BG96 Hardware Design

LPWA Module Series

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Quectel Wireless Solutions Co., Ltd.
Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China
Tel: +86 21 5108 6236
Email: info@quectel.com

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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 fueling 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	2017-08-04	Lyndon LIU/ Daryl DU	Initial
1.1	2017-08-31	Daryl DU	1. Modified GSM features in Table 2. 2. Added a note for e-I-DRX in Chapter 3.3. 3. Elaborated the description of e-I-DRX in Chapter 3.4.3. 4. Updated RF receiving sensitivity in Chapter 6.6.
1.2	2017-12-22	Lyndon LIU/ Daryl DU	1. Added the storage temperature of the module in Table 2 and Chapter 6.3. 2. Updated transmitting power values in Table 2. 3. Added the description of sleep mode in Table 5 and Chapter 3.4.4. 4. Added the description of ADC interfaces in Chapter 3.16. 5. Updated the GNSS performance in Table 21. 6. Updated the peak supply current values in Table 28. 7. Updated the current consumption values in Chapter 6.4. 8. Updated RF output power values in Table 34. 9. Updated LTE Cat NB1 RF receiving sensitivity values (without repetitions) in Table 35. 10. Updated the recommended footprint in Chapter 7.2.
1.3	2018-07-18	Lyndon LIU/ Daryl DU/ Hyman DING	1. Updated the USB interface reference design (Figure 15). 2. Added the description of GPIO interfaces (Chapter 3.17). 3. Updated GNSS performance parameters in Table 25. 4. Updated the GNSS antenna interface reference design (Figure 27). 5. Updated GNSS current consumption parameters in Table 35. 6. Updated the module's baking temperature and baking hours in Chapter 8.1.

			7. Updated the recommended reflow soldering thermal profile and related parameters in Chapter 8.2.
1.4	2019-08-15	Lyndon LIU/ Rex WANG	1. Added B25 and the note thereof. 2. Updated supported internet protocols and USB serial drivers in Table 2. 3. Updated functional diagram in Figure 1. 4. Enabled W_DISABLE# for airplane mode control in Chapter 3.4.1. 5. Updated DC characteristics of PWRKEY (Table 4, Table 7). 6. Updated DC characteristics of RESET_N (Table 4, Table 8). 7. Updated the description of power supply reference design in Chapter 3.5.2. 8. Updated power-on timing of the module in Figure 8. 9. Added ADC analog-input bandwidth and ADC sampling rate in Table 22. 10. Updated the GPIO configuration command in Chapter 3.17. 11. Updated BG96 operating frequency in Table 27. 12. Updated GNSS frequency in Table 29. 13. Updated BG96 current consumption in Table 34. 14. Updated the recommended stencil thickness and the peak reflow temperature in Chapter 8.2. 15. Updated packaging information of the module in Chapter 8.3.
1.5	2022-08-19	Lex LI/ Fly ZHU	1. Updated the dimensional tolerance from 0.15 mm to 0.20 mm. 2. Added the footnote description of B26. 3. Deleted the information of LTE HD-FDD B39. 4. Updated the information of USB serial drivers in Table 3. 5. Updated the trace width of VBAT_RF from “not less than 2.0 mm” to “not less than 2.7 mm” in Chapter 3.5.2. 6. Added the VoLTE description of PCM and I2C interface in Chapter 3.12. 7. Updated the max. value of I_{VBAT} from 2.0 A to 2.7 A in Chapter 6.2. 8. Updated the information of power consumption in Table 33. 9. Updated the GNSS power consumption in Table 34. 10. Updated the information of Rx sensitivity in Table 36. 11. Updated the information of manufacturing and

			soldering; and added the note of ultrasonic soldering cleaning and conformal coating in Chapter 8.2. 12. Added the note of package warpage level of the module in Chapter 7.1.
1.6	2023-02-21	Lex LI	1. Added the note for module turn-off procedure in Chapter 3.7. 2. Updated the GNSS VSWR requirement from VSWR < 2 to VSWR ≤ 2 in Table 29. 3. Updated the recommended thermal profile parameter in Chapter 8.2. 4. Added the mounting direction subchapter in Chapter 8.3.

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Table Index

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1 Introduction

The document defines BG96 module and describes its air interface and hardware interfaces which are connected with your applications.

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

2 Product Overview

2.1. Frequency Bands and Functions

BG96 is an embedded IoT (LTE Cat M1/LTE Cat NB1/EGPRS) wireless communication module. It provides data connectivity on LTE HD-FDD/GPRS/EGPRS networks, and supports half-duplex operation in LTE networks. It also provides GNSS [1] and voice functionality [2] to meet your specific application demands.

BG96 module is an industrial-grade module for industrial and commercial applications only.

The following table shows the frequency bands and functions of BG96 module.

Table 1: Frequency Bands and Functions of BG96 Module

LTE Bands	EGPRS	Rx-diversity	GNSS [1]
Cat M1 & NB1: LTE HD-FDD: B1/B2/B3/B4/B5/B8/B12/B13/ B18/B19/B20/B25 [3]/B26 [4]/B28	GSM850/EGSM900/ DCS1800/PCS1900	-	GPS, GLONASS, BDS, Galileo, QZSS

With a compact profile of 26.5 mm × 22.5 mm × 2.3 mm, BG96 can meet most requirements for M2M applications such as smart metering, tracking system, security, wireless POS, etc.

BG96 is an SMD type module which can be embedded into applications through its 102 LGA pins. BG96 supports internet service protocols like TCP, UDP and PPP. Extended AT commands have been developed for you to use these internet service protocols easily.

[1] GNSS function is optional.
[2] BG96 supports VoLTE (Voice over LTE) under LTE Cat M1 network.
[3] LTE HD-FDD B25 is supported on BG96 of R1.2 hardware version.
[4] LTE HD-FDD B26 is supported on BG96 of R1.1 hardware version (support Cat M1 B26 only).

2.2. Key Features

The following table describes the detailed features of BG96 module.

Table 2: Key Features of BG96 Module

Features	Details
Power Supply	● Supply voltage: 3.3–4.3 V ● Typical supply voltage: 3.8 V
Transmitting Power	● Class 3 (23 dBm ±2 dB) for LTE HD-FDD bands ● 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
LTE Features	● Support LTE Cat M1 and LTE Cat NB1 ● Support 1.4 MHz RF bandwidth for LTE Cat M1 ● Support 200 kHz RF bandwidth for LTE Cat NB1 ● Support SISO in DL direction ● LTE Cat M1: Max. 375 kbps (DL)/ 375 kbps (UL) ● LTE Cat NB1: Max. 32 kbps (DL)/ 70 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)/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)/236.8 kbps (UL)
Internet Protocol Features	● Support PPP/TCP/UDP/SSL/TLS/FTP(S)/HTTP(S)/NITZ/PING/MQTT 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: 1.8/3.0 V
Audio Feature	Supports one digital audio interface
USB Interface	● Compliant with USB 2.0 specification (slave only) and the data transfer rate can reach up to 480 Mbps ● Used for AT command communication, data transmission, GNSS NMEA messages output, software debugging and firmware upgrade ● Support USB serial drivers for Windows 7/8/8.1/10/11, Linux 2.6–5.18, Android 4.x–12.x
UART Interfaces	**UART1:** ● Used for data transmission and AT command communication ● Baud rates: 115200 bps by default ● The default frame format is 8N1 (8 data bits, no parity, 1 stop bit) ● Supports RTS and CTS hardware flow control **UART2:** ● Used for debugging and log output ● Baud rate: 115200 bps **UART3:** ● Used for outputting GNSS data or GNSS NMEA sentences ● Baud rate: 115200 bps
AT Commands	● *3GPP TS 27.007* and *3GPP TS 27.005* AT commands ● Quectel enhanced AT commands
Network Indication	One NETLIGHT pin for network connectivity status indication
Antenna Interfaces	● Main antenna interface (ANT_MAIN) ● GNSS antenna interface (ANT_GNSS)
Physical Characteristics	● Dimensions: (26.5 ±0.2) mm × (22.5 ±0.2) mm × (2.3 ±0.2) mm ● Weight: approx. 3.1 g
Temperature Range	● Operating temperature range: -35 °C to +75 °C [5] ● Extended temperature range: -40 °C to +85 °C [6] ● Storage temperature range: -40 °C to +90 °C
Firmware Upgrade	USB interface, DFOTA
RoHS	All hardware components are fully compliant with EU RoHS directive

[5] Within the operating temperature range, the module meets 3GPP specifications.
[6] Within the extended temperature range, the module remains the ability to establish and maintain functions such as voice, SMS, data transmission, emergency call, etc., without any unrecoverable malfunction. Radio spectrum and radio network are not influenced, while one or more specifications, such as P_{out}, may exceed the specified tolerances of 3GPP. When the temperature returns to the operating temperature range, the module meets 3GPP specifications again.

2.3. Functional Diagram

The following figure shows a block diagram of BG96 and illustrates the major functional parts.

- Power management
- Baseband
- DDR2 + NAND flash
- Radio frequency
- Peripheral interfaces

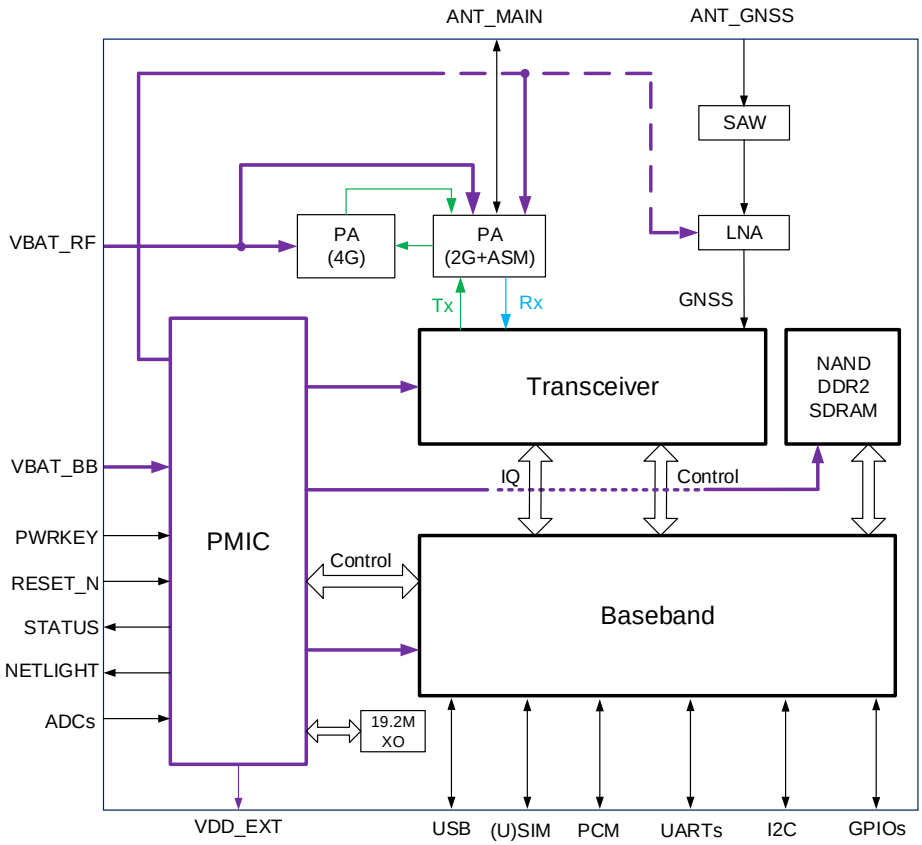


Figure 1: Functional Diagram

2.4. EVB Kit

To help you develop applications conveniently with BG96, Quectel supplies an evaluation board (UMTS&LTE EVB), USB to RS-232 converter cables, a USB data cable, antennas and other peripherals to control or test the module. For more details, see ***document [1]***.

3 Application Interfaces

BG96 is equipped with 102 LGA pins that can be connected to your cellular application platforms. The following sub-chapters provide detailed description of interfaces listed below:

- Power supply
- (U)SIM interface
- USB interface
- UART interfaces
- PCM and I2C interfaces
- Indication signals
- USB_BOOT interface
- ADC interfaces
- GPIO interfaces

3.1. Pin Assignment

The following figure shows the pin assignment of BG96.

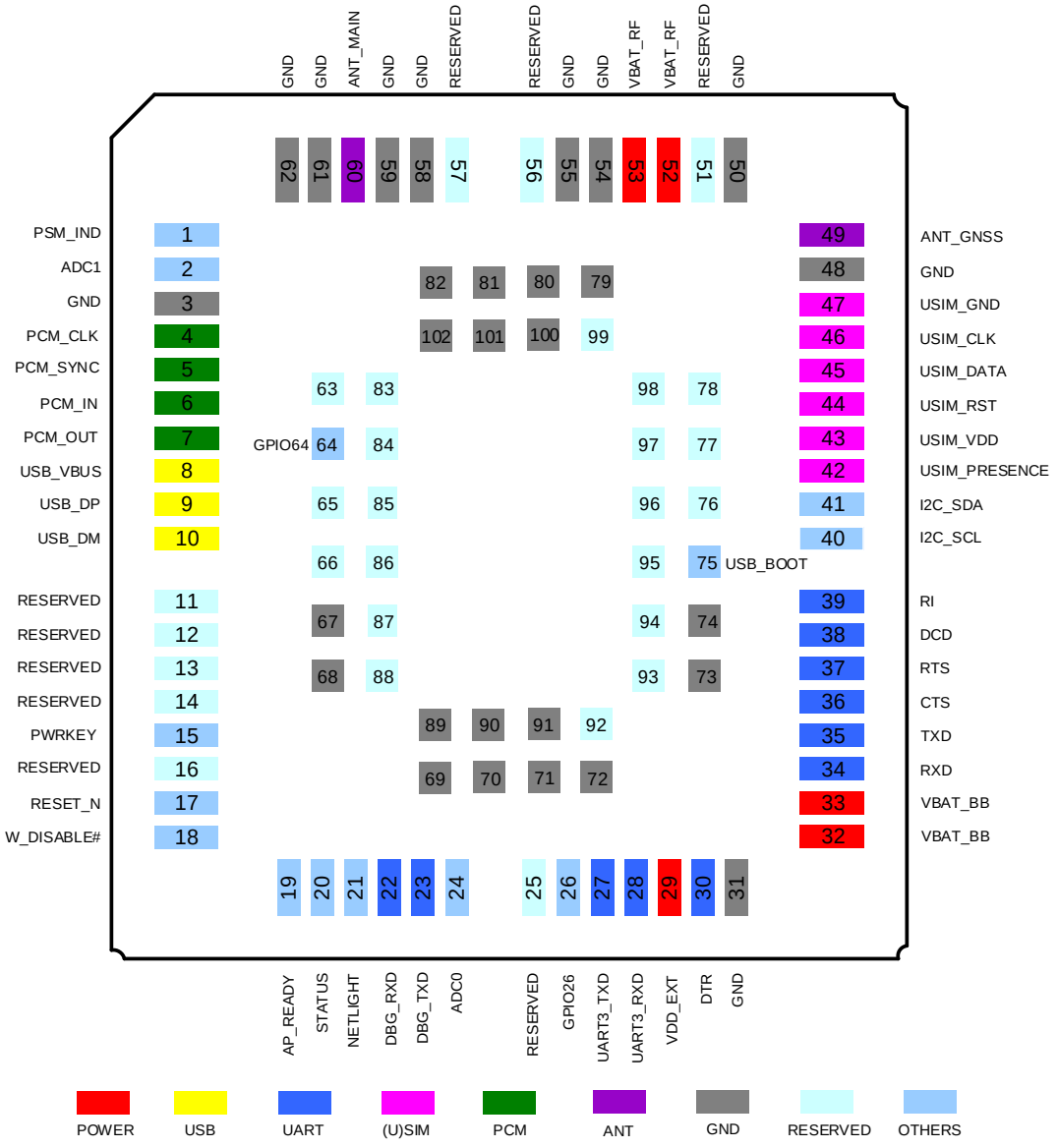


Figure 2: Pin Assignment (Top View)

NOTE

1. Keep all RESERVED pins and unused pins unconnected.
2. Connect GND to ground in the design.
3. PWRKEY output voltage is 0.8 V because of the diode drop inside the chipset.

