BC65 Hardware Design

NB-IoT Module Series

Version: 1.0

Date: 2021-02-08

Status: Released

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

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

Or our local office. For more information, please visit:
http://www.quectel.com/support/sales.htm.

For technical support, or to report documentation errors, please visit:
http://www.quectel.com/support/technical.htm
Or email to support@quectel.com.

General Notes

Quectel offers the information as a service to its customers. The information provided is based upon customers' requirements. Quectel makes every effort to ensure the quality of the information it makes available. Quectel does not make any warranty as to the information contained herein, and does not accept any liability for any injury, loss or damage of any kind incurred by use of or reliance upon the information. All information supplied herein is subject to change without prior notice.

Disclaimer

While Quectel has made efforts to ensure that the functions and features under development are free from errors, it is possible that these functions and features could contain errors, inaccuracies and omissions. Unless otherwise provided by valid agreement, Quectel makes no warranties of any kind, implied or express, with respect to the use of features and functions under development. To the maximum extent permitted by law, Quectel excludes all liability for any loss or damage suffered in connection with the use of the functions and features under development, regardless of whether such loss or damage may have been foreseeable.

Duty of Confidentiality

The Receiving Party shall keep confidential all documentation and information provided by Quectel, except when the specific permission has been granted by Quectel. The Receiving Party shall not access or use Quectel's documentation and information for any purpose except as expressly provided herein. Furthermore, the Receiving Party shall not disclose any of the Quectel's documentation and information to any third party without the prior written consent by Quectel. For any noncompliance to the above requirements, unauthorized use, or other illegal or malicious use of the documentation and information, Quectel will reserve the right to take legal action.

Copyright

Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating the module. Manufacturers of the cellular terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all manuals of the product. Otherwise, Quectel assumes no liability for customers' failure to comply with these precautions.

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

About the Document

Revision History

Version	Date	Author	Description
-	2019-07-19	Jerry WANG/ Jack WU/ Louis GU	Creation of the document
1.0	2021-02-08	Jerry WANG/ Jack WU/ Louis GU	First official release

Contents

Table Index

Figure Index

1 Introduction

This document defines Quectel BC65 module and describes its air interface and hardware interfaces which are connected with your applications.

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

1.1. Special Mark

Table 1: Special Mark

Mark	Definition
*	When an asterisk (*) is used after a function, feature, interface, pin name, AT command, or argument, it indicates that the function, feature, interface, pin name, AT command, or argument is under development and currently not supported, unless otherwise specified.

2 Product Concept

2.1. General Description

BC65 is a high-performance NB-IoT module with extremely low power consumption. It is designed to communicate with infrastructures of mobile network operators through NB-IoT radio protocols (3GPP Rel-13 and 3GPP Rel-14). BC65 supports a certain range of frequency bands as listed below.

Table 2: Frequency Bands of BC65 Module

Mode	Frequency Bands
H-FDD	B1*/B3/B5/B8/B20/B28

BC65 is an SMD type module with LCC package, and has an ultra-compact profile of 17.7 mm × 15.8 mm × 2.2 mm. These features allow the module to be easily embedded into size-constrained applications and provide reliable connectivity with applications.

BC65 provides abundant external interfaces (UART, ADC, etc.) and protocol stacks (UDP/TCP/MQTT, etc.), which provide a great convenience for customers' applications.

Due to compact form factor, ultra-low power consumption and extended temperature range, BC65 is one of the best choices for a certain range of IoT applications, such as smart metering, bike sharing, smart wearables, smart parking, smart city, home appliances, security and asset tracking, agricultural and environmental monitoring, etc. It is able to provide a complete range of SMS* and data transmission services to meet customers' demands.

The module fully complies with the RoHS directive of the European Union.

2.2. Key Features

The following table describes the detailed features of BC65 module.

Table 3: Key Features

Feature	Details
Power Supply	● Supply voltage range: 3.2–4.2 V ● Typical supply voltage: 3.8 V
Power Saving	Typical power consumption: 4 μA
Frequency Bands	B1*/B3/B5/B8/B20/B28
Transmitting Power	23 dBm ±2 dB
USIM Interface	Supports 1.8/3.0 V USIM card
UART Interfaces	**Main UART:** ● Used for AT command communication and data transmission. ● When used for AT command communication and data transmission, baud rates 4800 bps, 9600 bps (default), and 57600 bps are supported. **Debug UART:** ● Used for firmware debugging and upgrading. ● Support 921600 bps baud rate. **Auxiliary UART*:** ● Used for AT command communication and data transmission. ● When used for AT command communication and data transmission, baud rates 4800 bps, 9600 bps (default), and 57600 bps are supported.
Network Protocols	Supports UDP/TCP/SNTP/MQTT/CoAP*/PPP/TLS*/DTLS*/HTTP* protocols
SMS*	Text/PDU Mode
Data Transmission Rate	**Cat NB1 (Max):** ● Single-tone: 25.5 kbps (DL)/ 16.7 kbps (UL) ● Multi-tone: 25.5 kbps (DL)/ 62.5 kbps (UL) **Cat NB2 (Max):** ● 127 kbps (DL)/ 158.5 kbps (UL)
AT Commands	● 3GPP TS 27.005/3GPP TS 27.007 AT commands (3GPP Rel-13/Rel-14) ● Quectel Enhanced AT commands
Firmware Update	● DFOTA ● Debug UART
Physical Characteristics	● Size: (17.7 ±0.15) mm × (15.8 ±0.15) mm × (2.2 ±0.2) mm ● Weight: approx. 1.0 ± 0.1 g

Temperature Ranges	● Operating temperature range: -25 °C to +75 °C [1)] ● Extended temperature range: -40 °C to +85 °C [2)] ● Storage temperature range: -40 °C to +90 °C
Antenna Interface	● 50 Ω impedance control
RoHS	● All hardware components are fully compliant with EU RoHS directive

NOTES

1. [1)] Within the operating temperature range, the module meets 3GPP specifications.
2. [2)] Within the extended temperature range, the module keeps the ability to establish and maintain functions such as SMS*, data transmission, 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 operating temperature range, the module will meet 3GPP specifications again.

2.3. Functional Diagram

The following figure shows a block diagram of BC65 and illustrates the major functional parts.

- Radio frequency
- Baseband
- Power management
- Peripheral interfaces

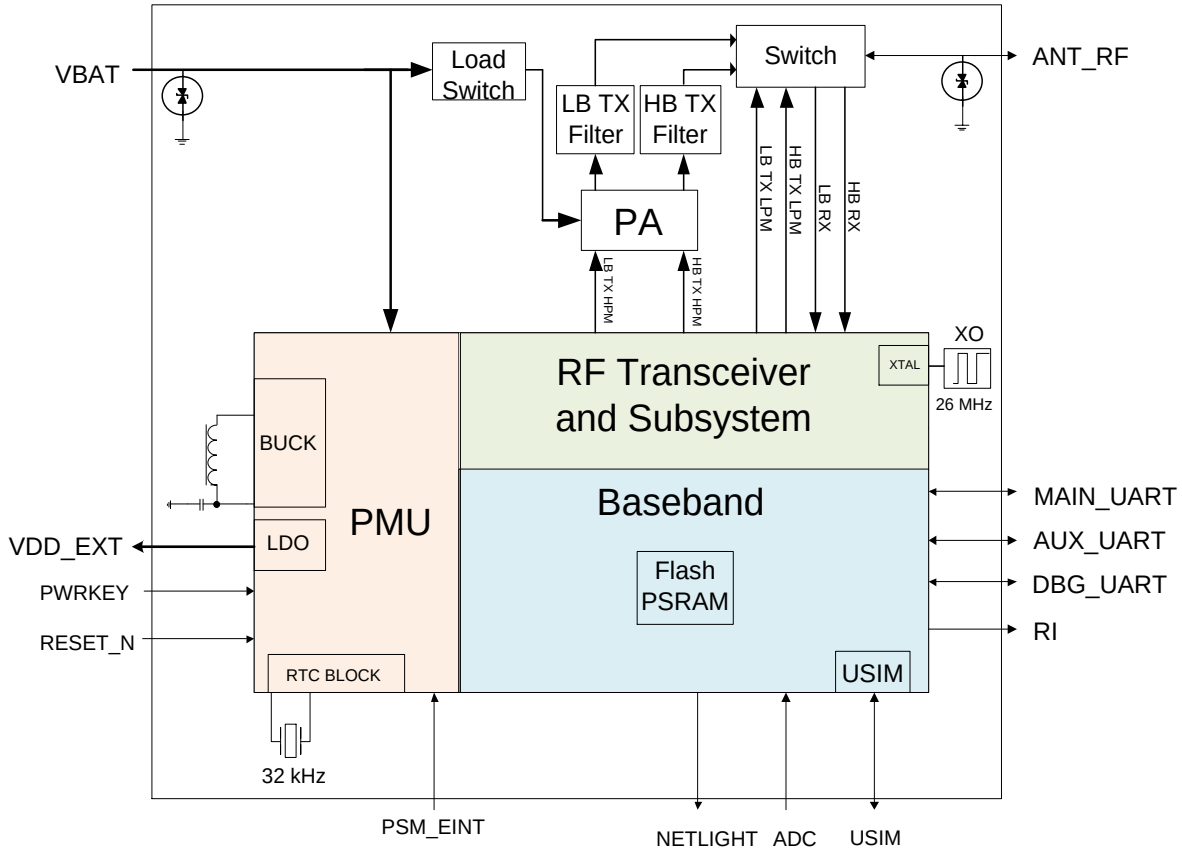


Figure 1: Functional Diagram

2.4. Development Board

Quectel provides a complete set of development tools to facilitate the use and test of BC65 module. The development tool kit includes the TE-B board, USB cable, antenna and other peripherals. For more details, see ***Document [1]***.

3 Application Interfaces

3.1. General Description

BC65 is equipped with a total of 58 pins, including 44 LCC pins and 14 LGA pins. The subsequent chapters provide detailed descriptions of the following functions and interfaces:

- Operating Modes
- Power Saving
- Power Supply
- Turn On/Off and Reset
- UART Interfaces
- USIM Interface
- ADC Interface
- RI Behaviors
- Network Status Indication

3.2. Pin Assignment

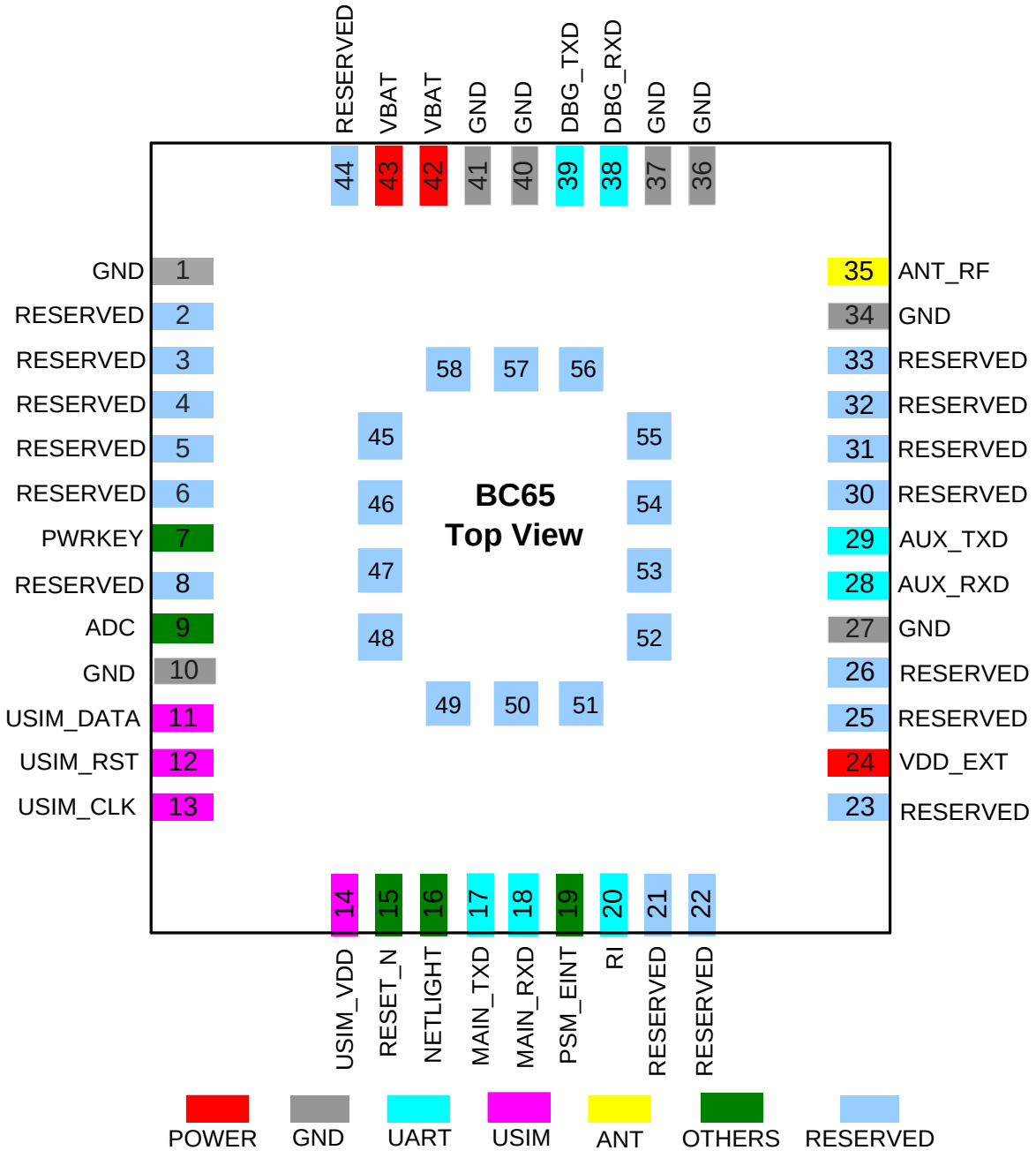


Figure 2: Pin Assignment (Top View)

NOTE

All RESERVED pins should be kept unconnected.

