

EP06 Hardware Design

LTE-A Module Series

Rev. EP06_Hardware_Design_V1.2

Date: 2019-01-31

Status: Released



Our aim is to provide customers with timely and comprehensive service. For any assistance, please contact our company headquarters:

Quectel Wireless Solutions Co., Ltd.

7th Floor, Hongye Building, No.1801 Hongmei Road, Xuhui District, Shanghai 200233, China

Tel: +86 21 5108 6236

Email: info@quectel.com

Or our local office. For more information, please visit:

<http://www.quectel.com/support/sales.htm>

For technical support, or to report documentation errors, please visit:

<http://www.quectel.com/support/technical.htm>

Or email to: support@quectel.com

GENERAL NOTES

QUECTEL OFFERS THE INFORMATION AS A SERVICE TO ITS CUSTOMERS. THE INFORMATION PROVIDED IS BASED UPON CUSTOMERS' REQUIREMENTS. QUECTEL MAKES EVERY EFFORT TO ENSURE THE QUALITY OF THE INFORMATION IT MAKES AVAILABLE. QUECTEL DOES NOT MAKE ANY WARRANTY AS TO THE INFORMATION CONTAINED HEREIN, AND DOES NOT ACCEPT ANY LIABILITY FOR ANY INJURY, LOSS OR DAMAGE OF ANY KIND INCURRED BY USE OF OR RELIANCE UPON THE INFORMATION. ALL INFORMATION SUPPLIED HEREIN IS SUBJECT TO CHANGE WITHOUT PRIOR NOTICE.

COPYRIGHT

THE INFORMATION CONTAINED HERE IS PROPRIETARY TECHNICAL INFORMATION OF QUECTEL WIRELESS SOLUTIONS CO., LTD. TRANSMITTING, REPRODUCTION, DISSEMINATION AND EDITING OF THIS DOCUMENT AS WELL AS UTILIZATION OF THE CONTENT ARE FORBIDDEN WITHOUT PERMISSION. OFFENDERS WILL BE HELD LIABLE FOR PAYMENT OF DAMAGES. ALL RIGHTS ARE RESERVED IN THE EVENT OF A PATENT GRANT OR REGISTRATION OF A UTILITY MODEL OR DESIGN.

Copyright © Quectel Wireless Solutions Co., Ltd. 2019. All rights reserved.

About the Document

History

Revision	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. <ol style="list-style-type: none"> Deleted EP06-APAC and all the related information and added EP06-CN and the related information. Updated the supported bands and 2×CA combination of EG06-A in Table 1. Updated the names of pins 8, 10, 12 and 14 of USIM1 interface. Updated the Reference Circuit of USB 2.0 & 3.0 Interface in Figure 5.
1.2	2019-01-31	Ewent LU/ Xavier XIA/ Reed WANG	<ol style="list-style-type: none"> Added Chapter 4 GNSS Receiver and updated the GNSS Performance in Table 14. Updated the description of antenna connectors and antenna requirements in Chapter 5. Updated EP06-E and EP06-A Conducted RF Receiving Sensitivity in Chapter 6.4. Updated EP06-E and EP06-A Current Consumption in Chapter 6.7.

Contents

About the Document.....	2
Contents.....	3
Table Index.....	5
Figure Index.....	6
1 Introduction	7
1.1. Safety Information.....	8
2 Product Concept.....	9
2.1. General Description.....	9
2.2. Key Features	10
2.3. Functional Diagram	13
2.4. Evaluation Board	13
3 Application Interfaces	14
3.1. Pin Assignment.....	14
3.2. Pin Description.....	15
3.3. Power Supply.....	18
3.4. (U)SIM Interfaces.....	19
3.5. USB Interface	20
3.6. PCM and I2C Interfaces	22
3.7. Control and Indicator Signals	25
3.7.1. WAKE_N Signal*.....	25
3.7.2. W_DISABLE_N Signal*.....	26
3.7.3. RESET_N Signal.....	26
3.7.4. WWAN_LED_N Signal.....	27
3.8. Tunable Antenna Control Interface*	28
4 GNSS Receiver.....	29
4.1. General Description.....	29
4.2. GNSS Performance.....	29
4.3. Layout Guidelines.....	30
5 Antenna Connection.....	31
5.1. Main/Rx-diversity Antenna Connectors	31
5.1.1. Description of Main/Rx-diversity Antenna Connectors	31
5.1.2. Operating Frequency	32
5.2. GNSS Antenna Connector.....	34
5.3. Antenna Connectors and Mating Plugs.....	35
5.4. Antenna Requirements.....	36
6 Electrical, Reliability and Radio Characteristics	38
6.1. General Description.....	38
6.2. Absolute Maximum Ratings.....	38

6.3.	Power Supply Requirements	39
6.4.	RF Characteristics	39
6.5.	Operation and Storage Temperatures	41
6.6.	Electrostatic Discharge	41
6.7.	Current Consumption	42
6.8.	Thermal Consideration	47
7	Mechanical Dimensions	50
7.1.	Mechanical Dimensions of EP06 Module.....	50
7.2.	Standard Dimensions of Mini PCI Express	51
7.3.	Design Effect Drawings of EP06 Module	52
7.4.	Packaging	53
8	Appendix References	54

Table Index

TABLE 1: FREQUENCY BANDS AND GNSS TYPES OF EP06 SERIES MODULE	9
TABLE 2: KEY FEATURES OF EP06.....	10
TABLE 3: DEFINITION OF I/O PARAMETERS.....	15
TABLE 4: PIN DESCRIPTION	15
TABLE 5: DEFINITION OF VCC AND GND PINS.....	18
TABLE 6: PIN DEFINITION OF (U)SIM INTERFACES	19
TABLE 7: PIN DEFINITION OF USB INTERFACE	21
TABLE 8: PIN DEFINITION OF PCM AND I2C INTERFACES	22
TABLE 9: PIN DEFINITION OF CONTROL AND INDICATOR SIGNALS.....	25
TABLE 10: RF FUNCTION STATUS	26
TABLE 11: INDICATIONS OF NETWORK STATUS (AT+QCFG="LEDMODE", 0, DEFAULT SETTING).....	27
TABLE 12: INDICATIONS OF NETWORK STATUS (AT+QCFG="LEDMODE", 2)	27
TABLE 13: PIN DEFINITION OF TUNABLE ANTENNA CONTROL INTERFACE*	28
TABLE 14: GNSS PERFORMANCE	29
TABLE 15: DESCRIPTION OF MAIN/RX-DIVERSITY ANTENNA CONNECTORS.....	31
TABLE 16: EP06-E OPERATING FREQUENCIES	32
TABLE 17: EP06-A OPERATING FREQUENCIES	33
TABLE 18: DESCRIPTION OF GNSS ANTENNA CONNECTOR	34
TABLE 19: GNSS FREQUENCY	34
TABLE 20: ANTENNA REQUIREMENTS.....	36
TABLE 21: ABSOLUTE MAXIMUM RATINGS	38
TABLE 22: EP06 POWER SUPPLY REQUIREMENTS	39
TABLE 23: RF OUTPUT POWER	39
TABLE 24: EP06-E CONDUCTED RF RECEIVING SENSITIVITY	39
TABLE 25: EP06-A CONDUCTED RF RECEIVING SENSITIVITY	40
TABLE 26: OPERATION AND STORAGE TEMPERATURES	41
TABLE 27: ELECTROSTATIC DISCHARGE CHARACTERISTICS (TEMPERATURE: 25°C, HUMIDITY: 45%)	42
TABLE 28: EP06-E CURRENT CONSUMPTION	42
TABLE 29: EP06-A CURRENT CONSUMPTION.....	45
TABLE 30: RELATED DOCUMENTS	54
TABLE 31: TERMS AND ABBREVIATIONS	54

