BG950A-GL&BG951A-GL Hardware Design

LPWA Module Series

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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 emergent 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
-	2021-07-07	Lex LI/ Ben JIANG	Creation of the document
1.0.0	2021-07-07	Lex LI/ Ben JIANG	Preliminary
1.0.1	2021-11-04	Lex LI/ Ben JIANG	Preliminary: 1. Updated pin 27 from AUX/GNSS_TXD into CLI/GNSS_TXD; Updated pin 28 from AUX/GNSS_RXD into CLI/GNSS_RXD; Updated pin 94 from RESERVED into CLI_RXD; Updated pin 95 from RESERVED into CLI_TXD; Updated pin 75 from RESERVED into GNSS_BOOT; Updated pin 76 from RESERVED into GNSS_NRST; Updated pin 97 from RESERVED into GNSS_EN; Updated pin 98 from RESERVED into SFNIND_1PPS. 2. Added the weight of BG950A-GL&BG951A-GL (Table 2). 3. Added the GNSS function description of BG951A-GL (Table 3). 4. Updated the USB serial driver information (Table 4). 5. Added the block diagram of BG951A-GL (Figure 2). 6. Updated the power up timing (Figure 9). 7. Updated the power down timing in (Figure 10&11) 8. Added the recovery mode (Chapter 3.1&Chapter 3.6). 9. Added the steps to let the module enter e-I-DRX mode (Chapter 3.4). 10. Updated the description of sleep mode (Chapter 3.5). 11. Updated the description of the PON_TRIG pin (Chapter 3.3&Chapter 3.11). 12. Updated the information UART interface (Table 4&Chapter 4.3).

	13. Updated the reference design of PSM_IND, NET_STATUS and STATUS (Figure 22&Figure 23&Figure 24). 14. Added the description of GNSS layout guidelines (Chapter 5.3). 15. Updated the power consumption of BG950A-GL (Chpater 6.3). 16. Added the top views of BG951A-GL (Chapter 7.3) 17. Updated the packaging specifications (Chpater 8.3).

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1 Introduction

This document defines BG950A-GL & BG951A-GL modules and describes their air interfaces and hardware interfaces which connected to your applications.

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

1.1. Special Mark

Table 1: Special Mark

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.

2 Product Overview

BG950A-GL/BG951A-GL module is an embedded IoT (LTE Cat M1, LTE Cat NB1/Cat NB2*) wireless communication module. It provides data connectivity on LTE HD-FDD network, and supports half-duplex operation in LTE network. It also provides GNSS and voice* [1] functionality to meet your specific application demands.

BG950A-GL and BG951A-GL modules are industrial-grade modules for industrial and commercial applications only.

BG950A-GL/BG951A-GL module is an SMD type module which can be engineered into M2M applications, such as smart metering, tracking system, security, wireless POS, and other wearable devices, etc. Related information and details are listed in the table below:

Table 2: Brief Introduction of BG950A-GL & BG951A-GL Modules

Categories	
Packaging and pins number	LGA;102 pieces
Dimensions	(23.6 ±0.2) mm × (19.9 ±0.2) mm × (2.2 ±0.2) mm
Weight	Approx.2.15 g
Wireless functions	LTE and GNSS
Variants	BG950A-GL, BG951A-GL

[1] BG950A-GL & BG951A-GL supports VoLTE* (Voice over LTE) under LTE Cat M1.

2.1. Frequency Bands and Functions

Table 3: Wireless Network Type

Module	Supported Bands [2]	Power Class	GNSS
BG950A-GL	**Cat M1 [3]:** LTE HD-FDD: B1/B2/B3/B4/B5/B8/B12/B13/B18/B19/B20/ B25/B26/B27/B28/B66	Power Class 3 (23 dBm ± 2.7 dB)	GPS, GLONASS
BG951A-GL	**Cat NB1/NB2* [4]:** LTE HD-FDD: B1/B2/B3/B4/B5/B8/B12/B13/B17/B18/B19/ B20/B25/B28/B66		GPS, GLONASS, BeiDou, Galileo, QZSS, SBAS.

NOTE

Please noted that BG950A-GL integrates the GNSS function inside the baseband chip, while for BG951A-GL, the internal baseband chip and GNSS chip are separated. Therefore, BG950A-GL does not support concurrent operation of LTE and GNSS, however, LTE and GNSS are concurrency for BG951A-GL.

2.2. Key Features

Table 4: Key Features

Features	Details
Power Supply	● Supply voltage: 2.2–4.35 V ● Typical supply voltage: 3.3 V
SMS*	● Text and PDU mode ● Point-to-point MO and MT ● SMS cell broadcast ● SMS storage: ME by default

[2] LTE HD-FDD B26 and B27 are supported by LTE Cat M1 only.
[3] BG950A-GL and BG951A-GL support VoLTE* (Voice over LTE) under LTE Cat M1.
[4] LTE Cat NB2* is backward compatible with LTE Cat NB1.

(U)SIM Interface	Supports 1.8 V (U)SIM card only
Audio Features	● Supports one digital audio interfaces: PCM and I2C ● LTE: VoLTE* under LTE Cat M1
PCM Interface*	● Support one digital audio interface: PCM interface for VoLTE* only ● Used for audio function with external codec
I2C Interface*	● One I2C interface ● Multi-master mode is not supported
USB Interface*	● Compliant with USB 2.0 specifications ● Used AT command communication, data transmission, software debugging and firmware upgrade ● USB serial driver: – Windows 7/8/8.1/10 – Linux 2.6–5.12 – Android 4.x/5.x/6.x/7.x/8.x/9.x/10.x/11.x system
UART Interfaces	**Main UART:** ● Used for AT command communication and data transmission ● Baud rate: 115200 bps baud by default ● The default frame format is 8N1 (8 data bits, no parity, 1 stop bit) ● Supports RTS and CTS hardware flow control **CLI UART:** ● Used for firmware upgrade, software debugging, log output, GNSS data and NMEA sentences output ● 115200 bps baud rate by default ● The default frame format is 8N1 (8 data bits, no parity, 1 stop bit) ● Supports RTS and CTS hardware flow control **Debug UART:** ● Used for RF calibration and log output ● 961200 bps baud rate by default ● The default frame format is 8N1 (8 data bits, no parity, 1 stop bit) ● Supports RTS and CTS hardware flow control **CLI/GNSS UART:** ● Used for GNSS data and NMEA sentences output ● 115200 bps baud rate by default
Network Indication	NET_STATUS to indicate network connectivity status.
AT Commands	● *3GPP TS 27.007* and *3GPP TS 27.005* AT commands ● Quectel enhanced AT commands
Antenna Interface	● Main antenna interface (ANT_MAIN) ● GNSS antenna interface (ANT_GNSS) 50 Ω impedance
Transmitting Power	Class 3 (23 dBm ± 2.7 dB) for LTE HD-FDD bands
LTE Features	● Support 3GPP Rel-14* ● Supports LTE Cat M1 and LTE Cat NB1/NB2*

	● Supports 1.4 MHz RF bandwidth for LTE Cat M1 ● Support 200 kHz RF bandwidth for LTE Cat NB1/NB2* ● Cat M1: 588 kbps (DL)/1119 kbps (UL) ● Cat NB1: 27.2 kbps (DL)/62.5 kbps (UL) ● Cat NB2*: 127 kbps (DL)/158 kbps (UL)
Internet Protocol Features	● Support PPP/TCP/UDP/SSL/MQTT/FTP(S)/HTTP(S)/LwM2M/IPv4/IPv6/ TLS/DTLS/PING/CoAP/NITZ protocols ● Supports PAP and CHAP for PPP connections
GNSS Features	● BG950A-GL: supports GPS, GLONASS ● BG951A-GL: supports GPS, GLONASS, BeiDou, Galileo, QZSS, SBAS
Temperature Range	● Operating temperature range [5]: -35 to +75 °C ● Extended temperature range [6]: -40 to +85 °C ● Storage temperature range: -40 to +90 °C
Firmware Upgrade	● CLI UART interface ● USB 2.0 interface* ● DFOTA
RoHS	All hardware components are fully compliant with EU RoHS directive

2.3. Functional Diagram

The following figure shows the block diagrams of the modules and illustrates the major functional parts.

- Power management
- Baseband
- Radio frequency
- Peripheral interface

[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* and data transmission, 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.

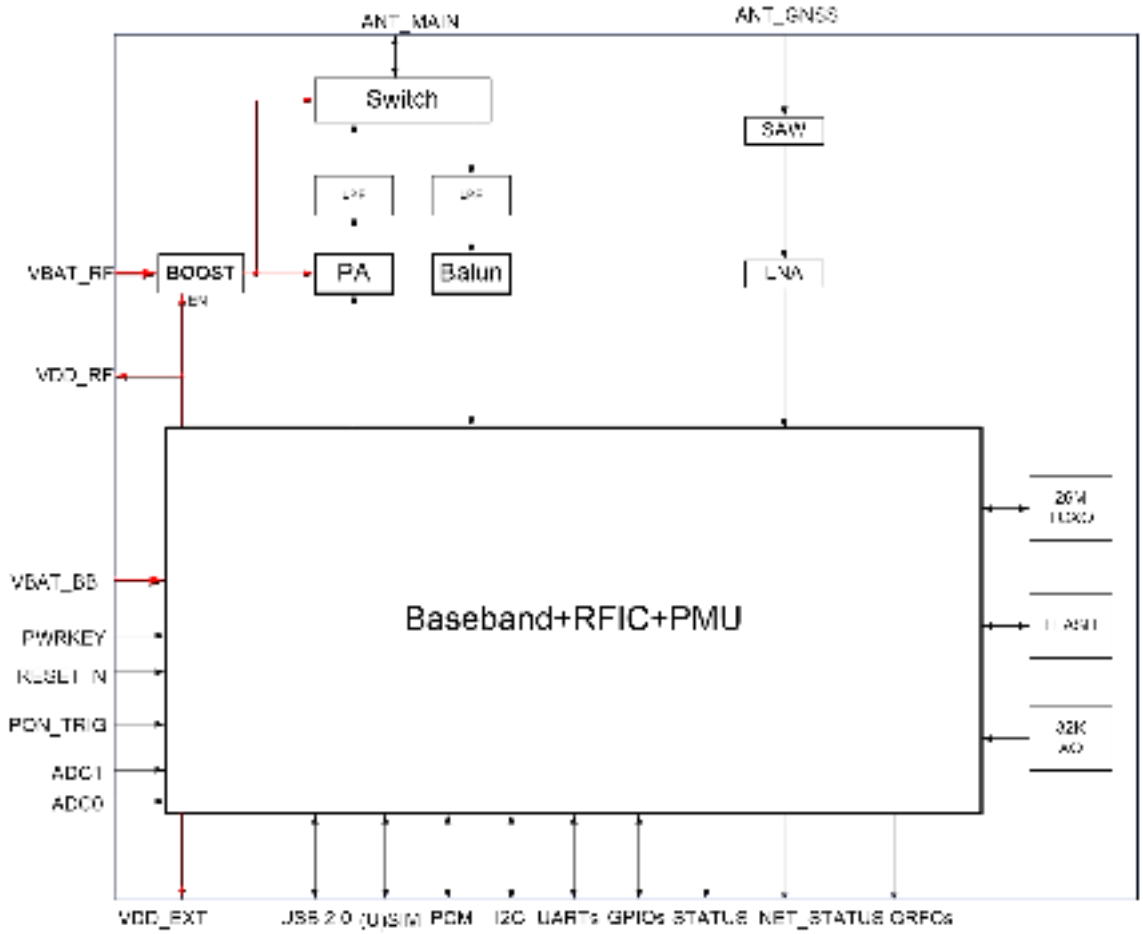


Figure 1: Functional Diagram of BG950A-GL

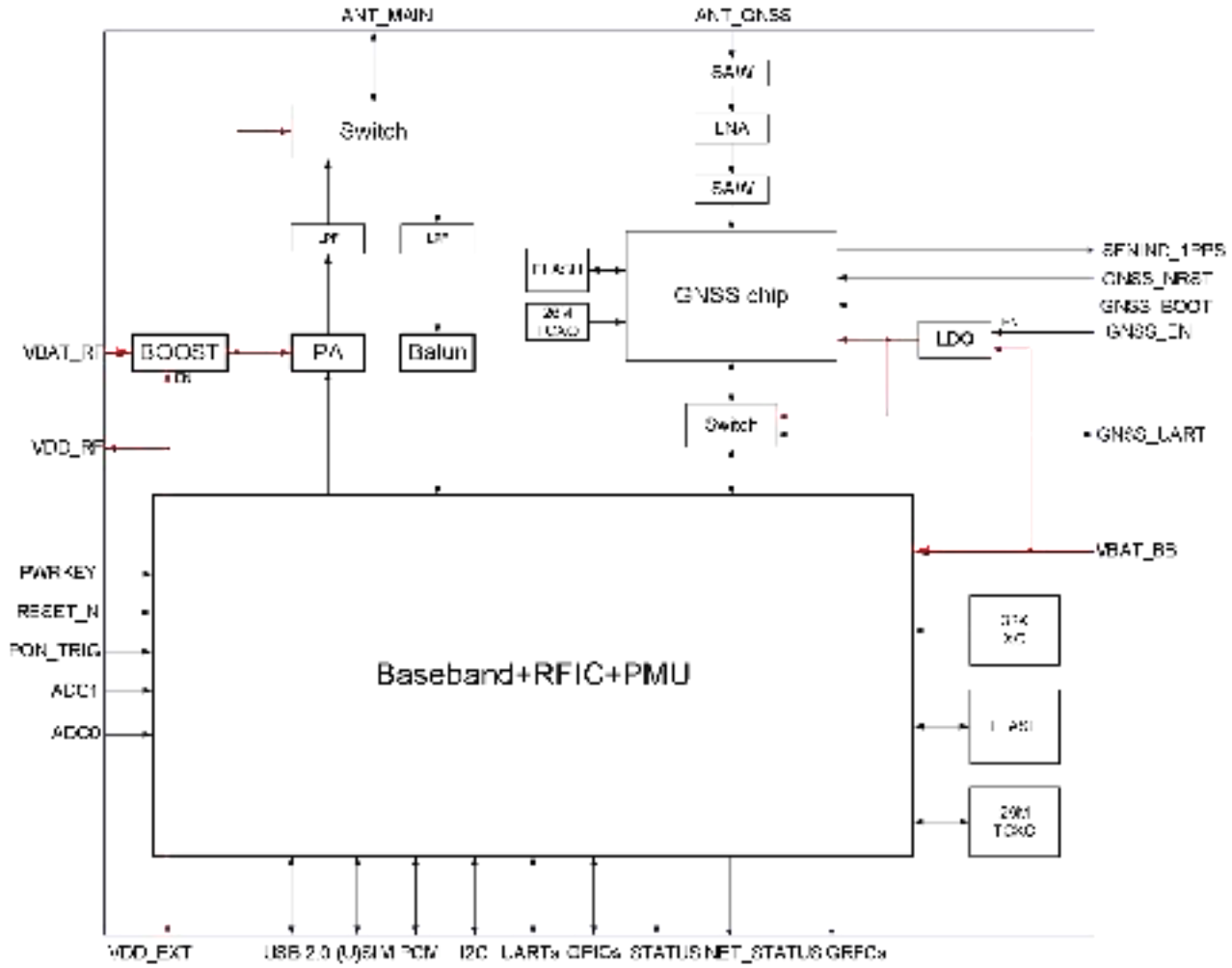


Figure 2: Functional Diagram of BG951A-GL

NOTE

PCM and I2C interfaces are used for VoLTE* only.

2.4. Pin Assignment

The following figure illustrates the pin assignment of BG950A-GL and BG951A-GL.

