perpendicularly to the primary antenna. The diversity antenna can be placed farther away from the MU609 module. Antenna isolation can be measured with a two-port vector network analyzer.

The following antenna isolation is recommended for the antennas on laptops:

- **Isolation between the primary and diversity antennas: ≤ –12 dB**
- **Isolation between the primary(diversity) antenna and the GPS antenna: ≤ –15 dB**
- **Isolation between the primary antenna and the Wi-Fi antenna: ≤ –15 dB**

Polarization

The polarization of an antenna is the orientation of the electric field vector that rotates with time in the direction of maximum radiation.

The linear polarization is recommended for the antenna of MU609 module.

Radiation Pattern

The radiation pattern of an antenna reflects the radiation features of the antenna in the remote field region. The radiation pattern of an antenna commonly describes the power or field strength of the radiated electromagnetic waves in various directions from the antenna. The power or field strength varies with the angular coordinates (θ and φ), but is independent of the radial coordinates.

The radiation pattern of half wave dipole antennas is omnidirectional in the horizontal plane, and the incident waves of base stations are often in the horizontal plane. For this reason, the receiving performance is optimal.

The following radiation patterns are recommended for the antenna of MU609 module.

Primary/Diversity/GPS antenna: omnidirectional

In addition, the diversity antenna's pattern should be complementary with the primary's.

Envelope Correlation Coefficient

The envelope correlation coefficient indicates the correlation between different antennas in a multi-antenna system (primary antenna, diversity antenna, and MIMO antenna). The correlation coefficient shows the similarity of radiation patterns, that is, amplitude and phase, of the antennas. The ideal correlation coefficient of a diversity antenna system or a MIMO antenna system is 0. A small value of the envelope correlation coefficient between the primary antenna and the diversity antenna indicates a high diversity gain. The envelope correlation coefficient depends on the following factors:

- Distance between antennas
- Antenna type

- Antenna direction

The antenna correlation coefficient differs from the antenna isolation. Sufficient antenna isolation does not represent a satisfactory correlation coefficient. For this reason, the two indicators need to be evaluated separately.

For the antennas on laptops, the recommended envelope correlation coefficient between the primary antenna and the diversity antenna is smaller than 0.5.

Gain and Directivity

The radiation pattern of an antenna represents the field strength of the radiated electromagnetic waves in all directions, but not the power density that the antenna radiates in the specific direction. The directivity of an antenna, however, measures the power density that the antenna radiates.

Gain, as another important parameter of antennas, correlates closely to the directivity. The gain of an antenna takes both the directivity and the efficiency of the antenna into account. The appropriate antenna gain prolongs the service life of relevant batteries.

The following antenna gain is recommended for MU609 module. **Gain of the primary/diversity antenna ≤ 2.5 dBi**

NOTE

- The antenna consists of the antenna body and the relevant RF transmission cable. Take the RF transmission cable into account when measuring any of the preceding antenna indicators.
- Huawei cooperates with various famous antenna suppliers who are able to make suggestions on antenna design, for example, Amphenol, Skycross, etc.

4.5.2 Interference

Besides the antenna performance, the interference on the user board also affects the radio performance (especially the TIS) of the module. To guarantee high performance of the module, the interference sources on the user board must be properly controlled.

On the user board, there are various interference sources, such as the LCD, CPU, audio circuits, and power supply. All the interference sources emit interference signals that affect the normal operation of the module. For example, the module sensitivity can be decreased due to interference signals. Therefore, during the design, you need to consider how to reduce the effects of interference sources on the module. You can take the following measures: Use an LCD with optimized performance; shield the LCD interference signals; shield the signal cable of the board; or design filter circuits.

Huawei is able to make technical suggestions on radio performance improvement of the module.

4.5.3 GSM/WCDMA/GPS Antenna Requirements

The antenna for MU609 module must fulfill the following requirements:

GSM/WCDMA/GPS Antenna Requirements	
Frequency range	Depending on frequency band(s) provided by the network operator, the customer must use the most suitable antenna for that/those band(s)
Bandwidth	70 MHz in GSM850 80 MHz in GSM900 170 MHz in DCS 140 MHz in PCS 70 MHZ in WCDMA850 (25MHz for diversity antenna) 80 MHz in WCDMA900 (35MHz for diversity antenna) 140 MHz in WCDMA1900 (60MHz for diversity antenna) 250 MHz in WCDMA2100 (60MHz for diversity antenna) 2 MHz in GPS
Gain	≤ 2.5 dBi
Impedance	50 Ω
VSWR absolute max	≤ 3:1 (≤ 2:1 for GPS antenna)
VSWR recommended	≤ 2:1 (≤ 1.5:1 for GPS antenna)

4.5.4 Radio Test Environment

The antenna efficiency, antenna gain, radiation pattern, total radiated power (TRP), and TIS can be tested in a microwave testing chamber.

