

# **EM06** Hardware Design

**LTE-A Module Series**

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# About the Document

## History

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# 1 Introduction

This document defines EM06 module and describes its air interface and hardware interfaces which are connected with customers' applications.

This document can help customers to quickly understand the interface specifications, electrical and mechanical details, as well as other related information of EM06 module. To facilitate its application in different fields, reference design is also provided for customers' reference. Associated with application notes and user guides, 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 the operation, such as usage, service or repair of any cellular terminal or mobile incorporating EM06 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

EM06 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 standard PCI Express M.2 interface.

EM06 supports embedded operating systems such as Windows CE, Linux and Android, and also provides GNSS<sup>1)</sup> and voice functionality<sup>2)</sup> to meet customers' specific application demands. EM06 contains four variants: EM06-E, EM06-J, EM06-A\* and EM06-LA\*. Customers can select a dedicated type based on the region or operator.

The following table shows the frequency bands and GNSS type of EM06 series module.

**Table 1: Frequency Bands and GNSS Type of EM06 Series Module**

Mode	EM06-E	EM06-J	EM06-A*	EM06-LA*
LTE-FDD (with Rx-diversity)	B1/B3/B5/B7/ B8/B20/B28/B32 <sup>3)</sup>	B1/B3/B8/B18/B19/ B26/B28	B2/B4/B5/B7/B12/ B13/B25/B26/B29 <sup>3)</sup> / B30/B66	B2/B3/B4/B5/B7/B8/ B20/B28
LTE-TDD (with Rx-diversity)	B38/B40/B41	B41	Not supported	Not supported
2xCA	B1+B1/B5/B8/ B20/B28; B3+B3/B5/B7/ B8/B20/B28; B7+B5/B7/B8/ B20/B28; B20+B32 <sup>3)</sup> ; B38+B38; B40+B40; B41+B41	B1+B1/B8/B18/B19/ B26/B28; B3+B3/B8/B18/B19/ B26/B28; B41+B41	B2+B2/B5/B12/ B13/B26/B29 <sup>3)</sup> ; B4+B4/B5/B12/ B13/B26/B29 <sup>3)</sup> ; B7+B5/B7/B12/ B13/B26/B29 <sup>3)</sup> ; B25+B5/B12/ B13/B25/B26/B29 <sup>3)</sup> ; B30+B5/B12/ B13/B26/B29 <sup>3)</sup> ; B66+B5/B12/	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

			B13/B26/B29 <sup>3)</sup> / B66	
WCDMA (with Rx-diversity)	B1/B3/B5/B8	B1/B3/B6/B8/ B19	B2/B4/B5	B2/B3/B4/B5/ B8
GNSS <sup>1)</sup>	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

- <sup>1)</sup> GNSS function is optional.
- <sup>2)</sup> EM06 series module (EM06-E/EM06-J/EM06-A\*/EM06-LA\*) contains **Telematics** version and **Data-only** version. **Telematics** version supports voice and data functions, while **Data-only** version only supports data function.
- <sup>3)</sup> LTE-FDD B29 and B32 support Rx only and are only for secondary component carrier.
- "\*" means under development.

EM06 can be applied in the following fields:

- Rugged Tablet PC and Laptop Computer
- 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 EM06.

**Table 2: Key Features of EM06**

Feature	Details
Function Interface	PCI Express M.2 Interface
Power Supply	Supply voltage: 3.135V~4.4V Typical supply voltage: 3.7V

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
LTE Features	Support up to LTE Cat 6 Support 1.4MHz to 40MHz (2×CA) RF bandwidth Support MIMO in DL direction <ul style="list-style-type: none"> <li>● FDD: Max 300Mbps (DL)/50Mbps (UL)</li> <li>● TDD: Max 226Mbps (DL)/28Mbps (UL)</li> </ul>
UMTS Features	Support 3GPP R8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA Support QPSK, 16-QAM and 64-QAM modulation <ul style="list-style-type: none"> <li>● DC-HSDPA: Max 42Mbps (DL)</li> <li>● HSUPA: Max 5.76Mbps (UL)</li> <li>● WCDMA: Max 384Kbps (DL)/Max 384Kbps (UL)</li> </ul>
Internet Protocol Features	<ul style="list-style-type: none"> <li>● Support PPP/QMI/NTP*/TCP*/UDP*/FTP*/HTTP*/PING*/HTTPS*/SMTP*/MMS*/FTPS*/SMTPS*/SSL* protocols</li> <li>● Support the protocols PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) usually used for PPP connections</li> </ul>
SMS	Text and PDU mode Point to point MO and MT SMS cell broadcast SMS storage: ME by default
(U)SIM Interfaces	<ul style="list-style-type: none"> <li>● Support (U)SIM card: 1.8V, 3.0V</li> <li>● Include USIM1 and USIM2 interfaces</li> <li>● Support Dual SIM Single Standby*</li> </ul>
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	<ul style="list-style-type: none"> <li>● Used for audio function with external codec</li> <li>● Support 16-bit linear data format</li> <li>● Support long frame synchronization and short frame synchronization</li> <li>● Support master and slave modes, but must be the master in long frame synchronization</li> </ul>
USB Interface	<ul style="list-style-type: none"> <li>● 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.</li> <li>● Used for AT command communication, data transmission, firmware upgrade, software debugging, GNSS NMEA sentence output and voice over USB*</li> <li>● 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</li> </ul>
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: (42.0±0.15)mm × (30.0±0.15)mm × (2.3±0.1)mm Weight: approx. 6.0g
Temperature Range	Operation temperature range: -30°C~ +70°C <sup>1)</sup> Extended temperature range: -40°C~ +85°C <sup>2)</sup> Storage temperature range: -40°C ~ +90°C
Firmware Upgrade	USB 2.0 interface and DFOTA*
RoHS	All hardware components are fully compliant with EU RoHS directive

## NOTES

- <sup>1)</sup> Within operation temperature range, the module is 3GPP compliant.
- <sup>2)</sup> 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<sub>out</sub> 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.
- “\*” means under development.

## 2.3. Functional Diagram

The following figure shows a block diagram of EM06.

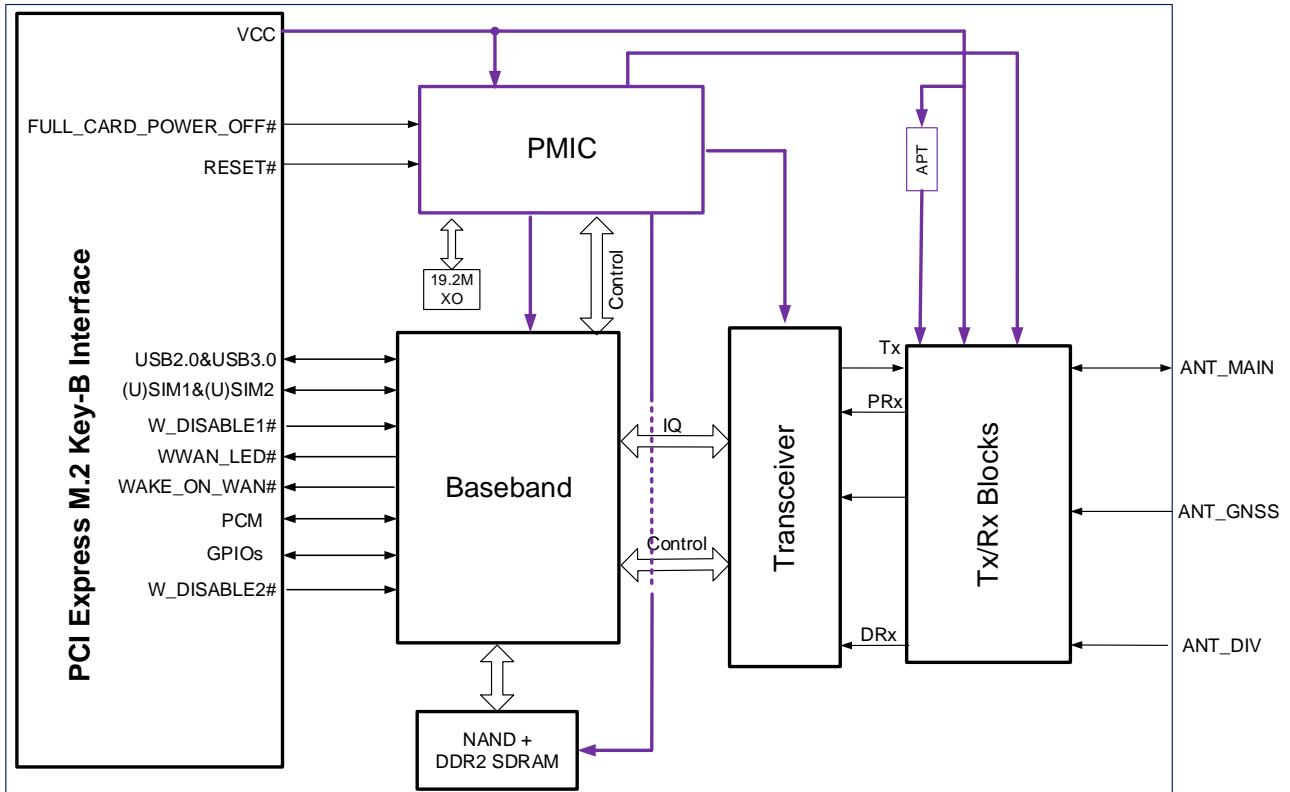


Figure 1: Functional Diagram

## 2.4. Evaluation Board

In order to help customers develop applications conveniently with EM06, Quectel supplies the evaluation board (M.2 EVB), USB to RS-232 converter cable, USB type-C 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 EM06 comply with PCI Express M.2 specifications. This chapter mainly describes the definition and application of the following interfaces/signals/pins of EM06:

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

## NOTE

“\*” means under development.

### 3.1. Pin Assignment

The following figure shows the pin assignment of EM06. The top side contains EM06 module and antenna connectors.

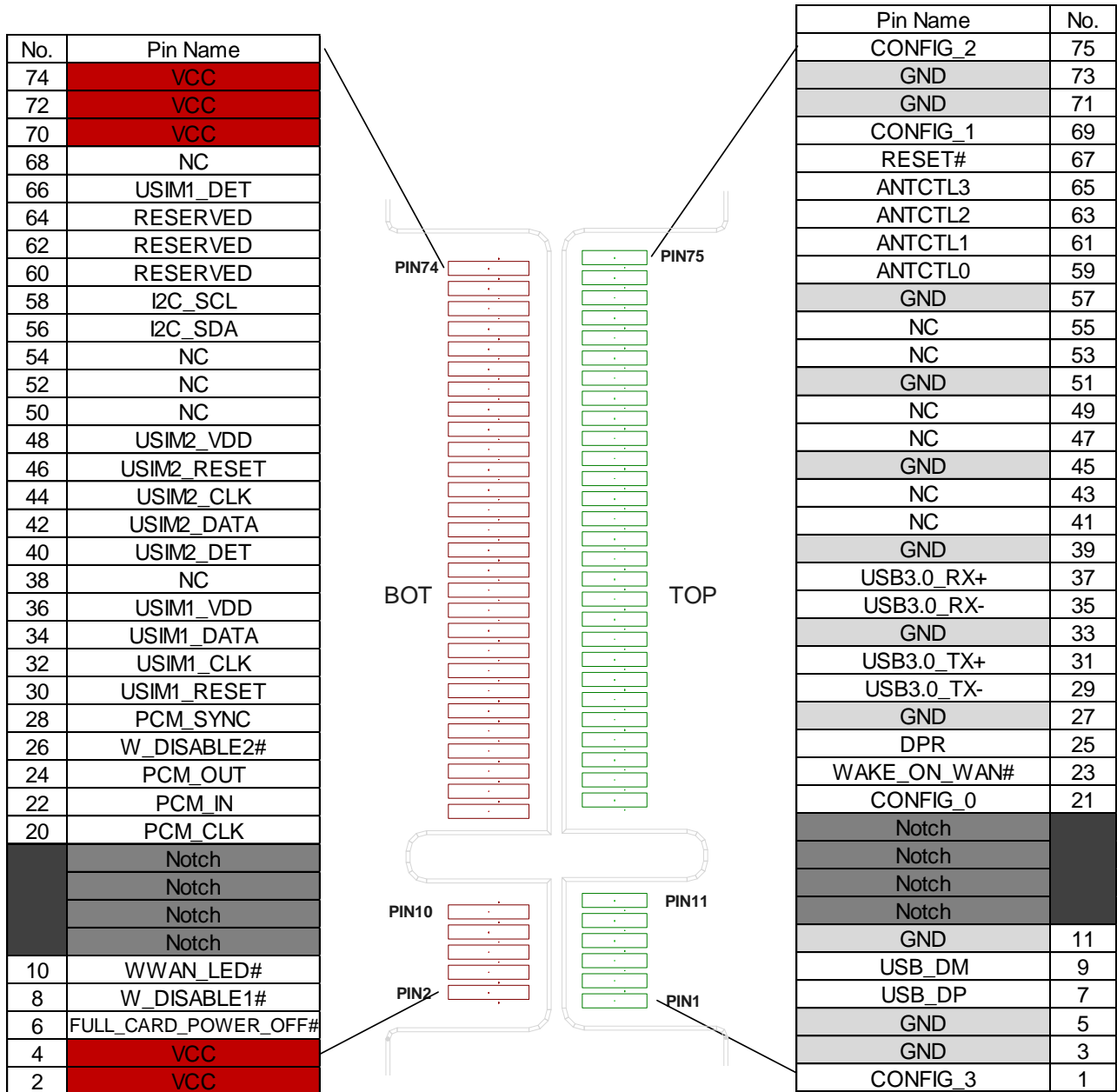


Figure 2: Pin Assignment



## 3.2. Pin Description

The following tables show the pin definition and description of EM06 on the 75-pin application.

