EP06 Series

Hardware Design

LTE-A Module Series

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About the Document

Revision History

Version	Date	Author	Description
1.0	2018-06-25	Vae LIU/ Wison HE	Initial
1.1	2018-08-07	Vae LIU	Updated the extended temperature range in Table 2 and 27.
1.2	2019-01-31	Ewent LU/ Xavier XIA/ Reed WANG	1. Deleted EP06-APAC and all the related information and added EP06-CN and the related information. 2. Updated the supported bands and 2×CA combination of EP06-A in Table 1. 3. Updated the names of pins 8, 10, 12 and 14 of USIM1 interface. 4. Updated the Reference Circuit of USB 2.0 & 3.0 Interface in Figure 5. 5. Added Chapter 4 GNSS Receiver and updated the GNSS Performance in Table 14. 6. Updated the description of antenna connectors and antenna requirements in Chapter 5. 7. Updated EP06-E and EP06-A Conducted RF Receiving Sensitivity in Chapter 6.4. 8. Updated EP06-E and EP06-A Current Consumption in Chapter 6.7.
1.3	2020-08-08	Archibald JIANG	1. Deleted EP06-LA and EP06-CN. 2. Updated the weight and the dimensions in Table 2. 3. Updated the note for GNSS antenna requirements in Chapter 5.4. 4. Added the GNSS current consumption of EP06-E and EP06-A in Chapter 6.7. 5. Updated mechanical dimensions of the module in Chapter 7.1.

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1 Introduction

The document defines the EP06 series module and describes its air interface and hardware interfaces which are connected with customers' applications.

This document helps customers quickly understand module interface specifications, electrical and mechanical details, as well as other related information of the module. To facilitate application designs, it also includes some reference designs for your reference. The document, coupled with application notes and user guides, makes it easy to design and set up mobile applications with EP06 series.

1.1. Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating the module. Manufacturers of the cellular terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all manuals of the product. Otherwise, Quectel assumes no liability for customers' failure to comply with these precautions.

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

2 Product Concept

2.1. General Description

EP06 is a series of LTE-A/UMTS/HSPA+ wireless communication modules with receive diversity. It provides data connectivity on LTE-FDD, LTE-TDD, DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA networks with PCI Express Mini Card 1.2 standard interface.

EP06 series supports embedded operating systems such as Windows CE, Linux and Android, and also provides GNSS [1)] and voice functionality [2)] to meet your specific application demands. EP06 series contains two variants: EP06-E and EP06-A. You can select a dedicated type based on your application regions or target operators.

The following table shows the frequency bands and GNSS types of EP06 series.

Table 1: Frequency Bands and GNSS Types of EP06 Series

Mode	EP06-E	EP06-A
LTE-FDD (with Rx-diversity)	B1/B3/B5/B7/B8/B20/B28/B32 [3)]	B2/B4/B5/B7/B12/B13/B25/B26/ B29 [3)]/B30/B66
LTE-TDD (with Rx-diversity)	B38/B40/B41	Not supported
2 × CA	B1+B1/B5/B8/B20/B28; B3+B3/B5/B7/B8/B20/B28; B7+B5/B7/B8/B20/B28; B20+B32 [3)]; B38+B38; B40+B40; B41+B41	B2+B2/B5/B12/B13/B29 [3)]; B4+B4/B5/B12/B13/B29 [3)]; B7+B5/B7/B12/B26; B25+B5/B12/B25/B26; B30+B5/B12/B29[4)]; B66+B5/B12/B13/B29[4)]/B66
WCDMA (with Rx-diversity)	B1/B3/B5/B8	B2/B4/B5
GNSS	GPS, GLONASS, BeiDou/Compass, Galileo, QZSS	GPS, GLONASS, BeiDou/Compass, Galileo, QZSS QZSS

NOTES

1. [1)] GNSS function is optional.
2. [2)] EP06 series contains **Telematics** version and **Data-only** version. **Telematics** version supports voice and data functions, while **Data-only** version only supports data function.
3. [3)] LTE-FDD B29 and B32 support Rx only, and in 2 × CA they are only for secondary component carrier.

EP06 series can be applied in the following fields:

- Rugged Tablet PC
- Remote Monitor System
- Vehicle System
- Wireless POS System
- Smart Metering System
- Wireless Router and Switch
- Other Wireless Terminal Devices

2.2. Key Features

The following table describes the detailed features of EP06 series.

Table 2: Key Features of EP06 Series

Feature	Details
Functional Interface	PCI Express Mini Card 1.2 Standard Interface
Power Supply	Supply voltage: 3.1–4.4 V Typical supply voltage: 3.3 V
Transmitting Power	Class 3 (23 dBm ±2 dB) for LTE-FDD bands Class 3 (23 dBm ±2 dB) for LTE-TDD bands Class 3 (24 dBm +1/-3 dB) for WCDMA bands
LTE Features	Support up to LTE Cat 6 Support 1.4 to 40 MHz (DL 2 × CA) RF bandwidth Support 2 × 2 MIMO in DL direction FDD: Max 300 Mbps (DL)/50 Mbps (UL) TDD: Max 226 Mbps (DL)/28 Mbps (UL)
UMTS Features	Support 3GPP R8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA Support QPSK, 16-QAM and 64-QAM modulation DC-HSDPA: Max 42 Mbps

	HSUPA: Max 5.76 Mbps WCDMA: Max 384 kbps (DL)/Max 384 kbps (UL)
Internet Protocol Features	Support PPP/QMI/TCP*/UDP*/FTP*/HTTP*/NTP*/PING*/HTTPS*/SMTP*/MMS*/FTPS*/SMTPS*/SSL* protocols Support PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) protocols usually used for PPP connections
SMS	Text and PDU mode Point to point MO and MT SMS cell broadcast SMS storage: ME by default
(U)SIM Interface	Support (U)SIM card: 1.8 V, 3.0 V Include USIM1 and USIM2 interfaces Support Dual SIM Single Standby
Audio Feature	Support one digital audio interface: PCM interface WCDMA: AMR/AMR-WB LTE: AMR/AMR-WB Support echo cancellation and noise suppression
PCM Interface	Used for audio function with external codec Support 16-bit linear data formats Support long frame synchronization and short frame synchronization Support master and slave mode, but must be the master in long frame synchronization
USB 2.0&3.0 Interface	Compliant with USB 3.0 and 2.0 specifications, with maximum transmission rates up to 5 Gbps on USB 3.0 and 480 Mbps on USB 2.0. Used for AT command communication, data transmission, firmware upgrade, software debugging, GNSS NMEA sentence output and voice over USB* Support USB serial drivers for: Windows 7/8/8.1/10, Windows CE 5.0/6.0/7.0*, Linux 2.6/3.x/4.1–4.14, Android 4.x/5.x/6.x/7.x/8.x
Antenna Interfaces	Include main antenna, diversity antenna and GNSS antenna interfaces
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	Dimensions: (30.0 ±0.15) mm × (50.95 ±0.15) mm × (3.95 ±0.20) mm Weight: approx. 10.1 g
Temperature Range	Operating temperature range: -35°C to +75°C[1)] Extended temperature range: -40°C to +85°C[2)] Storage temperature range: -40°C to +90°C

Firmware Upgrade	USB interface and DFOTA
RoHS	All hardware components are fully compliant with EU RoHS directive

NOTES

1. "*" means under development.
2. [1] Within operating temperature range, the module is 3GPP compliant.
3. [2] Within extended temperature range, proper mounting, heating sinks and active cooling may be required to make certain functions of the module such as voice, SMS, data transmission, emergency call to be realized. Only one or more parameters like Pout might reduce in their value and exceed the specified tolerances. When the temperature returns to normal operating temperature levels, the module will meet 3GPP specifications again.

2.3. Functional Diagram

The following figure shows the block diagram of EP06 series.

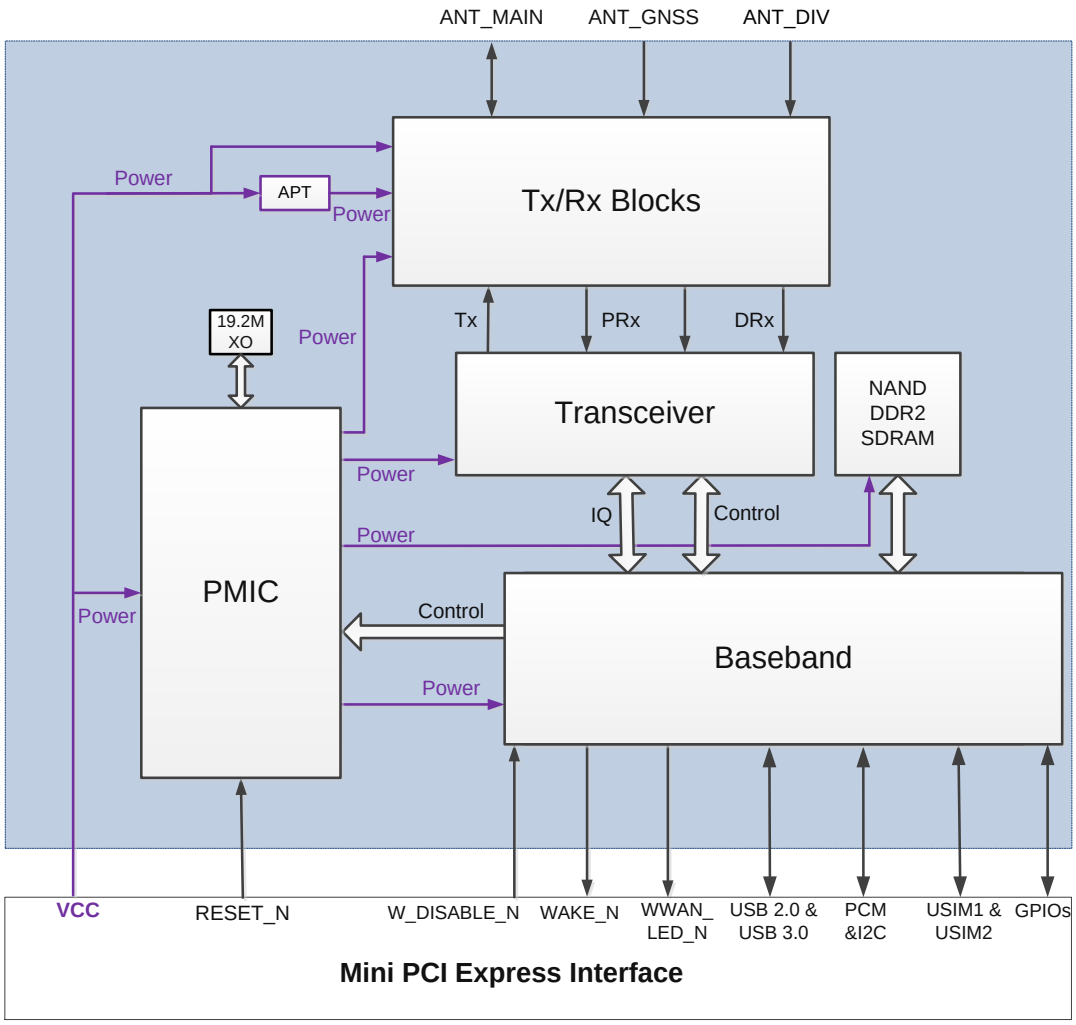


Figure 1: Functional Diagram

2.4. Evaluation Board

In order to help you develop applications conveniently with the module, Quectel supplies an evaluation board (EPXX EVB), USB Type-C cable, USB to RS-232 converter cable, earphone, antenna and other peripherals to control or test the module. For more details, refer to ***document [1]***.