3.2. Pin Description

The following tables show the pin definition and description of BG96.

Table 3: Definition of I/O Parameters

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

DC characteristics include power domain and rate current, etc.

Table 4: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT_BB	32, 33	PI	Power supply for the module's baseband part	Vmax = 4.3 V Vmin = 3.3 V Vnom = 3.8 V	
VBAT_RF	52, 53	PI	Power supply for the module's RF part	Vmax = 4.3 V Vmin = 3.3 V Vnom = 3.8 V	
VDD_EXT	29	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.

					If unused, keep this pin open.
GND	3, 31, 48, 50, 54, 55, 58, 59, 61, 62, 67–74, 79–82, 89–91, 100–102				
Turn On/Off					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	15	DI	Turn on/off the module	Vnom = 0.8 V V_{IL}max = 0.5 V	The output voltage is 0.8 V because of the diode drop inside the chipset.
RESET_N	17	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 this pin open.
Status Indication					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PSM_IND [7]	1	DO	Indicate the module's power saving mode	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep these pins open.
STATUS	20	DO	Indicate the module's operation status		
NETLIGHT	21	DO	Indicate the module's network activity status		
USB Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_VBUS	8	AI	USB connection detect	Vmax = 5.25 V Vmin = 3.0 V Vnom = 5.0 V	
USB_DP	9	AIO	USB differential data (+)		Compliant with USB 2.0 standard specification. Require differential impedance of
USB_DM	10	AIO	USB differential data (-)		

[7] When PSM is enabled and then reboot the module, the function of PSM_IND pin will be activated. This pin outputs a high voltage level when the module is in full functionality mode, and outputs a low voltage level when the module enters PSM.

					90 Ω.
(U)SIM Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USIM_ PRESENCE	42	DI	(U)SIM card hot-plug 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 this pin open.
USIM_VDD	43	PO	(U)SIM card power supply	**For 1.8 V (U)SIM:** Vmax = 1.9 V Vmin = 1.7 V **For 3.0 V (U)SIM:** Vmax = 3.05 V Vmin = 2.7 V $I_O$max = 50 mA	Either 1.8 V or 3.0 V is supported by the module automatically.
USIM_RST	44	DO	(U)SIM card reset	**For 1.8 V (U)SIM:** V_{OL}max = 0.45 V V_{OH}min = 1.35 V **For 3.0 V (U)SIM:** V_{OL}max = 0.45 V V_{OH}min = 2.55 V	
USIM_DATA	45	DIO	(U)SIM card data	**For 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 **For 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	46	DO	(U)SIM card clock	**For 1.8 V (U)SIM:** V_{OL}max = 0.45 V V_{OH}min = 1.35 V **For 3.0 V (U)SIM:** V_{OL}max = 0.45 V V_{OH}min = 2.55 V	

USIM_GND	47	-	Specified ground for (U)SIM card		
UART1 Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DTR	30	DI	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. If unused, keep these pins open.
RXD	34	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	
TXD	35	DO	Transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	
CTS	36	DO	DTE clear to send signal from DCE	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	Connect to DTE's CTS. 1.8 V power domain.
RTS	37	DI	DTE request to send signal to 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	Connect to DTE's RTS. 1.8 V power domain.
DCD	38	DO	Data carrier detect	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep them open.
RI	39	DO	Ring indication		
UART2 Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DBG_RXD	22	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	1.8 V power domain. If unused, keep them open.
DBG_TXD	23	DO	Debug UART transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	
UART3 Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
UART3_TXD	27	DO	UART3 transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain.

UART3_RXD	28	DI	UART3 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	If unused, keep them open.
PCM Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PCM_CLK	4	DO	PCM clock	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep these pins open.
PCM_SYNC	5	DO	PCM frame sync	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	
PCM_IN	6	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	
PCM_OUT	7	DO	PCM data output	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	
I2C Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
I2C_SCL	40	OD	I2C serial clock (for external codec)		External pull-up resistor is required. 1.8 V only. If unused, keep them open.
I2C_SDA	41	OD	I2C serial data (for external codec)		
Antenna Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_MAIN	60	AIO	Main antenna interface		50 Ω impedance.
ANT_GNSS	49	AI	GNSS antenna interface		50 Ω impedance. If unused, keep this pin open.
Other Interface Pins					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
W_DISABLE#	18	DI	Airplane mode control	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V	1.8 V power domain. Pull-up by default.

				V_{IH}max = 2.0 V	In low voltage level, the module will enter airplane mode. If unused, keep this pin open.
AP_READY	19	DI	Application processor ready	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 these pins open.
USB_BOOT	75	DI	Force the module into emergency download mode		
GPIO26	26	DIO	General-purpose input/output	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	
GPIO64	64	DIO	General-purpose input/output		
ADC Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ADC1	2	AI	General-purpose ADC interface	Voltage range: 0.3–1.8 V	If unused, keep them open.
ADC0	24	AI	General-purpose ADC interface	Voltage range: 0.3–1.8 V	
RESERVED Pins					
Pin Name	**Pin No.**				**Comment**
RESERVED	11–14, 16, 25, 51, 56, 57, 63, 65, 66, 76–78, 83–88, 92–99				Keep these pins open.

NOTE

Keep all RESERVED pins and unused pins unconnected.

3.3. Operating Modes

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

Table 5: Overview of Operating Modes

Mode	Details	
Full Functionality Mode	Voice/Data	The module is connected to network. Its current consumption varies with the network setting and data transfer rate.
	Idle	The module remains registered on network, and is ready to send and receive data. In this mode, the software is active.
Extended Idle DRX Mode (e-I-DRX)	The module and the network may negotiate over non-access stratum signaling the use of e-I-DRX for reducing power consumption, while being available for mobile terminating data and/or network originated procedures within a certain delay dependent on the DRX cycle value.	
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 case, both RF function and (U)SIM card are invalid.	
Sleep Mode	The module remains the ability to receive paging message, SMS and TCP/UDP data from the network normally. In this mode, the current consumption is reduced to a low level.	
Power Saving Mode (PSM)	PSM is similar to power-off, but module remains registered on the network and there is no need to re-attach or re-establish PDN connections. Its current consumption is reduced to a minimized level.	
Power OFF Mode	The module's power supply is shut down 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.	

NOTE

1. For more details about **AT+CFUN**, see ***document [2]***.
2. During e-I-DRX, it is recommended to use UART interface for data communication, as the use of USB interface will increase power consumption.

3.4. Power Saving

3.4.1. Airplane Mode

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

Hardware:

W_DISABLE# is pulled up by default. Driving it low will set the module to airplane mode.

Software:

AT+CFUN=<fun> provides choice of the functionality level, through specifying **<fun>** as 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. Airplane mode control via W_DISABLE# is disabled in firmware by default. It can be enabled by **AT+QCFG="airplanecontrol"**. For more details about the command, see ***document [3]***.
2. The execution of **AT+CFUN** will not affect GNSS function.

3.4.2. Power Saving Mode (PSM)

The module minimizes its power consumption through entering PSM. The mode is similar to power-off, but the module remains registered on the network and there is no need to re-attach or re-establish PDN connections. Therefore, the module in PSM cannot immediately respond to your requests.

When the module wants to use the PSM, it shall request an Active Time value during every Attach and TAU procedures. If the network supports PSM and accepts that the module uses PSM, it will confirm the usage of PSM by allocating an Active Time value to the module. If the module wants to change the Active Time value, e.g. when the conditions are changed in the module, the module consequently requests the value it wants in the TAU procedure.

If PSM is supported by the network, then it can be enabled via **AT+CPSMS**. See ***document [2]*** for details about **AT+CPSMS**.

Either of the following methods will wake up the module from PSM:

- Wake up the module by driving PWRKEY low.
- When the TAU timer expires, the module wakes up from PSM automatically.

3.4.3. Extended Idle Mode DRX (e-I-DRX)

The module (UE) and the network may negotiate over non-access stratum signalling the use of e-I-DRX for reducing its power consumption, while being available for mobile terminating data and/or network originated procedures within a certain delay dependent on the DRX cycle value.

Applications that want to use e-I-DRX need to consider specific handling of mobile terminating services or data transfers, and in particular they need to consider the delay tolerance of mobile terminated data.

In order to negotiate the use of e-I-DRX, the UE requests e-I-DRX parameters during attach procedure and RAU/TAU procedure. The EPC may reject or accept the UE request for enabling e-I-DRX. In case the EPC accepts e-I-DRX, the EPC based on operator policies and, if available, the e-I-DRX cycle length value in the subscription data from the HSS, may also provide different values of the e-I-DRX parameters than what was requested by the UE. If the EPC accepts the use of e-I-DRX, the UE applies e-I-DRX based on the received e-I-DRX parameters. If the UE does not receive e-I-DRX parameters in the relevant accept message because the EPC rejected its request or because the request was received by EPC not supporting e-I-DRX, the UE shall apply its regular discontinuous reception.

If e-I-DRX is supported by the network, then it can be enabled by **AT+CEDRXS=1**. See ***document [2]*** for details about **AT+CEDRXS**.

3.4.4. Sleep Mode

The module is able to reduce its current consumption to a lower value during the sleep mode. The following sub-chapters describe the power saving procedure of the module.

3.4.4.1. UART Application Scenario

If the host communicates with the module via UART1 interface, the following preconditions can set the module to sleep mode.

- Execute **AT+QSCLK=1** (see ***document [2]***) to enable sleep mode.
- Drive DTR high.

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

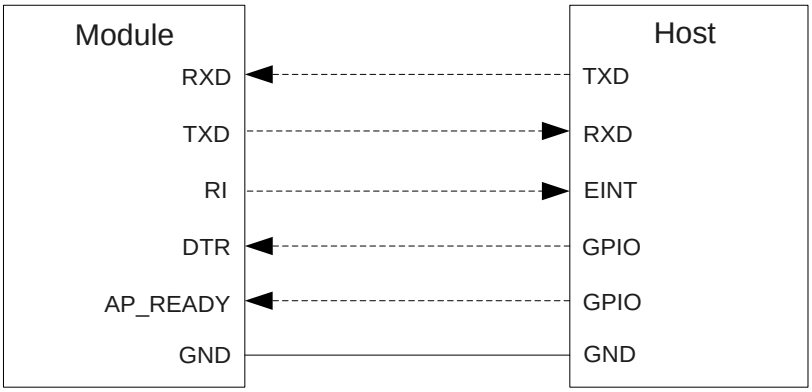


Figure 3: Sleep Mode Application via UART

- Driving the host DTR low will wake up the module.
- When BG96 has a URC to report, RI will wake up the host. See ***Chapter 3.13.3*** for details about RI behavior.
- AP_READY will detect the sleep state of the host (can be configured to high level or low level detection). See ***document [3]*** for more details about **AT+QCFG="apready"**.

3.5. Power Supply

3.5.1. Power Supply Pins

BG96 provides the following four VBAT pins for connection with an external power supply. There are two separate voltage domains for VBAT.

- Two VBAT_RF pins for module's RF part.
- Two VBAT_BB pins for module's baseband part.

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

Table 6: VBAT and GND Pins

Pin Name	Pin No.	Description	Min.	Typ.	Max.	Unit
VBAT_RF	52, 53	Power supply for the module's RF part	3.3	3.8	4.3	V
VBAT_BB	32, 33	Power supply for the module's baseband part	3.3	3.8	4.3	V
GND	3, 31, 48, 50, 54, 55, 58, 59, 61, 62, 67–74, 79–82, 89–91, 100–102					

3.5.2. 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 LTE Cat M1 and LTE Cat NB1 networks.

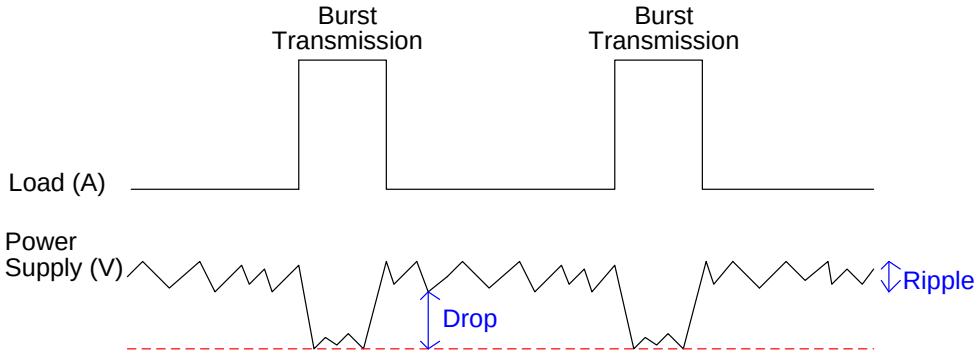


Figure 4: Power Supply Limits During Burst Transmission

To decrease voltage drop, a bypass capacitor of about 100 μF with low ESR should be used for VBAT_BB and VBAT_RF respectively, and a multi-layer ceramic chip capacitor (MLCC) array should also be reserved due to its low ESR. It is recommended to use three ceramic capacitors (100 nF, 33 pF, 10 pF) for composing the MLCC array, and place these capacitors close to VBAT 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 not less than 0.5 mm, and the width of VBAT_RF trace should not be less than 2.7 mm. In principle, the longer the VBAT trace is, the wider it should be.

In addition, to get a stable power source, it is suggested to use a TVS with low leakage current and suitable reverse stand-off voltage, and also it is recommended to place it as close to the VBAT pins as possible. The following figure shows the star structure of the power supply.