Huawei has a complete set of OTA test environments (SATIMO microwave testing chambers and ETS microwave testing chambers). The testing chambers are certified by professional organizations and are applicable to testing at frequencies ranging from 380 MHz to 6 GHz. The test items are described as follows:

Passive Tests

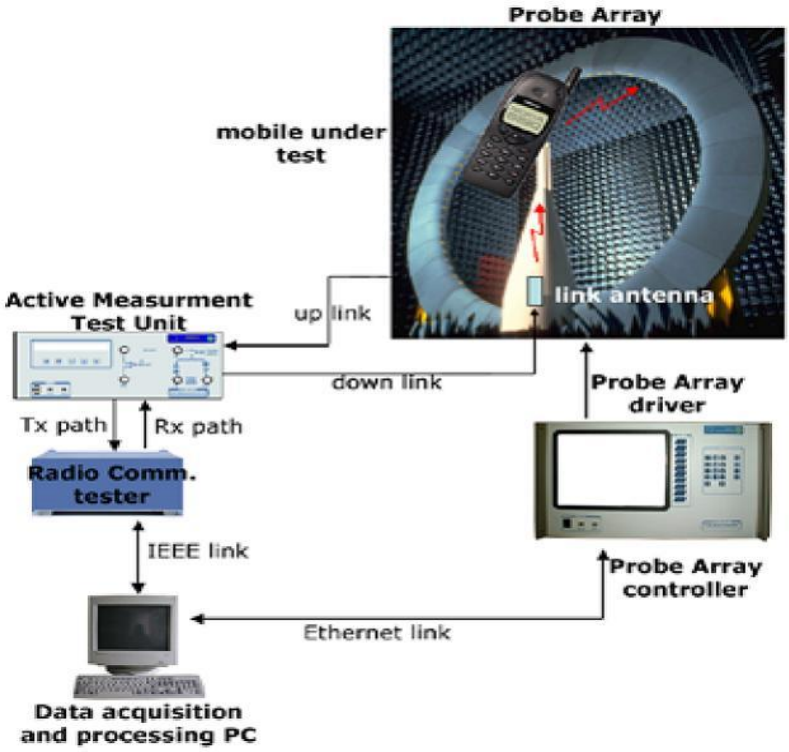
- Antenna efficiency
- Gain
- Pattern shape
- Envelope correlation coefficient

Active Tests

- **TRP:** GSM, WCDMA systems
- **TIS:** GSM, WCDMA systems

Figure 4-1 shows the SATIMO microwave testing chamber.

Figure 4-1 SATIMO microwave testing chamber



5 Electrical and Reliability Features

5.1 About This Chapter

This chapter describes the electrical and reliability features of the interfaces in the MU609 module, including:

- Absolute Ratings
- Operating and Storage Temperatures
- Electrical Features of USIM
- Power Supply Features
- Reliability Features
- EMC and ESD Features

5.2 Absolute Ratings

WARNING

Table 5-1 lists the absolute ratings for the MU609 module. Using the module beyond these conditions may result in permanent damage to the module.

Table 5-1 Absolute ratings for the MU609 module

Symbol	Specification	Min.	Max.	Unit
VCC_3V3	External power voltage	–0.3	4.0	V
VI	Digital input voltage	–0.3	2.3	V

5.3 Operating and Storage Temperatures

Table 5-2 lists the operating and storage temperatures for the MU609 module.

Table 5-2 Operating and storage temperatures for the MU609 module

Specification	Min.	Max.	Unit
Normal working temperatures[1]	–30	+70	°C
Ambient temperature for storage	–40	+85	°C

NOTE
[1]: When the MU609 module works at this temperature, all its RF indexes comply with the 3GPP TS 45.005 and 3GPP TS 34.121-1 specifications.

5.4 Electrical Features of USIM

Table 5-3 Electrical features of digital pins in the I/O supply domain of the USIM Interface

Parameter	Description	Min.	Max.	Notes	Unit
V_{IH}	High-level input voltage	0.7 x V_{DDP_USIM}	3.3	V_{DDP_USIM} = 1.8 V or 2.85 V	V
V_{IL}	Low-level input voltage	0	0.2 x V_{DDP_USIM}	V_{DDP_USIM} = 1.8 V or 2.85 V	V
V_{OH}	High-level output voltage	0.7 x V_{DDP_USIM}	3.3	V_{DDP_USIM} = 1.8 V or 2.85 V	V
V_{OL}	Low-level output voltage	0	0.2 x V_{DDP_USIM}	V_{DDP_USIM} = 1.8 V or 2.85 V	V

5.5 Electrical Features of Application Interfaces

Table 5-4 lists electrical features

Table 5-4 Electrical features of application interfaces

Parameter	Description	minimum Value	Maximum Value	Unit
V_{IH}	Logic high-level input voltage	0.65 x V_{DD_PX}	V_{DD_PX} + 0.3	V

Parameter	Description	minimum Value	Maximum Value	Unit
V_{IL}	Logic low-level input voltage	–0.3	0.35 x V_{DD_PX}	V
V_{OH}	Logic high-level output voltage	V_{DD_PX} – 0.45	V_{DD_PX}	V
V_{OL}	Logic low-level output voltage	0	0.45	V

5.6 Power Supply Features

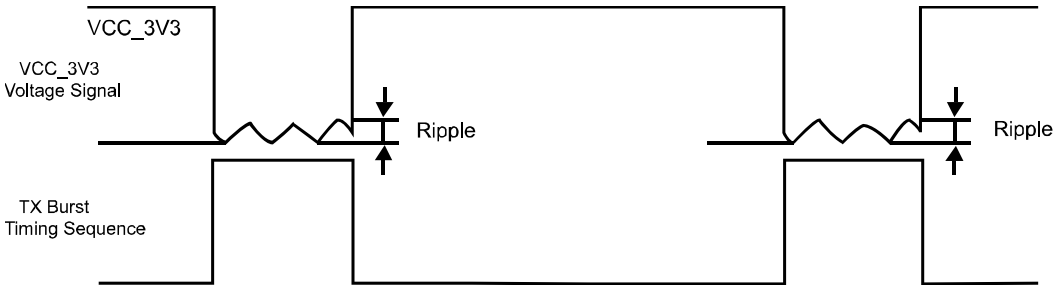
5.6.1 Input Power Supply

Table 5-5 lists the requirements for input power of the MU609 module.

