EC21 Series

Hardware Design

LTE Standard Module Series

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Our aim is to provide customers with timely and comprehensive service. For any assistance, please contact our company headquarters:

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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 the module. Manufacturers of the cellular terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all manuals of the product. Otherwise, Quectel assumes no liability for customers' failure to comply with these precautions.

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

About the Document

Revision History

Version	Date	Author	Description
1.0	2016-04-15	Yeoman CHEN	Initial
1.1	2016-09-22	Yeoman CHEN/ Frank WANG/ Lyndon LIU	1. Updated frequency bands in Table 1. 2. Updated transmitting power, supported maximum baud rate of main UART, supported internet protocols, supported USB drivers of USB interface, and temperature range in Table 2. 3. Updated timing of turning on module in Figure 12. 4. Updated timing of turning off module in Figure 13. 5. Updated timing of resetting module in Figure 16. 6. Updated main UART supports baud rate in Chapter 3.11. 7. Added notes for ADC interface in Chapter 3.13. 8. Updated GNSS Performance in Table 21. 9. Updated operating frequencies of module in Table 23. 10. Added current consumption in Chapter 6.4. 11. Updated RF output power in Chapter 6.5. 12. Added RF receiving sensitivity in Chapter 6.6.
1.2	2016-11-04	Lyndon LIU/ Michael ZHANG	1. Added SGMII and WLAN interfaces in Table 2. 2. Updated function diagram in Figure 1. 3. Updated pin assignment (Top View) in Figure 2. 4. Added description of SGMII and WLAN interfaces in Table 4. 5. Added SGMII interface in Chapter 3.17. 6. Added WLAN interface in Chapter 3.18. 7. Added USB_BOOT interface in Chapter 3.19. 8. Added reference design of RF layout in Chapter 5.1.4. 9. Added current consumption of EC21-V in Chapter

			6.4 10. Added note about SIMO in Chapter 6.6.
1.3	2017-01-24	Lyndon LIU/ Rex WANG	1. Updated frequency bands in Table 1. 2. Updated function diagram in Figure 1. 3. Updated pin assignment (top view) in Figure 2. 4. Added BT interface in Chapter 3.18.2. 5. Updated reference circuit of wireless connectivity interfaces with FC20 module in Figure 29. 6. Updated GNSS performance in Table 24. 7. Updated module operating frequencies in Table 26. 8. Added EC21-AUV current consumption in Table 38. 9. Updated EC21-A conducted RF receiving sensitivity of in Table 42. 10. Added EC21-J conducted RF receiving sensitivity in Table 48.
1.4	2017-03-01	Geely YANG	Deleted the LTE band TDD B41 of EC21-CT
1.5	2018-03-05	Annice ZHANG/ Lyndon LIU/ Frank WANG	1. Updated functional diagram in Figure 1. 2. Updated frequency bands in Table 1. 3. Updated UMTS and GSM features in Table 2. 4. Updated description of pin 40/136/137/138. 5. Updated PWRKEY pulled down time to 500ms in chapter 3.7.1 and reference circuit in Figure 10. 6. Updated reference circuit of (U)SIM interface in Figure 17&18. 7. Updated reference circuit of USB interface in Figure 19. 8. Updated PCM mode in Chapter 3.12. 9. Updated USB_BOOT reference circuit in Chapter 3.20. 10. Added SD card interface in Chapter 3.13. 11. Updated module operating frequencies in Table 26. 12. Updated EC21 series modules current consumption in Chapter 6.5. 13. Updated EC21 series modules conducted RF receiving sensitivity in Chapter 6.6. 14. Added thermal consideration description in Chapter 6.8. 15. Updated dimension tolerance information in Chapter 7. 16. Added storage temperature range in Table 2 and Chapter 6.3. 17. Updated RF output power in Table 42. 18. Updated antenna requirements in Table 29.

			19. Updated GPRS multi-slot classes in Table 55. 20. Updated storage information in Chapter 8.1
1.6	2019-04-30	Woody WU/ Nathan LIU/ Frank WANG	1. Added new variants EC21-EU and related information. 2. Updated star structure of the power supply in Figure 8. 3. Updated power-on scenario of module in Figure 12. 4. Updated reference circuit with translator chip in Figure 20. 5. Added timing sequence for entering emergency download mode of USB_BOOT interface in Figure 32. 6. Updated GNSS frequency in Table 29. 7. Updated antenna requirements in Table 30. 8. Added EC21-EU current consumption in Table 41. 9. Added EC21-EC current consumption in Table 42. 10. Updated EC21-E conducted RF receiving sensitivity in Table 44. 11. Updated EC21-A conducted RF receiving sensitivity in Table 45. 12. Updated EC21-V conducted RF receiving sensitivity in Table 46. 13. Updated EC21-AUT conducted RF receiving sensitivity in Table 47. 14. Updated EC21-AU conducted RF receiving sensitivity in Table 51. 15. Added EC21-EU conducted RF receiving sensitivity in Table 52. 16. Added EC21-EC conducted RF receiving sensitivity in Table 53. 17. Updated recommended stencil thickness as 0.18mm–0.20mm and reflow soldering thermal profile in Chapter 8.2.
1.7	2019-08-19	Ward WANG/ Owen WEI	1. Added ThreadX variant EC21-AUX and updated related information in Table 1 and Chapter 2.1. 2. Deleted the information of GNSS supported on EC21-EC in Table 1 3. Updated supported protocols and USB serial driver in Table 2. 4. Updated functional diagram in Figure 1. 5. Updated notes in Chapter 3.7.1. 6. Updated EC21-E current consumption (GSM voice call) in Table 34. 7. Updated EC21-EU current consumption in Table

			41. 8. Updated EC21-EC current consumption in Table 42. 9. Added EC21-AUX current consumption in Table 43. 10. Updated EC21-EU conducted RF receiving sensitivity in Table 53. 11. Added EC21-AUX conducted RF receiving sensitivity in Table 55. 12. Updated module bottom dimensions (bottom view) in Figure 45. 13. Added tape and reel directions in Figure 51.
1.8	2019-11-26	Fanny CHEN	1. Removed related information of ThreadX OS because the baseline has been updated. 2. Updated the supported protocols and USB serial drivers in Table 2. 3. AT command AT+QCFG="airplanecontrol" has been fully developed in Chapter 3.5. 4. Updated the notes for GNSS performance in Chapter 4.2. 5. Updated the AT command be used to disable the receive diversity in Chapter 5.1.3.
1.9	2021-08-17	Barret XIONG	1. Added the related information of EC21-EUX. 2. Added the Wi-Fi&Bluetooth module FC21 for use with EC21 series module. 3. Deleted the related information of EC21-EC and EC21-AUV. 4. Updated the USB serial drivers (Chapter 2.2). 5. Added the power consumption of EC21-AU (Table 48). 6. Updated all unmarked dimension tolerances from ±0.05 mm to ±0.2 mm (Chapter 6). 7. Updated the information of storage, manufacturing and packaging; added the description of spraying, ultrasonic cleaning and soldering process (Chapter 7.1&7.2).

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1 Introduction

This document defines EC21 series 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 EC21 series 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 EC21 series module to design and set up mobile applications easily.

1.1. Special Marks

Table 1: Special Marks

Mark	Definition
*	Unless otherwise specified, when an asterisk (*) is used after a function, feature, interface, pin name, AT command, or argument, it indicates that the function, feature, interface, pin, AT command, or argument is under development and currently not supported; and the asterisk (*) after a model indicates that the sample of such model is currently unavailable.
[…]	Brackets ([…]) used after a pin enclosing a range of numbers indicate all pins of the same type. For example, SDC2_DATA[0:3] refers to all four SDC2_DATA pins: SDC2_DATA0, SDC2_DATA1, SDC2_DATA2, and SDC2_DATA3.

2 Product Overview

2.1. Frequency Bands and Functions

EC21 series module 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 [1] and voice functionality [2] for customers' specific applications. EC21 series module contains 12 variants: EC21-E, EC21-A, EC21-V, EC21-AU, EC21-EU, EC21-AUT, EC21-J, EC21-KL, EC21-AUX and EC21-EUX. Customers can choose a dedicated type based on the region or operator. The following table shows the frequency bands of EC21 series module.

Table 2: Supported Frequency Bands and GNSS Function of EC21 Series Module

EC21 Series [2]	LTE	WCDMA	GSM	Rx-diversity	GNSS [1]
EC21-E	FDD: B1/B3/B5/B7/B8/B20	B1/B5/B8	900/1800 MHz	√	GPS, GLONASS, BeiDou (COMPASS), Galileo, QZSS
EC21-A	FDD: B2/B4/B12	B2/B4/B5	-	√	
EC21-V	FDD: B4/B13	-	-	√	
EC21-AU	FDD: B1/B2 [3]/B3/B4/B5/B7/B8/B28 TDD: B40	B1/B2/B5/B8	850/900/1800/1900 MHz	√	
EC21-EU	FDD: B1/B3/B7/B8/B20/B28A	B1/B8	900/1800 MHz	√	
EC21-AUT	FDD: B1/B3/B5/B7/B28	B1/B5	-	√	

[1] GNSS function is optional.

[2] EC21 series module contains **Data + Voice** version and **Data-only** version. **Data + Voice** version supports voice and data functions, while **Data-only** version only supports data function.

[3] B2 of EC21-AU and EC21-AUX module does not support Rx-diversity.

EC21-J	FDD: B1/B3/B8/B18/B19/ B26	-	-	√	-
EC21-KL	FDD: B1/B3/B5/B7/B8	-	-	√	-
EC21-AUX [3]	FDD: B1/B2/B3/B4/B5/B7/ B8/B28 TDD: B40	B1/B2/B4/ B5/B8	850/900/1800/ 1900 MHz	√	√
EC21-EUX	FDD: B1/B3/B7/B8/B20/ B28A	B1/B8	900/1800 MHz	√	√

With a compact profile of 29.0 mm × 32.0 mm × 2.4 mm, EC21 series module can meet almost all requirements for M2M applications such as metering, tracking system, security, router, wireless POS, mobile computing device, PDA phone, tablet PC, etc.

EC21 series module is an SMD type module which can be embedded into applications through its 144 pins, including 80 LCC pins and 64 LGA pins.

NOTE

"√" means supported.

2.2. Key Features

The following table describes the detailed features of EC21 series module.

Table 3: Key Features of EC21 Series Module

Features	Description
Power Supply	● Supply voltage: 3.3–4.3 V ● Typical supply voltage: 3.8 V
Transmitting Power	● Class 4 (33 dBm ±2 dB) for GSM850 ● Class 4 (33 dBm ±2 dB) for EGSM900 ● Class 1 (30 dBm ±2 dB) for DCS1800 ● Class 1 (30 dBm ±2 dB) for PCS1900 ● Class E2 (27 dBm ±3 dB) for GSM850 8-PSK ● Class E2 (27 dBm ±3 dB) for EGSM900 8-PSK

	● Class E2 (26 dBm ±3 dB) for DCS1800 8-PSK ● Class E2 (26 dBm ±3 dB) for PCS1900 8-PSK ● Class 3 (24 dBm +1/-3 dB) for WCDMA bands ● Class 3 (23 dBm ±2 dB) for LTE-FDD bands ● Class 3 (23 dBm ±2 dB) for LTE-TDD bands
LTE Features	● Support up to non-CA Cat 1 FDD and TDD ● Support 1.4/3/5/10/15/20 MHz RF bandwidth ● Support MIMO in DL direction ● LTE-FDD: Max. 10 Mbps (DL)/Max. 5 Mbps (UL) ● LTE-TDD: Max. 8.96 Mbps (DL)/Max. 3.1 Mbps (UL)
UMTS Features	● Support 3GPP Rel-8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA ● Support QPSK, 16QAM and 64QAM modulation ● DC-HSDPA: Max. 42 Mbps (DL) ● HSUPA: Max. 5.76 Mbps (UL) ● WCDMA: Max. 384 kbps (DL)/Max. 384 kbps (UL)
GSM Features	**GPRS:** ● Support GPRS multi-slot class 33 (33 by default) ● Coding scheme: CS-1, CS-2, CS-3 and CS-4 ● Max. 107 kbps (DL)/Max. 85.6 kbps (UL) **EDGE:** ● Support EDGE multi-slot class 33 (33 by default) ● Support GMSK and 8-PSK for different MCS (Modulation and Coding Scheme) ● Downlink coding schemes: MCS 1-9 ● Uplink coding schemes: MCS 1-9 ● Max. 296 kbps (DL)/Max. 236.8 kbps (UL)
Internet Protocol Features	● Support TCP/UDP/PPP/FTP/FTPS/HTTP/HTTPS/NTP/PING/QMI/ NITZ/SMTP/SSL/MQTT/CMUX/SMTPS/MMS*/FILE* protocols ● Support PAP and CHAP for PPP connections
SMS	● Text and PDU mode ● Point-to-point MO and MT ● SMS cell broadcast ● SMS storage: ME by default
(U)SIM Interface	Supports USIM/SIM card: 1.8 V, 3.0 V
Audio Features	● Support one digital audio interface: PCM interface ● GSM: HR/FR/EFR/AMR/AMR-WB ● WCDMA: AMR/AMR-WB ● LTE: AMR/AMR-WB ● Support echo cancellation and noise suppression
PCM Interface	● Used for audio function with external codec ● Supports 16-bit linear data format ● Supports long frame synchronization and short frame synchronization

	● Supports 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 480 Mbps ● Used for AT command communication, data transmission, GNSS NMEA output, software debugging, firmware upgrade and voice over USB ● Support USB serial drivers for: Windows 7/8/8.1/10, Linux 2.6–5.12, Android 4.x–11.x, etc.
UART Interfaces	**Main UART:** ● Used for AT command communication and data transmission ● Baud rates reach up to 921600 bps, 115200 bps by default ● Support RTS and CTS hardware flow control **Debug UART:** ● Used for Linux console and log output ● 115200 bps baud rate by default
SD Card Interface	Supports SD 3.0 protocol
SGMII Interface	● Supports 10M/100M/1000M Ethernet work mode ● Supports Max. 10 Mbps (DL)/Max. 5 Mbps (UL) for 4G network
Interfaces WLAN and Bluetooth Applications	● Support a low-power SDIO 3.0 interface for WLAN ● Support UART & PCM interfaces for Bluetooth
Rx-diversity	Support LTE/WCDMA Rx-diversity
GNSS Features	● Protocol: *NMEA 0183* ● Data update rate: 1 Hz by default
AT Commands	● Compliant with *3GPP TS 27.007*, *3GPP TS 27.005* ● Quectel enhanced AT commands
Network Status Indication	Two pins including NET_MODE and NET_STATUS to indicate network connectivity status
Antenna Interfaces	● Main antenna interface (ANT_MAIN) ● Rx-diversity antenna interface (ANT_DIV) ● GNSS antenna interface (ANT_GNSS)
Physical Characteristics	● Size: (29.0 ±0.15) mm × (32.0 ±0.15) mm × (2.4 ±0.2) mm ● Weight: approx. 4.9 g
Temperature Range	Operating temperature range: -35 °C to +75 °C [4] Extended temperature range: -40 °C to +85 °C [5] Storage temperature range: -40 °C to +90 °C

[4] Within operating temperature range, the module is 3GPP compliant.
[5] Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call*, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to normal operation temperature levels, the module will meet 3GPP specifications again.

Firmware Upgrade	USB 2.0 interface or DFOTA
RoHS	All hardware components are fully compliant with EU RoHS directive

2.3. Functional Diagram

The following figure shows a block diagram of EC21 series and illustrates the major functional parts.

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

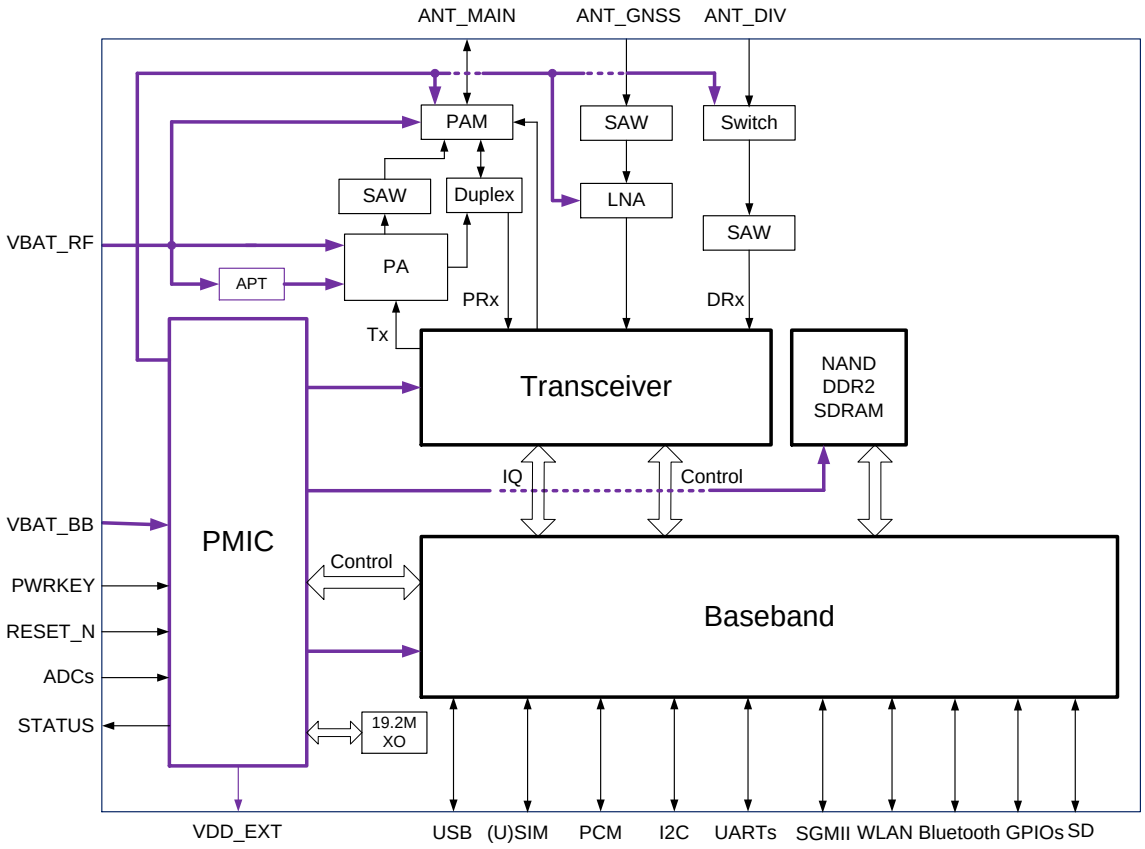


Figure 1: Functional Diagram

2.4. EVB

To help customers develop applications with EC21 series, 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, see ***document [1].***

3 Application Interfaces

3.1. General Description

EC21 series module is equipped with 80 LCC pins plus 64 LGA pins that can be connected to cellular application platform. The subsequent chapters will provide detailed descriptions of the following interfaces/functions.

- Power supply
- (U)SIM interface
- USB interface
- UART interfaces
- PCM and I2C interfaces
- SD card interface
- Interfaces for WLAN & Bluetooth applications
- ADC interface
- Network status indication
- SGMII interface
- USB_BOOT interface

3.2. Pin Assignment

The following figure shows the pin assignment of EC21 series module.

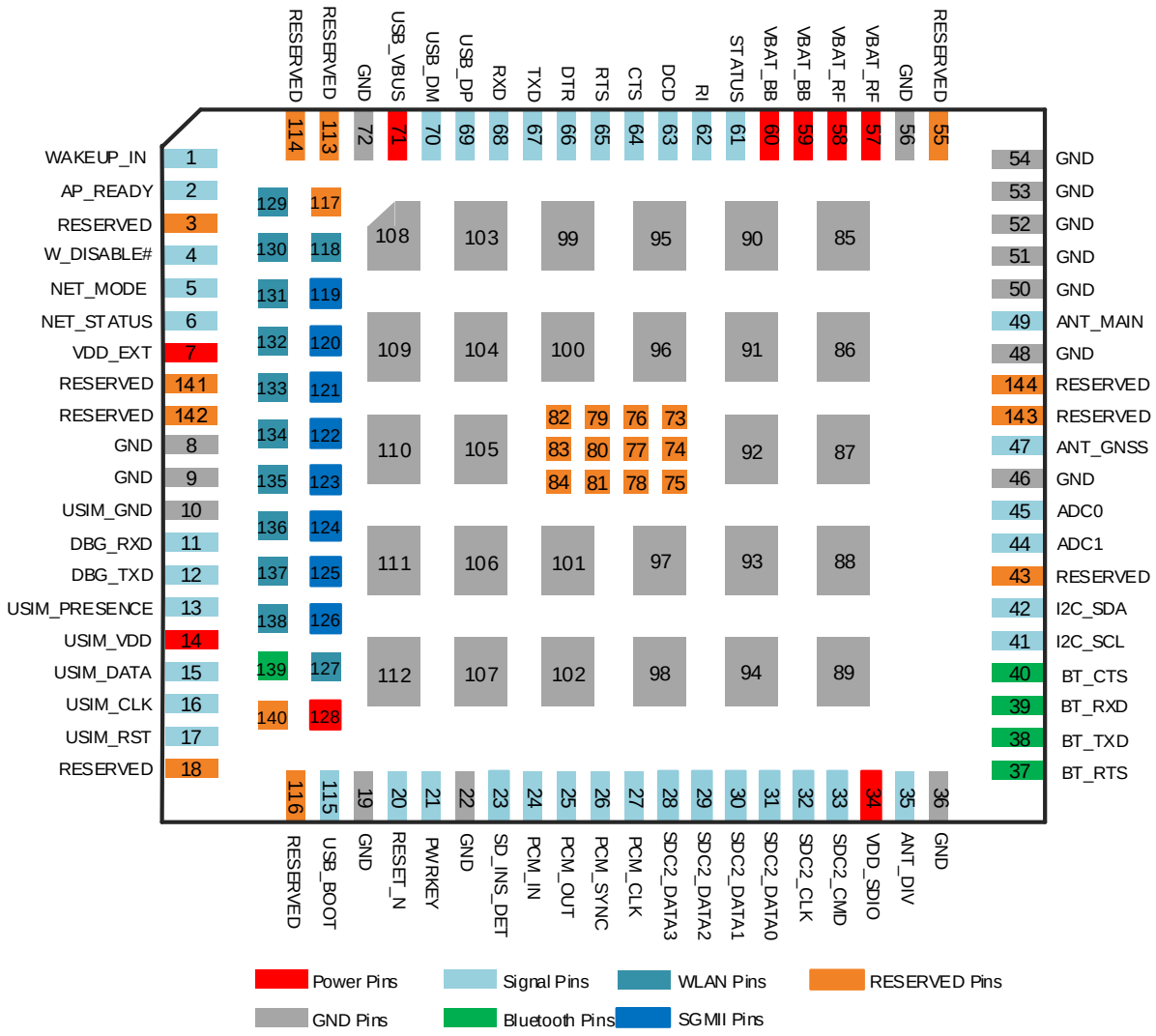


Figure 2: Pin Assignment (Top View)

NOTE

1. WAKEUP_IN, NET_MODE, WLAN_EN, COEX_UART_RX, COEX_UART_TX, USB_BOOT and BT_CTS cannot be pulled up before startup.
2. PWRKEY output voltage is 0.8 V because of the diode drop in the baseband chipset.
3. Digital audio (PCM) is only supported on **Data + Voice** version.
4. Pins 37–40, 118, 127 and 129–139 are used for WLAN & Bluetooth application interfaces, among which pins 118, 127 and 129–138 are WLAN function pins, and the rest of pins are Bluetooth

function pins. Bluetooth function is under development.
5. Pins 119–126 and pin 128 are used for SGMII interface.
6. Pins 24–27 for PCM function are used for audio design on EC21 series module and Bluetooth function on FC20 series/FC21 modules.
7. Keep all RESERVED pins and unused pins unconnected.
8. 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 EC21 series module.