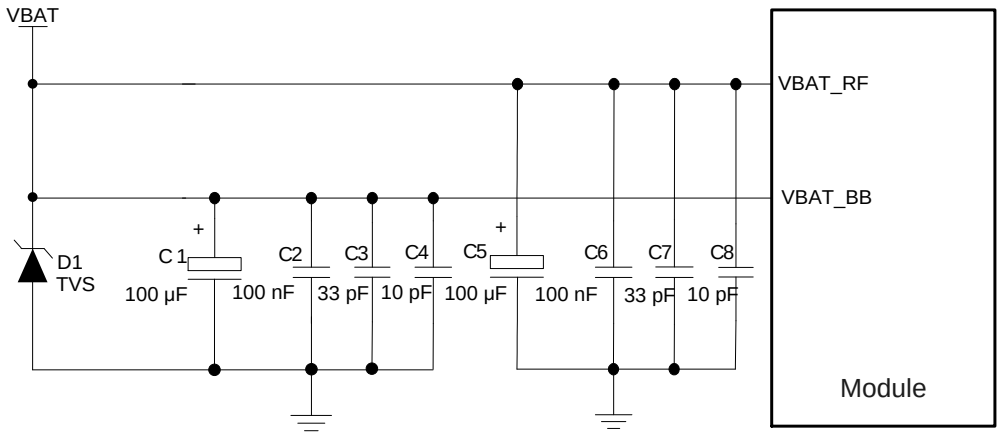


Figure 5: Star Structure of the Power Supply

3.5.3. Power Supply Voltage Monitoring

AT+CBC can be used to monitor the VBAT_BB voltage value. For more details, see ***document [2]***.

3.6. Turn On

3.6.1. Turn On with PWRKEY

The following table shows the pin definition of PWRKEY.

Table 7: Pin Definition of PWRKEY

Pin Name	Pin No.	Description	DC Characteristics	Comment
PWRKEY	15	Turn on/off the module	Vnom = 0.8 V V_{IL}max = 0.5 V	The output voltage is 0.8 V because of the diode drop inside the chipset.

When the module is in power off mode, it can be turned on by driving PWRKEY low for at least 500 ms. It is recommended to use an open drain/collector driver to control the PWRKEY. After STATUS pin outputs a high voltage level, PWRKEY pin can be released.

A simple reference circuit is illustrated in the following figure.

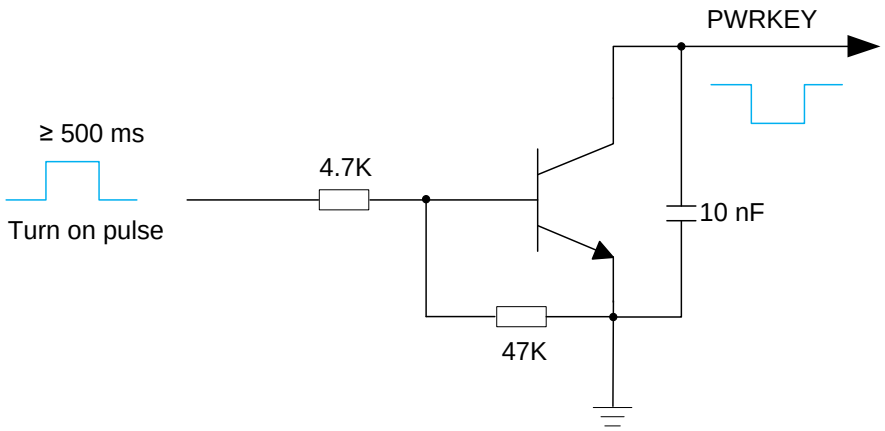


Figure 6: Turn On the Module Using Driving Circuit

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

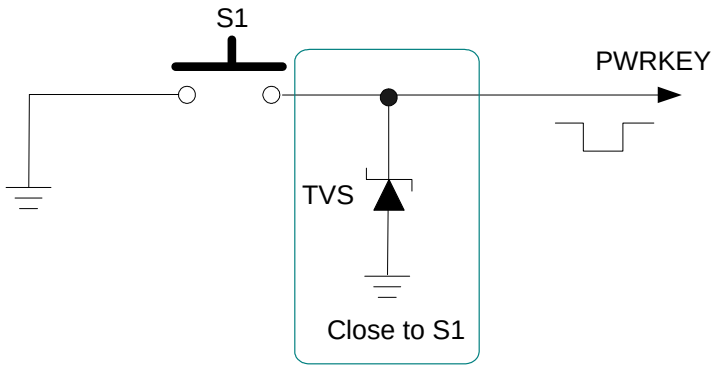


Figure 7: Turn On the Module with a Button

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

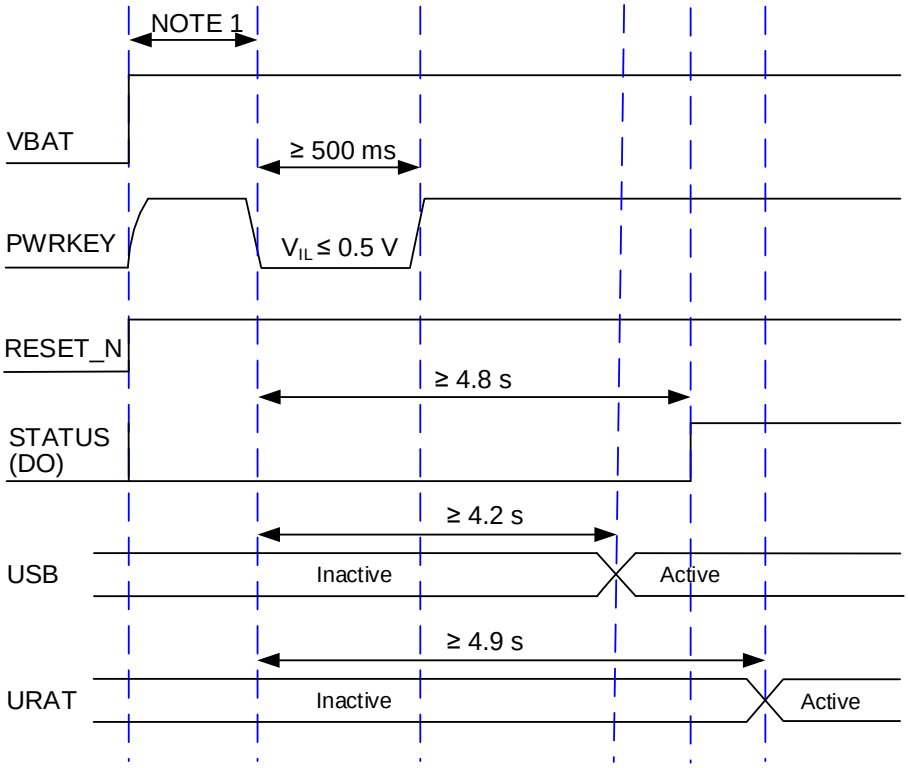


Figure 8: Power-up Timing

NOTE

1. Make sure that VBAT is stable before pulling down PWRKEY pin, and keep the interval not less than 30 ms.
2. PWRKEY is internally pulled up to an internal voltage inside the chipset, and its output voltage is the internal voltage minus a diode drop in the chipset. After calculated in this way, the PWRKEY

output voltage is expected to be 0.8 V.

3.7. Turn Off

Either of the following methods can be used to turn off the module normally:

- Turn off the module with PWRKEY.
- Turn off the module using **AT+QPOWD**.

NOTE

To avoid corrupting the data in the internal flash, do not switch off the power supply when the module is working. Only after the module is shut down with PWRKEY or AT command can the power supply be cut off

3.7.1. Turn Off with PWRKEY

Drive PWRKEY low at least 650 ms and then release it, so that the module will execute power-down procedure. The power-down scenario is illustrated in the following figure.

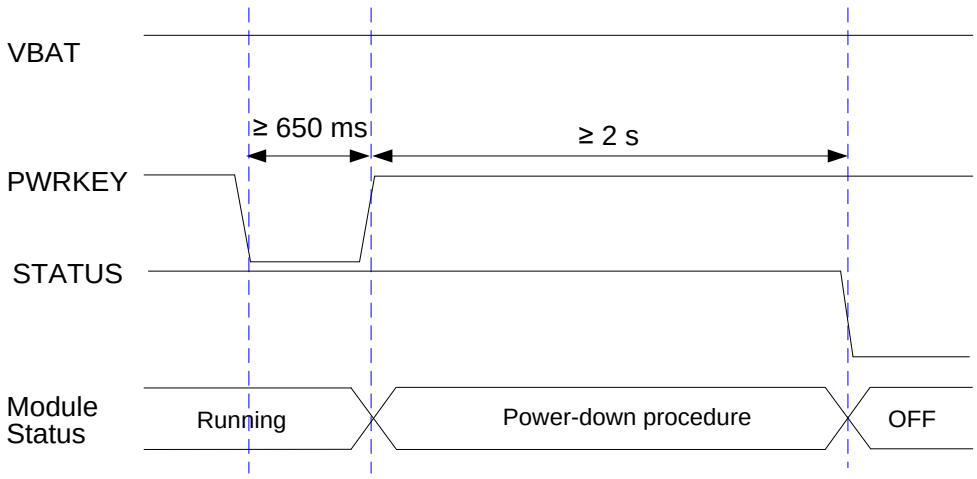


Figure 9: Power-down Timing

3.7.2. 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. See ***document [2]*** for details about **AT+QPOWD**.

3.8. Reset

The module can be reset by driving RESET_N low for 150–460 ms.

Table 8: RESET_N Pin Description

Pin Name	Pin No.	Description	DC Characteristics	Comment
RESET_N	17	Reset the module	V_{IH}max = 2.1 V V_{IH}min = 1.3 V V_{IL}max = 0.5 V	If unused, keep this pin open.

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.

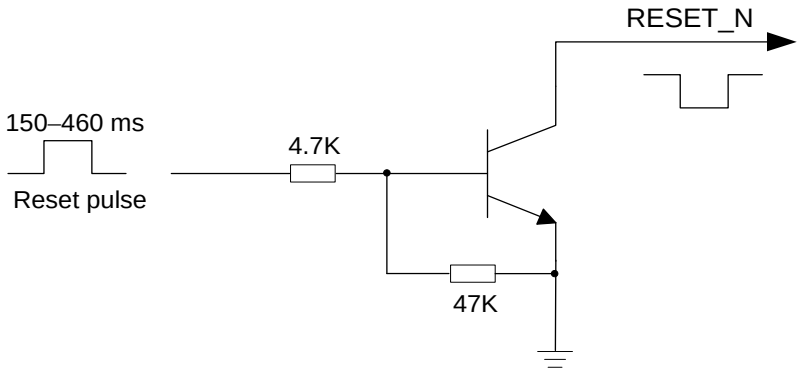


Figure 10: Reference Circuit of RESET_N with a Driving Circuit

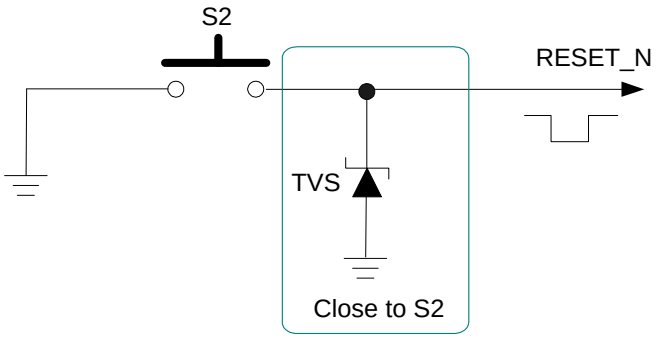


Figure 11: Reference Circuit of RESET_N by Using Button

The reset scenario is illustrated in the following figure.

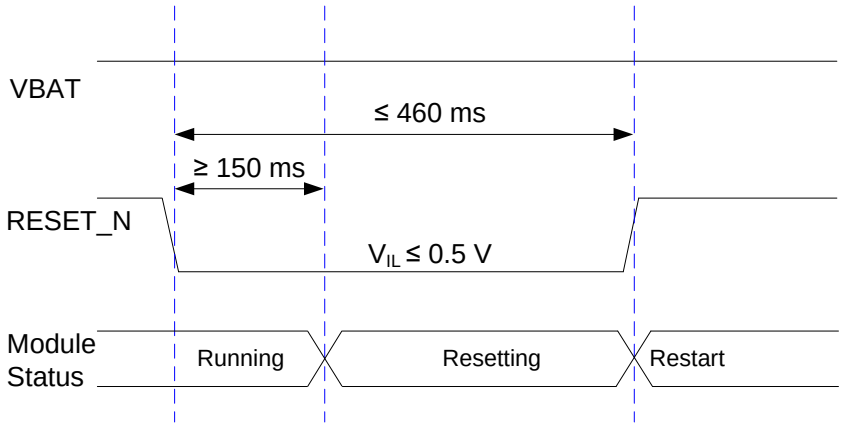


Figure 12: Reset Timing

NOTE

1. Use RESET_N only when you fail to turn off the module with **AT+QPOWD** and PWRKEY.
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 9: Pin Definition of (U)SIM Interface

Pin Name	Pin No.	I/O	Description	Comment
USIM_ PRESENCE	42	DI	(U)SIM card hot plug detect	1.8 V power domain. If unused, keep this pin open.
USIM_VDD	43	PO	(U)SIM card power supply	Either 1.8 V or 3.0 V is supported by the module automatically.
USIM_RST	44	DO	(U)SIM card reset	
USIM_DATA	45	DIO	(U)SIM card data	
USIM_CLK	46	DO	(U)SIM card clock	
USIM_GND	47	-	Specified ground for (U)SIM	

card

BG96 supports (U)SIM card hot-plug via USIM_PRESENCE, and both high and low level detections are supported. The function is disabled by default. See ***document [2]*** for more details about **AT+QSIMDET.**

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

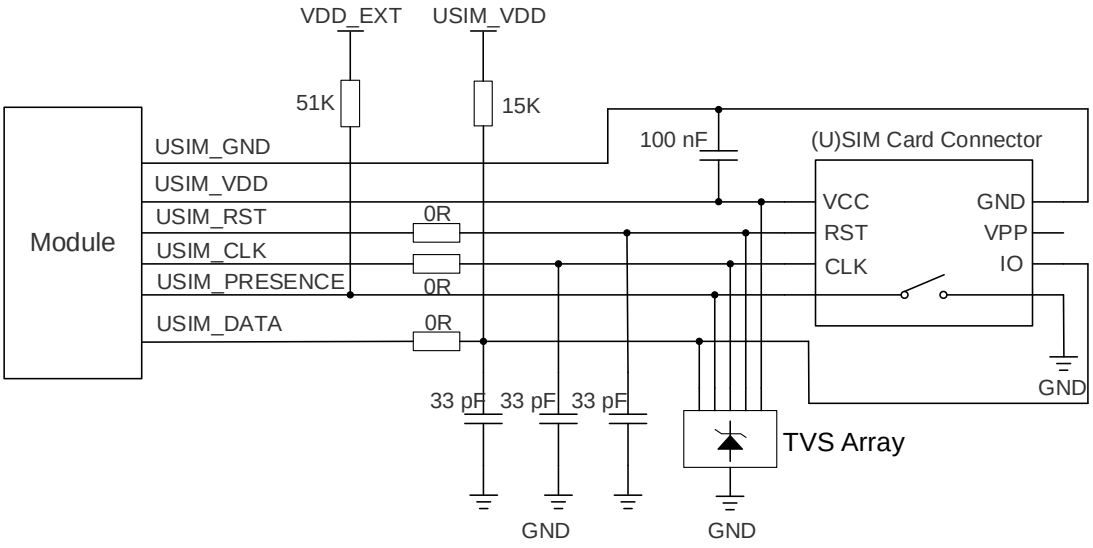


Figure 13: Reference Design of (U)SIM Interface with an 8-Pin (U)SIM Card Connector

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.

