EM06 Series

Hardware Design

LTE-A Module Series

Version: 1.4

Date: 2020-12-21

Status: Released

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About the Document

Revision History

Version	Date	Author	Description
1.0	2018-07-17	King MA/ Wison HE	Initial
1.1	2019-10-31	Jared WANG/ Jeremy LI	1. Updated CA feature of EM06-A (Table 1). 2. Updated Internet protocol features of EM06 (Table 2). 3. Deleted information about USB 3.0 and changed USB 3.0 pins into NC pins (Figure 2 and Table 4). 4. Added operating modes (Chapter 3.3) 5. Added GNSS performance (Chapter 4.2) 6. Updated EM06-A current consumption (Table 35). Added EM06-A conducted RF receiving sensitivity (Table 39). 7. Variant EM06-A, function DFOTA and dual SIM single standby have been fully developed.
1.2	2019-11-11	Jeremy LI	1. Updated GNSS performance (Table 21). 2. Updated the reference circuit of (U)SIM interface with normally closed (U)SIM card connector (Figure 13) and the reference circuit of (U)SIM interface with normally open (U)SIM card connector (Figure 14).
1.3	2020-09-07	Jada LIN/ Jerax KONG	1. Updated the definition of FULL_CARD_POWER_OFF# (Table 7). 2. Updated the timing of turning on module (Figure 8) and the timing of turning off the module through FULL_CARD_POWER_OFF# (Figure 9). 3. Added the timing of (U)SIM (Figure 16) and the timing of hot-plug (Figure 17). 4. Deleted the information about active antenna (Table 26).

			5. Deleted the information about EM06-LA. 6. Added a reference design for power supply circuit with buck DC-DC converter (Figure 5).
1.4	2020-12-21	Eysen Wang/ Archibald JIANG	1. Updated the current consumption of EM06-E in Chapter 31. 2. Deleted M.2 Socket 2 USB 3.0-Based Pinout row in Table 4.

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1 Introduction

This document defines the EM06 series module and describes its air and hardware interfaces which connect to your applications.

It helps you quickly understand EM06 series' interface specifications, electrical and mechanical details, as well as other related information. To facilitate application of the series in different fields, its reference designs are also provided for your reference. With the hardware design document, application notes and user guides, you can use the product 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 EM06 series module. Manufacturers of the cellular terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all manuals of the product. Otherwise, Quectel assumes no liability for customers' failure to comply with these precautions.

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

2 Product Concept

2.1. General Description

The EM06 series modules are a series of LTE-A/UMTS/HSPA+ wireless communication modules featuring receive diversity. With standard PCI Express M.2 interfaces, the series supports data connection on LTE-FDD, LTE-TDD, DC-HSDPA, DC-HSPA+, HSDPA, HSUPA and WCDMA networks.

EM06 series supports embedded operating systems such as Windows, Linux and Android, and also carries GNSS [1)] and voice functionality [2)] to meet specific application demands. It contains three variants: EM06-E, EM06-J and EM06-A. You can select a dedicated type based on your region or operator(s).

The following table lists the frequency bands, CA combinations and GNSS types supported by the module.

Table 1: Frequency Bands, CA Combinations and GNSS Types Supported

Mode	EM06-E	EM06-J	EM06-A
LTE-FDD (with Rx-diversity)	B1/B3/B5/B7/ B8/B20/B28/B32 [3)]	B1/B3/B8/B18/B19/ B26/B28	B2/B4/B5/B7/B12/ B13/B25/B26/ B29 [3)]/B30/B66
LTE-TDD (with Rx-diversity)	B38/B40/B41	B41	B41
2×CA	B1 + B1/B5/B8/ B20/B28; B3 + B3/B5/B7/ B8/B20/B28; B7 + B5/B7/B8/ B20/B28; B20 + B32 [3)]; B38 + B38; B40 + B40; B41 + B41	B1 + B1/B8/B18/B19/B26/ B28; B3 + B3/B8/B18/B19/B26/ B28; B41 + B41	B2 + B2/B5/B12/ B13/B29 [3)]; B4 + B4/B5/B12/ B13/B29 [3)]; B5 + B5/B7/B25/ B30/B66; B7 + B7/B12/B26; B12 + B12/B25/B30/ B66; B13 + B66; B25 + B25/B26; B30 + B29 [3)];

			B66 + B29 [3]/B66; B41 + B41
WCDMA (with Rx-diversity)	B1/B3/B5/B8	B1/B3/B6/B8/B19	B2/B4/B5
GNSS [1]	GPS, GLONASS, BeiDou/Compass Galileo, QZSS	GPS, GLONASS, BeiDou/Compass Galileo, QZSS	GPS, GLONASS, BeiDou/Compass Galileo, QZSS

NOTES

1. [1] The GNSS function is optional.
2. [2] EM06 series modules (EM06-E/EM06-J/EM06-A) come in two versions: **Telematics** and **Data-only**. The **Telematics** version supports voice and data functions, while the **Data-only** version only supports the data function.
3. [3] LTE-FDD B29 and B32 are supported only for Rx and secondary component carrier(s).

EM06 series module is applicable to:

- 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 details the features of EM06 series modules.

Table 2: Key Features of EM06 Series

Features	Details
Function Interface	● PCI Express M.2 Interface
Power Supply	● Supply voltage: 3.135–4.4 V ● Typical supply voltage: 3.7 V

Transmitting Power	● Class 3 (23 dBm ±2 dB) for LTE-FDD bands ● Class 3 (23 dBm ±2 dB) for LTE-TDD bands ● Class 3 (24 dBm +1/-3 dB) for WCDMA
LTE Features	● Up to LTE Cat 6 ● 1.4 MHz to 40 MHz (2 × CA) RF bandwidth ● MIMO in DL direction ● LTE-FDD: - DL: Max. 300 Mbps - UL: Max. 50 Mbps ● LTE-TDD: - DL: Max. 226 Mbps - UL: Max. 28 Mbps
UMTS Features	● 3GPP R8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA ● QPSK, 16QAM and 64QAM modulation ● DC-HSDPA: Max. 42 Mbps (DL) ● HSUPA: Max. 5.76 Mbps (UL) ● WCDMA: Max. 384 kbps (DL/ UL)
Internet Protocol Features	● PPP/QMI/NTP*/TCP*/UDP*/FTP*/HTTP*/PING*/HTTPS*/SMTP*/ MMS*/FTPS*/SMTPS*/SSL* protocols ● Support PAP and CHAP protocols, which are usually used for PPP connection
SMS	● Text and PDU modes ● Point to point MO and MT ● SMS cell broadcast ● SMS storage: ME by default
(U)SIM Interfaces	● Support (U)SIM card: 1.8 V, 3.0 V ● Include USIM1 and USIM2 interfaces ● Dual SIM Single Standby
Audio Feature	● One digital audio interface: PCM interface ● WCDMA: AMR/AMR-WB ● LTE: AMR/AMR-WB ● Echo cancellation and noise suppression
PCM Interface	● Used for audio function with external codec ● Support 16-bit linear data format ● Support long frame synchronization and short frame synchronization ● Support master and slave modes, but must be the master in long frame synchronization
USB Interface	● Compliant with USB 2.0 specifications, with maximum transmission rate up to 480 Mbps on USB 2.0. ● Used for AT command communication, data transmission, firmware upgrade, software debug, GNSS NMEA sentences output and voice over USB* ● Support USB serial drivers for:

	- Windows 7/8/8.1/10 - Linux 2.6–5.4 - Android 4.x/5.x/6.x/7.x/8.x/9.x
Antenna Connectors	● Include main antenna, Rx-diversity antenna and GNSS antenna connectors
Rx-diversity	● Support LTE/WCDMA Rx-diversity
GNSS Features	● Gen8C Lite of Qualcomm ● Protocol: NMEA 0183 ● Data rate: 1 Hz
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 ±0.10) mm ● Weight: approx. 6.5 g
Temperature Range	● Operation temperature range: -30 °C to +70 °C [1)] ● Extended temperature range: -40 °C to +85 °C [2)] ● Storage temperature range: -40 °C to +90 °C
Firmware Upgrade	● Through USB 2.0 interface ● DFOTA
RoHS	All hardware components are fully compliant with EU RoHS directive

NOTES

1. [1)] Within operation temperature range, the module is 3GPP compliant.
2. [2)] Within extended temperature range, the module keeps the ability to establish and maintain a voice, SMS, data transmission, emergency call, etc. There won't be unrecoverable malfunctions. Nor will there be effects on the radio spectrum or harm to radio networks. Only one or more parameters like P_{out} might reduce in the value and exceed specified tolerances. When the temperature returns to normal operation temperature levels, the module will meet 3GPP specifications again.
3. "*" means under development.

2.3. Functional Diagram

Below is the functional diagram of an EM06 series module.

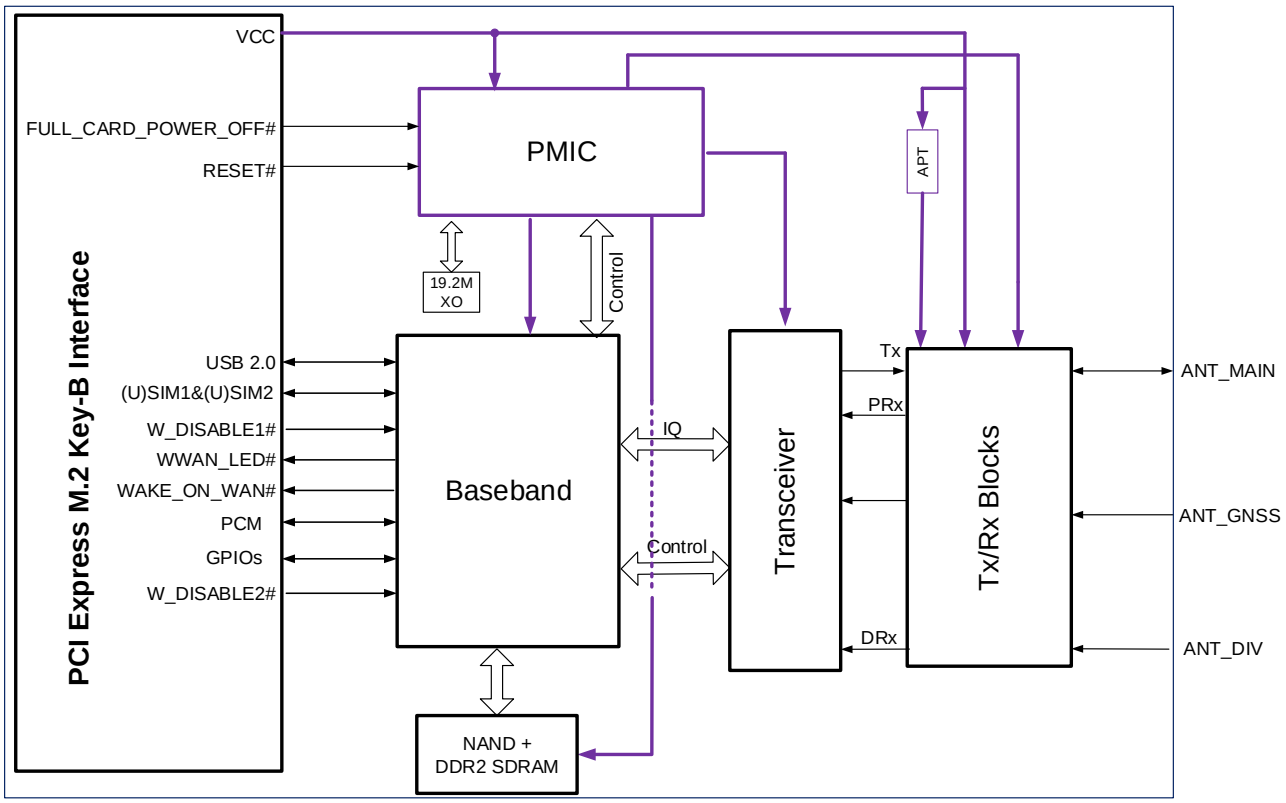


Figure 1: Functional Diagram

2.4. Evaluation Board

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

- Power supply
- (U)SIM interfaces
- USB interface
- PCM and I2C interfaces
- Control and indication signals
- Antenna tuner control interface*
- Configuration pins

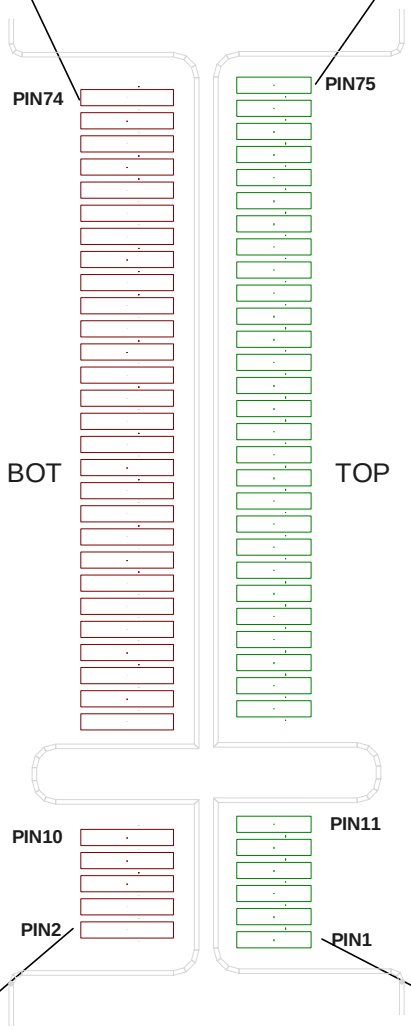
NOTE

"*" means under development.