Figure Index

FIGURE 1: FUNCTIONAL DIAGRAM	13
FIGURE 2: EP06 PIN ASSIGNMENT.....	14
FIGURE 3: REFERENCE DESIGN OF POWER SUPPLY	19
FIGURE 4: REFERENCE CIRCUIT OF (U)SIM CARD INTERFACE WITH A 6-PIN (U)SIM CARD CONNECTOR.....	20
FIGURE 5: REFERENCE CIRCUIT OF USB 2.0 & 3.0 INTERFACE	21
FIGURE 6: PRIMARY MODE TIMING	23
FIGURE 7: AUXILIARY MODE TIMING	24
FIGURE 8: REFERENCE CIRCUIT OF PCM APPLICATION WITH AUDIO CODEC	24
FIGURE 9: WAKE_N BEHAVIOR.....	25
FIGURE 10: TIMING OF RESETTING MODULE	26
FIGURE 11: WWAN_LED_N SIGNAL REFERENCE CIRCUIT DIAGRAM	27
FIGURE 12: ANTENNA CONNECTORS ON THE MODULE	31
FIGURE 13: DIMENSIONS OF THE ANTENNA CONNECTORS (UNIT: MM).....	35
FIGURE 14: MECHANICALS OF U.FL-LP MATING PLUGS	35
FIGURE 15: SPACE FACTOR OF MATING PLUGS (UNIT: MM).....	36
FIGURE 16: REFERENCED HEATSINK DESIGN	48
FIGURE 17: REFERENCED THERMAL PAD DESIGN	48
FIGURE 18: MECHANICAL DIMENSIONS OF EP06 MODULE	50
FIGURE 19: STANDARD DIMENSIONS OF MINI PCI EXPRESS.....	51
FIGURE 20: DIMENSIONS OF THE MINI PCI EXPRESS CONNECTOR (MOLEX 679100002).....	52
FIGURE 21: TOP VIEW OF THE MODULE	52
FIGURE 22: BOTTOM VIEW OF THE MODULE.....	53

1 Introduction

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

This document can help customers quickly understand the interface specifications, electrical and mechanical details, as well as other related information of EP06 module. To facilitate its application in different fields, 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 EP06 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.

2 Product Concept

2.1. General Description

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

EP06 supports embedded operating systems such as Windows CE, Linux and Android, and also provides GNSS¹⁾ and voice functionality²⁾ to meet customers' specific application demands. EP06 contains four variants: EP06-E, EP06-A, EP06-LA³⁾ and EP06-CN³⁾. Customers can select a dedicated type based on the region or operator.

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

Table 1: Frequency Bands and GNSS Types of EP06 Series Module

Mode	EP06-E	EP06-A	EP06-LA ³⁾	EP06-CN ³⁾
LTE-FDD (with Rx-diversity)	B1/B3/B5/B7/B8/ B20/B28/B32 ⁴⁾	B2/B4/B5/B7/B12/ B13/B25/B26/B29 ⁴⁾ / B30/B66	B2/B3/B4/B5/B7/ B8/B20/B28	B1/B3/B5/B8
LTE-TDD (with Rx-diversity)	B38/B40/B41	Not supported	Not supported	B34/B39/B40/B41
2xCA	B1+B1/B5/B8/B20/ B28; B3+B3/B5/B7/B8/ B20/B28; B7+B5/B7/B8/B20/ B28; B20+B32 ⁴⁾ ; B38+B38; B40+B40; B41+B41	B2+B2/B5/B12/B13/ B29 ⁴⁾ ; B4+B4/B5/B12/B13/ B29 ⁴⁾ ; B7+B5/B7/B12/ B26/; B25+B5/B12/B25/ B26; B30+B5/B12/B29 ⁴⁾ ; B66+B5/B12/B13/ B29 ⁴⁾ /B66	B2+B2/B5/B8/B20/ B28; B3+B3/B5/B7/B8/ B20/B28; B4+B4/B5/B8/B20/ B28; B7+B5/B7/B8/B20/ B28	B1+B3/B5/B8; B3+B5/B8; B39+B39; B39+B41; B40+B40; B41+B41

WCDMA (with Rx-diversity)	B1/B3/B5/B8	B2/B4/B5	B2/B3/B4/B5/B8	B1/B8
GNSS	GPS, GLONASS, BeiDou/Compass Galileo, QZSS	GPS, GLONASS, BeiDou/Compass Galileo, QZSS	GPS, GLONASS, BeiDou/Compass Galileo, QZSS	GPS, GLONASS, BeiDou/Compass Galileo, QZSS

NOTES

- ¹⁾ GNSS function is optional.
- ²⁾ EP06 series module contains **Telematics** version and **Data-only** version. **Telematics** version supports voice and data functions, while **Data-only** version only supports data function.
- ³⁾ EP06-LA and EP06-CN are under planning.
- ⁴⁾ LTE-FDD B29 and B32 support Rx only, and in 2×CA they are only for secondary component carrier.

EP06 module 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 module.

Table 2: Key Features of EP06

Feature	Details
Functional Interface	PCI Express Mini Card 1.2 Standard Interface
Power Supply	Supply voltage: 3.1V~4.4V Typical supply voltage: 3.3V
Transmitting Power	Class 3 (23dBm±2dB) for LTE-FDD bands Class 3 (23dBm±2dB) for LTE-TDD bands

	Class 3 (24dBm+1/-3dB) for WCDMA bands
LTE Features	Support up to LTE Cat 6 Support 1.4 to 40MHz (DL 2×CA) RF bandwidth Support 2×2 MIMO in DL direction FDD: Max 300Mbps (DL)/50Mbps (UL) TDD: Max 226Mbps (DL)/28Mbps (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 HSUPA: Max 5.76Mbps WCDMA: Max 384Kbps (DL)/Max 384Kbps (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: 1.8V, 3.0V 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 5Gbps on USB 3.0 and 480Mbps 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 Interface	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	Size: (30.0±0.2)mm × (50.95±0.2)mm × (4.3±0.1)mm Weight: approx. 6.0g
Temperature Range	Operation temperature range: -35°C ~ +75°C ¹⁾ Extended temperature range: -40°C ~ +85°C ²⁾ Storage temperature range: -40°C ~ +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.

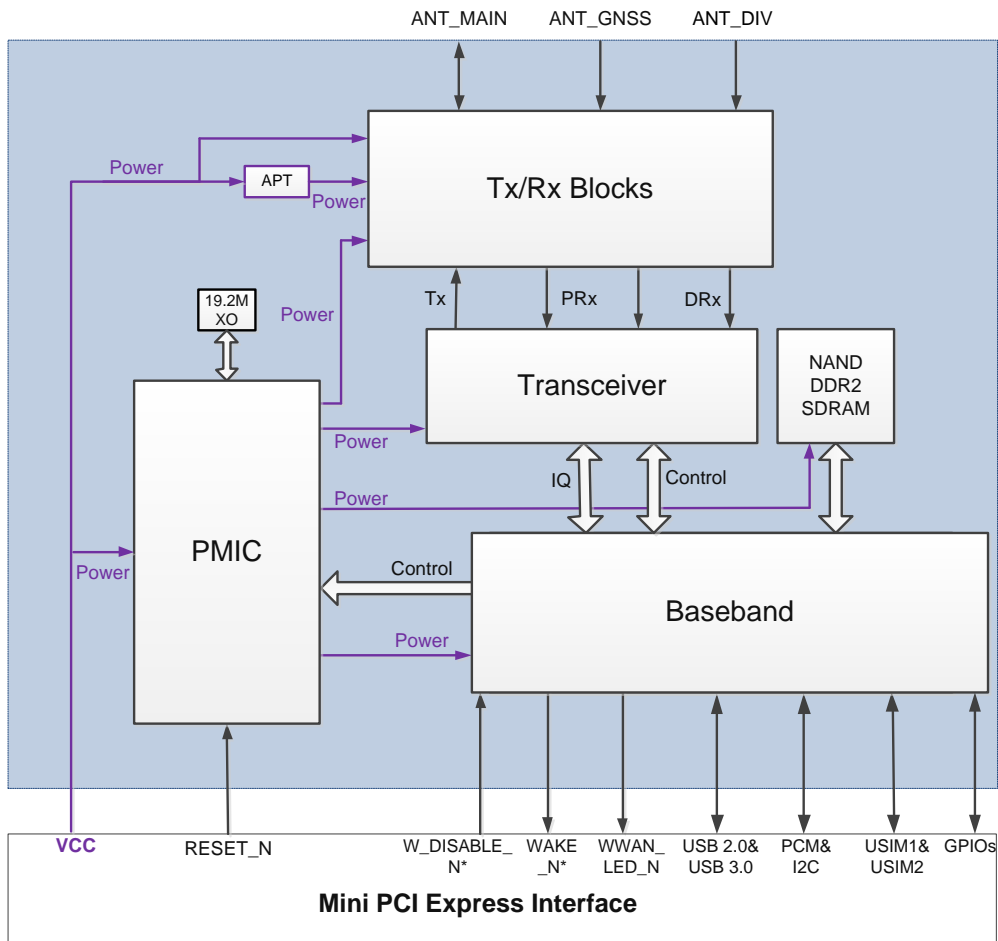


Figure 1: Functional Diagram

NOTE

"*" means under development.