3.3. Pin Description

Table 4: I/O Parameters Definition

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

Table 5: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT	42, 43	PI	Power supply for the module	Vmax = 4.2 V Vmin = 3.2 V Vnorm = 3.8 V	VBAT = 3.2–4.2 V
VDD_EXT	24	PO	Provides 1.8 V for external circuit	Vnorm = 1.8 V	No voltage output in Deep Sleep mode. It is intended to supply power for the module's pull-up circuits, and thus it is not recommended to be used as the power supply for external circuits.
GND	1, 10, 27, 34, 36, 37, 40, 41				
Power Key Interface					

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
PWRKEY	7	DI	Turn on the module	Vnorm = 1.07 V	Active Low
Reset Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESET_N	15	DI	Reset the module	Vnorm = 1.07 V	Active Low
PSM_EINT Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PSM_EINT	19	DI	Dedicated external interrupt pin. Used to wake up the module from Deep Sleep.	Vnorm = 1.07 V	Valid on the falling edge
Network Status Indication					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
NETLIGHT	16	DO	Network status indication		1.8 V power domain. If unused, keep this pin unconnected.
ADC Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ADC	9	AI	General-purpose ADC interface	Voltage range: 0 – 1.8 V	
Main UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
MAIN_RXD	18	DI	Main UART receive		1.8 V power domain.
MAIN_TXD	17	DO	Main UART transmit		
Auxiliary UART Interface*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**

AUX_RXD	28	DI	Auxiliary UART receive		1.8 V power domain.
AUX_TXD	29	DO	Auxiliary UART transmit		
Debug UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DBG_RXD	38	DI	Debug UART receive		1.8 V power domain.
DBG_TXD	39	DO	Debug UART transmit		
RI Signal					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RI	20	DO	Ring indication		1.8 V power domain.
USIM Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USIM_VDD	14	PO	USIM card power supply	Vnorm = 1.8/3.0 V	All signals of USIM interface should be protected against ESD with a TVS diode array. Maximum trace length from the module pin to USIM card connector is 200 mm.
USIM_RST	12	DO	USIM card reset	V_{OL}max = 0.1 × USIM_VDD V_{OH}min = 0.8 × USIM_VDD	
USIM_DATA	11	IO	USIM card data	V_{IL}max = 0.2 × USIM_VDD V_{IH}min = 0.7 × USIM_VDD V_{OL}max = 0.1 × USIM_VDD V_{OH}min = 0.8 × USIM_VDD	
USIM_CLK	13	DO	USIM card clock	V_{OL}max = 0.1 × USIM_VDD V_{OH}min = 0.8 × USIM_VDD	
Antenna Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_RF	35	IO	Antenna interface		50Ω impedance control
Reserved Pins					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESERVED	2–6, 8, 21–23, 25, 26, 30–33, 44–58				Keep these pins unconnected.

NOTE

Unused pins should be kept unconnected.

3.4. Operating Modes

The module mainly consists of AP, modem and entire module operating modes, and the tables below describe the NB-IoT operating modes of them.

Table 6: AP Operating Modes

Mode	Description
Normal	In normal mode, the AP handles tasks, such as AT command communication.
Idle	When all tasks are suspended, the AP will enter idle mode.

Table 7: Modem Operating Modes

Mode	Description
Connected	The network is connected and the module supports data transmission. In this case, the modem can switch to PSM or DRX/eDRX mode.
DRX/eDRX	The modem is in idle mode, and downlink data can only be received during PTW. In this case, the modem can switch to PSM or connected mode.
PSM	In power saving mode, the modem is disconnected from the network and cannot receive any downlink data. In this case, the modem can switch to connected mode.

Table 8: Module Operating Modes

Mode	Description
Active	When the AP is in normal mode or the modem is in connected mode, the module will be active and support all services and functions. The current consumption in active mode is higher than that in sleep modes.
Light Sleep	When the AP is in idle mode and the modem is in DRX/eDRX mode, the module will enter Light Sleep mode. In this case, the AP tasks will be suspended and the modem will only be able to receive downlink data during PTW. In Light Sleep mode, the current consumption of the module is reduced greatly.

Deep Sleep	When the AP is in idle mode and the modem is in PSM, the module will enter Deep Sleep mode in which the CPU is powered off and only the 32 kHz RTC clock is working. In Deep Sleep mode, the current consumption will be reduced to the minimum (typically 4 μA).

3.5. Power Saving

Upon system requirements, there are several ways to drive the module into low current consumption status.

3.5.1. Light Sleep Mode

In this mode, the UART interface is still active and the module can be woken up through the main UART interface.

3.5.2. Deep Sleep Mode

Based on system performance, the module consumes an ultra-low current (typically 4 μA current consumption) in Deep Sleep mode. Deep Sleep mode is designed to reduce the power consumption of the module and improve battery life. In this mode, the UART interface is inactive. The following figure shows the power consumption of the module (modem) in different modes.

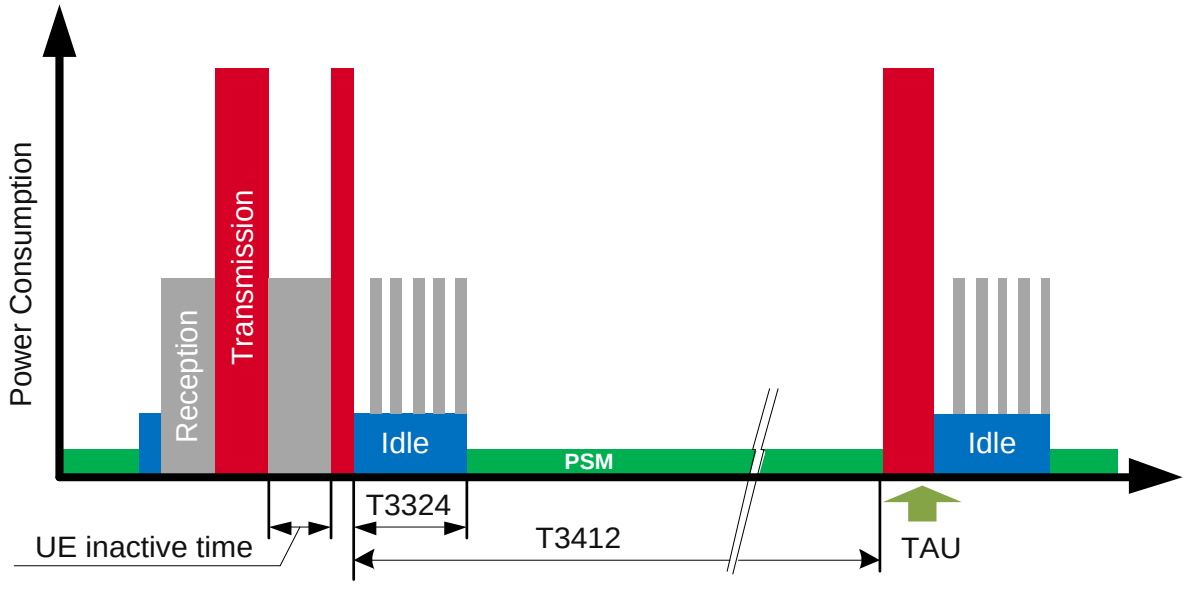


Figure 3: Module (Modem) Power Consumption in Different Modes

When the modem remains in PSM and the AP is in idle mode, the module will enter Deep Sleep mode.

The procedure of the modem entering PSM is as follows:

The modem requests to enter PSM in "**ATTACH REQUEST**" message during attach/TAU (Tracking Area Update) procedure. Then the network accepts the request and provides an active time value (T3324) to the modem and the mobile reachable timer starts. When the T3324 timer expires, the modem enters PSM for a duration of T3412 (periodic TAU timer). Note that the module cannot request PSM when it is establishing an emergency attachment or initializing the PDN (Public Data Network) connection.

When the module is in Deep Sleep mode, it will be woken up in either of the following cases:

- After the T3412 timer expires, the module will exit from Deep Sleep mode automatically.
- Pulling down PSM_EINT (falling edge) will wake up the module from Deep Sleep mode.

The timing of waking up the module from Deep Sleep mode is illustrated below.

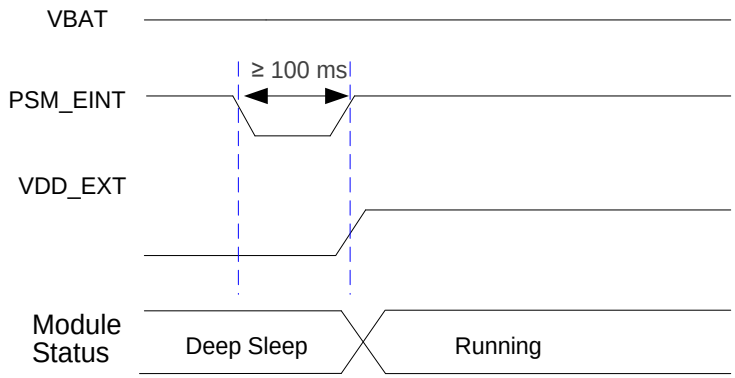


Figure 4: Timing of Waking Up Module from Deep Sleep

3.6. Power Supply

3.6.1. Power Supply Pins

BC65 provides two VBAT pins for connection with an external power supply. The table below describes the module's VBAT and ground pins.

Table 9: Power Supply Pins

Pin Name	Pin No.	Description	Min.	Typ.	Max.	Unit
VBAT	42, 43	Power supply for the module	3.2	3.8	4.2	V
GND	1, 10, 27, 34, 36, 37, 40, 41	GND	-	-	-	-

3.6.2. Reference Design for Power Supply

Power design for a module is critical to its performance. It is recommended to use a low quiescent current LDO with output current capacity of 0.8 A when supplying power for BC65. A Li-MnO2/2S alkaline battery can also be used as the power supply. The supply voltage of the module ranges from 3.2 to 4.2 V. When the module is working, make sure its input voltage will never drop below 3.2 V; otherwise, the module will be abnormal.

For better power performance, it is recommended to place a 100 µF tantalum capacitor with low ESR (ESR = 0.7 Ω) and three ceramic capacitors (100 nF, 100 pF and 22 pF) near the VBAT pins. Also, it is recommended to add a TVS diode on the VBAT trace (near VBAT pins) to improve surge withstand capability. In principle, the longer the VBAT trace is, the wider the TVS diode should be. A reference circuit for power supply is illustrated in the following figure.