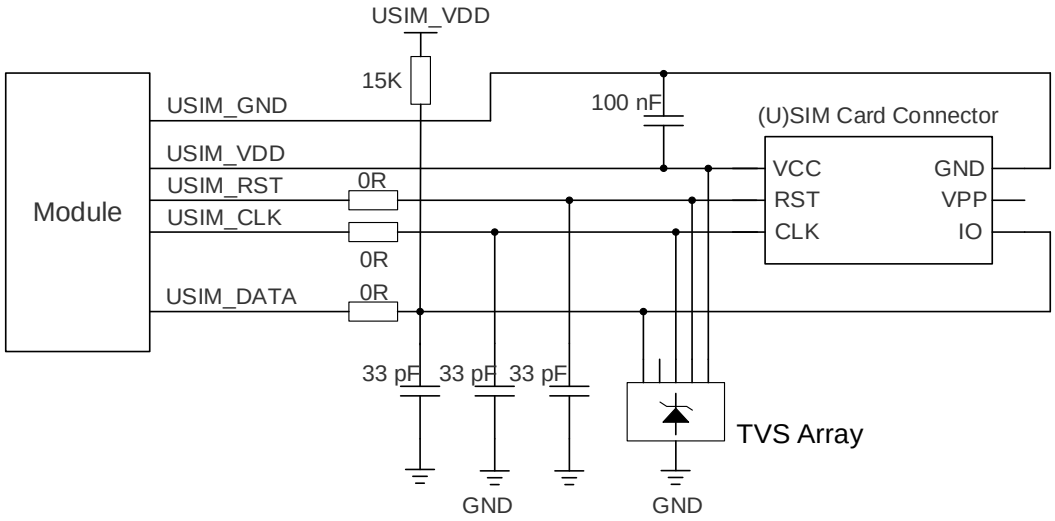


Figure 14: Reference Design of (U)SIM Interface with a 6-Pin (U)SIM Card Connector

To enhance the reliability and availability of the (U)SIM card in applications, follow the criteria below in (U)SIM circuit design:

- Place the (U)SIM card connector as close to the module as possible. Keep the trace length less than 200 mm.
- Keep (U)SIM card signals away from RF and power supply traces.
- Assure the ground trace between the module and the (U)SIM card connector short and wide. Keep the trace width of ground and USIM_VDD not less than 0.5 mm to maintain the same electric potential. 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 system ground plane is complete, USIM_GND can be connected to the system ground directly.
- To avoid cross-talk between USIM_DATA and USIM_CLK, keep them away from each other and shield them with surrounded ground. USIM_RST should also be surrounded with ground.
- To offer good ESD protection, it is recommended to add a TVS array with parasitic capacitance not exceeding 15 pF. To facilitate debugging, it is recommended to reserve series resistors for the (U)SIM signals of the module. The 33 pF capacitors are used for filtering interference of EGSM900. 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

The module 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 is used for AT command communication, data transmission, GNSS NMEA sentences output, software debugging and firmware upgrade.

The following table shows the pin definition of USB interface.

Table 10: Pin Definition of USB Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_VBUS	8	AI	USB connection detect	Typ. 5.0 V
USB_DP	9	AIO	USB differential data (+)	Require differential impedance of 90 Ω.
USB_DM	10	AIO	USB differential data (-)	
GND	3		Ground	

For more details about USB 2.0 specification, visit http://www.usb.org/home.

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

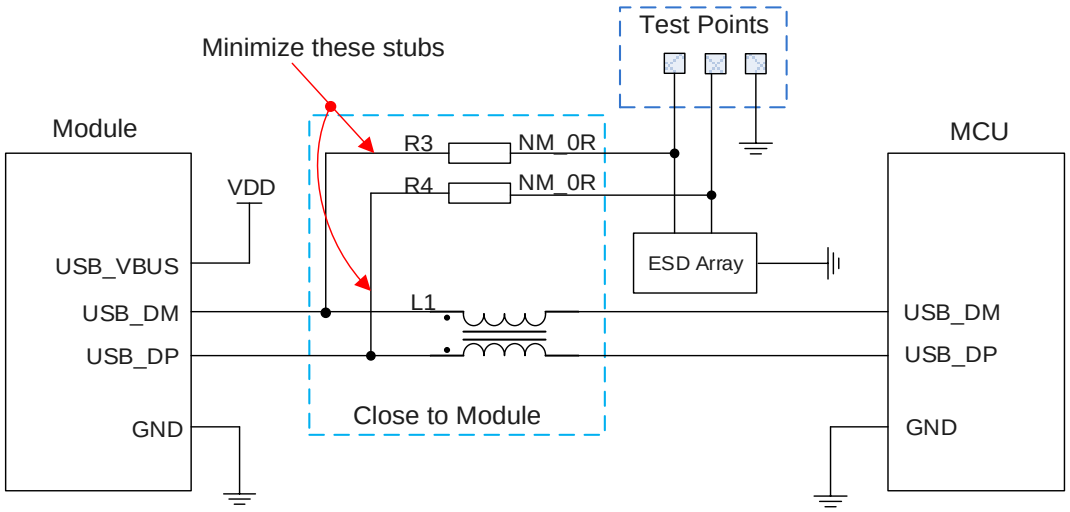


Figure 15: Reference Circuit of USB Interface

A common mode choke L1 is recommended to be added in series between the module and MCU 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. To ensure the integrity of USB data trace signal, L1, R3 and R4 components must be placed close to the module, and also these resistors should be placed close to each other. The extra stubs of trace must be as short as possible.

To meet USB 2.0 specification, comply with the following principles while designing 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. It is important to 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 device. Typically, the stray capacitance should be less than 2 pF.
- Keep the ESD protection components as close to the USB connector as possible.

NOTE

BG96 module can only be used as a slave device.

3.11. UART Interfaces

The module serves as DCE (Data Communication Equipment), which is connected in the traditional DCE-DTE (Data Terminal Equipment) mode.

The module provides three UART interfaces: UART1, UART2 and UART3 interfaces. The following are their features.

- UART1 interface supports 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 is used for data transmission and AT command communication.
- UART2 interface supports 115200 bps baud rate, and it is used for debugging and log output.
- UART3 interface supports 115200 bps baud rate, and it is used for outputting GNSS data and GNSS NMEA sentences.

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

Table 11: Pin Definition of UART1 Interface

Pin Name	Pin No.	I/O	Description	Comment
DTR	30	DI	Data terminal ready (sleep mode control)	1.8 V power domain.
RXD	34	DI	Receive	
TXD	35	DO	Transmit	
CTS	36	DO	DTE clear to send signal from DCE	Connect to DTE's CTS. 1.8 V power domain.
RTS	37	DI	DTE request to send signal to DCE	Connect to DTE's RTS. 1.8 V power domain.
DCD	38	DO	Data carrier detect	1.8 V power domain.
RI	39	DO	Ring indication	

NOTE

AT+IPR can be used to set the baud rate of the UART interface, and **AT+IFC** can be used to set the hardware flow control (hardware flow control is disabled by default). See ***document [2]*** for more details.

Table 12: Pin Definition of UART2 Interface

Pin Name	Pin No.	I/O	Description	Comment
DBG_RXD	22	DI	Debug UART receive	1.8 V power domain
DBG_TXD	23	DO	Debug UART transmit	1.8 V power domain

Table 13: Pin Definition of UART3 Interface

Pin Name	Pin No.	I/O	Description	Comment
UART3_TXD	27	DO	UART3 transmit	1.8 V power domain
UART3_RXD	28	DI	UART3 receive	1.8 V power domain

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

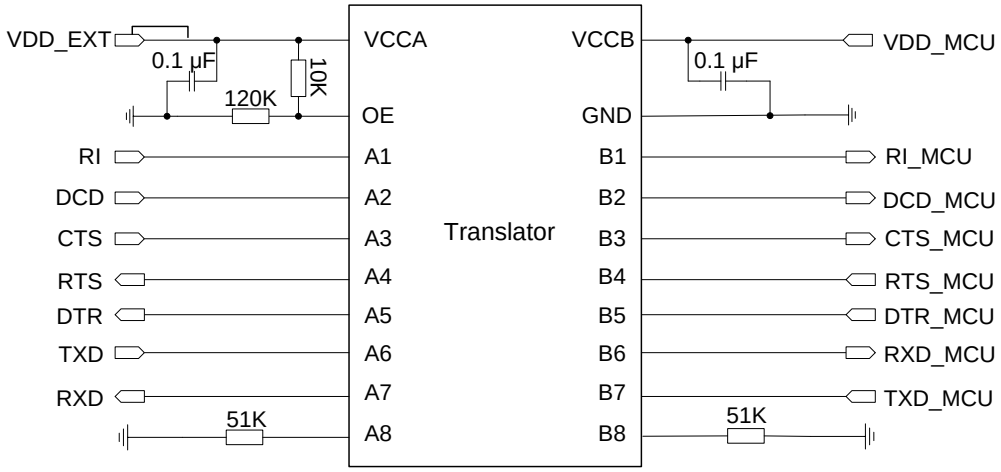


Figure 16: Reference Design with Translator Chip

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, refer to that of circuits in solid lines, but pay attention to the direction of connection.

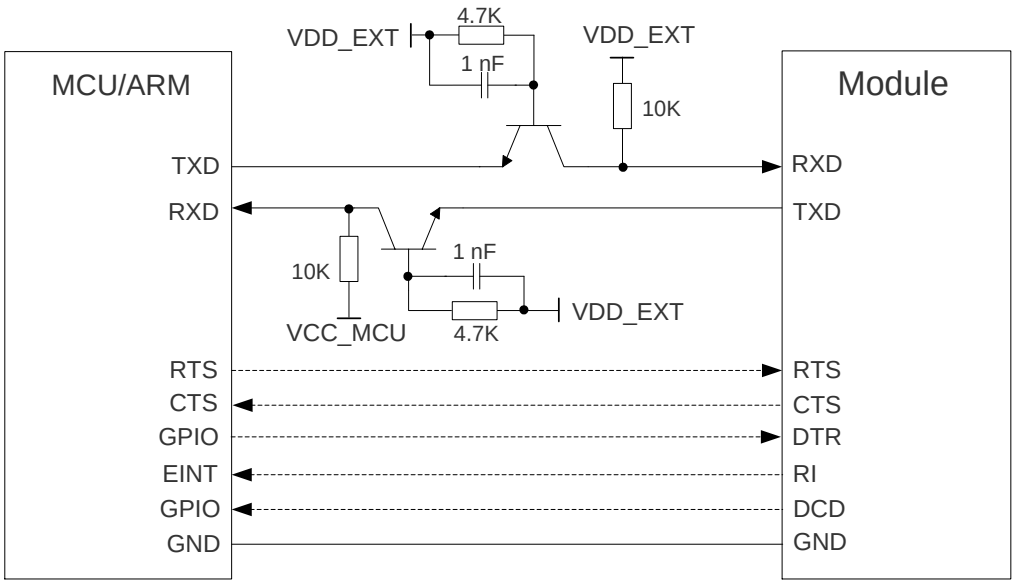


Figure 17: Reference Design with Transistor Circuit

NOTE

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

3.12. PCM and I2C Interfaces

BG96 provides one Pulse Code Modulation (PCM) digital interface and one I2C interface. The following table shows the pin definition of the two 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_CLK	4	DO	PCM clock	1.8 V power domain. If unused, keep these pins open.
PCM_SYNC	5	DO	PCM frame sync	
PCM_IN	6	DI	PCM data input	
PCM_OUT	7	DO	PCM data output	

I2C_SCL	40	OD	I2C serial clock (for external codec)	External pull-up resistor is required. 1.8 V only. If unused, keep them open.
I2C_SDA	41	OD	I2C serial data (for external codec)	

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

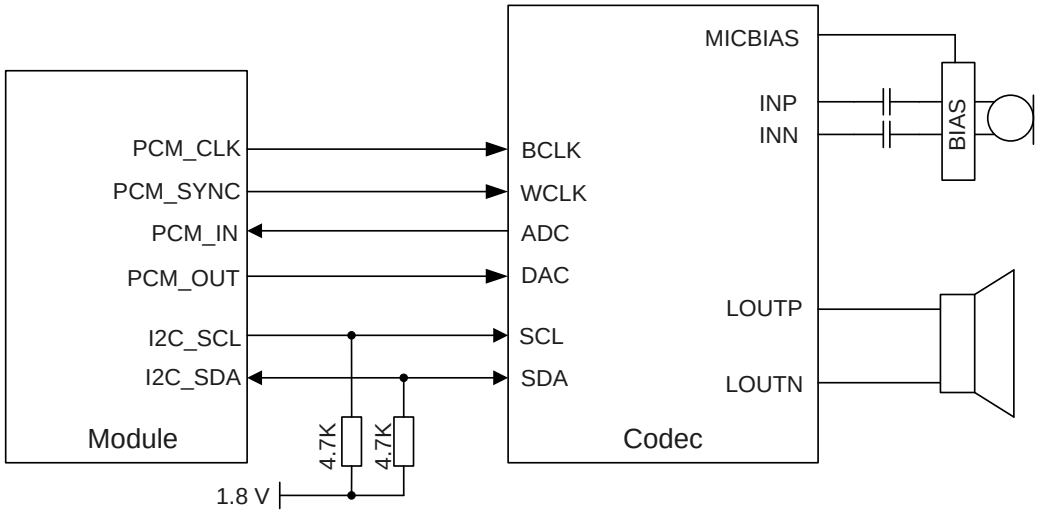


Figure 18: Reference Design of PCM Application with Audio Codec

NOTE

PCM and I2C interfaces support VoLTE only. For specific information about the software version of VoLTE, please contact Quectel Technical Support (support@quectel.com).

3.13. Indication Signals

3.13.1. Network Status Indication

BG96 provides one network status indication pin: NETLIGHT. The pin is used to drive a network status indication LED. The following tables describe the pin definition and logic level changes of NETLIGHT in different network activity status.