Table 5-5 Requirements for input power for the MU609 module

Parameter	Min.	Typ.	Max.	Ripple	Unit
VCC_3V3	3.0	3.3	3.6	0.05	V

Figure 5-1 Power Supply During Burst Emission



NOTE

The VCC_3V3 minimum value must be guaranteed during the burst (with 2.7 A Peak in GSM 2 slot mode). So A low-dropout (LDO) regulator or switch power with current output of more than 3.5 A is strongly recommended for external power supply.

Table 5-6 Requirements for input current of the MU609 module

Power	Module	Peak (GSM 2 slot)	Normal (WCDMA)
VCC_3V3	MU609	2750 mA	1100 mA

5.6.2 Power Consumption

The power consumptions of MU609 module in different scenarios are respectively listed in Table 5-7 , Table 5-8 , Table 5-9 and Table 5-10 .

The power consumption listed in this section is tested when the power supply of the MU609 module is 3.3 V.

Table 5-7 Averaged standby DC power consumption

Description	Bands	Test Value	Units	Notes/Configuration
HSPA/WCDMA (Standby)	UMTS bands	2.1	mA	DRX cycle=8 (2.56 s) Module is registered on and not connected to the 3G network. USB is in suspend mode.
HSPA/WCDMA (Standby)	UMTS bands	2.6	mA	DRX cycle=6 (0.64 s) Module is registered on and not connected to the 3G network. USB is in suspend mode.
GPRS/EDGE (Standby)	GSM bands	2.3	mA	MFRMS=5 (1.175 s) Module is registered on and not connected to the 2G network. USB is in suspend mode.
GPRS/EDGE (Standby)	GSM bands	2.8	mA	MFRMS=2 (0.47 s) Module is registered on and not connected to the 2G network. USB is in suspend mode.

Table 5-8 DC power consumption (HSPA/WCDMA)

Description	Band	Test Value	Units	Power (dBm)
WCDMA	Band I (IMT 2100)	300	mA	1 dBm Tx Power
		360		10 dBm Tx Power
		750		24 dBm Tx Power
	Band II (PCS 1900)	305	mA	1 dBm Tx Power
		380		10 dBm Tx Power
		780		24 dBm Tx Power

Description	Band	Test Value	Units	Power (dBm)
	Band V (850 MHz)	260	mA	1 dBm Tx Power
		315		10 dBm Tx Power
		680		24 dBm Tx Power
	Band VIII (900 MHz)	260	mA	1 dBm Tx Power
		340		10 dBm Tx Power
		730		24 dBm Tx Power
HSDPA	Band I (IMT 2100)	410	mA	1 dBm Tx Power
		470		10 dBm Tx Power
		810		24 dBm Tx Power
	Band II (PCS 1900)	400	mA	1 dBm Tx Power
		480		10 dBm Tx Power
		840		24 dBm Tx Power
	Band V (850 MHz)	370	mA	1 dBm Tx Power
		415		10 dBm Tx Power
		720		24 dBm Tx Power
	Band VIII (900 MHz)	380	mA	1 dBm Tx Power
		440		10 dBm Tx Power
		760		24 dBm Tx Power
HSUPA	Band I (IMT 2100)	420	mA	1 dBm Tx Power
		490		10 dBm Tx Power
		820		24 dBm Tx Power
	Band II (PCS 1900)	420	mA	1 dBm Tx Power
		500		10 dBm Tx Power
		850		24 dBm Tx Power
	Band V (850 MHz)	390	mA	1 dBm Tx Power
		430		10 dBm Tx Power
		740		24 dBm Tx Power
	Band VIII (900 MHz)	390	mA	1 dBm Tx Power
		460		10 dBm Tx Power

Description	Band	Test Value	Units	Power (dBm)
		780		24 dBm Tx Power

Table 5-9 DC power consumption (GPRS/EDGE)

Description	Test Value	Units	PCL	Configuration
GPRS850	370	mA	5	1 Up/1 Down
	530			2 Up/1 Down
	710			4 Up/1 Down
	220	mA	10	1 Up/1 Down
	310			2 Up/1 Down
	550			4 Up/1 Down
GPRS900	320	mA	5	1 Up/1 Down
	490			2 Up/1 Down
	680			4 Up/1 Down
	190	mA	10	1 Up/1 Down
	310			2 Up/1 Down
	500			4 Up/1 Down
GPRS1800	270	mA	0	1 Up/1 Down
	390			2 Up/1 Down
	540			4 Up/1 Down
	125	mA	10	1 Up/1 Down
	180			2 Up/1 Down
	250			4 Up/1 Down
GPRS1900	280	mA	0	1 Up/1 Down
	410			2 Up/1 Down
	590			4 Up/1 Down
	120	mA	10	1 Up/1 Down
	190			2 Up/1 Down
	250			4 Up/1 Down
EDGE850	320	mA	8	1 Up/1 Down
	490			2 Up/1 Down

Description	Test Value	Units	PCL	Configuration
	620			4 Up/1 Down
	180	mA	15	1 Up/1 Down
	300			2 Up/1 Down
	460			4 Up/1 Down
EDGE900	280	mA	8	1 Up/1 Down
	440			2 Up/1 Down
	600			4 Up/1 Down
	170	mA	15	1 Up/1 Down
	280			2 Up/1 Down
	460			4 Up/1 Down
EDGE1800	230	mA	2	1 Up/1 Down
	350			2 Up/1 Down
	480			4 Up/1 Down
	130	mA	10	1 Up/1 Down
	160			2 Up/1 Down
	250			4 Up/1 Down
EDGE1900	240	mA	2	1 Up/1 Down
	360			2 Up/1 Down
	525			4 Up/1 Down
	120	mA	10	1 Up/1 Down
	160			2 Up/1 Down
	230			4 Up/1 Down

Table 5-10 DC power consumption (GPS)

Description	Max Test Value	Units	Configuration
GPS location request	180	mA	

NOTE

The above values are the average of some test samples.