3 Application Interfaces

Physical connections and signal levels of the module comply with PCI Express Mini CEM specifications. This chapter mainly describes definition and application of the following module interfaces and signals:

- Power supply
- (U)SIM interfaces
- USB interface
- PCM and I2C interfaces
- Control and indicator signals
- Tunable antenna control interface*
- Antenna interfaces

NOTE

"*" means under development.

3.1. Pin Assignment

The following figure shows the pin assignment of the module. The module and antenna connectors are disposed on the top side.

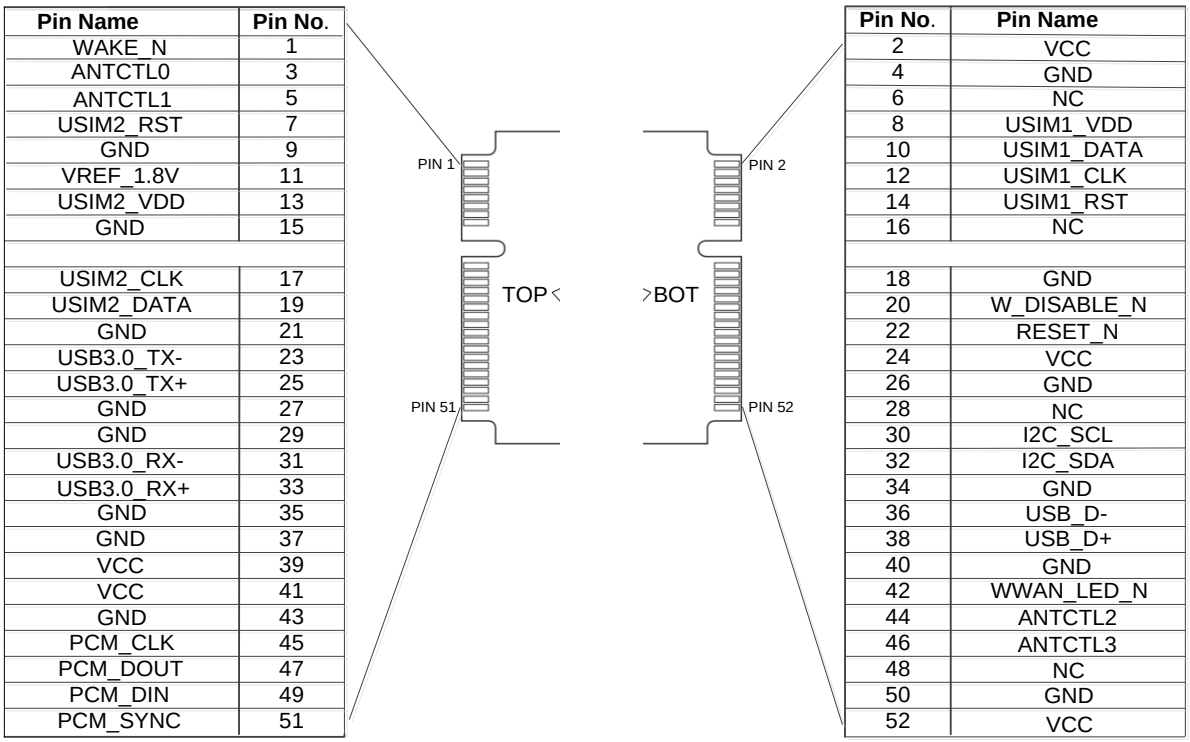


Figure 2: Pin Assignment of EP06 Series

3.2. Pin Description

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

Table 3: Definition of I/O Parameters

Type	Description
AI	Analog Input
AO	Analog Output
DI	Digital Input
DO	Digital Output
IO	Bidirectional
OC	Open Collector
OD	Open Drain

PI	Power Input
PO	Power Output

Table 4: Pin Description

Pin No.	Mini PCI Express Standard Name	Pin Name	I/O	Description	Comment
1	WAKE#	WAKE_N*	OD	Output signal to wake up the host	
2	3.3Vaux	VCC	PI	3.3 V DC power supply	Vmin = 3.1 V Vnorm = 3.3 V Vmax = 4.4 V
3	COEX1	ANTCTL0*	DO	Tunable antenna control	1.8 V power domain
4	GND	GND		Ground	
5	COEX2	ANTCTL1*	DO	Tunable antenna control	1.8 V power domain
6	1.5V	NC		Not connected	
7	CLKREQ#	USIM2_RST	DO	Reset signal of (U)SIM2 card	1.8/ 3.0 V
8	UIM_PWR	USIM1_VDD	PO	Power supply for (U)SIM1 card	1.8/ 3.0 V
9	GND	GND		Ground	
10	UIM_DATA	USIM1_DATA	IO	Data signal of (U)SIM1 card	1.8/ 3.0 V
11	REFCLK-	VREF_1.8V	PO	1.8 V reference voltage output	
12	UIM_CLK	USIM1_CLK	DO	Clock signal of (U)SIM1 card	1.8/ 3.0 V
13	REFCLK+	USIM2_VDD	PO	Power supply for (U)SIM2 card	1.8/ 3.0 V
14	UIM_RESET	USIM1_RST	DO	Reset signal of (U)SIM1 card	1.8/ 3.0 V
15	GND	GND		Ground	
16	UIM_VPP	NC		Not connected	
17	RESERVED	USIM2_CLK	DO	Clock signal of (U)SIM2 card	1.8/ 3.0 V
18	GND	GND		Ground	
19	RESERVED	USIM2_DATA	IO	Data signal of (U)SIM2 card	1.8/ 3.0 V

20	W_DISABLE#	W_DISABLE_N*	DI	Airplane mode control	1.8 V power domain
21	GND	GND		Ground	
22	PERST#	RESET_N	DI	System reset	Active low
23	PERn0	USB3.0_TX-	AO	USB 3.0 transmit data (-)	
24	3.3Vaux	VCC	PI	3.3 V DC power supply	Vmin = 3.1 V Vnorm = 3.3 V Vmax = 4.4 V
25	PERp0	USB3.0_TX+	AO	USB 3.0 transmit data (+)	
26	GND	GND		Ground	
27	GND	GND		Ground	
28	1.5V	NC		Not connected	
29	GND	GND		Ground	
30	SMB_CLK	I2C_SCL	DO	I2C serial clock	Externally pulled up to 1.8 V
31	PETn0	USB3.0_RX-	AI	USB 3.0 receive data (-)	
32	SMB_DATA	I2C_SDA	IO	I2C serial data	Externally pulled up to 1.8 V
33	PETp0	USB3.0_RX+	AI	USB 3.0 receive data (+)	
34	GND	GND		Ground	
35	GND	GND		Ground	
36	USB_D-	USB_D-	AI/AO	USB 2.0 differential data (-)	
37	GND	GND		Ground	
38	USB_D+	USB_D+	AI/AO	USB 2.0 differential data (+)	
39	3.3Vaux	VCC	PI	3.3 V DC power supply	Vmin = 3.1 V Vnorm = 3.3 V Vmax = 4.4 V
40	GND	GND		Ground	
41	3.3Vaux	VCC	PI	3.3 V DC power supply	Vmin = 3.1 V Vnorm = 3.3 V Vmax = 4.4 V
42	LED_WWAN#	WWAN_LED_N	OD	It is an open collector and active low signal. It allows the module to	

				provide RF status indication via LED devices provided by the system.	
43	GND	GND		Ground	
44	LED_WLAN#	ANTCTL2*	DO	Tunable antenna control	1.8 V power domain
45	RESERVED	PCM_CLK	DI/DO	PCM clock signal	
46	LED_WPAN#	ANTCTL3*	DO	Tunable antenna control	1.8 V power domain
47	RESERVED	PCM_DOUT	DO	PCM data output	
48	1.5V	NC		Not connected	
49	RESERVED	PCM_DIN	DI	PCM data input	
50	GND	GND		Ground	
51	RESERVED	PCM_SYNC	DI/DO	PCM frame synchronization signal	In master mode, it is an output signal. In slave mode, it is an input signal.
52	3.3Vaux	VCC	PI	3.3 V DC power supply	Vmin = 3.1 V Vnorm = 3.3 V Vmax = 4.4 V

NOTES

1. Keep all NC and unused pins unconnected.
2. "*" means under development.

3.3. Power Supply

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

Table 5: Definition of VCC and GND Pins

Pin No.	Pin Name	I/O	Power Domain	Description
2, 24, 39, 41, 52	VCC	PI	3.1–4.4 V	3.3 V typical DC power supply

4, 9, 15, 18, 21, 26, 27, 29, 34, 35, 37, 40, 43, 50	GND	Ground

The typical supply voltage of the module is 3.3 V. The power supply must be able to provide at least 2 A current, and a bypass capacitor of no less than 470 µF with low ESR should be used to prevent the voltage from dropping.

The following figure shows a reference design of power supply. The tolerance of resistors R2 and R3 is recommended to be 1 %, and the capacitor C3 needs a low ESR.

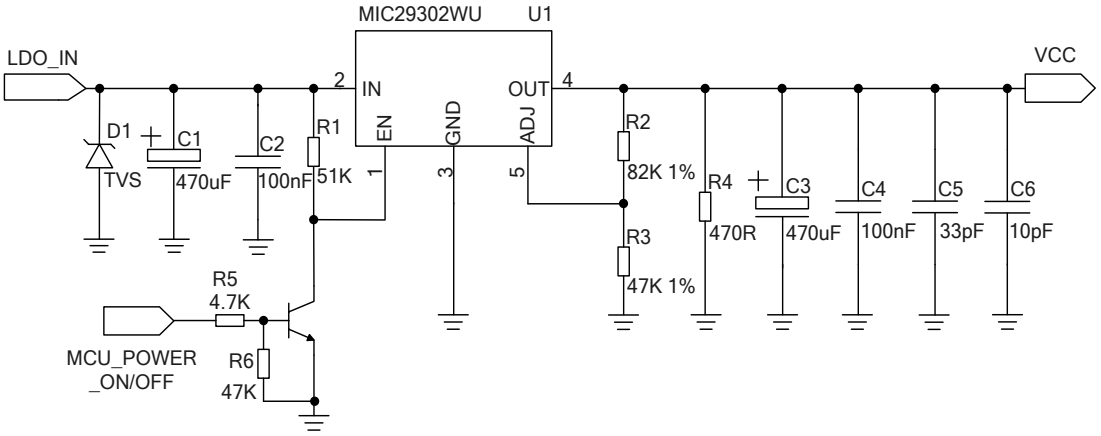


Figure 3: Reference Design of Power Supply

3.4. (U)SIM Interfaces

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

The following table shows the pin definition of (U)SIM interfaces.