Table 15: Pin Definition of NETLIGHT

Pin Name	Pin No.	I/O	Description	Comment
NETLIGHT	21	DO	Indicate the module's network activity status	1.8 V power domain.

Table 16: Working State of NETLIGHT

Pin Name	Logic Level Changes	Network Status
NETLIGHT	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.

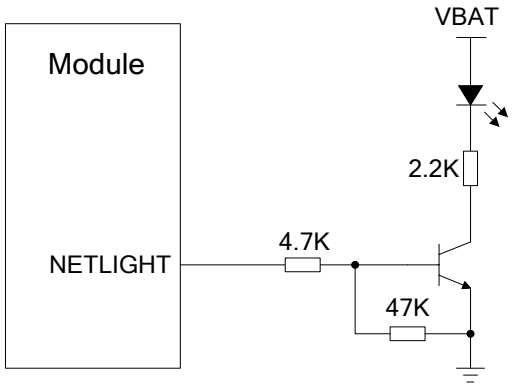


Figure 19: Reference Design of NETLIGHT

3.13.2. STATUS

The STATUS pin is used to indicate the operation status of the module. It will output high level when the module is powered on.

The following table describes the pin definition of STATUS.

Table 17: Pin Definition of STATUS

Pin Name	Pin No.	I/O	Description	Comment
STATUS	20	DO	Indicate the module's operation status	1.8 V power domain.

The following figure shows a reference circuit of STATUS.

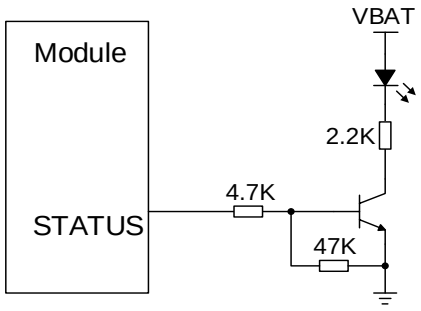


Figure 20: Reference Design of STATUS

3.13.3. RI

AT+QCFG="risignaltype", "physical" can be used to configure RI behavior. No matter which port URC is presented on, the URC will trigger the behavior of RI.

The default behaviors of RI are shown as below.

Table 18: Default Behaviors of RI

State	Response
Idle	RI keeps in high level.
URC	RI outputs 120 ms low pulse when a new URC returns.

The default RI behaviors can be configured flexibly by **AT+QCFG="urc/ri/ring"**. For more details, see ***document [3]***.

NOTE

A 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.

3.14. USB_BOOT Interface

BG96 provides a USB_BOOT pin. During development or factory production, USB_BOOT can force the module to boot from USB port for firmware upgrade.

Table 19: Pin Definition of USB_BOOT Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_BOOT	75	DI	Force the module into emergency download mode	1.8 V power domain. Active high. If unused, keep it open.

The following figure shows a reference circuit of USB_BOOT interface.

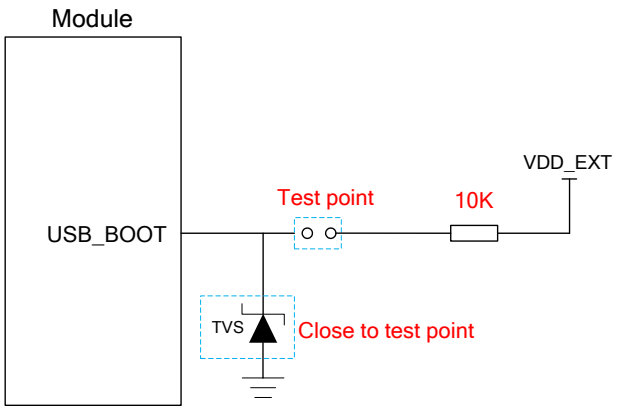


Figure 21: Reference Circuit of USB_BOOT Interface

NOTE

It is recommended to reserve the above circuit design during application design.

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 voltage values, the trace of ADC should be surrounded by ground.

Table 20: Pin Definition of ADC Interfaces

Pin Name	Pin No.	Description
ADC0	24	General-purpose ADC interface
ADC1	2	General-purpose ADC interface

The following table describes the characteristics of ADC interfaces.

Table 21: Characteristics of ADC Interfaces

Parameter	Min.	Typ.	Max.	Unit
ADC0 Voltage Range	0.3	-	1.8	V
ADC1 Voltage Range	0.3	-	1.8	V
ADC Resolution	-	-	15	bits
ADC Analog Bandwidth	-	100	-	kHz
ADC Sampling Rate	-	2.4	-	MHz

NOTE

1. ADC input voltage must not exceed 1.8 V.
2. It is prohibited to supply any voltage to ADC pins when VBAT is removed.
3. It is recommended to use resistor divider circuit for ADC application, and the divider resistor accuracy should be not less than 1 %.

3.16. GPIO Interfaces

The module provides two general-purpose input and output (GPIO) interfaces. **AT+QCFG="GPIO"** can be used to configure corresponding GPIO pin's status. For more details about the AT command, see ***document [3]***.

Table 22: Pin Definition of GPIO Interfaces

Pin Name	Pin No.	Description
GPIO26	26	General purpose input/output
GPIO64	64	General purpose input/output

4 GNSS Receiver

4.1. General Description

BG96 includes a fully integrated global navigation satellite system solution that supports GPS, GLONASS, BDS, Galileo and QZSS.

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

By default, the 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 [4]***.

4.2. GNSS Performance

The following table shows the GNSS performance of BG96 module.

Table 23: GNSS Performance

Parameter	Description	Conditions	Typ.	Unit
Sensitivity	Acquisition	Autonomous	-146	dBm
	Reacquisition	Autonomous	-157	dBm
	Tracking	Autonomous	-157	dBm
TTFF	Cold start @ open sky	Autonomous	31	s
		XTRA enabled	11.54	s
	Warm start @ open sky	Autonomous	21	s
		XTRA enabled	2.52	s

	Hot start @ open sky	Autonomous	2.7	s
		XTRA enabled	1.82	s
Accuracy	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. Acquisition sensitivity: the minimum GNSS signal power at which the module can fix position successfully within 3 minutes after executing cold start command.

4.3. Layout Guidelines

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

- Maximize the distance between the GNSS antenna and the main antenna.
- Digital circuits such as (U)SIM card, USB interface, camera module, display connector and SD card 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.

Refer to ***Chapter 5.2*** for GNSS antenna reference design and antenna installation information.

5 Antenna Interfaces

BG96 includes a main antenna interface and a GNSS antenna interface. The impedance of antenna ports is 50 Ω.

5.1. Main Antenna Interface

5.1.1. Pin Definition

The pin definition of main antenna interface is shown below.

Table 24: Pin Definition of Main Antenna Interface

Pin Name	Pin No.	I/O	Description	Comment
ANT_MAIN	60	AIO	Main antenna interface	50 Ω characteristic impedance

5.1.2. Operating Frequency

Table 25: BG96 Operating Frequency

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
LTE HD-FDD B1	1920–1980	2110–2170	MHz
LTE HD-FDD B2	1850–1910	1930–1990	MHz
LTE HD-FDD B3	1710–1785	1805–1880	MHz
LTE HD-FDD B4	1710–1755	2110–2155	MHz

LTE HD-FDD B5	824–849	869–894	MHz
LTE HD-FDD B8	880–915	925–960	MHz
LTE HD-FDD B12	699–716	729–746	MHz
LTE HD-FDD B13	777–787	746–756	MHz
LTE HD-FDD B18	815–830	860–875	MHz
LTE HD-FDD B19	830–845	875–890	MHz
LTE HD-FDD B20	832–862	791–821	MHz
LTE HD-FDD B25 [8]	1850–1915	1930–1995	MHz
LTE HD-FDD B26 [9]	814–849	859–894	MHz
LTE HD-FDD B28	703–748	758–803	MHz

5.1.3. Reference Design

A reference design of main antenna interface is shown as below. It is recommended to reserve a π-type matching circuit for better RF performance, and the π-type matching components (R1/C1/C2) should be placed as close to the antenna as possible. The capacitors are not mounted by default.

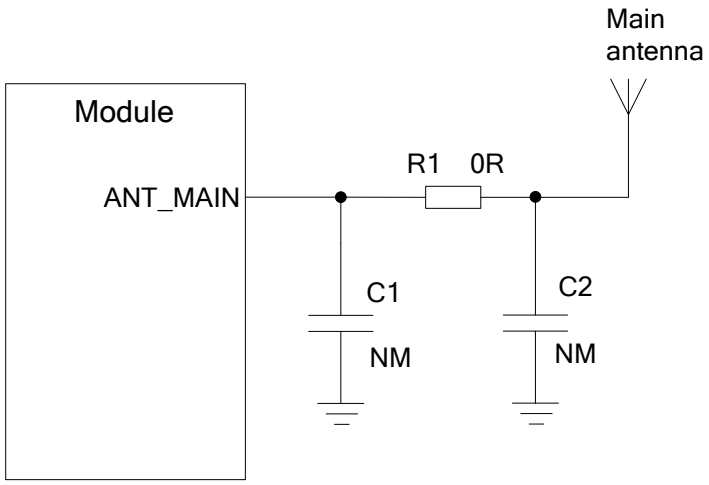


Figure 22: Reference Design of Main Antenna Interface

[8] LTE HD-FDD B25 is supported on BG96 of R1.2 hardware version.
[9] LTE HD-FDD B26 is supported on BG96 of R1.1 hardware version (support Cat M1 B26 only).

5.2. GNSS Antenna Interface

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

Table 26: Pin Definition of GNSS Antenna Interface

Pin Name	Pin No.	I/O	Description	Comment
ANT_GNSS	49	AI	GNSS antenna interface	50 Ω impedance

Table 27: GNSS Frequency

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

A reference design of GNSS antenna interface is shown as below.

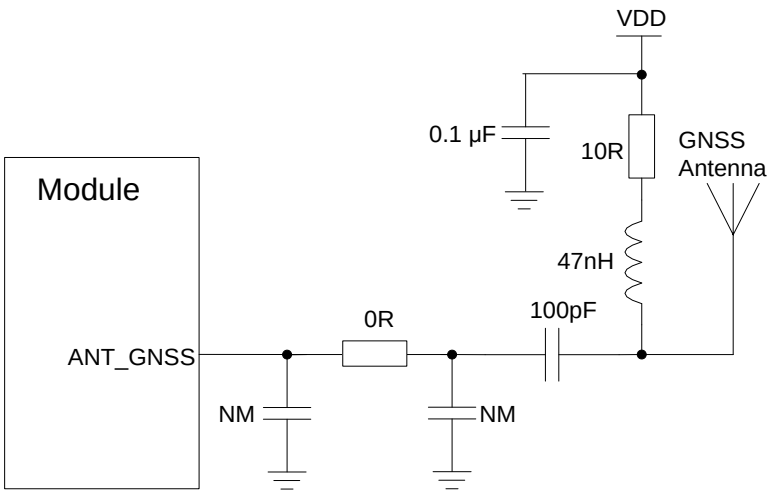


Figure 23: Reference Design of GNSS Antenna Interface

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.

5.3. 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, height from the reference ground to the signal layer (H), and the clearance 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.

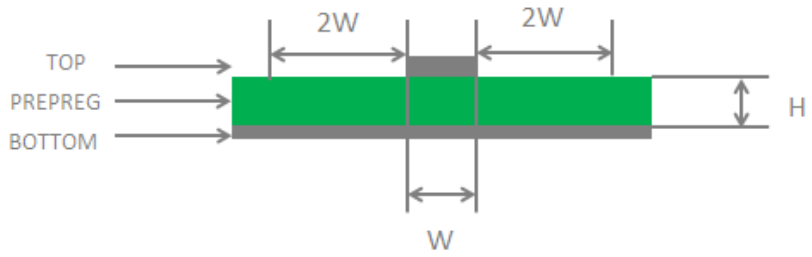


Figure 24: Microstrip Design on a 2-layer PCB

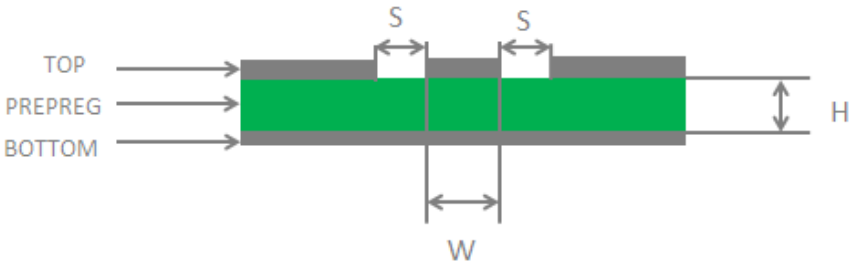


Figure 25: Coplanar Waveguide Design on a 2-layer PCB

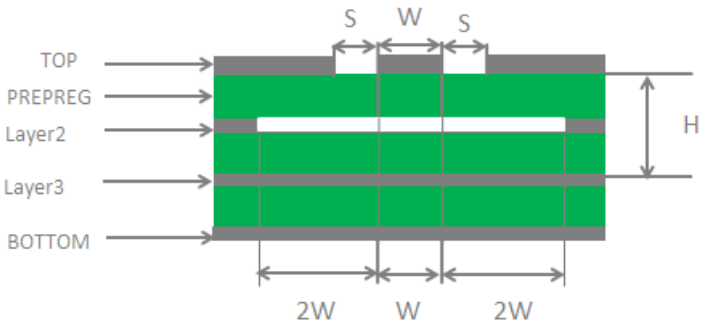


Figure 26: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

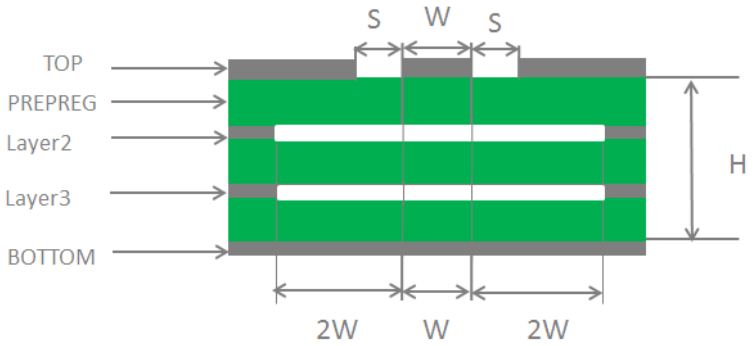


Figure 27: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

To ensure RF performance and reliability, the following principles should be complied with 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.
- 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 the RF traces should be not less than two times as wide as the 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 [5]***.

5.4. Antenna Design Requirements

The following table shows the requirements on main antenna and GNSS antenna.