5.7 Reliability Features

Table 5-11 lists the test conditions and results of the reliability of the MU609 module .

Table 5-11 Test conditions and results of the reliability of the MU609 module

Item	Test Condition	Standard
Low-temperature storage	Temperature: –40ºC±2ºC Test duration: 24 h	IEC60068
High-temperature storage	Temperature: 85ºC±2ºC Test duration: 24 h	IEC60068
Low-temperature working	Temperature: –30ºC±2ºC Test duration: 24 h	IEC60068
High-temperature working	Temperature: 70ºC±2ºC Test duration: 24 h	IEC60068
Damp heat cycling	High temperature: 55ºC±2ºC Low temperature: 25ºC±2ºC Humidity: 95% Repetition times: 4 Test duration: 12 h+12 h	IEC60068
Temperature shock	Low temperature: –40ºC±2ºC High temperature: 85ºC±2ºC Temperature change interval: < 30s Test duration: 15 min Repetition times: 100	IEC60068
Salty fog test	Temperature: 35°C Density of the NaCl solution: 5%±1% Spraying interval: 8 h Duration of exposing the module to the temperature of 35°C: 16 h	IEC60068
Sine vibration	Frequency range: 5 Hz to 200 Hz Acceleration: 10 m/s^2 Frequency scan rate: 1 oct/min Test period: 3 axial directions. Five circles for each axial direction.	IEC60068
Shock test	Half-sine wave shock Peak acceleration: 300 m/s^2 Shock duration: 11 ms Test period: 6 axial directions. One shock for each axial direction.	IEC60068

Item	Test Condition	Standard
Clash test	Half-sine wave Peak acceleration: 180 m/s^2 Pulse duration: 6 ms Repetition time: 6 directions. 1000 times for each direction.	IEC60068
Drop test	First case: 0.3 m in height. Drop the MU609 module on the marble terrace with one surface facing downwards twice. Six surfaces should be tested. Second case: 0.8 m in height. Drop the MU609 module on the marble terrace with one surface facing downwards twice. Six surfaces should be tested.	IEC60068

5.8 EMC and ESD Features

EMC tests have to be performed on the application as soon as possible to detect any potential problems.

Special attention should be paid to the following:

- Possible harmful emissions radiated by the application to the RF receiver in the receiver band.
- ESD protection is mandatory on all signals which are externally accessible
- Typically, ESD protection is mandatory for the following:
  - UIM
  - USB
- Length of the USIM interface lines (preferably <10 cm).
- EMC protection on audio input/output (filters against 900 MHz emissions).
- Ground plane: recommends a common ground plane for analog/digital/RF grounds.
- A metallic or plastic case with conductive paint is recommended, except for the area around the antenna.

NOTE

The HUAWEI MU609 module does not include any protection against over voltage.

6 Mechanical Specifications

6.1 About This Chapter

This chapter mainly describes mechanical specifications of MU609 module, including:

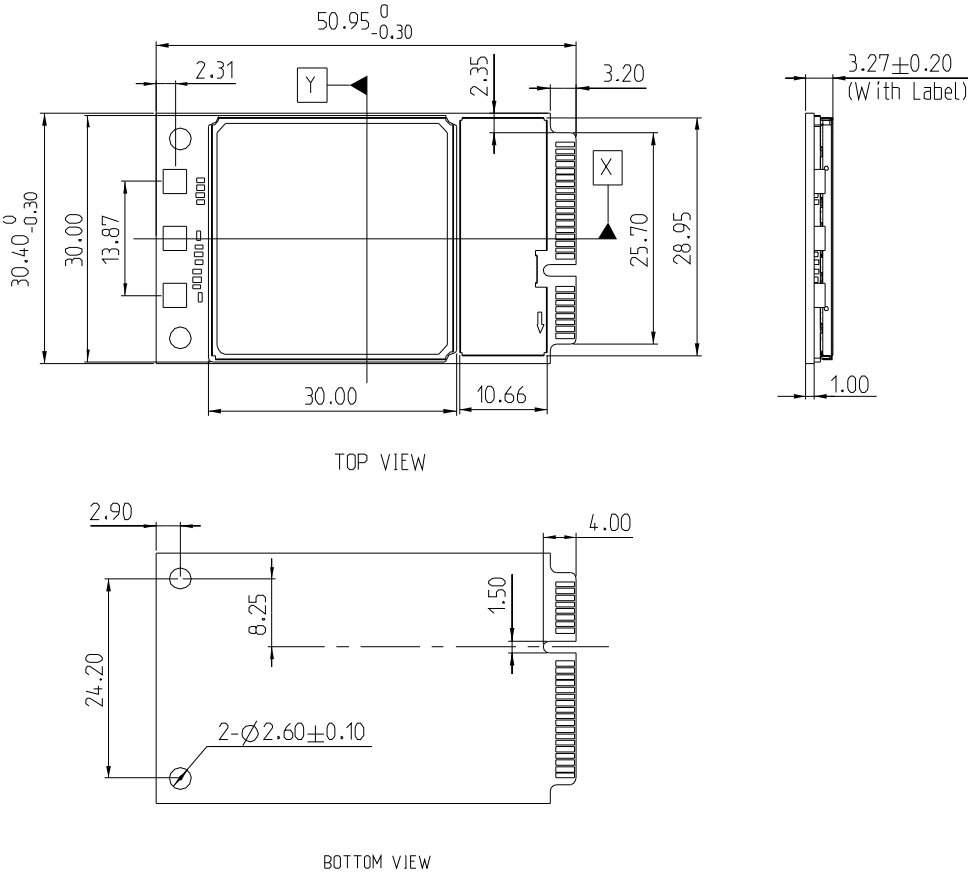
- Dimensions and Interfaces
- Dimensions of the Mini PCI Express Connector
- Specification Selection for Fasteners

