

Module : EC25-AUX

# EC25 Hardware Design

**LTE Standard Module Series**

Rev. EC25\_Hardware\_Design\_V2.2

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# About the Document

## History

| Revision | Date       | Author                       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------|------------|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.0      | 2016-04-01 | Woody WU                     | Initial                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 1.1      | 2016-09-22 | Lyndon LIU/<br>Frank WANG    | <ol style="list-style-type: none"> <li>Updated EC25 series frequency bands in Table 1.</li> <li>Updated transmitting power, supported maximum baud rate of main UART/internal protocols/USB drivers of USB interface, firmware upgrade and temperature range in Table 2.</li> <li>Updated timing of turning on module in Figure 12.</li> <li>Updated timing of turning off module in Figure 13.</li> <li>Updated timing of resetting module in Figure 16.</li> <li>Updated supported baud rates of main UART in Chapter 3.11.</li> <li>Added notes for ADC interface in Chapter 3.13.</li> <li>Updated GNSS performance in Table 21.</li> <li>Updated operating frequencies of module in Table 23.</li> <li>Added current consumption in Chapter 6.4.</li> <li>Updated RF output power in Chapter 6.5.</li> <li>Added RF receiving sensitivity in Chapter 6.6.</li> </ol> |
| 1.2      | 2016-11-04 | Lyndon LIU/<br>Michael ZHANG | <ol style="list-style-type: none"> <li>Added SGMII and WLAN interfaces in Table 2.</li> <li>Updated function diagram in Figure 1.</li> <li>Updated pin assignment (Top View) in Figure 2.</li> <li>Added description of SGMII and WLAN interfaces in Table 4.</li> <li>Added SGMII interface in Chapter 3.17.</li> <li>Added WLAN interface in Chapter 3.18.</li> <li>Added USB_BOOT interface in Chapter 3.19.</li> <li>Added reference design of RF layout in Chapter 5.1.4.</li> <li>Added note about SIMO in Chapter 6.6.</li> </ol>                                                                                                                                                                                                                                                                                                                                  |
| 1.3      | 2017-01-24 | Lyndon LIU/<br>Frank WANG    | <ol style="list-style-type: none"> <li>Updated function diagram in Figure 1.</li> <li>Updated pin assignment (top view) in Figure 2.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

|     |            |                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----|------------|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|     |            |                                           | <ol style="list-style-type: none"> <li>Added BT interface in Chapter 3.18.2.</li> <li>Updated GNSS performance in Table 24.</li> <li>Updated reference circuit of wireless connectivity interfaces with FC20 module in Figure 29.</li> <li>Updated current consumption of EC25-E module in Table 33.</li> <li>Updated EC25-A conducted RF receiving sensitivity in Table 38.</li> <li>Added EC25-J conducted RF receiving sensitivity in Table 40.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 1.4 | 2018-03-05 | AnniceZHANG/<br>Lyndon LIU/<br>Frank WANG | <ol style="list-style-type: none"> <li>Updated functional diagram in Figure 1.</li> <li>Updated LTE, UMTS and GSM features in Table 2.</li> <li>Updated description of pin 40/136/137/138.</li> <li>Updated PWRKEY pulled down time to 500ms in Chapter 3.7.1 and reference circuit in Figure 10.</li> <li>Updated reference circuit of (U)SIM interface in Figure 17&amp;18.</li> <li>Updated reference circuit of USB interface in Figure 19.</li> <li>Updated PCM mode in Chapter 3.12.</li> <li>Added SD card interface in Chapter 3.13.</li> <li>Updated USB_BOOT reference circuit in Chapter 3.20.</li> <li>Updated module operating frequencies in Table 26.</li> <li>Updated antenna requirements in Table 30.</li> <li>Updated EC25 series module current consumption in Chapter 6.4.</li> <li>Updated EC25 series module conducted RF receiving sensitivity in Chapter 6.6.</li> <li>Added thermal consideration description in Chapter 6.8.</li> <li>Added dimension tolerance information in Chapter 7.</li> <li>Added storage temperature range in Table 2 and Chapter 6.3.</li> <li>Updated RF output power in Table 41.</li> <li>Updated GPRS multi-slot classes in Table 53.</li> <li>Updated storage information in Chapter 8.1.</li> </ol> |
| 1.5 | 2018-04-20 | Kinsey ZHANG                              | <ol style="list-style-type: none"> <li>Added information of EC25-AF in Table 1.</li> <li>Updated module operating frequencies in Table 27.</li> <li>Added current consumption of EC25-AF module in Table 40.</li> <li>Changed GNSS current consumption of EC25 series module into Table 41.</li> <li>Added EC25-AF conducted RF receiving sensitivity in</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

Table 50.

|     |            |                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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| 2.0 | 2019-04-30 | Nathan LIU/<br>Frank WANG/<br>Ward WANG/<br>Ethan SHAN | <ol style="list-style-type: none"> <li>1. Added new variants EC25-EU/-EC/-EUX/-MX and related information.</li> <li>2. Updated functional diagram in Figure 1.</li> <li>3. Updated star structure of the power supply in Figure 8.</li> <li>4. Updated power-on scenario of module in Figure 12.</li> <li>5. Updated reference circuit with translator chip in Figure 20.</li> <li>6. Added timing sequence for entering into emergency download mode of USB_BOOT interface in Figure 32.</li> <li>7. Updated general description in Table 1.</li> <li>8. Updated module operating frequencies in Table 27.</li> <li>9. Updated GNSS frequency in Table 29.</li> <li>10. Updated antenna requirements in Table 30.</li> <li>11. Updated EC25-V current consumption in Table 36.</li> <li>12. Added EC25-EU current consumption in Table 41</li> <li>13. Added EC25-EC current consumption in Table 42.</li> <li>14. Added EC25-EUX current consumption in Table 43.</li> <li>15. Added EC25-MX current consumption in Table 44.</li> <li>16. Updated EC25-E conducted RF receiving sensitivity in Table 47.</li> <li>17. Updated EC25-A conducted RF receiving sensitivity in Table 48.</li> <li>18. Updated EC25-V conducted RF receiving sensitivity in Table 49.</li> <li>19. Updated EC25-AUT conducted RF receiving sensitivity in Table 52.</li> <li>20. Updated EC25-AUTL conducted RF receiving sensitivity in Table 53.</li> <li>21. Added EC25-EU conducted RF receiving sensitivity in Table 55.</li> <li>22. Added EC25-EC conducted RF receiving sensitivity in Table 56.</li> <li>23. Added EC25-EUX conducted RF receiving sensitivity in Table 57.</li> <li>24. Added EC25-MX conducted RF receiving sensitivity in Table 58.</li> <li>25. Updated recommended stencil thickness as 0.18mm~0.20mm and reflow soldering thermal profile in Chapter 8.2.</li> </ol> |
| 2.1 | 2019-07-05 | Fanny CHEN/<br>Ethan SHAN                              | <ol style="list-style-type: none"> <li>1. Added new variants EC25-AFX/-AUX and related information.</li> <li>2. Added notes for interfaces not supported by ThreadX</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

|     |            |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----|------------|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|     |            |                                       | modules.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|     |            |                                       | 3. Updated supported protocols and USB serial drivers in Table 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|     |            |                                       | 4. Updated reference circuit of wireless connectivity interfaces with FC20 module in Figure 26.                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|     |            |                                       | 5. Added EC25-AFX current consumption in Table 41.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|     |            |                                       | 6. Added EC25-AFX conducted RF receiving sensitivity in Table 56.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|     |            |                                       | 7. Updated mechanical dimensions of the module in Figure 45.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|     |            |                                       | 8. Added tape and reel directions in Figure 51.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 2.2 | 2019-08-19 | Ward WANG/<br>Owen WEI/<br>Frank WANG | 1. Updated EC25-J current consumption in Table 37.<br>2. Deleted the LTE-TDD bands information of EC25-AUT current consumption in Table 39.<br>3. Updated EC25-EC current consumption in Table 43.<br>4. Updated EC25-EUX current consumption in Table 44.<br>5. Added EC25-AUX current consumption in Table 46.<br>6. Updated EC25-AU conducted RF receiving sensitivity in Table 53.<br>7. Updated EC25-EU conducted RF receiving sensitivity in Table 58.<br>8. Added EC25-AUX conducted RF receiving sensitivity in Table 62. |

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# 1 Introduction

This document defines EC25 module and describes its air interface and hardware interfaces which are connected with customers' applications.

This document can help customers quickly understand module interface specifications, electrical and mechanical details, as well as other related information of EC25 module. To facilitate its application in different fields, relevant reference design is also provided for customers' reference. Associated with application note and user guide, customers can use EC25 module to design and set up mobile applications easily.

1. CAUTION : RISK OF EXPLOSION IF BATTERY IS REPLACED BY AN INCORRECT TYPE. DISPOSE OF USED BATTERIES ACCORDING TO THE INSTRUCTIONS.
2. Operating temperature: -40 °C to 85° C
3. EC25-AUX, EC25-AUX MINIPCI support frequency bands : GSM900/1800 , WCDMA I/V/VIII, LTE Band 1/3/5/7/8/20/28/40 ;
4. EC25-AUX, EC25-AUX MINIPCI max output power :  
GSM900/1800 , WCDMA I/V/VIII, LTE Band 1/3/5/7/8/20/28/40 : 23dBm ;

The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter and must be installed to provide a separation distance of at least 20cm from all persons.

## Declaration of Conformity

Hereby, Quectel Wireless Solutions Co., Ltd

declares that the radio equipment type EC25-AUX, EC25-AUX  
MINIPCI is in compliance with

Directives: 2014/53/EU. The full text of the EU declaration of conformity is available  
at the following internet

address: <http://www.quectel.com/support/downloadb/TechnicalDocuments.htm>

## 1.1. Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating EC25 module. Manufacturers of the cellular terminal should send the following safety information to users and operating personnel, and incorporate these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for customers' failure to comply with these precautions.



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



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



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



Cellular terminals or mobiles operating over radio signals and cellular network cannot be guaranteed to connect in all possible conditions (for example, with unpaid bills or with an invalid (U)SIM card). When emergent help is needed in such conditions, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength.



The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.



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

---

# 2 Product Concept

## 2.1. General Description

EC25 is a series of LTE-FDD/LTE-TDD/WCDMA/GSM wireless communication module with receive diversity. It provides data connectivity on LTE-FDD, LTE-TDD, DC-HSDPA, HSPA+, HSDPA, HSUPA, WCDMA, EDGE and GPRS networks. It also provides GNSS<sup>1)</sup> and voice functionality<sup>2)</sup> for customers' specific applications. EC25 contains 14 variants: EC25-E, EC25-A, EC25-V, EC25-J, EC25-AU, EC25-AUX, EC25-AUT, EC25-AF, EC25-AFX, EC25-EU, EC25-EUX, EC25-AUTL, EC25-EC and EC25-MX. Customers can choose a dedicated type based on the region or operator. The following table shows the frequency bands of EC25 series module.

**Table 1: Frequency Bands of EC25 Series Module**

| Modules <sup>2)</sup>        | LTE Bands                                                    | WCDMA Bands        | GSM Bands                | Rx-diversity | GNSS <sup>1)</sup>                                          |
|------------------------------|--------------------------------------------------------------|--------------------|--------------------------|--------------|-------------------------------------------------------------|
| <b>EC25-E</b>                | FDD: B1/B3/B5/B7/B8/B20<br>TDD: B38/B40/B41                  | B1/B5/B8           | 900/1800MHz              | Y            |                                                             |
| <b>EC25-A</b>                | FDD: B2/B4/B12                                               | B2/B4/B5           | N                        | Y            |                                                             |
| <b>EC25-V</b>                | FDD: B4/B13                                                  | N                  | N                        | Y            |                                                             |
| <b>EC25-J</b>                | FDD: B1/B3/B8/B18/B19/<br>B26<br>TDD: B41                    | B1/B6/B8/B19       | N                        | Y            | GPS,<br>GLONASS,<br>BeiDou/<br>Compass,<br>Galileo,<br>QZSS |
| <b>EC25-AU<sup>3)</sup></b>  | FDD: B1/B2/B3/B4/B5/B7/<br>B8/B28<br>TDD: B40                | B1/B2/B5/B8        | 850/900/<br>1800/1900MHz | Y            |                                                             |
| <b>EC25-AUX<sup>4)</sup></b> | FDD: B1/B2 <sup>3)</sup> /B3/B4/B5/B7/<br>B8/B28<br>TDD: B40 | B1/B2/B4/B5/<br>B8 | 850/900/<br>1800/1900MHz | Y            |                                                             |
| <b>EC25-AUT</b>              | FDD: B1/B3//B5/B7/B28                                        | B1/B5              | N                        | Y            |                                                             |
| <b>EC25-AF</b>               | FDD: B2/B4//B5/B12/B13/<br>B14/B66/B71                       | B2/B4/B5           | N                        | Y            |                                                             |

|                               |                                                   |          |             |   |   |
|-------------------------------|---------------------------------------------------|----------|-------------|---|---|
| <b>EC25-AFX</b> <sup>4)</sup> | FDD: B2/B4//B5/B12/B13/<br>B14/B66/B71            | B2/B4/B5 | N           | Y |   |
| <b>EC25-EU</b>                | FDD: B1/B3/B7/B8/B20/<br>B28A<br>TDD: B38/B40/B41 | B1/B8    | 900/1800MHz | Y |   |
| <b>EC25-EUX</b> <sup>4)</sup> | FDD: B1/B3/B7/B8/B20/<br>B28A<br>TDD: B38/B40/B41 | B1/B8    | 900/1800MHz | Y |   |
| <b>EC25-AUTL</b>              | FDD: B3/B7/B28                                    | N        | N           | Y | N |
| <b>EC25-EC</b>                | FDD: B1/B3/B7/B8/B20/<br>B28A                     | B1/B8    | 900/1800MHz | Y | N |
| <b>EC25-MX</b> <sup>4)</sup>  | FDD: B2/B4//B5/B7/B28/<br>B66                     | B2/B4/B5 | N           | Y | N |

#### NOTES

- <sup>1)</sup> GNSS function is optional.
- <sup>2)</sup> EC25 series module contains **Telematics** version and **Data-only** version. **Telematics** version supports voice and data functions, while **Data-only** version only supports data function.
- <sup>3)</sup> B2 band on EC25-AU and EC25-AUX modules do not support Rx-diversity.
- <sup>4)</sup> EC25-AFX, EC25-EUX, EC25-AUX and EC25-MX are based on ThreadX OS.
- Y = Supported. N = Not supported.

With a compact profile of 29.0mm × 32.0mm × 2.4mm, EC25 can meet almost all requirements for M2M applications such as automotive, metering, tracking system, security, router, wireless POS, mobile computing device, PDA phone, tablet PC, etc.

EC25 is an SMD type module which can be embedded into applications through its 144-pin pads, including 80 LCC signal pads and 64 LGA pads.

## 2.2. Key Features

The following table describes the detailed features of EC25 module.

**Table 2: Key Features of EC25 Module**

| Features     | Details                                                   |
|--------------|-----------------------------------------------------------|
| Power Supply | Supply voltage: 3.3V~4.3V<br>Typical supply voltage: 3.8V |

|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Transmitting Power         | Class 4 (33dBm±2dB) for GSM850<br>Class 4 (33dBm±2dB) for EGSM900<br>Class 1 (30dBm±2dB) for DCS1800<br>Class 1 (30dBm±2dB) for PCS1900<br>Class E2 (27dBm±3dB) for GSM850 8-PSK<br>Class E2 (27dBm±3dB) for EGSM900 8-PSK<br>Class E2 (26dBm±3dB) for DCS1800 8-PSK<br>Class E2 (26dBm±3dB) for PCS1900 8-PSK<br>Class 3 (24dBm+1/-3dB) for WCDMA bands<br>Class 3 (23dBm±2dB) for LTE-FDD bands<br>Class 3 (23dBm±2dB) for LTE-TDD bands |
| LTE Features               | Support up to non-CA Cat 4 FDD and TDD<br>Support 1.4/3/5/10/15/20MHz RF bandwidth<br>Support MIMO in DL direction<br>LTE-FDD: Max 150Mbps (DL)/Max 50Mbps (UL)<br>LTE-TDD: Max 130Mbps (DL)/Max 30Mbps (UL)                                                                                                                                                                                                                               |
| UMTS Features              | Support 3GPP R8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA<br>Support QPSK, 16-QAM and 64-QAM modulation<br>DC-HSDPA: Max 42Mbps (DL)<br>HSUPA: Max 5.76Mbps (UL)<br>WCDMA: Max 384Kbps (DL)/Max 384Kbps (UL)                                                                                                                                                                                                                                 |
| GSM Features               | <b>GPRS:</b><br>Support GPRS multi-slot class 33 (33 by default)<br>Coding scheme: CS-1, CS-2, CS-3 and CS-4<br>Max 107Kbps (DL)/Max 85.6Kbps (UL)<br><b>EDGE:</b><br>Support EDGE multi-slot class 33 (33 by default)<br>Support GMSK and 8-PSK for different MCS (Modulation and Coding Scheme)<br>Downlink coding schemes: CS 1-4 and MCS 1-9<br>Uplink coding schemes: CS 1-4 and MCS 1-9<br>Max 296Kbps (DL)/Max 236.8Kbps (UL)       |
| Internet Protocol Features | Support TCP/UDP/PPP/FTP/FTPS/HTTP/HTTPS/NTP/PING/QMI/NITZ/MMS/SMTP/SSL/MQTT/FILE/CMUX*/SMTPS* protocols<br>Support PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) protocols which are usually used for PPP connections                                                                                                                                                                      |
| SMS                        | Text and PDU mode<br>Point to point MO and MT<br>SMS cell broadcast<br>SMS storage: ME by default                                                                                                                                                                                                                                                                                                                                          |
| (U)SIM Interface           | Support USIM/SIM card: 1.8V, 3.0V                                                                                                                                                                                                                                                                                                                                                                                                          |

|                                                |                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Audio Features                                 | Support one digital audio interface: PCM interface<br>GSM: HR/FR/EFR/AMR/AMR-WB<br>WCDMA: AMR/AMR-WB<br>LTE: AMR/AMR-WB<br>Support echo cancellation and noise suppression                                                                                                                                                                                |
| PCM Interface                                  | Used for audio function with external codec<br>Support 16-bit linear data format<br>Support long frame synchronization and short frame synchronization<br>Support master and slave modes, but must be the master in long frame synchronization                                                                                                            |
| USB Interface                                  | Compliant with USB 2.0 specification (slave only); the data transfer rate can reach up to 480Mbps<br>Used for AT command communication, data transmission, GNSS NMEA output, software debugging, firmware upgrade and voice over USB<br>Support USB serial drivers for: Windows 7/8/8.1/10, Linux 2.6/3.x/4.1~4.15, Android 4.x/5.x/6.x/7.x/8.x/9.x, etc. |
| UART Interfaces                                | <b>Main UART:</b><br>Used for AT command communication and data transmission<br>Baud rates reach up to 921600bps, 115200bps by default<br>Support RTS and CTS hardware flow control<br><b>Debug UART:</b><br>Used for Linux console and log output<br>115200bps baud rate                                                                                 |
| SD Card Interface <sup>1)</sup>                | Support SD 3.0 protocol                                                                                                                                                                                                                                                                                                                                   |
| SGMII Interface <sup>1)</sup>                  | Support 10M/100M/1000M Ethernet work mode<br>Support maximum 150Mbps (DL)/50Mbps (UL) for 4G network                                                                                                                                                                                                                                                      |
| Wireless Connectivity Interfaces <sup>1)</sup> | Support a low-power SDIO 3.0 interface for WLAN and UART/PCM interfaces for Bluetooth                                                                                                                                                                                                                                                                     |
| Rx-diversity                                   | Support LTE/WCDMA Rx-diversity                                                                                                                                                                                                                                                                                                                            |
| GNSS Features                                  | Gen8C Lite of Qualcomm<br>Protocol: NMEA 0183                                                                                                                                                                                                                                                                                                             |
| AT Commands                                    | Compliant with 3GPP TS 27.007, 27.005 and Quectel enhanced AT commands                                                                                                                                                                                                                                                                                    |
| Network Indication                             | Two pins including NET_MODE and NET_STATUS to indicate network connectivity status                                                                                                                                                                                                                                                                        |
| Antenna Interfaces                             | Including main antenna interface (ANT_MAIN), Rx-diversity antenna interface (ANT_DIV) and GNSS antenna interface (ANT_GNSS)                                                                                                                                                                                                                               |
| Physical Characteristics                       | Size: (29.0±0.15)mm × (32.0±0.15)mm × (2.4±0.2)mm<br>Weight: approx. 4.9g                                                                                                                                                                                                                                                                                 |
| Temperature Range                              | Operation temperature range: -35°C ~ +75°C <sup>2)</sup><br>Extended temperature range: -40°C ~ +85°C <sup>3)</sup><br>Storage temperature range: -40°C ~ +90°C                                                                                                                                                                                           |

---

|                  |                         |
|------------------|-------------------------|
| Firmware Upgrade | USB interface or DFOTA* |
|------------------|-------------------------|

---

|      |                                                                    |
|------|--------------------------------------------------------------------|
| RoHS | All hardware components are fully compliant with EU RoHS directive |
|------|--------------------------------------------------------------------|

---

**NOTES**

- 1) SD card, wireless connectivity and SGMII interfaces are not supported on ThreadX modules.
- 2) Within operation temperature range, the module is 3GPP compliant.
- 3) Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call\* (emergency call is not supported on ThreadX modules), etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like  $P_{out}$  might reduce in their value and exceed the specified tolerances. When the temperature returns to normal operation temperature levels, the module will meet 3GPP specifications again.
4. "\*" means under development.

## 2.3. Functional Diagram

The following figure shows a block diagram of EC25 and illustrates the major functional parts.

- Power management
- Baseband
- DDR+NAND flash
- Radio frequency
- Peripheral interfaces



In order to help customers develop applications with EC25, Quectel supplies an evaluation board (UMTS&LTE EVB), USB to RS-232 converter cable, earphone, antenna and other peripherals to control or test the module. For more details, please refer to **document [8]**.

# 3 Application Interfaces

## 3.1. General Description

EC25 is equipped with 80 LCC pads plus 64 LGA pads that can be connected to cellular application platform. The subsequent chapters will provide detailed descriptions of the following functions/pins/interfaces.

- Power supply
- (U)SIM interface
- USB interface
- UART interfaces
- PCM and I2C interfaces
- SD card interface<sup>1)</sup>
- ADC interfaces
- Status indication
- SGMII interface<sup>1)</sup>
- Wireless connectivity interfaces<sup>1)</sup>
- USB\_BOOT interface

### NOTE

<sup>1)</sup> SD card, wireless connectivity and SGMII interfaces are not supported on ThreadX modules.

## 3.2. Pin Assignment

The following figure shows the pin assignment of EC25 module.

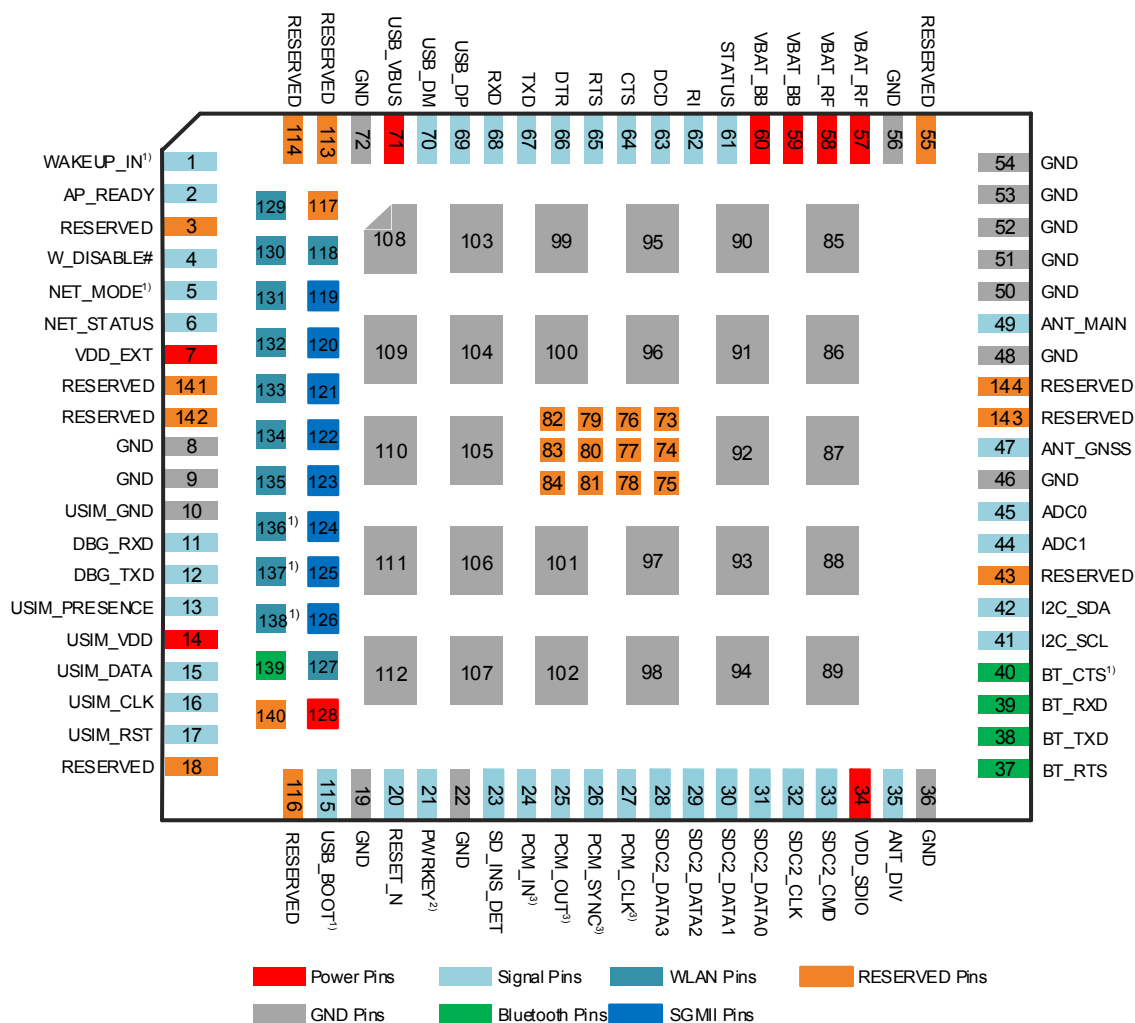


Figure 2: Pin Assignment (Top View)

### NOTES

- <sup>1)</sup> means pins WAKEUP\_IN, NET\_MODE, WLAN\_EN, COEX\_UART\_RX, COEX\_UART\_TX, USB\_BOOT and BT\_CTS cannot be pulled up before startup.
- <sup>2)</sup> PWRKEY output voltage is 0.8V because of the diode drop in the Qualcomm chipset.
- <sup>3)</sup> means digital audio (PCM) is only supported on **Telematics** version.
- Pins 37~40, 118, 127 and 129~139 are used for wireless connectivity interfaces, among which pins 118, 127 and 129~138 are WLAN function pins, and the rest are Bluetooth (BT) function pins. BT function is under development.

5. Pins 119~126 and 128 are used for SGMII interface.
6. Pins 24~27 for PCM function are multiplexing pins used for audio design on EC25 module and BT function on FC20 module.
7. SD card, wireless connectivity and SGMII interfaces (pins 37~40, 118, 127, 129~139, 119~126, 128, 23, 28~34) are not supported on ThreadX modules.
8. Keep all RESERVED pins and unused pins unconnected.
9. GND pins 85~112 should be connected to ground in the design. RESERVED pins 73~84 should not be designed in schematic and PCB decal, and these pins should be served as a keepout area.

### 3.3. Pin Description

The following tables show the pin definition of EC25 module.

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

| Type | Description    |
|------|----------------|
| AI   | Analog Input   |
| AO   | Analog Output  |
| DI   | Digital Input  |
| DO   | Digital Output |
| IO   | Bidirectional  |
| OD   | Open Drain     |
| PI   | Power Input    |
| PO   | Power Output   |

**Table 4: Pin Description**

| Power Supply |         |     |                                         |                                      |                                                         |
|--------------|---------|-----|-----------------------------------------|--------------------------------------|---------------------------------------------------------|
| Pin Name     | Pin No. | I/O | Description                             | DC Characteristics                   | Comment                                                 |
| VBAT_BB      | 59, 60  | PI  | Power supply for module's baseband part | Vmax=4.3V<br>Vmin=3.3V<br>Vnorm=3.8V | It must be provided with sufficient current up to 0.8A. |

|         |                                                             |    |                                   |                                       |                                                                                 |
|---------|-------------------------------------------------------------|----|-----------------------------------|---------------------------------------|---------------------------------------------------------------------------------|
| VBAT_RF | 57, 58                                                      | PI | Power supply for module's RF part | Vmax=4.3V<br>Vmin=3.3V<br>Vnorm=3.8V  | It must be provided with sufficient current up to 1.8A in a burst transmission. |
| VDD_EXT | 7                                                           | PO | Provide 1.8V for external circuit | Vnorm=1.8V<br>I <sub>O</sub> max=50mA | Power supply for external GPIO's pull-up circuits.<br>If unused, keep it open.  |
| GND     | 8, 9, 19,<br>22, 36, 46,<br>48, 50~54,<br>56, 72,<br>85~112 |    | Ground                            |                                       |                                                                                 |

**Power-on/off**

| Pin Name | Pin No. | I/O | Description                | DC Characteristics                                                               | Comment                                                                       |
|----------|---------|-----|----------------------------|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| PWRKEY   | 21      | DI  | Turn on/off the module     | V <sub>H</sub> =0.8V                                                             | The output voltage is 0.8V because of the diode drop in the Qualcomm chipset. |
| RESET_N  | 20      | DI  | Reset signal of the module | V <sub>IH</sub> max=2.1V<br>V <sub>IH</sub> min=1.3V<br>V <sub>IL</sub> max=0.5V | If unused, keep it open.                                                      |

**Status Indication**

| Pin Name   | Pin No. | I/O | Description                                     | DC Characteristics                                     | Comment                                                                                  |
|------------|---------|-----|-------------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------------------------|
| STATUS     | 61      | OD  | Indicate the module operating status            | The drive current should be less than 0.9mA.           | An external pull-up resistor is required.<br>If unused, keep it open.                    |
| NET_MODE   | 5       | DO  | Indicate the module's network registration mode | V <sub>OH</sub> min=1.35V<br>V <sub>OL</sub> max=0.45V | 1.8V power domain.<br>It cannot be pulled up before startup.<br>If unused, keep it open. |
| NET_STATUS | 6       | DO  | Indicate the module's network activity status   | V <sub>OH</sub> min=1.35V<br>V <sub>OL</sub> max=0.45V | 1.8V power domain.<br>If unused, keep it open.                                           |

**USB Interface**

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|----------|---------|-----|-------------|--------------------|---------|
|----------|---------|-----|-------------|--------------------|---------|

|          |    |    |                                          |                                                                              |                                                                    |
|----------|----|----|------------------------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------|
| USB_VBUS | 71 | PI | USB power supply, used for USB detection | V <sub>max</sub> =5.25V<br>V <sub>min</sub> =3.0V<br>V <sub>norm</sub> =5.0V | Typical: 5.0V<br>If unused, keep it open.                          |
| USB_DP   | 69 | IO | USB differential data bus (+)            | Compliant with USB 2.0 standard specification.                               | Require differential impedance of 90Ω.<br>If unused, keep it open. |
| USB_DM   | 70 | IO | USB differential data bus (-)            | Compliant with USB 2.0 standard specification.                               | Require differential impedance of 90Ω.<br>If unused, keep it open. |

#### (U)SIM Interface

| Pin Name      | Pin No. | I/O | Description                      | DC Characteristics                                                                                                                                                                                                                                                                          | Comment                                                       |
|---------------|---------|-----|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| USIM_GND      | 10      |     | Specified ground for (U)SIM card |                                                                                                                                                                                                                                                                                             |                                                               |
| USIM_PRESENCE | 13      | DI  | (U)SIM card insertion detection  | V <sub>IL</sub> min=-0.3V<br>V <sub>IL</sub> max=0.6V<br>V <sub>IH</sub> min=1.2V<br>V <sub>IH</sub> max=2.0V                                                                                                                                                                               | 1.8V power domain.<br>If unused, keep it open.                |
| USIM_VDD      | 14      | PO  | Power supply for (U)SIM card     | <b>For 1.8V(U)SIM:</b><br>V <sub>max</sub> =1.9V<br>V <sub>min</sub> =1.7V<br><br><b>For 3.0V(U)SIM:</b><br>V <sub>max</sub> =3.05V<br>V <sub>min</sub> =2.7V<br>I <sub>O</sub> max=50mA                                                                                                    | Either 1.8V or 3.0V is supported by the module automatically. |
| USIM_DATA     | 15      | IO  | Data signal of (U)SIM card       | <b>For 1.8V (U)SIM:</b><br>V <sub>IL</sub> max=0.6V<br>V <sub>IH</sub> min=1.2V<br>V <sub>OL</sub> max=0.45V<br>V <sub>OH</sub> min=1.35V<br><br><b>For 3.0V (U)SIM:</b><br>V <sub>IL</sub> max=1.0V<br>V <sub>IH</sub> min=1.95V<br>V <sub>OL</sub> max=0.45V<br>V <sub>OH</sub> min=2.55V |                                                               |
| USIM_CLK      | 16      | DO  | Clock signal of (U)SIM card      | <b>For 1.8V (U)SIM:</b><br>V <sub>OL</sub> max=0.45V<br>V <sub>OH</sub> min=1.35V                                                                                                                                                                                                           |                                                               |

|          |    |    |                             |                                                                                                                                            |
|----------|----|----|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
|          |    |    |                             | <b>For 3.0V (U)SIM:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=2.55V$                                                                          |
| USIM_RST | 17 | DO | Reset signal of (U)SIM card | <b>For 1.8V (U)SIM:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$<br><br><b>For 3.0V (U)SIM:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=2.55V$ |

