EC21 Mini PCIe

Hardware Design

LTE Standard Module Series

Rev. EC21_Mini_PCIe_Hardware_Design_V1.3

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Quectel Wireless Solutions Co., Ltd.
Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China 200233
Tel: +86 21 5108 6236
Email: info@quectel.com

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About the Document

History

Revision	Date	Author	Description
1.0	2016-06-07	Yeoman CHEN/ Frank WANG	Initial
1.1	2017-01-24	Lyndon LIU/ Rex WANG	1. Deleted description of EC21-AUTL and EC21-CT Mini PCIe in Table 1. 2. Updated key features of EC21 Mini PCIe in Table 2. 3. Added current consumption of EC21 Mini PCIe in Chapter 4.7. 4. Updated mechanical dimensions of EC21 Mini PCIe in Figure 15. 5. Updated conducted RF output power in Table 16. 6. Updated conducted RF receiving sensitivity of EC21-A in Table 18. 7. Added conducted RF receiving sensitivity of EC21-KL in Table 21. 8. Added conducted RF receiving sensitivity of EC21-J in Table 22.
1.2	2019-04-30	Woody WU/ Nathan LIU/ Frank WANG	1. Added new variants EC21-EU Mini PCIe/EC21-EC Mini PCIe and related information. 2. Added pin definition and description of pin 44 in Figure 2 and Table 4. 3. Updated mechanical dimensions in Figure 18. 4. Added USIM_PRESENCE in (U)SIM interface and updated the reference circuit in Chapter 3.4. 5. Updated reference circuit of USB interface in Chapter 3.5. 6. Modified description of W_DISABLE# signal in Chapter 3.8.3. 7. Modified description of LED_WWAN# signal in Chapter 3.8.5.

			8. Added thermal consideration in Chapter 6.7. 9. Updated UMTS and GSM features and added storage temperature range in Table 2. 10. Added operating frequencies in Table 15 11. Added GNSS frequency in Table 16. 12. Updated antenna requirements in Table 17. 13. Updated EC21 Mini PCIe conducted RF output power in Table 20. 14. Updated conducted RF receiving sensitivity of EC21-E Mini PCIe in Table 21. 15. Updated conducted RF receiving sensitivity of EC21-A Mini PCIe in Table 22. 16. Updated conducted RF receiving sensitivity of EC21-V Mini PCIe in Table 23 17. Updated conducted RF receiving sensitivity of EC21-AUT Mini PCIe in Table 24. 18. Added conducted RF receiving sensitivity of EC21-AU Mini PCIe in Table 27. 19. Added conducted RF receiving sensitivity of EC21-EU Mini PCIe in Table 28. 20. Added conducted RF receiving sensitivity of EC21-EC Mini PCIe in Table 29. 21. Added current consumption of EC21-EC Mini PCIe in Table 34.
1.3	2019-08-19	Ward WANG/ Owen WEI	1. Deleted the information of GNSS supported on EC21-EC Mini PCIe in Table 1. 2. Added ThreadX variant EC21-AUX Mini PCIe and updated related contents in Table 1. 3. Updated supported protocols and USB serial driver in Table 2. 4. Updated conducted RF receiving sensitivity of EC21-EU Mini PCIe in Table 29. 5. Added conducted RF receiving sensitivity of EC21-AUX Mini PCIe in Table 31. 6. Added current consumption of EC21-AUX Mini PCIe in Table 36. 7. Added current consumption of EC21-EU Mini PCIe in Table 37. 8. Added current consumption of EC21-AU Mini PCIe in Table 38. 9. Added note 2 for antenna requirement in Chapter 5.4.1. 10. Deleted current consumption of EC21-EC Mini PCIe, and the data will be updated in the future

	version.

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1 Introduction

This document defines EC21 Mini PCIe module, and describes its air interfaces and hardware interfaces which are connected with customers' applications.

This document can help customers to quickly understand module interface specifications, electrical and mechanical details as well as other related information of EC21 Mini PCIe module. To facilitate its application in different fields, relevant reference design is also provided for customers' reference. Associated with application note and user guide, customers can use the module to design and set up mobile applications easily.

1.1. Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating EC21 Mini PCIe module. Manufacturers of the cellular terminal should send the following safety information to users and operating personnel, and incorporate these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for customers' failure to comply with these precautions.

	Full attention must be given to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the cellular terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If the device offers an Airplane Mode, then it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on boarding the aircraft.
	Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.
	Cellular terminals or mobiles operating over radio signals and cellular network cannot be guaranteed to connect in all possible conditions (for example, with unpaid bills or with an invalid (U)SIM card). When emergent help is needed in such conditions, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength.
	The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with potentially explosive atmospheres, obey all posted signs to turn off wireless devices such as your phone or other cellular terminals. Areas with potentially explosive atmospheres include fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust or metal powders, etc.

FCC Certification Requirements.

According to the definition of mobile and fixed device is described in Part 2.1091(b), this device is a mobile device.

And the following conditions must be met:

1. This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based time-averaging duty factor, antenna gain and cable loss must satisfy MPE categorical Exclusion Requirements of 2.1091.

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

3.A label with the following statements must be attached to the host end product: This device contains FCC ID: XMR201909EC21AUX.

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

- ❒ GSM850: <11.206dBi
- ❒ GSM1900: <12.140dBi
- ❒ WCDMA B2/LTE B2/ LTE B7: <8dBi
- ❒ WCDMA B4LTE B4: <5dBi
- ❒ WCDMA B5/LTE B5: <9.416dBi

5. This module must not transmit simultaneously with any other antenna or transmitter

6. The host end product must include a user manual that clearly defines operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.

For portable devices, in addition to the conditions 3 through 6 described above, a separate approval is required to satisfy the SAR requirements of FCC Part 2.1093

If the device is used for other equipment that separate approval is required for all other operating configurations, including portable configurations with respect to 2.1093 and different antenna configurations.

For this device, OEM integrators must be provided with labeling instructions of finished products. Please refer to KDB784748 D01 v07, section 8. Page 6/7 last two paragraphs:

A certified modular has the option to use a permanently affixed label, or an electronic label. For a permanently affixed label, the module must be labeled with an FCC ID - Section 2.926 (see 2.2 Certification (labeling requirements) above). The OEM manual must provide clear instructions explaining to the OEM the labeling requirements, options and OEM user manual instructions that are required (see next paragraph).

For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straightforward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module:"Contains Transmitter Module FCC ID: XMR201909EC21AUX" or "Contains FCC ID: XMR201909EC21AUX" must be used. The host OEM user manual must also contain clear instructions on how end users can find and/or access the module and the FCC ID.

The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by this section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.

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.

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

To ensure compliance with all non-transmitter functions the host manufacturer is responsible for ensuring compliance with the module(s) installed and fully operational. For example, if a host was previously authorized as an unintentional radiator under the Declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that the after the module is installed and operational the host continues to be compliant with the Part 15B unintentional radiator requirements.

2 Product Concept

2.1. General Description

EC21 Mini PCIe module provides data connectivity on LTE-FDD, LTE-TDD, DC-HSDPA, HSPA+, HSDPA, HSUPA, WCDMA, EDGE and GPRS networks with PCI Express Mini Card 1.2 standard interface. It supports embedded operating systems such as WinCE, Linux, Android etc., and also provides audio, high-speed data transmission and GNSS functionalities for customers' applications.

EC21 Mini PCIe module can be applied in the following fields:

- PDA and Laptop Computer
- Remote Monitor System
- Vehicle System
- Wireless POS System
- Intelligent Meter Reading System
- Wireless Router and Switch
- Other Wireless Terminal Devices

This chapter generally introduces the following aspects of EC21 Mini PCIe module:

- Product Series
- Key Features
- Functional Diagram

NOTE

EC21 Mini PCIe contains **Telematics** version and **Data-only** version. **Telematics** version supports voice and data functions, while **Data-only** version only supports data function.

2.2. Description of Product Series

EC21 Mini PCIe series contains 10 variants, and are listed in the following table.

Table 1: Description of EC21 Mini PCIe

Product Series	Description
EC21-E Mini PCIe	Support GSM: 900/1800MHz Support WCDMA: B1/B5/B8 Support LTE-FDD: B1/B3/B5/B7/B8/B20 Support LTE/WCDMA receive diversity Support GNSS[1)] Support digital audio[2)]
EC21-A Mini PCIe	Support WCDMA: B2/B4/B5 Support LTE-FDD: B2/B4/B12 Support LTE/WCDMA receive diversity Support GNSS[1)] Support digital audio[2)]
EC21-V Mini PCIe	Support LTE-FDD: B4/B13 Support LTE receive diversity Support GNSS[1)] Support digital audio[2)]
EC21-AUT Mini PCIe	Support WCDMA: B1/B5 Support LTE-FDD: B1/B3/B5/B7/B28 Support LTE/WCDMA receive diversity Support GNSS[1)] Support digital audio[2)]
EC21-AU Mini PCIe[3)]	Support GSM: 850/900/1800/1900MHz Support WCDMA: B1/B2/B5/B8 Support LTE-FDD: B1/B2/B3/B4/B5/B7/B8/B28 Support LTE-TDD: B40 Support LTE/WCDMA receive diversity[3)] Support GNSS[1)] Support digital audio[2)]
EC21-J Mini PCIe	Support LTE-FDD: B1/B3/B8/B18/B19/B26 Support LTE receive diversity Support digital audio[2)]
EC21-KL Mini PCIe	Support LTE-FDD: B1/B3/B5/B7/B8 Support LTE receive diversity Support digital audio[2)]

EC21-EU Mini PCIe	Support GSM: 900/1800MHz Support WCDMA: B1/B8 Support LTE-FDD: B1/B3/B7/B8/B20/B28A Support LTE/WCDMA receive diversity Support GNSS[1)] Support digital audio[2)]
EC21-EC Mini PCIe	Support LTE-FDD: B1/B3/B7/B8/B20/B28A Support WCDMA: B1/B8 Support GSM: 900/1800MHz Support LTE/WCDMA receive diversity Support digital audio[2)]
EC21-AUX Mini PCIe[3)]	Support GSM: 850/900/1800/1900MHz Support WCDMA: B1/B2/B4/B5/B8 Support LTE-FDD: B1/B2/B3/B4/B5/B7/B8/B28 Support LTE-TDD: B40 Support LTE/WCDMA receive diversity[3)] Support GNSS[1)] Support digital audio[2)]

NOTES

1. [1)] GNSS function is optional.
2. [2)] Digital audio (PCM) function is only supported on **Telematics** version.
3. [3)] B2 band on EC21-AU Mini PCIe and EC21-AUX Mini PCIe module does not support receive diversity. Additionally, EC21-AUX Mini PCIe is based on ThreadX OS.

2.3. Key Features

The following table describes the detailed features of EC21 Mini PCIe module.

Table 2: Key Features of EC21 Mini PCIe

Feature	Details
Function Interface	PCI Express Mini Card 1.2 Standard Interface
Power Supply	Supply voltage: 3.0V~3.6V Typical supply voltage: 3.3V
Transmitting Power	Class 4 (33dBm±2dB) for GSM850 Class 4 (33dBm±2dB) for EGSM900 Class 1 (30dBm±2dB) for DCS1800

	Class 1 (30dBm±2dB) for PCS1900 Class E2 (27dBm±3dB) for GSM850 8-PSK Class E2 (27dBm±3dB) for EGSM900 8-PSK Class E2 (26dBm±3dB) for DCS1800 8-PSK Class E2 (26dBm±3dB) for PCS1900 8-PSK Class 3 (24dBm+1/-3dB) for WCDMA bands Class 3 (23dBm±2dB) for LTE-FDD bands Class 3 (23dBm±2dB) for LTE-TDD bands
LTE Features	Support up to non-CA Cat 1 FDD and TDD Support 1.4/3/5/10/15/20MHz RF bandwidth Support MIMO in DL direction LTE-FDD: Max 10Mbps (DL)/Max 5Mbps (UL) LTE-TDD: Max 8.96Mbps (DL)/Max 3.1Mbps (UL)
UMTS Features	Support 3GPP R8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA Support QPSK, 16-QAM and 64-QAM modulation DC-HSDPA: Max 42Mbps (DL) HSUPA: Max 5.76Mbps (UL) WCDMA: Max 384Kbps (DL)/Max 384Kbps (UL)
GSM Features	**GPRS:** Support GPRS multi-slot class 33 (33 by default) Coding scheme: CS-1, CS-2, CS-3 and CS-4 Max 107Kbps (DL)/Max 85.6Kbps (UL) **EDGE:** Support EDGE multi-slot class 33 (33 by default) Support GMSK and 8-PSK for different MCS (Modulation and Coding Scheme) Downlink coding schemes: CS 1-4 and MCS 1-9 Uplink coding schemes: CS 1-4 and MCS 1-9 Max 296Kbps (DL)/Max 236.8Kbps (UL)
Internet Protocol Features	Support TCP/UDP/PPP/FTP/FTPS/HTTP/HTTPS/NTP/PING/QMI/NITZ/MMS/SMTP/SSL/MQTT/FILE/CMUX*/SMTPS* protocols Support PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) protocols which are usually used for PPP connection
SMS	Text and PDU mode Point-to-point MO and MT SMS cell broadcast SMS storage: ME by default
(U)SIM Interface	Support USIM/SIM card: 1.8V, 3.0V
UART Interface	Baud rate can reach up to 230400bps, 115200bps by default Used for AT command communication
Audio Features	Support one digital audio interface: PCM interface GSM: HR/FR/EFR/AMR/AMR-WB

	WCDMA: AMR/AMR-WB LTE: AMR/AMR-WB Support echo cancellation and noise suppression
PCM Interface	Support 16-bit linear data format Support long frame synchronization and short frame synchronization Support master and slave modes, but must be the master in long frame synchronization
USB Interface	Compliant with USB 2.0 specification (slave only); the data transfer rate can reach up to 480Mbps Used for AT command communication, data transmission, GNSS NMEA output, software debugging, firmware upgrade and voice over USB Support USB serial drivers for: Windows 7/8/8.1/10, Linux 2.6/3.x/4.1~4.15, Android 4.x/5.x/6.x/7.x/8.x/9.x, etc.
Antenna Connectors	Include main antenna, diversity antenna and GNSS antenna receptacle connectors
Rx-diversity	Support LTE/WCDMA Rx-diversity
GNSS Features	Gen8C Lite of Qualcomm Protocol: NMEA 0183
AT Commands	Compliant with 3GPP TS 27.007, 27.005 and Quectel enhanced AT commands
Physical Characteristics	Size: (51.0±0.15)mm × (30.0±0.15)mm × (4.9±0.2)mm Weight: approx. 9.8g
Temperature Range	Operation temperature range: -35°C ~ +75°C [1)] Extended temperature range: -40°C ~ +80°C [2)] Storage temperature range: -40°C ~ +90°C
Firmware Upgrade	Upgrade via USB interface or DFOTA*
RoHS	All hardware components are fully compliant with EU RoHS directive

NOTES

1. [1)] Within operation temperature range, the module is 3GPP compliant.
2. [2)] Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call* (emergency call is not supported on ThreadX module), etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to normal operation temperature levels, the module will meet 3GPP specifications again.
3. "*" means under development.