Table 6: Pin Definition of (U)SIM Interfaces

Pin No.	Pin Name	I/O	Power Domain	Description
8	USIM1_VDD	PO	1.8/ 3.0 V	Power source for (U)SIM1 card
10	USIM1_DATA	IO	1.8/ 3.0 V	Data signal of (U)SIM1 card
12	USIM1_CLK	DO	1.8/ 3.0 V	Clock signal of (U)SIM1 card

14	USIM1_RST	DO	1.8/ 3.0 V	Reset signal of (U)SIM1 card
13	USIM2_VDD	PO	1.8/ 3.0 V	Power source for (U)SIM2 card
19	USIM2_DATA	IO	1.8/ 3.0 V	Data signal of (U)SIM2 card
17	USIM2_CLK	DO	1.8/ 3.0 V	Clock signal of (U)SIM2 card
7	USIM2_RST	DO	1.8/ 3.0 V	Reset signal of (U)SIM2 card

The following figure shows a reference design for (U)SIM card interface with a 6-pin (U)SIM card connector.

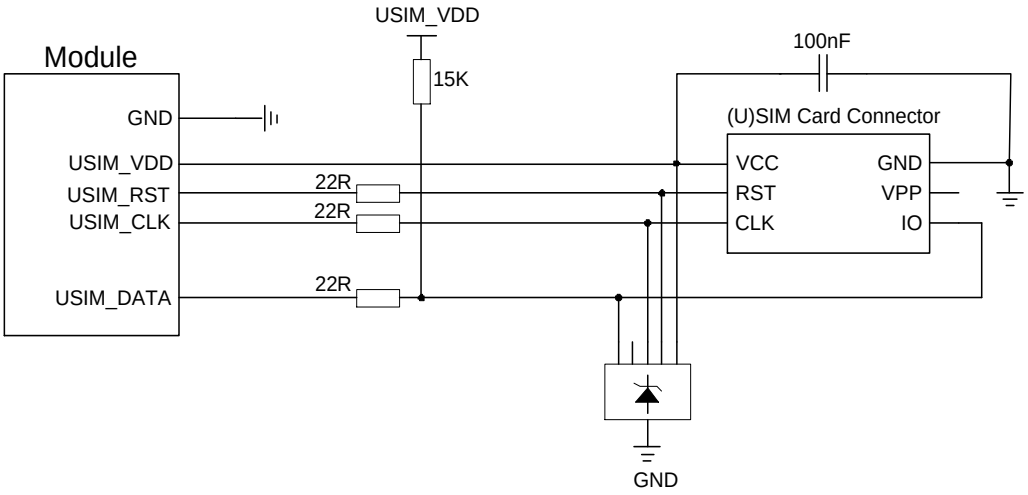


Figure 4: Reference Circuit of (U)SIM Card Interface with a 6-pin (U)SIM Card Connector

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

- Place the (U)SIM card connector as close to the module as possible. Keep the trace length as less than 200 mm as possible.
- Keep (U)SIM card signals away from RF and power supply traces.
- Keep the trace width of ground and USIM_VDD no less than 0.5 mm to maintain the same electric potential. The decoupling capacitor of USIM_VDD should be less than 1uF and must be placed close to (U)SIM card connector.
- 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 array with parasitic capacitance not exceeding 50pF. The 22 Ω resistors should be added in series between the module and the (U)SIM card so as to suppress EMI spurious transmission and enhance ESD protection. 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

is applied and sensitive occasion occurs, and should be placed close to the (U)SIM card connector.

3.5. USB Interface

The module provides one integrated Universal Serial Bus (USB) interface which complies with the USB 3.0/2.0 specifications and supports super speed (5 Gbps) on USB 3.0, high speed (480 Mbps) and full speed (12 Mbps) modes on USB 2.0. The USB interface is used for AT command communication, data transmission, GNSS NMEA output, software debugging, firmware upgrade and voice over USB*.

The following table shows the pin definition of USB interface.

Table 7: Pin Definition of USB Interface

Pin No.	Pin Name	I/O	Power Domain	Description	Comment
36	USB_D-	AI/AO	Compliant with USB 2.0 standard specification	USB 2.0 differential data (-)	Require differential impedance of 90 Ω
38	USB_D+	AI/AO		USB 2.0 differential data (+)	
23	USB3.0_TX-	AO	Compliant with USB 3.0 standard specification	USB 3.0 transmit data (-)	Require differential impedance of 90 Ω
25	USB3.0_TX+	AO		USB 3.0 transmit data (+)	
31	USB3.0_RX-	AI		USB 3.0 receive data (-)	
33	USB3.0_RX+	AI		USB 3.0 receive data (+)	

For more details about the USB 2.0 & 3.0 specifications, please visit http://www.usb.org/home.

The USB interface is recommended to be reserved for firmware upgrade in customers' designs. The following figure shows a reference circuit of USB 2.0 & 3.0 interfaces.

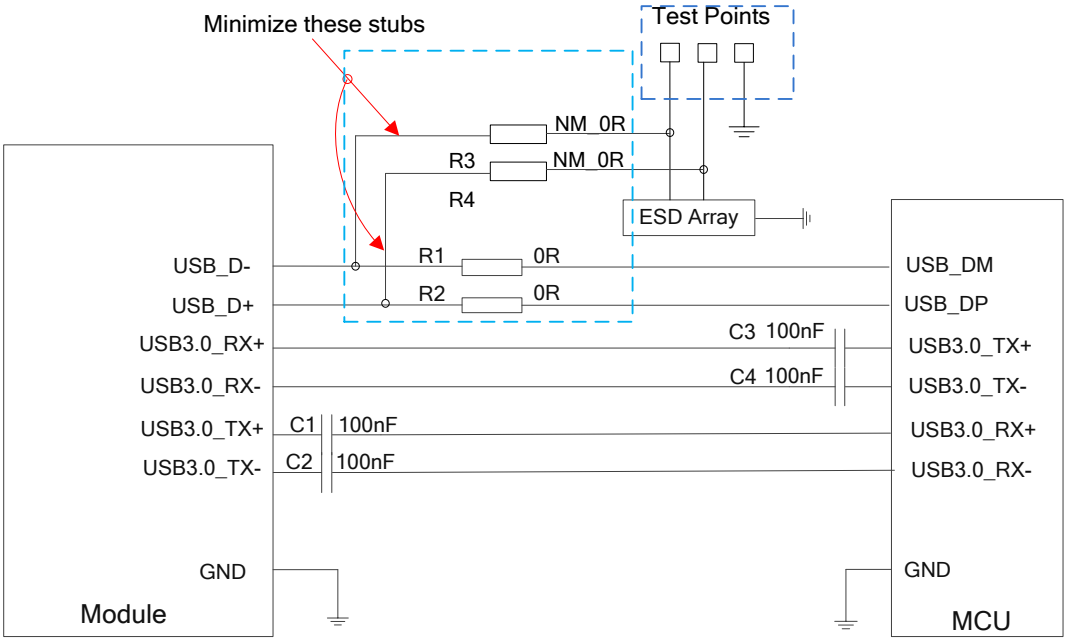


Figure 5: Reference Circuit of USB 2.0 & 3.0 Interfaces

In order to ensure the signal integrity of USB data lines, C1 and C2 have been placed inside the module, C3 and C4 should be placed close to the MCU, and R1, R2, R3 and R4 should be placed close to the module and also close to each other. The extra stubs of trace must be as short as possible.

The following principles of USB interface design should be complied with, so as to meet USB 2.0 & USB 3.0 specifications.

- It is important to route the USB signal traces as differential pairs with ground surrounded. The impedance of USB differential trace is 90 Ω.
- For USB 2.0 signal traces, the trace length difference of the differential pair should be less than 2 mm.
- For USB 3.0 signal traces, the trace length difference of each differential pair (TX/RX) should be less than 0.7 mm.
- Do not route signal traces under crystals, oscillators, magnetic devices or RF signal traces. It is important to route the USB 2.0 and 3.0 differential traces in inner-layer of the PCB, and surround the traces with ground on that layer and with ground planes above and below.
- If a USB connector is used, please keep the ESD protection components as close to the USB connector as possible. Junction capacitance of the ESD protection device might cause influences on USB 2.0 and 3.0 data lines, so please pay attention to the selection of the device. Typically, the stray capacitance should be less than 2.0 pF for USB 2.0, and less than 0.4 pF for USB 3.0.
- If possible, reserve a 0 Ω resistor on USB_D+ and USB_D- lines, respectively.

NOTE

"*" means under development.

3.6. PCM and I2C Interfaces

The module supports audio communication via Pulse Code Modulation (PCM) digital interface and I2C interface.

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

Table 8: Pin Definition of PCM and I2C Interfaces

Pin No.	Pin Name	I/O	Power Domain	Description	Comment
45	PCM_CLK	DI/DO	1.8 V	PCM clock signal	
47	PCM_DOUT	DO	1.8 V	PCM data output	
49	PCM_DIN	DI	1.8 V	PCM data input	
51	PCM_SYNC	DI/DO	1.8 V	PCM frame synchronization signal	In master mode, it is an output signal. In slave mode, it is an input signal.
30	I2C_SCL	DO	1.8 V	I2C serial clock	Externally pulled up to 1.8 V.
32	I2C_SDA	IO	1.8 V	I2C serial data	Externally pulled up to 1.8 V.

