

# **EM12-G** Hardware Design

**LTE-A Module Series**

Rev. EM12\_Hardware\_Design\_

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# About the Document

## History

| Revision | Date       | Author                  | Description |
|----------|------------|-------------------------|-------------|
| Draft    | 2018-09-28 | Oscar LIU/<br>Reed Wang | Initial     |

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# 1 Introduction

This document defines EM12 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 EM12 module. To facilitate its application in different fields, reference design is also provided for customers' reference. Associated with application note and user guide, customers can use the module to design and set up mobile applications easily.

減少電磁波影響，請妥適使用。



The device could be used with a separation distance of 20cm to the human body.

Hereby, [Quectel Wireless Solutions Co., Ltd.] declares that the radio equipment type [EM12-G] is in compliance with Directive 2014/53/EU.

The full text of the EU declaration of conformity is available at the following internet address:  
<http://www.quectel.com>

## FCC Regulations:

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.

This device has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiated radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is

encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Caution: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

## **RF Exposure Information**

This device complies with FCC radiation exposure limits set forth for an uncontrolled environment. In order to avoid the possibility of exceeding the FCC radio frequency exposure limits, human proximity to the antenna shall not be less than 20cm (8 inches) during normal operation.

## **ISED Notice**

This device complies with Innovation, Science and Economic Development Canada license-exempt RSS standard(s). 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.

Le présent appareil est conforme aux CNR Innovation, Sciences et Développement économique 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, et
- (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en

This device complies with the Canadian ICES-003 Class B specifications.  
CAN ICES-3(B)/ NMB-3(B)

## **ISED Radiation Exposure Statement**

This device complies with RSS-102 radiation exposure limits set forth for an uncontrolled environment. In order to avoid the possibility of exceeding the ISED radio frequency exposure limits, human proximity to the antenna shall not be less than 20cm (8 inches) during normal operation.

Cet appareil est conforme aux limites d'exposition aux rayonnements de la CNR-102 définies pour un environnement non contrôlé. Afin d'éviter la possibilité de dépasser les limites d'exposition aux

fréquences radio de la CNR-102, la proximité humaine à l'antenne ne doit pas être inférieure à 20 cm (8 pouces) pendant le fonctionnement normal.

## **IMPORTANT NOTE:**

This module is intended for OEM integrator. The OEM integrator is still responsible for the FCC compliance requirement of the end product, which integrates this module. 20cm minimum distance has to be able to be maintained between the antenna and the users for the host this module is integrated into. Under such configuration, the FCC radiation exposure limits set forth for an population/uncontrolled environment can be satisfied.

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

## **USERS MANUAL OF THE END PRODUCT:**

In the users manual of the end product, the end user has to be informed to keep at least 20cm separation with the antenna while this end product is installed and operated. The end user has to be informed that the FCC radio-frequency exposure guidelines for an uncontrolled environment can be satisfied. The end user has to also be informed that any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment. If the size of the end product is smaller than 8x10cm, then additional FCC part 15.19 statement is required to be available in the users manual: This device complies with Part 15 of 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.

## **LABEL OF THE END PRODUCT:**

The final end product must be labeled in a visible area with the following " Contains Transmitter Module FCC ID: XMR201901EM12G ". If the size of the end product is larger than 8x10cm, then the following FCC part 15.19 statement has to also be available on the label: This device complies with Part 15 of 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.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host device; otherwise, the host device must be labeled to display the Innovation, Science and Economic Development Canada certification number for the module, preceded by the words "Contains transmitter module IC: 10224A-201901EM12G"

## 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 EM12-G 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

EM12-G is a LTE/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.

EM12-G 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.

The following table shows the frequency bands and GNSS type of EM12-G module.

**Table 1: Frequency Bands and GNSS Type of EM12-G Module**

| Mode                           | EM12-G                                                                                                                                                                                                                                                                                            |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| LTE-FDD<br>(with Rx-diversity) | B1/B2/B3/B4/B5/B7/B8/B9/B12/B13/B14/B17/B18/B19/B20/B21 <sup>3)</sup> /B25/B26/<br>B28/B29/B30/B32/B66;                                                                                                                                                                                           |
| LTE-TDD<br>(with Rx-diversity) | B38/39/B40/B41                                                                                                                                                                                                                                                                                    |
| DL 2×CA                        | B1+3,5,18,19,20,26;<br>B2+2,4,5,12,13,17,29,30,66;<br>B3+3,5,7,8,19,20,28;<br>B4+4(CA_4C only),5,12,13,17,29,30;<br>B5+7,25,30,66;<br>B7+7,20,28;<br>B12+25,30;<br>B13+66;<br>B19+21 <sup>3)</sup> ;<br>B20+B32;<br>B25+25,26,41<br>B29+30;<br>B38+38;<br>B39+39 (CA_39C only);<br>B39+39; B39+41 |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                              | B40+40 (CA_40C only);<br>B41+41;<br>B66+66 (CA_66C only);12,29,30,5;<br>B2+B14;B14+B30;B14+B66;<br>(Note: B29, B32 is only for secondary component carrier)                                                                                                                                                                                                                                                                                                                                                                                           |
| DL 3×CA                      | DL inter-band 3CA:<br>1+3+7, 1+3+19, 1+3+20, 1+3+5, 1+3+8, 1+3+28,1+7+20,1+3+5,<br>2+4+5, 2+4+13, 2+5+30, 2+12+30, 2+29+30 ,<br>3+7+20, 3+7+28 , 3+7+8,<br>4+5+30, 4+12+30, 4+29+30 ,<br>5+66+2, 13+66+2,<br>66+12+30,66+29+30,66+5+30;<br>B2+B14+B66;<br>DL 2 intra-band plus inter-band 3CA:<br>2+2+5, 2+2+13 ,<br>3+3+7, 3+7+7, 3+3+20 , 3+3+28,3+3+1,<br>4+4+5, 4+4+13,<br>7+7+28,<br>5+66+66, 13+66+66, 66+66+2,<br>B39+B39+B41; B39+B41+B41;<br>B14+B66+B66<br>B25+B25+B26, B25+B41+B41<br>DL 3 intra-band 3CA:<br>40+40+40, 41+41+41, 66+66+66 |
| UL CA                        | B3C;B7C;B38C;B40C;B41C;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| WCDMA<br>(with Rx-diversity) | B1/B2/B3/B4/B5/B8/B9/B19                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| GNSS <sup>1)</sup>           | GPS, GLONASS, BeiDou, Galileo                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

## NOTES

- <sup>1)</sup> GNSS function is optional.
- <sup>2)</sup> EM12-G 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> B21 band follow up will be developed

EM12-G 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 EM12-G.

**Table 2: Key Features of EM12-G**

| Feature                    | Details                                                                                                                                                                                                                                                                     |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Function Interface         | PCI Express M.2 Interface                                                                                                                                                                                                                                                   |
| Power Supply               | Supply voltage: 3.135V~4.4V<br>Typical supply voltage: 3.7V                                                                                                                                                                                                                 |
| Transmitting Power         | Class 3 (23dBm±2dB) for LTE-FDD bands<br>Class 3 (23dBm±2dB) for LTE-TDD bands<br>Class 3 (24dBm+1/-3dB) for WCDMA                                                                                                                                                          |
| LTE Features               | Support up to LTE Cat 12<br>Support 1.4MHz to 20MHz RF bandwidth<br>Support MIMO in DL direction <ul style="list-style-type: none"> <li>● FDD: Max 600Mbps (DL)/150Mbps (UL)</li> <li>● TDD: Max 408Mbps (DL)/90Mbps (UL)</li> </ul>                                        |
| UMTS Features              | Support 3GPP R8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA<br>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 | Support PPP/QMI/NTP*/TCP*/UDP*/FTP*/HTTP*/PING*/HTTPS*/SMTP*/MMS*/FTPS*/SMTPS*/SSL* protocols<br>Support the protocols PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) usually used for PPP connections                       |
| SMS                        | Text and PDU mode<br>Point to point MO and MT<br>SMS cell broadcast<br>SMS storage: ME by default                                                                                                                                                                           |
| (U)SIM Interfaces          | Support (U)SIM card: 1.8V, 3.0V<br>Include USIM1 and USIM2 interfaces<br>Support Dual SIM Single Standby*                                                                                                                                                                   |

|                          |                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Audio Feature            | Support one digital audio interface: PCM interface<br>WCDMA: AMR/AMR-WB<br>LTE: AMR/AMR-WB<br>Support echo cancellation and noise suppression                                                                                                                                                                                                                                                              |
| PCM Interface            | Used for audio function with external codec<br>Support 16-bit linear data format<br>Support long frame synchronization and short frame synchronization<br>Support master and slave modes, but must be the master in long frame synchronization                                                                                                                                                             |
| USB Interface            | Compliant with USB 3.0 and 2.0 specifications, with maximum transmission rates up to 5Gbps on USB 3.0 and 480Mbps on USB 2.0.<br>Used for AT command communication, data transmission, firmware upgrade, software debugging, GNSS NMEA sentence output and voice over USB*<br>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 |
| PCIE Interface*          | Support PCIE interface, under development                                                                                                                                                                                                                                                                                                                                                                  |
| Antenna Interface        | Include main antenna, diversity antenna and GNSS antenna interfaces                                                                                                                                                                                                                                                                                                                                        |
| Rx-diversity             | Support LTE/WCDMA Rx-diversity                                                                                                                                                                                                                                                                                                                                                                             |
| GNSS Features            | Gen 9HT Lite of Qualcomm<br>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<br>Weight: TBD                                                                                                                                                                                                                                                                                                                                           |
| Temperature Range        | Operation temperature range: -30°C~ +70°C <sup>1)</sup><br>Extended temperature range: -40°C~ +85°C <sup>2)</sup><br>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 EM12-G.