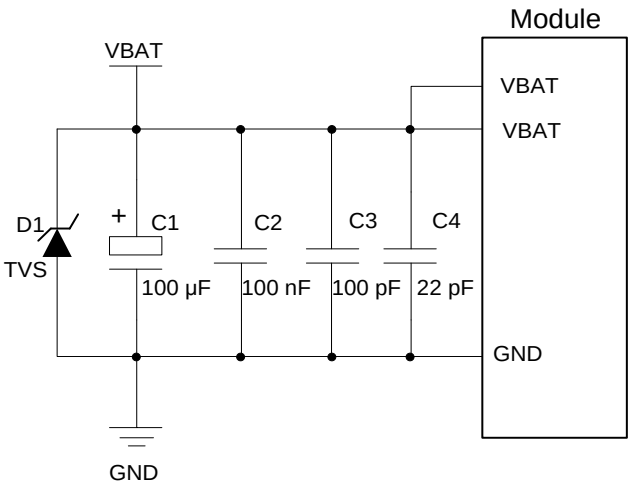


Figure 5: Reference Circuit for Power Supply

3.7. Turn On/Off and Reset

3.7.1. Turn On

BC65 will be turned on after driving PWRKEY [1)] to a low-level voltage for at least 1000 ms.

Table 10: PWRKEY Pin

Pin Name	Pin No.	Description	PWRKEY Pull-down Time
PWRKEY	7	Turn on the module	≥ 1000 ms

It is recommended to use an open drain/collector driver circuit to control the PWRKEY. A simple reference circuit is illustrated in the following figure.

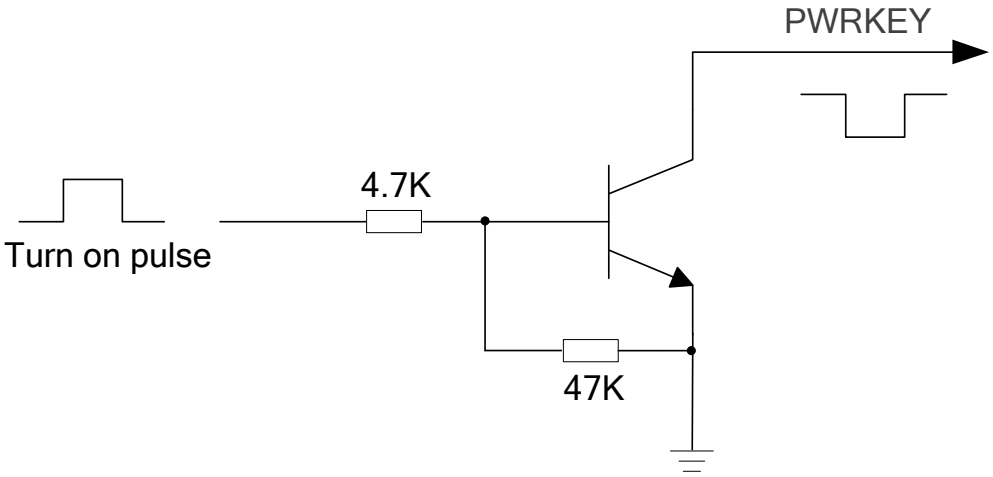


Figure 6: Turn on the Module by Using Driver Circuit

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

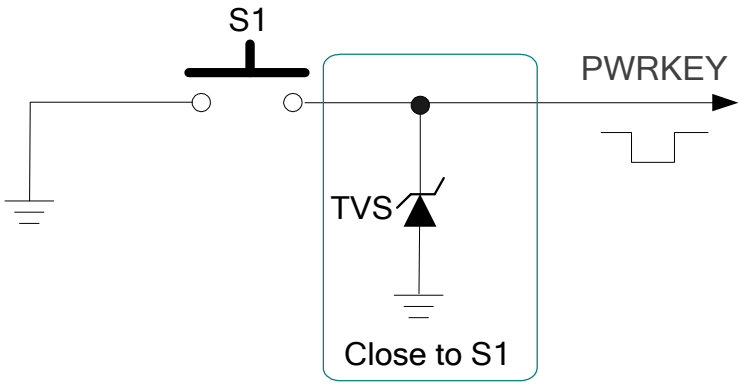


Figure 7: Turn on the Module by Using Button

The turn-on timing is illustrated in the following figure.

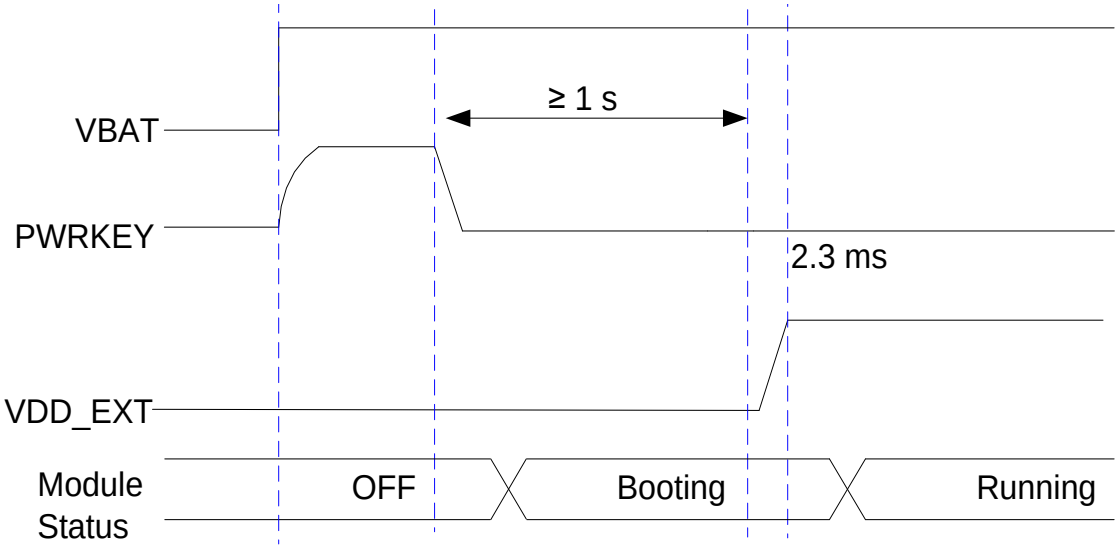


Figure 8: Turn-on Timing

NOTES

1. [1)] After the module is turned on, the PWRKEY pin is at low level. When the module is shut down by AT command, it can be woken up by pulling down PSM_EINT pin.
2. If PWRKEY button is not needed for the turn-on, PWRKEY pin can be connected to GND, and the module will turn on automatically.
3. For the normal initialization of PWRKEY, make sure the VBAT voltage is lower than 0.5 V before power-on.
4. It is recommended that the MCU retain the control of RESET_N, for the purpose of resetting the module when abnormal booting occurs due to abnormal power-on timing.

3.7.2. Turn Off

BC65 can be turned off by any of the following methods:

- Turn off by AT command **AT+QPOWD=1** (see ***document [2]***).
- In emergency conditions, the module can be turned off through disconnecting VBAT power supply.
- The module will be turned off automatically when VBAT drops below 3.2 V.

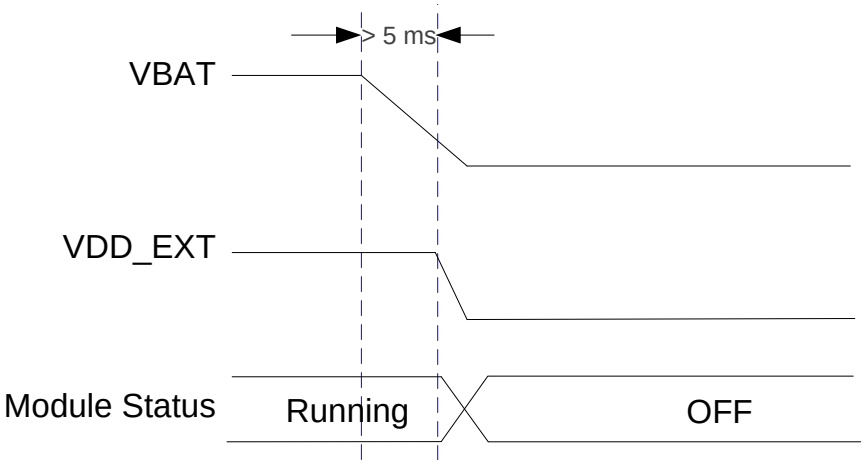


Figure 9: Turn-off Timing (Turn Off by Disconnecting VBAT)

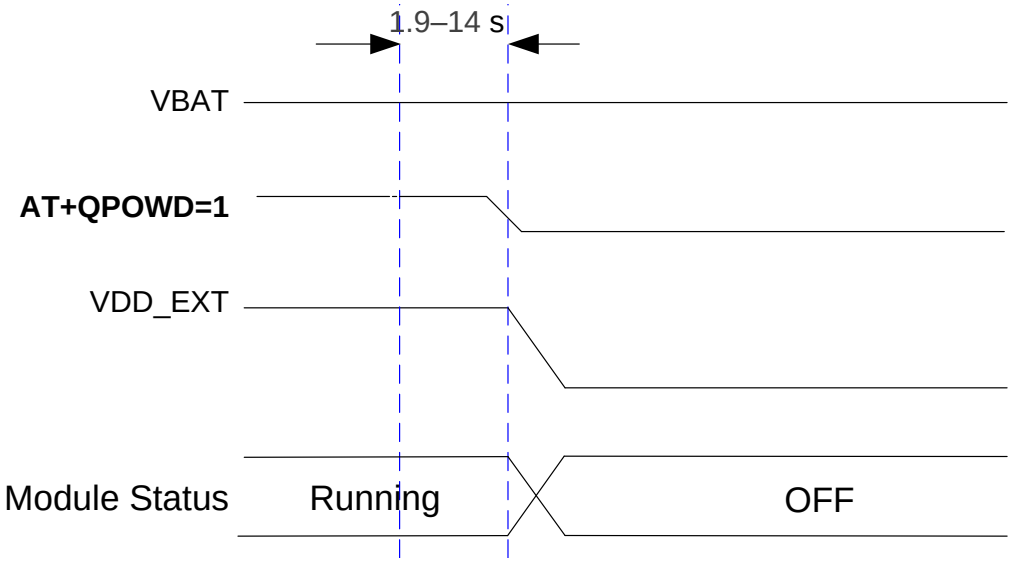


Figure 10: Turn-off Timing (Turn Off by AT Command AT+QPOWD=1)

3.7.3. Reset the Module

Driving the RESET_N pin to a low-level voltage for at least 1000 ms will reset the module.

Table 11: Reset Pin

Pin Name	Pin No.	Description	Reset Pull-down Time
RESET_N	15	Reset the module. Active Low.	≥ 1000 ms

The recommended circuits of resetting the module are shown below. An open drain/collector driver or button can be used to control the RESET_N pin.

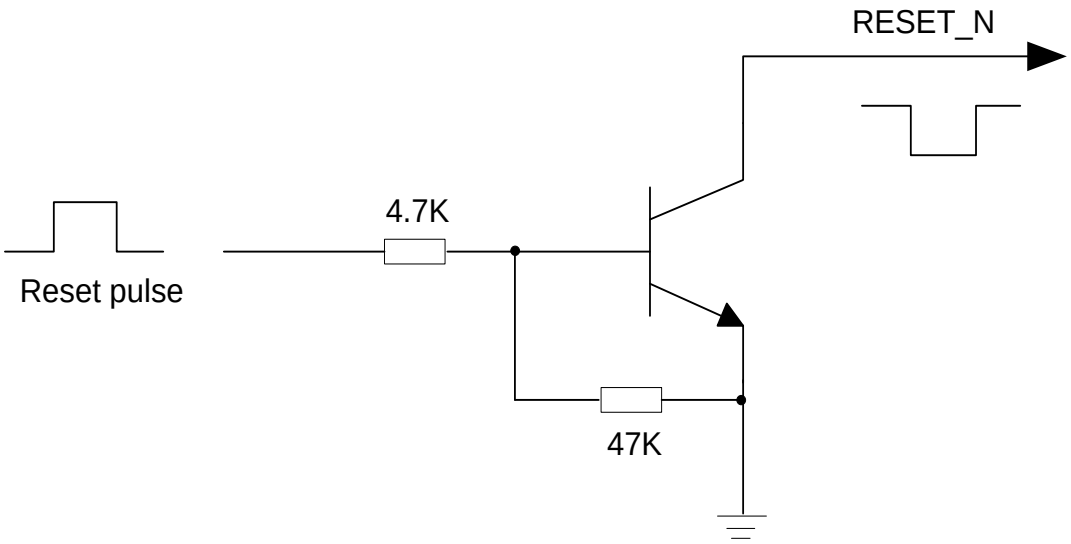


Figure 11: Reference Circuit of RESET_N by Using Driving Circuit

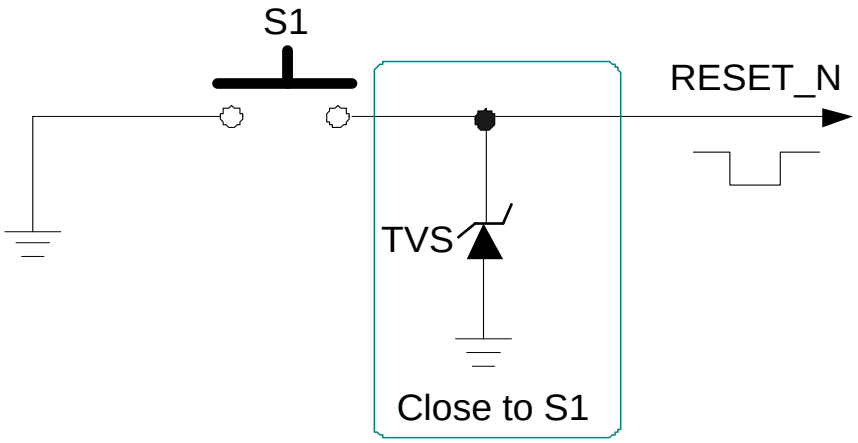


Figure 12: Reference Circuit of RESET_N by Using Button

The reset timing is illustrated in the following figure.

