

# EM160R-GL

# Hardware Design

**LTE-A Module Series**

Version: 1.3.3

Date: 2023-10-18

Status: Preliminary



At Quectel, our aim is to provide timely and comprehensive services to our customers. If you require any assistance, please contact our headquarters:

**Quectel Wireless Solutions Co., Ltd.**

Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China

Tel: +86 21 5108 6236

Email: [info@quectel.com](mailto:info@quectel.com)

**Or our local offices. For more information, please visit:**

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

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

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

Or email us at: [support@quectel.com](mailto:support@quectel.com).

## Legal Notices

We offer information as a service to you. The provided information is based on your requirements and we make every effort to ensure its quality. You agree that you are responsible for using independent analysis and evaluation in designing intended products, and we provide reference designs for illustrative purposes only. Before using any hardware, software or service guided by this document, please read this notice carefully. Even though we employ commercially reasonable efforts to provide the best possible experience, you hereby acknowledge and agree that this document and related services hereunder are provided to you on an “as available” basis. We may revise or restate this document from time to time at our sole discretion without any prior notice to you.

## Use and Disclosure Restrictions

### License Agreements

Documents and information provided by us shall be kept confidential, unless specific permission is granted. They shall not be accessed or used for any purpose except as expressly provided herein.

### Copyright

Our and third-party products hereunder may contain copyrighted material. Such copyrighted material shall not be copied, reproduced, distributed, merged, published, translated, or modified without prior written consent. We and the third party have exclusive rights over copyrighted material. No license shall be granted or conveyed under any patents, copyrights, trademarks, or service mark rights. To avoid ambiguities, purchasing in any form cannot be deemed as granting a license other than the normal non-exclusive, royalty-free license to use the material. We reserve the right to take legal action for noncompliance with abovementioned requirements, unauthorized use, or other illegal or malicious use of the material.

## Trademarks

Except as otherwise set forth herein, nothing in this document shall be construed as conferring any rights to use any trademark, trade name or name, abbreviation, or counterfeit product thereof owned by Quectel or any third party in advertising, publicity, or other aspects.

## Third-Party Rights

This document may refer to hardware, software and/or documentation owned by one or more third parties ("third-party materials"). Use of such third-party materials shall be governed by all restrictions and obligations applicable thereto.

We make no warranty or representation, either express or implied, regarding the third-party materials, including but not limited to any implied or statutory, warranties of merchantability or fitness for a particular purpose, quiet enjoyment, system integration, information accuracy, and non-infringement of any third-party intellectual property rights with regard to the licensed technology or use thereof. Nothing herein constitutes a representation or warranty by us to either develop, enhance, modify, distribute, market, sell, offer for sale, or otherwise maintain production of any our products or any other hardware, software, device, tool, information, or product. We moreover disclaim any and all warranties arising from the course of dealing or usage of trade.

## Privacy Policy

To implement module functionality, certain device data are uploaded to Quectel's or third-party's servers, including carriers, chipset suppliers or customer-designated servers. Quectel, strictly abiding by the relevant laws and regulations, shall retain, use, disclose or otherwise process relevant data for the purpose of performing the service only or as permitted by applicable laws. Before data interaction with third parties, please be informed of their privacy and data security policy.

## Disclaimer

- a) We acknowledge no liability for any injury or damage arising from the reliance upon the information.
- b) We shall bear no liability resulting from any inaccuracies or omissions, or from the use of the information contained herein.
- c) While we have made every effort to ensure that the functions and features under development are free from errors, it is possible that they could contain errors, inaccuracies, and omissions. Unless otherwise provided by valid agreement, we make no warranties of any kind, either implied or express, and exclude all liability for any loss or damage suffered in connection with the use of features and functions under development, to the maximum extent permitted by law, regardless of whether such loss or damage may have been foreseeable.
- d) We are not responsible for the accessibility, safety, accuracy, availability, legality, or completeness of information, advertising, commercial offers, products, services, and materials on third-party websites and third-party resources.

**Copyright © Quectel Wireless Solutions Co., Ltd. 2023. All rights reserved.**

## Safety Information

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



Full attention must be paid to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.



Switch off the terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If there is an Airplane Mode, it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on an aircraft.



Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.



Terminals or mobiles operating over radio signal and cellular network cannot be guaranteed to connect in certain conditions, such as when the mobile bill is unpaid or the (U)SIM card is invalid. When emergency help is needed in such conditions, use emergency call if the device supports it. In order to make or receive a call, the terminal or mobile must be switched on in a service area with adequate cellular signal strength. In an emergency, the device with emergency call function cannot be used as the only contact method considering network connection cannot be guaranteed under all circumstances.



The terminal or mobile contains a transceiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV sets, radios, computers or other electric equipment.



In locations with explosive or potentially explosive atmospheres, obey all posted signs and turn off wireless devices such as mobile phone or other terminals. Areas with explosive or potentially explosive atmospheres include fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, and areas where the air contains chemicals or particles such as grain, dust or metal powders.

# About the Document

## Revision History

| Update Log |            |                                                                                                              |                          |                        |
|------------|------------|--------------------------------------------------------------------------------------------------------------|--------------------------|------------------------|
| Version    | Date       | What/Where                                                                                                   | Why                      | Update                 |
| 1.0.0      | 2020-08-31 |                                                                                                              | Creation of the document |                        |
| 1.0        | 2020-12-23 |                                                                                                              | First official release   | Jim HAN/<br>Lewis PENG |
| 1.1        | 2021-01-15 | Updated the function diagram (Figure 1).                                                                     |                          | Jim HAN/<br>Lewis PENG |
|            |            | Updated the I/O parameter definitions (Table 3).                                                             |                          |                        |
|            |            | Updated the description of turn-on timing (Table 7).                                                         |                          |                        |
|            |            | Updated the figure of turn-off timing through FULL_CARD_POWER_OFF# (Figure 8).                               |                          |                        |
|            |            | Updated the figure of turn-off timing through AT command and power supply (Figure 10).                       |                          |                        |
|            |            | Updated the figure of reset timing (Figure 14).                                                              |                          |                        |
|            |            | Updated the description of reset timing (Table 10).                                                          |                          |                        |
|            |            | Updated the description of PCIe power-on timing requirements (Table 13).                                     |                          |                        |
|            |            | Update GNSS to Gen9-VT.                                                                                      |                          |                        |
|            |            | Updated the receiving sensitivity (Table 40, delta of 0.1 dB for B8/B20 and delta of 0.2 dB for B3/B18/B28). |                          |                        |
|            |            | Add four-antenna conducted receiving sensitivity (Table 41).                                                 |                          |                        |
|            |            | Updated the mechanical dimensions figure (Figure 38).                                                        |                          |                        |
|            |            | Updated the bottom view figures (Figure 42 and Figure 44).                                                   |                          |                        |
| 1.2        | 2021-02-01 | Updated the functional diagram (Figure 1).                                                                   |                          | Davon ZHAO             |

|       |            |                                                                                          |                                                                                                                                                       |                            |
|-------|------------|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
|       |            | Updated the description about EVB (Chapter 2.4).                                         |                                                                                                                                                       |                            |
|       |            | Added the ripple and VBAT data in the figure of power supply limits (Figure 3).          |                                                                                                                                                       |                            |
|       |            | Updated the turn-on and turn-off timing information (Chapters 3.4.1.1 and 3.4.2.1).      |                                                                                                                                                       |                            |
|       |            | Deleted the information about turning off the module through AT command.                 |                                                                                                                                                       |                            |
|       |            | Updated the module reset information (Chapter 3.5).                                      |                                                                                                                                                       |                            |
|       |            | Changed pin 24 into VDDIO in the table of PCM interface pin (Table 13).                  |                                                                                                                                                       |                            |
|       |            | Deleted the figure of PCIe turn-on timing requirements of M.2 Specification.             |                                                                                                                                                       |                            |
|       |            | Updated the figure of thermal dissipation area on bottom side of the module (Figure 33). |                                                                                                                                                       |                            |
| 1.3.0 | 2023-06-05 | Deleted the related information of EM120R-GL.                                            | To meet the specific demanding of Lenovo.                                                                                                             | Iyukee SHEN/<br>Lewis PENG |
|       |            | Updated the PCIE_REFCLK in turn-on timing (Figure 7).                                    | To prevent module unrecognition problems caused by incorrect reference clock timing.                                                                  | Iyukee SHEN                |
|       |            | Updated the PCIE_REFCLK and CLKREQ# in timing of resetting the module (Figure 11).       | To prevent module unrecognition problems caused by incorrect reference clock timing.                                                                  | Iyukee SHEN                |
|       |            | Updated the PCIe Interface Reference Circuit (EP Mode) (Figure 16).                      | To prevent module unrecognition problems caused by incorrect GPIO configuration during host turn-on.                                                  | Iyukee SHEN                |
|       |            | Updated the PCIe D3 Cold State Timing (Figure 17).                                       | The timing of the wake-up control signal is provided to the customer, which more intuitively shows the process of the module from D3cold to D0 state. | Iyukee SHEN                |
|       |            | Updated reference circuit of DPR (Chapter 3.9.5).                                        | To prevent customers from directly connecting, which may cause the module to fail to work properly.                                                   | Iyukee SHEN                |
|       |            | Updated configuration of config pins (Figure 24 and Table 24).                           | To meet the specific demanding of Lenovo.                                                                                                             | Iyukee SHEN                |
|       |            | Added B29/B32/B46 in Rx Sensitivity (Chapter 4.1.2).                                     | To add the data of Rx only.                                                                                                                           | Lewis PENG                 |
|       |            | Remove the type Compass in GNSS frequency (Chapter 4.2).                                 | To follow the specification of EM160R-GL.                                                                                                             | Lewis PENG                 |
|       |            | Updated the data in GNSS performance (Table 35).                                         | To add the data of GNSS performance.                                                                                                                  | Lewis PENG                 |
|       |            | Updated the top view of the module (Chapter 6.2).                                        | Follow Quectel standard.                                                                                                                              | Iyukee SHEN                |
|       |            | Added the description of module installation (Chapter 6.4).                              | To remind customers to assemble correctly so as to make sure the normal operation of the module.                                                      | Iyukee SHEN                |
| 1.3.1 | 2023-07-15 | Updated packaging specifications (Chapter 6.5).                                          | Follow Quectel standard.                                                                                                                              | Iyukee SHEN                |
|       |            | Added a note to the host in the procedure of turning on (Chapter 3.4.1).                 | To remind customers not to drive RESET# low after FULL_CARD_POWER_OFF# is de-asserted at booting stage so as to turn on successfully.                 | Fung ZHU                   |
|       |            | Updated the pulling down time of RESET# (Chapter 3.5).                                   | To meet the specific demanding of Lenovo.                                                                                                             | Fung ZHU                   |
| 1.3.2 | 2023-09-01 | Updated the time of T1 in the turn-off procedure (Table 9).                              | To disable PCIe interface successfully by asserting PERST#.                                                                                           | Fung ZHU                   |
|       |            | Updated the timing of RESET# (Table 11).                                                 | To meet the specific demanding of Lenovo.                                                                                                             | Fung ZHU                   |

|       |            |                                                                          |                                                  |          |
|-------|------------|--------------------------------------------------------------------------|--------------------------------------------------|----------|
| 1.3.3 | 2023-10-18 | Added related note description in turn-on chapter (Chapter 3.4.1).       | Optimize the description and reduce risk points. | Fung ZHU |
|       |            | Added related note description of RESET# (Chapter 3.5).                  | Optimize the description and reduce risk points. | Fung ZHU |
|       |            | Added related note description in (U)SIM design notices (Chapter 3.6.4). | Optimize the description and reduce risk points. | Fung ZHU |
|       |            | Added related note description in DPR (Chapter 3.8.5).                   | Optimize the description and reduce risk points. | Fung ZHU |

# Contents

|                                                    |           |
|----------------------------------------------------|-----------|
| Safety Information.....                            | 3         |
| About the Document.....                            | 4         |
| Contents .....                                     | 7         |
| Table Index.....                                   | 9         |
| Figure Index .....                                 | 11        |
| <b>1 Introduction .....</b>                        | <b>12</b> |
| 1.1. Introduction .....                            | 12        |
| 1.2. Reference Standard .....                      | 12        |
| 1.3. Special Marks.....                            | 13        |
| <b>2 Product Overview .....</b>                    | <b>14</b> |
| 2.1. Frequency Bands and Functions .....           | 14        |
| 2.2. Key Features.....                             | 15        |
| 2.3. Functional Diagram .....                      | 17        |
| 2.4. EVB Kit.....                                  | 17        |
| <b>3 Application Interfaces .....</b>              | <b>18</b> |
| 3.1. Pin Assignment .....                          | 19        |
| 3.2. Pin Description .....                         | 20        |
| 3.3. Power Supply .....                            | 24        |
| 3.3.1. Voltage Stability Requirements .....        | 24        |
| 3.3.2. Reference Design for Power Supply.....      | 25        |
| 3.4. Turn On, Turn Off and Reset Scenarios .....   | 26        |
| 3.4.1. Turn On .....                               | 26        |
| 3.4.2. Turn Off .....                              | 28        |
| 3.5. RESET# .....                                  | 29        |
| 3.6. (U)SIM Interface .....                        | 31        |
| 3.6.1. (U)SIM Hot-Plug.....                        | 31        |
| 3.6.2. Normally Closed (U)SIM Card Connector.....  | 32        |
| 3.6.3. Normally Open (U)SIM Card Connector .....   | 33        |
| 3.6.4. (U)SIM Card Connector Without Hot-Plug..... | 34        |
| 3.7. PCIe Interface .....                          | 35        |
| 3.7.1. Endpoint Mode .....                         | 36        |
| 3.7.2. PCIe D3 <sub>cold</sub> State.....          | 37        |
| 3.8. Control and Indication Interfaces .....       | 38        |
| 3.8.1. W_DISABLE1#.....                            | 39        |
| 3.8.2. W_DISABLE2#* .....                          | 39        |
| 3.8.3. WWAN_LED#.....                              | 40        |
| 3.8.4. WAKE_ON_WAN# .....                          | 42        |
| 3.8.5. DPR.....                                    | 42        |
| 3.8.6. ANT_CONFIG .....                            | 43        |
| 3.9. COEX UART* .....                              | 44        |

|          |                                                   |           |
|----------|---------------------------------------------------|-----------|
| 3.10.    | Antenna Tuner Control Interfaces*                 | 44        |
| 3.10.1.  | Antenna Tuner Control Interface through GPIOs     | 44        |
| 3.10.2.  | Antenna Tuner Control Interface through RFFE      | 45        |
| 3.11.    | Configuration Pins                                | 45        |
| <b>4</b> | <b>RF Specifications</b>                          | <b>47</b> |
| 4.1.     | Cellular Network                                  | 47        |
| 4.1.1.   | Antenna Interface & Frequency Bands               | 47        |
| 4.1.2.   | Rx Sensitivity                                    | 49        |
| 4.1.3.   | Tx Power                                          | 51        |
| 4.2.     | GNSS                                              | 52        |
| 4.2.1.   | Antenna Interface & Frequency Bands               | 52        |
| 4.2.2.   | GNSS Performance                                  | 53        |
| 4.3.     | Antenna Connectors                                | 54        |
| 4.3.1.   | Antenna Connector Location                        | 54        |
| 4.3.2.   | Antenna Connector Specifications                  | 55        |
| 4.3.3.   | Antenna Connector Installation                    | 56        |
| 4.4.     | Antenna Requirements                              | 58        |
| <b>5</b> | <b>Electrical Characteristics and Reliability</b> | <b>59</b> |
| 5.1.     | Absolute Maximum Ratings                          | 59        |
| 5.2.     | Power Supply Ratings                              | 59        |
| 5.3.     | Digital I/O Characteristics                       | 60        |
| 5.4.     | Operating and Storage Temperatures                | 61        |
| 5.5.     | Power Consumption                                 | 61        |
| 5.6.     | ESD Protection                                    | 64        |
| 5.7.     | Thermal Dissipation                               | 65        |
| 5.8.     | Notification                                      | 66        |
| 5.8.1.   | Coating                                           | 66        |
| 5.8.2.   | Cleaning                                          | 66        |
| <b>6</b> | <b>Mechanical Information</b>                     | <b>67</b> |
| 6.1.     | Mechanical Dimensions                             | 67        |
| 6.2.     | Top and Bottom Views                              | 68        |
| 6.3.     | M.2 Connector                                     | 68        |
| 6.4.     | Module Installation                               | 69        |
| 6.5.     | Packaging Specifications                          | 70        |
| 6.5.1.   | Blister Tray                                      | 70        |
| 6.5.2.   | Packaging Process                                 | 71        |
| <b>7</b> | <b>Appendix References</b>                        | <b>72</b> |

## Table Index

|                                                                                 |    |
|---------------------------------------------------------------------------------|----|
| Table 1: Special Marks .....                                                    | 13 |
| Table 2: Frequency Bands and GNSS Functions of EM160R-GL .....                  | 14 |
| Table 3: Key Features of EM160R-GL .....                                        | 15 |
| Table 4: Parameter Definition .....                                             | 20 |
| Table 5: Pin Description .....                                                  | 20 |
| Table 6: Pin Definition of VCC and GND Pins .....                               | 24 |
| Table 7: Pin Definition of FULL_CARD_POWER_OFF# .....                           | 26 |
| Table 8: Description of Turn-on Timing .....                                    | 27 |
| Table 9: Description of the Turn-off Timing through FULL_CARD_POWER_OFF# .....  | 28 |
| Table 10: Pin Definition of RESET# .....                                        | 29 |
| Table 11: Description of Reset Timing .....                                     | 30 |
| Table 12: Pin Definition of (U)SIM Interface .....                              | 31 |
| Table 13: Pin Definition of PCIe Interface .....                                | 35 |
| Table 14: Exit D3 <sub>cold</sub> State Timing of the Module .....              | 38 |
| Table 15: Pin Definition of Control and Indication Interfaces .....             | 38 |
| Table 16: RF Function Status .....                                              | 39 |
| Table 17: GNSS Function Status .....                                            | 39 |
| Table 18: RF Status Indications of WWAN_LED# .....                              | 41 |
| Table 19: State of the WAKE_ON_WAN# .....                                       | 42 |
| Table 20: Function of the DPR Signal .....                                      | 42 |
| Table 21: Pin Definition of ANT_CONFIG .....                                    | 43 |
| Table 22: Pin Definition of COEX UART .....                                     | 44 |
| Table 23: Pin Definition of Antenna Tuner Control Interface through GPIOs ..... | 44 |
| Table 24: Pin Definition of Antenna Tuner Control Interface through RFFE .....  | 45 |
| Table 25: Configuration Pins of the Module .....                                | 45 |
| Table 26: Configuration Pins List of M.2 Specification .....                    | 46 |
| Table 27: EM160R-GL Connector Definition of Antenna Interfaces .....            | 47 |
| Table 28: Frequency Bands .....                                                 | 48 |
| Table 29: Dual-Antenna Conducted RF Receiver Sensitivity (Unit: dBm) .....      | 49 |
| Table 30: Four-Antenna Conducted RF Receiver Sensitivity .....                  | 51 |
| Table 31: EM160R-GL Transmitting Power .....                                    | 52 |
| Table 32: GNSS Frequency .....                                                  | 52 |
| Table 33: GNSS Performance .....                                                | 53 |
| Table 34: Major Specifications of the RF Connector .....                        | 55 |
| Table 35: Antenna Requirements .....                                            | 58 |
| Table 36: Absolute Maximum Ratings .....                                        | 59 |
| Table 37: Power Supply Requirements .....                                       | 59 |
| Table 38: Logic Levels of 1.8 V Digital I/O .....                               | 60 |
| Table 39: Logic Levels of 3.3 V Digital I/O .....                               | 60 |
| Table 40: (U)SIM High/Low-voltage I/O Requirements .....                        | 60 |
| Table 41: Operating and Storage Temperatures .....                              | 61 |