2.4. Functional Diagram

The following figure shows the block diagram of EC21 Mini PCIe.

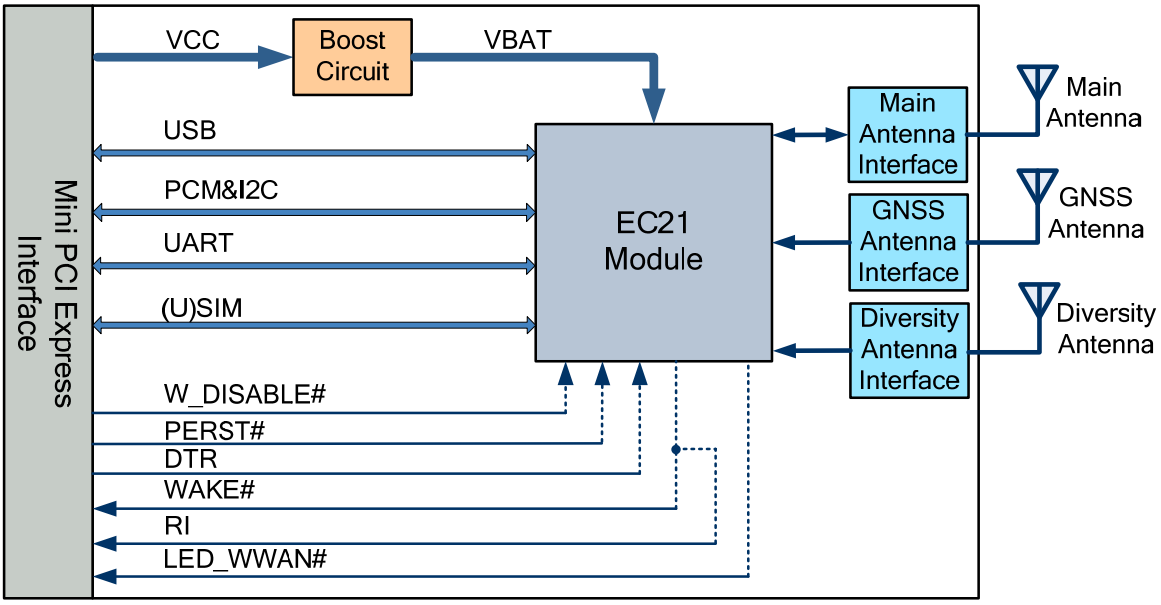


Figure 1: Functional Diagram

3 Application Interfaces

The physical connections and signal levels of EC21 Mini PCIe comply with PCI Express Mini CEM specifications. This chapter mainly describes the definition and application of the following interfaces of EC21 Mini PCIe:

- Power supply
- (U)SIM interface
- USB interface
- UART interface
- PCM and I2C interfaces
- Control and indicator signals
- Antenna interfaces

3.1. Pin Assignment

The following figure shows the pin assignment of EC21 Mini PCIe module. The top side contains EC21 module and antenna connectors.

Pin Name	Pin No.
WAKE#	1
RESERVED	3
RESERVED	5
RESERVED	7
GND	9
UART_RX	11
UART_TX	13
GND	15
RI	17
RESERVED	19
GND	21
UART_CTS	23
UART_RTS	25
GND	27
GND	29
DTR	31
RESERVED	33
GND	35
GND	37
VCC_3V3	39
VCC_3V3	41
GND	43
PCM_CLK	45
PCM_DOUT	47
PCM_DIN	49
PCM_SYNC	51

Pin No.	Pin Name
2	VCC_3V3
4	GND
6	NC
8	USIM_VDD
10	USIM_DATA
12	USIM_CLK
14	USIM_RST
16	RESERVED
18	GND
20	W_DISABLE#
22	PERST#
24	RESERVED
26	GND
28	NC
30	I2C_SCL
32	I2C_SDA
34	GND
36	USB_DM
38	USB_DP
40	GND
42	LED_WWAN#
44	USIM_PRESENCE
46	RESERVED
48	NC
50	GND
52	VCC_3V3

Figure 2: Pin Assignment

3.2. Pin Description

The following tables show the pin definition and description of EC21 Mini PCIe on the 52-pin application.

Table 3: I/O Parameters Definition

Type	Description
DI	Digital Input
DO	Digital Output
IO	Bidirectional
OC	Open Collector
PI	Power Input
PO	Power Output

Table 4: Pin Description

Pin No.	Mini PCI Express Standard Name	EC21 Mini PCIe Pin Name	I/O	Description	Comment
1	WAKE#	WAKE#	OC	Output signal used to wake up the host	
2	3.3Vaux	VCC_3V3	PI	3.3V DC supply	
3	COEX1	RESERVED		Reserved	It is prohibited to be pulled up to high level before startup.
4	GND	GND		Mini card ground	
5	COEX2	RESERVED		Reserved	It is prohibited to be pulled up to high level before startup.
6	1.5V	NC		Not connected	

7	CLKREQ#	RESERVED		Reserved	
8	UIM_PWR	USIM_VDD	PO	Power source for the (U)SIM card	
9	GND	GND		Mini card ground	
10	UIM_DATA	USIM_DATA	IO	Data signal of (U)SIM card	
11	REFCLK-	UART_RX	DI	UART receive data	Connect to DTE's TX
12	UIM_CLK	USIM_CLK	DO	Clock signal of (U)SIM card	
13	REFCLK+	UART_TX	DO	UART transmit data	Connect to DTE's RX
14	UIM_RESET	USIM_RST	DO	Reset signal of (U)SIM card	
15	GND	GND		Mini card ground	
16	UIM_VPP	RESERVED		Reserved	
17	RESERVED	RI	DO	Output signal to wake up the host	
18	GND	GND		Mini card ground	
19	RESERVED	RESERVED		Reserved	
20	W_DISABLE#	W_DISABLE#	DI	Airplane mode control	Pulled up by default. Active low.
21	GND	GND		Mini card ground	
22	PERST#	PERST#	DI	Fundamental reset signal	Pulled up by default. Active low.
23	PERn0	UART_CTS	DI	UART clear to send	Connect to DTE's RTS
24	3.3Vaux	RESERVED		Reserved	
25	PERp0	UART_RTS	DO	UART request to send	Connect to DTE's CTS
26	GND	GND		Mini card ground	
27	GND	GND		Mini card ground	
28	1.5V	NC		Not connected	

29	GND	GND		Mini card ground	
30	SMB_CLK	I2C_SCL	DO	I2C serial clock	Require external pull-up to 1.8V.
31	PETn0	DTR	DI	Sleep mode control	
32	SMB_DATA	I2C_SDA	IO	I2C serial data	Require external pull-up to 1.8V.
33	PETp0	RESERVED		Reserved	
34	GND	GND		Mini card ground	
35	GND	GND		Mini card ground	
36	USB_D-	USB_DM	IO	USB differential data (-)	Require differential impedance of 90Ω.
37	GND	GND		Mini card ground	
38	USB_D+	USB_DP	IO	USB differential data (+)	Require differential impedance of 90Ω.
39	3.3Vaux	VCC_3V3	PI	3.3V DC supply	
40	GND	GND		Mini card ground	
41	3.3Vaux	VCC_3V3	PI	3.3V DC supply	
42	LED_WWAN#	LED_WWAN#	OC	LED signal for indicating the network status of the module	Active low
43	GND	GND		Mini card ground	
44	LED_WLAN#	USIM_ PRESENCE	DI	(U)SIM card insertion detection	
45	RESERVED	PCM_CLK[1)]	IO	PCM clock signal	
46	LED_WPAN#	RESERVED		Reserved	
47	RESERVED	PCM_DOUT[1)]	DO	PCM data output	

48	1.5V	NC		Not connected
49	RESERVED	PCM_DIN[1)]	DI	PCM data input
50	GND	GND		Mini card ground
51	RESERVED	PCM_SYNC[1)]	IO	PCM frame synchronization
52	3.3Vaux	VCC_3V3	PI	3.3V DC supply

NOTES

1. Keep all NC, reserved and unused pins unconnected.
2. [1)] The digital audio (PCM) function is only supported on **Telematics** version.

3.3. Power Supply

The following table shows pin definition of VCC_3V3 pins and ground pins.

Table 5: Pin Definition of VCC_3V3 and GND Pins

Pin Name	Pin No.	I/O	Power Domain	Description
VCC_3V3	2, 39, 41, 52	PI	3.0V~3.6V	3.3V DC supply
GND	4, 9, 15, 18, 21, 26, 27, 29, 34, 35, 37, 40, 43, 50			Mini card ground

The typical supply voltage of EC21 Mini PCIe is 3.3V. In the 2G network, the input peak current may reach 2.7A during the transmitting time. Therefore, the power supply must be able to provide enough current, and a bypass capacitor of no less than 470μF with low ESR should be used to prevent the voltage from dropping.

The following figure shows a reference design of power supply. The precision of resistor R2 and R3 is 1%, and the capacitor C3 needs a low ESR.

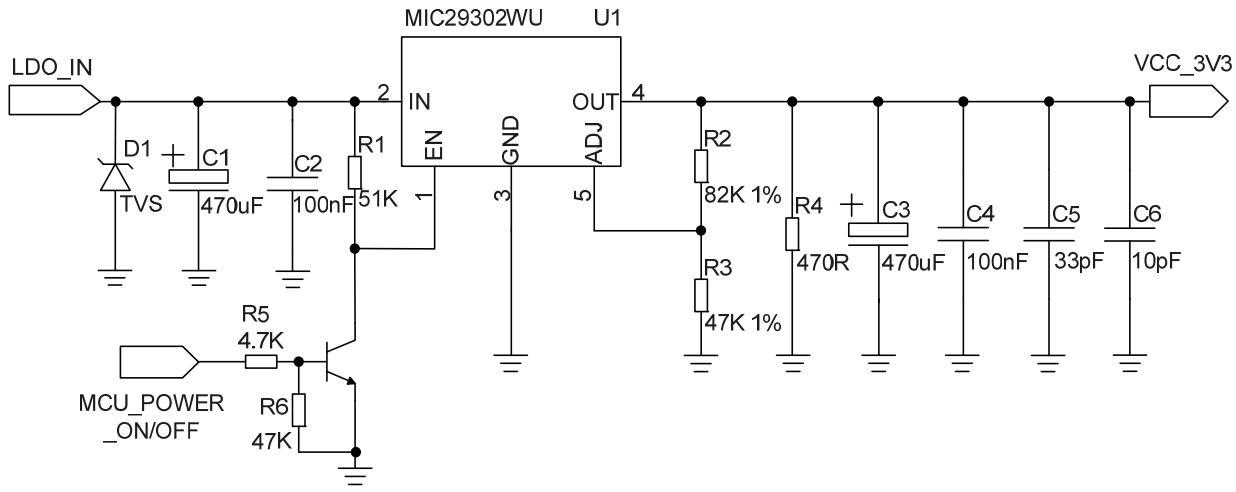


Figure 3: Reference Circuit of Power Supply

3.4. (U)SIM Interface

The (U)SIM interface circuitry meets ETSI and IMT-2000 requirements. Both 1.8V and 3.0V (U)SIM cards are supported. The following table shows the pin definition of (U)SIM interface.

Table 6: Pin Definition of (U)SIM Interface

Pin Name	Pin No.	I/O	Power Domain	Description
USIM_VDD	8	PO	1.8V/3.0V	Power source for (U)SIM card
USIM_DATA	10	IO	1.8V/3.0V	Data signal of (U)SIM card
USIM_CLK	12	DO	1.8V/3.0V	Clock signal of (U)SIM card
USIM_RST	14	DO	1.8V/3.0V	Reset signal of (U)SIM card
USIM_PRESENCE	44	DI	1.8V	(U)SIM card insertion detection

EC21 Mini PCIe supports (U)SIM card hot-plug via the USIM_PRESENCE pin. The function supports low level and high level detections, and it is disabled by default. For more details of **AT+QSIMDET** command, please refer to ***document [2]***.