#### Main UART Interface

| Pin Name | Pin No. | I/O | Description                             | DC Characteristics                                                            | Comment                                                                                                   |
|----------|---------|-----|-----------------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| RI       | 62      | DO  | Ring indicator                          | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                        | 1.8V power domain.<br>If unused, keep it open.                                                            |
| DCD      | 63      | DO  | Data carrier detection                  | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                        | 1.8V power domain.<br>If unused, keep it open.                                                            |
| CTS      | 64      | DO  | Clear to send                           | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                        | 1.8V power domain.<br>If unused, keep it open.                                                            |
| RTS      | 65      | DI  | Request to send                         | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>If unused, keep it open.                                                            |
| DTR      | 66      | DI  | Data terminal ready, sleep mode control | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>Pulled up by default.<br>Low level wakes up the module.<br>If unused, keep it open. |
| TXD      | 67      | DO  | Transmit data                           | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                        | 1.8V power domain.<br>If unused, keep it open.                                                            |
| RXD      | 68      | DI  | Receive data                            | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>If unused, keep it open.                                                            |

#### Debug UART Interface

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|----------|---------|-----|-------------|--------------------|---------|
|----------|---------|-----|-------------|--------------------|---------|

| DBG_TXD                           | 12      | DO  | Transmit data                               | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                                                                  | 1.8V power domain.<br>If unused, keep it open.                                                                                     |
|-----------------------------------|---------|-----|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| DBG_RXD                           | 11      | DI  | Receive data                                | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$                                           | 1.8V power domain.<br>If unused, keep it open.                                                                                     |
| <b>ADC Interfaces</b>             |         |     |                                             |                                                                                                                         |                                                                                                                                    |
| Pin Name                          | Pin No. | I/O | Description                                 | DC Characteristics                                                                                                      | Comment                                                                                                                            |
| ADC0                              | 45      | AI  | General purpose analog to digital converter | Voltage range: 0.3V to VBAT_BB                                                                                          | If unused, keep it open.                                                                                                           |
| ADC1                              | 44      | AI  | General purpose analog to digital converter | Voltage range: 0.3V to VBAT_BB                                                                                          | If unused, keep it open.                                                                                                           |
| <b>PCM Interface<sup>1)</sup></b> |         |     |                                             |                                                                                                                         |                                                                                                                                    |
| Pin Name                          | Pin No. | I/O | Description                                 | DC Characteristics                                                                                                      | Comment                                                                                                                            |
| PCM_IN                            | 24      | DI  | PCM data input                              | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$                                           | 1.8V power domain.<br>If unused, keep it open.                                                                                     |
| PCM_OUT                           | 25      | DO  | PCM data output                             | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                                                                  | 1.8V power domain.<br>If unused, keep it open.                                                                                     |
| PCM_SYNC                          | 26      | IO  | PCM data frame synchronization signal       | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>In master mode, it is an output signal.<br>In slave mode, it is an input signal.<br>If unused, keep it open. |
| PCM_CLK                           | 27      | IO  | PCM clock                                   | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>In master mode, it is an output signal.<br>In slave mode, it is an input signal.<br>If unused, keep it open. |
| <b>I2C Interface</b>              |         |     |                                             |                                                                                                                         |                                                                                                                                    |

| Pin Name                 | Pin No. | I/O | Description                                   | DC Characteristics                                                                                                                                                                                                                                                                                             | Comment                                                                                                                                               |
|--------------------------|---------|-----|-----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| I2C_SCL                  | 41      | OD  | I2C serial clock.<br>Used for external codec. |                                                                                                                                                                                                                                                                                                                | An external pull-up resistor is required.<br>1.8V only.<br>If unused, keep it open.                                                                   |
| I2C_SDA                  | 42      | OD  | I2C serial data.<br>Used for external codec.  |                                                                                                                                                                                                                                                                                                                | An external pull-up resistor is required.<br>1.8V only.<br>If unused, keep it open.                                                                   |
| <b>SD Card Interface</b> |         |     |                                               |                                                                                                                                                                                                                                                                                                                |                                                                                                                                                       |
| Pin Name                 | Pin No. | I/O | Description                                   | DC Characteristics                                                                                                                                                                                                                                                                                             | Comment                                                                                                                                               |
| SDC2_DATA3               | 28      | IO  | SD card SDIO bus DATA3                        | <b>1.8V signaling:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.4V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.58V$<br>$V_{IHmin}=1.27V$<br>$V_{IHmax}=2.0V$<br><br><b>3.0V signaling:</b><br>$V_{OLmax}=0.38V$<br>$V_{OHmin}=2.01V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.76V$<br>$V_{IHmin}=1.72V$<br>$V_{IHmax}=3.34V$ | SDIO signal level can be selected according to SD card supported level, please refer to SD 3.0 protocol for more details.<br>If unused, keep it open. |
| SDC2_DATA2               | 29      | IO  | SD card SDIO bus DATA2                        | <b>1.8V signaling:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.4V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.58V$<br>$V_{IHmin}=1.27V$<br>$V_{IHmax}=2.0V$<br><br><b>3.0V signaling:</b><br>$V_{OLmax}=0.38V$<br>$V_{OHmin}=2.01V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.76V$<br>$V_{IHmin}=1.72V$                      | SDIO signal level can be selected according to SD card supported level, please refer to SD 3.0 protocol for more details.<br>If unused, keep it open. |

|             |    |    |                          |                                                                                                                                                                                                                                                                                                                |                                                                                                                                                    |
|-------------|----|----|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
|             |    |    |                          | $V_{IHmax}=3.34V$                                                                                                                                                                                                                                                                                              |                                                                                                                                                    |
| SDC2_ DATA1 | 30 | IO | SD card SDIO bus DATA1   | <b>1.8V signaling:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.4V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.58V$<br>$V_{IHmin}=1.27V$<br>$V_{IHmax}=2.0V$<br><br><b>3.0V signaling:</b><br>$V_{OLmax}=0.38V$<br>$V_{OHmin}=2.01V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.76V$<br>$V_{IHmin}=1.72V$<br>$V_{IHmax}=3.34V$ | SDIO signal level can be selected according to SD card supported level, please refer to SD 3.0 protocol for more details. If unused, keep it open. |
| SDC2_ DATA0 | 31 | IO | SD card SDIO bus DATA0   | <b>1.8V signaling:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.4V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.58V$<br>$V_{IHmin}=1.27V$<br>$V_{IHmax}=2.0V$<br><br><b>3.0V signaling:</b><br>$V_{OLmax}=0.38V$<br>$V_{OHmin}=2.01V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.76V$<br>$V_{IHmin}=1.72V$<br>$V_{IHmax}=3.34V$ | SDIO signal level can be selected according to SD card supported level, please refer to SD 3.0 protocol for more details. If unused, keep it open. |
| SDC2_CLK    | 32 | DO | SD card SDIO bus clock   | <b>1.8V signaling:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.4V$<br><br><b>3.0V signaling:</b><br>$V_{OLmax}=0.38V$<br>$V_{OHmin}=2.01V$                                                                                                                                                                        | SDIO signal level can be selected according to SD card supported level, please refer to SD 3.0 protocol for more details. If unused, keep it open. |
| SDC2_CMD    | 33 | IO | SD card SDIO bus command | <b>1.8V signaling:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.4V$<br>$V_{ILmin}=-0.3V$                                                                                                                                                                                                                           | SDIO signal level can be selected according to SD card supported level, please refer to                                                            |

|            |    |    |                                |                                                                                                                                                                                                                        |                                                                                           |
|------------|----|----|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
|            |    |    |                                | $V_{ILmax}=0.58V$<br>$V_{IHmin}=1.27V$<br>$V_{IHmax}=2.0V$<br><br><b>3.0V signaling:</b><br>$V_{OLmax}=0.38V$<br>$V_{OHmin}=2.01V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.76V$<br>$V_{IHmin}=1.72V$<br>$V_{IHmax}=3.34V$ | SD 3.0 protocol for more details.<br>If unused, keep it open.                             |
| SD_INS_DET | 23 | DI | SD card insertion detect       | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$                                                                                                                                          | 1.8V power domain.<br>If unused, keep it open.                                            |
| VDD_SDIO   | 34 | PO | SD card SDIO bus pull-up power | $I_{Omax}=50mA$                                                                                                                                                                                                        | 1.8V/2.85V configurable.<br>Cannot be used for SD card power.<br>If unused, keep it open. |

#### SGMII Interface

| Pin Name    | Pin No. | I/O | Description                                    | DC Characteristics                                                                                                                                | Comment                                              |
|-------------|---------|-----|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| EPHY_RST_N  | 119     | DO  | Ethernet PHY reset                             | <b>For 1.8V:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.4V$<br><br><b>For 2.85V:</b><br>$V_{OLmax}=0.35V$<br>$V_{OHmin}=2.14V$                      | 1.8V/2.85V power domain.<br>If unused, keep it open. |
| EPHY_INT_N  | 120     | DI  | Ethernet PHY interrupt                         | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$                                                                     | 1.8V power domain.<br>If unused, keep it open.       |
| SGMII_MDATA | 121     | IO  | SGMII MDIO (Management Data Input/Output) data | <b>For 1.8V:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.4V$<br>$V_{ILmax}=0.58V$<br>$V_{IHmin}=1.27V$<br><br><b>For 2.85V:</b><br>$V_{OLmax}=0.35V$ | 1.8V/2.85V power domain.<br>If unused, keep it open. |

|            |     |    |                                                 |                                                                                                                              |                                                                                                                             |
|------------|-----|----|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
|            |     |    |                                                 | $V_{OHmin}=2.14V$<br>$V_{ILmax}=0.71V$<br>$V_{IHmin}=1.78V$                                                                  |                                                                                                                             |
| SGMII_MCLK | 122 | DO | SGMII MDIO (Management Data Input/Output) clock | <b>For 1.8V:</b><br>$V_{OLmax}=0.45V$<br>$V_{OHmin}=1.4V$<br><br><b>For 2.85V:</b><br>$V_{OLmax}=0.35V$<br>$V_{OHmin}=2.14V$ | 1.8V/2.85V power domain.<br>If unused, keep it open.                                                                        |
| USIM2_VDD  | 128 | PO | SGMII MDIO pull-up power source                 |                                                                                                                              | Configurable power source.<br>1.8V/2.85V power domain.<br>External pull-up for SGMII MDIO pins.<br>If unused, keep it open. |
| SGMII_TX_M | 123 | AO | SGMII transmission - minus                      |                                                                                                                              | Connect with a 0.1uF capacitor, and is close to the PHY side.<br>If unused, keep it open.                                   |
| SGMII_TX_P | 124 | AO | SGMII transmission - plus                       |                                                                                                                              | Connect with a 0.1uF capacitor, and is close to the PHY side.<br>If unused, keep it open.                                   |
| SGMII_RX_P | 125 | AI | SGMII receiving - plus                          |                                                                                                                              | Connect with a 0.1uF capacitor, and is close to EC25 module.<br>If unused, keep it open.                                    |
| SGMII_RX_M | 126 | AI | SGMII receiving - minus                         |                                                                                                                              | Connect with a 0.1uF capacitor, and is close to EC25 module.<br>If unused, keep it open.                                    |

#### Wireless Connectivity Interfaces

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|----------|---------|-----|-------------|--------------------|---------|
|----------|---------|-----|-------------|--------------------|---------|

|                  |     |    |                                               |                                                                                                                         |                                                                                                       |
|------------------|-----|----|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| SDC1_DATA3       | 129 | IO | WLAN SDIO data bus D3                         | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>If unused, keep it open.                                                        |
| SDC1_DATA2       | 130 | IO | WLAN SDIO data bus D2                         | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>If unused, keep it open.                                                        |
| SDC1_DATA1       | 131 | IO | WLAN SDIO data bus D1                         | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>If unused, keep it open.                                                        |
| SDC1_DATA0       | 132 | IO | WLAN SDIO data bus D0                         | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$<br>$V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>If unused, keep it open.                                                        |
| SDC1_CLK         | 133 | DO | WLAN SDIO bus clock                           | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                                                                  | 1.8V power domain.<br>If unused, keep it open.                                                        |
| SDC1_CMD         | 134 | DO | WLAN SDIO bus command                         | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                                                                  | 1.8V power domain.<br>If unused, keep it open.                                                        |
| PM_ENABLE        | 127 | DO | WLAN power control                            | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                                                                  | 1.8V power domain.<br>If unused, keep it open.                                                        |
| WAKE_ON_WIRELESS | 135 | DI | Wake up the host (EC25 module) by FC20 module | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$                                           | 1.8V power domain.<br>Active low.<br>If unused, keep it open.                                         |
| WLAN_EN          | 136 | DO | WLAN function control via FC20 module         | $V_{OLmax}=0.45V$<br>$V_{OHmin}=1.35V$                                                                                  | 1.8V power domain.<br>Active high.<br>Cannot be pulled up before startup.<br>If unused, keep it open. |

|              |     |    |                                     |                                                                                                               |                                                                                       |
|--------------|-----|----|-------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| COEX_UART_RX | 137 | DI | LTE/WLAN&BT coexistence signal      | V <sub>IL</sub> min=-0.3V<br>V <sub>IL</sub> max=0.6V<br>V <sub>IH</sub> min=1.2V<br>V <sub>IH</sub> max=2.0V | 1.8V power domain.<br>Cannot be pulled up before startup.<br>If unused, keep it open. |
| COEX_UART_TX | 138 | DO | LTE/WLAN&BT coexistence signal      | V <sub>OL</sub> max=0.45V<br>V <sub>OH</sub> min=1.35V                                                        | 1.8V power domain.<br>Cannot be pulled up before startup.<br>If unused, keep it open. |
| WLAN_SLP_CLK | 118 | DO | WLAN sleep clock                    |                                                                                                               | If unused, keep it open.                                                              |
| BT_RTS       | 37  | DI | BT UART request to send             | V <sub>IL</sub> min=-0.3V<br>V <sub>IL</sub> max=0.6V<br>V <sub>IH</sub> min=1.2V<br>V <sub>IH</sub> max=2.0V | 1.8V power domain.<br>If unused, keep it open.                                        |
| BT_TXD       | 38  | DO | BT UART transmit data               | V <sub>OL</sub> max=0.45V<br>V <sub>OH</sub> min=1.35V                                                        | 1.8V power domain.<br>If unused, keep it open.                                        |
| BT_RXD       | 39  | DI | BT UART receive data                | V <sub>IL</sub> min=-0.3V<br>V <sub>IL</sub> max=0.6V<br>V <sub>IH</sub> min=1.2V<br>V <sub>IH</sub> max=2.0V | 1.8V power domain.<br>If unused, keep it open.                                        |
| BT_CTS       | 40  | DO | BT UART clear to send               | V <sub>OL</sub> max=0.45V<br>V <sub>OH</sub> min=1.35V                                                        | 1.8V power domain.<br>Cannot be pulled up before startup.<br>If unused, keep it open. |
| BT_EN        | 139 | DO | BT function control via FC20 module | V <sub>OL</sub> max=0.45V<br>V <sub>OH</sub> min=1.35V                                                        | 1.8V power domain.<br>If unused, keep it open.                                        |

#### RF Interfaces

| Pin Name | Pin No. | I/O | Description       | DC Characteristics | Comment                                    |
|----------|---------|-----|-------------------|--------------------|--------------------------------------------|
| ANT_DIV  | 35      | AI  | Diversity antenna |                    | 50Ω impedance.<br>If unused, keep it open. |
| ANT_MAIN | 49      | IO  | Main antenna      |                    | 50Ω impedance.                             |
| ANT_GNSS | 47      | AI  | GNSS antenna      |                    | 50Ω impedance.<br>If unused, keep it open. |

### Other Interface Pins

| Pin Name   | Pin No. | I/O | Description                                 | DC Characteristics                                                            | Comment                                                                                                                        |
|------------|---------|-----|---------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| WAKEUP_IN  | 1       | DI  | Sleep mode control                          | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>Cannot be pulled up before startup.<br>Low level wakes up the module.<br>If unused, keep it open.        |
| W_DISABLE# | 4       | DI  | Airplane mode control                       | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>Pull-up by default.<br>At low voltage level, module can enter airplane mode.<br>If unused, keep it open. |
| AP_READY   | 2       | DI  | Application processor sleep state detection | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>If unused, keep it open.                                                                                 |

### USB\_BOOT Interface

| Pin Name | Pin No. | I/O | Description                                       | DC Characteristics                                                            | Comment                                                                                               |
|----------|---------|-----|---------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| USB_BOOT | 115     | DI  | Force the module to enter emergency download mode | $V_{ILmin}=-0.3V$<br>$V_{ILmax}=0.6V$<br>$V_{IHmin}=1.2V$<br>$V_{IHmax}=2.0V$ | 1.8V power domain.<br>Cannot be pulled up before startup.<br>It is recommended to reserve test point. |

### RESERVED Pins

| Pin Name | Pin No.                                            | I/O | Description | DC Characteristics | Comment                      |
|----------|----------------------------------------------------|-----|-------------|--------------------|------------------------------|
| RESERVED | 3, 18, 43, 55, 73~84, 113, 114, 116, 117, 140-144. |     | Reserved    |                    | Keep these pins unconnected. |

## NOTES

- 1) PCM interface pins are multiplexing pins used for audio design on EC25 module and BT function on FC20 module.
- SD card, wireless connectivity and SGMII interfaces pins are not supported on ThreadX modules.
- BT function is under development.

## 3.4. Operating Modes

The table below briefly summarizes the various operating modes referred in the following chapters.

**Table 5: Overview of Operating Modes**

| Mode                       | Details                                                                                                                                                                                                              |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Normal Operation           | Idle<br>Software is active. The module has registered on the network, and it is ready to send and receive data.                                                                                                      |
|                            | Talk/Data<br>Network connection is ongoing. In this mode, the power consumption is decided by network setting and data transfer rate.                                                                                |
| Minimum Functionality Mode | <b>AT+CFUN</b> command can set the module to a minimum functionality mode without removing the power supply. In this case, both RF function and (U)SIM card will be invalid.                                         |
| Airplane Mode              | <b>AT+CFUN</b> command or W_DISABLE# pin can set the module to airplane mode. In this case, RF function will be invalid.                                                                                             |
| Sleep Mode                 | In this mode, the current consumption of the module will be reduced to the minimal level. During this mode, the module can still receive paging message, SMS, voice call and TCP/UDP data from the network normally. |
| Power Down Mode            | In this mode, the power management unit shuts down the power supply. Software is not active. The serial interface is not accessible. Operating voltage (connected to VBAT_RF and VBAT_BB) remains applied.           |

## 3.5. Power Saving

### 3.5.1. Sleep Mode

EC25 is able to reduce its current consumption to a minimum value during the sleep mode. The following section describes power saving procedures of EC25 module.

### 3.5.1.1. UART Application

If the host communicates with module via UART interface, the following preconditions can let the module enter sleep mode.

- Execute **AT+QSCLK=1** command to enable sleep mode.
- Drive DTR to high level.

The following figure shows the connection between the module and the host.

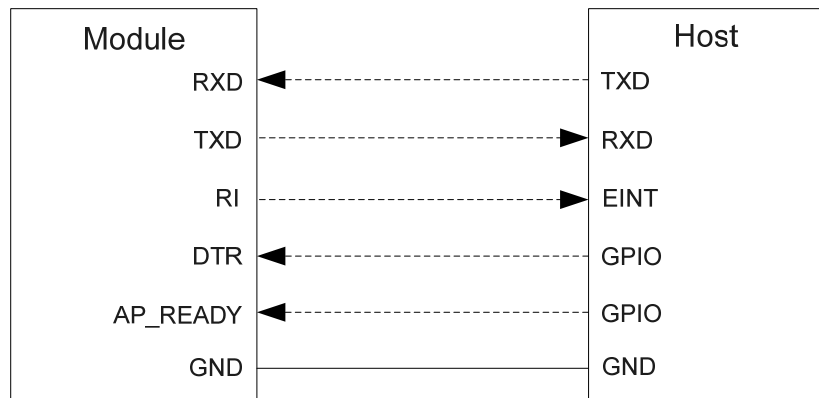


**Figure 3: Sleep Mode Application via UART**

- Driving the host DTR to low level will wake up the module.
- When EC25 has a URC to report, RI signal will wake up the host. Please refer to **Chapter 3.19** for details about RI behaviors.
- AP\_READY will detect the sleep state of the host (can be configured to high level or low level detection). Please refer to **AT+QCFG="apready"** command for details.

### 3.5.1.2. USB Application with USB Remote Wakeup Function

If the host supports USB suspend/resume and remote wakeup functions, the following three preconditions must be met to let the module enter sleep mode.

- Execute **AT+QSCLK=1** command to enable sleep mode.
- Ensure the DTR is held at high level or keep it open.
- The host's USB bus, which is connected with the module's USB interface, enters suspend state.

The following figure shows the connection between the module and the host.

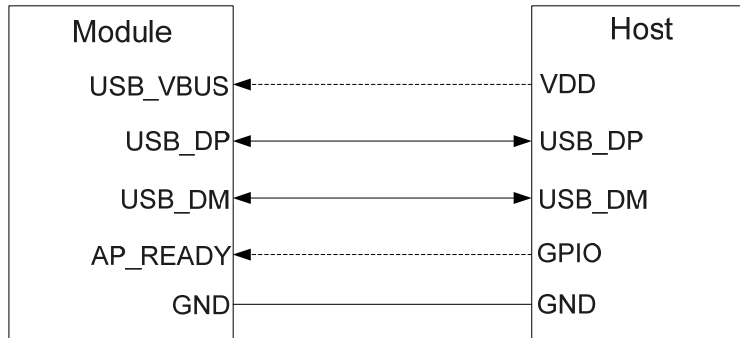


**Figure 4: Sleep Mode Application with USB Remote Wakeup**

Sending data to EC25 via USB will wake up the module.

- When EC25 has a URC to report, the module will send remote wake-up signals via USB bus so as to wake up the host.

### 3.5.1.3. USB Application with USB Suspend/Resume and RI Function

If the host supports USB suspend and resume, but does not support remote wake-up function, the RI signal is needed to wake up the host.

There are three preconditions to let the module enter sleep mode.

- Execute **AT+QSClk=1** command to enable sleep mode.
- Ensure the DTR is held at high level or keep it open.
- The host's USB bus, which is connected with the module's USB interface, enters suspend state.

The following figure shows the connection between the module and the host.

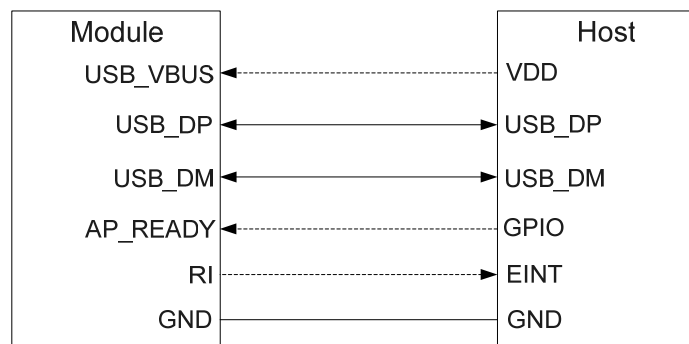


**Figure 5: Sleep Mode Application with RI**

- Sending data to EC25 via USB will wake up the module.
- When EC25 has a URC to report, RI signal will wake up the host.

#### 3.5.1.4. USB Application without USB Suspend Function

If the host does not support USB suspend function, USB\_VBUS should be disconnected via an additional control circuit to let the module enter sleep mode.

- Execute **AT+QSClk=1** command to enable sleep mode.
- Ensure the DTR is held at high level or keep it open.
- Disconnect USB\_VBUS.

The following figure shows the connection between the module and the host.

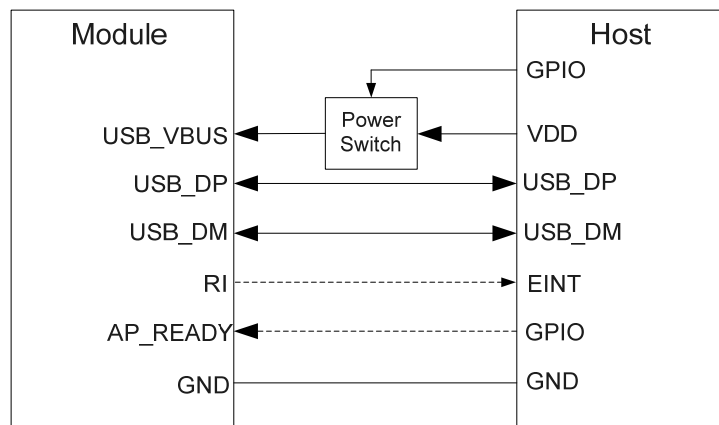


**Figure 6: Sleep Mode Application without Suspend Function**

Switching on the power switch to supply power to USB\_VBUS will wake up the module.

#### NOTE

Please pay attention to the level match shown in dotted line between the module and the host. For more details about EC25 power management application, please refer to **document [1]**.

#### 3.5.2. Airplane Mode

When the module enters airplane mode, the RF function does not work, and all AT commands correlative with RF function will be inaccessible. This mode can be set via the following ways.

## Hardware:

The W\_DISABLE# pin is pulled up by default. Driving it to low level will let the module enter airplane mode.

## Software:

**AT+CFUN** command provides the choice of the functionality level through setting **<fun>** into 0, 1 or 4.

- **AT+CFUN=0**: Minimum functionality mode. Both (U)SIM and RF functions are disabled.
- **AT+CFUN=1**: Full functionality mode (by default).
- **AT+CFUN=4**: Airplane mode. RF function is disabled.

## NOTES

1. The W\_DISABLE# control function is disabled in firmware by default. It can be enabled by **AT+QCFG="airplanecontrol"** command, and this command is under development.
2. The execution of **AT+CFUN** command will not affect GNSS function.

## 3.6. Power Supply

### 3.6.1. Power Supply Pins

EC25 provides four VBAT pins for connection with the external power supply. There are two separate voltage domains for VBAT.

- Two VBAT\_RF pins for module's RF part
- Two VBAT\_BB pins for module's baseband part

The following table shows the details of VBAT pins and ground pins.

**Table 6: VBAT and GND Pins**

| Pin Name | Pin No.                                               | Description                             | Min. | Typ. | Max. | Unit |
|----------|-------------------------------------------------------|-----------------------------------------|------|------|------|------|
| VBAT_RF  | 57, 58                                                | Power supply for module's RF part       | 3.3  | 3.8  | 4.3  | V    |
| VBAT_BB  | 59, 60                                                | Power supply for module's baseband part | 3.3  | 3.8  | 4.3  | V    |
| GND      | 8, 9, 19, 22, 36,<br>46, 48, 50~54,<br>56, 72, 85~112 | Ground                                  | -    | 0    | -    | V    |

### 3.6.2. Decrease Voltage Drop

The power supply range of the module is from 3.3V to 4.3V. Please make sure that the input voltage will never drop below 3.3V. The following figure shows the voltage drop during burst transmission in 2G network. The voltage drop will be less in 3G and 4G networks.

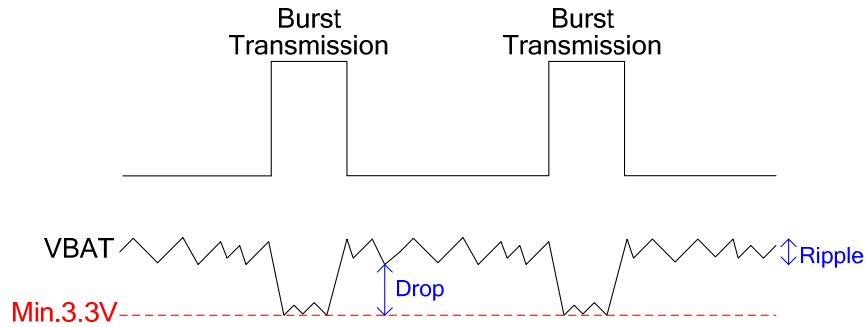


**Figure 7: Power Supply Limits during Burst Transmission**

To decrease voltage drop, a bypass capacitor of about 100μF with low ESR (ESR=0.7Ω) should be used, and a multi-layer ceramic chip (MLCC) capacitor array should also be reserved due to its ultra-low ESR. It is recommended to use three ceramic capacitors (100nF, 33pF, 10pF) for composing the MLCC array, and place these capacitors close to VBAT\_BB/VBAT\_RF pins. The main power supply from an external application has to be a single voltage source and can be expanded to two sub paths with star structure. The width of VBAT\_BB trace should be no less than 1mm; and the width of VBAT\_RF trace should be no less than 2mm. In principle, the longer the VBAT trace is, the wider it will be.

In addition, in order to avoid the damage caused by electric surge and ESD, it is suggested that a TVS diode with suggested low reverse stand-off voltage  $V_{RWM}$  4.5V, low clamping voltage  $V_C$  and high reverse peak pulse current  $I_{PP}$  should be used. The following figure shows the star structure of the power supply.

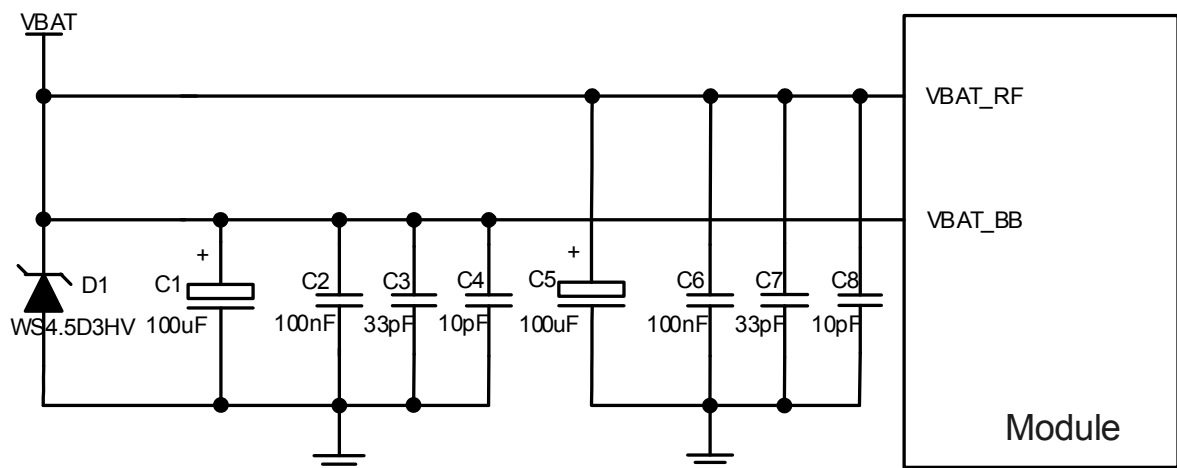


**Figure 8: Star Structure of the Power Supply**

### 3.6.3. Reference Design for Power Supply

Power design for the module is very important, as the performance of the module largely depends on the power source. The power supply should be able to provide sufficient current up to 2.0A at least. If the voltage drop between the input and output is not too high, it is suggested that an LDO should be used to supply power for the module. If there is a big voltage difference between the input source and the desired output (VBAT), a buck converter is preferred to be used as the power supply.

The following figure shows a reference design for +5.0V input power source. The typical output of the power supply is about 3.8V and the maximum load current is 3.0A.