Table 28: Antenna Design Requirements

Antenna Type	Requirements
GNSS [10]	Frequency range: 1559–1609 MHz Polarization: RHCP or linear VSWR: ≤ 2 (Typ.)
	For passive antenna usage: Passive antenna gain: > 0 dBi
	For active antenna usage: Passive antenna gain: > 0 dBi Active antenna noise figure: < 1.5 dB (Typ.) Active antenna embedded LNA gain: < 17 dB (Typ.)
LTE/EGPRS	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)

[10] It is recommended to use a passive GNSS antenna when LTE B13 is supported, as the use of active antenna may generate harmonics which will affect the GNSS performance.

5.5. RF Connector Recommendation

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

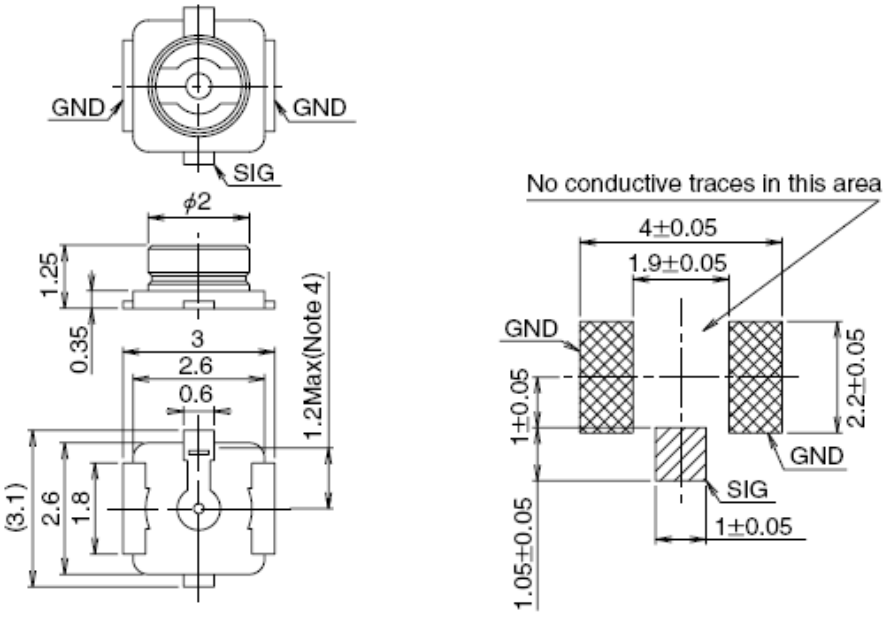


Figure 28: Dimensions of the Receptacle (Unit: mm)

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

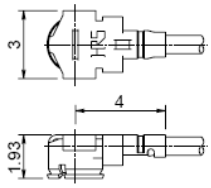
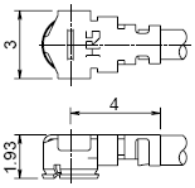
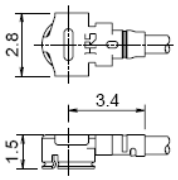
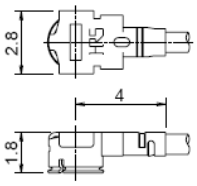
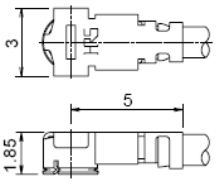
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 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 29: Specifications of Mated Plugs

The following figure describes the space factor of mated connectors.

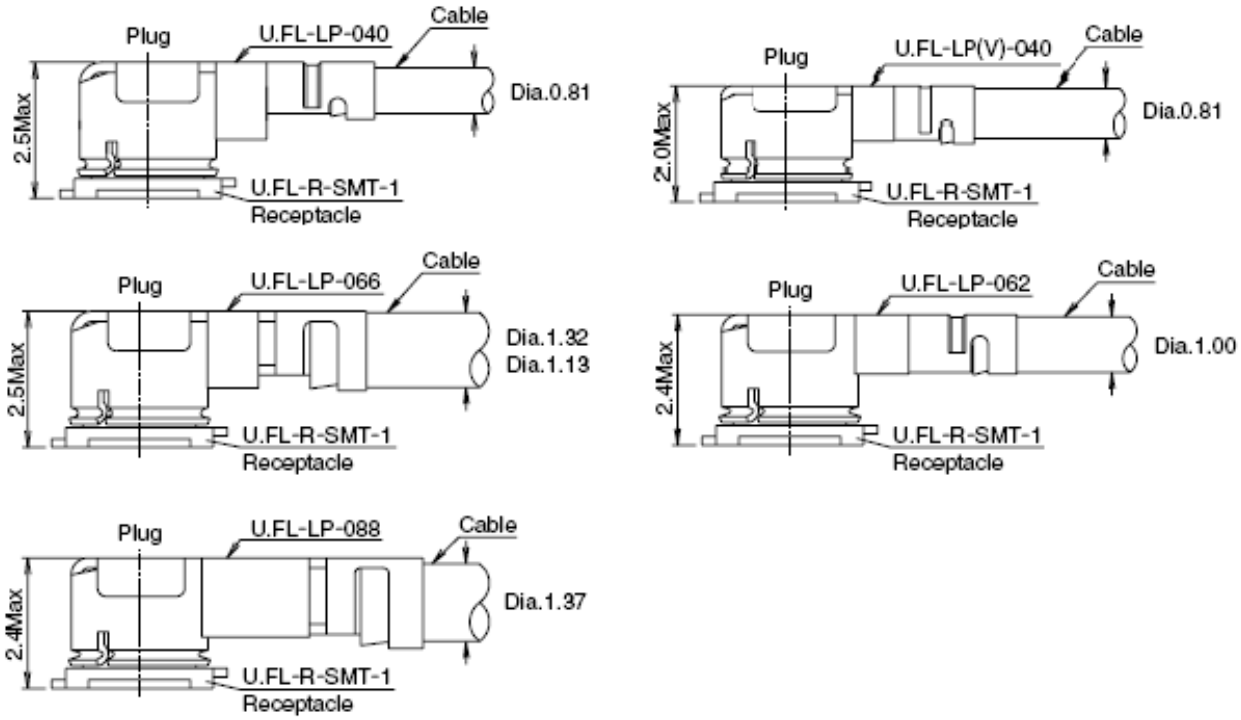


Figure 30: Space Factor of Mated Connectors (Unit: mm)

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

6 Reliability, Radio and Electrical Characteristics

6.1. Absolute Maximum Ratings

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

Table 29: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT_BB	-0.5	6	V
VBAT_RF	-1.2	6	V
USB_VBUS	-0.3	5.5	V
Voltage at Digital Pins	-0.3	2.3	V

6.2. Power Supply Ratings

Table 30: 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
I_{VBAT}	Peak supply current	Maximum power control level	-	1.8	2.7	A

USB_VBUS	USB connection detect	-	3.0	5.0	5.25	V

6.3. Operating and Storage Temperatures

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

Table 31: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operating Temperature Range [11]	-35	+25	+75	ºC
Extended Temperature Range [12]	-40	-	+85	ºC
Storage Temperature Range	-40	-	+90	ºC

6.4. Power Consumption

The following table shows power consumption of BG96 module.

Table 32: BG96 Power Consumption

Description	Conditions	Avg. [13]	Unit
Leakage	Power-off @ USB/UART disconnected	6.8	μA
PSM	PSM @ USB/UART disconnected	8.85	μA
Rock Bottom [14]	**AT+CFUN=0** @ Sleep mode	0.8	mA
Sleep Mode	LTE Cat M1 DRX = 1.28 s	1.54	mA

[11] Within the operating temperature range, the module meets 3GPP specifications.
[12] Within the extended temperature range, the module remains the ability to establish and maintain functions such as voice, SMS, data transmission, emergency call, etc., without any unrecoverable malfunction. Radio spectrum and radio network are not influenced, while one or more specifications, such as P_{out}, may exceed the specified tolerances of 3GPP. When the temperature returns to the operating temperature range, the module meets 3GPP specifications again.
[13] "Avg." value means the average current consumption value.
[14] "Rock Bottom" of sleep mode means the operation is performed with **AT+CFUN=0** and **AT+QSLCK=1** (DTR pin at high level).

(USB disconnected)	LTE Cat NB1 DRX = 1.28 s	2.03	mA
	LTE Cat M1 e-I-DRX = 40.96 s, PTW = 10.24 s	1.0	mA
	LTE Cat NB1 e-I-DRX = 40.96 s, PTW = 10.24 s	1.05	mA
Idle State (USB disconnected)	LTE Cat M1 DRX = 1.28 s	17.6	mA
	LTE Cat NB1 DRX = 1.28 s	17.91	mA
	LTE Cat M1 e-I-DRX = 40.96 s, PTW = 10.24 s	17.21	mA
	LTE Cat NB1 e-I-DRX = 40.96 s, PTW = 10.24 s	17.54	mA
LTE Cat M1 Data Transfer (GNSS OFF)	LTE HD-FDD B1 @ 22.97 dBm	253.64	mA
	LTE HD-FDD B2 @ 23.02 dBm	244.14	mA
	LTE HD-FDD B3 @ 23.05 dBm	228.21	mA
	LTE HD-FDD B4 @ 23.13 dBm	205.93	mA
	LTE HD-FDD B5 @ 22.94 dBm	224.73	mA
	LTE HD-FDD B8 @ 22.65 dBm	236.46	mA
	LTE HD-FDD B12 @ 22.64 dBm	226.45	mA
	LTE HD-FDD B13 @ 22.88 dBm	246.23	mA
	LTE HD-FDD B18 @ 22.99 dBm	22.99	mA
	LTE HD-FDD B19 @ 22.74 dBm	224.69	mA
	LTE HD-FDD B20 @ 23.45 dBm	261.92	mA
	LTE HD-FDD B25 @ 23.31 dBm	210.11	mA
	LTE HD-FDD B26 @ 23.55 dBm	242.46	mA
	LTE HD-FDD B28 @ 22.69 dBm	223.7	mA
LTE Cat NB1 Data Transfer (GNSS OFF)	LTE HD-FDD B1 @ 23.21 dBm	187.66	mA
	LTE HD-FDD B2 @ 23.17 dBm	177.54	mA
	LTE HD-FDD B3 @ 23.2 dBm	162.9	mA
	LTE HD-FDD B4 @ 23.29 dBm	163.44	mA

	LTE HD-FDD B5 @ 23.09 dBm	192.92	mA
	LTE HD-FDD B8 @ 23.01 dBm	176.91	mA
	LTE HD-FDD B12 @ 22.65 dBm	168.43	mA
	LTE HD-FDD B13 @ 22.66 dBm	184.54	mA
	LTE HD-FDD B18 @ 23.03 dBm	194.86	mA
	LTE HD-FDD B19 @ 23.1 dBm	193.09	mA
	LTE HD-FDD B20 @ 23.08 dBm	194.06	mA
	LTE HD-FDD B25 @ 22.82 dBm	166.71	mA
	LTE HD-FDD B28 @ 22.95 dBm	158.72	mA
GPRS Data Transfer (GNSS OFF)	GSM850 4UL/1DL @ 30.22 dBm	600.67	mA
	GSM850 3UL/2DL @ 31.43 dBm	519.74	mA
	GSM850 2UL/3DL @ 32.46 dBm	391.13	mA
	GSM850 1UL/4DL @ 32.65 dBm	225.93	mA
	EGSM900 4UL/1DL @ 29.42 dBm	574.3	mA
	EGSM900 3UL/2DL @ 30.7 dBm	481.01	mA
	EGSM900 2UL/3DL @ 32.25 dBm	418.42	mA
	EGSM900 1UL/4DL @ 32.53 dBm	234.19	mA
	DCS1800 4UL/1DL @ 30.01 dBm	551.54	mA
	DCS1800 3UL/2DL @ 29.67 dBm	401.73	mA
	DCS1800 2UL/3DL @ 29.85 dBm	288.49	mA
	DCS1800 1UL/4DL @ 30.02 dBm	175.51	mA
	PCS1900 4UL/1DL @ 29.56 dBm	527.27	mA
	PCS1900 3UL/2DL @ 29.68 dBm	409.72	mA
	PCS1900 2UL/3DL @ 29.85 dBm	309.9	mA
	PCS1900 1UL/4DL @ 30.11 dBm	180.15	mA
EDGE Data Transfer	GSM850 4UL/1DL @ 25.94 dBm	394.86	mA

(GNSS OFF)	GSM850 3UL/2DL @ 26.16 dBm	318.38	mA
	GSM850 2UL/3DL @ 26.4 dBm	233.13	mA
	GSM850 1UL/4DL @ 26.7 dBm	147.14	mA
	EGSM900 4UL/1DL @ 25.49 dBm	401.44	mA
	EGSM900 3UL/2DL @ 25.72 dBm	323.34	mA
	EGSM900 2UL/3DL @ 26.05 dBm	235.55	mA
	EGSM900 1UL/4DL @ 26.35 dBm	148.71	mA
	DCS1800 4UL/1DL @ 25.16 dBm	378.79	mA
	DCS1800 3UL/2DL @ 25.21 dBm	304.75	mA
	DCS1800 2UL/3DL @ 25.34 dBm	219.88	mA
	DCS1800 1UL/4DL @ 25.54 dBm	135.9	mA
	PCS1900 4UL/1DL @ 25.34 dBm	404.94	mA
	PCS1900 3UL/2DL @ 25.48 dBm	315	mA
	PCS1900 2UL/3DL @ 25.64 dBm	228.05	mA
	PCS1900 1UL/4DL @ 25.79 dBm	144.53	mA

NOTE

Sleep mode with UART connected and USB disconnected. The module can enter sleep mode through executing **AT+QSCLK=1** via UART interface and then controlling the module's DTR pin. For details, see ***Chapter 3.4.4***.

Table 33: GNSS Power Consumption

Description	Conditions	Typ.	Unit
Acquisition (**AT+CFUN=0**)	Cold Start @ Instrument	36.13	mA
	Warm Start @ Instrument	36.10	mA
	Hot Start @ Instrument	36.19	mA
	Lost State @ Instrument	36.62	mA
Tracking (**AT+CFUN=0**)	Instrument Environment @ Passive Antenna	13.36	mA
	Open Sky @ Real Network, Passive Antenna	36	mA
	Open Sky @ Real Network, Active Antenna	35	mA

6.5. Tx Power

Table 34: BG96 RF Output Power

Frequency Bands	Max. RF Output Power	Min. RF Output Power
LTE HD-FDD B1/B2/B3/B4/B5/B8/B12/B13/B18/B19/B20 /B25 [15]/B26 [16]/B28	23 dBm ±2 dB	<-39 dBm
GSM850/EGSM900 (GPRS)	33 dBm ±2 dB	5 dBm ±5 dB
DCS1800/PCS1900 (GPRS)	30 dBm ±2 dB	0 dBm ±5 dB
GSM850/EGSM900 (EGPRS)	27 dBm ±3 dB	5 dBm ±5 dB
DCS1800/PCS1900 (EGPRS)	26 dBm ±3 dB	0 dBm ±5 dB

[15] LTE HD-FDD B25 is supported on BG96 of R1.2 hardware version.
[16] LTE HD-FDD B26 is supported on BG96 of R1.1 hardware version (support Cat M1 B26 only).