The PCM interface supports the following modes:

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

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

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

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

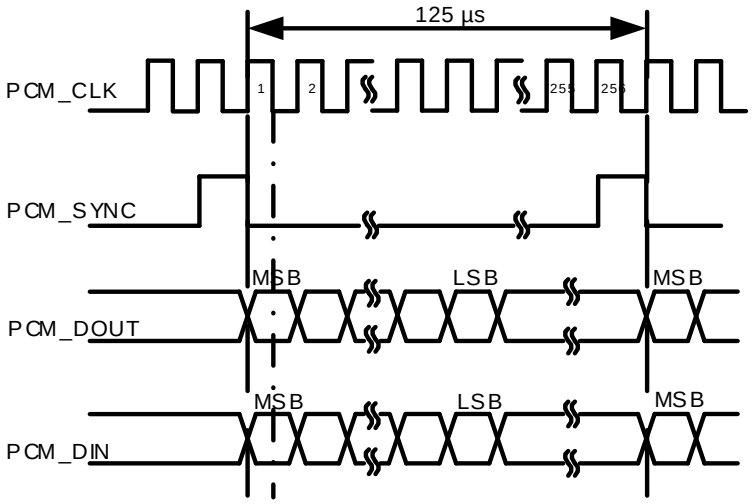


Figure 6: Primary Mode Timing

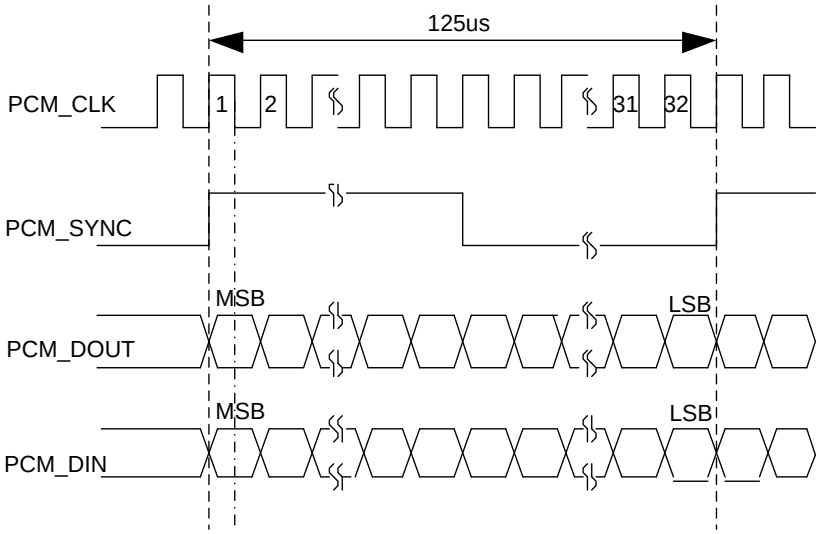


Figure 7: Auxiliary Mode Timing

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

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

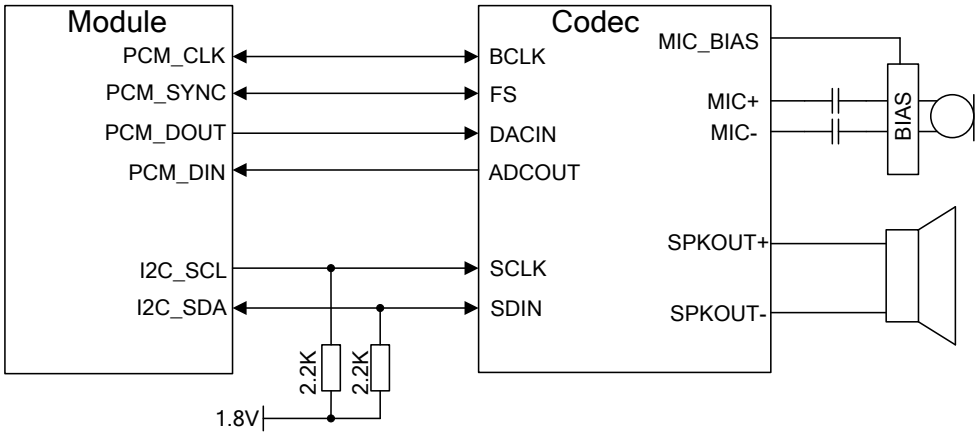


Figure 8: Reference Circuit of PCM Application with Audio Codec

NOTES

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

3.7. Control and Indicator Signals

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

Table 9: Pin Definition of Control and Indicator Signals

Pin No.	Pin Name	I/O	Power Domain	Description	Comment
1	WAKE_N*	OD		Output signal to wake up the host.	
20	W_DISABLE_N*	DI	1.8 V	Airplane mode control	Active low.
22	RESET_N	DI	1.8 V	System reset.	Active low.

42	WWAN_LED_N	OD	It is an open collector and active low signal. It allows the module to provide RF status indication via LED devices provided by the system.	Active low.

NOTE

"*" means under development.

3.7.1. WAKE_N Signal*

The WAKE_N signal is an open collector signal, but a host pull-up resistor and **AT+QCFG="risignaltype","physical"** command are required. When a URC is returned, a low level pulse will be outputted. The state of WAKE_N signal is shown below.

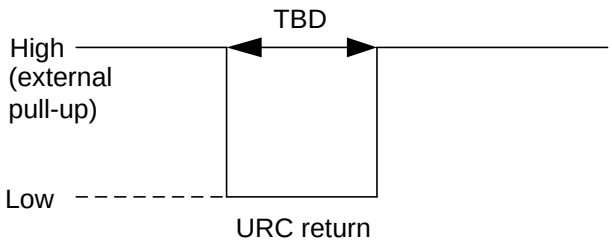


Figure 9: WAKE_N Behavior

3.7.2. W_DISABLE_N Signal*

The module provides a W_DISABLE_N signal to disable or enable the RF function (excluding GNSS). W_DISABLE_N for RF function control is disabled by default, and **AT+QCFG="airplanecontrol",1** can be used to enable the function.

W_DISABLE_N is pulled up by default. Driving it low sets the module into airplane mode.

Table 10: RF Function Status

W_DISABLE_N Level	AT Commands	RF Function Status
High Level	**AT+CFUN=1**	Enabled
High Level	**AT+CFUN=0**	Disabled

	AT+CFUN=4	
Low Level	**AT+CFUN=0** **AT+CFUN=1** **AT+CFUN=4**	Disabled

NOTE

"*" means under development.

3.7.3. RESET_N Signal

The RESET_N signal can be used to force a hardware reset of the module. Driving the pin low for 250–600 ms and then releasing it resets the module. The reset scenario is illustrated in the following figure.

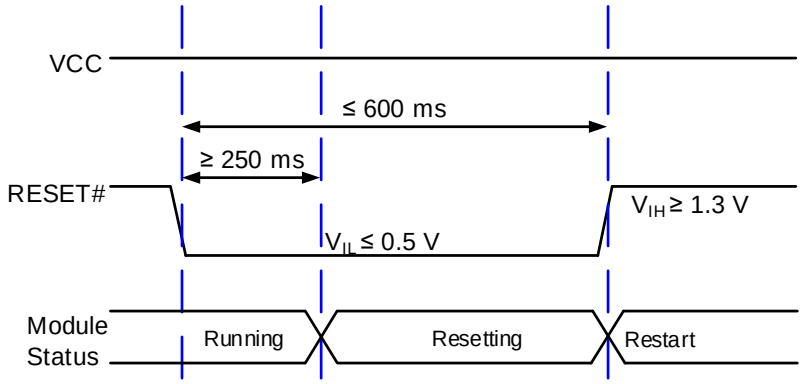


Figure 10: Timing of Resetting Module

3.7.4. WWAN_LED_N Signal

The WWAN_LED_N signal of the module is used to indicate the network status of the module and its maximum sink current is 40 mA. As shown in 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 WWAN_LED_N output signal is active low.

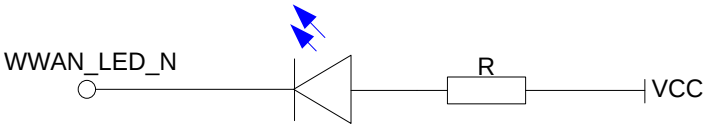


Figure 11: WWAN_LED_N Signal Reference Circuit Diagram

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

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

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

Table 11: Indications of Network Status (AT+QCFG="ledmode",0, Default Setting)

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

Table 12: 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_N signal is at low level. (RF function is disabled) • **AT+CFUN=0**, **AT+CFUN=4**

3.8. Tunable Antenna Control Interface*

ANTCTL[0:3] signals are used for tunable antenna control and should be routed to an appropriate antenna control circuitry.

More details about the interface will be added in the future version of the document.

Table 13: Pin Definition of Tunable Antenna Control Interface*

Pin Name	Pin No.	I/O	Description	Comment
ANTCTL0	3	DO	Tunable antenna control	1.8 V power domain
ANTCTL1	5	DO	Tunable antenna control	1.8 V power domain
ANTCTL2	44	DO	Tunable antenna control	1.8 V power domain
ANTCTL3	46	DO	Tunable antenna control	1.8 V power domain

NOTE

"*" means under development.

4 GNSS Receiver

4.1. General Description

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

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

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

4.2. GNSS Performance

The following table shows GNSS performance of the module.

Table 14: GNSS Performance

Parameter	Description	Conditions	Typ.	Unit
Sensitivity (GNSS)	Cold start	Autonomous	-145	dBm
	Reacquisition	Autonomous	-157	dBm
	Tracking	Autonomous	-157	dBm
TTFF (GNSS)	Cold start @ open sky	Autonomous	34.56	s
		XTRA enabled	19.41	s
	Warm start @ open sky	Autonomous	25.77	s
		XTRA enabled	2.26	s

	Hot start @open sky	Autonomous	2.66	s
		XTRA enabled	2.03	s
Accuracy (GNSS)	CEP-50	Autonomous @open sky	2.5	m

NOTES

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

4.3. Layout Guidelines

The following layout guidelines should be taken into account in customers' design.

- Maximize the distance among GNSS antenna, main antenna and Rx-diversity antenna.
- Digital circuits such as (U)SIM card, USB interface, camera module, display connector and SD card should be kept away from the antennas.
- Use ground vias around the GNSS trace and sensitive analog signal traces to provide coplanar isolation and protection.

5 Antenna Connection

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

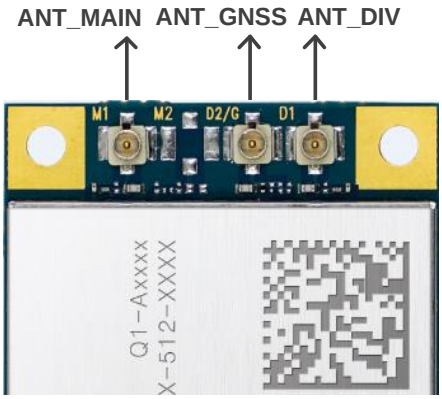


Figure 12: Antenna Connectors on the Module

5.1. Main/Rx-diversity Antenna Connectors

5.1.1. Description of Main/Rx-diversity Antenna Connectors

The details of main antenna and Rx-diversity antenna connectors are shown below.