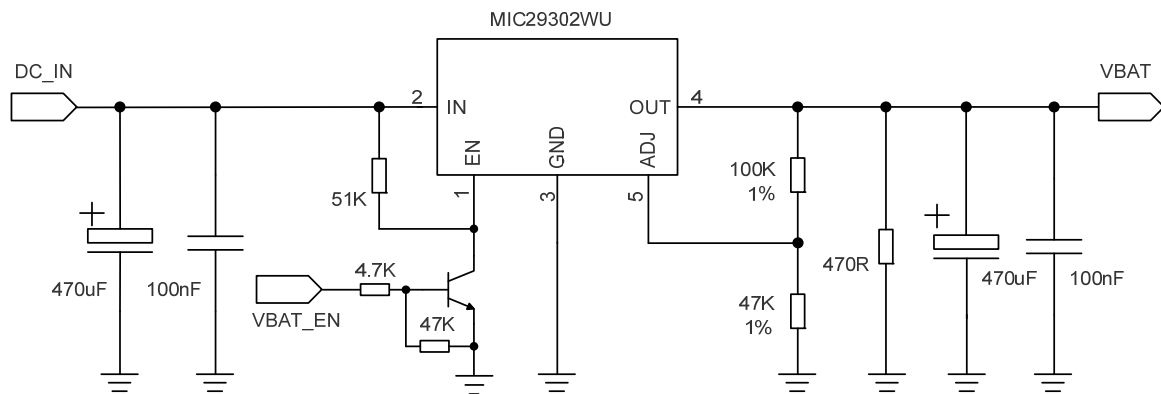


Figure 9: Reference Circuit of Power Supply

#### NOTE

In order to avoid damaging internal flash, please do not switch off the power supply when the module works normally. Only after the module is shut down by PWRKEY or AT command, then the power supply can be cut off.

### 3.6.4. Monitor the Power Supply

AT+CBC command can be used to monitor the VBAT\_BB voltage value. For more details, please refer to [document \[2\]](#).

## 3.7. Power-on/off Scenarios

### 3.7.1. Turn on Module Using the PWRKEY

The following table shows the pin definition of PWRKEY.

**Table 7: Pin Definition of PWRKEY**

| Pin Name | Pin No. | I/O | Description            | Comment                                                                       |
|----------|---------|-----|------------------------|-------------------------------------------------------------------------------|
| PWRKEY   | 21      | DI  | Turn on/off the module | The output voltage is 0.8V because of the diode drop in the Qualcomm chipset. |

When EC25 is in power down mode, it can be turned on to normal mode by driving the PWRKEY pin to a low level for at least 500ms. It is recommended to use an open drain/collector driver to control the PWRKEY. After STATUS pin (require external pull-up resistor) outputs a low level, PWRKEY pin can be released. A simple reference circuit is illustrated in the following figure.

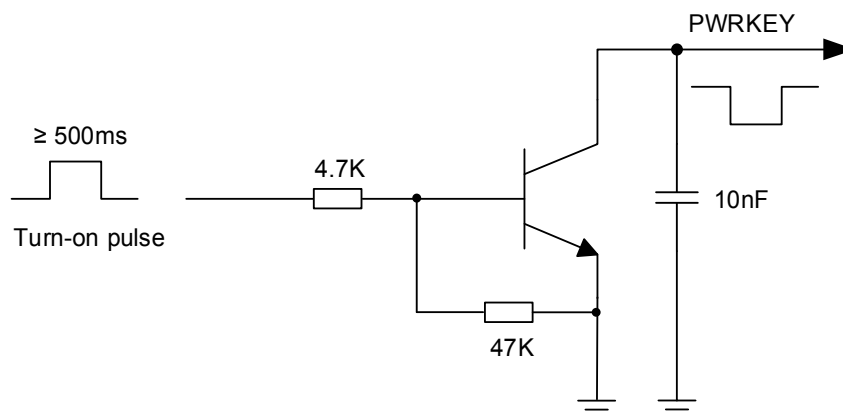


**Figure 10: Turn on the Module by Using Driving Circuit**

The other way to control the PWRKEY is using a button directly. When pressing the key, electrostatic strike may generate from finger. Therefore, a TVS component is indispensable to be placed nearby the button for ESD protection. A reference circuit is shown in the following figure.

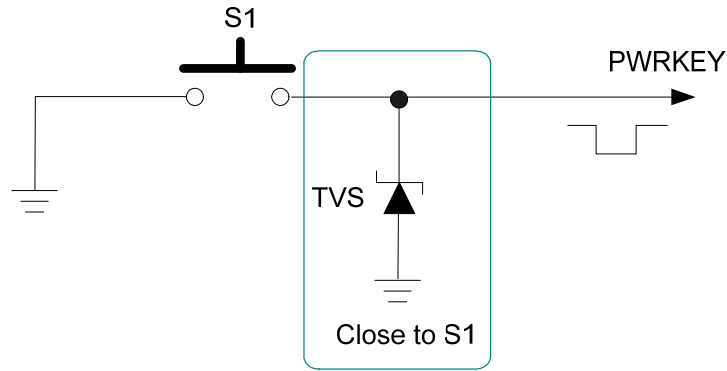


**Figure 11: Turn on the Module by Using Keystroke**

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

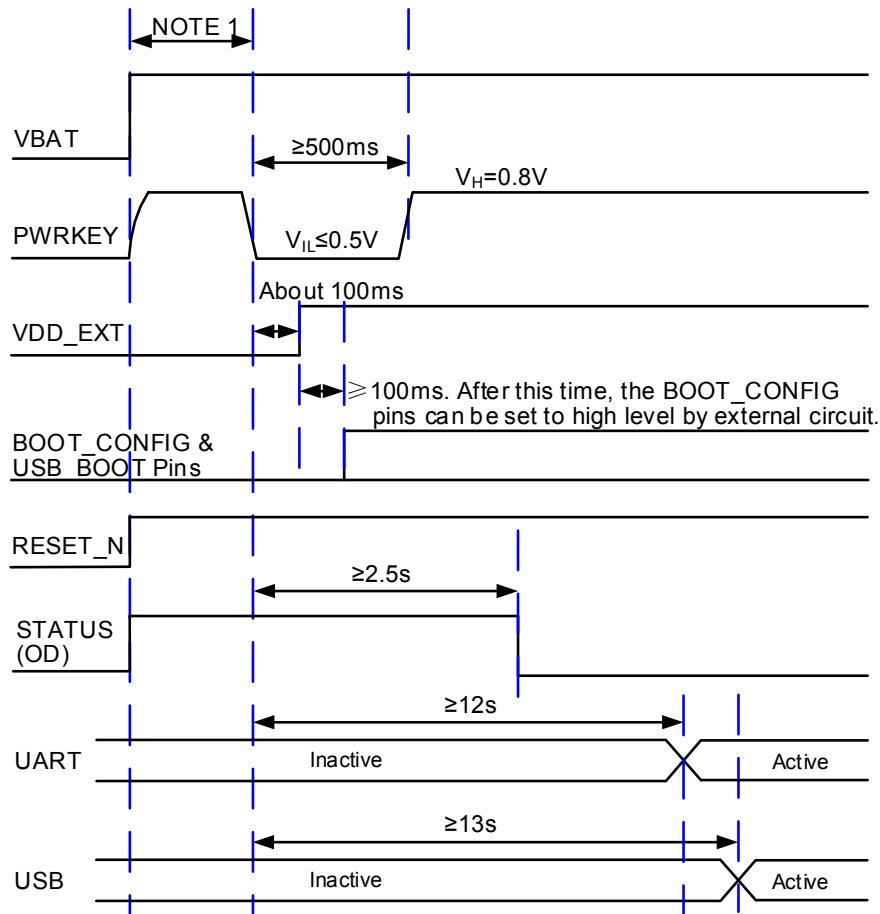


**Figure 12: Timing of Turning on Module**

## NOTES

1. Please make sure that VBAT is stable before pulling down PWRKEY pin. It is recommended that the time between powering up VBAT and pulling down PWRKEY pin is no less than 30ms.
2. PWRKEY can be pulled down directly to GND with a recommended 10KΩ resistor if module needs to be powered on automatically and shutdown is not needed.

### 3.7.2. Turn off Module

The following procedures can be used to turn off the module:

- Normal power-off procedure: Turn off the module using the PWRKEY pin.
- Normal power-off procedure: Turn off the module using **AT+QPOWD** command.

#### 3.7.2.1. Turn off Module Using the PWRKEY Pin

Driving the PWRKEY pin to a low level voltage for at least 650ms, the module will execute power-off procedure after the PWRKEY is released. The power-off scenario is illustrated in the following figure.

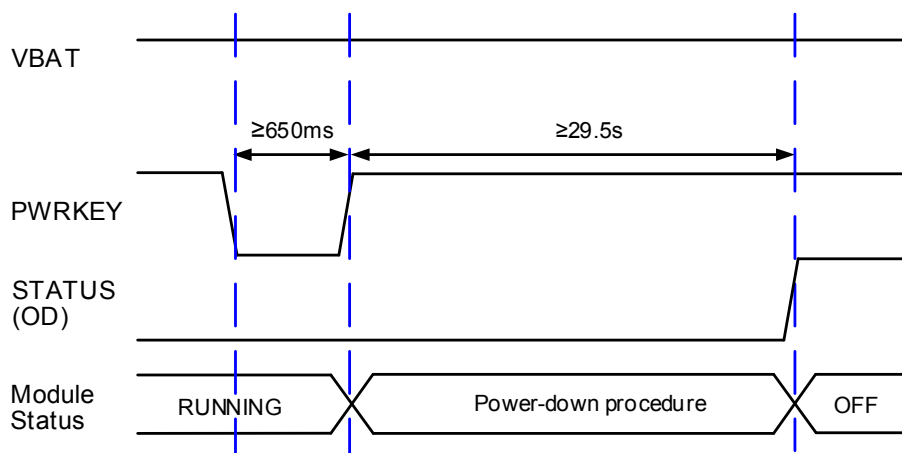


Figure 13: Timing of Turning off Module

#### 3.7.2.2. Turn off Module Using AT Command

It is also a safe way to use **AT+QPOWD** command to turn off the module, which is similar to turning off the module via PWRKEY pin.

Please refer to *document [2]* for details about **AT+QPOWD** command.

## NOTES

1. In order to avoid damaging internal flash, please do not switch off the power supply when the module works normally. Only after the module is shut down by PWRKEY or AT command, then the power supply can be cut off.
2. When turning off module with AT command, please keep PWRKEY at high level after the execution of power-off command. Otherwise the module will be turned on again after successfully turn-off.

## 3.8. Reset Module

The RESET\_N pin can be used to reset the module. The module can be reset by driving RESET\_N to a low level voltage for time between 150ms and 460ms.

Table 8: Pin Definition of RESET\_N

| Pin Name | Pin No. | I/O | Description      | Comment           |
|----------|---------|-----|------------------|-------------------|
| RESET_N  | 20      | DI  | Reset the module | 1.8V power domain |

The recommended circuit is similar to the PWRKEY control circuit. An open drain/collector driver or button can be used to control the RESET\_N.

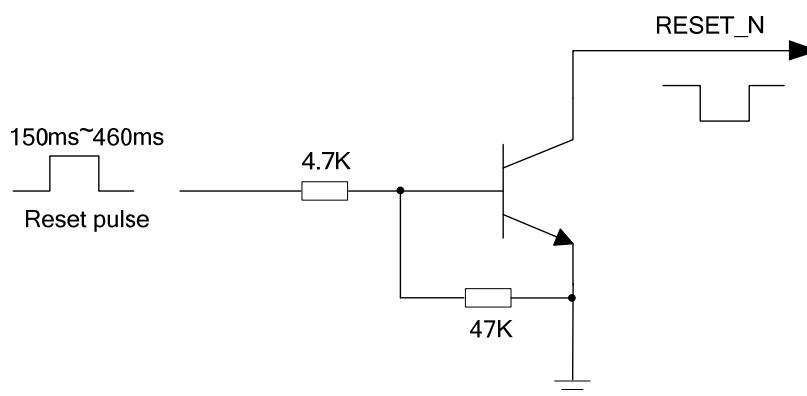


Figure 14: Reference Circuit of RESET\_N by Using Driving Circuit

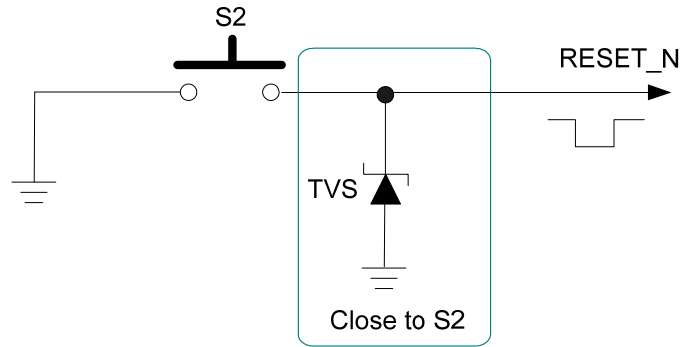


Figure 15: Reference Circuit of RESET\_N by Using Button

The reset scenario is illustrated in the following figure.

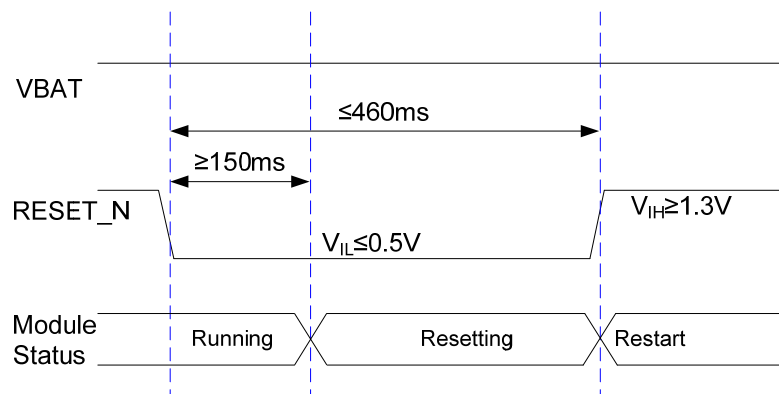


Figure 16: Timing of Resetting Module

#### NOTES

1. Use RESET\_N only when failed to turn off the module by **AT+QPOWD** command and PWRKEY pin.
2. Ensure that there is no large capacitance on PWRKEY and RESET\_N pins.

### 3.9. (U)SIM Interface

The (U)SIM interface circuitry meets ETSI and IMT-2000 requirements. Both 1.8V and 3.0V (U)SIM cards are supported.

**Table 9: Pin Definition of (U)SIM Interface**

| Pin Name      | Pin No. | I/O | Description                      | Comment                                                       |
|---------------|---------|-----|----------------------------------|---------------------------------------------------------------|
| USIM_VDD      | 14      | PO  | Power supply for (U)SIM card     | Either 1.8V or 3.0V is supported by the module automatically. |
| USIM_DATA     | 15      | IO  | Data signal of (U)SIM card       |                                                               |
| USIM_CLK      | 16      | DO  | Clock signal of (U)SIM card      |                                                               |
| USIM_RST      | 17      | DO  | Reset signal of (U)SIM card      |                                                               |
| USIM_PRESENCE | 13      | DI  | (U)SIM card insertion detection  | 1.8V power domain.<br>If unused, keep it open.                |
| USIM_GND      | 10      |     | Specified ground for (U)SIM card |                                                               |

EC25 supports (U)SIM card hot-plug via the USIM\_PRESENCE pin. The function supports low level and high level detections, and is disabled by default. Please refer to **document [2]** for more details about **AT+QSIMDET** command.

The following figure shows a reference design for (U)SIM interface with an 8-pin (U)SIM card connector.

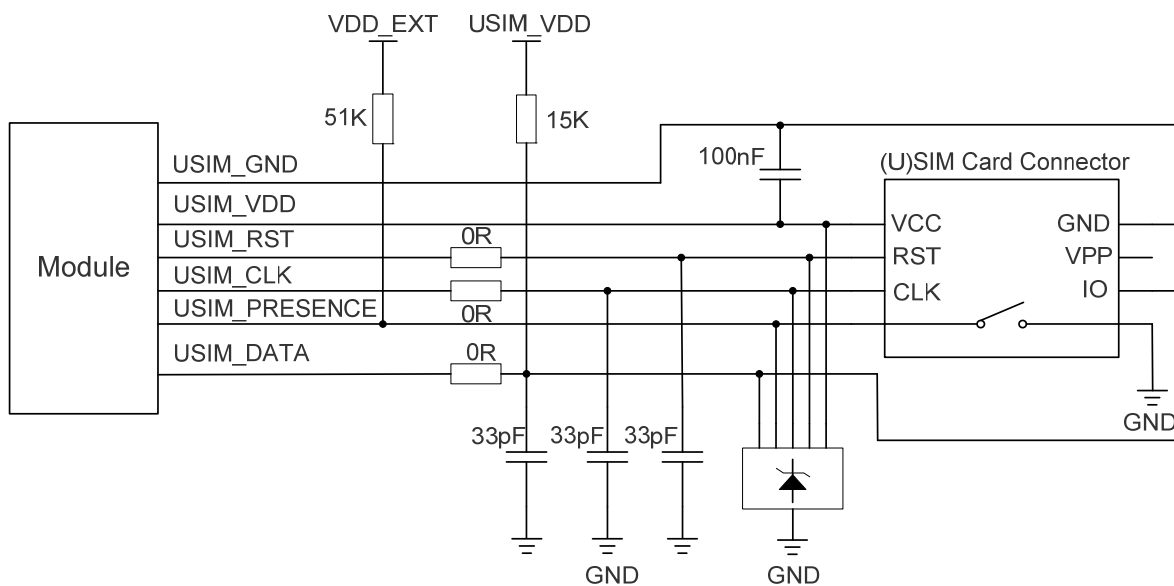


**Figure 17: Reference Circuit of (U)SIM Interface with an 8-pin (U)SIM Card Connector**

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

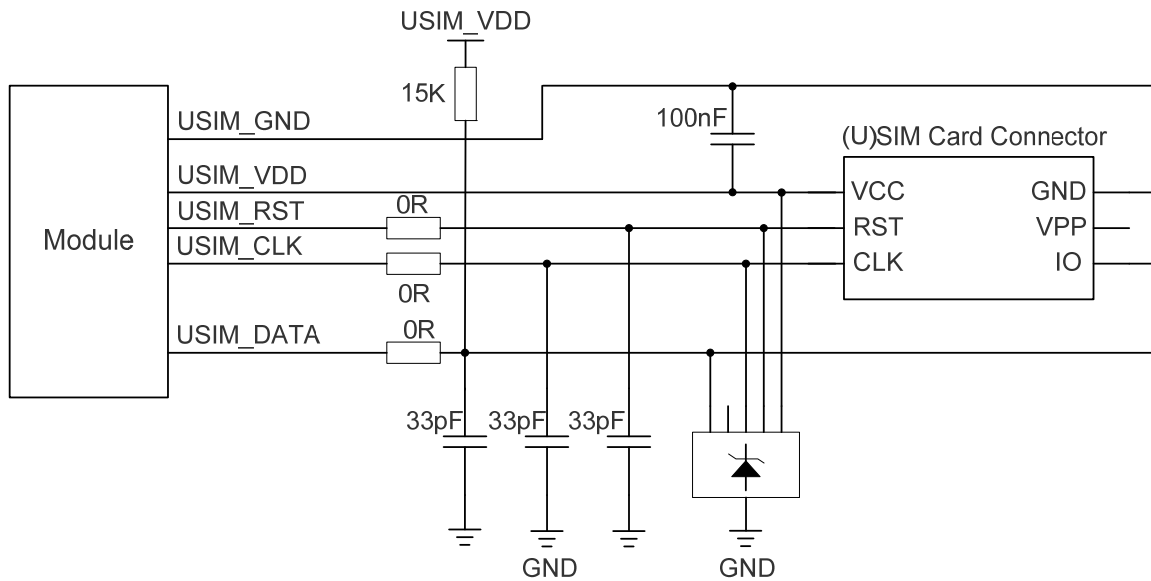


**Figure 18: Reference Circuit of (U)SIM Interface with a 6-pin (U)SIM Card Connector**

In order to enhance the reliability and availability of the (U)SIM card in customers' applications, please follow the criteria below in (U)SIM circuit design:

- Keep placement of (U)SIM card connector to the module as close as possible. Keep the trace length as less than 200mm as possible.
- Keep (U)SIM card signals away from RF and VBAT traces.
- Make sure the bypass capacitor between USIM\_VDD and USIM\_GND less than 1uF, and place it as close to (U)SIM card connector as possible. If the ground is complete on customers' PCB, USIM\_GND can be connected to PCB ground directly.
- To avoid cross-talk between USIM\_DATA and USIM\_CLK, keep them away from each other and shield them with surrounded ground.
- In order to offer good ESD protection, it is recommended to add a TVS diode array whose parasitic capacitance should not be more than 15pF. The 0Ω resistors should be added in series between the module and the (U)SIM card to facilitate debugging. The 33pF capacitors are used for filtering interference of EGSM900. Please note that the (U)SIM peripheral circuit should be close to the (U)SIM card connector.
- The pull-up resistor on USIM\_DATA line can improve anti-jamming capability when long layout trace and sensitive occasion are applied, and should be placed close to the (U)SIM card connector.

### 3.10. USB Interface

EC25 contains one integrated Universal Serial Bus (USB) interface which complies with the USB 2.0 specification and supports high-speed (480Mbps) and full-speed (12Mbps) modes. The USB interface can only serve as a slave device and is used for AT command communication, data transmission, GNSS NMEA sentences output, software debugging, firmware upgrade and voice over USB. The following table shows the pin definition of USB interface.

**Table 10: Pin Description of USB Interface**

| Pin Name | Pin No. | I/O | Description                              | Comment                               |
|----------|---------|-----|------------------------------------------|---------------------------------------|
| USB_DP   | 69      | IO  | USB differential data bus (+)            | Require differential impedance of 90Ω |
| USB_DM   | 70      | IO  | USB differential data bus (-)            | Require differential impedance of 90Ω |
| USB_VBUS | 71      | PI  | USB power supply, used for USB detection | Typical 5.0V                          |
| GND      | 72      |     | Ground                                   |                                       |

For more details about the USB 2.0 specifications, please visit <http://www.usb.org/home>.

The USB interface is recommended to be reserved for firmware upgrade in customers' designs. The following figure shows a reference circuit of USB interface.

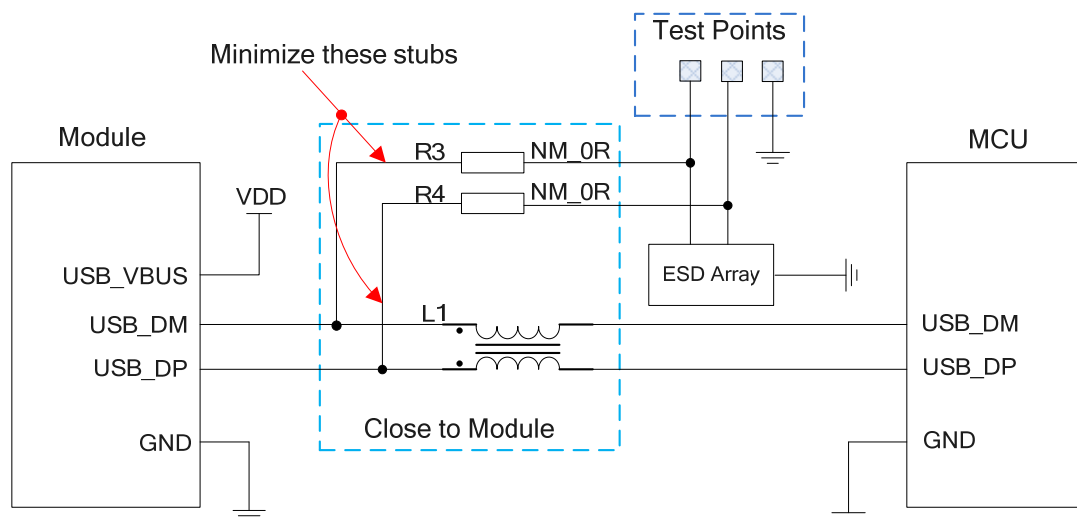


**Figure 19: Reference Circuit of USB Application**

A common mode choke L1 is recommended to be added in series between the module and customer's MCU in order to suppress EMI spurious transmission. Meanwhile, the 0Ω resistors (R3 and R4) should be added in series between the module and the test points so as to facilitate debugging, and the resistors are not mounted by default. In order to ensure the integrity of USB data line signal, L1/R3/R4 components must be placed close to the module, and also these resistors should be placed close to each other. The extra stubs of trace must be as short as possible.

The following principles should be complied with when design the USB interface, so as to meet USB 2.0 specification.

- It is important to route the USB signal traces as differential pairs with total grounding. The impedance of USB differential trace is 90Ω.
- Do not route signal traces under crystals, oscillators, magnetic devices and RF signal traces. It is important to route the USB differential traces in inner-layer with ground shielding on not only upper and lower layers but also right and left sides.
- Pay attention to the influence of junction capacitance of ESD protection components on USB data lines. Typically, the capacitance value should be less than 2.0pF.
- Keep the ESD protection components to the USB connector as close as possible.

### 3.11. UART Interfaces

The module provides two UART interfaces: the main UART interface and the debug UART interface. The following shows their features.

- The main UART interface supports 4800bps, 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps and 921600bps baud rates, and the default is 115200bps. This interface is used for data transmission and AT command communication.
- The debug UART interface supports 115200bps baud rate. It is used for Linux console and log output.

The following tables show the pin definition of the UART interfaces.

**Table 11: Pin Definition of Main UART Interface**

| Pin Name | Pin No. | I/O | Description            | Comment           |
|----------|---------|-----|------------------------|-------------------|
| RI       | 62      | DO  | Ring indicator         | 1.8V power domain |
| DCD      | 63      | DO  | Data carrier detection |                   |
| CTS      | 64      | DO  | Clear to send          |                   |

|     |    |    |                                            |
|-----|----|----|--------------------------------------------|
| RTS | 65 | DI | Request to send                            |
| DTR | 66 | DI | Data terminal ready,<br>sleep mode control |
| TXD | 67 | DO | Transmit data                              |
| RXD | 68 | DI | Receive data                               |

**Table 12: Pin Definition of Debug UART Interface**

| Pin Name | Pin No. | I/O | Description   | Comment           |
|----------|---------|-----|---------------|-------------------|
| DBG_TXD  | 12      | DO  | Transmit data | 1.8V power domain |
| DBG_RXD  | 11      | DI  | Receive data  |                   |

The logic levels are described in the following table.

**Table 13: Logic Levels of Digital I/O**

| Parameter | Min. | Max. | Unit |
|-----------|------|------|------|
| $V_{IL}$  | -0.3 | 0.6  | V    |
| $V_{IH}$  | 1.2  | 2.0  | V    |
| $V_{OL}$  | 0    | 0.45 | V    |
| $V_{OH}$  | 1.35 | 1.8  | V    |

The module provides 1.8V UART interface. A level translator should be used if customers' application is equipped with a 3.3V UART interface. A level translator TXS0108EPWR provided by *Texas Instruments* is recommended. The following figure shows a reference design.

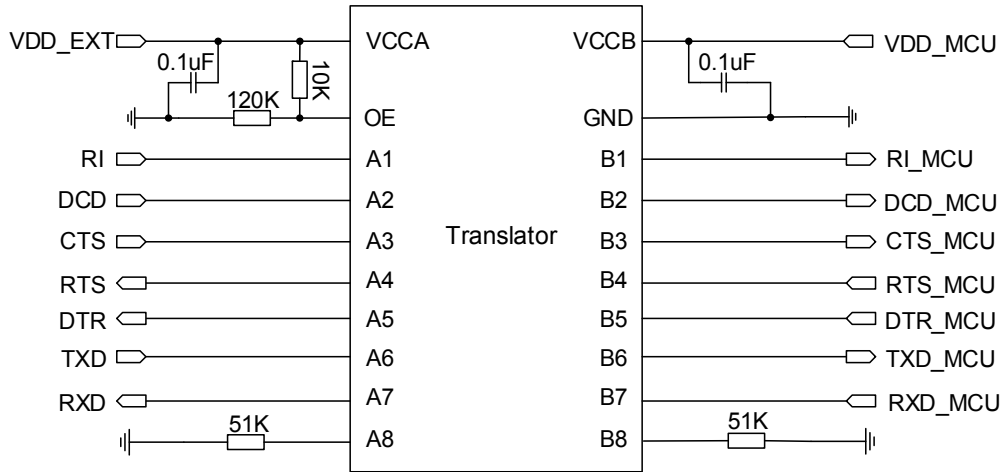


**Figure 20: Reference Circuit with Translator Chip**

Please visit <http://www.ti.com> for more information.

Another example with transistor translation circuit is shown as below. The circuit design of dotted line section can refer to the design of solid line section, in terms of both module's input and output circuit designs, but please pay attention to the direction of connection.

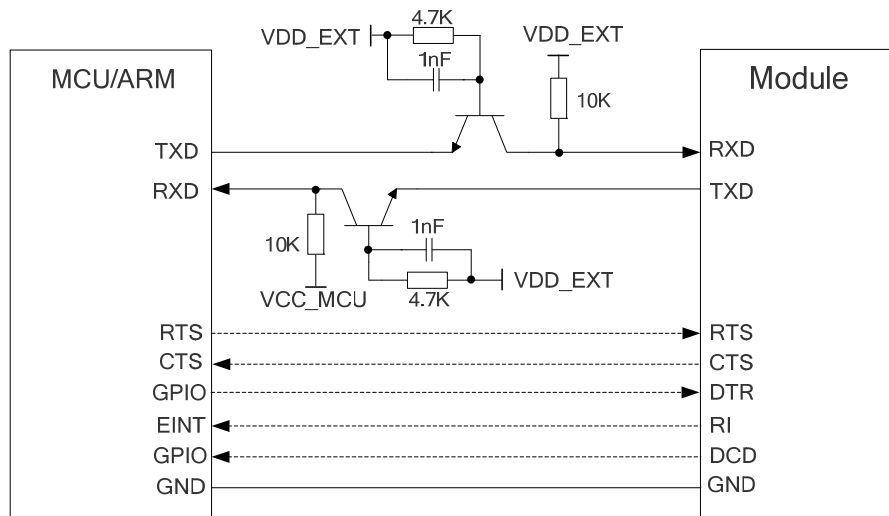


**Figure 21: Reference Circuit with Transistor Circuit**

**NOTE**

Transistor circuit solution is not suitable for applications with high baud rates exceeding 460Kbps.

### 3.12. PCM and I2C Interfaces

EC25 provides one Pulse Code Modulation (PCM) digital interface for audio design, which supports the following modes and one I2C interface:

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

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

In auxiliary mode, the data is sampled on the falling edge of the PCM\_CLK and transmitted on the rising edge. The PCM\_SYNC rising edge represents the MSB. In this mode, the PCM interface operates with a 256KHz, 512KHz, 1024KHz or 2048KHz PCM\_CLK and an 8KHz, 50% duty cycle PCM\_SYNC.

EC25 supports 16-bit linear data format. The following figures show the primary mode's timing relationship with 8KHz PCM\_SYNC and 2048KHz PCM\_CLK, as well as the auxiliary mode's timing relationship with 8KHz PCM\_SYNC and 256KHz PCM\_CLK.