2.4. Evaluation Board

In order to help customers develop applications conveniently with EP06, 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, please refer to **document [1]**.

3 Application Interfaces

The physical connections and signal levels of EP06 comply with PCI Express Mini CEM specifications. This chapter mainly describes definition and application of the following EP06 interfaces and signals:

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

3.1. Pin Assignment

The following figure shows the pin assignment of EP06 module. The top side contains EP06 module and antenna connectors.

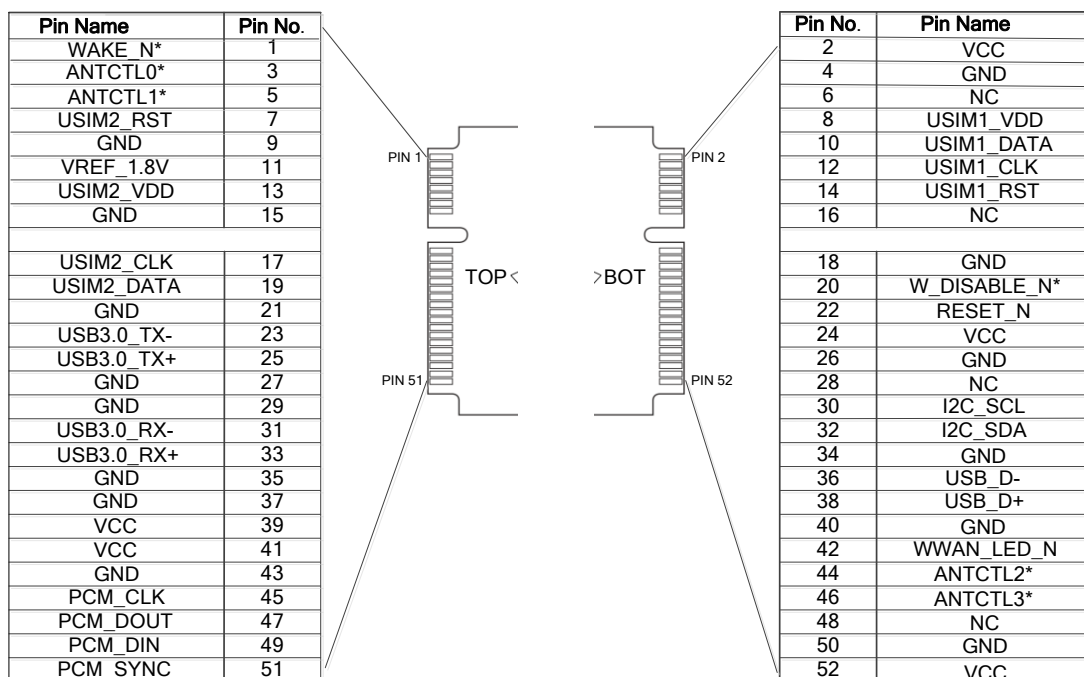


Figure 2: EP06 Pin Assignment

3.2. Pin Description

The following tables show the pin definition and description of EP06 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	EP06 Pin Name	I/O	Description	Comment
1	WAKE#	WAKE_N*	OD	Output signal to wake up the host	
2	3.3Vaux	VCC	PI	3.3V DC power supply	Vmin=3.1V Vnorm=3.3V Vmax=4.4V
3	COEX1	ANTCTL0*	DO	Tunable antenna control	1.8V power domain
4	GND	GND		Ground	
5	COEX2	ANTCTL1*	DO	Tunable antenna control	1.8V power domain
6	1.5V	NC		Not connected	

7	CLKREQ#	USIM2_RST	DO	Reset signal of (U)SIM2 card	1.8V/3.0V
8	UIM_PWR	USIM1_VDD	PO	Power supply for (U)SIM1 card	1.8V/3.0V
9	GND	GND		Ground	
10	UIM_DATA	USIM1_DATA	IO	Data signal of (U)SIM1 card	1.8V/3.0V
11	REFCLK-	VREF_1.8V	PO	1.8V reference voltage output	
12	UIM_CLK	USIM1_CLK	DO	Clock signal of (U)SIM1 card	1.8V/3.0V
13	REFCLK+	USIM2_VDD	PO	Power supply for (U)SIM2 card	1.8V/3.0V
14	UIM_RESET	USIM1_RST	DO	Reset signal of (U)SIM1 card	1.8V/3.0V
15	GND	GND		Ground	
16	UIM_VPP	NC		Not connected	
17	RESERVED	USIM2_CLK	DO	Clock signal of (U)SIM2 card	1.8V/3.0V
18	GND	GND		Ground	
19	RESERVED	USIM2_DATA	IO	Data signal of (U)SIM2 card	1.8V/3.0V
20	W_DISABLE#	W_DISABLE_N*	DI	Airplane mode control	1.8V 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	3.3V DC power supply	Vmin=3.1V Vnorm=3.3V Vmax=4.4V
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 1.8V
31	PETn0	USB3.0_RX-	AI	USB 3.0 receive data (-)	
32	SMB_DATA	I2C_SDA	IO	I2C serial data	Externally pulled

					up to 1.8V
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/A O	USB 2.0 differential data (-)	
37	GND	GND		Ground	
38	USB_D+	USB_D+	AI/A O	USB 2.0 differential data (+)	
39	3.3Vaux	VCC	PI	3.3V DC power supply	Vmin=3.1V Vnorm=3.3V Vmax=4.4V
40	GND	GND		Ground	
41	3.3Vaux	VCC	PI	3.3V DC power supply	Vmin=3.1V Vnorm=3.3V Vmax=4.4V
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	1.8V power domain
45	RESERVED	PCM_CLK	DI/D O	PCM clock signal	
46	LED_WPAN#	ANTCTL3*	DO	Tunable antenna control	1.8V 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/D O	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	3.3V DC power supply		Vmin=3.1V Vnorm=3.3V Vmax=4.4V

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	3.1V~4.4V	3.3V 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 EP06 is 3.3V. The power supply must be able to provide sufficient current up to 2A at least, 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 recommended to be 1%, and the capacitor C3 needs a low ESR.

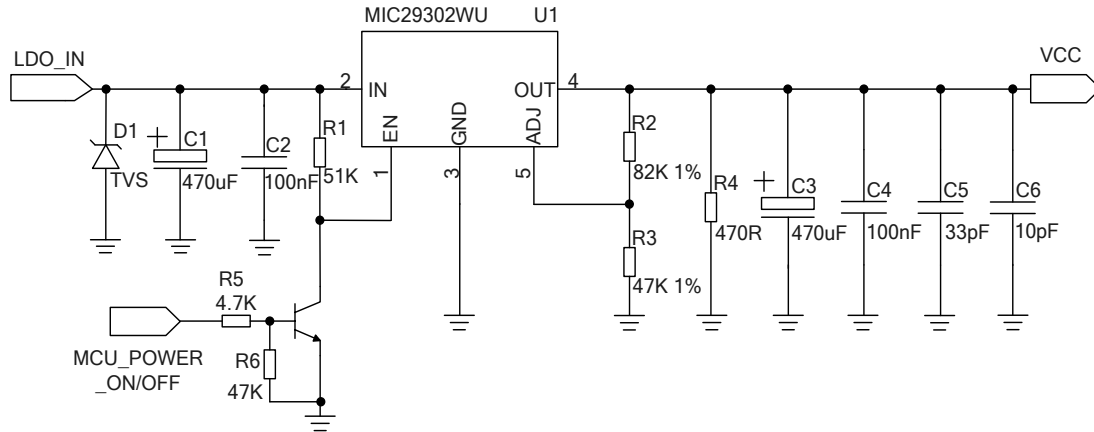


Figure 3: Reference Design of Power Supply

3.4. (U)SIM Interfaces

The (U)SIM interface circuitry meets ETSI and IMT-2000 requirements. Both 1.8V and 3.0V (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	1.8V/3.0V	Power source for (U)SIM1 card
10	USIM1_DATA	IO	1.8V/3.0V	Data signal of (U)SIM1 card
12	USIM1_CLK	DO	1.8V/3.0V	Clock signal of (U)SIM1 card
14	USIM1_RST	DO	1.8V/3.0V	Reset signal of (U)SIM1 card
13	USIM2_VDD	PO	1.8V/3.0V	Power source for (U)SIM2 card
19	USIM2_DATA	IO	1.8V/3.0V	Data signal of (U)SIM2 card
17	USIM2_CLK	DO	1.8V/3.0V	Clock signal of (U)SIM2 card
7	USIM2_RST	DO	1.8V/3.0V	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.