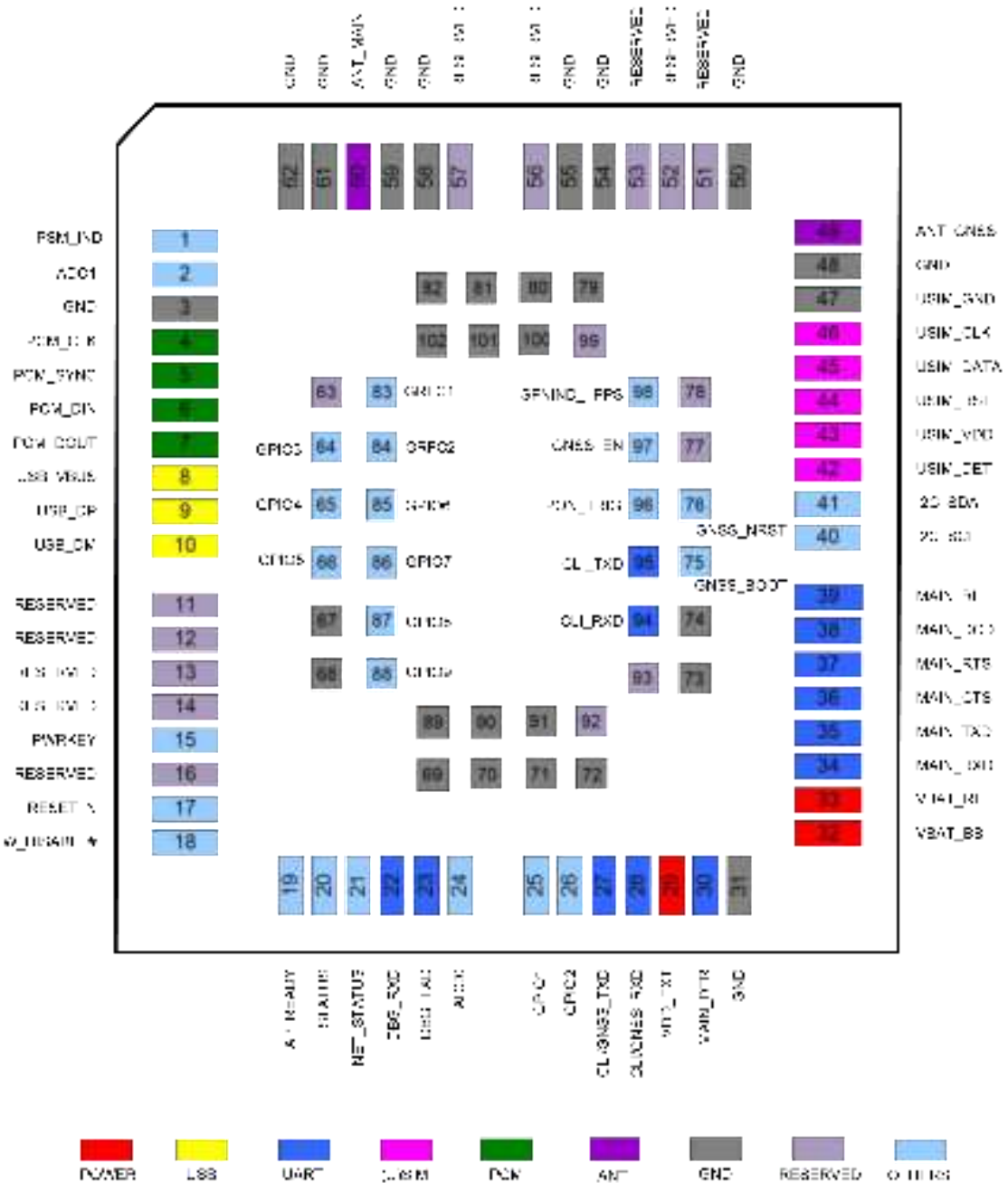


Figure 3: Pin Assignment of BG950A-GL & BG951A-GL (Top View)

NOTE

1. ADC input voltage must not exceed 1.8 V.
2. Keep all RESERVED pins and unused pins unconnected.
3. GND pins should be connected to ground in the design.
4. PCM and I2C interfaces are used for VoLTE* only.
5. Only BG951A-GL supports GNSS_BOOT (pin 75), GNSS_NRST (pin 76), GNSS_EN (pin 97), SFNIND_1PPS (pin 98).
6. For BG950A-GL, pin 27 and pin 28 can only be used as CLI UART interface. When pin 27 and pin 28 are used as CLI_TXD and CLI_RXD, the two pins should be connected to pin 95 and pin 94 respectively inside the module. For BG951A-GL, pin 27 and pin 28 can only be used as GNSS UART interface.

2.5. Pin Description

The following table shows the DC characteristics and pin descriptions.

Table 5: I/O Parameters Definition

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

Table 6: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT_BB	32	PI	Power supply for the module's baseband part	Vmax = 4.35 V Vmin = 2.2 V Vnom = 3.3 V	See NOTE 1.
VBAT_RF	33	PI	Power supply for the module's RF part		See NOTE 1.
VDD_EXT	29	PO	Provide 1.8 V for external circuits	Vnom = 1.8 V $I_O$max = 50 mA	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	V_{IL}max = 0.3 V V_{IH}min = 1.0 V	Internally pulled up with a 470 kΩ resistor.
Reset					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESET_N	17	DI	Reset the module	V_{IL}max = 0.3 V V_{IH}min = 1.3 V	Internally pulled up with a 470 kΩ resistor.
Status Indication					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PSM_IND	1	DO	Indicate the module's power saving mode	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	1.8 V power domain. If unused, keep these pins open.
STATUS	20	DO	Indicate the module's operation status		
NET_STATUS	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	Vnom = 5.0 V	Typical 5.0 V
USB_DP	9	AIO	USB differential data (+)	Vmax = 4.1 V Vmin = -0.2 V	Compliant with USB 2.0 standard specification.
USB_DM	10	AIO	USB differential data (-)		

					Require differential impedance of 90 Ω.
(U)SIM Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USIM_DET	42	DI	(U)SIM card hot-plug detect	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 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	Vmax = 1.9 V Vmin = 1.7 V	Only 1.8 V (U)SIM card is supported.
USIM_RST	44	DO	(U)SIM card reset	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	1.8 V power domain.
USIM_DATA	45	DIO	(U)SIM card data	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V V_{OL}max = 0.36 V V_{OH}min = 1.44 V	
USIM_CLK	46	DO	(U)SIM card clock	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	
USIM_GND	47		Specified ground for (U)SIM card		
Main UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
MAIN_DTR	30	DI	Main UART data terminal ready	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	1.8 V power domain. If these pins are unused, keep them open.
MAIN_RXD	34	DI	Main UART receive		
MAIN_TXD	35	DO	Main UART transmit	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	
MAIN_CTS	36	DO	DTE clear to send signal from DCE (Connect to DTE's RTS)		
MAIN_RTS	37	DI	DTE request to send signal from DCE (Connect to DTE's RTS)	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	
MAIN_DCD	38	DO	Main UART data carrier detect	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	
MAIN_RI*	39	DO	Main UART ring indication		

CLI UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
CLI_RXD	94	DI	CLI UART receive	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	1.8 V power domain. If these pins are unused, keep them open.
CLI_TXD	95	DO	CLI UART transmit	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	
DBG UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DBG_RXD	22	DI	Debug UART receive	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	1.8 V power domain. If these pins are unused, keep them open.
DBG_TXD	23	DO	Debug UART transmit	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	
CLI/GNSS UART Interface [7]					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
CLI/GNSS_TXD	27	DO	CLI/GNSS UART transmit	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	1.8 V power domain. If these pins are unused, keep them open.
CLI/GNSS_RXD	28	DI	CLI/GNSS UART receive	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	
PCM Interface*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PCM_CLK	4	DO	PCM clock	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	1.8 V power domain. If unused, keep them open.
PCM_SYNC	5	DO	PCM data frame sync		
PCM_DIN	6	DI	PCM data input	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	
PCM_DOUT	7	DO	PCM data output	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	
I2C Interface*					

BG951A-GL module, pin 27 and pin 28 can only be used as GNSS UART 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. It is recommended to use VDD_EXT as the power supply of the external pull-up resistor. 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.
GPIO Interfaces*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GPIO1	25	DIO	General-purpose input/output	V_{OL}max = 0.36 V V_{OH}min = 1.44 V V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep these pins open.
GPIO2	26	DIO			
GPIO3	64	DIO			
GPIO4	65	DIO			
GPIO5	66	DIO			
GPIO6	85	DIO			
GPIO7	86	DIO			
GPIO8	87	DIO			
GPIO9	88	DIO			
ADC Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ADC0	24	AI	General-purpose ADC interface	Voltage range: 0–1.8 V	If unused, keep them open.

ADC1	2	AI	General-purpose ADC interface	Voltage range: 0–1.8 V	
Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
W_DISABLE#	18	DI	Airplane mode control	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	1.8 V power domain. Pulled up by default. When it is at low level, the module can enter airplane mode. If unused, keep this pin open.
AP_READY*	19	DI	Application processor sleep state detect	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
PON_TRIG	96	DI	Used for main UART function control and for entering/exiting e-I-DRX, PSM, sleep and power off modes	V_{IL}min = -0.2 V V_{IL}max = 0.3 V V_{IH}min = 1 V V_{IH}max = 1.98 V	1.8 V power domain. Pulled-down by default.
GRFC Interface*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GRFC1	83	DO	Generic RF controller	V_{OL}max = 0.36 V V_{OH}min = 1.44 V V_{OH}max = 2.0 V	1.8 V power domain. If these pins are unused, keep them open.
GRFC2	84	DO	Generic RF controller		
GNSS Interface [8]					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GNSS_BOOT	75	DI	Force the GNSS chip of the module into emergency download mode	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
GNSS_NRST	76	DI	Reset input signal of the GNSS chip	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V	1.8 V power domain. If unused, keep this

[8] Only BG951A-GL supports GNSS_BOOT (pin 75), GNSS_NRST (pin 76), GNSS_EN (pin 97), SFNIND_1PPS (pin 98).

				V_{IH}max = 2.0 V	pin open.
GNSS_EN	97	DI	Enable internal GNSS chip	V_{IL}min = -0.2 V V_{IL}max = 0.54 V V_{IH}min = 1.26 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
SFNIND_1PPS	98	DO	One pulse per second	V_{OL}max = 0.36 V V_{OH}min = 1.44 V	Synchronized at rising edge, the pulse width is 100 ms. If unused, please keep this pin open.

RESERVED Pins

Pin Name	Pin No.	Comment
RESERVED	11–14, 16, 51–53, 56, 57, 63, 75, 76, 77, 78, 92–93, 97–99	Keep these pins open.

NOTE

1. When the module starts up normally, in order to ensure full-function mode, the minimum power supply voltage should be higher than 2.2 V. For every VBAT transition/re-insertion from 0 V, VBAT slew rate < 25 mV/μs. In order to ensure that the module can start normally, pull down PWRKEY to turn on the module after VBAT remains stable for 100 ms.
2. After entering PSM or power off mode, it is prohibited to provide any external voltage to the module's I/O ports that are not defined as a wake-up source (PON_TRIG pin).
3. PCM and I2C interfaces are for VoLTE* only.
4. Keep all RESERVED pins and unused pins unconnected.

2.6. EVB

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

3 Operating Characteristics

3.1. Operating Modes

The table below outlines operating modes of the module.

Table 7: Overview of Operating Modes

Mode	Details	
Normal Operation	Idle	The module remains registered on network, and is ready to send and receive data. In this mode, the software is active.
	Connected	The module remains registered on network, and is ready to send and receive data. In this mode, the software is active.
Extended Idle Mode DRX (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 mode, 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 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_BB and VBAT_RF) remains applied.	
Power Saving Mode (PSM)	PSM 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. The current consumption is reduced to a minimized level.	
Recovery Mode	The module can burn firmware with an empty serial flash, or recover from firmware malfunction. For more details, see ***Chapter 3.6.***	

NOTE

During e-I-DRX, it is recommended to use the main UART interface for data communication, as the use of USB interface* will increase power consumption.

3.2. Airplane Mode

When the module enters airplane mode, the RF function will be disabled, 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 let the module enter airplane mode.

Software:

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

- **AT+CFUN=0:** Minimum functionality mode. Both RF and (U)SIM 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 of the command, see ***document [2].***
2. For BG950A-GL, the execution of **AT+CFUN** will affect GNSS function. Since the module does not support concurrent operation of WWAN and GNSS, the GNSS function can be used when **<fun>**=0 or 4, but cannot be used when **<fun>**=1.
3. For BG951A-GL, the execution of **AT+CFUN** will not affect GNSS function.

3.3. Power Saving Mode (PSM)

BG950A-GL/BG951A-GL 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, BG950A-GL/BG951A-GL module in PSM cannot immediately respond to users' 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**. In this case, driving PON_TRIG low will set the module into PSM.

Any of the following methods can wake up the module from PSM:

- Drive PON_TRIG high and remain it high, the module will wake up from PSM. PON_TRIG is pulled down by default.
- When the T3412 timer expires, the module wakes up from PSM automatically. In this case, the main UART interface is inaccessible until PON_TRIG is pulled high.

NOTE

1. PON_TRIG must be pulled high after executing any PSM wake-up event, otherwise the main UART will be inaccessible. In any case, the main UART interface is inaccessible until PON_TRIG is pulled high.
2. See ***document [3]*** for details about **AT+CPSMS**.

3.4. 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, perform the steps below in sequence to let the module enter

e-I-DRX mode, in which case the main UART interface is inaccessible.

1. Send **AT+CPSMS=0** to disable PSM mode.
2. Send **AT+CEDRXS=1** to enable e-I-DRX mode.
3. Send **AT+QSCLK=2** to enable sleep mode.
4. Drive MAIN_DTR high.
5. Drive PON_TRIG low.

NOTE

1. See ***document [3]*** for details about the above AT commands.
2. Follow the steps for exiting sleep mode to exit e-I-DRX.

3.5. Sleep Mode

BG950A-GL/BG951A-GL can reduce their current consumption to a lower value during the sleep mode. The following sub-chapter describes the power saving procedures of BG950A-GL & BG951A-GL.

3.5.1. UART Application Scenario

If the host communicates with the module via main UART interface, perform the steps below in sequence to let the module enter sleep mode, in which case the main UART interface is not accessible.

1. Send **AT+CFUN=0** to set the module into minimum function mode.
2. Drive MAIN_DTR low.
3. Execute **AT+QSCLK=2** to enable sleep mode.
4. Drive MAIN_DTR high.
5. Drive PON_TRIG low.

When the module is in sleep mode, perform the steps below in sequence to let the module exit sleep mode.

- Drive PON_TRIG high.
- Drive MAIN_DTR low.
- Execute **AT+QSCLK=0** to disable sleep mode.
- Send **AT+CFUN=1** to set the module into minimum function mode.
- Drive MAIN_DTR high.

The figure illustrates the connection between the module and the host.

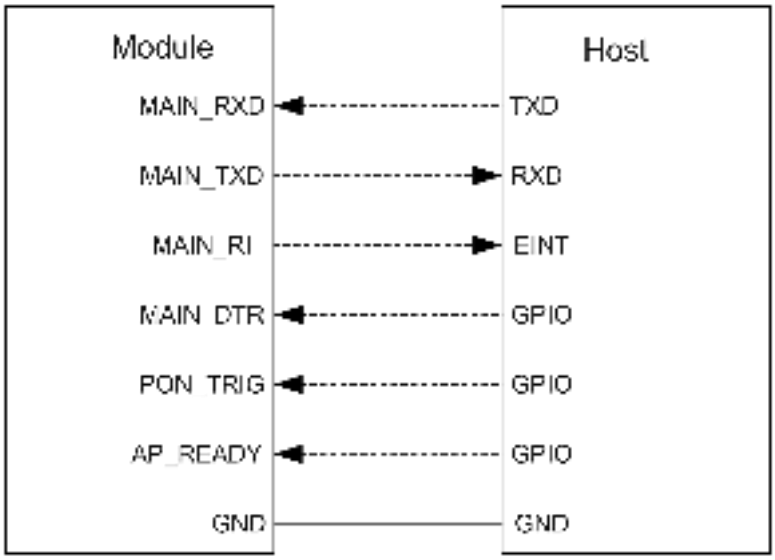


Figure 4: Sleep Mode Application via UART Interface

- When the module has a URC to report, MAIN_RI* will wake up the host. See ***Chapter 4.6.4*** for details about MAIN_RI* behavior.
- After the module is turned on, MAIN_DTR is internally pulled up by default.
- AP_READY* will detect the sleep state of the host (can be configured to high voltage level or low voltage level detection). See **AT+QCFG="apready"** in ***document [2]*** for details.

3.6. Recovery Mode

BG770A-GL provides the recovery mode for firmware upgrade in emergency cases. Recovery mode can force the module to boot via debug UART interface for firmware upgrade.

The following preconditions can set the module into recovery mode.

1. Short-circuit DBG_TXD and DBG_RXD pins.
2. Drive PWRKEY low to turn on the module. In this case the module will enter recovery mode.
3. After the module enters recovery mode successfully, disconnect the connection between DBG_TXD and DBG_RXD.
4. Upgrade firmware via debug UART interface.

NOTE

1. In the design, it is recommended to reserve all the test points of the debug UART interface, and keep DBG_TXD close to DBG_RXD.

2. Ensure that VBAT remains stable for at least 100 ms before pulling down PWRKEY.

3.7. Power Supply

3.7.1. Power Supply Pins

The module provides two VBAT pins for connection with an external power supply.