Table 4: I/O Parameters Definition

Type	Description
AI	Analog Input
AO	Analog Output
AIO	Analog Input/Output
DI	Digital Input
DO	Digital Output
DIO	Digital Input/Output
OD	Open Drain
PI	Power Input
PO	Power Output

Table 5: 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 = 4.3 V Vmin = 3.3 V Vnom = 3.8 V	It must be provided with sufficient current up to 0.8 A.

VBAT_RF	57, 58	PI	Power supply for module's RF part	Vmax = 4.3 V Vmin = 3.3 V Vnom = 3.8 V	It must be provided with sufficient current up to 1.8 A in a burst transmission.
VDD_EXT	7	PO	Provide 1.8 V for external circuit	Vnom = 1.8 V $I_O$max = 50 mA	Power supply for external GPIO's pull-up circuits. When used with FC20 series/FC21 modules, it also defaults to supply power to the VIO pin of FC20 series/FC21 modules. If unused, keep it open.
GND	8, 9, 19, 22, 36, 46, 48, 50–54, 56, 72, 85–112				
Power-on/off					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	21	DI	Turn on/off the module	V_H = 0.8 V	The output voltage is 0.8 V because of the diode drop in the baseband chipset.
RESET_N	20	DI	Reset the module	V_{IH}max = 2.1 V V_{IH}min = 1.3 V V_{IL}max = 0.5 V	If unused, keep it open.
Status Indication Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
STATUS	61	OD	Indicate the module's operation status		The driving current should be less than 0.9 mA. An external pull-up resistor is required. If unused, keep it open.
NET_MODE	5	DO	Indicate the module's network registration mode	V_{OH}min = 1.35 V V_{OL}max = 0.45 V	1.8 V power domain. Cannot be pulled up before startup. If unused, keep it open.

NET_STATUS	6	DO	Indicate the module's network activity status	V_{OH}min = 1.35 V V_{OL}max = 0.45 V	1.8 V power domain. If unused, keep it open.
USB Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_VBUS	71	DI	USB connection detect	Vmax = 5.25 V Vmin = 3.0 V Vnom = 5.0 V	
USB_DP	69	AIO	USB differential data (+)		USB 2.0 Compliant. Require differential impedance of 90 Ω. If unused, keep them open.
USB_DM	70	AIO	USB differential data (-)		
(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 detect	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep it open.
USIM_VDD	14	PO	(U)SIM card power supply	Iomax = 50 mA **1.8 V (U)SIM:** Vmax = 1.9 V Vmin = 1.7 V **3.0 V (U)SIM:** Vmax = 3.05 V Vmin = 2.7 V	Either 1.8 V or 3.0 V is supported by the module automatically.
USIM_DATA	15	DIO	(U)SIM card data	**1.8 V (U)SIM:** V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{OL}max = 0.45 V V_{OH}min = 1.35 V **3.0 V (U)SIM:** V_{IL}max = 1.0 V V_{IH}min = 1.95 V V_{OL}max = 0.45 V	

				V_{OH}min = 2.55 V	
USIM_CLK	16	DO	(U)SIM card clock	**1.8 V (U)SIM:** V_{OL}max = 0.45 V V_{OH}min = 1.35 V **3.0 V (U)SIM:** V_{OL}max = 0.45 V V_{OH}min = 2.55 V	
USIM_RST	17	DO	(U)SIM card reset	**1.8 V (U)SIM:** V_{OL}max = 0.45 V V_{OH}min = 1.35 V **3.0 V (U)SIM:** V_{OL}max = 0.45 V V_{OH}min = 2.55 V	
Main UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RI	62	DO	Ring indication	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep them open.
DCD	63	DO	Data carrier detect		
CTS	64	DO	DTE clear to send signal from DCE		
RTS	65	DI	DTE request to send signal from DCE	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep it open.
DTR	66	DI	DTE Data terminal ready, sleep mode control	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. Pulled up by default. Low level can wake up the module. If unused, keep it open.
TXD	67	DO	Transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep it open.
RXD	68	DI	Receive	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep it open.
Debug UART Interface					

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
DBG_TXD	12	DO	Debug UART transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep them open.
DBG_RXD	11	DI	Debug UART receive	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	
ADC Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ADC0	45	AI	General-purpose ADC interface	Voltage range: 0.3 V to VBAT_BB	If unused, keep them open.
ADC1	44	AI	General-purpose ADC interface	Voltage range: 0.3 V to VBAT_BB	
PCM Interface [6]					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PCM_IN	24	DI	PCM data input	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep them open.
PCM_OUT	25	DO	PCM data output	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	
PCM_SYNC	26	DIO	PCM data frame sync	V_{OL}max = 0.45 V V_{OH}min = 1.35 V V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. Serve as output signal in master mode. Serve as input signal in slave mode. If unused, keep them open.
PCM_CLK	27	DIO	PCM clock		
I2C Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
I2C_SCL	41	OD	I2C serial clock (for external codec)		An external 1.8 V pull-up resistor is required. If unused, keep them open.
I2C_SDA	42	OD	I2C serial data (for external codec)		

[6] The pins of PCM interface are used for audio design on EC21 series module and Bluetooth function on FC20 series/FC21 modules.

SD Card Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
SDC2_DATA3	28	DIO	SD card SDIO data bit 3	**1.8 V signaling:** V_{OL}max = 0.45 V V_{OH}min = 1.4 V V_{IL}min = -0.3 V V_{IL}max = 0.58 V V_{IH}min = 1.27 V V_{IH}max = 2.0 V **3.0 V signaling:** V_{OL}max = 0.38 V V_{OH}min = 2.01 V V_{IL}min = -0.3 V V_{IL}max = 0.76 V V_{IH}min = 1.72 V V_{IH}max = 3.34 V	SDIO signal level can be selected according to the signal level supported by SD card, see SD 3.0 protocol for more details. If unused, keep them open.
SDC2_DATA2	29	DIO	SD card SDIO data bit 2		
SDC2_DATA1	30	DIO	SD card SDIO data bit 1		
SDC2_DATA0	31	DIO	SD card SDIO data bit 0		
SDC2_CLK	32	DO	SD card SDIO clock	**1.8 V signaling:** V_{OL}max = 0.45 V V_{OH}min = 1.4 V **3.0 V signaling:** V_{OL}max = 0.38 V V_{OH}min = 2.01 V	SDIO signal level can be selected according to the signal level supported by SD card, see SD 3.0 protocol for more details. If unused, keep it open.
SDC2_CMD	33	DIO	SD card SDIO command	**1.8 V signaling:** V_{OL}max = 0.45 V V_{OH}min = 1.4 V V_{IL}min = -0.3 V V_{IL}max = 0.58 V V_{IH}min = 1.27 V V_{IH}max = 2.0 V **3.0 V signaling:** V_{OL}max = 0.38 V V_{OH}min = 2.01 V V_{IL}min = -0.3 V V_{IL}max = 0.76 V V_{IH}min = 1.72 V V_{IH}max = 3.34 V	SDIO signal level can be selected according to the signal level supported by SD card, see SD 3.0 protocol for more details. If unused, keep it open.
SD_INS_DET	23	DI	SD card insertion detect	V_{IL}min = -0.3 V V_{IL}max = 0.6 V	1.8 V power domain. If unused, keep it

				V_{IH}min = 1.2 V V_{IH}max = 2.0 V	open.
VDD_SDIO	34	PO	SD card SDIO pull-up power	$I_O$max = 50 mA	Configurable power supply. 1.8/2.85 V power domain. Cannot be used for SD card power supply. 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	**1.8 V:** V_{OL}max = 0.45 V V_{OH}min = 1.4 V **2.85 V:** V_{OL}max = 0.35 V V_{OH}min = 2.14 V	1.8/2.85 V power domain. If unused, keep it open.
EPHY_INT_N	120	DI	Ethernet PHY interrupt	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep it open.
SGMII_MDATA	121	DIO	SGMII MDIO data	**1.8 V：** V_{IL}max = 0.58 V V_{IH}min = 1.27 V V_{OL}max = 0.45 V V_{OH}min = 1.4 V **2.85 V：** V_{IL}max = 0.71 V V_{IH}min = 1.78 V V_{OL}max = 0.35 V V_{OH}min = 2.14 V	1.8/2.85 V power domain. If unused, keep it open.
SGMII_MCLK	122	DO	SGMII MDIO clock	**1.8 V:** V_{OL}max = 0.45 V V_{OH}min = 1.4 V **2.85 V:** V_{OL}max = 0.35 V V_{OH}min = 2.14 V	1.8/2.85 V power domain. If unused, keep it open.

SGMII_TX_M	123	AO	SGMII transmit (-)		Connect it with a 0.1 μF capacitor, and close to the PHY side. If unused, keep them open.
SGMII_TX_P	124	AO	SGMII transmit (+)		
SGMII_RX_P	125	AI	SGMII receive (+)		Connect it with a 0.1 μF capacitor, and close to the module. If unused, keep them open.
SGMII_RX_M	126	AI	SGMII receive (-)		
USIM2_VDD	128	PO	SGMII_MDATA pull-up power supply		Configurable power supply. 1.8/2.85 V power domain. If unused, keep it open.
Interfaces for WLAN and Bluetooth Applications					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
SDC1_DATA3	129	DIO	WLAN SDIO data bit 3	V_{OL}max = 0.45 V V_{OH}min = 1.35 V V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep them open.
SDC1_DATA2	130	DIO	WLAN SDIO data bit 2		
SDC1_DATA1	131	DIO	WLAN SDIO data bit 1		
SDC1_DATA0	132	DIO	WLAN SDIO data bit 0		
SDC1_CLK	133	DO	WLAN SDIO clock	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep it open.
SDC1_CMD	134	DIO	WLAN SDIO command		1.8 V power domain. If unused, keep it open.
PM_ENABLE	127	DO	WLAN power control		1.8 V power domain. If unused, keep it open. Active high.
WAKE_ON_WIRELESS	135	DI	WLAN wake up the module	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. Active low. If unused, keep it open.
WLAN_EN	136	DO	WLAN function enable	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. Active high.

					Cannot be pulled up before startup. If unused, keep it open.
COEX_UART_RX	137	DI	LTE/WLAN & Bluetooth coexistence receive	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. Cannot be pulled up before startup. If unused, keep it open.
COEX_UART_TX	138	DO	LTE/WLAN & Bluetooth coexistence transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. Cannot be pulled up before startup. If unused, keep it open.
WLAN_SLP_CLK	118	DO	WLAN sleep clock		If unused, keep it open.
BT_RTS*	37	DI	DTE request to send signal from DCE	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep them open.
BT_TXD*	38	DO	Bluetooth UART transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	
BT_RXD*	39	DI	Bluetooth UART receive	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	
BT_CTS*	40	DO	DTE clear to send signal from DCE	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. Cannot be pulled up before startup. If unused, keep it open.
BT_EN*	139	DO	Bluetooth function enable	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep it open.
Antenna Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_DIV	35	AI	Diversity antenna interface		50 Ω impedance. If unused, keep it open.
ANT_MAIN	49	AIO	Main antenna interface		50 Ω impedance.

ANT_GNSS	47	AI	GNSS antenna interface		50 Ω impedance. 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_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. Cannot be pulled up before startup. Low level can wake up the module. If unused, keep it open.
W_DISABLE#	4	DI	Airplane mode control	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. Pull-up by default. At low level, module can enter airplane mode. If unused, keep it open.
AP_READY	2	DI	Application processor sleep state detection	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. 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_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. Cannot be pulled up before startup. Active high. It is recommended to reserve test point.
RESERVED Pins					
Pin Name	**Pin No.**				**Comment**
RESERVED	3, 18, 43, 55, 73–84, 113, 114, 116, 117, 140–144				Keep these pins unconnected.

3.4. Operating Modes

The following table briefly outlines the operating modes to be mentioned in the following chapters.

Table 6: Overview of Operating Modes

Mode	Details	
Normal Operation	Idle	The module remains registered on the network, and is ready to send and receive data. In this mode, the software is active.
	Talk/Data	The module is connected to network. Its current consumption varies with the network setting and data transfer rate.
Airplane Mode	**AT+CFUN=4** or W_DISABLE# pin can set the module into airplane mode where the RF function is invalid.	
Minimum Functionality Mode	**AT+CFUN=0** can set the module into a minimum functionality mode without removing the power supply. In this mode, both RF function and (U)SIM card are invalid.	
Sleep Mode	The module remains the ability to receive paging message, SMS, voice call and TCP/UDP data from the network normally. In this mode, the current consumption of the module is reduced to a very low level.	
Power Down Mode	The module's power supply is cut off by its power management unit. In this mode, the software is inactive, the serial interfaces are inaccessible, while the operating voltage (connected to VBAT_RF and VBAT_BB) remains applied.	

For details of the command, see ***document [2]***.

3.5. Power Saving

3.5.1. Sleep Mode

EC21 series can reduce its current consumption to a minimum value during the sleep mode. The following section describes power saving procedures of the module.

3.5.1.1. UART Application Scenario

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

- Execute **AT+QSCLK=1** to enable sleep mode. For details of the command, see ***document [2]***.
- Drive DTR to high level.

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

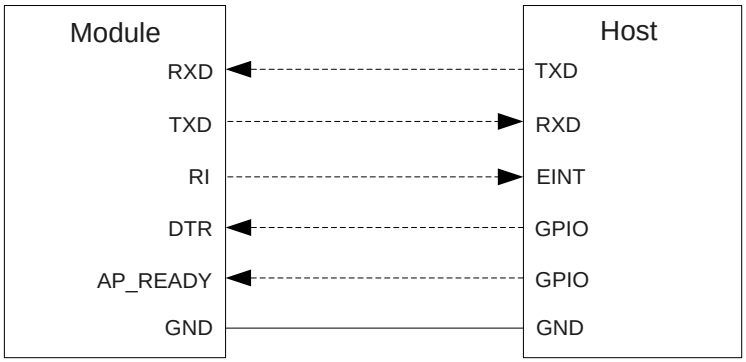


Figure 3: Sleep Mode Application via UART

- Driving the module's DTR to low level will wake up the module.
- When module has a URC to report, RI signal will wake up the host. See ***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). For more details about **AT+QCFG="apready"**, see ***document [3]***.

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** to enable sleep mode.
- Ensure 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.

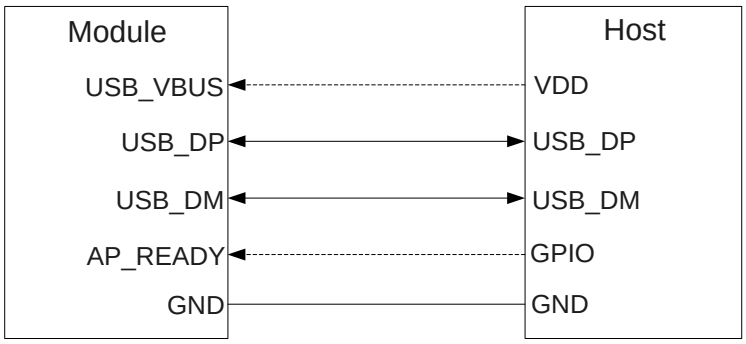


Figure 4: Sleep Mode Application with USB Remote Wakeup

- Sending data to module via USB will wake up the module.
- When module has a URC to report, the module will send remote wake-up signals via USB bus 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** to enable sleep mode.
- Ensure 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.

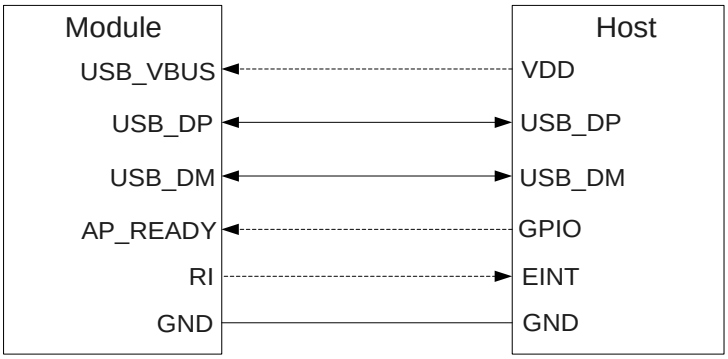


Figure 5: Sleep Mode Application with RI

- Sending data to module via USB will wake up the module.
- When module 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** 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.

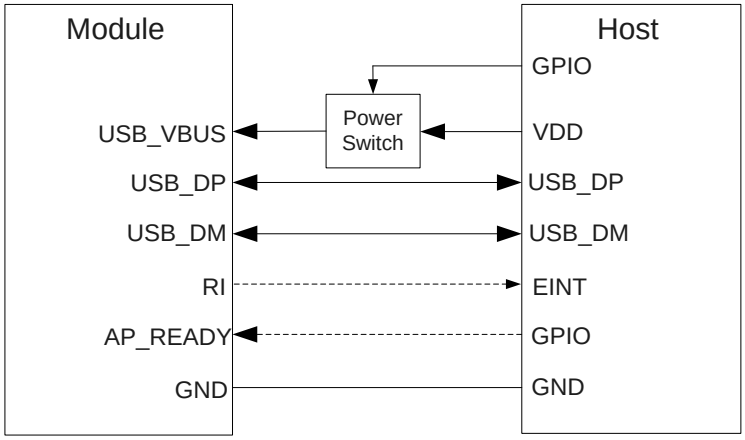


Figure 6: Sleep Mode Application Without Suspend Function

Switching on the power switch to supply power to USB_VBUS will wake up the module.

NOTE

Pay attention to the voltage-level matching of the circuit in dotted line between the module and the host. For more details about EC21 series power management application, see ***document [4]***.

3.5.2. Airplane Mode

When the module enters airplane mode, the RF function will be disabled, and all AT commands related to it 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=<fun> 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.

NOTE

1. The W_DISABLE# control function is disabled in firmware by default. It can be enabled by **AT+QCFG="airplanecontrol"**. For details of the command, see ***document [2]***.
2. The execution of AT+CFUN will not affect GNSS function.

3.6. Power Supply

3.6.1. Power Supply Pins

EC21 series 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 7: 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, 46, 48, 50–54, 56, 72, 85–112					

3.6.2. Voltage Stability Requirements

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

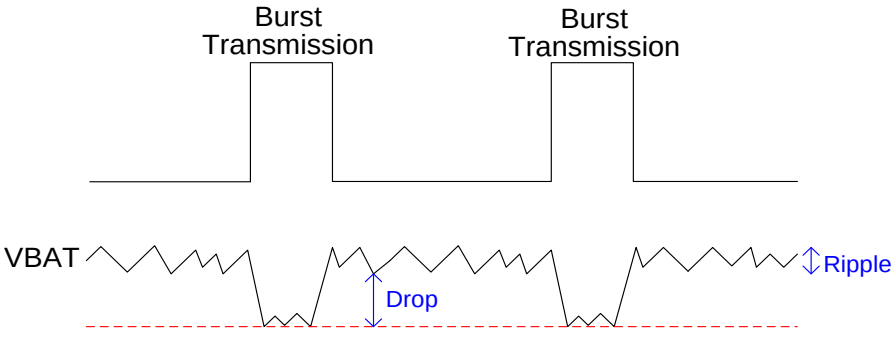


Figure 7: Power Supply Limits during Burst Transmission

To decrease voltage-drop, use bypass capacitors of at least 100 µF with low ESR, and reserve a multi-layer ceramic chip capacitor (MLCC) array due to their low ESR. It is recommended to use at least three ceramic capacitors (100 nF, 33 pF, 10 pF) for composing the MLCC array, and place these capacitors close to VBAT_BB and 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 1 mm; and the width of VBAT_RF trace should be no less than 2 mm. 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} 4.5 V, 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.

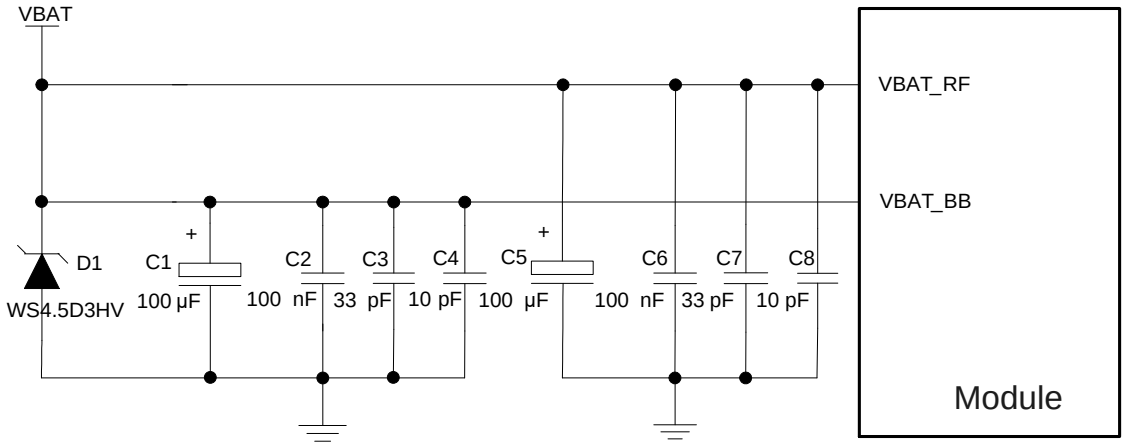


Figure 8: Star Structure of the Power Supply

3.6.3. Reference Design for Power Supply

The performance of the module largely depends on the power source. The power supply should be able to provide sufficient current up to 2.0 A 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 +5.0 V input power source. The typical output of the power supply is about 3.8 V and the maximum load current is 3.0 A.

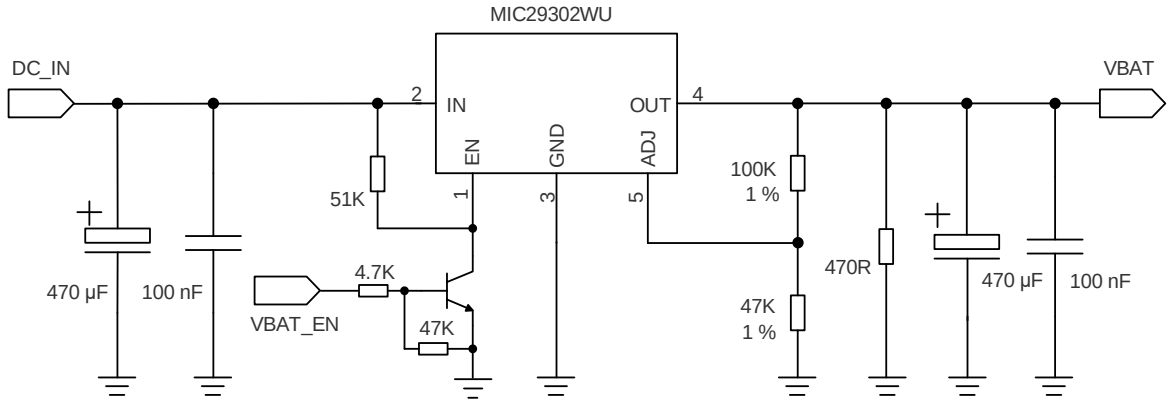


Figure 9: Reference Circuit of Power Supply

NOTE

To avoid damaging internal flash, 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 can be used to monitor the VBAT_BB voltage value. For details of the command, see ***document [2]***..