The following figure shows a reference design for (U)SIM interface with an 8-pin (U)SIM card connector.

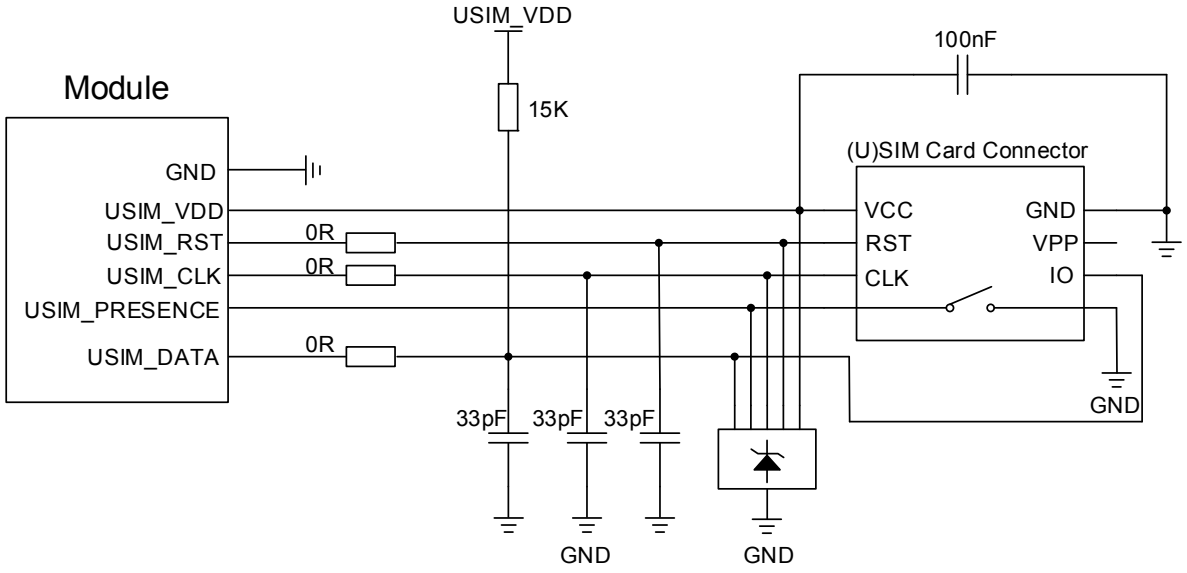


Figure 4: Reference Circuit of (U)SIM Interface with an 8-pin (U)SIM Card Connector

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

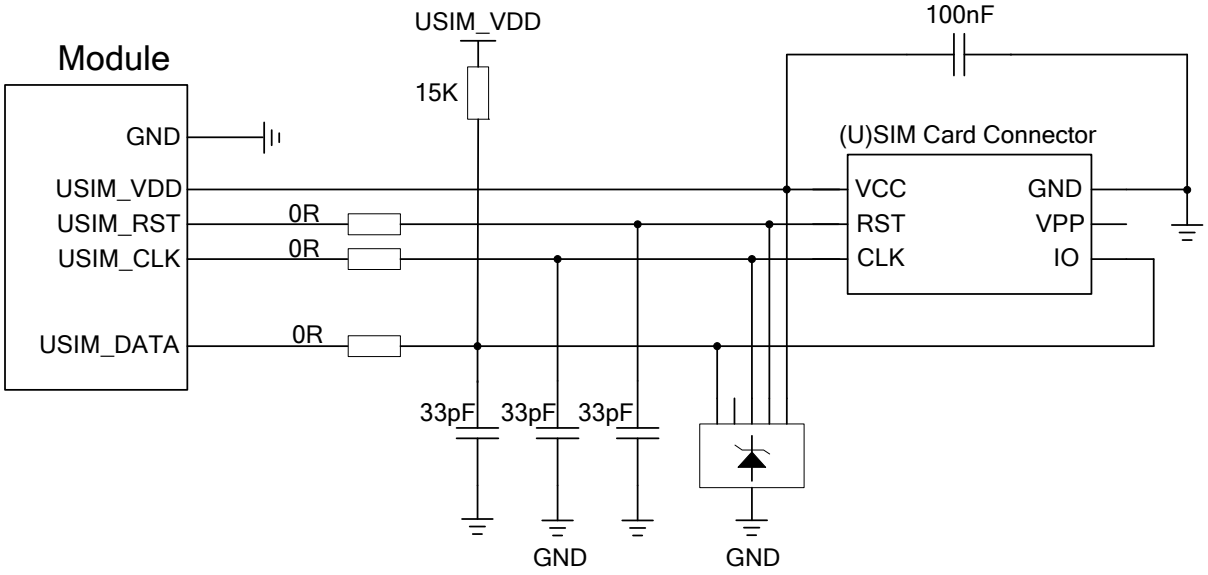


Figure 5: Reference Circuit of (U)SIM Interface with a 6-pin (U)SIM Card Connector

In order to enhance the reliability and availability of the (U)SIM card in customers' applications, please follow the criteria below in (U)SIM circuit design:

- Keep placement of (U)SIM card connector to the module as close as possible. Keep the trace length as less than 200mm as possible.
- Keep (U)SIM card signals away from RF and power supply traces.
- To avoid cross-talk between USIM_DATA and USIM_CLK, keep them away from each other and shield them with surrounded ground.
- In order to offer good ESD protection, it is recommended to add a TVS diode with parasitic capacitance not exceeding 15pF. The 0Ω resistors should be added in series between the module and the (U)SIM card so as to facilitate debugging. The 33pF capacitors are used for filtering interference of EGSM900. Please note that the (U)SIM peripheral circuit should be close to the (U)SIM card connector.
- The pull-up resistor on USIM_DATA line can improve anti-jamming capability when long layout trace and sensitive occasion are applied, and should be placed close to the (U)SIM card connector.

3.5. USB Interface

The following table shows the pin definition of USB interface.

Table 7: Pin Definition of USB Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_DM	36	IO	USB differential data (-)	Require differential impedance of 90Ω
USB_DP	38	IO	USB differential data (+)	Require differential impedance of 90Ω

EC21 Mini PCIe is compliant with USB 2.0 specification. It can only be used as a slave device. Meanwhile, it supports high speed (480Mbps) mode and full speed (12Mbps) mode. The USB interface is used for AT command communication, data transmission, GNSS NMEA output, software debugging, firmware upgrade and voice over USB. The following figure shows a reference circuit of USB interface.

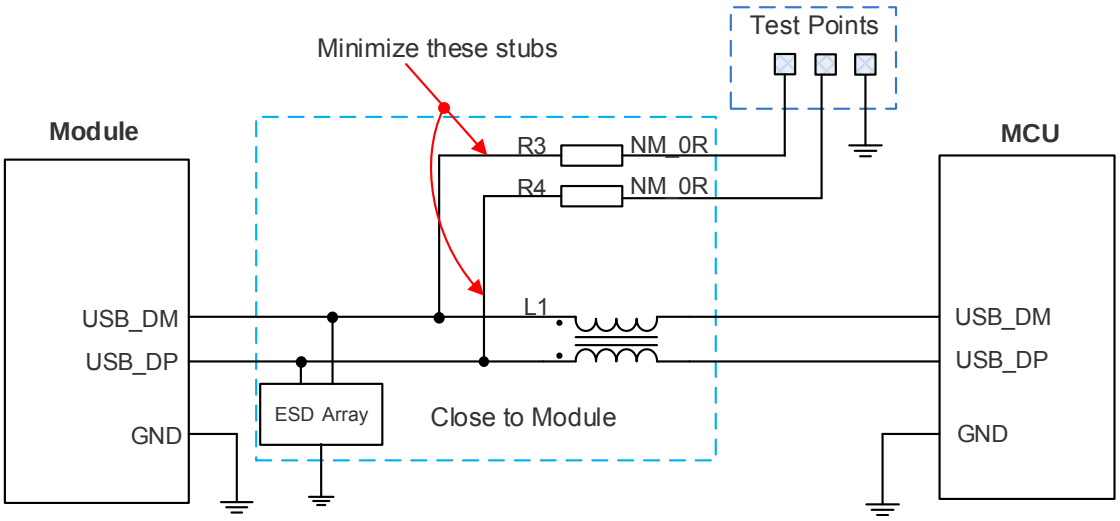


Figure 6: Reference Circuit of USB Interface

A common mode choke L1 is recommended to be added in series between the module and customer's MCU in order to suppress EMI spurious transmission. Meanwhile, the 0Ω resistors (R3 and R4) should be added in series between the module and the test points so as to facilitate debugging, and the resistors are not mounted by default. In order to ensure the integrity of USB data line signal, L1/R3/R4 components must be placed close to the module, and also these resistors should be placed close to each other. The extra stubs of trace must be as short as possible.

The following principles should be complied with when design the USB interface, so as to meet USB 2.0 specification.

- It is important to route the USB signal traces as differential pairs with total grounding. The impedance of USB differential trace is 90Ω.
- Do not route signal traces under crystals, oscillators, magnetic devices and RF signal traces. It is important to route the USB differential traces in inner-layer with ground shielding on not only upper and lower layers but also right and left sides.
- Pay attention to the influence of junction capacitance of ESD protection components on USB data lines. Typically, the capacitance value should be less than 2pF.
- Keep the ESD protection components to the USB connector as close as possible.

NOTES

1. There are three preconditions when enabling EC21 Mini PCIe to enter into the sleep mode:
   a) Execute **AT+QSCLK=1** command to enable the sleep mode. Please refer to ***document [2]*** for details.
   b) DTR pin should be kept at high level (pulled up internally).
   c) USB interface on Mini PCIe must be connected with the USB interface of the host and please guarantee the USB of the host is in suspend state.

2. The ESD device used for USB interface protection has been built in the Mini PCIe, thus the external ESD device can be reserved for the further use.

3.6. UART Interface

The following table shows the pin definition of the UART interface.

Table 8: Pin Definition of UART Interface

Pin Name	Pin No.	I/O	Power Domain	Description
UART_RX	11	DI	3.3V	UART receive data
UART_TX	13	DO	3.3V	UART transmit data
UART_CTS	23	DI	3.3V	UART clear to send
UART_RTS	25	DO	3.3V	UART request to send

The UART interface supports 9600bps, 19200bps, 38400bps, 57600bps, 115200bps and 230400bps baud rates, and the default is 115200bps. This interface can be used for AT command communication.

NOTE

AT+IPR command can be used to set the baud rate of the UART, and **AT+IFC** command can be used to set the hardware flow control (hardware flow control is disabled by default). Please refer to ***document [2]*** for details.

3.7. PCM and I2C Interfaces

EC21 Mini PCIe provides one Pulse Code Modulation (PCM) digital interface and one I2C interface.

The following table shows the pin definition of PCM and 12C interfaces that can be applied in audio codec design.

Table 9: Pin Definition of PCM and I2C Interfaces

Pin Name	Pin No.	I/O	Power Domain	Description
PCM_CLK [1)]	45	IO	1.8V	PCM clock signal
PCM_DOUT [1)]	47	DO	1.8V	PCM data output
PCM_DIN [1)]	49	DI	1.8V	PCM data input
PCM_SYNC [1)]	51	IO	1.8V	PCM frame synchronization
I2C_SCL	30	DO	1.8V	I2C serial clock. Require external pull-up to 1.8V.
I2C_SDA	32	IO	1.8V	I2C serial data. Require external pull-up to 1.8V.

EC21 Mini PCIe provides one PCM digital interface, which supports 16-bit linear data format and the following modes:

- Primary mode (short frame synchronization, works as either master or slave)
- Auxiliary mode (long frame synchronization, works as master only)

NOTE

[1)] The digital audio (PCM) function is only supported on **Telematics** version.

In primary mode, the data is sampled on the falling edge of the PCM_CLK and transmitted on the rising edge. The PCM_SYNC falling edge represents the MSB. In this mode, the PCM interface supports 256KHz, 512KHz, 1024KHz or 2048KHz PCM_CLK at 8KHz PCM_SYNC, and also supports 4096KHz PCM_CLK at 16KHz PCM_SYNC. The following figure shows the timing relationship in primary mode with 8KHz PCM_SYNC and 2048KHz PCM_CLK.

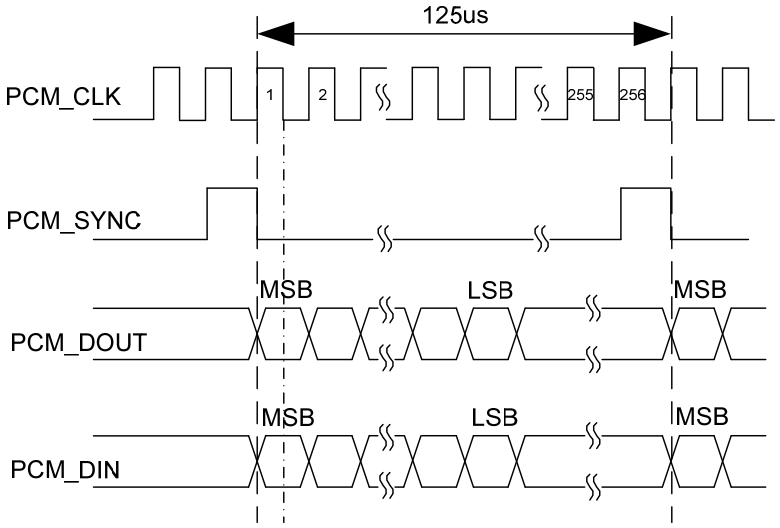


Figure 7: Timing in Primary Mode

In auxiliary mode, the data is sampled on the falling edge of the PCM_CLK and transmitted on the rising edge. The PCM_SYNC rising edge represents the MSB. In this mode, the PCM interface operates with a 256KHz, 512KHz, 1024KHz or 2048KHz PCM_CLK and an 8KHz, 50% duty cycle PCM_SYNC. The following figure shows the timing relationship in auxiliary mode with 8KHz PCM_SYNC and 256KHz PCM_CLK.