Table 42: EM160R-GL Power Consumption ..... 61

Table 43: Electrostatic Discharge Characteristics (Temperature: 25–30 °C, Humidity: 40 ±5 %)..... 64

Table 44: Related Documents ..... 72

Table 45: Terms and Abbreviations ..... 72

## Figure Index

|                                                                                        |    |
|----------------------------------------------------------------------------------------|----|
| Figure 1: Functional Diagram.....                                                      | 17 |
| Figure 2: Pin Assignment .....                                                         | 19 |
| Figure 3: Power Supply Limits During Burst Transmission.....                           | 24 |
| Figure 4: Reference Design of VCC .....                                                | 25 |
| Figure 5: Reference Design of Power Supply.....                                        | 25 |
| Figure 6: Turn on the Module with a Host GPIO.....                                     | 26 |
| Figure 7: Turn-on Timing .....                                                         | 27 |
| Figure 8: Reference Circuit for Laptop PCIe Reset Logic .....                          | 28 |
| Figure 9: Turn-off Timing through FULL_CARD_POWER_OFF# .....                           | 28 |
| Figure 10: Reference Design of RESET# with NMOS Driver Circuit .....                   | 29 |
| Figure 11: Timing of Resetting the Module .....                                        | 30 |
| Figure 12: Reference Circuit of Normally Closed (U)SIM Card Connector .....            | 33 |
| Figure 13: Reference Circuit of Normally Open (U)SIM Card Connector .....              | 34 |
| Figure 14: Reference Circuit of a 6-Pin (U)SIM Card Connector .....                    | 34 |
| Figure 15: PCIe Interface Reference Circuit (EP Mode).....                             | 37 |
| Figure 16: PCIe D3 <sub>Cold</sub> State Timing .....                                  | 38 |
| Figure 17: Reference Design of W_DISABLE1# and W_DISABLE2# .....                       | 40 |
| Figure 18: Reference Design of WWAN_LED# .....                                         | 41 |
| Figure 19: Reference Design of WAKE_ON_WAN#.....                                       | 42 |
| Figure 20: Reference Design of DPR .....                                               | 43 |
| Figure 21: Recommended Circuit of EM160R-GL Configuration Pins .....                   | 46 |
| Figure 22: Antenna Connectors on the EM160R-GL Module .....                            | 54 |
| Figure 23: Dimensions of the Receptacle (Unit: mm).....                                | 55 |
| Figure 24: Dimensions of Mated Plugs (Ø 0.81 mm Coaxial Cables) (Unit: mm).....        | 56 |
| Figure 25: Space Factor of Mated Connectors (Ø 0.81 mm Coaxial Cables) (Unit: mm)..... | 56 |
| Figure 26: Space Factor of Mated Connectors (Ø 1.13 mm Coaxial Cables) (Unit: mm)..... | 57 |
| Figure 27: Distribution of Heat Source Chips Inside the Module.....                    | 65 |
| Figure 28: Placement and Fixing of the Heatsink .....                                  | 66 |
| Figure 29: Mechanical Dimensions.....                                                  | 67 |
| Figure 30: Top and Bottom Views of the Module .....                                    | 68 |
| Figure 31: Installation Schematic.....                                                 | 69 |
| Figure 32: Blister Tray Dimension Drawing .....                                        | 70 |
| Figure 33: Packaging Process .....                                                     | 71 |

# 1 Introduction

## 1.1. Introduction

This document introduces EM160R-GL module and describes its air interfaces and hardware interfaces which are connected to your applications.

With this document, you can quickly understand module interface specifications, electrical and mechanical details, as well as other related information of the module. This document, coupled with application notes and user guides, makes it easy to design and set up mobile applications with the module.

## 1.2. Reference Standard

The module complies with the following standards:

- *PCI Express M.2 Specification Revision 4.0*
- *PCI Express Base Specification Revision 4.0*
- *ISO/IEC 7816-3*
- *MIPI Alliance Specification for RF Front-End Control Interface version 2.0*
- *3GPP TS 27.007 and 3GPP TS 27.005*

## 1.3. Special Marks

Table 1: Special Marks

| Mark  | Definition                                                                                                                                                                                                                                                                                                                                                                                |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *     | Unless otherwise specified, when an asterisk (*) is used after a function, feature, interface, pin name, AT command, argument, and so on, it indicates that the function, feature, interface, pin, AT command, argument, and so on, is under development and currently not supported; and the asterisk (*) after a model indicates that the sample of the model is currently unavailable. |
| [...] | Brackets ([...]) used after a pin enclosing a range of numbers indicate all pins of the same type. For example, SDIO_DATA[0:3] refers to all four SDIO pins: SDIO_DATA0, SDIO_DATA1, SDIO_DATA2, and SDIO_DATA3.                                                                                                                                                                          |

## 2 Product Overview

### 2.1. Frequency Bands and Functions

EM160R-GL is an LTE-A/UMTS/HSPA+ wireless communication module with receive diversity. It provides data connectivity on LTE-FDD, LTE-TDD, DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA networks with standard PCI Express M.2 interface.

It supports embedded operating systems such as Windows, Linux and Android, and provides GNSS <sup>1</sup> to meet your specific application demands.

The following table shows the frequency bands and GNSS functions of the module.

**Table 2: Frequency Bands and GNSS Functions of EM160R-GL**

| Mode                           | Frequency Band                                                                                            |
|--------------------------------|-----------------------------------------------------------------------------------------------------------|
| LTE-FDD<br>(with Rx-diversity) | B1/B2/B3/B4/B5/B7/B8/B12/B13/B14/<br>B18/B19/B20/B25/B26/B28/B29 <sup>2</sup> /B30 /B32 <sup>2</sup> /B66 |
| LTE-TDD<br>(with Rx-diversity) | B38/B39/B40/B41/B42/B43/B46 <sup>2</sup> /B48                                                             |
| LTE DL 4 × 4 MIMO              | B1/B2/B3/B4/B7/B25/B30/B32/B38/B39/B40/B41/B66                                                            |
| WCDMA<br>(with Rx-diversity)   | B1/B2/B3/B4/B5/B6/B8/B19                                                                                  |
| GNSS <sup>1</sup>              | GPS;<br>GLONASS;<br>BDS;<br>Galileo                                                                       |

#### NOTE

For details about CA combinations, see **document [1]**.

<sup>1</sup> GNSS function is optional.

<sup>2</sup> LTE-FDD B29/B32 and LTE-TDD B46 support Rx only and are only for secondary component carrier.

## 2.2. Key Features

**Table 3: Key Features of EM160R-GL**

| Feature                    | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Function Interface         | PCI Express M.2 Interface                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Power Supply               | Supply voltage: 3.135–4.4 V<br>Typical supply voltage: 3.7 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Transmitting Power         | <ul style="list-style-type: none"> <li>● WCDMA: Class 3 (23 dBm <math>\pm</math>2 dB)</li> <li>● LTE-FDD <ul style="list-style-type: none"> <li>- B30: Class 3 (22 dBm <math>\pm</math>1 dB)</li> <li>- Other Bands: Class 3 (24 dBm <math>\pm</math>1 dB)</li> </ul> </li> <li>● LTE-TDD <ul style="list-style-type: none"> <li>- B41: Class 3 (23 dBm <math>\pm</math>1 dB)</li> <li>- B41 HPUE: Class 2 (25.5 dBm +1/-1.5 dB)</li> <li>- B42/B43/B48: Class 3 (21 dBm <math>\pm</math>1 dB)</li> <li>- Other Bands: Class 3 (24 dBm <math>\pm</math>1 dB)</li> </ul> </li> </ul>                                                                                                                           |
| LTE Features               | <ul style="list-style-type: none"> <li>● Supports FDD and TDD</li> <li>● Supports CA Categories: <ul style="list-style-type: none"> <li>- Supports up to UL CA Cat 13</li> <li>- Supports up to DL CA Cat 16</li> </ul> </li> <li>● Supports 1.4/3/5/10/15/20 MHz RF bandwidths</li> <li>● Supports 4 <math>\times</math> 4 MIMO in DL direction</li> <li>● Supports modulations: <ul style="list-style-type: none"> <li>- Uplink: QPSK, 16QAM and 64QAM modulations</li> <li>- Downlink: QPSK, 16QAM and 64QAM and 256QAM modulations</li> </ul> </li> <li>● Maximum transmission data rates <sup>3</sup>: <ul style="list-style-type: none"> <li>- LTE: 1000 Mbps (DL)/150 Mbps (UL)</li> </ul> </li> </ul> |
| UMTS Features              | <ul style="list-style-type: none"> <li>● Support 3GPP Rel-9 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA</li> <li>● Support QPSK, 16QAM and 64QAM modulations</li> <li>● Maximum transmission data rates <sup>3</sup>: <ul style="list-style-type: none"> <li>- DC-HSDPA: 42 Mbps (DL)</li> <li>- HSUPA: 5.76 Mbps (UL)</li> <li>- WCDMA: 384 kbps (DL)/384 kbps (UL)</li> </ul> </li> </ul>                                                                                                                                                                                                                                                                                                                       |
| Internet Protocol Features | Supports QMI/MBIM/NITZ/PING/HTTP/HTTPS protocols                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| SMS                        | <ul style="list-style-type: none"> <li>● Text and PDU modes</li> <li>● Point-to-point MO and MT</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

<sup>3</sup> The maximum rates are theoretical and the actual values depend on the network configuration.

|                          |                                                                                                                                                                                                                                                                |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                          | <ul style="list-style-type: none"> <li>● SMS cell broadcast</li> <li>● SMS storage: ME by default</li> </ul>                                                                                                                                                   |
| (U)SIM Interface         | <ul style="list-style-type: none"> <li>● Support (U)SIM card: 1.8/3.0 V</li> <li>● Support Dual SIM Single Standby</li> </ul>                                                                                                                                  |
| eSIM                     | <ul style="list-style-type: none"> <li>● Support eSIM function</li> </ul>                                                                                                                                                                                      |
| PCIe Interface           | <ul style="list-style-type: none"> <li>● Complaint with PCIe Gen 2</li> <li>● PCIe × 1, supporting 5 Gbps per lane</li> <li>● Used for AT command communication, data transmission, firmware upgrade, software debugging, GNSS NMEA sentence output</li> </ul> |
| Antenna connectors       | <ul style="list-style-type: none"> <li>● Main, Rx-diversity/GNSS, MIMO1 and MIMO2 antenna connectors</li> <li>● 50 Ω impedance</li> </ul>                                                                                                                      |
| Rx-diversity             | <ul style="list-style-type: none"> <li>● LTE/WCDMA</li> </ul>                                                                                                                                                                                                  |
| GNSS Features            | <ul style="list-style-type: none"> <li>● Support GPS, GLONASS, BDS and Galileo</li> <li>● Protocol: NMEA 0183</li> <li>● Data update rate: 1 Hz</li> </ul>                                                                                                     |
| AT Commands              | <ul style="list-style-type: none"> <li>● Compliant with 3GPP TS 27.007 and 3GPP TS 27.005</li> <li>● Quectel enhanced AT commands</li> </ul>                                                                                                                   |
| Physical Characteristics | <ul style="list-style-type: none"> <li>● Size: 42.0 mm × 30.0 mm × 2.3 mm</li> <li>● Weight: approx. 6.8 g</li> </ul>                                                                                                                                          |
| Temperature Ranges       | <ul style="list-style-type: none"> <li>● Operating temperature range: -25 to +75 °C <sup>4</sup></li> <li>● Extended temperature range: -40 to +85 °C <sup>5</sup></li> <li>● Storage temperature range: -40 to +90 °C</li> </ul>                              |
| Firmware Upgrade         | <ul style="list-style-type: none"> <li>● PCIe interface</li> <li>● DFOTA</li> </ul>                                                                                                                                                                            |
| RoHS                     | All hardware components are fully compliant with EU RoHS directive                                                                                                                                                                                             |

<sup>4</sup> To meet the normal operating temperature range requirements, it is necessary to ensure effective thermal dissipation, e.g., by adding passive or active heat sinks, heat pipes, vapor chambers. Within the temperature range of -10 °C to +55 °C, the mentioned RF performance margins higher than 3GPP specifications can be guaranteed. When temperature goes beyond temperature range of -10 °C to 55 °C, a few RF performances of module may be slightly off 3GPP specifications.

<sup>5</sup> To meet the extended operating temperature range requirements, it is necessary to ensure effective thermal dissipation, e.g., by adding passive or active heat sinks, heat pipes, vapor chambers. Within this range, the module remains the ability to establish and maintain functions such as SMS, without any unrecoverable malfunction. Radio spectrum and radio network are not influenced, while one or more specifications, such as P<sub>out</sub>, may undergo a reduction in value, exceeding the specified tolerances of 3GPP. When the temperature returns to the normal operating temperature level, the module will meet 3GPP specifications again.

## 2.3. Functional Diagram

The following figure shows a block diagram of EM160R-GL.

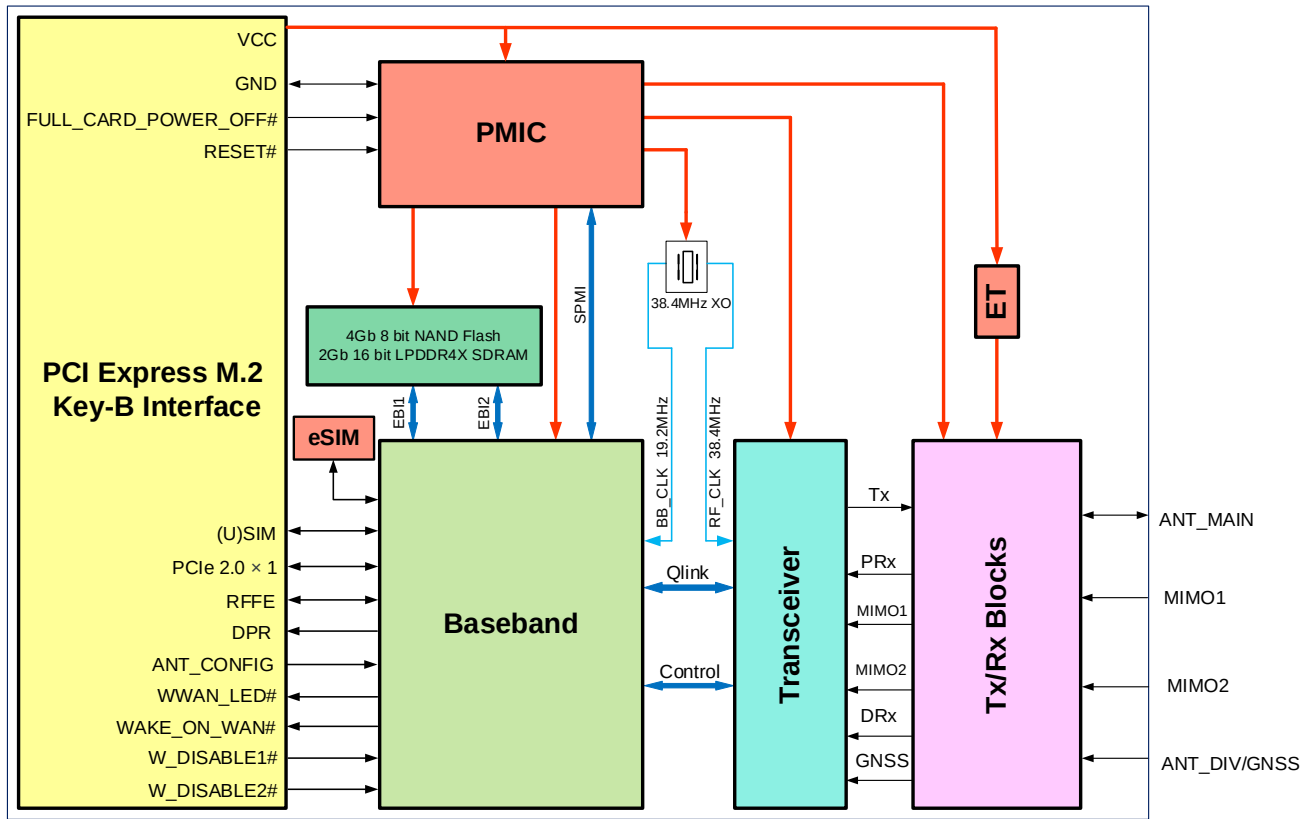


Figure 1: Functional Diagram

## 2.4. EVB Kit

Quectel supplies an evaluation board (5G-M2 EVB) with accessories to develop and test the module. For more details, see [document \[2\]](#).

# 3 Application Interfaces

The physical connections and signal levels of EM160R-GL comply with PCI Express M.2 specifications. This chapter mainly describes the definition and application of the following interfaces/signals/pins of EM160R-GL:

- Power supply
- (U)SIM interface
- PCIe interface
- Control and indicator signals
- COEX UART\*
- Antenna tuner control interfaces\*
- Configuration pins

### 3.1. Pin Assignment

The following figure shows the pin assignment of EM160R-GL. The top side contains EM160R-GL and antenna connectors.

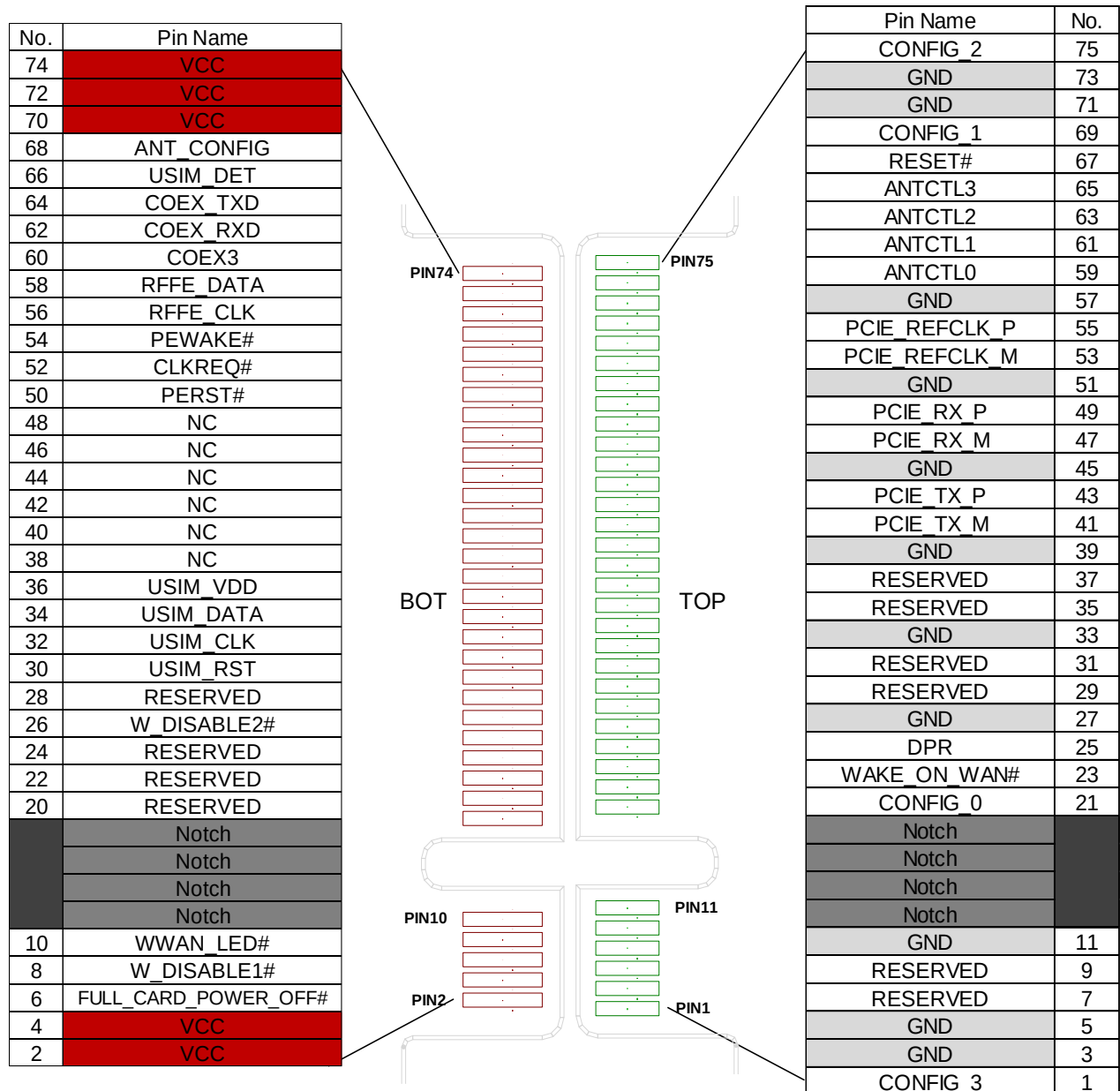


Figure 2: Pin Assignment

## 3.2. Pin Description

The following tables show the pin definition and description of EM160R-GL.