3.7. Power-on/off Scenarios

3.7.1. Turn on with PWRKEY

The following table shows the pin definition of PWRKEY.

Table 8: Pin Definition of PWRKEY

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

When the module is in power down mode, it can be turned on by driving the PWRKEY pin low for at least 500 ms. 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.

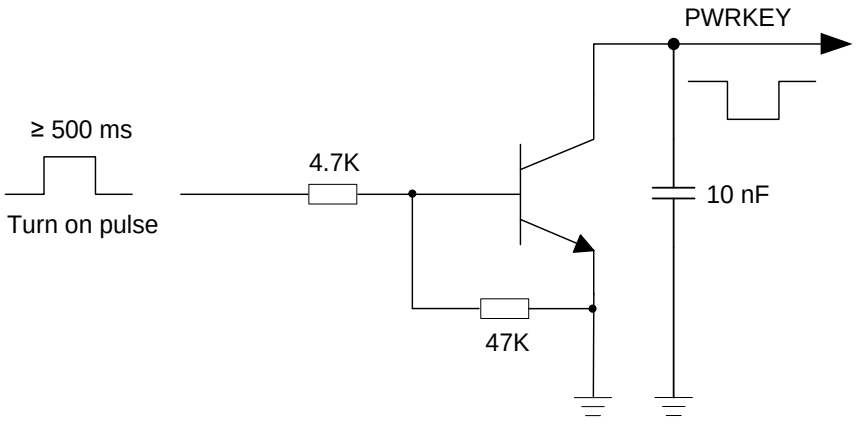


Figure 10: Turn on the Module by Using Driving Circuit

The other way to control the PWRKEY is using a button directly. When pressing the button, 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.

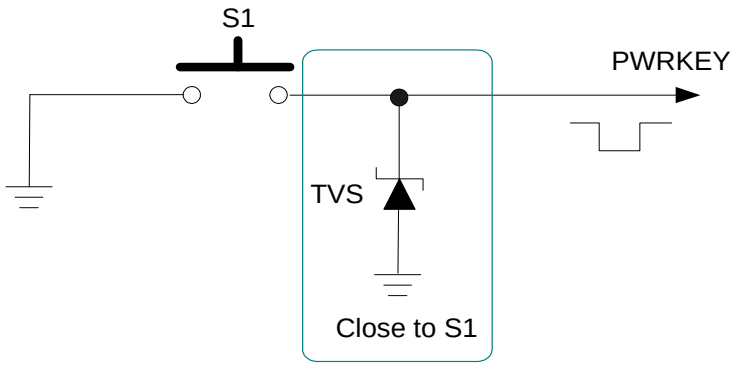


Figure 11: Turn on the Module by Using a Button

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

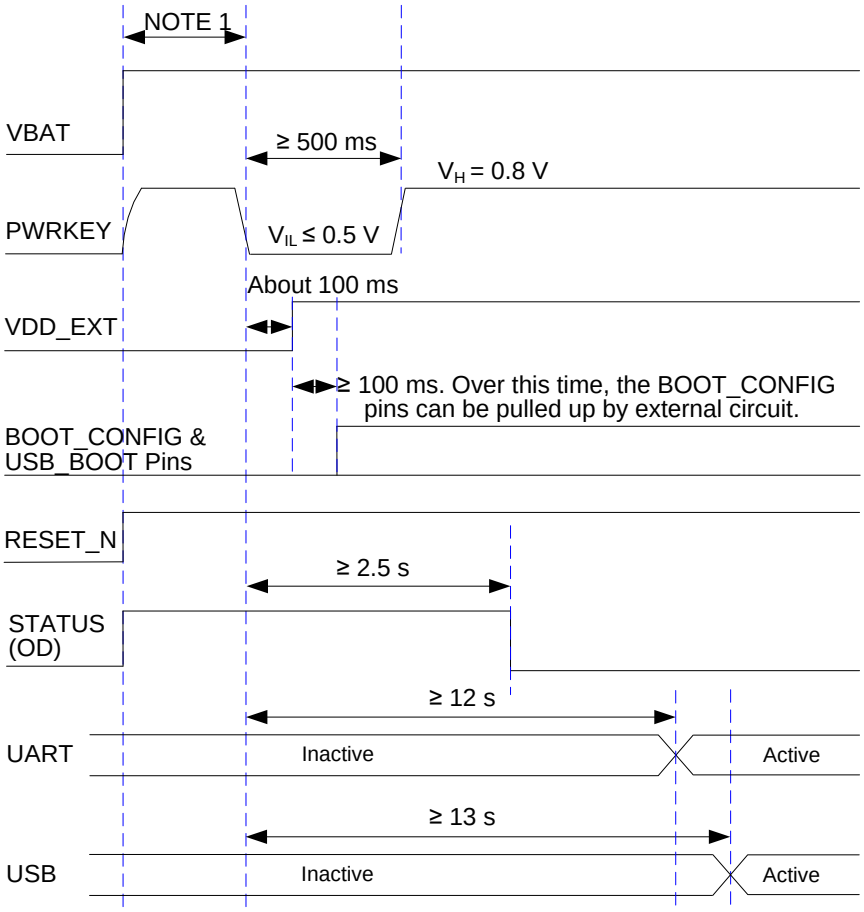


Figure 12: Power-up Timing

NOTE

1. 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 30 ms.
2. PWRKEY can be pulled down directly to GND with a recommended 10 kΩ resistor if the 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 normally:

- Turn off the module using the PWRKEY pin.
- Turn off the module using **AT+QPOWD**. For details of the command, see ***document [2]***.

3.7.2.1. Turn off with PWRKEY

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

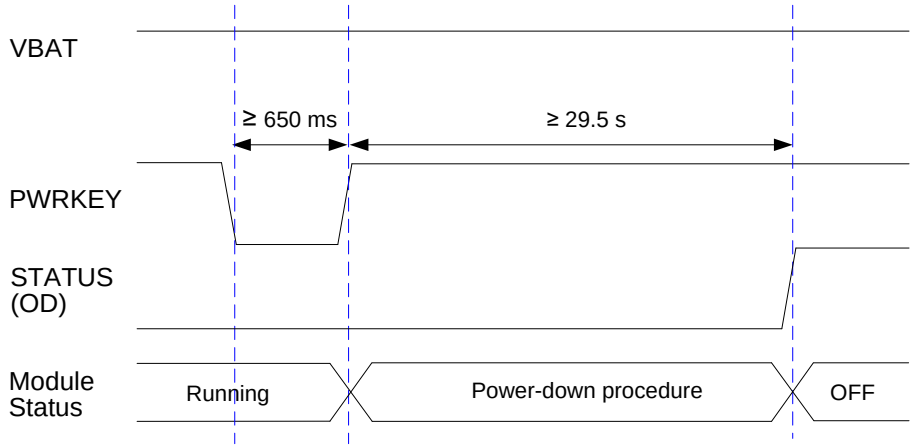


Figure 13: Power-down Timing

3.7.2.2. Turn off with AT Command

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

NOTE

1. To avoid damaging internal flash, 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 the AT command, keep PWRKEY at high level after the execution of the command. Otherwise, the module will be turned on again after successfully turn-off.

3.8. Reset

The RESET_N pin can be used to reset the module. The module can be reset by driving RESET_N low for 150–460 ms.

Table 9: Pin Definition of RESET_N

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

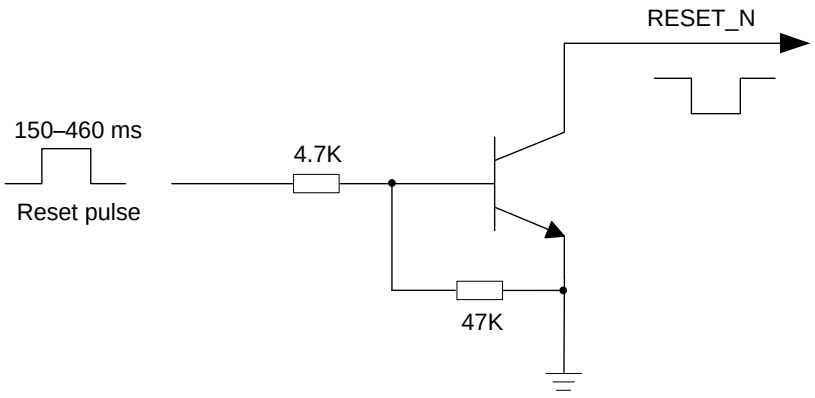


Figure 14: Reference Circuit of RESET_N by Using Driving Circuit

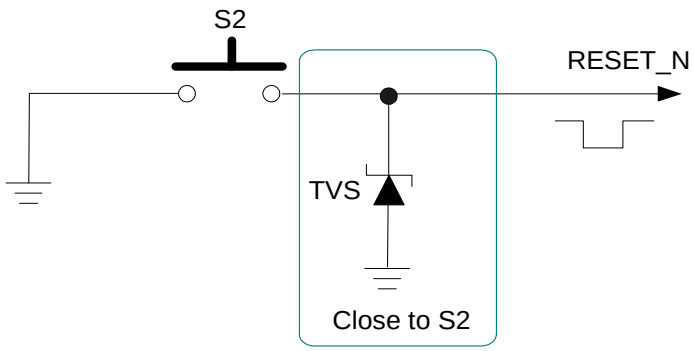


Figure 15: Reference Circuit of RESET_N by Using a Button

The reset scenario is illustrated in the following figure.

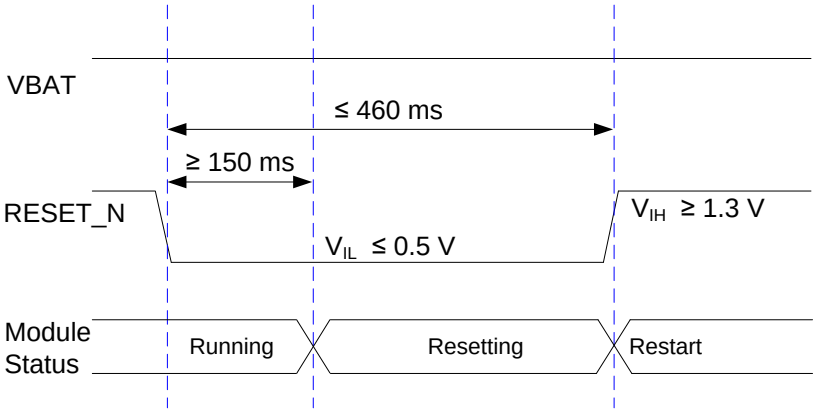


Figure 16: Reset Timing

NOTE

1. Use RESET_N only when failed to turn off the module by **AT+QPOWD** 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 1.8 V and 3.0 V (U)SIM cards are supported.

Table 10: Pin Definition of (U)SIM Interface

Pin Name	Pin No.	I/O	Description	Comment
USIM_VDD	14	PO	(U)SIM card power supply	Either 1.8 V or 3.0 V is supported by the module automatically.
USIM_DATA	15	DIO	(U)SIM card data	
USIM_CLK	16	DO	(U)SIM card clock	
USIM_RST	17	DO	(U)SIM card reset	
USIM_ PRESENCE	13	DI	(U)SIM card insertion detect	1.8 V power domain. If unused, keep it open.
USIM_GND	10		Specified ground for (U)SIM card	

EC21 series supports (U)SIM card hot-plug via the USIM_PRESENCE pin. The function supports low level and high level detections. By default, it is disabled, and can be configured via **AT+QSIMDET**. See ***document [2]*** for more details about the command.

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

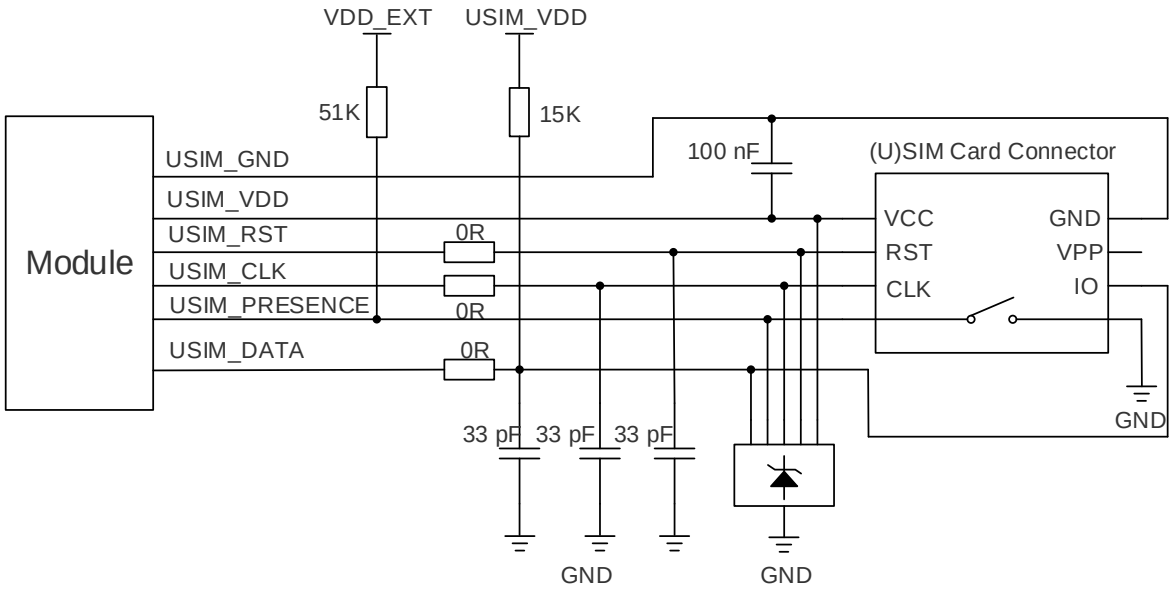


Figure 17: Reference Circuit of (U)SIM Interface with an 8-pin (U)SIM Card Connector

If (U)SIM card detection function is not needed, 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.

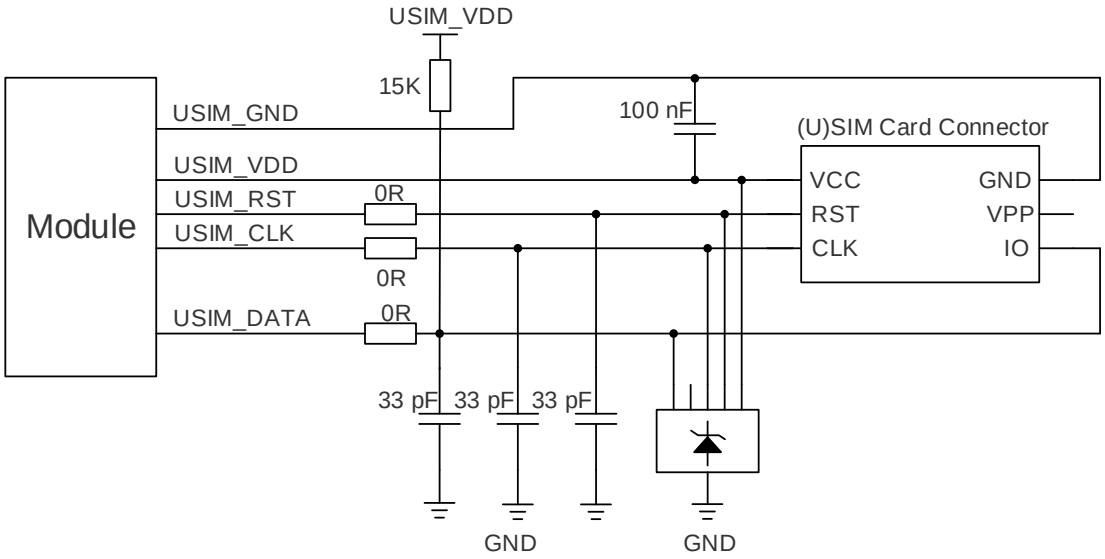


Figure 18: Reference Circuit of (U)SIM Interface with a 6-pin (U)SIM Card Connector

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 200 mm 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 1 μF, 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.
- For better ESD protection, it is recommended to add a TVS diode array whose parasitic capacitance should not be more than 15 pF. The 0 Ω resistors should be added in series between the module and the (U)SIM card to facilitate debugging. The 33 pF 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 trace 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

EC21 series contains one integrated Universal Serial Bus (USB) interface which complies with the USB 2.0 specification and supports high-speed (480 Mbps) and full-speed (12 Mbps) modes. The USB interface can only serve as a slave device.

EC21 series module can be 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 11: Pin Description of USB Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_DP	69	AIO	USB differential data (+)	USB 2.0 Compliant. Require differential impedance of 90 Ω. If unused, keep them open.
USB_DM	70	AIO	USB differential data (-)	
USB_VBUS	71	DI	USB connection detect	Typical 5.0 V
GND	72	-	Ground	-

For more details about the USB 2.0 specifications, 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.

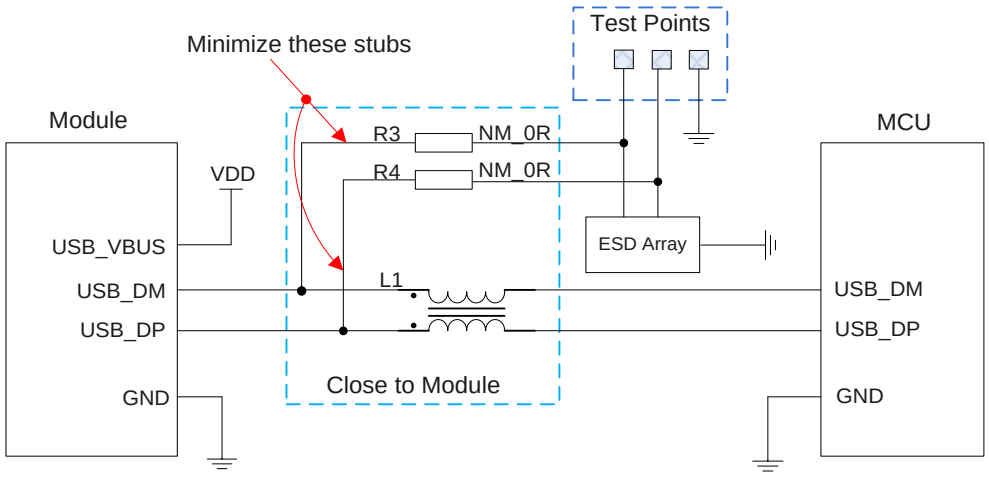


Figure 19: Reference Circuit of USB Application

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 0 Ω resistors (R3 and R4) should be added in series between the module and the test points to facilitate debugging, and the resistors are not mounted by default. In order to ensure the integrity of USB data trace signal, L1 & R3 & R4 components must be placed close to the module, and these resistors should be placed close to each other. The extra stubs of trace must be as short as possible.

To meet USB 2.0 specification, the following principles should be complied with when design the USB interface.

- It is important to route the USB signal traces as differential pairs with total grounding. The impedance of USB differential trace is 90 Ω.
- Do not route signal traces under crystals, oscillators, magnetic devices and RF signal traces. Route the USB differential traces in inner-layer of the PCB, and surround the traces with ground on that layer and with ground planes above and below.
- Junction capacitance of the ESD protection component might cause influences on USB data traces, so pay attention to the selection of the component. Typically, the stray capacitance should be less than 2 pF.
- 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 4800 bps, 9600 bps, 19200 bps, 38400 bps, 57600 bps, 115200 bps, 230400 bps, 460800 bps and 921600 bps baud rates, and the default is 115200 bps. It also supports RTS and CTS hardware flow control, and can be used for data transmission and AT command communication.
- The debug UART interface supports 115200 bps baud rate. It is used for Linux console and log output.

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

Table 12: Pin Definition of Main UART Interface

Pin Name	Pin No.	I/O	Description	Comment
RI	62	DO	Ring indication	1.8 V power domain If unused, keep them open.
DCD	63	DO	Data carrier detect	

CTS	64	DO	DTE clear to send signal from DCE	
RTS	65	DI	DTE request to send signal from DCE	
DTR	66	DI	Data terminal ready, sleep mode control	1.8 V power domain. Pulled up by default. Driving it low can wake up the module. If unused, keep it open.
TXD	67	DO	Transmit	1.8 V power domain. If unused, keep them open.
RXD	68	DI	Receive	

Table 13: Pin Definition of Debug UART Interface

Pin Name	Pin No.	I/O	Description	Comment
DBG_TXD	12	DO	Debug UART transmit	1.8 V power domain If unused, keep them open.
DBG_RXD	11	DI	Debug UART receive	

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

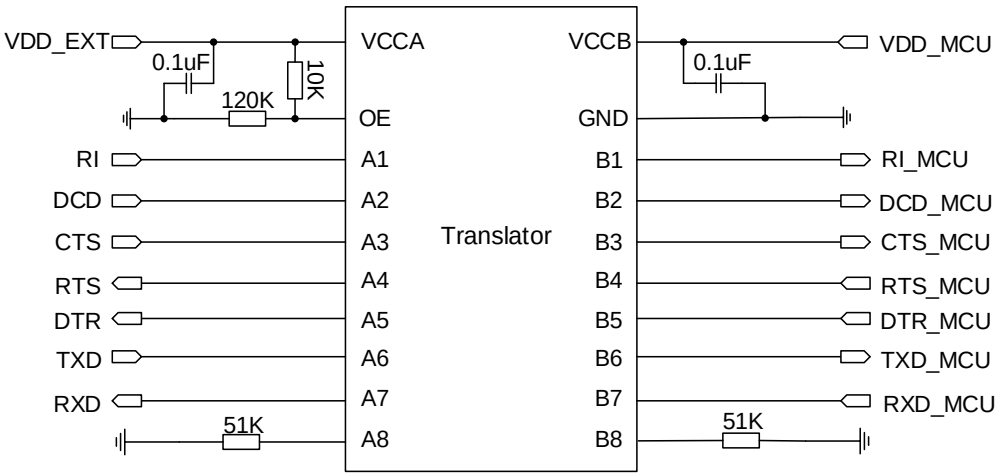


Figure 20: Reference Circuit with Translator Chip

Visit http://www.ti.com for more information.

Another example with transistor translation circuit is shown as below. For the design of circuits in dotted lines, please refer to that of circuits in solid lines, but please pay attention to the direction of connection.