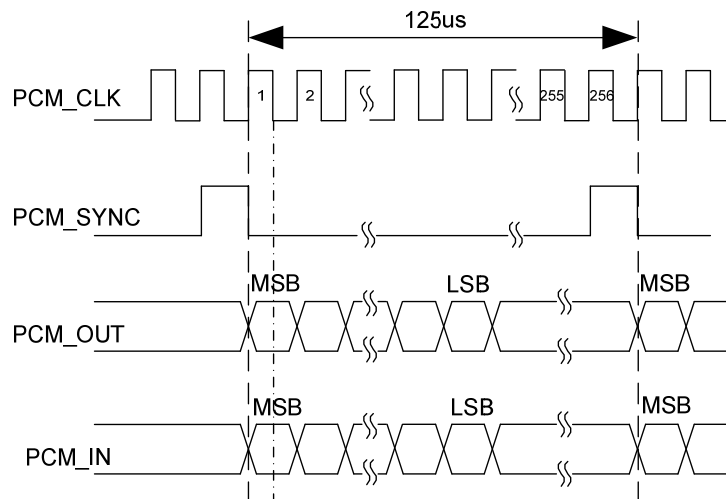


**Figure 22: Primary Mode Timing**

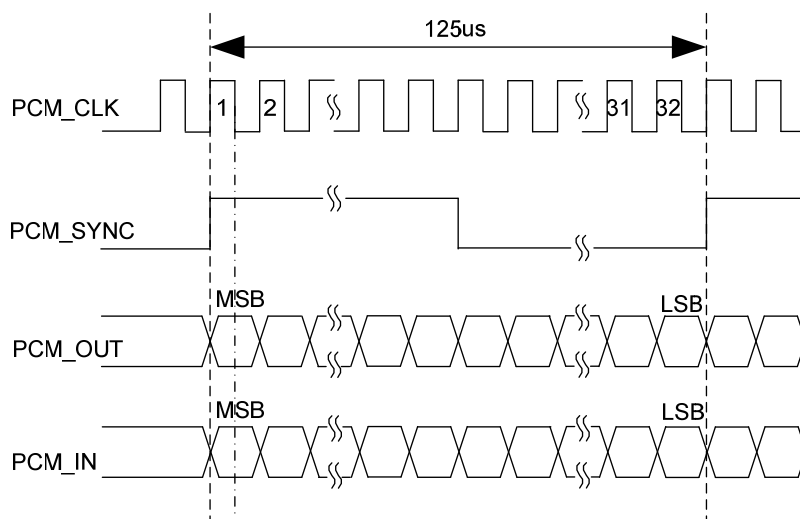


**Figure 23: Auxiliary Mode Timing**

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

**Table 14: Pin Definition of PCM and I2C Interfaces**

| Pin Name | Pin No. | I/O | Description                           | Comment                          |
|----------|---------|-----|---------------------------------------|----------------------------------|
| PCM_IN   | 24      | DI  | PCM data input                        | 1.8V power domain                |
| PCM_OUT  | 25      | DO  | PCM data output                       | 1.8V power domain                |
| PCM_SYNC | 26      | IO  | PCM data frame synchronization signal | 1.8V power domain                |
| PCM_CLK  | 27      | IO  | PCM data bit clock                    | 1.8V power domain                |
| I2C_SCL  | 41      | OD  | I2C serial clock                      | Require external pull-up to 1.8V |
| I2C_SDA  | 42      | OD  | I2C serial data                       | Require external pull-up to 1.8V |

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

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

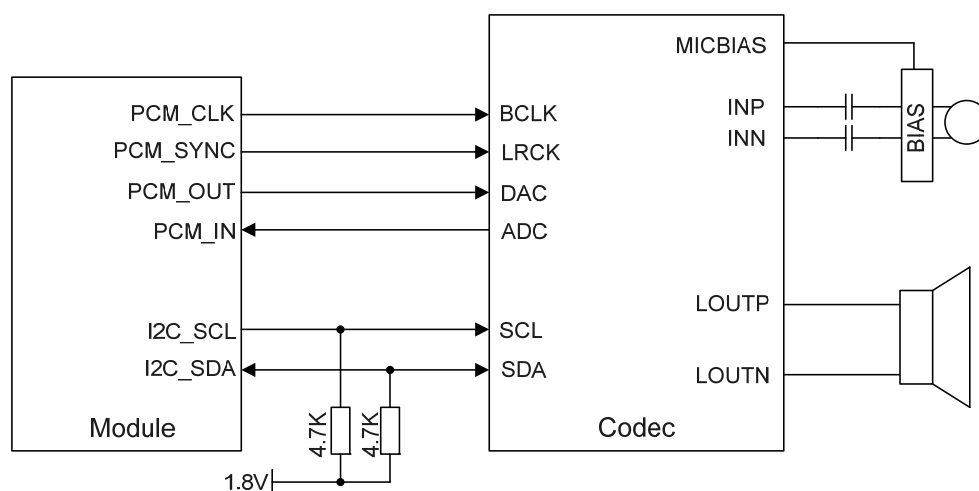


Figure 24: Reference Circuit of PCM Application with Audio Codec

#### NOTES

1. It is recommended to reserve an RC ( $R=22\Omega$ ,  $C=22pF$ ) circuits on the PCM lines, especially for PCM\_CLK.
2. EC25 works as a master device pertaining to I2C interface.

### 3.13. SD Card Interface

EC25 supports SDIO 3.0 interface for SD card.

The following table shows the pin definition of SD card interface.

Table 15: Pin Definition of SD Card Interface

| Pin Name   | Pin No. | I/O | Description            | Comment                                                                                                                                            |
|------------|---------|-----|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| SDC2_DATA3 | 28      | IO  | SD card SDIO bus DATA3 | SDIO signal level can be selected according to SD card supported level, please refer to SD 3.0 protocol for more details. If unused, keep it open. |
| SDC2_DATA2 | 29      | IO  | SD card SDIO bus DATA2 |                                                                                                                                                    |
| SDC2_DATA1 | 30      | IO  | SD card SDIO bus DATA1 |                                                                                                                                                    |
| SDC2_DATA0 | 31      | IO  | SD card SDIO bus DATA0 |                                                                                                                                                    |
| SDC2_CLK   | 32      | DO  | SD card SDIO bus clock |                                                                                                                                                    |

|            |    |    |                                |                                                                                           |
|------------|----|----|--------------------------------|-------------------------------------------------------------------------------------------|
| SDC2_CMD   | 33 | IO | SD card SDIO bus command       |                                                                                           |
| VDD_SDIO   | 34 | PO | SD card SDIO bus pull up power | 1.8V/2.85V configurable.<br>Cannot be used for SD card power.<br>If unused, keep it open. |
| SD_INS_DET | 23 | DI | SD card insertion detection    | 1.8V power domain.<br>If unused, keep it open.                                            |

The following figure shows a reference design of SD card.

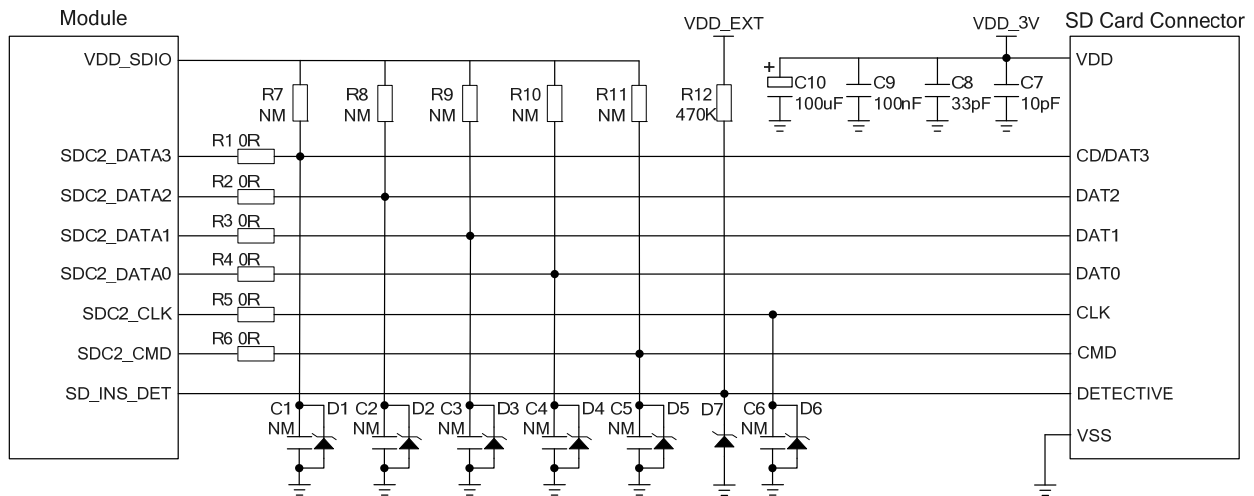


**Figure 25: Reference Circuit of SD Card Interface**

In SD card interface design, in order to ensure good communication performance with SD card, the following design principles should be complied with:

- SD\_INS\_DET must be connected.
- The voltage range of SD card power supply VDD\_3V is 2.7V~3.6V and a sufficient current up to 0.8A should be provided. As the maximum output current of VDD\_SDIO is 50mA which can only be used for SDIO pull-up resistors, an externally power supply is needed for SD card.
- To avoid jitter of bus, resistors R7~R11 are needed to pull up the SDIO to VDD\_SDIO. Value of these resistors is among 10KΩ~100KΩ and the recommended value is 100KΩ. VDD\_SDIO should be used as the pull-up power.
- In order to adjust signal quality, it is recommended to add 0Ω resistors R1~R6 in series between the module and the SD card. The bypass capacitors C1~C6 are reserved and not mounted by default. All resistors and bypass capacitors should be placed close to the module.
- In order to offer good ESD protection, it is recommended to add a TVS diode on SD card pins near the SD card connector with junction capacitance less than 15pF.
- Keep SDIO signals far away from other sensitive circuits/signals such as RF circuits, analog signals, etc., as well as noisy signals such as clock signals, DCDC signals, etc.

- It is important to route the SDIO signal traces with total grounding. The impedance of SDIO data trace is  $50\Omega$  ( $\pm 10\%$ ).
- Make sure the adjacent trace spacing is two times of the trace width and the load capacitance of SDIO bus should be less than 15pF.
- It is recommended to keep the trace length difference between CLK and DATA/CMD less than 1mm and the total routing length less than 50mm. The total trace length inside the module is 27mm, so the exterior total trace length should be less than 23mm.

**NOTE**

SD card interface is not supported on ThreadX modules.

### 3.14. Wireless Connectivity Interfaces

EC25 supports a low-power SDIO 3.0 interface for WLAN and UART/PCM interfaces for BT function.

The following table shows the pin definition of wireless connectivity interfaces.

**Table 16: Pin Definition of Wireless Connectivity Interfaces**

| Pin Name                            | Pin No. | I/O | Description                            | Comment                                                                   |
|-------------------------------------|---------|-----|----------------------------------------|---------------------------------------------------------------------------|
| <b>WLAN Part</b>                    |         |     |                                        |                                                                           |
| SDC1_DATA3                          | 129     | IO  | WLAN SDIO data bus D3                  | 1.8V power domain                                                         |
| SDC1_DATA2                          | 130     | IO  | WLAN SDIO data bus D2                  | 1.8V power domain                                                         |
| SDC1_DATA1                          | 131     | IO  | WLAN SDIO data bus D1                  | 1.8V power domain                                                         |
| SDC1_DATA0                          | 132     | IO  | WLAN SDIO data bus D0                  | 1.8V power domain                                                         |
| SDC1_CLK                            | 133     | DO  | WLAN SDIO bus clock                    | 1.8V power domain                                                         |
| SDC1_CMD                            | 134     | IO  | WLAN SDIO bus command                  | 1.8V power domain                                                         |
| WLAN_EN                             | 136     | DO  | WLAN function control via FC20 module. | 1.8V power domain.<br>Active high.<br>Cannot be pulled up before startup. |
| <b>Coexistence and Control Part</b> |         |     |                                        |                                                                           |

|                        |     |    |                                               |                                                           |
|------------------------|-----|----|-----------------------------------------------|-----------------------------------------------------------|
| PM_ENABLE              | 127 | DO | WLAN power control                            | 1.8V power domain<br>Active high.                         |
| WAKE_ON_WIRELESS       | 135 | DI | Wake up the host (EC25 module) by FC20 module | 1.8V power domain                                         |
| COEX_UART_RX           | 137 | DI | LTE/WLAN&BT coexistence signal                | 1.8V power domain.<br>Cannot be pulled up before startup. |
| COEX_UART_TX           | 138 | DO | LTE/WLAN&BT coexistence signal                | 1.8V power domain.<br>Cannot be pulled up before startup. |
| WLAN_SLP_CLK           | 118 | DO | WLAN sleep clock                              |                                                           |
| <b>BT Part</b>         |     |    |                                               |                                                           |
| BT_RTS                 | 37  | DI | BT UART request to send                       | 1.8V power domain                                         |
| BT_TXD                 | 38  | DO | BT UART transmit data                         | 1.8V power domain                                         |
| BT_RXD                 | 39  | DI | BT UART receive data                          | 1.8V power domain                                         |
| BT_CTS                 | 40  | DO | BT UART clear to send                         | 1.8V power domain.<br>Cannot be pulled up before startup. |
| PCM_IN <sup>1)</sup>   | 24  | DI | PCM data input                                | 1.8V power domain                                         |
| PCM_OUT <sup>1)</sup>  | 25  | DO | PCM data output                               | 1.8V power domain                                         |
| PCM_SYNC <sup>1)</sup> | 26  | IO | PCM data frame synchronization signal         | 1.8V power domain                                         |
| PCM_CLK <sup>1)</sup>  | 27  | IO | PCM data bit clock                            | 1.8V power domain                                         |
| BT_EN                  | 139 | DO | BT function control via FC20 module.          | 1.8V power domain<br>Active high.                         |

The following figure shows a reference design of wireless connectivity interfaces with Quectel FC20 module.

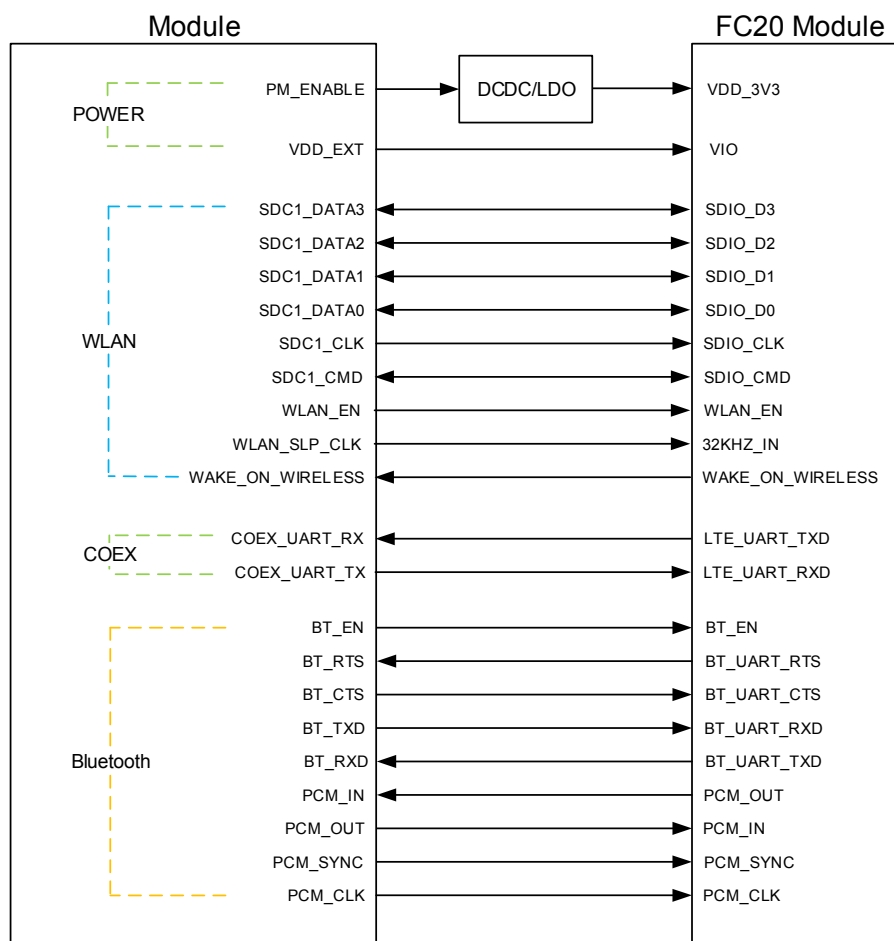


Figure 26: Reference Circuit of Wireless Connectivity Interfaces with FC20 Module

## NOTES

1. FC20 module can only be used as a slave device.
2. When BT function is enabled on EC25 module, PCM\_SYNC and PCM\_CLK pins are only used to output signals. BT function is under development.
3. <sup>1)</sup> Pins 24~27 are multiplexing pins used for audio design on EC25 module and BT function on BT module.
4. Wireless connectivity interfaces are not supported on ThreadX modules.
5. For more information about wireless connectivity interfaces, please refer to **document [5]**.

### 3.14.1. WLAN Interface

EC25 provides a low-power SDIO 3.0 interface and control interface for WLAN design.

SDIO interface supports SDR mode (up to 50MHz).

As SDIO signals are very high-speed, in order to ensure the SDIO interface design corresponds with the SDIO 3.0 specification, please comply with the following principles:

- It is important to route the SDIO signal traces with total grounding. The impedance of SDIO signal trace is  $50\Omega \pm 10\%$ .
- Keep SDIO signals far away from other sensitive circuits/signals such as RF circuits, analog signals, etc., as well as noisy signals such as clock signals, DCDC signals, etc.
- It is recommended to keep matching length between CLK and DATA/CMD less than 1mm and total routing length less than 50mm.
- Keep termination resistors within  $15\Omega \sim 24\Omega$  on clock lines near the module and keep the route distance from the module clock pins to termination resistors less than 5mm.
- Make sure the adjacent trace spacing is 2 times of the trace width and bus capacitance is less than 15pF.

### 3.14.2. BT Interface\*

EC25 supports a dedicated UART interface and a PCM interface for BT application.

Further information about BT interface will be added in future version of this document.

#### NOTE

“\*” means under development.

## 3.15. ADC Interfaces

The module provides two analog-to-digital converter (ADC) interfaces. **AT+QADC=0** command can be used to read the voltage value on ADC0 pin. **AT+QADC=1** command can be used to read the voltage value on ADC1 pin. For more details about these AT commands, please refer to **document [2]**.

In order to improve the accuracy of ADC, the trace of ADC should be surrounded by ground.

**Table 17: Pin Definition of ADC Interfaces**

| Pin Name | Pin No. | Description                                 |
|----------|---------|---------------------------------------------|
| ADC0     | 45      | General purpose analog to digital converter |
| ADC1     | 44      | General purpose analog to digital converter |

The following table describes the characteristic of ADC function.

**Table 18: Characteristic of ADC**

| Parameter          | Min. | Typ. | Max.    | Unit |
|--------------------|------|------|---------|------|
| ADC0 Voltage Range | 0.3  |      | VBAT_BB | V    |
| ADC1 Voltage Range | 0.3  |      | VBAT_BB | V    |
| ADC Resolution     |      | 15   |         | bits |

#### NOTES

1. ADC input voltage must not exceed that of VBAT\_BB.
2. It is prohibited to supply any voltage to ADC pins when VBAT power supply is removed.
3. It is recommended to use a resistor divider circuit for ADC application.

## 3.16. SGMII Interface

EC25 includes an integrated Ethernet MAC with an SGMII interface and two management interfaces. The key features of the SGMII interface are shown below:

- IEEE802.3 compliant
- Support 10M/100M/1000M Ethernet work mode
- Support maximum 150Mbps (DL)/50Mbps (UL) for 4G network
- Support VLAN tagging
- Support IEEE1588 and Precision Time Protocol (PTP)
- Can be used to connect to external Ethernet PHY like AR8033, or to an external switch
- Management interfaces support dual voltage 1.8V/2.85V

The following table shows the pin definition of SGMII interface.

Table 19: Pin Definition of SGMII Interface

| Pin Name                   | Pin No. | I/O | Description                                     | Comment                                                                                                      |
|----------------------------|---------|-----|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| <b>Control Signal Part</b> |         |     |                                                 |                                                                                                              |
| EPHY_RST_N                 | 119     | DO  | Ethernet PHY reset                              | 1.8V/2.85V power domain                                                                                      |
| EPHY_INT_N                 | 120     | DI  | Ethernet PHY interrupt                          | 1.8V power domain                                                                                            |
| SGMII_MDATA                | 121     | IO  | SGMII MDIO (Management Data Input/Output) data  | 1.8V/2.85V power domain                                                                                      |
| SGMII_MCLK                 | 122     | DO  | SGMII MDIO (Management Data Input/Output) clock | 1.8V/2.85V power domain                                                                                      |
| USIM2_VDD                  | 128     | PO  | SGMII MDIO pull-up power source                 | Configurable power source.<br>1.8V/2.85V power domain.<br>External pull-up power source for SGMII MDIO pins. |
| <b>SGMII Signal Part</b>   |         |     |                                                 |                                                                                                              |
| SGMII_TX_M                 | 123     | AO  | SGMII transmission - minus                      | Connect with a 0.1uF capacitor, and is close to the PHY side.                                                |
| SGMII_TX_P                 | 124     | AO  | SGMII transmission - plus                       |                                                                                                              |
| SGMII_RX_P                 | 125     | AI  | SGMII receiving - plus                          | Connect with a 0.1uF capacitor, and is close to EC25 module.                                                 |
| SGMII_RX_M                 | 126     | AI  | SGMII receiving - minus                         |                                                                                                              |

The following figure shows the simplified block diagram for Ethernet application.

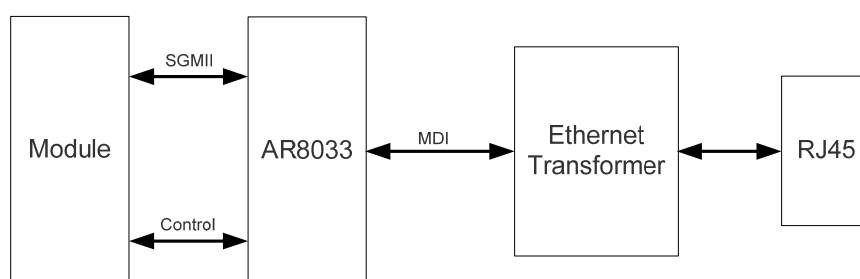


Figure 27: Simplified Block Diagram for Ethernet Application

The following figure shows a reference design of SGMII interface with PHY AR8033 application.

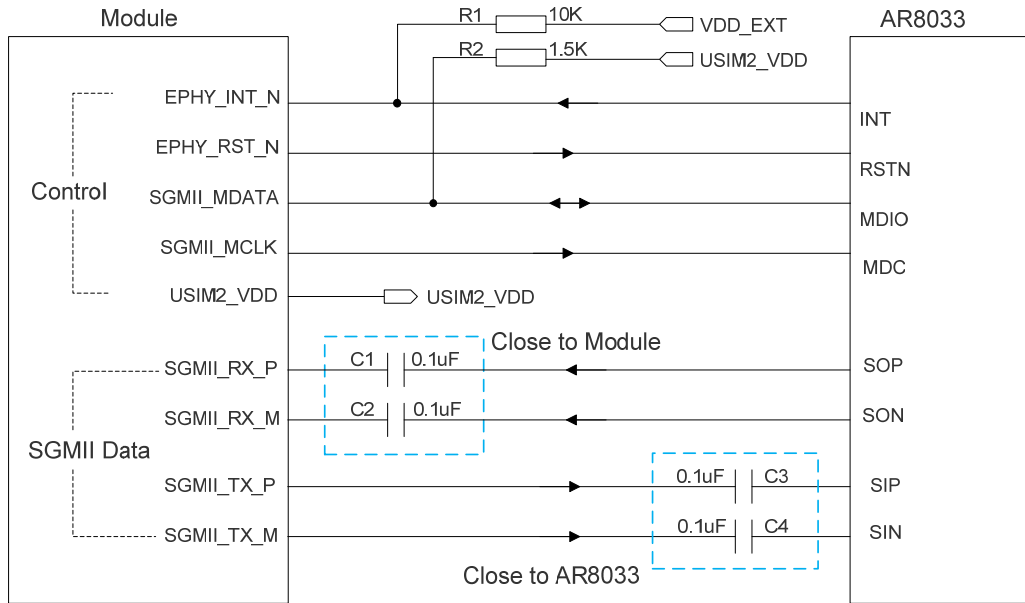


**Figure 28: Reference Circuit of SGMII Interface with PHY AR8033 Application**

In order to enhance the reliability and availability in customers' applications, please follow the criteria below in the Ethernet PHY circuit design:

- Keep SGMII data and control signals away from other sensitive circuits/signals such as RF circuits, analog signals, etc., as well as noisy signals such as clock signals, DC-DC signals, etc.
- Keep the maximum trace length less than 10-inch and keep skew on the differential pairs less than 20mil.
- The differential impedance of SGMII data trace is  $100\Omega \pm 10\%$ , and the reference ground of the area should be complete.
- Make sure the trace spacing between SGMII RX and TX is at least 3 times of the trace width, and the same to the adjacent signal traces.

**NOTE**

SGMII interface is not supported on ThreadX modules.

### 3.17. Network Status Indication

The network indication pins can be used to drive network status indication LEDs. The module provides two pins which are NET\_MODE and NET\_STATUS. The following tables describe the pin definition and logic level changes in different network status.

**Table 20: Pin Definition of Network Connection Status/Activity Indicator**

| Pin Name   | Pin No. | I/O | Description                                     | Comment                                                 |
|------------|---------|-----|-------------------------------------------------|---------------------------------------------------------|
| NET_MODE   | 5       | DO  | Indicate the module's network registration mode | 1.8V power domain<br>Cannot be pulled up before startup |
| NET_STATUS | 6       | DO  | Indicate the module's network activity status   | 1.8V power domain                                       |

**Table 21: Working State of Network Connection Status/Activity Indicator**

| Pin Name   | Logic Level Changes                    | Network Status            |
|------------|----------------------------------------|---------------------------|
| NET_MODE   | Always High                            | Registered on LTE network |
|            | Always Low                             | Others                    |
| NET_STATUS | Flicker slowly (200ms High/1800ms Low) | Network searching         |
|            | Flicker slowly (1800ms High/200ms Low) | Idle                      |
|            | Flicker quickly (125ms High/125ms Low) | Data transfer is ongoing  |
|            | Always High                            | Voice calling             |

A reference circuit is shown in the following figure.

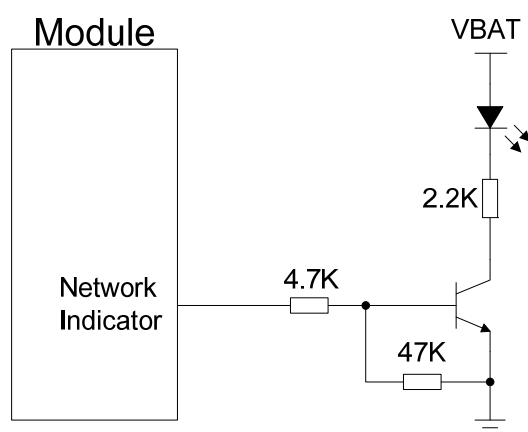


**Figure 29: Reference Circuit of the Network Indicator**

### 3.18. STATUS

The STATUS pin is an open drain output for indicating the module's operation status. It can be connected to a GPIO of DTE with a pull-up resistor, or as LED indication circuit as below. When the module is turned on normally, the STATUS will present the low state. Otherwise, the STATUS will present high-impedance state.

**Table 22: Pin Definition of STATUS**

| Pin Name | Pin No. | I/O | Description                            | Comment                                                               |
|----------|---------|-----|----------------------------------------|-----------------------------------------------------------------------|
| STATUS   | 61      | OD  | Indicate the module's operation status | An external pull-up resistor is required.<br>If unused, keep it open. |

The following figure shows different circuit designs of STATUS, and customers can choose either one according to customers' application demands.

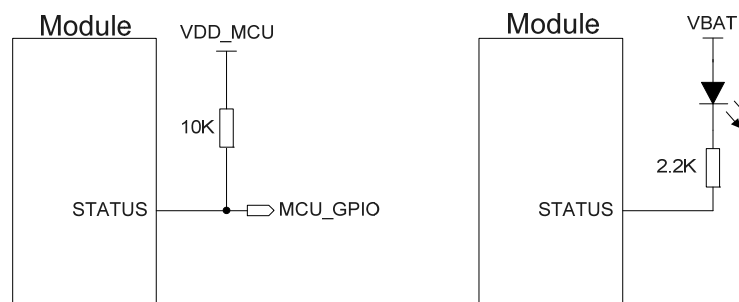


**Figure 30: Reference Circuits of STATUS**

#### NOTES

The status pin cannot be used as indication of module shutdown status when VBAT power supply is removed.

### 3.19. Behaviors of RI

AT+QCFG="risignaltype","physical" command can be used to configure RI behavior.

No matter on which port a URC is presented, the URC will trigger the behaviors of RI pin.

**NOTE**

URC can be outputted from UART port, USB AT port and USB modem port through configuration via **AT+QURCCFG** command. The default port is USB AT port.

In addition, RI behavior can be configured flexibly. The default behaviors of the RI is shown as below.

**Table 23: Behaviors of RI**

| State | Response                                          |
|-------|---------------------------------------------------|
| Idle  | RI keeps at high level                            |
| URC   | RI outputs 120ms low pulse when a new URC returns |

The RI behavior can be changed by **AT+QCFG="urc/ri/ring"** command. Please refer to *document [2]* for details.

### 3.20. USB\_BOOT Interface

EC25 provides a USB\_BOOT pin. Customers can pull up USB\_BOOT to 1.8V before VDD\_EXT is powered up, and the module will enter emergency download mode when it is powered on. In this mode, the module supports firmware upgrade over USB interface.

**Table 24: Pin Definition of USB\_BOOT Interface**

| Pin Name | Pin No. | I/O | Description                                       | Comment                                                                          |
|----------|---------|-----|---------------------------------------------------|----------------------------------------------------------------------------------|
| USB_BOOT | 115     | DI  | Force the module to enter emergency download mode | 1.8V power domain.<br>Active high.<br>It is recommended to reserve a test point. |

The following figure shows a reference circuit of USB\_BOOT interface.

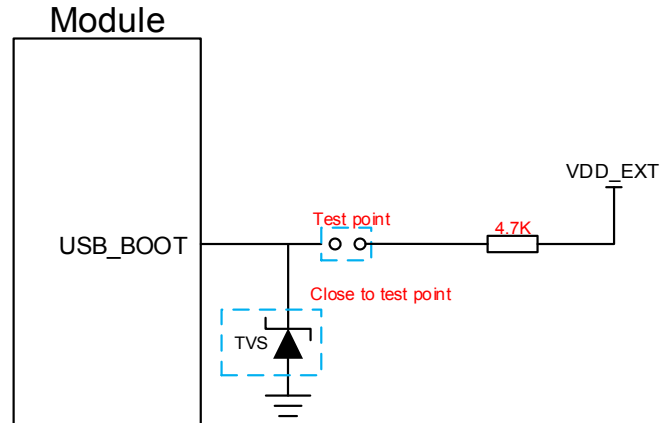


Figure 31: Reference Circuit of USB\_BOOT Interface

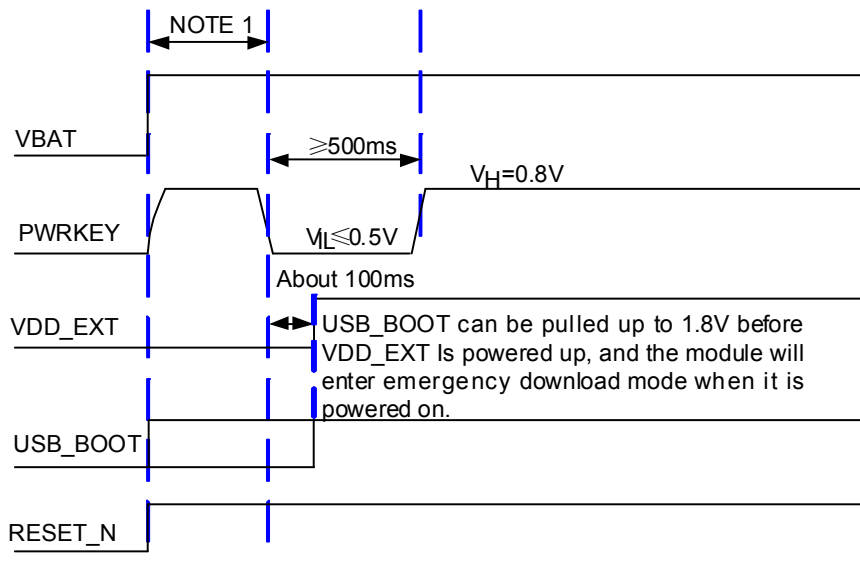


Figure 32: Timing Sequence for Entering Emergency Download Mode

#### NOTES

1. Please make sure that VBAT is stable before pulling down PWRKEY pin. It is recommended that the time between powering up VBAT and pulling down PWRKEY pin is no less than 30ms.
2. When using MCU to control module to enter the emergency download mode, please follow the above timing sequence. It is not recommended to pull up USB\_BOOT to 1.8V before powering up VBAT. Short the test points as shown in **Figure 31** can manually force the module to enter download mode.

# 4 GNSS Receiver

## 4.1. General Description

EC25 includes a fully integrated global navigation satellite system solution that supports Gen8C-Lite of Qualcomm (GPS, GLONASS, BeiDou, Galileo and QZSS).

EC25 supports standard NMEA-0183 protocol, and outputs NMEA sentences at 1Hz data update rate via USB interface by default.

By default, EC25 GNSS engine is switched off. It has to be switched on via AT command. For more details about GNSS engine technology and configurations, please refer to **document [3]**.

## 4.2. GNSS Performance

The following table shows the GNSS performance of EC25.

**Table 25: GNSS Performance**

| Parameter          | Description          | Conditions   | Typ. | Unit |
|--------------------|----------------------|--------------|------|------|
| Sensitivity (GNSS) | Cold start           | Autonomous   | -146 | dBm  |
|                    | Reacquisition        | Autonomous   | -157 | dBm  |
|                    | Tracking             | Autonomous   | -157 | dBm  |
| TTFF (GNSS)        | Cold start @open sky | Autonomous   | 35   | s    |
|                    |                      | XTRA enabled | 18   | s    |
|                    | Warm start @open sky | Autonomous   | 26   | s    |
|                    |                      | XTRA enabled | 2.2  | s    |

|                    |                        |                         |      |   |
|--------------------|------------------------|-------------------------|------|---|
|                    | Hot start<br>@open sky | Autonomous              | 2.5  | s |
|                    |                        | XTRA enabled            | 1.8  | s |
| Accuracy<br>(GNSS) | CEP-50                 | Autonomous<br>@open sky | <2.5 | m |

#### NOTES

1. Tracking sensitivity: the lowest GNSS signal value at the antenna port on which the module can keep on positioning for 3 minutes.
2. Reacquisition sensitivity: the lowest GNSS signal value at the antenna port on which the module can fix position again within 3 minutes after loss of lock.
3. Cold start sensitivity: the lowest GNSS signal value at the antenna port on which the module fixes position within 3 minutes after executing cold start command.