- One VBAT_RF pin for RF part.
- One VBAT_BB pin for baseband part.

Table 8: Pin Definition of Power Supply

Pin Name	Pin No.	Description	Min.	Typ.	Max.	Unit
VBAT_BB	32	Power supply for the module's baseband part	2.2	3.3	4.35	V
VBAT_RF	33	Power supply for the module's RF part	2.2	3.3	4.35	V
GND	3, 31, 48, 50, 54, 55, 58, 59, 61, 62, 67–74, 79–82, 89–91, 100–102		-	-	-	-

NOTE

For every VBAT transition/re-insertion from 0 V, VBAT slew rate < 25 mV/μs. After the module starts up normally, in order to ensure full-function mode, the minimum power supply voltage should be higher than 2.2 V.

3.7.2. Voltage Stability Requirements

The power supply range of the module is from 2.2 V to 4.35 V. Make sure the input voltage will never drop below 2.2 V.

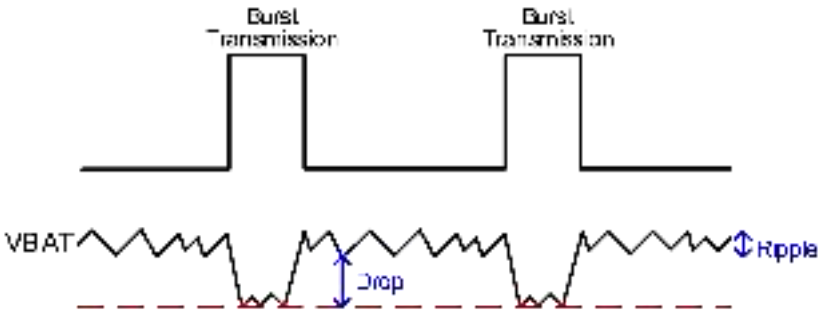


Figure 5: Power Supply Limits During Burst Transmission

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

In addition, to ensure the stability of the power supply, it is necessary to add two high-power TVSs at the front end of each power supply. Reference circuit of power supply is shown as below:

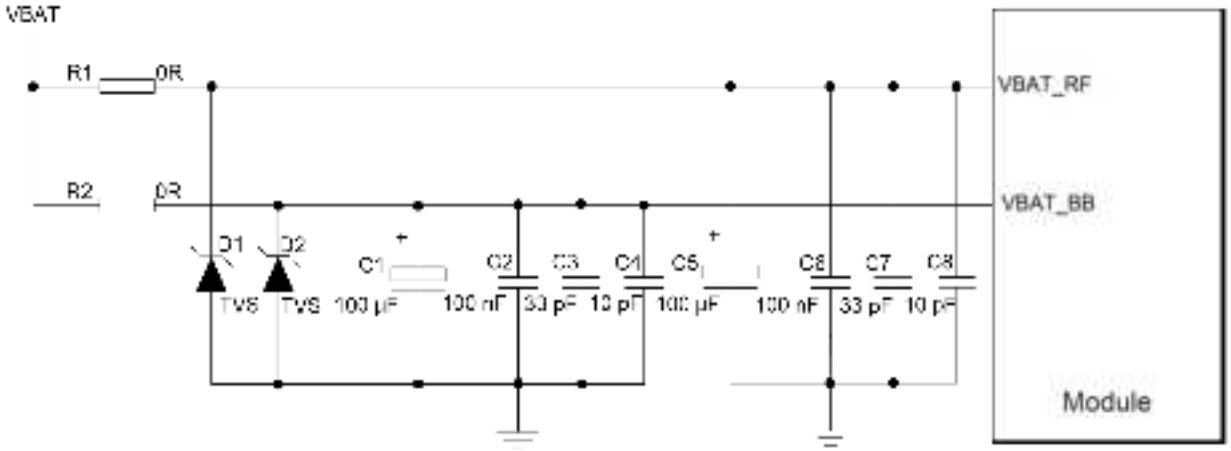


Figure 6: Star Structure of the Power Supply

Power design for a module is critical to its performance. The power supply of the module should be able to provide sufficient current of 0.6 A at least, and it is recommended to select a DC-DC converter chip or an LDO chip with ultra-low leakage current and current output no less than 1.0 A for the power supply design.

3.7.3. Power Supply Monitoring

AT+CBC can monitor the VBAT_BB voltage value. For more details, see ***document [3].***

3.8. Turn On

3.8.1. Turn on the Module with PWRKEY

Table 9: Pin Definition of PWRKEY

Pin Name	Pin No.	I/O	Description	Comment
PWRKEY	15	DI	Turn on/off the module	Internally pulled up with a 470 kΩ resistor.

When the module is in power off mode, driving PWRKEY low for 500–1000 ms and then releasing it will turn on the module. It is recommended to use an open drain/collector driver to control the PWRKEY.

A simple reference design is illustrated in the following figure.

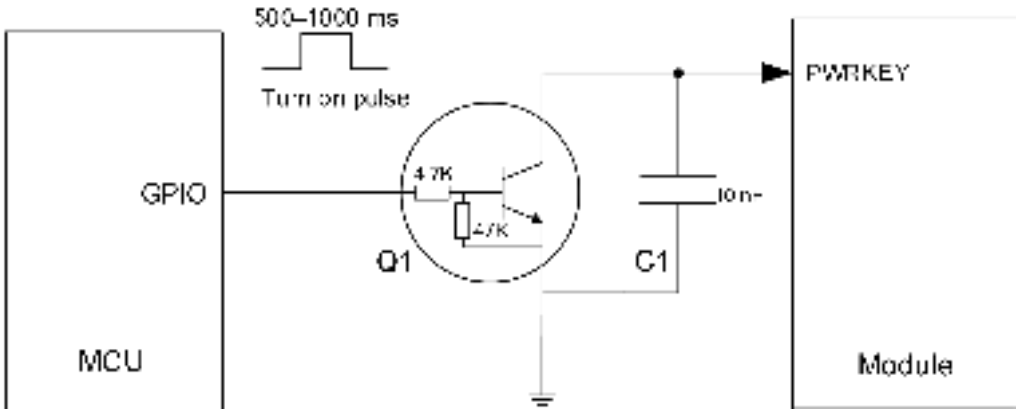


Figure 7: Turn on the Module with Driving Circuit

Another way to control the PWRKEY is by using a button directly. When pressing the button, an electrostatic strike may generate from fingers. Therefore, a TVS component is indispensable to be placed nearby the button for ESD protection.

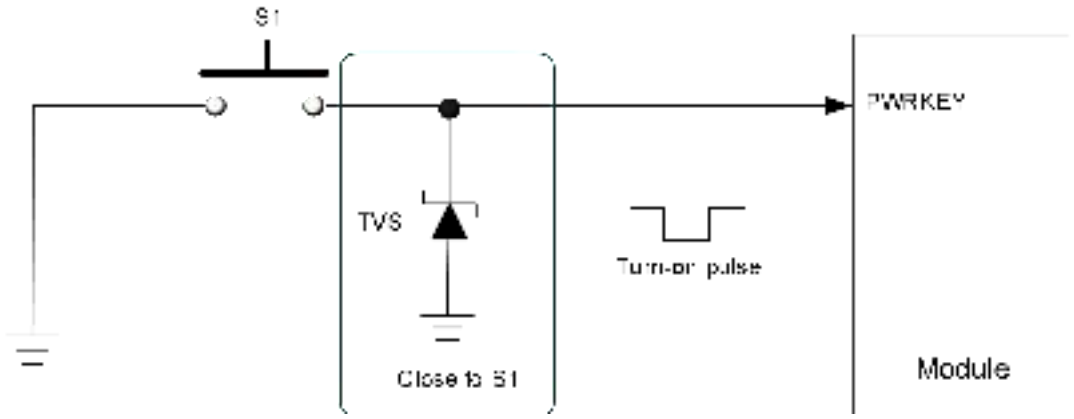


Figure 8: Turn on the Module a Button

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

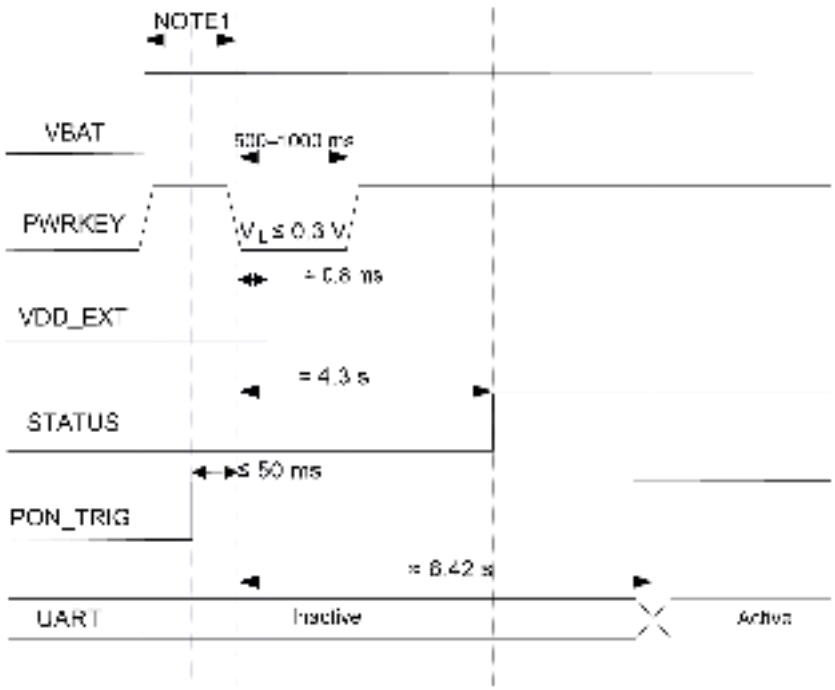


Figure 9: Power-up Timing

NOTE

3. Ensure that VBAT is stable for at least 100 ms before pulling down the PWRKEY.
4. Pull PON_TRIG high before the module is turned on, and then drive PWRKEY low for 500–1000 ms and release, otherwise, the main UART interface will be inaccessible.

3.9. Turn Off

After the module is turned off or enters PSM, do not pull up any I/O pin of the module. Otherwise, the module will have additional power consumption and may have damaged pins. Either of the following methods can be used to turn off the module normally:

- Turn off the module through PWRKEY and PON_TRIG.
- Turn off the module through **AT+QPOWD** and PON_TRIG.

3.9.1. Turn off with PWRKEY and PON_TRIG

When the module is powered on, driving PWRKEY low for 650–1500 ms and then releasing it, and pull down the PON_TRIG with 200 ms, after which the module will execute a power-down procedure.

The power-down timing is illustrated in the following figure.

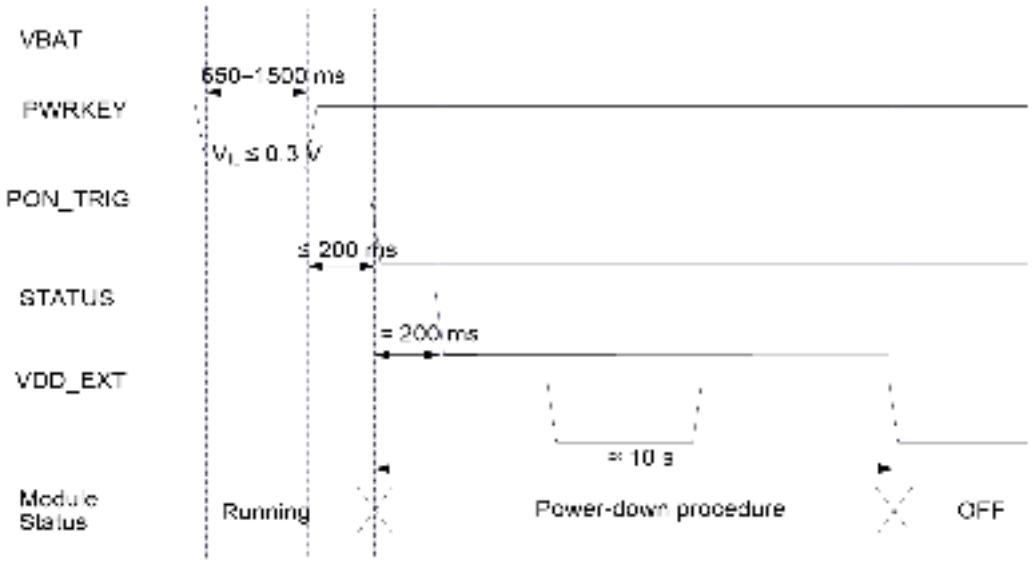


Figure 10: Power-down Timing (PWRKEY & PON_TRIG)

3.9.2. Turn off the Module with AT Command and PON_TRIG

It is also a safe way to use **AT+QPOWD** to turn off the module, which is similar to turning off the module with PWRKEY. After the **AT+QPOWD** is sent, pull down PON_TRIG within 200 ms, and the module will execute the power-down procedure.

See ***document [3]*** for details about **AT+QPOWD**.

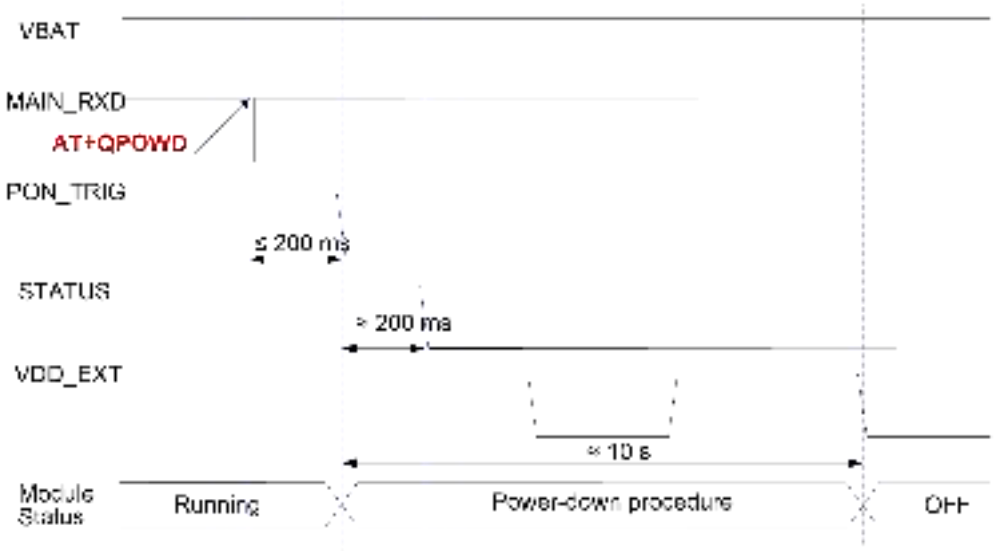


Figure 11: Power-down Timing（AT Command & PON_TRIG）

NOTE

1. To avoid damaging the internal flash, do not switch off the power supply when the module works normally. Only after the module is turned off by PWRKEY & PON_TRIG or AT command & PON_TRIG, the power supply can be cut off.
2. When turning off themodule with AT command, keep PWRKEY at a high level after the execution of power-off command. Otherwise, the module will be turned on again after turned off.

3.10. Reset

The module can be reset by driving RESET_N low for at least 100 ms and releasing it. The RESET_N signal is sensitive to interference, so it is recommended to route the trace as short as possible and surround it with ground.

Table 10: Pin Definition of RESET_N

Pin Name	Pin No.	I/O	Description
RESET_N	17	DI	Reset the module. Internally pulled up with a 470 kΩ resistor.