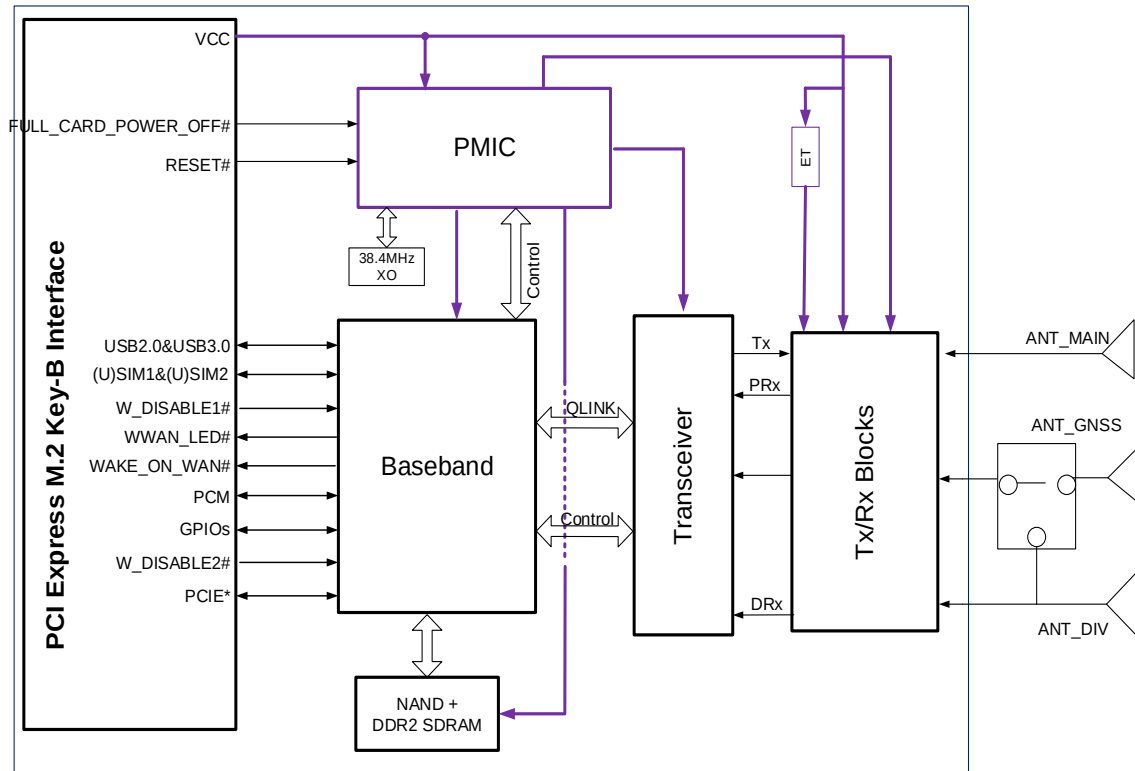


Figure 1: Functional Diagram

## 2.4. Evaluation Board

In order to help customers develop applications conveniently with EM12-G, 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 EM12-G comply with PCI Express M.2 specifications. This chapter mainly describes the definition and application of the following interfaces/signals/pins of EM12-G:

- Power supply
- (U)SIM interfaces
- USB interface
- PCIE 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 EM12-G. The top side contains EM12-G module and antenna connectors.

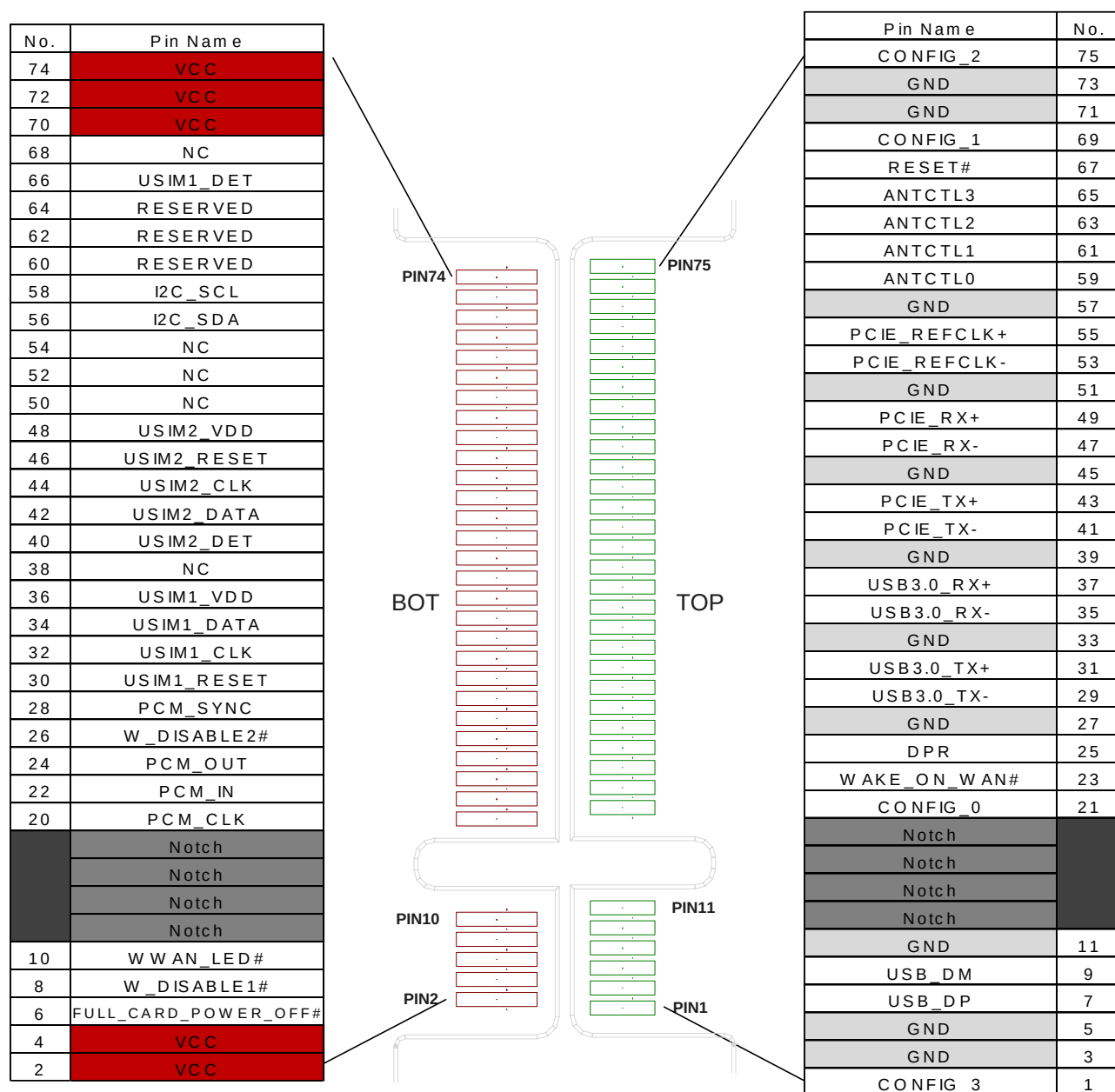


Figure 2: Pin Assignment

## 3.2. Pin Description

The following tables show the pin definition and description of EM12-G 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 WWAN Module Pinout | EM12-G Pin Name      | I/O | Description                                                                                                                                      | Comment                                |
|---------|---------------------------------|----------------------|-----|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| 1       | CONFIG_3                        | CONFIG_3             |     | Not connected internally. EM12-G is configured as WWAN-USB 3.0.                                                                                  |                                        |
| 2       | 3.3V                            | VCC                  | PI  | Power supply                                                                                                                                     | Vmin=3.135V<br>Vnorm=3.7V<br>Vmax=4.4V |
| 3       | GND                             | GND                  |     | Ground                                                                                                                                           |                                        |
| 4       | 3.3V                            | VCC                  | PI  | Power supply                                                                                                                                     | Vmin=3.135V<br>Vnorm=3.7V<br>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.<br>Active low.                                                                                                          | 1.8V/3.3V<br>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.<br>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<br>(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.<br>EM12-G is configured as WWAN-USB 3.0.                                                                          |                           |
| 22 | GPIO_6<br>(AUDIO_1)      | PCM_IN       | DI | PCM data input                                                                                                                                 | 1.8V power domain         |
| 23 | GPIO_11<br>(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<br>(AUDIO_2)      | PCM_OUT      | DO | PCM data output                                                                                                                                | 1.8V power domain         |
| 25 | DPR                      | DPR          | DI | Dynamic power reduction.<br>High level by default.                                                                                             | 1.8V power domain         |
| 26 | GPIO_10<br>(W_DISABLE2#) | W_DISABLE2#* | DI | GNSS enable control.<br>Active low.                                                                                                            | 1.8V/3.3V<br>power domain |
| 27 | GND                      | GND          |    | Ground                                                                                                                                         |                           |
| 28 | GPIO_8                   | PCM_SYNC     | IO | PCM data frame synchronization                                                                                                                 | 1.8V power                |