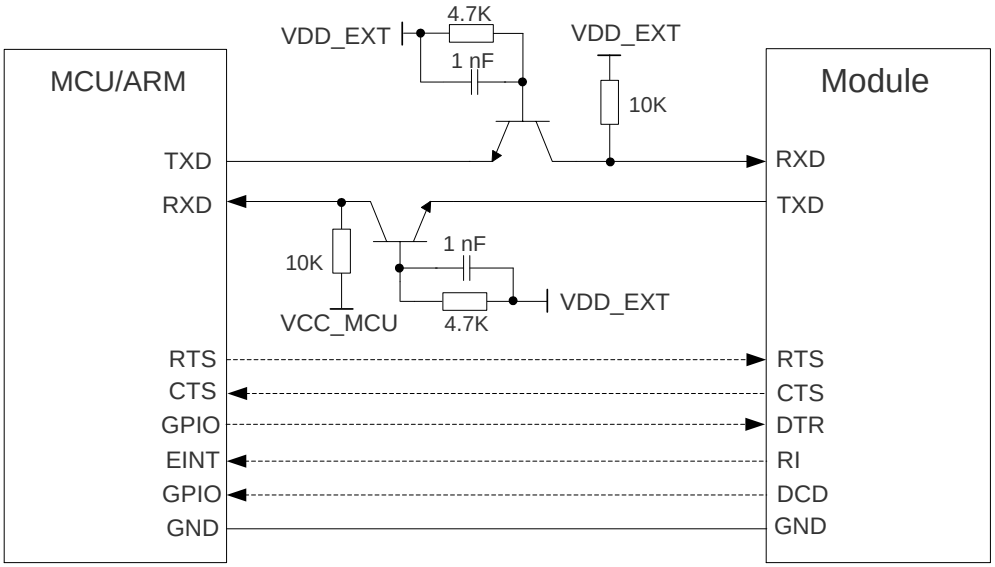


Figure 21: Reference Circuit with Transistor Circuit

NOTE

1. Transistor circuit solution is not suitable for applications with high baud rates exceeding 460 kbps.
2. Please note that the module CTS is connected to the host CTS, and the module RTS is connected to the host RTS.

3.12. PCM and I2C Interfaces

EC21 series 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 256 kHz, 512 kHz, 1024 kHz or 2048 kHz PCM_CLK at 8 kHz PCM_SYNC, and also supports 4096 kHz PCM_CLK at 16 kHz 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 256 kHz, 512 kHz, 1024 kHz or 2048 kHz PCM_CLK and an 8 kHz, 50 % duty cycle PCM_SYNC.

EC21 series supports 16-bit linear data format. The following figures show the primary mode's timing relationship with 8 kHz PCM_SYNC and 2048 kHz PCM_CLK, as well as the auxiliary mode's timing relationship with 8 kHz PCM_SYNC and 256 kHz PCM_CLK.

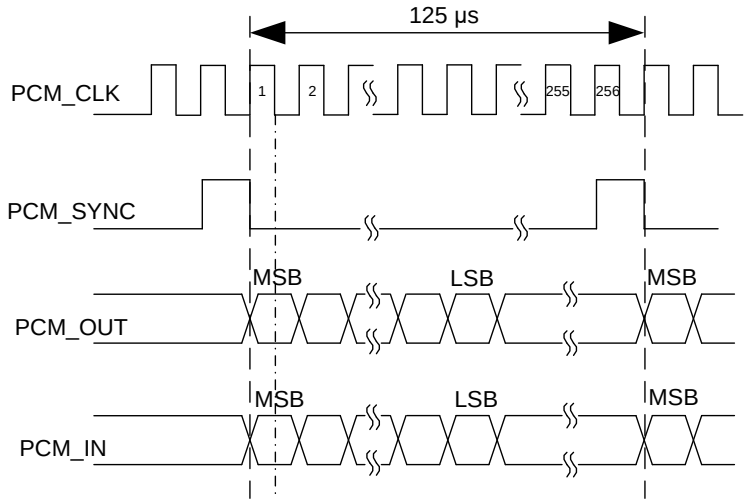


Figure 22: Primary Mode Timing

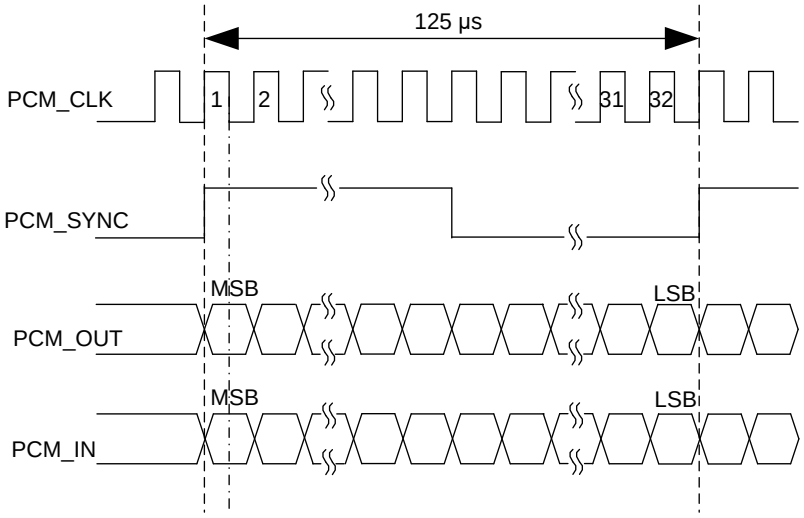


Figure 23: Auxiliary Mode Timing

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	1.8 V power domain If unused, keep them open.
PCM_OUT	25	DO	PCM data output	
PCM_SYNC	26	DIO	PCM data frame sync	1.8 V power domain. Serve as output signal in master mode. Serve as input signal in slave mode. If unused, keep them open.
PCM_CLK	27	DIO	PCM clock	
I2C_SCL	41	OD	I2C serial clock (for external codec)	An external 1.8 V pull-up resistor is required. If unused, keep them open.
I2C_SDA	42	OD	I2C serial data (for external codec)	

Clock and mode can be configured by AT command, and the default configuration is master mode using short frame synchronization format with 2048 kHz PCM_CLK and 8 kHz PCM_SYNC. See ***document [2]*** for more details about **AT+QDAI**.

The following figure shows a reference design of PCM and I2C interfaces with external codec IC.

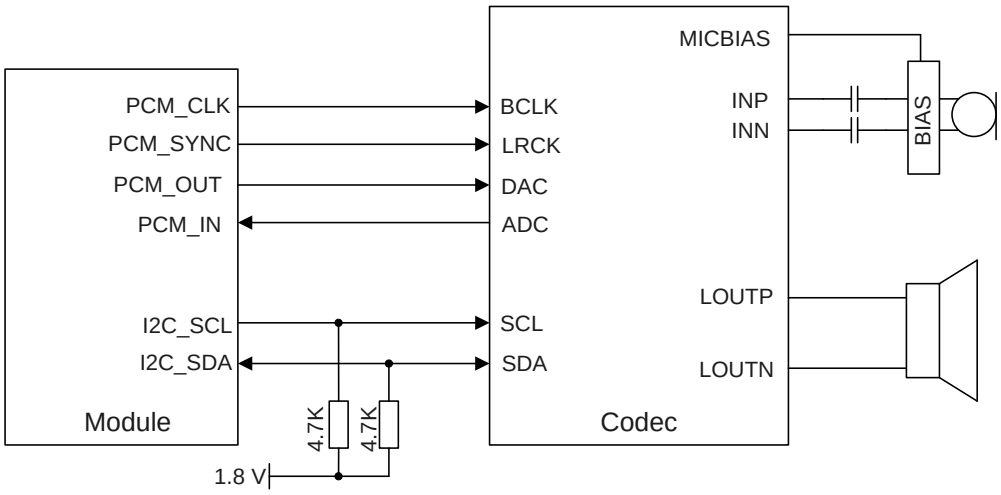


Figure 24: Reference Circuit of PCM and I2C Application with Audio Codec

NOTE

1. It is recommended to reserve an RC (R = 22 Ω, C = 22 pF) circuits on the PCM lines, especially for PCM_CLK.
2. EC21 series only works as a master device pertaining to I2C interface.

3.13. SD Card Interface

EC21 series module 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	DIO	SD card SDIO data bit 3	SDIO signal output voltage can be selected according to the signal output voltage supported by SD card, see SD 3.0 protocol for more details. If unused, keep them open.
SDC2_DATA2	29	DIO	SD card SDIO data bit 2	
SDC2_DATA1	30	DIO	SD card SDIO data bit 1	
SDC2_DATA0	31	DIO	SD card SDIO data bit 0	
SDC2_CLK	32	DO	SD card SDIO clock	
SDC2_CMD	33	DIO	SD card SDIO command	
VDD_SDIO	34	PO	SD card SDIO pull-up power	1.8/2.85 V power domain. Configurable power supply. Cannot be used for SD card power supply. If unused, keep it open.
SD_INS_DET	23	DI	SD card insertion detect	1.8 V power domain. If unused, keep it open.

The following figure shows a reference design of SD card.

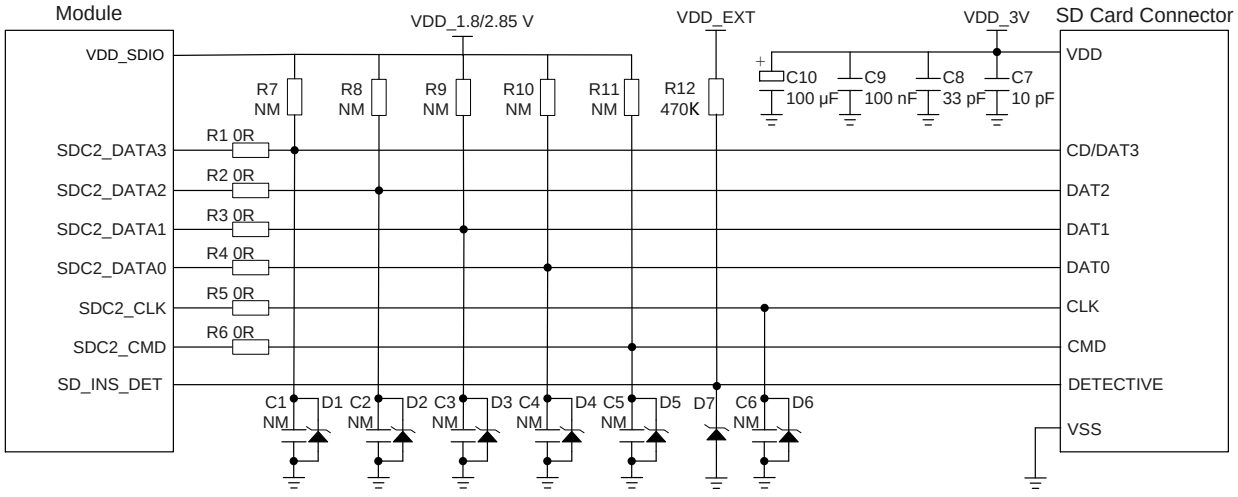


Figure 25: Reference Circuit of SD Card Interface

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 2.7–3.6 V and sufficient current up to 0.8 A should be provided. As the maximum output current of VDD_SDIO is 50 mA 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. The value of these resistors is among 10–100 kΩ and the recommended value is 100 kΩ. VDD_SDIO should be used as the pull-up power.
- In order to adjust signal quality, it is recommended to add 0 Ω 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 15 pF.
- 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, DC-DC signals, etc.
- It is important to route the SDIO signal traces with total grounding. The impedance of SDIO data trace is 50 Ω (±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 15 pF.
- It is recommended to keep the trace length difference between SDC2_CLK and SDC2_DATA[0:3]/ SDC2_CMD less than 1 mm and the total routing length less than 50 mm. The total trace length inside the module is 27 mm, so the exterior total trace length should be less than 23 mm.

3.14. Interfaces for WLAN & Bluetooth Applications

EC21 series supports a low-power SDIO 3.0 interface for WLAN and UART/PCM interfaces for Bluetooth function.

The following table shows the pin definition of WLAN & Bluetooth application interfaces.

Table 16: Pin Definition of Interfaces for WLAN & Bluetooth Applications

Pin Name	Pin No.	I/O	Description	Comment
WLAN Application Interface				
SDC1_DATA3	129	DIO	WLAN SDIO data bit 3	1.8 V power domain. If unused, keep them open.
SDC1_DATA2	130	DIO	WLAN SDIO data bit 2	

SDC1_DATA1	131	DIO	WLAN SDIO data bit 1	
SDC1_DATA0	132	DIO	WLAN SDIO data bit 0	
SDC1_CLK	133	DO	WLAN SDIO clock	
SDC1_CMD	134	DIO	WLAN SDIO command	
WLAN_EN	136	DO	WLAN function enable	1.8 V power domain Active high. Cannot be pulled up before startup. If unused, keep it open.
Coexistence and Control Interface				
PM_ENABLE	127	DO	WLAN power control	1.8 V power domain. Active high. If unused, keep it open.
WAKE_ON_WIRELESS	135	DI	WLAN wake up the module	1.8 V power domain. Active low. If unused, keep it open.
COEX_UART_RX	137	DI	LTE/WLAN & Bluetooth coexistence receive	1.8 V power domain. Cannot be pulled up before startup. If unused, keep them open.
COEX_UART_TX	138	DO	LTE/WLAN & Bluetooth coexistence transmit	
WLAN_SLP_CLK	118	DO	WLAN sleep clock	If unused, keep it open.
Bluetooth Application Interface				
BT_RTS	37	DI	DTE request to send signal from DCE	1.8 V power domain. If unused, keep them open.
BT_TXD	38	DO	Bluetooth UART transmit	
BT_RXD	39	DI	Bluetooth UART receive	
BT_CTS	40	DO	DTE clear to send signal from DCE	1.8 V power domain Cannot be pulled up before startup. If unused, keep it open.
BT_EN	139	DO	Bluetooth function enable	1.8 V power domain Active high. If unused, keep them open.
PCM Interface [7]				
PCM_IN	24	DI	PCM data input	1.8 V power domain.

[7] The PCM function of pins 24–27 can be used for audio design on EC21 series module and Bluetooth function on FC20 series/FC21 modules.

PCM_OUT	25	DO	PCM data output	If unused, keep them open.
PCM_SYNC	26	DIO	PCM data frame sync	1.8 V power domain. Serve as output signal in master mode. Serve as input signal in slave mode. If unused, keep them open.
PCM_CLK	27	DIO	PCM clock	

The following figure shows a reference design of interfaces for WLAN and Bluetooth application with Quectel FC20 series/FC21 modules.

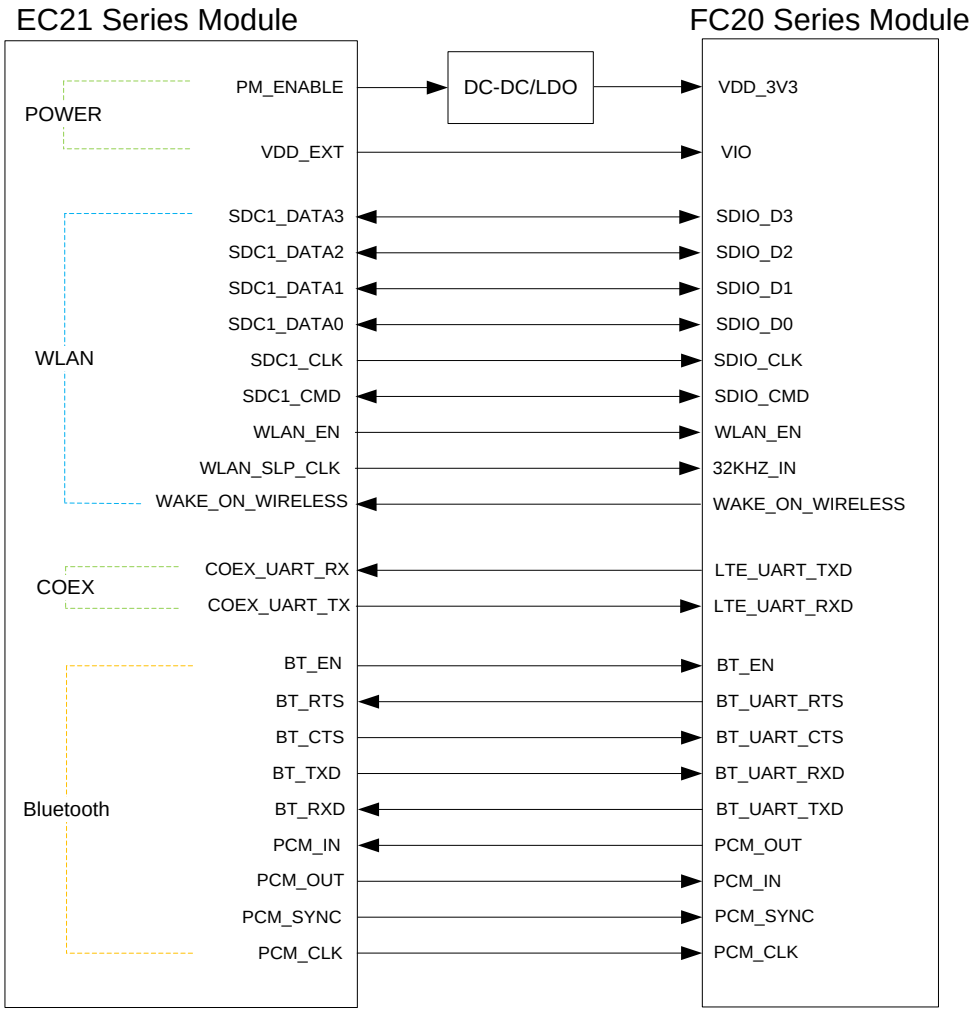


Figure 26: Reference Design of WLAN & Bluetooth Applications Interfaces with FC20 Series/FC21

NOTE

1. FC20 series/FC21 modules can only be used as a slave device.
2. When Bluetooth function is enabled on EC21 series module, PCM_SYNC and PCM_CLK pins are only used to output signals. Bluetooth function is under development.
3. For more information about interfaces for WLAN and Bluetooth applications, see ***document [6]***.

3.14.1. WLAN Application Interface

EC21 series provides a low power SDIO 3.0 interface and a control interface for WLAN design. SDIO interface supports the SDR mode, and the maximum frequency is up to 50 MHz.

As SDIO signals are 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 Ω ±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, DC-DC signals, etc.
- It is recommended to keep matching length between SDC1_CLK and SDC1_DATA[0:3]/SDC1_CMD less than 1 mm and total routing length less than 50 mm.
- Keep termination resistors within 15–24 Ω on SDC1_CLK signal traces near the module and keep the routing distance from the module's SDC1_CLK pin to termination resistors less than 5 mm.
- Make sure the adjacent trace spacing is 2 times of the trace width and bus capacitance is less than 15 pF.

3.14.2. Bluetooth Application Interface

EC21 series module supports a dedicated UART interface and a PCM interface for Bluetooth application. And Bluetooth functions are under development.

Further information about Bluetooth application interface will be provided in future version of this document.

3.15. ADC Interfaces

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

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	Comment
ADC0	45	General-purpose ADC interface	If unused, keep them open.
ADC1	44	General-purpose ADC interface	

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

NOTE

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

EC21 series module 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 10 Mbps (DL)/5 Mbps (UL) for 4G network
- Support VLAN tagging
- Support IEEE1588 and PTP
- Can be used to connect to external Ethernet PHY like AR8033, or to an external switch
- Management interfaces support dual voltage 1.8/2.85 V

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
Control Signal Interface				
EPHY_RST_N	119	DO	Ethernet PHY reset	1.8/2.85 V power domain. If unused, keep them open.
EPHY_INT_N	120	DI	Ethernet PHY interrupt	
SGMII_MDATA	121	DIO	SGMII MDIO data	
SGMII_MCLK	122	DO	SGMII MDIO clock	
USIM2_VDD	128	PO	SGMII_MDATA pull-up power supply	Configurable power supply. 1.8/2.85 V power domain. If unused, keep it open.
SGMII Data Interface				
SGMII_TX_M	123	AO	SGMII transmit (-)	Connect it with a 0.1 μF capacitor, and close to the PHY side. If unused, keep them open.
SGMII_TX_P	124	AO	SGMII transmit (+)	
SGMII_RX_P	125	AI	SGMII receive (+)	Connect it with a 0.1 μF capacitor, and close to the module. If unused, keep them open.
SGMII_RX_M	126	AI	SGMII receive (-)	

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

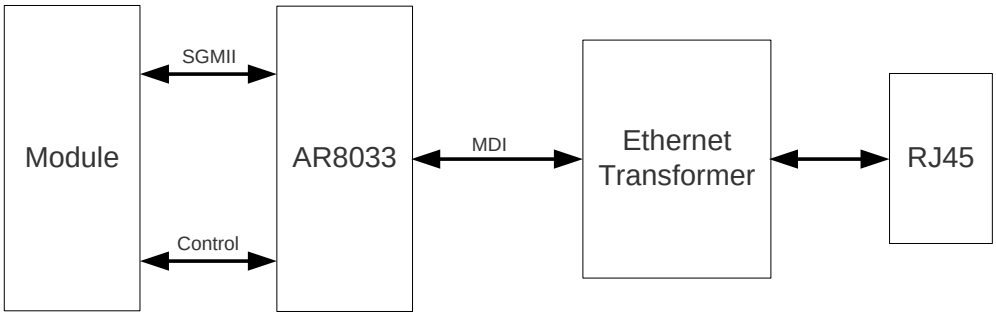


Figure 27: Brief Block Diagram for Ethernet Application

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

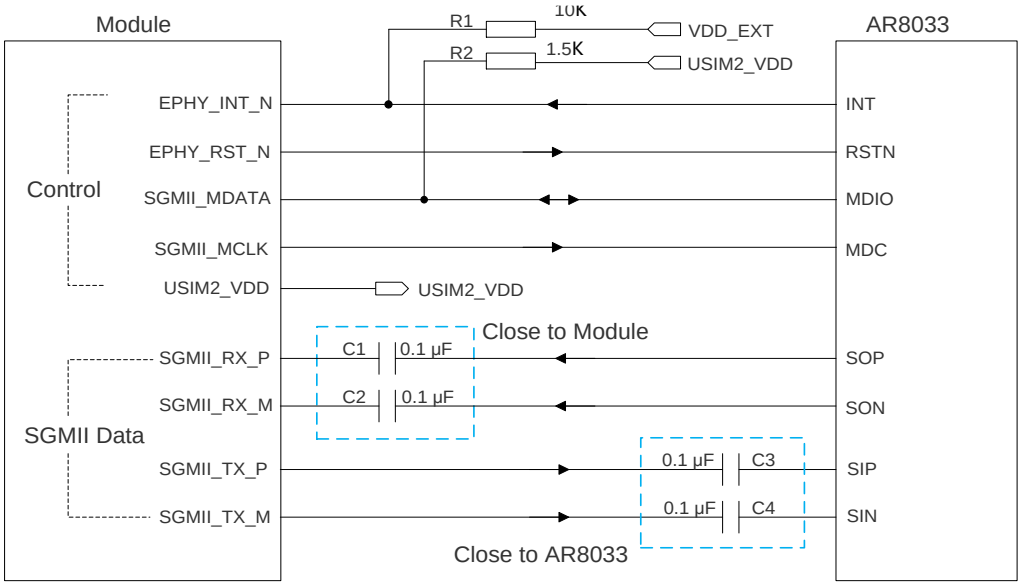


Figure 28: Reference Design of SGMII Interface with PHY AR8033 Application

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 25.4 cm and keep the length difference on the differential pairs less than 0.5 mm.
- The differential impedance of SGMII data trace is 100 Ω ±10%, and the reference ground of the area should be complete.
- Make sure the trace spacing between SGMII_TX and corresponding SGMII_TX is at least 3 times of the trace width, and the same to the adjacent signal traces.