**Table 4: Parameter Definition**

| Parameter | Description          |
|-----------|----------------------|
| AI        | Analog Input         |
| AO        | Analog Output        |
| AIO       | Analog Input/Output  |
| DI        | Digital Input        |
| DO        | Digital Output       |
| DIO       | Digital Input/Output |
| OD        | Open Drain           |
| PI        | Power Input          |
| PO        | Power Output         |
| PU        | Pull Up              |
| PD        | Pull Down            |

DC characteristics include power domain and rated current in the table below.

**Table 5: Pin Description**

| Pin No. | Pin Name | I/O | Description                 | DC Characteristics                             | Comment |
|---------|----------|-----|-----------------------------|------------------------------------------------|---------|
| 1       | CONFIG_3 | DO  | Not connected internally    |                                                |         |
| 2       | VCC      | PI  | Power supply for the module | Vmin = 3.135 V<br>Vnom = 3.7 V<br>Vmax = 4.4 V |         |
| 3       | GND      |     | Ground                      |                                                |         |
| 4       | VCC      | PI  | Power supply for the module | Vmin = 3.135 V<br>Vnom = 3.7 V<br>Vmax = 4.4 V |         |
| 5       | GND      |     | Ground                      |                                                |         |

|    |                      |           |                                  |                                                                                         |                                                        |
|----|----------------------|-----------|----------------------------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------|
| 6  | FULL_CARD_POWER_OFF# | DI,<br>PD | Turn on/off the module           | $V_{IHmax} = 4.4\text{ V}$<br>$V_{IHmin} = 1.19\text{ V}$<br>$V_{ILmax} = 0.2\text{ V}$ | Internally pulled down with a 100 k $\Omega$ resistor. |
| 7  | RESERVED             |           | Reserved                         |                                                                                         |                                                        |
| 8  | W_DISABLE1#          | DI,<br>PU | Airplane mode control            | 1.8/3.3 V                                                                               | Active low.                                            |
| 9  | RESERVED             |           | Reserved                         |                                                                                         |                                                        |
| 10 | WWAN_LED#            | OD        | RF status indication LED         |                                                                                         | Open drain and active low signal.                      |
| 11 | GND                  |           | Ground                           |                                                                                         |                                                        |
| 12 | Notch                |           | Notch                            |                                                                                         |                                                        |
| 13 | Notch                |           | Notch                            |                                                                                         |                                                        |
| 14 | Notch                |           | Notch                            |                                                                                         |                                                        |
| 15 | Notch                |           | Notch                            |                                                                                         |                                                        |
| 16 | Notch                |           | Notch                            |                                                                                         |                                                        |
| 17 | Notch                |           | Notch                            |                                                                                         |                                                        |
| 18 | Notch                |           | Notch                            |                                                                                         |                                                        |
| 19 | Notch                |           | Notch                            |                                                                                         |                                                        |
| 20 | RESERVED             |           | Reserve for PCM* clock           |                                                                                         |                                                        |
| 21 | CONFIG_0             | DO        | Connected to GND internally      |                                                                                         |                                                        |
| 22 | RESERVED             |           | Reserve for PCM* data input      |                                                                                         |                                                        |
| 23 | WAKE_ON_WAN#         | OD        | Wake up the host.                | 1.8/3.3 V                                                                               | Active low.                                            |
| 24 | RESERVED             |           | Reserve for PCM* data output     |                                                                                         |                                                        |
| 25 | DPR                  | DI        | Dynamic power reduction          | 1.8 V                                                                                   | Active low.                                            |
| 26 | W_DISABLE2#*         | DI,<br>PU | GNSS enable control              | 1.8/3.3 V                                                                               | Active low.                                            |
| 27 | GND                  |           | Ground                           |                                                                                         |                                                        |
| 28 | RESERVED             |           | Reserve for PCM* data frame sync |                                                                                         |                                                        |
| 29 | RESERVED             |           | Reserved                         |                                                                                         |                                                        |
| 30 | USIM_RST             | DO        | (U)SIM card reset                | 1.8/3.0 V                                                                               |                                                        |
| 31 | RESERVED             |           | Reserved                         |                                                                                         |                                                        |
| 32 | USIM_CLK             | DO        | (U)SIM card clock                | 1.8/3.0 V                                                                               |                                                        |

|    |               |            |                              |                                                                                                                                                     |                                          |
|----|---------------|------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| 33 | GND           |            | Ground                       |                                                                                                                                                     |                                          |
| 34 | USIM_DATA     | DIO,<br>PU | (U)SIM card data             | 1.8/3.0 V                                                                                                                                           | Internally pulled up.                    |
| 35 | RESERVED      |            | Reserved                     |                                                                                                                                                     |                                          |
| 36 | USIM_VDD      | PO         | Power supply for (U)SIM card | <b>High-Voltage:</b><br>Vmin = 3.05 V<br>Vnom = 2.85 V<br>Vmax = 2.7 V<br><br><b>Low-Voltage:</b><br>Vmin = 1.95 V<br>Vnom = 1.8 V<br>Vmax = 1.65 V |                                          |
| 37 | RESERVED      |            | Reserved                     |                                                                                                                                                     |                                          |
| 38 | NC            |            | NC                           |                                                                                                                                                     |                                          |
| 39 | GND           |            | Ground                       |                                                                                                                                                     |                                          |
| 40 | NC            |            | NC                           |                                                                                                                                                     |                                          |
| 41 | PCIE_TX_M     | AO         | PCIe transmit (-)            |                                                                                                                                                     | Requires differential impedance of 95 Ω. |
| 42 | NC            |            | NC                           |                                                                                                                                                     |                                          |
| 43 | PCIE_TX_P     | AO         | PCIe transmit (+)            |                                                                                                                                                     | Requires differential impedance of 95 Ω. |
| 44 | NC            |            | NC                           |                                                                                                                                                     |                                          |
| 45 | GND           |            | Ground                       |                                                                                                                                                     |                                          |
| 46 | NC            |            | NC                           |                                                                                                                                                     |                                          |
| 47 | PCIE_RX_M     | AI         | PCIe receive (-)             |                                                                                                                                                     | Requires differential impedance of 95 Ω. |
| 48 | NC            |            | NC                           |                                                                                                                                                     |                                          |
| 49 | PCIE_RX_P     | AI         | PCIe receive (+)             |                                                                                                                                                     | Requires differential impedance of 95 Ω. |
| 50 | PERST#        | DI         | PCIe reset                   | 1.8/3.3 V                                                                                                                                           | Active low.                              |
| 51 | GND           |            | Ground                       |                                                                                                                                                     |                                          |
| 52 | CLKREQ#       | DO         | PCIe clock request           |                                                                                                                                                     | Active low.                              |
| 53 | PCIE_REFCLK_M | AIO        | PCIe reference clock (-)     |                                                                                                                                                     | Requires differential impedance of 95 Ω. |
| 54 | PEWAKE#       | DO         | PCIe wake up                 | 1.8/3.3 V                                                                                                                                           | Active low.                              |
| 55 | PCIE_REFCLK_P | AIO        | PCIe reference clock (+)     |                                                                                                                                                     | Requires differential impedance of 95 Ω. |

|    |            |        |                                   |                                                |                                                                      |
|----|------------|--------|-----------------------------------|------------------------------------------------|----------------------------------------------------------------------|
| 56 | RFFE_CLK*  | DO     | Used for external MIPI IC control |                                                | If unused, keep it open.                                             |
| 57 | GND        |        | Ground                            |                                                |                                                                      |
| 58 | RFFE_DATA* | DIO    | Used for external MIPI IC control |                                                | If unused, keep it open.                                             |
| 59 | ANTCTL0*   | DO     | Antenna tuner control             | 1.8 V                                          |                                                                      |
| 60 | COEX3*     | DIO    | COEX GPIO                         | 1.8 V                                          |                                                                      |
| 61 | ANTCTL1*   | DO     | Antenna tuner control             | 1.8 V                                          |                                                                      |
| 62 | COEX_RXD*  | DI     | LTE&WLAN coexistence receive      | 1.8 V                                          |                                                                      |
| 63 | ANTCTL2*   | DO     | Antenna tuner control             | 1.8 V                                          |                                                                      |
| 64 | COEX_TXD*  | DO     | LTE&WLAN coexistence transmit     | 1.8 V                                          |                                                                      |
| 65 | ANTCTL3*   | DO     | Antenna tuner control             | 1.8 V                                          |                                                                      |
| 66 | USIM_DET   | DI     | (U)SIM card hot-plug detect       | 1.8 V                                          |                                                                      |
| 67 | RESET#     | DI, PU | Reset the module                  | 1.8 V                                          | Active low.<br>A test point is recommended to be reserved if unused. |
| 68 | ANT_CONFIG | DI     | Antenna configuration             | 1.8 V                                          |                                                                      |
| 69 | CONFIG_1   | DO     | Connected to GND internally       |                                                |                                                                      |
| 70 | VCC        | PI     | Power supply for the module       | Vmin = 3.135 V<br>Vnom = 3.7 V<br>Vmax = 4.4 V |                                                                      |
| 71 | GND        |        | Ground                            |                                                |                                                                      |
| 72 | VCC        | PI     | Power supply for the module       | Vmin = 3.135 V<br>Vnom = 3.7 V<br>Vmax = 4.4 V |                                                                      |
| 73 | GND        |        | Ground                            |                                                |                                                                      |
| 74 | VCC        | PI     | Power supply for the module       | Vmin = 3.135 V<br>Vnom = 3.7 V<br>Vmax = 4.4 V |                                                                      |
| 75 | CONFIG_2   | DO     | Not connected internally          |                                                |                                                                      |

**NOTE**

Keep all NC, reserved and unused pins unconnected.

### 3.3. Power Supply

**Table 6: Pin Definition of VCC and GND Pins**

| Pin No.                                  | Pin Name | I/O | DC Characteristics                     | Description                 |
|------------------------------------------|----------|-----|----------------------------------------|-----------------------------|
| 2, 4, 70, 72, 74                         | VCC      | PI  | 3.135–4.4 V<br>3.7 V typical DC supply | Power supply for the module |
| 3, 5, 11, 27, 33, 39, 45, 51, 57, 71, 73 | GND      |     |                                        | Ground                      |

#### 3.3.1. Voltage Stability Requirements

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

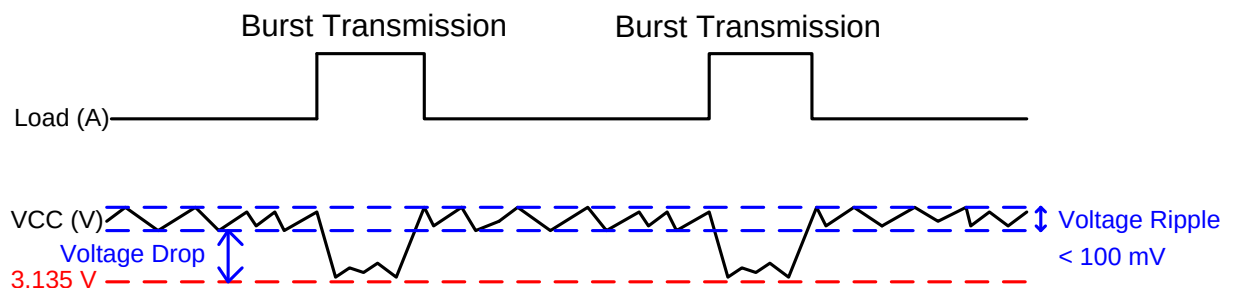


**Figure 3: Power Supply Limits During Burst Transmission**

To decrease the voltage drop, a bypass capacitor of about 220  $\mu\text{F}$  with low ESR 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 four ceramic capacitors (1  $\mu\text{F}$ , 100 nF, 33 pF, 10 pF) for composing the MLCC array, and place these capacitors close to VCC pins. The main power supply from an external application must be a single voltage source. The width of VCC trace should be not less than 2 mm. In principle, the longer the VCC trace is, the wider it should be.

In addition, to ensure the stability of the power supply, it is recommended to use a TVS with working peak reverse voltage of 5 V.

The following figure shows a reference circuit of VCC.

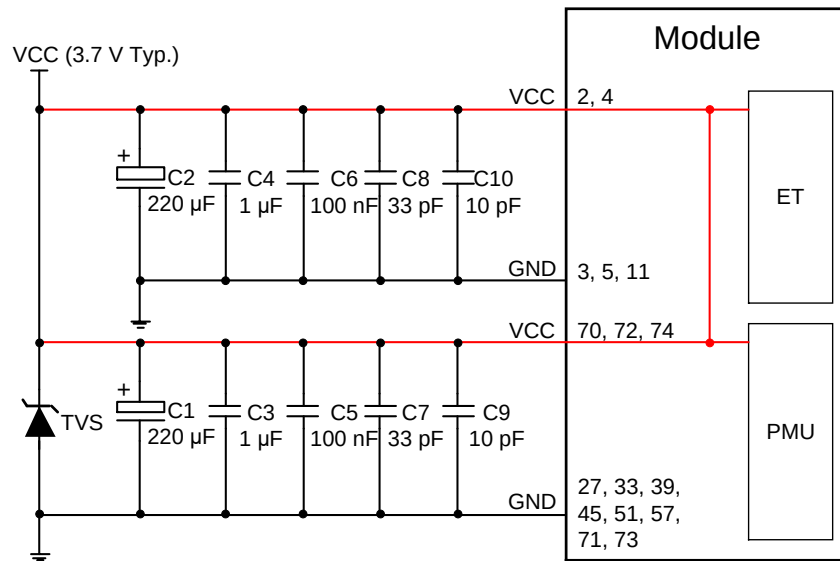


**Figure 4: Reference Design of VCC**

### 3.3.2. Reference Design for Power Supply

The power source is critical to the module's performance. The power supply of the module should be able to provide a sufficient current of 2 A at least and the peak current should be 3 A at least.

The following figure shows a reference design for +5.0 V input power source. The typical output of the power supply is about 3.7 V.

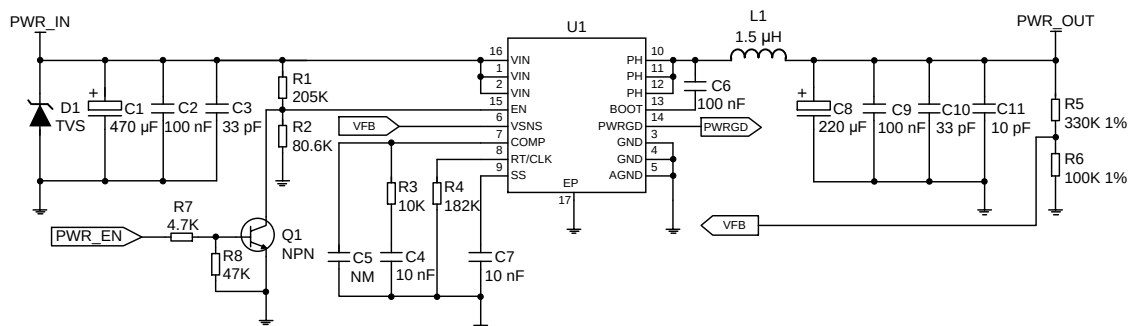


**Figure 5: Reference Design of Power Supply**

#### NOTE

To avoid corrupting the data in the internal flash, do not switch off the power supply when the module works normally. Only after shutting down the module with FULL\_CARD\_POWER\_OFF# or AT command, can you cut off the power supply.

### 3.4. Turn On, Turn Off and Reset Scenarios

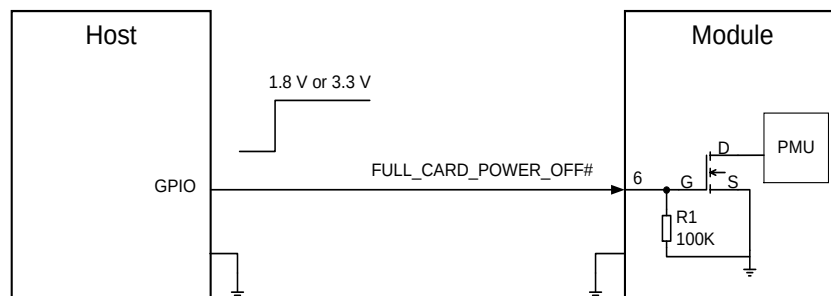
#### 3.4.1. Turn On

Pulling up the FULL\_CARD\_POWER\_OFF# pin will turn on the module.

Table 7: Pin Definition of FULL\_CARD\_POWER\_OFF#

| Pin Name             | Pin No. | Description            | Comment                                        |
|----------------------|---------|------------------------|------------------------------------------------|
| FULL_CARD_POWER_OFF# | 6       | Turn on/off the module | Internally pulled down with a 100 kΩ resistor. |

It is recommended to use a host GPIO to turn on the module by pulling up FULL\_CARD\_POWER\_OFF#. A simple reference circuit is illustrated in the following figure.



**NOTE:** The voltage of pin 6 should be not less than 1.19 V when it is at high level.

Figure 6: Turn on the Module with a Host GPIO

The turn-on timing is illustrated in the following figure.

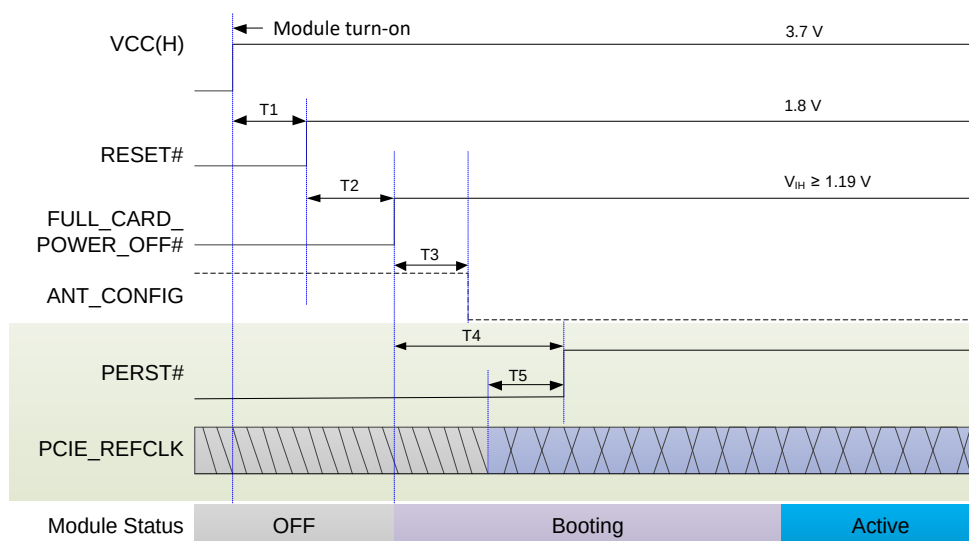


**Figure 7: Turn-on Timing**
**Table 8: Description of Turn-on Timing**

| Index | Min.        | Typ.  | Max. | Comment                                                                                                                                                                                                                                                                          |
|-------|-------------|-------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| T1    | 0 ms        | 50 ms | -    | RESET# will be pulled high internally and automatically when the host doesn't pull high RESET#. If the host pulls low RESET#, module will be under reset state.                                                                                                                  |
| T2    | 0 ms        | -     | -    | The module is waiting for turning on.                                                                                                                                                                                                                                            |
| T3    | 0 ms        | -     | -    | <ul style="list-style-type: none"> <li>ANT_CONFIG is used for the antenna configuration High/Floating: 2 antennas (high by default); Low: 4 antennas.</li> <li>Assert ANT_CONFIG before de-asserting PERST#.</li> <li>If ANT_CONFIG is not used, T3 could be ignored.</li> </ul> |
| T4    | 100 ms      | -     | -    | De-assert PERST# 100 ms after de-asserting FULL_CARD_POWER_OFF#.                                                                                                                                                                                                                 |
| T5    | 100 $\mu$ s | -     | -    | The period during which PCIE_REFCLK_P/M is stable before PERST# is de-asserted.                                                                                                                                                                                                  |

**NOTE**

- **Module:**
  - 1) If FULL\_CARD\_POWER\_OFF# is driven high at the same time with VCC, the module will be able to turn on normally.
  - 2) PERST# needs to be driven high over 100 ms after FULL\_CARD\_POWER\_OFF# is driven high. Then, PCIe interface will be enabled.
- **Host:**
  - 1) When the FULL\_CARD\_POWER\_OFF# signal is low, please avoid any leakage current entering the module's DPR pin from the host.
  - 2) The host should control FULL\_CARD\_POWER\_OFF# and PERST# based on the timing sequence.
  - 3) If the host fails to control FULL\_CARD\_POWER\_OFF# and PERST# based on the timing sequence, instability in PCIe interface will be caused.