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

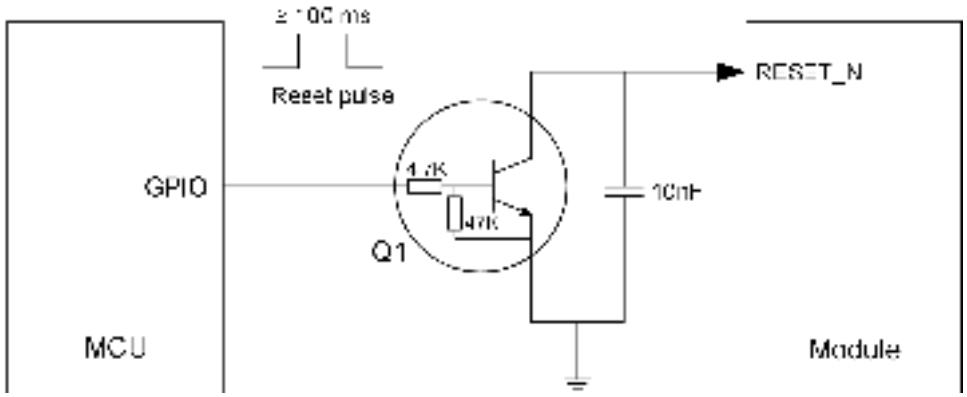


Figure 12: Reference Circuit of RESET_N with Driving Circuit

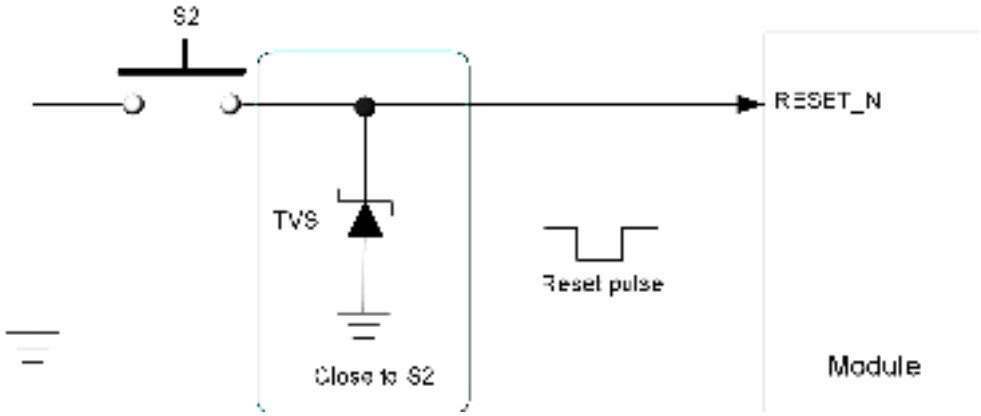


Figure 13: Reference Circuit of RESET_N with a Button

The reset timing is illustrated in the following figure.

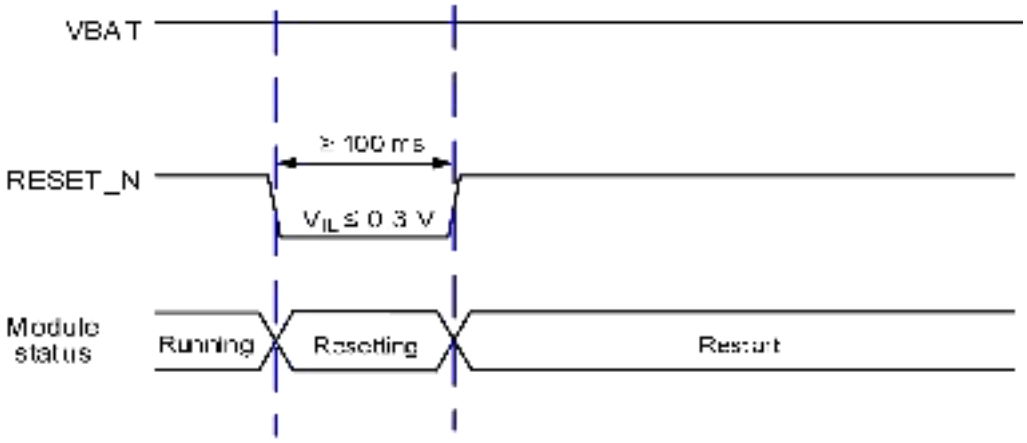


Figure 14: Reset Timing

NOTE

Ensure that there is no large capacitance on RESET_N pin.

3.11. PON_TRIG

BG950A-GL & BG951A-GL modules provide one PON_TRIG pin which is used to wake up the module from PSM.

Table 11: Pin Definition of PON_TRIG

Pin Name	Pin No.	I/O	Description	Comment
PON_TRIG	96	DI	Used for main UART function control and for entering/exiting e-I-DRX, PSM, sleep and power off modes	1.8 V power domain Pull down by default.

PON_TRIG can realize the following functions:

- Control the module to enter or exit PSM mode and sleep mode.
- Enable/disable the main UART interface communication function.
- Used for the turn-on/off application of the module.

PON_TRIG must be designed to allow for external control. A reference circuit is shown in the following figure.

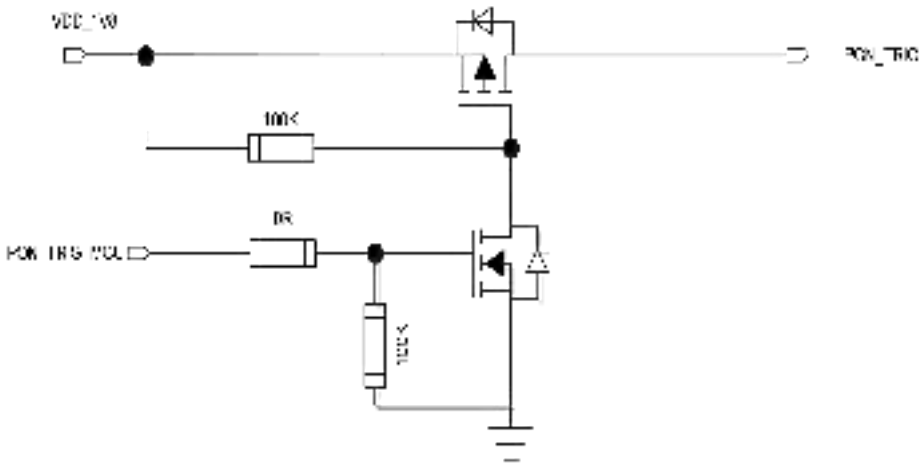


Figure 15: Reference Circuit of PON_TRIG

NOTE

VDD_1V8 is provided by an external LDO.

The following is a brief description about the use of PON_TRIG.

- PON_TRIG is pull down by default. Before the module is turned on, PON_TRIG must be pulled high. Otherwise, the main UART interface will be inaccessible.
- When the module is powered on, pull down PON_TRIG within 200 ms after you send **AT+QPOWED** or drive PWRKEY low, after which the module will excute a power-down procedure. For more details, see ***Chapter 3.9.***
- Pull down PON_TRIG and remain it low in e-I-DRX, PSM, sleep and power off modes. In other cases, pull high PON_TRIG and remain it high to make sure the main UART is accessible. For details about PON_TRIG usage in e-I-DRX and sleep modes, see ***Chapter 3.4*** and ***Chapter 3.5*** respectively.
- After sending **AT+QPSMS** to enable PSM, driving PON_TRIG low will set the module into PSM. Drive PON_TRIG high and remain it high, the module will wake up from PSM. In this case, PON_TRIG must remain high, otherwise the module will re-enter PSM.

4 Application Interfaces

4.1. (U)SIM Interface

BG950A-GL/BG951A-GL support 1.8 V (U)SIM card only. The circuitry of (U)SIM interfaces meet *ETSI* and *IMT-2000* requirements.

Table 12: Pin Definition of (U)SIM Interface

Pin Name	Pin No.	I/O	Description	Comment
USIM_DET	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	Only 1.8 V (U)SIM card is supported.
USIM_RST	44	DO	(U)SIM card reset	1.8 V power domain.
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	

BG950A-GL/BG951A-GL supports (U)SIM card hot-plug via the USIM_DET, and both high-level and low-level detections are supported. The function is disabled by default, and refer to **AT+QSIMDET** in ***document [3]*** for more details.

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

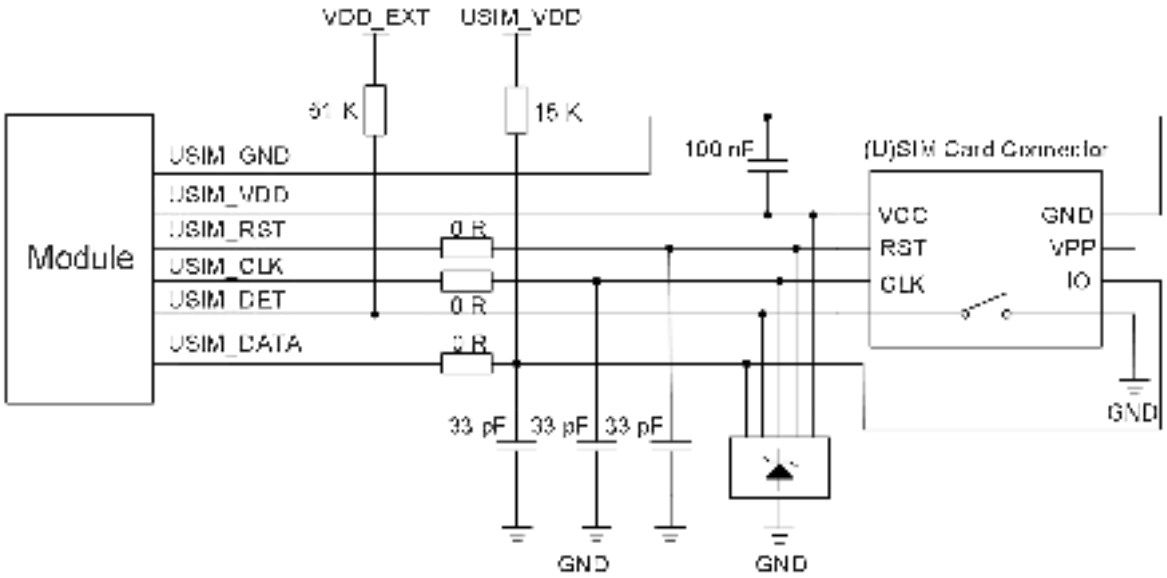


Figure 16: Reference Circuit of (U)SIM Interface with an 8-Pin (U)SIM Card Connector

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

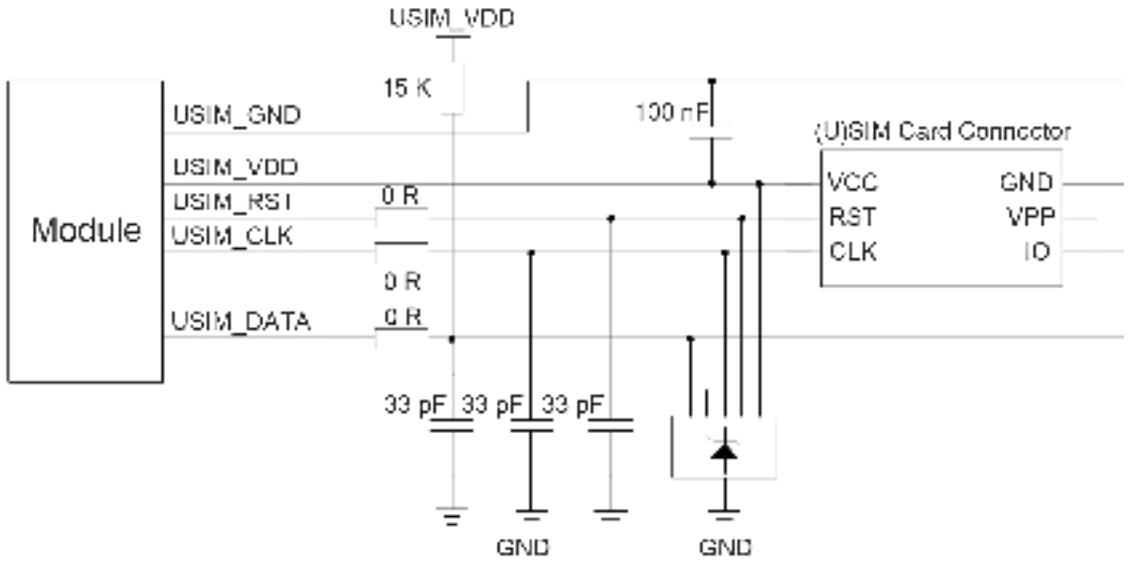


Figure 17: Reference Circuit of (U)SIM Interface with a 6-Pin (U)SIM Card Connector

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

- Keep the placement of (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 VBAT 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 no 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 diode array with parasitic capacitance not exceeding 15 pF. It is recommended to reserve 0 Ω series resistors for the (U)SIM signals of the module to facilitate debugging. 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 occasions are applied, and should be placed close to the (U)SIM card connector.

4.2. USB Interface*

BG950A-GL/BG951A-GL provides one integrated Universal Serial Bus (USB) interface which complies with the USB 2.0 specification and supports full speed mode only. USB interface is used AT command communication, data transmission, software debugging and firmware upgrade.

The following table shows the pin definition of USB interface.

Table 13: 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 (+)	Compliant with USB 2.0 standard specification. Require differential impedance of 90 Ω.
USB_DM	10	AIO	USB differential data (-)	

It is recommended to reserve test points for debugging and firmware upgrading in your designs.

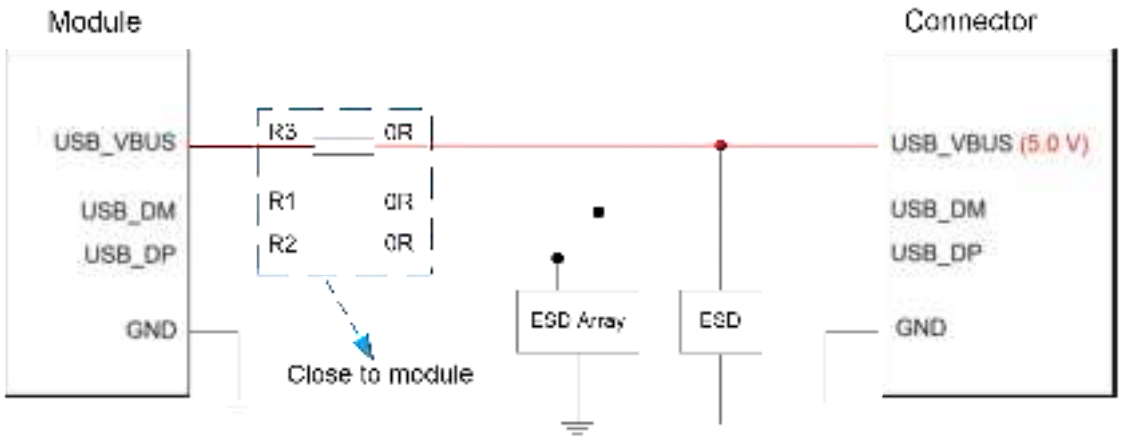


Figure 18: Reference Circuit of USB Application

To ensure the integrity of USB data signals, If possible, reserve a 0 Ω resistor on USB_DP and USB_DM traces respectively. And resistors R1 and R2 should 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, comply with the following principles while designing the USB interface.

- It is important to route the USB signal traces as differential pairs with ground surrounded. 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 device 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 devices as close to the USB connector as possible.
- If possible, reserve a 0 Ω resistor on USB_DP and USB_DM traces respectively.

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

NOTE

After the module is turned off or enters PSM, do not pull up any pin of USB interface. Otherwise, the module will have additional power consumption and may have damaged pins.

4.3. UART Interfaces

BG950A-GL/BG951A-GL module provides four UART interfaces and the following shows their features:

- **Main UART:**
  It supports 9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600 and 3000000 bps baud rates, and the default baud rate is 115200 bps. It is used for AT command communication and data transmission, and supports RTS and CTS hardware flow control. The default frame format is 8N1 (8 data bits, no parity, 1 stop bit).
- **CLI UART:**
  It supports 9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600 and 3000000 bps baud rates, and the default baud rate is 115200 bps. It is used for firmware upgrade, software debugging, log output, GNSS data and NMEA sentences output, and supports RTS and CTS hardware flow control. The default frame format is 8N1 (8 data bits, no parity, 1 stop bit).
- **Debug UART:**
- It supports 921600 bps baud rate by default, and is used for RF calibration and log output, and supports RTS and CTS hardware flow control. The default frame format is 8N1 (8 data bits, no parity, 1 stop bit).
- **CLI/GNSS UART:**
  For BG950A-GL module, this interface can only be used as CLI UART interface. And pin 27 and pin 28 should be connected to pin 95 and pin 94 respectively inside the module. For BG951A-GL module, this interface can only be used as GNSS UART interface. The GNSS UART interface supports 115200 bps baud rate by default, and it is used for GNSS data and NMEA sentences output.