### 4.3. Layout Guidelines

The following layout guidelines should be taken into account in customers' designs.

- Maximize the distance among GNSS antenna, main antenna and Rx-diversity antenna.
- Digital circuits such as (U)SIM card, USB interface, camera module and display connector should be kept away from the antennas.
- Use ground vias around the GNSS trace and sensitive analog signal traces to provide coplanar isolation and protection.
- Keep 50Ω characteristic impedance for the ANT\_GNSS trace.

Please refer to **Chapter 5** for GNSS antenna reference design and antenna installation information.

# 5 Antenna Interfaces

EC25 antenna interfaces include a main antenna interface, an Rx-diversity antenna interface which is used to resist the fall of signals caused by high speed movement and multipath effect, and a GNSS antenna interface. The antenna ports have an impedance of 50Ω.

## 5.1. Main/Rx-diversity Antenna Interfaces

### 5.1.1. Pin Definition

The pin definition of main antenna and Rx-diversity antenna interfaces is shown below.

Table 26: Pin Definition of RF Antennas

| Pin Name | Pin No. | I/O | Description               | Comment                                    |
|----------|---------|-----|---------------------------|--------------------------------------------|
| ANT_MAIN | 49      | IO  | Main antenna              | 50Ω impedance                              |
| ANT_DIV  | 35      | AI  | Receive diversity antenna | 50Ω impedance.<br>If unused, keep it open. |

### 5.1.2. Operating Frequency

Table 27: Module Operating Frequencies

| 3GPP Band | Transmit  | Receive   | Unit |
|-----------|-----------|-----------|------|
| GSM850    | 824~849   | 869~894   | MHz  |
| EGSM900   | 880~915   | 925~960   | MHz  |
| DCS1800   | 1710~1785 | 1805~1880 | MHz  |
| PCS1900   | 1850~1910 | 1930~1990 | MHz  |
| WCDMA B1  | 1920~1980 | 2110~2170 | MHz  |

|             |           |           |     |
|-------------|-----------|-----------|-----|
| WCDMA B2    | 1850~1910 | 1930~1990 | 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 B26 | 814~849   | 859~894   | MHz |
| LTE-FDD B28 | 703~748   | 758~803   | MHz |
| LTE-TDD B38 | 2570~2620 | 2570~2620 | MHz |
| LTE-TDD B40 | 2300~2400 | 2300~2400 | MHz |
| LTE-TDD B41 | 2555~2655 | 2555~2655 | MHz |
| LTE-FDD B66 | 1710~1780 | 2100~2200 | MHz |

LTE-FDD B71

663~698

617~652

MHz

### 5.1.3. Reference Design of RF Antenna Interface

A reference design of ANT\_MAIN and ANT\_DIV antenna pads is shown as below. A  $\pi$ -type matching circuit should be reserved for better RF performance. The capacitors are not mounted by default.

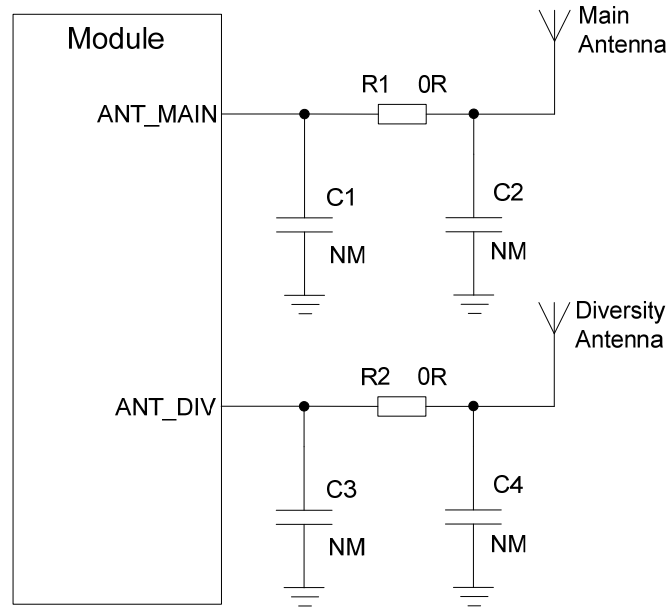


Figure 33: Reference Circuit of RF Antenna Interface

#### NOTES

1. Keep a proper distance between the main antenna and the Rx-diversity antenna to improve the receiving sensitivity.
2. ANT\_DIV function is enabled by default. **AT+QCFG="diversity",0** command can be used to disable receive diversity. Please refer to **document [2]** for details.
3. Place the  $\pi$ -type matching components (R1&C1&C2, R2&C3&C4) as close to the antenna as possible.

### 5.1.4. Reference Design of RF Layout

For user's PCB, the characteristic impedance of all RF traces should be controlled as 50 $\Omega$ . The impedance of the RF traces is usually determined by the trace width (W), the materials' dielectric constant, height from the reference ground to the signal layer (H), and the space between the RF trace and the ground (S). Microstrip and coplanar waveguide are typically used in RF layout to control characteristic impedance. The following figures are reference designs of microstrip or coplanar waveguide with different PCB structures.

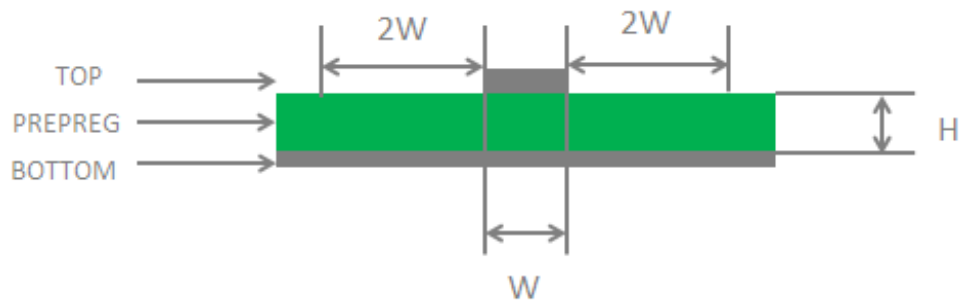


Figure 34: Microstrip Design on a 2-layer PCB

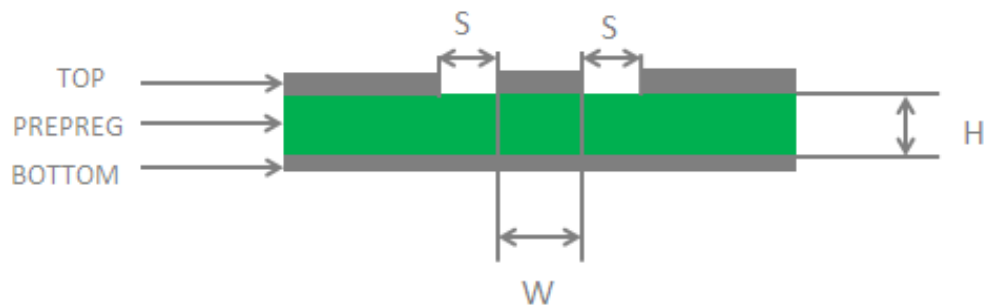


Figure 35: Coplanar Waveguide Design on a 2-layer PCB

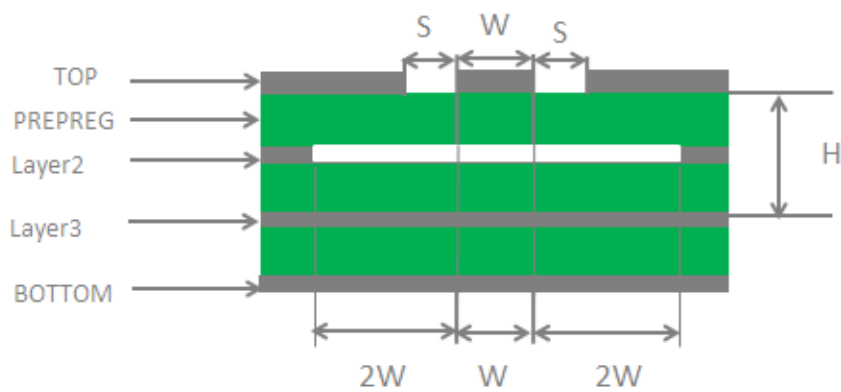


Figure 36: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

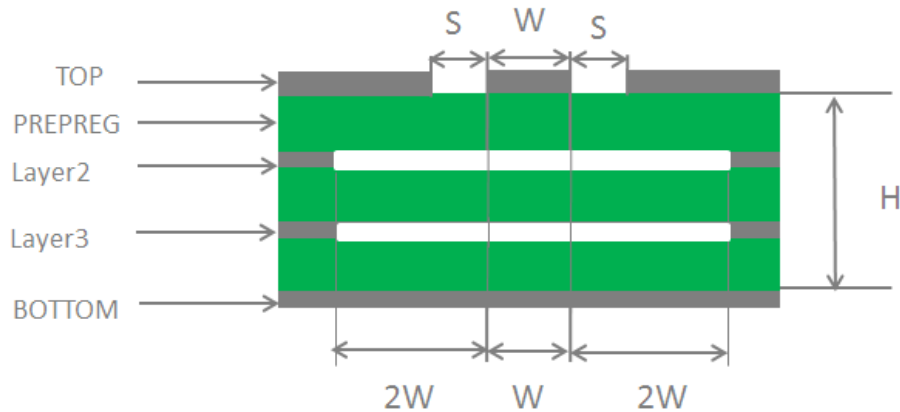


**Figure 37: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)**

In order to ensure RF performance and reliability, the following principles should be complied with in RF layout design:

- Please use an impedance simulation tool to control the characteristic impedance of RF traces as 50Ω.
- The GND pins adjacent to RF pins should not be designed as thermal relief pads, and should be fully connected to ground.
- The distance between the RF pins and the RF connector should be as short as possible, and all the right angle traces should be changed to curved ones.
- There should be clearance area under the signal pin of the antenna connector or solder joint.
- The reference ground of RF traces should be complete. Meanwhile, adding some ground vias around RF traces and the reference ground could help to improve RF performance. The distance between the ground vias and RF traces should be no less than two times the width of RF signal traces ( $2 \times W$ ).

For more details about RF layout, please refer to **document [6]**.

## 5.2. GNSS Antenna Interface

The following tables show the pin definition and frequency specification of GNSS antenna interface.

**Table 28: Pin Definition of GNSS Antenna Interface**

| Pin Name | Pin No. | I/O | Description  | Comment                                    |
|----------|---------|-----|--------------|--------------------------------------------|
| ANT_GNSS | 47      | AI  | GNSS antenna | 50Ω impedance.<br>If unused, keep it open. |

Table 29: GNSS Frequency

| Type    | Frequency      | Unit |
|---------|----------------|------|
| GPS     | 1575.42±1.023  | MHz  |
| GLONASS | 1597.5~1605.8  | MHz  |
| Galileo | 1575.42±2.046  | MHz  |
| BeiDou  | 1561.098±2.046 | MHz  |
| QZSS    | 1575.42        | MHz  |

A reference design of GNSS antenna is shown as below.

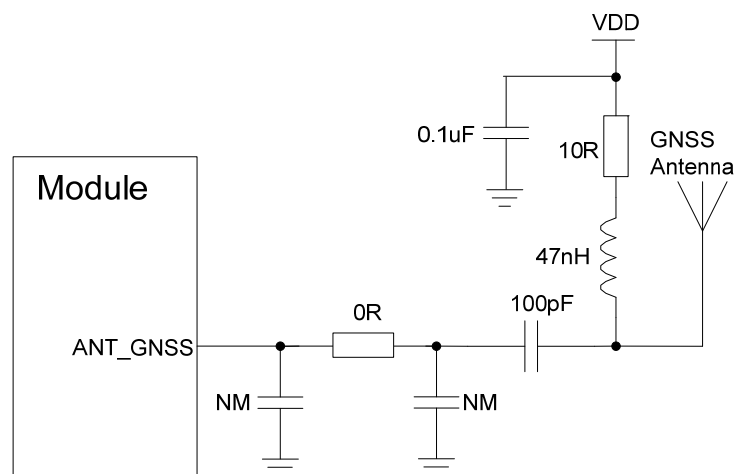


Figure 38: Reference Circuit of GNSS Antenna

#### NOTES

1. An external LDO can be selected to supply power according to the active antenna requirement.
2. If the module is designed with a passive antenna, then the VDD circuit is not needed.

## 5.3. Antenna Installation

### 5.3.1. Antenna Requirement

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

**Table 30: Antenna Requirements**

| Type               | Requirements                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GNSS <sup>1)</sup> | Frequency range: 1559MHz~1609MHz<br>Polarization: RHCP or linear<br>VSWR: < 2 (Typ.)<br>Passive antenna gain: > 0dBi<br>Active antenna noise figure: < 1.5dB<br>Active antenna gain: > 0dBi<br>Active antenna embedded LNA gain:< 17dB                                                                                                                                              |
| GSM/WCDMA/LTE      | VSWR: ≤ 2<br>Efficiency: > 30%<br>Max input power: 50W<br>Input impedance: 50Ω<br>Cable insertion loss: < 1dB<br>(GSM850, EGSM900, WCDMA B5/B6/B8/B19,<br>LTE-FDD B5/B8/B12/B13/B14/B18/B19/B20/B26/B28/B71)<br>Cable insertion loss: < 1.5dB<br>(DCS1800, PCS1900, WCDMA B1/B2/B4,<br>LTE-FDD B1/B2/B3/B4/B66)<br>Cable insertion loss: < 2dB<br>(LTE-FDD B7, LTE-TDD B38/B40/B41) |

#### NOTE

<sup>1)</sup> It is recommended to use a passive GNSS antenna when LTE B13 or B14 is supported, as the use of active antenna may generate harmonics which will affect the GNSS performance.



The following figure describes the space factor of mated connector.

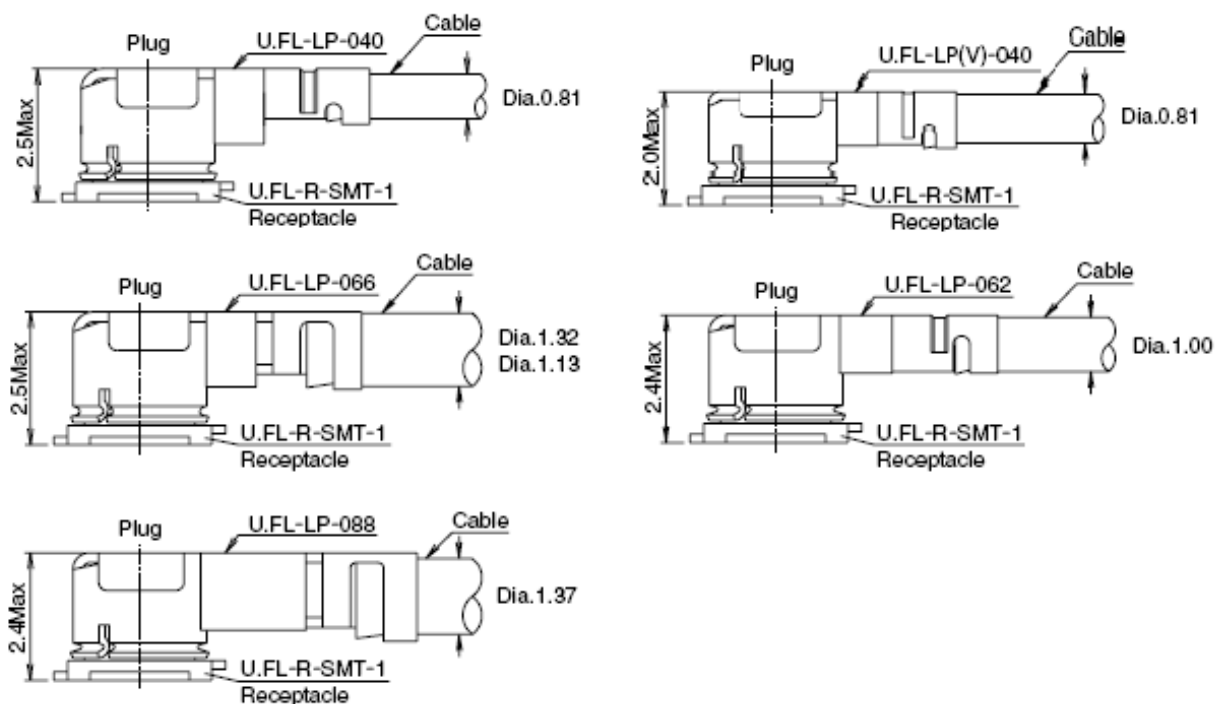


Figure 41: Space Factor of Mated Connector (Unit: mm)

For more details, please visit <http://www.hirose.com>.

# 6 Electrical, Reliability and Radio Characteristics

## 6.1. Absolute Maximum Ratings

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

**Table 31: Absolute Maximum Ratings**

| Parameter               | Min. | Max.    | Unit |
|-------------------------|------|---------|------|
| VBAT_RF/VBAT_BB         | -0.3 | 4.7     | V    |
| USB_VBUS                | -0.3 | 5.5     | V    |
| Peak Current of VBAT_BB | 0    | 0.8     | A    |
| Peak Current of VBAT_RF | 0    | 1.8     | A    |
| Voltage at Digital Pins | -0.3 | 2.3     | V    |
| Voltage at ADC0         | 0    | VBAT_BB | V    |
| Voltage at ADC1         | 0    | VBAT_BB | V    |

## 6.2. Power Supply Ratings

Table 32: Power Supply Ratings

| Parameter         | Description                                    | Conditions                                                                     | Min. | Typ. | Max. | Unit |
|-------------------|------------------------------------------------|--------------------------------------------------------------------------------|------|------|------|------|
| VBAT              | VBAT_BB and VBAT_RF                            | The actual input voltages must be kept between the minimum and maximum values. | 3.3  | 3.8  | 4.3  | V    |
|                   | Voltage drop during burst transmission         | Maximum power control level on EGSM900.                                        |      |      | 400  | mV   |
| I <sub>VBAT</sub> | Peak supply current (during transmission slot) | Maximum power control level on EGSM900.                                        |      | 1.8  | 2.0  | A    |
| USB_VBUS          | USB power supply, used for USB detection       |                                                                                | 3.0  | 5.0  | 5.25 | V    |

## 6.3. Operation and Storage Temperatures

The operation and storage temperatures are listed in the following table.

Table 33: Operation and Storage Temperatures

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

### NOTES

- <sup>1)</sup> Within operation temperature range, the module is 3GPP compliant.
- <sup>2)</sup> Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call\* (emergency call is not supported on ThreadX modules), etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum

and no harm to radio network. Only one or more parameters like  $P_{out}$  might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operation temperature levels, the module will meet 3GPP specifications again.

3. “\*” means under development.

## 6.4. Current Consumption

The values of current consumption are shown below.

**Table 34: EC25-E Current Consumption**

| Parameter  | Description | Conditions                          | Typ. | Unit |
|------------|-------------|-------------------------------------|------|------|
| $I_{VBAT}$ | OFF state   | Power down                          | 11   | uA   |
|            |             | <b>AT+CFUN=0</b> (USB disconnected) | 1.16 | mA   |
|            |             | GSM DRX=2 (USB disconnected)        | 2.74 | mA   |
|            |             | GSM DRX=9 (USB disconnected)        | 2.00 | mA   |
|            |             | WCDMA PF=64 (USB disconnected)      | 2.15 | mA   |
|            | Sleep state | WCDMA PF=128 (USB disconnected)     | 1.67 | mA   |
|            |             | LTE-FDD PF=64 (USB disconnected)    | 2.60 | mA   |
|            |             | LTE-FDD PF=128 (USB disconnected)   | 1.90 | mA   |
|            |             | LTE-TDD PF=64 (USB disconnected)    | 2.79 | mA   |
|            |             | LTE-TDD PF=128 (USB disconnected)   | 2.00 | mA   |
|            | Idle state  | GSM DRX=5 (USB disconnected)        | 19.5 | mA   |
|            |             | GSM DRX=5 (USB connected)           | 29.5 | mA   |
|            |             | WCDMA PF=64 (USB disconnected)      | 21.0 | mA   |
|            |             | WCDMA PF=64 (USB connected)         | 31.0 | mA   |
|            |             | LTE-FDD PF=64 (USB disconnected)    | 20.7 | mA   |
|            |             | LTE-FDD PF=64 (USB connected)       | 30.8 | mA   |

|                                   |                                  |       |    |
|-----------------------------------|----------------------------------|-------|----|
|                                   | LTE-TDD PF=64 (USB disconnected) | 20.8  | mA |
|                                   | LTE-TDD PF=64 (USB connected)    | 32.0  | mA |
| GPRS data transfer<br>(GNSS OFF)  | EGSM900 4DL/1UL @33.22dBm        | 271.0 | mA |
|                                   | EGSM900 3DL/2UL @33.0dBm         | 464.0 | mA |
|                                   | EGSM900 2DL/3UL @30.86dBm        | 524.0 | mA |
|                                   | EGSM900 1DL/4UL @29.58dBm        | 600.0 | mA |
|                                   | DCS1800 4DL/1UL @29.92dBm        | 192.0 | mA |
|                                   | DCS1800 3DL/2UL @29.84dBm        | 311.0 | mA |
|                                   | DCS1800 2DL/3UL @29.67dBm        | 424.0 | mA |
|                                   | DCS1800 1DL/4UL @29.48dBm        | 539.0 | mA |
| EDGE data transfer<br>(GNSS OFF)  | EGSM900 4DL/1UL PCL=8 @27.40dBm  | 174.0 | mA |
|                                   | EGSM900 3DL/2UL PCL=8 @27.24dBm  | 281.0 | mA |
|                                   | EGSM900 2DL/3UL PCL=8 @27.11dBm  | 379.0 | mA |
|                                   | EGSM900 1DL/4UL PCL=8 @26.99dBm  | 480.0 | mA |
|                                   | DCS1800 4DL/1UL PCL=2 @25.82dBm  | 159.0 | mA |
|                                   | DCS1800 3DL/2UL PCL=2 @25.85dBm  | 251.0 | mA |
|                                   | DCS1800 2DL/3UL PCL=2 @25.68dBm  | 340.0 | mA |
|                                   | DCS1800 1DL/4UL PCL=2 @25.57dBm  | 433.0 | mA |
| WCDMA data transfer<br>(GNSS OFF) | WCDMA B1 HSDPA @22.47dBm         | 613.0 | mA |
|                                   | WCDMA B1 HSUPA @22.44dBm         | 609.0 | mA |
|                                   | WCDMA B5 HSDPA @23.07dBm         | 671.0 | mA |
|                                   | WCDMA B5 HSUPA @23.07dBm         | 669.0 | mA |
|                                   | WCDMA B8 HSDPA @22.67dBm         | 561.0 | mA |
|                                   | WCDMA B8 HSUPA @22.39dBm         | 557.0 | mA |
| LTE data                          | LTE-FDD B1 @23.27dBm             | 754.0 | mA |

|                        |                         |       |    |
|------------------------|-------------------------|-------|----|
| transfer<br>(GNSS OFF) | LTE-FDD B3 @23.54dBm    | 774.0 | mA |
|                        | LTE-FDD B5 @22.83dBm    | 762.0 | mA |
|                        | LTE-FDD B7 @23.37dBm    | 842.0 | mA |
|                        | LTE-FDD B8 @23.48dBm    | 720.0 | mA |
|                        | LTE-FDD B20 @22.75dBm   | 714.0 | mA |
|                        | LTE-TDD B38 @23.05dBm   | 481.0 | mA |
|                        | LTE-TDD B40 @23.17dBm   | 431.8 | mA |
|                        | LTE-TDD B41 @23.02dBm   | 480.0 | mA |
| GSM<br>voice call      | EGSM900 PCL=5 @33.08dBm | 264.0 | mA |
|                        | DCS1800 PCL=0 @29.75dBm | 190.0 | mA |
| WCDMA voice<br>call    | WCDMA B1 @23.22dBm      | 680.0 | mA |
|                        | WCDMA B5 @23.18dBm      | 677.0 | mA |
|                        | WCDMA B8 @23.54dBm      | 618.0 | mA |

**Table 35: EC25-A Current Consumption**

| Parameter         | Description | Conditions                        | Typ. | Unit |
|-------------------|-------------|-----------------------------------|------|------|
| I <sub>VBAT</sub> | OFF state   | Power down                        | 10   | uA   |
|                   |             | AT+CFUN=0 (USB disconnected)      | 1.1  | mA   |
|                   |             | WCDMA PF=64 (USB disconnected)    | 1.8  | mA   |
|                   | Sleep state | WCDMA PF=128 (USB disconnected)   | 1.5  | mA   |
|                   |             | LTE-FDD PF=64 (USB disconnected)  | 2.2  | mA   |
|                   |             | LTE-FDD PF=128 (USB disconnected) | 1.6  | mA   |
|                   | Idle state  | WCDMA PF=64 (USB disconnected)    | 21.0 | mA   |
|                   |             | WCDMA PF=64 (USB connected)       | 31.0 | mA   |
|                   |             | LTE-FDD PF=64 (USB disconnected)  | 21.0 | mA   |

|                                |                               |       |    |
|--------------------------------|-------------------------------|-------|----|
| WCDMA data transfer (GNSS OFF) | LTE-FDD PF=64 (USB connected) | 31.0  | mA |
|                                | WCDMA B2 HSDPA @21.9dBm       | 591.0 | mA |
|                                | WCDMA B2 HSUPA @21.62dBm      | 606.0 | mA |
|                                | WCDMA B4 HSDPA @22.02dBm      | 524.0 | mA |
|                                | WCDMA B4 HSUPA @21.67dBm      | 540.0 | mA |
|                                | WCDMA B5 HSDPA @22.71dBm      | 490.0 | mA |
|                                | WCDMA B5 HSUPA @22.58dBm      | 520.0 | mA |
|                                | LTE-FDD B2 @22.93dBm          | 715.0 | mA |
|                                | LTE-FDD B4 @22.96dBm          | 738.0 | mA |
|                                | LTE-FDD B12 @23.35dBm         | 663.0 | mA |
| WCDMA voice call               | WCDMA B2 @22.93dBm            | 646.0 | mA |
|                                | WCDMA B4 @23dBm               | 572.0 | mA |
|                                | WCDMA B5 @23.78dBm            | 549.0 | mA |

**Table 36: EC25-V Current Consumption**

| Parameter        | Description                  | Conditions                          | Typ.  | Unit |
|------------------|------------------------------|-------------------------------------|-------|------|
| I <sub>BAT</sub> | OFF state                    | Power down                          | 10    | uA   |
|                  |                              | <b>AT+CFUN=0</b> (USB disconnected) | 0.85  | mA   |
|                  | Sleep state                  | LTE-FDD PF=64 (USB disconnected)    | 2.0   | mA   |
|                  |                              | LTE-FDD PF=128 (USB disconnected)   | 1.5   | mA   |
|                  | Idle state                   | LTE-FDD PF=64 (USB disconnected)    | 20.0  | mA   |
|                  |                              | LTE-FDD PF=64 (USB connected)       | 31.0  | mA   |
|                  | LTE data transfer (GNSS OFF) | LTE-FDD B4 @23.14dBm                | 770.0 | mA   |
|                  |                              | LTE-FDD B13 @23.48dBm               | 531.0 | mA   |

Table 37: EC25-J Current Consumption

| Parameter         | Description                    | Conditions                        | Typ.   | Unit |
|-------------------|--------------------------------|-----------------------------------|--------|------|
| I <sub>VBAT</sub> | Sleep state                    | AT+CFUN=0 (USB disconnected)      | 2.9    | mA   |
|                   |                                | WCDMA PF=64 (USB disconnected)    | 4.0    | mA   |
|                   |                                | WCDMA PF=128 (USB disconnected)   | 3.5    | mA   |
|                   |                                | LTE-FDD PF=64 (USB disconnected)  | 4.8    | mA   |
|                   |                                | LTE-FDD PF=128 (USB disconnected) | 4.0    | mA   |
|                   |                                | LTE-TDD PF=64 (USB disconnected)  | 4.9    | mA   |
|                   |                                | LTE-TDD PF=128 (USB disconnected) | 4.1    | mA   |
|                   | Idle state                     | WCDMA PF=64 (USB disconnected)    | 29.6   | mA   |
|                   |                                | WCDMA PF=64 (USB connected)       | 42.7   | mA   |
|                   |                                | LTE-FDD PF=64 (USB disconnected)  | 29.8   | mA   |
|                   |                                | LTE-FDD PF=64 (USB connected)     | 41.3   | mA   |
|                   |                                | LTE-TDD PF=64 (USB disconnected)  | 29.9   | mA   |
|                   |                                | LTE-TDD PF=64 (USB connected)     | 42.7   | mA   |
|                   | WCDMA data transfer (GNSS OFF) | WCDMA B1 HSDPA @22.30dBm          | 823.4  | mA   |
|                   |                                | WCDMA B1 HSUPA @21.98dBm          | 835.2  | mA   |
|                   |                                | WCDMA B6 HSDPA @22.32dBm          | 616.6  | mA   |
|                   |                                | WCDMA B6 HSUPA @21.78dBm          | 621.6  | mA   |
|                   |                                | WCDMA B8 HSDPA @22.17dBm          | 658.3  | mA   |
|                   |                                | WCDMA B8 HSUPA @21.98dBm          | 690.1  | mA   |
|                   |                                | WCDMA B19 HSDPA @22.44dBm         | 615.7  | mA   |
|                   |                                | WCDMA B19 HSUPA @21.82dBm         | 617.2  | mA   |
|                   | LTE data transfer (GNSS OFF)   | LTE-FDD B1 @23.13dBm              | 1075.0 | mA   |
|                   |                                | LTE-FDD B3 @23.07dBm              | 988.5  | mA   |

|  |                     |                       |       |    |
|--|---------------------|-----------------------|-------|----|
|  |                     | LTE-FDD B8 @23.32dBm  | 882.3 | mA |
|  |                     | LTE-FDD B18 @23.61dBm | 867.0 | mA |
|  |                     | LTE-FDD B19 @23.67dBm | 911.4 | mA |
|  |                     | LTE-FDD B26 @22.86dBm | 909.6 | mA |
|  |                     | LTE-TDD B41 @22.40dBm | 563.4 | mA |
|  | WCDMA<br>voice call | WCDMA B1 @23.23dBm    | 964.8 | mA |
|  |                     | WCDMA B6 @23.02dBm    | 667.9 | mA |
|  |                     | WCDMA B8 @23.12dBm    | 735.4 | mA |
|  |                     | WCDMA B19 @22.99dBm   | 664.8 | mA |