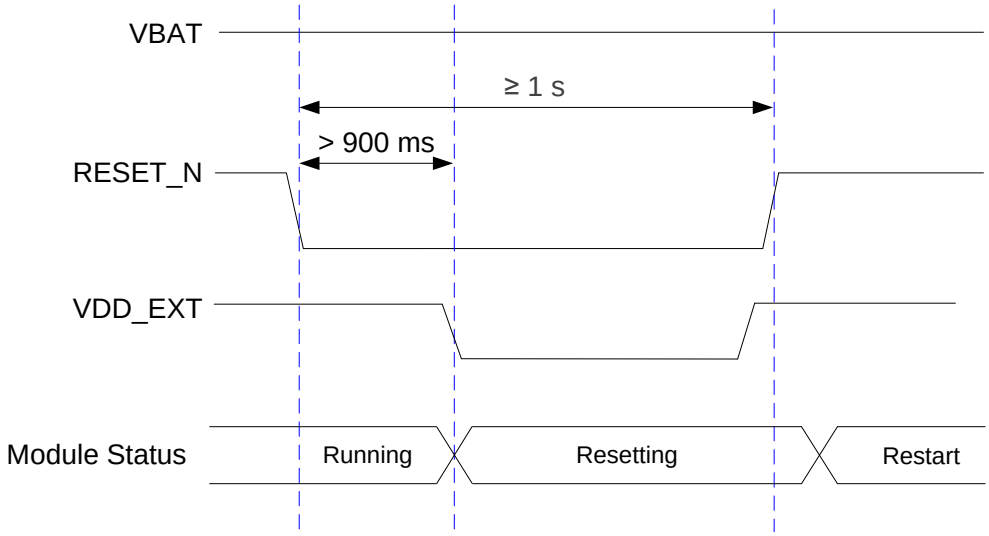


Figure 13: Reset Timing

3.8. UART Interfaces

The module provides three UART interfaces: one main UART, one debug UART and one auxiliary UART*. The module is designed as DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection.

Table 12: Pin Definition of UART Interfaces

Interface	Pin Name	Pin No.	Description	Comment
Main UART	MAIN_RXD	18	Main UART receive	1.8 V power domain
	MAIN_TXD	17	Main UART transmit	
Debug UART	DBG_RXD	38	Debug UART receive	
	DBG_TXD	39	Debug UART transmit	
Auxiliary UART*	AUX_RXD	28	Auxiliary UART receive	
	AUX_TXD	29	Auxiliary UART transmit	
Ring Indication	RI	20	Ring indication signal (when there is an SMS or URC output, the module will inform DTE with RI pin)	

3.8.1. Main UART Interface

The main UART interface can be used for AT command communication and data transmission, and in such case, the baud rates should be 4800 bps, 9600 bps (default) and 57600 bps. The main UART interface is available in active mode and idle mode.

The figure below shows the connection between DCE and DTE.

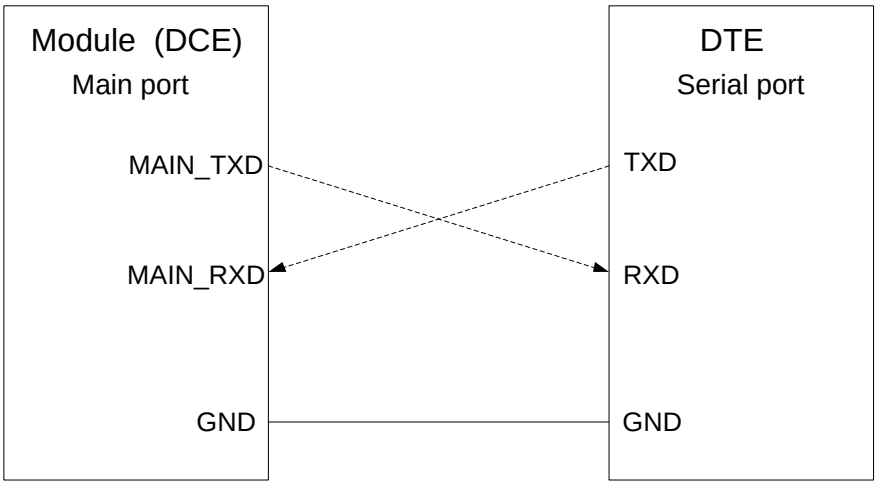


Figure 14: Reference Design for Main UART Interface

3.8.2. Debug UART Interface

Through debug tools, the debug UART interface can be used to output logs for firmware debugging and upgrading. The baud rate is 921600 bps by default. The following figure is a reference design for debug UART interface.

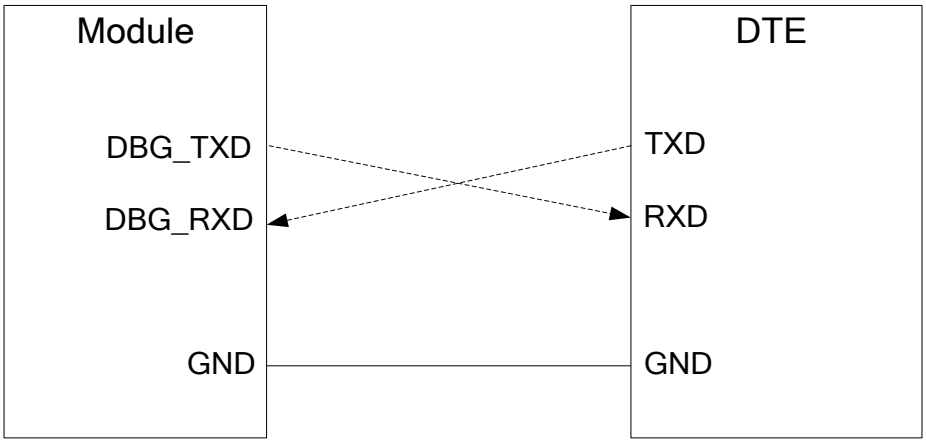


Figure 15: Reference Design for Debug UART Interface

3.8.3. Auxiliary UART Interface*

The auxiliary UART interface is designed as a general-purpose UART for communication with DTE. Its baud rates are 4800 bps, 9600 bps (default), and 57600 bps. The following is a reference design for auxiliary UART interface.

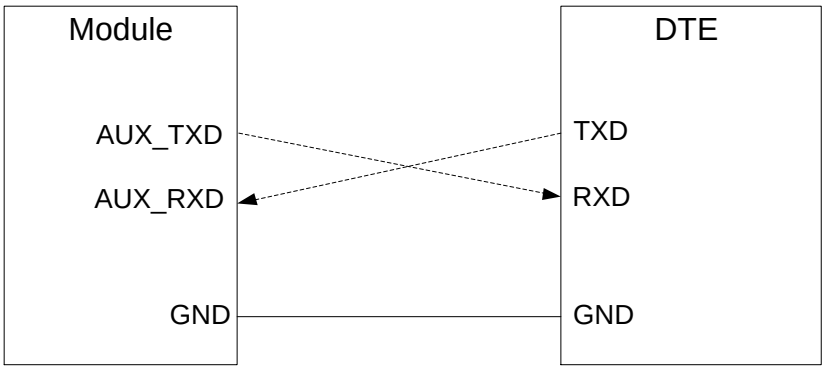


Figure 16: Reference Design for Auxiliary UART Interface

3.8.4. UART Application

The module provides 1.8 V UART interfaces. A level translator should be used if the application is equipped with a 3.3 V UART interface. A level translator TXS0108EPWR provided by *Texas Instruments* (visit http://www.ti.com for more information) is recommended. The following figure shows a reference design.

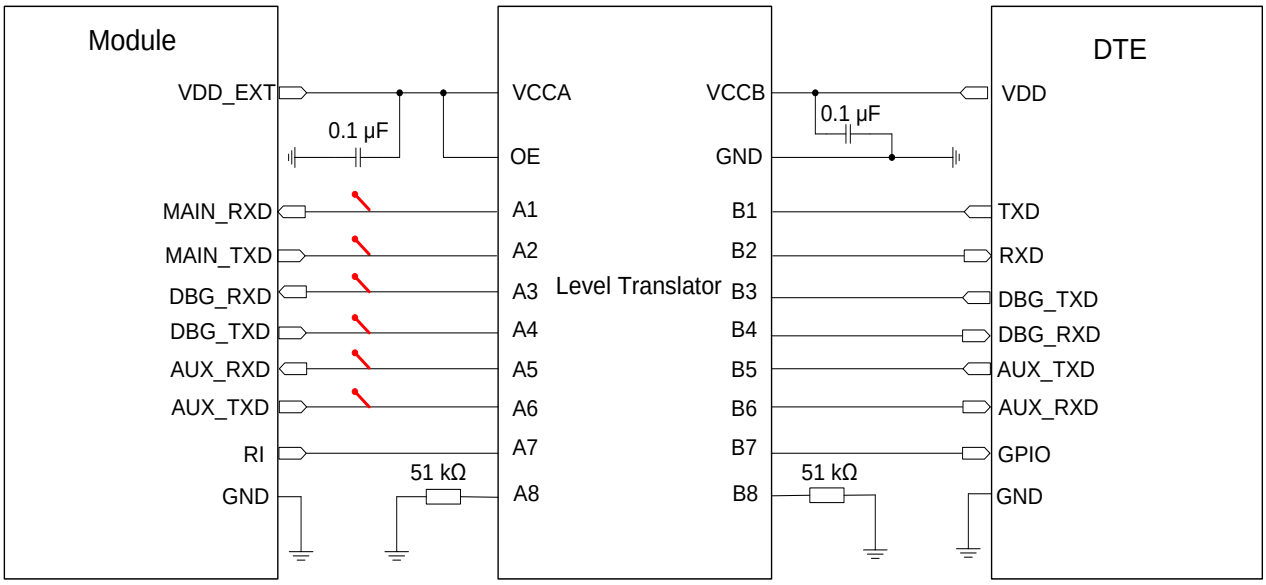


Figure 17: Reference Circuit with Level Translator Chip

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

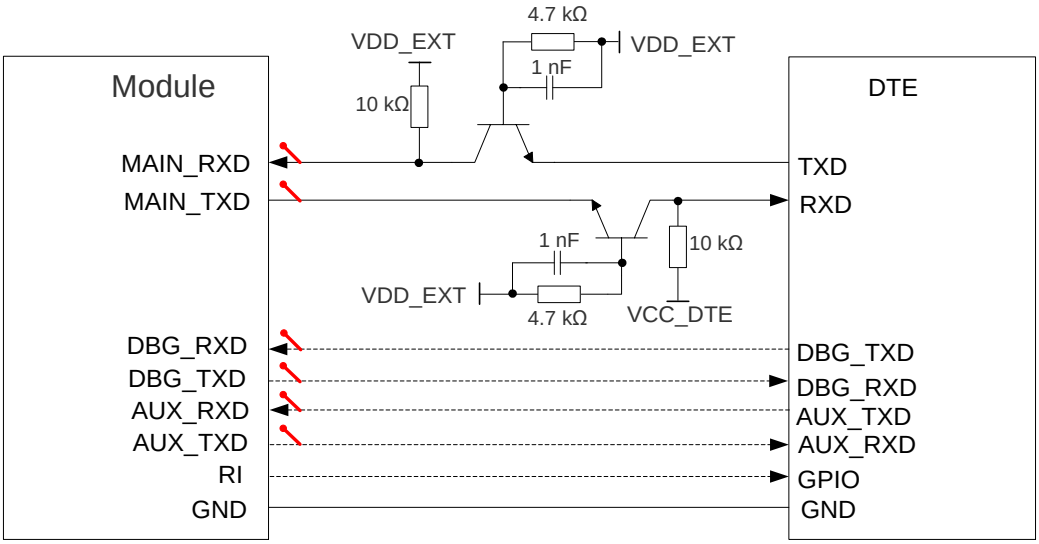


Figure 18: Reference Circuit with Transistor Circuit

The following circuit shows a reference design for the communication between the module and a PC with standard RS-232 transceiver. Make sure the I/O voltage of level translator which is connected to the module is 1.8 V.