**Table 3: Definition of I/O Parameters**

Type	Description
IO	Bidirectional
DI	Digital input
DO	Digital output
OD	Open drain
PI	Power input
PO	Power output

**Table 4: Pin Description**

Pin No.	M.2 Socket 2 USB 3.0-Based Pinout	EM06 Pin Name	I/O	Description	Comment
1	CONFIG_3	CONFIG_3		Not connected internally. EM06 is configured as WWAN-USB 3.0.	
2	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V
3	GND	GND		Ground	
4	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V
5	GND	GND		Ground	
6	FULL_CARD_POWER_OFF#	FULL_CARD_POWER_OFF#	DI	A signal to control power-on/-off of the module. When it is at low level, the module powers off. When it is at high level, the module powers on.	Pulled down internally
7	USB_D+	USB_DP	IO	USB 2.0 differential data bus (+)	

8	W_DISABLE1#	W_DISABLE1#	DI	Airplane mode control. Active low.	1.8V/3.3V power domain
9	USB_D-	USB_DM	IO	USB 2.0 differential data bus (-)	
10	GPIO_9	WWAN_LED#	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.	3.3V power domain
11	GND	GND		Ground	
12	Key	Notch		Notch	
13	Key	Notch		Notch	
14	Key	Notch		Notch	
15	Key	Notch		Notch	
16	Key	Notch		Notch	
17	Key	Notch		Notch	
18	Key	Notch		Notch	
19	Key	Notch		Notch	
20	GPIO_5 (AUDIO_0)	PCM_CLK	IO	PCM data bit clock. In master mode, it is an output signal. In slave mode, it is an input signal. If unused, keep it open.	1.8V power domain
21	CONFIG_0	CONFIG_0		Connected to GND internally. EM06 is configured as WWAN-USB 3.0.	
22	GPIO_6 (AUDIO_1)	PCM_IN	DI	PCM data input	1.8V power domain
23	GPIO_11 (WOWWAN#)	WAKE_ON_WAN#	OD	A signal to wake up the host. It is an open collector and active low signal.	1.8V power domain
24	GPIO_7 (AUDIO_2)	PCM_OUT	DO	PCM data output	1.8V power domain
25	DPR	DPR	DI	Dynamic power reduction. High level by default.	1.8V power domain
26	GPIO_10 (W_DISABLE2#)	W_DISABLE2#*	DI	GNSS enable control. Active low.	1.8V/3.3V power domain
27	GND	GND		Ground	
28	GPIO_8 (AUDIO_3)	PCM_SYNC	IO	PCM data frame synchronization signal	1.8V power domain

29	USB3.0-TX-	USB3.0_TX-	DO	USB 3.0 transmit data (-)	
30	UIM-RESET	USIM1_RESET	DO	(U)SIM1 card reset	1.8V/3.0V power domain
31	USB3.0-TX+	USB3.0_TX+	DO	USB 3.0 transmit data (+)	
32	UIM-CLK	USIM1_CLK	DO	(U)SIM1 card clock	1.8V/3.0V power domain
33	GND	GND		Ground	
34	UIM-DATA	USIM1_DATA	IO	(U)SIM1 card data	Pulled up to USIM2_VDD internally
35	USB3.0-RX-	USB3.0_RX-	DI	USB 3.0 receive data (-)	
36	UIM-PWR	USIM1_VDD	PO	Power supply for (U)SIM1 card	1.8V/3.0V power domain
37	USB3.0-RX+	USB3.0_RX+	DI	USB 3.0 receive data (+)	
38	N/C	NC		NC	
39	GND	GND		Ground	
40	GPIO_0 (SIM_DET2)	USIM2_DET	DI	(U)SIM2 card insertion detection	Pulled up internally
41	N/C	NC		NC	
42	GPIO_1 (SIM_DAT2)	USIM2_DATA	IO	(U)SIM2 card data	Pulled up to USIM2_VDD internally
43	N/C	NC		NC	
44	GPIO_2 (SIM_CLK2)	USIM2_CLK	DO	(U)SIM2 card clock	1.8V/3.0V power domain
45	GND	GND		Ground	
46	GPIO_3 (SIM_RST2)	USIM2_RESET	DO	(U)SIM2 card reset	1.8V/3.0V power domain
47	N/C	NC		NC	
48	GPIO_4 (SIM_PWR2)	USIM2_VDD	PO	Power supply for (U)SIM2 card	1.8V/3.0V power domain
49	N/C	NC		NC	
50	N/C	NC		NC	
51	GND	GND		Ground	

52	N/C	NC		NC	
53	N/C	NC		NC	
54	N/C	NC		NC	
55	N/C	NC		NC	
56	N/C	I2C_SDA	IO	I2C serial data. Used for external codec.	
57	GND	GND		Ground	
58	N/C	I2C_SCL	DO	I2C serial clock. Used for external codec.	
59	ANTCTL0	ANTCTL0*	DO	Tunable antenna control.	1.8V power domain
60	COEX3	RESERVED		Reserved	
61	ANTCTL1	ANTCTL1*	DO	Tunable antenna control.	1.8V power domain
62	COEX2	RESERVED		Reserved	
63	ANTCTL2	ANTCTL2*	DO	Tunable antenna control.	1.8V power domain
64	COEX1	RESERVED		Reserved	
65	ANTCTL3	ANTCTL3*	DO	Tunable antenna control.	1.8V power domain
66	SIM_DETECT	USIM1_DET	DI	(U)SIM1 card insertion detection	Pulled up internally
67	RESET#	RESET#	DI	System reset. Active low.	
68	SUSCLK (32kHz)	NC		NC	
69	CONFIG_1	CONFIG_1		Connected to GND internally. EM06 is configured as WWAN-USB 3.0.	
70	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V
71	GND	GND		Ground	
72	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V
73	GND	GND		Ground	

74	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V
75	CONFIG_2	CONFIG_2		Not connected internally. EM06 is configured as WWAN-USB 3.0.	

### NOTES

1. Keep all NC, reserved and unused pins unconnected.
2. “\*” means under development.

## 3.3. Power Supply

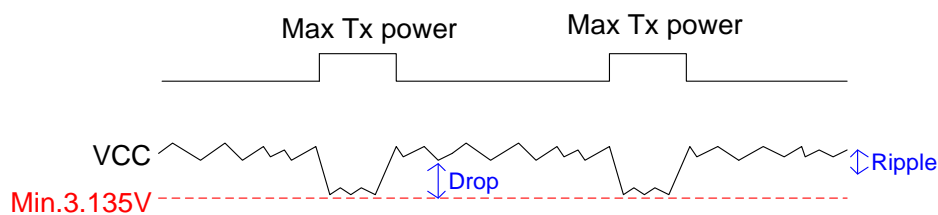
The following table shows pin definition of VCC pins and ground pins.

**Table 5: Definition of VCC and GND Pins**

Pin No.	Pin Name	I/O	Power Domain	Description
2, 4, 70, 72, 74	VCC	PI	3.135V~4.4V	3.7V typical DC supply
3, 5, 11, 27, 33, 39, 45, 51, 57, 71, 73	GND			Ground

### 3.3.1. Decrease Voltage Drop

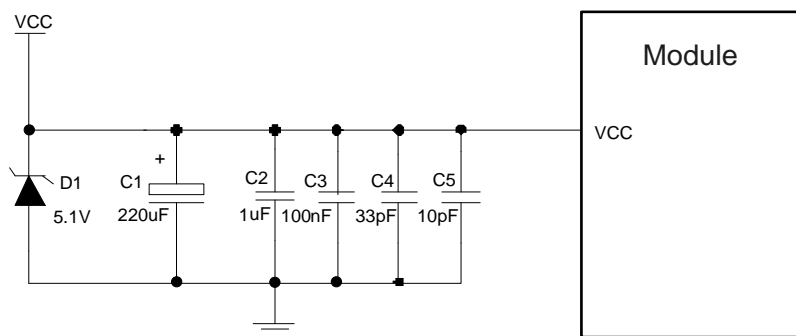
The power supply range of the module is from 3.135V to 4.4V. Please make sure that the input voltage will never drop below 3.135V, otherwise the module will be powered off automatically. The following figure shows the maximum voltage drop during radio transmission in 3G and 4G networks.



**Figure 3: Power Supply Limits during Radio Transmission**

To decrease voltage drop, a bypass capacitor of about 220 $\mu$ F with low ESR (ESR=0.7 $\Omega$ ) should be used, and a multi-layer ceramic chip capacitor (MLCC) array should also be reserved due to its ultra-low ESR. It is recommended to use three ceramic capacitors (100nF, 33pF, 10pF) for composing the MLCC array, and place these capacitors close to VCC pins. The main power supply from an external application has to be a single voltage source. The width of VCC trace should be no less than 2mm. In principle, the longer the VCC trace is, the wider it will be.

In addition, in order to get a stable power source, it is recommended to use a zener diode with reverse zener voltage of 5.1V and dissipation power more than 0.5W. The following figure shows a reference circuit of VCC.



**Figure 4: Reference Circuit of VCC**

### 3.3.2. Reference Design for Power Supply

Power design for the module is very important, as the performance of the module largely depends on the power source. The power supply is capable of providing sufficient current up to 2A at least. If the voltage drop between the input and output is not too high, it is suggested that an LDO should be used to supply power for the module. If there is a big voltage difference between the input source and the desired output (VCC), a buck converter is preferred to be used as the power supply.

The following figure shows a reference design for +5V input power source. The typical output of the power supply is about 3.7V and the maximum load current is 3A.