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	1.8 V power domain. Cannot be pulled up before startup. If unused, keep it open.
NET_STATUS	6	DO	Indicate the module's network activity status	1.8 V power domain If unused, keep it open.

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 (200 ms High/1800 ms Low)	Network searching
	Flicker slowly (1800 ms High/200 ms Low)	Idle
	Flicker quickly (125 ms High/125 ms Low)	Data transfer is ongoing
	Always High	Voice calling

A reference circuit is shown in the following figure.

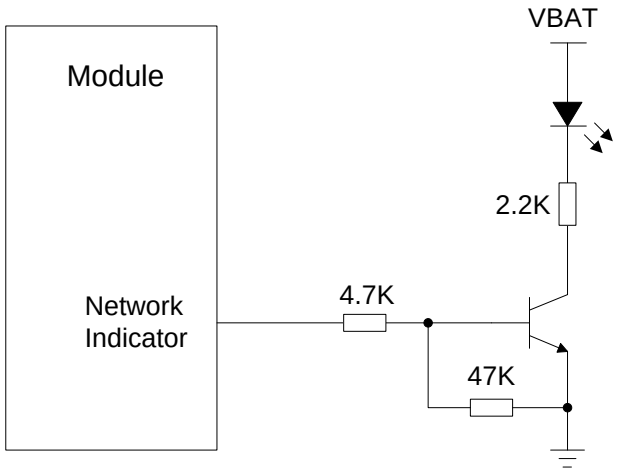


Figure 29: Reference Circuit of the Network Indicator

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	The driving current should be less than 0.9 mA. An external pull-up resistor is required. 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.

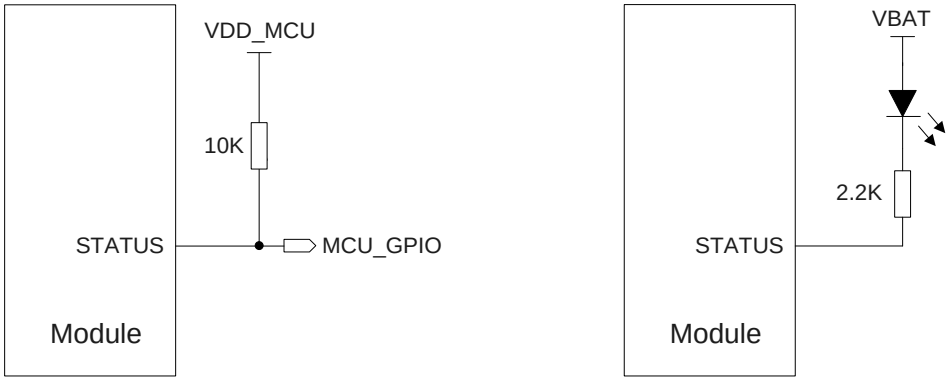


Figure 30: Reference Design of STATUS

NOTE

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

3.19. RI

AT+QCFG="risignaltype","physical" 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. See ***document [3]*** for details.

NOTE

URC can be outputted from UART port, USB AT port and USB modem port through configuration via **AT+QURCCFG**. The default port is USB AT port. See ***document [2]*** for details.

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 120 ms low pulse when a new URC returns

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

3.20. USB_BOOT Interface

EC21 series provides a USB_BOOT pin. Customers can pull up USB_BOOT to 1.8 V 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	1.8 V power domain. Cannot be pulled up before startup. Active high. It is recommended to reserve test point.

The following figure shows a reference circuit of USB_BOOT interface.

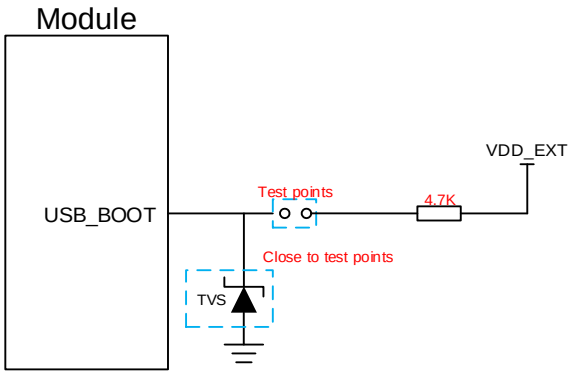


Figure 31: Reference Circuit of USB_BOOT Interface

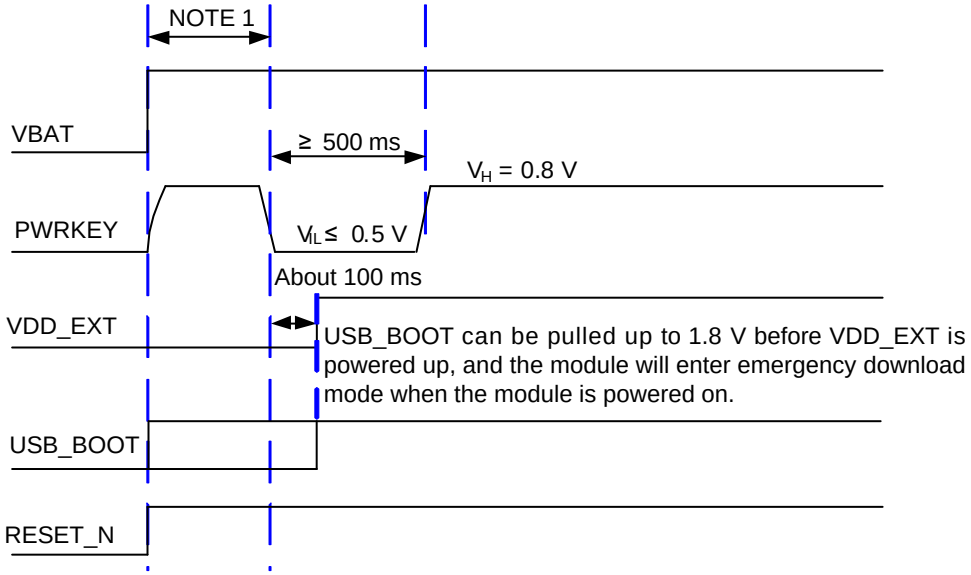


Figure 32: Timing Sequence for Entering Emergency Download Mode

NOTE

1. 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 30 ms.
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 1.8 V before powering up VBAT. Connect the test points as shown in ***Figure 31*** can manually force the module to enter download mode.

4 RF Specifications

EC21 series 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 impedance of antenna ports is 50 Ω.

4.1. Cellular Network

4.1.1. Antenna Interfaces & Frequency Bands

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

Table 25: Pin Definition of RF Antennas

Pin Name	Pin No.	I/O	Description	Comment
ANT_MAIN	49	AIO	Main antenna interface	50 Ω impedance
ANT_DIV	35	AI	Diversity antenna interface	50 Ω impedance. If unused, keep it open.

4.1.2. Operating Frequency

Table 26: 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 B8	880–915	925–960	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 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 B40	2300–2400	2300–2400	MHz

4.1.3. Tx Power

The following table shows the RF output power of EC21 series module.

Table 27: RF Output Power

Frequency	Max. RF output power	Min. RF output power
GSM850/EGSM900	33 dBm ±2 dB	5 dBm ±5 dB
DCS1800/PCS1900	30 dBm ±2 dB	0 dBm ±5 dB
GSM850/EGSM900 (8-PSK)	27 dBm ±3 dB	5 dBm ±5 dB
DCS1800/PCS1900 (8-PSK)	26 dBm ±3 dB	0 dBm ±5 dB
WCDMA bands	24 dBm +1/-3 dB	< -49 dBm
LTE-FDD bands	23 dBm ±2 dB	< -39 dBm
LTE-TDD bands	23 dBm ±2 dB	< -39 dBm

NOTE

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

4.1.4. Rx Sensitivity

The following tables show the conducted RF receiving sensitivity of EC21 series module.

Table 28: EC21-E Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
EGSM900	-109.0 dBm	-	-	-102.0 dBm

[8] 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.

DCS1800	-109.0 dBm	-	-	-102.0 dBm
WCDMA B1	-110.5 dBm	-	-	-106.7 dBm
WCDMA B5	-110.5 dBm	-	-	-104.7 dBm
WCDMA B8	-110.5 dBm	-	-	-103.7 dBm
LTE-FDD B1 (10 MHz)	-98.0 dBm	-98.0 dBm	-101.5 dBm	-96.3 dBm
LTE-FDD B3 (10 MHz)	-96.5 dBm	-98.5 dBm	-101.5 dBm	-93.3 dBm
LTE-FDD B5 (10 MHz)	-98.0 dBm	-98.5 dBm	-101.0 dBm	-94.3 dBm
LTE-FDD B7 (10 MHz)	-97.0 dBm	-97.0 dBm	-99.5 dBm	-94.3 dBm
LTE-FDD B8 (10 MHz)	-97.0 dBm	-97.0 dBm	-101.0 dBm	-93.3 dBm
LTE-FDD B20 (10 MHz)	-97.5 dBm	-99.0 dBm	-102.5 dBm	-93.3 dBm

Table 29: EC21-A Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
WCDMA B2	-110.0 dBm	-	-	-104.7 dBm
WCDMA B4	-110.0 dBm	-	-	-106.7 dBm
WCDMA B5	-110.5 dBm	-	-	-104.7 dBm
LTE-FDD B2 (10 MHz)	-98.0 dBm	-98.0 dBm	-101.0 dBm	-94.3 dBm
LTE-FDD B4 (10 MHz)	-97.5 dBm	-99.0 dBm	-101.0 dBm	-96.3 dBm
LTE-FDD B12 (10 MHz)	-97.2 dBm	-98.0 dBm	-101.0 dBm	-93.3 dBm

Table 30: EC21-V Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
LTE-FDD B4 (10 MHz)	-97.5 dBm	-99.0 dBm	-101.0 dBm	-96.3 dBm

LTE-FDD B13 (10 MHz)	-97.7 dBm	-97.0 dBm	-100.0 dBm	-93.3 dBm

Table 31: EC21-AU Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
GSM850	-109.0 dBm	-	-	-102.0 dBm
EGSM900	-109.0 dBm	-	-	-102.0 dBm
DCS1800	-109.0 dBm	-	-	-102.0 dBm
PCS1900	-109.0 dBm	-	-	-102.0 dBm
WCDMA B1	-110.0 dBm	-	-	-106.7 dBm
WCDMA B2	-110.0 dBm	-	-	-104.7 dBm
WCDMA B5	-111.0 dBm	-	-	-104.7 dBm
WCDMA B8	-111.0 dBm	-	-	-103.7 dBm
LTE-FDD B1 (10 MHz)	-97.2 dBm	-97.5 dBm	-100.2 dBm	-96.3 dBm
LTE-FDD B2 (10 MHz)	-98.2 dBm	-	-	-94.3 dBm
LTE-FDD B3 (10 MHz)	-98.7 dBm	-98.6 dBm	-102.2 dBm	-93.3 dBm
LTE-FDD B4 (10 MHz)	-97.7 dBm	-97.4 dBm	-100.2 dBm	-96.3 dBm
LTE-FDD B5 (10 MHz)	-98.0 dBm	-98.2 dBm	-101.0 dBm	-94.3 dBm
LTE-FDD B7 (10 MHz)	-97.7 dBm	-97.7 dBm	-101.2 dBm	-94.3 dBm
LTE-FDD B8 (10 MHz)	-99.2 dBm	-98.2 dBm	-102.2 dBm	-93.3 dBm
LTE-FDD B28 (10 MHz)	-98.6 dBm	-98.7 dBm	-102.0 dBm	-94.8 dBm
LTE-TDD B40 (10 MHz)	-97.2 dBm	-98.4 dBm	-101.2 dBm	-96.3 dBm

Table 32: EC21-EU Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
EGSM900	-109.0 dBm	-	-	-102.0 dBm
DCS1800	-109.0 dBm	-	-	-102.0 dBm
WCDMA B1	-110.5 dBm	-	-	-106.7 dBm
WCDMA B8	-110.5 dBm	-	-	-103.7 dBm
LTE-FDD B1 (10 MHz)	-98.2 dBm	-99 dBm	-101.7 dBm	-96.3 dBm
LTE-FDD B3 (10 MHz)	-98.7 dBm	-99.5 dBm	-101.2 dBm	-93.3 dBm
LTE-FDD B7 (10 MHz)	-96.8 dBm	-98.5 dBm	-100.7 dBm	-94.3 dBm
LTE-FDD B8 (10 MHz)	-98.7 dBm	-100 dBm	-101.7 dBm	-93.3 dBm
LTE-FDD B20 (10 MHz)	-98.2 dBm	-99.5 dBm	-101.8 dBm	-93.3 dBm
LTE-FDD B28A (10 MHz)	-98.8 dBm	-100 dBm	-101.5 dBm	-94.8 dBm

Table 33: EC21-AUT Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
WCDMA B1	-110.0 dBm	-	-	-106.7 dBm
WCDMA B5	-110.5 dBm	-	-	-104.7 dBm
LTE-FDD B1 (10 MHz)	-98.5 dBm	-98.0 dBm	-101.0 dBm	-96.3 dBm
LTE-FDD B3 (10 MHz)	-98.0 dBm	-97.0 dBm	-100.0 dBm	-93.3 dBm
LTE-FDD B5 (10 MHz)	-98.0 dBm	-99.0 dBm	-102.5 dBm	-94.3 dBm
LTE-FDD B7 (10 MHz)	-97.0 dBm	-97.0 dBm	-98.5 dBm	-94.3 dBm
LTE-FDD B28 (10 MHz)	-97.0 dBm	-99.0 dBm	-102.0 dBm	-94.8 dBm

Table 34: EC21-J Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
LTE-FDD B1 (10 MHz)	-97.5 dBm	-98.7 dBm	-100.2 dBm	-96.3 dBm
LTE-FDD B3 (10 MHz)	-96.5 dBm	-97.1 dBm	-100.5 dBm	-93.3 dBm
LTE-FDD B8 (10 MHz)	-98.4 dBm	-99.0 dBm	-101.2 dBm	-93.3 dBm
LTE-FDD B18 (10 MHz)	-99.5 dBm	-99.0 dBm	-101.7 dBm	-96.3 dBm
LTE-FDD B19 (10 MHz)	-99.2 dBm	-99.0 dBm	-101.4 dBm	-96.3 dBm
LTE-FDD B26 (10 MHz)	-99.5 dBm	-99.0 dBm	-101.5 dBm	-93.8 dBm

Table 35: EC21-KL Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
LTE-FDD B1 (10 MHz)	-98.0 dBm	-99.5 dBm	-100.5 dBm	-96.3 dBm
LTE-FDD B3 (10 MHz)	-97.0 dBm	-97.5 dBm	-99.5 dBm	-93.3 dBm
LTE-FDD B5 (10 MHz)	-98.0 dBm	-99.5 dBm	-100.5 dBm	-94.3 dBm
LTE-FDD B7 (10 MHz)	-96.0 dBm	-96.0 dBm	-98.5 dBm	-94.3 dBm
LTE-FDD B8 (10 MHz)	-97.0 dBm	-99.0 dBm	-101.0 dBm	-93.3 dBm

Table 36: EC21-AUX Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
GSM850	-109.0 dBm	-	-	-102.0 dBm
EGSM900	-109.0 dBm	-	-	-102.0 dBm
DCS1800	-109.0 dBm	-	-	-102.0 dBm

PCS1900	-109.0 dBm	-	-	-102.0 dBm
WCDMA B1	-110.0 dBm	-109.5 dBm	-112 dBm	-106.7 dBm
WCDMA B2	-110.5 dBm	-	-	-104.7 dBm
WCDMA B4	-110.0 dBm	-110 dBm	-112 dBm	-104.7 dBm
WCDMA B5	-111.0 dBm	-112 dBm	-113 dBm	-104.7 dBm
WCDMA B8	-111.0 dBm	-112 dBm	-113 dBm	-103.7 dBm
LTE-FDD B1 (10 MHz)	-98.0 dBm	-97.7 dBm	-101.2 dBm	-96.3 dBm
LTE-FDD B2 (10 MHz)	-98.5 dBm	-	-	-94.3 dBm
LTE-FDD B3 (10 MHz)	-99.0 dBm	-98.8 dBm	-102.2 dBm	-93.3 dBm
LTE-FDD B4 (10 MHz)	-97.7 dBm	-97.6 dBm	-100.2 dBm	-96.3 dBm
LTE-FDD B5 (10 MHz)	-98.5 dBm	-98.2 dBm	-101.0 dBm	-94.3 dBm
LTE-FDD B7 (10 MHz)	-97.7 dBm	-97.7 dBm	-101.2 dBm	-94.3 dBm
LTE-FDD B8 (10 MHz)	-99.0 dBm	-98.5 dBm	-102.2 dBm	-93.3 dBm
LTE-FDD B28 (10 MHz)	-98.0 dBm	-98.7 dBm	-101.5 dBm	-94.8 dBm
LTE-TDD B40 (10 MHz)	-97.5 dBm	-98.2 dBm	-101.2 dBm	-96.3 dBm

Table 37: EC21-EUX Conducted RF Receiving Sensitivity

Frequency Bands	Receiving Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO [8]	
EGSM900	-109.0 dBm	-	-	-102.0 dBm
DCS1800	-109.0 dBm	-	-	-102.0 dBm
WCDMA B1	-110.5 dBm	-	-	-106.7 dBm
WCDMA B8	-110.5 dBm	-	-	-103.7 dBm
LTE-FDD B1 (10 MHz)	-98.0 dBm	-98.0 dBm	-101.0 dBm	-96.3 dBm
LTE-FDD B3 (10 MHz)	-98.5 dBm	-98.5 dBm	-101.0 dBm	-93.3 dBm

LTE-FDD B7 (10 MHz)	-97.0 dBm	-96.0 dBm	-99.5 dBm	-94.3 dBm
LTE-FDD B8 (10 MHz)	-98.5 dBm	-97.0 dBm	-101.0 dBm	-93.3 dBm
LTE-FDD B20 (10 MHz)	-97.5 dBm	-99.0 dBm	-100.5 dBm	-93.3 dBm
LTE-FDD B28 (10 MHz)	-98.0 dBm	-98.7 dBm	-101.0 dBm	-94.8 dBm

4.1.5. Reference Design

A reference design of ANT_MAIN and ANT_DIV antenna pads is shown as below. A π-type matching circuit should be reserved for better RF performance. The capacitors are not mounted by default.

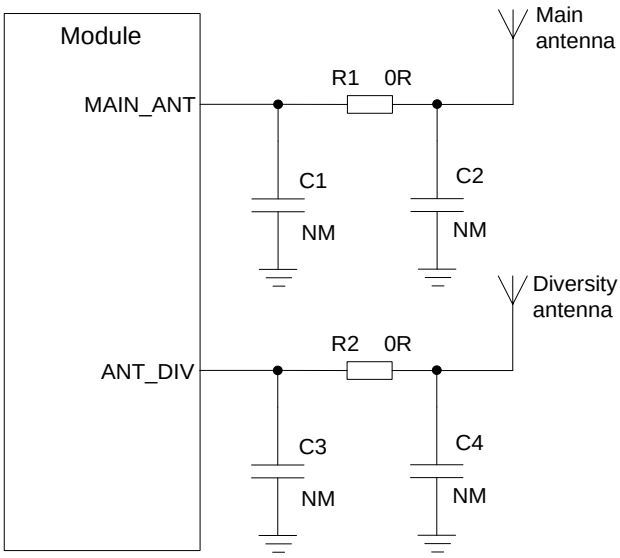


Figure 33: Reference Circuit of RF Antenna Interface

NOTE

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="divctl",0** can be used to disable receive diversity. See ***document [3]*** for details.
3. Place the π-type matching components (R1 & C1 & C2, R2 & C3 & C4) as close to the antenna as possible.

4.2. GNSS

4.2.1. Antenna Interface and Frequency Bands

EC21 series includes a fully integrated global navigation satellite system solution that supports GPS, GLONASS, BeiDou (COMPASS), Galileo and QZSS.

EC21 series supports standard *NMEA-0183* protocol, and outputs NMEA sentences at 1 Hz data update rate via USB interface by default.

By default, EC21 series GNSS engine is switched off. It has to be switched on via AT command. For more details about GNSS engine technology and configurations, see ***document [5]***.

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

Table 38: Pin Definition of GNSS Antenna Interface

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

Table 39: GNSS Frequency

Type	Frequency	Unit
GPS	1575.42 ±1.023	MHz
GLONASS	1597.5–1605.8	MHz
Galileo	1575.42 ±2.046	MHz
BeiDou (COMPASS)	1561.098 ±2.046	MHz
QZSS	1575.42	MHz

4.2.2. GNSS Performance

The following table shows the GNSS performance of EC21 series.

Table 40: 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 @ open sky	Autonomous	2.5	s
		XTRA enabled	1.8	s
Accuracy (GNSS)	CEP-50	Autonomous @ open sky	< 2.5	m

NOTE

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

4.2.3. Reference Design

A reference design of GNSS antenna is shown as below.

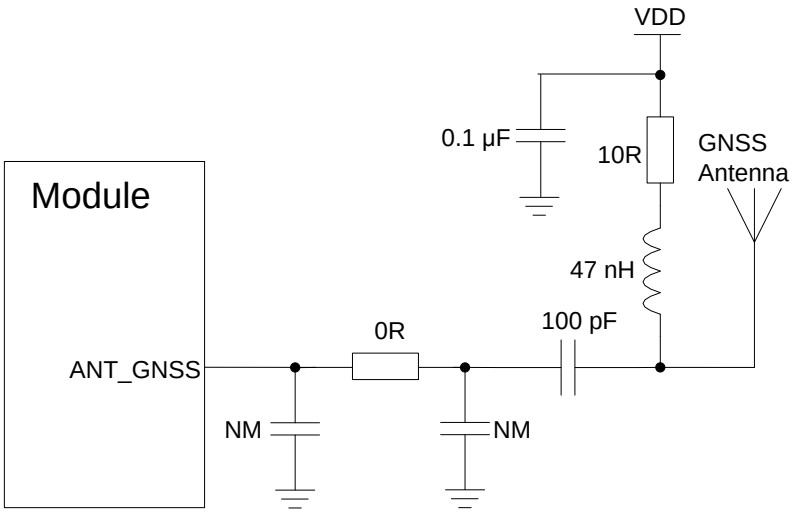


Figure 34: Reference Circuit of GNSS Antenna

NOTE

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.

4.2.4. 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 50 Ω characteristic impedance for the ANT_GNSS trace.

4.3. RF Routing Guidelines

For user's PCB, the characteristic impedance of all RF traces should be controlled to 50 Ω. The impedance of the RF traces is usually determined by the trace width (W), the materials' dielectric constant, the height from the reference ground to the signal layer (H), and the spacing between RF

traces and grounds (S). Microstrip or coplanar waveguide is typically used in RF layout to control characteristic impedance. The following are reference designs of microstrip or coplanar waveguide with different PCB structures.