For the laptop platform, if there are two reset signals to control PERST# pin of the module, and the following figure is for reference. It is recommended that AUX Reset be pulled up before Global PCIe Reset is de-asserted.

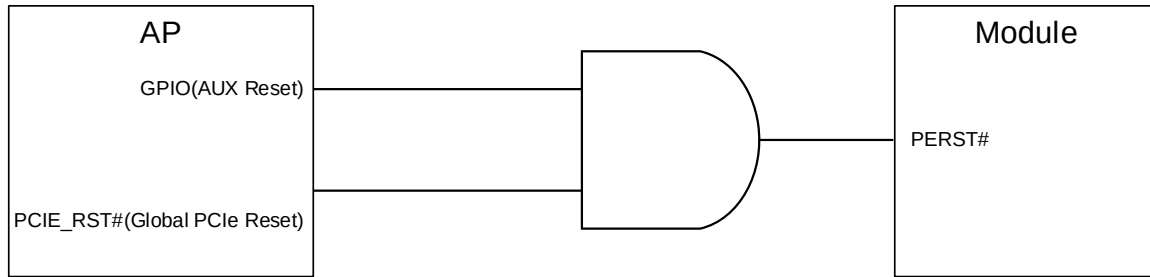


**Figure 8: Reference Circuit for Laptop PCIe Reset Logic**

### 3.4.2. Turn Off

Pulling down the FULL\_CARD\_POWER\_OFF# pin will turn off the module. The turn-off timing is illustrated in the following figure.

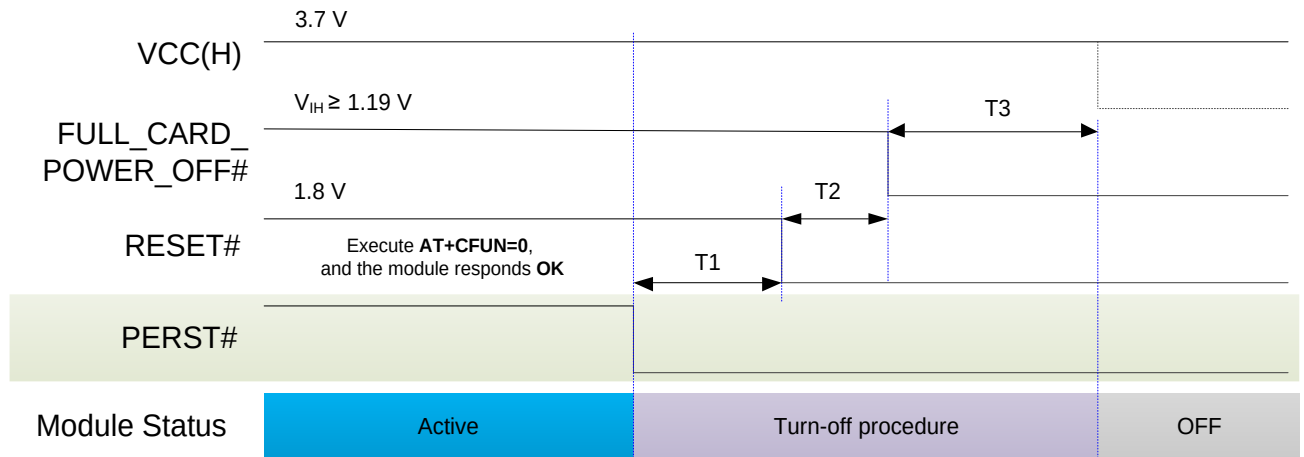


**Figure 9: Turn-off Timing through FULL\_CARD\_POWER\_OFF#**

**Table 9: Description of the Turn-off Timing through FULL\_CARD\_POWER\_OFF#**

| Index | Min.   | Typ.   | Max. | Comment                                                                                                                                                                    |
|-------|--------|--------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| T1    | 15 ms  | -      | -    | PCIe interface is disabled by asserting PERST#.                                                                                                                            |
| T2    | 0 ms   | 100 ms | -    | The period from the host pulling down RESET# to it pulling down FULL_CARD_POWER_OFF#.                                                                                      |
| T3    | 900 ms | -      | -    | The period from the host pulling down FULL_CARD_POWER_OFF# to the module turning off. It is recommended to cut off the VCC when the module has been turned off completely. |

### 3.5. RESET#

RESET# is an active low signal (1.8 V logic level). When this pin is asserted, the module will immediately enter reset condition.

Please note that triggering the RESET# signal will lead to loss of all data in the module and removal of system drivers. It will also disconnect the modem from the network.

**Table 10: Pin Definition of RESET#**

| Pin Name | Pin No. | Description      | Comment                                                              |
|----------|---------|------------------|----------------------------------------------------------------------|
| RESET#   | 67      | Reset the module | Active low.<br>A test point is recommended to be reserved if unused. |

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

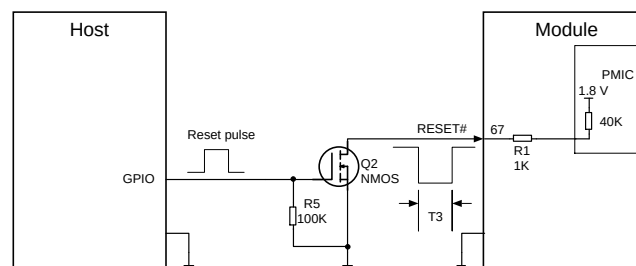


**Figure 10: Reference Design of RESET# with NMOS Driver Circuit**

The reset scenario is illustrated in the following figure.

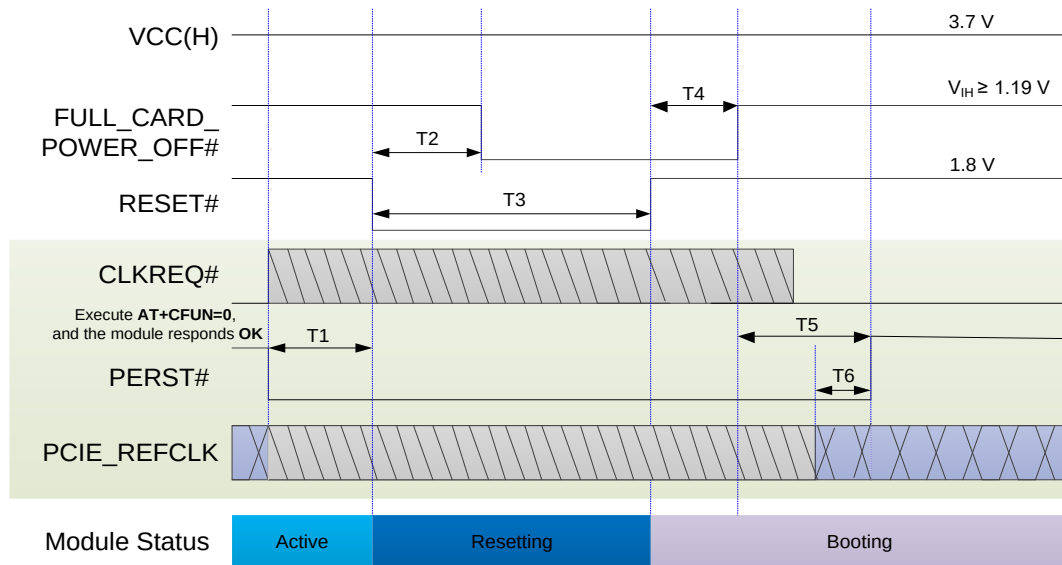


Figure 11: Timing of Resetting the Module

Table 11: Description of Reset Timing

| Index | Min.        | Typ.   | Max. | Comment                                                                                             |
|-------|-------------|--------|------|-----------------------------------------------------------------------------------------------------|
| T1    | 15 ms       | -      | -    | The period from the host PERST# asserting to the its RESET# asserting.                              |
| T2    | 0 ms        | 100 ms | -    | The period from the host RESET# asserting to its FULL_CARD_POWER_OFF# asserting.                    |
| T3    | 250 ms      | -      | -    | RESET# should be pulled down for at least 250 ms. An asserting time less than 250 ms is unreliable. |
| T4    | 0 ms        | -      | -    | The period from the host RESET# releasing to its FULL_CARD_POWER_OFF# releasing.                    |
| T5    | 100 ms      | -      | -    | De-assert PERST# 100 ms after de-asserting FULL_CARD_POWER_OFF#.                                    |
| T6    | 100 $\mu$ s | -      | -    | The period during which PCIE_REFCLK_P/M is stable before PERST# is de-asserted.                     |

**NOTE**

- **Module:**
  - 1) When RESET# is kept at low level for 250 ms or more, the module will reset stably.
  - 2) If PERST# is not pulled down before RESET#, instability in PCIe will be caused. If PERST# is not pulled high after reset, a system pause will be caused.
- **Host:**
  - 1) VCC of the system should supply power continuously and FULL\_CARD\_POWER\_OFF# should be kept at high level.

- 2) The host should control RESET# and PERST# based on the timing sequence.
- 3) If the host fails to control RESET# and PERST# based on the timing sequence, instability in PCIe will be caused.
- 4) When the FULL\_CARD\_POWER\_OFF# signal is low, please avoid any leakage current entering the module's DPR pin from the host.

## 3.6. (U)SIM Interface

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

**Table 12: Pin Definition of (U)SIM Interface**

| Pin Name  | Pin No. | I/O        | Description                  | Comment               |
|-----------|---------|------------|------------------------------|-----------------------|
| USIM_VDD  | 36      | PO         | Power supply for (U)SIM card |                       |
| USIM_DATA | 34      | DIO,<br>PU | (U)SIM card data             | Internally pulled up. |
| USIM_CLK  | 32      | DO         | (U)SIM card clock            |                       |
| USIM_RST  | 30      | DO         | (U)SIM card reset            |                       |
| USIM_DET  | 66      | DI         | (U)SIM card hot-plug detect  |                       |

### 3.6.1. (U)SIM Hot-Plug

The module supports (U)SIM card hot-plug via the (U)SIM card hot-plug detect pin (USIM\_DET), which is enabled by default. (U)SIM card is detected by USIM\_DET interruption. (U)SIM card insertion is detected by high/low level.

The following command enables or disables (U)SIM card hot-plug function. The level of (U)SIM card detection pin should also be set when the (U)SIM card is inserted.

| <b>AT+QSIMDET (U)SIM Card Detection</b>                                |                                                                                                                                             |
|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Test Command<br><b>AT+QSIMDET=?</b>                                    | Response<br><b>+QSIMDET:</b> (list of supported <b>&lt;enable&gt;s</b> ),(list of supported <b>&lt;insert_level&gt;s</b> )<br><br><b>OK</b> |
| Read Command<br><b>AT+QSIMDET?</b>                                     | Response<br><b>+QSIMDET:</b> <b>&lt;enable&gt;</b> , <b>&lt;insert_level&gt;</b><br><br><b>OK</b>                                           |
| Write Command<br><b>AT+QSIMDET=&lt;enable&gt;,&lt;insert_level&gt;</b> | Response<br><b>OK</b><br><br>If there is any error:<br><b>ERROR</b>                                                                         |
| Maximum Response Time                                                  | 300 ms                                                                                                                                      |
| Characteristics                                                        | The command takes effect after the module is restarted.<br>The configuration will be saved automatically.                                   |

## Parameter

|                             |                                                                                                                          |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <b>&lt;enable&gt;</b>       | Integer type. Enable or disable (U)SIM card detection.<br>0    Disable<br><u>1</u> Enable                                |
| <b>&lt;insert_level&gt;</b> | Integer type. The level of (U)SIM detection pin when a (U)SIM card is inserted.<br>0    Low level<br><u>1</u> High level |

### NOTE

- Hot-plug function is invalid if the configured value of **<insert\_level>** is inconsistent with hardware design.
- The underlined value is the default.
- USIM\_DET is pulled high by default, and will be internally pulled up to 1.8 V by software configuration only when (U)SIM hot-plug is enabled by **AT+QSIMDET**.

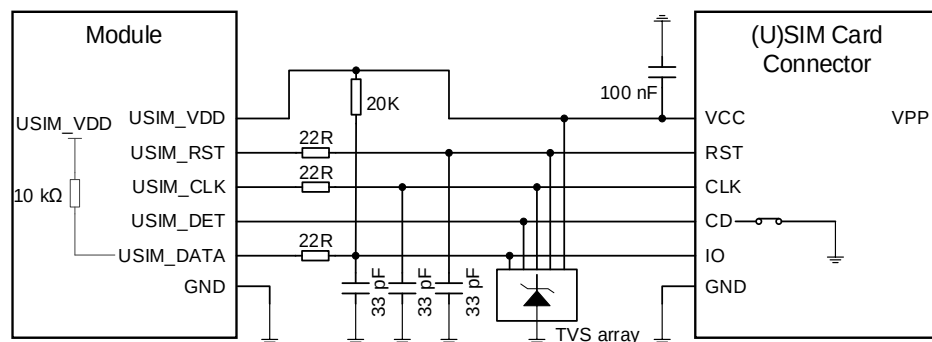
## 3.6.2. Normally Closed (U)SIM Card Connector

With a normally closed (U)SIM card connector, USIM\_DET pin is shorted to ground when there is no (U)SIM card inserted. (U)SIM card detection by high level is applicable to this type of connector. Once

(U)SIM hot-plug is enabled by executing **AT+QSIMDET=1,1**, a (U)SIM card insertion will drive USIM\_DET from low to high level, and the removal of it will drive USIM\_DET from high to low level.

- When the (U)SIM is absent, CD is shorted to ground and USIM\_DET is at low level.
- When the (U)SIM is present, CD is open from ground and USIM\_DET is at high level.

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



**NOTE:** All these resistors, capacitors and TVS array should be close to (U)SIM card connector in PCB layout. The external pull-up resistor of USIM\_DATA is optional.

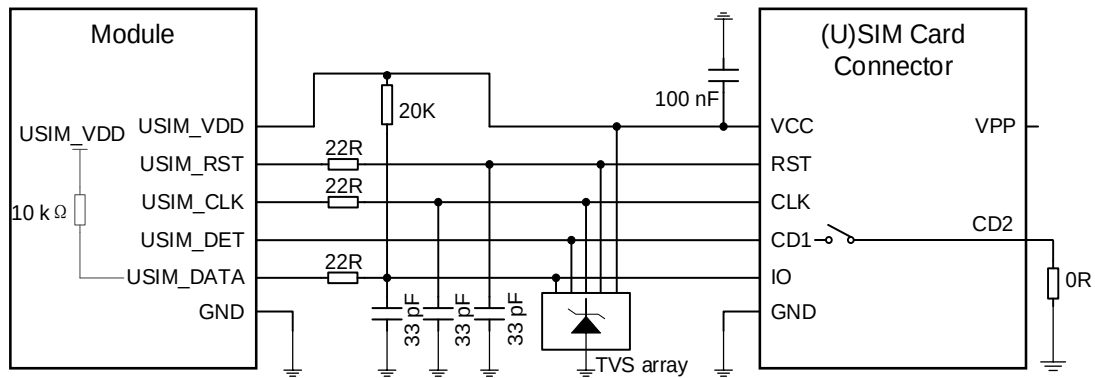
**Figure 12: Reference Circuit of Normally Closed (U)SIM Card Connector**

### 3.6.3. Normally Open (U)SIM Card Connector

With a normally open (U)SIM card connector, CD1 and CD2 of the connector are disconnected when there is no (U)SIM card inserted. (U)SIM card detection by low level is applicable to this type of connector. Once (U)SIM hot-plug is enabled by executing **AT+QSIMDET=1,0**, a (U)SIM card insertion will drive USIM\_DET from high to low level, and the removal of it will drive USIM\_DET from low to high level.

- When the (U)SIM is absent, CD1 is open from CD2 and USIM\_DET is at high level.
- When the (U)SIM is present, CD1 is pull down to ground and USIM\_DET is at low level.

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

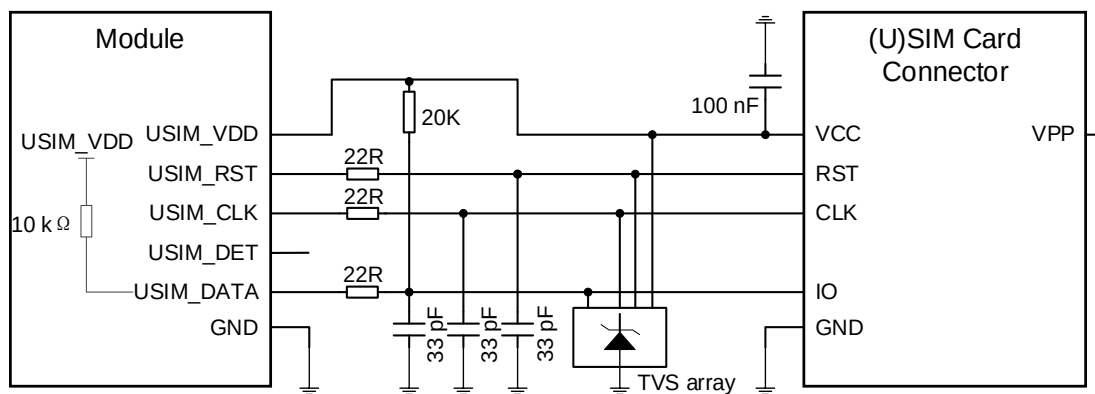


**NOTE:** All these resistors, capacitors and TVS array should be close to (U)SIM card connector in PCB layout. The external pull-up resistor of USIM\_DATA is optional.

**Figure 13: Reference Circuit of Normally Open (U)SIM Card Connector**

### 3.6.4. (U)SIM Card Connector Without Hot-Plug

If (U)SIM card hot-plug 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 by the following figure.



**NOTE:** All these resistors, capacitors and TVS array should be close to (U)SIM card connector in PCB layout. The external pull-up resistor of USIM\_DATA is optional.

**Figure 14: Reference Circuit of a 6-Pin (U)SIM Card Connector**

#### NOTE

1. If the (U)SIM card detection function is not needed, please keep USIM\_DET unconnected.
2. If the (U)SIM card detection function is required, note that a pull-up resistor should not be added to the USIM1\_DET and USIM2\_DET signals.