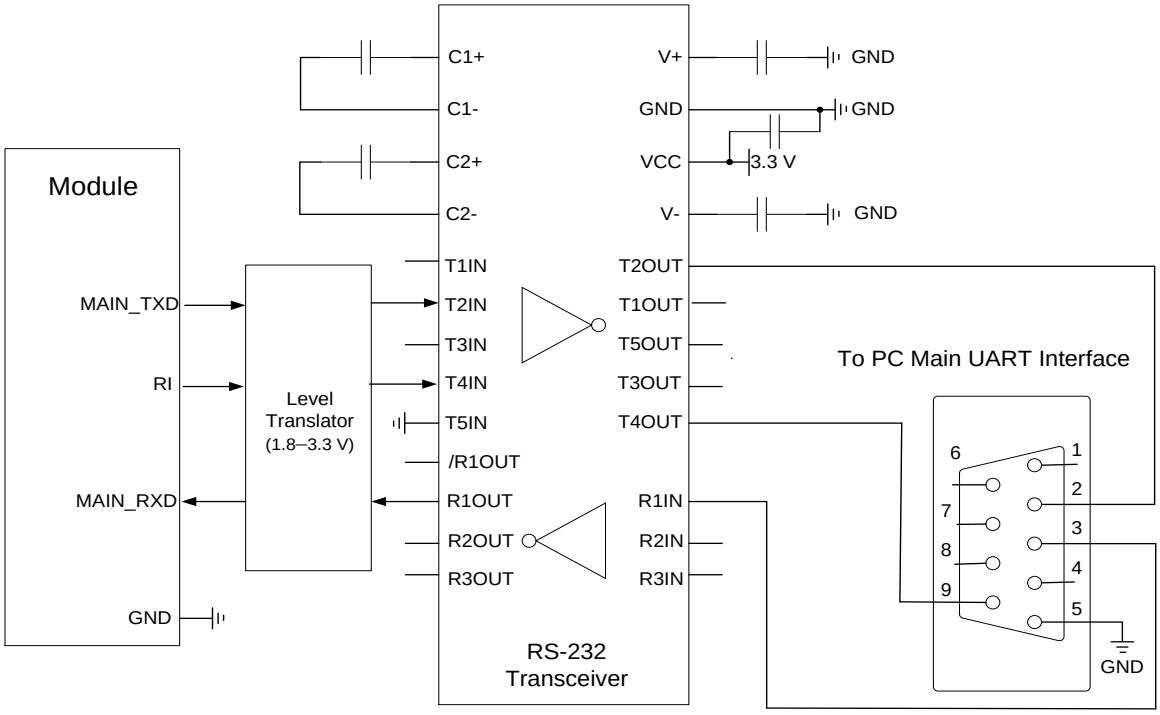


Figure 19: Sketch Map for RS-232 Interface Match

Visit vendors' websites to select a suitable RS-232 transceiver, such as: http://www.exar.com and http://www.maximintegrated.com.

NOTES

1. Transistor circuit solution is not suitable for applications with high baud rates exceeding 460 kbps.
2. " " represents the test point of UART interfaces. It is also recommended to reserve the test points of VBAT and PWRKEY for convenient firmware upgrading and debugging when necessary.
3. Please note that the module CTS is connected to the host CTS, and the module RTS is connected to the host RTS.

3.9. USIM Interface

The module provides a USIM interface compliant with ISO/IEC 7816-3, enabling the module to access to an external 1.8/3.0 V USIM card.

The external USIM card is powered by an internal regulator in the module and supports 1.8/3.0 V power supply.

Table 13: Pin Definition of USIM Interface

Pin Name	Pin No.	Description	Comment
USIM_VDD	14	USIM card power supply	Voltage accuracy: 1.8/3.0 V.
USIM_CLK	13	USIM card clock	
USIM_DATA	11	USIM card data	
USIM_RST	12	USIM card reset	

A reference circuit design for USIM interface with a 6-pin USIM card connector is illustrated below.

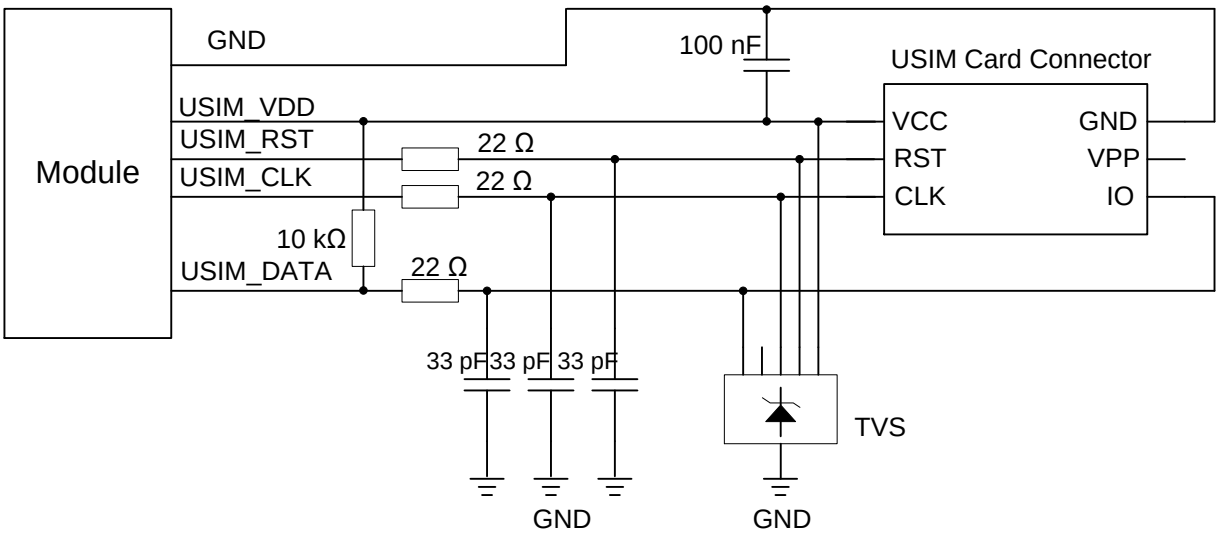


Figure 20: Reference Circuit for USIM Interface with a 6-pin USIM Card Connector

For more information of USIM card connector, visit http://www.amphenol.com or http://www.molex.com.

To enhance the reliability and availability of USIM card in application, follow the criteria below in USIM circuit design:

- Place the USIM card connector as close to the module as possible. Keep the trace length less than 200 mm to the greatest extent possible.
- Keep USIM card signals away from RF and VBAT traces.
- USIM_DATA needs to be pulled up to USIM_VDD through a 10 kΩ resistor.
- Make sure the trace between the ground of module and that of USIM card connector is short and wide. Keep the trace width of ground no less than 0.5 mm to maintain the same electric potential. The decoupling capacitor between USIM_VDD and GND should not be more than 1 μF and be placed close to the USIM card connector.
- To avoid cross talk between USIM_DATA and USIM_CLK, keep them away from each other and shield them separately with surrounded ground.
- For better ESD protection, it is recommended to add a TVS diode array. For more information of TVS diode, visit http://www.onsemi.com. The ESD protection device should be placed as close to USIM card connector as possible, and make sure the USIM card signal lines go through the ESD protection device first and then to the module. The 22 Ω resistors should be connected in series between the module and the USIM card connector to suppress EMI, such as spurious transmission and enhance ESD protection. Note that the USIM peripheral circuit should be close to the USIM card connector.
- Place the RF bypass capacitors (33 pF) close to the USIM card connector on all signal traces to improve EMI suppression.

3.10. ADC Interface

The module provides one Analog-to-Digital Converter (ADC) interface. The interface is available in active and idle modes.

Table 14: Pin Definition of ADC Interface

Pin Name	Pin No.	Description	Comment
ADC	9	General-purpose ADC interface	0–1.8 V

3.11. RI Behaviors

When a URC is received, RI will be driven low for at least 120 ms:

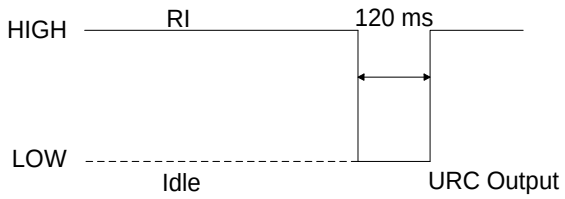


Figure 21: RI Timing When a URC Is Received

3.12. Network Status Indication

The NETLIGHT pin can be used to indicate the network status of the module. The following table illustrates the module status indicated by NETLIGHT.

Table 15: Module Status Indicated by NETLIGHT

NETLIGHT Level	Module Status
Always Low (LED Off)	The module is not working or the modem is in idle/PSM mode

64 ms High (LED On)/800 ms Low (LED OFF)	Network searching
64 ms High (LED On)/2000 ms Low (LED OFF)	Network connected

A reference circuit is shown as below.

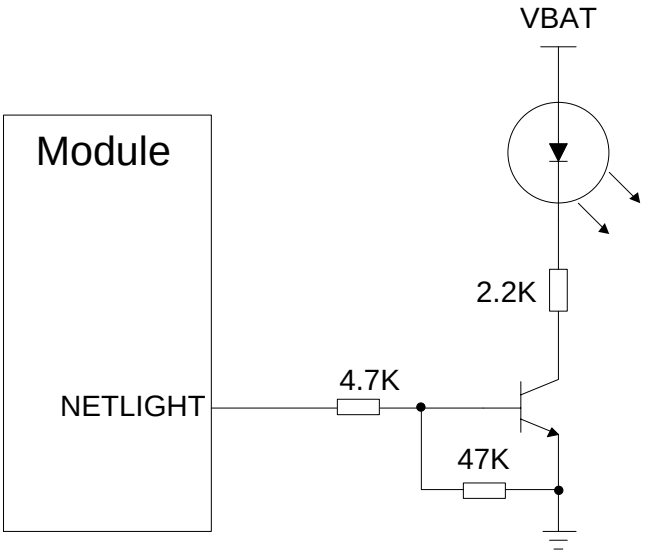


Figure 22: Reference Design for NETLIGHT

4 Antenna Interface

Pin 35 is the module's NB-IoT antenna interface, whose characteristic impedance is 50 Ω.

4.1. Antenna Interface

Table 16: Pin Definition of the NB-IoT Antenna Interface

Pin Name	Pin No.	Description
ANT_RF	35	Antenna interface
GND	34, 36, 37	Ground

4.1.1. Operating Bands

Table 17: Module Operating Bands

Frequency Band	Receiving Frequency	Transmitting Frequency
B1*	2110–2170 MHz	1920–1980 MHz
B3	1805–1880 MHz	1710–1785 MHz
B5	869–894 MHz	824–849 MHz
B8	925–960 MHz	880–915 MHz
B20	791–821 MHz	832–862 MHz
B28	758–803 MHz	703–748 MHz

4.1.2. Antenna Reference Design

BC65 provides an RF antenna pad for external NB-IoT antenna connection.

- The RF trace on the host PCB connected to the module's RF antenna pin should be coplanar waveguide or microstrip, whose characteristic impedance should be close to 50 Ω.
- BC65 comes with ground pins which are next to the antenna pin to give a better grounding.
- To achieve better RF performance, it is recommended to reserve a π-type matching circuit and place the π-type matching components (R1/C1/C2) as close to the antenna as possible. By default, the capacitors (C1/C2) are not mounted and a 0 Ω resistor is mounted on R1.

Reference design for the NB-IoT antenna interface is shown as below.