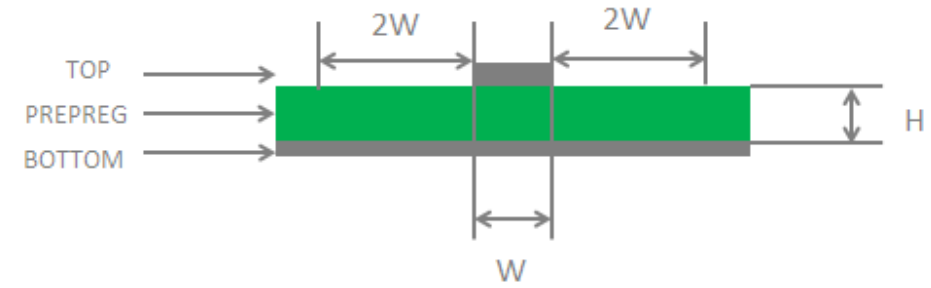


Figure 35: Microstrip Design on a 2-layer PCB

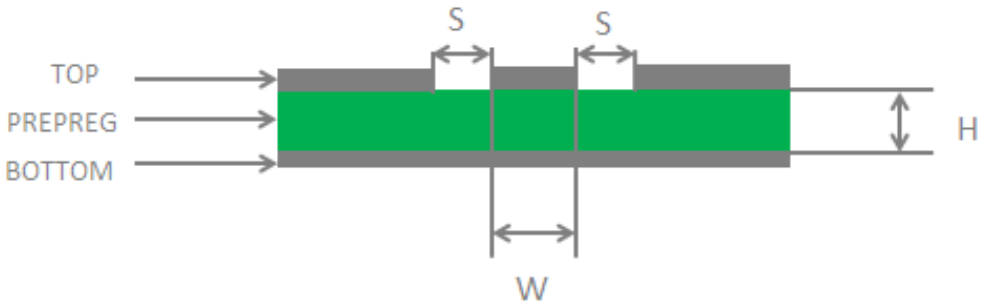


Figure 36: Coplanar Waveguide Design on a 2-layer PCB

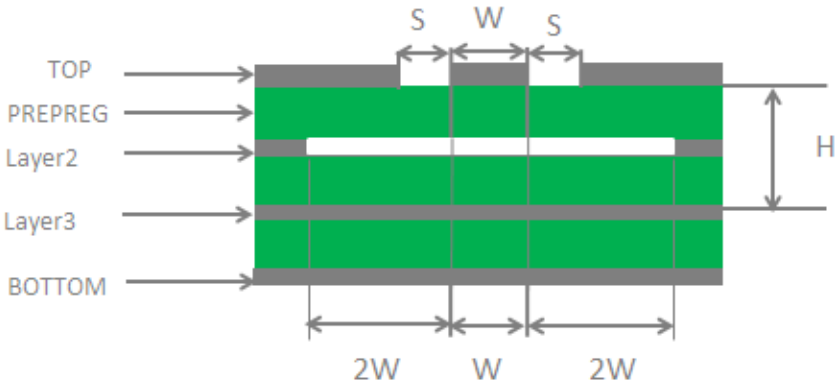


Figure 37: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

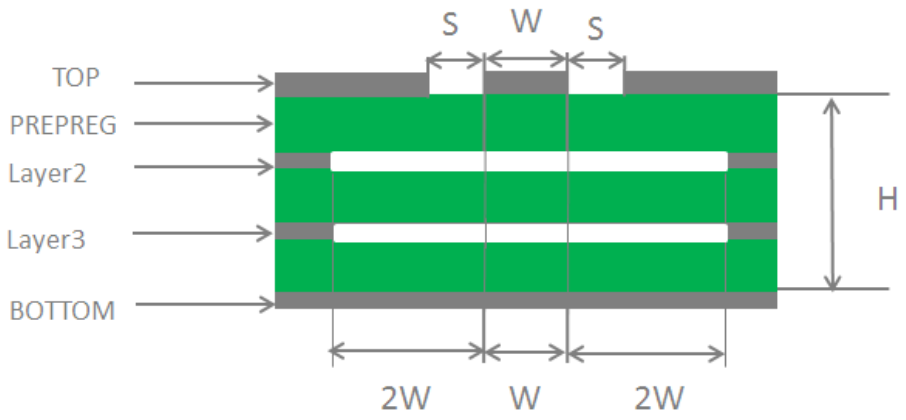


Figure 38: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

To ensure RF performance and reliability, follow the principles below in RF layout design:

- Use an impedance simulation tool to accurately control the characteristic impedance of RF traces to 50 Ω.
- 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. The recommended trace angle is 135°.
- There should be clearance 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 × W).
- Keep RF traces away from interference sources, and avoid intersection and paralleling between traces on adjacent layers.

For more details about RF layout, see ***document [7]***.

4.4. Antenna Design Requirements

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

Table 41: Antenna Requirements

Type	Requirements
GNSS [9]	Frequency range: 1559–1609 MHz Polarization: RHCP or linear VSWR: < 2 (Typ.) Passive antenna gain: > 0 dBi Active antenna noise figure: < 1.5 dB Active antenna gain: > 0 dBi Active antenna embedded LNA gain: < 17 dB
GSM/WCDMA/LTE	VSWR: ≤ 2 Efficiency: > 30 % Max input power: 50 W Input impedance: 50 Ω Cable insertion loss: **< 1 dB:** LB (<1 GHz) **< 1.5 dB:** MB (1–2.3 GHz) **< 2 dB:** HB (> 2.3 GHz)

NOTE

When the module supports LTE B13 or B14, it is recommended to use passive GNSS antennas, since active antennas may cause harmonics that affect GNSS performance.

4.5. RF Connector Recommendation

If RF connector is used for antenna connection, it is recommended to use U.FL-R-SMT connector provided by Hirose.

[9] 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.

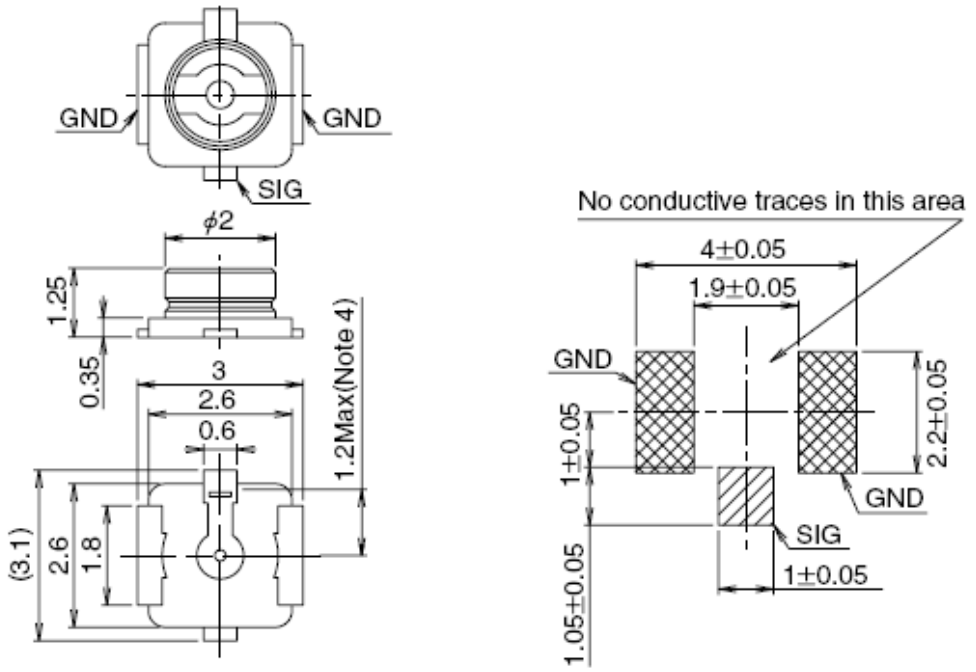


Figure 39: Dimensions of the U.FL-R-SMT Connector (Unit: mm)

U.FL-LP serial connectors listed in the following figure can be used to match the U.FL-R-SMT.

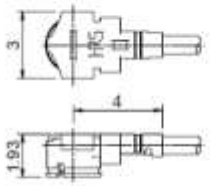
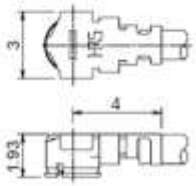
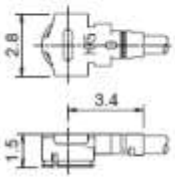
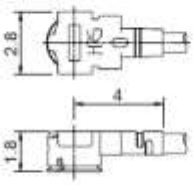
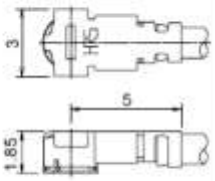
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 0.81mm Coaxial cable	Dia. 1mm Coaxial cable	Dia. 1.37mm Coaxial cable
Weight (mg)	53.7	59.1	34.8	45.5	71.7
RoHS	YES				

Figure 40: Mechanicals of U.FL-LP Connectors

The following figure describes the space factor of mated connector.

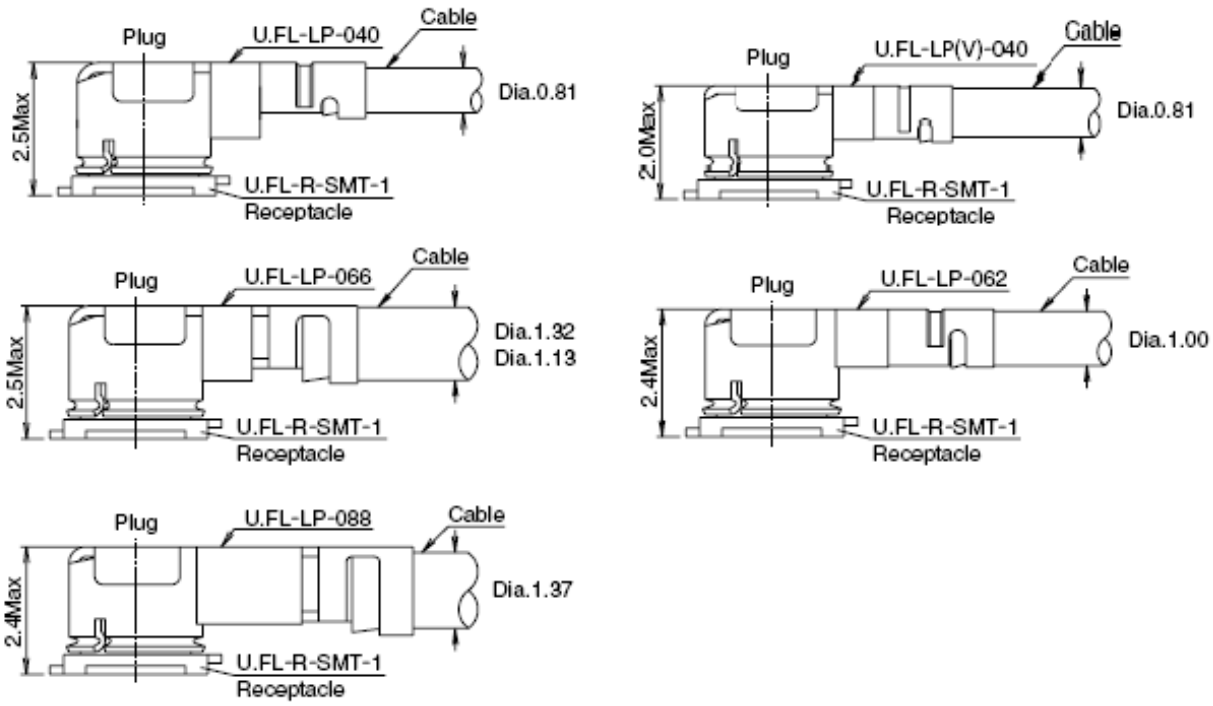


Figure 41: Space Factor of Mated Connector (Unit: mm)

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

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5 Electrical Characteristic and Reliability

5.1. 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 42: 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

5.2. Power Supply Ratings

Table 43: 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_{VBAT}	Peak supply current (during transmission slot)	Maximum power control level on EGSM900	-	1.8	2.0	A
USB_VBUS	USB connection detection	-	3.0	5.0	5.25	V

5.3. Operating and Storage Temperatures

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

Table 44: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operating Temperature Range [10]	-35	+25	+75	ºC
Extended Temperature Range [11]	-40	-	+85	ºC
Storage Temperature Range	-40	-	+90	ºC

[10] Within operation temperature range, the module is 3GPP compliant.
[11] Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call*, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operation temperature levels, the module will meet 3GPP specifications again.

5.4. Power Consumption

The values of current consumption are shown below.

Table 45: EC21-E Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	13	μA
Sleep state	**AT+CFUN=0** (USB disconnected)	1.4	mA
	EGSM900 @ DRX = 9 (USB disconnected)	1.8	mA
	DCS1800 @ DRX = 9 (USB disconnected)	1.8	mA
	WCDMA PF = 64 (USB disconnected)	2.4	mA
	WCDMA PF = 128 (USB disconnected)	1.9	mA
	LTE-FDD PF = 64 (USB disconnected)	3.2	mA
	LTE-FDD PF = 128 (USB disconnected)	2.1	mA
Idle state (GNSS OFF)	EGSM900 @ DRX = 5 (USB disconnected)	22.0	mA
	EGSM900 @ DRX = 5 (USB connected)	32.0	mA
	WCDMA PF = 64 (USB disconnected)	22.5	mA
	WCDMA PF = 64 (USB connected)	32.7	mA
	LTE-FDD PF = 64 (USB disconnected)	22.5	mA
	LTE-FDD PF = 64 (USB connected)	32.5	mA
GPRS data transfer (GNSS OFF)	EGSM900 4DL/1UL @ 32.3 dBm	220	mA
	EGSM900 3DL/2UL @ 32.18 dBm	387	mA
	EGSM900 2DL/3UL @ 30.3 dBm	467	mA
	EGSM900 1DL/4UL @ 29.4 dBm	555	mA
	DCS1800 4DL/1UL @ 29.6 dBm	185	mA
	DCS1800 3DL/2UL @ 29.1 dBm	305	mA

	DCS1800 2DL/3UL @ 28.8 dBm	431	mA
	DCS1800 1DL/4UL @ 29.1 dBm	540	mA
EDGE data transfer (GNSS OFF)	EGSM900 4DL/1UL @ 26 dBm	148	mA
	EGSM900 3DL/2UL @ 26 dBm	245	mA
	EGSM900 2DL/3UL @ 25 dBm	338	mA
	EGSM900 1DL/4UL @ 25 dBm	432	mA
	DCS1800 4DL/1UL @ 26 dBm	150	mA
	DCS1800 3DL/2UL @ 25 dBm	243	mA
	DCS1800 2DL/3UL @ 25 dBm	337	mA
	DCS1800 1DL/4UL @ 25 dBm	430	mA
WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA @ 22.5 dBm	659	mA
	WCDMA B1 HSUPA @ 21.11 dBm	545	mA
	WCDMA B5 HSDPA @ 23.5 dBm	767	mA
	WCDMA B5 HSUPA @ 21.4 dBm	537	mA
	WCDMA B8 HSDPA @ 22.41 dBm	543	mA
	WCDMA B8 HSUPA @ 21.2 dBm	445	mA
LTE data transfer (GNSS OFF)	LTE-FDD B1 @ 23.45 dBm	807	mA
	LTE-FDD B3 @ 23.4 dBm	825	mA
	LTE-FDD B5 @ 23.4 dBm	786	mA
	LTE-FDD B7 @ 23.86 dBm	887	mA
	LTE-FDD B8 @ 23.5 dBm	675	mA
	LTE-FDD B20 @ 23.57 dBm	770	mA
GSM voice call	EGSM900 PCL = 5 @ 33.08 dBm	264.0	mA
	DCS1800 PCL = 0 @ 29.75 dBm	190.0	mA
WCDMA voice call	WCDMA B1 @ 23.69 dBm	683	mA

	WCDMA B5 @ 23.61 dBm	741	mA
	WCDMA B8 @ 23.35 dBm	564	mA

Table 46: EC21-A Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	10	μA
Sleep state	**AT+CFUN=0** (USB disconnected)	1.25	mA
	WCDMA PF = 64 (USB disconnected)	2.03	mA
	WCDMA PF = 128 (USB disconnected)	1.65	mA
	LTE-FDD PF = 64 (USB disconnected)	2.31	mA
	LTE-FDD PF = 128 (USB disconnected)	1.85	mA
Idle state (GNSS OFF)	WCDMA PF = 64 (USB disconnected)	23.1	mA
	WCDMA PF = 64 (USB connected)	32.8	mA
	LTE-FDD PF = 64 (USB disconnected)	22.8	mA
	LTE-FDD PF = 64 (USB connected)	32.8	mA
WCDMA data transfer (GNSS OFF)	WCDMA B2 HSDPA @ 21.54 dBm	479.0	mA
	WCDMA B2 HSUPA @ 22.19 dBm	530.0	mA
	WCDMA B4 HSDPA @ 22.15 dBm	539.0	mA
	WCDMA B4 HSUPA @ 21.82 dBm	531.0	mA
	WCDMA B5 HSDPA @ 22.22 dBm	454.0	mA
	WCDMA B5 HSUPA @ 21.45 dBm	433.0	mA
LTE data transfer (GNSS OFF)	LTE-FDD B2 @ 23.11 dBm	721.0	mA
	LTE-FDD B4 @ 23.16 dBm	748.0	mA
	LTE-FDD B12 @ 23.25 dBm	668.0	mA
WCDMA voice call	WCDMA B2 @ 22.97 dBm	565.0	mA

	WCDMA B4 @ 22.91 dBm	590.0	mA
	WCDMA B5 @ 23.06 dBm	493.0	mA

Table 47: EC21-V Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	10	μA
Sleep state	**AT+CFUN = 0** (USB disconnected)	1.07	mA
	LTE-FDD PF = 64 (USB disconnected)	2.85	mA
	LTE-FDD PF = 128 (USB disconnected)	2.26	mA
Idle state (GNSS OFF)	LTE-FDD PF = 64 (USB disconnected)	22.0	mA
	LTE-FDD PF = 64 (USB connected)	32.0	mA
LTE data transfer (GNSS OFF)	LTE-FDD B4 @ 22.77 dBm	762.0	mA
	LTE-FDD B13 @ 23.05 dBm	533.0	mA

Table 48: EC21-AU Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	11	μA
Sleep state	**AT+CFUN = 0** (USB disconnected)	0.97	mA
	EGSM DRX = 2 (USB disconnected)	1.93	mA
	EGSM DRX = 5 (USB disconnected)	1.41	mA
	EGSM DRX = 5 (USB suspend)	1.64	mA
	DCS DRX = 2 (USB disconnected)	1.82	mA
	DCS DRX = 5 (USB disconnected)	1.31	mA
	DCS DRX = 5 (USB suspend)	1.55	mA
	WCDMA PF = 64 (USB disconnected)	1.85	mA

	WCDMA PF = 128 (USB disconnected)	1.34	mA
	LTE-FDD PF = 64 (USB disconnected)	2.01	mA
	LTE-FDD PF = 128 (USB disconnected)	1.41	mA
	LTE-TDD PF = 64 (USB disconnected)	2.31	mA
	LTE-TDD PF = 128 (USB disconnected)	1.68	mA
Idle state (GNSS OFF)	EGSM900 @ DRX = 5 (USB disconnected)	19.8	mA
	EGSM900 @ DRX = 5 (USB connected)	29.6	mA
	WCDMA PF = 64 (USB disconnected)	19.5	mA
	WCDMA PF = 64 (USB connected)	29.4	mA
	LTE-FDD PF = 64 (USB disconnected)	20.3	mA
	LTE-FDD PF = 64 (USB connected)	30.4	mA
	LTE-TDD PF = 64 (USB connected)	20.0	mA
	LTE-TDD PF = 64 (USB connected)	30.4	mA
GPRS data transfer (GNSS OFF)	GSM850 4DL/1UL @ 32.45 dBm	220.8	mA
	GSM850 3DL/2UL @ 32.3 dBm	385.4	mA
	GSM850 2DL/3UL @ 30.1 dBm	446.5	mA
	GSM850 1DL/4UL @ 28.8 dBm	513.4	mA
	EGSM900 4DL/1UL @ 32.67 dBm	227.7	mA
	EGSM900 3DL/2UL @ 32.56 dBm	404.8	mA
	EGSM900 2DL/3UL @ 30.56 dBm	472.9	mA
	EGSM900 1DL/4UL @ 29.23 dBm	545.8	mA
	DCS1800 4DL/1UL @ 29.47 dBm	169.1	mA
	DCS1800 3DL/2UL @ 29.34 dBm	289	mA
	DCS1800 2DL/3UL @ 29.2 dBm	396.1	mA
	DCS1800 1DL/4UL @ 27.05 dBm	502.7	mA

	PCS1900 4DL/1UL @ 29.73 dBm	164	mA
	PCS1900 3DL/2UL @ 29.67 dBm	280.1	mA
	PCS1900 2DL/3UL @ 29.53 dBm	388	mA
	PCS1900 1DL/4UL @ 29.36 dBm	490.9	mA
EDGE data transfer (GNSS OFF)	EGSM900 4DL/1UL @ 26.99 dBm	146.5	mA
	EGSM900 3DL/2UL @ 26.91 dBm	245.0	mA
	EGSM900 2DL/3UL @ 26.77 dBm	341.2	mA
	EGSM900 1DL/4UL @ 26.69 dBm	439.3	mA
	DCS1800 4DL/1UL @ 25.76 dBm	140.8	mA
	DCS1800 3DL/2UL @ 25.56 dBm	231.6	mA
	DCS1800 2DL/3UL @ 25.44 dBm	322.6	mA
	DCS1800 1DL/4UL @ 25.40 dBm	411.1	mA
	GSM850 4DL/1UL @ 26.5 dBm	140.6	mA
	GSM850 3DL/2UL @ 26.35 dBm	230.0	mA
	GSM850 2DL/3UL @ 26.33 dBm	323.0	mA
	GSM850 1DL/4UL @ 26.1 dBm	410.8	mA
	PCS1900 4DL/1UL @ 25.93 dBm	135.9	mA
	PCS1900 3DL/2UL @ 25.68 dBm	227.7	mA
	PCS1900 2DL/3UL @ 25.6 dBm	313.7	mA
	PCS1900 1DL/4UL @ 25.47 dBm	401.0	mA
WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA @ 22.13 dBm	564.4	mA
	WCDMA B1 HSUPA @ 21.69 dBm	559.3	mA
	WCDMA B2 HSDPA @ 22.1 dBm	568.6	mA
	WCDMA 2 HSUPA @ 21.75 dBm	554.7	mA
	WCDMA B5 HSDPA @ 22.9 dBm	537.5	mA

	WCDMA B5 HSUPA @ 21.2 dBm	496.2	mA
	WCDMA B8 HSDPA @ 22.14 dBm	553.2	mA
	WCDMA B8 HSUPA @ 21.78 dBm	559.7	mA
LTE data transfer (GNSS OFF)	LTE-FDD B1 @ 22.85 dBm	742.2	mA
	LTE-FDD B2 @ 22.5 dBm	770.6	mA
	LTE-FDD B3 @ 23.00 dBm	770.1	mA
	LTE-FDD B4 @ 22.7 dBm	684.3	mA
	LTE-FDD B5 @ 23.16 dBm	649.5	mA
	LTE-FDD B7 @ 22.91 dBm	731.9	mA
	LTE-FDD B8 @ 23.09 dBm	633.6	mA
	LTE-FDD B28 @ 23.24 dBm	769.8	mA
	LTE-TDD B40 @ 22.66 dBm	390.8	mA
GSM voice call	GSM900 PCL = 5 @ 32.85 dBm	244.0	mA
	GSM850 PCL = 5 @ 32.57 dBm	231.7	mA
	PCS1900 PCL = 0 @ 29.7 dBm	170.9	mA
	DCS1800 PCL = 0 @ 29.68 dBm	180.1	mA
WCDMA voice call	WCDMA B1 @ 22.90 dBm	598.1	mA
	WCDMA B2 @ 23.03 dBm	630.4	mA
	WCDMA B5 @ 23.03 dBm	563.4	mA
	WCDMA B8 @ 23.04 dBm	605.0	mA