6.6. Rx Sensitivity

Table 35: BG96 Conducted RF Receiving Sensitivity

Network	Frequency Bands	Primary	Diversity	Receiving Sensitivity (dBm)	
				Cat M1/3GPP	Cat NB1 [17]/3GPP
LTE	LTE HD-FDD B1	Supported	-	-107.0/-102.7	-112.5/-107.5
	LTE HD-FDD B2			-106.7/-100.3	-112.5/-107.5
	LTE HD-FDD B3			-106.8/-99.3	-113/-107.5
	LTE HD-FDD B4			-106.9/-102.3	-112.5/-107.5
	LTE HD-FDD B5			-107.0/-100.8	-114/-107.5
	LTE HD-FDD B8			-107.3/-99.8	-113/-107.5
	LTE HD-FDD B12			-107.7/-99.3	-113.5/-107.5
	LTE HD-FDD B13			-106.5/-99.3	-112/-107.5
	LTE HD-FDD B18			-107.5/-102.3	-113.5/-107.5
	LTE HD-FDD B19			-107.1/-102.3	-114/-107.5
	LTE HD-FDD B20			-107.2/-99.8	-114/-107.5
	LTE HD-FDD B25 [18]			-106/-100.3	-112/-107.5
	LTE HD-FDD B26 [19]			TBD/-100.3	TBD/-107.5
	LTE HD-FDD B28			-107.2/-100.8	-113/-107.5

Network	Frequency Bands	Primary	Coding Scheme	Receiving Sensitivity (dBm)
				GPRS/EGPRS/3GPP
GPRS	GSM850/EGSM900	Supported	CS-2	-112/-103
			CS-4	-106/-100

[17] LTE Cat NB1 receiving sensitivity without repetitions.
[18] LTE HD-FDD B25 is supported on BG96 of R1.2 hardware version.
[19] LTE HD-FDD B26 is supported on BG96 of R1.1 hardware version (support Cat M1 B26 only).

	DCS1800/PCS1900	Supported	CS-2	-115/-101
			CS-4	-105/-98
EGPRS	GSM850/EGSM900	Supported	MCS-5	-106/-98
			MCS-9	-95/-86
	DCS1800/PCS1900	Supported	MCS-5	-105/-98
			MCS-9	-95/-86

6.7. ESD Protection

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

The following table shows the electrostatic discharge characteristics of BG96 module.

Table 36: Electrostatic Discharge Characteristics (25 ºC, 45 % Relative Humidity)

Tested Interfaces	Contact Discharge	Air Discharge	Unit
VBAT, GND	±10	±15	kV
Main/GNSS Antenna Interfaces	±10	±15	kV

7 Mechanical Information

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

7.1. Mechanical Dimensions

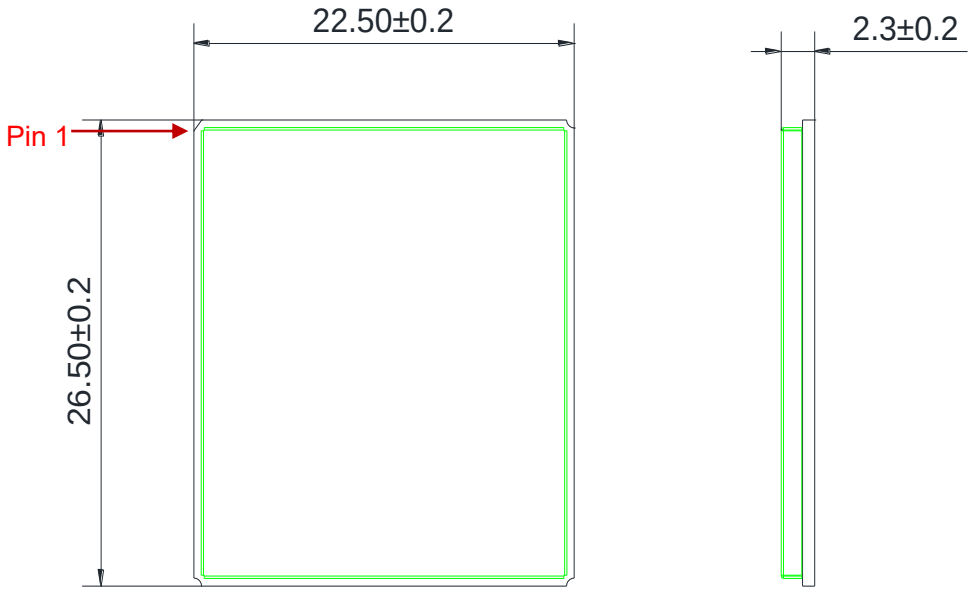


Figure 31: Module Top and Side Dimensions

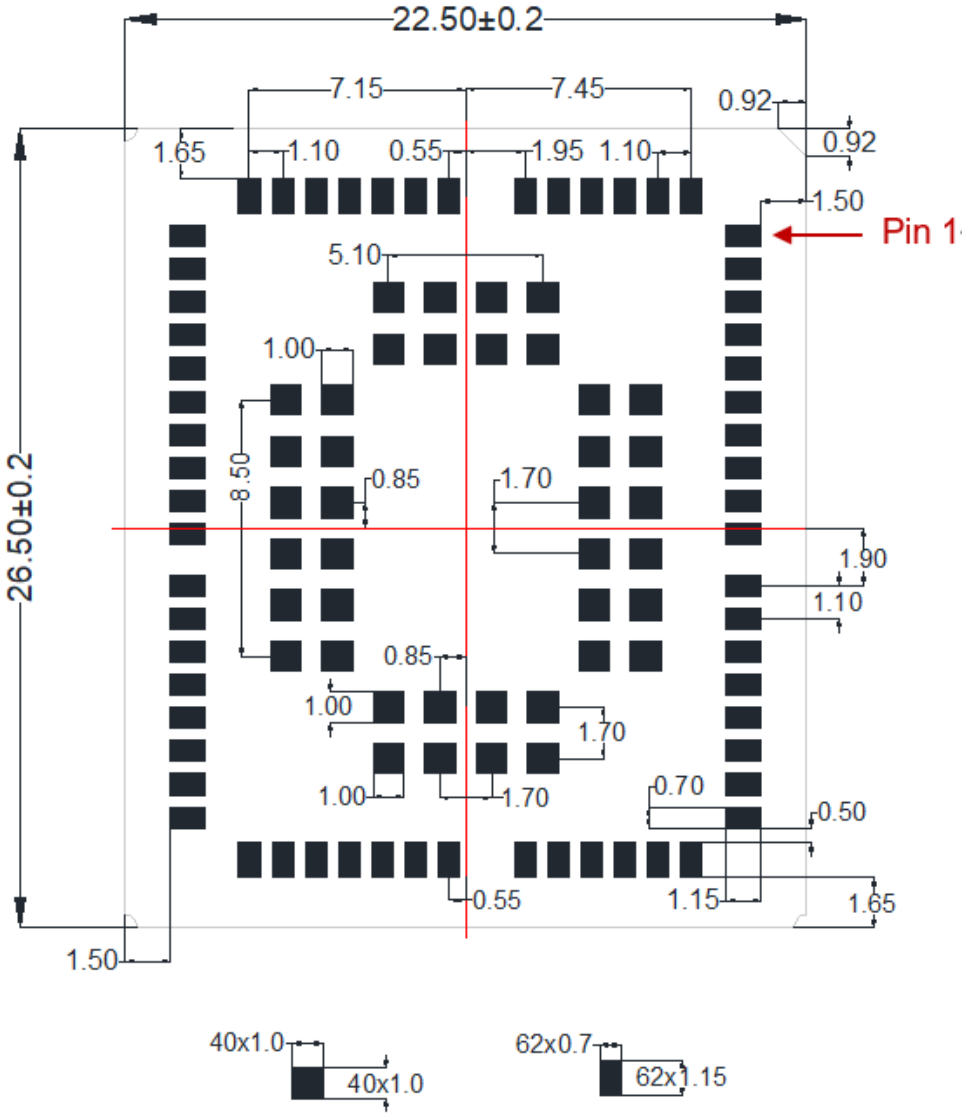


Figure 32: Bottom Dimensions (Bottom View)

NOTE

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

7.2. Recommended Footprint

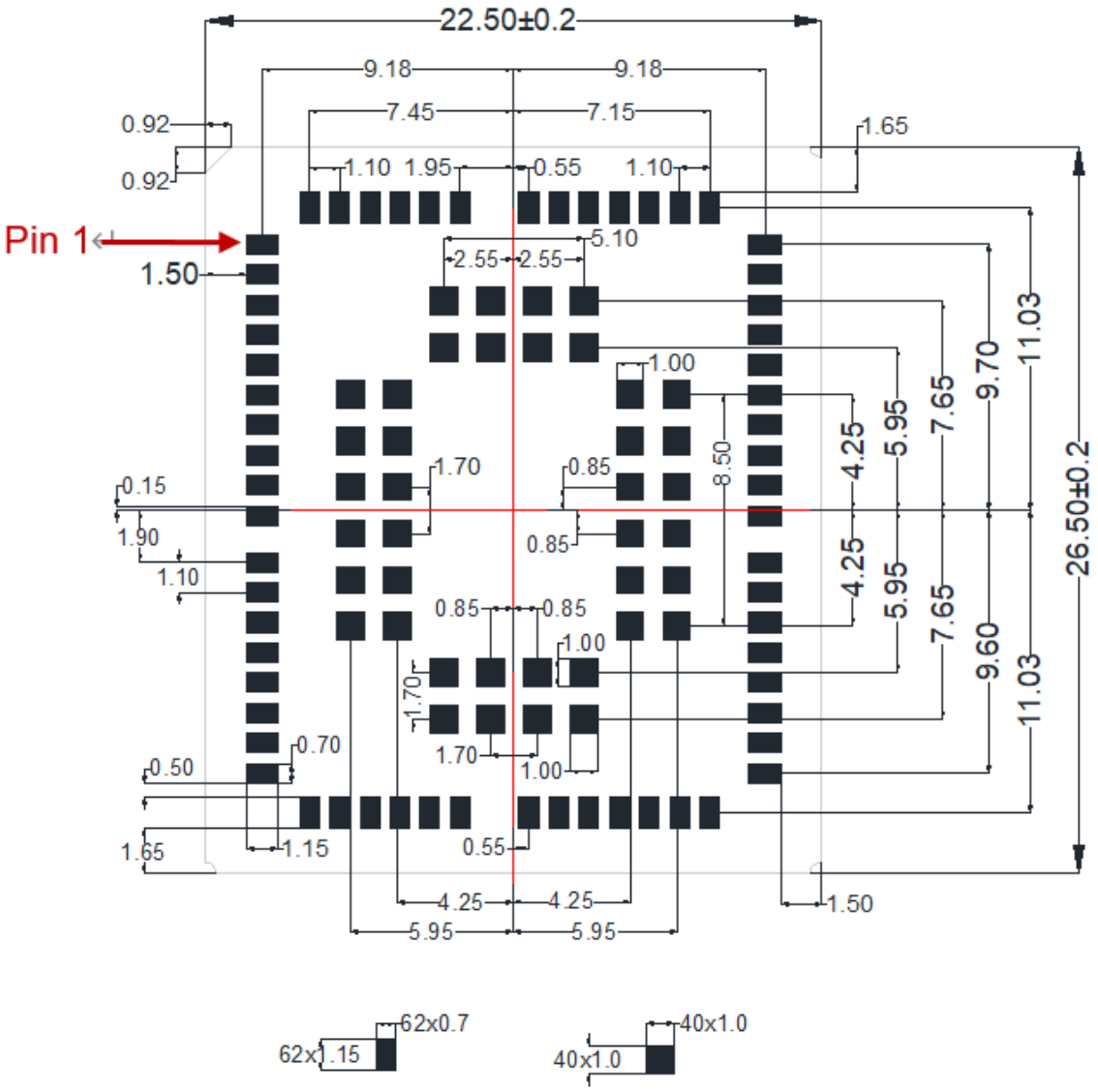


Figure 33: Recommended Footprint

NOTE

1. Keep at least 3 mm between the module and other components on the motherboard to improve soldering quality and maintenance convenience.
2. All RESERVED pins must be kept open.
3. For stencil design requirements of the module, see ***document [6]***.

7.3. Top and Bottom Views

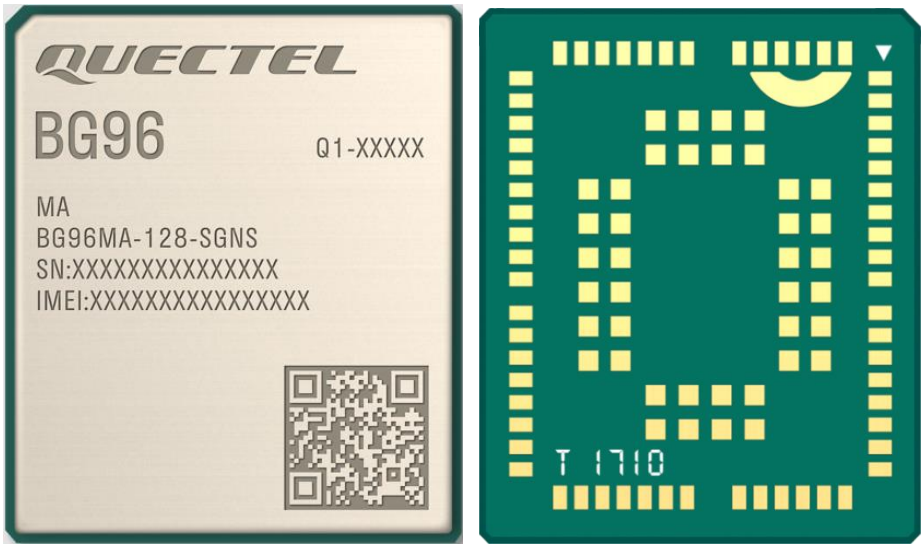


Figure 34: Top and Bottom Views of the Module

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.

8 Storage, Manufacturing and Packaging

8.1. 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. Shelf life (in a vacuum-sealed packaging): 12 months in Recommended Storage Condition.

3. Floor life: 168 hours [20] in a factory 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 dry 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 mentioned above;
   - 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;
   - The module must be soldered to PCB within 24 hours after the baking, otherwise it should be put in a dry environment such as in a dry cabinet.

[20] 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*. Do not unpack the modules in large quantities until they are 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. 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.

8.2. Manufacturing and Soldering

Push the squeegee to apply the solder paste on the surface of stencil, thus making the paste fill the stencil openings and then penetrate to the PCB. 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 0.13–0.15 mm. For more details, see ***document [6]***.

The recommended 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 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. .