Table 15: Description of Main/Rx-diversity Antenna Connectors

Connector	I/O	Description	Comment
M1	IO	Main antenna connector	50 Ω impedance
D1	AI	Receive diversity antenna connector	50 Ω impedance

5.1.2. Operating Frequency

Table 16: EP06-E Operating Frequencies

3GPP Band	Transmit	Receive	Unit
WCDMA B1	1920–1980	2110–2170	MHz
WCDMA B3	1710–1785	1805–1880	MHz
WCDMA B5	824–849	869–894	MHz
WCDMA B8	880–915	925–960	MHz
LTE B1	1920–1980	2110–2170	MHz
LTE B3	1710–1785	1805–1880	MHz
LTE B5	824–849	869–894	MHz
LTE B7	2500–2570	2620–2690	MHz
LTE B8	880–915	925–960	MHz
LTE B20	832–862	791–821	MHz
LTE B28	703–748	758–803	MHz
LTE B32 [1)]	-	1452–1496	MHz
LTE B38	2570–2620	2570–2620	MHz
LTE B40	2300–2400	2300–2400	MHz
LTE B41	2545–2655	2545–2655	MHz

NOTE

[1)] LTE-FDD B32 supports Rx only, and in 2 × CA it is only for secondary component carrier.

Table 17: EP06-A Operating Frequencies

3GPP Band	Transmit	Receive	Unit
WCDMA B2	1850–1910	1930–1990	MHz
WCDMA B4	1710–1755	2110–2155	MHz
WCDMA B5	824–849	869–894	MHz
LTE B2	1850–1910	1930–1990	MHz
LTE B4	1710–1755	2110–2155	MHz
LTE B5	824–849	869–894	MHz
LTE B7	2500–2570	2620–2690	MHz
LTE B12	699–716	729–746	MHz
LTE B13	777–787	746–756	MHz
LTE B25	1850–1915	1930–1995	MHz
LTE B26	814–849	859–894	MHz
LTE B29[1)]	-	717–728	MHz
LTE B30	2305–2315	2350–2360	MHz
LTE B66	1710–1780	2110–2200	MHz

NOTE

[1)] LTE-FDD B29 supports Rx only, and in 2 × CA it is only for secondary component carrier.

5.2. GNSS Antenna Connector

The following tables show details of GNSS antenna connector and the frequency specification of GNSS antenna.

Table 18: Description of GNSS Antenna Connector

Connector	I/O	Description	Comment
D2/G	AI	GNSS antenna connector	50 Ω impedance

Table 19: 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. Antenna Connectors and Mating Plugs

The dimensions of the antenna connectors are shown as below.

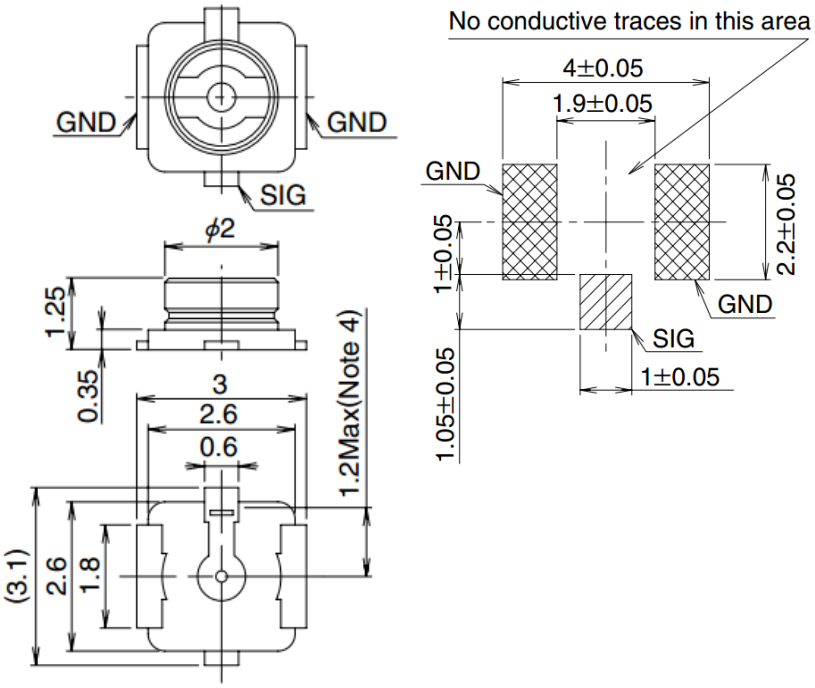


Figure 13: Dimensions of the Antenna Connectors (Unit: mm)

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

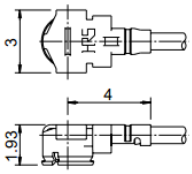
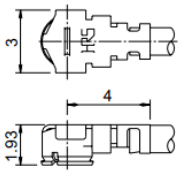
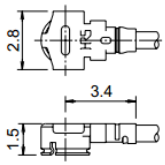
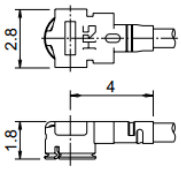
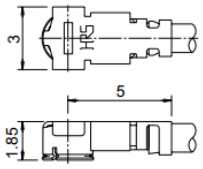
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 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 14: Mechanicals of U.FL-LP Mating Plugs

The following figure describes the space factor of mating plugs.

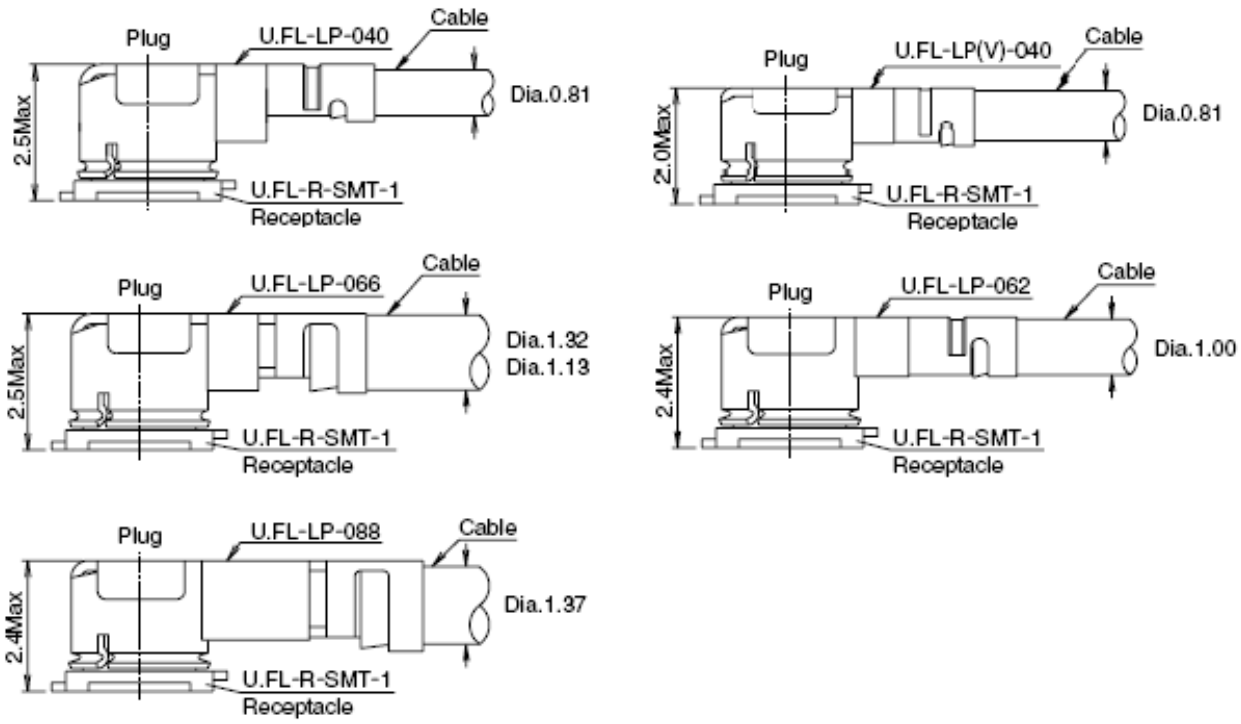


Figure 15: Space Factor of Mating Plugs (Unit: mm)

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

5.4. Antenna Requirements

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

Table 20: Antenna Requirements

Type	Requirements
GNSS[1)]	Frequency Range: 1559–1609 MHz Polarization: RHCP or linear VSWR: < 2 (Typ.) Passive Antenna Gain: > 0 dBi
WCDMA/LTE	VSWR: ≤ 2 Efficiency: >30 % Max Input Power: 50 W Input Impedance: 50 Ω Cable Insertion Loss: <1 dB (WCDMA B5/B6/B8/B19,

	LTE B5/B8/B12/B13/B18/B19/B20/B26/B28/B29) Cable Insertion Loss: <1.5 dB (WCDMA B1/B2/B3/B4/B9, LTE B1/B2/B3/B4/B25/B32/B39/B66) Cable Insertion Loss: < 2 dB (LTE B7/B38/B40/B41/B30)

NOTE

1) EP06 series module supports only passive GNSS antenna. If an active antenna is intended to be used, then it is necessary to design an external power supply circuit for the GNSS antenna. However, when LTE B13 or B14 is supported, it is recommended to use a passive GNSS antenna as the use of active antenna may generate harmonics which will affect the GNSS performance.

6 Electrical, Reliability and Radio Characteristics

6.1. General Description

This chapter mainly describes the following electrical and radio characteristics of the module:

- Absolute maximum ratings
- Power supply requirements
- RF characteristics
- GNSS performance
- Operating and storage temperatures
- ESD characteristics
- Current consumption
- Thermal consideration

6.2. Absolute Maximum Ratings

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

Table 21: Absolute Maximum Ratings

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

6.3. Power Supply Requirements

The typical input voltage of the module is 3.3 V, as specified by *PCI Express Mini CEM Specifications 1.2*. And the power supply of the module should be able to provide sufficient current 2 A at least. The following table shows the power supply requirements of the module.

Table 22: Power Supply Requirements of EP06 Series

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Power Supply	3.1	3.3	4.4	V

6.4. RF Characteristics

The following tables show the RF output power and receiving sensitivity of the module.