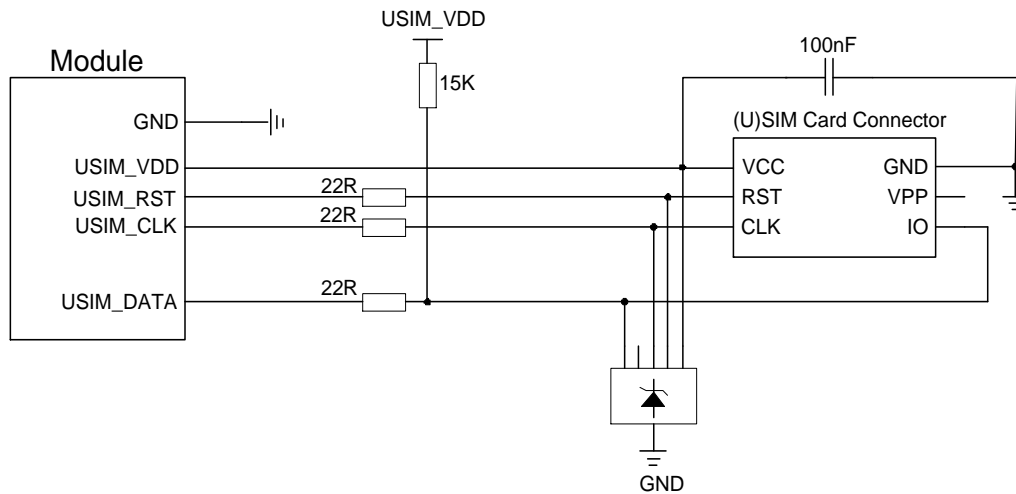


Figure 4: Reference Circuit of (U)SIM Card Interface with a 6-pin (U)SIM Card Connector

In order to enhance the reliability and availability of the (U)SIM card in customers' applications, please follow the criteria below 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.
- Keep the trace width of ground and USIM_VDD no less than 0.5mm to maintain the same electric potential. The decoupling capacitor of USIM_VDD should be less than 1uF and must near 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 22Ω 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 and sensitive occasion are applied, and should be placed close to the (U)SIM card connector.

3.5. USB Interface

EP06 provides one integrated Universal Serial Bus (USB) interface which complies with the USB 3.0/2.0 specifications and supports super speed (5Gbps) 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 90Ω
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 90Ω
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 interface.

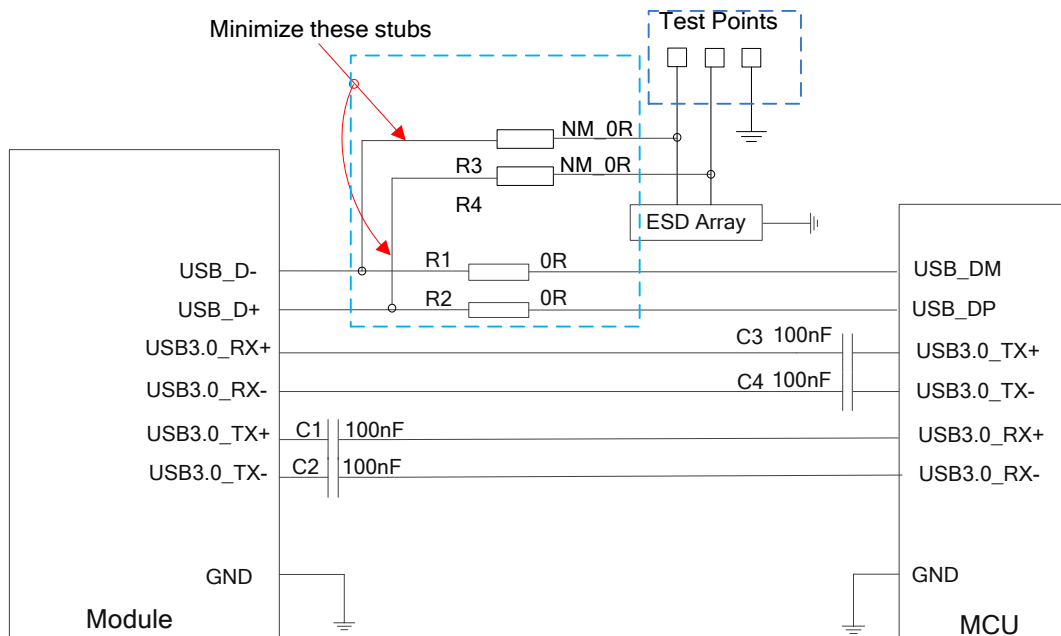


Figure 5: Reference Circuit of USB 2.0 & 3.0 Interface

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 total grounding. The impedance of USB differential trace is 90Ω.
- For USB 2.0 signal traces, the trace length difference of the differential pair should be less than 2mm.
- For USB 3.0 signal traces, the trace length difference of each differential pair (TX/RX) should be less than 0.7mm.
- Do not route signal traces under crystals, oscillators, magnetic devices or RF signal traces. It is important to route the USB 2.0 & 3.0 differential traces in inner-layer with ground shielding on not only upper and lower layers but also right and left sides.
- If a USB connector is used, please keep the ESD protection components to the USB connector as close as possible. Pay attention to the influence of junction capacitance of ESD protection components on USB 2.0 & 3.0 data lines. The capacitance value of ESD protection components should be less than 2.0pF for USB 2.0, and less than 0.4pF for USB 3.0.
- If possible, reserve a 0Ω resistor on USB_D+ and USB_D- lines, respectively.

NOTE

"*" means under development.

3.6. PCM and I2C Interfaces

EP06 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/D O	1.8V	PCM clock signal	
47	PCM_DOUT	DO	1.8V	PCM data output	
49	PCM_DIN	DI	1.8V	PCM data input	

51	PCM_SYNC	DI/D O	1.8V	PCM frame synchronization signal	In master mode, it is an output signal. In slave mode, it is an input signal.
30	I2C_SCL	DO	1.8V	I2C serial clock	Externally pulled up to 1.8V.
32	I2C_SDA	IO	1.8V	I2C serial data	Externally pulled up to 1.8V.

The PCM interface supports the following modes:

- Primary mode (short frame synchronization, works as either master or slave)
- Auxiliary mode (long frame synchronization, works 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 256kHz, 512kHz, 1024kHz or 2048kHz PCM_CLK at 8kHz PCM_SYNC, and also supports 4096kHz PCM_CLK at 16kHz 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 256kHz PCM_CLK and an 8kHz, 50% duty cycle PCM_SYNC only.

EP06 supports 16-bit linear data format. The following figures show the primary mode's timing relationship with 8kHz PCM_SYNC and 2048kHz PCM_CLK, as well as the auxiliary mode's timing relationship with 8kHz PCM_SYNC and 256kHz PCM_CLK.