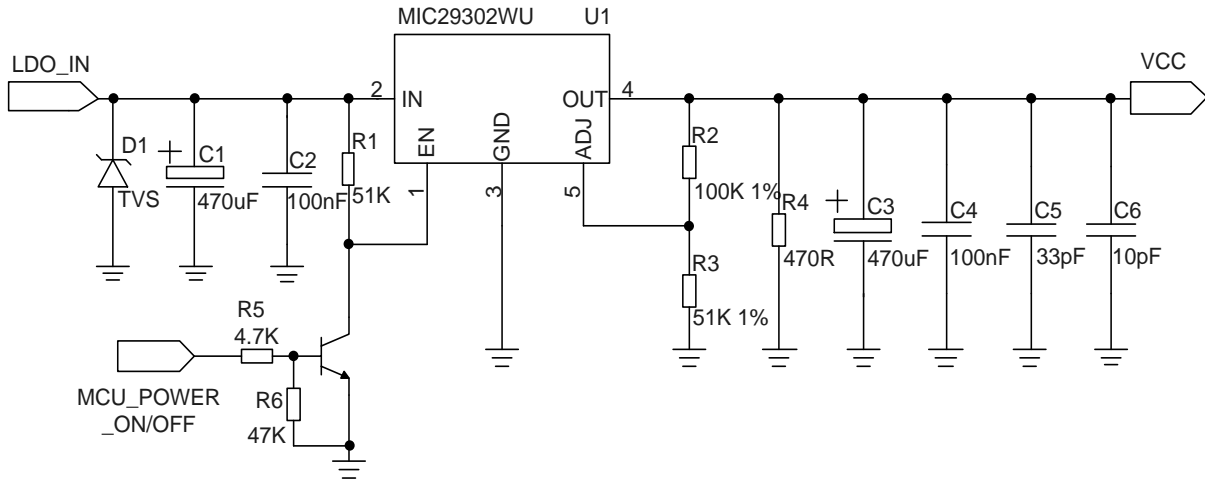


Figure 5: Reference Design of Power Supply

**NOTE**

In order to avoid damages to the internal flash, please do not switch off the power supply directly when the module is working. It is suggested that the power supply can be cut off after pulling down FULL\_CARD\_POWER\_OFF# for about 100ms.

### 3.4. Turn on and off Scenarios

#### 3.4.1. Turn on the Module

Driving the FULL\_CARD\_POWER\_OFF# pin to a high level will power on the module. The following table shows the definition of FULL\_CARD\_POWER\_OFF#.

Table 6: Definition of FULL\_CARD\_POWER\_OFF# Pin

Pin Name	Pin No.	Description	DC Characteristics	Comment
FULL_CARD_POWER_OFF#	6	A signal to control power-on/-off of the module. When it is at low level, the module powers off. When it is at high level, the module powers on.	$V_{IHmax}=4.4V$ $V_{IHmin}=0.7V$ $V_{ILmax}=0.5V$	Pulled down internally.

### 3.4.1.1. Turn on the Module Through GPIO Controlled FULL\_CARD\_POWER\_OFF#

It is recommended to use a GPIO from host to control FULL\_CARD\_POWER\_OFF#. A simple reference circuit is illustrated in the following figure.

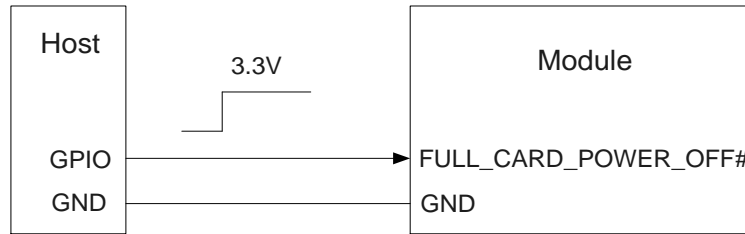


Figure 6: Turn on the Module Through GPIO Controlled FULL\_CARD\_POWER\_OFF#

### 3.4.1.2. Turn on the Module Automatically

If FULL\_CARD\_POWER\_OFF# is pulled up to 3.3V with a 5kΩ~10kΩ resistor, the module will be powered on automatically when the power supply for VCC is applied, and will be powered off when the power supply is removed.

A reference circuit is shown in the following figure.

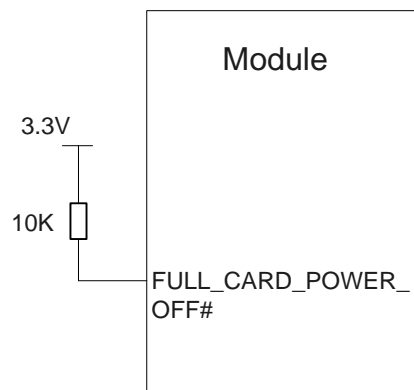
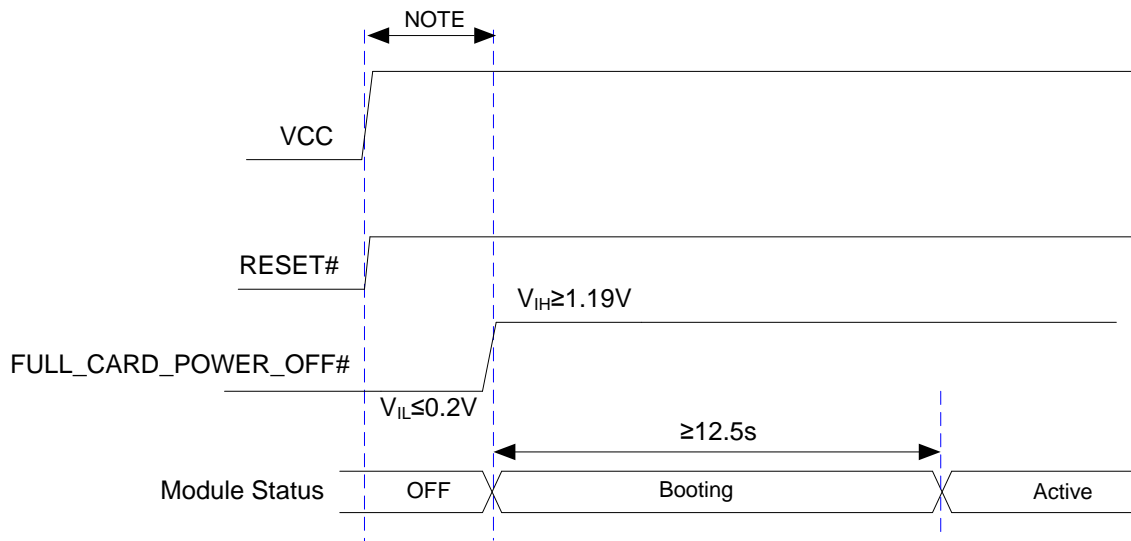


Figure 7: Turn on the Module Automatically



The turn on scenario is illustrated in the following figure.



**Figure 8: Timing of Turning on Module**

**NOTE**

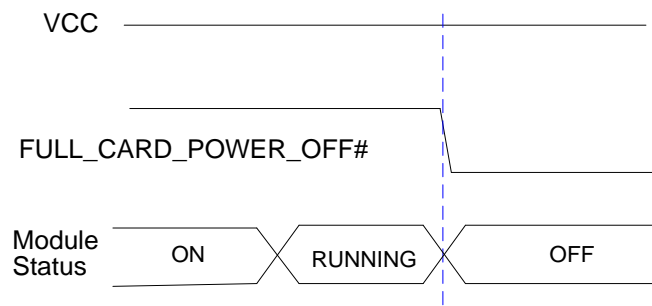
Please make sure that VCC is stable before pulling down FULL\_CARD\_POWER\_OFF# pin. The time between them is no less than 30ms.

### 3.4.2. Turn off the Module

#### 3.4.2.1. Turn off the Module Through FULL\_CARD\_POWER\_OFF#

Driving the FULL\_CARD\_POWER\_OFF# pin to low will turn off the module.

The power-down scenario is illustrated in the following figure.



**Figure 9: Timing of Turning off the Module Through FULL\_CARD\_POWER\_OFF#**

### 3.4.2.2. Turn off the Module via AT Command

The module can also be turned off by **AT+QPOWD** command. For more details about the command, please refer to *document [2]*.

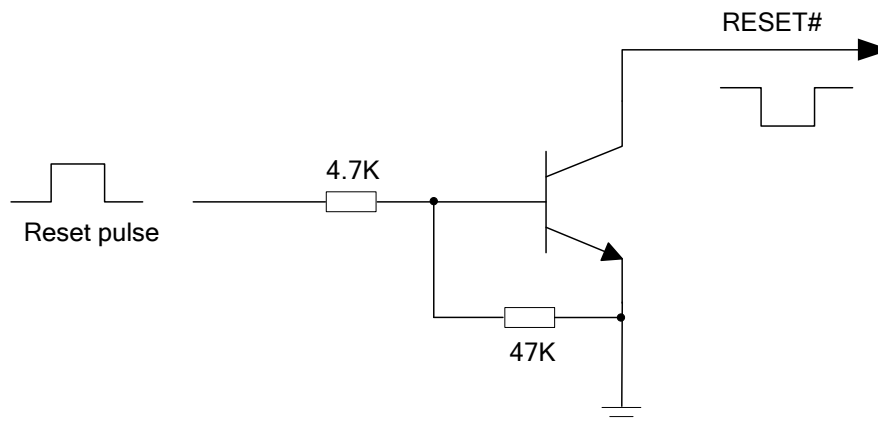
## 3.5. Reset the Module

The RESET# pin is used to reset the module. The module can be reset by driving RESET# to a low level voltage for 250ms~600ms.

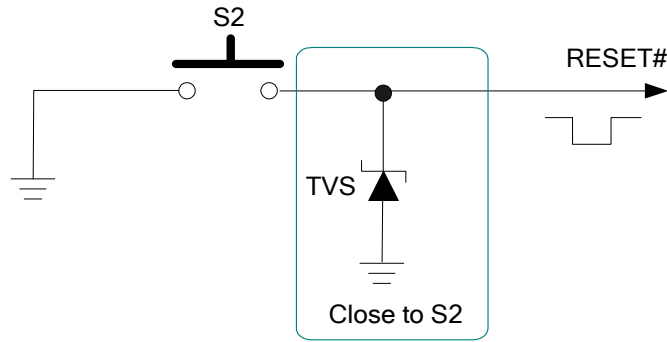
**Table 7: RESET# Pin Definition**

Pin Name	Pin No.	Description	DC Characteristics	Comment
RESET#	67	Reset the module	V <sub>IH</sub> max=2.1V V <sub>IH</sub> min=1.3V V <sub>IL</sub> max=0.5V	

An open collector/collector driver or button can be used to control the RESET# pin.

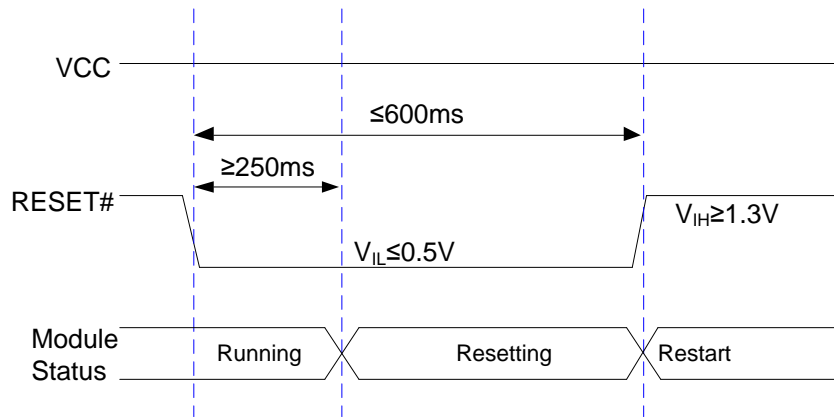


**Figure 10: Reference Circuit of RESET# by Using Driving Circuit**



**Figure 11: Reference Circuit of RESET# by Using Button**

The reset scenario is illustrated in the following figure.



**Figure 12: Timing of Resetting Module**

**NOTE**

Please ensure that there is no large capacitance on RESET# pin.