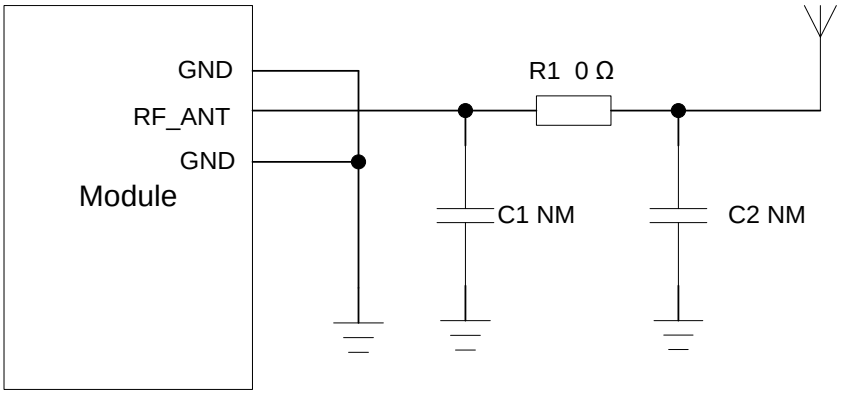


Figure 23: Reference Design for NB-IoT Antenna Interface

4.1.3. Antenna Requirements

To minimize the loss on RF trace and RF cable, pay attention to the antenna design. The following tables show the requirements for the antenna.

Table 18: Antenna Cable Insertion Loss Requirements

Frequency Range	Requirements
703–960 MHz	Cable insertion loss: < 1 dB
1710–2170 MHz	Cable insertion loss: < 1.5 dB

Table 19: Required NB-IoT Antenna Parameters

Parameters	Requirements
Frequency range	703–2170 MHz
VSWR	≤ 2
Efficiency	> 30 %
Max input power (W)	50
Input impedance (Ω)	50

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

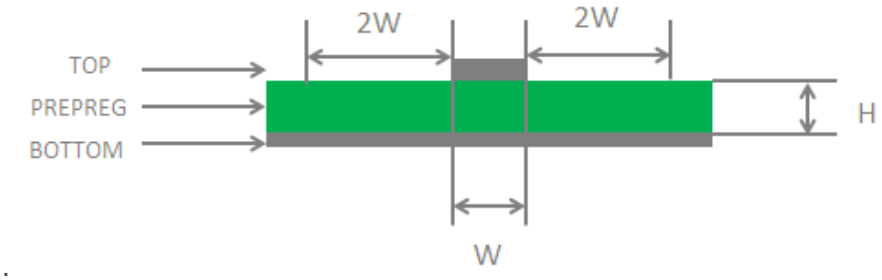


Figure 24: Microstrip Design on a 2-layer PCB

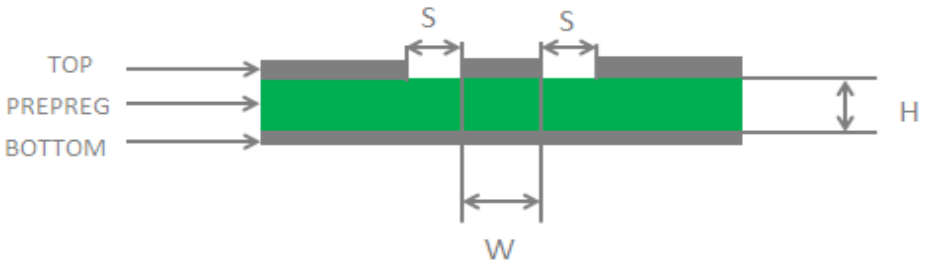


Figure 25: Coplanar Waveguide Design on a 2-layer PCB

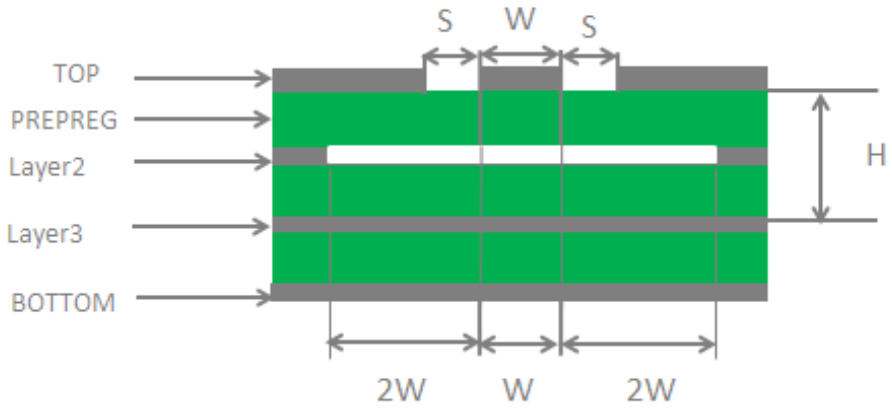


Figure 26: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

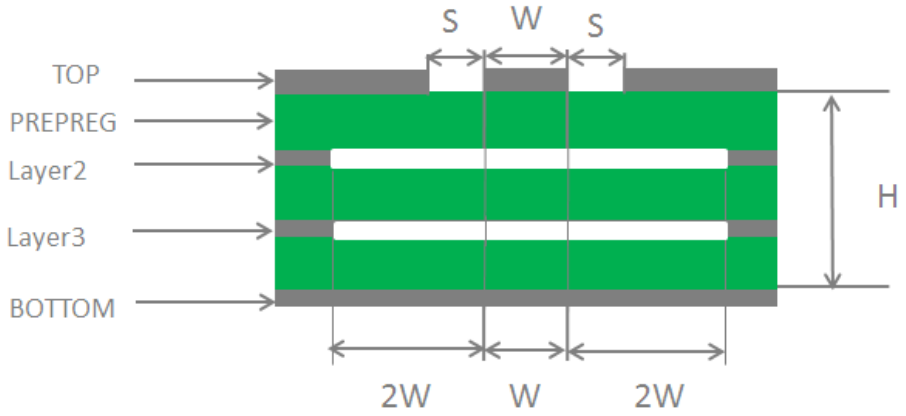


Figure 27: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

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

- Use an impedance simulation tool to accurately control the characteristic impedance of RF traces to 50 Ω.
- The GND pins adjacent to RF pins should not be designed as thermal relief pads, and should be fully connected to ground.
- The distance between the RF pins and the RF connector should be as short as possible, and all the right-angle traces should be changed to curved ones. 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).

For more details, see ***Document [3]***.

4.3. 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*.

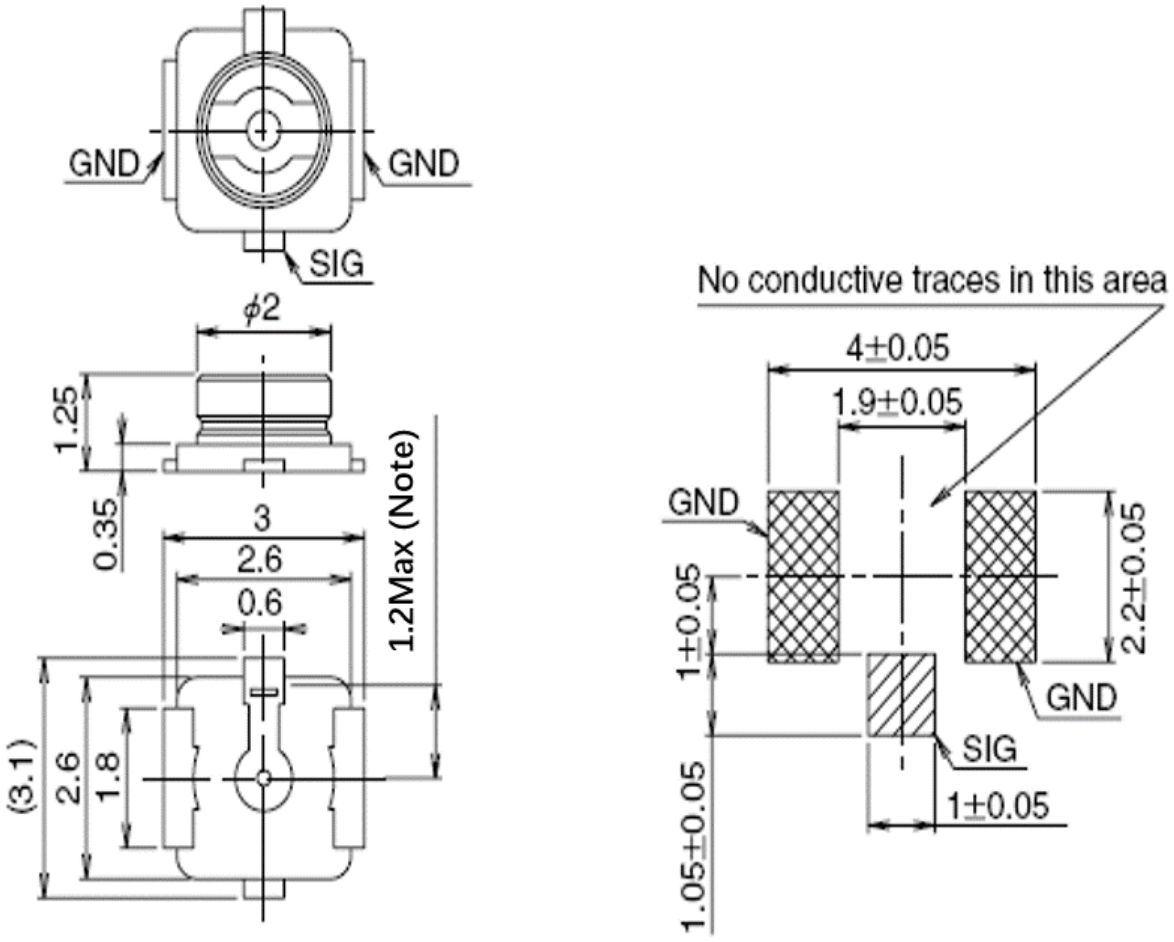


Figure 28: Dimensions of the U.FL-R-SMT Connector (Unit: mm)

(Note) Tolerance value of mold resin applied to center contact.

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

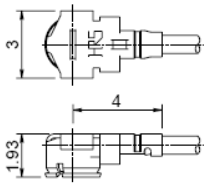
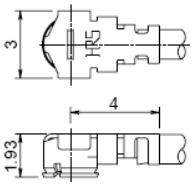
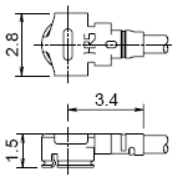
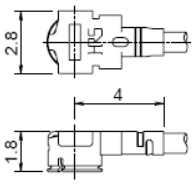
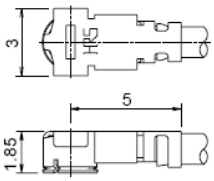
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia.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

The following figure describes the space factor of mated connector.

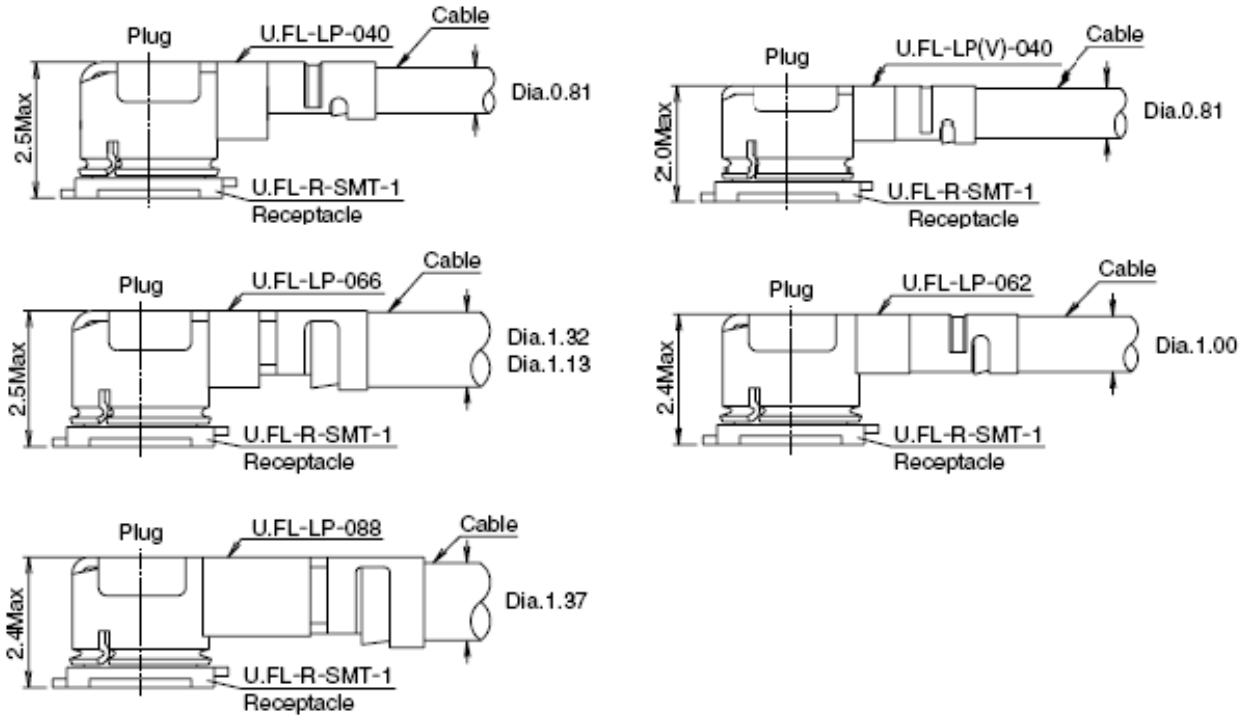


Figure 30: Space Factor of Mated Connector (Unit: mm)

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

5 Reliability, Radio and Electrical Characteristics

5.1. Operating and Storage Temperatures

The following table lists the operating and storage temperatures of BC65.