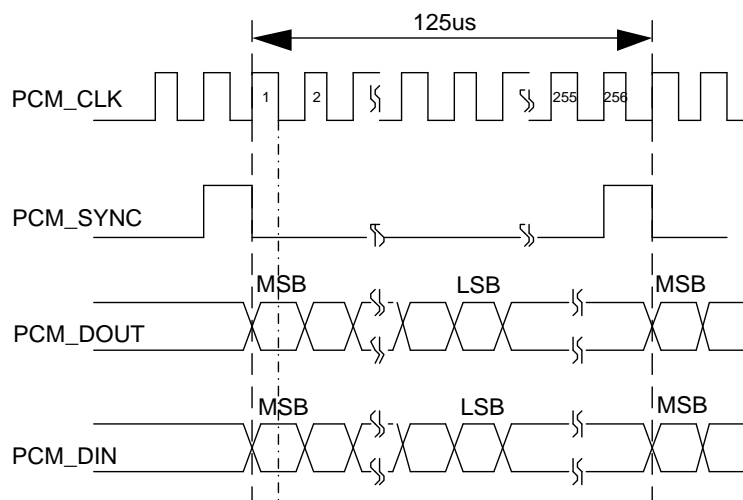


Figure 6: Primary Mode Timing

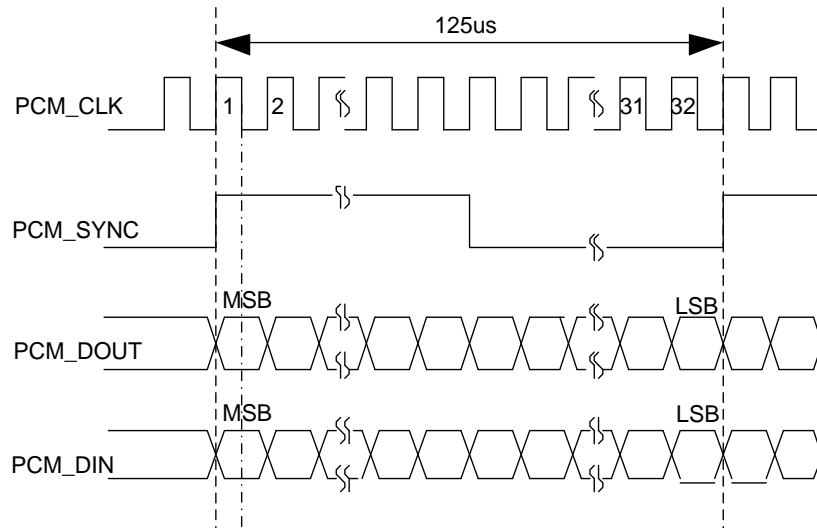


Figure 7: Auxiliary Mode Timing

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

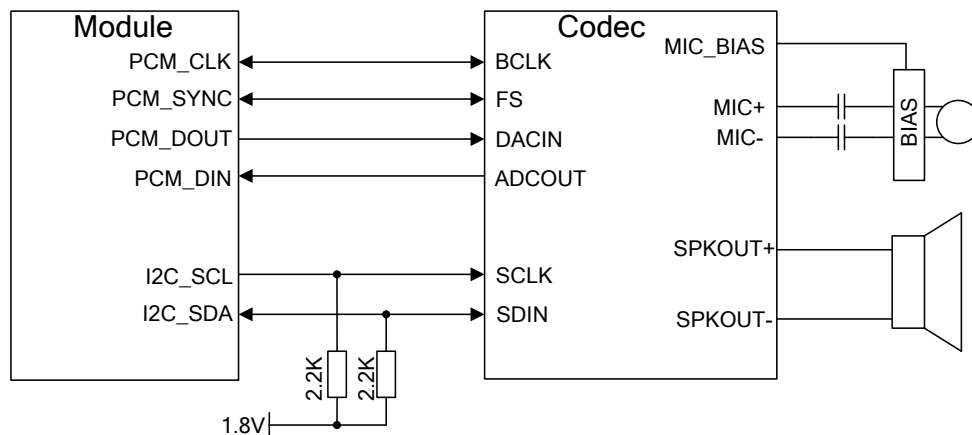


Figure 8: Reference Circuit of PCM Application with Audio Codec

NOTES

1. It is recommended to reserve an RC ($R=22\Omega$, $C=22pF$) circuit on the PCM lines, especially for PCM_CLK.
2. EP06 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	1.8V	Airplane mode control	Active low.
22	RESET_N	DI	1.8V	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="risignalttype","physical"** command are required. When a URC returns, a low level pulse will be outputted. The state of WAKE_N signal is shown as below.

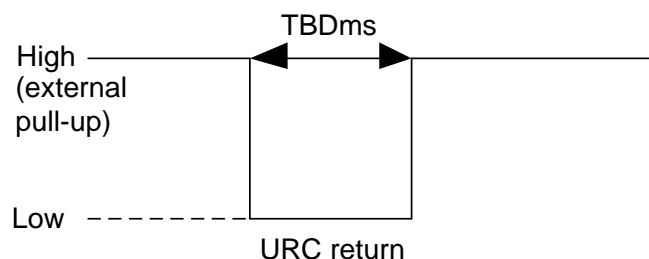


Figure 9: WAKE_N Behavior

3.7.2. W_DISABLE_N Signal*

EP06 module provides a W_DISABLE_N signal to disable or enable the RF function (not include GNSS). W_DISABLE_N for RF function control is disabled by default, and **AT+QCFG="airplanecontrol",1** can be used to enable the function.

The W_DISABLE_N pin is pulled up by default. Driving it to low level will let the module enter 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 AT+CFUN=4	Disabled
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. Customers can reset the module by driving the RESET_N to a low level voltage within the time frame of 250ms~600ms and then releasing it. The reset scenario is illustrated in the following figure.

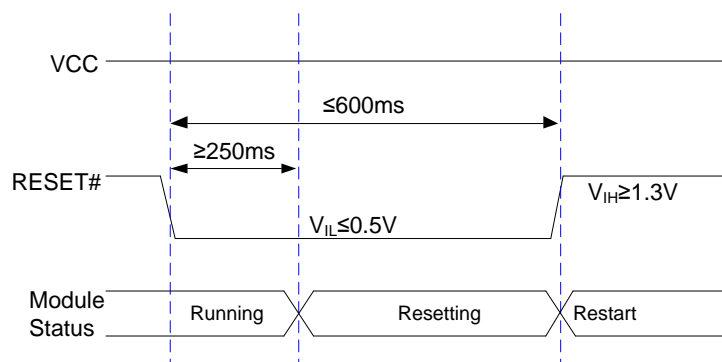


Figure 10: Timing of Resetting Module

3.7.4. WWAN_LED_N Signal

The WWAN_LED_N signal of EP06 module is used to indicate the network status of the module and its maximum sink current is 40mA. 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.

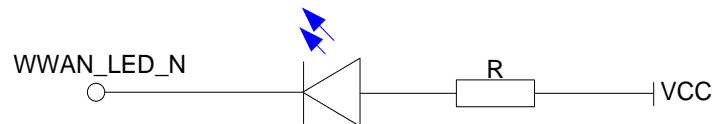


Figure 11: WWAN_LED_N Signal Reference Circuit Diagram

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 (200ms High/1800ms Low)	Network searching
Flicker slowly (1800ms High/200ms Low)	Idle
Flicker quickly (125ms High/125ms 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)	<ul style="list-style-type: none"> ● 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	1.8V power domain
ANTCTL1*	5	DO	Tunable antenna control	1.8V power domain
ANTCTL2*	44	DO	Tunable antenna control	1.8V power domain
ANTCTL3*	46	DO	Tunable antenna control	1.8V power domain

NOTE

“*” means under development.

4 GNSS Receiver

4.1. General Description

EP06 includes a fully integrated global navigation satellite system solution that supports Gen8C-Lite of Qualcomm (GPS, GLONASS, BeiDou, Galileo and QZSS).

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

By default, EP06 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]**.

4.2. GNSS Performance

The following table shows GNSS performance of EP06.

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	Autonomous	34.56	s
	@open sky	XTRA enabled	19.41	s
	Warm start	Autonomous	25.77	s
	@open sky	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 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.

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

EP06 is mounted with three 2mm × 2mm 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 50Ω.

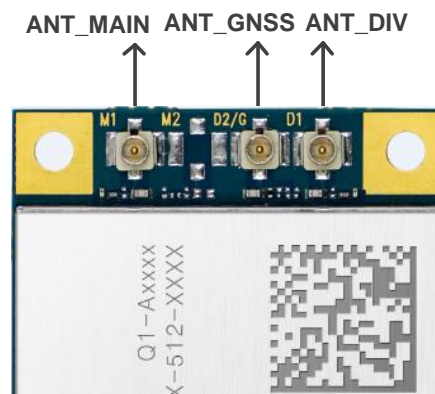


Figure 12: Antenna Connectors on the Module

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	50Ω impedance
D1	AI	Receive diversity antenna connector	50Ω 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	50Ω 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.