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

Table 14: Pin Definition of Main UART Interface

Pin Name	Pin No.	I/O	Description	Comment
MAIN_DTR	30	DI	Main UART data terminal ready	1.8 V power domain If these pins are unused, keep them open.
MAIN_RXD	34	DI	Main UART receive	
MAIN_TXD	35	DO	Main UART transmit	
MAIN_CTS	36	DO	DTE clear to send signal from DCE (Connect to DTE's RTS)	
MAIN_RTS	37	DI	DTE request to send signal from DCE (Connect to DTE's RTS)	
MAIN_DCD	38	DO	Main UART data carrier detect	
MAIN_RI	39	DO	Main UART ring indication	

Table 15: Pin Definition of CLI UART Interface

Pin Name	Pin No.	I/O	Description	Comment
CLI_TXD	95	DO	CLI UART transmit	1.8 V power domain If these pins are unused, keep them open.
CLI_RXD	94	DI	CLI UART receive	

Table 16: Pin Definition of Debug UART Interface

Pin Name	Pin No.	I/O	Description	Comment
DBG_TXD	23	DO	Debug UART transmit	1.8 V power domain If these pins are unused, keep them open.
DBG_RXD	22	DI	Debug UART receive	

Table 17: Pin Definition of CLI/GNSS UART Interface

Pin Name	Pin No.	I/O	Description	Comment
CLI/GNSS_TXD	27	DO	CLI/GNSS UART transmit	1.8 V power domain If these pins are unused, keep them open.
CLI/GNSS_RXD	28	DI	CLI/GNSS UART receive	

NOTE

AT+IPR can be used to set the baud rate of the main UART interface, and **AT+IFC** can be used to set the hardware flow control (the function is disabled by default). See ***document [3]*** for more details about these AT commands.

The module provides 1.8 V UART interfaces. A voltage-level translator should be used if your application is equipped with a 3.3 V UART interface. It is recommended to use a level-shifting chip without internal pull-up. The voltage-level translator TXB0108PWR provided by *Texas Instruments* is recommended.

The following figure shows a reference design of the main UART interface:

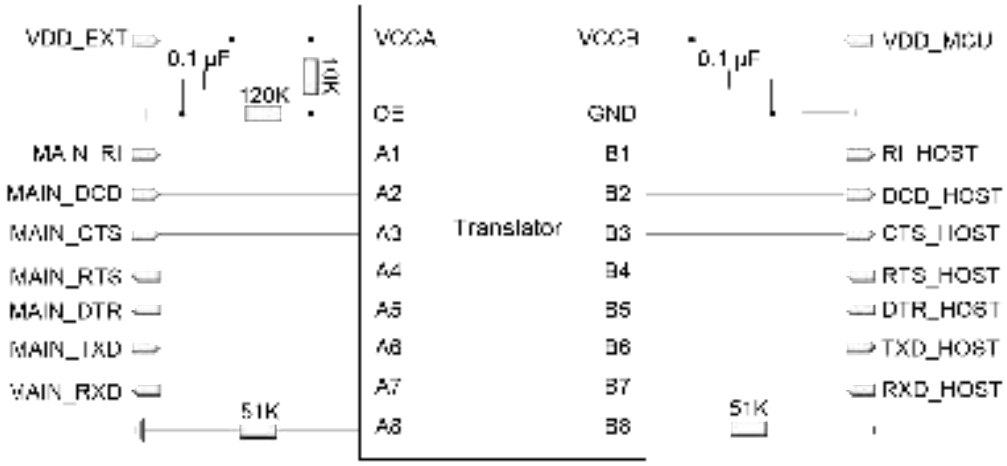


Figure 19: Main UART Reference Design (Translator Chip)

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

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

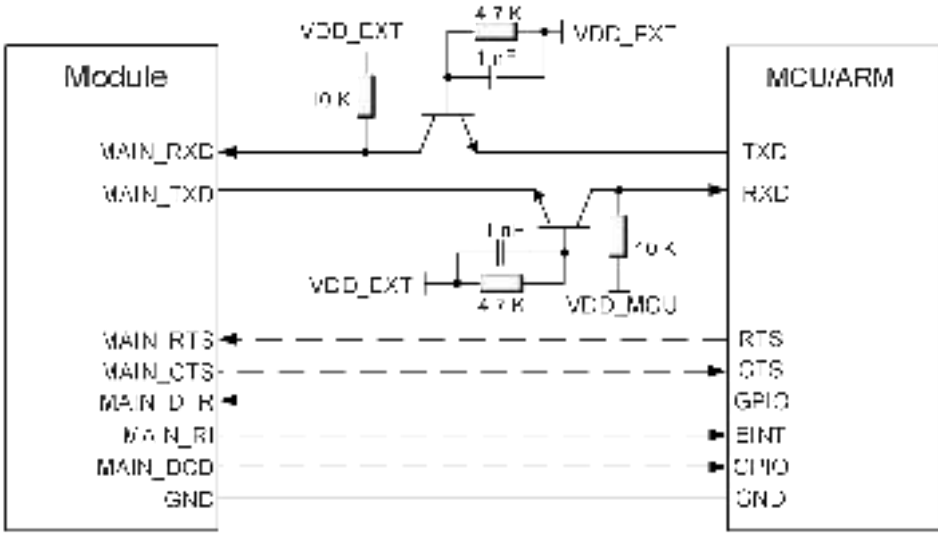


Figure 20: Main UART Reference Design (Transistor Circuit)

NOTE

1. Transistor circuit solution is not suitable for applications with high baud rates exceeding 460 kbps.
2. The main UART interface of the module should be disconnected in PSM and power off modes. Otherwise, the module will have additional power consumption and may have damaged pins.
3. It is recommended to use a level-shifting chip without internal pull-up, such as TXB0108PWR, for voltage level translation.

4. Please note that the module's CTS is connected to the host's CTS, and the module's RTS is connected to the host's RTS.

4.4. PCM and I2C Interfaces*

The module provides one Pulse Code Modulation (PCM) digital interface and one I2C interface for VoLTE* only. The following table shows the pin definition of the two interfaces which can be applied on audio codec design.

Table 18: Pin Definition of PCM Interface

Pin Name	Pin No.	I/O	Description	Comment
PCM_CLK	4	DO	PCM clock	1.8 V power domain. If these pins are unused, keep them open.
PCM_SYNC	5	DO	PCM data frame sync	
PCM_DIN	6	DI	PCM data input	
PCM_DOUT	7	DO	PCM data output	

Table 19: Pin Definition of I2C Interface

Pin Name	Pin No.	I/O	Description	Comment
I2C_SCL	40	OD	I2C serial clock (for external codec)	Require external pull-up to 1.8 V only. If these pins are unused, keep them open.
I2C_SDA	41	OD	I2C serial data (for external codec)	

The reference design is illustrated as follows:

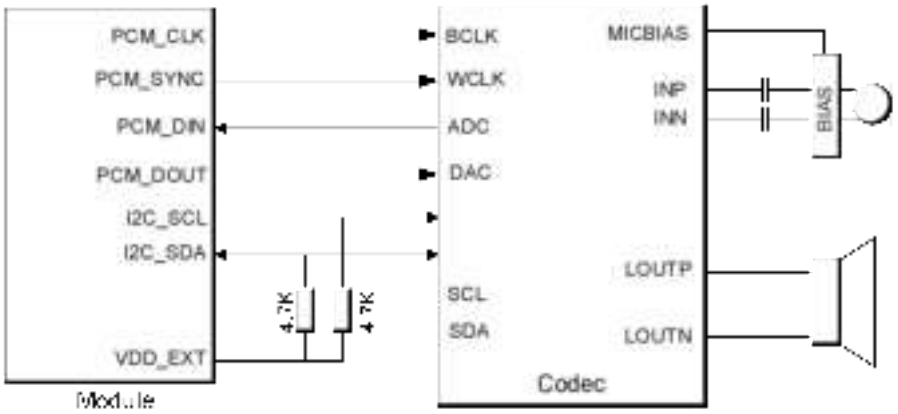


Figure 21: Reference Design of PCM Application with Audio Codec

4.5. ADC Interfaces

The module provides two Analog-to-Digital Converter (ADC) interfaces. To improve the accuracy of ADC voltage values, the traces of ADC should be surrounded with ground.

Table 20: Pin Definition of ADC Interfaces

Pin Name	Pin No.	I/O	Description	Comment
ADC0	24	AI	General-purpose ADC interface	Voltage range: 0–1.8 V
ADC1	2	AI	General-purpose ADC interface	

The voltage value on ADC pins can be read via **AT+QADC=<port>**:

- **AT+QADC=0:** read the voltage value on ADC0
- **AT+QADC=1:** read the voltage value on ADC1

For more details about the AT command, see ***document [3]***.

The resolution of the ADC is up to 12 bits. The following table describes the characteristic of the ADC interfaces.

Table 21: Characteristics of ADC Interfaces

Name	Min.	Typ.	Max.	Unit
Voltage Range	0	-	1.8	V
Resolution	6	-	12	bit

NOTE

1. ADC input voltage must not exceed 1.8 V.
2. It is prohibited to supply any voltage to ADC pin when VBAT is removed.
3. It is recommended to use resistor divider circuit for ADC application, and the divider's resistor accuracy should be no less than 1 %.
4. After the module is turned off or enters PSM, do not pull up any pin of ADC interfaces. Otherwise, the module will have additional power consumption and may have damaged pins.

4.6. Indication Signals

4.6.1. PSM Status Indication

Table 22: Pin Definition of PSM_IND

Pin Name	Pin No.	I/O	Description	Comment
PSM_IND	1	DO	Indicate the module's power saving mode	1.8 V power domain. If this pin is unused, keep this pin open.

When PSM is enabled, the function of PSM_IND will be activated after the module is rebooted. When PSM_IND is in high level, the module is in normal operation state. When it is in low level, the module is in PSM.

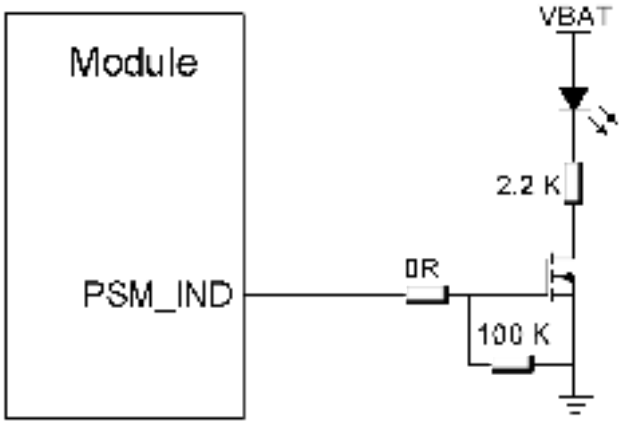


Figure 22: Reference Circuit of the PSM Status Indication

4.6.2. Network Status Indication

Table 23: Pin Definition of NET_STATUS

Pin Name	Pin No.	I/O	Description	Comment
NET_STATUS	21	DO	Indicate the module's network activity status	1.8 V power domain. If this pin is unused, keep it open.

The network indication pins can be used to drive network status indication LEDs. The module provides one network indication pin: NET_STATUS. The following tables describe pin definition and logic level changes in different network status.

Table 24: Working State of Network Connection Status Indication

Pin Name	Status	Description
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.

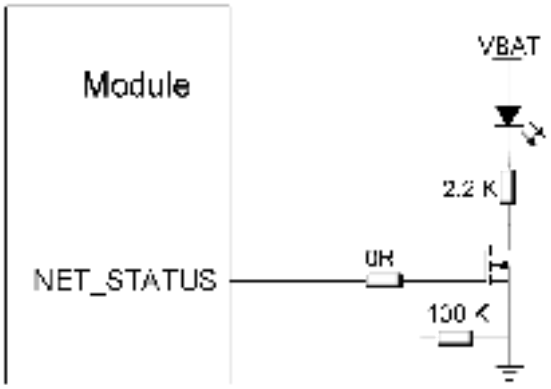


Figure 23: Reference Circuit of Network Status Indication

4.6.3. STATUS

The STATUS pin is an open drain output for indicating the module's operation status. It will output high level when module is powered on successfully.

Table 25: 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

A reference circuit is shown as below.

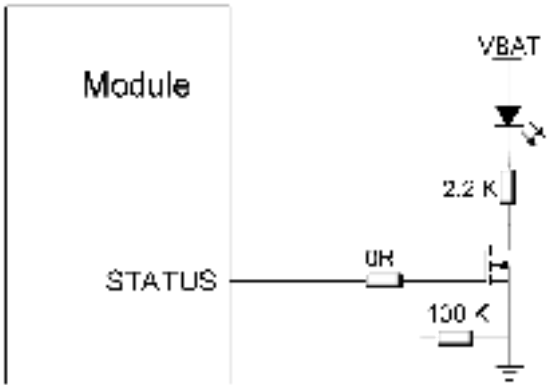


Figure 24: Reference Circuits of STATUS

4.6.4. MAIN_RI*

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

Table 26: Pin Definition of MAIN_RI

Pin Name	Pin No.	I/O	Description	Comment
MAIN_RI	39	DO	Main UART ring indication	1.8 V power domain. If this pin is unused, keep this pin open.

The default MAIN_RI behaviors can be configured flexibly by **AT+QCFG="urc/ri/ring"***. Refer to ***document [2]*** for details. The default behavior of the MAIN_RI is shown as below.

Table 27: Default Behaviors of MAIN_RI

State	Response
Idle	MAIN_RI keeps at high level.
URC	MAIN_RI outputs 120 ms low pulse in case of a new URC returns.

NOTE

A URC can be outputted from the main UART interface (default), the CLI UART or the debug UART through configuration via **AT+QURCCFG**.

4.7. GRFC Interfaces*

The module provides two generic RF control interfaces for the control of external antenna tuners.

Table 28: Pin Definition of GRFC Interfaces

Pin Name	Pin No.	I/O	Description	Comment
GRFC1	83	DO	Generic RF controller	1.8 V power domain. If these pins are unused, keep them open.
GRFC2	84	DO	Generic RF controller	

Table 29: Truth Table of GRFC Interfaces

GRFC1 Level	GRFC2 Level	Frequency Range (MHz)	Band
Low	Low	TBD	TBD
Low	High	TBD	TBD
High	Low	TBD	TBD

4.8. GPIO Interface*

BG950A-GL/BG951A-GL module provides nine general-purpose input and output (GPIO) interfaces. **AT+QCFG="gpio"** can be used to configure the status of GPIO pins. For more details about the AT command, see ***document [2].***

Table 30: Pin Definition of GPIO Interface

Pin Name	Pin No.	I/O	Description	Comment
GPIO1	25	DIO	General-purpose input/output	1.8 V power domain.
GPIO2	26	DIO	General-purpose input/output	
GPIO3	64	DIO	General-purpose input/output	
GPIO4	65	DIO	General-purpose input/output	
GPIO5	66	DIO	General-purpose input/output	
GPIO6	85	DIO	General-purpose input/output	
GPIO7	86	DIO	General-purpose input/output	
GPIO8	87	DIO	General-purpose input/output	
GPIO9	88	DIO	General-purpose input/output	

5 RF Specifications

5.1. Cellular Network

5.1.1. Antenna Interface & Frequency Bands

The pin definition is shown as below:

Table 31: Pin Definition of Cellular Network Interface

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

NOTE

Only passive antennas are supported.

Table 32: Operating Frequency of BG950A-GL & BG951A-GL

Operating Frequency	Transmit (MHz)	Receive (MHz)	Unit
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 B17 [9]	704–716	734–746	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	1850–1915	1930–1995	MHz
LTE HD-FDD B26 [10]	814–849	859–894	MHz
LTE HD-FDD B27 [10]	807–824	852–869	MHz
LTE HD-FDD B28	703–748	758–803	MHz
LTE HD-FDD B66	1710–1780	2110–2180	MHz

5.1.2. Tx Power

The following table shows the Tx power of the module.

Table 33: RF Output Power

Frequency Bands	Max. Tx Power	Min. Tx Power
LTE HD-FDD: B1/B2/B3/B4/B5/B8/B12/B13/B17 [9]/B18/B19/ B20/B25/B26 [10]/B27 [10]/B28/B66	23 dBm ±2.7 dB	< -39 dBm

[9] LTE HD-FDD B17 is supported by Cat NB2* only.
[10] LTE HD-FDD B26 and B27 are supported by Cat M1 only.

5.1.3. Rx Sensitivity

The following table shows conducted Rx sensitivity of the module.

Table 34: Conducted RF Receiving Sensitivity of BG950A-GL

Frequency Band	Primary	Diversity	Sensitivity (dBm)	
			Cat M1/3GPP	Cat NB1 [11]/3GPP
LTE HD-FDD B1			TBD/-102.3	TBD/-107.5
LTE HD-FDD B2			TBD/-100.3	TBD/-107.5
LTE HD-FDD B3			TBD/-99.3	TBD/-107.5
LTE HD-FDD B4			TBD/-102.3	TBD/-107.5
LTE HD-FDD B5			TBD/-100.8	TBD/-107.5
LTE HD-FDD B8			TBD/-99.8	TBD/-107.5
LTE HD-FDD B12			TBD/-99.3	TBD/-107.5
LTE HD-FDD B13			TBD/-99.3	TBD/-107.5
LTE HD-FDD B17 [12]	Supported	-	-	TBD/-107.5
LTE HD-FDD B18			TBD/-102.3	TBD/-107.5
LTE HD-FDD B19			TBD/-102.3	TBD/-107.5
LTE HD-FDD B20			TBD/-99.8	TBD/-107.5
LTE HD-FDD B25			TBD/-100.3	TBD/-107.5
LTE HD-FDD B26 [13]			TBD/-100.3	-
LTE HD-FDD B27 [13]			TBD/-100.8	-
LTE HD-FDD B28			TBD/-100.8	TBD/-107.5
LTE HD-FDD B66			TBD/-101.8	TBD/-107.5

[11] LTE Cat NB2* receiving sensitivity without repetitions.
[12] LTE HD-FDD B17 is supported by Cat NB2* only.
[13] LTE HD-FDD B26 and B27 are supported by Cat M1 only.