3.1. Pin Assignment

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

No.	Pin Name
74	VCC
72	VCC
70	VCC
68	NC
66	USIM1_DET
64	RESERVED
62	RESERVED
60	RESERVED
58	I2C_SCL
56	I2C_SDA
54	NC
52	NC
50	NC
48	USIM2_VDD
46	USIM2_RST
44	USIM2_CLK
42	USIM2_DATA
40	USIM2_DET
38	NC
36	USIM1_VDD
34	USIM1_DATA
32	USIM1_CLK
30	USIM1_RST
28	PCM_SYNC
26	W_DISABLE2#
24	PCM_OUT
22	PCM_IN
20	PCM_CLK
	Notch
	Notch
	Notch
	Notch
10	WWAN_LED#
8	W_DISABLE1#
6	FULL_CARD_POWER_OFF#
4	VCC
2	VCC



Pin Name	No.
CONFIG_2	75
GND	73
GND	71
CONFIG_1	69
RESET#	67
ANTCTL3	65
ANTCTL2	63
ANTCTL1	61
ANTCTL0	59
GND	57
NC	55
NC	53
GND	51
NC	49
NC	47
GND	45
NC	43
NC	41
GND	39
NC	37
NC	35
GND	33
NC	31
NC	29
GND	27
DPR	25
WAKE_ON_WAN#	23
CONFIG_0	21
Notch	
Notch	
Notch	
Notch	
GND	11
USB_DM	9
USB_DP	7
GND	5
GND	3
CONFIG_3	1

Figure 2: Pin Assignment

3.2. Pin Description

The following tables define and describe the pins of EM06 series on a 75-pin application.

Table 3: Definition of I/O Parameters

Type	Description
DI	Digital Input
DO	Digital Output
IO	Bidirectional
OD	Open Drain
PI	Power Input
PO	Power Output

Table 4: Pin Description

Pin No.	Pin Name	I/O	Description	Comment
1	CONFIG_3		Not connected internally	
2	VCC	PI	Power supply	Vmin = 3.135 V Vnorm = 3.7 V Vmax = 4.4 V
3	GND		Ground	
4	VCC	PI	Power supply	Vmin = 3.135 V Vnorm = 3.7 V Vmax = 4.4 V
5	GND		Ground	
6	FULL_CARD_ POWER_OFF#	DI	A signal to power on/off 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_DP	IO	USB 2.0 differential data bus (+)	

8	W_DISABLE1#	DI	Airplane mode control Active low	1.8/3.3 V power domain
9	USB_DM	IO	USB 2.0 differential data bus (-)	
10	WWAN_LED#	OD	An open collector and active low signal Allows the module to provide RF status indication via LED devices provided by the system	3.3 V power domain
11	GND		Ground	
12	Notch		Notch	
13	Notch		Notch	
14	Notch		Notch	
15	Notch		Notch	
16	Notch		Notch	
17	Notch		Notch	
18	Notch		Notch	
19	Notch		Notch	
20	PCM_CLK	IO	PCM data bit clock In master mode, it serves as an output signal; In slave mode, it serves as an input signal. If unused, keep it open.	1.8 V power domain
21	CONFIG_0		Connected to GND internally	
22	PCM_IN	DI	PCM data input	1.8 V power domain
23	WAKE_ON_WAN#	OD	A signal to wake up the host An open collector and active low signal	1.8 V power domain
24	PCM_OUT	DO	PCM data output	1.8 V power domain
25	DPR	DI	Dynamic power reduction High level by default	1.8 V power domain
26	W_DISABLE2#	DI	GNSS enablement control Active low	1.8/3.3 V power domain

27	GND		Ground	
28	PCM_SYNC	IO	PCM data frame synchronization signal	1.8 V power domain
29	NC		NC	
30	USIM1_RST	DO	(U)SIM1 card reset	1.8/3.0 V power domain
31	NC		NC	
32	USIM1_CLK	DO	(U)SIM1 card clock	1.8/3.0 V power domain
33	GND		Ground	
34	USIM1_DATA	IO	(U)SIM1 card data	Pulled up to USIM1_VDD internally
35	NC		NC	
36	USIM1_VDD	PO	Power supply for (U)SIM1 card	1.8/3.0 V power domain
37	NC		NC	
38	NC		NC	
39	GND		Ground	
40	USIM2_DET	DI	(U)SIM2 card insertion detection	Pulled up internally
41	NC		NC	
42	USIM2_DATA	IO	(U)SIM2 card data	Pulled up to USIM2_VDD internally
43	NC		NC	
44	USIM2_CLK	DO	(U)SIM2 card clock	1.8/3.0 V power domain
45	GND		Ground	
46	USIM2_RST	DO	(U)SIM2 card reset	1.8/3.0 V power domain
47	NC		NC	
48	USIM2_VDD	PO	Power supply for (U)SIM2 card	1.8/3.0 V power domain
49	NC		NC	
50	NC		NC	

51	GND		Ground	
52	NC		NC	
53	NC		NC	
54	NC		NC	
55	NC		NC	
56	I2C_SDA	IO	I2C serial data Used for external codec	
57	GND		Ground	
58	I2C_SCL	DO	I2C serial clock Used for external codec	
59	ANTCTL0	DO	Antenna tuner control	1.8 V power domain
60	RESERVED		Reserved	
61	ANTCTL1	DO	Antenna tuner control	1.8 V power domain
62	RESERVED		Reserved	
63	ANTCTL2	DO	Antenna tuner control	1.8 V power domain
64	RESERVED		Reserved	
65	ANTCTL3	DO	Antenna tuner control	1.8 V power domain
66	USIM1_DET	DI	(U)SIM1 card insertion detection	Pulled up internally
67	RESET#	DI	Resets the system Active low	
68	NC		NC	
69	CONFIG_1		Connected to GND internally	
70	VCC	PI	Power supply	Vmin = 3.135 V Vnorm = 3.7 V Vmax = 4.4 V
71	GND		Ground	
72	VCC	PI	Power supply	Vmin = 3.135 V Vnorm = 3.7 V Vmax = 4.4 V
73	GND		Ground	

74	VCC	PI	Power supply	Vmin = 3.135 V Vnorm = 3.7 V Vmax = 4.4 V
75	CONFIG_2		Not connected internally	

NOTE

Please keep all NC, reserved and unused pins unconnected.

3.3. Operating Modes

The table below summarizes different operating modes of EM06 series.

Table 5: Overview of Operating Modes

Mode	Details	
Normal Operating mode	Idle	The module has registered on network and is ready to send and receive data, its software being active.
	Talk/Data	The module is connected to network, its power consumption decided by network settings and data transfer rates.
Minimum Functionality Mode	The **AT+CFUN=0** command can enable the minimum functionality mode without removing the power supply. In this mode, both the RF function and (U)SIM card are invalid.	
Airplane Mode	Executing the **AT+CFUN=4** command or driving the W_DISABLE1# pin to low level can enable the airplane mode. In this case, the RF function is invalid.	
Sleep Mode	The module keeps receiving paging messages, SMS, voice calls and TCP/UDP data from the network, its current consumption reduced to the minimal level.	
Power Down Mode	The module's power supply is cut off by its power management unit, its software being inactive and USB interface inaccessible while the operating voltage (connected to VCC) remains applied.	

NOTE

See ***document [2]*** for more details about **AT+CFUN** command.

3.4. Power Supply

The following table defines VCC and GND pins.

Table 6: Definition of VCC and GND Pins

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

3.4.1. Decrease Voltage Drop

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

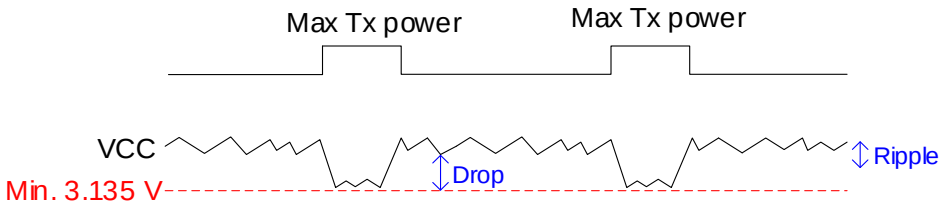


Figure 3: Voltage Drop Limits during Radio Transmission

To decrease voltage drop, a bypass capacitor of about 220 μF with low ESR (ESR = 0.7 Ω) should be used, so does a multi-layer ceramic chip capacitor (MLCC) array for its ultra-low ESR. It is recommended to add three ceramic capacitors (100 nF, 33 pF, 10 pF) close to VCC pins to compose the MLCC array. The main power supply from an external application has to be the sole voltage source. The width of the VCC trace should be no less than 2 mm. In principle, the longer the VCC trace is, the wider it should be. In addition, in order to get a stable power source, it is recommended to use a zener diode with a reverse zener voltage of 5.1 V and a dissipation power higher than 0.5 W. The following figure shows a reference circuit of VCC.

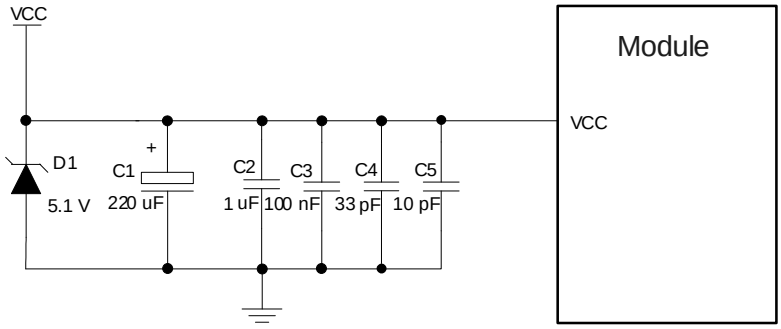


Figure 4: Reference Design of VCC

3.4.2. Reference Design of Power Supply

Power design is critical as the module's performance largely depends on its power source. The power supply should be capable of providing a sufficient current of 2 A at least. If the voltage drop between the input and output is not too big, it is suggested that an LDO is used while supplying power for the module; If there is a big voltage difference between the input source and the desired output (VCC = 3.7 V Typ.), a buck DC-DC converter is preferred.

The following figure shows a reference design of a +5 V input power source with the DC-DC TPS54319. The typical output of the power supply is about 3.7 V and the maximum load current is 3 A.

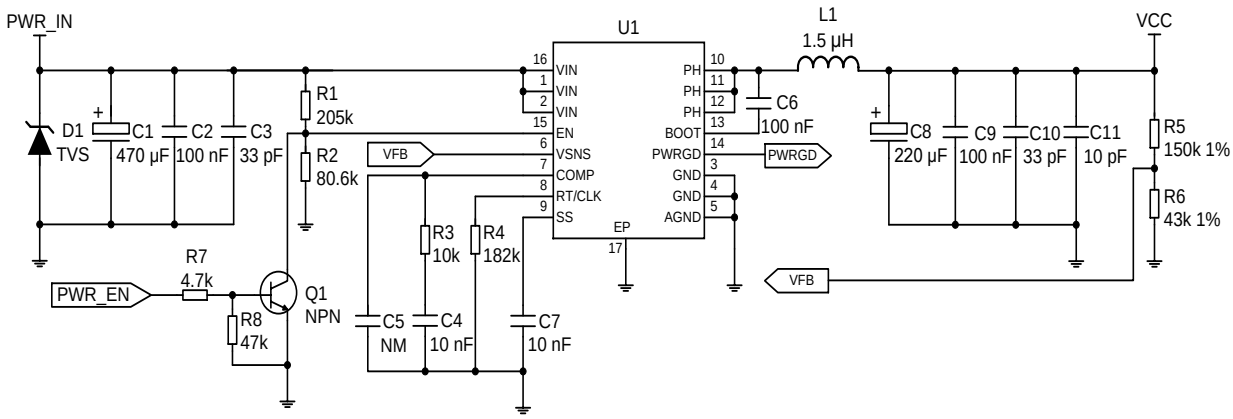


Figure 5: Reference Design of Power Supply

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 be cut off after pulling down the FULL_CARD_POWER_OFF# pin for about 100 ms.

3.5. Turn On/Off

3.5.1. Turn On the Module

Driving the FULL_CARD_POWER_OFF# pin to high level will power on the module. The following table shows the definition of FULL_CARD_POWER_OFF#.