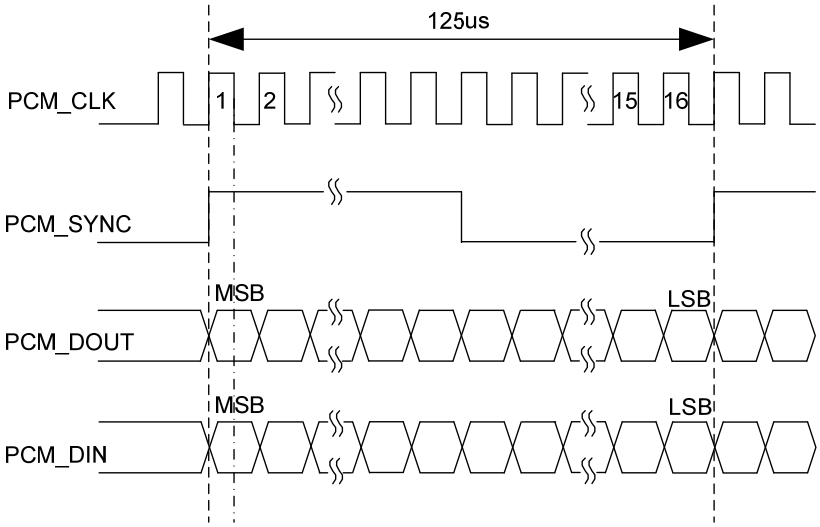


Figure 8: Timing in Auxiliary Mode

Clock and mode can be configured by AT command, and the default configuration is master mode using short frame synchronization format with 2048KHz PCM_CLK and 8KHz PCM_SYNC. In addition, EC21 Mini PCIe's firmware has integrated the configuration on some PCM codec's application with I2C interface. Please refer to ***document [2]*** for details about **AT+QDAI** command.

The following figure shows a reference design of PCM interface with an external codec IC.

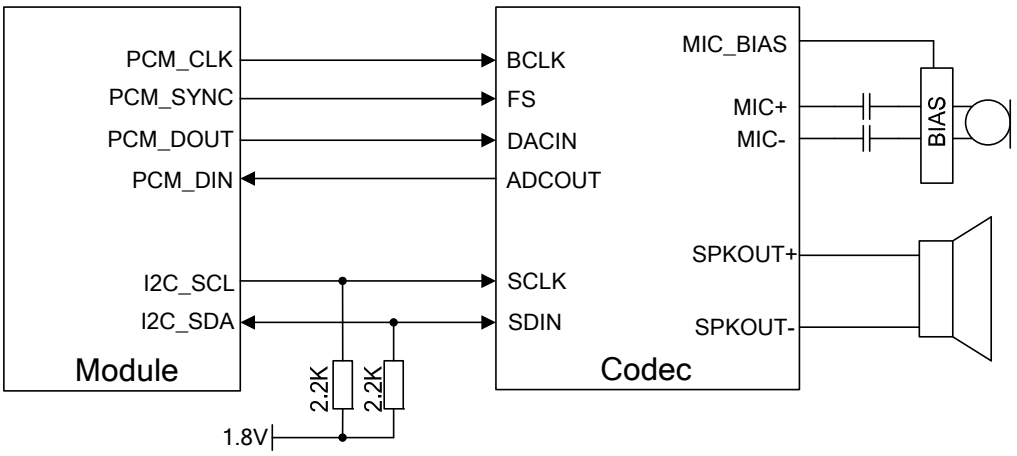


Figure 9: Reference Circuit of PCM Application with Audio Codec

3.8. Control and Indicator Signals

The following table shows the pin definition of control and indicator signals.

Table 10: Pin Definition of Control and Indicator Signals

Pin Name	Pin No.	I/O	Power Domain	Description
RI	17	DO	3.3V	Output signal used to wake up the host
DTR	31	DI	3.3V	Sleep mode control
W_DISABLE#	20	DI	3.3V	Airplane mode control; Pulled up by default; Active low.
PERST#	22	DI	3.3V	Fundamental reset signal; Active low.
LED_WWAN#	42	OC		LED signal for indicating the network status of the module; Active low.
WAKE#	1	OC		Output signal to wake up the host

3.8.1. RI Signal

The RI signal can be used to wake up the host. When a URC returns, there will be the following behaviors on the RI pin after executing **AT+QCFG="risignaltype","physical"** command.

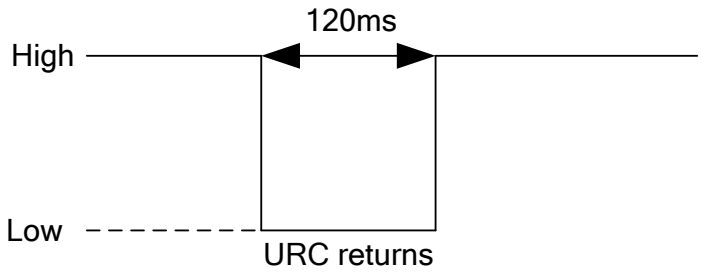


Figure 10: RI Behavior

3.8.2. DTR Signal

The DTR signal supports sleep control function. Driving it to low level will wake up the module.

3.8.3. W_DISABLE# Signal

EC21 Mini PCIe provides a W_DISABLE# signal to disable or enable the RF function (GNSS not included). W_DISABLE# signal function is disabled by default, and **AT+QCFG="airplanecontrol",1** can be used to enable this function. The W_DISABLE# pin is pulled up by default. Driving it to low level will let the module enter airplane mode.

AT+CFUN can also be used to control the RF status, and the details are as follows:

Table 11: Airplane Mode Controlled by Hardware Method

W_DISABLE#	RF Function Status	Module Operation Mode
High level	RF enabled	Normal mode
Low level	RF disabled	Airplane mode

Software method can be controlled by **AT+CFUN**, and has the same effect with W_DISABLE# signal function, the details is as follows.

Table 12: Airplane Mode Controlled by Software Method

AT+CFUN=?	RF Function Status	Module Operation Mode	Conditions
0	RF and (U)SIM disabled	Minimum functionality mode	Keep W_DISABLE# at high level.

3.8.4. PERST# Signal

The PERST# signal can be used to force a hardware reset on the card. Customers can reset the module by driving the PERST# to a low level voltage within the time frame of 150ms~460ms and then releasing it. The reset scenario is illustrated in the following figure.

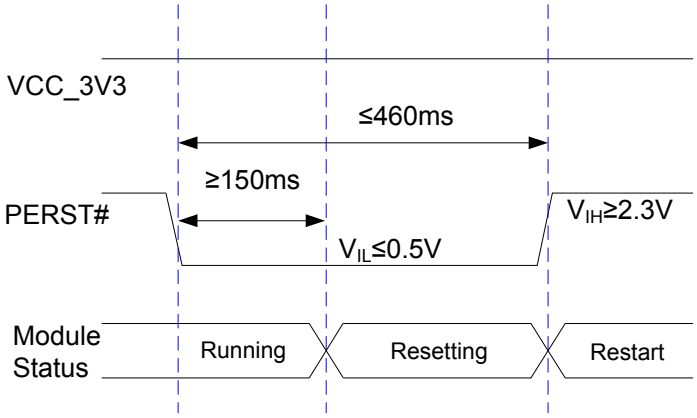


Figure 11: Timing of Resetting Module

3.8.5. LED_WWAN# Signal

The LED_WWAN# signal of EC21 Mini PCIe is used to indicate the network status of the module, and can absorb the current up to 40mA. According to the following circuit, in order to reduce the current of the LED, a resistor must be placed in series with the LED. The LED is emitting light when the LED_WWAN# output signal is active low.

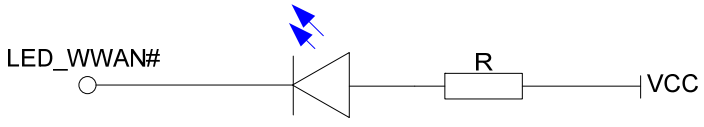


Figure 12: LED_WWAN# Signal Reference Circuit Diagram

There are two indication modes for LED_WWAN# signal to indicate network status, which can be switched through following AT commands:

- **AT+QCFG="ledmode",0 (Default setting)**
- **AT+QCFG="ledmode",2**

The following tables show the detailed network status indications of the LED_WWAN# signal.

Table 13: Indications of Network Status (AT+QCFG="ledmode",0, Default Setting)

Pin Status	Description
Flicker slowly (200ms Low/1800ms High)	Network searching
Flicker slowly (1800ms Low/200ms High)	Idle
Flicker quickly (125ms Low/125ms High)	Data transfer is ongoing
Always Low	Voice calling

Table 14: Indications of Network Status (AT+QCFG="ledmode",2)

Pin Status	Description
Low Level (Light on)	Registered on network
High-impedance (Light off)	• No network coverage or not registered • W_DISABLE# signal is at low level. (Disable the RF) • **AT+CFUN=0**, **AT+CFUN=4**

3.8.6. WAKE# Signal

The WAKE# signal is an open collector signal which is similar to RI signal, but a host pull-up resistor and **AT+QCFG="risignaltype","physical"** command are required. When a URC returns, a 120ms low level pulse will be outputted. The state of WAKE# signal is shown as below.

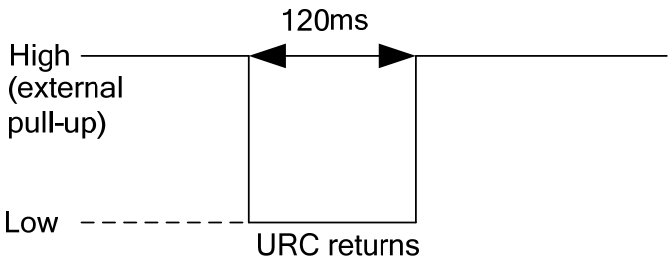


Figure 13: WAKE# Behavior

4 GNSS Receiver

EC21 Mini PCIe includes a fully integrated global navigation satellite system solution that supports Gen8C-Lite of Qualcomm (GPS, GLONASS, BeiDou, Galileo and QZSS).

EC21 Mini PCIe supports standard NMEA-0183 protocol, and outputs NMEA sentences at 1Hz data update rate via USB interface by default.

By default, EC21 Mini PCIe GNSS engine is switched off. It has to be switched on via AT command. For more details about GNSS engine technology and configurations, please refer to ***document [3]***.

5 Antenna Connection

EC21 Mini PCIe is mounted with three antenna connectors for external antenna connection: a main antenna connector, an Rx-diversity antenna connector, and a GNSS antenna connector. And Rx-diversity function is enabled by default. The impedance of the antenna connectors is 50Ω.

5.1. Operating Frequency

The following table shows the operating frequencies of EC21 Mini PCIe.

Table 15: Operating Frequencies

3GPP Band	Transmit	Receive	Unit
GSM850	824~849	869~894	MHz
EGSM900	880~915	925~960	MHz
DCS1800	1710~1785	1805~1880	MHz
PCS1900	1850~1910	1930~1990	MHz
WCDMA B1	1920~1980	2110~2170	MHz
WCDMA B2	1850~1910	1930~1990	MHz
WCDMA B4	1710~1755	2110~2155	MHz
WCDMA B5	824~849	869~894	MHz
WCDMA B8	880~915	925~960	MHz
LTE-FDD B1	1920~1980	2110~2170	MHz
LTE-FDD B2	1850~1910	1930~1990	MHz
LTE-FDD B3	1710~1785	1805~1880	MHz
LTE-FDD B4	1710~1755	2110~2155	MHz

LTE-FDD B5	824~849	869~894	MHz
LTE-FDD B7	2500~2570	2620~2690	MHz
LTE-FDD B8	880~915	925~960	MHz
LTE-FDD B12	699~716	729~746	MHz
LTE-FDD B13	777~787	746~756	MHz
LTE-FDD B18	815~830	860~875	MHz
LTE-FDD B19	830~845	875~890	MHz
LTE-FDD B20	832~862	791~821	MHz
LTE-FDD B26	814~849	859~894	MHz
LTE-FDD B28	703~748	758~803	MHz
LTE-TDD B40	2300~2400	2300~2400	MHz

5.2. GNSS Frequency

The following table shows the GNSS frequency of EC21 Mini PCIe.

Table 16: GNSS Frequency

Type	Frequency	Unit
GPS	1575.42±1.023	MHz
GLONASS	1597.5~1605.8	MHz
Galileo	1575.42±2.046	MHz
BeiDou	1561.098±2.046	MHz
QZSS	1575.42	MHz

5.3. GNSS Performance

The following table shows the GNSS performance of EC21 Mini PCIe.