### 3.6. (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.

**Table 8: Pin Definition of (U)SIM Interfaces**

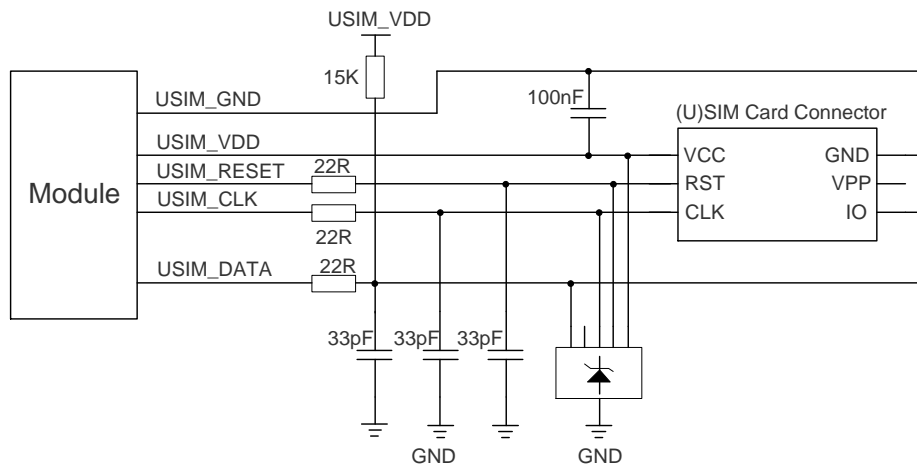
Pin Name	Pin No.	I/O	Description	Comment
USIM1_VDD	36	PO	Power supply for (U)SIM1 card	Either 1.8V or 3.0V is supported by the module automatically.
USIM1_DATA	34	IO	Data signal of (U)SIM1 card	
USIM1_CLK	32	DO	Clock signal of (U)SIM1 card	
USIM1_RESET	30	DO	Reset signal of (U)SIM1 card	
USIM1_DET	66	DI	(U)SIM1 card insertion detection. Active high.	Pulled up internally. When (U)SIM1 card is present, it is at high level. When (U)SIM1 card is absent, it is at low level.
USIM2_VDD	48	PO	Power supply for (U)SIM2 card	Either 1.8V or 3.0V is supported by the module automatically.
USIM2_DATA	42	IO	Data signal of (U)SIM2 card	
USIM2_CLK	44	DO	Clock signal of (U)SIM2 card	
USIM2_RESET	46	DO	Reset signal of (U)SIM2 card	
USIM2_DET	40	DI	(U)SIM2 card insertion detection. Active high.	Pulled up internally. When (U)SIM2 card is present, it is at high level. When (U)SIM2 card is absent, it is at low level.

EM06 supports (U)SIM card hot-plug via the USIM\_DET pin, which is a level trigger pin. The USIM\_DET is normally short-circuited to ground when (U)SIM card is not inserted. When the (U)SIM card is inserted, the USIM\_DET will change from low to high level. The rising edge will indicate insertion of the (U)SIM card. When the (U)SIM card is removed, the USIM\_DET will change from high to low level. This falling edge will indicate the absence of the (U)SIM card.

The following figure shows a reference design of (U)SIM interface with normally short-circuited (U)SIM card connector.



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



**Figure 15: Reference Circuit of 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 as close as possible to the module. Keep the trace length as less than 200mm as possible.
- Keep (U)SIM card signals away from RF and VCC traces.
- Assure the ground between the module and the (U)SIM card connector short and wide. Keep the trace width of ground and USIM\_VDD no less than 0.5mm to maintain the same electric potential.
- 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 10pF. The 22Ω resistors should be added in series between the module and the (U)SIM card connector so as to suppress EMI spurious transmission and enhance ESD protection. The 33pF capacitors are used to filter out RF interference. 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.

**NOTE**

“\*” means under development.

### 3.7. USB Interface

EM06 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\*.

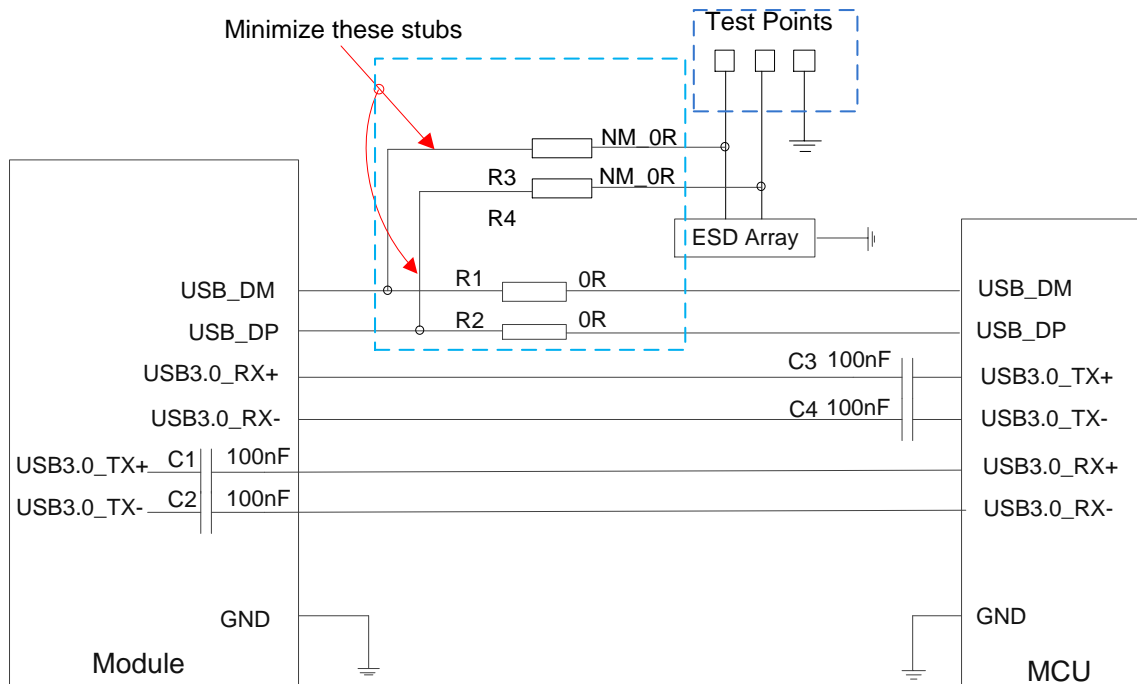
The following table shows the pin definition of USB interface.

**Table 9: Pin Definition of USB Interface**

Pin No.	Pin Name	I/O	Description	Comment
7	USB_DP	IO	USB 2.0 differential data bus (+)	Require differential impedance of 90Ω
9	USB_DM	IO	USB 2.0 differential data bus (-)	
29	USB3.0_TX-	DO	USB 3.0 transmit data (-)	Require differential impedance of 90Ω
31	USB3.0_TX+	DO	USB 3.0 transmit data (+)	
35	USB3.0_RX-	DI	USB 3.0 receive data (-)	Require differential impedance of 90Ω
37	USB3.0_RX+	DI	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 & USB 3.0 interface.



**Figure 16: Reference Circuit of USB 2.0 & 3.0 Interface**

In order to ensure the integrity of USB 2.0 & 3.0 data line signal, R1/R2/R3/R4 components must be placed close to the module, capacitors C1 and C2 have been placed inside the module, capacitors C3 and C4 must be placed close to the MCU, and these components should be placed close to each other.

In order to ensure the USB interface design corresponding with USB 2.0 & 3.0 specifications, please comply with the following principles:

- It is important to route the USB 2.0 & 3.0 signal traces as differential pairs with total grounding.
  - 1) For USB 2.0 routing traces, the trace impedance of the differential pair should be  $90\Omega$ , and the trace length difference between the differential pair should be less than 2mm.
  - 2) For USB 3.0 routing traces, the trace impedance of Tx and Rx differential pairs should be  $90\Omega$ , and the trace length difference between Tx and Rx differential pairs 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 USB connector is used, please keep the ESD protection components as close as possible to the USB connector. 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 0R resistor on USB\_DP and USB\_DM lines, respectively.



**NOTE**

“\*” means under development.

### 3.8. PCM and I2C Interfaces

EM06 supports audio communication via Pulse Code Modulation (PCM) digital interface and I2C interface.

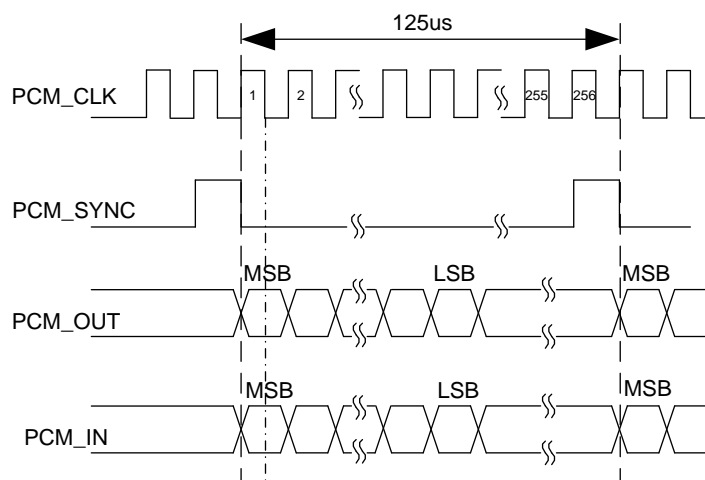
The PCM interface supports the following modes:

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

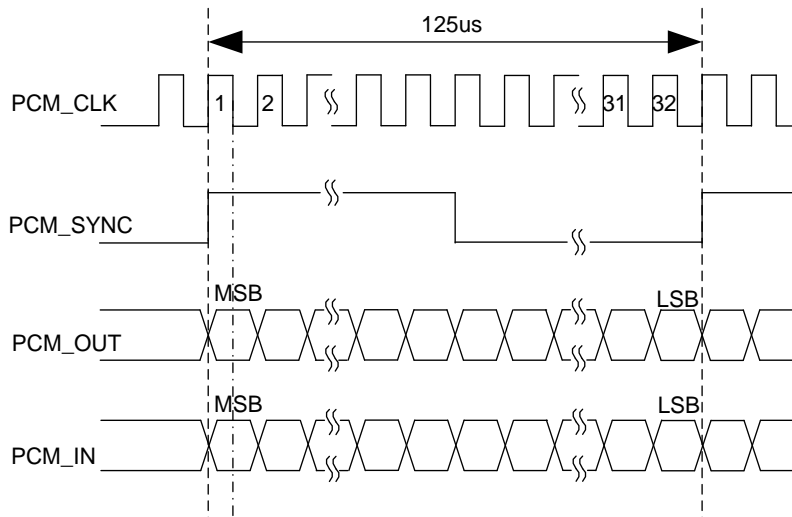
In primary mode, the data is sampled on the falling edge of the PCM\_CLK and transmitted on the rising edge. The PCM\_SYNC falling edge represents the MSB. In this mode, the PCM interface supports 256kHz, 512kHz, 1024kHz or 2048kHz PCM\_CLK at 8kHz PCM\_SYNC, and also supports 4096kHz PCM\_CLK at 16kHz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

EM06 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 17: Primary Mode Timing**



**Figure 18: Auxiliary Mode Timing**

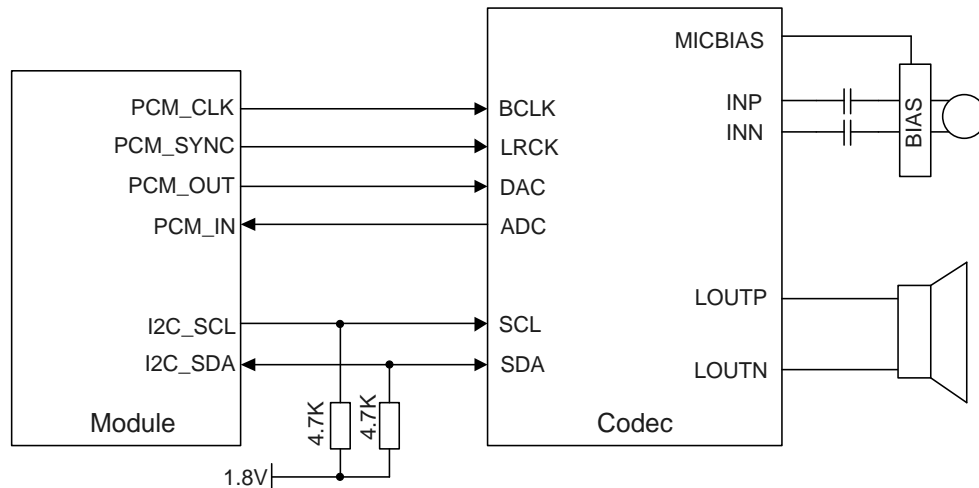
The following table shows the pin definition of PCM and I2C interfaces which can be applied on audio codec design.