Table 7: Pin Definition of FULL_CARD_POWER_OFF#

Pin Name	Pin No.	Description	DC Characteristics	Comment
FULL_CARD_POWER_OFF#	6	A signal to turn on/off the module When it is at low level, the module is turned off. When it is at high level, the module is turned on.	V_{IH}max = 4.4 V V_{IH}min = 1.19 V V_{IL}max = 0.2 V	Pulled down internally.

3.5.1.1. Turn On through GPIO Controlled FULL_CARD_POWER_OFF#

It is recommended to use a GPIO from the host to control the FULL_CARD_POWER_OFF# pin. A simple reference circuit is illustrated by the following figure.

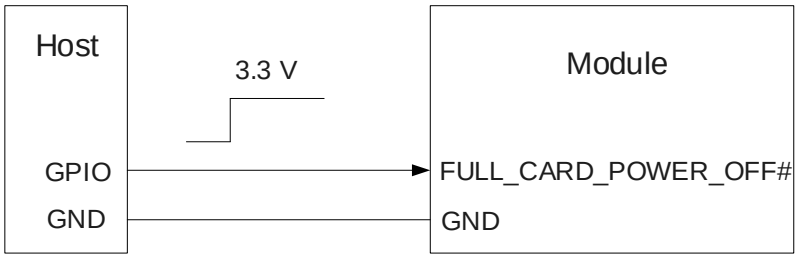


Figure 6: Turn on the Module Through GPIO Controlled FULL_CARD_POWER_OFF#

3.5.1.2. Turn On Automatically

If FULL_CARD_POWER_OFF# is pulled up to 3.3 V with a resistor of 5–10 kΩ, the module will be powered on automatically when the power supply for VCC is applied, and be powered off when the power supply is removed.

A reference circuit is shown in the following figure.

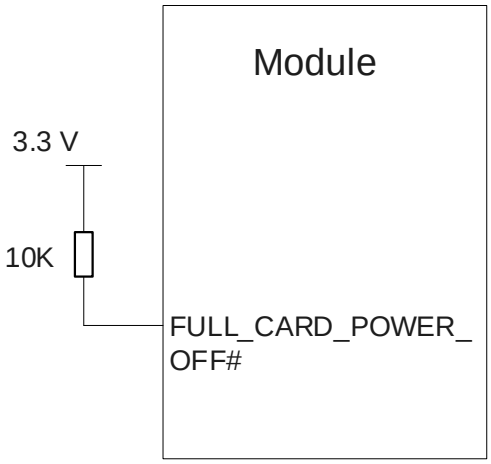


Figure 7: Turn on the Module Automatically

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

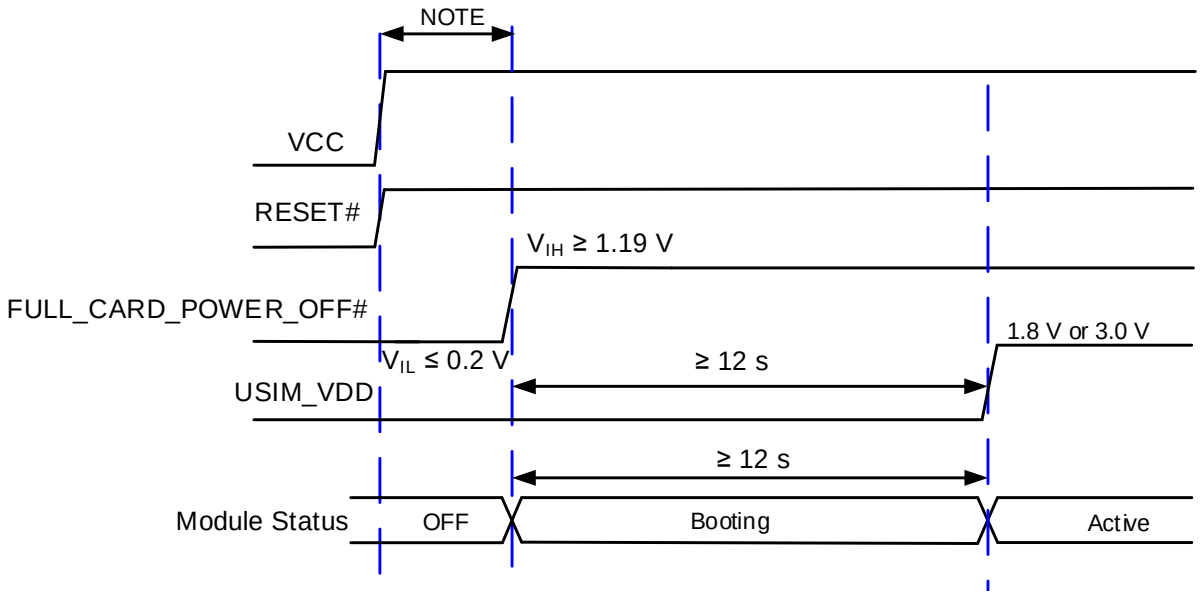


Figure 8: Timing of Turning on Module

NOTE

Please ensure that VCC is stable for no less than 30 ms before pulling down FULL_CARD_POWER_OFF#.

3.5.2. Turn Off the Module

3.5.2.1. Turn Off through FULL_CARD_POWER_OFF#

Driving the FULL_CARD_POWER_OFF# pin to low level will turn off the module.

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

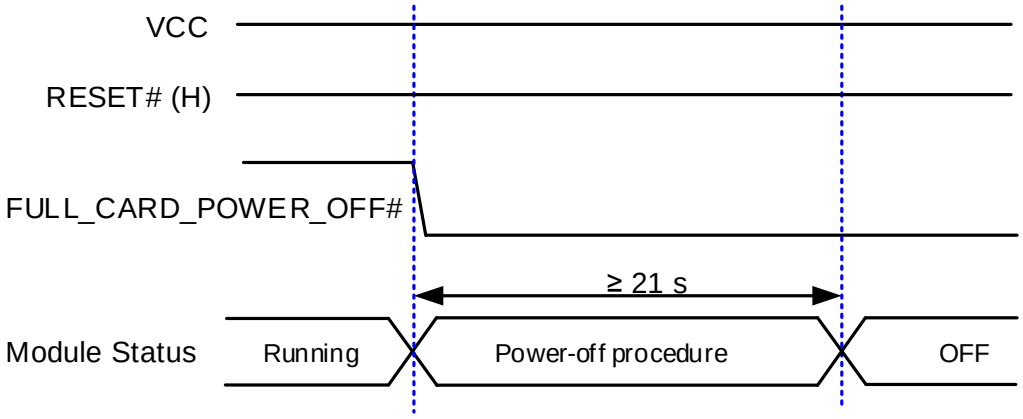


Figure 9: Timing of Turning off the Module Through FULL_CARD_POWER_OFF#

3.5.2.2. Turn Off via AT Command

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

3.6. Reset the Module

The RESET# pin is for resetting the module by being driven to a low voltage level for 250–600 ms.

Table 8: Pin Definition of RESET#

Pin Name	Pin No.	Description	DC Characteristics	Comment
RESET#	67	Resets the module	V_{IH}max = 2.1 V	

	V_{IH}min = 1.3 V V_{IL}max = 0.5 V

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

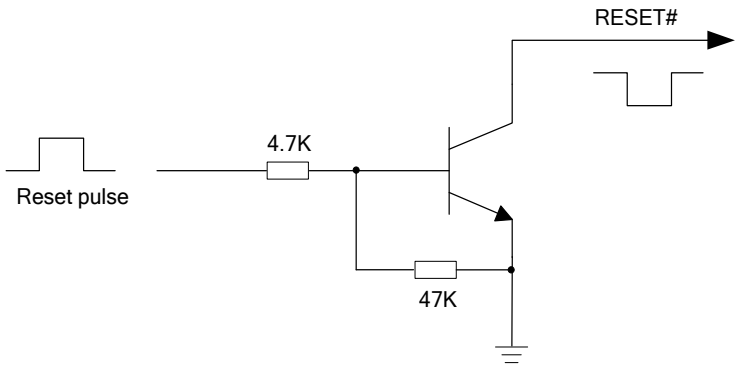


Figure 10: Reference Design of Resetting Using Driving Circuit

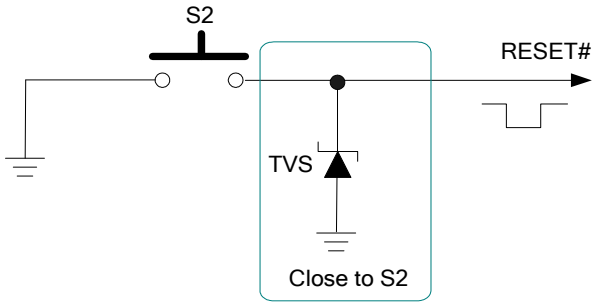


Figure 11: Reference Design of Resetting Using Button

The timing of resetting is illustrated in the following figure.

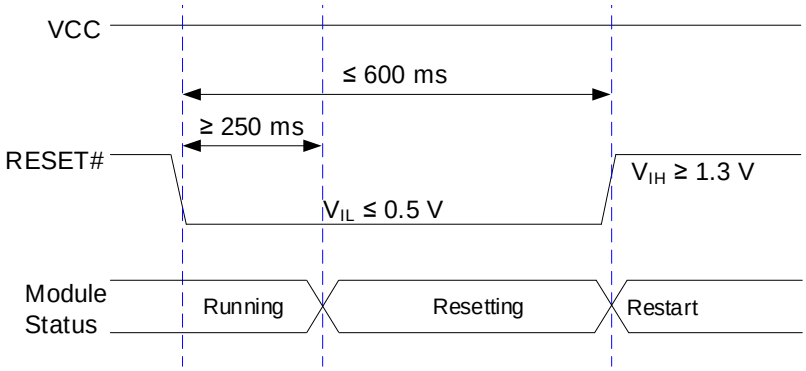


Figure 12: Timing of Resetting Module

NOTE

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

3.7. (U)SIM Interfaces

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

Table 9: 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 1.8 V or 3.0 V is supported by the module automatically.
USIM1_DATA	34	IO	(U)SIM1 card data	
USIM1_CLK	32	DO	(U)SIM1 card clock	
USIM1_RST	30	DO	(U)SIM1 card reset	
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 1.8 V or 3.0 V is supported by the module automatically.
USIM2_DATA	42	IO	(U)SIM2 card data	
USIM2_CLK	44	DO	(U)SIM2 card clock	
USIM2_RST	46	DO	(U)SIM2 card reset	
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 series modules support (U)SIM card hot-plug via the USIM_DET pin, a level trigger pin normally

short-circuited to ground when no (U)SIM card inserted. When a (U)SIM card gets inserted, the pin will change from low to high level with a rising edge indicating the insertion of a (U)SIM card; when the card is removed, the pin will return to low level with a falling edge indicating the removal of card.

The following figure shows a reference design of the (U)SIM interface with normally closed (U)SIM card connector (CD switch closed).

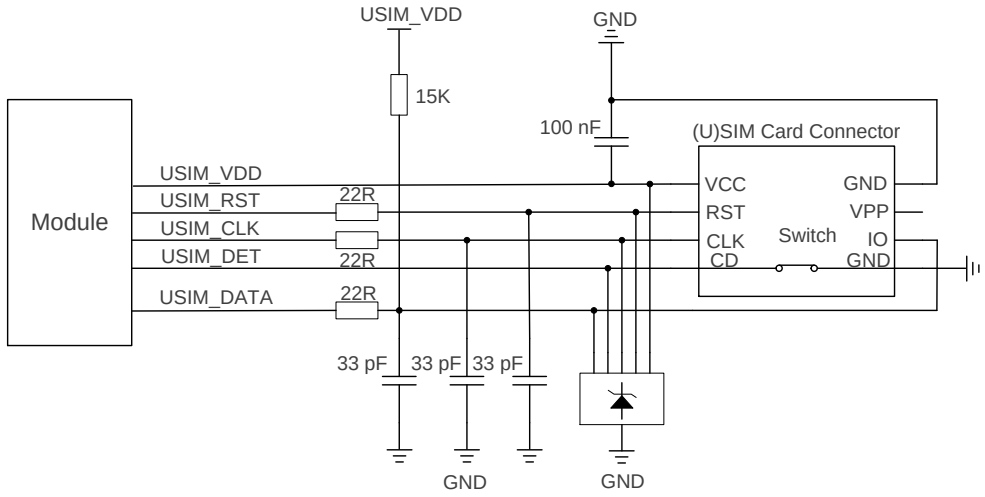


Figure 13: Reference Design of (U)SIM Interface with Normally Closed (U)SIM Card Connector

Normally Closed (U)SIM Card Connector:

- When the (U)SIM card is absent, the switch is closed and USIM_DET is at low level.
- When the (U)SIM card is inserted, the switch is open and USIM_DET is at high level.