Table 17: GNSS Performance

Parameter	Description	Conditions	Typ.	Unit
Sensitivity (GNSS)	Cold start	Autonomous	-146	dBm
	Reacquisition	Autonomous	-157	dBm
	Tracking	Autonomous	-157	dBm
TTFF (GNSS)	Cold start @open sky	Autonomous	35	s
		XTRA enabled	18	s
	Warm start @open sky	Autonomous	26	s
		XTRA enabled	2.2	s
	Hot start @open sky	Autonomous	2.5	s
		XTRA enabled	1.8	s
Accuracy (GNSS)	CEP-50	Autonomous @open sky	<2.5	m

NOTES

1. Tracking sensitivity: the lowest GNSS signal value at the antenna port on which the module can keep on positioning for 3 minutes.
2. Reacquisition sensitivity: the lowest GNSS signal value at the antenna port on which the module can fix position again within 3 minutes after loss of lock.
3. Cold start sensitivity: the lowest GNSS signal value at the antenna port on which the module fixes position within 3 minutes after executing cold start command.

5.4. Antenna Requirements

5.4.1. Antenna Requirements

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

Table 18: Antenna Requirements

Type	Requirements
GNSS[1)]	Frequency range: 1559MHz~1609MHz Polarization: RHCP or linear VSWR: < 2 (Typ.) Passive antenna gain: > 0dBi Active antenna noise figure: <1.5dB Active antenna gain: > 0dBi Active antenna embedded LNA gain: <17dB
GSM/UMTS/LTE	VSWR: ≤ 2 Efficiency: > 30% Max input power: 50W Input impedance: 50Ω Cable insertion loss: < 1dB (GSM850, EGSM900, WCDMA B5/B8, LTE-FDD B5/B8/B12/B13/B18/B19/B20/B26/B28) Cable insertion loss: < 1.5dB (DCS1800, PCS1900, WCDMA B1/B2/B4, LTE-FDD B1/B2/B3/B4) Cable insertion loss < 2dB (LTE-FDD B7, LTE-TDD B40)

NOTES

1. 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.
2. Since the GNSS port has a 2.85V voltage output, a passive antenna that causes shorting to GND, such as PIFA antenna is not recommended.

5.4.2. Antenna Connectors and Mating Plugs

The dimensions of the antenna connectors are shown as below.

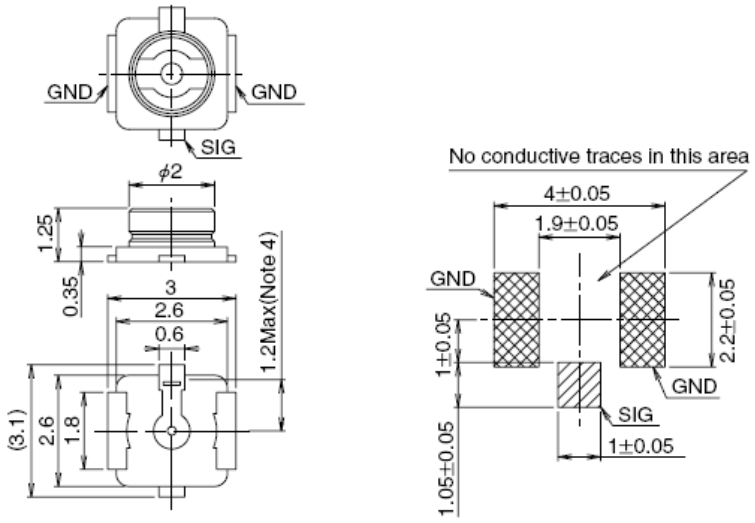


Figure 14: Dimensions of Antenna Connectors (Unit: mm)

It is recommended to use U.FL-LP mating plugs listed in the following figure to match the antenna connectors.

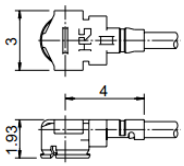
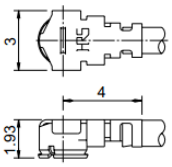
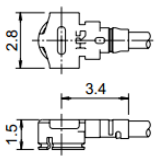
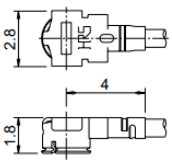
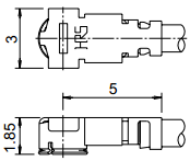
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 0.81mm Coaxial cable	Dia. 1mm Coaxial cable	Dia. 1.37mm Coaxial cable
Weight (mg)	53.7	59.1	34.8	45.5	71.7
RoHS	YES				

Figure 15: Mechanicals of U.FL-LP Mating Plugs

The following figure describes the space factor of mating plugs.

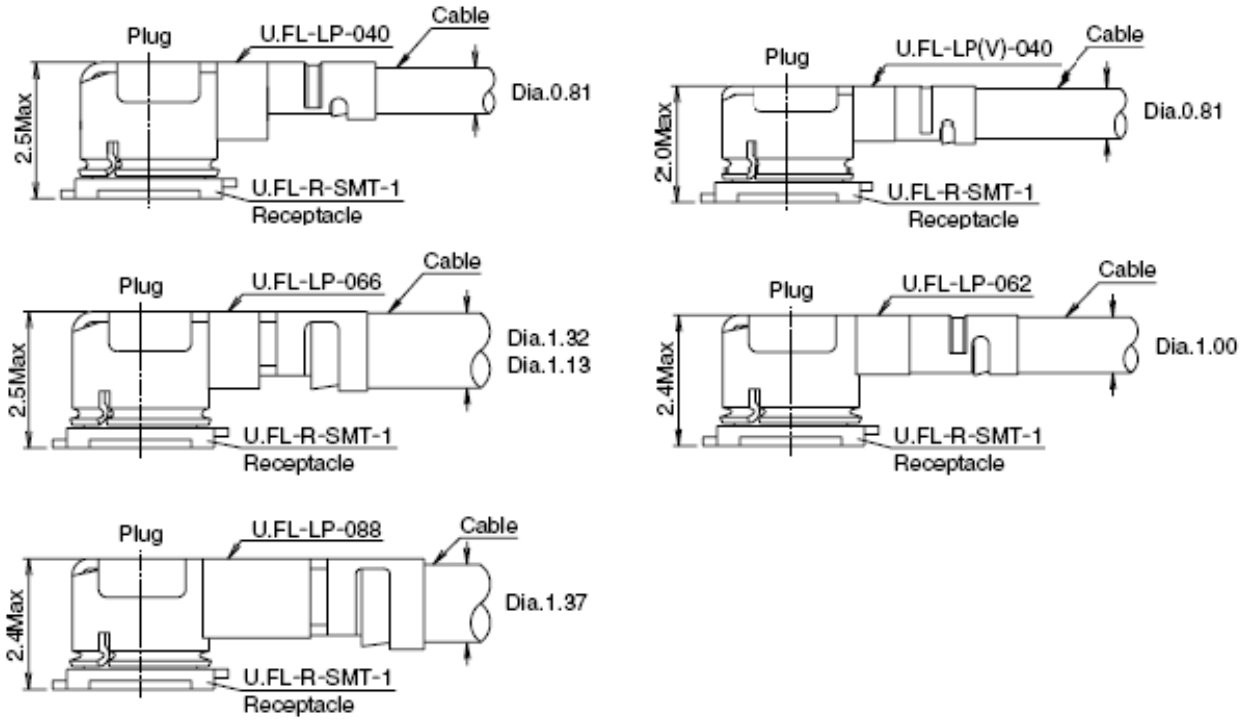


Figure 16: Space Factor of Mating Plugs (Unit: mm)

For more details of the recommended mating plugs, please visit http://www.hirose.com.

6 Electrical, Reliability and Radio Characteristics

6.1. General Description

This chapter mainly describes the following electrical and radio characteristics of EC21 Mini PCIe:

- Power supply requirements
- I/O requirements
- RF characteristics
- GNSS receiver
- ESD characteristics
- Current consumption
- Thermal consideration

6.2. Power Supply Requirements

The input voltage of EC21 Mini PCIe is 3.3V±9%, as specified by *PCI Express Mini CEM Specifications 1.2*. The following table shows the power supply requirements of EC21 Mini PCIe.

Table 19: Power Supply Requirements

Parameter	Description	Min.	Typ.	Max.	Unit
VCC_3V3	Power supply	3.0	3.3	3.6	V

6.3. I/O Requirements

The following table shows the I/O requirements of EC21 Mini PCIe.

Table 20: I/O Requirements

Parameter	Description	Min.	Max.	Unit
V_{IH}	Input High Voltage	0.7 × VCC_3V3	VCC_3V3+0.3	V
V_{IL}	Input Low Voltage	-0.3	0.3 × VCC_3V3	V
V_{OH}	Output High Voltage	VCC_3V3-0.5	VCC_3V3	V
V_{OL}	Output Low Voltage	0	0.4	V

NOTES

1. The PCM and I2C interfaces belong to 1.8V power domain and other I/O interfaces belong to VCC_3V3 power domain.
2. The maximum voltage value of V_{IL} for PERST# signal and W_DISABLE# signal is 0.5V.

6.4. RF Characteristics

The following tables show the conducted RF output power and receiving sensitivity of EC21 Mini PCIe module.

Table 21: Conducted RF Output Power of EC21 Mini PCIe

Frequency	Max.	Min.
GSM850/EGSM900	33dBm±2dB	5dBm±5dB
DCS1800/PCS1900	30dBm±2dB	0dBm±5dB
GSM850/EGSM900 (8-PSK)	27dBm±3dB	5dBm±5dB
DCS1800/PCS1900 (8-PSK)	26dBm±3dB	0dBm±5dB
WCDMA bands	24dBm+1/-3dB	< -49dBm

LTE-FDD bands	23dBm±2dB	< -39dBm
LTE-TDD bands	23dBm±2dB	< -39dBm

Table 22: Conducted RF Receiving Sensitivity of EC21-E Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
EGSM900	-109.0dBm	/	/	-102.0dBm
DCS1800	-109.0dBm	/	/	-102.0dbm
WCDMA B1	-110.5dBm	/	/	-106.7dBm
WCDMA B5	-110.5dBm	/	/	-104.7dBm
WCDMA B8	-110.5dBm	/	/	-103.7dBm
LTE-FDD B1 (10MHz)	-98.0dBm	-98.0dBm	-101.5dBm	-96.3dBm
LTE-FDD B3 (10MHz)	-96.5dBm	-98.5dBm	-101.5dBm	-93.3dBm
LTE-FDD B5 (10MHz)	-98.0dBm	-98.5dBm	-101.0dBm	-94.3dBm
LTE-FDD B7 (10MHz)	-97.0dBm	-97.0dBm	-99.5dBm	-94.3dBm
LTE-FDD B8 (10MHz)	-97.0dBm	-97.0dBm	-101.0dBm	-93.3dBm
LTE-FDD B20 (10MHz)	-97.5dBm	-99.0dBm	-102.5dBm	-93.3dBm

Table 23: Conducted RF Receiving Sensitivity of EC21-A Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
WCDMA B2	-110.0dBm	/	/	-104.7dBm
WCDMA B4	-110.0dBm	/	/	-106.7dBm
WCDMA B5	-110.5dBm	/	/	-104.7dBm
LTE-FDD B2 (10MHz)	-98.0dBm	-98.0dBm	-101.0dBm	-94.3dBm
LTE-FDD B4 (10MHz)	-97.5dBm	-99.0dBm	-101.0dBm	-96.3dBm
LTE-FDD B12 (10MHz)	-97.2dBm	-98.0dBm	-101.0dBm	-93.3dBm

Table 24: Conducted RF Receiving Sensitivity of EC21-V Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
LTE-FDD B4 (10MHz)	-97.5dBm	-99.0dBm	-101.0dBm	-96.3dBm
LTE-FDD B13 (10MHz)	-97.7dBm	-97.0dBm	-100.0dBm	-93.3dBm

Table 25: Conducted RF Receiving Sensitivity of EC21-AUT Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
WCDMA B1	-110.0dBm	/	/	-106.7dBm
WCDMA B5	-110.5dBm	/	/	-104.7dBm
LTE-FDD B1 (10MHz)	-98.5dBm	-98.0dBm	-101.0dBm	-96.3dBm
LTE-FDD B3 (10MHz)	-98.0dBm	-97.0dBm	-100.0dBm	-93.3dBm
LTE-FDD B5 (10MHz)	-98.0dBm	-99.0dBm	-102.5dBm	-94.3dBm
LTE-FDD B7 (10MHz)	-97.0dBm	-97.0dBm	-98.5dBm	-94.3dBm
LTE-FDD B28 (10MHz)	-97.0dBm	-99.0dBm	-102.0dBm	-94.8dBm

Table 26: Conducted RF Receiving Sensitivity of EC21-KL Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
LTE-FDD B1 (10MHz)	-98.0dBm	-99.5dBm	-100.5dBm	-96.3dBm
LTE-FDD B3 (10MHz)	-97.0dBm	-97.5dBm	-99.5dBm	-93.3dBm
LTE-FDD B5 (10MHz)	-98.0dBm	-99.5dBm	-100.5dBm	-94.3dBm
LTE-FDD B7 (10MHz)	-96.0dBm	-96.0dBm	-98.5dBm	-94.3dBm
LTE-FDD B8 (10MHz)	-97.0dBm	-99.0dBm	-101.0dBm	-93.3dBm

Table 27: Conducted RF Receiving Sensitivity of EC21-J Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
LTE-FDD B1 (10MHz)	-97.5dBm	-98.7dBm	-100.2dBm	-96.3dBm
LTE-FDD B3 (10MHz)	-96.5dBm	-97.1dBm	-100.5dBm	-93.3dBm
LTE-FDD B8 (10MHz)	-98.4dBm	-99.0dBm	-101.2dBm	-93.3dBm
LTE-FDD B18 (10MHz)	-99.5dBm	-99.0dBm	-101.7dBm	-96.3dBm
LTE-FDD B19 (10MHz)	-99.2dBm	-99.0dBm	-101.4dBm	-96.3dBm
LTE-FDD B26 (10MHz)	-99.5dBm	-99.0dBm	-101.5dBm	-93.8dBm