### 3.7. PCIe Interface

The module provides one integrated PCIe interface, featuring as follows:

- *PCI Express Base Specification Revision 4.0, Version 1.1*
- Data rate up to 5 Gbps per lane

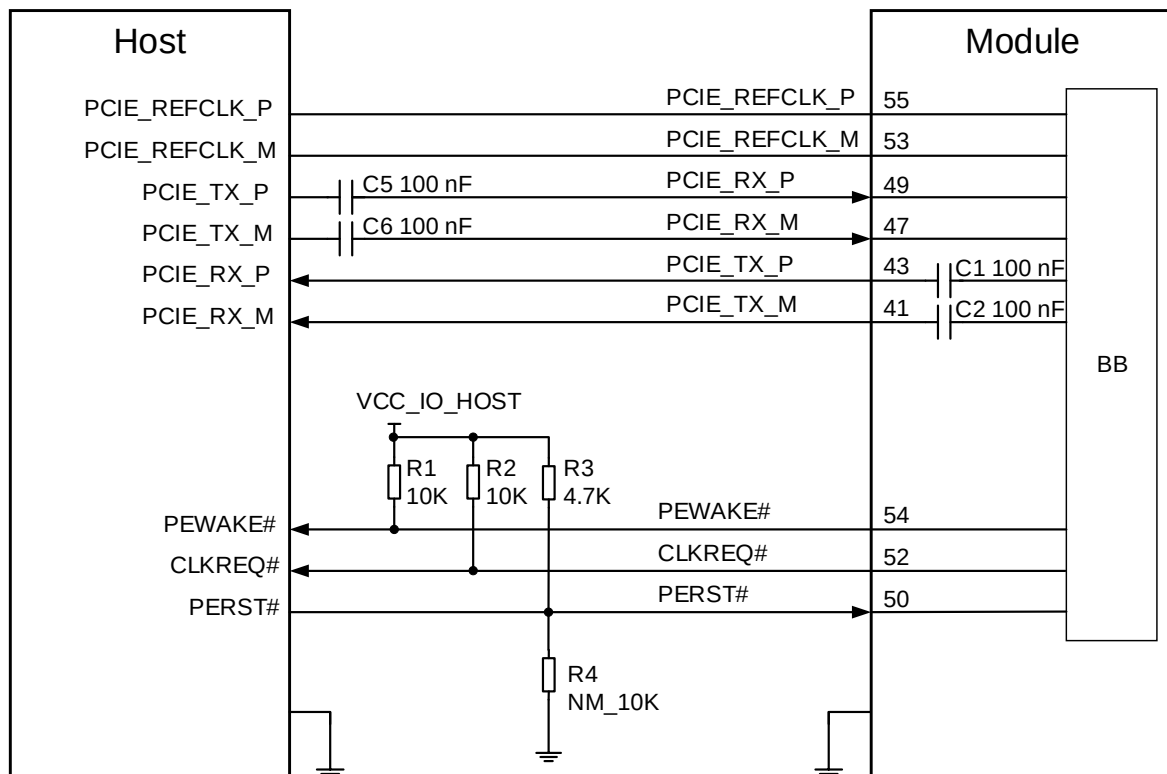
**Table 13: Pin Definition of PCIe Interface**

| Pin No. | Pin Name      | I/O | Description              | Comment                                          |
|---------|---------------|-----|--------------------------|--------------------------------------------------|
| 55      | PCIE_REFCLK_P | AIO | PCIe reference clock (+) | Requires differential impedance of 95 $\Omega$ . |
| 53      | PCIE_REFCLK_M | AIO | PCIe reference clock (-) |                                                  |
| 49      | PCIE_RX_P     | AI  | PCIe receive data (+)    | Requires differential impedance of 95 $\Omega$ . |
| 47      | PCIE_RX_M     | AI  | PCIe receive data (-)    |                                                  |
| 43      | PCIE_TX_P     | AO  | PCIe transmit data (+)   | Requires differential impedance of 95 $\Omega$ . |
| 41      | PCIE_TX_M     | AO  | PCIe transmit data (-)   |                                                  |
| 50      | PERST#        | DI  | PCIe reset input         | Active low.                                      |
| 52      | CLKREQ#       | DO  | PCIe clock request       | Active low.                                      |

|    |         |    |                       |             |
|----|---------|----|-----------------------|-------------|
| 54 | PEWAKE# | DO | PCIe wake up the host | Active low. |
|----|---------|----|-----------------------|-------------|

### 3.7.1. Endpoint Mode

EM160R-GL supports endpoint (EP) mode. In this mode, the module is configured as a PCIe EP device. The following figure shows a reference circuit of PCIe endpoint mode.



**NOTE:**

The voltage level VCC\_IO\_HOST depends on the host side due to open drain in pin 50, 52 and 54.

**Figure 15: PCIe Interface Reference Circuit (EP Mode)**

To ensure the signal integrity of PCIe interface, AC coupling capacitors C5 and C6 should be placed close to the host on PCB. C1 and C2 have been integrated inside the module, so do not place these two capacitors on your schematic and PCB.

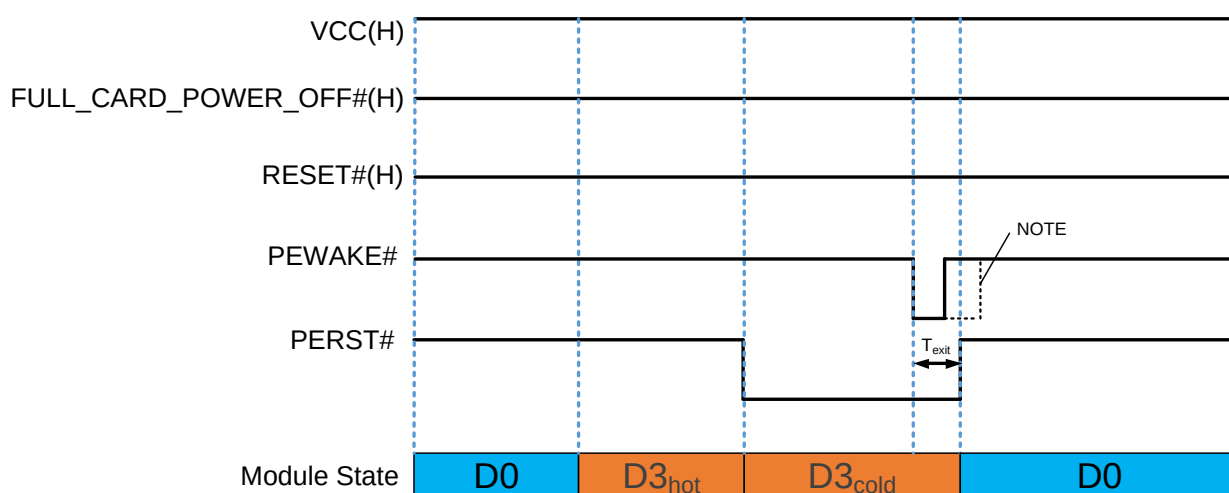
Comply with the following principles in PCIe interface design to meet *PCI Express Base Specification Revision 4.0*.

- Keep the PCIe data and control signals away from sensitive circuits and signals, such as RF, audio, crystal and oscillator signals.
- Add a capacitor in series on Tx/Rx traces to prevent any DC bias.
- Keep the maximum trace length less than 300 mm.
- Keep the length matching of each differential data pair (Tx/Rx) less than 0.7 mm for PCIe routing traces.
- Keep the differential impedance of PCIe data trace as  $95\ \Omega \pm 10\%$ .
- You must not route PCIe data traces under components or cross them with other traces.
- It is recommended to use a push-pull GPIO to output a low level that approaches 0 V rather than using a pull-down resistor to get a low level. Otherwise, voltage division may be formed with the pull-up resistor inside the module, resulting in an uncertain 0 V voltage that could further lead to unpredictable problems. If host uses a push-pull GPIO to control PERST#, R3 can be not mounted.

### **3.7.2. PCIe D3<sub>cold</sub> State**

For the laptop platform, module must go through D3<sub>hot</sub> before entering D3<sub>cold</sub>. In D3<sub>hot</sub> state, PERST# must be kept in high level.

The module enters D3<sub>cold</sub> state after PERST# is asserted. The module enters D0 state after PERST# is de-asserted.



**NOTE:** PEWAKE# may be pulled up before or after PERST# is pulled up, depending on when HOST pulls up PERST#. This time does not affect the normal operation of the module and can be ignored.

Figure 16: PCIe D3<sub>Cold</sub> State Timing

Table 14: Exit D3<sub>Cold</sub> State Timing of the Module

| Symbol            | Min.  | Typ.   | Max.   | Comment                                                                    |
|-------------------|-------|--------|--------|----------------------------------------------------------------------------|
| T <sub>exit</sub> | 50 ms | 150 ms | 500 ms | The period from the module pulling down PEWAKE# to HOST pulling up PERST#. |

### 3.8. Control and Indication Interfaces

Table 15: Pin Definition of Control and Indication Interfaces

| Pin Name     | Pin No. | I/O    | Description              | Comment     |
|--------------|---------|--------|--------------------------|-------------|
| WWAN_LED#    | 10      | OD     | RF status indication LED | Active low. |
| WAKE_ON_WAN# | 23      | OD     | Wake up the host         | Active low. |
| W_DISABLE1#  | 8       | DI, PU | Airplane mode control    | Active low. |
| W_DISABLE2#* | 26      | DI, PU | GNSS enable control      | Active low. |
| DPR          | 25      | DI     | Dynamic power reduction  | Active low. |

|            |    |    |                       |
|------------|----|----|-----------------------|
| ANT_CONFIG | 68 | DI | Antenna configuration |
|------------|----|----|-----------------------|

### 3.8.1. W\_DISABLE1#

The module provides a W\_DISABLE1# pin to disable or enable airplane mode through hardware operation. The W\_DISABLE1# pin is pulled up by default. Driving it low will set the module to airplane mode. In airplane mode, the RF function will be disabled.

The RF function can also be enabled or disabled through AT commands.

**Table 16: RF Function Status**

| Logic Level | AT Command | RF Function | Operating Mode             |
|-------------|------------|-------------|----------------------------|
| High Level  | AT+CFUN=1  | Enable      | Full functionality mode    |
|             | AT+CFUN=0  | Disable     | Minimum functionality mode |
|             | AT+CFUN=4  | Disable     | Airplane mode              |
| Low Level   | AT+CFUN=0  | Disable     | Airplane mode              |
|             | AT+CFUN=1  |             |                            |
|             | AT+CFUN=4  |             |                            |

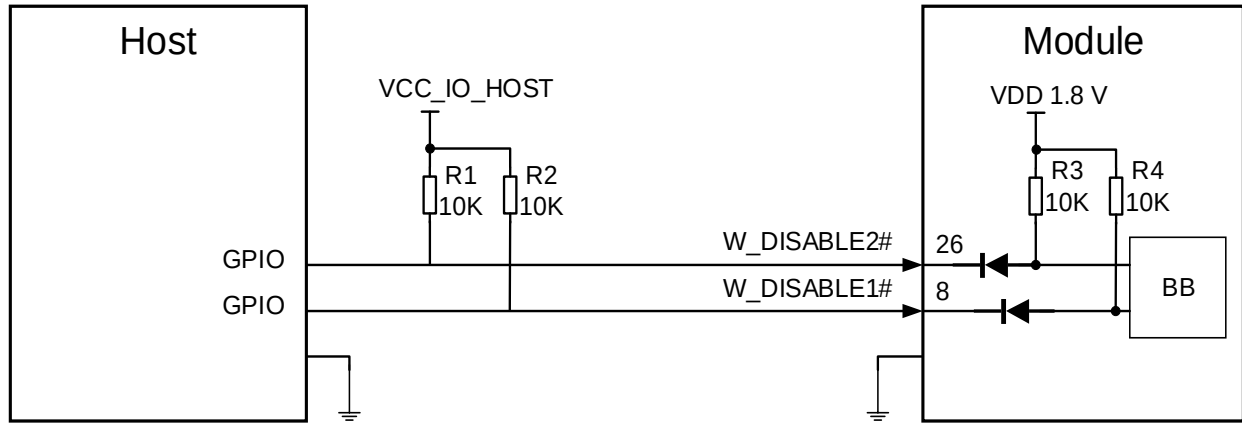
### 3.8.2. W\_DISABLE2#\*

The module provides a W\_DISABLE2# pin used to disable or enable the GNSS function. The W\_DISABLE2# pin is pulled up by default. Driving it low will disable the GNSS function. The combination of W\_DISABLE2# pin and AT commands can control the GNSS function.

**Table 17: GNSS Function Status**

| W_DISABLE2# Level | AT Command | GNSS Function Status |
|-------------------|------------|----------------------|
| High Level        | AT+QGPS=1  | Enable               |
|                   | AT+QGSEND  |                      |
| Low Level         | AT+QGPS=1  | Disable              |
|                   | AT+QGSEND  |                      |

A simple voltage-level translator based on diodes is used on W\_DISABLE1# pin and W\_DISABLE2# pin which are pulled up to a 1.8 V voltage in the module, as shown in the following figure. So, the control signals (GPIO) of the host device could be a 1.8 V or 3.3 V voltage level and pull-up resistor is not needed on the host side. These two signals are active low, and a reference circuit is shown below.



**NOTE:**

Host's GPIO could be a 1.8 V or 3.3 V voltage level.

**Figure 17: Reference Design of W\_DISABLE1# and W\_DISABLE2#**

### 3.8.3. WWAN\_LED#

The WWAN\_LED# signal is used to indicate RF status of the module, and its typical power consumption is up to 10 mA.

To reduce the power 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.

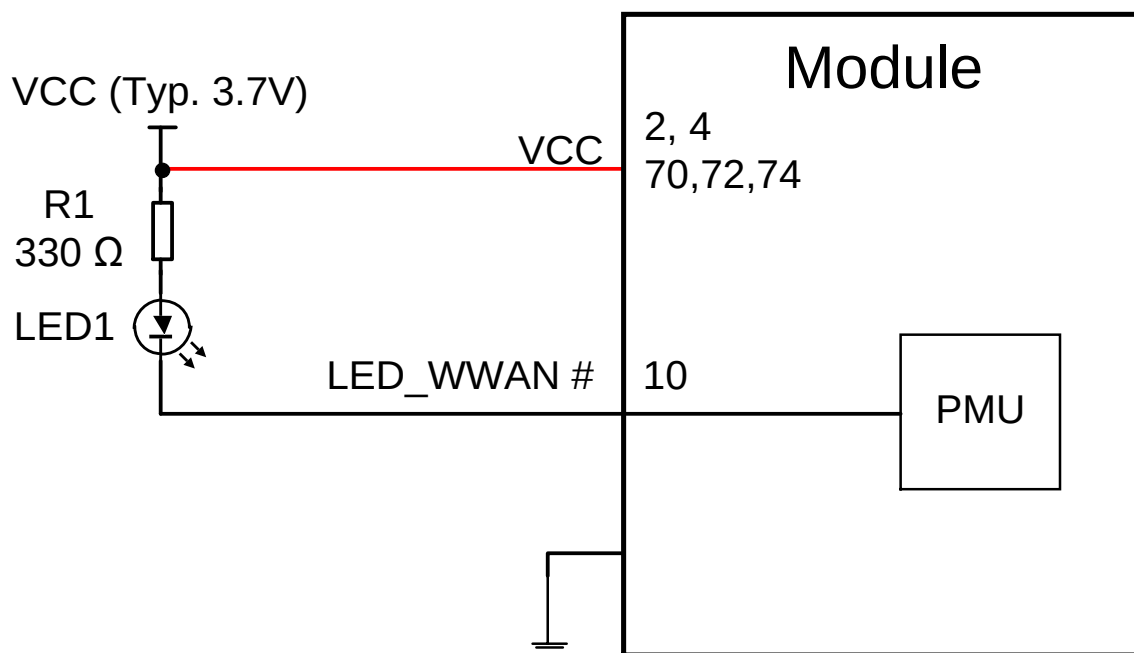


Figure 18: Reference Design of WWAN\_LED#

Table 18: RF Status Indications of WWAN\_LED#

| WWAN_LED# Level | LED | RF Status |
|-----------------|-----|-----------|
| Low Level       | On  | On        |
| High Level      | Off | Off       |

**NOTE**

RF function is turned off if any of the following circumstances occurs:

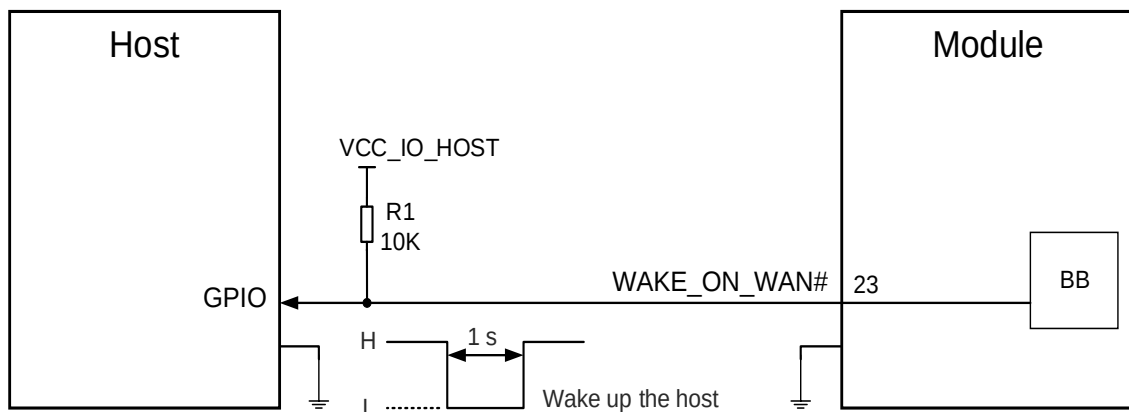
- The (U)SIM card is not working.
- W\_DISABLE1# is at low level (airplane mode enabled).

### 3.8.4. WAKE\_ON\_WAN#

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

**Table 19: State of the WAKE\_ON\_WAN#**

| WAKE_ON_WAN# State                            | Module Operation Status |
|-----------------------------------------------|-------------------------|
| Output a one-second pulse signal at low level | SMS                     |
| Always at high level                          | Idle/Sleep              |



**NOTE:** The voltage level on VCC\_IO\_HOST depends on the host side due to open drain in pin 23.

**Figure 19: Reference Design of WAKE\_ON\_WAN#**

### 3.8.5. DPR

EM160R-GL provides a DPR (Dynamic Power Reduction) signal for body SAR (Specific Absorption Rate) detection. The signal is sent by a host system proximity sensor to the module to provide an input trigger which will reduce the output power in the radio transmission.

**Table 20: Function of the DPR Signal**

| DPR Level     | Function                                  |
|---------------|-------------------------------------------|
| High/Floating | Max. transmitting power will not back off |
| Low           | Max. transmitting power will back off     |

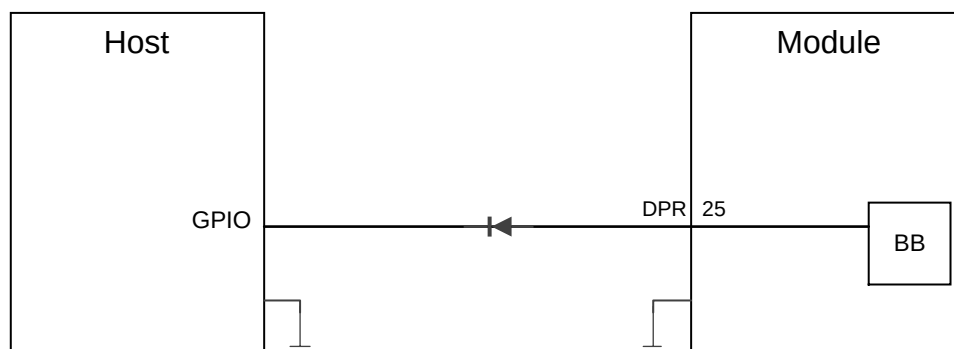


**Figure 20: Reference Design of DPR**

**NOTE**

1. Do not design pull-up resistors on the module side in DPR signal design.
2. See **document [3]** for more details about **AT+QCFG="sarcfg"**.