**Table 38: EC25-AU Current Consumption**

| Parameter         | Description | Conditions                          | Typ. | Unit |
|-------------------|-------------|-------------------------------------|------|------|
| I <sub>VBAT</sub> | OFF state   | Power down                          | 11   | uA   |
|                   |             | <b>AT+CFUN=0</b>                    | 1.3  | mA   |
|                   | Sleep state | <b>AT+CFUN=0</b> (USB disconnected) | 1.46 | mA   |
|                   |             | GSM850 DRX=5 (USB disconnected)     | 1.8  | mA   |
|                   |             | EGSM900 DRX=5 (USB disconnected)    | 2.0  | mA   |
|                   |             | DCS1800 DRX=5 (USB disconnected)    | 1.9  | mA   |
|                   |             | PCS1900 DRX=5 (USB disconnected)    | 1.9  | mA   |
|                   |             | WCDMA PF=64 (USB disconnected)      | 2.0  | mA   |
|                   |             | WCDMA PF=128 (USB disconnected)     | 1.6  | mA   |
|                   |             | LTE-FDD PF=64 (USB disconnected)    | 2.2  | mA   |
|                   |             | LTE-FDD PF=128 (USB disconnected)   | 1.6  | mA   |
|                   |             | LTE-TDD PF=64 (USB disconnected)    | 2.3  | mA   |
|                   |             | LTE-TDD PF=128 (USB disconnected)   | 1.6  | mA   |

|                                  |                                  |       |    |
|----------------------------------|----------------------------------|-------|----|
| Idle state                       | EGSM900 DRX=5 (USB disconnected) | 22.0  | mA |
|                                  | EGSM900 DRX=5 (USB connected)    | 34.0  | mA |
|                                  | WCDMA PF=64 (USB disconnected)   | 22.0  | mA |
|                                  | WCDMA PF=64 (USB connected)      | 33.0  | mA |
|                                  | LTE-FDD PF=64 (USB disconnected) | 24.0  | mA |
|                                  | LTE-FDD PF=64 (USB connected)    | 35.0  | mA |
| GPRS data transfer<br>(GNSS OFF) | GSM850 1UL/4DL @32.53dBm         | 232.0 | mA |
|                                  | GSM850 2UL/3DL @32.34dBm         | 384.0 | mA |
|                                  | GSM850 3UL/2DL @30.28dBm         | 441.0 | mA |
|                                  | GSM850 4UL/1DL @29.09dBm         | 511.0 | mA |
|                                  | EGSM900 1UL/4DL @32.34dBm        | 241.0 | mA |
|                                  | EGSM900 2UL/3DL @32.19dBm        | 397.0 | mA |
|                                  | EGSM900 3UL/2DL @30.17dBm        | 459.0 | mA |
|                                  | EGSM900 4UL/1DL @28.96dBm        | 533.0 | mA |
|                                  | DCS1800 1UL/4DL @29.71dBm        | 183.0 | mA |
|                                  | DCS1800 2UL/3DL @29.62dBm        | 289.0 | mA |
|                                  | DCS1800 3UL/2DL @29.49dBm        | 392.0 | mA |
|                                  | DCS1800 4UL/1DL @29.32dBm        | 495.0 | mA |
|                                  | PCS1900 1UL/4DL @29.61dBm        | 174.0 | mA |
|                                  | PCS1900 2UL/3DL @29.48dBm        | 273.0 | mA |
|                                  | PCS1900 3UL/2DL @29.32dBm        | 367.0 | mA |
|                                  | PCS1900 4UL/1DL @29.19dBm        | 465.0 | mA |
| EDGE data transfer<br>(GNSS OFF) | GSM850 1UL/4DL @27.09dBm         | 154.0 | mA |
|                                  | GSM850 2UL/3DL @26.94dBm         | 245.0 | mA |
|                                  | GSM850 3UL/2DL @26.64dBm         | 328.0 | mA |

|                                   |                           |       |    |
|-----------------------------------|---------------------------|-------|----|
|                                   | GSM850 4UL/1DL @26.53dBm  | 416.0 | mA |
|                                   | EGSM900 1UL/4DL @26.64dBm | 157.0 | mA |
|                                   | EGSM900 2UL/3DL @26.95dBm | 251.0 | mA |
|                                   | EGSM900 3UL/2DL @26.57dBm | 340.0 | mA |
|                                   | EGSM900 4UL/1DL @26.39dBm | 431.0 | mA |
|                                   | DCS1800 1UL/4DL @26.03dBm | 152.0 | mA |
|                                   | DCS1800 2UL/3DL @25.62dBm | 240.0 | mA |
|                                   | DCS1800 3UL/2DL @25.42dBm | 325.0 | mA |
|                                   | DCS1800 4UL/1DL @25.21dBm | 415.0 | mA |
|                                   | PCS1900 1UL/4DL @25.65dBm | 148.0 | mA |
|                                   | PCS1900 2UL/3DL @25.63dBm | 232.0 | mA |
|                                   | PCS1900 3UL/2DL @25.54dBm | 313.0 | mA |
|                                   | PCS1900 4UL/1DL @25.26dBm | 401.0 | mA |
|                                   | WCDMA B1 HSDPA @22.34dBm  | 625.0 | mA |
|                                   | WCDMA B1 HSUPA @21.75dBm  | 617.0 | mA |
| WCDMA data transfer<br>(GNSS OFF) | WCDMA B2 HSDPA @22.51dBm  | 610.0 | mA |
|                                   | WCDMA B2 HSUPA @22.14dBm  | 594.0 | mA |
|                                   | WCDMA B5 HSDPA @22.98dBm  | 576.0 | mA |
|                                   | WCDMA B5 HSUPA @22.89dBm  | 589.0 | mA |
|                                   | WCDMA B8 HSDPA @22.31dBm  | 556.0 | mA |
| LTE data transfer<br>(GNSS OFF)   | WCDMA B8 HSUPA @22.11dBm  | 572.0 | mA |
|                                   | LTE-FDD B1 @23.28dBm      | 817.0 | mA |
|                                   | LTE-FDD B2 @23.34dBm      | 803.0 | mA |
|                                   | LTE-FDD B3 @23.2dBm       | 785.0 | mA |
|                                   | LTE-FDD B4 @22.9dBm       | 774.0 | mA |

|  |                  |                        |       |    |
|--|------------------|------------------------|-------|----|
|  |                  | LTE-FDD B5 @23.45dBm   | 687.0 | mA |
|  |                  | LTE-FDD B7 @22.84dBm   | 843.0 | mA |
|  |                  | LTE-FDD B8 @22.92dBm   | 689.0 | mA |
|  |                  | LTE-FDD B28 @23.23dBm  | 804.0 | mA |
|  |                  | LTE-TDD B40 @23.3dBm   | 429.0 | mA |
|  | GSM voice call   | GSM850 PCL5 @32.66dBm  | 228.0 | mA |
|  |                  | EGSM900 PCL5 @32.59dBm | 235.0 | mA |
|  |                  | DCS1800 PCL0 @29.72dBm | 178.0 | mA |
|  |                  | PCS1900 PCL0 @29.82dBm | 170.0 | mA |
|  | WCDMA voice call | WCDMA B1 @23.27dBm     | 687.0 | mA |
|  |                  | WCDMA B2 @23.38dBm     | 668.0 | mA |
|  |                  | WCDMA B5 @23.38dBm     | 592.0 | mA |
|  |                  | WCDMA B8 @23.32dBm     | 595.0 | mA |

**Table 39: EC25-AUT Current Consumption**

| Parameter         | Description | Conditions                          | Typ. | Unit |
|-------------------|-------------|-------------------------------------|------|------|
| I <sub>VBAT</sub> | OFF state   | Power down                          | 10   | uA   |
|                   | Sleep state | <b>AT+CFUN=0</b> (USB disconnected) | 1.0  | mA   |
|                   |             | WCDMA PF=64 (USB disconnected)      | 1.9  | mA   |
|                   |             | WCDMA PF=128 (USB disconnected)     | 1.5  | mA   |
|                   |             | LTE-FDD PF=64 (USB disconnected)    | 2.3  | mA   |
|                   |             | LTE-FDD PF=128 (USB disconnected)   | 1.9  | mA   |
|                   | Idle state  | WCDMA PF=64 (USB disconnected)      | 23.0 | mA   |
|                   |             | WCDMA PF=64 (USB connected)         | 33.0 | mA   |
|                   |             | LTE-FDD PF=64 (USB disconnected)    | 17.0 | mA   |
|                   |             | LTE-FDD PF=64 (USB connected)       | 29.0 | mA   |

|                                |                          |       |    |
|--------------------------------|--------------------------|-------|----|
| WCDMA data transfer (GNSS OFF) | WCDMA B1 HSDPA @22.24dBm | 500.0 | mA |
|                                | WCDMA B1 HSUPA @22.05dBm | 499.0 | mA |
|                                | WCDMA B5 HSDPA @22.39dBm | 418.0 | mA |
|                                | WCDMA B5 HSUPA @22dBm    | 486.0 | mA |
| LTE data transfer (GNSS OFF)   | LTE-FDD B1 @23.28dBm     | 707.0 | mA |
|                                | LTE-FDD B3 @23.36dBm     | 782.0 | mA |
|                                | LTE-FDD B5 @23.32dBm     | 588.0 | mA |
|                                | LTE-FDD B7 @23.08dBm     | 692.0 | mA |
|                                | LTE-FDD B28A @23.37dBm   | 752.0 | mA |
|                                | LTE-FDD B28B @23.48dBm   | 770.0 | mA |
| WCDMA voice call               | WCDMA B1 @23.22dBm       | 546.0 | mA |
|                                | WCDMA B5 @23.01dBm       | 511.0 | mA |

**Table 40: EC25-AF Current Consumption**

| Parameter         | Description | Conditions                          | Typ. | Unit |
|-------------------|-------------|-------------------------------------|------|------|
| I <sub>VBAT</sub> | OFF state   | Power down                          | 10   | uA   |
|                   | Sleep state | <b>AT+CFUN=0</b> (USB disconnected) | 1.0  | mA   |
|                   |             | WCDMA PF=64 (USB disconnected)      | 1.8  | mA   |
|                   |             | WCDMA PF=128 (USB disconnected)     | 1.4  | mA   |
|                   |             | LTE-FDD PF=64 (USB disconnected)    | 2.2  | mA   |
|                   |             | LTE-FDD PF=128 (USB disconnected)   | 1.8  | mA   |
|                   | Idle state  | WCDMA PF=64 (USB disconnected)      | 23.3 | mA   |
|                   |             | WCDMA PF=64 (USB connected)         | 33.4 | mA   |
|                   |             | LTE-FDD PF=64 (USB disconnected)    | 17.6 | mA   |
|                   |             | LTE-FDD PF=64 (USB connected)       | 29.4 | mA   |

|                                |                          |       |    |
|--------------------------------|--------------------------|-------|----|
| WCDMA data transfer (GNSS OFF) | WCDMA B2 HSDPA @22.63dBm | 560.0 | mA |
|                                | WCDMA B2 HSUPA @22.49dBm | 564.0 | mA |
|                                | WCDMA B4 HSDPA @22.45dBm | 601.0 | mA |
|                                | WCDMA B4 HSUPA @22.57dBm | 610.0 | mA |
|                                | WCDMA B5 HSDPA @22.49dBm | 603.0 | mA |
|                                | WCDMA B5 HSUPA @22.43dBm | 617.0 | mA |
| LTE data transfer (GNSS OFF)   | LTE-FDD B2 @22.92dBm     | 698.0 | mA |
|                                | LTE-FDD B4 @23.12dBm     | 710.0 | mA |
|                                | LTE-FDD B5 @22.98dBm     | 650.0 | mA |
|                                | LTE-FDD B12 @23.42dBm    | 648.0 | mA |
|                                | LTE-FDD B13 @22.92dBm    | 690.0 | mA |
|                                | LTE-FDD B14 @23.42dBm    | 685.0 | mA |
|                                | LTE-FDD B66 @23.35dBm    | 715.0 | mA |
| WCDMA voice call               | LTE-FDD B71 @23.39dBm    | 689.0 | mA |
|                                | WCDMA B2 @23.59dBm       | 585.0 | mA |
|                                | WCDMA B4 @23.47dBm       | 610.0 | mA |
|                                | WCDMA B5 @23.46dBm       | 605.0 | mA |

**Table 41: EC25-AFX Current Consumption**

| Parameter        | Description | Conditions                          | Typ. | Unit |
|------------------|-------------|-------------------------------------|------|------|
| I <sub>BAT</sub> | OFF state   | Power down                          | 8    | uA   |
|                  | Sleep state | <b>AT+CFUN=0</b> (USB disconnected) | 0.83 | mA   |
|                  |             | WCDMA PF=64 (USB disconnected)      | 1.55 | mA   |
|                  |             | WCDMA PF=128 (USB disconnected)     | 1.24 | mA   |
|                  |             | WCDMA PF=256 (USB disconnected)     | 1.07 | mA   |
|                  |             |                                     |      |      |

|                                   |                                   |       |    |
|-----------------------------------|-----------------------------------|-------|----|
|                                   | WCDMA PF=512 (USB disconnected)   | 1.00  | mA |
|                                   | LTE-FDD PF=32 (USB disconnected)  | 2.97  | mA |
|                                   | LTE-FDD PF=64 (USB disconnected)  | 1.93  | mA |
|                                   | LTE-FDD PF=128 (USB disconnected) | 1.43  | mA |
|                                   | LTE-FDD PF=256 (USB disconnected) | 1.17  | mA |
| Idle state                        | WCDMA PF=64 (USB disconnected)    | 14.9  | mA |
|                                   | WCDMA PF=64 (USB connected)       | 34.2  | mA |
|                                   | LTE-FDD PF=64 (USB disconnected)  | 15.2  | mA |
|                                   | LTE-FDD PF=64 (USB connected)     | 34.8  | mA |
| WCDMA data transfer<br>(GNSS OFF) | WCDMA B2 HSDPA @22.1dBm           | 548.0 | mA |
|                                   | WCDMA B2 HSUPA @22.28dBm          | 545.0 | mA |
|                                   | WCDMA B4 HSDPA @22.2dBm           | 580.0 | mA |
|                                   | WCDMA B4 HSUPA @22.2dBm           | 596.0 | mA |
|                                   | WCDMA B5 HSDPA @22.1dBm           | 498.0 | mA |
|                                   | WCDMA B5 HSUPA @22.0dBm           | 500.0 | mA |
| LTE data transfer<br>(GNSS OFF)   | LTE-FDD B2 @23.36dBm              | 621.0 | mA |
|                                   | LTE-FDD B4 @22.7dBm               | 702.0 | mA |
|                                   | LTE-FDD B5 @22.7dBm               | 564.0 | mA |
|                                   | LTE-FDD B12 @22.66dBm             | 648.0 | mA |
|                                   | LTE-FDD B13 @22.79dBm             | 617.0 | mA |
|                                   | LTE-FDD B14 @22.72dBm             | 622.0 | mA |
|                                   | LTE-FDD B66 @22.86dBm             | 698.0 | mA |
|                                   | LTE-FDD B71 @22.73dBm             | 628.0 | mA |
| WCDMA voice call                  | WCDMA B2 @22.63dBm                | 578.0 | mA |
|                                   | WCDMA B4 @22.74dBm                | 581.0 | mA |

WCDMA B5 @22.6dBm

561.0

mA

**Table 42: EC25-EU Current Consumption**

| Parameter  | Description                   | Conditions                          | Typ.  | Unit |
|------------|-------------------------------|-------------------------------------|-------|------|
| $I_{VBAT}$ | OFF state                     | Power down                          | 11    | uA   |
|            |                               | <b>AT+CFUN=0</b> (USB disconnected) | 1.16  | mA   |
|            | Sleep state                   | GSM DRX=2 (USB disconnected)        | 2.74  | mA   |
|            |                               | GSM DRX=9 (USB disconnected)        | 2.0   | mA   |
|            |                               | WCDMA PF=64 (USB disconnected)      | 2.15  | mA   |
|            |                               | WCDMA PF=128 (USB disconnected)     | 1.67  | mA   |
|            |                               | LTE-FDD PF=64 (USB disconnected)    | 2.60  | mA   |
|            |                               | LTE-FDD PF=128 (USB disconnected)   | 1.90  | mA   |
|            |                               | LTE-TDD PF=64 (USB disconnected)    | 2.79  | mA   |
|            |                               | LTE-TDD PF=128 (USB disconnected)   | 2.00  | mA   |
|            | Idle state                    | GSM DRX=5 (USB disconnected)        | 19.5  | mA   |
|            |                               | GSM DRX=5 (USB connected)           | 29.5  | mA   |
|            |                               | WCDMA PF=64 (USB disconnected)      | 21.0  | mA   |
|            |                               | WCDMA PF=64 (USB connected)         | 31.0  | mA   |
|            |                               | LTE-FDD PF=64 (USB disconnected)    | 20.7  | mA   |
|            |                               | LTE-FDD PF=64 (USB connected)       | 30.8  | mA   |
|            |                               | LTE-TDD PF=64 (USB disconnected)    | 20.8  | mA   |
|            |                               | LTE-TDD PF=64 (USB connected)       | 32.0  | mA   |
|            | GPRS data transfer (GNSS OFF) | EGSM900 4DL/1UL @33.23dBm           | 243.0 | mA   |
|            |                               | EGSM900 3DL/2UL @31.96dBm           | 388.0 | mA   |
|            |                               | EGSM900 2DL/3UL @29.73dBm           | 453.0 | mA   |

|                                   |                                 |       |    |
|-----------------------------------|---------------------------------|-------|----|
|                                   | EGSM900 1DL/4UL @28.5dBm        | 522   | mA |
|                                   | DCS1800 4DL/1UL @30.49dBm       | 172.0 | mA |
|                                   | DCS1800 3DL/2UL @29.24dBm       | 274.0 | mA |
|                                   | DCS1800 2DL/3UL @27.15dBm       | 337.0 | mA |
|                                   | DCS1800 1DL/4UL @25.88dBm       | 406.0 | mA |
| EDGE data transfer<br>(GNSS OFF)  | EGSM900 4DL/1UL PCL=8 @26.60dBm | 142.0 | mA |
|                                   | EGSM900 3DL/2UL PCL=8 @25.43dBm | 229.0 | mA |
|                                   | EGSM900 2DL/3UL PCL=8 @23.4dBm  | 286.0 | mA |
|                                   | EGSM900 1DL/4UL PCL=8 @22.36dBm | 348.0 | mA |
|                                   | DCS1800 4DL/1UL PCL=2 @25.59dBm | 136.0 | mA |
|                                   | DCS1800 3DL/2UL PCL=2 @24.54dBm | 225.0 | mA |
|                                   | DCS1800 2DL/3UL PCL=2 @22.38dBm | 300.0 | mA |
|                                   | DCS1800 1DL/4UL PCL=2 @21.24dBm | 379.0 | mA |
|                                   |                                 |       |    |
| WCDMA data transfer<br>(GNSS OFF) | WCDMA B1 HSDPA @22.93dBm        | 504.0 | mA |
|                                   | WCDMA B1 HSUPA @22.62dBm        | 512.0 | mA |
|                                   | WCDMA B8 HSDPA @22.88dBm        | 562.0 | mA |
|                                   | WCDMA B8 HSUPA @22.14dBm        | 535.0 | mA |
| LTE data transfer<br>(GNSS OFF)   | LTE-FDD B1 @23.6dBm             | 664.0 | mA |
|                                   | LTE-FDD B3 @23.67dBm            | 728.0 | mA |
|                                   | LTE-FDD B7 @23.83dBm            | 821.0 | mA |
|                                   | LTE-FDD B8 @23.82dBm            | 695.0 | mA |
|                                   | LTE-FDD B20 @23.88dBm           | 649.0 | mA |
|                                   | LTE-FDD B28A @23.43dBm          | 689.0 | mA |
|                                   | LTE-TDD B38 @22.82dBm           | 438.0 | mA |
|                                   | LTE-TDD B40 @23.43dBm           | 355.0 | mA |

|                     |                         |       |    |
|---------------------|-------------------------|-------|----|
|                     | LTE-TDD B41 @23.46dBm   | 451.0 | mA |
| GSM<br>voice call   | EGSM900 PCL=5 @33.25dBm | 258.0 | mA |
|                     | DCS1800 PCL=0 @30.23dBm | 178.0 | mA |
| WCDMA voice<br>call | WCDMA B1 @23.88dBm      | 548.0 | mA |
|                     | WCDMA B8 @23.8dBm       | 615.0 | mA |

**Table 43: EC25-EC Current Consumption**

| Parameter        | Description                         | Conditions                          | Typ.  | Unit |
|------------------|-------------------------------------|-------------------------------------|-------|------|
| I <sub>BAT</sub> | OFF state                           | Power down                          | 9     | uA   |
|                  | Sleep state                         | <b>AT+CFUN=0</b> (USB disconnected) | 1.0   | mA   |
|                  |                                     | GSM DRX=2 (USB disconnected)        | 2.0   | mA   |
|                  |                                     | GSM DRX=9 (USB disconnected)        | 1.3   | mA   |
|                  |                                     | WCDMA PF=64 (USB disconnected)      | 2.1   | mA   |
|                  |                                     | WCDMA PF=128 (USB disconnected)     | 1.7   | mA   |
|                  |                                     | LTE-FDD PF=64 (USB disconnected)    | 2.3   | mA   |
|                  |                                     | LTE-FDD PF=128 (USB disconnected)   | 1.8   | mA   |
|                  | Idle state                          | GSM DRX=5 (USB disconnected)        | 17.3  | mA   |
|                  |                                     | GSM DRX=5 (USB connected)           | 28.3  | mA   |
|                  |                                     | WCDMA PF=64 (USB disconnected)      | 17.1  | mA   |
|                  |                                     | WCDMA PF=64 (USB connected)         | 27.2  | mA   |
|                  |                                     | LTE-FDD PF=64 (USB disconnected)    | 18.9  | mA   |
|                  |                                     | LTE-FDD PF=64 (USB connected)       | 28.7  | mA   |
|                  | GPRS data<br>transfer<br>(GNSS OFF) | EGSM900 4DL/1UL @32.91dBm           | 250.0 | mA   |
|                  |                                     | EGSM900 3DL/2UL @32.75dBm           | 462.0 | mA   |
|                  |                                     | EGSM900 2DL/3UL @30.87dBm           | 511.0 | mA   |

|                                   |                                 |       |    |
|-----------------------------------|---------------------------------|-------|----|
|                                   | EGSM900 1DL/4UL @28.84dBm       | 586.0 | mA |
|                                   | DCS1800 4DL/1UL @29.46dBm       | 156.0 | mA |
|                                   | DCS1800 3DL/2UL @29.41dBm       | 250.0 | mA |
|                                   | DCS1800 2DL/3UL @29.37dBm       | 344.0 | mA |
|                                   | DCS1800 1DL/4UL @29.28dBm       | 443.0 | mA |
| EDGE data transfer<br>(GNSS OFF)  | EGSM900 4DL/1UL PCL=8 @25.21dBm | 175.0 | mA |
|                                   | EGSM900 3DL/2UL PCL=8 @24.80dBm | 295.0 | mA |
|                                   | EGSM900 2DL/3UL PCL=8 @24.74dBm | 397.0 | mA |
|                                   | EGSM900 1DL/4UL PCL=8 @24.38dBm | 509.0 | mA |
|                                   | DCS1800 4DL/1UL PCL=2 @25.72dBm | 134.0 | mA |
|                                   | DCS1800 3DL/2UL PCL=2 @24.86dBm | 211.0 | mA |
|                                   | DCS1800 2DL/3UL PCL=2 @25.59dBm | 312.0 | mA |
|                                   | DCS1800 1DL/4UL PCL=2 @25.39dBm | 299.0 | mA |
| WCDMA data transfer<br>(GNSS OFF) | WCDMA B1 HSDPA @22.54dBm        | 567.0 | mA |
|                                   | WCDMA B1 HSUPA @22.45dBm        | 574.3 | mA |
|                                   | WCDMA B8 HSDPA @22.42dBm        | 481.9 | mA |
|                                   | WCDMA B8 HSUPA @21.91dBm        | 463.0 | mA |
| LTE data transfer<br>(GNSS OFF)   | LTE-FDD B1 @22.55dBm            | 752.0 | mA |
|                                   | LTE-FDD B3 @22.93dBm            | 701.5 | mA |
|                                   | LTE-FDD B7 @23.03dBm            | 715.4 | mA |
|                                   | LTE-FDD B20 @22.98dBm           | 724.6 | mA |
|                                   | LTE-FDD B28 @22.27dBm           | 782.5 | mA |
| GSM voice call                    | EGSM900 PCL=5 @33.84dBm         | 292.0 | mA |
|                                   | DCS1800 PCL=0 @29.62dBm         | 154.0 | mA |
| WCDMA voice                       | WCDMA B1 @23.94dBm              | 614.6 | mA |

|      |                    |       |    |
|------|--------------------|-------|----|
| call | WCDMA B8 @23.33dBm | 517.0 | mA |
|------|--------------------|-------|----|

**Table 44: EC25-EUX Current Consumption**

| Parameter         | Description                   | Conditions                        | Typ.  | Unit |
|-------------------|-------------------------------|-----------------------------------|-------|------|
| I <sub>VBAT</sub> | OFF state                     | Power down                        | 9     | uA   |
|                   |                               | AT+CFUN=0 (USB disconnected)      | 0.9   | mA   |
|                   |                               | GSM DRX=2 (USB disconnected)      | 1.8   | mA   |
|                   |                               | GSM DRX=9 (USB disconnected)      | 1.3   | mA   |
|                   |                               | WCDMA PF=64 (USB disconnected)    | 1.6   | mA   |
|                   | Sleep state                   | WCDMA PF=128 (USB disconnected)   | 1.3   | mA   |
|                   |                               | LTE-FDD PF=64 (USB disconnected)  | 2.2   | mA   |
|                   |                               | LTE-FDD PF=128 (USB disconnected) | 1.6   | mA   |
|                   |                               | LTE-TDD PF=64 (USB disconnected)  | 2.2   | mA   |
|                   |                               | LTE-TDD PF=128 (USB disconnected) | 1.6   | mA   |
|                   | Idle state                    | GSM DRX=5 (USB disconnected)      | 14.5  | mA   |
|                   |                               | GSM DRX=5 (USB connected)         | 34.3  | mA   |
|                   |                               | WCDMA PF=64 (USB disconnected)    | 14.7  | mA   |
|                   |                               | WCDMA PF=64 (USB connected)       | 35.3  | mA   |
|                   |                               | LTE-FDD PF=64 (USB disconnected)  | 15.0  | mA   |
|                   |                               | LTE-FDD PF=64 (USB connected)     | 36.5  | mA   |
|                   |                               | LTE-TDD PF=64 (USB disconnected)  | 15.0  | mA   |
|                   |                               | LTE-TDD PF=64 (USB connected)     | 36.5  | mA   |
|                   | GPRS data transfer (GNSS OFF) | EGSM900 4DL/1UL @33.02dBm         | 270.7 | mA   |
|                   |                               | EGSM900 3DL/2UL @32.24dBm         | 444.3 | mA   |
|                   |                               | EGSM900 2DL/3UL @30.08dBm         | 509.8 | mA   |

|                                   |                                 |       |    |
|-----------------------------------|---------------------------------|-------|----|
|                                   | EGSM900 1DL/4UL @29.50dBm       | 629.3 | mA |
|                                   | DCS1800 4DL/1UL @29.63dBm       | 157.4 | mA |
|                                   | DCS1800 3DL/2UL @28.96dBm       | 246.3 | mA |
|                                   | DCS1800 2DL/3UL @27.49dBm       | 310.6 | mA |
|                                   | DCS1800 1DL/4UL @26.44dBm       | 377.7 | mA |
| EDGE data transfer<br>(GNSS OFF)  | EGSM900 4DL/1UL PCL=8 @27.27dBm | 175.4 | mA |
|                                   | EGSM900 3DL/2UL PCL=8 @26.13dBm | 292.1 | mA |
|                                   | EGSM900 2DL/3UL PCL=8 @24.03dBm | 386.8 | mA |
|                                   | EGSM900 1DL/4UL PCL=8 @23.35dBm | 494.7 | mA |
|                                   | DCS1800 4DL/1UL PCL=2 @25.92dBm | 134.5 | mA |
|                                   | DCS1800 3DL/2UL PCL=2 @25.63dBm | 222.9 | mA |
|                                   | DCS1800 2DL/3UL PCL=2 @23.14dBm | 301.2 | mA |
|                                   | DCS1800 1DL/4UL PCL=2 @22.60dBm | 391.8 | mA |
| WCDMA data transfer<br>(GNSS OFF) | WCDMA B1 HSDPA @22.01dBm        | 534.8 | mA |
|                                   | WCDMA B1 HSUPA @21.38dBm        | 526.7 | mA |
|                                   | WCDMA B8 HSDPA @22.21dBm        | 459.8 | mA |
|                                   | WCDMA B8 HSUPA @21.85dBm        | 471.6 | mA |
| LTE data transfer<br>(GNSS OFF)   | LTE-FDD B1 @23.38dBm            | 743.4 | mA |
|                                   | LTE-FDD B3 @22.87dBm            | 674.6 | mA |
|                                   | LTE-FDD B7 @22.08dBm            | 658.8 | mA |
|                                   | LTE-FDD B8 @23.49dBm            | 607.3 | mA |
|                                   | LTE-FDD B20 @23.01dBm           | 711.0 | mA |
|                                   | LTE-FDD B28A @23.18dBm          | 788.2 | mA |
|                                   | LTE-TDD B38 @23.38dBm           | 446.6 | mA |
|                                   | LTE-TDD B40 @23.56dBm           | 344.4 | mA |

|                     |                         |       |    |
|---------------------|-------------------------|-------|----|
|                     | LTE-TDD B41 @23.17dBm   | 483.2 | mA |
| GSM<br>voice call   | EGSM900 PCL=5 @32.81dBm | 262.2 | mA |
|                     | DCS1800 PCL=0 @29.62dBm | 151.2 | mA |
| WCDMA voice<br>call | WCDMA B1 @23.09dBm      | 594.2 | mA |
|                     | WCDMA B8 @23.18dBm      | 504.3 | mA |

**Table 45: EC25-MX Current Consumption**

| Parameter         | Description                          | Conditions                          | Typ.  | Unit |
|-------------------|--------------------------------------|-------------------------------------|-------|------|
|                   | OFF state                            | Power down                          | 19    | uA   |
|                   |                                      | <b>AT+CFUN=0</b> (USB disconnected) | 1.0   | mA   |
|                   |                                      | WCDMA PF=64 (USB disconnected)      | 2.3   | mA   |
|                   | Sleep state                          | WCDMA PF=128 (USB disconnected)     | 1.7   | mA   |
|                   |                                      | LTE-FDD PF=64 (USB disconnected)    | 2.5   | mA   |
|                   |                                      | LTE-FDD PF=128 (USB disconnected)   | 2.2   | mA   |
|                   | Idle state                           | WCDMA PF=64 (USB disconnected)      | 12.9  | mA   |
|                   |                                      | WCDMA PF=64 (USB connected)         | 32.0  | mA   |
|                   |                                      | LTE-FDD PF=64 (USB disconnected)    | 13.7  | mA   |
|                   |                                      | LTE-FDD PF=64 (USB connected)       | 32.6  | mA   |
| I <sub>VBAT</sub> | WCDMA data<br>transfer<br>(GNSS OFF) | WCDMA B2 HSDPA @22.27dBm            | 581.9 | mA   |
|                   |                                      | WCDMA B2 HSUPA @22.15dBm            | 603.0 | mA   |
|                   |                                      | WCDMA B4 HSDPA @22.5dBm             | 578.0 | mA   |
|                   |                                      | WCDMA B4 HSUPA @22.5dBm             | 571.0 | mA   |
|                   |                                      | WCDMA B5 HSDPA @22.4dBm             | 499.0 | mA   |
|                   |                                      | WCDMA B5 HSUPA @22.17dBm            | 515.0 | mA   |
|                   | LTE data                             | LTE-FDD B2 @23.2dBm                 | 685.0 | mA   |

|                        |                       |       |    |
|------------------------|-----------------------|-------|----|
| transfer<br>(GNSS OFF) | LTE-FDD B4 @23.4dBm   | 744.0 | mA |
|                        | LTE-FDD B5 @23.2dBm   | 578.0 | mA |
|                        | LTE-FDD B7 @24.3dBm   | 868.0 | mA |
|                        | LTE-FDD B28 @23.45dBm | 631.0 | mA |
|                        | LTE-FDD B66 @22.68dBm | 781.0 | mA |
| WCDMA voice<br>call    | WCDMA B2 @23.47dBm    | 643.0 | mA |
|                        | WCDMA B4 @23.5dBm     | 633.0 | mA |
|                        | WCDMA B5 @23.5dBm     | 551.0 | mA |