**Table 10: Pin Definition of PCM and I2C Interfaces**

Pin Name	Pin No.	I/O	Description	Comment
PCM_IN	22	DI	PCM data input	1.8V power domain.
PCM_OUT	24	DO	PCM data output	1.8V power domain.
PCM_SYNC	28	IO	PCM data frame synchronization signal	1.8V power domain.
PCM_CLK	20	IO	PCM data bit clock	1.8V power domain. In master mode, it is an output signal. In slave mode, it is an input signal. If unused, keep it open.
I2C_SCL	58	DO	I2C serial clock	Used for external codec.
I2C_SDA	56	IO	I2C serial data	Require an external pull-up to 1.8V.

The clock and mode can be configured by AT command, and the default configuration is master mode using short frame synchronization format with 2048kHz PCM\_CLK and 8kHz PCM\_SYNC. Please refer to **document [2]** for details about **AT+QDAI** command.

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



**Figure 19: Reference Circuit of PCM Application with Audio Codec**

**NOTES**

1. It is recommended to reserve an RC ( $R=22\Omega$ ,  $C=22\text{pF}$ ) circuit on the PCM lines, especially for PCM\_CLK.
2. EM06 works as a master device pertaining to I2C interface.

### 3.9. Control and Indicator Signals

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

**Table 11: List of Control and Indicator Signals**

Pin No.	Pin Name	I/O	Power Domain	Description
10	WWAN_LED#	OD	3.3V	It is an open collector and active low signal. It is used to indicate the RF status of the module.
23	WAKE_ON_WAN#	OD	1.8V	A signal to wake up the host. It is an open collector and active low signal.
8	W_DISABLE1#	DI	1.8V/3.3V	Airplane mode control. Active low.
26	W_DISABLE2#*	DI	1.8V/3.3V	GNSS enable control. Active low.
25	DPR	DI	1.8V	Dynamic power reduction. High level by default.

**NOTE**

“\*” means under development.

### 3.9.1. W\_DISABLE1# Signal

EM06 provides a W\_DISABLE1# signal to disable or enable airplane mode through hardware operation. The W\_DISABLE1# pin is pulled up by default. Driving it to low level will let the module enter into airplane mode.

In airplane mode, the RF function will be disabled. The RF function can also be enabled or disabled through software AT commands. The following table shows the RF function status of the module.

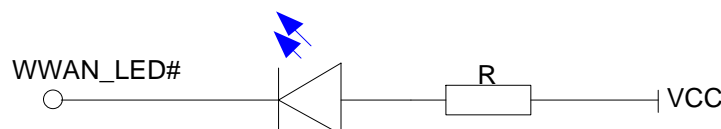
**Table 12: RF Function Status**

W_DISABLE1# Level	AT Commands	RF Function Status
High Level	<b>AT+CFUN=1</b>	Enabled
High Level	<b>AT+CFUN=0</b> <b>AT+CFUN=4</b>	Disabled
Low Level	<b>AT+CFUN=0</b> <b>AT+CFUN=1</b> <b>AT+CFUN=4</b>	Disabled

### 3.9.2. WWAN\_LED# Signal

The WWAN\_LED# signal is used to indicate the RF status of the module, and its typical current consumption is up to 40mA.

In order to reduce the current consumption of the LED, a resistor must be placed in series with the LED, as illustrated in the figure below. The LED is ON when the WWAN\_LED# signal is at a low voltage level.



**Figure 20: WWAN\_LED# Signal Reference Circuit Diagram**

The following table shows the RF status indicated by WWAN\_LED# signal.

**Table 13: Network Status Indications of WWAN\_LED# Signal**

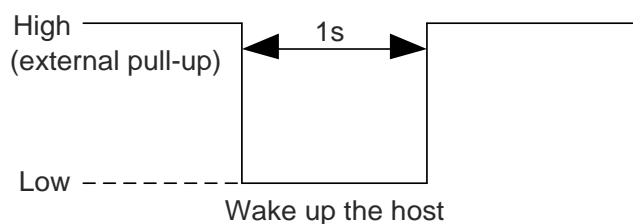
WWAN_LED# Level	Description
Low Level (LED ON)	RF function is turned on
High Level (LED OFF)	RF function is turned off if any of the following circumstances occurs: <ul style="list-style-type: none"> <li>● The (U)SIM card is not powered</li> <li>● W_DISABLE1# signal is at low level (airplane mode enabled).</li> <li>● <b>AT+CFUN=4</b> (RF function disabled)</li> </ul>

### 3.9.3. WAKE\_ON\_WAN# Signal

The WAKE\_ON\_WAN# signal is an open collector signal, which requires a pull-up resistor on the host. When a URC returns, a 1s low level pulse signal will be outputted to wake up the host. The module operation status indicated by WAKE\_ON\_WAN# is shown as below.

**Table 14: State of the WAKE\_ON\_WAN# Signal**

WAKE_ON_WAN# State	Module Operation Status
Output a 1s low level pulse signal	Call/SMS/Data is incoming (to wake up the host)
Always at high level	Idle/Sleep



**Figure 21: WAKE\_ON\_WAN# Behavior**

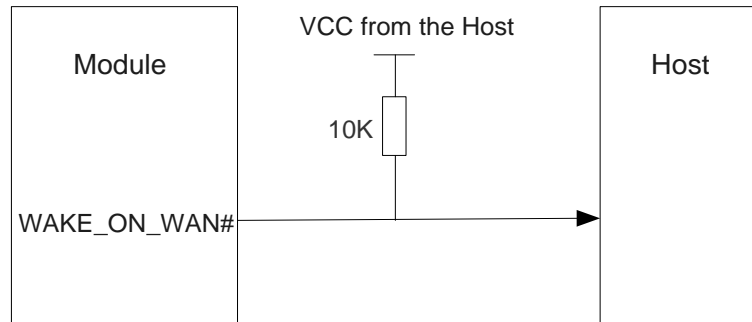


Figure 22: WAKE\_ON\_WAN# Signal Reference Circuit Design

### 3.9.4. DPR Signal

EM06 provides a DPR (Dynamic Power Reduction) signal for body SAR (Specific Absorption Rate) detection. The signal is sent by a host system proximity sensor to EM06 module to provide an input trigger which will reduce the output power in the radio transmission.

Table 15: Function of the DPR Signal

DPR Level	Function
High/Floating	Max transmitting power will NOT be backed off
Low	Max transmitting power will be backed off by executing <b>AT+QCFG="sarcfg"</b> command

#### NOTE

Please refer to *document [2]* for more details about **AT+QCFG="sarcfg"** command.

### 3.10. 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 16: Pin Definition of Tunable Antenna Control Interface\***

Pin Name	Pin No.	I/O	Description	Comment
ANTCTL0*	59	DO	Tunable antenna control	1.8V power domain
ANTCTL1*	61	DO	Tunable antenna control	1.8V power domain
ANTCTL2*	63	DO	Tunable antenna control	1.8V power domain
ANTCTL3*	65	DO	Tunable antenna control	1.8V power domain

**NOTE**

“\*” means under development.

### 3.11. Configuration Pins

EM06 provides 4 configuration pins, and it is configured as WWAN-USB 3.0 2.

**Table 17: Pin Definition of Configuration Pins**

Pin No.	Pin Name	I/O	Power Domain	Description
21	CONFIG_0		0	Connected to GND internally.
69	CONFIG_1		0	Connected to GND internally.
75	CONFIG_2		0	NC
1	CONFIG_3		0	NC

The 4 pins on EM06 module are defined as below:

**Table 18: List of Configuration Pins**

Config_0 (Pin 21)	Config_1 (Pin 69)	Config_2 (Pin 75)	Config_3 (Pin 1)	Module Type and Main Host Interface	Port Configuration
GND	GND	NC	NC	WWAN-USB 3.0	2

# 4 GNSS Receiver

## 4.1. General Description

EM06 includes a fully integrated global navigation satellite system solution that supports Gen8C-Lite of Qualcomm (GPS, GLONASS, BeiDou/Compass, Galileo and QZSS).

EM06 supports standard NMEA-0183 protocol, and outputs NMEA sentences at 1Hz data update rate via USB interface by default.

By default, EM06 GNSS engine is switched off. It has to be switched on via AT command. For more details about GNSS engine technology and configurations, please refer to **document [3]**.



# 5 Antenna Interfaces

EM06 provides a main antenna interface, an Rx-diversity antenna interface which is used to resist the fall of signals caused by high speed movement and multipath effect, and a GNSS antenna interface. The antenna ports have an impedance of 50Ω.

## 5.1. Main/Rx-diversity Antenna Interfaces

The main/Rx-diversity/GNSS antenna interfaces are shown as below.



Figure 23: Antenna Interfaces on the Module

### 5.1.1. Operating Frequency

**Table 19: EM06-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 <sup>1)</sup>	-	1452~1496	MHz
LTE B38	2570~2620	2570~2620	MHz
LTE B40	2300~2400	2300~2400	MHz
LTE B41	2545~2655	2545~2655	MHz

**Table 20: EM06-J Operating Frequencies**

3GPP Band	Transmit	Receive	Unit
WCDMA B1	1920~1980	2110~2170	MHz
WCDMA B3	1710~1785	1805~1880	MHz
WCDMA B6	830~840	875~885	MHz
WCDMA B8	880~915	925~960	MHz

WCDMA B19	830~845	875~890	MHz
LTE B1	1920~1980	2110~2170	MHz
LTE B3	1710~1785	1805~1880	MHz
LTE B8	880~915	925~960	MHz
LTE B18	815~830	860~875	MHz
LTE B19	830~845	875~890	MHz
LTE B26	814~849	859~894	MHz
LTE B28	703~748	758~803	MHz
LTE B41	2545~2655	2545~2655	MHz

**Table 21: EM06-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 <sup>1)</sup>	-	716~728	MHz
LTE B30	2305~2315	2350~2360	MHz
LTE B66	1710~1780	2110~2200	MHz

**Table 22: EM06-LA\* Operating Frequencies**

3GPP Band	Transmit	Receive	Unit
WCDMA B2	1850~1910	1930~1990	MHz
WCDMA B3	1710~1785	1805~1880	MHz
WCDMA B4	1710~1755	2110~2155	MHz
WCDMA B5	824~849	869~894	MHz
WCDMA B8	880~915	925~960	MHz
LTE B2	1850~1910	1930~1990	MHz
LTE B3	1710~1785	1805~1880	MHz
LTE B4	1710~1755	2110~2155	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

#### NOTES

- <sup>1)</sup> LTE-FDD B29 and B32 support Rx only and are only for secondary component carrier.
- “\*” means under development.

## 5.2. GNSS Antenna Interface

The following table shows frequency specification of GNSS antenna interface.

**Table 19: GNSS Frequency**

Type	Frequency	Unit
GPS/Galileo/QZSS	1575.42±1.023	MHz

GLONASS	1597.5~1605.8	MHz
BeiDou/Compass	1561.098±2.046	MHz

## 5.3. Antenna Installation

### 5.3.1. Antenna Requirements

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

**Table 23: Antenna Requirements**

Type	Requirements
GNSS <sup>1)</sup>	Frequency range: 1559MHz ~ 1609MHz Polarization: RHCP or linear VSWR: < 2 (Typ.) Passive antenna gain: > 0dBi Active antenna noise figure: < 1.5dB Active antenna gain: > 0dBi Active antenna embedded LNA gain: < 17dB
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, LTE B1/B2/B3/B4/B25/B32/B66) Cable insertion loss <2dB (LTE B7/B38/B40/B41/B30)

#### NOTE

<sup>1)</sup> 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.