### 3.8.6. ANT\_CONFIG

EM160R-GL provides an ANT\_CONFIG pin for antenna configuration. The signal of the pin is sent from host system to the module. ANT\_CONFIG is an input port which is pulled high internally by default. The definition of ANT\_CONFIG is shown in the table below.

**Table 21: Pin Definition of ANT\_CONFIG**

| ANT_CONFIG Level | Function           |
|------------------|--------------------|
| High/Floating    | Support 2 antennas |
| Low              | Support 4 antennas |

### 3.9. COEX UART\*

The module provides one COEX UART.

**Table 22: Pin Definition of COEX UART**

| Pin Name | Pin No. | I/O | Description                   |
|----------|---------|-----|-------------------------------|
| COEX3    | 60      | DIO | COEX GPIO                     |
| COEX_RXD | 62      | DI  | LTE&WLAN coexistence receive  |
| COEX_TXD | 64      | DO  | LTE&WLAN coexistence transmit |

#### NOTE

Please note that COEX\_RXD and COEX\_TXD cannot be used as general UART.

### 3.10. Antenna Tuner Control Interfaces\*

ANTCTL[0:3] and RFFE signals are used for antenna tuner control and should be routed to an appropriate antenna control circuit. More details about the interface will be added in a future version of the document.

#### 3.10.1. Antenna Tuner Control Interface through GPIOs

**Table 23: Pin Definition of Antenna Tuner Control Interface through GPIOs**

| Pin Name | Pin No. | I/O | Description           |
|----------|---------|-----|-----------------------|
| ANTCTL0  | 59      | DO  | Antenna tuner control |
| ANTCTL1  | 61      | DO  |                       |
| ANTCTL2  | 63      | DO  |                       |
| ANTCTL3  | 65      | DO  |                       |

### 3.10.2. Antenna Tuner Control Interface through RFFE

**Table 24: Pin Definition of Antenna Tuner Control Interface through RFFE**

| Pin Name  | Pin No. | I/O | Description                       | Comment                    |
|-----------|---------|-----|-----------------------------------|----------------------------|
| RFFE_CLK  | 56      | DO  | Used for external MIPI IC control | If unused, keep them open. |
| RFFE_DATA | 58      | DIO | Used for external MIPI IC control |                            |

### 3.11. Configuration Pins

EM160R-GL provides four configuration pins which are defined as below.

**Table 25: Configuration Pins of the Module**

| Pin No. | Pin Name | I/O | Description                  |
|---------|----------|-----|------------------------------|
| 21      | CONFIG_0 | DO  | Connected to GND internally. |
| 69      | CONFIG_1 | DO  | Connected to GND internally. |
| 75      | CONFIG_2 | DO  | Not connected internally     |
| 1       | CONFIG_3 | DO  | Not connected internally     |

The following figure shows a reference circuit of these four pins.

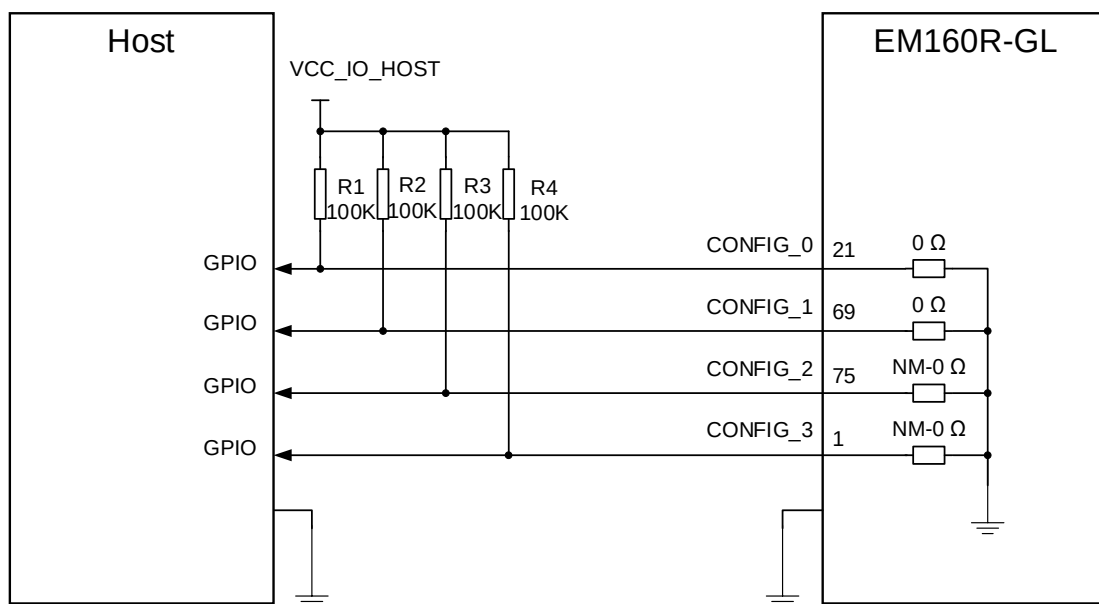


**Figure 21: Recommended Circuit of EM160R-GL Configuration Pins**

**Table 26: Configuration Pins List of M.2 Specification**

| 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 Configuration  |
|----------------------|----------------------|----------------------|---------------------|----------------------------------------|---------------------|
| GND                  | GND                  | NC                   | NC                  | WWAN-PCIe,<br>USB 3.1                  | 2 (Quectel defined) |

# 4 RF Specifications

Appropriate antenna type and design should be used with matched antenna parameters according to specific application. It is required to perform a comprehensive functional test for the RF design before mass production of terminal products. The entire content of this chapter is provided for illustration only. Analysis, evaluation and determination are still necessary when designing target products.

The module provides one main antenna interface, one Rx-diversity antenna interface, two MIMO antenna interfaces, and one GNSS antenna interface. They are used to resist the fall of signals caused by high-speed movement and multipath effect. The impedance of antenna ports is 50  $\Omega$ .

## 4.1. Cellular Network

### 4.1.1. Antenna Interface & Frequency Bands

Table 27: EM160R-GL Connector Definition of Antenna Interfaces

| Connector Name                | I/O | Description                                                                                                                                 | Comment               |
|-------------------------------|-----|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Main Antenna                  | AIO | Main antenna interface: <ul style="list-style-type: none"> <li>● LTE: TRX</li> <li>● WCDMA: TRX</li> </ul>                                  |                       |
| Rx-diversity/<br>GNSS Antenna | AI  | Rx-diversity/GNSS antenna interface: <ul style="list-style-type: none"> <li>● LTE: DRX</li> <li>● WCDMA: DRX</li> <li>● GNSS: L1</li> </ul> | 50 $\Omega$ impedance |
| MIMO1 Antenna                 | AI  | MIMO1 antenna interface: <ul style="list-style-type: none"> <li>● LTE: MHB_MIMO1</li> </ul>                                                 |                       |
| MIMO2 Antenna                 | AI  | MIMO2 antenna interface: <ul style="list-style-type: none"> <li>● LTE: MHB_MIMO2</li> </ul>                                                 |                       |

Table 28: Frequency Bands

| 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 B6    | 830–840   | 875–885   | MHz  |
| WCDMA B8    | 880–915   | 925–960   | MHz  |
| WCDMA B19   | 830–845   | 875–890   | MHz  |
| LTE-FDD B1  | 1920–1980 | 2110–2170 | MHz  |
| LTE-FDD B2  | 1850–1910 | 1930–1990 | MHz  |
| LTE-FDD B3  | 1710–1785 | 1805–1880 | MHz  |
| LTE-FDD B4  | 1710–1755 | 2110–2155 | MHz  |
| LTE-FDD B5  | 824–849   | 869–894   | MHz  |
| LTE-FDD B7  | 2500–2570 | 2620–2690 | MHz  |
| LTE-FDD B8  | 880–915   | 925–960   | MHz  |
| LTE-FDD B12 | 699–716   | 729–746   | MHz  |
| LTE-FDD B13 | 777–787   | 746–756   | MHz  |
| LTE-FDD B14 | 788–798   | 758–768   | MHz  |
| LTE-FDD B18 | 815–830   | 860–875   | MHz  |
| LTE-FDD B19 | 830–845   | 875–890   | MHz  |
| LTE-FDD B20 | 832–862   | 791–821   | MHz  |
| LTE-FDD B25 | 1850–1915 | 1930–1995 | MHz  |
| LTE-FDD B26 | 814–849   | 859–894   | MHz  |

|                          |           |           |     |
|--------------------------|-----------|-----------|-----|
| LTE-FDD B28              | 703–748   | 758–803   | MHz |
| LTE-FDD B29 <sup>6</sup> | -         | 717–728   | MHz |
| LTE-FDD B30              | 2305–2315 | 2350–2360 | MHz |
| LTE-FDD B32 <sup>6</sup> | -         | 1452–1496 | MHz |
| LTE-TDD B38              | 2570–2620 | 2570–2620 | MHz |
| LTE-TDD B39              | 1880–1920 | 1880–1920 | MHz |
| LTE-TDD B40              | 2300–2400 | 2300–2400 | MHz |
| LTE-TDD B41              | 2496–2690 | 2496–2690 | MHz |
| LTE-TDD B42              | 3400–3600 | 3400–3600 | MHz |
| LTE-TDD B43              | 3600–3800 | 3600–3800 | MHz |
| LTE-TDD B46 <sup>6</sup> | -         | 5150–5925 | MHz |
| LTE-TDD B48              | 3550–3700 | 3550–3700 | MHz |
| LTE-FDD B66              | 1710–1780 | 2110–2200 | MHz |

#### 4.1.2. Rx Sensitivity

The following table shows the Rx sensitivity of the module.

**Table 29: Dual-Antenna Conducted RF Receiver Sensitivity (Unit: dBm)**

| Frequency | Rx Sensitivity <sup>7</sup> (Typical) (dBm) | 3GPP (dBm) | Comment <sup>8</sup> |
|-----------|---------------------------------------------|------------|----------------------|
| WCDMA B1  | -110.5                                      | -106.7     |                      |
| WCDMA B2  | -110                                        | -104.7     |                      |
| WCDMA B3  | -111                                        | -103.7     |                      |
| WCDMA B4  | -110.5                                      | -106.7     |                      |
| WCDMA B5  | -112                                        | -104.7     |                      |
| WCDMA B6  | -111                                        | -106.7     |                      |

<sup>6</sup> LTE-FDD B29/B32 and LTE-TDD B46 support Rx only and are only for secondary component carrier.

<sup>7</sup> Rx Sensitivity values are measured in dual antennas condition (Primary + Diversity). For single primary antenna (without Diversity), the sensitivity will drop around 3 dBm for each LTE band.

<sup>8</sup> The RB configuration follows 3GPP specification.

|                          |        |        |        |
|--------------------------|--------|--------|--------|
| WCDMA B8                 | -111   | -103.7 |        |
| WCDMA B19                | -111   | -106.7 |        |
| LTE-FDD B1               | -100.7 | -96.3  | 10 MHz |
| LTE-FDD B2               | -100.3 | -94.3  | 10 MHz |
| LTE-FDD B3               | -100.6 | -93.3  | 10 MHz |
| LTE-FDD B4               | -100.6 | -96.3  | 10 MHz |
| LTE-FDD B5               | -102   | -94.3  | 10 MHz |
| LTE-FDD B7               | -99.4  | -94.3  | 10 MHz |
| LTE-FDD B8               | -101.6 | -93.3  | 10 MHz |
| LTE-FDD B12              | -102.3 | -93.3  | 10 MHz |
| LTE-FDD B13              | -102.5 | -93.3  | 10 MHz |
| LTE-FDD B14              | -101.8 | -93.3  | 10 MHz |
| LTE-FDD B18              | -102   | -96.3  | 10 MHz |
| LTE-FDD B19              | -102   | -96.3  | 10 MHz |
| LTE-FDD B20              | -102.1 | -93.3  | 10 MHz |
| LTE-FDD B25              | -100.3 | -92.8  | 10 MHz |
| LTE-FDD B26              | -101.9 | -93.8  | 10 MHz |
| LTE-FDD B28              | -101.9 | -94.8  | 10 MHz |
| LTE-FDD B29 <sup>9</sup> | -101   | -93.3  | 10 MHz |
| LTE-FDD B30              | -99.5  | -95.3  | 10 MHz |
| LTE-FDD B32 <sup>9</sup> | -99    | -96.3  | 10 MHz |
| LTE-TDD B38              | -100.1 | -96.3  | 10 MHz |
| LTE-FDD B39              | -100.5 | -96.3  | 10 MHz |
| LTE-TDD B40              | -99.2  | -96.3  | 10 MHz |
| LTE-TDD B41              | -99.7  | -94.3  | 10 MHz |
| LTE-TDD B42              | -100.7 | -95.0  | 10 MHz |
| LTE-TDD B43              | -100.7 | -95.0  | 10 MHz |

<sup>9</sup> The test results are based on CA\_2A-29A, CA\_20A-32A and CA\_46A-66A.

|                          |        |       |        |
|--------------------------|--------|-------|--------|
| LTE-TDD B46 <sup>9</sup> | -96.5  | -88.5 | 20 MHz |
| LTE-TDD B48              | -100.6 | -95.0 | 10 MHz |
| LTE-FDD B66              | -100.4 | -95.8 | 10 MHz |

**Table 30: Four-Antenna Conducted RF Receiver Sensitivity**

| Frequency Band            | Rx Sensitivity (Typical) (dBm) <sup>7</sup> | 3GPP (dBm) | Comment <sup>8</sup> |
|---------------------------|---------------------------------------------|------------|----------------------|
| LTE-FDD B1                | -103.5                                      | -99        | 10 MHz               |
| LTE-FDD B2                | -103                                        | -97        | 10 MHz               |
| LTE-FDD B3                | -102.8                                      | -96        | 10 MHz               |
| LTE-FDD B4                | -103                                        | -99        | 10 MHz               |
| LTE-FDD B7                | -102.3                                      | -97        | 10 MHz               |
| LTE-FDD B25               | -103                                        | -95.5      | 10 MHz               |
| LTE-FDD B30               | -102.5                                      | -98        | 10 MHz               |
| LTE-FDD B32 <sup>10</sup> | -102                                        | -          | 10 MHz               |
| LTE-TDD B38               | -102.5                                      | -          | 10 MHz               |
| LTE-TDD B39               | -102.5                                      | -99        | 10 MHz               |
| LTE-TDD B40               | -102.2                                      | -99        | 10 MHz               |
| LTE-TDD B41               | -102                                        | -97        | 10 MHz               |
| LTE-FDD B66               | -103                                        | -98.5      | 10 MHz               |

#### 4.1.3. Tx Power

The following table shows the transmitting power of the module.

<sup>10</sup> The test result is based on CA\_20A-32A.

Table 31: EM160R-GL Transmitting Power

| Frequency Band                    | Modulation | Max.                | Min.      | Comment     |
|-----------------------------------|------------|---------------------|-----------|-------------|
| WCDMA bands                       | BPSK       | 23 dBm $\pm$ 2 dB   | < -50 dBm |             |
| LTE bands                         | QPSK       | 24 dBm $\pm$ 1 dB   | < -40 dBm | 10 MHz, 1RB |
| LTE-FDD (B30)                     | QPSK       | 22 dBm $\pm$ 1 dB   | < -40 dBm | 10 MHz, 1RB |
| LTE-TDD (B41)                     | QPSK       | 23 dBm $\pm$ 1 dB   | < -40 dBm | 10 MHz, 1RB |
| LTE-TDD (B41 HPUE <sup>11</sup> ) | QPSK       | 25.5 dBm +1/-1.5 dB | < -40 dBm | 10 MHz, 1RB |
| LTE-TDD (B42/B43/B48)             | QPSK       | 21 dBm $\pm$ 1 dB   | < -40 dBm | 10 MHz, 1RB |

## 4.2. GNSS <sup>12</sup>

### 4.2.1. Antenna Interface & Frequency Bands

EM160R-GL includes a fully integrated global navigation satellite system solution that supports GPS, GLONASS, BDS and Galileo. The module supports standard NMEA 0183 protocol, and outputs NMEA sentences at 1 Hz data update rate.

The GNSS engine is switched off by default. It has to be switched on via AT command. For more details about GNSS engine technology and configurations, see **document [4]**.

Table 32: GNSS Frequency

| Type        | Frequency            | Unit |
|-------------|----------------------|------|
| GPS/Galileo | 1575.42 $\pm$ 1.023  | MHz  |
| GLONASS     | 1601.65 $\pm$ 4.15   | MHz  |
| BDS         | 1561.098 $\pm$ 2.046 | MHz  |

<sup>11</sup> For B41 HPUE, based on the power reduction of QPSK (25.5 dBm +1/-1.5 dB), the power tolerance of 16QAM and 64QAM is +1/-2 dB.

<sup>12</sup> GNSS function is optional.

## 4.2.2. GNSS Performance

Table 33: GNSS Performance

| Parameter   | Description              | Condition                | Typ.  | Unit |
|-------------|--------------------------|--------------------------|-------|------|
| Sensitivity | Cold start               | Autonomous               | -146  | dBm  |
|             | Reacquisition            | Autonomous               | -158  | dBm  |
|             | Tracking                 | Autonomous               | -158  | dBm  |
| TTFF        | Cold start<br>@ open sky | Autonomous               | 31.13 | s    |
|             |                          | XTRA enabled             | 17.87 | s    |
|             | Warm start<br>@ open sky | Autonomous               | 26.59 | s    |
|             |                          | XTRA enabled             | 7.07  | s    |
|             | Hot start<br>@ open sky  | Autonomous               | 2.12  | s    |
|             |                          | XTRA enabled             | 2.6   | s    |
| Accuracy    | CEP-50                   | Autonomous<br>@ open sky | 2     | m    |

### NOTE

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

## 4.3. Antenna Connectors

### 4.3.1. Antenna Connector Location

The module has four antenna connectors: main, Rx-diversity/GNSS, MIMO1 and MIMO2, which are shown below.



**Figure 22: Antenna Connectors on the QM160R-GL Module**

### 4.3.2. Antenna Connector Specifications

EM160R-GL is mounted with standard 2 mm × 2 mm receptacle antenna connectors for convenient antenna connection. The connector dimensions are illustrated below:

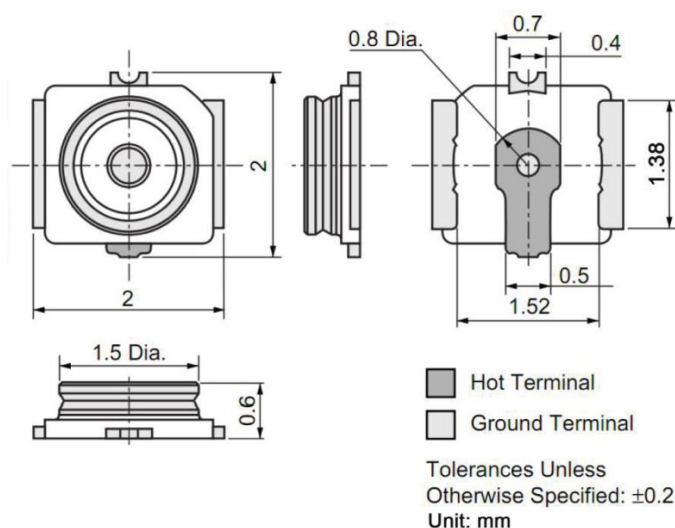


**Figure 23: Dimensions of the Receptacle (Unit: mm)**

**Table 34: Major Specifications of the RF Connector**

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

### 4.3.3. Antenna Connector Installation

The receptacle RF connector used in conjunction with EM160R-GL will accept two types of mated plugs that will meet a maximum height of 1.2 mm using a  $\varnothing$  0.81 mm coaxial cable or a maximum height of 1.4 mm utilizing a  $\varnothing$  1.13 mm coaxial cable.