**Table 46: EC25-AUX Current Consumption**

| Parameter        | Description | Conditions                          | Typ.  | Unit |
|------------------|-------------|-------------------------------------|-------|------|
| I <sub>BAT</sub> | OFF state   | Power down                          | 9     | uA   |
|                  | Sleep state | <b>AT+CFUN=0</b> (USB disconnected) | 0.9   | mA   |
|                  |             | GSM DRX=2 (USB disconnected)        | 2.4   | mA   |
|                  |             | LTE-FDD PF=128 (USB disconnected)   | 2.5   | mA   |
|                  |             | LTE-TDD PF=64 (USB disconnected)    | 3.4   | mA   |
|                  | Idle state  | GSM DRX=5 (USB disconnected)        | 16.9  | mA   |
|                  |             | GSM DRX=5 (USB connected)           | 34.5  | mA   |
|                  |             | WCDMA PF=64 (USB disconnected)      | 17.9  | mA   |
|                  |             | WCDMA PF=64 (USB connected)         | 35.2  | mA   |
|                  |             | LTE-FDD PF=64 (USB disconnected)    | 18.3  | mA   |
|                  |             | LTE-FDD PF=64 (USB connected)       | 35.1  | mA   |
|                  |             | LTE-TDD PF=64 (USB disconnected)    | 18.4  | mA   |
|                  |             | LTE-TDD PF=64 (USB connected)       | 35.1  | mA   |
|                  | GPRS data   | GSM850 4DL/1UL @32.48dBm            | 240.1 | mA   |

|                                     |                           |       |    |
|-------------------------------------|---------------------------|-------|----|
| transfer<br>(GNSS OFF)              | GSM850 3DL/2UL @31.59dBm  | 384.8 | mA |
|                                     | GSM850 2DL/3UL @29.51dBm  | 452.1 | mA |
|                                     | GSM850 1DL/4UL @28.41dBm  | 542.1 | mA |
|                                     | EGSM900 4DL/1UL @33.27dBm | 272.7 | mA |
|                                     | EGSM900 3DL/2UL @31.99dBm | 406.9 | mA |
|                                     | EGSM900 2DL/3UL @29.67dBm | 470.2 | mA |
|                                     | EGSM900 1DL/4UL @28.44dBm | 547.1 | mA |
|                                     | DCS1800 4DL/1UL @29.44dBm | 164.5 | mA |
|                                     | DCS1800 3DL/2UL @28.47dBm | 235.7 | mA |
|                                     | DCS1800 2DL/3UL @26.29dBm | 292.2 | mA |
|                                     | DCS1800 1DL/4UL @25.26dBm | 363.8 | mA |
|                                     | PCS1900 4DL/1UL @29.44dBm | 162.9 | mA |
|                                     | PCS1900 3DL/2UL @28.59dBm | 246.8 | mA |
|                                     | PCS1900 2DL/3UL @26.51dBm | 300.6 | mA |
|                                     | PCS1900 1DL/4UL @25.34dBm | 370.5 | mA |
| EDGE data<br>transfer<br>(GNSS OFF) | GSM850 4DL/1UL @26.94dBm  | 177.5 | mA |
|                                     | GSM850 3DL/2UL @25.90dBm  | 290.8 | mA |
|                                     | GSM850 2DL/3UL @23.70dBm  | 394.0 | mA |
|                                     | GSM850 1DL/4UL @22.47dBm  | 504.5 | mA |
|                                     | EGSM900 4DL/1UL @27.18dBm | 176.6 | mA |
|                                     | EGSM900 3DL/2UL @26.03dBm | 289.6 | mA |
|                                     | EGSM900 2DL/3UL @23.97dBm | 390.7 | mA |
|                                     | EGSM900 1DL/4UL @22.68dBm | 502.1 | mA |
|                                     | DCS1800 4DL/1UL @26.01dBm | 141.0 | mA |
|                                     | DCS1800 3DL/2UL @25.02dBm | 227.5 | mA |

|                                   |                           |       |    |
|-----------------------------------|---------------------------|-------|----|
|                                   | DCS1800 2DL/3UL @23.04dBm | 316.3 | mA |
|                                   | DCS1800 1DL/4UL @22.11dBm | 411.0 | mA |
|                                   | PCS1900 4DL/1UL @26.24dBm | 143.3 | mA |
|                                   | PCS1900 3DL/2UL @25.46dBm | 231.4 | mA |
|                                   | PCS1900 2DL/3UL @23.45dBm | 316.1 | mA |
|                                   | PCS1900 1DL/4UL @22.38dBm | 411.0 | mA |
| WCDMA data transfer<br>(GNSS OFF) | WCDMA B1 HSDPA @22.60dBm  | 534.6 | mA |
|                                   | WCDMA B1 HSUPA @22.48dBm  | 541.3 | mA |
|                                   | WCDMA B2 HSDPA @21.60dBm  | 572.9 | mA |
|                                   | WCDMA B2 HSUPA @22.06dBm  | 560.0 | mA |
|                                   | WCDMA B4 HSDPA @22.97dBm  | 495.8 | mA |
|                                   | WCDMA B4 HSUPA @23.20dBm  | 512.4 | mA |
|                                   | WCDMA B5 HSDPA @22.63dBm  | 493.1 | mA |
|                                   | WCDMA B5 HSUPA @22.98dBm  | 504.7 | mA |
|                                   | WCDMA B8 HSDPA @22.46dBm  | 545.5 | mA |
|                                   | WCDMA B8 HSUPA @21.89dBm  | 541.1 | mA |
| LTE data transfer<br>(GNSS OFF)   | LTE-FDD B1 @22.91dBm      | 713.5 | mA |
|                                   | LTE-FDD B2 @22.85dBm      | 713.4 | mA |
|                                   | LTE-FDD B3 @23.12dBm      | 675.7 | mA |
|                                   | LTE-FDD B4 @22.52dBm      | 607.8 | mA |
|                                   | LTE-FDD B5 @23.12dBm      | 563.1 | mA |
|                                   | LTE-FDD B7 @22.95dBm      | 702.9 | mA |
|                                   | LTE-FDD B8 @23.55dBm      | 728.8 | mA |
|                                   | LTE-FDD B28A @23.23dBm    | 769.3 | mA |
|                                   | LTE-TDD B40 @23.54dBm     | 335.5 | mA |

|                   |                        |       |    |
|-------------------|------------------------|-------|----|
| GSM<br>voice call | GSM850 PCL5 @32.36dBm  | 240.3 | mA |
|                   | EGSM900 PCL5 @33.15dBm | 260.9 | mA |
|                   | DCS1800 PCL0 @29.38dBm | 153.0 | mA |
|                   | PCS1900 PCL0 @29.47dBm | 160.3 | mA |
|                   | WCDMA B1 @23.13dBm     | 568.9 | mA |
|                   | WCDMA B2 @22.99dBm     | 628.4 | mA |
|                   | WCDMA B4 @22.90dBm     | 506.3 | mA |
|                   | WCDMA B5 @23.10dBm     | 507.5 | mA |
| WCDMA voice call  | WCDMA B8 @22.90dBm     | 581.5 | mA |

**Table 47: GNSS Current Consumption of EC25 Series Module**

| Parameter                   | Description              | Conditions                  | Typ. | Unit |
|-----------------------------|--------------------------|-----------------------------|------|------|
| I <sub>VBAT</sub><br>(GNSS) | Searching<br>(AT+CFUN=0) | Cold start @Passive Antenna | 54.0 | mA   |
|                             |                          | Lost state @Passive Antenna | 53.9 | mA   |
|                             | Tracking<br>(AT+CFUN=0)  | Instrument Environment      | 30.5 | mA   |
|                             |                          | Open Sky @Passive Antenna   | 33.2 | mA   |
|                             |                          | Open Sky @Active Antenna    | 40.8 | mA   |

## 6.5. RF Output Power

The following table shows the RF output power of EC25 module.

**Table 48: RF Output Power**

| Frequency      | Max.      | Min.     |
|----------------|-----------|----------|
| GSM850/EGSM900 | 33dBm±2dB | 5dBm±5dB |

|                         |              |          |
|-------------------------|--------------|----------|
| DCS1800/PCS1900         | 30dBm±2dB    | 0dBm±5dB |
| GSM850/EGSM900 (8-PSK)  | 27dBm±3dB    | 5dBm±5dB |
| DCS1800/PCS1900 (8-PSK) | 26dBm±3dB    | 0dBm±5dB |
| WCDMA bands             | 24dBm+1/-3dB | < -49dBm |
| LTE-FDD bands           | 23dBm±2dB    | < -39dBm |
| LTE-TDD bands           | 23dBm±2dB    | < -39dBm |

**NOTE**

In GPRS 4 slots TX mode, the maximum output power is reduced by 3.0dB. The design conforms to the GSM specification as described in **Chapter 13.16** of 3GPP TS 51.010-1.

## 6.6. RF Receiving Sensitivity

The following tables show the conducted RF receiving sensitivity of EC25 series module.

**Table 49: EC25-E Conducted RF Receiving Sensitivity**

| Frequency          | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|--------------------|-----------|-----------|--------------------|-------------|
| EGSM900            | -109.0dBm | /         | /                  | -102.0dBm   |
| DCS1800            | -109.0dBm | /         | /                  | -102.0dbm   |
| WCDMA B1           | -110.5dBm | /         | /                  | -106.7dBm   |
| WCDMA B5           | -110.5dBm | /         | /                  | -104.7dBm   |
| WCDMA B8           | -110.5dBm | /         | /                  | -103.7dBm   |
| LTE-FDD B1 (10MHz) | -98.0dBm  | -98.0dBm  | -101.5dBm          | -96.3dBm    |
| LTE-FDD B3 (10MHz) | -96.5dBm  | -98.5dBm  | -101.5dBm          | -93.3dBm    |
| LTE-FDD B5 (10MHz) | -98.0dBm  | -98.5dBm  | -101.0dBm          | -94.3dBm    |
| LTE-FDD B7 (10MHz) | -97.0dBm  | -97.0dBm  | -99.5dBm           | -94.3dBm    |

|                     |          |          |           |          |
|---------------------|----------|----------|-----------|----------|
| LTE-FDD B8 (10MHz)  | -97.0dBm | -97.0dBm | -101.0dBm | -93.3dBm |
| LTE-FDD B20 (10MHz) | -97.5dBm | -99.0dBm | -102.5dBm | -93.3dBm |
| LTE-TDD B38 (10MHz) | -95dBm   | -97.0dBm | -98.9dBm  | -96.3dBm |
| LTE-TDD B40 (10MHz) | -96.3dBm | -98.0dBm | -101.0dBm | -96.3dBm |
| LTE-TDD B41 (10MHz) | -94.5dBm | -97.0dBm | -98.5dBm  | -94.3dBm |

**Table 50: EC25-A Conducted RF Receiving Sensitivity**

| Frequency           | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|---------------------|-----------|-----------|--------------------|-------------|
| WCDMA B2            | -110.0dBm | /         | /                  | -104.7dBm   |
| WCDMA B4            | -110.0dBm | /         | /                  | -106.7dBm   |
| WCDMA B5            | -110.5dBm | /         | /                  | -104.7dBm   |
| LTE-FDD B2 (10MHz)  | -98.0dBm  | -98.0dBm  | -101.0dBm          | -94.3dBm    |
| LTE-FDD B4 (10MHz)  | -97.5dBm  | -99.0dBm  | -101.0dBm          | -96.3dBm    |
| LTE-FDD B12 (10MHz) | -97.2dBm  | -98.0dBm  | -101.0dBm          | -93.3dBm    |

**Table 51: EC25-V Conducted RF Receiving Sensitivity**

| Frequency           | Primary  | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|---------------------|----------|-----------|--------------------|-------------|
| LTE-FDD B4 (10MHz)  | -97.5dBm | -99.0dBm  | -101.0dBm          | -96.3dBm    |
| LTE-FDD B13 (10MHz) | -97.7dBm | -97.0dBm  | -100.0dBm          | -93.3dBm    |

**Table 52: EC25-J Conducted RF Receiving Sensitivity**

| Frequency | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|-----------|-----------|-----------|--------------------|-------------|
| WCDMA B1  | -110.0dBm | /         | /                  | -106.7dBm   |
| WCDMA B6  | -110.5dBm | /         | /                  | -106.7dBm   |
| WCDMA B8  | -110.5dBm | /         | /                  | -103.7dBm   |

|                     |           |          |           |           |
|---------------------|-----------|----------|-----------|-----------|
| WCDMA B19           | -110.5dBm | /        | /         | -106.7dBm |
| LTE-FDD B1 (10MHz)  | -97.5dBm  | -98.7dBm | -100.2dBm | -96.3dBm  |
| LTE-FDD B3 (10MHz)  | -96.5dBm  | -97.1dBm | -100.5dBm | -93.3dBm  |
| LTE-FDD B8 (10MHz)  | -98.4dBm  | -99.0dBm | -101.2dBm | -93.3dBm  |
| LTE-FDD B18 (10MHz) | -99.5dBm  | -99.0dBm | -101.7dBm | -96.3dBm  |
| LTE-FDD B19 (10MHz) | -99.2dBm  | -99.0dBm | -101.4dBm | -96.3dBm  |
| LTE-FDD B26 (10MHz) | -99.5dBm  | -99.0dBm | -101.5dBm | -93.8dBm  |
| LTE-TDD B41 (10MHz) | -95.0dBm  | -95.7dBm | -99.0dBm  | -94.3dBm  |

**Table 53: EC25-AU Conducted RF Receiving Sensitivity**

| Frequency          | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|--------------------|-----------|-----------|--------------------|-------------|
| GSM850             | -109.0dBm | /         | /                  | -102.0dBm   |
| EGSM900            | -109.0dBm | /         | /                  | -102.0dBm   |
| DCS1800            | -109.0dBm | /         | /                  | -102.0dBm   |
| PCS1900            | -109.0dBm | /         | /                  | -102.0dBm   |
| WCDMA B1           | -110.0dBm | -109dBm   | -112dBm            | -106.7dBm   |
| WCDMA B2           | -110.0dBm | /         | /                  | -104.7dBm   |
| WCDMA B5           | -111.0dBm | -112dBm   | -113dBm            | -104.7dBm   |
| WCDMA B8           | -111.0dBm | -111dBm   | -113dBm            | -103.7dBm   |
| LTE-FDD B1 (10MHz) | -97.2dBm  | -97.5dBm  | -100.2dBm          | -96.3dBm    |
| LTE-FDD B2 (10MHz) | -98.2dBm  | /         | /                  | -94.3dBm    |
| LTE-FDD B3 (10MHz) | -98.7dBm  | -98.6dBm  | -102.2dBm          | -93.3dBm    |
| LTE-FDD B4 (10MHz) | -97.7dBm  | -97.4dBm  | -100.2dBm          | -96.3dBm    |
| LTE-FDD B5 (10MHz) | -98.0dBm  | -98.2dBm  | -101.0dBm          | -94.3dBm    |
| LTE-FDD B7 (10MHz) | -97.7dBm  | -97.7dBm  | -101.2dBm          | -94.3dBm    |

|                     |          |          |           |          |
|---------------------|----------|----------|-----------|----------|
| LTE-FDD B8 (10MHz)  | -99.2dBm | -98.2dBm | -102.2dBm | -93.3dBm |
| LTE-FDD B28 (10MHz) | -98.6dBm | -98.7dBm | -102.0dBm | -94.8dBm |
| LTE-TDD B40 (10MHz) | -97.2dBm | -98.4dBm | -101.2dBm | -96.3dBm |

**Table 54: EC25-AUT Conducted RF Receiving Sensitivity**

| Frequency           | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|---------------------|-----------|-----------|--------------------|-------------|
| WCDMA B1            | -110.0dBm | /         | /                  | -106.7dBm   |
| WCDMA B5            | -110.5dBm | /         | /                  | -104.7dBm   |
| LTE-FDD B1 (10MHz)  | -98.5dBm  | -98.0dBm  | -101.0dBm          | -96.3dBm    |
| LTE-FDD B3 (10MHz)  | -98.0dBm  | -97.0dBm  | -100.0dBm          | -93.3dBm    |
| LTE-FDD B5 (10MHz)  | -98.0dBm  | -99.0dBm  | -102.5dBm          | -94.3dBm    |
| LTE-FDD B7 (10MHz)  | -97.0dBm  | -97.0dBm  | -98.5dBm           | -94.3dBm    |
| LTE-FDD B28 (10MHz) | -97.0dBm  | -99.0dBm  | -102.0dBm          | -94.8dBm    |

**Table 55: EC25-AUTL Conducted RF Receiving Sensitivity**

| Frequency           | Primary  | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|---------------------|----------|-----------|--------------------|-------------|
| LTE-FDD B3 (10MHz)  | -98.0dBm | -97.0dBm  | -100.0dBm          | -93.3dBm    |
| LTE-FDD B7 (10MHz)  | -97.0dBm | -97.0dBm  | -98.5dBm           | -94.3dBm    |
| LTE-FDD B28 (10MHz) | -97.0dBm | -99.0dBm  | -102.0dBm          | -94.8dBm    |

**Table 56: EC25-AF Conducted RF Receiving Sensitivity**

| Frequency | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|-----------|-----------|-----------|--------------------|-------------|
| WCDMA B2  | -109.5dBm | -110dBm   | -110.4dBm          | -104.7dBm   |
| WCDMA B4  | -109.6dBm | -110dBm   | -110.6dBm          | -106.7dBm   |
| WCDMA B5  | -110dBm   | -110dBm   | -110.7dBm          | -104.7dBm   |

|                     |          |          |           |          |
|---------------------|----------|----------|-----------|----------|
| LTE-FDD B2 (10MHz)  | -98.0dBm | -98.5dBm | -100.5dBm | -94.3dBm |
| LTE-FDD B4 (10MHz)  | -97.5dBm | -98.2dBm | -99.5dBm  | -96.3dBm |
| LTE-FDD B5 (10MHz)  | -98.0dBm | -98.5dBm | -100.5dBm | -94.3dBm |
| LTE-FDD B12 (10MHz) | -99.0dBm | -99.5dBm | -100.5dBm | -93.3dBm |
| LTE-FDD B13 (10MHz) | -98.5dBm | -99.5dBm | -100.7dBm | -93.3dBm |
| LTE-FDD B14 (10MHz) | -99.4dBm | -99.5dBm | -100.9dBm | -93.3dBm |
| LTE-FDD B66 (10MHz) | -97.5dBm | -98.5dBm | -99.6dBm  | -95.8dBm |
| LTE-FDD B71 (10MHz) | -98.6dBm | -99.5dBm | -100dBm   | -93.5dBm |

**Table 57: EC25-AFX Conducted RF Receiving Sensitivity**

| Frequency           | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|---------------------|-----------|-----------|--------------------|-------------|
| WCDMA B2            | -109.5dBm | -110dBm   | -110.4dBm          | -104.7dBm   |
| WCDMA B4            | -109.6dBm | -110dBm   | -110.6dBm          | -106.7dBm   |
| WCDMA B5            | -110dBm   | -110dBm   | -110.7dBm          | -104.7dBm   |
| LTE-FDD B2 (10MHz)  | -98.0dBm  | -98.5dBm  | -100.5dBm          | -94.3dBm    |
| LTE-FDD B4 (10MHz)  | -97.5dBm  | -98.2dBm  | -99.5dBm           | -96.3dBm    |
| LTE-FDD B5 (10MHz)  | -98.0dBm  | -98.5dBm  | -100.5dBm          | -94.3dBm    |
| LTE-FDD B12 (10MHz) | -99.0dBm  | -99.5dBm  | -100.5dBm          | -93.3dBm    |
| LTE-FDD B13 (10MHz) | -98.5dBm  | -99.5dBm  | -100.7dBm          | -93.3dBm    |
| LTE-FDD B14 (10MHz) | -99.4dBm  | -99.5dBm  | -100.9dBm          | -93.3dBm    |
| LTE-FDD B66 (10MHz) | -97.5dBm  | -98.5dBm  | -99.6dBm           | -95.8dBm    |
| LTE-FDD B71 (10MHz) | -98.6dBm  | -99.5dBm  | -100dBm            | -93.5dBm    |

**Table 58: EC25-EU Conducted RF Receiving Sensitivity**

| Frequency           | Primary   | Diversity  | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|---------------------|-----------|------------|--------------------|-------------|
| EGSM900             | -108.5dBm | /          | /                  | -102.0dBm   |
| DCS1800             | -108.5dBm | /          | /                  | -102.0dbm   |
| WCDMA B1            | -109.5dBm | -109.5dBm  | /                  | -106.7dBm   |
| WCDMA B8            | -110.0dBm | -111.5 dBm | /                  | -103.7dBm   |
| LTE-FDD B1 (10MHz)  | -98.5dBm  | -99.0dBm   | -101.7dBm          | -96.3dBm    |
| LTE-FDD B3 (10MHz)  | -98.2dBm  | -99.8dBm   | -102dBm            | -93.3dBm    |
| LTE-FDD B7 (10MHz)  | -96.7dBm  | -98.5dBm   | -100.7dBm          | -94.3dBm    |
| LTE-FDD B8 (10MHz)  | -98.5dBm  | -100.4dBm  | -102.4dBm          | -93.3dBm    |
| LTE-FDD B20 (10MHz) | -98.7dBm  | -100.2dBm  | -102.7dBm          | -93.3dBm    |
| LTE-FDD B28 (10MHz) | -98.7dBm  | -100.5dBm  | -102.5dBm          | -94.8dBm    |
| LTE-TDD B38 (10MHz) | -95.2dBm  | -97.0dBm   | -100.2dBm          | -96.3dBm    |
| LTE-TDD B40 (10MHz) | -95.7dBm  | -98.2dBm   | -101.2dBm          | -96.3dBm    |
| LTE-TDD B41 (10MHz) | -95.0dBm  | -97.1dBm   | -100.2dBm          | -94.3dBm    |

**Table 59: EC25-EC Conducted RF Receiving Sensitivity**

| Frequency          | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|--------------------|-----------|-----------|--------------------|-------------|
| EGSM900            | -108.8dBm | /         | /                  | -102.0dBm   |
| DCS1800            | -109.0dBm | /         | /                  | -102.0dbm   |
| WCDMA B1           | -110.5dBm | /         | /                  | -106.7dBm   |
| WCDMA B8           | -110.5dBm | /         | /                  | -103.7dBm   |
| LTE-FDD B1 (10MHz) | -98.0dBm  | -98.0dBm  | -101.0dBm          | -96.3dBm    |
| LTE-FDD B3 (10MHz) | -96.5dBm  | -98.5dBm  | -100.0dBm          | -93.3dBm    |
| LTE-FDD B7 (10MHz) | -97.0dBm  | -95.5dBm  | -99.5dBm           | -94.3dBm    |

|                     |          |          |           |          |
|---------------------|----------|----------|-----------|----------|
| LTE-FDD B8 (10MHz)  | -97.0dBm | -97.0dBm | -101.0dBm | -93.3dBm |
| LTE-FDD B20 (10MHz) | -97.5dBm | -99.0dBm | -101.0dBm | -93.3dBm |
| LTE-FDD B28 (10MHz) | -98.6dBm | -98.7dBm | -101.5dBm | -94.8dBm |

**Table 60: EC25-EUX Conducted RF Receiving Sensitivity**

| Frequency           | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|---------------------|-----------|-----------|--------------------|-------------|
| EGSM900             | -109.0dBm | /         | /                  | -102.0dBm   |
| DCS1800             | -109.0dBm | /         | /                  | -102.0dbm   |
| WCDMA B1            | -110.5dBm | /         | /                  | -106.7dBm   |
| WCDMA B8            | -110.5dBm | /         | /                  | -103.7dBm   |
| LTE-FDD B1 (10MHz)  | -98.0dBm  | -98.0dBm  | -101dBm            | -96.3dBm    |
| LTE-FDD B3 (10MHz)  | -96.5dBm  | -98.5dBm  | -99.5dBm           | -93.3dBm    |
| LTE-FDD B7 (10MHz)  | -97.0dBm  | -94.5dBm  | -99.5dBm           | -94.3dBm    |
| LTE-FDD B8 (10MHz)  | -97.0dBm  | -97.0dBm  | -100.0dBm          | -93.3dBm    |
| LTE-FDD B20 (10MHz) | -97.5dBm  | -99.0dBm  | -101.5dBm          | -93.3dBm    |
| LTE-FDD B28 (10MHz) | -98.6dBm  | -98.7dBm  | -101.0dBm          | -94.8dBm    |
| LTE-TDD B38 (10MHz) | -96.3dBm  | -97dBm    | -98.5dBm           | -96.3dBm    |
| LTE-TDD B40 (10MHz) | -96.9dBm  | -98.0dBm  | -99.1dBm           | -96.3dBm    |
| LTE-TDD B41 (10MHz) | -95.3dBm  | -97.5dBm  | -98.0dBm           | -94.3dBm    |

**Table 61: EC25-MX Conducted RF Receiving Sensitivity**

| Frequency | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|-----------|-----------|-----------|--------------------|-------------|
| WCDMA B2  | -109dBm   | -110.5dBm | /                  | -104.7dBm   |
| WCDMA B4  | -109.5dBm | -110dBm   | /                  | -106.7dBm   |
| WCDMA B5  | -110dBm   | -111dBm   | /                  | -104.7dBm   |

|                     |          |          |           |          |
|---------------------|----------|----------|-----------|----------|
| LTE-FDD B2 (10MHz)  | -98dBm   | -99.1dBm | -101.5dBm | -94.3dBm |
| LTE-FDD B4 (10MHz)  | -98.5dBm | -98.2dBm | -101.5dBm | -96.3dBm |
| LTE-FDD B5 (10MHz)  | -99dBm   | -99.2dBm | -102.5dBm | -94.3dBm |
| LTE-FDD B7 (10MHz)  | -97dBm   | -98.5dBm | -101.5dBm | -94.3dBm |
| LTE-FDD B28(10MHz)  | -98dBm   | -99.3dBm | -102dBm   | -94.8dBm |
| LTE-FDD B66 (10MHz) | -98dBm   | -98.4dBm | -101.5dBm | -95.8dBm |

**Table 62: EC25-AUX Conducted RF Receiving Sensitivity**

| Frequency          | Primary   | Diversity | SIMO <sup>1)</sup> | 3GPP (SIMO) |
|--------------------|-----------|-----------|--------------------|-------------|
| GSM850             | -109.0dBm | /         | /                  | -102.0dBm   |
| EGSM900            | -109.0dBm | /         | /                  | -102.0dBm   |
| DCS1800            | -109.0dBm | /         | /                  | -102.0dBm   |
| PCS1900            | -109.0dBm | /         | /                  | -102.0dBm   |
| WCDMA B1           | -110.0dBm | -109.5dBm | -112dBm            | -106.7dBm   |
| WCDMA B2           | -110.5dBm | /         | /                  | -104.7dBm   |
| WCDMA B4           | -110.0dBm | -110dBm   | -112dBm            | -104.7dBm   |
| WCDMA B5           | -111.0dBm | -112dBm   | -113dBm            | -104.7dBm   |
| WCDMA B8           | -111.0dBm | -112dBm   | -113dBm            | -103.7dBm   |
| LTE-FDD B1 (10MHz) | -98.0dBm  | -97.7dBm  | -101.2dBm          | -96.3dBm    |
| LTE-FDD B2 (10MHz) | -98.5dBm  | /         | /                  | -94.3dBm    |
| LTE-FDD B3 (10MHz) | -99.0dBm  | -98.8dBm  | -102.2dBm          | -93.3dBm    |
| LTE-FDD B4 (10MHz) | -97.7dBm  | -97.6dBm  | -100.2dBm          | -96.3dBm    |
| LTE-FDD B5 (10MHz) | -98.5dBm  | -98.2dBm  | -101.0dBm          | -94.3dBm    |
| LTE-FDD B7 (10MHz) | -97.7dBm  | -97.7dBm  | -101.2dBm          | -94.3dBm    |
| LTE-FDD B8 (10MHz) | -99.0dBm  | -98.5dBm  | -102.2dBm          | -93.3dBm    |

|                     |          |          |           |          |
|---------------------|----------|----------|-----------|----------|
| LTE-FDD B28 (10MHz) | -98.0dBm | -98.7dBm | -101.5dBm | -94.8dBm |
| LTE-TDD B40 (10MHz) | -97.5dBm | -98.2dBm | -101.2dBm | -96.3dBm |

**NOTE**

<sup>1)</sup> SIMO is a smart antenna technology that uses a single antenna at the transmitter side and two antennas at the receiver side, which can improve RX performance.

## 6.7. Electrostatic Discharge

The module is not protected against electrostatics discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates the module.

The following table shows the module's electrostatics discharge characteristics.

**Table 63: Electrostatics Discharge Characteristics (25°C, 45% Relative Humidity)**

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

## 6.8. Thermal Consideration

In order to achieve better performance of the module, it is recommended to comply with the following principles for thermal consideration:

- On customers' PCB design, please keep placement of the module away from heating sources, especially high power components such as ARM processor, audio power amplifier, power supply, etc.
- Do not place components on the opposite side of the PCB area where the module is mounted, in order to facilitate adding of heatsink when necessary.

- Do not apply solder mask on the opposite side of the PCB area where the module is mounted, so as to ensure better heat dissipation performance.
- The reference ground of the area where the module is mounted should be complete, and add ground vias as many as possible for better heat dissipation.
- Make sure the ground pads of the module and PCB are fully connected.
- According to customers' application demands, the heatsink can be mounted on the top of the module, or the opposite side of the PCB area where the module is mounted, or both of them.
- The heatsink should be designed with as many fins as possible to increase heat dissipation area. Meanwhile, a thermal pad with high thermal conductivity should be used between the heatsink and module/PCB.

The following shows two kinds of heatsink designs for reference and customers can choose one or both of them according to their application structure.

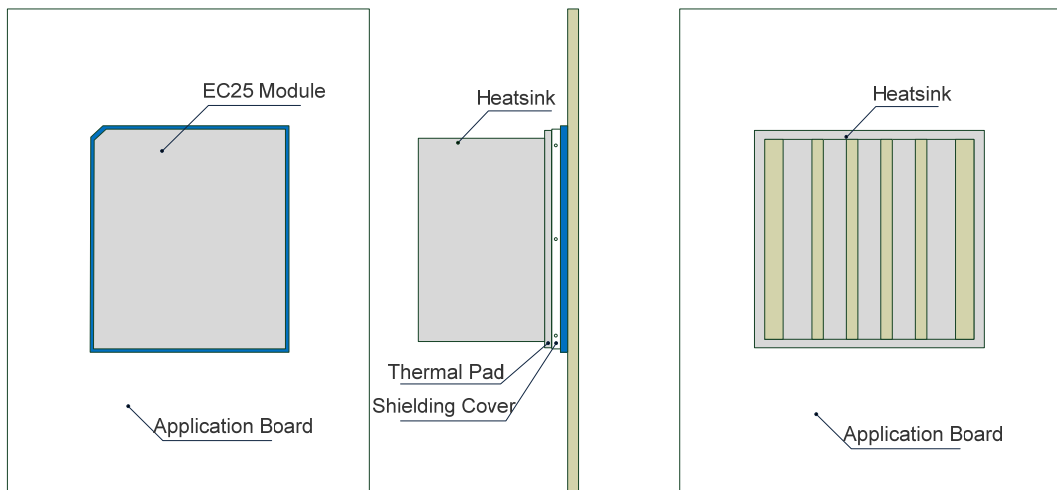


**Figure 42: Referenced Heatsink Design (Heatsink at the Top of the Module)**

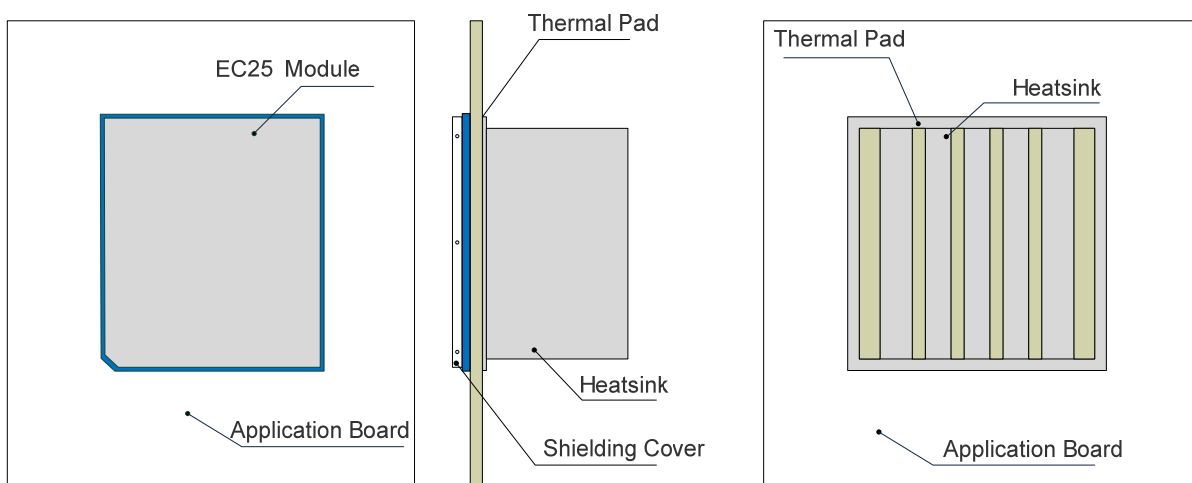


**Figure 43: Referenced Heatsink Design (Heatsink at the Backside of Customers' PCB)**

**NOTES**

1. The module offers the best performance when the internal BB chip stays below 105°C. When the maximum temperature of the BB chip reaches or exceeds 105°C, the module works normal but provides reduced performance (such as RF output power, data rate, etc.). When the maximum BB chip temperature reaches or exceeds 115°C, the module will disconnect from the network, and it will recover to network connected state after the maximum temperature falls below 115°C. Therefore, the thermal design should be maximally optimized to make sure the maximum BB chip temperature always maintains below 105°C. Customers can execute **AT+QTEMP** command and get the maximum BB chip temperature from the first returned value.
2. For more detailed guidelines on thermal design, please refer to *document [7]*.

# 7 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module. All dimensions are measured in mm, and the dimensional tolerances are  $\pm 0.05\text{mm}$  unless otherwise specified.