### 5.3.2. Recommended RF Connector for Antenna Installation

EM06 is mounted with standard 2mm × 2mm receptacle RF connectors for convenient antenna connection. The connector dimensions are illustrated below:

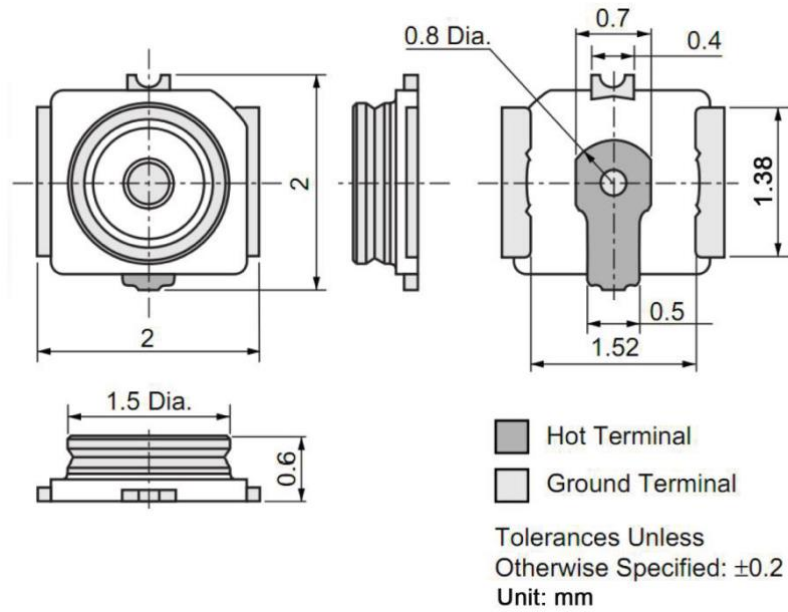


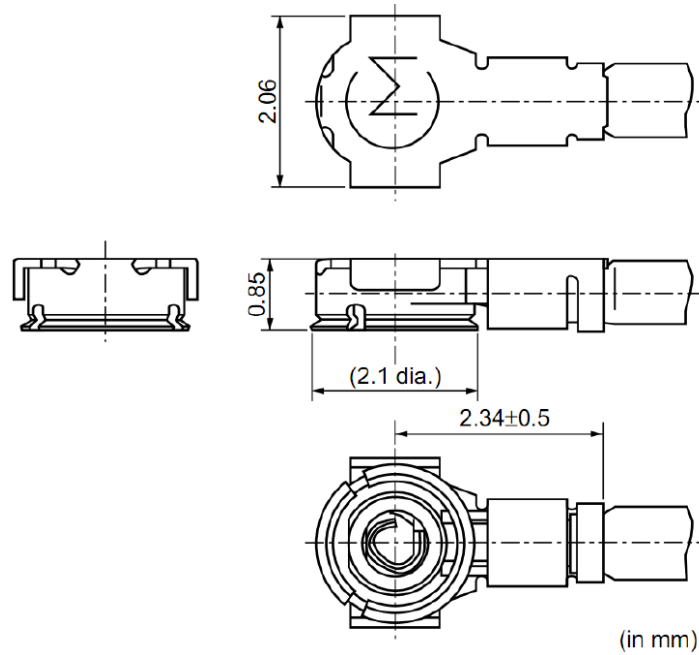
Figure 24: EM06 RF Connector Dimensions (Unit: mm)

Table 24: Major Specifications of the RF Connector

Item	Specification
Nominal Frequency Range	DC to 6GHz
Nominal Impedance	50Ω
Temperature Rating	-40°C to +85°C
Voltage Standing Wave Ratio (VSWR)	Meet the requirements of: Max 1.3 (DC~3GHz) Max 1.45 (3GHz~6GHz)

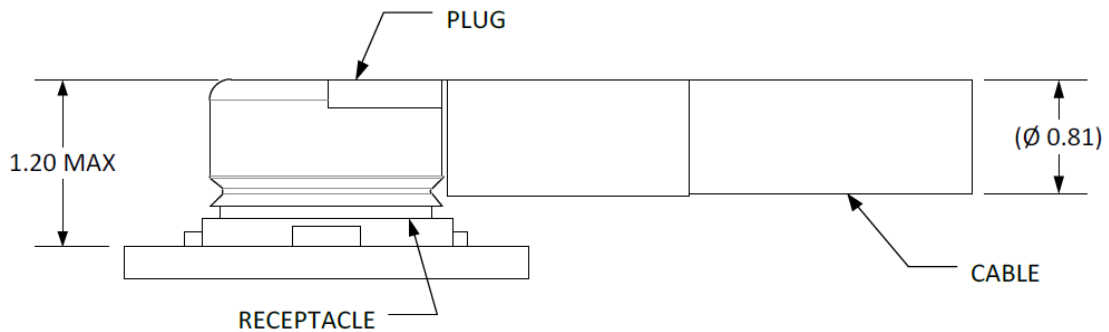
The receptacle RF connector used in conjunction with EM06 will accept two types of mating plugs that will meet a maximum height of 1.2mm using a Ø0.81mm coaxial cable or a maximum height of 1.45mm utilizing a Ø1.13mm coaxial cable.

The following figure shows the specifications of mating plugs using Ø0.81mm coaxial cables.



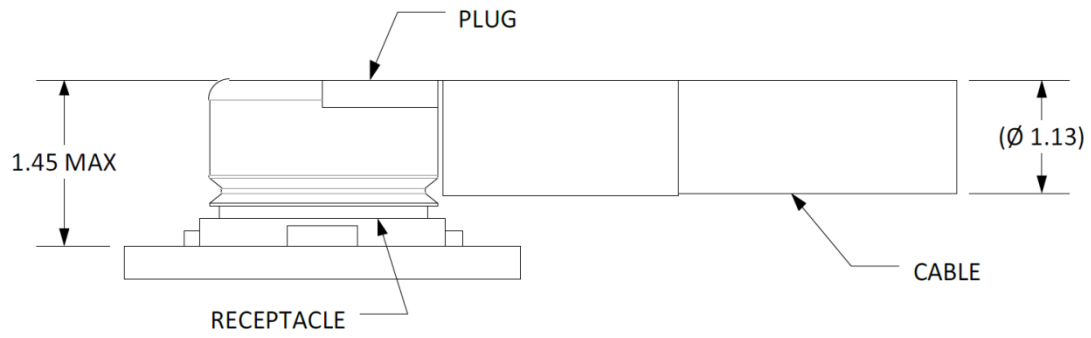
**Figure 25: Specifications of Mating Plugs Using Ø0.81mm Coaxial Cables**

The following figure illustrates the connection between the receptacle RF connector on EM06 and the mating plug using a Ø0.81mm coaxial cable.



**Figure 26: Connection between RF Connector and Mating Plug Using Ø0.81mm Coaxial Cable**

The following figure illustrates the connection between the receptacle RF connector on EM06 and the mating plug using a Ø1.13mm coaxial cable.



**Figure 27: Connection between RF Connector and Mating Plug Using  $\varnothing 1.13$ mm Coaxial Cable**



# 6 Electrical, Reliability and Radio Characteristics

## 6.1. Absolute Maximum Ratings

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

**Table 25: Absolute Maximum Ratings**

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

## 6.2. Power Supply Requirements

The typical input voltage of EM06 is 3.7V, as specified by *PCIe M.2 Electromechanical Spec Rev1.0*. The following table shows the power supply requirements of EM06.

**Table 26: Power Supply Requirements**

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Power Supply	3.135	3.7	4.4	V

## 6.3. I/O Requirements

Table 27: I/O Requirements

Parameter	Description	Min.	Max.	Unit
V <sub>IH</sub>	Input high voltage	0.7 × V <sub>DD18</sub> <sup>1)</sup>	V <sub>DD18</sub> +0.3	V
V <sub>IL</sub>	Input low voltage	-0.3	0.3 × V <sub>DD18</sub>	V
V <sub>OH</sub>	Output high voltage	V <sub>DD18</sub> -0.5	V <sub>DD18</sub>	V
V <sub>OL</sub>	Output low voltage	0	0.4	V

### NOTE

<sup>1)</sup>V<sub>DD18</sub> refers to I/O power domain.

## 6.4. Operation and Storage Temperatures

Table 28: Operation and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operation Temperature Range <sup>1)</sup>	-30	+25	+70	°C
Extended Temperature Range <sup>2)</sup>	-40		+85	°C
Storage temperature Range	-40		+90	°C

### NOTES

- <sup>1)</sup> Within operation temperature range, the module is 3GPP compliant.
- <sup>2)</sup> 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<sub>out</sub> 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.

## 6.5. Current Consumption

Table 29: EM06-E Current Consumption

Parameter	Description	Conditions	Typ.	Unit	
I <sub>BAT</sub>	OFF state	Power down	50	uA	
	Sleep state	<b>AT+CFUN=0</b> (USB disconnected)	2.77	mA	
		WCDMA PF=64 (USB disconnected)	2.91	mA	
		WCDMA PF=128 (USB disconnected)	3.05	mA	
		WCDMA PF=256 (USB disconnected)	2.83	mA	
		LTE-FDD PF=64 (USB disconnected)	3.88	mA	
		LTE-FDD PF=128 (USB disconnected)	3.88	mA	
		LTE-FDD PF=256 (USB disconnected)	4.19	mA	
		LTE-TDD PF=64 (USB disconnected)	3.79	mA	
		LTE-TDD PF=128 (USB disconnected)	3.91	mA	
		LTE-TDD PF=256 (USB disconnected)	4.36	mA	
		Idle state	WCDMA PF=64 (USB disconnected, band 1)	22.1	mA
			WCDMA PF=64 (USB connected, band 1)	26.27	mA
			LTE-FDD PF=64 (USB disconnected, band 1)	20.61	mA
			LTE-FDD PF=64 (USB connected, band 1)	20.72	mA
	LTE-TDD PF=64 (USB disconnected, band 38)		20.56	mA	
	LTE-TDD PF=64 (USB connected, band 38)		20.96	mA	
	WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA CH10700 @23dBm	565	mA	
		WCDMA B1 HSUPA CH10700 @22.4dBm	557	mA	
		WCDMA B3 HSDPA CH1338 @22.7dBm	582	mA	
WCDMA B3 HSUPA CH1338 @22.1dBm		580	mA		
WCDMA B5 HSDPA CH4407 @22.6dBm		584	mA		

	WCDMA B5 HSUPA CH4407 @22dBm	572	mA
	WCDMA B8 HSDPA CH3012 @22.3dBm	566	mA
	WCDMA B8 HSUPA CH3012 @21.8dBm	553	mA
LTE data transfer (GNSS OFF)	LTE-FDD B1 CH300 @23.8dBm	670	mA
	LTE-FDD B3 CH1575 @23.8dBm	830	mA
	LTE-FDD B5 CH2525 @23.3dBm	647	mA
	LTE-FDD B7 CH3100 @23.48dBm	880	mA
	LTE-FDD B8 CH3625 @23.2dBm	640	mA
	LTE-FDD B20 CH6300 @22.8dBm	770	mA
	LTE-FDD B28 CH27460 @22.7dBm	692	mA
	LTE-TDD B38 CH38000 @23.8dBm	341	mA
	LTE-TDD B40 CH39150 @23.6dBm	377	mA
	LTE-TDD B41 CH40740 @23.8dBm	345	mA
2CA data transfer	LTE-FDD B1+B1 @21.8dBm	811	mA
	LTE-FDD B1+B5 @21.7dBm	749	mA
	LTE-FDD B1+B8 @21.8dBm	761	mA
	LTE-FDD B1+B20 @21.9dBm	810	mA
	LTE-FDD B1+B28 @21.8dBm	821	mA
	LTE-FDD B3+B3 @21.3dBm	757	mA
	LTE-FDD B3+B5 @21.2dBm	734	mA
	LTE-FDD B3+B7 @21.2dBm	795	mA
	LTE-FDD B3+B8 @21.2dBm	744	mA
	LTE-FDD B3+B20 @21.2dBm	801	mA
LTE-FDD B3+B28 @21.2dBm	810	mA	
LTE-FDD B7+B5 @20.6dBm	798	mA	
LTE-FDD B7+B7 @21.5dBm	803	mA	
LTE-FDD B7+B8 @21.2dBm	811	mA	

	LTE-FDD B7+B20 @20.7dBm	840	mA
	LTE-FDD B7+B28 @20.1dBm	830	mA
	LTE-FDD B20+B32 @21.9dBm	701	mA
	LTE-TDD B38+B38 @21.4dBm	424	mA
	LTE-TDD B40+B40 @21.8dBm	464	mA
	LTE-TDD B41+B41 @21.5dBm	435	mA
WCDMA voice call	WCDMA B1 CH10700 @23.1dBm	663	mA
	WCDMA B3 CH1338 @22.6dBm	665	mA
	WCDMA B5 CH4407 @22.7dBm	625	mA
	WCDMA B8 CH3012 @22.9dBm	633	mA