Table 20: Operating and Storage Temperatures

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

NOTES

1. [1)] Within the operating temperature range, the module meets 3GPP specifications.
2. [2)] Within the extended temperature range, the module keeps the ability to establish and maintain functions such as SMS* and data transmission, 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 operating temperature range, the module will meet 3GPP specifications again.

5.2. Current Consumption

The table below lists the current consumption of BC65 under different modes.

Table 21: Module Current Consumption (3.8 V VBAT Power Supply)

Parameter	Mode	Description	Band	Typ.	Unit
I_{VBAT}	Deep Sleep	Deep Sleep state		4.0	μA
	Idle mode	DRX = 2.56 s, ECL0		1.0	mA
	Active mode @ Single-tone (3.75/15 kHz)	Radio transmission 23 dBm	B1*	TBD	mA
			B3	280	mA
			B5	280	mA
			B8	350	mA
			B20	280	mA
			B28	350	mA
		Radio transmission 12 dBm	B1*	TBD	mA
			B3	140	mA
			B5	140	mA
			B8	140	mA
			B20	140	mA
			B28	140	mA
		Radio transmission 0 dBm	B1*	TBD	mA
			B3	70	mA
			B5	70	mA
			B8	70	mA
			B20	70	mA
			B28	70	mA

Active mode @ Multi-tone (15 kHz)	Radio transmission 23 dBm	B1*	TBD	mA
		B3	280	mA
		B5	280	mA
		B8	280	mA
		B20	280	mA
		B28	280	mA

5.3. RF Output Power

Table 22: RF Conducted Output Power

Band	Max RF Output Power	Min RF Output Power
B1*	TBD	TBD
B3	23 dBm ±2 dB	< -40 dBm
B5	23 dBm ±2 dB	< -40 dBm
B8	23 dBm ±2 dB	< -40 dBm
B20	23 dBm ±2 dB	< -40 dBm
B28	23 dBm ±2 dB	< -40 dBm

5.4. RF Receiving Sensitivity

Table 23: RF Receiving Sensitivity Without Retransmission (Throughput ≥ 95 %)

Band	Receiving Sensitivity	3GPP
B1*	TBD	TBD
B3	-114 dBm	-107.5 dBm
B5	-114 dBm	-107.5 dBm

B8	-114 dBm	-107.5 dBm
B20	-114 dBm	-107.5 dBm
B28	-114 dBm	-107.5 dBm

Table 24: RF Receiving Sensitivity in 128 Retransmissions (Throughput ≥ 95 %)

Band	Receiving Sensitivity
B1*	TBD
B3	-129 dBm
B5	-129 dBm
B8	-129 dBm
B20	-129 dBm
B28	-129 dBm

5.5. Electrostatic Discharge

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

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

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

Tested Interfaces	Contact Discharge	Air Discharge	Unit
VBAT, GND	±5	±10	kV
Antenna interface	±5	±10	kV
Other interfaces	±0.5	±1	kV

6 Mechanical Dimensions

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

6.1. Mechanical Dimensions of the Module

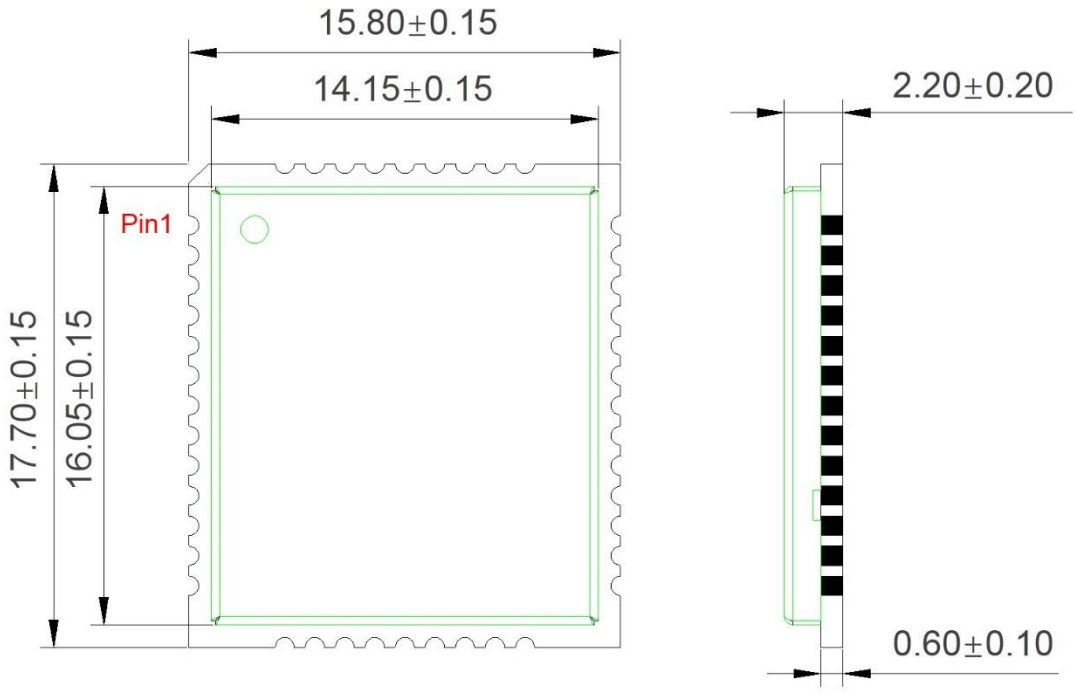


Figure 31: Module Top and Side Dimensions (Unit: mm)

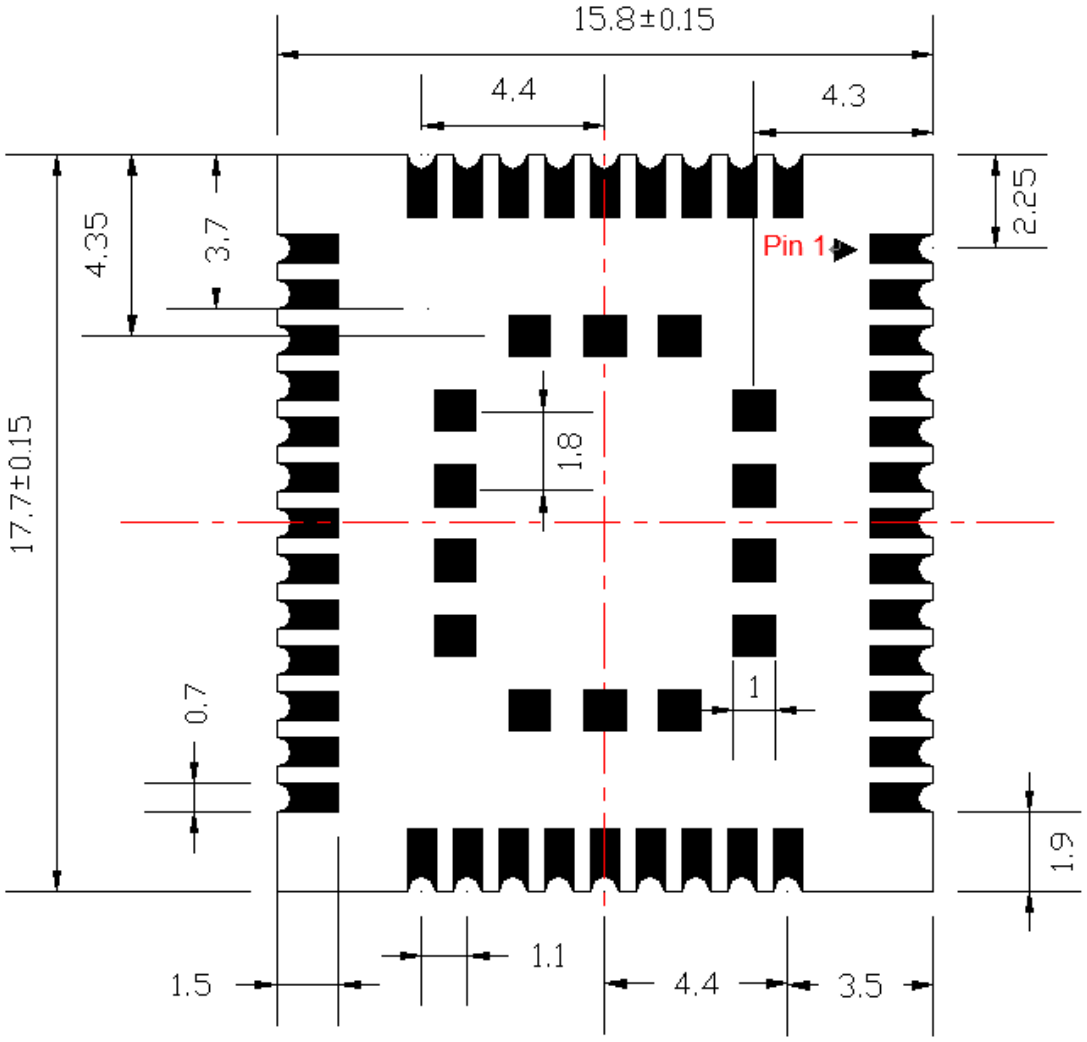


Figure 32: Module Bottom Dimension (Bottom View, Unit: mm)

NOTE

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

6.2. Recommended Footprint

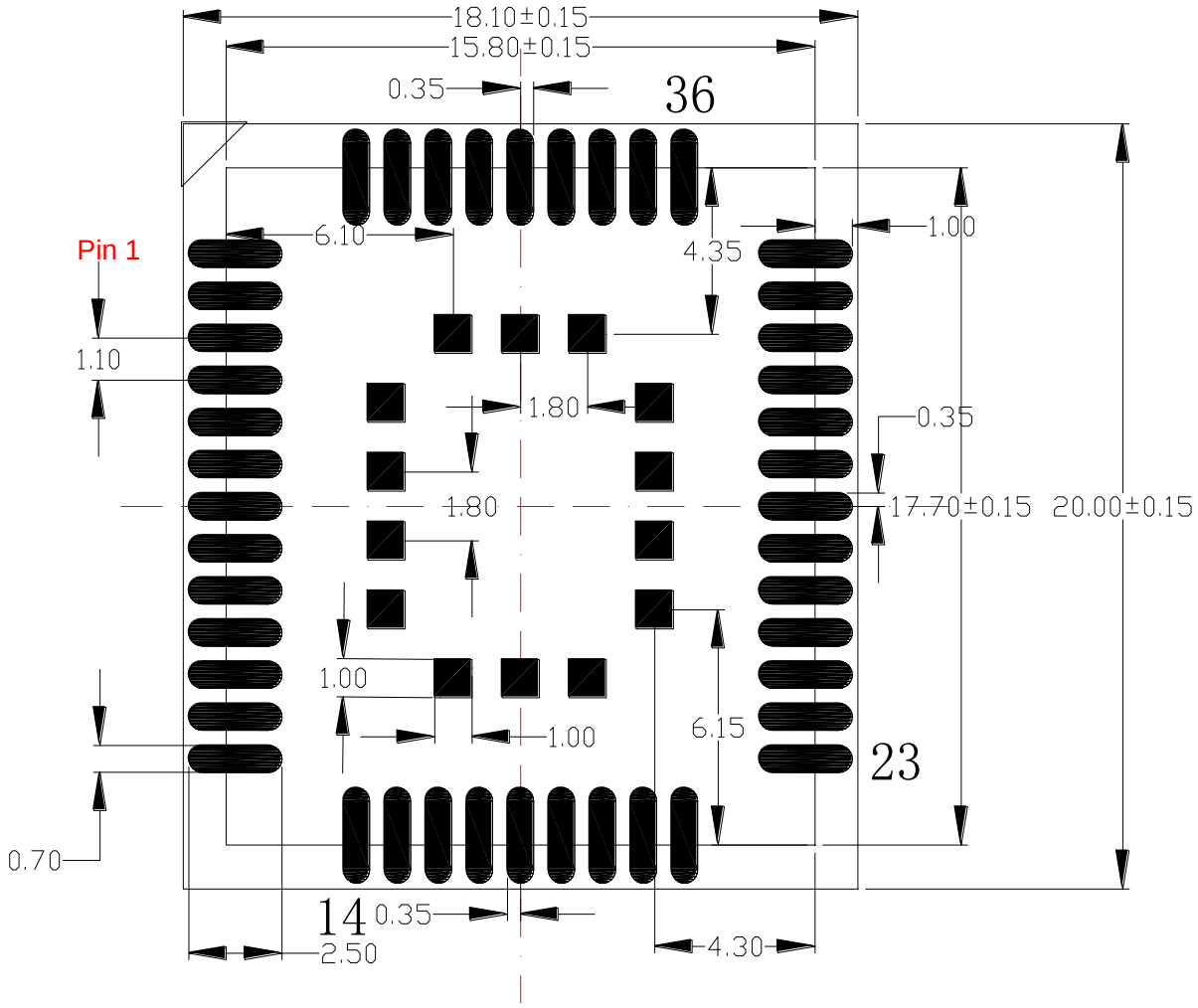


Figure 33: Recommended Footprint (Top View, Unit: mm)

NOTE

For easy maintenance of the module, keep about 3 mm between the module and other components on the motherboard.