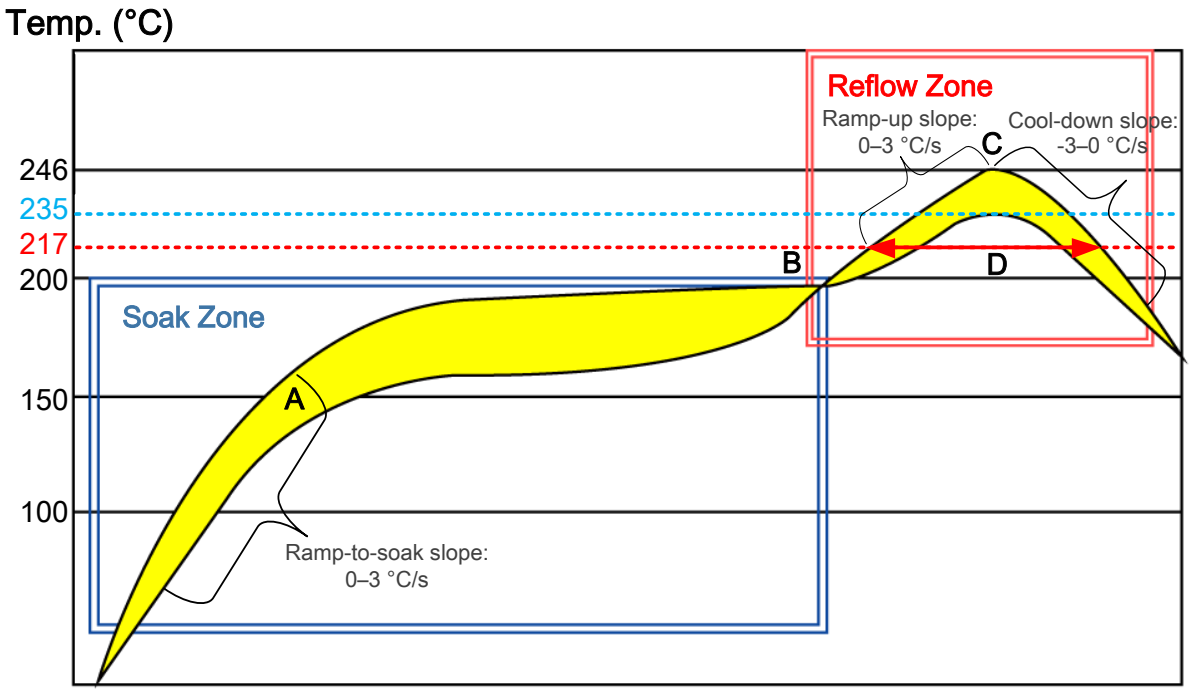


Figure 35: Recommended Reflow Soldering Thermal Profile

Table 37: Recommended Thermal Profile Parameters

Factor	Recommended Value
Soak Zone	
Ramp-to-soak slope	0–3 °C/s
Soak time (between A and B: 150 °C and 200 °C)	70–120 s
Reflow Zone	
Ramp-up slope	0–3 °C/s
Reflow time (D: over 217°C)	40–70 s
Max. temperature	235–246 °C
Cool-down slope	-3–0 °C/s
Reflow Cycle	
Max. reflow cycle	1

NOTE

1. The above profile parameter requirements are for the measured temperature of the solder joints. Both the hottest and coldest spots of solder joints on the PCB should meet the above requirements.
2. 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.
3. Avoid using ultrasonic technology for module cleaning since it can damage crystals inside the module.
4. Due to the complexity of the SMT process, please contact Quectel Technical Support in advance for any situation that you are not sure about, or any process (e.g. selective soldering, ultrasonic soldering) that is not mentioned in ***document [6]***.

8.3. Packaging Specifications

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

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

8.3.1. Carrier Tape

Dimension details are as follow:

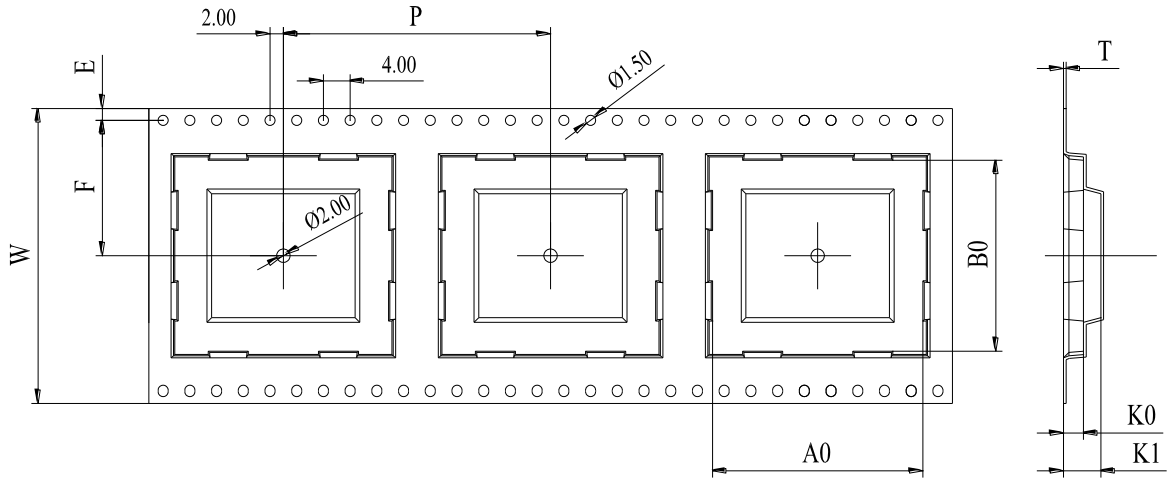


Figure 36: Carrier Tape Dimension Drawing

Table 38: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
44	32	0.35	22.8	26.8	3.1	6.9	20.2	1.75

8.3.2. Plastic Reel

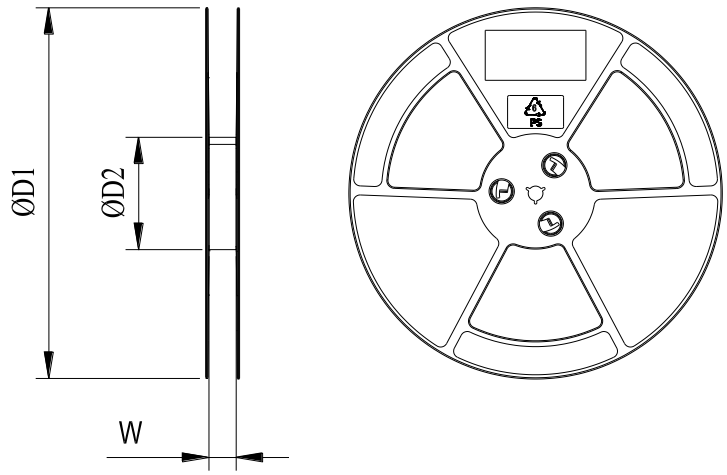


Figure 37: Plastic Reel Dimension Drawing

Table 39: Plastic Reel Dimension Table (Unit: mm)

øD1	øD2	W
330	100	44.5

8.3.3. Mounting Direction

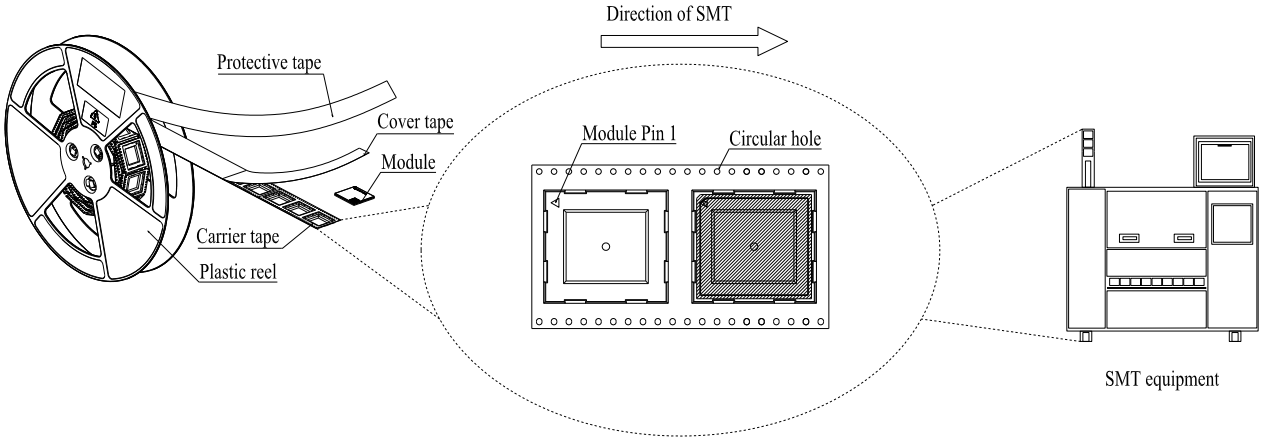
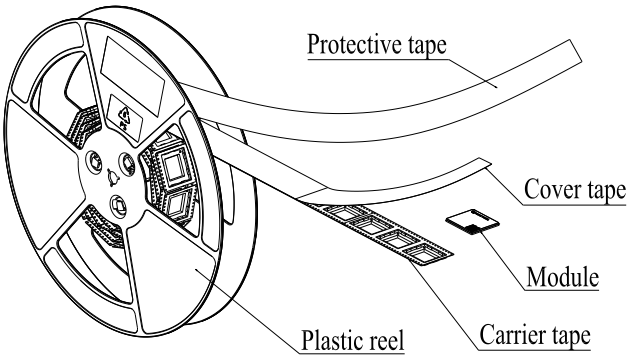


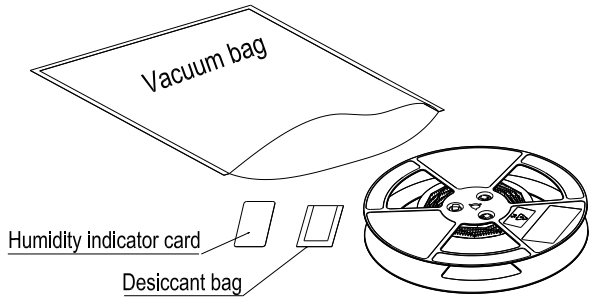
Figure 38: Mounting Direction

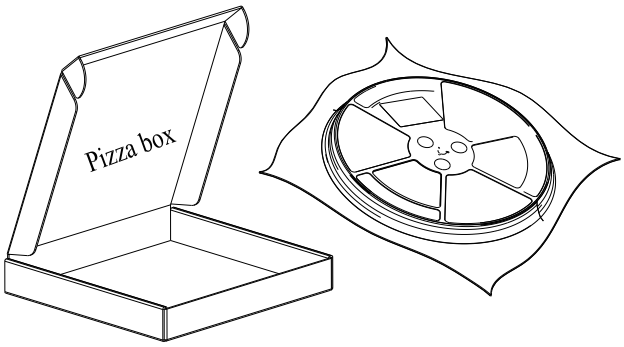
8.3.4. Packaging Process



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, 1 humidity indicator card and 1 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 carton box and seal it. 1 cartoon box can pack 1000 modules.

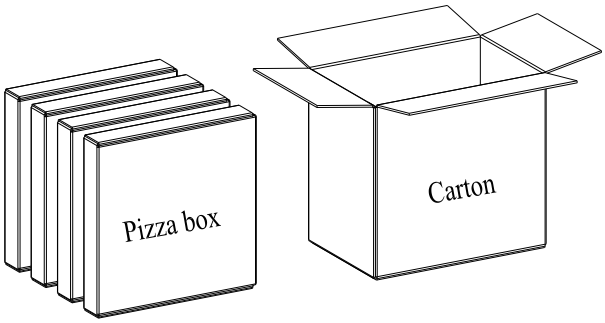


Figure 39: Packaging Process

9 Appendix References

Table 40: Related Documents

Document Name
[1] Quectel_UMTS&LTE_EVB_User_Guide
[2] Quectel_BG96_AT_Commands_Manual
[3] Quectel_BG96_QCFG_AT_Commands_Manual
[4] Quectel_BG96_GNSS_AT_Commands_Manual
[5] Quectel_RF_Layout_Application_Note
[6] Quectel_Module_SMT_Application_Note

Table 41: Terms and Abbreviations

Abbreviation	Description
8-PSK	8-Phase Shift Keying
ADC	Analog-to-digital Converter
AMR	Adaptive Multi-rate
ASM	Antenna Switch Modules
bps	Bits Per Second
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CTS	Clear To Send
DCE	Data Communications Equipment
DFOTA	Delta Firmware Upgrade Over The Air

DL	Downlink
DRX	Discontinuous Reception
DTE	Data Terminal Equipment
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EDGE	Enhanced Data Rates for GSM Evolution
e-I-DRX	Extended Idle Mode Discontinuous Reception
EPC	Evolved Packet Core
EGPRS	Enhanced General Packet Radio Service
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
ESR	Equivalent Series Resistance
FDD	Frequency Division Duplex
FR	Full Rate
FTP(S)	File Transfer Protocol (Secure)
GLONASS	Global Navigation Satellite System (Russia)
GMSK	Gaussian Minimum Shift Keying
GNSS	Global Navigation Satellite System
GPIO	General-Purpose Input/Output
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HSS	Home Subscriber Server
HTTP(S)	Hypertext Transfer Protocol
I/O	Input/Output

LED	Light Emitting Diode
LDO	Low-dropout Regulator
LGA	Land Grid Array
LNA	Low Noise Amplifier
LTE	Long Term Evolution
MCS	Modulation and Coding Scheme
MCU	Microcontroller Unit
ME	Mobile Equipment
MLCC	Multi-layer Ceramic Chip Capacitor
MO	Mobile Originated
MQTT	Message Queuing Telemetry Transport
MS	Mobile Station (GSM engine)
MSL	Moisture Sensitivity Levels
MT	Mobile Terminated
NITZ	Network Identity and Time Zone
NMEA	NMEA (National Marine Electronics Association) 0183 Interface Standard
PA	Power Amplifier
PAP	Password Authentication Protocol
PCB	Printed Circuit Board
PCM	Pulse Code Modulation
PDN	Packet Data Network
PDU	Protocol Data Unit
PING	Packet Internet Groper
PMIC	Power Management IC
PPP	Point-to-Point Protocol

PSM	Power Saving Mode
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
Rx	Receive
SAW	Surface Acoustic Wave
SISO	Single Input Single Output
SMD	Surface Mount Device
SMS	Short Message Service
SSL	Secure Sockets Layer
TAU	Tracking Area Update
TCP	Transmission Control Protocol
TDD	Time Division Duplexing
TLS	Transport Layer Security
TTFF	Time to First Fix
TX	Transmitting Direction
UART	Universal Asynchronous Receiver/Transmitter
UDP	User Datagram Protocol
UE	User Equipment
UL	Uplink
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
VSWR	Voltage Standing Wave Ratio