Table 23: RF Output Power

Frequency	Max.	Min.
WCDMA bands	24 dBm +1/-3 dB	< -50 dBm
LTE FDD bands	23 dBm ±2 dB	< -40 dBm
LTE TDD bands	23 dBm ±2 dB	< -40 dBm

Table 24: EP06-E Conducted RF Receiving Sensitivity

Frequency	Primary (Typ.)	Diversity (Typ.)	SIMO[1] (Typ.)	SIMO[2] (Worst Case)
WCDMA B1	-109.5 dBm	-107.5 dBm	/	-106.7 dBm
WCDMA B3	-108.5 dBm	-108.0 dBm	/	-103.7 dBm
WCDMA B5	-108.5 dBm	-109.0 dBm	/	-104.7 dBm
WCDMA B8	-109.5 dBm	-109.5 dBm	/	-103.7 dBm
LTE-FDD B1 (10 MHz)	-98.0 dBm	-96.0 dBm	-99.5 dBm	-96.3 dBm

LTE-FDD B3 (10 MHz)	-97.5 dBm	-97.5 dBm	-100.0 dBm	-93.3 dBm
LTE-FDD B5 (10 MHz)	-97.0 dBm	-98.5 dBm	-99.5 dBm	-94.3 dBm
LTE-FDD B7 (10 MHz)	-96.0 dBm	-96.0 dBm	-98.5 dBm	-94.3 dBm
LTE-FDD B8 (10 MHz)	-98.5 dBm	-98.0 dBm	-101.0 dBm	-93.3 dBm
LTE-FDD B20 (10 MHz)	-97.5 dBm	-99.0 dBm	-101.0 dBm	-93.3 dBm
LTE-FDD B28 (10 MHz)	-96.0 dBm	-98.0 dBm	-99.0 dBm	-94.8 dBm
LTE-TDD B38 (10 MHz)	-96.5 dBm	-96.0 dBm	-98.5 dBm	-96.3 dBm
LTE-TDD B40 (10 MHz)	-96.5 dBm	-97.0 dBm	-99.5 dBm	-96.3 dBm
LTE-TDD B41 (10 MHz)	-96.0 dBm	-96.0 dBm	-98.5 dBm	-94.3 dBm

Table 25: EP06-A Conducted RF Receiving Sensitivity

Frequency	Primary (Typ.)	Diversity (Typ.)	SIMO[1] (Typ.)	SIMO[2] (Worst Case)
WCDMA B2	-109.5 dBm	-108.5 dBm	/	-106.7 dBm
WCDMA B4	-109 dBm	-108.5 dBm	/	-103.7 dBm
WCDMA B5	-109.5 dBm	-110 dBm	/	-104.7 dBm
LTE-FDD B2 (10 MHz)	-98.2 dBm	-97.7 dBm	-100.7 dBm	-94.3 dBm
LTE-FDD B4 (10 MHz)	-97.7 dBm	-97.8 dBm	-100.2 dBm	-96.3 dBm
LTE-FDD B5 (10 MHz)	-98.0 dBm	-98.1 dBm	-100.9 dBm	-94.3 dBm
LTE-FDD B7 (10 MHz)	-96.2 dBm	-97 dBm	-98.2 dBm	-94.3 dBm
LTE-FDD B12 (10 MHz)	-97.2 dBm	-97.8 dBm	-101.7 dBm	-93.3 dBm
LTE-FDD B13 (10 MHz)	-97.7 dBm	-98.1 dBm	-100.7 dBm	-93.3 dBm
LTE-FDD B25 (10 MHz)	-98.8 dBm	-98.5 dBm	-100.5 dBm	-92.8 dBm
LTE-TDD B26 (10 MHz)	-98.5 dBm	-99.2 dBm	-101.8 dBm	-93.8 dBm
LTE-TDD B30 (10 MHz)	-96.9 dBm	-97.8 dBm	-99.2 dBm	-95.3 dBm
LTE-TDD B66 (10 MHz)	-98.1 dBm	-97.9 dBm	-100.6 dBm	-95.8 dBm

NOTES

1. [1] SIMO is a smart antenna technology that uses a single antenna at the transmitter side and two antennas at the receiver side to improve Rx performance.
2. [2] As per 3GPP specification.

6.5. Operating and Storage Temperatures

Table 26: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operating Temperature Range[1]	-35	+25	+75	ºC
Extended Temperature Range[2]	-40		+85	ºC
Storage temperature Range	-40		+90	ºC

NOTES

1. [1] Within the operating temperature range, the module meets 3GPP specifications..
2. [2] Within the extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, etc. without any unrecoverable malfunction. Radio spectrum and radio network will not be influenced, while one or more specifications, such as P_{out}, may undergo a reduction in value, exceeding the specified tolerances of 3GPP. When the temperature returns to the normal operating temperature level, the module meets 3GPP specifications again.

6.6. Electrostatic Discharge

The module is not protected against electrostatics discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates the module.

The following table shows the module electrostatic discharge characteristics.

Table 27: Electrostatic Discharge Characteristics (Temperature: 25 °C, Humidity: 45%)

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

6.7. Current Consumption

The following table shows the current consumption of EP06-E.

Table 28: EP06-E Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	Sleep state	**AT+CFUN=0** (USB disconnected)	1.69	mA
		WCDMA PF=64 (USB disconnected)	2.65	mA
		WCDMA PF=128 (USB disconnected)	2.69	mA
		WCDMA PF=256 (USB disconnected)	2.41	mA
		WCDMA PF=512 (USB disconnected)	2.66	mA
		LTE-FDD PF=32 (USB disconnected)	3.06	mA
		LTE-FDD PF=64 (USB disconnected)	3.26	mA
		LTE-FDD PF=128 (USB disconnected)	2.58	mA
		LTE-FDD PF=256 (USB disconnected)	2.26	mA
		LTE-TDD PF=32 (USB disconnected)	3.1	mA
		LTE-TDD PF=64 (USB disconnected)	3.3	mA
		LTE-TDD PF=128 (USB disconnected)	2.63	mA
		LTE-TDD PF=256 (USB disconnected)	2.29	mA
	Idle state	WCDMA PF=64 (USB disconnected)	24	mA

		WCDMA PF=64 (USB connected)	32.12	mA
		LTE-FDD PF=64 (USB disconnected)	19.2	mA
		LTE-FDD PF=64 (USB connected)	28.5	mA
		LTE-TDD PF=64 (USB disconnected)	21.3	mA
		LTE-TDD PF=64 (USB connected)	28.6	mA
	WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA CH10700 @ 23.2 dBm	621.1	mA
		WCDMA B1 HSUPA CH10700 @ 23.0 dBm	637.8	mA
		WCDMA B3 HSDPA CH 1338 @ 23.4 dBm	859.6	mA
		WCDMA B3 HSUPA CH 1338 @ 22.9 dBm	875.5	mA
		WCDMA B5 HSDPA CH4408 @ 23.0 dBm	608.7	mA
		WCDMA B5 HSUPA CH4408 @ 22.8 dBm	614.8	mA
		WCDMA B8 HSDPA CH3012 @ 22.9 dBm	693.5	mA
		WCDMA B8 HSUPA CH3012 @ 22.7 dBm	709.9	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B1 CH300 @ 23.1 dBm	681.3	mA
		LTE-FDD B3 CH1575 @ 22.5 dBm	905.6	mA
		LTE-FDD B5 CH2525 @ 22.9 dBm	625.7	mA
		LTE-FDD B7 CH3100 @ 23.1 dBm	1042.1	mA
		LTE-FDD B8 CH3625 @ 22.9 dBm	763.3	mA
		LTE-FDD B20 CH6300 @ 22.5 dBm	778.9	mA
		LTE-FDD B28 CH9510 @ 23.1 dBm	788.2	mA
		LTE-TDD B38 CH38000 @ 23.1 dBm	452.1	mA
		LTE-TDD B40 CH39150 @ 23.4 dBm	443.5	mA
		LTE-TDD B41 CH40740 @ 23.1 dBm	453.3	mA
	2×CA data transfer	LTE-FDD B1+B1 @ 23.5 dBm	770.5	mA
		LTE-FDD B1+B5 @ 23.3 dBm	823.1	mA
		LTE-FDD B1+B8 @ 22.5 dBm	820.3	mA
		LTE-FDD B1+B20 @ 22.6 dBm	832.3	mA

		LTE-FDD B1+B28 @ 23.2 dBm	920.3	mA
		LTE-FDD B3+B3 @ 23.37 dBm	986.8	mA
		LTE-FDD B3+B5 @ 23.1 dBm	1010.7	mA
		LTE-FDD B3+B7 @ 22.9 dBm	1046.8	mA
		LTE-FDD B3+B8 @ 22.8 dBm	1017.1	mA
		LTE-FDD B3+B20 @ 22.7 dBm	1060.8	mA
		LTE-FDD B3+B28 @ 22.6 dBm	1079.3	mA
		LTE-FDD B7+B5 @ 23.3 dBm	991.3	mA
		LTE-FDD B7+B7 @ 23.3 dBm	1022.2	mA
		LTE-FDD B7+B8 @ 23.3 dBm	1030.9	mA
		LTE-FDD B7+B20 @ 23.3 dBm	1095.8	mA
		LTE-FDD B7+B28 @ 23.2 dBm	1111.2	mA
		LTE-FDD B20+B32 @ 23.2 dBm	805.65	mA
		LTE-TDD B38+B38 @ 23.1 dBm	530.68	mA
		LTE-TDD B40+B40 @ 22.7 dBm	462.23	mA
		LTE-TDD B41+B41 @ 23.4 dBm	506.37	mA
	WCDMA voice call	WCDMA B1 CH10700 @ 23.2 dBm	622.18	mA
		WCDMA B3 CH1122 @ 23.2 dBm	862.14	mA
		WCDMA B5 CH4408 @ 22.9 dBm	611.89	mA
		WCDMA B8 CH3012 @ 22.9 dBm	699.91	mA

Table 29: GNSS Current Consumption of EP06-E

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT} (GNSS)	Searching (**AT+CFUN=0**)	Cold state @ Passive Antenna	60.77	mA
		Lost state @ Passive Antenna	60.5	mA
	Tracking (**AT+CFUN=0**)	Instrument environment	36.05	mA

	Open Sky @ Passive Antenna	TBD	mA

The following table shows the current consumption of EP06-A.