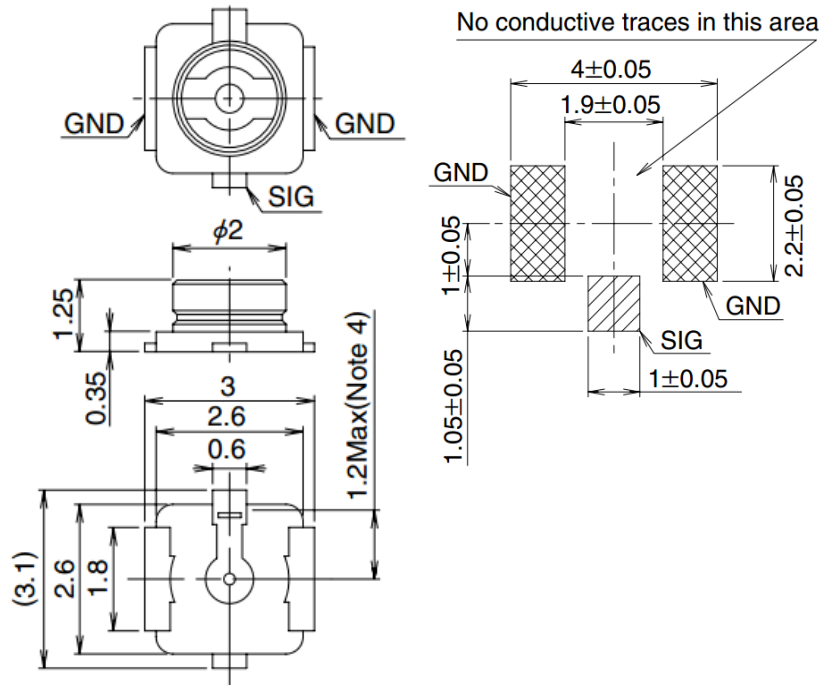


Figure 13: Dimensions of the Antenna Connectors (Unit: mm)

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.

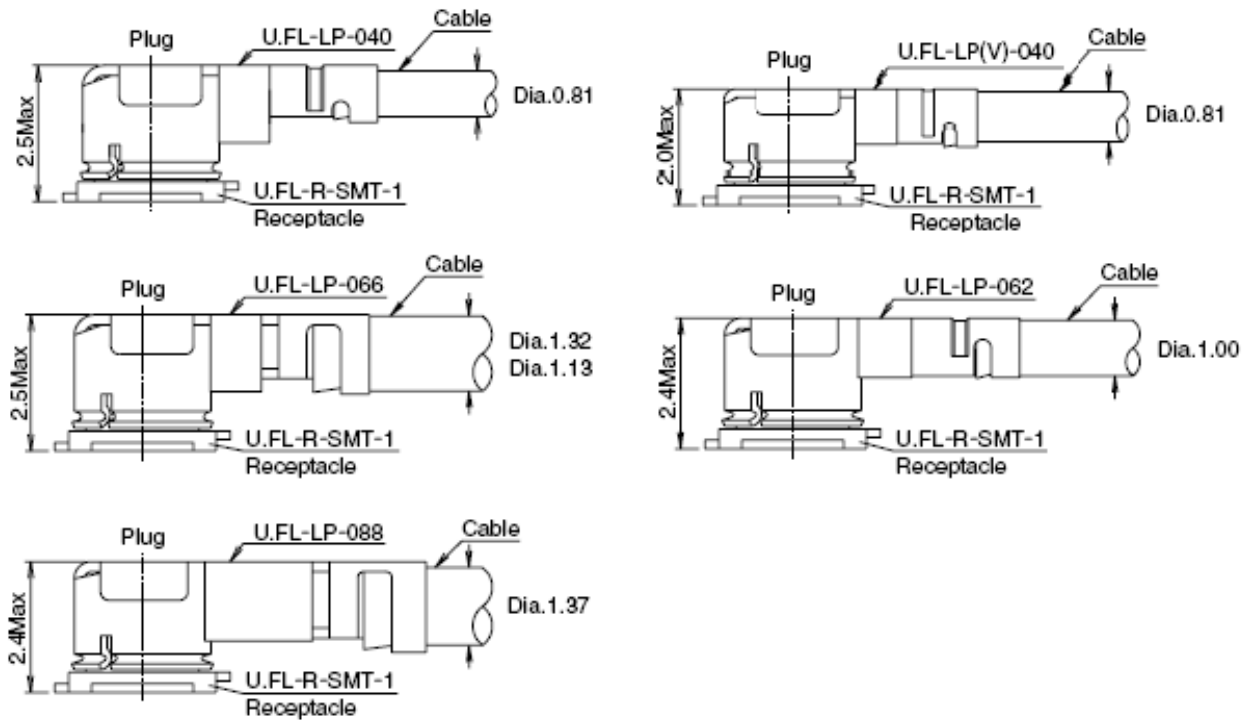


Figure 15: Space Factor of Mating Plugs (Unit: mm)

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: 1559MHz~1609MHz Polarization: RHCP or linear VSWR: <2 (Typ.) Passive Antenna Gain: >0dBi
WCDMA/LTE	VSWR: ≤2 Efficiency: >30% Max Input Power: 50W Input Impedance: 50Ω

Cable Insertion Loss: <1dB
(WCDMA B5/B6/B8/B19,
LTE B5/B8/B12/B13/B18/B19/B20/B26/B28/B29)

Cable Insertion Loss: <1.5dB
(WCDMA B1/B2/B3/B4/B9, LTE B1/B2/B3/B4/B25/B32/B39/B66)

Cable Insertion Loss <2dB
(LTE B7/B38/B40/B41/B30)

NOTE

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.

6 Electrical, Reliability and Radio Characteristics

6.1. General Description

This chapter mainly describes the following electrical and radio characteristics of EP06:

- Absolute maximum ratings
- Power supply requirements
- RF characteristics
- GNSS performance
- Operation 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 EP06 is 3.3V, as specified by *PCI Express Mini CEM Specifications 1.2*. And the power supply of EP06 should be able to provide sufficient current up to 2A at least. The following table shows the power supply requirements of EP06.

Table 22: EP06 Power Supply Requirements

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 EP06 module.

Table 23: RF Output Power

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

Table 24: EP06-E Conducted RF Receiving Sensitivity

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

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

Table 25: EP06-A Conducted RF Receiving Sensitivity

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

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, which can improve Rx performance.
2. ²⁾ Per 3GPP specification.

6.5. Operation and Storage Temperatures

Table 26: Operation and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operation Temperature Range ¹⁾	-35	+25	+75	°C
Extended Temperature Range ²⁾	-40		+85	°C
Storage temperature Range	-40		+90	°C

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, 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 the normal operating temperature levels, the module will meet 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

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

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

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

Table 29: EP06-A Current Consumption

Parameter	Description	Conditions	Typ.	Unit	
I _{VBAT}		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	
	Sleep state	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	
	I _{VBAT}	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 B2 HSDPA CH9400 @23.1dBm	563.4	mA	
WCDMA data transfer (GNSS OFF)		WCDMA B2 HSUPA CH9400 @23.1dBm	552.5	mA	
		WCDMA B4 HSDPA CH1412 @22.87dBm	648.5	mA	
		WCDMA B4 HSUPA CH1412 @22.7dBm	647.4	mA	

	WCDMA B5 HSDPA CH4407 @22.7dBm	565.1	mA
	WCDMA B5 HSUPA CH4407 @22.7dBm	588.2	mA
	LTE-FDD B2 CH900 @23.8dBm	723.5	mA
	LTE-FDD B4 CH 2175 @23.8dBm	837.5	mA
	LTE-FDD B5 CH2525 @23.5dBm	654.5	mA
	LTE-FDD B7 CH3100 @23.4dBm	1002	mA
LTE data transfer (GNSS OFF)	LTE-FDD B12 CH5095 @23.5dBm	615	mA
	LTE-FDD B13 CH5230 @23.5dBm	670.7	mA
	LTE-FDD B25 CH8365 @24.3dBm	778.8	mA
	LTE-FDD B26 CH8865 @23.4dBm	702.3	mA
	LTE-FDD B30 CH9820 @23.4dBm	802.6	mA
	LTE-FDD B66 CH132322 @23.8dBm	850.1	mA
	LTE-FDD B2+B2 @20.66dBm	737.4	mA
	LTE-FDD B2+B5 @20.98dBm	699.6	mA
2×CA data transfer	LTE-FDD B2+B12 @20.87dBm	700.4	mA
	LTE-FDD B2+B13 @21.06dBm	698	mA
	LTE-FDD B2+B29 @21.0dBm	699.8	mA
	LTE-FDD B4+B4 @21.55dBm	772.4	mA
	LTE-FDD B4+B5 @20.93dBm	810.1	mA
	LTE-FDD B4+B12 @20.75dBm	809.2	mA
	LTE-FDD B4+B13 @20.73dBm	814.5	mA
	LTE-FDD B4+B29 @20.77dBm	808.7	mA
	LTE-FDD B7+B5 @20.67dBm	909.2	mA
	LTE-FDD B7+B7 @20.63dBm	903.5	mA
I _{VBAT}	LTE-FDD B7+B12 @20.47dBm	915.8	mA