|    | (AUDIO_3)         |             | signal | domain                                                   |
|----|-------------------|-------------|--------|----------------------------------------------------------|
| 29 | USB3.0-TX-        | USB3.0_TX-  | DO     | USB 3.0 transmit data (-)                                |
| 30 | UIM-RESET         | USIM1_RESET | DO     | (U)SIM1 card reset<br>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<br>1.8V/3.0V power domain             |
| 33 | GND               | GND         |        | Ground                                                   |
| 34 | UIM-DATA          | USIM1_DATA  | IO     | (U)SIM1 card data<br>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<br>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<br>Pulled up internally |
| 41 | PETn0             | PCIE_TX-    | DO     | PCIE transmit data (-)                                   |
| 42 | GPIO_1 (SIM_DAT2) | USIM2_DATA  | IO     | (U)SIM2 card data<br>Pulled up to USIM2_VDD internally   |
| 43 | PETp0             | PCIE_TX+    | DO     | PCIE transmit data (+)                                   |
| 44 | GPIO_2 (SIM_CLK2) | USIM2_CLK   | DO     | (U)SIM2 card clock<br>1.8V/3.0V power domain             |
| 45 | GND               | GND         |        | Ground                                                   |
| 46 | GPIO_3 (SIM_RST2) | USIM2_RESET | DO     | (U)SIM2 card reset<br>1.8V/3.0V power domain             |
| 47 | PERn0             | PCIE_RX-    | DI     | PCIE receive data (-)                                    |
| 48 | GPIO_4 (SIM_PWR2) | USIM2_VDD   | PO     | Power supply for (U)SIM2 card<br>1.8V/3.0V power domain  |
| 49 | PERp0             | PCIE_RX+    | DI     | PCIE receive data (+)                                    |
| 50 | PRRST#            | PCIE_RST_N  | DI     | PCIE reset.<br>Active low.<br>3.3V power domain          |

|    |                |               |    |                                                                          |                                        |
|----|----------------|---------------|----|--------------------------------------------------------------------------|----------------------------------------|
| 51 | GND            | GND           |    | Ground                                                                   |                                        |
| 52 | CLKREQ#        | PCIE_CLKREQ_N | IO | PCIE clock request.<br>Active low.                                       | 3.3V power domain                      |
| 53 | REFCLKn        | PCIE_REFCLK-  | AI | PCIE reference clock(-)                                                  |                                        |
| 54 | PEWAKE#        | PCIE_WAKE_N   | IO | PCIE wake on host.<br>Active low.                                        | 3.3V power domain                      |
| 55 | REFCLKp        | PCIE_REFCLK+  | AI | PCIE reference clock(+)                                                  |                                        |
| 56 | N/C            | I2C_DATA      | IO | I2C serial data.<br>Used for external codec.                             |                                        |
| 57 | GND            | GND           |    | Ground                                                                   |                                        |
| 58 | N/C            | I2C_CLK       | DO | I2C serial clock.<br>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.<br>EM12-G is configured as<br>WWAN-USB 3.0. |                                        |
| 70 | 3.3V           | VCC           | PI | Power supply                                                             | Vmin=3.135V<br>Vnorm=3.7V<br>Vmax=4.4V |
| 71 | GND            | GND           |    | Ground                                                                   |                                        |
| 72 | 3.3V           | VCC           | PI | Power supply                                                             | Vmin=3.135V<br>Vnorm=3.7V<br>Vmax=4.4V |

|    |          |          |                                                                       |                                                        |
|----|----------|----------|-----------------------------------------------------------------------|--------------------------------------------------------|
| 73 | GND      | GND      | Ground                                                                |                                                        |
| 74 | 3.3V     | VCC      | PI                                                                    | Power supply<br>Vmin=3.135V<br>Vnorm=3.7V<br>Vmax=4.4V |
| 75 | CONFIG_2 | CONFIG_2 | Not connected internally.<br>EM12-G is configured as<br>WWAN-USB 3.0. |                                                        |

#### NOTES

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

### 3.3. Power Supply

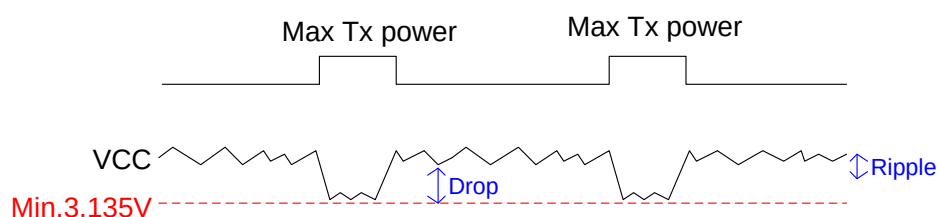
The following table shows pin definition of VCC pins and ground pins.

**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,<br>39, 45, 51, 57, 71,<br>73 | GND      |     |              | Ground                 |

#### 3.3.1. Decrease Voltage Drop

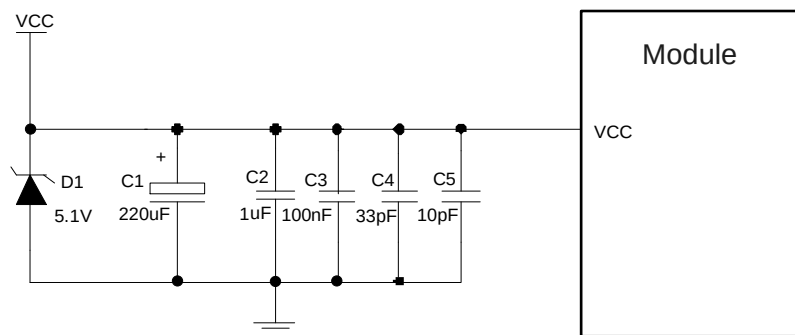
The power supply range of the module is from 3.135V to 4.4V. Please make sure that the input voltage will never drop below 3.135V, otherwise the module will be powered off automatically. The following figure shows the maximum voltage drop during radio transmission in 3G and 4G networks.



**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.

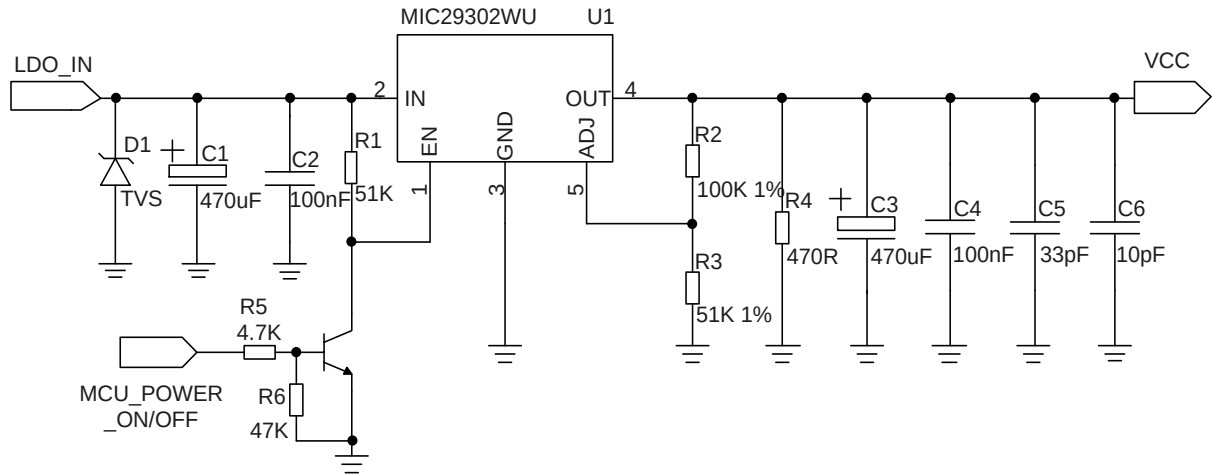


Figure 5: Reference Design of Power Supply

#### 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

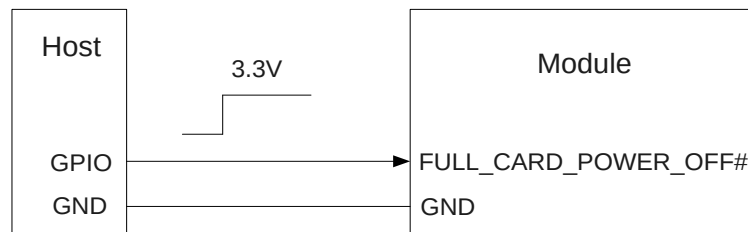
Driving the FULL\_CARD\_POWER\_OFF# pin to a high level will power on the module. The following table shows the definition of FULL\_CARD\_POWER\_OFF#.

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. | $V_{IHmax}=4.4V$<br>$V_{IHmin}=0.7V$<br>$V_{ILmax}=0.5V$ | 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.