Table 28: Conducted RF Receiving Sensitivity of EC21-AU Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
GSM850	-109.0dBm	/	/	-102.0dBm
EGSM900	-109.0dBm	/	/	-102.0dBm
DCS1800	-109.0dBm	/	/	-102.0dBm
PCS1900	-109.0dBm	/	/	-102.0dBm
WCDMA B1	-110.0dBm	/	/	-106.7dBm
WCDMA B2	-110.0dBm	/	/	-104.7dBm
WCDMA B5	-111.0dBm	/	/	-104.7dBm
WCDMA B8	-111.0dBm	/	/	-103.7dBm
LTE-FDD B1 (10MHz)	-97.2dBm	-97.5dBm	-100.2dBm	-96.3dBm
LTE-FDD B2 (10MHz)	-98.2dBm	/	/	-94.3dBm
LTE-FDD B3 (10MHz)	-98.7dBm	-98.6dBm	-102.2dBm	-93.3dBm
LTE-FDD B4 (10MHz)	-97.7dBm	-97.4dBm	-100.2dBm	-96.3dBm
LTE-FDD B5 (10MHz)	-98.0dBm	-98.2dBm	-101.0dBm	-94.3dBm
LTE-FDD B7 (10MHz)	-97.7dBm	-97.7dBm	-101.2dBm	-94.3dBm

LTE-FDD B8 (10MHz)	-99.2dBm	-98.2dBm	-102.2dBm	-93.3dBm
LTE-FDD B28 (10MHz)	-98.6dBm	-98.7dBm	-102.0dBm	-94.8dBm
LTE-TDD B40 (10MHz)	-97.2dBm	-98.4dBm	-101.2dBm	-96.3dBm

Table 29: Conducted RF Receiving Sensitivity of EC21-EU Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
EGSM900	-108.5dBm	/	/	-102.0dBm
DCS1800	-108.5dBm	/	/	-102.0dbm
WCDMA B1	-110dBm	/	/	-106.7dBm
WCDMA B8	-110dBm	/	/	-103.7dBm
LTE-FDD B1 (10MHz)	-98.5dBm	-99dBm	-101.2dBm	-96.3dBm
LTE-FDD B3 (10MHz)	-97.8dBm	-99.7dBm	-101.7dBm	-93.3dBm
LTE-FDD B7 (10MHz)	-96.7dBm	-98.5dBm	-99.7dBm	-94.3dBm
LTE-FDD B8 (10MHz)	-98.7dBm	-100dBm	-102.2dBm	-93.3dBm
LTE-FDD B20 (10MHz)	-98.7dBm	-99.5dBm	-102.2dBm	-93.3dBm
LTE-FDD B28 (10MHz)	-99dBm	-100dBm	-102.2dBm	-94.8dBm

Table 30: Conducted RF Receiving Sensitivity of EC21-EC Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
EGSM900	-108.8dBm	/	/	-102.0dBm
DCS1800	-109.0dBm	/	/	-102.0dbm
WCDMA B1	-110.5dBm	/	/	-106.7dBm
WCDMA B8	-110.5dBm	/	/	-103.7dBm
LTE-FDD B1 (10MHz)	-98.0dBm	-98.0dBm	-101.0dBm	-96.3dBm
LTE-FDD B3 (10MHz)	-96.5dBm	-98.5dBm	-100.0dBm	-93.3dBm

LTE-FDD B7 (10MHz)	-97.0dBm	-95.5dBm	-99.5dBm	-94.3dBm
LTE-FDD B8 (10MHz)	-97.0dBm	-97.0dBm	-101.0dBm	-93.3dBm
LTE-FDD B20 (10MHz)	-97.5dBm	-99.0dBm	-101.0dBm	-93.3dBm
LTE-FDD B28 (10MHz)	-98.6dBm	-98.7dBm	-101.5dBm	-94.8dBm

Table 31: Conducted RF Receiving Sensitivity of EC21-AUX Mini PCIe

Frequency	Primary	Diversity	SIMO[1)]	3GPP (SIMO)
GSM850	-109.0dBm	/	/	-102.0dBm
EGSM900	-109.0dBm	/	/	-102.0dBm
DCS1800	-109.0dBm	/	/	-102.0dBm
PCS1900	-109.0dBm	/	/	-102.0dBm
WCDMA B1	-110.0dBm	-109.5dBm	-112dBm	-106.7dBm
WCDMA B2	-110.5dBm	/	/	-104.7dBm
WCDMA B4	-110.0dBm	-110dBm	-112dBm	-104.7dBm
WCDMA B5	-111.0dBm	-112dBm	-113dBm	-104.7dBm
WCDMA B8	-111.0dBm	-112dBm	-113dBm	-103.7dBm
LTE-FDD B1 (10MHz)	-98.0dBm	-97.7dBm	-101.2dBm	-96.3dBm
LTE-FDD B2 (10MHz)	-98.5dBm	/	/	-94.3dBm
LTE-FDD B3 (10MHz)	-99.0dBm	-98.8dBm	-102.2dBm	-93.3dBm
LTE-FDD B4 (10MHz)	-97.7dBm	-97.6dBm	-100.2dBm	-96.3dBm
LTE-FDD B5 (10MHz)	-98.5dBm	-98.2dBm	-101.0dBm	-94.3dBm
LTE-FDD B7 (10MHz)	-97.7dBm	-97.7dBm	-101.2dBm	-94.3dBm
LTE-FDD B8 (10MHz)	-99.0dBm	-98.5dBm	-102.2dBm	-93.3dBm
LTE-FDD B28 (10MHz)	-98.0dBm	-98.7dBm	-101.5dBm	-94.8dBm
LTE-TDD B40 (10MHz)	-97.5dBm	-98.2dBm	-101.2dBm	-96.3dBm

NOTE

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

6.5. ESD Characteristics

The following table shows the ESD characteristics of EC21 Mini PCIe.

Table 32: ESD Characteristics of EC21 Mini PCIe

Tested Interfaces	Contact Discharge	Air Discharge	Unit
Power Supply and GND	+/-5	+/-10	KV
Antenna Interfaces	+/-4	+/-8	KV
USB Interface	+/-4	+/-8	KV
(U)SIM Interface	+/-4	+/-8	KV
Others	+/-0.5	+/-1	KV

6.6. Current Consumption

The following tables describe the current consumption of EC21 Mini PCIe series module.

Table 33: Current Consumption of EC21-A Mini PCIe

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	Sleep state	**AT+CFUN=0** (USB disconnected)	3.5	mA
		WCDMA PF=64 (USB disconnected)	5.0	mA
		WCDMA PF=128 (USB disconnected)	4.4	mA
		LTE-FDD PF=64 (USB disconnected)	5.3	mA
		LTE-FDD PF=128 (USB disconnected)	4.5	mA

	Idle state	WCDMA PF=64 (USB disconnected)	32.0	mA
		WCDMA PF=64 (USB connected)	45.0	mA
		LTE-FDD PF=64 (USB disconnected)	32.0	mA
		LTE-FDD PF=64 (USB connected)	45.0	mA
	WCDMA data transfer (GNSS OFF)	WCDMA B2 HSDPA @21.59dBm	582.0	mA
		WCDMA B2 HSUPA @22.17dBm	675.0	mA
		WCDMA B4 HSDPA @21.47dBm	575.0	mA
		WCDMA B4 HSUPA @21.73dBm	637.0	mA
		WCDMA B5 HSDPA @20.02dBm	686.0	mA
		WCDMA B5 HSUPA @20.18dBm	577.0	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B2 @22.93dBm	926.0	mA
		LTE-FDD B4 @22.72dBm	934.0	mA
		LTE-FDD B12 @23.26dBm	835.0	mA
	WCDMA voice call	WCDMA B2 @22.88dBm	610.0	mA
		WCDMA B4 @23.21dBm	743.0	mA
		WCDMA B5 @23.13dBm	643.0	mA

Table 34: Current Consumption of EC21-V Mini PCIe

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	Sleep state	**AT+CFUN=0** (USB disconnected)	3.8	mA
		LTE-FDD PF=64 (USB disconnected)	5.3	mA
		LTE-FDD PF=128 (USB disconnected)	4.9	mA
	Idle state	LTE-FDD PF=64 (USB disconnected)	30.0	mA
		LTE-FDD PF=64 (USB connected)	42.0	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B4 @23.59dBm	997.0	mA
		LTE-FDD B13 @24.05dBm	724.0	mA

Table 35: Current Consumption of EC21-KL Mini PCIe

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	Sleep state	**AT+CFUN=0** (USB disconnected)	3.5	mA
		LTE-FDD PF=64 (USB disconnected)	5.6	mA
		LTE-FDD PF=128 (USB disconnected)	4.7	mA
	Idle state	LTE-FDD PF=64 (USB disconnected)	35.0	mA
		LTE-FDD PF=64 (USB connected)	49.0	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B1 @22.78dBm	972.0	mA
		LTE-FDD B3 @23.03dBm	974.0	mA
		LTE-FDD B5 @23.03dBm	764.0	mA
		LTE-FDD B7 @22.89dBm	959.0	mA
		LTE-FDD B8 @22.86dBm	839.0	mA

Table 36: Current Consumption of EC21-AUX Mini PCIe

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	Sleep state	**AT+CFUN=0** (USB disconnected)	1.79	mA
		GSM DRX=2 (USB disconnected)	3.06	mA
		GSM DRX=9 (USB disconnected)	2.36	mA
		WCDMA PF=64 (USB disconnected)	3.70	mA
		WCDMA PF=128 (USB disconnected)	3.28	mA
		LTE-FDD PF=64 (USB disconnected)	4.41	mA
		LTE-FDD PF=128 (USB disconnected)	3.59	mA
		LTE-TDD PF=64 (USB disconnected)	4.45	mA
		LTE-TDD PF=128 (USB disconnected)	3.68	mA
	Idle state	GSM DRX=5 (USB disconnected)	22.4	mA
		GSM DRX=5 (USB connected)	42.8	mA

		WCDMA PF=64 (USB disconnected)	23.1	mA
		WCDMA PF=64 (USB connected)	43.4	mA
		LTE-FDD PF=64 (USB disconnected)	30.7	mA
		LTE-FDD PF=64 (USB connected)	43.5	mA
		LTE-TDD PF=64 (USB disconnected)	31.2	mA
		LTE-TDD PF=64 (USB connected)	43.8	mA
	GPRS data transfer (GNSS OFF)	GSM850 4DL/1UL @32.50dBm	335.0	mA
		GSM850 3DL/2UL @31.69dBm	537.0	mA
		GSM850 2DL/3UL @29.48dBm	605.0	mA
		GSM850 1DL/4UL @28.35dBm	701.0	mA
		EGSM900 4DL/1UL @33.50dBm	386.0	mA
		EGSM900 3DL/2UL @32.04dBm	563.0	mA
		EGSM900 2DL/3UL @29.52dBm	606.0	mA
		EGSM900 1DL/4UL @28.45dBm	703.0	mA
		DCS1800 4DL/1UL @29.72dBm	194.0	mA
		DCS1800 3DL/2UL @28.82dBm	291.0	mA
		DCS1800 2DL/3UL @26.79dBm	361.0	mA
		DCS1800 1DL/4UL @25.71dBm	450.0	mA
		PCS1900 4DL/1UL @29.44dBm	202.0	mA
		PCS1900 3DL/2UL @28.60dBm	306.0	mA
		PCS1900 2DL/3UL @26.46dBm	370.0	mA
		PCS1900 1DL/4UL @25.36dBm	456.0	mA
	EDGE data transfer (GNSS OFF)	GSM850 4DL/1UL PCL=8 @27.08dBm	223.0	mA
		GSM850 3DL/2UL PCL=8 @25.80dBm	370.0	mA
		GSM850 2DL/3UL PCL=8 @23.80dBm	492.0	mA

		GSM850 1DL/4UL PCL=8 @22.60dBm	623.0	mA
		EGSM900 4DL/1UL PCL=8 @27.42dBm	227.0	mA
		EGSM900 3DL/2UL PCL=8 @26.23dBm	371.0	mA
		EGSM900 2DL/3UL PCL=8 @24.10dBm	492.0	mA
		EGSM900 1DL/4UL PCL=8 @22.80dBm	626.0	mA
		DCS1800 4DL/1UL PCL=2 @26.50dBm	171.0	mA
		DCS1800 3DL/2UL PCL=2 @25.50dBm	280.0	mA
		DCS1800 2DL/3UL PCL=2 @23.60dBm	387.0	mA
		DCS1800 1DL/4UL PCL=2 @22.37dBm	504.0	mA
		PCS1900 4DL/1UL PCL=2 @26.26dBm	170.0	mA
		PCS1900 3DL/2UL PCL=2 @25.30dBm	280.0	mA
		PCS1900 2DL/3UL PCL=2 @23.10dBm	389.0	mA
		PCS1900 1DL/4UL PCL=2 @21.97dBm	508.0	mA
	WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA @21.57dBm	650.0	mA
		WCDMA B1 HSUPA @21.79dBm	667.0	mA
		WCDMA B2 HSDPA @22.00dBm	706.0	mA
		WCDMA B2 HSUPA @21.98dBm	715.0	mA
		WCDMA B5 HSDPA @22.90dBm	617.0	mA
		WCDMA B5 HSUPA @22.66dBm	633.0	mA
		WCDMA B8 HSDPA @21.59dBm	624.0	mA
		WCDMA B8 HSUPA @21.37dBm	654.0	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B1 @23.36dBm	938.0	mA
		LTE-FDD B2 @23.18dBm	953.0	mA
		LTE-FDD B3 @23.13dBm	814.0	mA
		LTE-FDD B4 @23.25dBm	778.0	mA