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

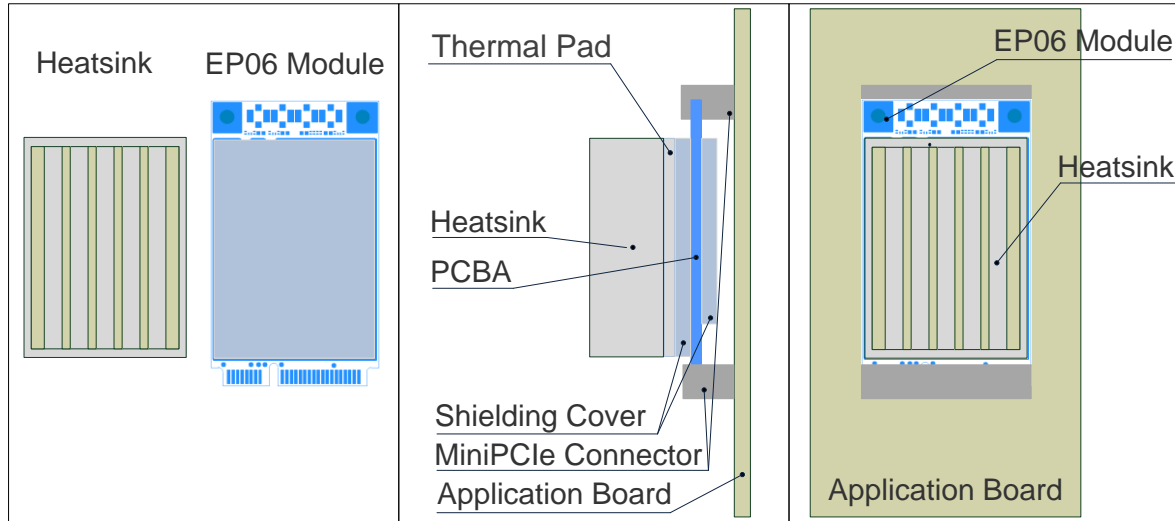


Figure 16: Referenced Heatsink Design

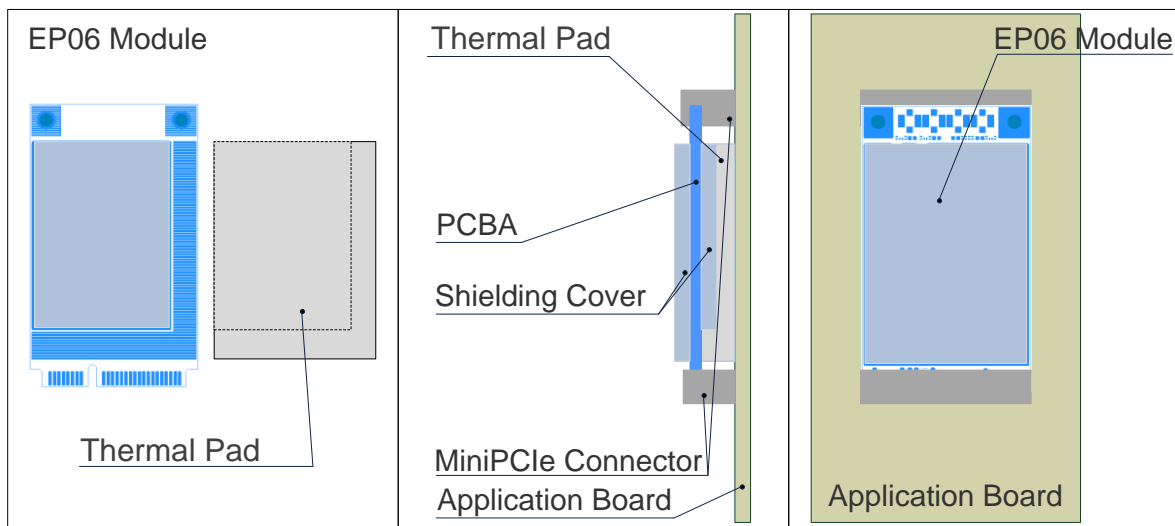


Figure 17: Referenced Thermal Pad Design

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, please refer to **document [5]**.

7 Mechanical Dimensions

This chapter mainly describes the mechanical dimensions as well as packaging specifications of EP06 module. All dimensions are measured in mm. The tolerances for dimensions without tolerance values are $\pm 0.05\text{mm}$.

7.1. Mechanical Dimensions of EP06 Module

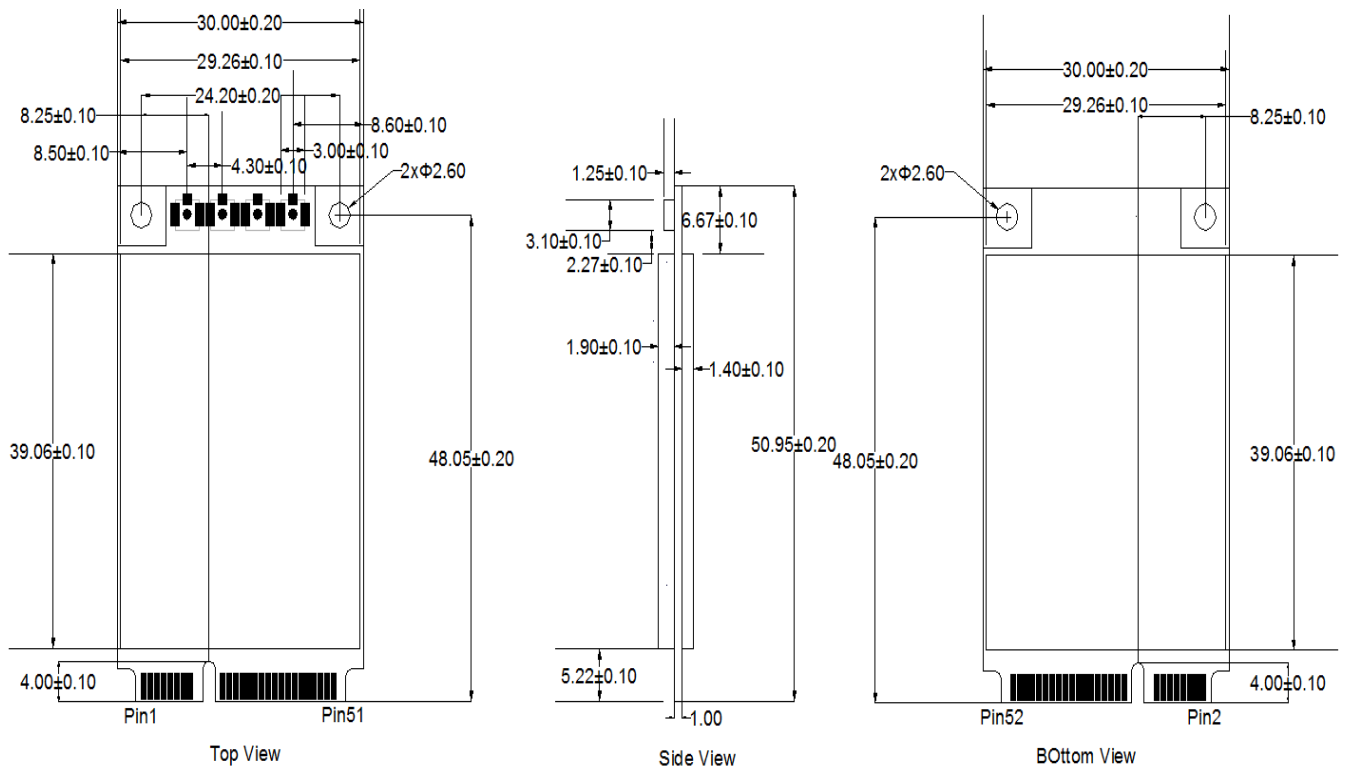


Figure 18: Mechanical Dimensions of EP06 Module

7.2. Standard Dimensions of Mini PCI Express

The following figure shows the standard dimensions of Mini PCI Express. Please refer to **document [6]** for detailed A and B.