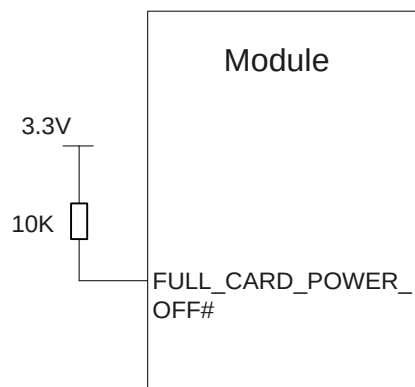


**Figure 6: Turn on the Module Through GPIO Controlled FULL\_CARD\_POWER\_OFF#**

#### 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.

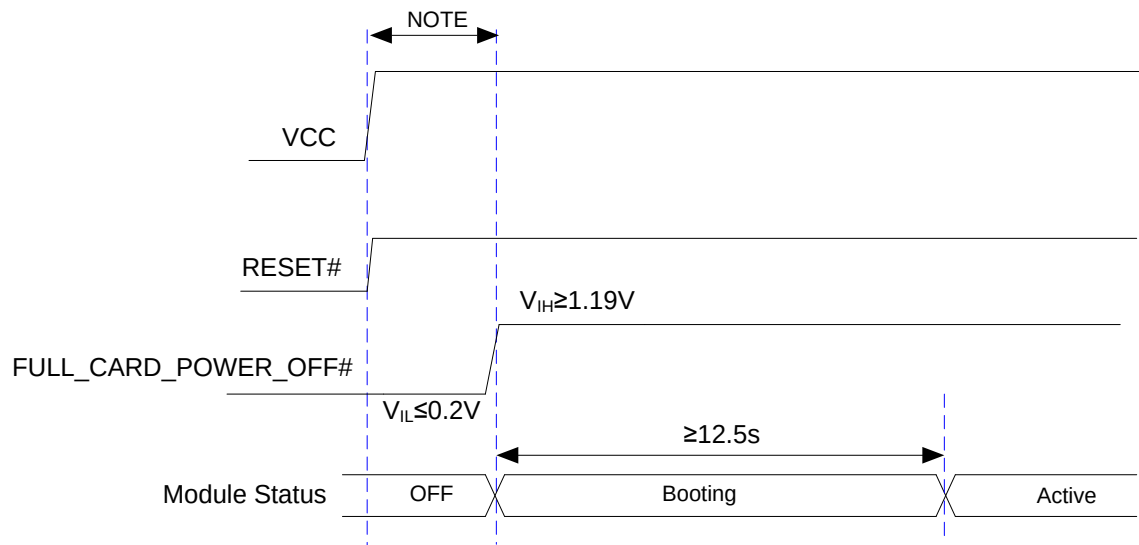


Figure 8: Timing of Turning on Module

**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.

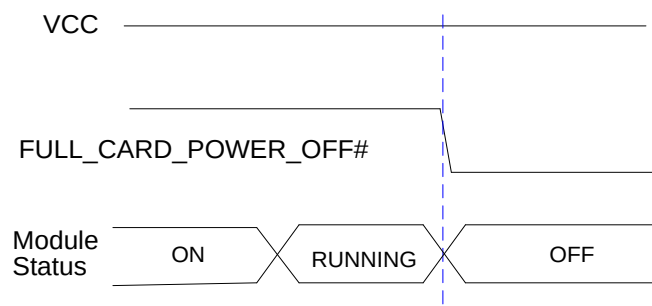


Figure 9: Timing of Turning off the Module Through FULL\_CARD\_POWER\_OFF#

### 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 | $V_{IHmax}=2.1V$<br>$V_{IHmin}=1.3V$<br>$V_{ILmax}=0.5V$ |         |

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

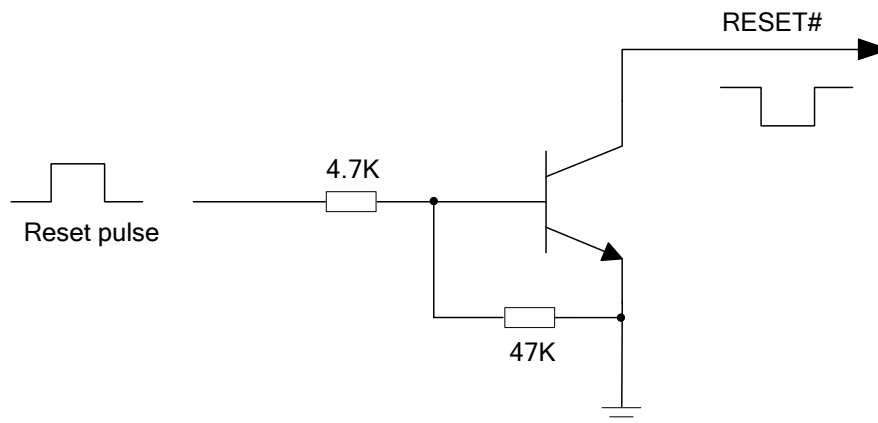
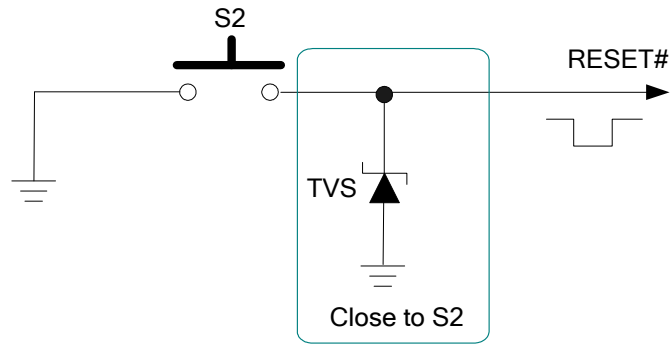
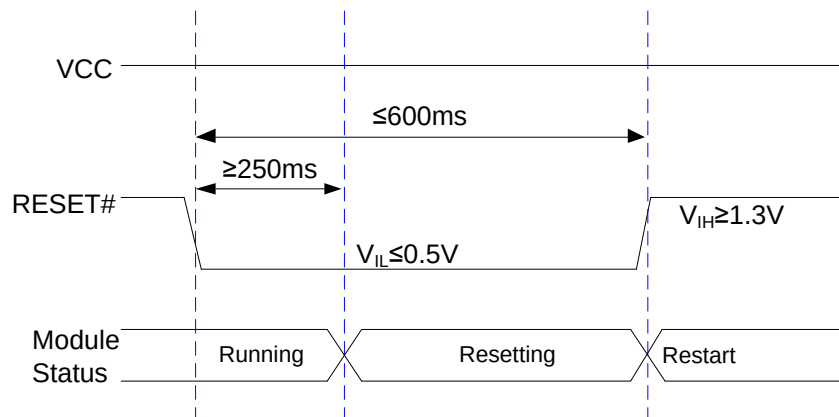


Figure 10: Reference Circuit of RESET# by Using Driving Circuit



**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.<br>Active high. | Pulled up internally.<br>When (U)SIM1 card is present, it is at high level.<br>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.<br>Active high. | Pulled up internally.<br>When (U)SIM2 card is present, it is at high level.<br>When (U)SIM2 card is absent, it is at low level. |

EM12-G 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.

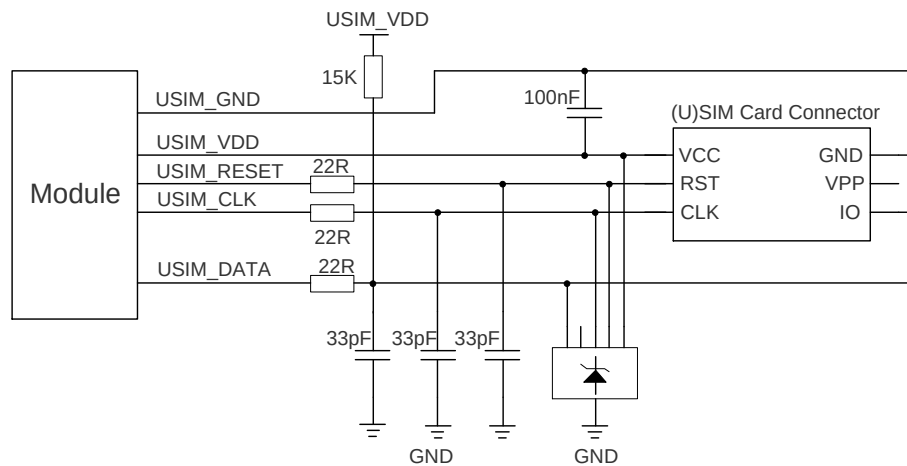
The following figure shows a reference design of (U)SIM interface with normally short-circuited (U)SIM card connector.



- When the (U)SIM is absent, CD is short-circuited to SW and USIM\_DET is at low level.
- When the (U)SIM is inserted, CD is open to SW and USIM\_DET is at high level.

- When the (U)SIM is absent, CD is open to SW and USIM\_DET is at low level.
- When the (U)SIM is inserted, CD is short-circuited to SW and USIM\_DET is at high level.

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

EM12-G 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\*.