**Table 30: EM06-J Current Consumption**

Parameter	Description	Conditions	Typ.	Unit	
I <sub>VBAT</sub>	OFF state	Power down	47	uA	
	Sleep state	<b>AT+CFUN=0</b> (USB disconnected)		2.96	mA
		WCDMA PF=64 (USB disconnected)		3.76	mA
		WCDMA PF=128 (USB disconnected)		3.29	mA
		WCDMA PF=512 (USB disconnected)		3.14	mA
		LTE-FDD PF=32 (USB disconnected)		5.12	mA
	Idle state	WCDMA PF=64 (USB disconnected)		19.5	mA
		WCDMA PF=64 (USB connected)		21.4	mA
		LTE-FDD PF=64 (USB disconnected)		21.9	mA
		LTE-FDD PF=64 (USB connected)		21.4	mA
		LTE-TDD PF=64 (USB disconnected)		20.1	mA
		LTE-TDD PF=64 (USB connected)		21.1	mA
	WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA CH10700 @23.4dBm		700	mA
		WCDMA B1 HSUPA CH10700 @22.2dBm		635	mA

	WCDMA B3 HSDPA CH1338 @23.4dBm	704	mA
	WCDMA B3 HSUPA CH1338 @22.7dBm	655	mA
	WCDMA B6 HSDPA CH4175 @23.7dBm	589	mA
	WCDMA B6 HSUPA CH4175 @23.5dBm	578	mA
	WCDMA B8 HSDPA CH3012 @23.4dBm	653	mA
	WCDMA B8 HSUPA CH3012 @22.4dBm	584	mA
	WCDMA B19 HSDPA CH738 @23.4dBm	628	mA
	WCDMA B19 HSUPA CH738 @22.4dBm	575	mA
LTE data transfer (GNSS OFF)	LTE-FDD B1 CH300 @23.3dBm	707	mA
	LTE-FDD B3 CH1575 @23.1dBm	769	mA
	LTE-FDD B8 CH3625 @24.1dBm	710	mA
	LTE-FDD B18 CH5925 @24.2dBm	728	mA
	LTE-FDD B19 CH6075 @23.4dBm	651	mA
	LTE-FDD B26 CH8865 @23.4dBm	604	mA
	LTE-FDD B28 CH27460 @23.5dBm	705	mA
	LTE-TDD B41 CH40740 @24.2dBm	363	mA
2CA data transfer	LTE-FDD B1+B1 @22.5dBm	815	mA
	LTE-FDD B1+B8 @22.6dBm	861	mA
	LTE-FDD B1+B18 @22.6dBm	913	mA
	LTE-FDD B1+B19 @23.1dBm	835	mA
	LTE-FDD B1+B28 @23.2dBm	812	mA
	LTE-FDD B3+B3 @23dBm	861	mA
	LTE-FDD B3+B8 @23dBm	913	mA
	LTE-FDD B3+B18 @22.3dBm	878	mA
	LTE-FDD B3+B19 @22.4dBm	857	mA
	LTE-FDD B3+B28 @22.4dBm	864	mA
LTE-TDD B41+B41 @23.6dBm	507	mA	

WCDMA voice call	WCDMA B1 CH10700 @23.7dBm	735	mA
	WCDMA B3 CH1338 @23.8dBm	740	mA
	WCDMA B6 CH4175 @23.7dBm	610	mA
	WCDMA B8 CH3012 @23.8dBm	675	mA
	WCDMA B19 CH738 @23.9dBm	650	mA

## 6.6. RF Output Power

The following table shows the RF output power of EM06 module.

**Table 31: RF Output Power**

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

## 6.7. RF Receiving Sensitivity

The following tables show conducted RF receiving sensitivity of EM06 module.

**Table 32: EM06-E Conducted RF Receiving Sensitivity**

Frequency	Primary (Typ.)	Diversity (Typ.)	SIMO <sup>1)</sup> (Typ.)	SIMO <sup>2)</sup> (Worst Case)
WCDMA B1	-109.5dBm	-109dBm	-111dBm	-106.7dBm
WCDMA B3	-109dBm	-109dBm	-111dBm	-103.7dBm
WCDMA B5	-109dBm	-109dBm	-111dBm	-104.7dBm
WCDMA B8	-109dBm	-109dBm	-111dBm	-103.7dBm
LTE-FDD B1 (10M)	-97.5dBm	-97dBm	-100dBm	-96.3dBm

LTE-FDD B3 (10M)	-97dBm	-97dBm	-100dBm	-93.3dBm
LTE-FDD B5 (10M)	-97dBm	-99dBm	-100.5dBm	-94.3dBm
LTE-FDD B7 (10M)	-95.5dBm	-98dBm	-99.5dBm	-94.3dBm
LTE-FDD B8 (10M)	-97.5dBm	-98dBm	-100.5dBm	-93.3dBm
LTE-FDD B20 (10M)	-96.5dBm	-98.5dBm	-100.5dBm	-93.3dBm
LTE-FDD B28 (10M)	-96.5dBm	-98.5dBm	-100.5dBm	-94.8dBm
LTE-TDD B38 (10M)	-96dBm	-97.5dBm	-99dBm	-96.3dBm
LTE-TDD B40 (10M)	-96dBm	-97.5dBm	-98.5dBm	-96.3dBm
LTE-TDD B41 (10M)	-95.5dBm	-97.5dBm	-98.5dBm	-94.3dBm

**Table 33: EM06-J Conducted RF Receiving Sensitivity**

Frequency	Primary (Typ.)	Diversity (Typ.)	SIMO <sup>1)</sup> (Typ.)	SIMO <sup>2)</sup> (Worst Case)
WCDMA B1	-109dBm	-109dBm	-111dBm	-106.7dBm
WCDMA B3	-109dBm	-109dBm	-111dBm	-103.7dBm
WCDMA B6	-108dBm	-109dBm	-111dBm	-106.7dBm
WCDMA B8	-109dBm	-109dBm	-111dBm	-103.7dBm
WCDMA B19	-109dBm	-109dBm	-111dBm	-106.7dBm
LTE-FDD B1 (10M)	-97.5dBm	-97dBm	-100dBm	-96.3dBm
LTE-FDD B3 (10M)	-97dBm	-97dBm	-100dBm	-93.3dBm
LTE-FDD B8 (10M)	-97.5dBm	-99dBm	-100.5dBm	-93.3dBm
LTE-FDD B18 (10M)	-96.5dBm	-98dBm	-100dBm	-96.3dBm
LTE-FDD B19 (10M)	-96.5dBm	-98dBm	-99.5dBm	-96.3dBm
LTE-FDD B26 (10M)	-96dBm	-97.5dBm	-98.5dBm	-96.3dBm
LTE-FDD B28 (10M)	-96.5dBm	-98.5dBm	-100.5dBm	-94.8dBm
LTE-TDD B41 (10M)	-95.5dBm	-97.5dBm	-98.5dBm	-94.3dBm



## NOTES

1. <sup>1)</sup> SIMO is a smart antenna technology that uses a single antenna at the transmitter side and multiple (two for EM06) antennas at the receiver side, which can improve Rx performance.
2. <sup>2)</sup> Per 3GPP specification.

## 6.8. ESD Characteristics

The module is not protected against electrostatic 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.

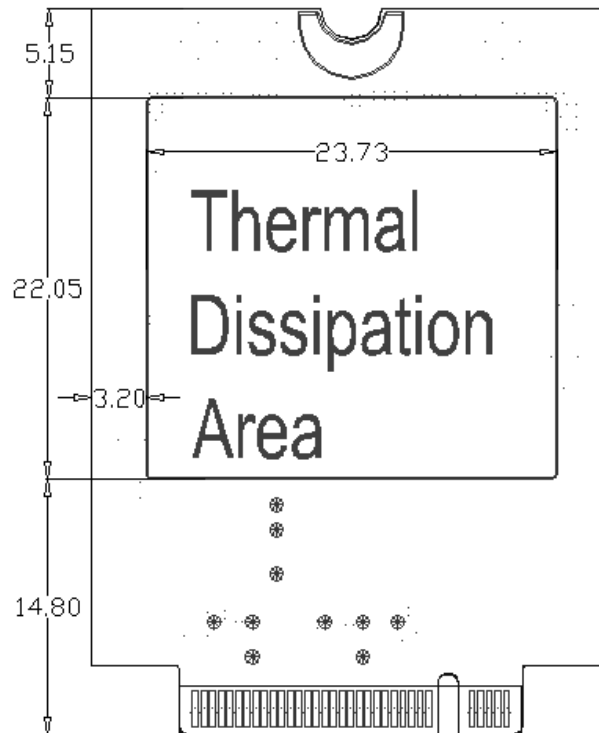
**Table 34: Electrostatic Discharge Characteristics (Temperature: 25°C, Humidity: 40%)**

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

## 6.9. Thermal Dissipation

EM06 is designed to work over an extended temperature range. In order to achieve a maximum performance while working under extended temperatures or extreme conditions (such as with maximum power or data rate, etc.) for a long time, it is strongly recommended to add a thermal pad or other thermally conductive compounds between the module and the main PCB for thermal dissipation.

The thermal dissipation area (i.e. the area for adding thermal pad) is show as below. The dimensions are measured in mm.



**Figure 28: Thermal Dissipation Area on Bottom Side of Module (Top View)**

There are some other measures to enhance heat dissipation performance:

- Add ground vias as many as possible on PCB.
- Maximize airflow over/around the module.
- Place the module away from other heating sources.
- Module mounting holes must be used to attach (ground) the device to the main PCB ground.
- It is NOT recommended to apply solder mask on the main PCB where the module's thermal dissipation area is located.
- Select an appropriate material, thickness and surface for the outer housing (i.e. the mechanical enclosure) of the application device that integrates the module so that it provides good thermal dissipation.
- Customers may also need active cooling to pull heat away from the module.
- If possible, add a heatsink on the top of the module. A thermal pad should be used between the heatsink and the module, and the heatsink should be designed with as many fins as possible to increase heat dissipation area.

# 7 Mechanical Dimensions and Packaging

This chapter mainly describes mechanical dimensions and packaging specifications of EM06 module. All dimensions are measured in mm, and the tolerances for dimensions without tolerance values are  $\pm 0.05\text{mm}$ .