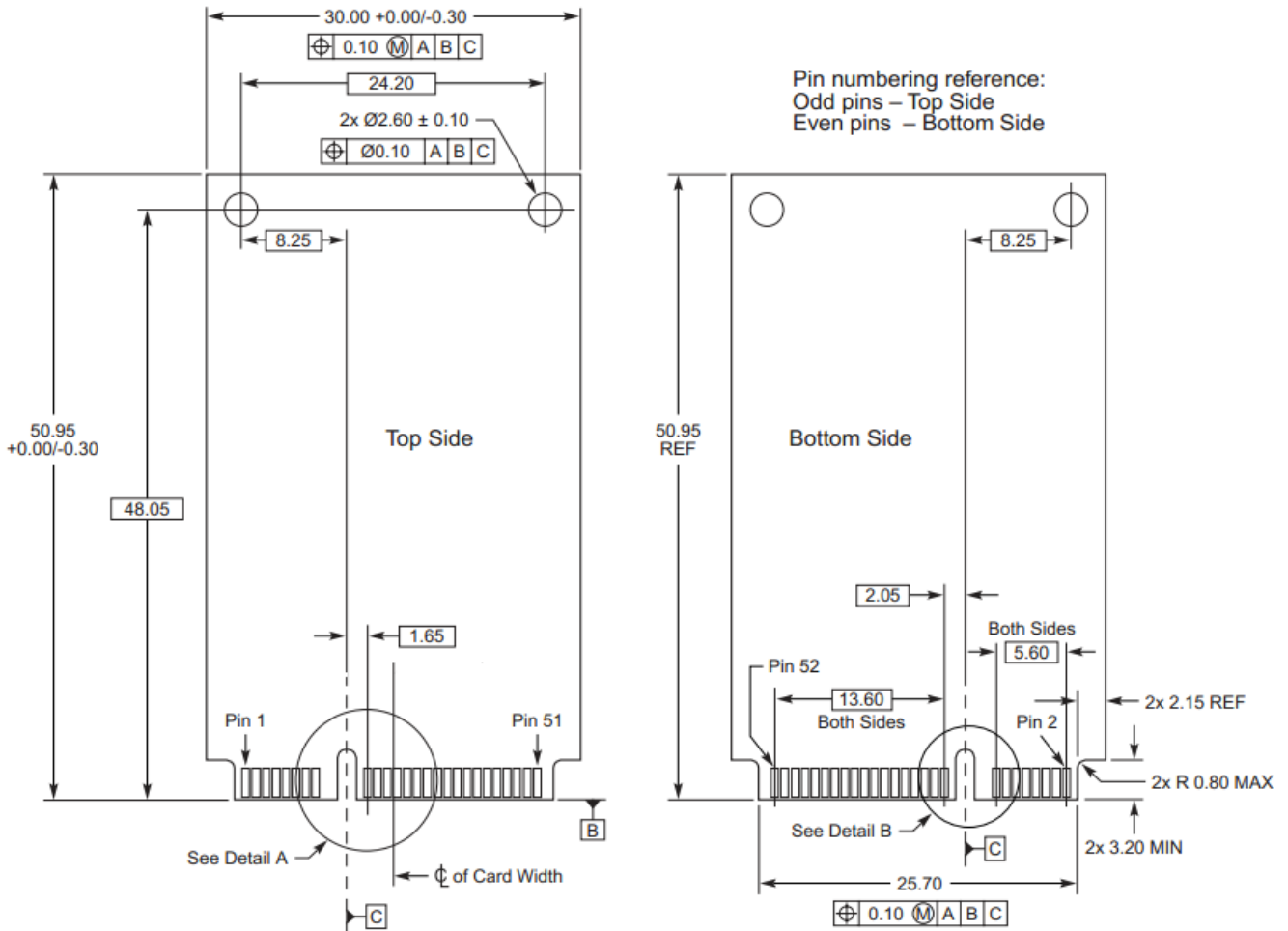


Figure 19: Standard Dimensions of Mini PCI Express

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

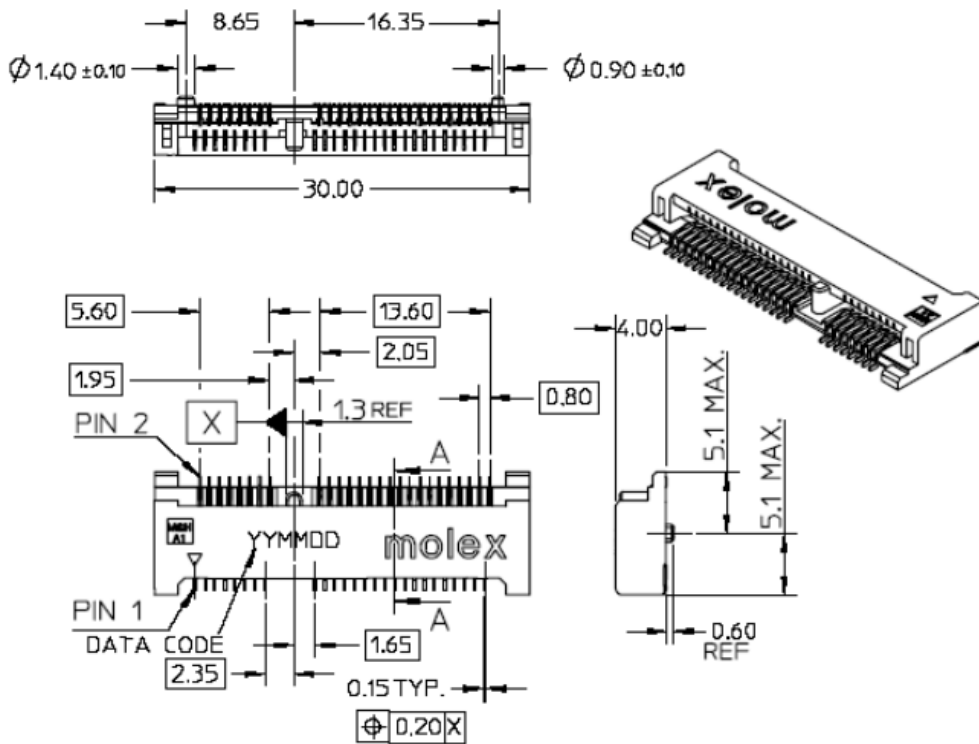


Figure 20: Dimensions of the Mini PCI Express Connector (Molex 679100002)

7.3. Design Effect Drawings of EP06 Module



Figure 21: Top View of the Module



Figure 22: Bottom View of the Module

NOTE

These are renderings of EP06 module. For authentic dimension and appearance, please refer to the module that you get from Quectel.

7.4. Packaging

EP06 module is packaged in a tray and each tray contains 10 modules. The smallest package of EP06 contains 100 modules.

8 Appendix References

Table 30: Related Documents

SN	Document Name	Remark
[1]	Quectel_EPXX_EVB_User_Guide	EPXX EVB User Guide
[2]	Quectel_EP06&EG06&EM06_AT_Commands_Manual	EP06, EG06 and EM06 AT Commands Manual
[3]	Quectel_EP06&EG06&EM06_GNSS_AT_Commands_Manual	GNSS AT Commands Manual for EP06, EG06 and EM06 Modules
[4]	Quectel_RF_Layout_Application_Note	RF Layout Application Note
[5]	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
[6]	PCI Express Mini Card Electromechanical Specification Revision 1.2	Mini PCI Express Specification

Table 31: Terms and Abbreviations

Abbreviation	Description
AMR	Adaptive Multi-rate
bps	Bits Per Second
CS	Coding Scheme
DFOTA	Delta Firmware Upgrade Over The Air
DL	Down Link
EFR	Enhanced Full Rate
ESD	Electrostatic Discharge
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
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	Up Link

URC

Unsolicited Result Code

WCDMA

Wideband Code Division Multiple Access