## 7.1. Mechanical Dimensions of the Module

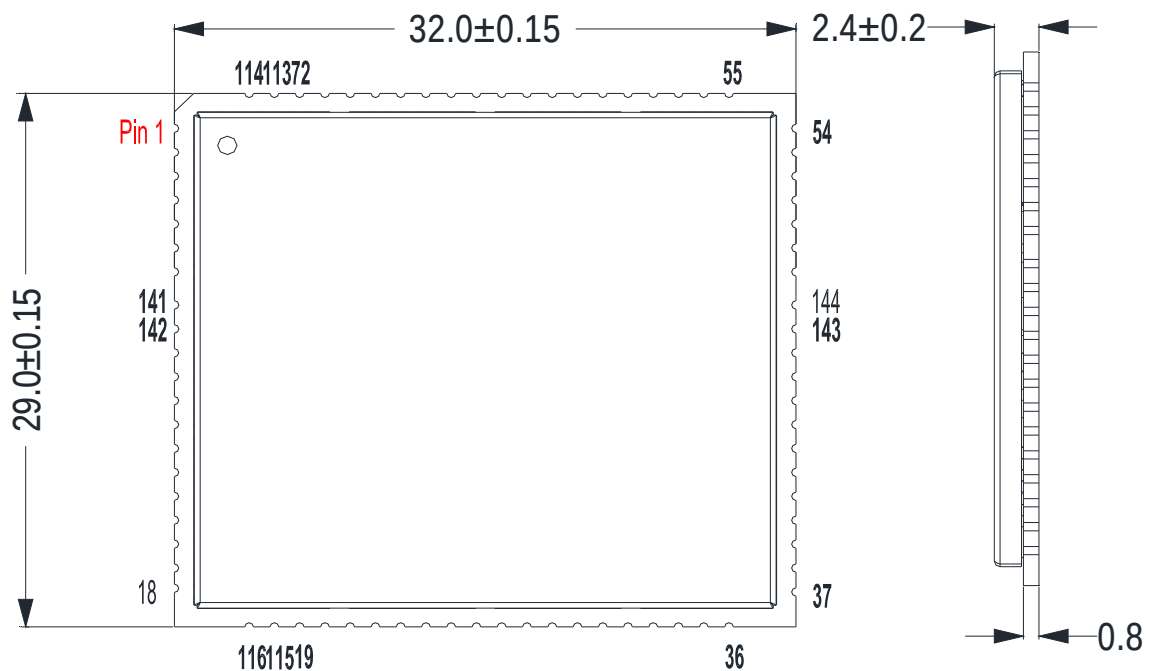


Figure 44: Module Top and Side Dimensions

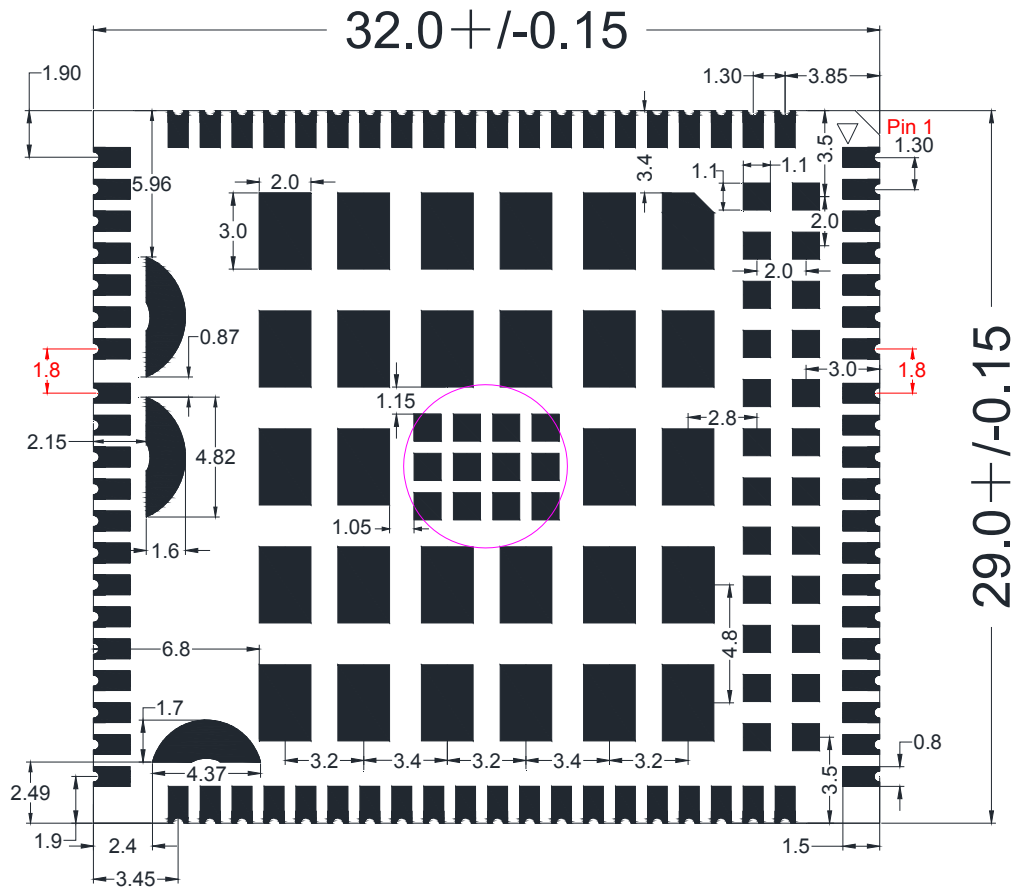


Figure 45: Module Bottom Dimensions (Bottom View)

## 7.2. Recommended Footprint

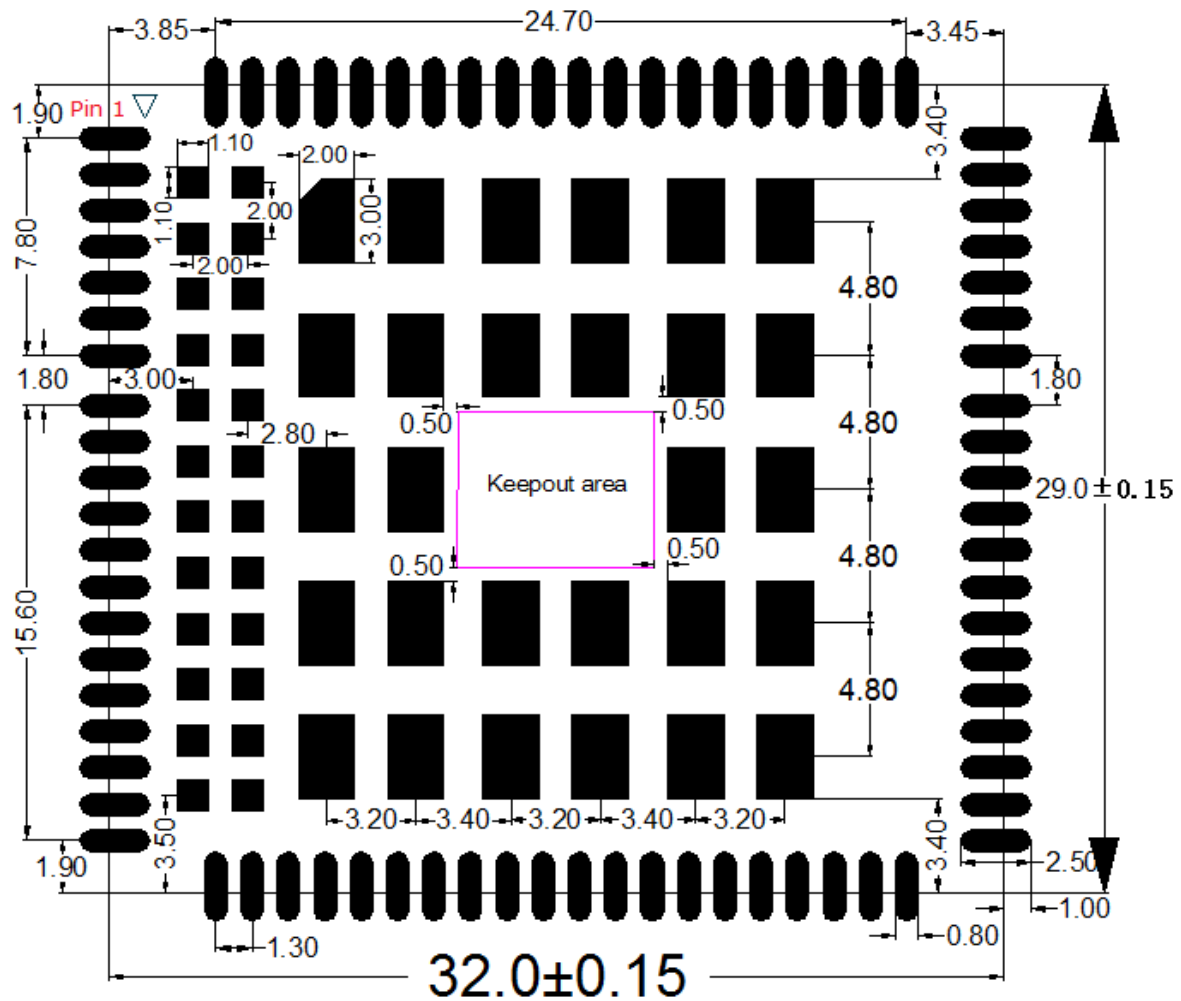


Figure 46: Recommended Footprint (Top View)

### NOTES

1. The keepout area should not be designed.
2. For easy maintenance of the module, please keep about 3mm between the module and other components in the host PCB.

### 7.3. Design Effect Drawings of the Module



Figure 47: Top View of the Module

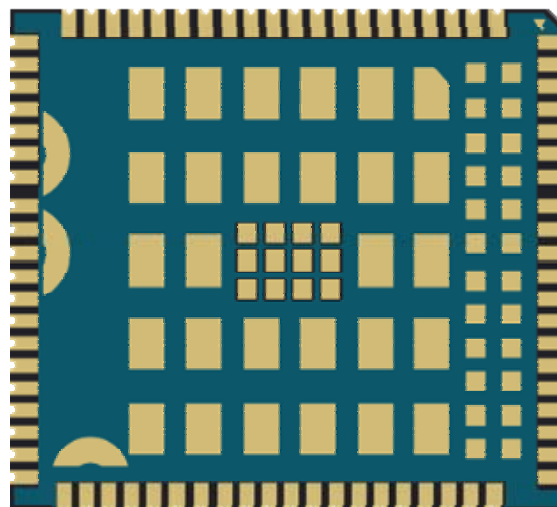


Figure 48: Bottom View of the Module

**NOTE**

These are renderings of EC25 module. For authentic appearance, please refer to the module that you receive from Quectel.

# 8 Storage, Manufacturing and Packaging

## 8.1. Storage

EC25 is stored in a vacuum-sealed bag. It is rated at MSL 3, and its storage restrictions are listed below.

1. Shelf life in vacuum-sealed bag: 12 months at  $<40^{\circ}\text{C}/90\%\text{RH}$ .
2. After the vacuum-sealed bag is opened, devices that will be subjected to reflow soldering or other high temperature processes must be:
  - Mounted within 168 hours at the factory environment of  $\leq 30^{\circ}\text{C}/60\%\text{RH}$ .
  - Stored at  $<10\%\text{RH}$ .
3. Devices require baking before mounting, if any circumstances below occurs:
  - When the ambient temperature is  $23^{\circ}\text{C}\pm 5^{\circ}\text{C}$  and the humidity indicator card shows the humidity is  $>10\%$  before opening the vacuum-sealed bag.
  - Device mounting cannot be finished within 168 hours at factory conditions of  $\leq 30^{\circ}\text{C}/60\%\text{RH}$ .
4. If baking is required, devices may be baked for 8 hours at  $120^{\circ}\text{C}\pm 5^{\circ}\text{C}$ .

### NOTE

As the plastic package cannot be subjected to high temperature, it should be removed from devices before high temperature ( $120^{\circ}\text{C}$ ) baking. If shorter baking time is desired, please refer to *IPC/JEDECJ-STD-033* for baking procedure.

## 8.2. Manufacturing and Soldering

Push the squeegee to apply the solder paste on the surface of stencil, thus making the paste fill the stencil openings and then penetrate to the PCB. The force on the squeegee should be adjusted properly so as to produce a clean stencil surface on a single pass. To ensure the module soldering quality, the thickness of stencil for the module is recommended to be 0.18mm~0.20mm. For more details, please refer to **document [4]**.

It is suggested that the peak reflow temperature is 238°C~245°C, and the absolute maximum reflow temperature is 245°C. To avoid damage to the module caused by repeated heating, it is strongly recommended that the module should be mounted after reflow soldering for the other side of PCB has been completed. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown below.

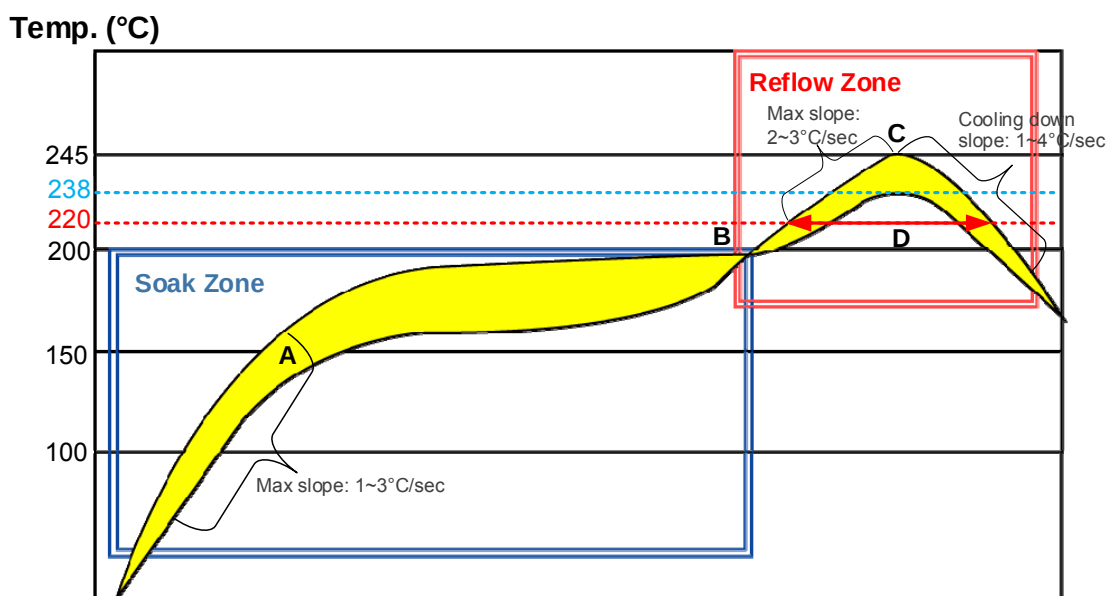


Figure 49: Reflow Soldering Thermal Profile

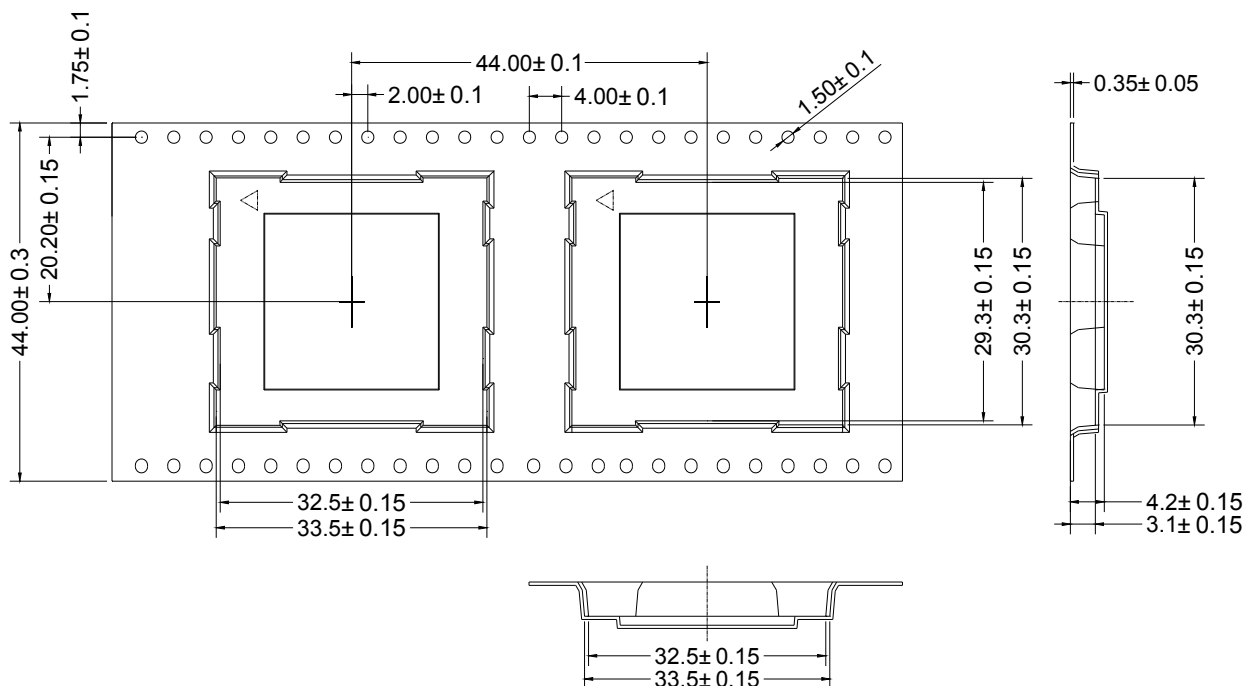
Table 64: Recommended Thermal Profile Parameters

| Factor                                       | Recommendation |
|----------------------------------------------|----------------|
| <b>Soak Zone</b>                             |                |
| Max slope                                    | 1~3°C/sec      |
| Soak time (between A and B: 150°C and 200°C) | 60~120sec      |
| <b>Reflow Zone</b>                           |                |

|                             |           |
|-----------------------------|-----------|
| Max slope                   | 2~3°C/sec |
| Reflow time (D: over 220°C) | 40~60sec  |
| Max temperature             | 238~245°C |
| Cooling down slope          | 1~4°C/sec |
| <b>Reflow Cycle</b>         |           |
| Max reflow cycle            | 1         |

### 8.3. Packaging

EC25 is packaged in tap and reel carriers. Each reel is 11.88m long and contains 250pcs modules. The figure below shows the package details, measured in mm.



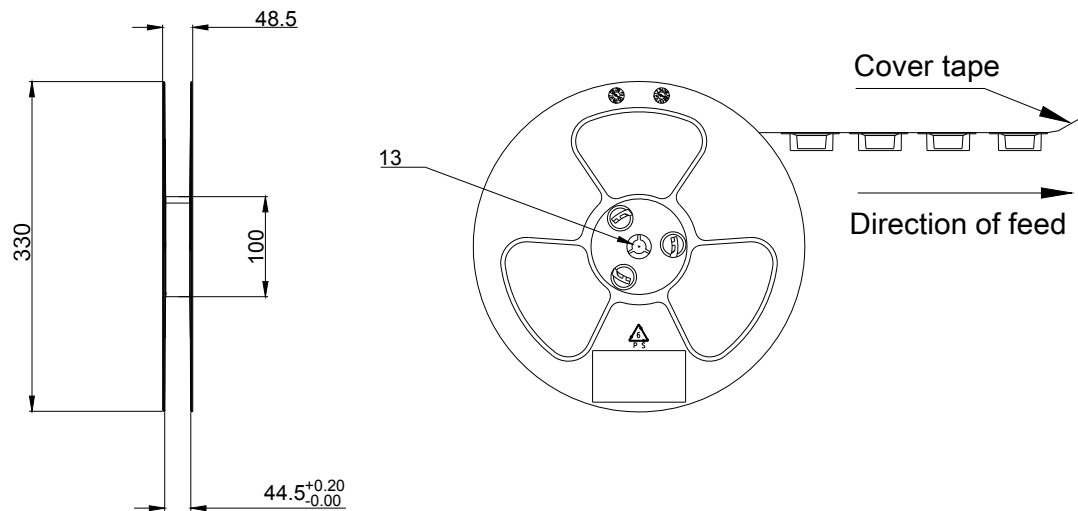


Figure 50: Tape and Reel Specifications

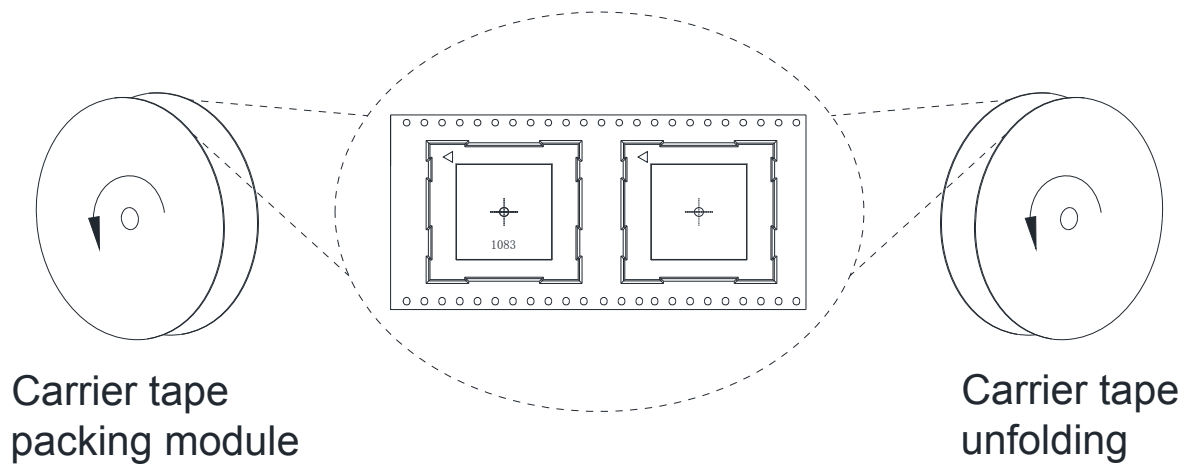


Figure 51: Tape and Reel Directions

# 9 Appendix A References

**Table 65: Related Documents**

| SN  | Document Name                                       | Remark                                                                                                |
|-----|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| [1] | Quectel_EC2x&EGxx_Power_Management_Application_Note | Power management application note for EC25, EC21, EC20 R2.0, EC20 R2.1, EG95, EG91 and EG25-G modules |
| [2] | Quectel_EC2x&EG9x&EM05_AT_Commands_Manual           | AT commands manual for EC25, EC21, EC20 R2.0, EC20 R2.1, EG91, EG95 and EM05 modules                  |
| [3] | Quectel_EC2x&EGxx&EM05_GNSS_AT_Commands_Manual      | GNSS AT Commands Manual for EC25, EC21, EC20 R2.0, EC20 R2.1, EG95, EG91, EG25-G and EM05 modules     |
| [4] | Quectel_Module_Secondary_SMT_User_Guide             | Module secondary SMT user guide                                                                       |
| [5] | Quectel_EC25_Reference_Design                       | EC25 reference design                                                                                 |
| [6] | Quectel_RF_Layout_Application_Note                  | RF layout application note                                                                            |
| [7] | Quectel_LTE_Module_Thermal_Design_Guide             | Thermal design guide for LTE standard, LTE-A and Automotive modules                                   |
| [8] | Quectel_UMTS&LTE_EVB_User_Guide                     | UMTS&LTE EVB user guide for UMTS&LTE modules                                                          |

**Table 66: Terms and Abbreviations**

| Abbreviation | Description                                 |
|--------------|---------------------------------------------|
| AMR          | Adaptive Multi-rate                         |
| bps          | Bits Per Second                             |
| CHAP         | Challenge Handshake Authentication Protocol |
| CS           | Coding Scheme                               |

|          |                                                                                                 |
|----------|-------------------------------------------------------------------------------------------------|
| CSD      | Circuit Switched Data                                                                           |
| CTS      | Clear To Send                                                                                   |
| DC-HSPA+ | Dual-carrier High Speed Packet Access                                                           |
| DFOTA    | Delta Firmware Upgrade Over-The-Air                                                             |
| DL       | Downlink                                                                                        |
| DTR      | Data Terminal Ready                                                                             |
| DTX      | Discontinuous Transmission                                                                      |
| EFR      | Enhanced Full Rate                                                                              |
| ESD      | Electrostatic Discharge                                                                         |
| FDD      | Frequency Division Duplex                                                                       |
| FR       | Full Rate                                                                                       |
| GLONASS  | GLObalnaya NAVigatsionnaya Sputnikovaya Sistema, the Russian Global Navigation Satellite System |
| GMSK     | Gaussian Minimum Shift Keying                                                                   |
| GNSS     | Global Navigation Satellite System                                                              |
| GPS      | Global Positioning System                                                                       |
| GSM      | Global System for Mobile Communications                                                         |
| HR       | Half Rate                                                                                       |
| HSPA     | High Speed Packet Access                                                                        |
| HSDPA    | High Speed Downlink Packet Access                                                               |
| HSUPA    | High Speed Uplink Packet Access                                                                 |
| I/O      | Input/Output                                                                                    |
| Inorm    | Normal Current                                                                                  |
| LED      | Light Emitting Diode                                                                            |
| LNA      | Low Noise Amplifier                                                                             |
| LTE      | Long Term Evolution                                                                             |

|          |                                                         |
|----------|---------------------------------------------------------|
| MIMO     | Multiple Input Multiple Output                          |
| MO       | Mobile Originated                                       |
| MS       | Mobile Station (GSM engine)                             |
| MT       | Mobile Terminated                                       |
| PAP      | Password Authentication Protocol                        |
| PCB      | Printed Circuit Board                                   |
| PDU      | Protocol Data Unit                                      |
| PPP      | Point-to-Point Protocol                                 |
| QAM      | Quadrature Amplitude Modulation                         |
| QPSK     | Quadrature Phase Shift Keying                           |
| RF       | Radio Frequency                                         |
| RHCP     | Right Hand Circularly Polarized                         |
| Rx       | Receive                                                 |
| SGMII    | Serial Gigabit Media Independent Interface              |
| SIM      | Subscriber Identification Module                        |
| SIMO     | Single Input Multiple Output                            |
| SMS      | Short Message Service                                   |
| TDD      | Time Division Duplexing                                 |
| TDMA     | Time Division Multiple Access                           |
| TD-SCDMA | Time Division-Synchronous Code Division Multiple Access |
| TX       | Transmitting Direction                                  |
| UL       | Uplink                                                  |
| UMTS     | Universal Mobile Telecommunications System              |
| URC      | Unsolicited Result Code                                 |
| (U)SIM   | (Universal) Subscriber Identity Module                  |

|                    |                                         |
|--------------------|-----------------------------------------|
| V <sub>max</sub>   | Maximum Voltage Value                   |
| V <sub>norm</sub>  | Normal Voltage Value                    |
| V <sub>min</sub>   | Minimum Voltage Value                   |
| V <sub>IHmax</sub> | Maximum Input High Level Voltage Value  |
| V <sub>IHmin</sub> | Minimum Input High Level Voltage Value  |
| V <sub>ILmax</sub> | Maximum Input Low Level Voltage Value   |
| V <sub>ILmin</sub> | Minimum Input Low Level Voltage Value   |
| V <sub>Imax</sub>  | Absolute Maximum Input Voltage Value    |
| V <sub>Imin</sub>  | Absolute Minimum Input Voltage Value    |
| V <sub>OHmax</sub> | Maximum Output High Level Voltage Value |
| V <sub>OHmin</sub> | Minimum Output High Level Voltage Value |
| V <sub>OLmax</sub> | Maximum Output Low Level Voltage Value  |
| V <sub>OLmin</sub> | Minimum Output Low Level Voltage Value  |
| VSWR               | Voltage Standing Wave Ratio             |
| WCDMA              | Wideband Code Division Multiple Access  |
| WLAN               | Wireless Local Area Network             |

# 10 Appendix B GPRS Coding Schemes

Table 67: Description of Different Coding Schemes

| Scheme                       | CS-1 | CS-2 | CS-3 | CS-4 |
|------------------------------|------|------|------|------|
| Code Rate                    | 1/2  | 2/3  | 3/4  | 1    |
| USF                          | 3    | 3    | 3    | 3    |
| Pre-coded USF                | 3    | 6    | 6    | 12   |
| Radio Block excl.USF and BCS | 181  | 268  | 312  | 428  |
| BCS                          | 40   | 16   | 16   | 16   |
| Tail                         | 4    | 4    | 4    | -    |
| Coded Bits                   | 456  | 588  | 676  | 456  |
| Punctured Bits               | 0    | 132  | 220  | -    |
| Data Rate Kb/s               | 9.05 | 13.4 | 15.6 | 21.4 |

# 11 Appendix C GPRS Multi-slot Classes

Thirty-three classes of GPRS multi-slot modes are defined for MS in GPRS specification. Multi-slot classes are product dependent, and determine the maximum achievable data rates in both the uplink and downlink directions. Written as 3+1 or 2+2, the first number indicates the amount of downlink timeslots, while the second number indicates the amount of uplink timeslots. The active slots determine the total number of slots the GPRS device can use simultaneously for both uplink and downlink communications.

The description of different multi-slot classes is shown in the following table.

**Table 68: GPRS Multi-slot Classes**

| Multislot Class | Downlink Slots | Uplink Slots | Active Slots |
|-----------------|----------------|--------------|--------------|
| 1               | 1              | 1            | 2            |
| 2               | 2              | 1            | 3            |
| 3               | 2              | 2            | 3            |
| 4               | 3              | 1            | 4            |
| 5               | 2              | 2            | 4            |
| 6               | 3              | 2            | 4            |
| 7               | 3              | 3            | 4            |
| 8               | 4              | 1            | 5            |
| 9               | 3              | 2            | 5            |
| 10              | 4              | 2            | 5            |
| 11              | 4              | 3            | 5            |
| 12              | 4              | 4            | 5            |
| 13              | 3              | 3            | NA           |
| 14              | 4              | 4            | NA           |

|    |   |   |    |
|----|---|---|----|
| 15 | 5 | 5 | NA |
| 16 | 6 | 6 | NA |
| 17 | 7 | 7 | NA |
| 18 | 8 | 8 | NA |
| 19 | 6 | 2 | NA |
| 20 | 6 | 3 | NA |
| 21 | 6 | 4 | NA |
| 22 | 6 | 4 | NA |
| 23 | 6 | 6 | NA |
| 24 | 8 | 2 | NA |
| 25 | 8 | 3 | NA |
| 26 | 8 | 4 | NA |
| 27 | 8 | 4 | NA |
| 28 | 8 | 6 | NA |
| 29 | 8 | 8 | NA |
| 30 | 5 | 1 | 6  |
| 31 | 5 | 2 | 6  |
| 32 | 5 | 3 | 6  |
| 33 | 5 | 4 | 6  |

# 12 Appendix D EDGE Modulation and Coding Schemes

Table 69: EDGE Modulation and Coding Schemes

| Coding Scheme | Modulation | Coding Family | 1 Timeslot | 2 Timeslot | 4 Timeslot |
|---------------|------------|---------------|------------|------------|------------|
| CS-1:         | GMSK       | /             | 9.05kbps   | 18.1kbps   | 36.2kbps   |
| CS-2:         | GMSK       | /             | 13.4kbps   | 26.8kbps   | 53.6kbps   |
| CS-3:         | GMSK       | /             | 15.6kbps   | 31.2kbps   | 62.4kbps   |
| CS-4:         | GMSK       | /             | 21.4kbps   | 42.8kbps   | 85.6kbps   |
| MCS-1         | GMSK       | C             | 8.80kbps   | 17.60kbps  | 35.20kbps  |
| MCS-2         | GMSK       | B             | 11.2kbps   | 22.4kbps   | 44.8kbps   |
| MCS-3         | GMSK       | A             | 14.8kbps   | 29.6kbps   | 59.2kbps   |
| MCS-4         | GMSK       | C             | 17.6kbps   | 35.2kbps   | 70.4kbps   |
| MCS-5         | 8-PSK      | B             | 22.4kbps   | 44.8kbps   | 89.6kbps   |
| MCS-6         | 8-PSK      | A             | 29.6kbps   | 59.2kbps   | 118.4kbps  |
| MCS-7         | 8-PSK      | B             | 44.8kbps   | 89.6kbps   | 179.2kbps  |
| MCS-8         | 8-PSK      | A             | 54.4kbps   | 108.8kbps  | 217.6kbps  |
| MCS-9         | 8-PSK      | A             | 59.2kbps   | 118.4kbps  | 236.8kbps  |

## 1.1. FCC Certification Requirements.

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

And the following conditions must be met:

1. This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based time-averaging duty factor, antenna gain and cable loss must satisfy MPE categorical Exclusion Requirements of 2.1091.

2. The EUT is a mobile device; maintain at least a 20 cm separation between the EUT and the user's body and must not transmit simultaneously with any other antenna or transmitter.

3. A label with the following statements must be attached to the host end product: This device contains FCC ID: XMR202006EC25AUX.

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

- ☐ GSM850 :  $\leq 8.571\text{dBi}$
- ☐ GSM1900 :  $\leq 10.03\text{dBi}$
- ☐ WCDMA Band2:  $\leq 8.000\text{dBi}$
- ☐ WCDMA Band5:  $\leq 9.541\text{ dBi}$
- ☐ LTE Band2:  $\leq 8.000\text{dBi}$
- ☐ LTE Band4:  $\leq 5.000\text{dBi}$
- ☐ LTE Band5:  $\leq 9.541\text{dBi}$
- ☐ LTE Band7:  $\leq 8.000\text{dBi}$

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

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

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

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

For this device, OEM integrators must be provided with labeling instructions of finished products. Please refer to KDB784748 D01 v07, section 8. Page 6/7 last two paragraphs:

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

For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straightforward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module: "Contains Transmitter Module FCC ID: XMR202006EC25AUX" or "Contains FCC ID: XMR202006EC25AUX" must be used. The host OEM user manual must also contain clear instructions on how end users can find and/or access the module and the FCC ID.

The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by

this section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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