## 7.1. Mechanical Dimensions of the Module

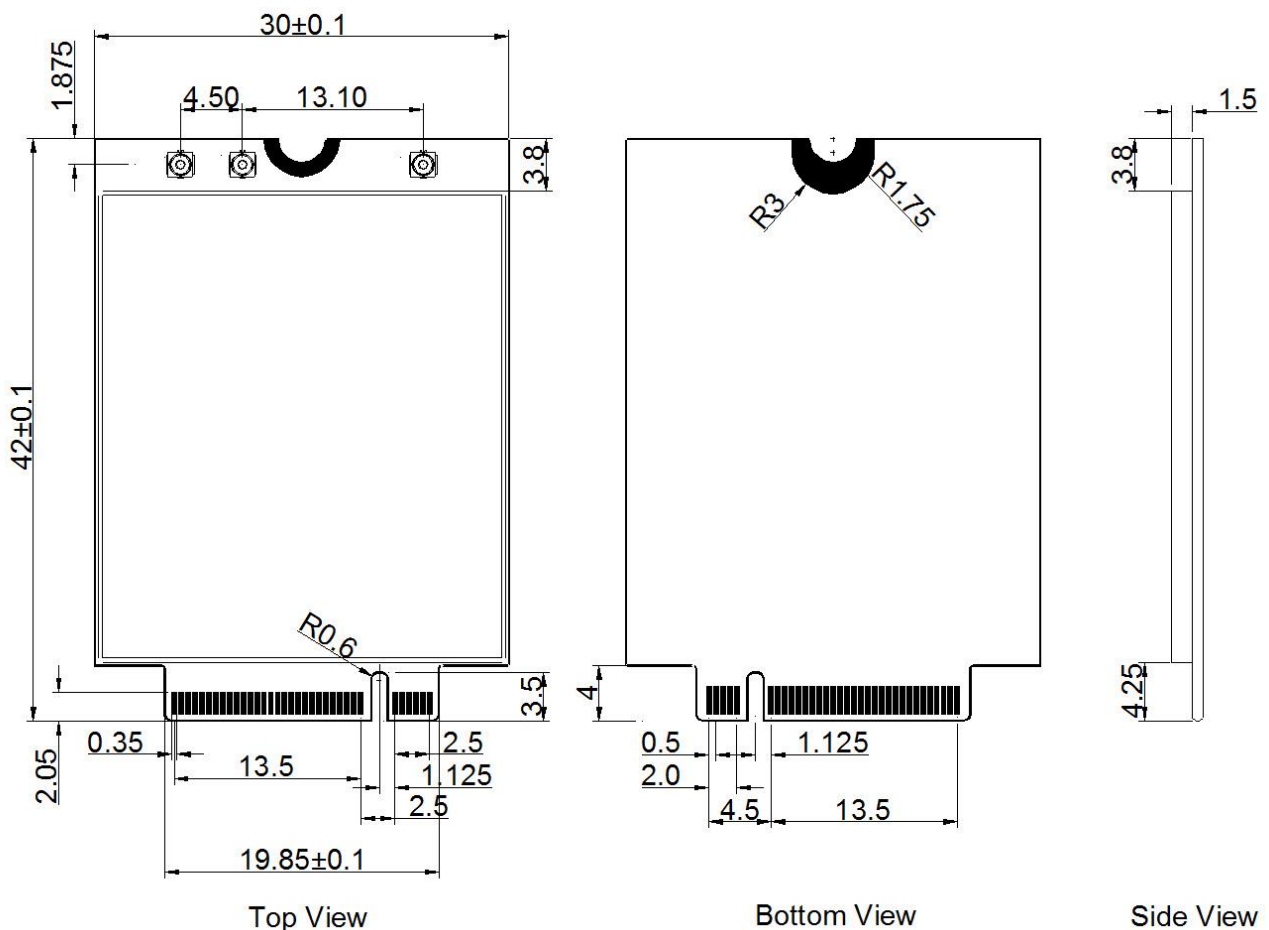
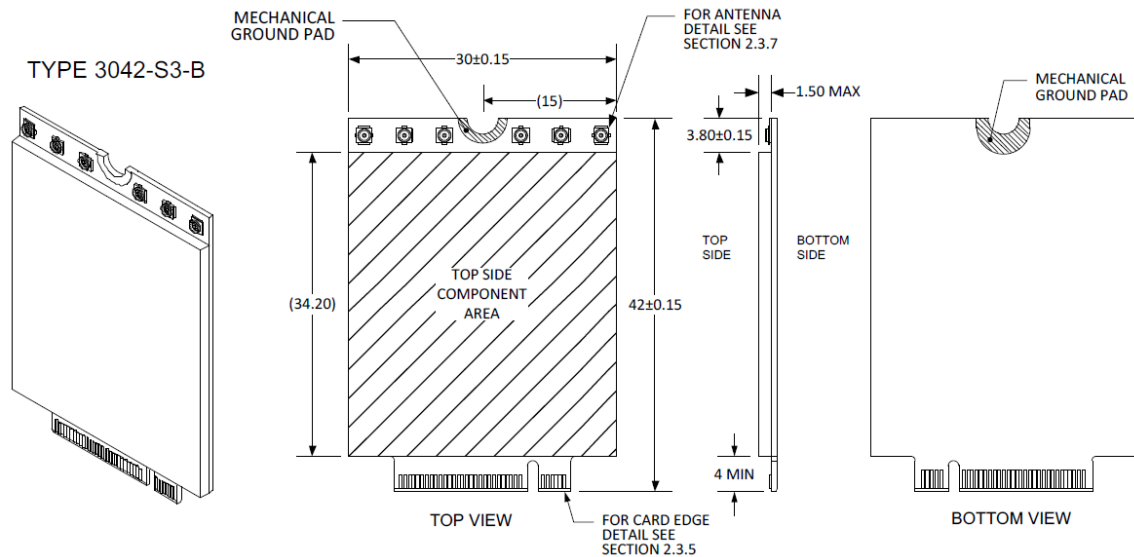


Figure 29: Mechanical Dimensions of EM06 (Unit: mm)

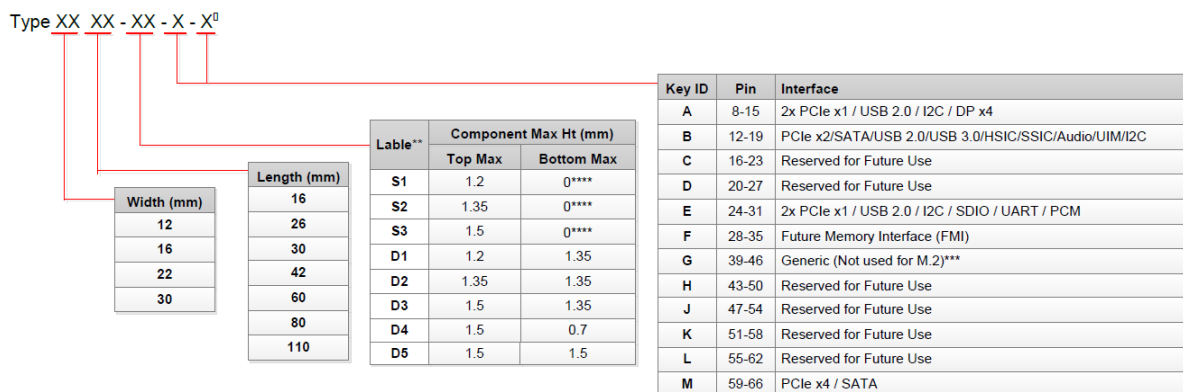
## 7.2. Standard Dimensions of M.2 PCI Express

The following figure shows the standard dimensions of M.2 PCI Express. Please refer to **document [4]** for detailed A and B.



**Figure 30: Standard Dimensions of M.2 Type 3042-S3 (Unit: mm)**

According to M.2 nomenclature, EM06 is Type 3042-S3-B (30.0mm × 42.0mm, max component height on the top is 1.5mm and single-sided, key ID is B).



- \* Use ONLY when a double slot is being specified
- \*\* Label included in height dimension
- \*\*\* Key G is intended for custom use. Devices with this key will not be M.2-compliant. Use at your own risk!
- \*\*\*\* Insulating label allowed on connector-based designs

**Figure 31: M.2 Nomenclature**

### 7.3. Design Effect Drawings of the Module



Figure 32: Top View of the Module

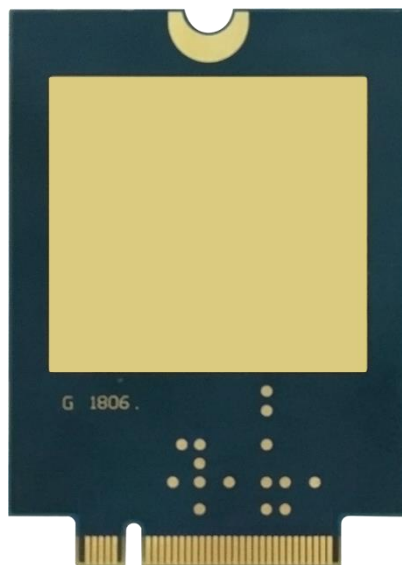


Figure 33: Bottom View of the Module

**NOTE**

These are design effect drawings of EM06 module. For more accurate pictures, please refer to the module that you get from Quectel.

## 7.4. M.2 Connector

EM06 adopts a standard PCI Express M.2 connector which complies with the directives and standards listed in the *document [4]*.

## 7.5. Packaging

EM06 modules are packaged in trays. Each tray contains 10 modules. The smallest package contains 100 modules.

## 8 Appendix References

**Table 35: Related Documents**

SN	Document Name	Remark
[1]	Quectel_M.2_EVB_User_Guide	M.2 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	EP06, EG06 and EM06 GNSS AT Commands Manual
[4]	PCI Express M.2 Specification	PCI Express Specification

**Table 36: Terms and Abbreviations**

Abbreviation	Description
bps	Bits Per Second
DC-HSPA+	Dual-carrier High Speed Packet Access
DFOTA	Delta Firmware Upgrade Over The Air
DL	Down Link
ESD	Electrostatic Discharge
FDD	Frequency Division Duplexing
GLONASS	GLObalnaya Navigatsionnaya Sputnikovaya Sistema, the Russian Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HR	Half Rate

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HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
kbps	Kilo Bits Per Second
LED	Light Emitting Diode
LTE	Long Term Evolution
Mbps	Million Bits Per Second
ME	Mobile Equipment (Module)
MIMO	Multiple-Input Multiple-Output
MLCC	Multiplayer Ceramic Chip Capacitor
MMS	Multimedia Messaging Service
MO	Mobile Originated
MT	Mobile Terminated
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
RF	Radio Frequency
Rx	Receive
SAR	Specific Absorption Rate
SMS	Short Message Service
Tx	Transmit
UART	Universal Asynchronous Receiver & Transmitter
UL	Up Link
URC	Unsolicited Result Code
(U)SIM	(Universal) Subscriber Identification Module
WCDMA	Wideband Code Division Multiple Access

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# 9 IC & FCC Requirement

FCC Certification Requirements.

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

And the following conditions must be met:

1. This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based timeaveraging

duty factor, antenna gain and cable loss must satisfy MPE categorical Exclusion Requirements of 2.1091.

2. The EUT is a mobile device; maintain at least a 20 cm separation between the EUT and the user's body

and must not transmit simultaneously with any other antenna or transmitter.

3. A label with the following statements must be attached to the host end product: This device contains FCC ID: XMR201906EM06A

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

Operating Band	FCC Max Antenna Gain ( dBi )	IC Max Antenna Gain ( dBi )
WCDMA BAND II	9.00	9.00
WCDMA BAND IV	6.00	6.00
WCDMA BAND V	10.42	9.26
LTE BAND 2	9.00	9.00
LTE BAND 4	6.00	6.00
LTE BAND 5	10.41	9.25
LTE BAND 7	9.00	9.00
LTE BAND 12	9.70	8.76
LTE BAND 13	10.16	9.09
LTE BAND 25	9.00	9.00
LTE BAND 26(814-824)	10.36	NA
LTE BAND 26(824-849)	10.41	9.25
LTE BAND 30	0.00	0.00
LTE BAND 41	9.00	9.00
LTE BAND 66	6.00	6.00

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

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

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

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

configurations.

For this device, OEM integrators must be provided with labeling instructions of finished products.

Please refer to KDB784748 D01 v07, section 8. Page 6/7 last two paragraphs:

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

For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straightforward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module: "Contains Transmitter Module FCC ID: XMR201906EM06A" or "Contains FCC ID: XMR201906EM06A" must be used. The host OEM user manual must also contain clear instructions on how end users can find and/or access the module and the FCC ID.

The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device. The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by this section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

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

#### **Manual Information To the End User**

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as show in this manual.

#### **IC Statement**

IRSS-GEN

"This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions: (1) This device may not cause interference; and (2) This device must accept any interference, including interference that may cause undesired operation of the device." or "Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes :

1) l'appareil ne doit pas produire de brouillage; 2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."

Déclaration sur l'exposition aux rayonnements RF

L'autre utilisé pour l'émetteur doit être installé pour fournir une distance de séparation d'au moins 20 cm de toutes les personnes et ne doit pas être colocalisé ou fonctionner conjointement avec une autre antenne ou un autre émetteur.

The host product shall be properly labeled to identify the modules within the host product.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labeled to display the Innovation, Science and Economic Development Canada certification number for the module, preceded by the word "Contains" or similar wording expressing the same meaning, as follows: "Contains IC: 10224A-201906EM06A" or "where: 10224A-201906EM06A is the module's certification number".

Le produit hôte doit être correctement étiqueté pour identifier les modules dans le produit hôte.

L'étiquette de certification d'Innovation, Sciences et Développement économique Canada d'un module doit être clairement visible en tout temps lorsqu'il est installé dans le produit hôte; sinon, le produit hôte doit porter une étiquette indiquant le numéro de certification d'Innovation, Sciences et Développement économique Canada pour le module, précédé du mot «Contient» ou d'un libellé semblable exprimant la même signification, comme suit:

"Contient IC: 10224A-201906EM06A " ou "où: 10224A-201906EM06A est le numéro de certification du module".