6.2 Dimensions and Interfaces

The dimensions of the MU609 module are 51 mm (length) × 30.4 mm (width) ×3.3 mm (height). Figure 6-1 shows the dimensions of MU609 module in detail.

Figure 6-1 shows the appearance of the interfaces on the MU609 module.

Figure 6-1 Dimensions of the MU609 module

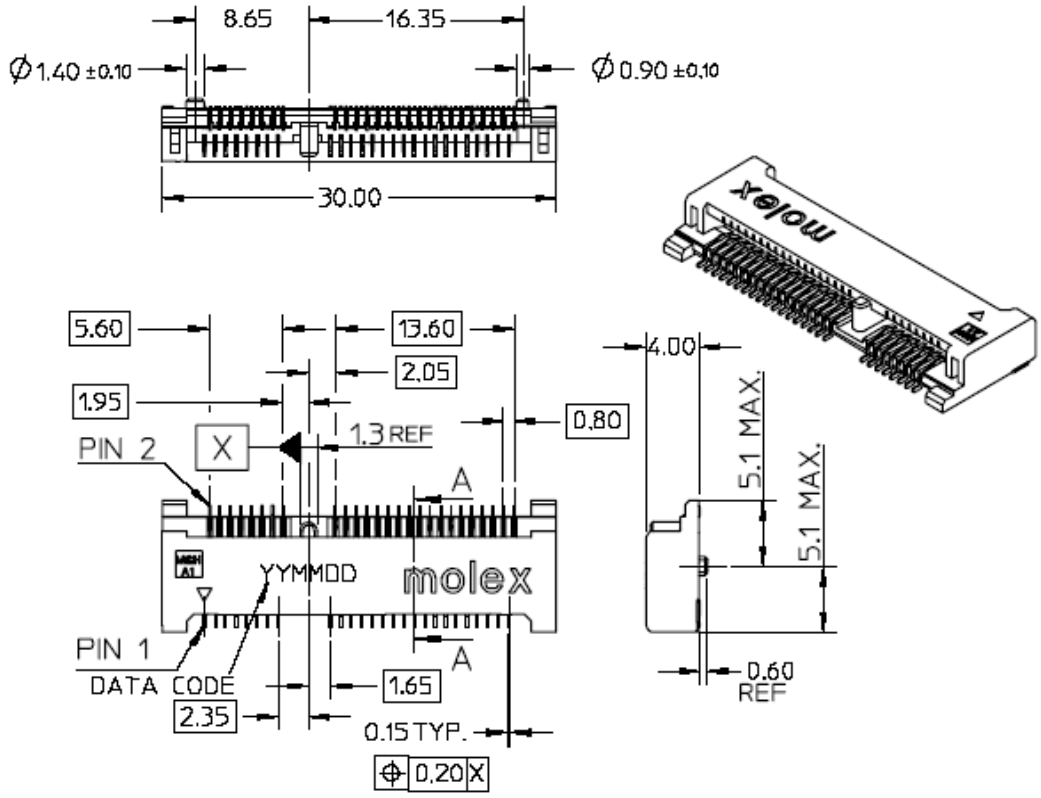


6.3 Dimensions of the Mini PCI Express Connector

The Mini PCIe Adapter adopts a standard Mini PCI Express connector that has 52 pins and complies with the *PCI Express Mini Card Electromechanical Specification Revision 1.2*.

Figure 6-2 shows a 52-pin Mini PCI Express connector (take the Molex 67910002 as an example).

Figure 6-2 Dimensions of the Mini PCI Express connector

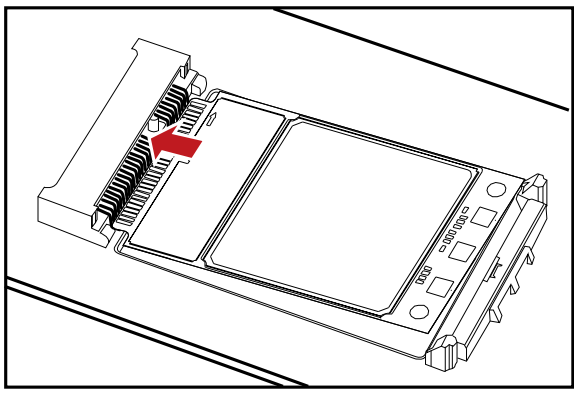


6.4 Specification Selection for Fasteners

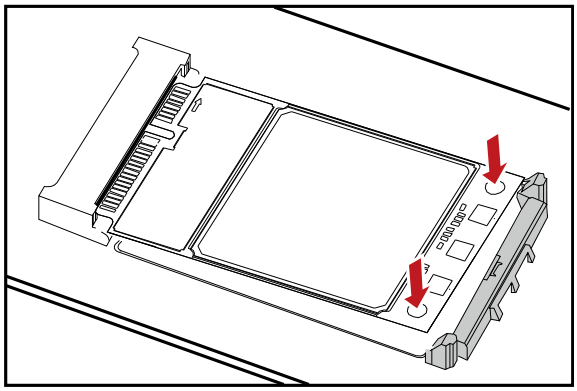
6.4.1 Installing the Mini PCIe Adapter on the Main Board