		LTE-FDD B5@23.06dBm	697.0	mA
		LTE-FDD B7 @23.17dBm	886.0	mA
		LTE-FDD B8 @22.89dBm	852.0	mA
		LTE-FDD B28 @22.55dBm	939.0.	mA
		LTE-TDD B40 @23.27dBm	421.0	mA
	GSM voice call	GSM850 PCL=5 @32.40dBm	322.0	mA
		EGSM900 PCL=5 @33.58dBm	379.0	mA
		DCS1800 PCL=0 @29.45dBm	182.0	mA
		PCS1900 PCL=0 @29.56dBm	195.0	mA
	WCDMA voice call	WCDMA B1 @22.15dBm	714.0	mA
		WCDMA B2 @22.77dBm	780.0	mA
		WCDMA B5 @23.16dBm	658.0	mA
		WCDMA B8 @22.62dBm	698.0	mA

Table 37: Current Consumption of EC21-EU Mini PCIe

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	Sleep state	**AT+CFUN=0** (USB disconnected)	3.6	mA
		GSM DRX=2 (USB disconnected)	5.3	mA
		GSM DRX=9 (USB disconnected)	4.2	mA
		WCDMA PF=64 (USB disconnected)	5.1	mA
		WCDMA PF=128 (USB disconnected)	4.5	mA
		LTE-FDD PF=64 (USB disconnected)	5.6	mA
		LTE-FDD PF=128 (USB disconnected)	4.8	mA
	Idle state	GSM DRX=5 (USB disconnected)	24.7	mA
		GSM DRX=5 (USB connected)	38.0	mA

		WCDMA PF=64 (USB disconnected)	25.3	mA
		WCDMA PF=64 (USB connected)	38.0	mA
		LTE-FDD PF=64 (USB disconnected)	26.0	mA
		LTE-FDD PF=64 (USB connected)	37.0	mA
	GPRS data transfer (GNSS OFF)	EGSM900 4DL/1UL @33.39dBm	389.3	mA
		EGSM900 3DL/2UL @32.47dBm	593.6	mA
		EGSM900 2DL/3UL @29.49dBm	611.6	mA
		EGSM900 1DL/4UL @28.05dBm	682.1	mA
		DCS1800 4DL/1UL @31.44dBm	260.9	mA
		DCS1800 3DL/2UL @30.38dBm	391.2	mA
		DCS1800 2DL/3UL @28.27dBm	464.2	mA
		DCS1800 1DL/4UL @27.01dBm	550.5	mA
	EDGE data transfer (GNSS OFF)	EGSM900 4DL/1UL PCL=8 @26.39dBm	198.6	mA
		EGSM900 3DL/2UL PCL=8 @25.39dBm	303.9	mA
		EGSM900 2DL/3UL PCL=8 @23.34dBm	372.8	mA
		EGSM900 1DL/4UL PCL=8 @22.26dBm	451.4	mA
		DCS1800 4DL/1UL PCL=2 @26.49dBm	190.5	mA
		DCS1800 3DL/2UL PCL=2 @25.23dBm	300.4	mA
		DCS1800 2DL/3UL PCL=2 @22.96dBm	394.8	mA
		DCS1800 1DL/4UL PCL=2 @22.08dBm	496.9	mA
	WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA @23.00dBm	754.6	mA
		WCDMA B1 HSUPA @22.57dBm	662.3	mA
		WCDMA B8 HSDPA @22.97dBm	749.9	mA
		WCDMA B8 HSUPA @22.52dBm	662.5	mA
	LTE data	LTE-FDD B1 @22.09dBm	875.2	mA

	transfer (GNSS OFF)	LTE-FDD B3 @22.42dBm	938.3	mA
		LTE-FDD B7 @22.21dBm	1036.0	mA
		LTE-FDD B8 @23.37dBm	897.5	mA
		LTE-FDD B20 @22.72dBm	913.0	mA
		LTE-FDD B28A @21.72dBm	898.8	mA
	GSM voice call	EGSM900 PCL=5 @33.53dBm	385.0	mA
		DCS1800 PCL=0 @31.20dBm	256.0	mA
	WCDMA voice call	WCDMA B1 @23.45dBm	794.6	mA
		WCDMA B8 @23.51dBm	792.0	mA

Table 38: Current Consumption of EC21-AU Mini PCIe

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	Sleep state	**AT+CFUN=0** (USB disconnected)	2.8	mA
		GSM DRX=2 (USB disconnected)	4.3	mA
		GSM DRX=9 (USB disconnected)	3.3	mA
		WCDMA PF=64 (USB disconnected)	3.5	mA
		WCDMA PF=128 (USB disconnected)	3.1	mA
		LTE-FDD PF=64 (USB disconnected)	4.6	mA
		LTE-FDD PF=128 (USB disconnected)	3.9	mA
		LTE-TDD PF=64 (USB disconnected)	4.7	mA
		LTE-TDD PF=128 (USB disconnected)	3.9	mA
	Idle state	GSM DRX=5 (USB disconnected)	24.1	mA
		GSM DRX=5 (USB connected)	37.4	mA
		WCDMA PF=64 (USB disconnected)	25.4	mA
		WCDMA PF=64 (USB connected)	38.4	mA

		LTE-FDD PF=64 (USB disconnected)	25.4	mA
		LTE-FDD PF=64 (USB connected)	38.8	mA
		LTE-TDD PF=64 (USB disconnected)	25.8	mA
		LTE-TDD PF=64 (USB connected)	39.0	mA
	GPRS data transfer (GNSS OFF)	GSM850 4DL/1UL @32.62dBm	312.8	mA
		GSM850 3DL/2UL @32.52dBm	530.6	mA
		GSM850 2DL/3UL @30.53dBm	602.5	mA
		GSM850 1DL/4UL @29.27dBm	686.0	mA
		EGSM900 4DL/1UL @32.76dBm	344.5	mA
		EGSM900 3DL/2UL @32.80dBm	590.8	mA
		EGSM900 2DL/3UL @30.52dBm	657.3	mA
		EGSM900 1DL/4UL @29.49dBm	752.4	mA
		DCS1800 4DL/1UL @30.05dBm	229.1	mA
		DCS1800 3DL/2UL @30.02dBm	365.2	mA
		DCS1800 2DL/3UL @29.73dBm	501.5	mA
		DCS1800 1DL/4UL @29.62dBm	637.5	mA
		PCS1900 4DL/1UL @29.82dBm	228.2	mA
		PCS1900 3DL/2UL @29.92dBm	366.9	mA
		PCS1900 2DL/3UL @29.76dBm	496.2	mA
		PCS1900 1DL/4UL @29.35dBm	628.4	mA
	EDGE data transfer (GNSS OFF)	GSM850 4DL/1UL PCL=8 @26.62dBm	191.0	mA
		GSM850 3DL/2UL PCL=8 @26.56dBm	303.0	mA
		GSM850 2DL/3UL PCL=8 @26.39dBm	414.2	mA
		GSM850 1DL/4UL PCL=8 @26.25dBm	537.2	mA
		EGSM900 4DL/1UL PCL=8 @26.74dBm	196.3	mA

		EGSM900 3DL/2UL PCL=8 @26.91dBm	343.9	mA
		EGSM900 2DL/3UL PCL=8 @26.78dBm	449.6	mA
		EGSM900 1DL/4UL PCL=8 @26.67dBm	570.8	mA
		DCS1800 4DL/1UL PCL=2 @26.33dBm	199.2	mA
		DCS1800 3DL/2UL PCL=2 @26.65dBm	306.3	mA
		DCS1800 2DL/3UL PCL=2 @26.33dBm	419.8	mA
		DCS1800 1DL/4UL PCL=2 @26.35dBm	540.1	mA
		PCS1900 4DL/1UL PCL=2 @26.01dBm	186.5	mA
		PCS1900 3DL/2UL PCL=2 @26.45dBm	315.3	mA
		PCS1900 2DL/3UL PCL=2 @26.12dBm	406.6	mA
		PCS1900 1DL/4UL PCL=2 @26.09dBm	524.5	mA
	WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA @22.30dBm	758.3	mA
		WCDMA B1 HSUPA @21.62dBm	755.7	mA
		WCDMA B2 HSDPA @21.93dBm	792.0	mA
		WCDMA B2 HSUPA @21.99dBm	799.1	mA
		WCDMA B5 HSDPA @22.44dBm	746.5	mA
		WCDMA B5 HSUPA @22.14dBm	741.1	mA
		WCDMA B8 HSDPA @21.62dBm	625.1	mA
		WCDMA B8 HSUPA @21.65dBm	647.4	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B1 @23.71dBm	1025.4	mA
		LTE-FDD B2 @23.00dBm	996.0	mA
		LTE-FDD B3 @23.34dBm	950.1	mA
		LTE-FDD B4 @23.05dBm	892.1	mA
		LTE-FDD B5 @22.84dBm	816.1	mA
		LTE-FDD B7 @22.77dBm	1198.1	mA

		LTE-FDD B8 @23.04dBm	807.4	mA
		LTE-FDD B28A @23.54dBm	932.0	mA
		LTE-TDD B40 @23.79dBm	585.2	mA
	GSM voice call	GSM850 PCL=5 @32.80dBm	316.2	mA
		EGSM900 PCL=5 @33.16dBm	348.7	mA
		DCS1800 PCL=0 @29.81dBm	216.8	mA
		PCS1900 PCL=0 @29.79dBm	214.9	mA
	WCDMA voice call	WCDMA B1 @23.27dBm	823.4	mA
		WCDMA B2 @22.89dBm	898.7	mA
		WCDMA B5 @22.87dBm	776.9	mA
		WCDMA B8 @22.89dBm	685.6	mA

Table 39: GNSS Current Consumption of EC21 Mini PCIe Series Module

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT} (GNSS)	Searching (AT+CFUN=0)	Cold start @Passive Antenna	75.0	mA
		Lost state @Passive Antenna	74.0	mA
	Tracking (AT+CFUN=0)	Instrument environment	44.0	mA
		Open Sky @Passive Antenna	53.0	mA
		Open Sky @Active Antenna	58.0	mA

6.7. Thermal Consideration

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

- On customers' PCB design, please keep placement of the PCI Express Mini Card away from heating sources.
- Do not place components on the PCB area where the module is mounted, in order to facilitate adding of heatsink.

- Do not apply solder mask on the PCB area where the module is mounted, so as to ensure better heat dissipation performance.
- The reference ground of the area where the module is mounted should be complete, and add ground vias as many as possible for better heat dissipation.
- Add a heatsink on the top of the module and the heatsink should be designed with as many fins as possible to increase heat dissipation area. Meanwhile, a thermal pad with high thermal conductivity should be used between the heatsink and module.
- Add a thermal pad with appropriate thickness at the bottom of the module to conduct the heat to PCB.

The following figure shows the referenced heatsink design.

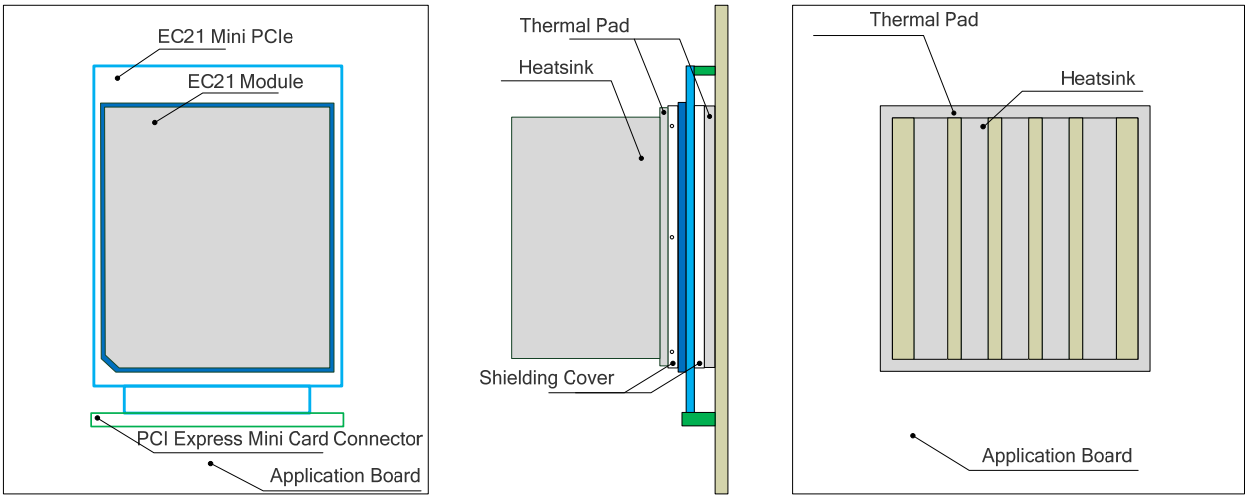


Figure 17: Referenced Heatsink Design

NOTES

1. The module offers the best performance when the internal BB chip stays below 105°C. When the maximum temperature of the BB chip reaches or exceeds 105°C, the module works normal but provides reduced performance (such as RF output power, data rate, etc.). When the maximum BB chip temperature reaches or exceeds 115°C, the module will disconnect from the network, and it will recover to network connected state after the maximum temperature falls below 115°C. Therefore, the thermal design should be maximally optimized to make sure the maximum BB chip temperature always maintains below 105°C. Customers can execute **AT+QTEMP** command and get the maximum BB chip temperature from the first returned value.
2. For more detailed guidelines on thermal design, please refer to ***document [4]***.