6.3. Top and Bottom Views of the Module

Figure 34: Top View of the Module

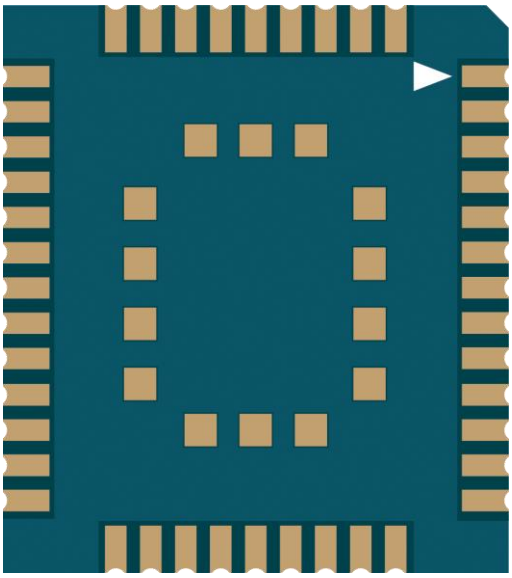


Figure 35: Bottom View of the Module

NOTE

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

7 Storage, Manufacturing and Packaging

7.1. Storage

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 [1)] 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.

NOTES

1. [1)] This floor life is only applicable when the environment conforms to *IPC/JEDEC J-STD-033*.
2. To avoid blistering, layer separation and other soldering issues, it is forbidden to expose the modules to the air for a long time. If the temperature and moisture do not conform to *IPC/JEDEC J-STD-033* or the relative moisture is over 60 %, it is recommended to start the solder reflow process within 24 hours after the package is removed. And do not remove the packages of tremendous modules if they are not ready for soldering.
3. Take the module out of the packaging and put it on high-temperature resistant fixtures before the baking. If shorter baking time is desired, see *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 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 0.15–0.18 mm. For more details, see ***Document [4]***.

It is suggested that the peak reflow temperature be 238 ºC to 246 ºC, and the absolute maximum reflow temperature be 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.

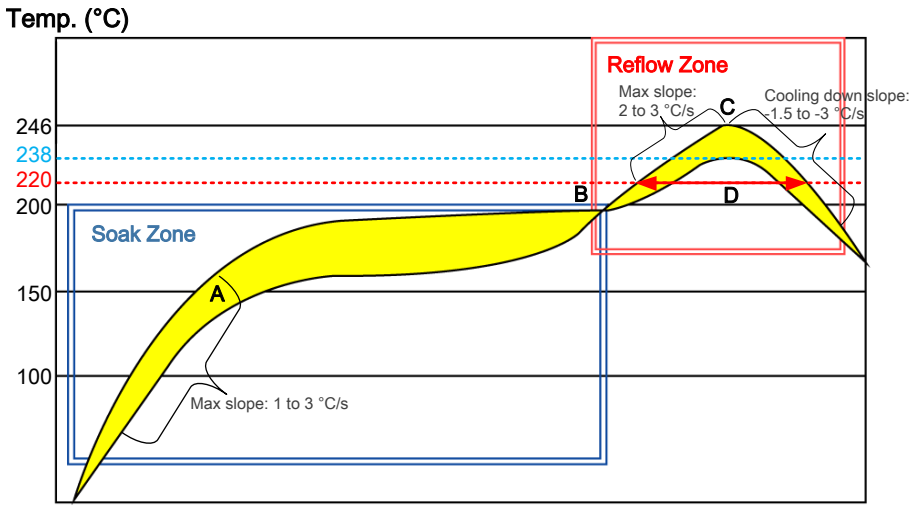


Figure 36: Recommended Reflow Soldering Thermal Profile

Table 26: Recommended Thermal Profile Parameters

Factor	Recommendation
Soak Zone	
Max slope	1 to 3 °C/s
Soak time (between A and B: 150 °C and 200 °C)	70–120 s
Reflow Zone	
Max slope	2 to 3 °C/s
Reflow time (D: over 220 °C)	45–70 s
Max temperature	238 °C to 246 °C
Cooling down slope	-1.5 to -3 °C/s
Reflow Cycle	
Max reflow cycle	1

NOTES

1. During manufacturing and soldering, or any other processes that may contact the module directly, NEVER wipe the module's shielding can with organic solvents, such as acetone, ethyl alcohol, isopropyl alcohol, trichloroethylene, etc. Otherwise, the shielding can may become rusted.
2. If a conformal coating is necessary for the module, do NOT use any coating material that may chemically react with the PCB or shielding cover, and prevent the coating material from flowing into the module.

7.3. Packaging

The modules are stored 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.

7.3.1. Tape and Reel Packaging

The reel is 330 mm in diameter and each reel contains 250 modules.

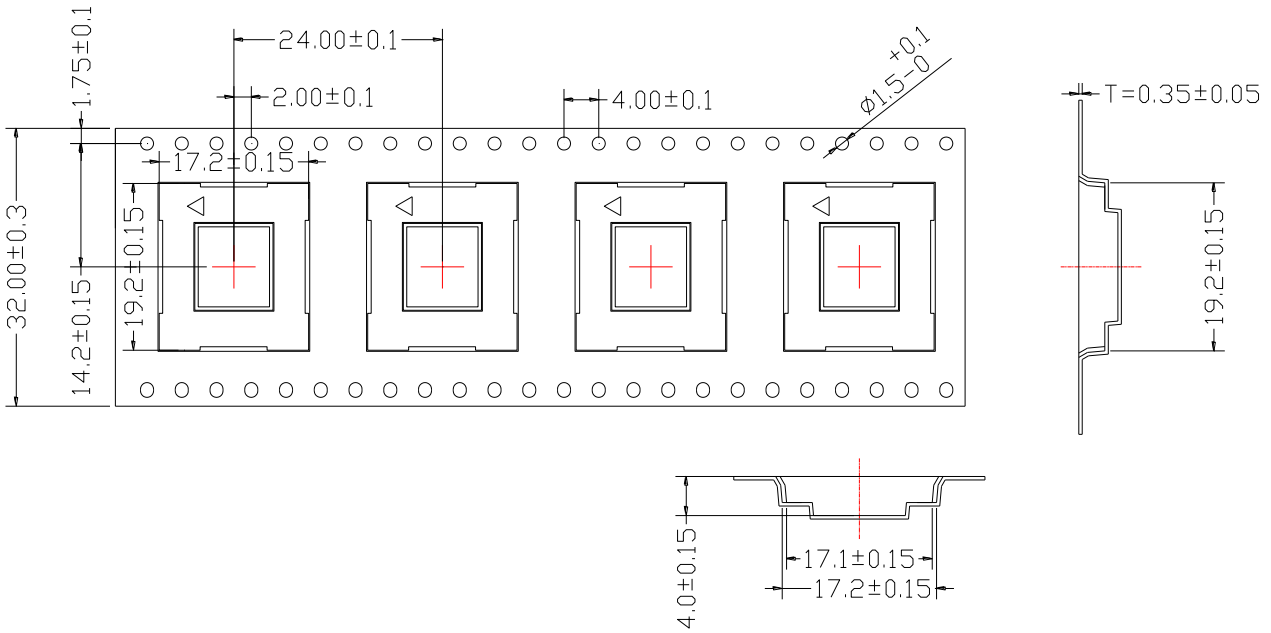


Figure 37: Tape Dimensions (Unit: mm)

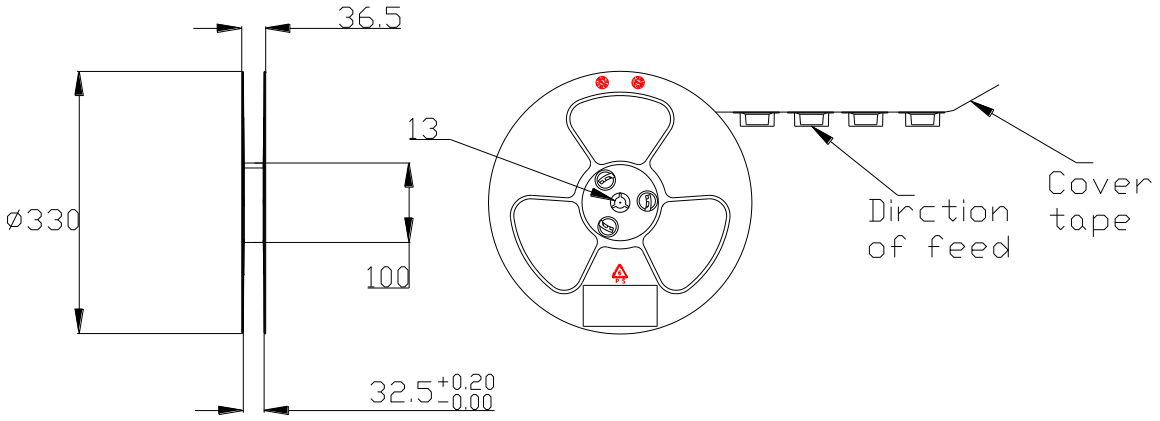


Figure 38: Reel Dimensions (Unit: mm)

8 Appendix Reference

Table 27: Related Documents

SN	Document Name	Description
[1]	Quectel_BC65-TE-B_User_Guide	BC65-TE-B User Guide
[2]	Quectel_BC65_AT_Commands_Manual	The AT commands manual of BC65
[3]	Quectel_RF_Layout_Application_Note	RF Layout Application Note
[4]	Quectel_Module_Secondary_SMT_User_Guide	Module Secondary SMT User Guide

Table 28: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
CPU	Central Processing Unit
DCE	Data Communications Equipment (typically module)
DTE	Data Terminal Equipment (typically computer, external controller)
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
ESR	Equivalent Series Resistance
HB	High Band
H-FDD	Half Frequency Division Duplexing
HPM	High Power Mode
HTTP	Hyper Text Transfer Protocol

I/O	Input/Output
kbps	Kilo Bits Per Second
LB	Low Band
LDO	Low-dropout Regulator
LED	Light Emitting Diode
Li-MnO2	Lithium-manganese Dioxide
LPM	Low Power Mode
LTE	Long Term Evolution
MQTT	Message Queuing Telemetry Transport
NB-IoT	Narrow Band- Internet of Things
PA	Power Amplifier
PCB	Printed Circuit Board
PDU	Protocol Data Unit
PMU	Power Management Unit
PSRAM	Pseudo Static Random-Access Memory
PSM	Power Saving Mode
PTW	Paging Time Window
RF	Radio Frequency
RTC	Real Time Clock
RX	Receive
RXD	Receive Data
SMS	Short Message Service
TCP	Transmission Control Protocol
TX	Transmit
TXD	Transmit Data

UART	Universal Asynchronous Receiver & Transmitter
UDP	User Datagram Protocol
URC	Unsolicited Result Code
USIM	Universal Subscriber Identification Module
VSWR	Voltage Standing Wave Ratio
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_{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