Table 30: EP06-A Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	Sleep state	**AT+CFUN=0** (USB disconnected)	1.88	mA
		WCDMA PF=64 (USB disconnected)	2.4	mA
		WCDMA PF=128 (USB disconnected)	2.29	mA
		WCDMA PF=256 (USB disconnected)	2.29	mA
		WCDMA PF=512 (USB disconnected)	2.28	mA
		LTE-FDD PF=32 (USB disconnected)	3.5	mA
		LTE-FDD PF=64 (USB disconnected)	3.47	mA
		LTE-FDD PF=128 (USB disconnected)	3.5	mA
		LTE-FDD PF=256 (USB disconnected)	3.49	mA
		LTE-TDD PF=32 (USB disconnected)	3.67	mA
		LTE-TDD PF=64 (USB disconnected)	3.6	mA
		LTE-TDD PF=128 (USB disconnected)	3.2	mA
		LTE-TDD PF=256 (USB disconnected)	3.54	mA
	Idle state	WCDMA PF=64 (USB disconnected)	21.2	mA
		WCDMA PF=64 (USB connected)	31.3	mA
		LTE-FDD PF=64 (USB disconnected)	22.7	mA
		LTE-FDD PF=64 (USB connected)	31.1	mA
		LTE-TDD PF=64 (USB disconnected)	23.9	mA
		LTE-TDD PF=64 (USB connected)	31.2	mA
	WCDMA data	WCDMA B2 HSDPA CH9400 @ 23.1 dBm	563.4	mA

	transfer (GNSS OFF)	WCDMA B2 HSUPA CH9400 @ 23.1 dBm	552.5	mA
		WCDMA B4 HSDPA CH1412 @ 22.87 dBm	648.5	mA
		WCDMA B4 HSUPA CH1412 @ 22.7 dBm	647.4	mA
		WCDMA B5 HSDPA CH4407 @ 22.7 dBm	565.1	mA
		WCDMA B5 HSUPA CH4407 @ 22.7 dBm	588.2	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B2 CH900 @ 23.8 dBm	723.5	mA
		LTE-FDD B4 CH 2175 @ 23.8 dBm	837.5	mA
		LTE-FDD B5 CH2525 @ 23.5 dBm	654.5	mA
		LTE-FDD B7 CH3100 @ 23.4 dBm	1002	mA
		LTE-FDD B12 CH5095 @ 23.5 dBm	615	mA
		LTE-FDD B13 CH5230 @ 23.5 dBm	670.7	mA
		LTE-FDD B25 CH8365 @ 24.3 dBm	778.8	mA
		LTE-FDD B26 CH8865 @ 23.4 dBm	702.3	mA
		LTE-FDD B30 CH9820 @ 23.4 dBm	802.6	mA
		LTE-FDD B66 CH132322 @ 23.8 dBm	850.1	mA
	2×CA data transfer	LTE-FDD B2+B2 @ 20.66 dBm	737.4	mA
		LTE-FDD B2+B5 @ 20.98 dBm	699.6	mA
		LTE-FDD B2+B12 @ 20.87 dBm	700.4	mA
		LTE-FDD B2+B13 @ 21.06 dBm	698	mA
		LTE-FDD B2+B29 @ 21.0 dBm	699.8	mA
		LTE-FDD B4+B4 @ 21.55 dBm	772.4	mA
		LTE-FDD B4+B5 @ 20.93 dBm	810.1	mA
		LTE-FDD B4+B12 @ 20.75 dBm	809.2	mA
		LTE-FDD B4+B13 @ 20.73 dBm	814.5	mA
		LTE-FDD B4+B29 @ 20.77 dBm	808.7	mA

		LTE-FDD B7+B5 @ 20.67 dBm	909.2	mA
		LTE-FDD B7+B7 @ 20.63 dBm	903.5	mA
		LTE-FDD B7+B12 @ 20.47 dBm	915.8	mA
		LTE-FDD B7+B26 @ 20.55 dBm	938	mA
		LTE-FDD B25+B5 @ 20.94 dBm	695.4	mA
		LTE-FDD B25+B12 @ 20.55 dBm	697.5	mA
		LTE-FDD B25+B25 @ 20.54 dBm	762.6	mA
		LTE-FDD B25+B26 @ 21.06 dBm	721.4	mA
		LTE-FDD B30+B5 @ 20.56 dBm	794.4	mA
		LTE-FDD B30+B12 @ 20.43 dBm	799.4	mA
		LTE-FDD B30+B29 @ 20.31 dBm	806.1	mA
		LTE-FDD B66+B5 @ 20.06 dBm	732.9	mA
		LTE-FDD B66+B12 @ 20.03 dBm	734	mA
		LTE-FDD B66+B29 @ 20.05 dBm	736.1	mA
		LTE-FDD B66+B66 @ 19.93 dBm	801.7	mA
		LTE-FDD B66+B13 @ 20.03 dBm	739.7	mA
	WCDMA voice call	WCDMA B2 CH9400 @ 24.2 dBm	608.1	mA
		WCDMA B4 CH1412 @ 23.8 dBm	720.8	mA
		WCDMA B5 CH4407 @ 23.5 dBm	619.6	mA

Table 31: GNSS Current Consumption of EP06-A

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT} (GNSS)	Searching (**AT+CFUN=0**)	Cold state @ Passive Antenna	59.5	mA
		Lost state @ Passive Antenna	54.4	mA
	Tracking (**AT+CFUN=0**)	Instrument environment	28.5	mA

	Open Sky @ Passive Antenna	30.0	mA

6.8. Thermal Consideration

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

- On customers' PCB design, please keep placement of the module away from heating sources, especially high power components such as ARM processor, audio power amplifier, power supply.
- Do not place components on the PCB area where the module is mounted, in order to facilitate adding of heatsink.
- 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 shows the referenced heatsink and thermal pad designs.

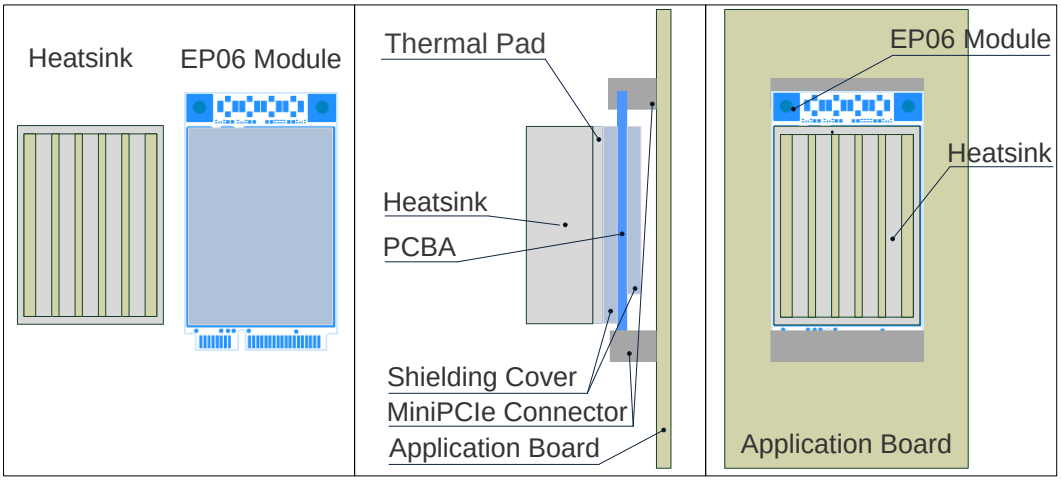


Figure 16: Referenced Heatsink Design

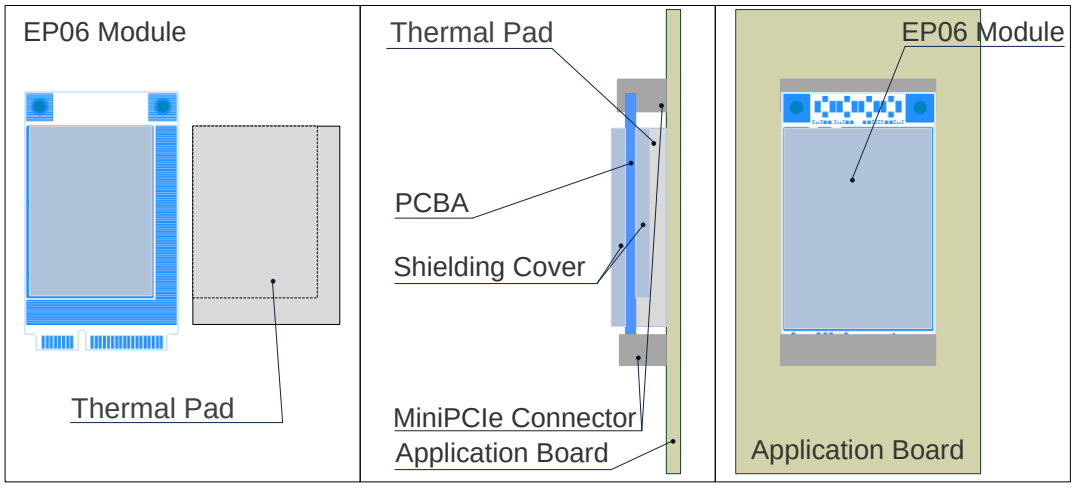


Figure 17: Referenced Thermal Pad Design

NOTES

1. Make sure that customers' PCB design provides sufficient cooling for the module: proper mounting, heatsinks, and active cooling may be required depending on the integrated application.
2. In order to protect the components from damage, the thermal design should be maximally optimized to make sure the module's internal temperature always maintains below 105°C. Customers can execute **AT+QTEMP** command to get the module's internal temperature.
3. For more detailed guidelines on thermal design, refer to ***document [5]***.

7 Mechanical Dimensions

This chapter mainly describes the mechanical dimensions as well as packaging specifications of the module. All dimensions are measured in millimeter (mm), and the dimensional tolerances are ±0.05 mm unless otherwise specified.

7.1. Mechanical Dimensions

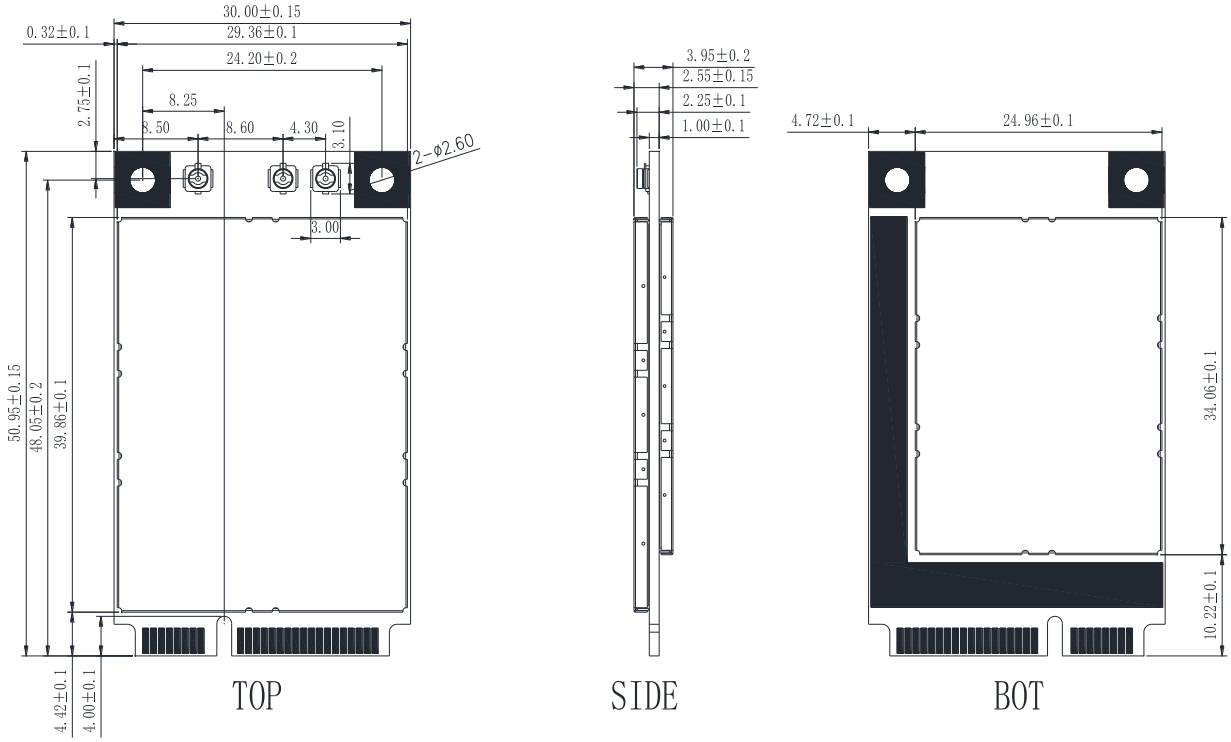


Figure 18: Mechanical Dimensions of EP06 Series

7.2. Standard Dimensions of Mini PCI Express

The following figure shows the standard dimensions of Mini PCI Express. Refer to ***document [6]*** for detailed dimensions.