7 Dimensions and Packaging

7.1. General Description

This chapter mainly describes mechanical dimensions as well as packaging specification of EC21 Mini PCIe module. All dimensions are measured in mm, and the dimensional tolerances are ±0.05mm unless otherwise specified.

7.2. Mechanical Dimensions of EC21 Mini PCIe

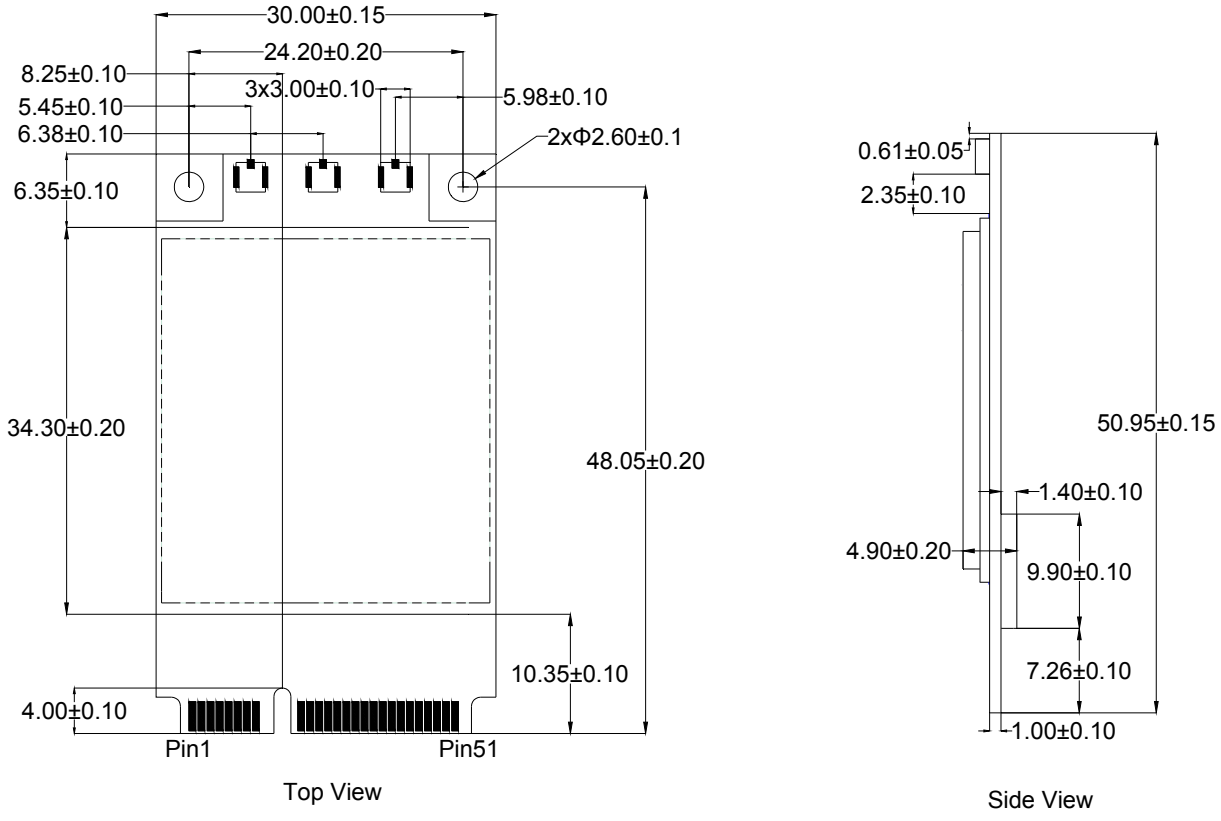


Figure 18: Mechanical Dimensions of EC21 Mini PCIe

7.3. Standard Dimensions of Mini PCI Express

The following figure shows the standard dimensions of Mini PCI Express. Please refer to ***document [1]*** for detailed A and B.

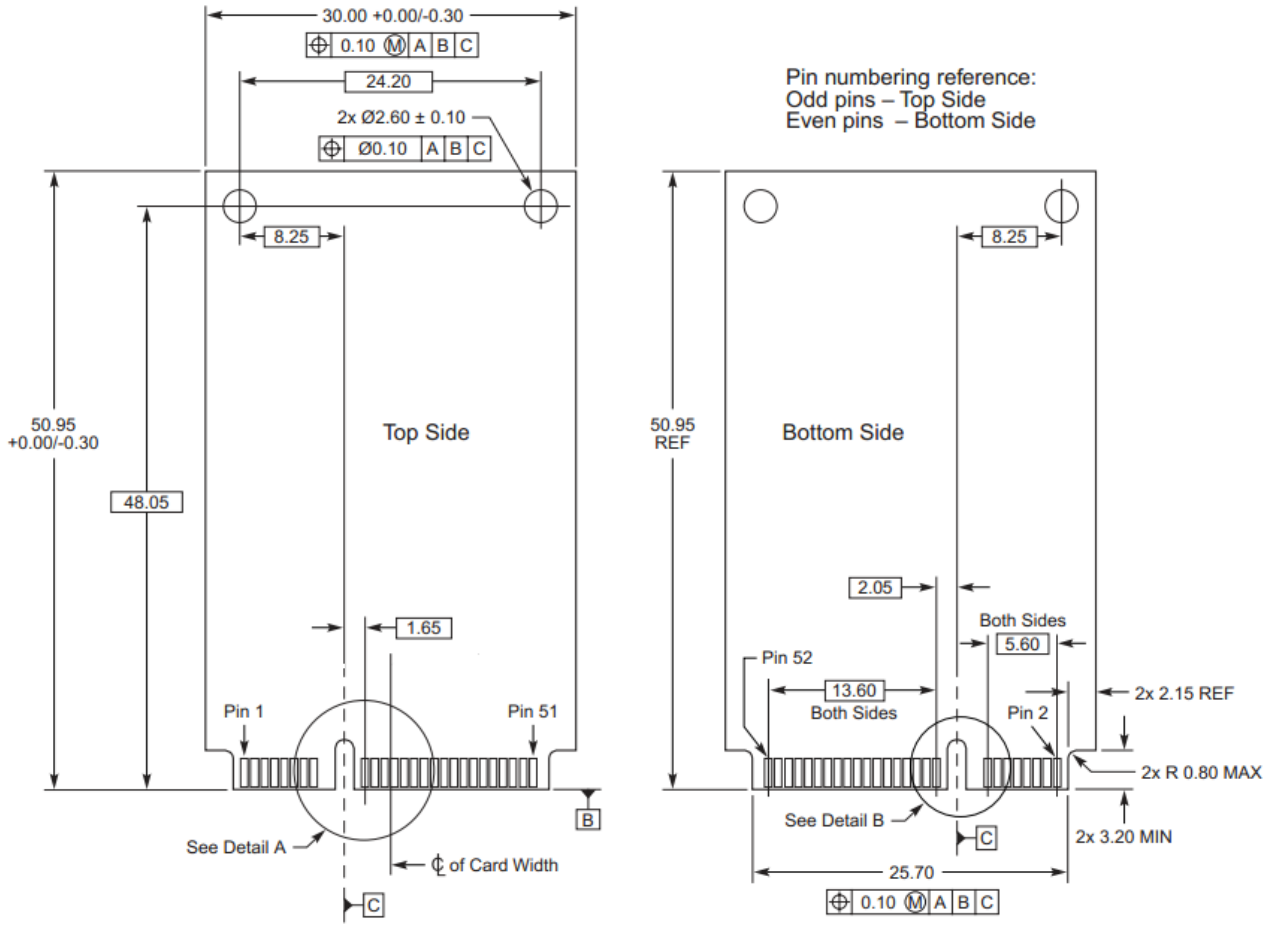


Figure 19: Standard Dimensions of Mini PCI Express

EC21 Mini PCIe adopts a standard Mini PCI Express connector which compiles with the directives and standards listed in the ***document [1]***. The following figure takes the Molex 679100002 as an example.

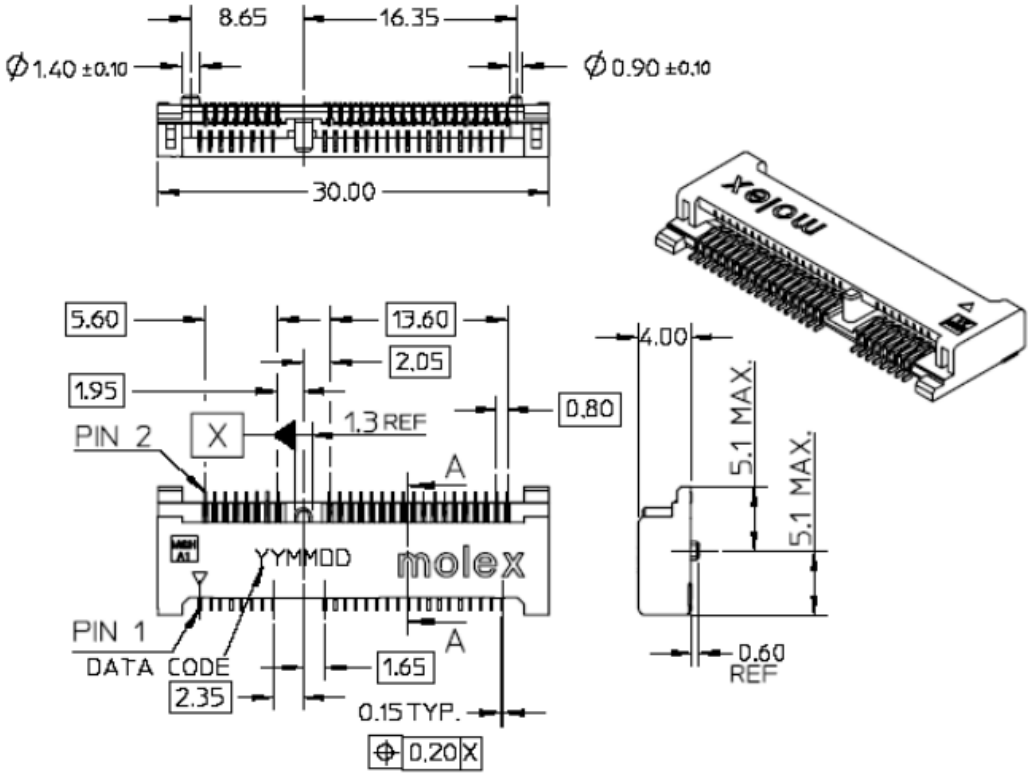


Figure 20: Dimensions of the Mini PCI Express Connector (Molex 679100002)

7.4. Packaging Specifications

The EC21 Mini PCIe is packaged in a tray. Each tray contains 10pcs of modules. The smallest package of EC21 Mini PCIe contains 100pcs.

8 Appendix A References

Table 40: Related Documents

SN	Document Name	Remark
[1]	PCI Express Mini Card Electromechanical Specification Revision 1.2	Mini PCI Express specification
[2]	Quectel_EC2x&EG9x&EM05_AT_Commands_Manual	AT commands manual for EC25, EC21, EC20 R2.0, EC20 R2.1, EG91, EG95 and EM05 modules
[3]	Quectel_EC2x&EGxx&EM05_GNSS_AT_Commands_Manual	GNSS AT Commands Manual for EC25, EC21, EC20 R2.0, EC20 R2.1, EG95, EG91, EG25-G and EM05 modules
[4]	Quectel_LTE_Module_Thermal_Design_Guide	Thermal design guide for LTE modules including EC25, EC21, EC20 R2.0, EC20 R2.1, EG91, EG95, EP06, EG06, EM06 and AG35.

Table 41: Terms and Abbreviations

Abbreviation	Description
AMR	Adaptive Multi-rate
bps	Bits Per Second
BT	Bluetooth
CS	Coding Scheme
CTS	Clear to Send
DC-HSPA+	Dual-carrier High Speed Packet Access
DFOTA	Delta Firmware Upgrade Over The Air
DL	Down Link

DTE	Data Terminal Equipment
DTR	Data Terminal Ready
EFR	Enhanced Full Rate
EMI	Electro Magnetic Interference
ESD	Electrostatic Discharge
ESR	Equivalent Series Resistance
FDD	Frequency Division Duplexing
FR	Full Rate
GLONASS	GLObalnaya Navigatsionnaya Sputnikovaya Sistema, the Russian Global Navigation Satellite System
GMSK	Gaussian Minimum Shift Keying
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HR	Half Rate
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
kbps	Kilo Bits Per Second
LED	Light Emitting Diode
LTE	Long-Term Evolution
Mbps	Million Bits Per Second
MCU	Micro Control Unit
ME	Mobile Equipment
MIMO	Multiple-Input Multiple-Output
MMS	Multimedia Messaging Service
MO	Mobile Originated

MT	Mobile Terminated
NMEA	National Marine Electronics Association
PCM	Pulse Code Modulation
PDA	Personal Digital Assistant
PDU	Protocol Data Unit
POS	Point of Sale
PPP	Point-to-Point Protocol
RF	Radio Frequency
RTS	Ready To Send
Rx	Receive
SIMO	Single Input Multiple Output
SMS	Short Message Service
TX	Transmitting Direction
TVS	Transient Voltage Suppressor
UART	Universal Asynchronous Receiver & Transmitter
UL	Up Link
URC	Unsolicited Result Code
USB	Universal Serial Bus
(U)SIM	(Universal) Subscriber Identification Module
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Networks