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

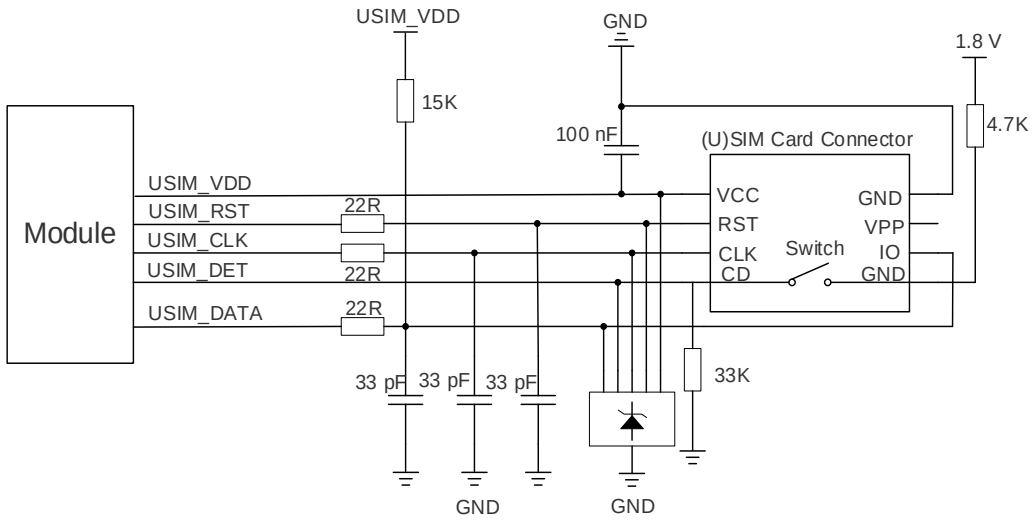


Figure 14: Reference Design of (U)SIM Interface with Normally Open (U)SIM Card Connector

Normally Open (U)SIM Card Connector:

- When the (U)SIM card is absent, the switch is open and USIM_DET is at low level.
- When the (U)SIM card is inserted, the switch is closed and USIM_DET is at high level.

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

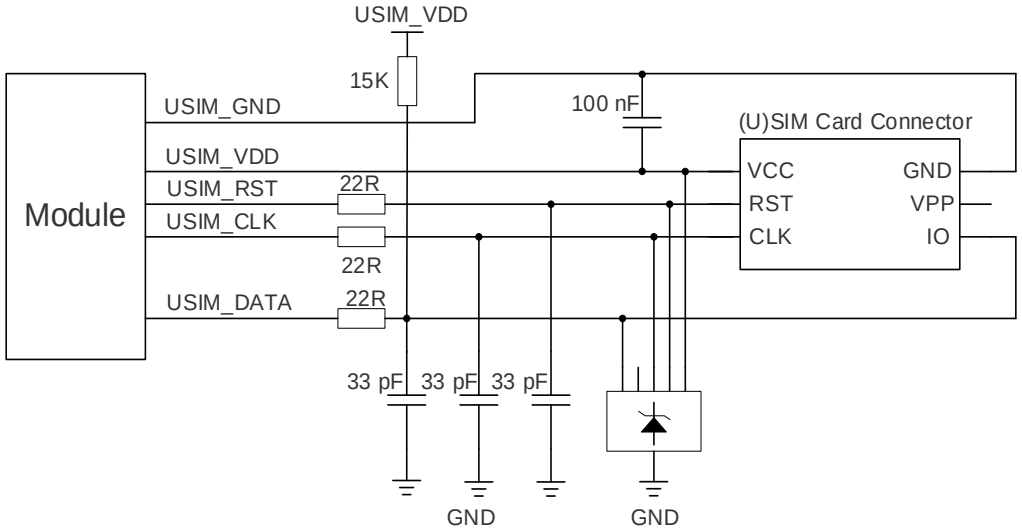
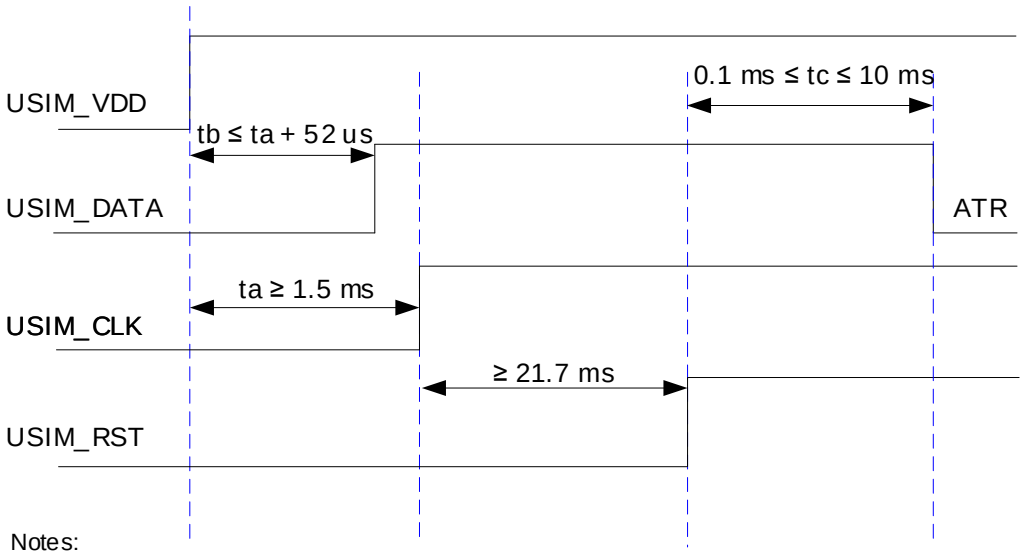


Figure 15: Reference Design of (U)SIM Interface with a 6-Pin (U)SIM Card Connector

The timing of (U)SIM is illustrated by the following figure.



Notes:

1. ta is the time interval between USIM_VDD HIGH level and USIM_CLK HIGH level.
2. tb is the time interval between USIM_VDD HIGH level and USIM_DATA HIGH level.
3. tc is the time interval between USIM_RST HIGH level and answer on USIM_DATA.

Figure 16: Timing of (U)SIM

When **AT+QSIMDET=1, 1** is set, the timing of hot plugging is illustrated by the following figure.

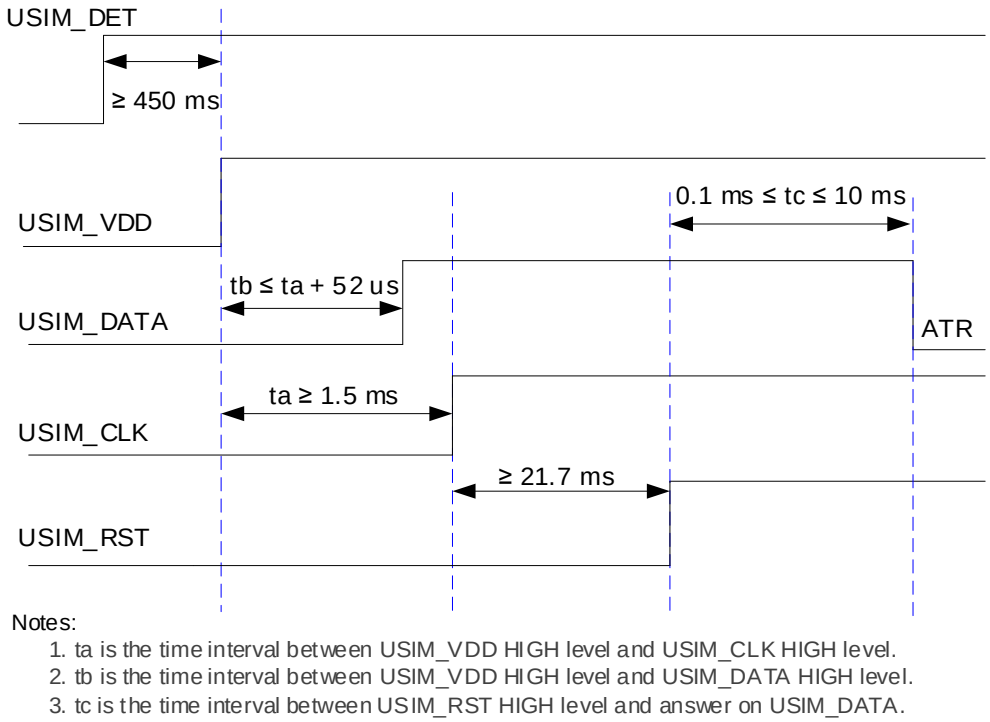


Figure 17: Timing of Hot Plugging

To enhance the reliability and usibility of the (U)SIM card in your applications, please follow the principles below in (U)SIM circuit design:

- Place the (U)SIM card connector as close to the module as possible. Keep the trace length within 200 mm, the shorter the better.
- Keep (U)SIM card signals away from RF and VCC traces.
- Ensure the ground traces between the module and the (U)SIM card connector are short and wide. Keep the trace width of ground and USIM_VDD no less than 0.5 mm 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 10 pF. The 22 ohm 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 33 pF 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 the USIM_DATA line can improve anti-jamming capability in sensitive occasions or when long traces are applied and should be placed close to the (U)SIM card connector.

3.8. USB Interface

Each EM06 series module provides one integrated Universal Serial Bus (USB) interface which complies with USB 2.0 specifications and supports 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 sentences output, software debugging, firmware upgrade and voice over USB*.

The following table shows the pin definition of USB interface.

Table 10: Pin Definition of USB Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_DP	7	IO	USB 2.0 differential data bus (+)	Require a differential impedance of 90 Ω
USB_DM	9	IO	USB 2.0 differential data bus (-)	

For more details about the specifications of USB 2.0, please visit this website down below:

https://www.usb.org/document-library/usb-20-specification.

The USB interface is recommended to be reserved for firmware upgrade. The following figure shows a reference circuit of USB 2.0 interface.

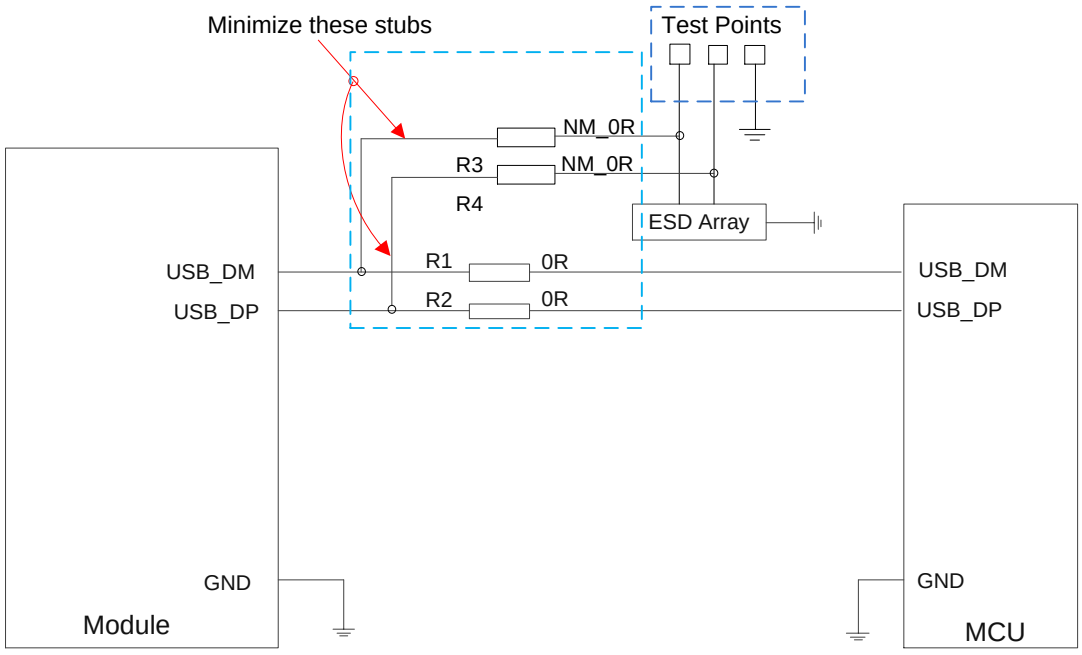


Figure 18: Reference Design of USB 2.0 Interface

In order to ensure the integrity of signal of USB 2.0 data line, the resistors R1, R2, R3 and R4 must be placed close to the module and to each other.

In order to ensure the compatibility of your USB interface design with the USB 2.0 specifications, please comply with the following principles:

- Route the USB 2.0 signal traces as a differential pair with total grounding.
  For USB 2.0 routing traces, the trace impedance of the differential pair should be 90 Ω, and the trace length difference between the pair should be less than 2 mm.
- Do not route signal traces under crystals, oscillators, magnetic devices or RF signal traces. Route the USB 2.0 differential traces in the inner-layer, and surround the traces with grounds on the same and adjacent layers.
- If a USB connector is used, keep the ESD protection components as close to it as possible. Pay attention to the influence of junction capacitance of ESD protection components on USB 2.0 data traces. The capacitance value of ESD protection components should be lower than 2.0 pF for USB 2.0.
- If possible, reserve a 0 ohm resistor on USB_DP and USB_DM lines respectively.