Table 35: Conducted RF Receiving Sensitivity of BG951A-GL

Frequency Band	Primary	Diversity	Sensitivity (dBm)	
			Cat M1/3GPP	Cat NB1 [14]/3GPP
LTE HD-FDD B1	Supported	-	TBD/-102.3	TBD/-107.5
LTE HD-FDD B2			TBD/-100.3	TBD/-107.5
LTE HD-FDD B3			TBD/-99.3	TBD/-107.5
LTE HD-FDD B4			TBD/-102.3	TBD/-107.5
LTE HD-FDD B5			TBD/-100.8	TBD/-107.5
LTE HD-FDD B8			TBD/-99.8	TBD/-107.5
LTE HD-FDD B12			TBD/-99.3	TBD/-107.5
LTE HD-FDD B13			TBD/-99.3	TBD/-107.5
LTE HD-FDD B17 [12]			-	TBD/-107.5
LTE HD-FDD B18			TBD/-102.3	TBD/-107.5
LTE HD-FDD B19			TBD/-102.3	TBD/-107.5
LTE HD-FDD B20			TBD/-99.8	TBD/-107.5
LTE HD-FDD B25			TBD/-100.3	TBD/-107.5
LTE HD-FDD B26 [13]			TBD/-100.3	-
LTE HD-FDD B27 [13]			TBD/-100.8	-
LTE HD-FDD B28			TBD/-100.8	TBD/-107.5
LTE HD-FDD B66			TBD/-101.8	TBD/-107.5

5.1.4. Reference Design

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

[14] LTE Cat NB2* receiving sensitivity without repetitions.

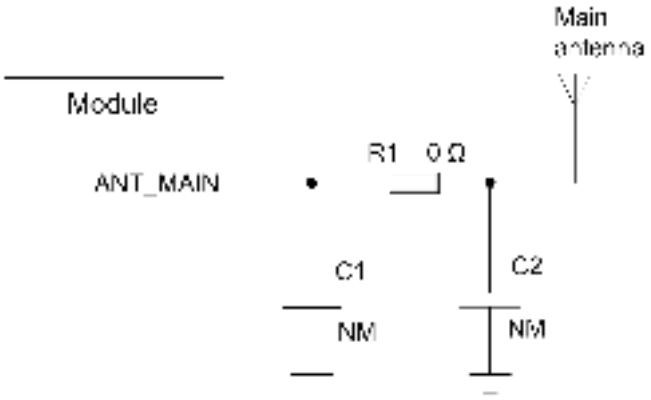


Figure 25: Reference Circuit of Main Antenna Interface

5.2. GNSS

BG950A-GL module includes a fully integrated global navigation satellite system solution that supports GPS, GLONASS. BG951A-GL module supports GPS, GLONASS, BeiDou, Galileo, QZSS, SBAS.

BG950A-GL/BG951A-GL module supports standard *NMEA-0183* protocol, and outputs NMEA sentences via debug UART interface (data update rate: 1–10 Hz, 1 Hz by default).

By default, the module's GNSS engine is switched off. It must be switched on via AT command. BG950A-GL does not support concurrent operation of LTE and GNSS, however, LTE and GNSS are concurrency for BG951A-GL. For more details about GNSS engine technology and configurations, see ***document [4]***.

5.2.1. Antenna Interface & Frequency Bands

The following table shows the pin definition, frequency bands, and performance of GNSS antenna interface.

Table 36: 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 37: GNSS Frequency

Type	Frequency	Unit
GPS	1575.42 ±1.023	MHz
GLONASS	1597.5–1605.8	MHz

5.2.2. GNSS Performance

Table 38: GNSS Performance

Parameter	Description	Conditions	Typ.	Unit
Sensitivity (GNSS)	Cold start	Autonomous	TBD	dBm
	Reacquisition	Autonomous	TBD	
	Tracking	Autonomous	TBD	
TTFF (GNSS)	Cold start @ open sky	Autonomous	TBD	s
		XTRA enabled	TBD	
	Warm start @ open sky	Autonomous	TBD	
		XTRA enabled	TBD	
	Hot start @ open sky	Autonomous	TBD	
		XTRA enabled	TBD	
Accuracy (GNSS)	CEP-50	Autonomous @ open sky	TBD	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.

5.2.3. Reference Design

The following is the reference circuit of GNSS antenna.

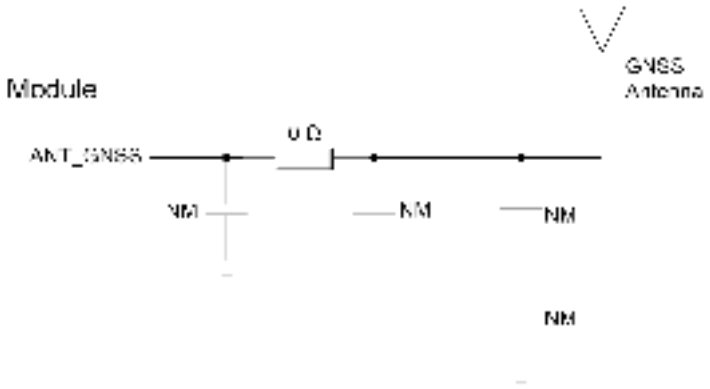


Figure 26: Reference Circuit of GNSS Antenna

NOTE

BG950A-GL/BG951A-GL module is designed with a passive antenna.

5.3. Layout Guidelines

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

- Maximize the distance between GNSS antenna and main antenna.
- Digital circuits such as (U)SIM card, USB interface, camera module, display connector and SD card should be kept away from 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 ANT_GNSS trace.

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

5.4. 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.

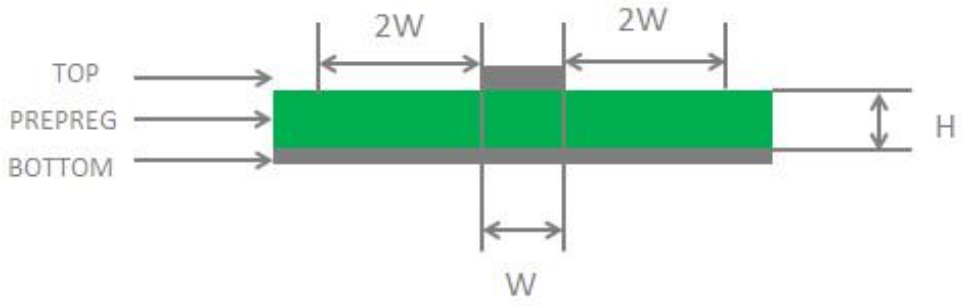


Figure 27: Microstrip Design on a 2-layer PCB

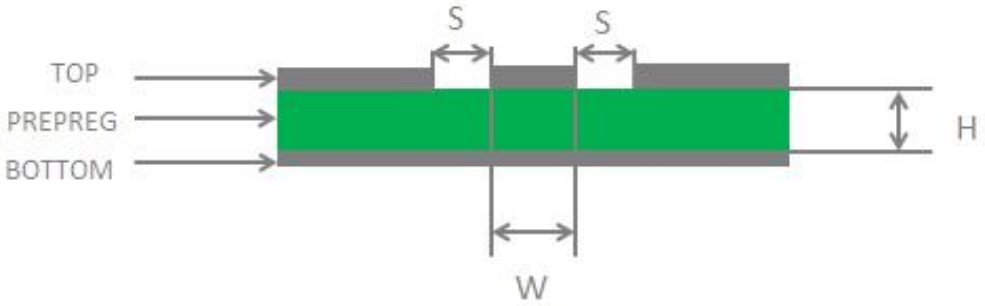


Figure 28: Coplanar Waveguide Design on a 2-layer PCB

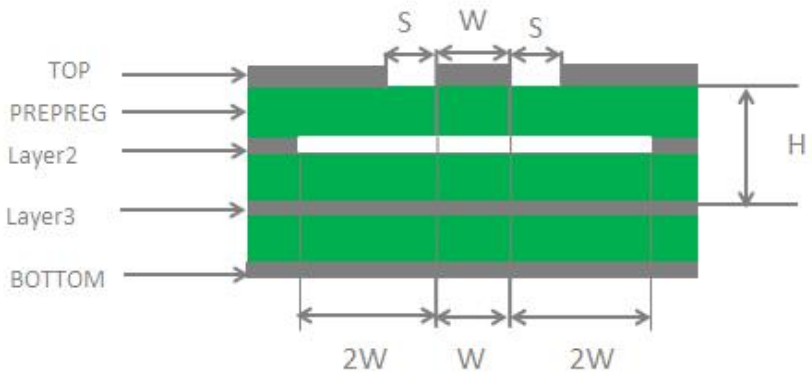


Figure 29: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

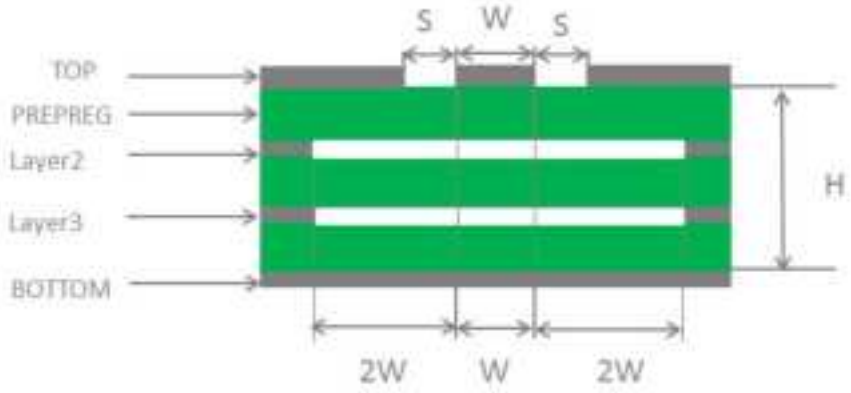


Figure 30: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

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 [5].***

5.5. Antenna Design Requirements

Table 39: Antenna Design Requirements

Antenna Type	Requirements
GNSS	Must be a passive antenna Frequency range: 1559–1609 MHz Polarization: RHCP or linear VSWR: < 2 (Typ.) Passive antenna gain: > 0 dBi
LTE	VSWR：≤ 2 Efficiency: > 30 % Gain: 1 dBi Max input power: 50 W Input impedance: 50 Ω Polarization: vertical Cable insertion loss: **< 1 dB:** LB (< 1 GHz) **< 1.5 dB**: MB (1–2.3 GHz)

5.6. RF Connector Recommendation

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

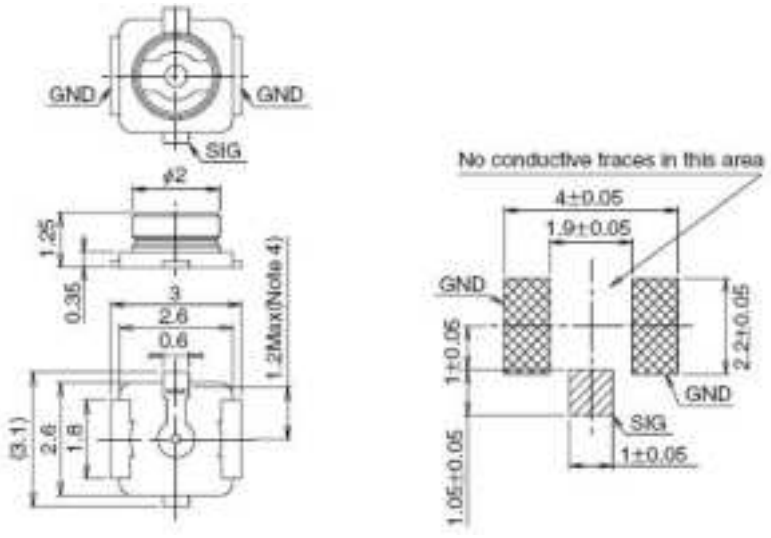


Figure 31: Dimensions of the U.FL-R-SMT Connector (Unit: mm)

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

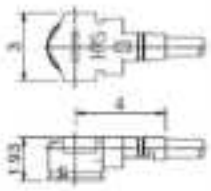
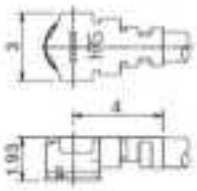
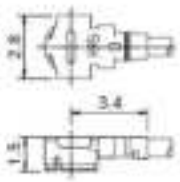
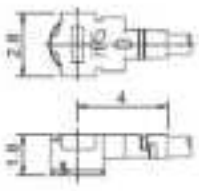
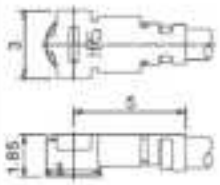
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 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 32: Mechanicals of U.FL-LP Connectors

The following figure describes the space factor of mated connector.

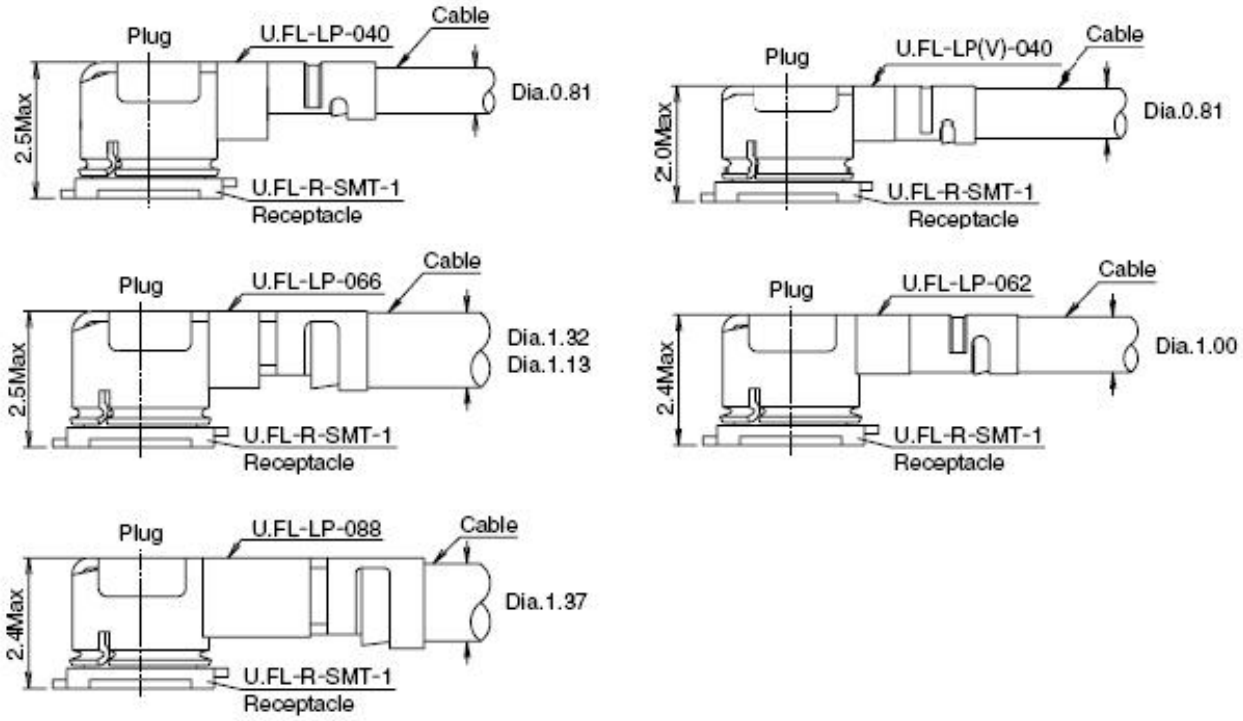


Figure 33: Space Factor of Mated Connector (Unit: mm)

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

6 Reliability and Electrical

7 Characteristics

7.1. 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 40: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT_RF/VBAT_BB	-0.2	4.35	V
USB_VBUS	-0.3	6.0	V
Voltage on Digital Pins	-0.3	2.0	V