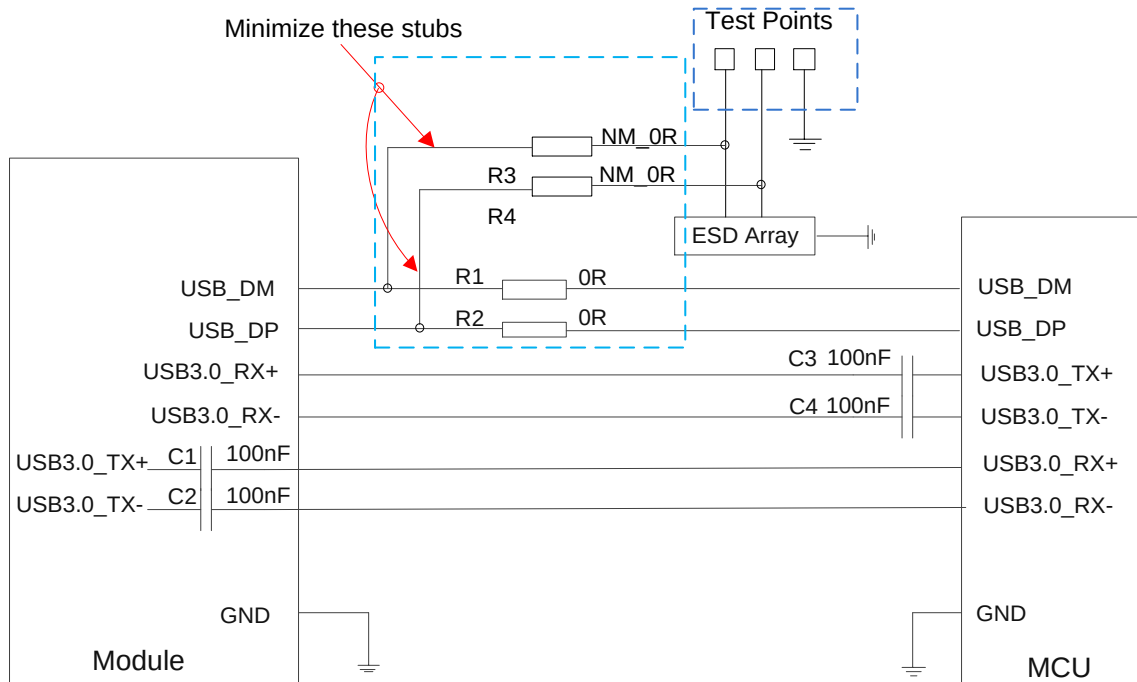
The following table shows the pin definition of USB interface.

**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. PCIE Interface

Under development

### 3.9. PCM and I2C Interfaces

EM12-G supports audio communication via Pulse Code Modulation (PCM) digital interface and I2C interface.

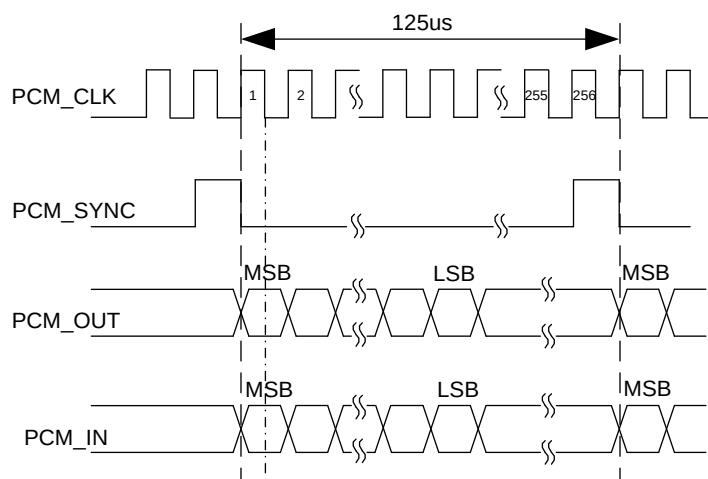
The PCM interface supports the following modes:

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

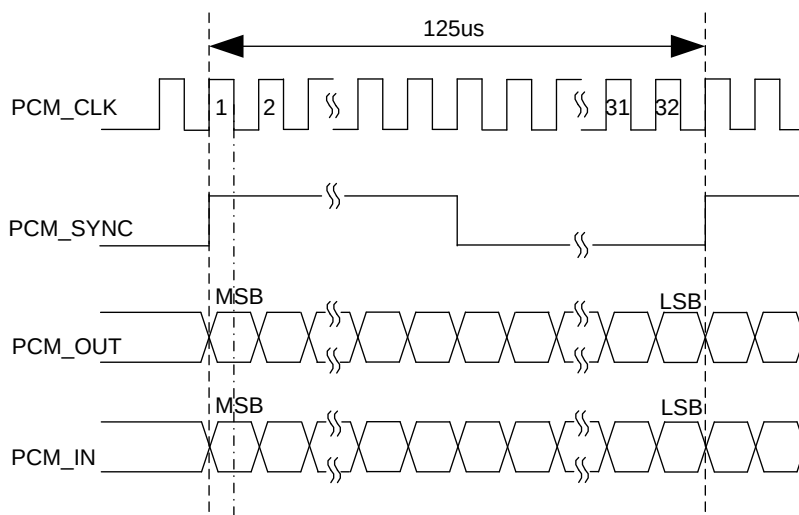
In primary mode, the data is sampled on the falling edge of the PCM\_CLK and transmitted on the rising edge. The PCM\_SYNC falling edge represents the MSB. In this mode, the PCM interface supports 256kHz, 512kHz, 1024kHz or 2048kHz PCM\_CLK at 8kHz PCM\_SYNC, and also supports 4096kHz PCM\_CLK at 16kHz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

EM12-G 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.

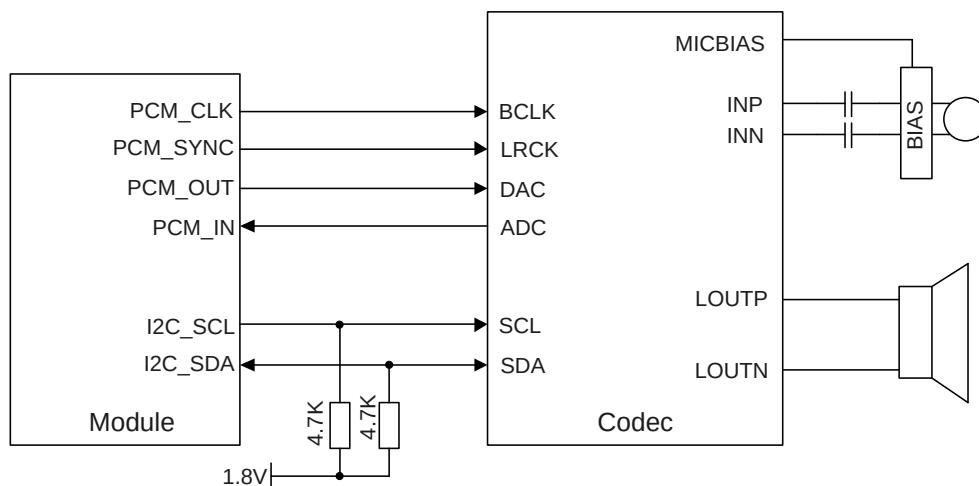
**Table 10: Pin Definition of PCM and I2C Interfaces**

| 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.<br>In master mode, it is an output signal. In slave mode, it is an input signal.<br>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=22Ω, C=22pF) circuit on the PCM lines, especially for PCM\_CLK.
2. EM12-G works as a master device pertaining to I2C interface.

### 3.10. Control and Indicator Signals

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

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

| NOTE | Pin Name | I/O          | Power Domain | Description                                                                                           |
|------|----------|--------------|--------------|-------------------------------------------------------------------------------------------------------|
|      | 10       | WWAN_LED#    | OD           | 3.3V                                                                                                  |
|      |          |              |              | It is an open collector and active low signal.<br>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.<br>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.                                                       |

\* means under development.

### 3.10.1. W\_DISABLE1# Signal

EM12-G 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        | AT+CFUN=1                           | Enabled            |
| High Level        | AT+CFUN=0<br>AT+CFUN=4              | Disabled           |
| Low Level         | AT+CFUN=0<br>AT+CFUN=1<br>AT+CFUN=4 | Disabled           |

### 3.10.2. 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.

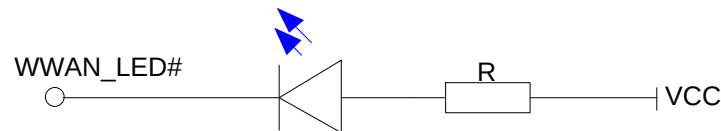


Figure 20: WWAN\_LED# Signal Reference Circuit Diagram

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>● AT+CFUN=4 (RF function disabled)</li> </ul> |

### 3.10.3. 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                                      |

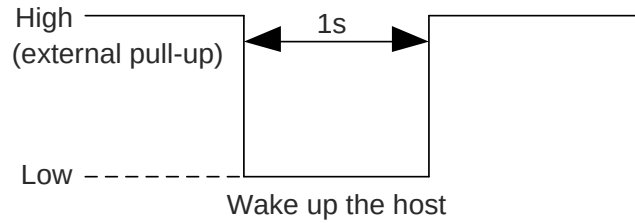


Figure 21: WAKE\_ON\_WAN# Behavior

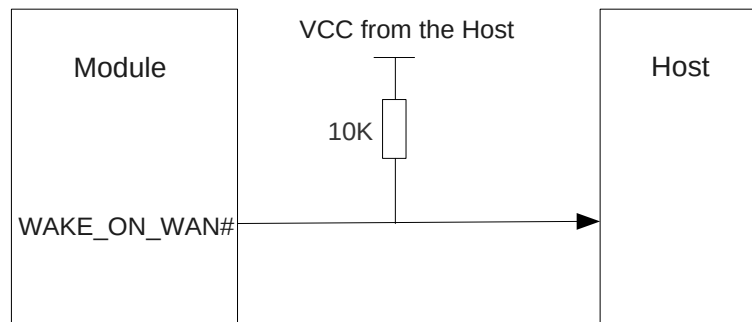


Figure 22: WAKE\_ON\_WAN# Signal Reference Circuit Design

#### 3.10.4. DPR Signal

EM12-G 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 EM12-G 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.