Table 49: EC21-EU Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	12.8	μA
Sleep state	**AT+CFUN = 0** (USB disconnected)	1.8	mA

	GSM DRX = 2 (USB disconnected)	3.0	mA
	GSM DRX = 9 (USB disconnected)	2.2	mA
	WCDMA PF = 64 (USB disconnected)	3.1	mA
	WCDMA PF = 128 (USB disconnected)	2.6	mA
	LTE-FDD PF = 64 (USB disconnected)	3.3	mA
	LTE-FDD PF = 128 (USB disconnected)	2.6	mA
Idle state (GNSS OFF)	EGSM900 @ DRX = 5 (USB disconnected)	17.6	mA
	EGSM900 @ DRX = 5 (USB connected)	27.7	mA
	WCDMA PF = 64 (USB disconnected)	17.9	mA
	WCDMA PF = 64 (USB connected)	27.9	mA
	LTE-FDD PF = 64 (USB disconnected)	17.9	mA
	LTE-FDD PF = 64 (USB connected)	28.0	mA
GPRS data transfer (GNSS OFF)	EGSM900 4DL/1UL @ 33.80 dBm	264.3	mA
	EGSM900 3DL/2UL @ 32.57 dBm	419.8	mA
	EGSM900 2DL/3UL @ 30.26 dBm	481.5	mA
	EGSM900 1DL/4UL @ 28.94 dBm	553.2	mA
	DCS1800 4DL/1UL @ 31.13 dBm	178.3	mA
	DCS1800 3DL/2UL @ 30.28 dBm	293.6	mA
	DCS1800 2DL/3UL @ 28.21 dBm	354.3	mA
	DCS1800 1DL/4UL @ 27.05 dBm	424.7	mA
EDGE data transfer (GNSS OFF)	EGSM900 4DL/1UL @ 27.08 dBm	147.1	mA
	EGSM900 3DL/2UL @ 25.91 dBm	240.0	mA
	EGSM900 2DL/3UL @ 23.83 dBm	296.2	mA
	EGSM900 1DL/4UL @ 22.73 dBm	357.1	mA
	DCS1800 4DL/1UL @ 26.65 dBm	138.7	mA

	DCS1800 3DL/2UL @ 25.61 dBm	227.4	mA
	DCS1800 2DL/3UL @ 23.46 dBm	302.8	mA
	DCS1800 1DL/4UL @ 22.19 dBm	381.7	mA
WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA @ 23.26 dBm	605.0	mA
	WCDMA B1 HSUPA @ 23.09 dBm	615.3	mA
	WCDMA B8 HSDPA @ 23.27 dBm	544.0	mA
	WCDMA B8 HSUPA @ 22.67 dBm	536.1	mA
LTE data transfer (GNSS OFF)	LTE-FDD B1 @ 24.50 dBm	798.7	mA
	LTE-FDD B3 @ 23.67 dBm	751.8	mA
	LTE-FDD B7 @ 23.75 dBm	878.7	mA
	LTE-FDD B8 @ 22.81 dBm	592.6	mA
	LTE-FDD B20 @ 24.08 dBm	777.8	mA
	LTE-FDD B28A @ 23.34 dBm	748.1	mA
GSM voice call	GSM900 PCL = 5 @ 33.85 dBm	279.9	mA
	DCS1800 PCL = 0 @ 31.20 dBm	189.5	mA
WCDMA voice call	WCDMA B1 @ 24.06 dBm	681.0	mA
	WCDMA B8 @ 24.17 dBm	593.0	mA

Table 50: EC21-AUT Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	10	μA
Sleep state	**AT+CFUN = 0** (USB disconnected)	0.99	mA
	WCDMA PF = 64 (USB disconnected)	2.1	mA
	WCDMA PF = 128 (USB disconnected)	1.7	mA
	LTE-FDD PF = 64 (USB disconnected)	2.9	mA

	LTE-FDD PF = 128 (USB disconnected)	2.4	mA
Idle state (GNSS OFF)	WCDMA PF = 64 (USB disconnected)	22.0	mA
	WCDMA PF = 64 (USB connected)	32.0	mA
	LTE-FDD PF = 64 (USB disconnected)	23.6	mA
	LTE-FDD PF = 64 (USB connected)	33.6	mA
WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA @ 22.59 dBm	589.0	mA
	WCDMA B1 HSUPA @ 22.29 dBm	623.0	mA
	WCDMA B5 HSDPA @ 22.22 dBm	511.0	mA
	WCDMA B5 HSUPA @ 21.64 dBm	503.0	mA
LTE data transfer (GNSS OFF)	LTE-FDD B1 @ 23.38 dBm	813.0	mA
	LTE-FDD B3 @ 22.87 dBm	840.0	mA
	LTE-FDD B5 @ 23.12 dBm	613.0	mA
	LTE-FDD B7 @ 22.96 dBm	761.0	mA
	LTE-FDD B28 @ 23.31 dBm	650.0	mA
WCDMA voice call	WCDMA B1 @ 24.21 dBm	687.0	mA
	WCDMA B5 @ 23.18 dBm	535.0	mA

Table 51: EC21-J Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	10	μA
Sleep state	**AT+CFUN = 0** (USB disconnected)	0.85	mA
	LTE-FDD PF = 64 (USB disconnected)	2.20	mA
	LTE-FDD PF = 128 (USB disconnected)	1.46	mA
Idle state (GNSS OFF)	LTE-FDD PF = 64 (USB disconnected)	23.5	mA
	LTE-FDD PF = 64 (USB connected)	33.8	mA

LTE data transfer (GNSS OFF)	LTE-FDD B1 @ 23.35 dBm	734.0	mA
	LTE-FDD B3 @ 22.95 dBm	778.0	mA
	LTE-FDD B8 @ 22.81 dBm	722.0	mA
	LTE-FDD B18 @ 23.15 dBm	677.0	mA
	LTE-FDD B19 @ 23.17 dBm	688.0	mA
	LTE-FDD B26 @ 23.37 dBm	723.0	mA

Table 52: EC21-KL Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	10	μA
Sleep state	**AT+CFUN = 0** (USB disconnected)	1.08	mA
	LTE-FDD PF = 64 (USB disconnected)	2.1	mA
	LTE-FDD PF = 128 (USB disconnected)	1.4	mA
Idle state (GNSS OFF)	LTE-FDD PF = 64 (USB disconnected)	24.8	mA
	LTE-FDD PF = 64 (USB connected)	33.5	mA
LTE data transfer (GNSS OFF)	LTE-FDD B1 @ 23.0 dBm	771.0	mA
	LTE-FDD B3 @ 23.36 dBm	780.0	mA
	LTE-FDD B5 @ 23.56 dBm	628.0	mA
	LTE-FDD B7 @ 23.32 dBm	754.0	mA
	LTE-FDD B8 @ 23.33 dBm	680.0	mA

Table 53: EC21-AUX Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	7	μA
Sleep state	**AT+CFUN=0** (USB disconnected)	1.00	mA

	GSM DRX = 2 (USB disconnected)	1.91	mA
	GSM DRX = 9 (USB disconnected)	1.31	mA
	WCDMA PF = 64 (USB disconnected)	2.19	mA
	WCDMA PF = 128 (USB disconnected)	1.91	mA
	LTE-FDD PF = 64 (USB disconnected)	2.74	mA
	LTE-FDD PF = 128 (USB disconnected)	2.12	mA
	LTE-TDD PF = 64 (USB disconnected)	2.68	mA
	LTE-TDD PF = 128 (USB disconnected)	2.16	mA
Idle state (GNSS OFF)	GSM DRX = 5 (USB disconnected)	16.6	mA
	GSM DRX = 5 (USB connected)	33.7	mA
	WCDMA PF = 64 (USB disconnected)	16.7	mA
	WCDMA PF = 64 (USB connected)	33.7	mA
	LTE-FDD PF = 64 (USB disconnected)	16.9	mA
	LTE-FDD PF = 64 (USB connected)	34.0	mA
	LTE-TDD PF = 64 (USB disconnected)	17.0	mA
	LTE-TDD PF = 64 (USB connected)	34.0	mA
GPRS data transfer (GNSS OFF)	GSM850 4DL/1UL @ 32.41 dBm	236.2	mA
	GSM850 3DL/2UL @ 31.48 dBm	380.2	mA
	GSM850 2DL/3UL @ 29.31 dBm	446.2	mA
	GSM850 1DL/4UL @ 28.21 dBm	527.7	mA
	EGSM900 4DL/1UL @ 33.06 dBm	259.0	mA
	EGSM900 3DL/2UL @ 31.74 dBm	398.0	mA
	EGSM900 2DL/3UL @ 29.32 dBm	448.0	mA
	EGSM900 1DL/4UL @ 28.30 dBm	532.0	mA
	DCS1800 4DL/1UL @ 29.20 dBm	149.0	mA

	DCS1800 3DL/2UL @ 28.16 dBm	225.0	mA
	DCS1800 2DL/3UL @ 26.05 dBm	283.0	mA
	DCS1800 1DL/4UL @ 25.14 dBm	357.0	mA
	PCS1900 4DL/1UL @ 29.39 dBm	159.7	mA
	PCS1900 3DL/2UL @ 28.06 dBm	234.6	mA
	PCS1900 2DL/3UL @ 26.01 dBm	289.0	mA
	PCS1900 1DL/4UL @ 25.20 dBm	363.9	mA
EDGE data transfer (GNSS OFF)	GSM850 4DL/1UL PCL = 8 @ 26.86 dBm	169.9	mA
	GSM850 3DL/2UL PCL = 8 @ 25.76 dBm	284.1	mA
	GSM850 2DL/3UL PCL = 8 @ 23.68 dBm	387.2	mA
	GSM850 1DL/4UL PCL = 8 @ 22.39 dBm	498.7	mA
	EGSM900 4DL/1UL PCL = 8 @ 27.01 dBm	171.0	mA
	EGSM900 3DL/2UL PCL = 8 @ 25.82 dBm	286.0	mA
	EGSM900 2DL/3UL PCL = 8 @ 23.64 dBm	389.0	mA
	EGSM900 1DL/4UL PCL = 8 @ 22.46 dBm	500.0	mA
	DCS1800 4DL/1UL PCL = 2 @ 25.90 dBm	133.0	mA
	DCS1800 3DL/2UL PCL = 2 @ 24.98 dBm	220.0	mA
	DCS1800 2DL/3UL PCL = 2 @ 22.92 dBm	308.0	mA
	DCS1800 1DL/4UL PCL = 2 @ 21.82 dBm	403.0	mA
	PCS1900 4DL/1UL PCL = 2 @ 25.36 dBm	132.4	mA
	PCS1900 3DL/2UL PCL = 2 @ 25.07 dBm	220.9	mA
	PCS1900 2DL/3UL PCL = 2 @ 23.13 dBm	307.2	mA
	PCS1900 1DL/4UL PCL = 2 @ 21.82 dBm	402.8	mA
WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA @ 22.78 dBm	530.0	mA
	WCDMA B1 HSUPA @ 22.12 dBm	542.0	mA

	WCDMA B2 HSDPA @ 22.54 dBm	556.3	mA
	WCDMA B2 HSUPA @ 22.17 dBm	542.4	mA
	WCDMA B4 HSDPA @ 23.27 dBm	491.0	mA
	WCDMA B4 HSUPA @ 23.19 dBm	504.0	mA
	WCDMA B5 HSDPA @ 23.18 dBm	480.4	mA
	WCDMA B5 HSUPA @ 22.90 dBm	490.0	mA
	WCDMA B8 HSDPA @ 22.32 dBm	504.0	mA
	WCDMA B8 HSUPA @ 22.26 dBm	528.0	mA
LTE data transfer (GNSS OFF)	LTE-FDD B1 @ 23.48 dBm	690.0	mA
	LTE-FDD B2 @ 22.85 dBm	696.7	mA
	LTE-FDD B3 @ 23.45 dBm	655.0	mA
	LTE-FDD B4 @ 23.16 dBm	603.0	mA
	LTE-FDD B5 @ 23.61 dBm	558.0	mA
	LTE-FDD B7 @ 23.40 dBm	704.0	mA
	LTE-FDD B8 @ 23.57 dBm	663.0	mA
	LTE-FDD B28A @ 23.49 dBm	763.0	mA
	LTE-FDD B28B @ 23.65 dBm	780.0	mA
	LTE-TDD B40 @ 23.66 dBm	340.3	mA
GSM voice call	GSM850 PCL = 5 @ 32.45 dBm	234.9	mA
	EGSM900 PCL = 5 @ 32.81 dBm	249.0	mA
	DCS1800 PCL = 0 @ 29.28 dBm	143.0	mA
	PCS1900 PCL = 0 @ 29.47 dBm	154.5	mA
WCDMA voice call	WCDMA B1 @ 23.44 dBm	568.0	mA
	WCDMA B2 @ 23.15 dBm	614.0	mA
	WCDMA B4 @ 23.20 dBm	497.0	mA

	WCDMA B5 @ 23.23 dBm	492.0	mA
	WCDMA B8 @ 23.05 dBm	553.0	mA

Table 54: EC21-EUX Current Consumption

Description	Conditions	Typ.	Unit
OFF state	Power down	7	μA
Sleep state	**AT+CFUN=0** (USB disconnected)	1.03	mA
	AT+CFUN=0 (USB suspend)	1.27	mA
	EGSM DRX = 2 (USB disconnected)	1.89	mA
	EGSM DRX = 9 (USB disconnected)	1.30	mA
	DCS 698 DRX = 2 (USB disconnected)	1.89	mA
	DCS 698 DRX = 9 (USB disconnected)	1.32	mA
	WCDMA PF = 64 (USB disconnected)	1.70	mA
	WCDMA PF = 128 (USB disconnected)	1.44	mA
	LTE-FDD PF = 64 (USB disconnected)	2.18	mA
	LTE-FDD PF = 128 (USB disconnected)	1.64	mA
Idle state (GNSS OFF)	WCDMA PF = 64 (USB disconnected)	14.08	mA
	WCDMA PF = 64 (USB connected)	23.69	mA
	LTE-FDD PF = 64 (USB disconnected)	14.02	mA
	LTE-FDD PF = 64 (USB connected)	23.81	mA
GPRS data transfer (GNSS OFF)	GSM900 4DL/1UL @ 32.70 dBm	218.7	mA
	GSM900 3DL/2UL @ 31.89 dBm	368.9	mA
	GSM900 2DL/3UL @ 29.38 dBm	421.8	mA
	GSM900 1DL/4UL @ 28.71 dBm	505.8	mA
	DCS1800 4DL/1UL @ 30.18 dBm	146.2	mA

	DCS1800 3DL/2UL @ 29.51 dBm	246.0	mA
	DCS1800 2DL/3UL @ 27.56 dBm	307.0	mA
	DCS1800 1DL/4UL @ 26.39 dBm	375.5	mA
EDGE data transfer (GNSS OFF)	GSM900 4DL/1UL @ 24.75 dBm	150.9	mA
	GSM900 3DL/2UL @ 24.37 dBm	269.4	mA
	GSM900 2DL/3UL @ 22.68 dBm	380.0	mA
	GSM900 1DL/4UL @ 21.85 dBm	489.7	mA
	DCS1800 4DL/1UL @ 26.02 dBm	128.0	mA
	DCS1800 3DL/2UL @ 25.39 dBm	221.2	mA
	DCS1800 2DL/3UL @ 22.81 dBm	311.3	mA
	DCS1800 1DL/4UL @ 22.21 dBm	404.9	mA
WCDMA data transfer (GNSS OFF)	WCDMA B1 HSDPA @ 22.83 dBm	495.7	mA
	WCDMA B1 HSUPA @ 22.80 dBm	488.1	mA
	WCDMA B8 HSDPA @ 22.29 dBm	501.8	mA
	WCDMA B8 HSUPA @ 21.32 dBm	475.7	mA
LTE data transfer (GNSS OFF)	LTE-FDD B1 @ 23.89 dBm	629.1	mA
	LTE-FDD B3 @ 23.75 dBm	680.0	mA
	LTE-FDD B7 @ 23.81 dBm	734.1	mA
	LTE-FDD B8 @ 23.68 dBm	651.2	mA
	LTE-FDD B20 @ 23.63 dBm	680.6	mA
	LTE-FDD B28A @ 23.80 dBm	796.0	mA
GSM voice call	GSM900 PCL = 5 @ 32.74 dBm	236.0	mA
	DCS1800 PCL = 0 @ 29.82 dBm	155.2	mA
WCDMA voice call	WCDMA B1 @ 23.02 dBm	505.4	mA
	WCDMA B8 @ 22.41 dBm	521.3	mA

Table 55: GNSS Current Consumption of EC21 Series Module

Description	Conditions	Typ.	Unit
Searching (**AT+CFUN=0**)	Cold start @ Passive Antenna	58	mA
	Lost state @ Passive Antenna	58	mA
Tracking (**AT+CFUN=0**)	Instrument Environment	33	mA
	Open Sky @ Passive Antenna	35	mA
	Open Sky @ Active Antenna	43	mA

5.5. ESD

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 56: Electrostatics Discharge Characteristics (Temperature: 25 ºC, Humidity: 45 %)

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

5.6. Thermal Dissipation

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.

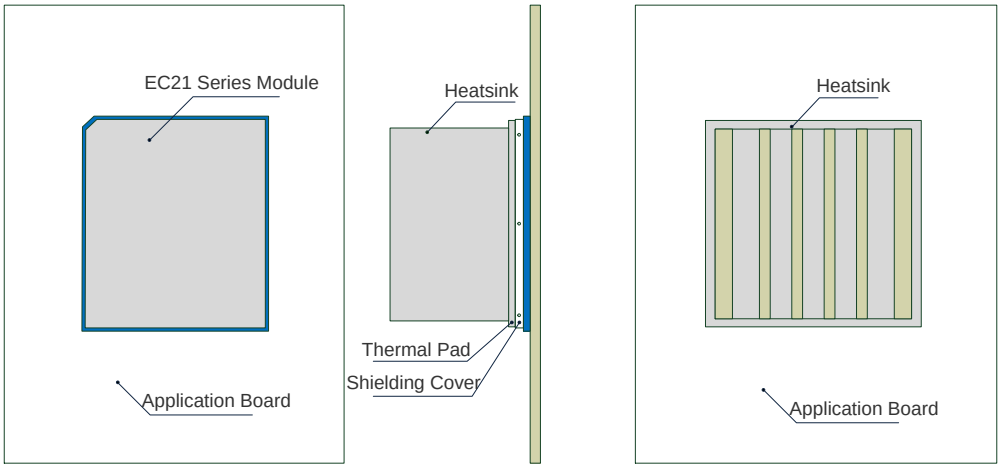


Figure 42: Referenced Heatsink Design (Heatsink at the Top of the Module)

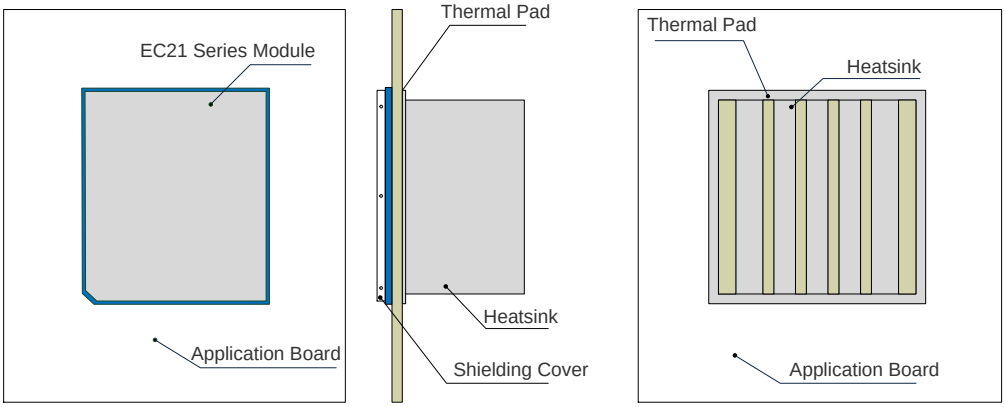


Figure 43: Referenced Heatsink Design (Heatsink at the Backside of Customers' PCB)

NOTE

1. The module offers the best performance when the internal baseband 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** and get the maximum BB chip temperature from the first returned value. For details of the command ,see ***document [3]***.
2. For more detailed guidelines on thermal design, see ***document [8]***.

6 Mechanical Information

This chapter describes the mechanical dimensions of the module. All dimensions are measured in mm, and the dimensional tolerances are ±0.2 mm unless otherwise specified.