7.2. Power Supply Ratings

Table 41: The Module's Power Supply Ratings

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
VBAT_BB/ VBAT_RF	Power supply for the module's baseband part/RF part	The actual input voltages must stay between the minimum and maximum values.	2.2	3.3	4.35	V
USB_VBUS	USB connection detect		-	5.0	-	V

7.3. Power Consumption

Table 42: BG950A-GL Power Consumption

BG950A-GL (Power Supply: 3.3 V, Room Temperature)				
Description	**Conditions**	**Avg.**	**Max.**	**Unit**
Leakage	Power-off @ USB/UART disconnected	1.35	-	μA
PSM	PSM @ USB/UART disconnected	1.43	-	μA
Rock bottom	**AT+CFUN=0** @ Sleep mode	54	-	μA
Sleep mode (USB disconnected)	LTE Cat M1 DRX = 1.28 s	1.09	-	mA
	LTE Cat NB1 DRX = 1.28 s	2.14	-	mA
	LTE Cat M1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	0.137	-	mA
	LTE Cat NB1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	0.138	-	mA
Idle state	LTE Cat M1 DRX = 1.28 s	15.62	-	mA
	LTE Cat NB1 DRX = 1.28 s	16.21	-	mA
	LTE Cat M1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	15.03	-	mA
	LTE Cat NB1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	14.64	-	mA
LTE Cat M1 data transfer (GNSS OFF)	LTE HD-FDD B1 @ 23.19 dBm	223.62	552.28	mA
	LTE HD-FDD B2 @ 23.25 dBm	208.00	500.24	mA
	LTE HD-FDD B3 @ 23.10 dBm	194.05	447.41	mA
	LTE HD-FDD B4 @ 23.08 dBm	195.35	450.43	mA

	LTE HD-FDD B5 @ 22.99 dBm	189.81	441.28	mA
	LTE HD-FDD B8 @ 23 dBm	204.86	493.13	mA
	LTE HD-FDD B12 @ 22.91 dBm	185.70	420.22	mA
	LTE HD-FDD B13 @ 22.43 dBm	177.34	389.41	mA
	LTE HD-FDD B18 @ 22.86 dBm	186.41	432.36	mA
	LTE HD-FDD B19 @ 23.06 dBm	190.79	446.71	mA
	LTE HD-FDD B20 @ 23.05 dBm	197.48	471.20	mA
	LTE HD-FDD B25 @ 23.22 dBm	216.49	528.12	mA
	LTE HD-FDD B26 @ 22.89 dBm	193.69	456.99	mA
	LTE HD-FDD B27 @ 22.83 dBm	184.06	423.48	mA
	LTE HD-FDD B28 @ 22.68 dBm	181.85	419.20	mA
	LTE HD-FDD B66 @ 23.01 dBm	196.32	461.80	mA
LTE Cat NB1 data transfer (GNSS OFF)	LTE HD-FDD B1 @ 23.16 dBm	215.81	553.23	mA
	LTE HD-FDD B2 @ 23.25 dBm	205.67	536.87	mA
	LTE HD-FDD B3 @ 23.15 dBm	188.92	478.17	mA
	LTE HD-FDD B4 @ 23.21 dBm	183.31	477.15	mA
	LTE HD-FDD B5 @ 23.01 dBm	176.99	445.83	mA
	LTE HD-FDD B8 @ 23.09 dBm	197.90	530.05	mA
	LTE HD-FDD B12 @ 23.01 dBm	175.02	441.49	mA
	LTE HD-FDD B13 @ 22.67 dBm	162.38	406.59	mA
	LTE HD-FDD B17 @ 23.01 dBm	168.53	416.74	mA
	LTE HD-FDD B18 @ 23.19 dBm	166.79	425.41	mA
	LTE HD-FDD B19 @ 22.61 dBm	174.28	461.28	mA
	LTE HD-FDD B20 @ 22.71 dBm	174.52	443.72	mA
	LTE HD-FDD B25 @ 23.36 dBm	200.58	512.86	mA
	LTE HD-FDD B28 @ 23.12 dBm	176.39	446.66	mA

	LTE HD-FDD B66 @ 23.10 dBm	189.72	475.43	mA

Table 43: BG951A-GL Power Consumption

BG951A-GL (Power Supply: 3.3 V, Room Temperature)				
Description	**Conditions**	**Avg.**	**Max.**	**Unit**
Leakage	Power-off @ USB/UART disconnected	2.1	-	μA
PSM	PSM @ USB/UART disconnected	TBD	-	μA
Rock bottom	**AT+CFUN=0** @ Sleep mode	TBD	-	mA
Sleep mode (USB disconnected)	LTE Cat M1 DRX = 1.28 s	TBD	-	mA
	LTE Cat NB1 DRX = 1.28 s	TBD	-	mA
	LTE Cat M1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	TBD	-	mA
	LTE Cat NB1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	TBD	-	mA
Idle state	LTE Cat M1 DRX = 1.28 s	TBD	-	mA
	LTE Cat NB1 DRX = 1.28 s	TBD	-	mA
	LTE Cat M1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	TBD	-	mA
	LTE Cat NB1 e-I-DRX = 81.92 s @ PTW = 2.56 s, DRX = 1.28 s	TBD	-	mA
LTE Cat M1 data transfer (GNSS OFF)	LTE HD-FDD B1 @ dBm	TBD	TBD	mA
	LTE HD-FDD B2 @ dBm	TBD	TBD	mA
	LTE HD-FDD B3 @ dBm	TBD	TBD	mA
	LTE HD-FDD B4 @ dBm	TBD	TBD	mA
	LTE HD-FDD B5 @ dBm	TBD	TBD	mA
	LTE HD-FDD B8 @ dBm	TBD	TBD	mA
	LTE HD-FDD B12 @ dBm	TBD	TBD	mA

	LTE HD-FDD B13 @ dBm	TBD	TBD	mA
	LTE HD-FDD B18 @ dBm	TBD	TBD	mA
	LTE HD-FDD B19 @ dBm	TBD	TBD	mA
	LTE HD-FDD B20 @ dBm	TBD	TBD	mA
	LTE HD-FDD B25 @ dBm	TBD	TBD	mA
	LTE HD-FDD B26 @ dBm	TBD	TBD	mA
	LTE HD-FDD B27 @ dBm	TBD	TBD	mA
	LTE HD-FDD B28 @ dBm	TBD	TBD	mA
	LTE HD-FDD B66 @ dBm	TBD	TBD	mA
LTE Cat NB1 data transfer (GNSS OFF)	LTE HD-FDD B1 @ dBm	TBD	TBD	mA
	LTE HD-FDD B2 @ dBm	TBD	TBD	mA
	LTE HD-FDD B3 @ dBm	TBD	TBD	mA
	LTE HD-FDD B4 @ dBm	TBD	TBD	mA
	LTE HD-FDD B5 @ dBm	TBD	TBD	mA
	LTE HD-FDD B8 @ dBm	TBD	TBD	mA
	LTE HD-FDD B12 @ dBm	TBD	TBD	mA
	LTE HD-FDD B13 @ dBm	TBD	TBD	mA
	LTE HD-FDD B17 @ dBm	TBD	TBD	mA
	LTE HD-FDD B18 @ dBm	TBD	TBD	mA
	LTE HD-FDD B19 @ dBm	TBD	TBD	mA
	LTE HD-FDD B20 @ dBm	TBD	TBD	mA
	LTE HD-FDD B25 @ dBm	TBD	TBD	mA
	LTE HD-FDD B28 @ dBm	TBD	TBD	mA
	LTE HD-FDD B66 @ dBm	TBD	TBD	mA

Table 44: BG950A-GL GNSS Current Consumption

BG950A-GL			
Description	**Conditions**	**Typ.**	**Unit**
Searching **(AT+CFUN=0)**	Cold start @ Passive antenna	TBD	mA
	Hot start @ Passive antenna	TBD	mA
	Lost state @ Passive antenna	TBD	mA
Tracking **(AT+CFUN=0)**	Instrument environment @ Passive antenna	TBD	mA
	Open sky @ Real network, Passive antenna	TBD	mA

Table 45: BG951A-GL GNSS Current Consumption

BG951A-GL			
Description	**Conditions**	**Typ.**	**Unit**
Searching **(AT+CFUN=0)**	Cold start @ Passive antenna	TBD	mA
	Hot start @ Passive antenna	TBD	mA
	Lost state @ Passive antenna	TBD	mA
Tracking **(AT+CFUN=0)**	Instrument environment @ Passive antenna	TBD	mA
	Open sky @ Real network, Passive antenna	TBD	mA

7.4. ESD

If the static electricity generated by various ways discharges to the module, the module maybe damaged to a certain extent. Thus, please take proper ESD countermeasures and handling methods. For example, wearing anti-static gloves during the development, production, assembly and testing of the module; adding ESD protective components to the ESD sensitive interfaces and points in the product design.

ESD characteristics of the module's pins are as follows:

Table 46: Electrostatics Discharge Characteristics (Temperature: 25 °C, Humidity: 45 %)

Tested Interfaces	Contact Discharge	Air Discharge	Unit
VBAT, GND	TBD	TBD	kV
All Antenna Interfaces	TBD	TBD	kV

7.5. Operating and Storage Temperatures

Table 47: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operating Temperature Range [15]	-35	+25	+75	°C
Extended Operating Temperature Range [16]	-40	-	+85	°C
Storage Temperature Range	-40	-	+90	°C

[15] Within the operating temperature range, the module meets 3GPP specifications.
[16] Within the extended temperature range, the module remains the ability to establish and maintain functions such as voice*, SMS* and data transmission, 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.

8 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.

8.1. Mechanical Dimensions

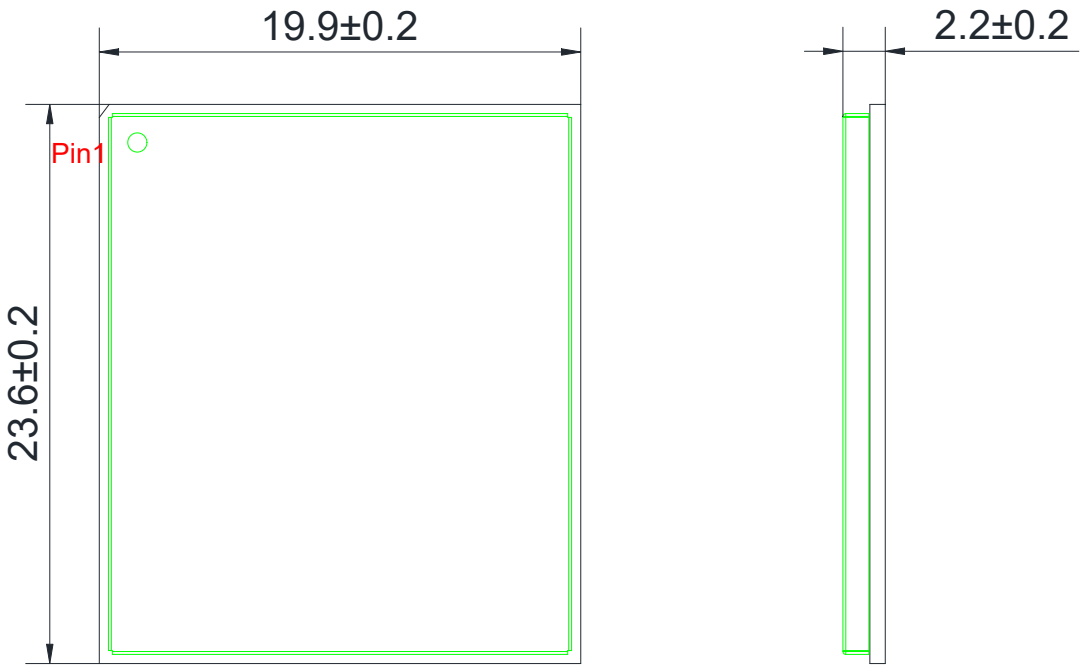


Figure 34: Module Top and Side Dimensions (Unit: mm)

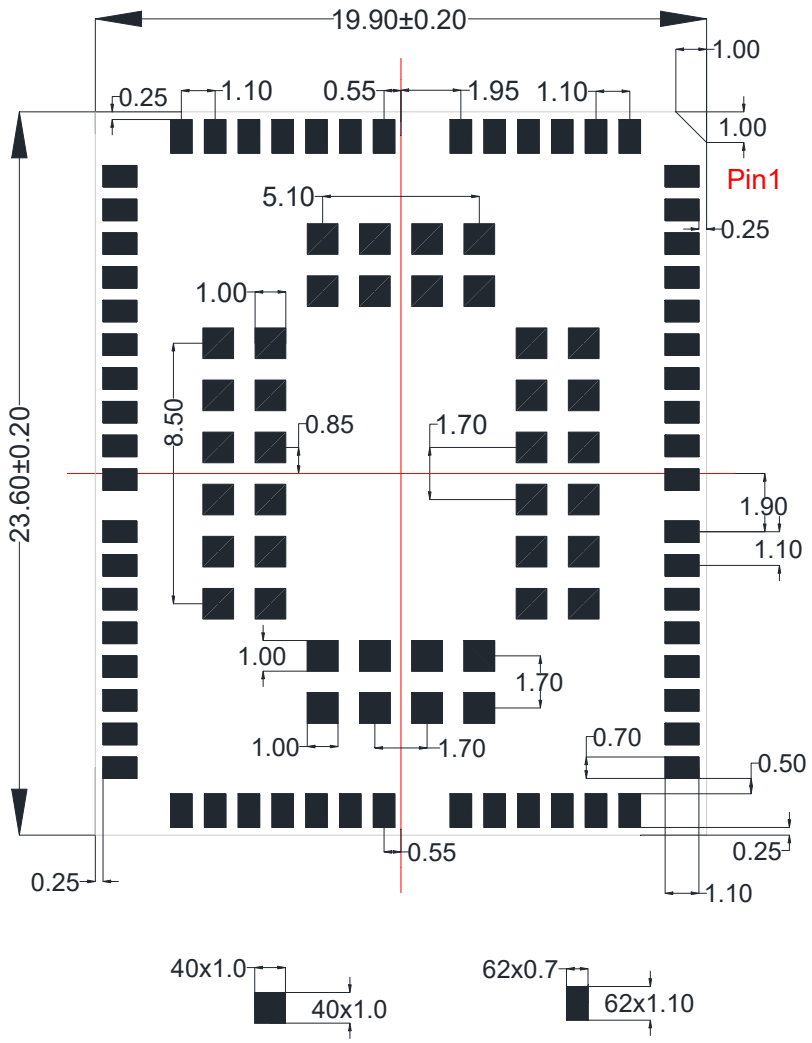


Figure 35: Module Bottom Dimensions (Bottom View, Unit: mm)

NOTE

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

8.2. Recommended Footprint

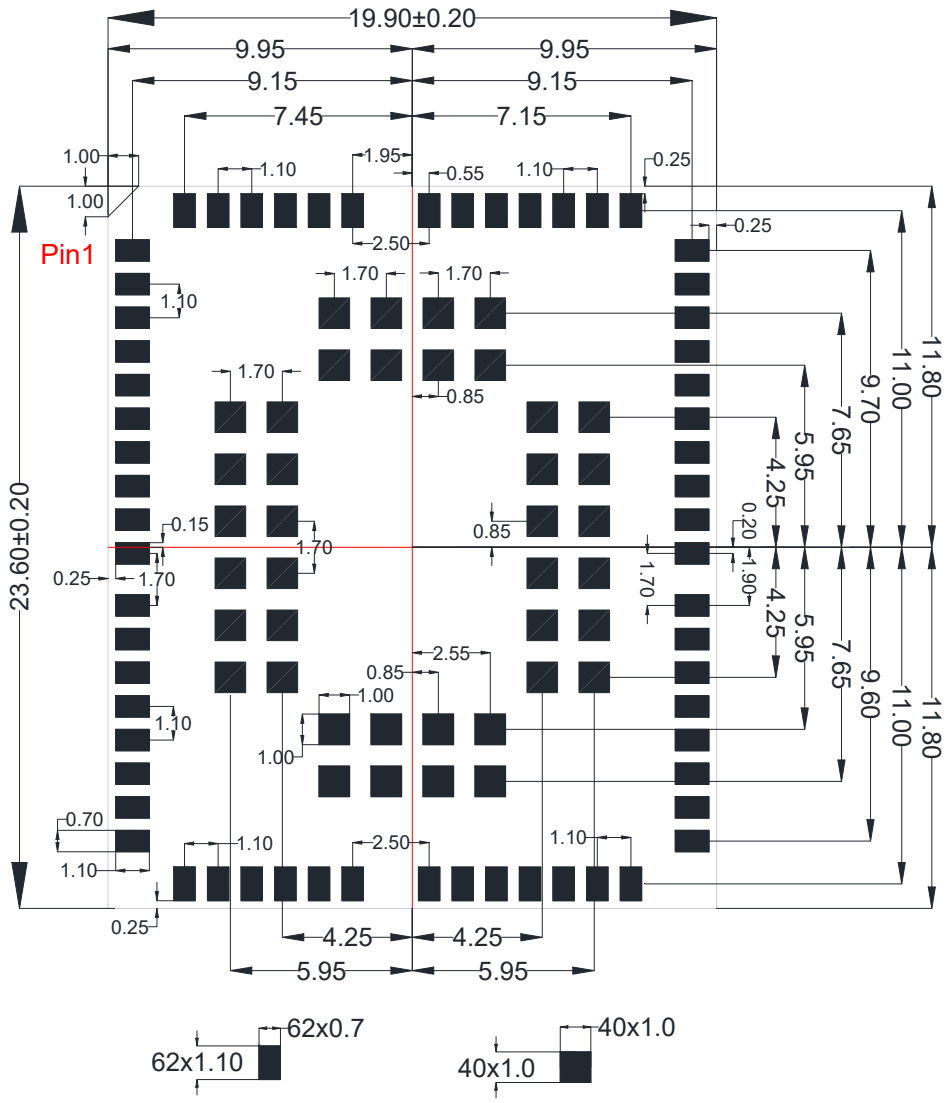


Figure 36: Recommended Footprint (Top View)

NOTE

1. For easy maintenance of the module, keep about 3 mm between the module and other components on the motherboard.
2. All reserved pins must be kept open.
3. For stencil design requirements of the module, see ***document [6].***

8.3. Top and Bottom Views

Figure 37: Top & Bottom Views of BG950A-GL & BG951A-GL

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.

9 Storage, Manufacturing & Packaging

9.1. 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 [17] 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.

[17] 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.

9.2. 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 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.

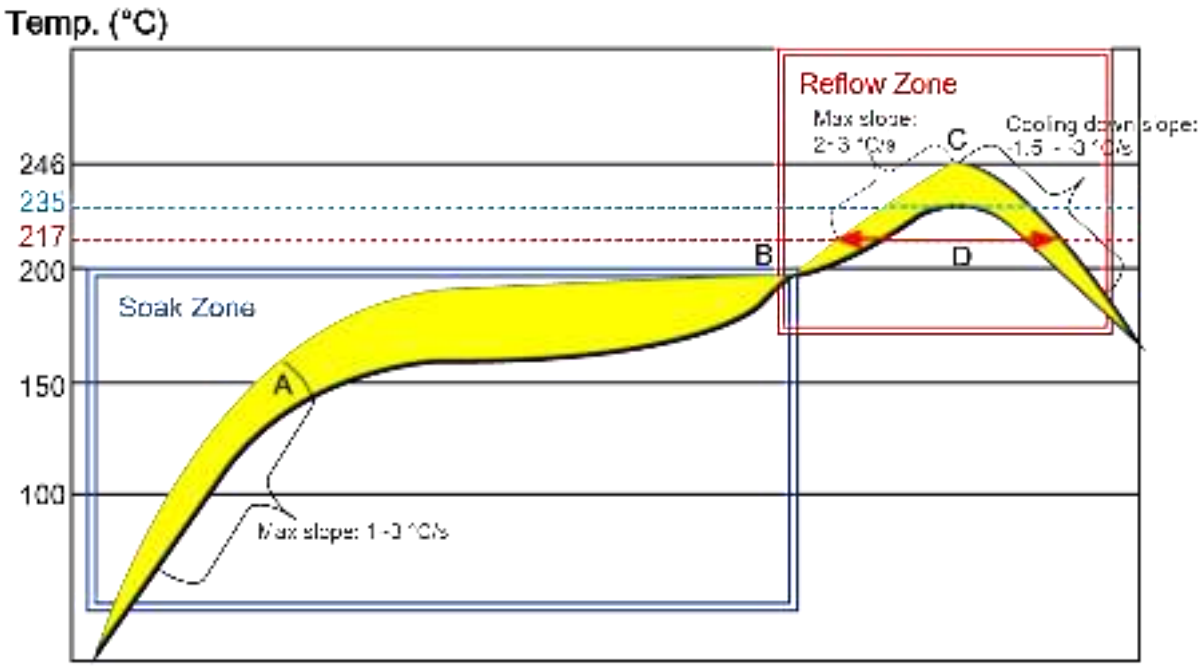


Figure 38: Recommended Reflow Soldering Thermal Profile

Table 48: Recommended Thermal Profile Parameters

Factor	Recommendation
Soak Zone	
Max slope	1–3 °C/s
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	235–246 °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 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, ultrasonic soldering) that is not mentioned in ***document [6].***

9.3. Packaging Specifications

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

9.3.1. Carrier Tape

Dimension details are as follow:

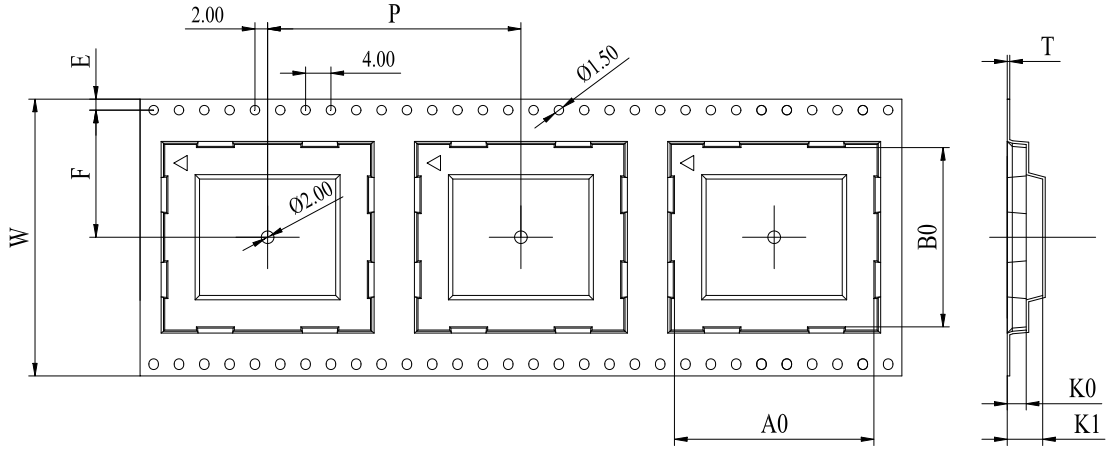


Figure 39: Carrier Tape Dimension Drawing

Table 49: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
44	32	0.35	20.2	24	3.15	6.65	20.2	1.75

9.3.2. Plastic Reel

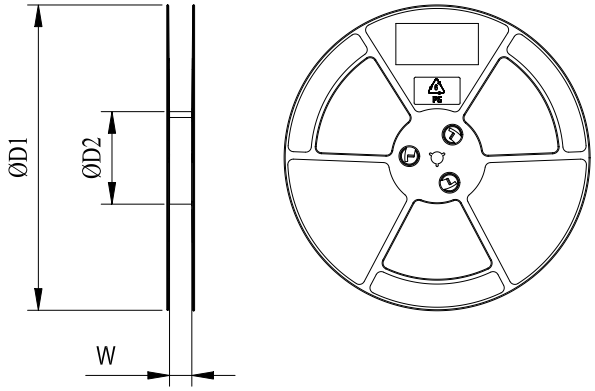
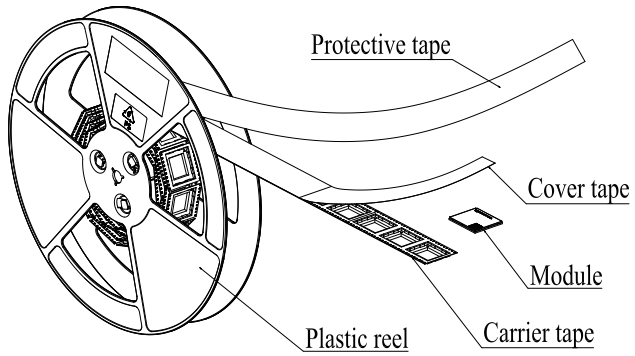


Figure 40: Plastic Reel Dimension Drawing

Table 50: Plastic Reel Dimension Table (Unit: mm)

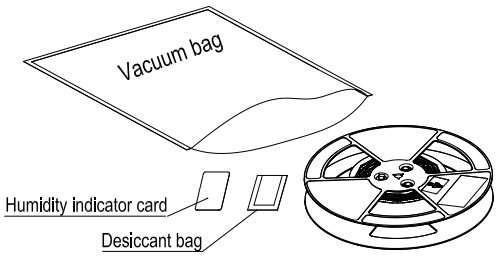
øD1	øD2	W
330	100	44.5

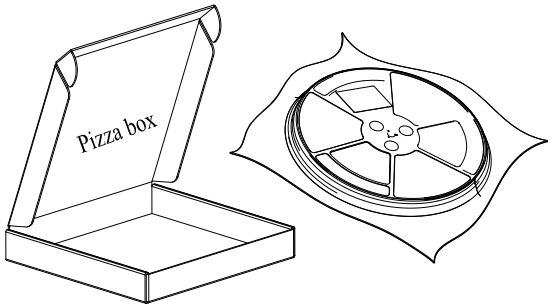
9.3.3. Packing Process



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

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





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

Put 4 pizza boxes into 1 carton and seal it. One carton can pack 1000 modules.

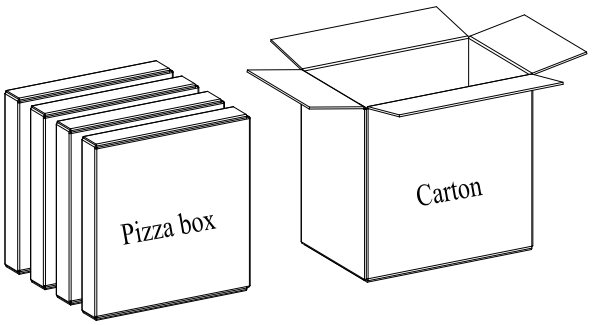


Figure 41: Packaging Process

10 Appendix References

Table 51: Related Documents

Document Name
[1] Quectel_UMTS&LTE_EVB_User_Guide
[2] Quectel_BG770A-GL&BG95xA-GL_QCFG_AT_Commands_Manual
[3] Quectel_BG770A-GL&BG95xA-GL_AT_Commands_Manual
[4] Quectel_BG770A-GL&BG95xA-GL_GNSS_Application_Note
[5] Quectel_RF_Layout_Application_Note
[6] Quectel_Module_Secondary_SMT_Application_Note

Table 52: Terms and Abbreviations

Abbreviation	Description
ADC	Analog to Digital Converter
Balun	Balanced to Unbalanced
bps	Bits Per Second
CHAP	Challenge Handshake Authentication Protocol
CoAP	Constrained Application Protocol
CTS	Clear to Send
DFOTA	Delta Firmware Upgrade Over the Air
DL	Downlink
DRX	Discontinuous Reception
EGSM	Extended GSM (Global System for Mobile Communications)

e-I-DRX	Extended Idle Mode Discontinuous Reception
EPC	Evolved Packet Core
ESD	Electrostatic Discharge
EVB	Evaluation Board
FDD	Frequency Division Duplex
FTP(S)	FTP over SSL
GNSS	Global Navigation Satellite System
GLONASS	Global Navigation Satellite System (Russia)
GPIO	General-purpose Input/Output
GPS	Global Positioning System
GRFC	Generic RF Controller
HD	Half Duplex
HSS	Home Subscriber Server
I/O	Input/Output
I2C	Inter-Integrated Circuit
Inom	Nominal Current
LDO	Low-dropout Regulator
LED	Light Emitting Diode
LGA	Land Grid Array
LPF	Low Pass Filter
LPWA	Low-Power Wide-Area (Network)
LTE	Long Term Evolution
LwM2M	Lightweight M2M
ME	Mobile Equipment
MLCC	Multi-layer Ceramic Chip

MO	Mobile Originated
MQTT	Message Queuing Telemetry Transport
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
PDU	Protocol Data Unit
PING	Packet Internet Groper
POS	Point of Sale
PPP	Point-to-Point Protocol
PSM	Power Saving Mode
RF	Radio Frequency
RFIC	Radio Frequency Integrated Circuit
RHCP	Right Hand Circularly Polarized
RoHS	Restriction of Hazardous Substances
RTS	Request to Send
SAW	Surface Acoustic Wave
SMD	Surface Mount Device
SMS	Short Message Service
SSL	Secure Sockets Layer
TCP	Transmission Control Protocol

TLS	Transport Layer Security
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
UDP	User Datagram Protocol
UL	Uplink
UE	User Equipment
URC	Unsolicited Result Code
(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_{OH}max	Maximum High-level Output Voltage
V_{OH}min	Minimum High-level Output Voltage
V_{OL}max	Maximum Low-level Output Voltage
VoLTE	Voice over LTE.
VSWR	Voltage Standing Wave Ratio
WWAN	Wireless Wide Area Network

CE Statement

The minimum distance between the user and/or any bystander and the radiating structure of the transmitter is 20cm.

Hereby, We, Quectel Wireless Solutions Co., Ltd. declares that the radio equipment type BG951A-GL is in compliance with the Directive 2014/53/EU.

The full text of the EU declaration of conformity is available at the following internet address:

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

200233, China

https://www.quectel.com/support/downloadb/TechnicalDocuments.htm

The device operates with the following frequency bands and transmitting power:

FCC Certification Requirements.

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

And the following conditions must be met:

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

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

3.A label with the following statements must be attached to the host end product: This device contains FCC ID: XMR2021BG951AGL.

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

- Catm LTE Band2/25:≤11.000dBi
- Catm LTE Band4/66:≤8.000dBi
- Catm LTE Band5/26:≤12.541dBi
- Catm LTE Band12:≤11.798dBi
- Catm LTE Band13:≤12.214dBi

- ❒ NB LTE Band2/25:≤11.000dBi
- ❒ NB LTE Band4/66:≤8.000dBi
- ❒ NB LTE Band5:≤12.541 dBi
- ❒ NB LTE Band12:≤11.798dBi
- ❒ NB LTE Band13:≤12.214dBi

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

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

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

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

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

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

For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straightforward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module:"Contains Transmitter Module FCC ID: XMR2021BG951AGL" or "Contains FCC ID: XMR2021BG951AGL" must be used. The host OEM user manual must also contain clear instructions on how end users can find and/or access the module and the FCC ID.

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

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

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

IC Statement

IRSS-GEN

"This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions: (1) This device may not cause interference; and (2) This device must accept any interference, including interference that may cause undesired operation of the device." or "Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

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

Déclaration sur l'exposition aux rayonnements RF

The EUT is a mobile device; maintain at least a 20 cm separation between the EUT and the user's body

and must not transmit simultaneously with any other antenna or transmitter.

L'autre utilisé pour l'émetteur doit être installé pour fournir une distance de séparation d'au moins 20 cm de toutes les personnes et ne doit pas être colocalisé ou fonctionner conjointement avec une autre antenne ou un autre émetteur.

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

- Catm LTE Band2/25:≤11.000dBi
- Catm LTE Band4/66:≤8.000dBi
- Catm LTE Band5/26:≤12.541dBi
- Catm LTE Band12:≤11.798dBi
- Catm LTE Band13:≤12.214dBi
- Catm LTE Band85:≤11.798dBi
- NB LTE Band2/25:≤11.000dBi
- NB LTE Band4/66:≤8.000dBi
- NB LTE Band5:≤12.541 dBi
- NB LTE Band12:≤11.798dBi
- NB LTE Band13:≤12.214dBi

The host product shall be properly labelled to identify the modules within the host product.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labeled to display the Innovation, Science and Economic Development Canada certification number for the module, preceded by the word “Contains” or similar wording expressing the same meaning, as follows:

“Contains IC: 10224A-2021BG951A” or “where: 10224A-2021BG951A is the module’s certification number”.

Le produit hôte doit être correctement étiqueté pour identifier les modules dans le produit hôte.

L'étiquette de certification d'Innovation, Sciences et Développement économique Canada d'un module doit être clairement visible en tout temps lorsqu'il est installédans le produit hôte; sinon, le produit hôte doit porter une étiquette indiquant le numéro de certification d'Innovation, Sciences et Développement économique Canada pour le module, précédé du mot «Contient» ou d'un libellé semblable exprimant la même signification, comme suit:"Contient IC: 10224A-2021BG951A " ou "où: 10224A-2021BG951A est le numéro de certification du module.