### 3.11. 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.

### 3.12. Configuration Pins

EM12-G 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 EM12-G module are defined as below:

**Table 18: List of Configuration Pins**

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

# 4 GNSS Receiver

## 4.1. General Description

EM12-G includes a fully integrated global navigation satellite system solution that supports Gen9C-Lite of Qualcomm (GPS, GLONASS, BeiDou Galileo and QZSS).

EM12-G supports standard NMEA-0183 protocol, and outputs NMEA sentences at 1Hz data update rate via USB interface by default.

By default, EM12-G 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

EM12-G 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: EM12-G Operating Frequencies**

| 3GPP Band | Transmit      | Receive       | Unit |
|-----------|---------------|---------------|------|
| WCDMA B1  | 1920~1980     | 2110~2170     | MHz  |
| 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  |
| WCDMA B9  | 1750~1785     | 1845~1880     | MHz  |
| WCDMA B19 | 830~845       | 875~890       | MHz  |
| LTE B1    | 1920~1980     | 2110~2170     | 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 B9    | 1749.9~1784.9 | 1844.9~1879.9 | MHz  |
| LTE B12   | 699~716       | 729~746       | MHz  |
| LTE B13   | 777~787       | 746~756       | MHz  |
| LTE B14   | 788~798       | 758~768       | MHz  |
| LTE B17   | 704~716       | 734~746       | MHz  |
| LTE B18   | 815~830       | 860~875       | MHz  |
| LTE B19   | 830~845       | 875~890       | MHz  |

|         |               |               |     |
|---------|---------------|---------------|-----|
| LTE B20 | 832~862       | 791~821       | MHz |
| LTE B21 | 1447.9~1462.9 | 1495.9~1510.9 | MHz |
| LTE B25 | 1850~1915     | 1930~1995     | MHz |
| LTE B26 | 814~849       | 859~894       | MHz |
| LTE B28 | 703~748       | 758~803       | MHz |
| LTE B29 | /             | 717~728       | MHz |
| LTE B30 | 2305~2315     | 2350~2360     | MHz |
| LTE B32 | /             | 1452~1496     | MHz |
| LTE B38 | 2570~2620     | 2570~2620     | MHz |
| LTE B39 | 1880~1920     | 1880~1920     | MHz |
| LTE B40 | 2300~2400     | 2300~2400     | MHz |
| LTE B41 | 2496~2690     | 2496~2690     | MHz |
| LTE B66 | 1710~1780     | 2110~2200     | MHz |

## 5.2. GNSS Antenna Interface

The following table shows frequency specification of GNSS antenna interface.

**Table 20: GNSS Frequency**

| Type        | Frequency      | Unit |
|-------------|----------------|------|
| GPS/Galileo | 1575.42±1.023  | MHz  |
| GLONASS     | 1597.5~1605.8  | MHz  |
| BeiDou      | 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 21: Antenna Requirements**

| Type               | Requirements                                                                                                                                                                                                                                                                                                                                                    |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GNSS <sup>1)</sup> | Frequency range: 1559MHz ~ 1609MHz<br>Polarization: RHCP or linear<br>VSWR: < 2 (Typ.)<br>Passive antenna gain: > 0dBi                                                                                                                                                                                                                                          |
| WCDMA/LTE          | VSWR: $\leq 2$<br>Efficiency: > 30%<br>Max Input Power: 50W<br>Input Impedance: 50 $\Omega$<br>Cable insertion loss: <1dB<br>(WCDMA B5/B8/B19,<br>LTE B5/B8/B12/B13/B14/B17/B18/B19/B20/B26/B28/B29)<br>Cable insertion loss: <1.5dB<br>(WCDMA B1/B2/B3/B4/B9, LTE B1/B2/B3/B4/B9/B21/B25/B32/B39/B66)<br>Cable insertion loss <2dB<br>(LTE B7/B30/B38/B40/B41) |

#### 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

EM12-G is mounted with standard 2mm × 2mm receptacle RF connectors for convenient antenna connection. The connector dimensions are illustrated below:

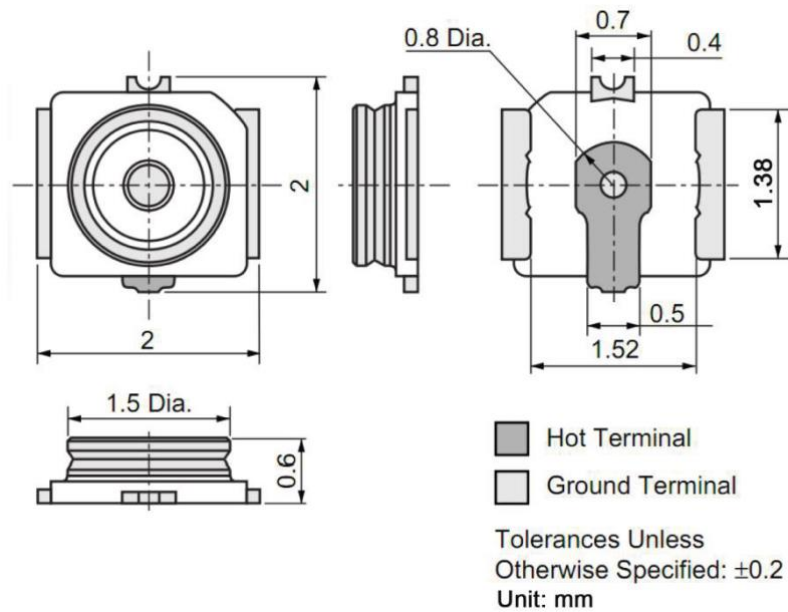


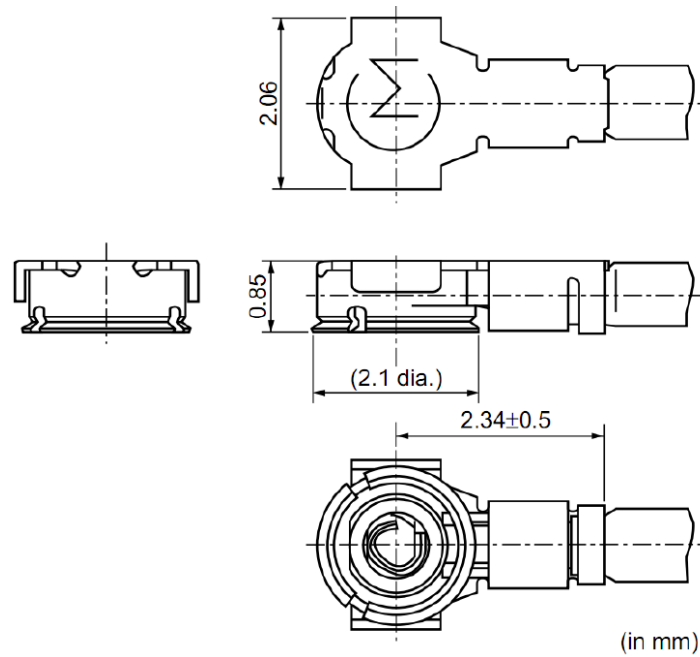
Figure 24: EM12-G RF Connector Dimensions (Unit: mm)

Table 22: Major Specifications of the RF Connector

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

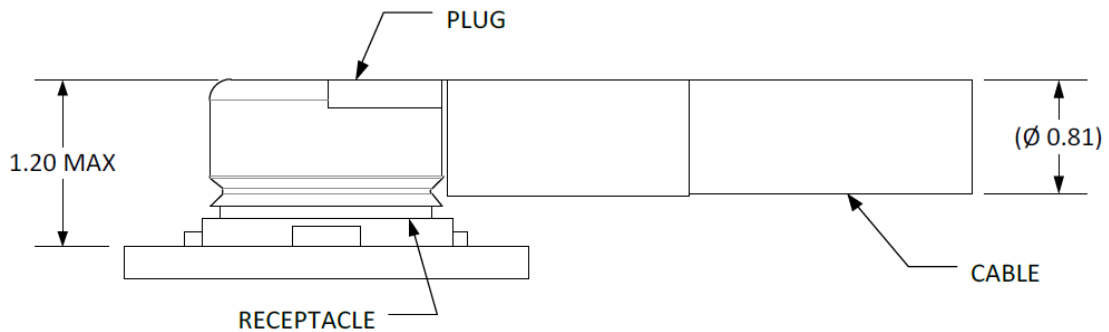
The receptacle RF connector used in conjunction with EM12-G will accept two types of mating plugs that will meet a maximum height of 1.2mm using a  $\varnothing 0.81$ mm coaxial cable or a maximum height of 1.45mm utilizing a  $\varnothing 1.13$ mm coaxial cable.