To install the Mini PCIe Adapter on the main board, do the following:

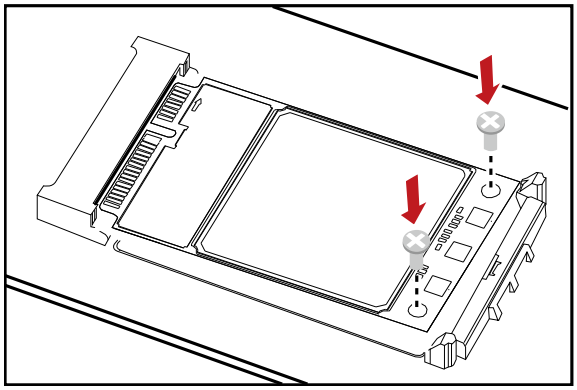
Step 1 Insert the Mini PCIe Adapter into the Mini PCI Express connector on the main board.



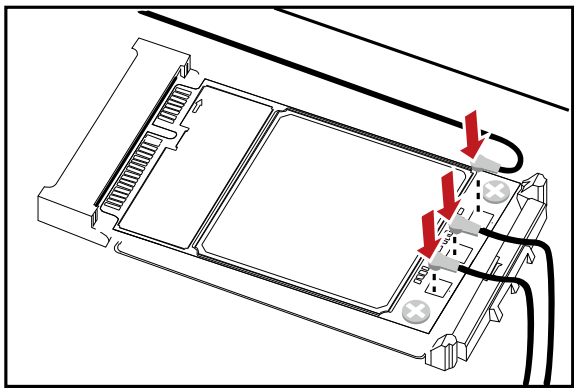
Step 2 Press downwards to fix the Mini PCIe Adapter in the module slot.



Step 3 Use a screwdriver to fix the Mini PCIe Adapter on the main board with two screws provided in the Mini PCIe Adapter packing box.



Step 4 Insert the connector of the main antenna into the MAIN antenna interface (M) of the Mini PCIe Adapter according to the indication on the label of the Mini PCIe Adapter. Insert the connector of the auxiliary antenna into the AUX antenna interface (A) of the Mini PCIe Adapter and the GPS antenna into the GPS antenna interface (G) of the Mini PCIe Adapter in the same way.

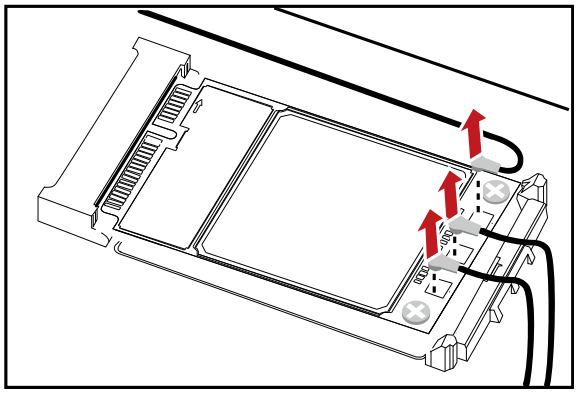


NOTE

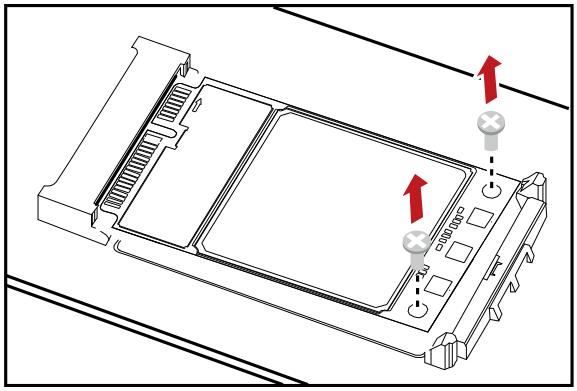
- Insert the antenna connectors vertically into the antenna interfaces of the Mini PCIe Adapter.
- Do not press or squeeze the antenna cable or damage the connectors. Otherwise, the wireless performance of the Mini PCIe Adapter may be reduced or the Mini PCIe Adapter cannot work normally.
- Ensure that the antenna cables are routed through the channel in the frame of the PC and do not lay the cables across the raised edges of the frame.