6.1. Mechanical Dimensions

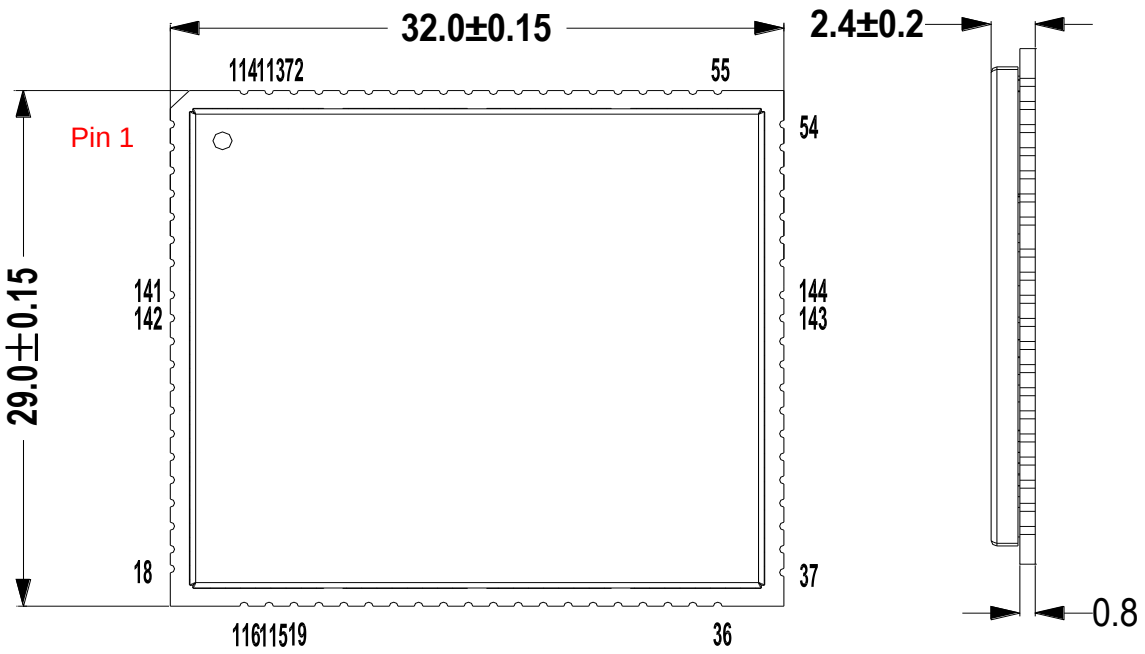


Figure 44: Module Top and Side Dimensions

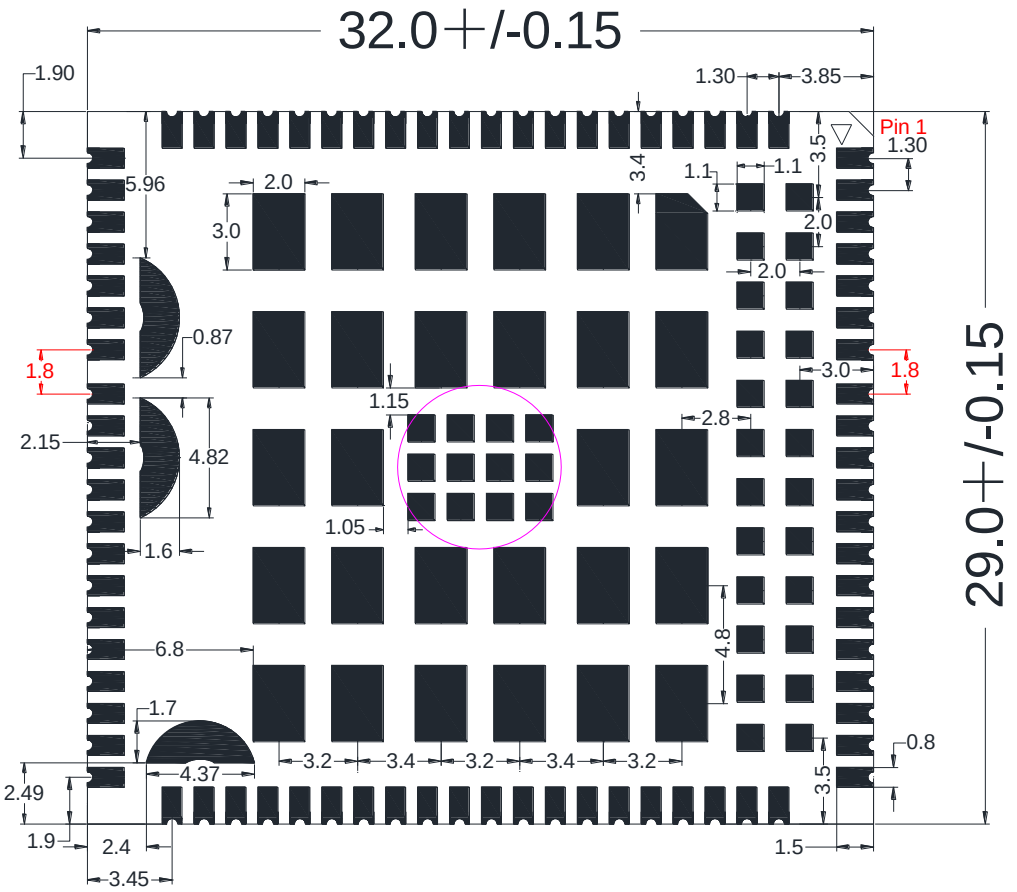


Figure 45: Module Bottom Dimensions (Bottom View)

NOTE

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

6.2. Recommended Footprint

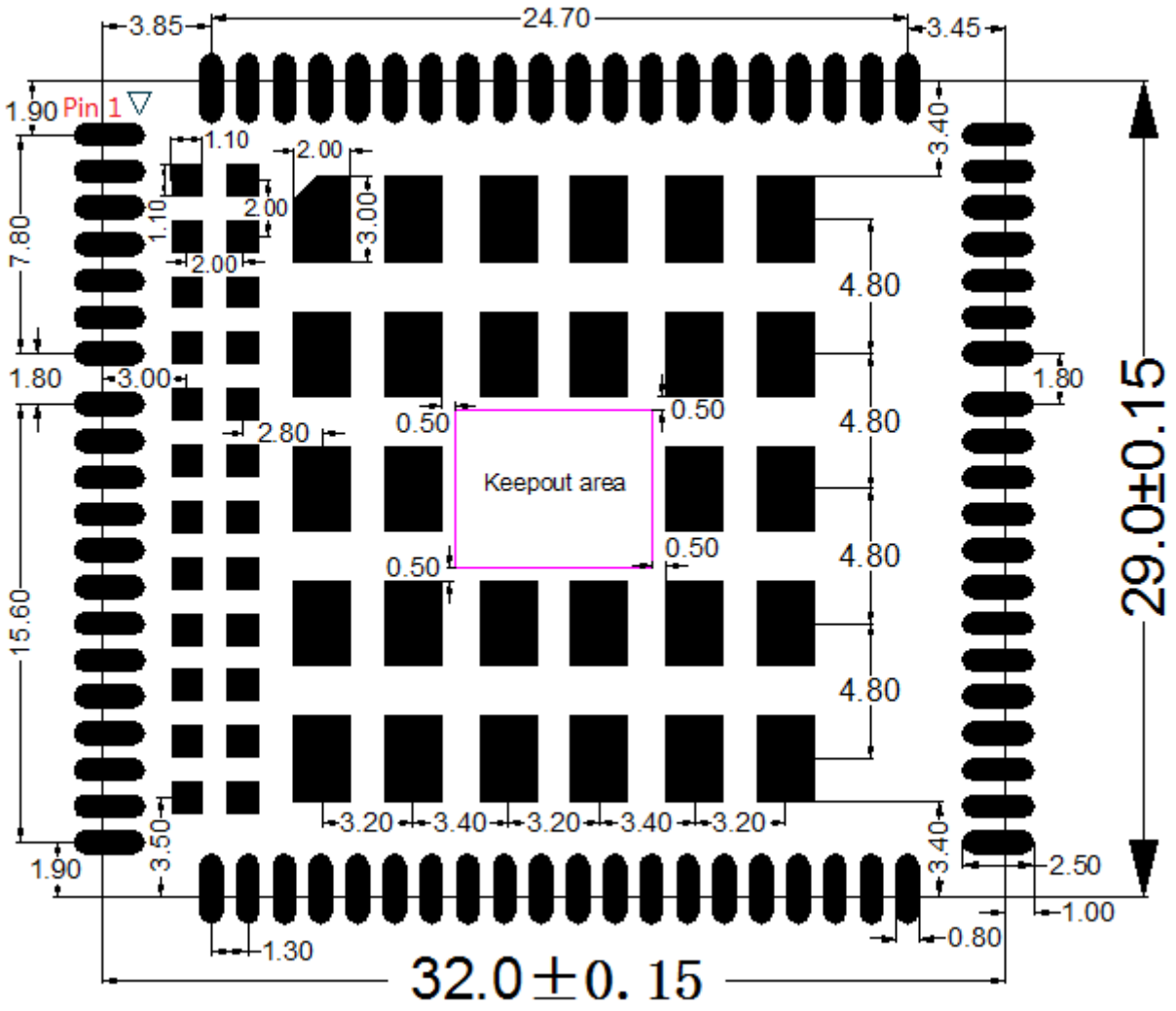


Figure 46: Recommended Footprint (Top View)

NOTE

1. The keepout area (pin 73–84) should not be designed.
2. For easy maintenance of the module, keep about 3 mm between the module and other components on the motherboard.

6.3. Top and Bottom Views

Figure 47: Top and Bottom Views of the Module

NOTE

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

7 Storage, Manufacturing and Packaging

7.1. Storage Conditions

The module is provided with vacuum-sealed packaging. MSL of the module is rated as 3. The storage requirements are shown below.

1. Recommended Storage Condition: The temperature should be 23 ±5 °C and the relative humidity should be 35–60 %.

2. The storage life (in vacuum-sealed packaging) is 12 months in Recommended Storage Condition.

3. The floor life of the module is 168 hours [12] in a plant where the temperature is 23 ±5 °C and relative humidity is below 60 %. After the vacuum-sealed packaging is removed, the module must be processed in reflow soldering or other high-temperature operations within 168 hours. Otherwise, the module should be stored in an environment where the relative humidity is less than 10 % (e.g. a drying cabinet).

4. The module should be pre-baked to avoid blistering, cracks and inner-layer separation in PCB under the following circumstances:

   - The module is not stored in Recommended Storage Condition;
   - Violation of the third requirement above occurs;
   - Vacuum-sealed packaging is broken, or the packaging has been removed for over 24 hours;
   - Before module repairing.

5. If needed, the pre-baking should follow the requirements below:

   - The module should be baked for 8 hours at 120 ±5 °C;
   - All modules must be soldered to PCB within 24 hours after the baking, otherwise they should be put in a dry environment such as in a drying oven.

[12] This floor life is only applicable when the environment conforms to *IPC/JEDEC J-STD-033*. It is recommended to start the solder reflow process within 24 hours after the package is removed if the temperature and moisture do not conform to, or are not sure to conform to *IPC/JEDEC J-STD-033*. And do not remove the packages of tremendous modules if they are not ready for soldering.

NOTE

1. To avoid blistering, layer separation and other soldering issues, extended exposure of the module to the air is forbidden.
2. Take out the module from the package and put it on high-temperature-resistant fixtures before baking. All modules must be soldered to PCB within 24 hours after the baking, otherwise put them in the drying oven. If shorter baking time is desired, see *IPC/JEDEC J-STD-033* for the baking procedure.
3. Pay attention to ESD protection, such as wearing anti-static gloves, when touching the modules.

7.2. 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. Apply proper force on the squeegee to produce a clean stencil surface on a single pass. To guarantee module soldering quality, the thickness of stencil for the module is recommended to be 0.18–0.20 mm. For more details, see ***document [9]***.

The peak reflow temperature should be 235–246 ºC, with 246 ºC as the absolute maximum reflow temperature. To avoid damage to the module caused by repeated heating, it is strongly recommended that the module should be mounted only 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.

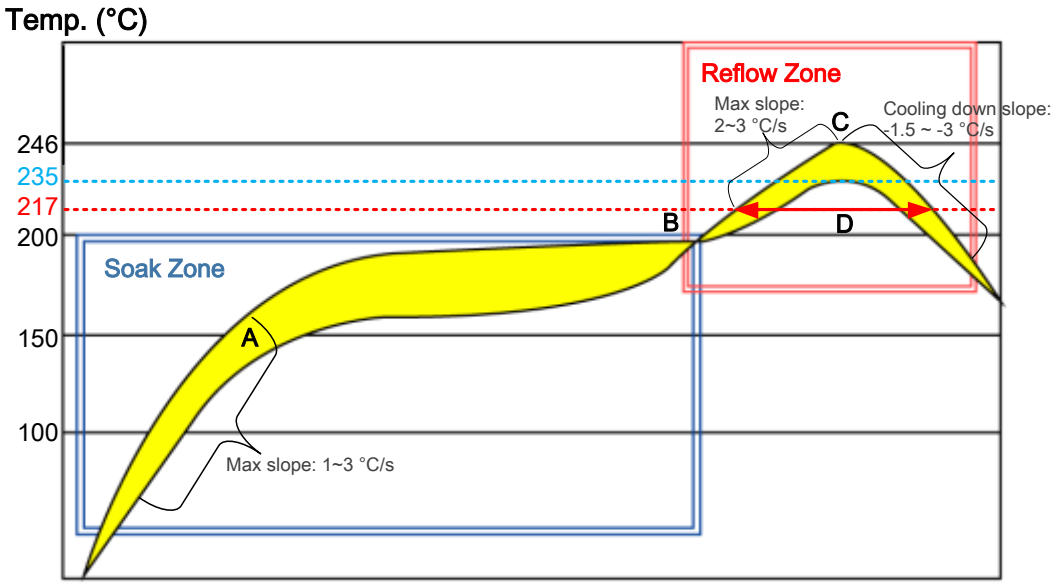


Figure 48: Reflow Soldering Thermal Profile

Table 57: Recommended Thermal Profile Parameters

Factor	Recommendation
Soak Zone	
Max slope	1–3 °C/sec
Soak time (between A and B: 150 °C and 200 °C)	70–120 s
Reflow Zone	
Max slope	2–3°C/s
Reflow time (D: over 217 °C)	40–70 s
Max temperature	235 °C to 246 °C
Cooling down slope	-1.5 to -3 °C/s
Reflow Cycle	
Max reflow cycle	1

NOTE

1. If a conformal coating is necessary for the module, do NOT use any coating material that may chemically react with the PCB or shielding cover, and prevent the coating material from flowing into the module.
2. Avoid using ultrasonic technology for module cleaning and soldering since it can damage crystals inside the module.
3. Due to the complexity of the SMT process, please contact Quectel Technical Supports in advance for any situation that you are not sure about, or any process (e.g. selective soldering) that is not mentioned in ***document [9]***.

7.3. Packaging Specifications

The module adopts carrier tape packaging and details are as follow:

7.3.1. Carrier Tape

Dimension details are as follow:

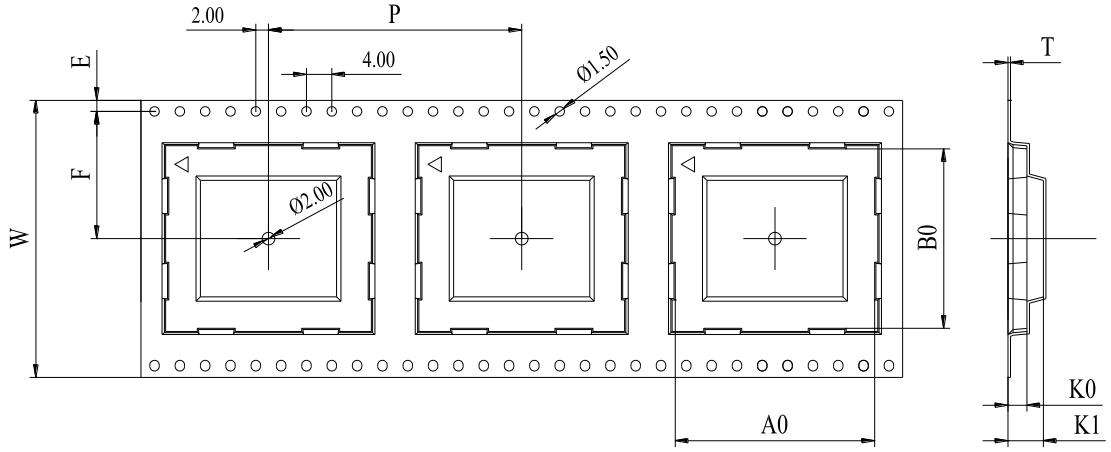


Figure 49: Carrier Tape Dimension Drawing

Table 58: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
44	44	0.35	32.5	29.5	3.0	3.8	20.2	1.75

7.3.2. Plastic Reel

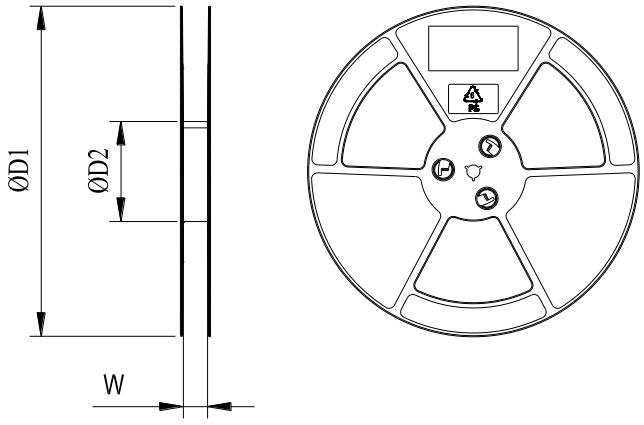
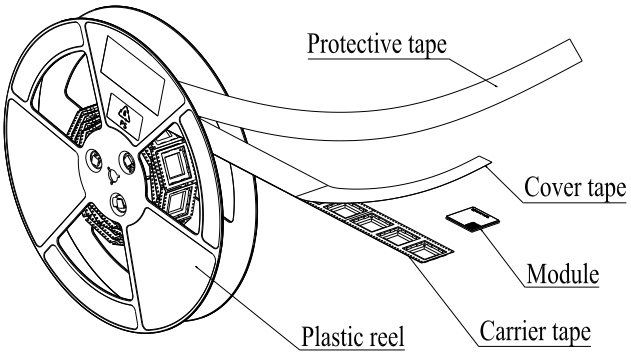


Figure 50: Plastic Reel Dimension Drawing

Table 59: Plastic Reel Dimension Table (Unit: mm)

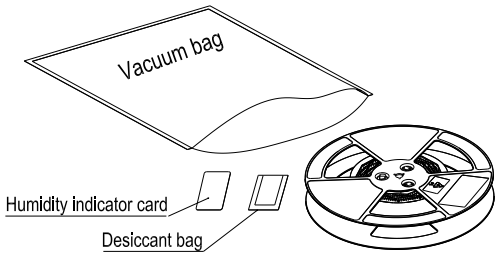
øD1	øD2	W
330	100	44.5

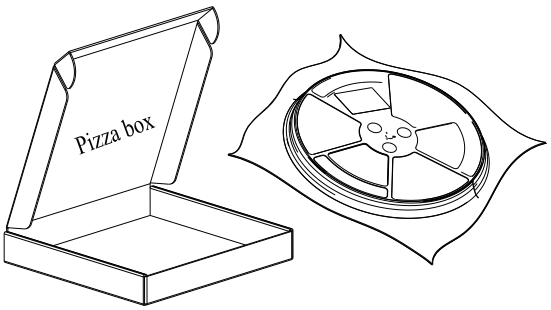
7.3.3. Packaging Process



Place the module into the carrier tape and use the cover tape to cover it; then wind the heat-sealed carrier tape to the plastic reel and use the protective tape for protection. 1 plastic reel can load 250 modules.

Place the packaged plastic reel, humidity indicator card and desiccant bag into a vacuum bag, vacuumize it.





Place the vacuum-packed plastic reel into the pizza box.

Put 4 packaged pizza boxes into 1 cartoon box and seal it. 1 cartoon box can pack 1000 modules.

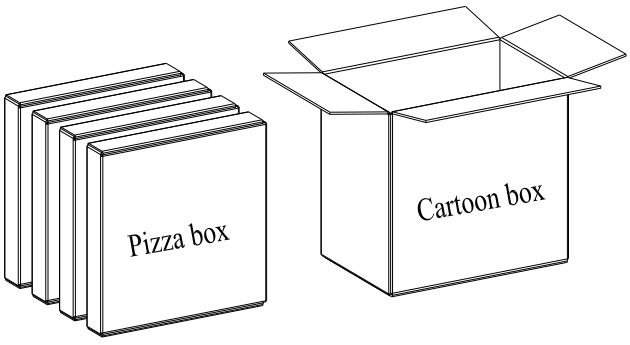


Figure 51: Packaging Process

8 Appendix References

Table 60: Related Documents

Document Name
[1] Quectel_UMTS&LTE_EVB_User_Guide
[2] Quectel_EC2x&EG9x&EG2x-G&EM05_Series_AT_Commands_Manual
[3] Quectel_EC2x&EG9x&EG2x-G&EM05_Series_QCFG_AT_Commands_Manual
[4] Quectel_EC2x&EG9x_Power_Management_Application_Note
[5] Quectel_EC2x&EG9x&EG2x-G&EM05_Series_GNSS_Application_Note
[6] Quectel_EC21_Reference_Design
[7] Quectel_RF_Layout_Application_Note
[8] Quectel_LTE_Module_Thermal_Design_Guide
[9] Quectel_Module_Secondary_SMT_Application_Guide

Table 61: Terms and Abbreviations

Abbreviation	Description
3GPP	3rd Generation Partnership Project
ADC	Analog-to-Digital Converter
AMR	Adaptive Multi-rate
APT	Average Power Tracking
bps	Bits Per Second
CHAP	Challenge Handshake Authentication Protocol
CMUX	Connection Multiplexing

CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear To Send
DCE	Data Communications Equipment
DC-HSPA+	Dual-carrier High Speed Packet Access
DCS	Digital Communication System
DFOTA	Delta Firmware Upgrade Over The Air
DL	Downlink
DTE	Data Terminal Equipment
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EDGE	Enhanced Data Rates for GSM Evolution
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
ESD	Electrostatic Discharge
ESR	Equivalent Series Resistance
FDD	Frequency Division Duplex
FR	Full Rate
FTPS	FTP over SSL
Galileo	Galileo Satellite Navigation System (EU)
GLONASS	Russian Global Navigation Satellite System
GMSK	Gaussian Minimum Shift Keying
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
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
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
I/O	Input/Output
Inom	Nominal Current
LCC	Leadless Chip Carrier (package)
LDO	Low-dropout Regulator
LED	Light Emitting Diode
LGA	Land Grid Array
LNA	Low Noise Amplifier
LSB	Least Significant Bit
LTE	Long Term Evolution
M2M	Machine to Machine
MCS	Modulation and Coding Scheme
MDIO	Management Data Input/Output
MIMO	Multiple Input Multiple Output
MLCC	Multi-layer Ceramic Chip
MMS	Multimedia Messaging Service
MO	Mobile Originated
MQTT	Message Queuing Telemetry Transport
MS	Mobile Station (GSM engine)

MSB	Most Significant Bit
MT	Mobile Terminated
NITZ	Network Identity and Time Zone / Network Informed Time Zone
NMEA	NMEA (National Marine Electronics Association) 0183 Interface Standard
NTP	Network Time Protocol
PA	Power Amplifier
PAM	Power Amplifier Module
PAP	Password Authentication Protocol
PCB	Printed Circuit Board
PCM	Pulse Code Modulation
PCS	Personal Communication System
PDA	Personal Digital Assistant
PDU	Protocol Data Unit
PING	Packet Internet Groper
PMIC	Power Management IC
POS	Point of Sale
PPP	Point-to-Point Protocol
PTP	Precision Time Protocol
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
RoHS	Restriction of Hazardous Substances
Rx	Receive

SAW	Surface Acoustic Wave
SDR	Software-Defined Radio
SGMII	Serial Gigabit Media Independent Interface
SIM	Subscriber Identification Module
SIMO	Single Input Multiple Output
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SMTPS	Simple Mail Transfer Protocol Secure
SSL	Secure Sockets Layer
TCP	Transmission Control Protocol
TDD	Time Division Duplexing
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division-Synchronous Code Division Multiple Access
TX	Transmitting Direction
UART	Universal Asynchronous Receiver/Transmitter
UDP	User Datagram Protocol
UL	Uplink
UMTS	Universal Mobile Telecommunications System
URC	Unsolicited Result Code
USB	Universal Serial Bus
(U)SIM	(Universal) Subscriber Identity Module
Vmax	Maximum Voltage
Vnom	Nominal Voltage
Vmin	Minimum Voltage
V_{IH}max	Maximum High-level Input Voltage

V_{IH}min	Minimum High-level Input Voltage
V_{IL}max	Maximum Low-level Input Voltage
V_{IL}min	Minimum Low-level Input Voltage
V_{I}max	Absolute Maximum Input Voltage
V_{I}min	Absolute Minimum Input Voltage
V_{OH}max	Maximum High-level Output Voltage
V_{OH}min	Minimum High-level Output Voltage
V_{OL}max	Maximum Low-level Output Voltage
V_{OL}min	Minimum Low-level Output Voltage
VLAN	Virtual Local Area Network
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network