The following figure shows the specifications of mating plugs using  $\varnothing 0.81$ mm coaxial cables.



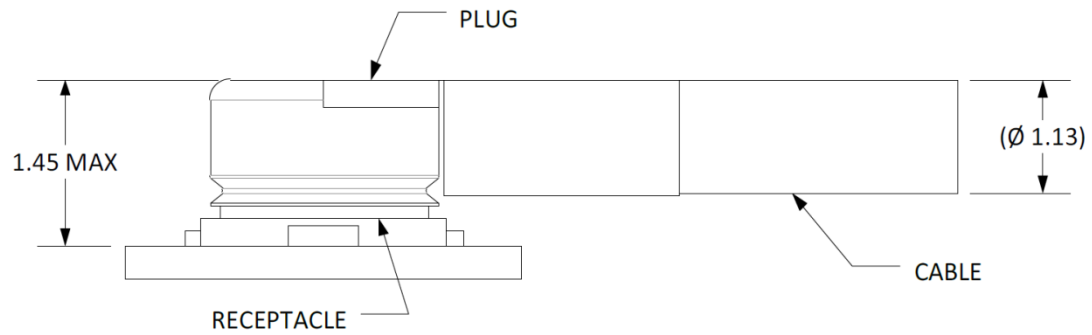
**Figure 25: Specifications of Mating Plugs Using Ø0.81mm Coaxial Cables**

The following figure illustrates the connection between the receptacle RF connector on EM12-G 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 EM12-G and the mating plug using a Ø1.13mm coaxial cable.



**Figure 27: Connection between RF Connector and Mating Plug Using Ø1.13mm 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 23: 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 EM12-G is 3.7V, as specified by *PCIe M.2 Electromechanical Spec Rev1.0*. The following table shows the power supply requirements of EM12-G.

**Table 24: 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 25: I/O Requirements

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

### NOTE

<sup>1)</sup>  $V_{DD18}$  refers to I/O power domain.

## 6.4. Operation and Storage Temperatures

Table 26: 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  $P_{out}$  might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operating temperature levels, the module will meet 3GPP specifications again.

## 6.5. Current Consumption(TBD)

## 6.6. RF Output Power

The following table shows the RF output power of EM12-G module.

**Table 27: 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 EM12-G module.

**Table 28: EM12-G Conducted RF Receiving Sensitivity(PRX、DRX TBD)**

| Frequency        | Primary (Typ.) | Diversity (Typ.) | SIMO <sup>1)</sup> (Typ.) | 3GPP (SIMO) |
|------------------|----------------|------------------|---------------------------|-------------|
| WCDMA B1         | -109.5         | /                | /                         | -106.7dBm   |
| WCDMA B2         | -109.5         | /                | /                         | -104.7dbm   |
| WCDMA B3         | -109.5         | /                | /                         | -103.7dbm   |
| WCDMA B4         | -109.0         | /                | /                         | -106.7dBm   |
| WCDMA B5         | -110.5         | /                | /                         | -104.7dbm   |
| WCDMA B8         | -110.5         | /                | /                         | -103.7dBm   |
| WCDMA B9         | -109.5         | /                | /                         | -105.7dBm   |
| WCDMA B19        | -110.5         | /                | /                         | -106.7dBm   |
| LTE-FDD B1 (10M) | -96.5          | -96.0            | -98.5dbm                  | -96.3dBm    |

|                   |       |       |           |          |
|-------------------|-------|-------|-----------|----------|
| LTE-FDD B2 (10M)  | -97.5 | -97.0 | -99.5dbm  | -94.3dBm |
| LTE-FDD B3 (10M)  | -97.0 | -96.5 | -99.0dbm  | -93.3dBm |
| LTE-FDD B4 (10M)  | -97.0 | -96.0 | -99.0dBm  | -96.3dBm |
| LTE-FDD B5 (10M)  | -98.5 | -98.5 | -100.5dBm | -94.3dBm |
| LTE-FDD B7 (10M)  | -96.5 | -96.0 | -98.5dBm  | -94.3dBm |
| LTE-FDD B8 (10M)  | -98.0 | -98.0 | -101.5dBm | -93.3dBm |
| LTE-FDD B9(10M)   | -97.5 | -97.5 | -100.0dBm | -95.3dBm |
| LTE-FDD B12 (10M) | -98.5 | -99.0 | -101.5dBm | -93.3dBm |
| LTE-FDD B13 (10M) | -99.0 | -99.0 | -101.0dBm | -93.3dBm |
| LTE-FDD B14 (10M) | -97.0 | -97.5 | -100.0dBm | -93.3dBm |
| LTE-FDD B17 (10M) | -99.0 | -99.0 | -101.0dBm | -93.3dBm |
| LTE-FDD B18 (10M) | -99.0 | -99.0 | -101.0dBm | -96.3dBm |
| LTE-FDD B19 (10M) | -98.5 | -98.5 | -100.5dBm | -96.3dBm |
| LTE-FDD B20 (10M) | -98.5 | -98.5 | -100.5dBm | -93.3dBm |
| LTE-FDD B21 (10M) | -96.0 | -96.0 | -98.0dBm  | -96.3dBm |
| LTE-TDD B25 (10M) | -96.5 | -97.0 | -99.0dBm  | -92.8dBm |
| LTE-TDD B26 (10M) | -99.0 | -98.5 | -100.5dBm | -93.8dBm |
| LTE-TDD B28 (10M) | -98.0 | -99.0 | -100.5dBm | -94.8dBm |
| LTE-TDD B29 (10M) | /     | /     | /         | /        |
| LTE-TDD B30 (10M) | -97.0 | -95.0 | -98.0dBm  | -95.3dBm |
| LTE-TDD B32 (10M) | /     | /     | /         | /        |
| LTE-TDD B38 (10M) | -96.5 | -96.0 | -98.0dBm  | -96.3dBm |
| LTE-TDD B39 (10M) | -97.0 | -97.5 | -99.5dBm  | -96.3dBm |
| LTE-TDD B40 (10M) | -96.5 | -96   | -98.0dBm  | -96.3dBm |
| LTE-TDD B41 (10M) | -96.0 | -95.5 | -97.5dBm  | -94.3dBm |

|                   |       |       |          |          |
|-------------------|-------|-------|----------|----------|
| LTE-TDD B66 (10M) | -97.0 | -96.0 | -99.0dBm | -95.8dBm |
|-------------------|-------|-------|----------|----------|

#### NOTES

- <sup>1)</sup> SIMO is a smart antenna technology that uses a single antenna at the transmitter side and multiple (two for EM12-G) antennas at the receiver side, which can improve Rx performance.
- <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.

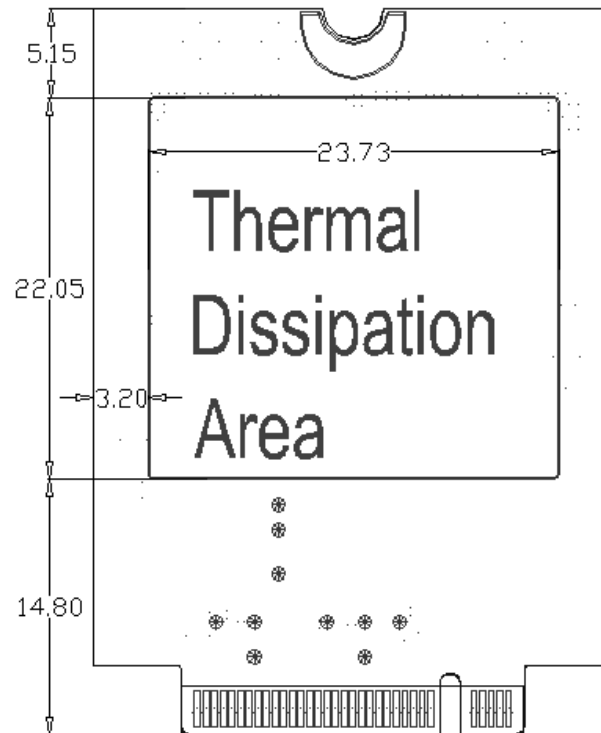
**Table 29: Electrostatic Discharge Characteristics (Temperature: 25°C, Humidity: 40%)**