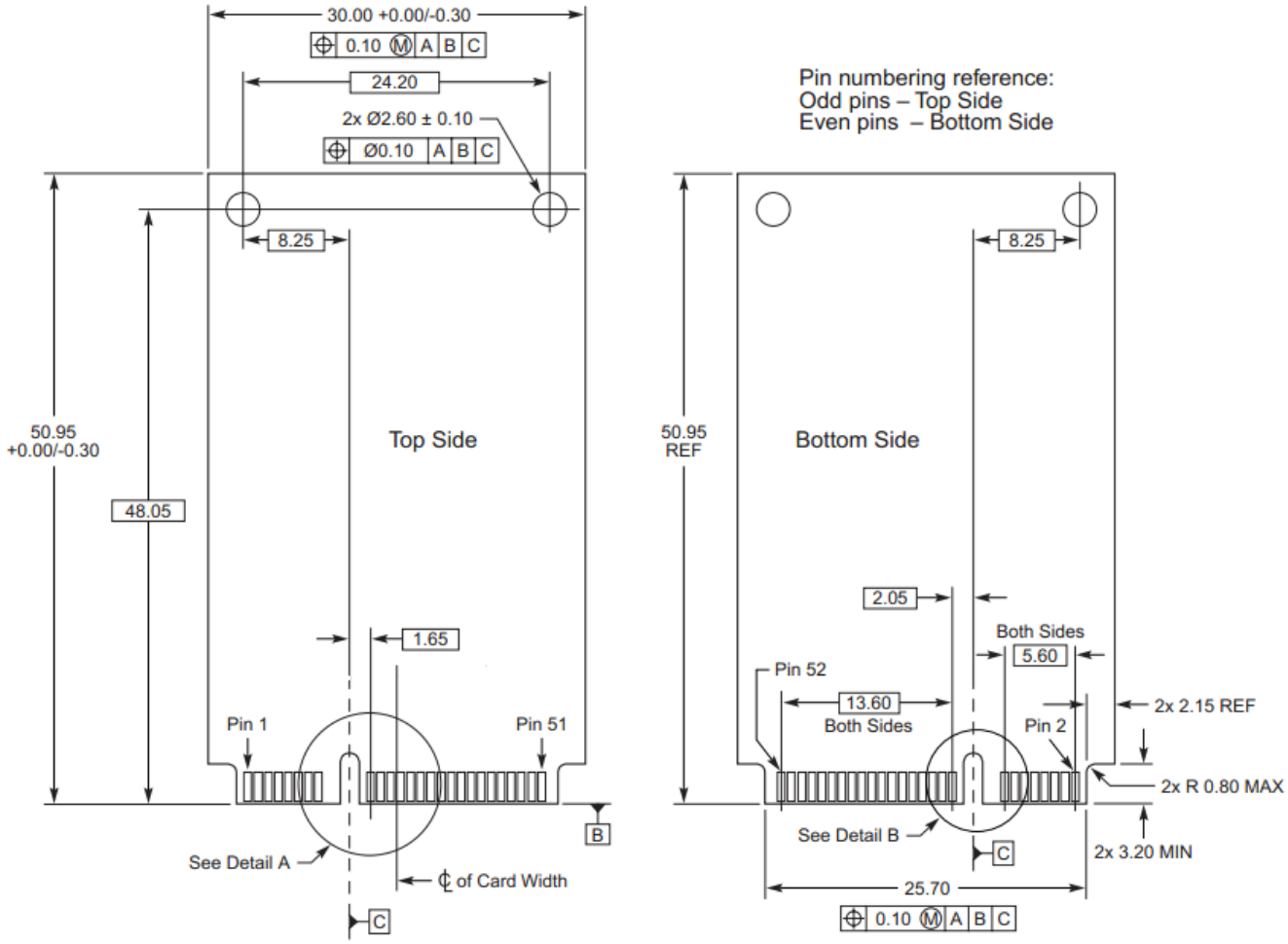


Figure 19: Standard Dimensions of Mini PCI Express

EP06 Mini PCIe adopts a standard Mini PCI Express connector which compiles with the directives and standards listed in the ***document [6]***. The following figure takes the Molex 679100002 as an example.

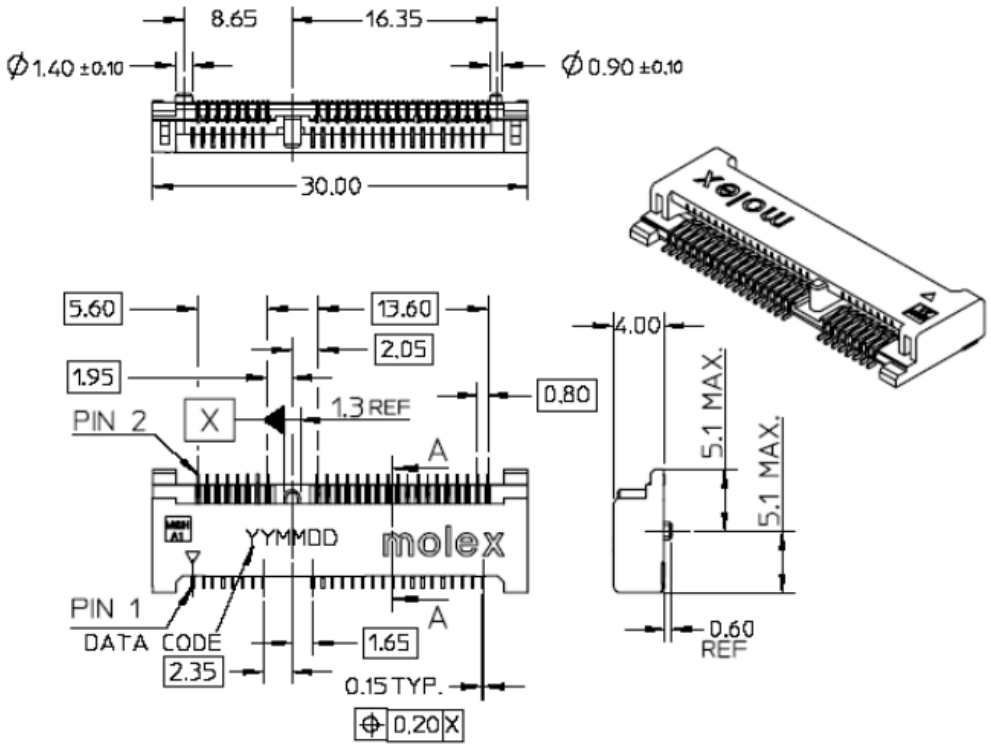


Figure 20: Dimensions of the Mini PCI Express Connector (Molex 679100002)

7.3. Top and Bottom Views

Figure 21: Top View of the Module

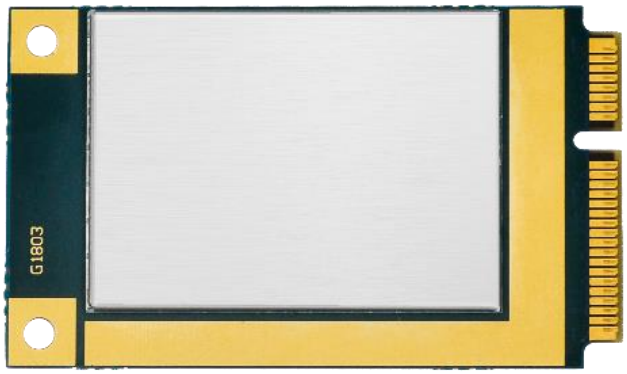


Figure 22: Bottom View of the Module

NOTE

These are renderings of the module. For authentic appearance, please refer to the module received from Quectel.

7.4. Packaging

The module is packaged in a tray and each tray contains 10 modules. The smallest package contains 100 modules.

8 Appendix A References

Table 32: Related Documents

SN	Document Name	Remark
[1]	Quectel_EPXX_EVB_User_Guide	EPXX EVB user guide
[2]	Quectel_EP06&EG06&EM06_AT_Commands_Manual	AT commands manual of EP06, EG06 and EM06 series modules
[3]	Quectel_EP06&EG06&EM06_GNSS_AT_Commands_Manual	GNSS application note of EP06, EG06 and EM06 series modules
[4]	Quectel_RF_Layout_Application_Note	RF layout application note
[5]	Quectel_LTE_Module_Thermal_Design_Guide	Thermal design guide for LTE standard, LTE-A and Automotive modules
[6]	PCI Express Mini Card Electromechanical Specification Revision 1.2	Mini PCI Express specification

Table 33: Terms and Abbreviations

Abbreviation	Description
AMR	Adaptive Multi-rate
bps	Bits per Second
CS	Coding Scheme
DFOTA	Delta Firmware Upgrade Over-the-Air
DL	Downlink
EFR	Enhanced Full Rate
ESD	Electrostatic Discharge
FDD	Frequency Division Duplex
FR	Full Rate

GLONASS	Global Navigation Satellite System (Russia)
GMSK	Gaussian Minimum Shift Keying
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HR	Half Rate
kbps	Kilo Bits per Second
LED	Light Emitting Diode
LTE-A	Long Term Evolution-Advanced
Mbps	Million Bits per Second
ME	Mobile Equipment (Module)
MIMO	Multiple-Input Multiple-Output
MMS	Multimedia Messaging Service
MO	Mobile Originated
MT	Mobile Terminated
PCM	Pulse Code Modulation
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
RF	Radio Frequency
Rx	Receive
(U)SIM	(Universal) Subscriber Identification Module
SIMO	Single Input Multiple Output
SMS	Short Message Service
UART	Universal Asynchronous Receiver/Transmitter
UL	Uplink
URC	Unsolicited Result Code
WCDMA	Wideband Code Division Multiple Access