NOTE

"*" means under development.

3.9. PCM and I2C Interfaces

EM06 series modules support audio communications via Pulse Code Modulation (PCM) digital interface and I2C interface.

The PCM interface supports the following modes:

- Primary mode (short frame synchronization): the module works as both master and slave.
- Auxiliary mode (long frame synchronization): the module works as master only.

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

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

The module supports 16-bit linear data format. The following two figures show respectively the timing relationship between 8 kHz PCM_SYNC and 2048 kHz PCM_CLK in the primary mode and that between 8 kHz PCM_SYNC and 256 kHz PCM_CLK in the auxiliary mode.

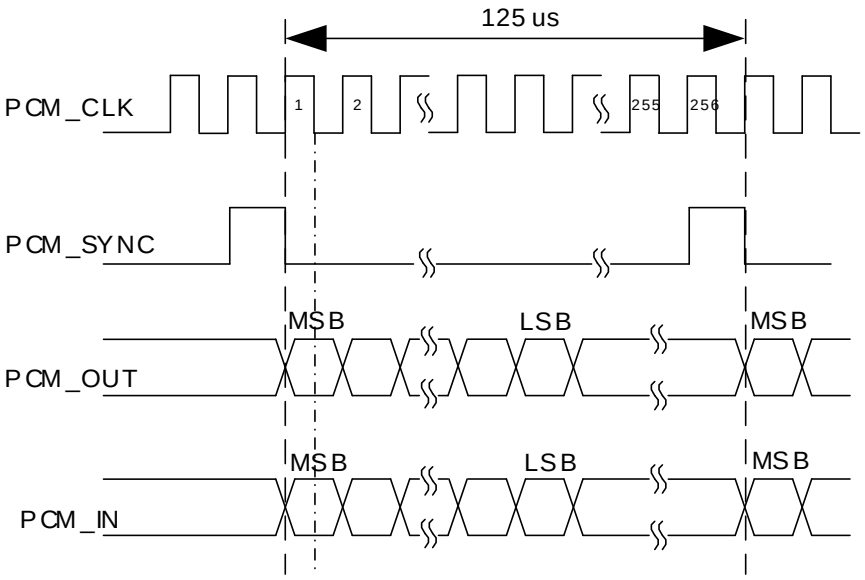


Figure 19: Primary Mode Timing

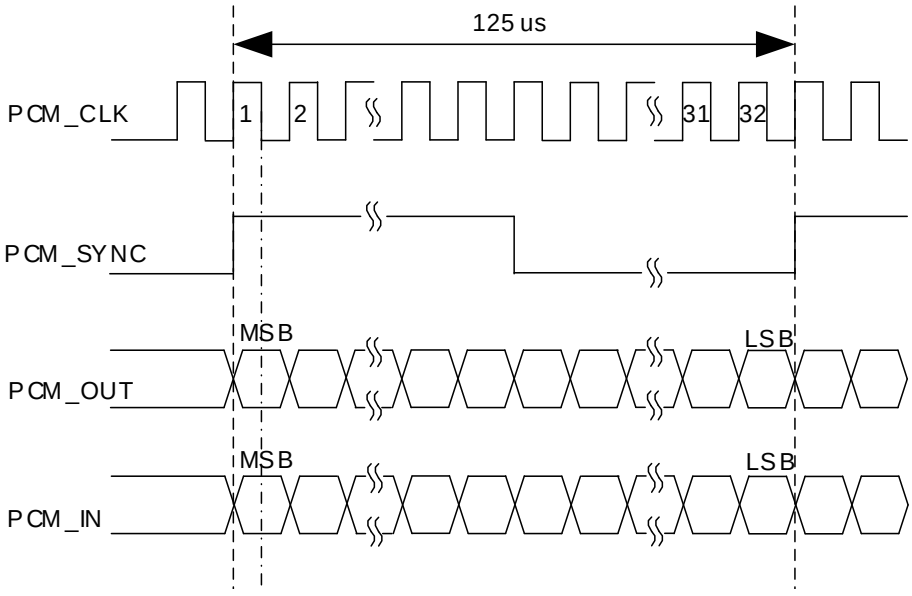


Figure 20: Auxiliary Mode Timing

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

Table 11: Pin Definition of PCM and I2C Interfaces

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

The clock and mode can be configured by AT command, and the default configuration is the master mode using short frame synchronization format with 2048 kHz PCM_CLK and 8 kHz PCM_SYNC. See ***document [2]*** for details about **AT+QDAI** command.
The following figure shows a reference design of PCM interface with an external codec IC.

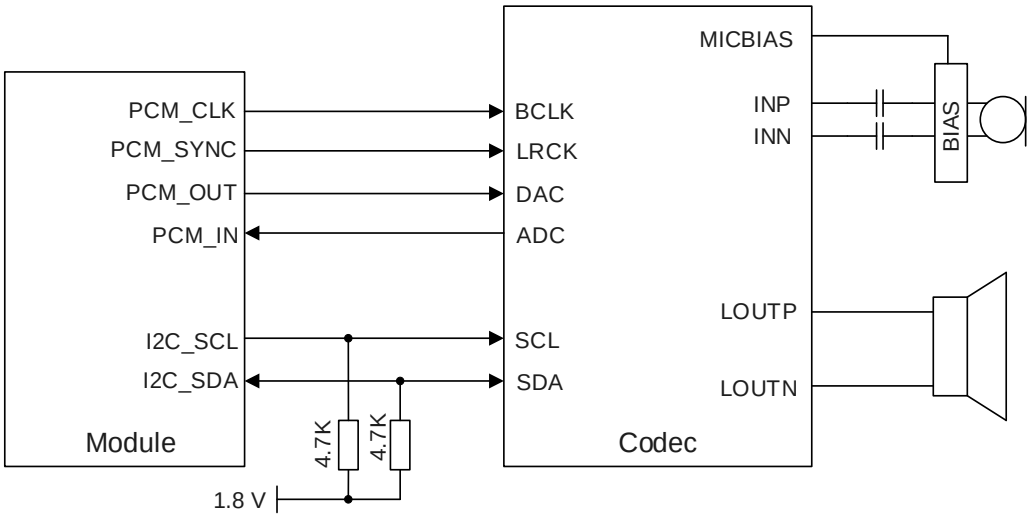


Figure 21: Reference Design of PCM Application with Audio Codec

NOTES

1. It is recommended to add an RC (R = 22 Ω, C = 22 pF) circuit on the PCM lines, especially for PCM_CLK.
2. EM06 series module works as a master device pertaining to I2C interface.

3.10. Control and Indication Interface

The following table shows the pin definition of control and indication interfaces.

Table 12: Pin Definition of Control and Indication Interfaces

Pin Name	Pin No.	I/O	Power Domain	Description
WWAN_LED#	10	OD	3.3 V	An open collector and active low signal. Indicates the RF status of the module.
WAKE_ON_WAN#	23	OD	1.8 V	An open collector and active low signal. Wakes up the host.
W_DISABLE1#	8	DI	1.8/3.3 V	Airplane mode control. Active low.
W_DISABLE2# [1)]	26	DI	1.8/3.3 V	GNSS enablement control. Active low.
DPR	25	DI	1.8 V	Dynamic power reduction. High level by default.

NOTE

[1)] means GNSS enablement control function is under development.

3.10.1. W_DISABLE1#

The module provides a W_DISABLE1# signal to disable or enable the airplane mode through hardware method. The W_DISABLE1# pin is pulled up by default. When **AT+CFUN=1**, driving W_DISABLE1# to low level will enable the airplane mode in which the RF function is disabled.

Table 13: Airplane Mode Controlled by Hardware

W_DISABLE1#	RF Function Status	Module Operating Mode
High level	RF enabled	Normal mode
Low level	RF disabled	Airplane mode

The software approach is by executing the command **AT+CFUN**, which has the same function with the W_DISABLE1# signal. The details are as follows.

Table 14: Airplane Mode Controlled by Software

AT+CFUN=?	RF Function Status	Module Operating Mode
0	RF and (U)SIM disabled	Minimum functionality mode
1	RF enabled	Normal mode
4	RF disabled	Airplane mode

3.10.2. WWAN_LED#

The WWAN_LED# signal indicates the RF status of the module, and its typical current consumption is up to 40 mA.

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

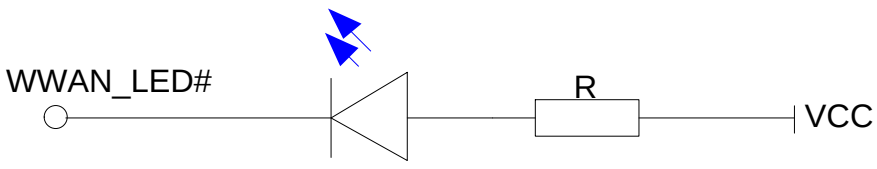


Figure 22: Reference Design of WWAN_LED#

The following table shows the RF status indicated by WWAN_LED# signal.

Table 15: Network Status Indication by 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: ● The (U)SIM card is not powered ● W_DISABLE1# is at low level (airplane mode enabled). ● **AT+CFUN=4** (RF function disabled)

3.10.3. WAKE_ON_WAN#

The WAKE_ON_WAN# is an open collector signal which requires a pull-up resistor on the host. When a URC returns, a one-second low level pulse signal will be outputted to wake up the host. The operation status of the module is indicated by WAKE_ON_WAN# as shown below.

Table 16: State of the WAKE_ON_WAN# Signal

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

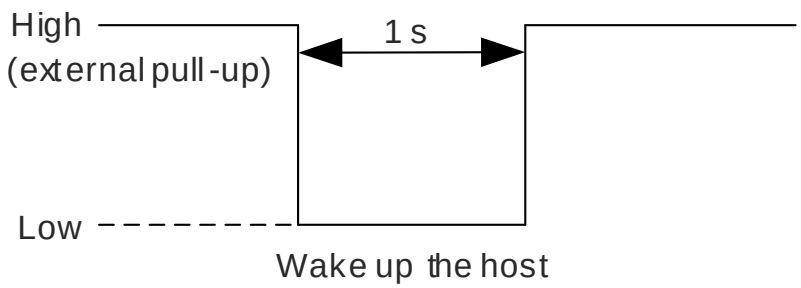


Figure 23: WAKE_ON_WAN# Behavior

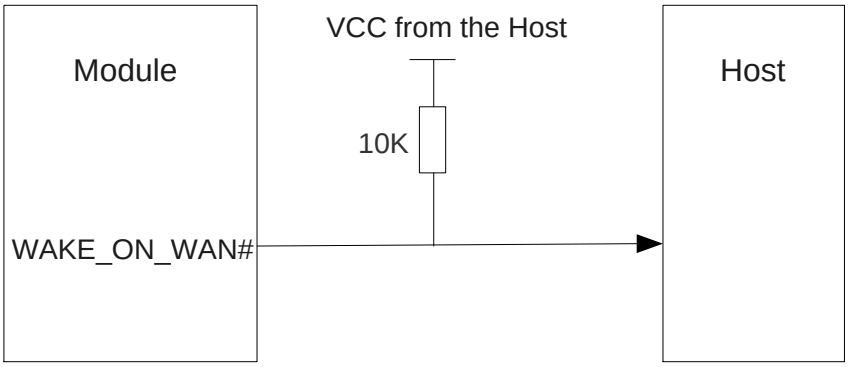


Figure 24: Reference Design of WAKE_ON_WAN#

3.10.4. DPR Signal

The module 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 the module to provide an input trigger which will reduce the output power in the radio transmission.

Table 17: Function of the DPR Signal

DPR Level	Function
High/Floating	Max transmitting power will NOT back off
Low	Max transmitting power will back off by executing **AT+QCFG="sarcfg"** command

NOTE

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

3.11. Antenna Tuner Control Interface*

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

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

Table 18: Pin Definition of Antenna Tuner Control Interface

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

NOTE

"*" means under development.

3.12. Configuration Pins

The module provides four configuration pins which are configured as WWAN-USB.

Table 19: Definitions 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 four pins on the module are defined as below:

Table 20: 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	2

4 GNSS Receiver

4.1. General Description

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

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

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

4.2. GNSS Performance

The following table shows the GNSS performance of EM06 series modules.