| 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

EM12-G 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)**

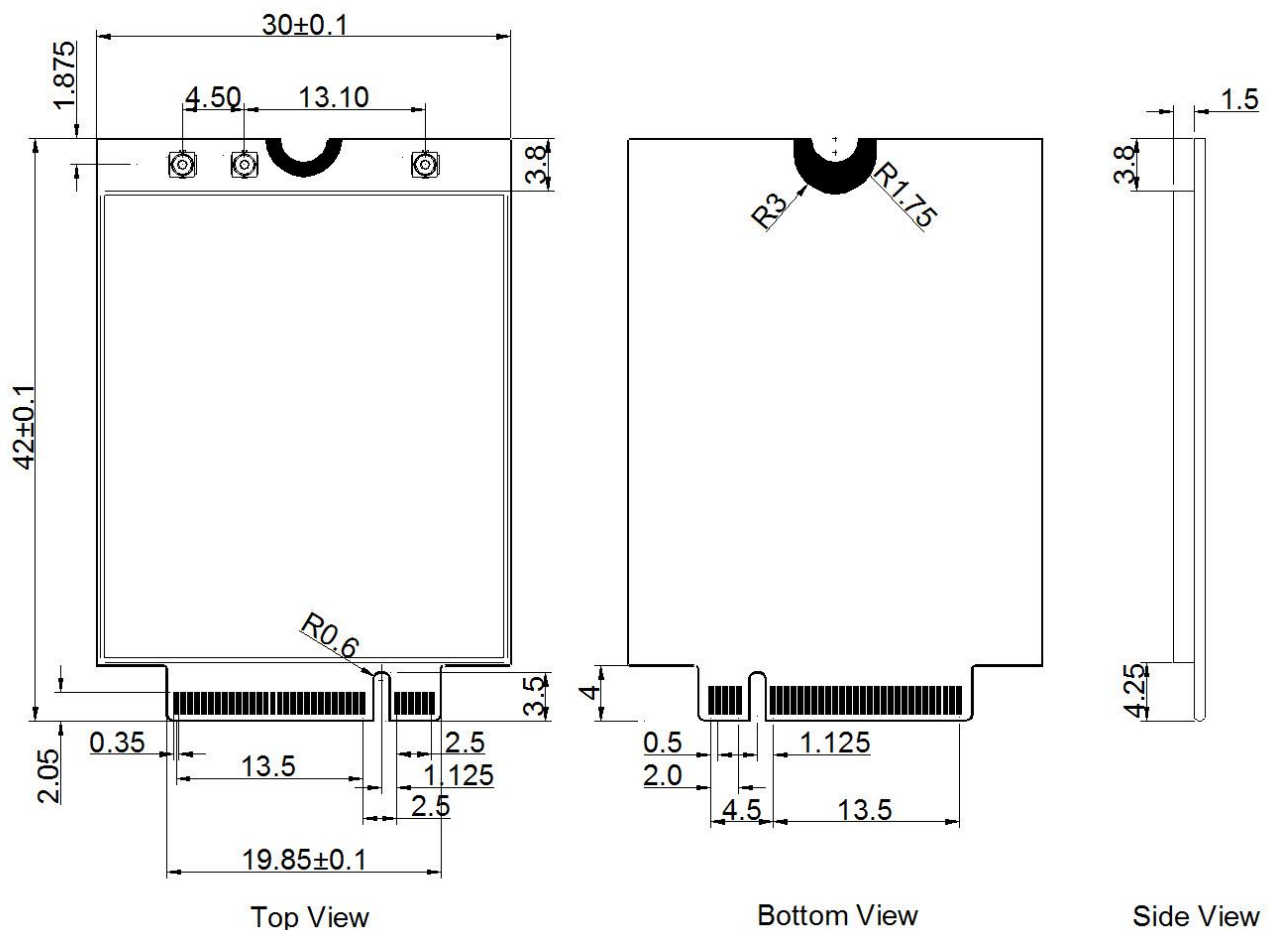
There are some other measures to enhance heat dissipation performance:

- 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 EM12-G 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 EM12-G (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.

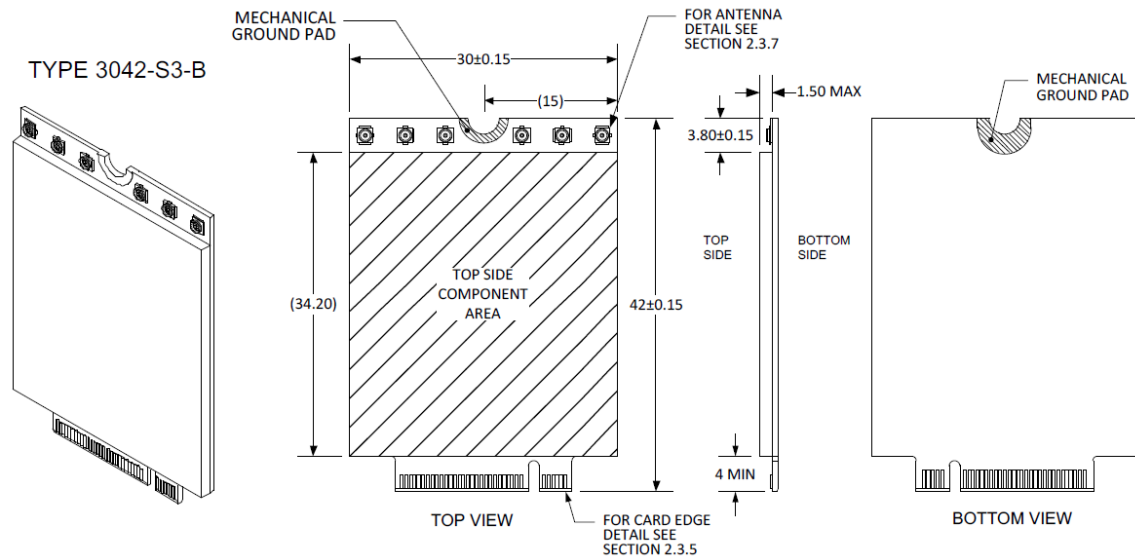


Figure 30: Standard Dimensions of M.2 Type 3042-S3 (Unit: mm)

According to M.2 nomenclature, EM12-G 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).

Type **XX** **XX** - **XX** - **X** - **X<sup>0</sup>**

|  | Width (mm) | Length (mm) | Label** | Component Max Ht (mm) |            |
|--|------------|-------------|---------|-----------------------|------------|
|  |            |             |         | Top Max               | Bottom Max |
|  | 12         | 16          | S1      | 1.2                   | 0****      |
|  | 16         | 26          | S2      | 1.35                  | 0****      |
|  | 22         | 30          | S3      | 1.5                   | 0****      |
|  | 30         | 42          | D1      | 1.2                   | 1.35       |
|  |            | 60          | D2      | 1.35                  | 1.35       |
|  |            | 80          | D3      | 1.5                   | 1.35       |
|  |            | 110         | 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 31: M.2 Nomenclature

### 7.3. Design Effect Drawings of the Module



Figure 32: Top View of the Module

#### NOTE

These are design effect drawings of EM12-G module. For more accurate pictures, please refer to the module that you get from Quectel.

### 7.4. M.2 Connector

EM12-G adopts a standard PCI Express M.2 connector which compiles with the directives and standards listed in the **document [4]**.

### 7.5. Barcode Rule

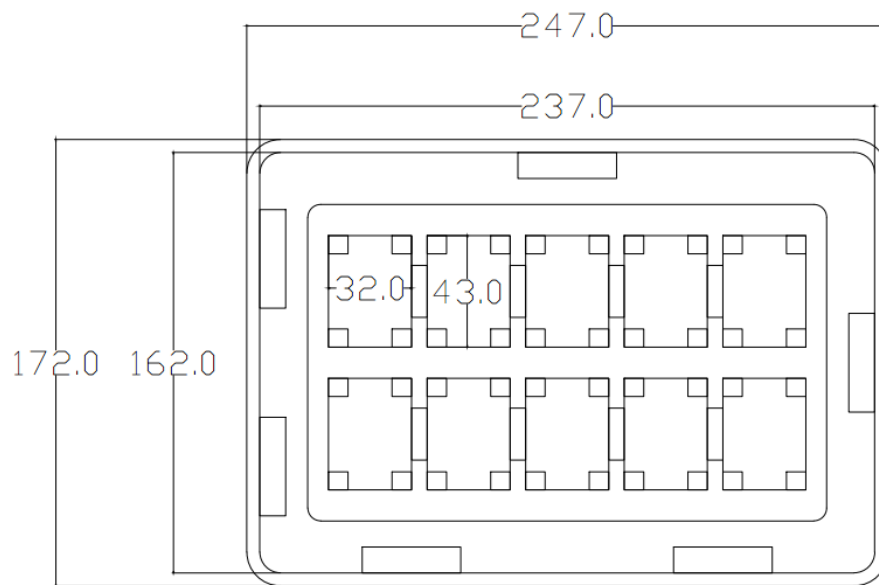
The **PN (Q1-A2449)** printed on the label is fixed for Quectel.

For the **SN** shown in the top view, the first two digits indicate project stage. For example, “D1” means DVT1. The next one digit indicates the code of the factory where the module is manufactured. The next

four digits indicate the day, month and year when the module is manufactured. For instance, “18FD” means 13<sup>th</sup> June, 2018. The next two digits indicate serial number of the manufacturing order. The last six digits vary by module which could not be the same in certain time. Meanwhile, the **SN** and **IMEI** can be checked by scanning the QR code.

## 7.6. Packaging

EM12-G modules are packaged in trays. The following figure shows the tray size.



**Figure 33: Tray Size**

Each tray contains 10 modules. The smallest package contains 100 modules. Tray packaging procedure as below.

1. Use 10 trays to package 100 modules at a time (tray size: 247mm × 172mm).
2. Place an empty tray on the top of the 10-tray stack.
3. Fix the stack with masking tape in “#” shape as shown in the figure.
4. Pack the stack with conductive bag, and then fix the bag with masking tape.
5. Place the IMEI No. list into the small carton.
6. Seal the carton and then label the seal with sealing sticker (small carton size: 250mm × 175mm × 128mm).



Figure 34: Tray Packaging Procedure

## 8 Appendix References

**Table 30: 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 31: 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                                                                                       |
| 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        |