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

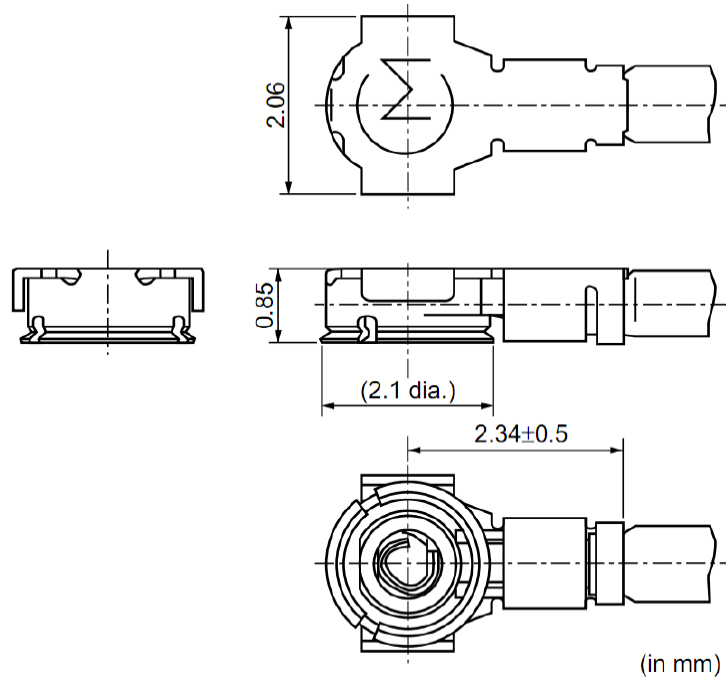


**Figure 24: Dimensions of Mated Plugs ( $\varnothing$  0.81 mm Coaxial Cables) (Unit: mm)**

The following figure illustrates the connection between the receptacle RF connector on EM160R-GL and the mated plug using a  $\varnothing$  0.81 mm coaxial cable.

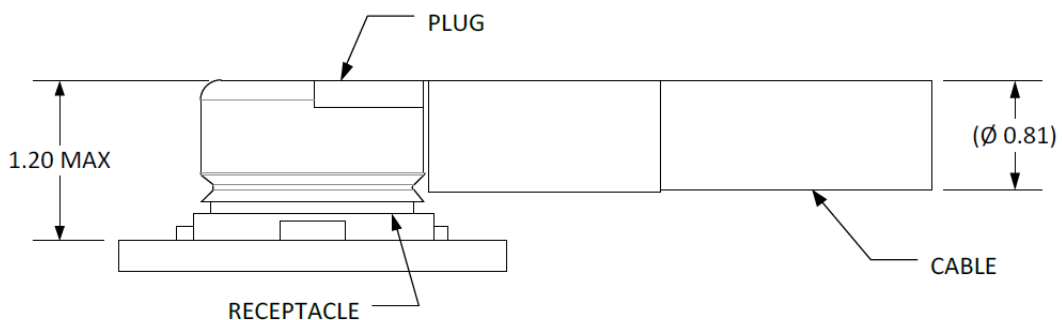


**Figure 25: Space Factor of Mated Connectors ( $\varnothing$  0.81 mm Coaxial Cables) (Unit: mm)**

The following figure illustrates the connection between the receptacle RF connector on EM160R-GL and the mated plug using a  $\varnothing 1.13$  mm coaxial cable.

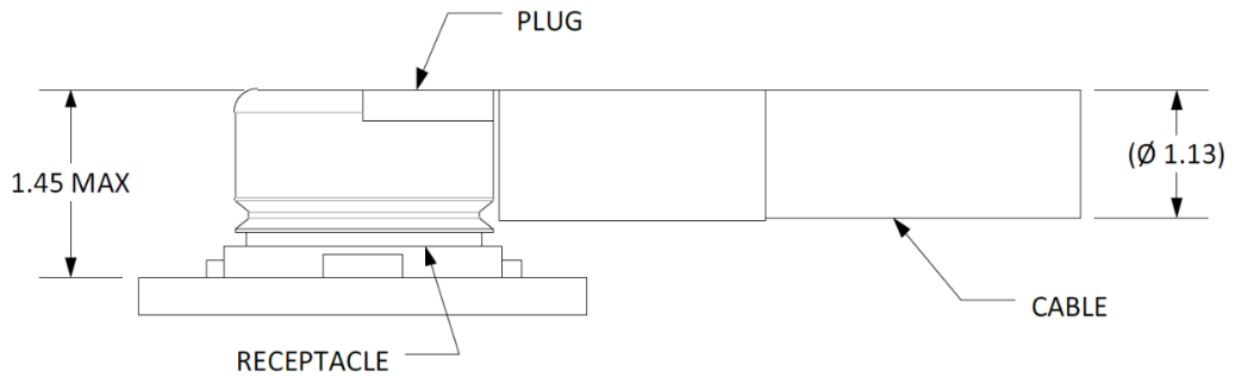


**Figure 26: Space Factor of Mated Connectors ( $\varnothing 1.13$  mm Coaxial Cables) (Unit: mm)**

## 4.4. Antenna Requirements

The following table shows the requirements on main antenna, GNSS antenna, MIMO1 and MIMO2 antennas.

**Table 35: Antenna Requirements**

| Type                      | Requirements                                                                                                                                                                                                 |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Main Antenna (Tx/Rx)      | <ul style="list-style-type: none"> <li>● VSWR: <math>\leq 2</math></li> <li>● Efficiency: <math>&gt; 30\%</math></li> <li>● Max input power: 50 W</li> </ul>                                                 |
| Rx-diversity/GNSS Antenna | <ul style="list-style-type: none"> <li>● Input impedance: 50 <math>\Omega</math></li> </ul>                                                                                                                  |
| MIMO1 Antenna (Rx)        | <ul style="list-style-type: none"> <li>● Cable insertion loss:</li> </ul>                                                                                                                                    |
| MIMO2 Antenna (Rx)        | <ul style="list-style-type: none"> <li>- <b>&lt; 1 dB:</b> LB (<math>&lt; 1</math> GHz)</li> <li>- <b>&lt; 1.5 dB:</b> MB (1–2.3 GHz)</li> <li>- <b>&lt; 2 dB:</b> HB (<math>&gt; 2.3</math> GHz)</li> </ul> |

### NOTE

Active GNSS antenna is not supported.

# 5 Electrical Characteristics and Reliability

## 5.1. Absolute Maximum Ratings

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

**Table 36: Absolute Maximum Ratings**

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

## 5.2. Power Supply Ratings

The typical input voltage of the module is 3.7 V. The following table shows the power supply requirements of the module.

**Table 37: Power Supply Requirements**

| Parameter | Description                 | Condition                                                                      | Min.  | Typ. | Max. | Unit |
|-----------|-----------------------------|--------------------------------------------------------------------------------|-------|------|------|------|
| VCC       | Power supply for the module | The actual input voltages must be kept between the minimum and maximum values. | 3.135 | 3.7  | 4.4  | V    |

### 5.3. Digital I/O Characteristics

**Table 38: Logic Levels of 1.8 V Digital I/O**

| Parameter       | Description               | Min.                            | Max.                            | Unit |
|-----------------|---------------------------|---------------------------------|---------------------------------|------|
| VDDIO_1V8       | Supply voltage            | 1.7                             | 1.94                            | V    |
| V <sub>IH</sub> | High-level input voltage  | $0.65 \times \text{VDDIO\_1V8}$ | $\text{VDDIO\_1V8} + 0.3$       | V    |
| V <sub>IL</sub> | Low-level input voltage   | -0.3                            | $0.35 \times \text{VDDIO\_1V8}$ | V    |
| V <sub>OH</sub> | High-level output voltage | $\text{VDDIO\_1V8} - 0.45$      | $\text{VDDIO\_1V8}$             | V    |
| V <sub>OL</sub> | Low-level output voltage  | 0                               | 0.45                            | V    |

**Table 39: Logic Levels of 3.3 V Digital I/O**

| Parameter       | Description              | Min.  | Max.  | Unit |
|-----------------|--------------------------|-------|-------|------|
| 3.3 V           | Supply voltage           | 3.135 | 3.465 | V    |
| V <sub>IH</sub> | High-level input voltage | 2.0   | 3.6   | V    |
| V <sub>IL</sub> | Low-level input voltage  | -0.5  | 0.8   | V    |

**Table 40: (U)SIM High/Low-voltage I/O Requirements**

| Parameter       | Description               | Min.                          | Max.                          | Unit |
|-----------------|---------------------------|-------------------------------|-------------------------------|------|
| V <sub>IH</sub> | High-level input voltage  | $0.7 \times \text{USIM\_VDD}$ | $\text{USIM\_VDD} + 0.3$      | V    |
| V <sub>IL</sub> | Low-level input voltage   | -0.3                          | $0.2 \times \text{USIM\_VDD}$ | V    |
| V <sub>OH</sub> | High-level output voltage | $0.8 \times \text{USIM\_VDD}$ | -                             | V    |
| V <sub>OL</sub> | Low-level output voltage  | -                             | 0.4                           | V    |

## 5.4. Operating and Storage Temperatures

Table 41: Operating and Storage Temperatures

| Parameter                                 | Min. | Typ. | Max. | Unit |
|-------------------------------------------|------|------|------|------|
| Operating temperature Range <sup>13</sup> | -25  | +25  | +75  | °C   |
| Extended Temperature Range <sup>14</sup>  | -40  | -    | +85  | °C   |
| Storage temperature Range                 | -40  | -    | +90  | °C   |

## 5.5. Power Consumption

Table 42: EM160R-GL Power Consumption

| Mode        | Condition       | Typ. | Unit |
|-------------|-----------------|------|------|
| OFF state   | Power off       | 54   | μA   |
|             | AT+CFUN=0       | 1.55 | mA   |
|             | WCDMA PF = 64   | 2.81 | mA   |
|             | WCDMA PF = 128  | 2.34 | mA   |
| Sleep State | WCDMA PF = 256  | 2.03 | mA   |
|             | WCDMA PF = 512  | 1.91 | mA   |
|             | LTE-FDD PF = 32 | 4.97 | mA   |
|             | LTE-FDD PF = 64 | 5.48 | mA   |

<sup>13</sup> To meet the normal operating temperature range requirements, it is necessary to ensure effective thermal dissipation, e.g., by adding passive or active heat sinks, heat pipes, vapor chambers. Within the temperature range of -10 °C to +55 °C, the mentioned RF performance margins higher than 3GPP specifications can be guaranteed. When temperature goes beyond temperature range of -10 °C to 55 °C, a few RF performances of module may be slightly off 3GPP specifications.

<sup>14</sup> To meet the extended operating temperature range requirements, it is necessary to ensure effective thermal dissipation, e.g., by adding passive or active heat sinks, heat pipes, vapor chambers. Within this range, the module remains the ability to establish and maintain functions such as SMS, without any unrecoverable malfunction. Radio spectrum and radio network are not influenced, while one or more specifications, such as P<sub>out</sub>, may undergo a reduction in value, exceeding the specified tolerances of 3GPP. When the temperature returns to the normal operating temperature level, the module will meet 3GPP specifications again.

|                                      |                                    |        |    |
|--------------------------------------|------------------------------------|--------|----|
|                                      | LTE-FDD PF = 128                   | 3.41   | mA |
|                                      | LTE-FDD PF = 256                   | 2.57   | mA |
|                                      | LTE-TDD PF = 32                    | 5.03   | mA |
|                                      | LTE-TDD PF = 64                    | 5.51   | mA |
|                                      | LTE-TDD PF = 128                   | 2.91   | mA |
|                                      | LTE-TDD PF = 256                   | 2.57   | mA |
| Idle State                           | WCDMA PF = 64                      | 18.76  | mA |
|                                      | LTE-FDD PF = 64                    | 15.38  | mA |
|                                      | LTE-TDD PF = 64                    | 14.69  | mA |
| WCDMA Data<br>Transfer (GNSS<br>Off) | WCDMA B1 HSDPA CH10700 @ 23.57 dBm | 654.21 | mA |
|                                      | WCDMA B1 HSUPA CH10700 @ 23.54 dBm | 646.25 | mA |
|                                      | WCDMA B2 HSDPA CH9800 @ 23.25 dBm  | 561.06 | mA |
|                                      | WCDMA B2 HSUPA CH9800 @ 23.29 dBm  | 588.27 | mA |
|                                      | WCDMA B3 HSDPA CH1338 @ 23.07 dBm  | 595.17 | mA |
|                                      | WCDMA B3 HSUPA CH1338 @ 23.26 dBm  | 598.19 | mA |
|                                      | WCDMA B4 HSDPA CH1638 @ 23.43 dBm  | 642.02 | mA |
|                                      | WCDMA B4 HSUPA CH1638 @ 23.5 dBm   | 661.27 | mA |
|                                      | WCDMA B5 HSDPA CH4407 @ 22.62 dBm  | 511.57 | mA |
|                                      | WCDMA B5 HSUPA CH4407 @ 22.8 dBm   | 508.58 | mA |
|                                      | WCDMA B6 HSDPA CH4400 @ 22.66 dBm  | 515.95 | mA |
|                                      | WCDMA B6 HSUPA CH4400 @ 22.83 dBm  | 532.86 | mA |
|                                      | WCDMA B8 HSDPA CH3012 @ 22.75 dBm  | 566.86 | mA |
|                                      | WCDMA B8 HSUPA CH3012 @ 22.93 dBm  | 570.14 | mA |
|                                      | WCDMA B19 HSDPA CH738 @ 22.52 dBm  | 507.47 | mA |
|                                      | WCDMA B19 HSUPA CH738 @ 22.34 dBm  | 489.19 | mA |

|                                    |                                  |        |    |
|------------------------------------|----------------------------------|--------|----|
| LTE Data<br>Transfer<br>(GNSS OFF) | LTE-FDD B1 CH300 @ 24.81 dBm     | 919.73 | mA |
|                                    | LTE-FDD B2 CH900 @ 24.86 dBm     | 785.26 | mA |
|                                    | LTE-FDD B3 CH1575 @ 24.35 dBm    | 784    | mA |
|                                    | LTE-FDD B4 CH2175 @ 24.79 dBm    | 895.19 | mA |
|                                    | LTE-FDD B5 CH2525 @ 24.64 dBm    | 707.23 | mA |
|                                    | LTE-FDD B7 CH3100 @ 23.62 dBm    | 902.96 | mA |
|                                    | LTE-FDD B8 CH3625 @ 24.91 dBm    | 810.75 | mA |
|                                    | LTE-FDD B12 CH5095 @ 24.64 dBm   | 683.56 | mA |
|                                    | LTE-FDD B13 CH5230 @ 24.39 dBm   | 705.3  | mA |
|                                    | LTE-FDD B14 CH5330 @ 24.54 dBm   | 680.13 | mA |
|                                    | LTE-FDD B18 CH5925 @ 24.83 dBm   | 716.38 | mA |
|                                    | LTE-FDD B19 CH6075 @ 24.99 dBm   | 662.82 | mA |
|                                    | LTE-FDD B20 CH6300 @ 24.32 dBm   | 673.72 | mA |
|                                    | LTE-FDD B25 CH8365 @ 24.68 dBm   | 752.8  | mA |
|                                    | LTE-FDD B26 CH8865 @ 24.4 dBm    | 676.59 | mA |
|                                    | LTE-FDD B28A CH9360 @ 24.62 dBm  | 706.65 | mA |
|                                    | LTE-FDD B28B CH9510 @ 24.35 dBm  | 694.21 | mA |
|                                    | LTE-FDD B30 CH9820 @ 22.17 dBm   | 917.82 | mA |
|                                    | LTE-FDD B66 CH132322 @ 24.73 dBm | 865.75 | mA |
|                                    | LTE-TDD B38 CH38000 @ 24.27 dBm  | 550.65 | mA |
|                                    | LTE-TDD B39 CH38450 @ 24.4 dBm   | 367.78 | mA |
|                                    | LTE-TDD B40 CH39150 @ 24.22 dBm  | 528.9  | mA |
|                                    | LTE-TDD B41 CH40620 @ 25.29 dBm  | 649.66 | mA |
|                                    | LTE-TDD B42 CH42590 @ 20.99 dBm  | 300.36 | mA |
|                                    | LTE-TDD B43 CH44590 @ 21.61 dBm  | 307.41 | mA |

|       |                                 |        |    |
|-------|---------------------------------|--------|----|
| WCDMA | LTE-TDD B48 CH55590 @ 21.88 dBm | 305.05 | mA |
|       | WCDMA B1 CH10700 @ 24.52 dBm    | 739.17 | mA |
|       | WCDMA B2 CH9800 @ 24.25 dBm     | 648.81 | mA |
|       | WCDMA B3 CH1338 @ 24.18 dBm     | 680.93 | mA |
|       | WCDMA B4 CH1638 @ 24.41 dBm     | 788.8  | mA |
|       | WCDMA B5 CH4407 @ 23.85 dBm     | 577.69 | mA |
|       | WCDMA B6 CH4400 @ 23.84 dBm     | 578.14 | mA |
|       | WCDMA B8 CH3012 @ 23.89 dBm     | 635.27 | mA |
|       | WCDMA B19 CH738 @ 23.83 dBm     | 566.84 | mA |

## 5.6. ESD Protection

Static electricity occurs naturally and it may damage the module. Therefore, applying proper ESD countermeasures and handling methods is imperative. For example, wear anti-static gloves during the development, production, assembly and testing of the module; add ESD protection components to the ESD sensitive interfaces and points in the product design.

**Table 43: Electrostatic Discharge Characteristics (Temperature: 25–30 °C, Humidity: 40 ±5 %)**

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

## 5.7. Thermal Dissipation

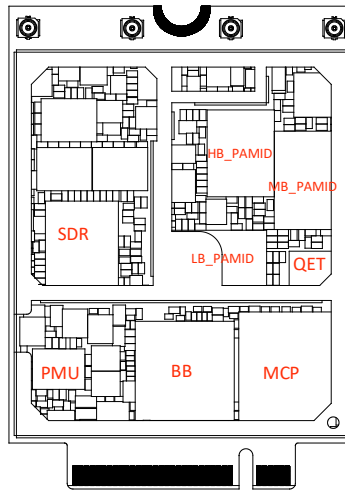


**Figure 27: Distribution of Heat Source Chips Inside the Module**

The module offers the best performance when all internal IC chips are working within their operating temperatures. When the IC chip reaches or exceeds the maximum junction temperature, the module may still work but the performance and function (such as RF output power and data rate) will be affected to a certain extent. Therefore, the thermal design should be maximally optimized to ensure all internal IC chips always work within the recommended operating temperature range.

The following principles for thermal consideration are provided for reference:

- Keep the module away from heat sources on your PCB, especially high-power components such as processor, power amplifier, and power supply.
- Maintain the integrity of the PCB copper layer and drill as many thermal vias as possible.
- Expose the copper in the PCB area where module is mounted.
- Apply a soft thermal pad with appropriate thickness and high thermal conductivity between the module and the PCB to conduct heat.
- Follow the principles below when the heatsink is necessary:
  - Do not place large size components in the area where the module is mounted on your PCB to reserve enough place for heatsink installation.
  - Attach the heatsink to the shielding cover of the module; In general, the base plate area of the heatsink should be larger than the module area to cover the module completely;
  - Choose the heatsink with adequate fins to dissipate heat;
  - Choose a TIM (Thermal Interface Material) with high thermal conductivity, good softness and good wettability and place it between the heatsink and the module;
  - Fasten the heatsink with four screws to ensure that it is in close contact with the module to prevent the heatsink from falling off during the drop, vibration test, or transportation.