Table 21: GNSS Performance

Parameter	Description	Conditions	Typ.	Unit
Sensitivity (GNSS)	Cold start	Autonomous	-145	dBm
	Reacquisition	Autonomous	-157	dBm
	Tracking	Autonomous	-157	dBm
TTFF (GNSS)	Cold start @open sky	Autonomous	43	s
		XTRA enabled	10.5	s
	Warm start @open sky	Autonomous	35	s
		XTRA enabled	4.5	s

	Hot start @open sky	Autonomous	4.5	s
		XTRA enabled	3.5	s
Accuracy (GNSS)	CEP-50	Autonomous @open sky	2.5	m

NOTES

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

5 Antenna Connection

The EM06 series module is mounted with three 2 mm × 2 mm antenna connectors (receptacles) for external antenna connection: a Main antenna connector, a Rx-diversity antenna connector which is used to resist the fall of signals caused by high speed movement and multipath effect, and a GNSS antenna connector. The impedance of the antenna connectors is 50 Ω.

5.1. Main/Rx-diversity/GNSS Antenna Connectors

5.1.1. Antenna Connectors

The Main, Rx-diversity and GNSS antenna connectors are shown as below.

Figure 25: Antenna Connectors on the Module

5.1.2. Operating Frequencies

5.1.2.1. Cellular Operating Frequencies

Table 22: 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-FDD B1	1920–1980	2110–2170	MHz
LTE-FDD B3	1710–1785	1805–1880	MHz
LTE-FDD B5	824–849	869–894	MHz
LTE-FDD B7	2500–2570	2620–2690	MHz
LTE-FDD B8	880–915	925–960	MHz
LTE-FDD B20	832–862	791–821	MHz
LTE-FDD B28	703–748	758–803	MHz
LTE-FDD B32 [1)]	-	1452–1496	MHz
LTE-TDD B38	2570–2620	2570–2620	MHz
LTE-TDD B40	2300–2400	2300–2400	MHz
LTE-TDD B41	2545–2655	2545–2655	MHz

Table 23: 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-FDD B1	1920–1980	2110–2170	MHz
LTE-FDD B3	1710–1785	1805–1880	MHz
LTE-FDD B8	880–915	925–960	MHz
LTE-FDD B18	815–830	860–875	MHz
LTE-FDD B19	830–845	875–890	MHz
LTE-FDD B26	814–849	859–894	MHz
LTE-FDD B28	703–748	758–803	MHz
LTE-TDD B41	2545–2655	2545–2655	MHz

Table 24: 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-FDD B2	1850–1910	1930–1990	MHz
LTE-FDD B4	1710–1755	2110–2155	MHz
LTE-FDD B5	824–849	869–894	MHz
LTE-FDD B7	2500–2570	2620–2690	MHz
LTE-FDD B12	699–716	729–746	MHz
LTE-FDD B13	777–787	746–756	MHz
LTE-FDD B25	1850–1915	1930–1995	MHz
LTE-FDD B26	814–849	859–894	MHz
LTE-FDD B29 [1)]	-	716–728	MHz

LTE-FDD B30	2305–2315	2350–2360	MHz
LTE-FDD B66	1710–1780	2110–2200	MHz
LTE-TDD B41	2496–2690	2496–2690	MHz

NOTES

1. [1)] LTE-FDD B29 and B32 are supported only for Rx and secondary component carrier(s).
2. "*" means under development.

5.1.2.2. GNSS Operating Frequencies

The following table shows frequency specifications of the GNSS antenna connector.

Table 25: GNSS Frequencies

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

5.2. Antenna Installation

5.2.1. Antenna Requirements

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

Table 26: Antenna Requirements

Type	Requirements
GNSS [1)]	Frequency range: 1559–1609 MHz Polarization: RHCP or linear VSWR: < 2 (Typ.)

	Passive antenna gain: > 0 dBi
WCDMA/LTE	VSWR: ≤ 2 Efficiency: > 30 % Max Input Power: 50 W Input Impedance: 50 Ω Cable insertion loss: < 1 dB (WCDMA B5/B6/B8/B19, LTE B5/B8/B12/B13/B18/B19/B20/B26/B28/B29) Cable insertion loss: < 1.5 dB (WCDMA B1/B2/B3/B4, LTE B1/B2/B3/B4/B25/B32/B66) Cable insertion loss < 2 dB (LTE B7/B38/B40/B41/B30)

NOTE

[1] GNSS can only be supported by passive antennas.

5.2.2. Antenna Connectors and Mating Plugs

The receptacle dimensions are illustrated as below.

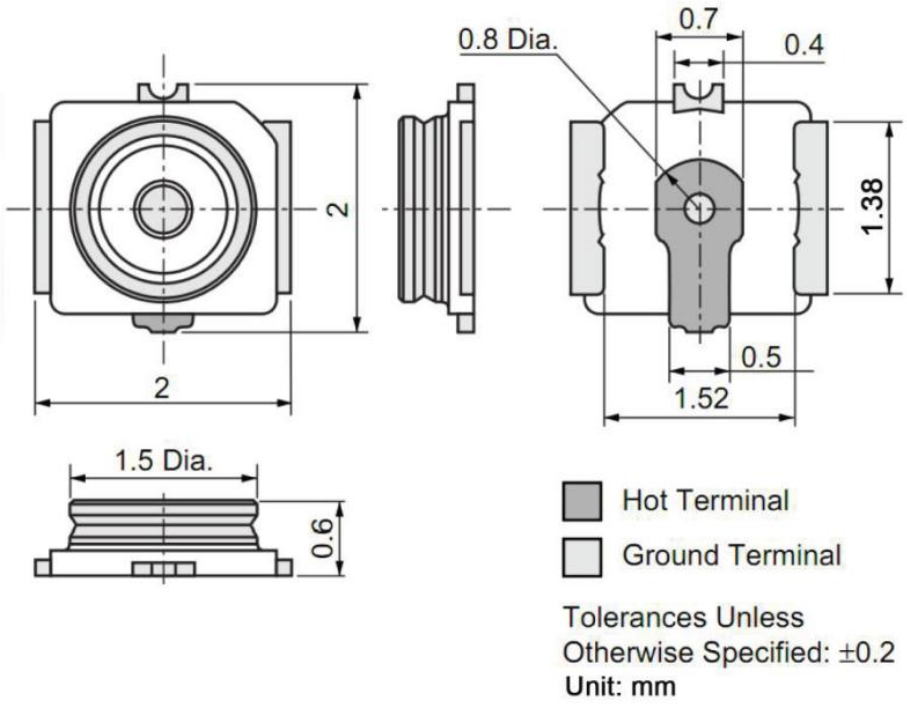


Figure 26: Dimensions of the Receptacles (Unit: mm)

Table 27: Major Specifications of Antenna Connectors

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

The receptacle accepts two types of mating plugs to meet two maximum mated heights: 1.20 mm (using a Ø 0.81 mm coaxial cable) and 1.45 mm (using a Ø 1.13 mm coaxial cable).

The following figure shows the specifications of mating plugs using Ø 0.81 mm coaxial cables.

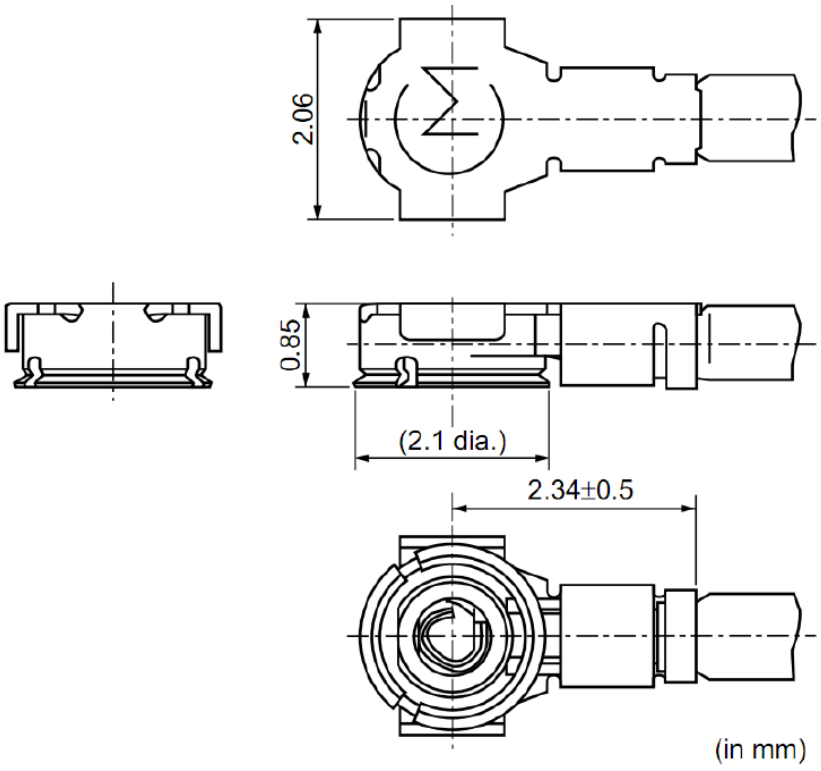


Figure 27: Specifications of Mating Plugs with Ø 0.81 mm Coaxial Cables

The following figure illustrates the connection between the receptacle antenna connector on EM06 series and the mating plug using a Ø 0.81 mm coaxial cable.

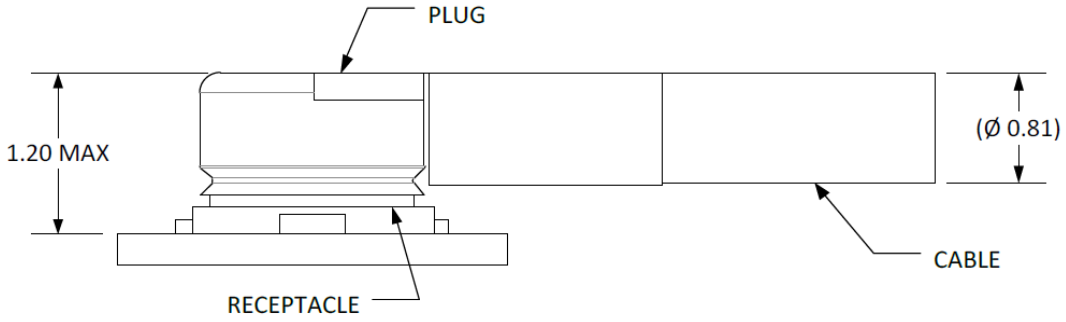


Figure 28: Connect Receptacle and Mating Plug Using Ø 0.81 mm Coaxial Cable

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

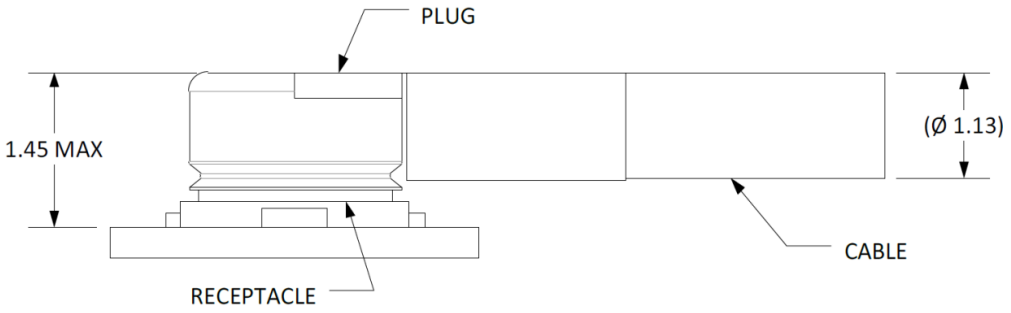


Figure 29: Connect Receptacle and Mating Plug Using Ø 1.13 mm Coaxial Cable

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 28: 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 series is 3.7 V, as specified by *PCIe M.2 Electromechanical Spec Rev1.0*. The following table shows the power supply requirements of the module.

Table 29: 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 30: I/O Requirements

Parameter	Description	Min.	Max.	Unit
V_{IH}	Input high voltage	0.7 × V_{DD18} 1)	V_{DD18} + 0.3	V
V_{IL}	Input low voltage	-0.3	0.3 × V_{DD18}	V
V_{OH}	Output high voltage	V_{DD18} - 0.5	V_{DD18}	V
V_{OL}	Output low voltage	0	0.4	V

NOTE

1) V_{DD18} refers to I/O power domain.

6.4. Current Consumption

Table 31: EM06-E Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	OFF state	Power down	50	μA
	Sleep state	**AT+CFUN=0** (USB disconnected)	2.77	mA
		WCDMA PF = 64 (USB disconnected)	4.06	mA
		WCDMA PF = 128 (USB disconnected)	3.66	mA
		WCDMA PF = 256 (USB disconnected)	3.48	mA
		LTE-FDD PF = 64 (USB disconnected)	4.49	mA
		LTE-FDD PF = 128 (USB disconnected)	3.89	mA
		LTE-FDD PF = 256 (USB disconnected)	3.59	mA

		LTE-TDD PF = 64 (USB disconnected)	4.54	mA
		LTE-TDD PF = 128 (USB disconnected)	3.91	mA
		LTE-TDD PF = 256 (USB disconnected)	3.59	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 @ 23 dBm	565	mA
		WCDMA B1 HSUPA CH10700 @ 22.4 dBm	557	mA
		WCDMA B3 HSDPA CH1338 @ 22.7 dBm	582	mA
		WCDMA B3 HSUPA CH1338 @ 22.1 dBm	580	mA
		WCDMA B5 HSDPA CH4407 @ 22.6 dBm	584	mA
		WCDMA B5 HSUPA CH4407 @ 22 dBm	572	mA
		WCDMA B8 HSDPA CH3012 @ 22.3 dBm	566	mA
		WCDMA B8 HSUPA CH3012 @ 21.8 dBm	553	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B1 CH300 @ 23.8 dBm	670	mA
		LTE-FDD B3 CH1575 @ 23.8 dBm	830	mA
		LTE-FDD B5 CH2525 @ 23.3 dBm	647	mA
		LTE-FDD B7 CH3100 @ 23.48 dBm	880	mA
		LTE-FDD B8 CH3625 @ 23.2 dBm	640	mA
		LTE-FDD B20 CH6300 @ 22.8 dBm	770	mA
		LTE-FDD B28 CH27460 @ 22.7 dBm	692	mA
		LTE-TDD B38 CH38000 @ 23.8 dBm	459	mA

		LTE-TDD B40 CH39150 @ 23.6 dBm	377	mA
		LTE-TDD B41 CH40740 @ 23.6 dBm	463	mA
	2CA data transfer	LTE-FDD B1 + B1 @ 21.8 dBm	811	mA
		LTE-FDD B1 + B5 @ 21.7 dBm	749	mA
		LTE-FDD B1 + B8 @ 21.8 dBm	761	mA
		LTE-FDD B1 + B20 @ 21.9 dBm	810	mA
		LTE-FDD B1 + B28 @ 21.8 dBm	821	mA
		LTE-FDD B3 + B3 @ 21.3 dBm	757	mA
		LTE-FDD B3 + B5 @ 21.2 dBm	734	mA
		LTE-FDD B3 + B7 @ 21.2 dBm	795	mA
		LTE-FDD B3 + B8 @ 21.2 dBm	744	mA
		LTE-FDD B3 + B20 @ 21.2 dBm	801	mA
		LTE-FDD B3 + B28 @ 21.2 dBm	810	mA
		LTE-FDD B7 + B5 @ 20.6 dBm	798	mA
		LTE-FDD B7 + B7 @ 21.5 dBm	803	mA
		LTE-FDD B7 + B8 @ 21.2 dBm	811	mA
		LTE-FDD B7 + B20 @ 20.7 dBm	840	mA
		LTE-FDD B7 + B28 @ 20.1 dBm	830	mA
		LTE-FDD B20 + B32 @ 21.9 dBm	701	mA
		LTE-TDD B38 + B38 @ 21.1 dBm	482	mA
		LTE-TDD B40 + B40 @ 21.8 dBm	464	mA
		LTE-TDD B41 + B41 @ 21.1 dBm	548	mA
	WCDMA voice call	WCDMA B1 CH10700 @ 23.1 dBm	663	mA
		WCDMA B3 CH1338 @ 22.6 dBm	665	mA
		WCDMA B5 CH4407 @ 22.7 dBm	625	mA

	WCDMA B8 CH3012 @ 22.9 dBm	633	mA

Table 32: EM06-J Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	OFF state	Power down	47	μA
	Sleep state	**AT+CFUN=0** (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 @ 23.4 dBm	700	mA
		WCDMA B1 HSUPA CH10700 @ 22.2 dBm	635	mA
		WCDMA B3 HSDPA CH1338 @ 23.4 dBm	704	mA
		WCDMA B3 HSUPA CH1338 @ 22.7 dBm	655	mA
		WCDMA B6 HSDPA CH4175 @ 23.7 dBm	589	mA
		WCDMA B6 HSUPA CH4175 @ 23.5 dBm	578	mA
		WCDMA B8 HSDPA CH3012 @ 23.4 dBm	653	mA
		WCDMA B8 HSUPA CH3012 @ 22.4 dBm	584	mA
		WCDMA B19 HSDPA CH738 @ 23.4 dBm	628	mA

		WCDMA B19 HSUPA CH738 @ 22.4 dBm	575	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B1 CH300 @ 23.3 dBm	707	mA
		LTE-FDD B3 CH1575 @ 23.1 dBm	769	mA
		LTE-FDD B8 CH3625 @ 24.1 dBm	710	mA
		LTE-FDD B18 CH5925 @ 24.2 dBm	728	mA
		LTE-FDD B19 CH6075 @ 23.4 dBm	651	mA
		LTE-FDD B26 CH8865 @ 23.4 dBm	604	mA
		LTE-FDD B28 CH27460 @ 23.5 dBm	705	mA
		LTE-TDD B41 CH40740 @ 24.2 dBm	363	mA
	2CA data transfer	LTE-FDD B1 + B1 @ 22.5 dBm	815	mA
		LTE-FDD B1 + B8 @ 22.6 dBm	861	mA
		LTE-FDD B1 + B18 @ 22.6 dBm	913	mA
		LTE-FDD B1 + B19 @ 23.1 dBm	835	mA
		LTE-FDD B1 + B28 @ 23.2 dBm	812	mA
		LTE-FDD B3 + B3 @ 23 dBm	861	mA
		LTE-FDD B3 + B8 @ 23 dBm	913	mA
		LTE-FDD B3 + B18 @ 22.3 dBm	878	mA
		LTE-FDD B3 + B19 @ 22.4 dBm	857	mA
		LTE-FDD B3 + B28 @ 22.4 dBm	864	mA
		LTE-TDD B41 + B41 @ 23.6 dBm	507	mA
	WCDMA voice call	WCDMA B1 CH10700 @ 23.7 dBm	735	mA
		WCDMA B3 CH1338 @ 23.8 dBm	740	mA
		WCDMA B6 CH4175 @ 23.7 dBm	610	mA
		WCDMA B8 CH3012 @ 23.8 dBm	675	mA
		WCDMA B19 CH738 @ 23.9 dBm	650	mA

Table 33: EM06-A Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	OFF state	Power down	50	μA
	Sleep state	**AT+CFUN=0** (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)	21.3	mA
		WCDMA PF = 64 (USB connected)	28.2	mA
		LTE-FDD PF = 64 (USB disconnected)	21.9	mA
		LTE-FDD PF = 64 (USB connected)	28.5	mA
		LTE-TDD PF = 64 (USB disconnected)	21.6	mA
		LTE-TDD PF = 64 (USB connected)	28.49	mA
	WCDMA data transfer (GNSS OFF)	WCDMA B2 HSDPA CH9800 @ 23 dBm	520	mA
		WCDMA B2 HSUPA CH9800 @ 23 dBm	520	mA
		WCDMA B4 HSDPA CH1638 @ 22.9 dBm	500	mA
		WCDMA B4 HSUPA CH1638 @ 23 dBm	510	mA
		WCDMA B5 HSDPA CH4407 @ 22.9 dBm	600	mA
		WCDMA B5 HSUPA CH4407 @ 22.9 dBm	600	mA
	LTE data transfer (GNSS OFF)	LTE-FDD B2 CH900 @ 23 dBm	700	mA
		LTE-FDD B4 CH2175 @ 22.8 dBm	650	mA
		LTE-FDD B5 CH2525 @ 23.1 dBm	680	mA
		LTE-FDD B7 CH3100 @ 24.2 dBm	895	mA
		LTE-FDD B12 CH5095 @ 22.9 dBm	670	mA

		LTE-FDD B13 CH5230 @ 22.7 dBm	660	mA
		LTE-FDD B25 CH8365 @ 23 dBm	705	mA
		LTE-FDD B26 CH8865 @ 22.9 dBm	650	mA
		LTE-FDD B30 CH9820 @ 23 dBm	700	mA
		LTE-FDD B66 CH132322 @ 23 dBm	720	mA
		LTE-TDD B41 CH40740 @ 23 dBm	390	mA
	2CA data transfer	LTE-FDD B2 + B2 @ 23.2 dBm	825	mA
		LTE-FDD B4 + B4 @ 22.6 dBm	910	mA
		LTE-FDD B7 + B7 @ 22 dBm	950	mA
		LTE-FDD B25 + B25 @ 22.5 dBm	800	mA
		LTE-FDD B66 + B66 @ 21.7 dBm	800	mA
		LTE-TDD B41 + B41 @ 23.1 dBm	550	mA
	WCDMA voice call	WCDMA B2 CH9800 @ 23.1 dBm	540	mA
		WCDMA B4 CH1638 @ 23.2 dBm	530	mA
		WCDMA B5 CH4407 @ 22.9 dBm	610	mA

6.5. RF Output Power

The following table shows the RF output power of EM06 series modules.

Table 34: RF Output Power

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

6.6. RF Receiving Sensitivity

The following tables show conducted RF receiving sensitivity of EM06 series modules.

Table 35: EM06-E Conducted RF Receiving Sensitivity

Frequency	Primary (Typ.)	Diversity (Typ.)	SIMO [1)] (Typ.)	SIMO [2)] (Worst Case)
WCDMA B1	-109.5 dBm	-109 dBm	-111 dBm	-106.7 dBm
WCDMA B3	-109 dBm	-109 dBm	-111 dBm	-103.7 dBm
WCDMA B5	-109 dBm	-109 dBm	-111 dBm	-104.7 dBm
WCDMA B8	-109 dBm	-109 dBm	-111 dBm	-103.7 dBm
LTE-FDD B1 (10 MHz)	-97.5 dBm	-97 dBm	-100 dBm	-96.3 dBm
LTE-FDD B3 (10 MHz)	-97 dBm	-97 dBm	-100 dBm	-93.3 dBm
LTE-FDD B5 (10 MHz)	-97 dBm	-99 dBm	-100.5 dBm	-94.3 dBm
LTE-FDD B7 (10 MHz)	-95.5 dBm	-98 dBm	-99.5 dBm	-94.3 dBm
LTE-FDD B8 (10 MHz)	-97.5 dBm	-98 dBm	-100.5 dBm	-93.3 dBm
LTE-FDD B20 (10 MHz)	-96.5 dBm	-98.5 dBm	-100.5 dBm	-93.3 dBm
LTE-FDD B28 (10 MHz)	-96.5 dBm	-98.5 dBm	-100.5 dBm	-94.8 dBm
LTE-TDD B38 (10 MHz)	-96 dBm	-97.5 dBm	-99 dBm	-96.3 dBm
LTE-TDD B40 (10 MHz)	-96 dBm	-97.5 dBm	-98.5 dBm	-96.3 dBm
LTE-TDD B41 (10 MHz)	-95.5 dBm	-97.5 dBm	-98.5 dBm	-94.3 dBm

Table 36: EM06-J Conducted RF Receiving Sensitivity

Frequency	Primary (Typ.)	Diversity (Typ.)	SIMO [1)] (Typ.)	SIMO [2)] (Worst Case)
WCDMA B1	-109 dBm	-109 dBm	-111 dBm	-106.7 dBm
WCDMA B3	-109 dBm	-109 dBm	-111 dBm	-103.7 dBm

WCDMA B6	-108 dBm	-109 dBm	-111 dBm	-106.7 dBm
WCDMA B8	-109 dBm	-109 dBm	-111 dBm	-103.7 dBm
WCDMA B19	-109 dBm	-109 dBm	-111 dBm	-106.7 dBm
LTE-FDD B1 (10 MHz)	-97.5 dBm	-97 dBm	-100 dBm	-96.3 dBm
LTE-FDD B3 (10 MHz)	-97 dBm	-97 dBm	-100 dBm	-93.3 dBm
LTE-FDD B8 (10 MHz)	-97.5 dBm	-99 dBm	-100.5 dBm	-93.3 dBm
LTE-FDD B18 (10 MHz)	-96.5 dBm	-98 dBm	-100 dBm	-96.3 dBm
LTE-FDD B19 (10 MHz)	-96.5 dBm	-98 dBm	-99.5 dBm	-96.3 dBm
LTE-FDD B26 (10 MHz)	-96 dBm	-97.5 dBm	-98.5 dBm	-96.3 dBm
LTE-FDD B28 (10 MHz)	-96.5 dBm	-98.5 dBm	-100.5 dBm	-94.8 dBm
LTE-TDD B41 (10 MHz)	-95.5 dBm	-97.5 dBm	-98.5 dBm	-94.3 dBm

Table 37: EM06-A Conducted RF Receiving Sensitivity

Frequency	Primary (Typ.)	Diversity (Typ.)	SIMO [1] (Typ.)	SIMO [2] (Worst Case)
WCDMA B2	-110 dBm	-110 dBm	-112 dBm	-106.7 dBm
WCDMA B4	-110 dBm	-110 dBm	-112 dBm	-103.7 dBm
WCDMA B5	-110 dBm	-110 dBm	-112 dBm	-106.7 dBm
LTE-FDD B2 (10 MHz)	-97.5 dBm	-97 dBm	-100 dBm	-96.3 dBm
LTE-FDD B4 (10 MHz)	-98 dBm	-98.5 dBm	-101 dBm	-93.3 dBm
LTE-FDD B5 (10 MHz)	-98 dBm	-99 dBm	-101 dBm	-93.3 dBm
LTE-FDD B7 (10 MHz)	-97 dBm	-97 dBm	-99.5 dBm	-96.3 dBm
LTE-FDD B12 (10 MHz)	-98.5 dBm	-98 dBm	-101 dBm	-96.3 dBm
LTE-FDD B13 (10 MHz)	-98.5 dBm	-98 dBm	-100.5 dBm	-96.3 dBm
LTE-FDD B25 (10 MHz)	-97.5 dBm	-98 dBm	-100 dBm	-96.3 dBm
LTE-FDD B26 (10 MHz)	-98 dBm	-98 dBm	-100.5 dBm	-96.3 dBm

LTE-FDD B30 (10 MHz)	-97.5 dBm	-98.5 dBm	-100 dBm	-94.8 dBm
LTE-FDD B66 (10 MHz)	-97.5 dBm	-98 dBm	-100 dBm	-94.8 dBm
LTE-TDD B41 (10 MHz)	-95.5 dBm	-97.5 dBm	-98.5 dBm	-94.3 dBm

NOTES

1. [1)] SIMO is a smart antenna technology that uses a single antenna at the transmitter side and multiple (two for EM06 series) antennas at the receiver side to improve Rx performance.
2. [2)] As per 3GPP specification.

6.7. ESD Characteristics

EM06 series are not protected against electrostatic discharge (ESD) in general. Consequently, they are 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 modules.

The following table shows the electrostatic discharge characteristics of the modules.

Table 38: Electrostatic Discharge Characteristics (Temperature: 25 ºC, Humidity: 40 %)

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

6.8. Thermal Dissipation

EM06 series modules are designed to work over an extended temperature range. In order to achieve optimal 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, where the thermal pad is added, is shown as below. The dimensions are measured in mm.

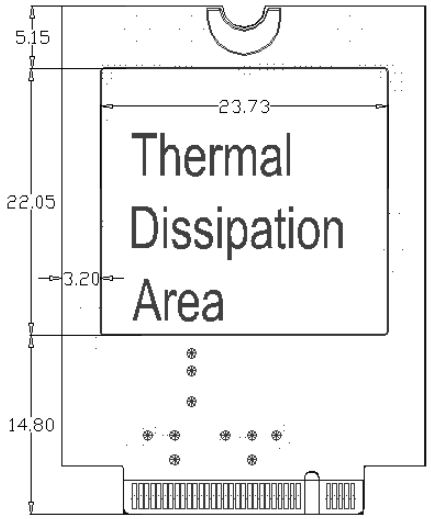


Figure 30: Thermal Dissipation Area on Bottom Side of Module (Top View)

There are some other measures to enhance heat dissipation performance:

- Add as many ground vias as possible on the PCB.
- Maximize the 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.
- To facilitate thermal dissipation, select an appropriate piece of material with suitable thickness and surface for the outer housing (i.e. the mechanical enclosure) of the application device that integrates the module.
- Use active cooling method when necessary to pull heat away from the module.
- Add a heatsink on the top of the module when possible. In that case, a thermal pad should be used between the heatsink and the module with the former being designed to have as many fins as possible to increase the heat dissipation area.

NOTE

For more detailed guidelines on thermal design, see ***document [5]***.

7 Mechanical Dimensions and Packaging

This chapter mainly describes the mechanical dimensions and packaging specifications of EM06 series modules. All dimensions are measured in millimeter (mm), and the dimensional tolerances are ±0.05 mm unless otherwise specified.

7.1. Mechanical Dimensions of the Module

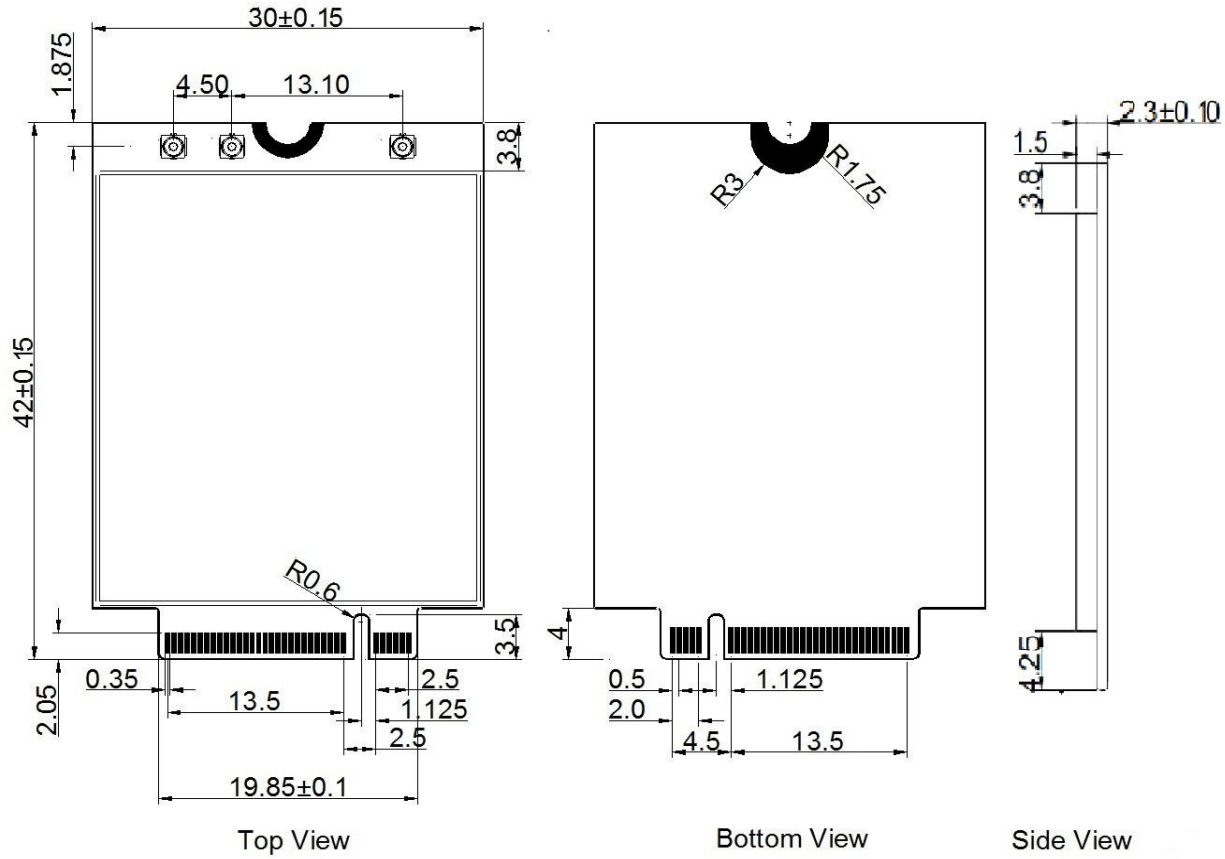


Figure 31: Mechanical Dimensions of EM06 Series (Unit: mm)

7.2. Standard Dimensions of M.2 PCI Express

The following figure shows the standard dimensions of M.2 PCI Express.

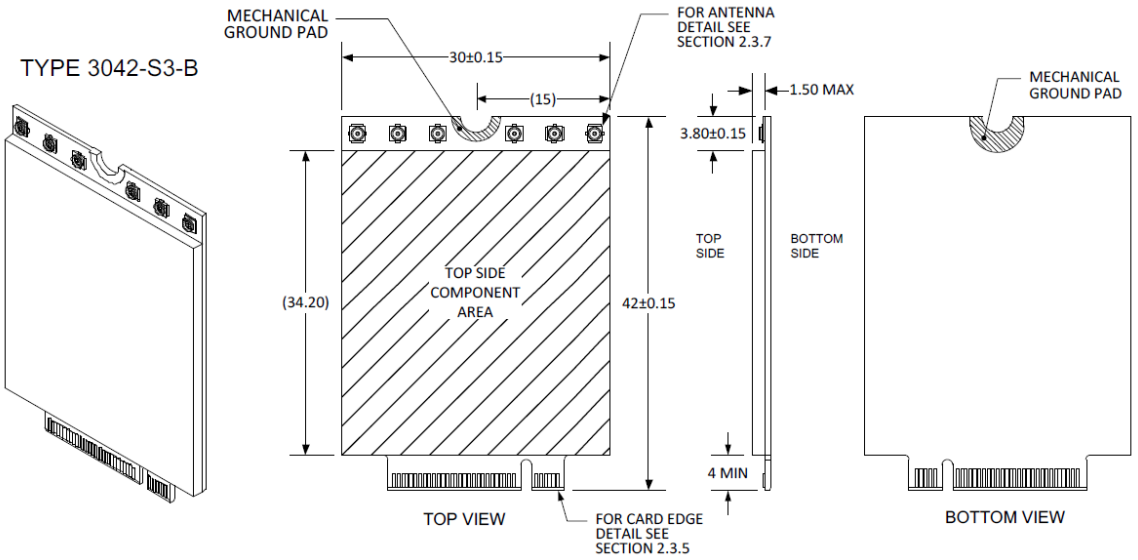


Figure 32: Standard Dimensions of M.2 Type 3042-S3 (Unit: mm)

According to M.2 nomenclature, EM06 series modules are Type 3042-S3-B (30.0 mm × 42.0 mm, max component height on the top is 1.5 mm and single-sided; key ID is B). See ***document [4]*** for detailed B.

Type XX XX - XX - X - X*

Width (mm)
12
16
22
30

Length (mm)
16
26
30
42
60
80
110

Lable**	Component Max Ht (mm)	
	Top Max	Bottom Max
S1	1.2	0****
S2	1.35	0****
S3	1.5	0****
D1	1.2	1.35
D2	1.35	1.35
D3	1.5	1.35
D4	1.5	0.7
D5	1.5	1.5

Key ID	Pin	Interface
A	8-15	2x PCIe x1 / USB 2.0 / I2C / DP x4
B	12-19	PCIe x2/SATA/USB 2.0/USB 3.0/HSIC/SSIC/Audio/UIM/I2C
C	16-23	Reserved for Future Use
D	20-27	Reserved for Future Use
E	24-31	2x PCIe x1 / USB 2.0 / I2C / SDIO / UART / PCM
F	28-35	Future Memory Interface (FMI)
G	39-46	Generic (Not used for M.2)***
H	43-50	Reserved for Future Use
J	47-54	Reserved for Future Use
K	51-58	Reserved for Future Use
L	55-62	Reserved for Future Use
M	59-66	PCIe x4 / SATA

* 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 33: M.2 Nomenclature

7.3. Top and Bottom Views of the Module

Figure 34: Top View of the Module

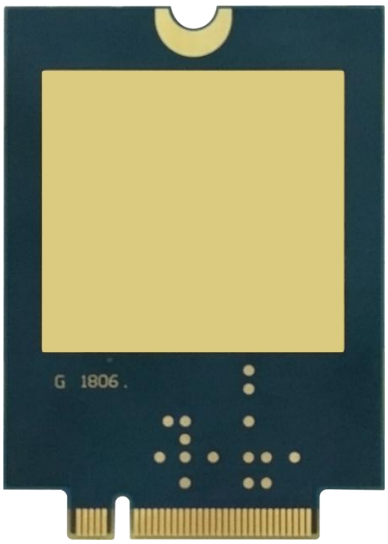


Figure 35: Bottom View of the Module

NOTE

Images above are for illustration purpose only and may differ from the actual module. For authentic appearance and label, please refer to the module received from Quectel.

7.4. M.2 Connector

EM06 series modules adopt standard PCI Express M.2 connectors compliant with the directives and standards listed in the ***document [4]***.

7.5. Packaging

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

8 Appendix References

Table 39: 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 M.2 Specification
[5]	Quectel_Module_Thermal_Design_Guide	Thermal Design Guide for Quectel modules

Table 40: Terms and Abbreviations

Abbreviation	Description
bps	bit(s) per second
CA	Carrier Aggregation
DC-HSDPA	Dual-Carrier High-Speed Downlink Packet Access
DC-HSPA+	Dual-Carrier High-Speed Packet Access Plus
DFOTA	Delta Firmware upgrade Over-The-Air
DL	Downlink
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
HSDPA	High-Speed Downlink Packet Access
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
kbps	kilobits per second
LED	Light Emitting Diode
LTE	Long-Term Evolution
Mbps	Megabits per second
ME	Mobile Equipment
MIMO	Multiple Input Multiple Output
MLCC	Multilayer Ceramic 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
SIMO	Single Input Multiple Output
SMS	Short Message Service
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter

UL	Uplink
UMTS	Universal Mobile Telecommunications Service
URC	Unsolicited Result Code
(U)SIM	(Universal) Subscriber Identity Module
WCDMA	Wideband Code Division Multiple Access