6.4.2 Romoving the Mini PCIe Adapter from the Main Board

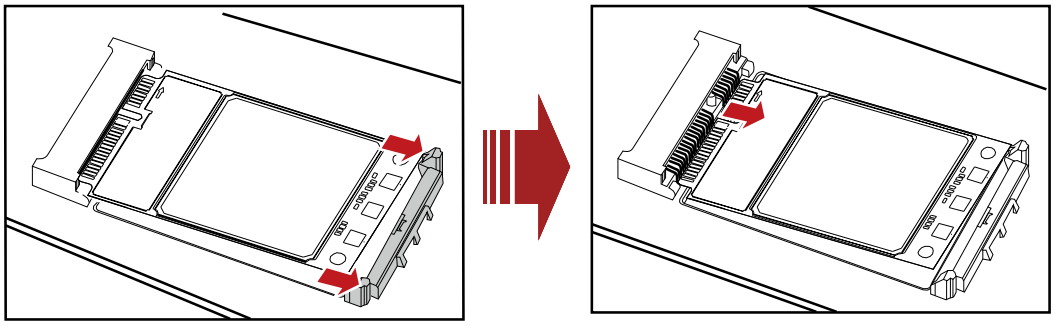
Step 1 Disconnect the antenna cables from the Mini PCIe Adapter. You can lift the connectors using a small screwdriver.



Step 2 Remove the two screws with the screwdriver.



Step 3 Slide backwards the two clips to release the Mini PCIe Adapter from the slot. Then, lift up the Mini PCIe Adapter.



7 Certifications

7.1 About This Chapter

This chapter gives a general description of certifications of MU609 module.

7.2 Certifications

NOTE
Table 7-1 shows certifications the MU609 module will be implemented. For more demands, please contact us for more details about this information.

Table 7-1 Product Certifications

Certification	Model name
	MU609
CE	√
FCC	√
CCC[1]	√
RoHS	√
WEEE	√

NOTE
[1]: For CCC certification, the certification model is HUAWEI MU609.

8 Safety Information

Read the safety information carefully to ensure the correct and safe use of your wireless device. Applicable safety information must be observed.

8.1 Interference

Power off your wireless device if using the device is prohibited. Do not use the wireless device when it causes danger or interference with electric devices.

8.2 Medical Device

- Power off your wireless device and follow the rules and regulations set forth by the hospitals and health care facilities.
- Some wireless devices may affect the performance of the hearing aids. For any such problems, consult your service provider.
- Pacemaker manufacturers recommend that a minimum distance of 15 cm be maintained between the wireless device and a pacemaker to prevent potential interference with the pacemaker. If you are using an electronic medical device, consult the doctor or device manufacturer to confirm whether the radio wave affects the operation of this device.

8.3 Area with Inflammables and Explosives

To prevent explosions and fires in areas that are stored with inflammable and explosive devices, power off your wireless device and observe the rules. Areas stored with inflammables and explosives include but are not limited to the following:

- Gas station
- Fuel depot (such as the bunk below the deck of a ship)
- Container/Vehicle for storing or transporting fuels or chemical products
- Area where the air contains chemical substances and particles (such as granule, dust, or metal powder)
- Area indicated with the "Explosives" sign

- Area indicated with the "Power off bi-direction wireless equipment" sign
- Area where you are generally suggested to stop the engine of a vehicle

8.4 Traffic Security

- Observe local laws and regulations while using the wireless device. To prevent accidents, do not use your wireless device while driving.
- RF signals may affect electronic systems of motor vehicles. For more information, consult the vehicle manufacturer.
- In a motor vehicle, do not place the wireless device over the air bag or in the air bag deployment area. Otherwise, the wireless device may hurt you owing to the strong force when the air bag inflates.

8.5 Airline Security

Observe the rules and regulations of airline companies. When boarding or approaching a plane, power off your wireless device. Otherwise, the radio signal of the wireless device may interfere with the plane control signals.

8.6 Safety of Children

Do not allow children to use the wireless device without guidance. Small and sharp components of the wireless device may cause danger to children or cause suffocation if children swallow the components.

8.7 Environment Protection

Observe the local regulations regarding the disposal of your packaging materials, used wireless device and accessories, and promote their recycling.

8.8 WEEE Approval

The wireless device is in compliance with the essential requirements and other relevant provisions of the Waste Electrical and Electronic Equipment Directive 2012/19/EU (WEEE Directive).

8.9 RoHS Approval

The wireless device is in compliance with the restriction of the use of certain hazardous substances in electrical and electronic equipment Directive 2011/65/EU (RoHS Directive).

8.10 Laws and Regulations Observance

Observe laws and regulations when using your wireless device. Respect the privacy and legal rights of the others.

8.11 Care and Maintenance

It is normal that your wireless device gets hot when you use or charge it. Before you clean or maintain the wireless device, stop all applications and power off the wireless device.

- Use your wireless device and accessories with care and in clean environment. Keep the wireless device from a fire or a lit cigarette.
- Protect your wireless device and accessories from water and vapour and keep them dry.
- Do not drop, throw or bend your wireless device.
- Clean your wireless device with a piece of damp and soft antistatic cloth. Do not use any chemical agents (such as alcohol and benzene), chemical detergent, or powder to clean it.
- Do not leave your wireless device and accessories in a place with a considerably low or high temperature.
- Use only accessories of the wireless device approved by the manufacture. Contact the authorized service center for any abnormity of the wireless device or accessories.
- Do not dismantle the wireless device or accessories. Otherwise, the wireless device and accessories are not covered by the warranty.
- The device should be installed and operated with a minimum distance of 20 cm between the radiator and your body.

8.12 Emergency Call

This wireless device functions through receiving and transmitting radio signals. Therefore, the connection cannot be guaranteed in all conditions. In an emergency, you should not rely solely on the wireless device for essential communications.

8.13 Regulatory Information

The following approvals and notices apply in specific regions as noted.