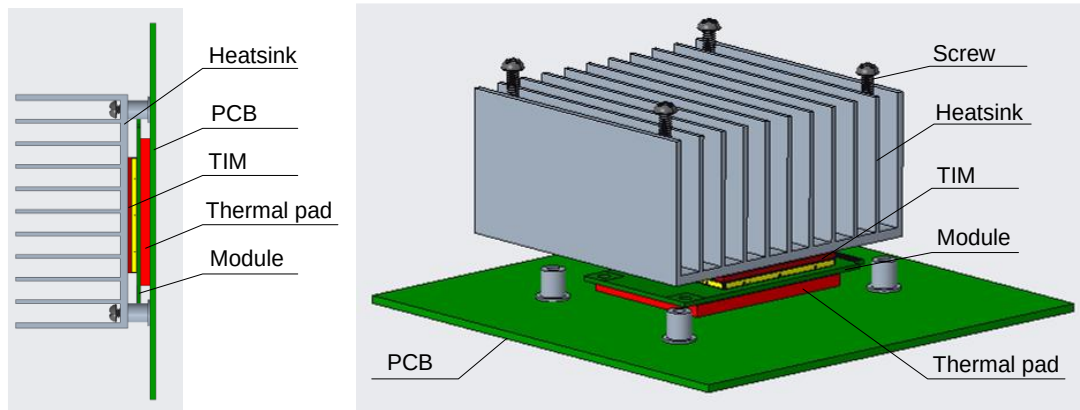


**Figure 28: Placement and Fixing of the Heatsink**

## 5.8. Notification

Please follow the principles below in the module application.

### 5.8.1. Coating

If a conformal coating is necessary for the module, do NOT use any coating material that may chemically react with the PCB or shielding cover, and prevent the coating material from flowing into the module.

### 5.8.2. Cleaning

Avoid using ultrasonic technology for module cleaning since it can damage crystals inside the module.

## 6 Mechanical Information

This chapter mainly describes mechanical dimensions and packaging specifications of the module. All dimensions are measured in millimeter (mm), and the dimensional tolerances are  $\pm 0.15$  mm unless otherwise specified.

### 6.1. Mechanical Dimensions

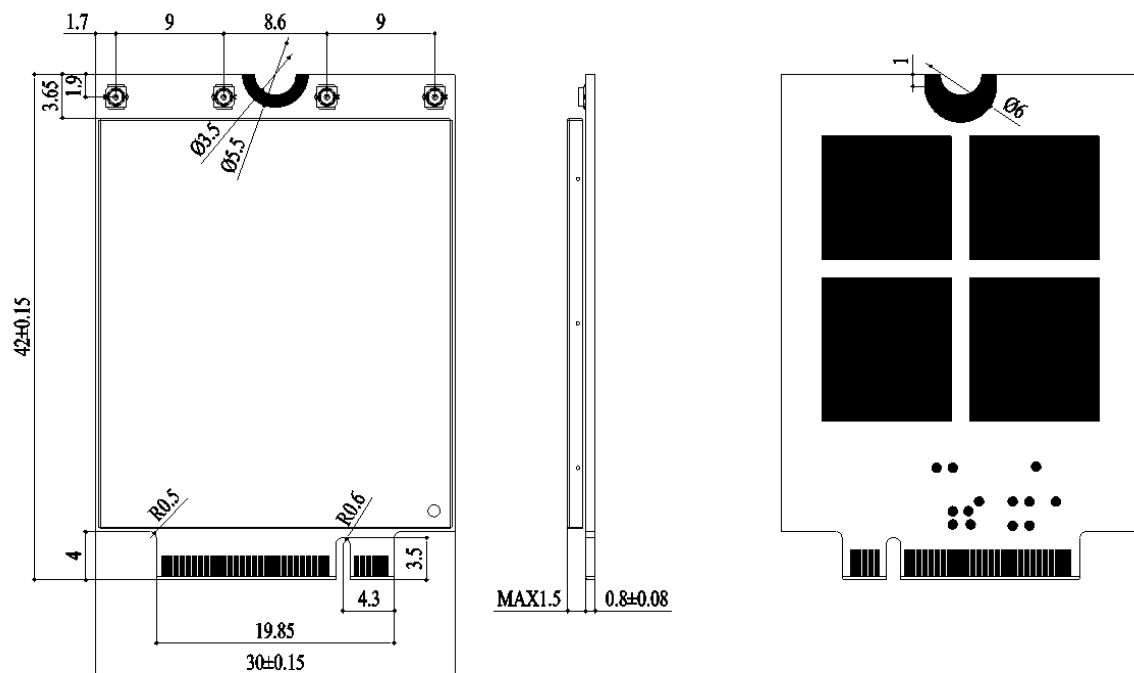


Figure 29: Mechanical Dimensions

#### NOTE

The package warpage level of the module refers to the JEITA ED-7306 standard.

## 6.2. Top and Bottom Views



**Figure 30: Top and Bottom Views of the Module**

### NOTE

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

## 6.3. M.2 Connector

EM160R-GL adopts a standard PCI Express M.2 connector which compiles with the directives and standards listed in *PCI Express M.2 Specification Revision 4.0*.

## 6.4. Module Installation

The module needs to be fixed firmly to avoid poor contact caused by shaking. When installing the module, it is recommended to be mounted on the socket with a screw as shown below.

It is recommended to use a screw with a head diameter  $\varnothing 5\text{--}\varnothing 5.5\text{ mm}$ .

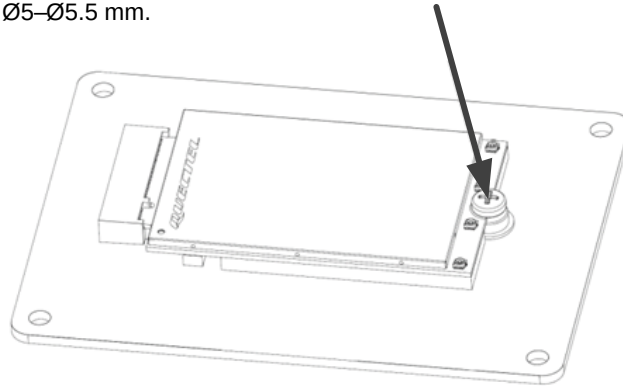


**Figure 31: Installation Schematic**

## 6.5. Packaging Specifications

This chapter describes only the key parameters and process of packaging. All figures below are for reference only. The appearance and structure of the packaging materials are subject to the actual delivery.

The module adopts blister tray packaging and details are as follow:

### 6.5.1. Blister Tray

Dimension details are as follow:

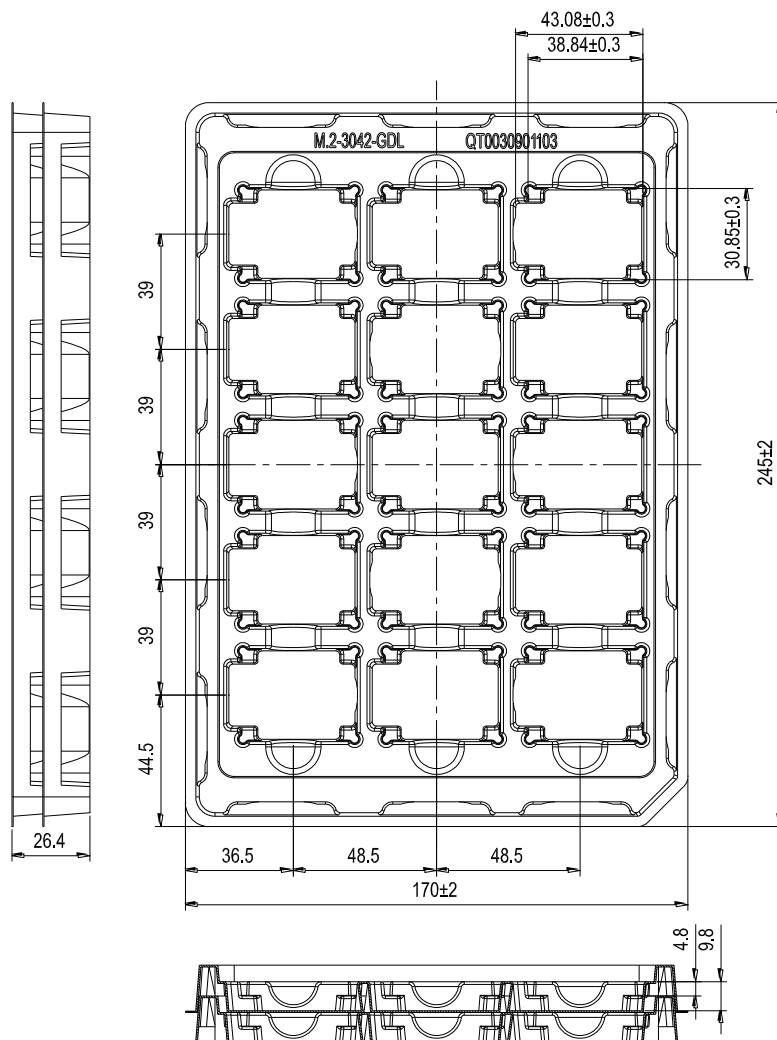
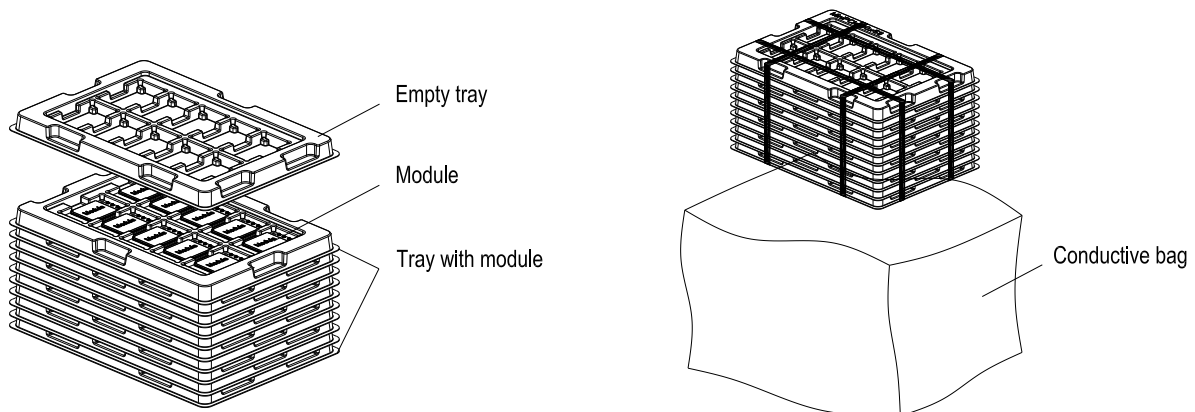


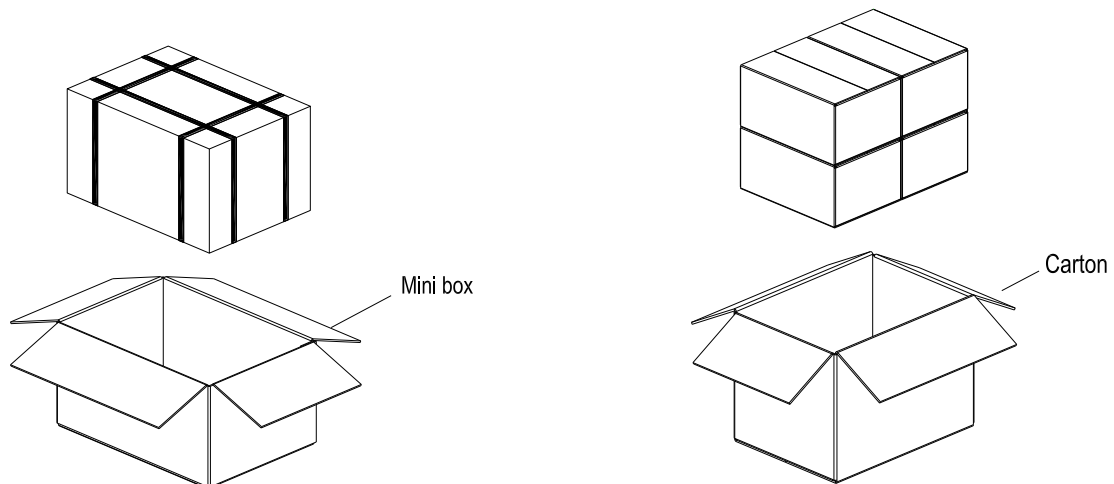
Figure 32: Blister Tray Dimension Drawing

## 6.5.2. Packaging Process



Each blister tray packs 15 modules. Stack 10 blister trays with modules together, and put 1 empty blister tray on the top.

Packing 11 blister trays together and then put blister trays into conductive bag, seal and pack the conductive bag.



Put the seal-packed blister trays into the mini box. 1 mini box can pack 150 modules.

Put 4 packaged mini boxes into 1 carton box and then seal it. 1 carton box can pack 600 modules.

**Figure 33: Packaging Process**

# 7 Appendix References

**Table 44: Related Documents**

| Document Name                                       |
|-----------------------------------------------------|
| [1] Quectel_EM160R-GL_CA_Feature                    |
| [2] Quectel_5G-M2_EVB_User_Guide                    |
| [3] Quectel_EG512R&EM1x0R_Series_AT_Commands_Manual |
| [4] Quectel_LTE-A(Q)_Series_GNSS_Application_Note   |
| [5] Quectel_LTE_Module_Thermal_Design_Guide         |

**Table 45: 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           | Downlink                                    |
| DRx          | Diversity Receive                           |
| ESD          | Electrostatic Discharge                     |
| FDD          | Frequency Division Duplexing                |
| GLONASS      | Global Navigation Satellite System (Russia) |
| GNSS         | Global Navigation Satellite System          |
| GPS          | Global Positioning System                   |
| GSM          | Global System for Mobile Communications     |
| 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                             |
| NMOS   | N-type Metal-Oxide-Semiconductor              |
| PDU    | Protocol Data Unit                            |
| PPP    | Point-to-Point Protocol                       |
| PRx    | Primary Receive                               |
| RF     | Radio Frequency                               |
| Rx     | Receive                                       |
| SAR    | Specific Absorption Rate                      |
| SMS    | Short Message Service                         |
| Tx     | Transmit                                      |
| UART   | Universal Asynchronous Receiver & Transmitter |
| UL     | Uplink                                        |
| URC    | Unsolicited Result Code                       |
| (U)SIM | (Universal) Subscriber Identification Module  |
| WCDMA  | Wideband Code Division Multiple Access        |

## OEM/Integrators Installation Manual

Important Notice to OEM integrators 1. This module is limited to OEM installation ONLY. 2. This module is limited to installation in mobile or fixed applications, according to Part 2.1091(b). 3. The separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093 and different antenna configurations 4. For FCC Part 15.31 (h) and (k): The host manufacturer is responsible for additional testing to verify compliance as a composite system. When testing the host device for compliance with Part 15 Subpart B, the host manufacturer is required to show compliance with Part 15 Subpart B while the transmitter module(s) are installed and operating. The modules should be transmitting and the evaluation should confirm that the module's intentional emissions are compliant (i.e. fundamental and out of band emissions). The host manufacturer must verify that there are no additional unintentional emissions other than what is permitted in Part 15 Subpart B or emissions are complaint with the transmitter(s) rule(s). The Grantee will provide guidance to the host manufacturer for Part 15 B requirements if needed.

### Important Note

notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify to **Quectel** that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the USI, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application

### End Product Labeling

When the module is installed in the host device, the FCC/IC ID label must be visible through a window on the final device or it must be visible when an access panel, door or cover is easily re-moved. If not, a second label must be placed on the outside of the final device that contains the following text: "Contains FCC ID: **XMR2023EM160RGL**" "Contains IC: **10224A-2020EM160GL**". The FCC ID/IC ID can

be used only when all FCC/IC compliance requirements are met.

## Antenna

- (1) The antenna must be installed such that 20 cm is maintained between the antenna and users,
- (2) The transmitter module may not be co-located with any other transmitter or antenna.

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC/IC authorization is no longer considered valid and the FCC ID/IC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC/IC authorization.

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

| Technology         | Frequency Range (MHz) | Antenna Type | Model       | Max Peak Gain (dBi) |
|--------------------|-----------------------|--------------|-------------|---------------------|
| WCDMA & LTE Band 2 | 1850 ~ 1910           | PIFA         | Y0QUE00ABAA | 3.87                |
| WCDMA & LTE Band 4 | 1710 ~ 1755           |              | Y0QUE00ABAA | 3.91                |
| WCDMA & LTE Band 5 | 824 ~ 849             |              | Y0QUE00ABBA | 3.32                |
| LTE Band 7         | 2500 ~ 2570           |              | Y0QUE00ABBA | 3.16                |
| LTE Band 12        | 699 ~ 716             |              | Y0QUE00ABDA | 3.19                |
| LTE Band 13        | 777 ~ 787             |              | Y0QUE00ABBA | 3.28                |
| LTE Band 14        | 788 ~ 798             |              | Y0QUE00ABBA | 3.25                |
| LTE Band 25        | 1850 ~ 1915           |              | Y0QUE00ABAA | 3.87                |
| LTE Band 26        | 814 ~ 849             |              | Y0QUE00ABBA | 3.32                |
| LTE Band 30        | 2305 ~ 2315           |              | Y0QUE00ABCA | 0.98                |
| LTE Band 38        | 2570 ~ 2620           |              | Y0QUE00ABBA | 3.07                |
| LTE Band 41        | 2496 ~ 2690           |              | Y0QUE00ABBA | 3.16                |
| LTE Band 66        | 1710 ~ 1780           |              | Y0QUE00ABAA | 3.91                |

## **Manual Information to the End User**

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

## **Federal Communication Commission Interference Statement**

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 equipment 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 radiate 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 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.

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

## **List of applicable FCC rules**

This module has been tested and found to comply with part 22, part 24, part 27, part 90, part 96 requirements for Modular Approval.

The modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is

responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuitry), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

**This device is intended only for OEM integrators under the following conditions: (For module device use)**

- 1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and
- 2) The transmitter module may not be co-located with any other transmitter or antenna.

As long as 2 conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

**Radiation Exposure Statement**

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator & your body.

## **Industry Canada Statement**

This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions:

- (1) This device may not cause interference; and
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

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

## **Radiation Exposure Statement**

This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator & your body

Déclaration d'exposition aux radiations:

Cet équipement est conforme aux limites d'exposition aux rayonnements ISSED établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20 cm de distance entre la source de rayonnement et votre corps.

## **This device is intended only for OEM integrators under the following conditions: (For module device use)**

- 1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and
- 2) The transmitter module may not be co-located with any other transmitter or antenna. As long as 2 conditions above are met, further transmitter test will not be

required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

**Cet appareil est conçu uniquement pour les intégrateurs OEM dans les conditions suivantes: (Pour utilisation de dispositif module)**

- 1) L'antenne doit être installée de telle sorte qu'une distance de 20 cm est respectée entre l'antenne et les utilisateurs, et
- 2) Le module émetteur peut ne pas être coïmplanté avec un autre émetteur ou antenne.

Tant que les 2 conditions ci-dessus sont remplies, des essais supplémentaires sur l'émetteur ne seront pas nécessaires. Toutefois, l'intégrateur OEM est toujours responsable des essais sur son produit final pour toutes exigences de conformité supplémentaires requis pour ce module installé.

**IMPORTANT NOTE:**

In the event that these conditions cannot be met (for example certain laptop configurations or colocation with another transmitter), then the Canada authorization is no longer considered valid and the IC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate Canada authorization.

**NOTE IMPORTANTE:**

Dans le cas où ces conditions ne peuvent être satisfaites (par exemple pour certaines configurations d'ordinateur portable ou de certaines co-localisation avec un autre émetteur), l'autorisation du Canada n'est plus considéré comme valide et l'ID IC ne peut pas être utilisé sur le produit final. Dans ces circonstances, l'intégrateur OEM sera chargé de réévaluer le produit final (y compris l'émetteur) et l'obtention d'une autorisation distincte au Canada.

**End Product Labeling**

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: "Contains IC: 10224A-2020EM160GL".

## **Plaque signalétique du produit final**

Ce module émetteur est autorisé uniquement pour une utilisation dans un dispositif où l'antenne peut être installée de telle sorte qu'une distance de 20cm peut être maintenue entre l'antenne et les utilisateurs. Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: "Contient des IC: 10224A-2020EM160GL".

## **Manual Information to the End User**

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

## **Manuel d'information à l'utilisateur final**

L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module.

Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel.