BG600L-M3

Hardware Design

LPWA Module Series

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About the Document

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1 Introduction

This document defines BG600L-M3 module and describes its air interface and hardware interfaces which are connected with customers' applications.

This document helps customers quickly understand the interface specifications, electrical and mechanical details, as well as other related information of BG600L-M3. To facilitate application designs, it also includes some reference designs for customers' reference. The document, coupled with application notes and user guides, makes it easy to design and set up mobile applications with BG600L-M3.

1.1 Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating BG600L-M3 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 signals and cellular network cannot be guaranteed to connect in all possible conditions (for example, with unpaid bills or with an invalid (U)SIM card). When emergent help is needed in such conditions, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength.
	The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with potentially explosive atmospheres, obey all posted signs to turn off wireless devices such as mobile phone or other cellular terminals. Areas with potentially explosive atmospheres include fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust or metal powders, etc.

1.2 CE Certificate Requirement

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 BG600L-M3 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:
GSM850/GSM1900: 33dBm[-2~+2dB]
CATM: B1/3/5/8/20/28: 21dBm [+1.7/-3 dB]
NB IoT: B1/3/5/8/20/28:: 21dBm [+1.7/-3 dB]
The device antenna Gain is: 4dBi.

1.3 FCC Certificate Requirement

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: XMR202004BG600LM3.
4.To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, maximum antenna gain (including cable loss) must not exceed:

- ❒ GSM850 :≤8.571dBi
- ❒ GSM1900 :≤10.03dBi
- ❒ 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
❒ NB LTE Band71:≤11.687dBi
❒NB LTE Band85:≤11.798 dBi

5. This module must not transmit simultaneously with any other antenna or transmitter
6. The host end product must include a user manual that clearly defines operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines. For portable devices, in addition to the conditions 3 through 6 described above, a separate approval is required to satisfy the SAR requirements of FCC Part 2.1093

If the device is used for other equipment that separate approval is required for all other operating configurations, including portable configurations with respect to 2.1093 and different antenna configurations.
For this device, OEM integrators must be provided with labeling instructions of finished products. Please refer to KDB784748 D01 v07, section 8. Page 6/7 last two paragraphs:
A certified modular has the option to use a permanently affixed label, or an electronic label. For a permanently affixed label, the module must be labeled with an FCC ID - Section 2.926 (see 2.2 Certification (labeling requirements) above). The OEM manual must provide clear instructions explaining to the OEM the labeling requirements, options and OEM user manual instructions that are required (see next paragraph).
For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straightforward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module:"Contains Transmitter Module FCC ID: XMR202004BG600LM3" or "Contains FCC ID: XMR202004BG600LM3" 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.

1.4 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:

- ❒ GSM850 :≤8.571dBi
- ❒ GSM1900 :≤10.03dBi
- ❒ 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
- ❒ NB LTE Band71:≤11.687dBi
- ❒ NB LTE Band85:≤11.798 dBi

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-20BG600LM3” or “where: 10224A-20BG600LM3 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-20BG600LM3 " ou "où: 10224A-20BG600LM3 est le numéro de certification du module.

2 Product Concept

2.1 General Description

BG600L-M3 is an embedded IoT (LTE Cat M1, LTE Cat NB2 and EGPRS) wireless communication module. It provides data connectivity on LTE-FDD and GPRS/EGPRS networks, and supports half-duplex operation in LTE network. It also provides GNSS and voice* [1] functionality to meet customers' specific application demands.

Table 1: Frequency Bands and GNSS Types of BG600L-M3 Module

Module	Supported Bands	Power Class	GNSS (Optional)
BG600L-M3	**Cat M1:** LTE-FDD: B1/B2/B3/B4/B5/B8/B12/B13/B14/ B18/B19/B20/B25/B26/B27/B28/ B66/B85 **Cat NB2** [2]**:** LTE-FDD: B1/B2/B3/B4/B5/B8/B12/B13/B18/ B19/B20/B25/B26/B28/B66/B71/B85 **EGPRS:** 850/900/1800/1900 MHz	Power Class 5 (21 dBm)	GPS, GLONASS, BeiDou, Galileo, QZSS

NOTES

1. [1] BG600L-M3 module supports VoLTE (Voice over LTE) under LTE Cat M1 and CS voice under GSM.
2. [2] LTE Cat NB2 is backward compatible with LTE Cat NB1.
3. GNSS function is optional.
4. "*" means under development.

With a compact profile of 18.7 mm × 16.0 mm × 2.1 mm, BG600L-M3 can meet almost all requirements for M2M applications such as security, smart metering, tracking system and wireless POS.

BG600L-M3 is an SMD type module which can be embedded into applications through its 68 LGA pads. It supports internet service protocols like TCP, UDP and PPP. Extended AT commands have been developed for customers to use these internet service protocols easily.

1.5 Key Features

The following table describes the detailed features of BG600L-M3 module.

Table 2: Key Features of BG600L-M3 Module

Features	Details
Power Supply	● Supply voltage: 3.3–4.3 V ● Typical supply voltage: 3.8 V
Transmitting Power	● Class 5 (21 dBm + 1.7/-3 dB) for LTE-FDD bands ● Class 4 (33 dBm ±2 dB) for GSM850 ● Class 4 (33 dBm ±2 dB) for EGSM900 ● Class 1 (30 dBm ±2 dB) for DCS1800 ● Class 1 (30 dBm ±2 dB) for PCS1900 ● Class E2 (27 dBm ±3 dB) for GSM850 8-PSK ● Class E2 (27 dBm ±3 dB) for EGSM900 8-PSK ● Class E2 (26 dBm ±3 dB) for DCS1800 8-PSK ● Class E2 (26 dBm ±3 dB) for PCS1900 8-PSK
LTE Features	● Support 3GPP Rel. 14 ● Support LTE Cat M1 and LTE Cat NB2 ● Support 1.4 MHz RF bandwidth for LTE Cat M1 ● Support 200 KHz RF bandwidth for LTE Cat NB2 ● Cat M1: Max. 588 kbps (DL)/ 1119 kbps (UL) ● Cat NB2: Max. 127 kbps (DL)/ 158.5 kbps (UL)
GSM Features	**GPRS:** ● Support GPRS multi-slot class 33 (33 by default) ● Coding scheme: CS-1, CS-2, CS-3 and CS-4 ● Max. 107 kbps (DL), Max. 85.6 kbps (UL) **EDGE:** ● Support EDGE multi-slot class 33 (33 by default) ● Support GMSK and 8-PSK for different MCS (Modulation and Coding Scheme) ● Downlink coding schemes: CS 1-4 and MCS 1-9 ● Uplink coding schemes: CS 1-4 and MCS 1-9 ● Max. 296 kbps (DL), Max. 236.8 kbps (UL)
Internet Protocol Features*	● Support PPP/TCP/UDP/SSL/TLS/FTP(S)/HTTP(S)/NITZ/PING/MQTT/CoAP*/IPv6* protocols ● Support PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) protocols which are usually used for PPP connections
SMS	● Text and PDU mode

	● Point to point MO and MT ● SMS cell broadcast ● SMS storage: ME by default
(U)SIM Interface	Support 1.8 V USIM/SIM card only
PCM Interface*	Support one digital audio interface: PCM interface
USB Interface	● Compliant with USB 2.0 specification (slave only) ● Support operations at low-speed and full-speed ● Used for AT command communication, data transmission, GNSS NMEA output, software debugging and firmware upgrade ● Support USB serial drivers for Windows 7/8/8.1/10, Linux 2.6–5.4, Android 4.x–9.x
UART Interfaces	**Main UART:** ● Used for data transmission and AT command communication ● 115200 bps baud rate by default ● The default frame format is 8N1 (8 data bits, no parity, 1 stop bit) ● Support hardware flow control **Debug UART:** ● Used for software debugging and log output ● Support 115200 bps baud rate **GNSS UART:** ● Used for GNSS data and NMEA sentences output ● 115200 bps baud rate by default
GNSS (Optional)	● Gen9 VT of Qualcomm (GPS, GLONASS, BeiDou, Galileo and QZSS) ● 1 Hz data update rate by default
AT Commands	3GPP TS 27.007 and 3GPP TS 27.005 AT commands, as well as Quectel enhanced AT commands
Network Indication	One NET_STATUS pin for network connectivity status indication
Antenna Interfaces	Main antenna (ANT_MAIN) and GNSS antenna (ANT_GNSS) interfaces
Physical Characteristics	● Dimensions: (18.7 ±0.15) mm × (16.0 ±0.15) mm × (2.1 ±0.20) mm ● Weight: approx. 1.25 ±0.1 g
Temperature Range	● Operation temperature range: -35 °C to +75 °C [1)] ● Extended temperature range: -40 °C to +85 °C [2)] ● Storage temperature range: -40 °C to +90 °C
Firmware Upgrade	USB interface and DFOTA*
RoHS	All hardware components are fully compliant with EU RoHS directive

NOTES

1. [1] Within operation temperature range, the module meets 3GPP specifications.
2. [2] Within the extended temperature range, the module remains the ability to establish and maintain functions such as voice, SMS, data transmission, emergency call, etc., without any unrecoverable malfunction. Radio spectrum and radio network will not be influenced, while one or more specifications, such as P_{out}, may undergo a reduction in value, exceeding the specified tolerances of 3GPP. When the temperature returns to the normal operating temperature level, the module will meet 3GPP specifications again.
3. "*" means under development.

1.6 Functional Diagram

The following figure shows a block diagram of BG600L-M3 and illustrates the major functional parts.

- Power management
- Baseband
- Radio frequency
- Peripheral interfaces

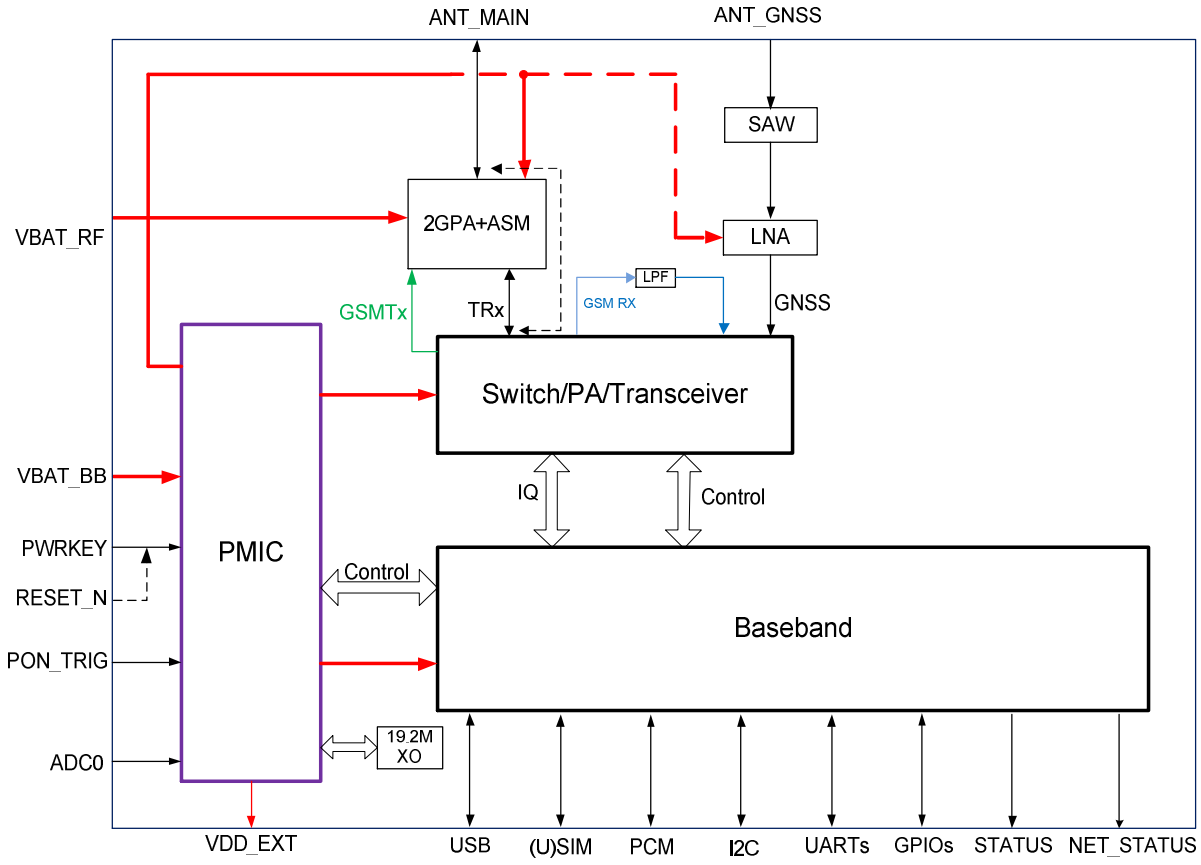


Figure 1: Functional Diagram

NOTES

1. PWRKEY output voltage is 1.5 V because of the voltage drop inside the Qualcomm chipset. Due to platform limitations, the chipset has integrated the reset function into PWRKEY. Therefore, PWRKEY should never be pulled down to GND permanently.
2. RESET_N is connected directly to PWRKEY inside the module.

1.7 Evaluation Board

In order to facilitate application development with BG600L-M3 conveniently, Quectel supplies the evaluation board (EVB), USB to RS-232 converter cable, USB data cable, earphone, antenna and other peripherals to control or test the module. For more details, please refer to ***document [1]***.

2 Application Interfaces

BG600L-M3 is equipped with 68 LGA pads that can be connected to customers' cellular application platforms. The subsequent chapters will provide detailed description of interfaces listed below:

- Power supply
- PON_TRIG interface
- (U)SIM interface
- USB interface
- UART interfaces
- PCM and I2C interfaces*
- Status indication interfaces
- USB_BOOT interface
- ADC interface
- GPIO interfaces*
- GRFC interfaces*

NOTE

"*" means under development.

2.1 Pin Assignment

The following figure shows the pin assignment of BG600L-M3.

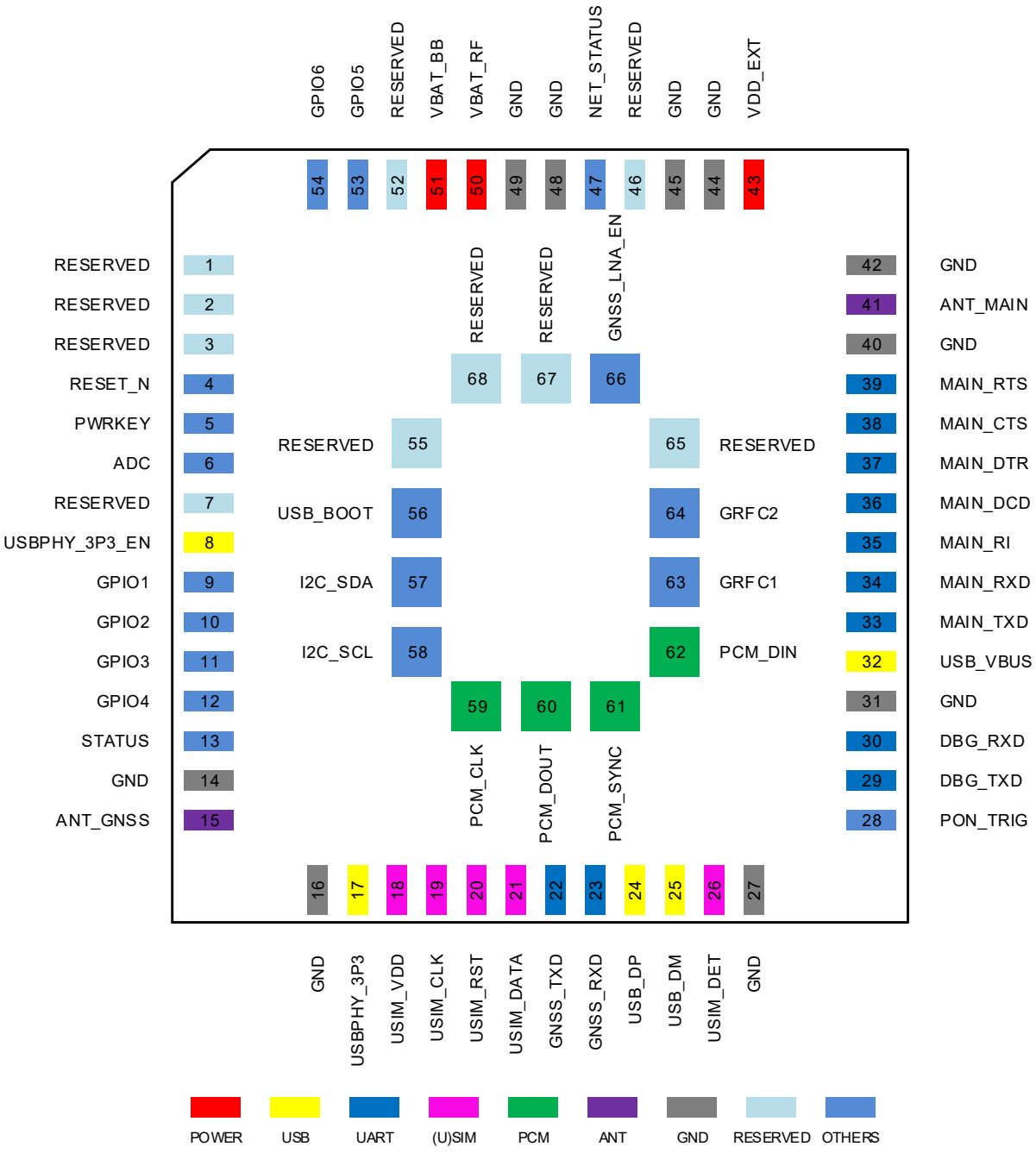


Figure 2: Pin Assignment (Top View)

NOTES

1. PWRKEY output voltage is 1.5 V because of the voltage drop inside the Qualcomm chipset. Due to platform limitations, the chipset has integrated the reset function into PWRKEY. Therefore, PWRKEY should never be pulled down to GND permanently.
2. RESET_N is connected directly to PWRKEY inside the module.
3. ADC input voltage must not exceed 1.8 V.
4. The input voltage range of USB_VBUS is 1.3–1.8 V.
5. GPIO1 (pin 9), NET_STATUS (pin 47), GRFC1 (pin 63) and GNSS_LNA_EN (pin 66) are BOOT_CONFIG pins, and please do not pull them up before startup.
6. Keep all RESERVED pins and unused pins unconnected.
7. GND pins should be connected to ground in the design.

2.2 Pin Description

The following tables show the pin definition and description of BG600L-M3.

Table 3: Definition of I/O Parameters

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

Table 4: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT_BB	51	PI	Power supply for the module's baseband part	Vmax = 4.3 V Vmin = 3.3 V Vnorm = 3.8 V	
VBAT_RF	50	PI	Power supply for the module's RF part	Vmax = 4.3 V Vmin = 3.3 V Vnorm = 3.8 V	
VDD_EXT	43	PO	1.8 V output power supply for external circuits	Vnorm = 1.8 V $I_O$max = 50 mA	If unused, keep this pin open.
GND	14, 16, 27, 31, 40, 42, 44, 45, 48, 49,		Ground		
Turn on/off					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	5	DI	Turn on/off the module	Vnorm = 1.5 V V_{IL}max = 0.45 V	PWRKEY should never be pulled down to GND permanently.
Reset					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESET_N	4	DI	Reset the module	Vnorm = 1.5 V V_{IL}max = 0.45 V	
Status Indication					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
STATUS	13	DO	Indicate the module's operation status	V_{OH}min = 1.35 V V_{OL}max = 0.45 V	1.8 V power domain. If unused, keep this pin open.
NET_STATUS	47	DO	Indicate the module's network activity status	V_{OH}min = 1.35 V V_{OL}max = 0.45 V	BOOT_CONFIG. Do not pull it up before startup. 1.8 V power domain. If unused, keep this

					pin open.
USB Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_VBUS	32	AI	USB connection detect	V_{IH}max = 1.8 V V_{IH}min = 1.3 V	
USB_DP	24	IO	USB differential data (+)		Compliant with USB 2.0 standard specification. Require differential impedance of 90 Ω.
USB_DM	25	IO	USB differential data (-)		
USBPHY_3P3	17	PI	Power supply for USB PHY circuit	Vnorm = 3.3 V	
USBPHY_3P3_EN	8	DO	External LDO enable control for USB	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain.
(U)SIM Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USIM_DET *	26	DI	(U)SIM card hot-plug detect	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
USIM_VDD	18	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	20	DO	(U)SIM card reset	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain.
USIM_DATA	21	IO	(U)SIM card data	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain.
USIM_CLK	19	DO	(U)SIM card clock	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain.
Main UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
MAIN_DTR	37	DI	Main UART data terminal ready	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V	1.8 V power domain. If unused, keep this pin open.

				V_{IH}max = 2.0 V	
MAIN_RXD	34	DI	Main UART receive	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
MAIN_TXD	33	DO	Main UART transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
MAIN_CTS	38	DO	Main UART clear to send	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
MAIN_RTS	39	DI	Main UART request to send	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
MAIN_DCD	36	DO	Main UART data carrier detect	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
MAIN_RI	35	DO	Main UART ring indication	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
Debug UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DBG_RXD	30	DI	Debug UART receive	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
DBG_TXD	29	DO	Debug UART transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
GNSS UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GNSS_TXD	22	DO	GNSS UART transmit	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
GNSS_ RXD	23	DI	GNSS UART receive	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.

PCM Interface*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PCM_CLK	59	DO	PCM clock	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
PCM_SYNC	61	DO	PCM data frame sync	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
PCM_DIN	62	DI	PCM data input	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
PCM_DOUT	60	DO	PCM data output	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
I2C Interface*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
I2C_SCL	58	OD	I2C serial clock (for external codec)		External pull-up resistor is required. 1.8 V only. If unused, keep this pin open.
I2C_SDA	57	OD	I2C serial data (for external codec)		External pull-up resistor is required. 1.8 V only. If unused, keep this pin open.
Antenna Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_MAIN	41	IO	Main antenna interface		50 Ω impedance
ANT_GNSS	15	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	9	IO	General-purpose	V_{OL}max = 0.45 V	BOOT_CONFIG.

			input/output	V_{OH}min = 1.35 V V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	Do not pull it up before startup. 1.8 V power domain. If unused, keep this pin open.
GPIO2	10	IO	General-purpose input/output	V_{OL}max = 0.45 V V_{OH}min = 1.35 V V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
GPIO3	11	IO	General-purpose input/output	V_{OL}max = 0.45 V V_{OH}min = 1.35 V V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
GPIO4	12	IO	General-purpose input/output	V_{OL}max = 0.45 V V_{OH}min = 1.35 V V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
GPIO5	53	IO	General-purpose input/output	V_{OL}max = 0.45 V V_{OH}min = 1.35 V V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
GPIO6	54	IO	General-purpose input/output	V_{OL}max = 0.45 V V_{OH}min = 1.35 V V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
ADC Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ADC	6	AI	General-purpose ADC interface	Voltage range: 0.1–1.8 V	If unused, keep this pin open.
GRFC Interfaces*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**

GRFC1	63	DO	Generic RF controller	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	BOOT_CONFIG. Do not pull it up before startup. 1.8 V power domain. If unused, keep this pin open.
GRFC2	64	DO	Generic RF controller	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	1.8 V power domain. If unused, keep this pin open.
PON_TRIG Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PON_TRIG	28	DI	Wake up the module from PSM		1.8 V power domain. Rising-edge triggered. If unused, keep this pin open.
Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_BOOT	56	DI	Force the module into emergency download mode	V_{IL}min = -0.3 V V_{IL}max = 0.6 V V_{IH}min = 1.2 V V_{IH}max = 2.0 V	1.8 V power domain. If unused, keep this pin open.
GNSS_LNA_EN	66	DO	External LNA enable control	V_{OL}max = 0.45 V V_{OH}min = 1.35 V	BOOT_CONFIG. Do not pull it up before startup. 1.8 V power domain. If unused, keep this pin open.
RESERVED Pins					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESERVED	1–3, 7, 46, 52, 55, 65, 67, 68		Reserved		Keep these pins open.

NOTES

1. PWRKEY output voltage is 1.5 V because of the voltage drop inside the Qualcomm chipset. Due to platform limitations, the chipset has integrated the reset function into PWRKEY. Therefore, PWRKEY

should never be pulled down to GND permanently.
2. RESET_N is connected directly to PWRKEY inside the module.
3. The input voltage range of USB_VBUS is 1.3–1.8 V.
4. GPIO1 (pin 9), NET_STATUS (pin 47), GRFC1 (pin 63) and GNSS_LNA_EN (pin 66) are BOOT_CONFIG pins, and please do not pull them up before startup.
5. USBPHY_3P3 and USBPHY_3P3_EN pins are used for USB PHY circuits.
6. Keep all RESERVED pins and unused pins unconnected.
7. "*" means under development.

2.3 Operating Modes

The table below briefly summarizes the various operating modes of BG600L-M3.

Table 5: Overview of Operating Modes

Mode	Details	
Normal Operation	Connected	Network has been connected. In this mode, the power consumption may vary with the network setting and data transfer rate.
	Idle	Software is active. The module remains registered on network, and it is ready to send and receive data.
Extended Idle Mode DRX (e-I-DRX)	BG600L-M3 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** can set the module into airplane mode. In this case, RF function will be invalid.	
Minimum Functionality Mode	**AT+CFUN=0** can set the module into a minimum functionality mode without removing the power supply. In this case, both RF function and (U)SIM card will be invalid.	
Sleep Mode	In this mode, the current consumption of the module will be reduced to a lower level. During this mode, the module can still receive paging message, SMS and TCP/UDP data from the network normally.	
Power OFF Mode	In this mode, the power management unit shuts down the power supply. The software is not active. The serial interfaces are not accessible. But the operating voltage (connected to VBAT_RF and VBAT_BB) remains applied.	
Power Saving Mode (PSM)	BG600L-M3 module may enter Power Saving Mode to further reduce its power consumption. 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.	

NOTE

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

2.4 Power Saving

2.4.1 Airplane Mode

When the module enters airplane mode, the RF function does not work, and all AT commands correlative with RF function will be inaccessible.

The module can be set into Airplane mode through **AT+CFUN=<fun>**. The command provides choice of the functionality level, through setting **<fun>** into 0, 1 or 4.

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

NOTE

The execution of **AT+CFUN** command will not affect GNSS function.

2.4.2 Power Saving Mode (PSM)

BG600L-M3 module can enter PSM to reduce its power consumption. 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. So BG600L-M3 in PSM cannot immediately respond 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** command.

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

- A rising edge on PON_TRIG will wake up the module from PSM. (Recommended)

- Drive PWRKEY low will wake up the module.
- When the T3412_Ext timer expires, the module will be woken up automatically.

NOTE

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

2.4.3 Extended Idle Mode DRX (e-I-DRX)

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

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

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

If e-I-DRX is supported by the network, then it can be enabled by **AT+CEDRXS=1** command.

NOTE

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

2.4.4 Sleep Mode

BG600L-M3 is able to reduce its current consumption to a lower value during the sleep mode. The following sub-chapters describe the power saving procedure of BG600L-M3 module.

2.4.4.1 UART Application

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

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

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

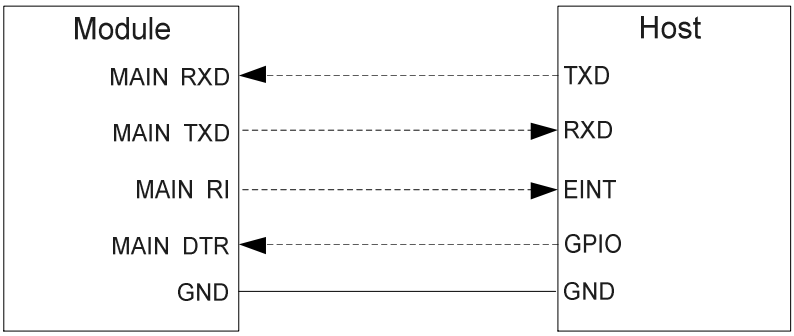


Figure 3: Sleep Mode Application via UART

- When BG600L-M3 has URC to report, MAIN_RI signal will wake up the host. Please refer to ***Chapter 3.15*** for details about MAIN_RI behavior.
- Driving the MAIN_DTR of host low will wake up the module.

2.5 Power Supply

2.5.1 Power Supply Pins

BG600L-M3 provides the following two VBAT pins for connection with an external power supply. There are two separate voltage domains for VBAT.

- One VBAT_RF pin for module's RF part.
- One VBAT_BB pin for module's baseband part.

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

Table 6: VBAT and GND Pins

Pin Name	Pin No.	Description	Min.	Typ.	Max.	Unit
VBAT_RF	50	Power supply for the module's RF part	3.3	3.8	4.3	V
VBAT_BB	51	Power supply for the module's baseband part	3.3	3.8	4.3	V

GND	14, 16, 27, 31, 40, 42, 44, 45, 48, 49	Ground	-	-	-	-

2.5.2 Decrease Voltage Drop

The power supply range of the BG600L-M3 is 3.3–4.3 V. Please make sure that the input voltage will never drop below 3.3 V.

The following figure shows the voltage drop during burst transmission in 2G network of BG600L-M3 module. The voltage drop will be less in LTE Cat M1 and/or LTE Cat NB2 networks.

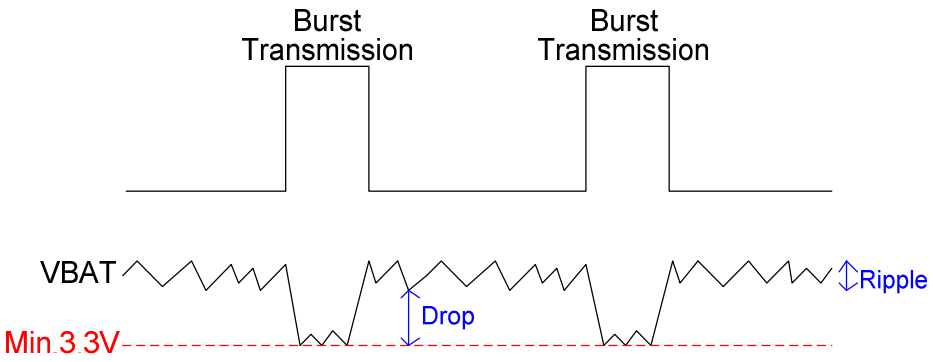


Figure 4: Power Supply Limits during Burst Transmission

To decrease voltage drop, a bypass capacitor of about 100 μF with low ESR should be used, and a multi-layer ceramic chip capacitor (MLCC) array should also be reserved due to its low ESR. It is recommended to use three ceramic capacitors (100 nF, 33 pF, 10 pF) for composing the MLCC array, and place these capacitors close to VBAT pins. The main power supply from an external application has to be a single voltage source and can be expanded to two sub paths with star structure. The width of VBAT_BB trace should be no less than 0.5 mm, and the width of VBAT_RF trace should be no less than 2 mm. In principle, the longer the VBAT trace is, the wider it will be.

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

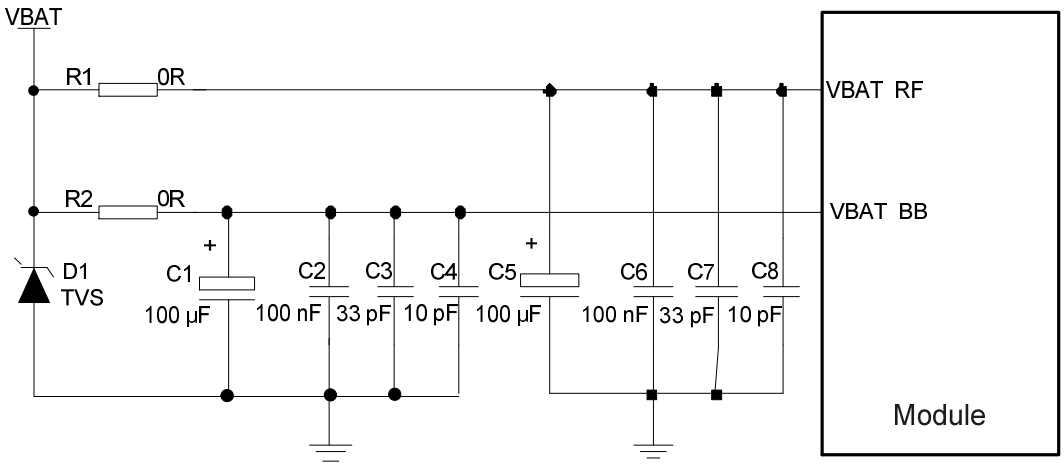


Figure 5: Star Structure of the Power Supply

2.5.3 Monitor the Power Supply

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

2.6 Turn on and off Scenarios

2.6.1 Turn on Module with PWRKEY

The following table shows the pin definition of PWRKEY.

Table 7: Pin Definition of PWRKEY

Pin Name	Pin No.	Description	DC Characteristics	Comment
PWRKEY	5	Turn on/off the module	Vnorm = 1.5 V V_{IL}max = 0.45 V	The output voltage is 1.5 V because of the voltage drop inside the Qualcomm chipset.

When BG600L-M3 is in power off mode, it can be turned on by driving PWRKEY low for 500–1000 ms. It is recommended to use an open drain/collector driver to control the PWRKEY. A simple reference circuit is illustrated in the following figure.

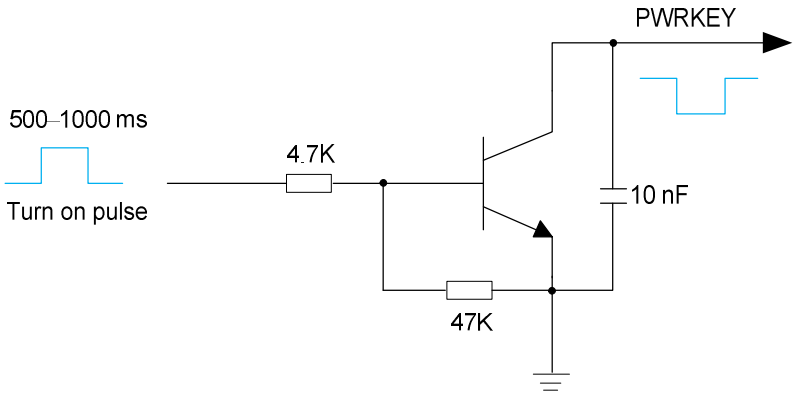


Figure 6: Turn on the Module Using Driving Circuit

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

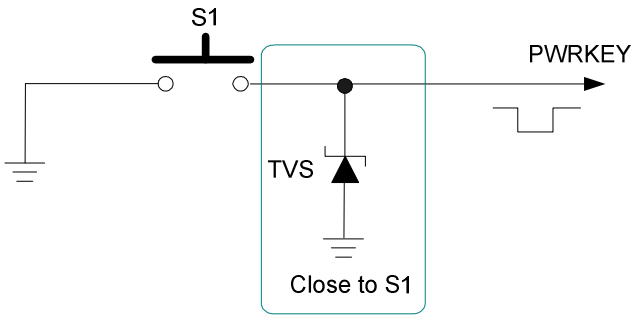


Figure 7: Turn on the Module Using Keystroke

The power on scenario is illustrated in the following figure.

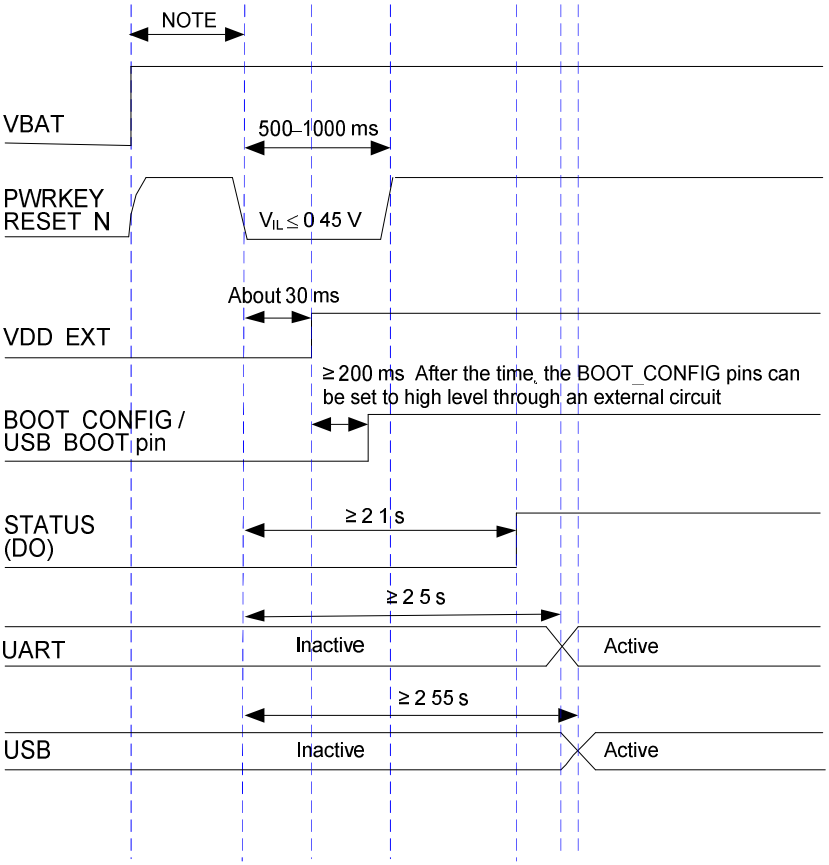


Figure 8: Power-on Timing

NOTES

1. Make sure that VBAT is stable before pulling down PWRKEY pin and keep the interval no less than 30 ms.
2. PWRKEY output voltage is 1.5 V because of the voltage drop inside the Qualcomm chipset. Due to platform limitations, the chipset has integrated the reset function into PWRKEY. Therefore, PWRKEY should never be pulled down to GND permanently.

2.6.2 Turn off Module

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

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

2.6.2.1 Turn off Module with PWRKEY

Driving PWRKEY low for 650–1500 ms, the module will execute power-down procedure after PWRKEY is released.

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

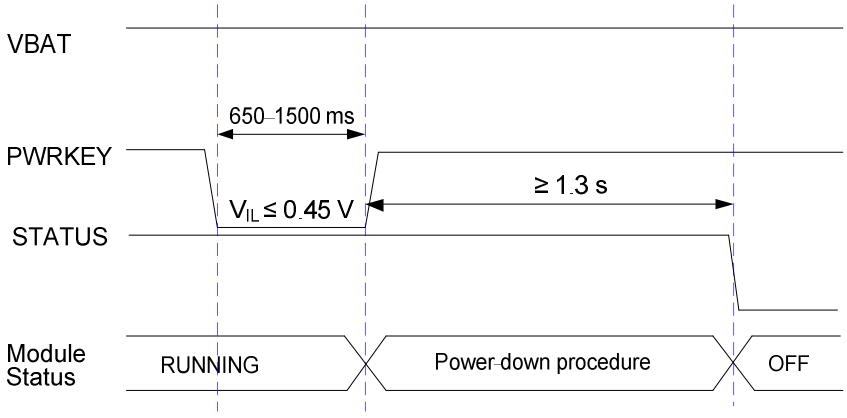


Figure 9: Power-off Timing

2.6.2.2 Turn off Module with AT Command

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

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

2.7 Reset the Module

RESET_N is used to reset the module. Due to platform limitations, the chipset has integrated the reset function into PWRKEY, and RESET_N is connected directly to PWRKEY inside the module.

The module can be reset by driving RESET_N low for 2–3.8 s.

Table 8: Pin Definition of RESET_N

Pin Name	Pin No.	Description	DC Characteristics	Comment
RESET_N	4	Reset the module	V_{IL}max = 0.45 V	Multiplexed from PWRKEY (connected directly to PWRKEY inside the module).

The reset scenario is illustrated in the following figure.

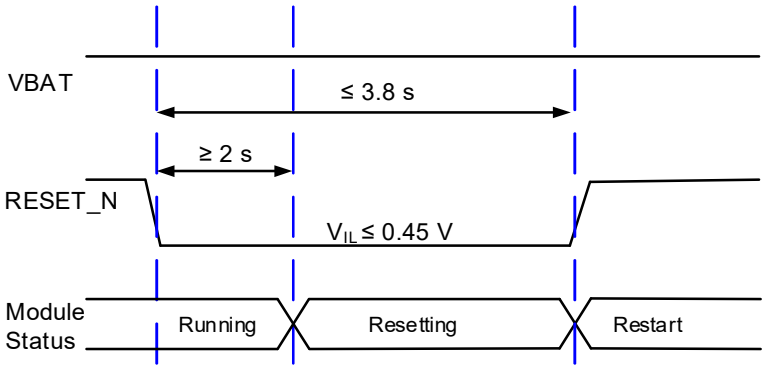


Figure 10: Reset Timing

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

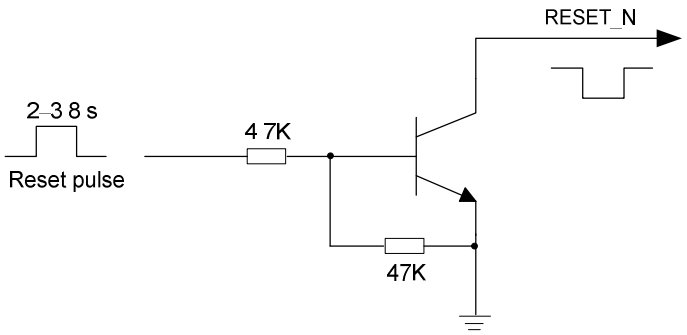


Figure 11: Reference Circuit of RESET_N by Using Driving Circuit

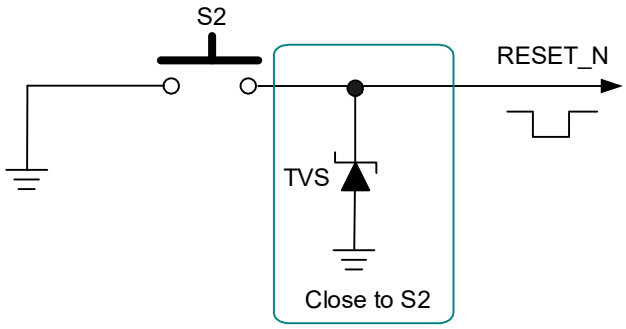


Figure 12: Reference Circuit of RESET_N by Using Button

NOTE

Please assure that there is no large capacitance on RESET_N pin.

2.8 PON_TRIG Interface

BG600L-M3 module provides one PON_TRIG pin, which is used to wake up the module from PSM. When the pin detects a rising edge, the module will be woken up from PSM.

Table 9: Pin Definition of PON_TRIG Interface

Pin Name	Pin No.	I/O	Description	Comment
PON_TRIG	28	DI	Wake up the module from PSM	Rising-edge triggered. Pulled-down by default. 1.8 V power domain.

A reference circuit is shown in the following figure.

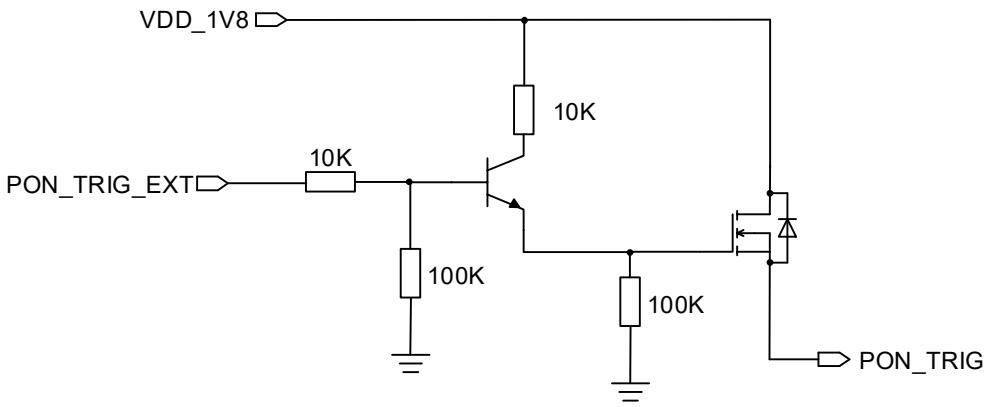


Figure 13: Reference Design of PON_TRIG

NOTE

VDD_1V8 is provided by an external LDO.

2.9 (U)SIM Interface

BG600L-M3 supports 1.8 V (U)SIM card only. The (U)SIM interface circuitry meets ETSI and IMT-2000 requirements.

Table 10: Pin Definition of (U)SIM Interface

Pin Name	Pin No.	I/O	Description	Comment
USIM_DET*	26	DI	(U)SIM card hot-plug detect	1.8 V power domain.
USIM_VDD	18	PO	(U)SIM card power supply	Only 1.8 V (U)SIM card is supported.
USIM_RST	20	DO	(U)SIM card reset	1.8 V power domain.
USIM_DATA	21	IO	(U)SIM card data	1.8 V power domain.
USIM_CLK	19	DO	(U)SIM card clock	1.8 V power domain.

BG600L-M3 supports (U)SIM card hot-plug via the USIM_DET pin, and both high and low level detections are supported. The function is disabled by default, and please refer to **AT+QSIMDET** command in ***document [2]*** for more details.

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

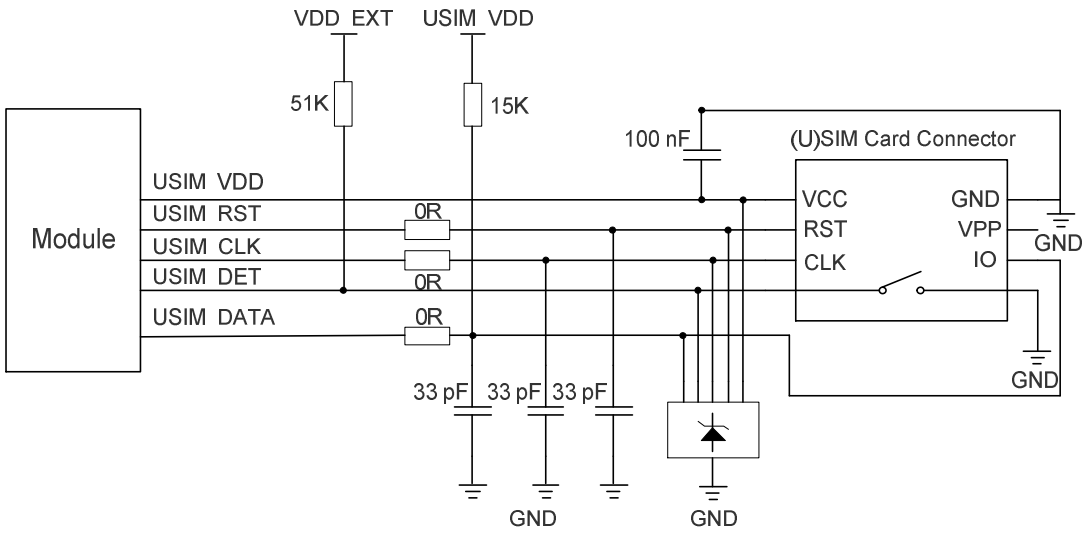


Figure 14: Reference Circuit of (U)SIM Interface with an 8-Pin (U)SIM Card Connector

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

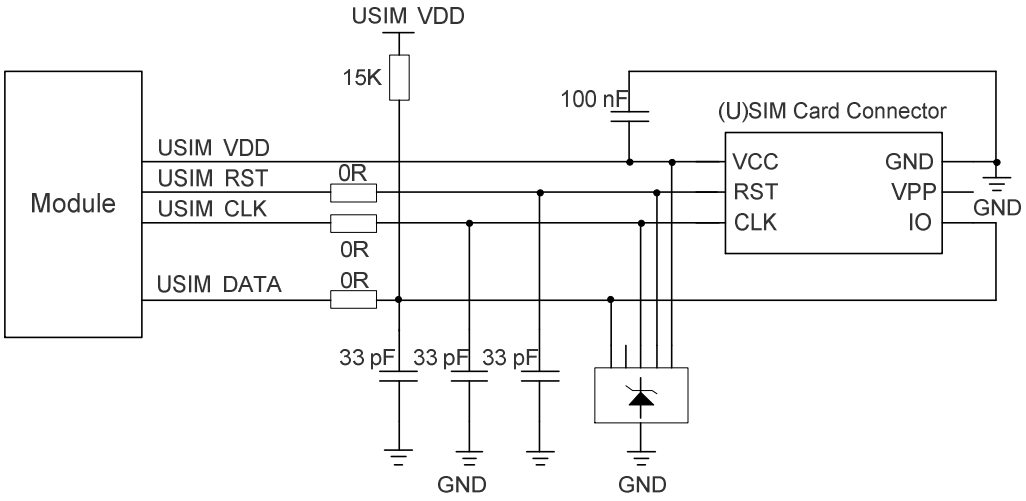


Figure 15: Reference Circuit of (U)SIM Interface with a 6-Pin (U)SIM Card Connector

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

- Keep the placement of (U)SIM card connector as close to the module as possible. Keep the trace length as less than 200 mm as possible.

- 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.
- 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.
- In order to offer good ESD protection, it is recommended to add a TVS diode array with parasitic capacitance not exceeding 15 pF. In order to facilitate debugging, it is recommended to reserve series resistors for the (U)SIM signals of the module. The 33 pF capacitors are used for filtering interference of EGSM900. Please note that the (U)SIM peripheral circuit should be close to the (U)SIM card connector.
- The pull-up resistor on USIM_DATA line can improve anti-jamming capability when long layout trace and sensitive occasion are applied, and should be placed close to the (U)SIM card connector.

NOTE

"*" means under development.

2.10 USB Interface

BG600L-M3 provides one integrated Universal Serial Bus (USB) interface which complies with the USB 2.0 specification and supports operation at low-speed (1.5 Mbps) and full-speed (12 Mbps) modes. For more details about USB 2.0 specification, please visit https://www.usb.org/.

The USB interface is used for AT command communication, data transmission, software debugging and firmware upgrade. The following table shows the pin definition of USB interface.

Table 11: Pin Definition of USB Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_VBUS	32	AI	USB connection detect	Input range: 1.3–1.8 V
USB_DP	24	IO	USB differential data (+)	Require differential impedance of 90 Ω
USB_DM	25	IO	USB differential data (-)	
USBPHY_3P3	17	PI	Power supply for USB PHY circuit	Vnorm = 3.3 V
USBPHY_3P3_EN	8	DO	External LDO enable control for USB	1.8 V power domain
GND	31		Ground	

The USB interface is recommended to be reserved for firmware upgrade or debugging in application designs. The following figures illustrate reference designs of USB PHY and USB interface.

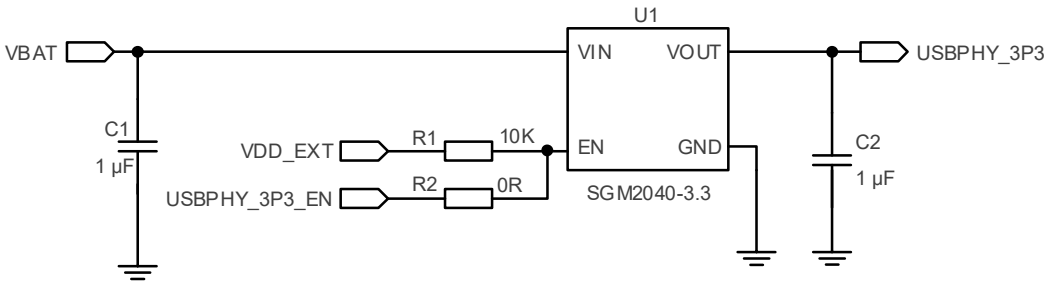


Figure 16: Reference Design of USB PHY

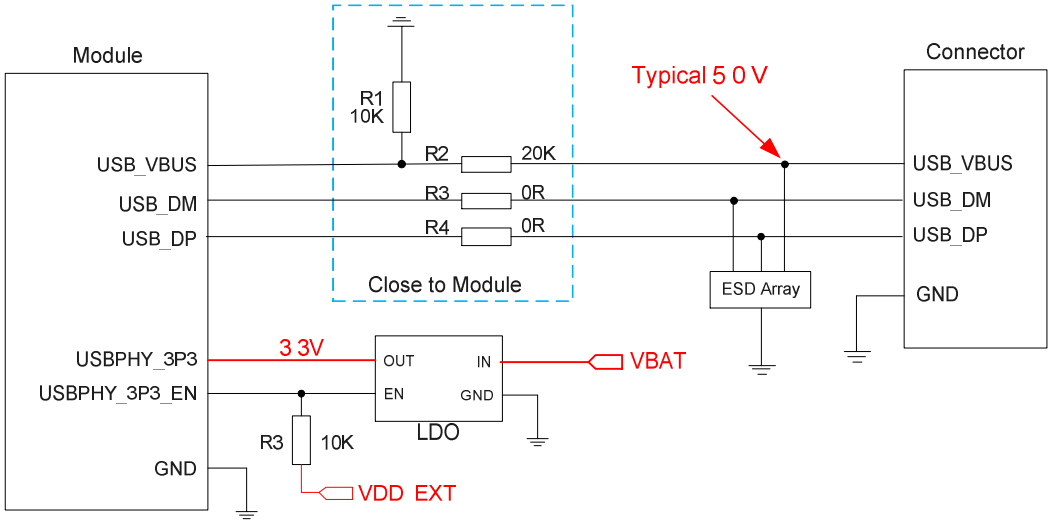


Figure 17: Reference Circuit of USB Interface

In order to ensure the integrity of USB data line signal, components R3 and R4 should be placed close to the module, and also these resistors should be placed close to each other. The extra stubs of trace must be as short as possible.

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

- 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 lines, so please 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.

NOTES

1. BG600L-M3 can only be used as a slave device.
2. The input voltage range of USB_VBUS is 1.3–1.8 V.

2.11 UART Interfaces

The module provides three UART interfaces: the main UART, debug UART and the GNSS UART interfaces. Features of them are illustrated below:

- The main UART interface supports 9600, 19200, 38400, 57600, 115200, 230400, 460800 and 921600 bps baud rates, and the default is 115200 bps. It is used for data transmission and AT command communication, and supports hardware flow control. The default frame format is 8N1 (8 data bits, no parity, 1 stop bit).
- The debug UART interface supports a fixed baud rate of 115200 bps, and is used for software debugging and log output.
- The GNSS UART interface supports 115200 bps baud rate by default, and is used for GNSS data and NMEA sentences output.

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

Table 12: Pin Definition of Main UART Interface

Pin Name	Pin No.	I/O	Description	Comment
MAIN_DTR	37	DI	Main UART data terminal ready	1.8 V power domain
MAIN_RXD	34	DI	Main UART receive	1.8 V power domain
MAIN_TXD	33	DO	Main UART transmit	1.8 V power domain
MAIN_CTS	38	DO	Main UART clear to send	1.8 V power domain
MAIN_RTS	39	DI	Main UART request to send	1.8 V power domain
MAIN_DCD	36	DO	Main UART data carrier detect	1.8 V power domain

MAIN_RI	35	DO	Main UART ring indication	1.8 V power domain

NOTE

AT+IPR command can be used to set the baud rate of the main UART interface, and **AT+IFC** command can be used to enable/disable hardware flow control (hardware flow control is disabled by default). Please refer to ***document [2]*** for more details about these AT commands.

Table 13: Pin Definition of Debug UART Interface

Pin Name	Pin No.	I/O	Description	Comment
DBG _TXD	29	DO	Debug UART transmit	1.8 V power domain
DBG _RXD	30	DI	Debug UART receive	1.8 V power domain

Table 14: Pin Definition of GNSS UART Interface

Pin Name	Pin No.	I/O	Description	Comment
GNSS_ TXD	22	DO	GNSS UART transmit	1.8 V power domain
GNSS_ RXD	23	DI	GNSS UART receive	1.8 V power domain

The logic levels of UART interfaces are described in the following table.

Table 15: Logic Levels of Digital I/O

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

The module provides 1.8 V UART interfaces. A voltage-level translator should be used if customers' application is equipped with a 3.3 V UART interface. The voltage-level translator TXS0108EPWR provided by *Texas Instruments* is recommended, and please visit http://www.ti.com for more information.

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

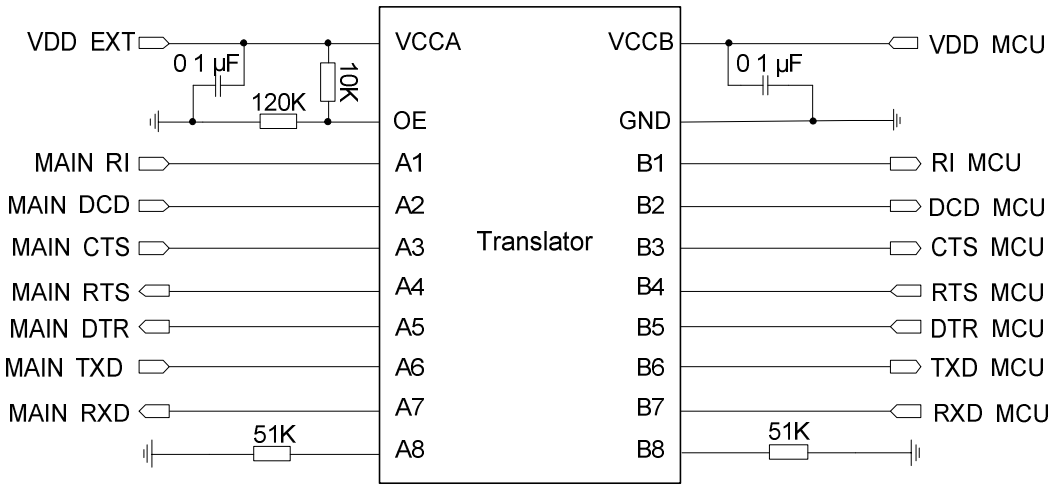


Figure 18: Main UART Reference Design (Translator Chip)

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

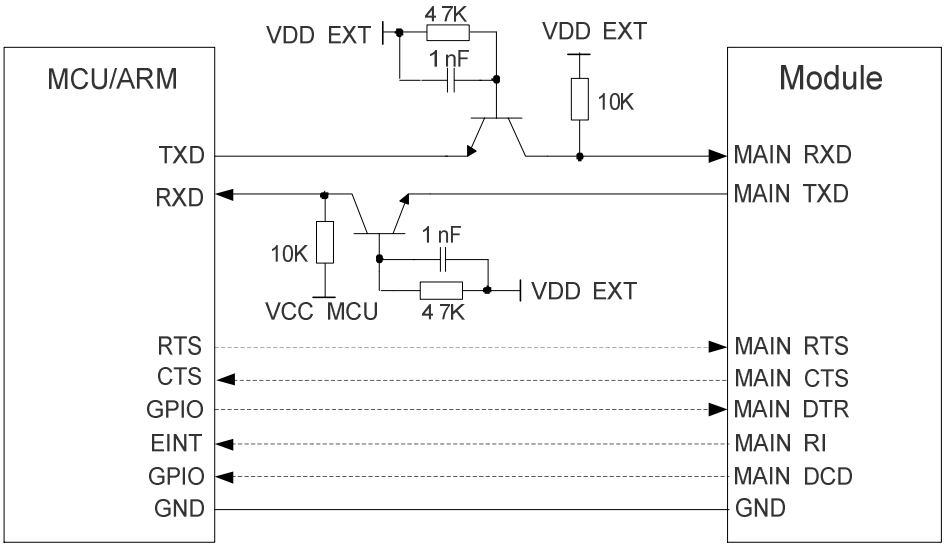


Figure 19: Main UART Reference Design (Transistor Circuit)

NOTE

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

2.12 PCM and I2C Interfaces*

BG600L-M3 provides one Pulse Code Modulation (PCM) digital interface and one I2C interface. The following table shows the pin definition of the two interfaces which can be applied on audio codec design.

Table 16: Pin Definition of PCM and I2C Interfaces

Pin Name	Pin No.	I/O	Description	Comment
PCM_CLK	59	DO	PCM clock	1.8 V power domain
PCM_SYNC	61	DO	PCM data frame sync	1.8 V power domain
PCM_DIN	62	DI	PCM data input	1.8 V power domain
PCM_DOUT	60	DO	PCM data output	1.8 V power domain
I2C_SCL	58	OD	I2C serial clock (for external codec)	Require external pull-up to 1.8 V
I2C_SDA	57	OD	I2C serial data (for external codec)	Require external pull-up to 1.8 V

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

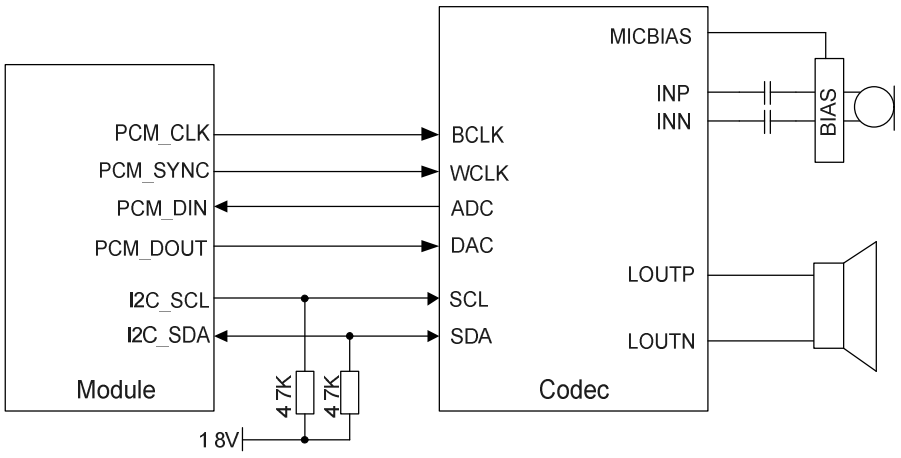


Figure 20: Reference Circuit of PCM Application with Audio Codec

NOTE

"*" means under development.

2.13 Network Status Indication

BG600L-M3 provides one network status indication pin: NET_STATUS. The pin is used to drive a network status indication LED. The following tables describe the pin definition and logic level changes of NET_STATUS in different network activity status.

Table 17: Pin Definition of NET_STATUS

Pin Name	Pin No.	I/O	Description	Comment
NET_STATUS	47	DO	Indicate the module's network activity status	BOOT_CONFIG. Do not pull it up before startup. 1.8 V power domain

Table 18: Working State of NET_STATUS

Pin Name	Logic Level Changes	Network Status
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.

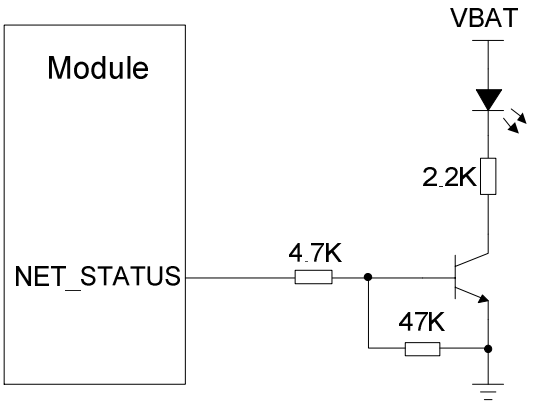


Figure 21: Reference Circuit of the Network Status Indicator

2.14 STATUS

The STATUS pin is used to indicate the operation status of BG600L-M3 module. It will output high level when the module is powered on.

The following table describes the pin definition of STATUS.

Table 19: Pin Definition of STATUS

Pin Name	Pin No.	I/O	Description	Comment
STATUS	13	DO	Indicate the module's operation status	1.8 V power domain

The following figure shows a reference circuit of STATUS.

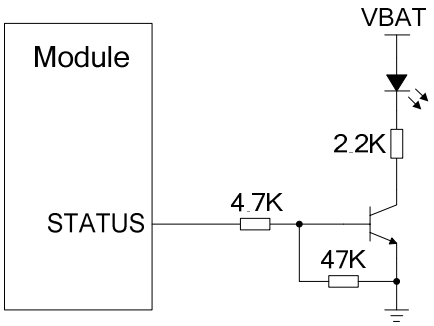


Figure 22: Reference Design of STATUS

2.15 Behaviors of MAIN_RI

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

No matter on which port URC is presented, URC will trigger the behavior of MAIN_RI pin.

The default behaviors of MAIN_RI are shown as below.

Table 20: Default Behaviors of MAIN_RI

State	Response
Idle	MAIN_RI keeps in high level.

URC	MAIN_RI outputs 120 ms low pulse when a new URC returns.

The default MAIN_RI behaviors can be configured flexibly by **AT+QCFG="urc/ri/ring"** command. For more details about **AT+QCFG**, please refer to ***document [2]***.

NOTE

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

2.16 USB_BOOT Interface

BG600L-M3 provides a USB_BOOT pin. During development or factory production, USB_BOOT can force the module to boot from USB port for firmware upgrade.

Table 21: Pin Definition of USB_BOOT Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_BOOT	56	DI	Force the module into emergency download mode	1.8 V power domain. Active high. If unused, keep it open.

The following figure shows a reference circuit of USB_BOOT interface.

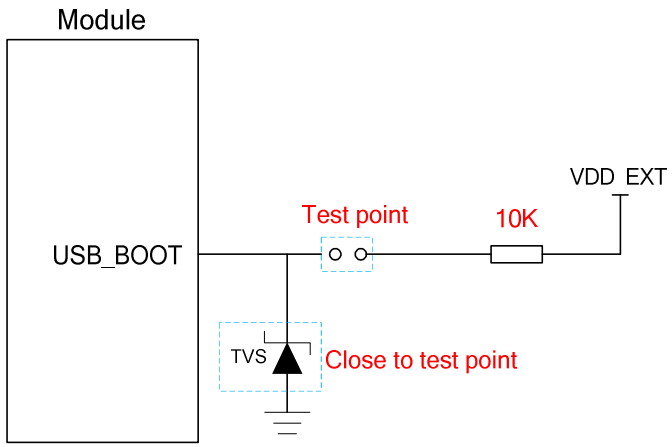


Figure 23: Reference Design of USB_BOOT Interface

The following figure shows the timing of USB_BOOT.

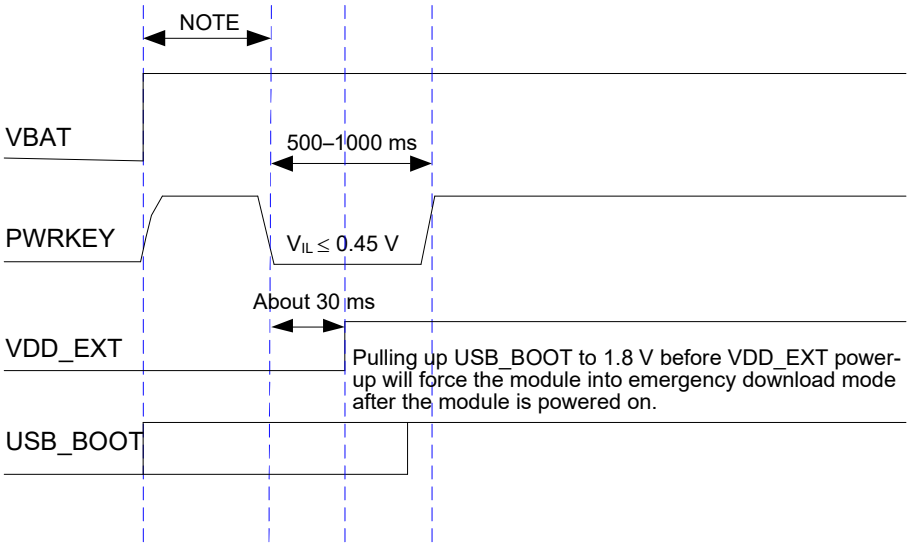


Figure 24: Timing of Turning on Module with USB_BOOT

NOTES

1. It is recommended to reserve the above circuit design during application design.
2. Please make sure that VBAT is stable before pulling down PWRKEY. It is recommended that the time between powering up VBAT and pulling down PWRKEY is no less than 30 ms.
3. When using MCU to control the module entering emergency download mode, please follow the above timing sequence. Connecting the test points as shown in ***Figure 23*** can manually force the module to enter download mode.

2.17 ADC Interface

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

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

Table 22: Pin Definition of ADC Interface

Pin Name	Pin No.	I/O	Description	Comment
ADC	6	AI	General-purpose ADC interface	Voltage range: 0.1–1.8 V

The following table describes the characteristics of ADC interface.

Table 23: Characteristics of ADC Interface

Parameter	Min.	Typ.	Max.	Unit
Voltage Range	0.1		1.8	V
Resolution (LSB)		64.979		μV
Analog Bandwidth		500		kHz
Sample Clock		4.8		MHz
Input Resistance	10			MΩ

NOTES

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 resistor accuracy should be no less than 1%.

2.18 GPIO Interfaces*

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

Table 24: Pin Definition of GPIO Interfaces

Pin Name	Pin No.	I/O	Description	Comment
GPIO1	9	IO	General-purpose input/output	BOOT_CONFIG. Do not pull it up before startup.

GPIO2	10	IO	General-purpose input/output
GPIO3	11	IO	General-purpose input/output
GPIO4	12	IO	General-purpose input/output
GPIO5	53	IO	General-purpose input/output
GPIO6	54	IO	General-purpose input/output

The following table describes the characteristics of GPIO interfaces.

Table 25: Logic Levels of GPIO Interfaces

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

NOTES

1. GPIO1 is a BOOT_CONFIG pin, and please do not pull it up before startup.
2. "*" means under development.

2.19 GRFC Interfaces*

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

Table 26: Pin Definition of GRFC Interfaces

Pin Name	Pin No.	I/O	Description	Comment
GRFC1	63	DO	Generic RF controller	BOOT_CONFIG. Do not pull it up before startup.
GRFC2	64	DO	Generic RF controller	

Table 27: Logic Levels of GRFC Interfaces

Parameter	Min.	Max.	Unit
V_{OL}	0	0.45	V
V_{OH}	1.35	1.8	V

Table 28: Truth Table of GRFC Interfaces

GRFC1 Level	GRFC2 Level	Frequency Range (MHz)	Band
Low	Low	880–2200	B1, B2, B3, B4, B8, B25, B66
High	Low	791–894	B5, B18, B19, B20, B26, B27
Low	High	698–803	B12, B13, B14, B28, B85
High	High	617–698	B71

NOTES

1. GRFC1 is a BOOT_CONFIG pin, and please do not pull it up before startup.
2. "*" means under development.

3 GNSS Receiver

3.1 General Description

BG600L-M3 includes a fully integrated global navigation satellite system solution that supports Gen9 VT of Qualcomm (GPS, GLONASS, BeiDou, Galileo and QZSS).

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

By default, BG600L-M3 GNSS engine is switched off. It has to be switched on via AT command. For more details about GNSS engine technology and configurations, please refer to ***document [3]***.

3.2 GNSS Performance

The following table shows the GNSS performance of BG600L-M3.

Table 29: GNSS Performance

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

	@ open sky	XTRA enabled	TBD	s
Accuracy (GNSS)	CEP-50	Autonomous @ open sky	TBD	m

NOTES

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.

3.3 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 the antennas.
- Use ground vias around the GNSS trace and sensitive analog signal traces to provide coplanar isolation and protection.
- Keep 50 Ω characteristic impedance for ANT_GNSS trace.

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

4 Antenna Interfaces

BG600L-M3 includes a main antenna interface and a GNSS antenna interface. The antenna ports have an impedance of 50 Ω.

4.1 Main Antenna Interface

4.1.1 Pin Definition

The pin definition of main antenna interface is shown below.

Table 30: Pin Definition of Main Antenna Interface

Pin Name	Pin No.	I/O	Description	Comment
ANT_MAIN	41	IO	Main antenna interface	50 Ω characteristic impedance

4.1.2 Operating Frequency

Table 31: BG600L-M3 Operating Frequency

3GPP Band	Transmit	Receive	Unit
LTE-FDD B1	1920–1980	2110–2170	MHz
LTE-FDD B2, PCS1900	1850–1910	1930–1990	MHz
LTE-FDD B3, DCS1800	1710–1785	1805–1880	MHz
LTE-FDD B4	1710–1755	2110–2155	MHz
LTE-FDD B5, GSM850	824–849	869–894	MHz
LTE-FDD B8, EGSM900	880–915	925–960	MHz
LTE-FDD B12	699–716	729–746	MHz

LTE-FDD B13	777–787	746–756	MHz
LTE-FDD B14 1)	788–798	758–768	MHz
LTE-FDD B18	815–830	860–875	MHz
LTE-FDD B19	830–845	875–890	MHz
LTE-FDD B20	832–862	791–821	MHz
LTE-FDD B25	1850–1915	1930–1995	MHz
LTE-FDD B26	814–849	859–894	MHz
LTE-FDD B27 1)	807–824	852–869	MHz
LTE-FDD B28	703–748	758–803	MHz
LTE-FDD B66	1710–1780	2110–2180	MHz
LTE-FDD B71 2)	663–698	617–652	MHz
LTE-FDD B85	698–716	728–746	MHz

NOTES

1. 1) LTE-FDD B14 and B27 are supported by LTE Cat M1 only.
2. 2) LTE-FDD B71 is supported by LTE Cat NB2 only.

4.1.3 Reference Design of Main Antenna Interface

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

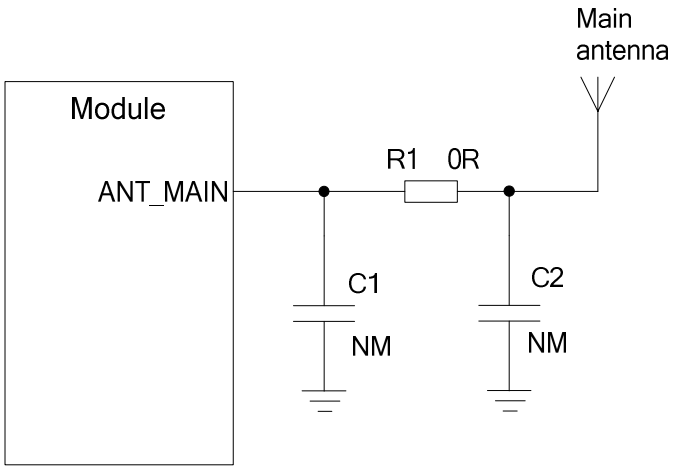


Figure 25: Reference Design of Main Antenna Interface

4.1.4 Reference Design of RF Layout

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.

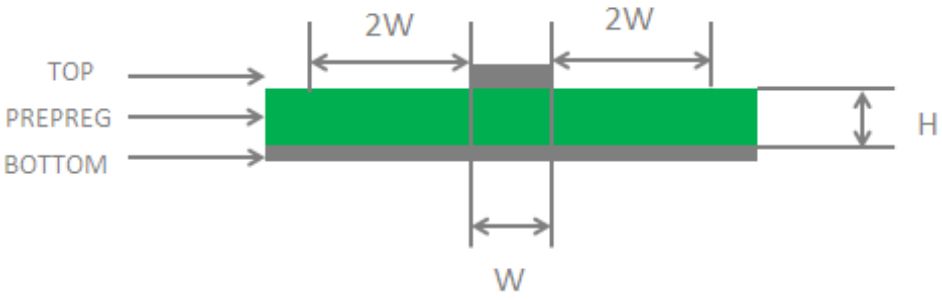


Figure 26: Microstrip Design on a 2-layer PCB

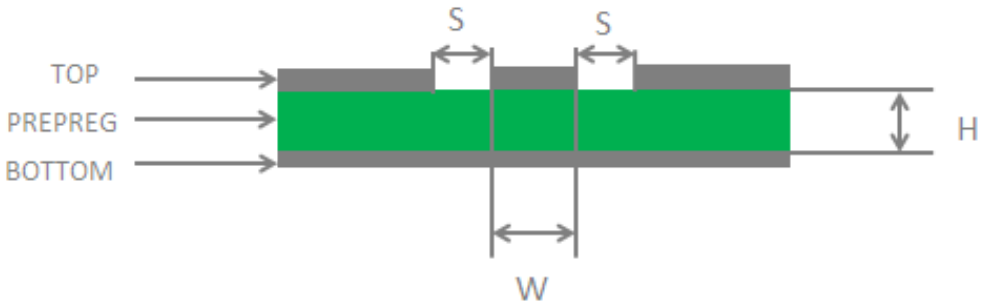


Figure 27: Coplanar Waveguide Design on a 2-layer PCB

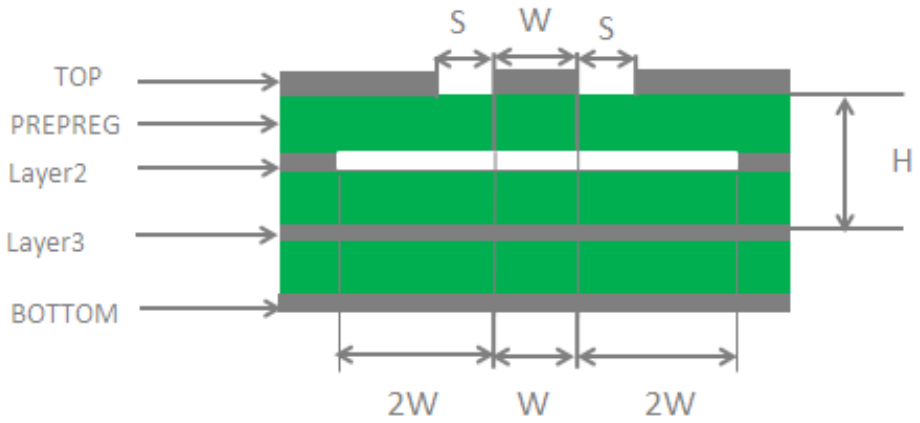


Figure 28: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

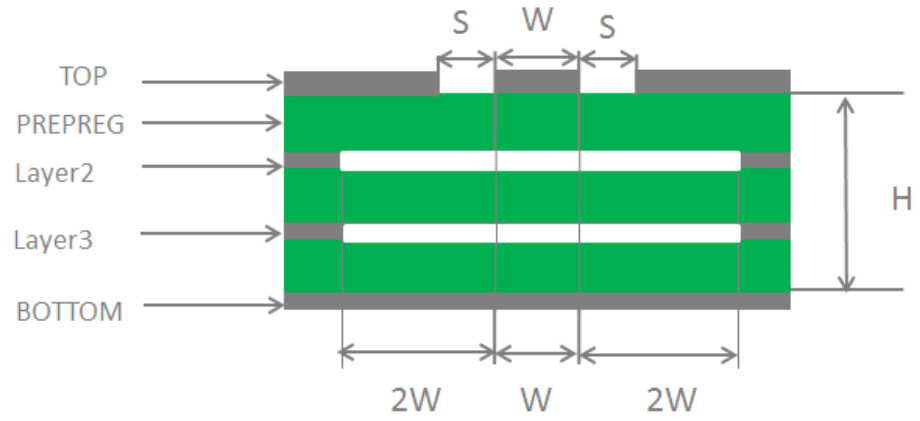


Figure 29: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

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

- 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, please refer to ***document [4]***.

4.2 GNSS Antenna Interface

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

Table 32: Pin Definition of GNSS Antenna Interface

Pin Name	Pin No.	I/O	Description	Comment
ANT_GNSS	15	AI	GNSS antenna interface	50 Ω impedance

Table 33: GNSS Frequency

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

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

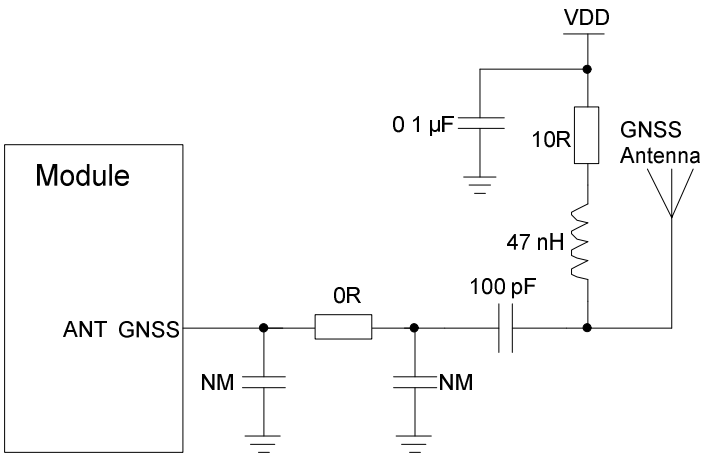


Figure 30: Reference Design of GNSS Antenna Interface

NOTES

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

4.3 Antenna Installation

4.3.1 Antenna Requirements

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

Table 34: Antenna Requirements

Antenna Type	Requirements
GNSS [1)]	Frequency range: 1559–1609 MHz Polarization: RHCP or linear VSWR: < 2 (Typ.) Passive antenna gain: > 0 dBi Active antenna noise figure: < 1.5 dB Active antenna gain: > 0 dBi Active antenna embedded LNA gain: < 17 dB
LTE/GSM	VSWR: ≤ 2 Efficiency: > 30%

	Max Input Power: 50 W Input Impedance: 50 Ω Cable Insertion Loss: < 1 dB (LTE B5/B8/B12/B13/B14/B18/B19/B20/B26/B27/B28/B71/B85, GSM850/EGSM900) Cable Insertion Loss: < 1.5 dB (LTE B1/B2/B3/B4/B25/B66, DCS1800/PCS1900)

NOTE

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

4.3.2 Recommended RF Connector for Antenna Installation

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

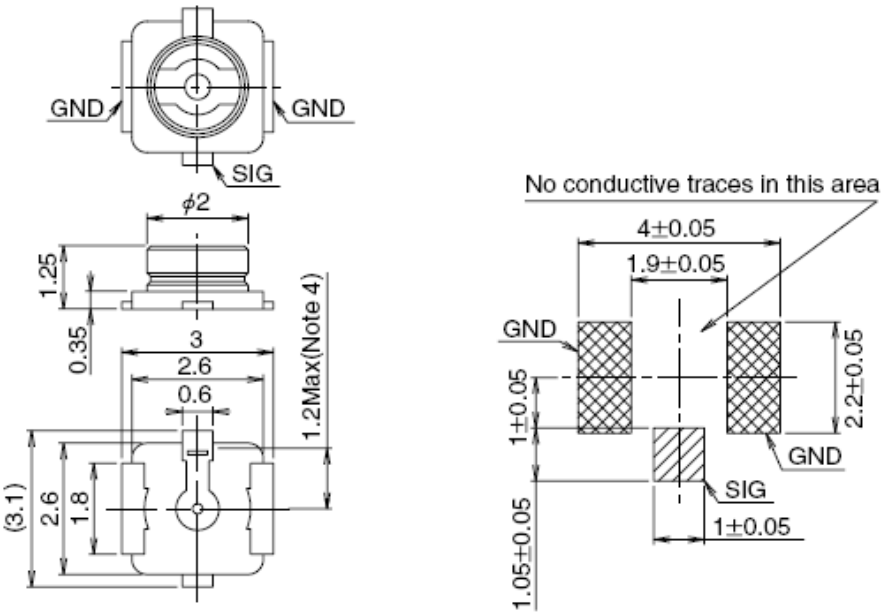


Figure 31: Dimensions of the U.FL-R-SMT Connector (Unit: mm)

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

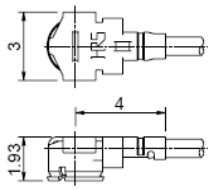
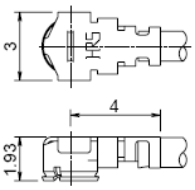
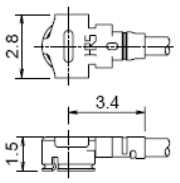
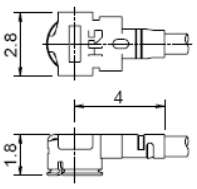
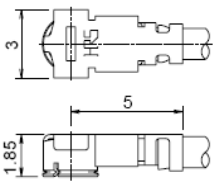
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia.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

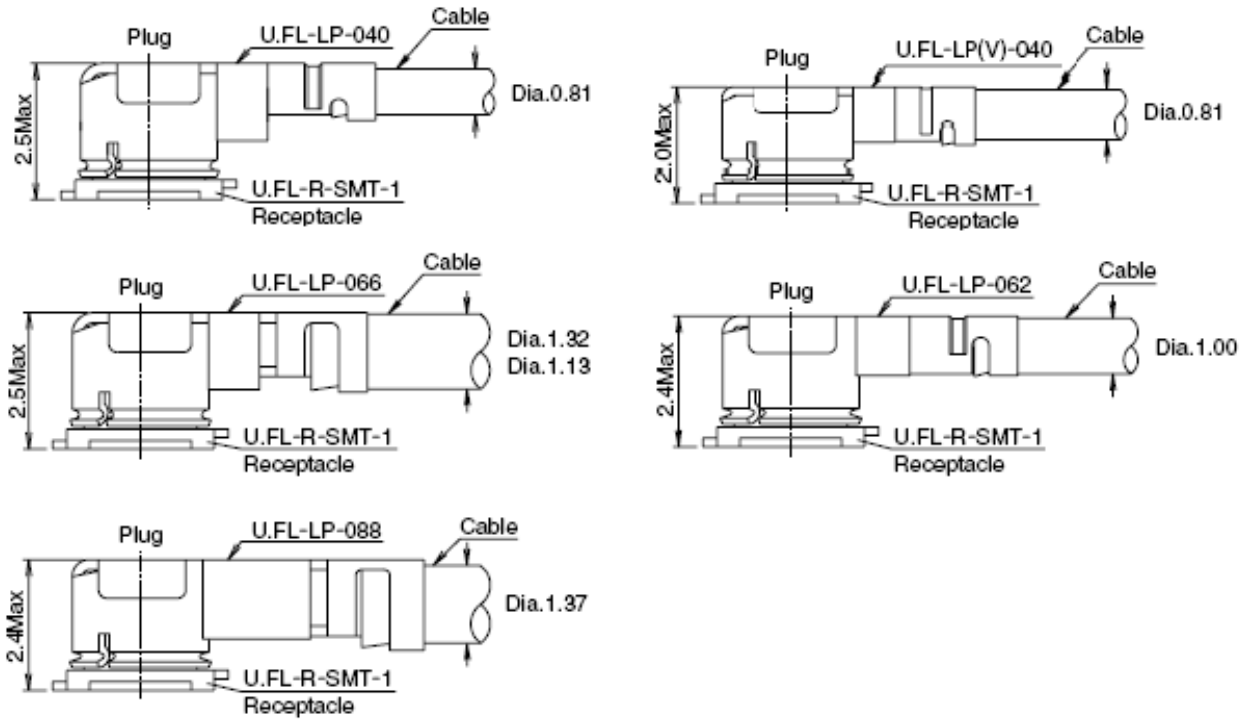


Figure 33: Space Factor of Mated Connector (Unit: mm)

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

5 Electrical, Reliability and Radio Characteristics

5.1 Absolute Maximum Ratings

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

Table 35: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT_BB	-0.5	6.0	V
VBAT_RF	-0.3	6.0	V
USB_VBUS	1.3	1.8	V
Voltage at Digital Pins	-0.3	2.09	V

5.2 Power Supply Ratings

Table 36: Power Supply Ratings

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
VBAT	VBAT_BB/ VBAT_RF	The actual input voltages must be kept between the minimum and maximum values.	3.3	3.8	4.3	V
I_{VBAT}	Peak supply current (during transmission slot)	Maximum power control level on EGSM900		1.8	2.0	A

USB_VBUS	USB detection	1.3	1.8	V

5.3 Operation and Storage Temperatures

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

Table 37: Operation and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operation Temperature Range [1)]	-35	+25	+75	ºC
Extended Temperature Range [2)]	-40		+85	ºC
Storage Temperature Range	-40		+90	ºC

NOTES

1. [1)] Within operation temperature range, the module meets 3GPP specifications.
2. [2)] Within the extended temperature range, the module remains the ability to establish and maintain functions such as voice, SMS, data transmission, emergency call, etc., without any unrecoverable malfunction. Radio spectrum and radio network will not be influenced, while one or more specifications, such as P_{out}, may undergo a reduction in value, exceeding the specified tolerances of 3GPP. When the temperature returns to the normal operating temperature level, the module will meet 3GPP specifications again.

5.4 Current Consumption

The following table shows current consumption of BG600L-M3 module.

Table 38: BG600L-M3 Current Consumption

Description	Conditions	Average	Max.	Unit
Leakage [1)]	Power-off	12.5	-	μA
PSM [2)]	Power Saving Mode	4	-	μA

Rock Bottom Current	**AT+CFUN=0** @ Sleep State	0.68	-	mA
Sleep State (USB disconnected)	LTE Cat M1 DRX = 1.28 s	1.61	-	mA
	LTE Cat NB1 DRX = 1.28 s	1.34	-	mA
	LTE Cat M1 e-I-DRX = 81.92 s @ PTW = 20.48 s, DRX = 2.56 s	0.87	-	mA
	LTE Cat NB1 e-I-DRX = 81.92 s @ PTW = 20.48 s, DRX = 2.56 s	1.22	-	mA
LTE Cat M1 data transfer (GNSS OFF)	LTE-FDD B1 @ 21.15 dBm	184	406	mA
	LTE-FDD B2 @ 21.01 dBm	182	400	mA
	LTE-FDD B3 @ 20.85 dBm	175	376	mA
	LTE-FDD B4 @ 20.88 dBm	175	376	mA
	LTE-FDD B5 @ 20.92 dBm	192	440	mA
	LTE-FDD B8 @ 21.15 dBm	194	436	mA
	LTE-FDD B12 @ 21.01 dBm	186	414	mA
	LTE-FDD B13 @ 21.14 dBm	204	478	mA
	LTE-FDD B14 @ 20.2 dBm	184	405	mA
	LTE-FDD B18 @ 21.01 dBm	196	448	mA
	LTE-FDD B19 @ 21.29 dBm	199	466	mA
	LTE-FDD B20 @ 21 dBm	197	448	mA
	LTE-FDD B25 @ 20.93 dBm	180	392	mA
	LTE-FDD B26 @ 21.09 dBm	196	448	mA
	LTE-FDD B27 @ 20.91 dBm	194	445	mA
	LTE-FDD B28A @ 21.06 dBm	187	417	mA
	LTE-FDD B28B @ 20.79 dBm	189	421	mA
	LTE-FDD B66 @ 20.83 dBm	173	375	mA

	LTE-FDD B85 @ 21.14 dBm	185	417	mA
LTE Cat NB1 data transfer (GNSS OFF)	LTE-FDD B1 @ 21.48 dBm	146	365	mA
	LTE-FDD B2 @ 21.5 dBm	147	379	mA
	LTE-FDD B3 @ 20.92 dBm	132	329	mA
	LTE-FDD B4 @ 20.97 dBm	133	337	mA
	LTE-FDD B5 @ 21.13 dBm	161	423	mA
	LTE-FDD B8 @ 21.35 dBm	159	408	mA
	LTE-FDD B12 @ 21.37 dBm	155	410	mA
	LTE-FDD B13 @ 21.1 dBm	164	432	mA
	LTE-FDD B18 @ 21.39 dBm	166	428	mA
	LTE-FDD B19 @ 21.16 dBm	161	420	mA
	LTE-FDD B20 @ 21.34 dBm	161	415	mA
	LTE-FDD B25 @ 21.24 dBm	137	357	mA
	LTE-FDD B26 @ 21.26 dBm	161	415	mA
	LTE-FDD B28 @ 21 dBm	157	407	mA
	LTE-FDD B66 @ 21.24 dBm	135	343	mA
	LTE-FDD B71 @ TBD	TBD	TBD	mA
	LTE-FDD B85 @ 21.73 dBm	157	409	mA
GPRS data transfer (GNSS OFF)	GSM850 4UL 1DL @ 28 dBm	570	1187	mA
	GSM850 3UL 2DL @ 29 dBm	491	1325	mA
	GSM850 2UL 3DL @ 32 dBm	426	1624	mA
	GSM850 1UL 4DL @ 32 dBm	272	1055	mA
	EGSM900 4UL 1DL @ 28 dBm	573	1201	mA
	EGSM900 3UL 2DL @ 29 dBm	495	1342	mA
	EGSM900 2UL 3DL @ 31 dBm	402	1521	mA

	EGSM900 1UL 4DL @ 32 dBm	272	1059	mA
	DCS1800 4UL 1DL @ 26 dBm	402	794	mA
	DCS1800 3UL 2DL @ 27 dBm	321	804	mA
	DCS1800 2UL 3DL @ 28 dBm	253	848	mA
	DCS1800 1UL 4DL @ 30 dBm	182	589	mA
	PCS1900 4UL 1DL @ 25 dBm	414	824	mA
	PCS1900 3UL 2DL @ 26 dBm	331	831	mA
	PCS1900 2UL 3DL @ 29 dBm	271	927	mA
	PCS1900 1UL 4DL @ 30 dBm	193	660	mA
EDGE data transfer (GNSS OFF)	GSM850 4UL 1DL @ 23 dBm	404	1272	mA
	GSM850 3UL 2DL @ 24 dBm	339	1301	mA
	GSM850 2UL 3DL @ 26 dBm	276	1313	mA
	GSM850 1UL 4DL @ 26 dBm	182	703	mA
	EGSM900 4UL 1DL @ 23 dBm	404	1288	mA
	EGSM900 3UL 2DL @ 24 dBm	339	1321	mA
	EGSM900 2UL 3DL @ 26 dBm	273	1311	mA
	EGSM900 1UL 4DL @ 26 dBm	181	700	mA
	DCS1800 4UL 1DL @ 22 dBm	345	834	mA
	DCS1800 3UL 2DL @ 23 dBm	276	843	mA
	DCS1800 2UL 3DL @ 25 dBm	218	841	mA
	DCS1800 1UL 4DL @ 26 dBm	155	488	mA
	PCS1900 4UL 1DL @ 22 dBm	351	919	mA
	PCS1900 3UL 2DL @ 23 dBm	283	922	mA
	PCS1900 2UL 3DL @ 25 dBm	227	922	mA
	PCS1900 1UL 4DL @ 26 dBm	160	499	mA

NOTES

1. [1] The current consumption in PSM is much lower than that in power off mode, and this is because of the following two designs:
   - More internal power supplies are powered off in PSM.
   - Also the internal clock frequency is reduced in PSM.
2. [2] The module's USB and UART are disconnected and GSM network does not support PSM.

Table 39: GNSS Current Consumption

Description	Conditions	Typ.	Unit
Searching (**AT+CFUN=0**)	Cold start @ Instrument	TBD	mA
	Cold start @ Real network with half sky, Active Antenna	TBD	mA
Tracking (**AT+CFUN=0**)	Instrument Environment @ DPO off	TBD	mA
	Instrument Environment @ DPO on	TBD	mA
	Half Sky @ Real network, Active Antenna, DPO off	TBD	mA

5.5 RF Output Power

The following table shows the RF output power of BG600L-M3.

Table 40: BG600L-M3 RF Output Power

Frequency	Max.	Min.
LTE-FDD B1/B2/B3/B4/B5/B8/B12/B13/B14 [1]/ B18/B19/B20/B25/B26/B27 [1]/B28/B66/B71 [2]/B85	21 dBm +1.7/-3 dB	<-39 dBm
GSM850/EGSM900	33 dBm ±2 dB	5 dBm ±5 dB
DCS1800/PCS1900	30 dBm ±2 dB	0 dBm ±5 dB
GSM850/EGSM900 (8-PSK)	27 dBm ±3 dB	5 dBm ±5 dB
DCS1800/PCS1900 (8-PSK)	26 dBm ±3 dB	0 dBm ±5 dB

NOTES

1. [1] LTE-FDD B14 and B27 are supported by LTE Cat M1 only.
2. [2] LTE-FDD B71 is supported by LTE Cat NB2 only.

5.6 RF Receiving Sensitivity

The following table shows the conducted RF receiving sensitivity of BG600L-M3.

Table 41: BG600L-M3 Conducted RF Receiving Sensitivity (25 °C, 3.8 V)

Network	Band	Primary	Diversity	Sensitivity (dBm)	
				Cat M1/3GPP	Cat NB2 [1]/3GPP
LTE	LTE-FDD B1	Supported	Not Supported	-107/-102.3	-115.5/-107.5
	LTE-FDD B2			-107 /-100.3	-115.5/-107.5
	LTE-FDD B3			-107 /-99.3	-115.5/-107.5
	LTE-FDD B4			-107 /-102.3	-115/-107.5
	LTE-FDD B5			-107 /-100.8	-115.5/-107.5
	LTE-FDD B8			-107 /-99.8	-115.5/-107.5
	LTE-FDD B12			-107 /-99.3	-115.5/-107.5
	LTE-FDD B13			-107 /-99.3	-115.5/-107.5
	LTE-FDD B14			-107 /-99.3	Not Supported
	LTE-FDD B18			-107 /-102.3	-115.5/-107.5
	LTE-FDD B19			-107 /-102.3	-115.5/-107.5
	LTE-FDD B20			-107 /-99.8	-115/-107.5
	LTE-FDD B25			-107 /-100.3	-115.5/-107.5
	LTE-FDD B26			-107 /-100.3	-115.5/-107.5
	LTE-FDD B27			-107 /-100.8	Not Supported

	LTE-FDD B28		-107 /-100.8	-115.5/-107.5
	LTE-FDD B66		-108/-101.8	-116/-107.5
	LTE-FDD B71		Not Supported	-115/-107.5
	LTE-FDD B85		-106/-99.3	-115.5/-107.5

Network	Band	Primary	Diversity	Sensitivity (dBm)
				GSM/3GPP
GSM	GSM850/EGSM900	Supported	Not Supported	-107/-102
	DCS1800/PCS1900			-107/-102

NOTE

[1] LTE Cat NB2 receiving sensitivity without repetitions.

5.7 Electrostatic Discharge

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

The following table shows the electrostatic discharge characteristics of BG600L-M3 module.

Table 42: Electrostatic Discharge Characteristics (25 ºC, 45% Relative Humidity)

Tested Interfaces	Contact Discharge	Air Discharge	Unit
VBAT, GND	±6	±10	kV
Main/GNSS Antenna Interfaces	±5	±8	kV

6 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module. All dimensions are measured in millimeter (mm), and the dimensional tolerances are ±0.05 mm unless otherwise specified.

6.1 Mechanical Dimensions

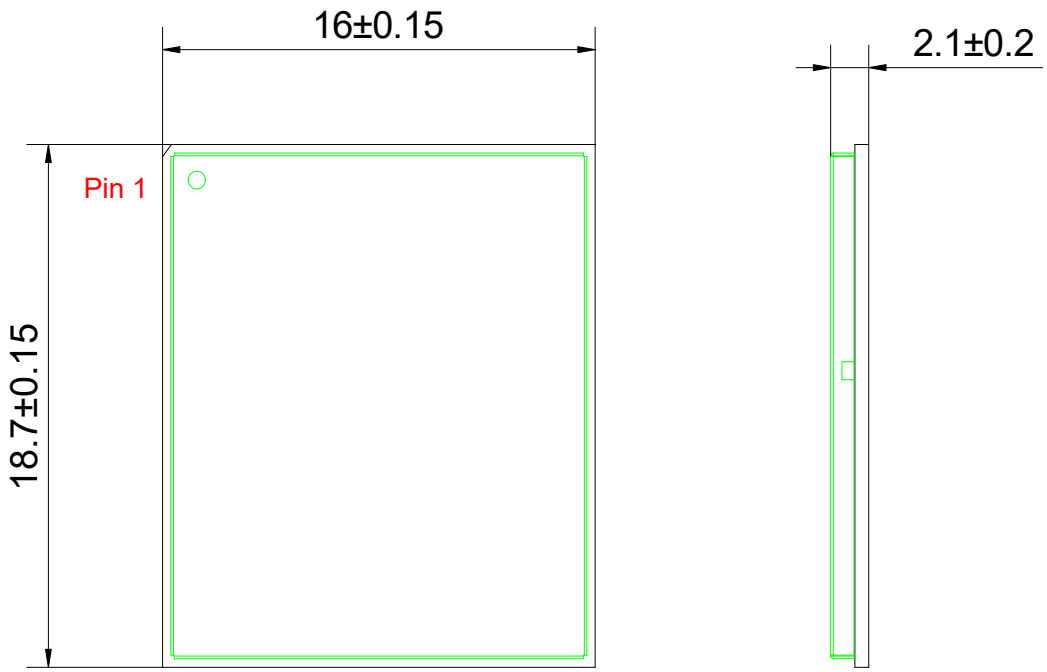


Figure 34: Module Top and Side Dimensions

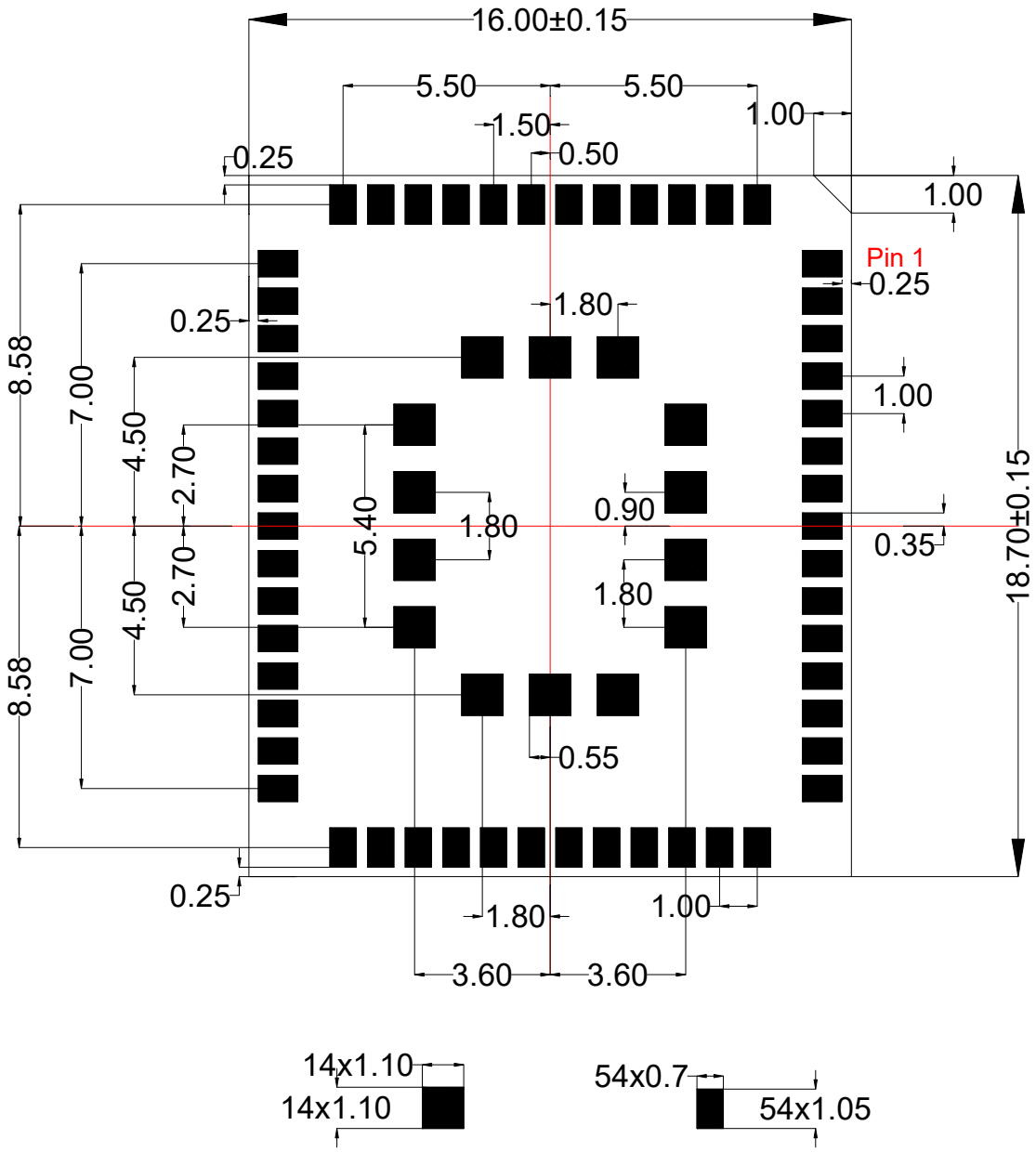


Figure 35: Module Bottom Dimensions (Bottom View)

NOTE

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

6.2 Recommended Footprint

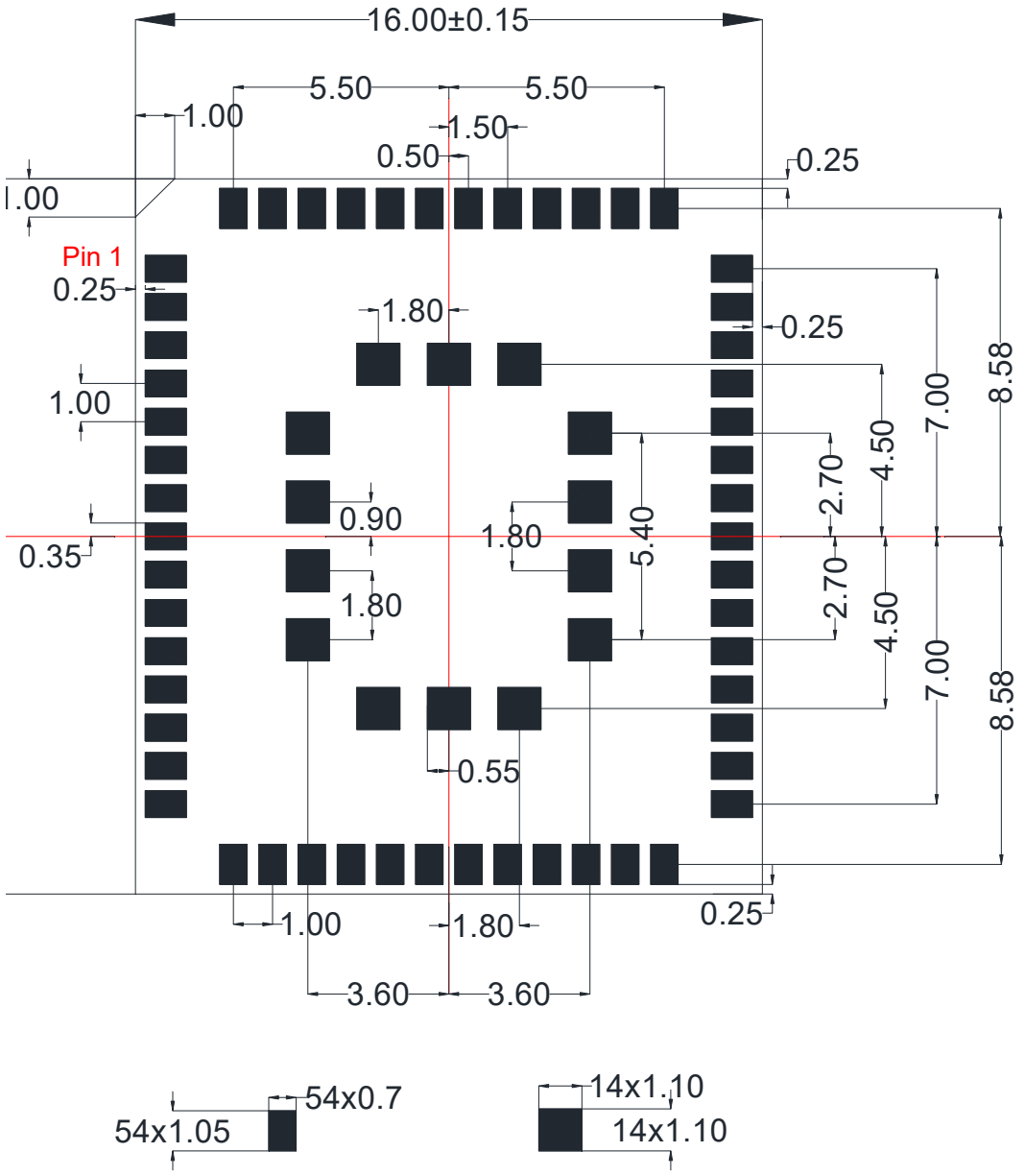


Figure 36: Recommended Footprint (Top View)

NOTES

1. For easy maintenance of the module, please keep about 3 mm between the module and other components on the motherboard.
2. All reserved pins must be kept open.

6.3 Top and Bottom Views

Figure 37: Top View of the Module

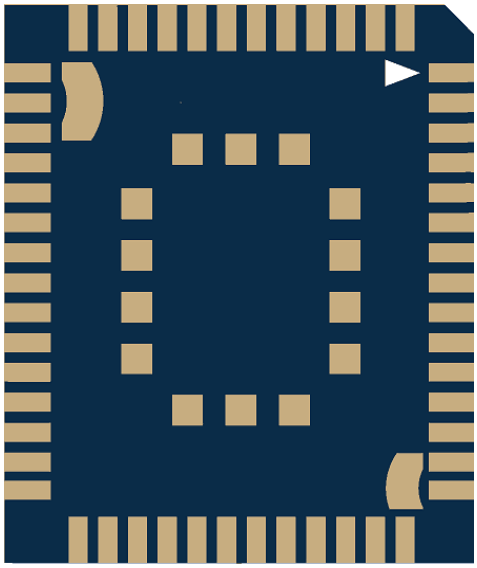


Figure 38: Bottom View of the Module

NOTE

These are renderings of BG600L-M3 module. For authentic appearance, please refer to the module received from Quectel.

7 Storage, Manufacturing and Packaging

7.1 Storage

BG600L-M3 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 24 hours 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 24 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.

NOTE

Please take the module out of the packaging and put it on high-temperature resistant fixtures before the baking. If shorter baking time is desired, please refer to *IPC/JEDEC J-STD-033* for baking procedure.

7.2 Manufacturing and Soldering

Push the squeegee to apply the solder paste on the surface of stencil, thus making the paste fill the stencil openings and then penetrate to the PCB. The force on the squeegee should be adjusted properly so as to produce a clean stencil surface on a single pass. To ensure the module soldering quality, the thickness of stencil for the module is recommended to be 0.13–0.15 mm. For more details, please refer to ***document [5]***.

It is suggested that the peak reflow temperature is 238–246 ºC, and the absolute maximum reflow temperature is 246 ºC. To avoid damage to the module caused by repeated heating, it is strongly recommended that the module should be mounted after reflow soldering for the other side of PCB has been completed. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown below.

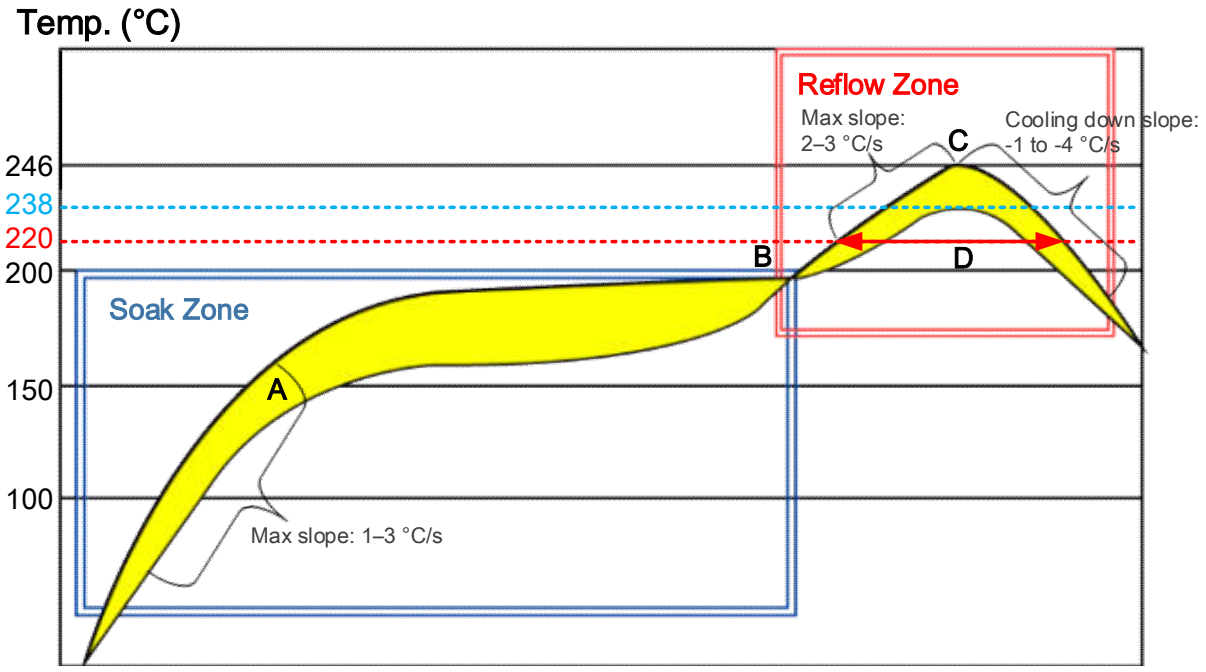


Figure 39: Recommended Reflow Soldering Thermal Profile

Table 43: 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 220°C)	45–70 s
Max temperature	238–246 °C
Cooling down slope	-1 to -4 °C/s
Reflow Cycle	
Max reflow cycle	1

7.3 Packaging

BG600L-M3 is packaged in a vacuum-sealed bag which is ESD protected. The bag should not be opened until the devices are ready to be soldered onto the application.

The reel is 330 mm in diameter and each reel contains 250 modules. The following figures show the packaging details, measured in millimeter (mm).

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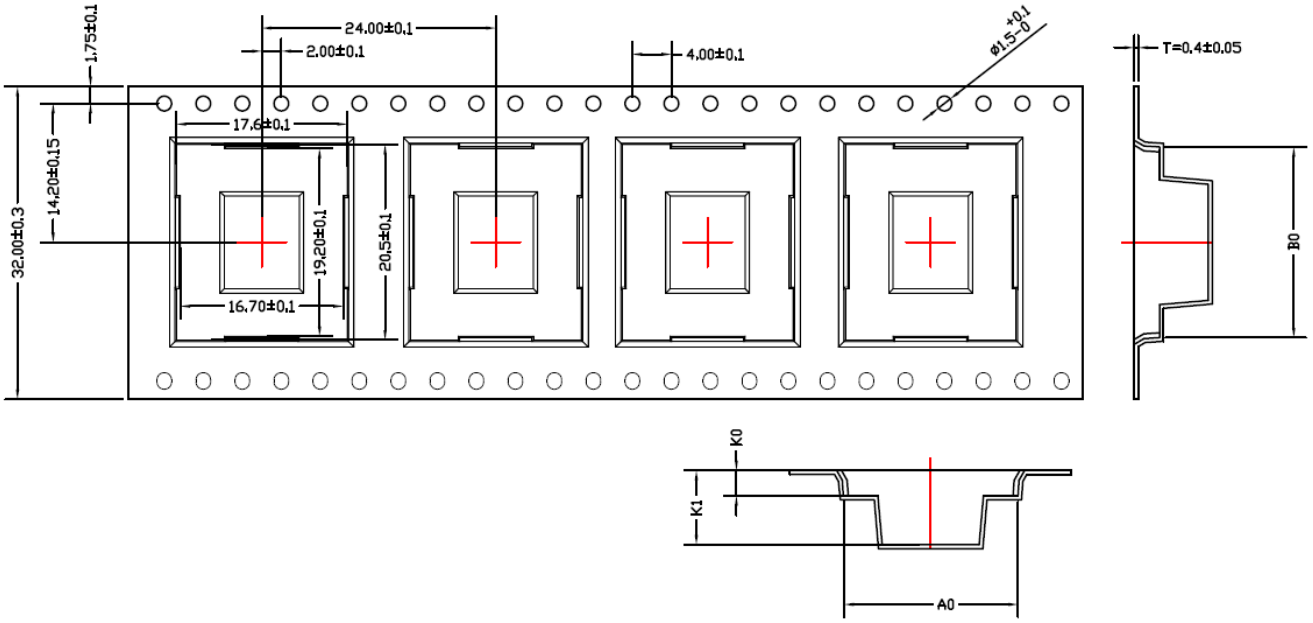

Figure 40: Tape Dimensions

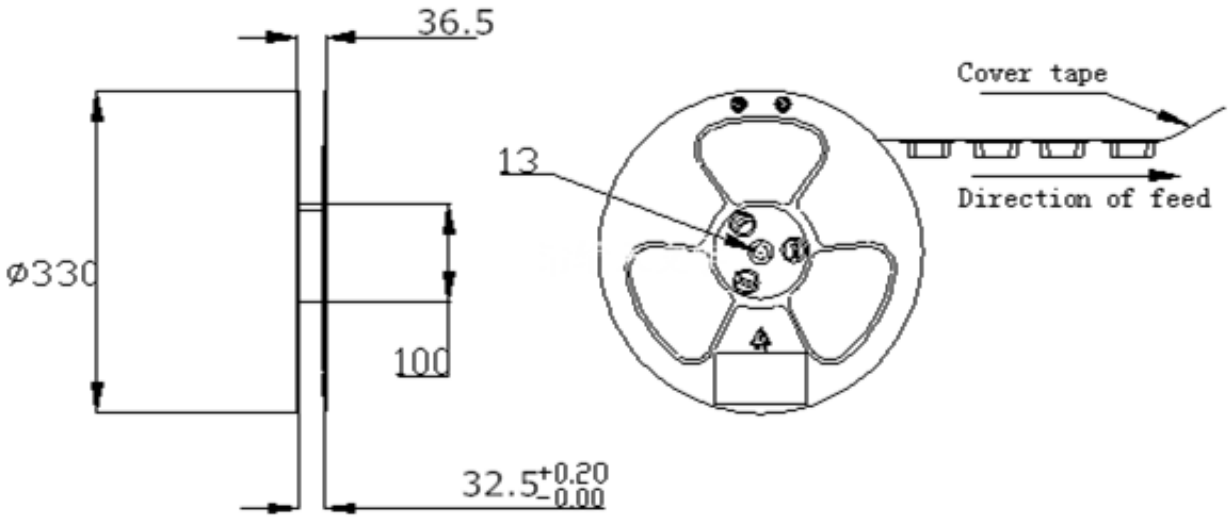

Figure 41: Reel Dimensions

Table 44: Module Packaging Specifications

MOQ for MP	Minimum Package: 250	Minimum Package x 4 = 1000
250	Size: 370 mm × 350 mm × 56 mm N.W: TBD G.W: TBD	Size: 380 mm × 250 mm × 365 mm N.W: TBD G.W: TBD

8 Appendix A References

Table 45: Related Documents

SN	Document Name	Remark
[1]	Quectel_UMTS&LTE_EVB_User_Guide	UMTS&LTE EVB User Guide
[2]	Quectel_BG95&BG77&BG600L&BC69_Series_AT_Commands_Manual	AT Commands Manual of BG95 series, BG77, BG600L-M3 and BC69 modules
[3]	Quectel_ BG95&BG77&BG600L&BC69_Series_GNSS_Application_Note	GNSS Application Note of BG95 series, BG77, BG600L-M3 and BC69 modules
[4]	Quectel_RF_Layout_Application_Note	RF Layout Application Note
[5]	Quectel_Module_Secondary_SMT_Application_Note	Module Secondary SMT Application Note

Table 46: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
bps	Bits Per Second
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CTS	Clear To Send
DFOTA	Delta Firmware Upgrade Over The Air
DL	Downlink
DTX	Discontinuous Transmission
e-I-DRX	Extended Idle Mode Discontinuous Reception
EPC	Evolved Packet Core

ESD	Electrostatic Discharge
FDD	Frequency Division Duplex
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GSM	Global System for Mobile Communications
HSS	Home Subscriber Server
I/O	Input/Output
Inorm	Normal Current
LED	Light Emitting Diode
LNA	Low Noise Amplifier
LTE	Long Term Evolution
MO	Mobile Originated
MS	Mobile Station (GSM engine)
MT	Mobile Terminated
PAP	Password Authentication Protocol
PCB	Printed Circuit Board
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
PSM	Power Saving Mode
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
Rx	Receive
SISO	Single Input Single Output
SMS	Short Message Service
TDD	Time Division Duplexing

TX	Transmitting Direction
UL	Uplink
UE	User Equipment
URC	Unsolicited Result Code
(U)SIM	(Universal) Subscriber Identity Module
Vmax	Maximum Voltage Value
Vnorm	Normal Voltage Value
Vmin	Minimum Voltage Value
V_{IH}max	Maximum Input High Level Voltage Value
V_{IH}min	Minimum Input High Level Voltage Value
V_{IL}max	Maximum Input Low Level Voltage Value
V_{IL}min	Minimum Input Low Level Voltage Value
V_{I}max	Absolute Maximum Input Voltage Value
V_{I}min	Absolute Minimum Input Voltage Value
V_{OH}max	Maximum Output High Level Voltage Value
V_{OH}min	Minimum Output High Level Voltage Value
V_{OL}max	Maximum Output Low Level Voltage Value
V_{OL}min	Minimum Output Low Level Voltage Value
VSWR	Voltage Standing Wave Ratio

9 Appendix B GPRS Coding Schemes

Table 47: Description of Different Coding Schemes

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

10 Appendix C GPRS Multi-slot Classes

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

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

Table 48: GPRS Multi-slot Classes

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

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

11 Appendix D EDGE Modulation and Coding Schemes

Table 49: EDGE Modulation and Coding Schemes

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