8.13.1 CE Approval (European Union)

The wireless device is approved to be used in the member states of the EU. The wireless device is in compliance with the essential requirements and other relevant provisions of the Radio and Telecommunications Terminal Equipment Directive 1999/5/EC (R&TTE Directive).

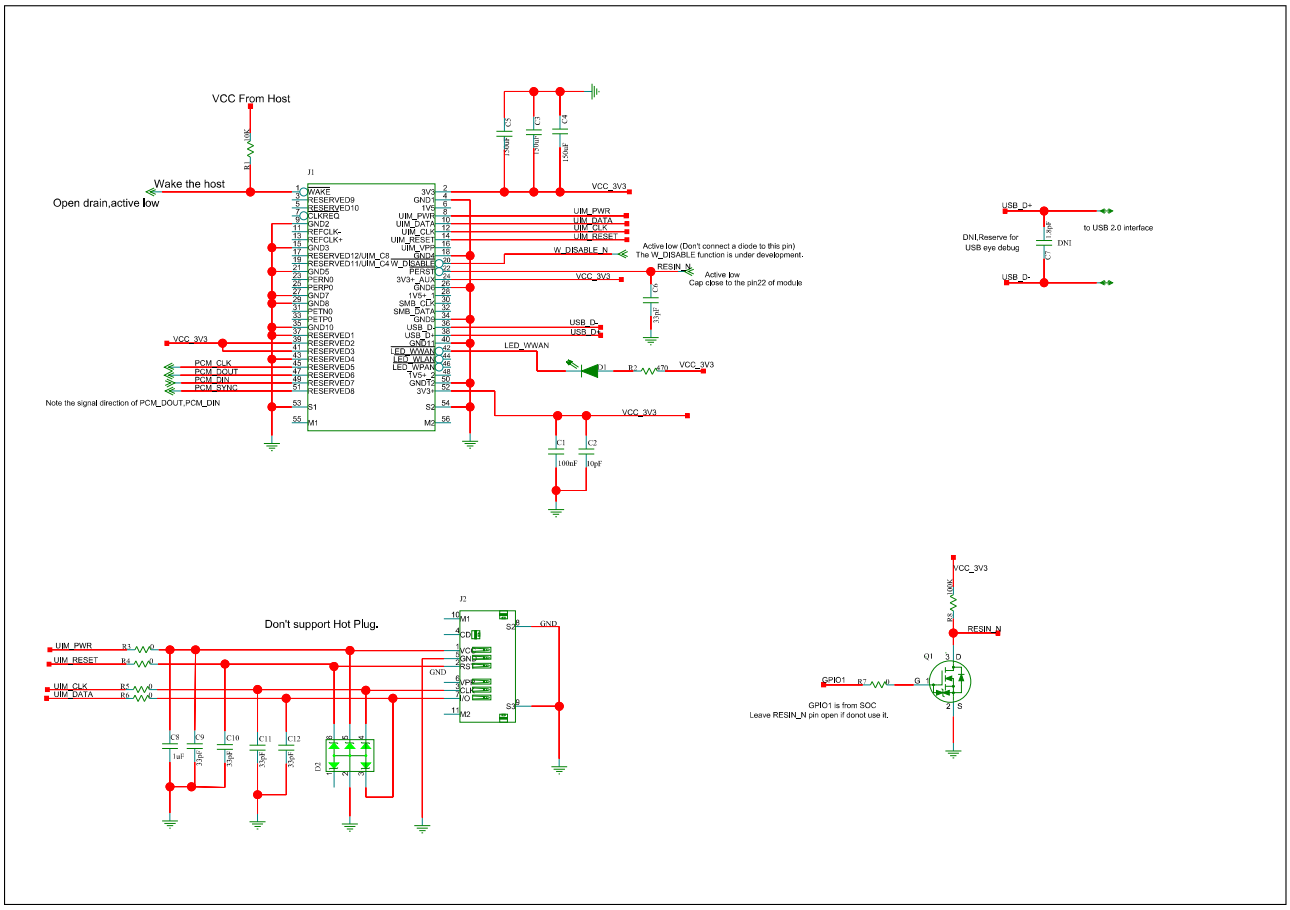
8.13.2 FCC Statement

Federal Communications Commission Notice (United States): Before a wireless device model is available for sale to the public, it must be tested and certified to the FCC that it does not exceed the limit established by the government-adopted requirement for safe exposure.

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.

Warning: Changes or modifications made to this equipment not expressly approved by HUAWEI may void the FCC authorization to operate this equipment.

9 Appendix A Circuit of Typical Interface



10 Appendix B Acronyms and Abbreviations

Acronym or Abbreviation	Expansion
CCC	China Compulsory Certification
CE	European Conformity
CS	Coding Scheme
CSD	Circuit Switched Data
DC	Direct Current
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
EU	European Union
FCC	Federal Communications Commission
GPIO	General-purpose I/O
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
HSDPA	High-Speed Downlink Packet Access
HSPA	High Speed Packet Access
HSUPA	High Speed Up-link Packet Access
ISO	International Standards Organization
LDO	Low-Dropout
LED	Light-Emitting Diode
MCP	Multi-chip Package
PCB	Printed Circuit Board

Acronym or Abbreviation	Expansion
RF	Radio Frequency
RoHS	Restriction of the Use of Certain Hazardous Substances
TVS	Transient Voltage Suppressor
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access
AUX	Auxiliary
3GPP	Third Generation Partnership Project
EDGE	Enhanced Data Rate for GSM Evolution
WEEE	Waste Electrical and Electronic Equipment